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PREFACE

An annual report helps to demonstrate the accomplishments to current and future stake holders, cultivate new partnerships, and recognize important issues. However, for an organization that aims at innovations and improvements in the agriculture and allied sector, compilation of the report threading all small bits into a chain is a difficult task. I compliment the Editorial Board for making their best efforts to highlight all major efforts and achievements of ICAR Research Complex in tandem with its six regional centres during the year 2010 – 2011.

The overall impact of research in areas of responsibility, I am happy to mention, has been quite satisfying. The institute worked untiringly to find solutions for the problems of resource poor and topographically disadvantageous farmers. Through the efforts of its dedicated staff the institute could add four rice and one tomato variety to its existing list of varieties. Area under horticultural crops showed tremendous growth and the region is now surplus in various horticultural commodities. Efforts made in the field of technology dissemination were commendable and technologies like farming systems, watershed management, conservation agriculture, SRI, ICM, vermi-composting with indigenous earthworm species, low cost poly house technology, implement making etc were transferred to farmers of remote areas. Farmers of the most backward districts of the region benefitted immensely through the programmes of NAIP. The support extended by the Animal Sciences and Fishery group helped in improving output. All these efforts helped in increasing cropping intensity from an average of 114% to 150%. Effect of climate change on agriculture has been a matter of concern. The institute has initiated research in the area of climate resilient agriculture.

The institute organized a number of seminars/symposia/workshops/meetings etc. on the upcoming areas of interest to different sections of stake holders. The institute also successfully coordinated entrepreneurship development and technology showcasing for bringing in private partners in technology dissemination.

All these were possible due to the constant support and able guidance received from our Director General and Secretary, DARE, Govt. of India, Dr. S. Ayappan and Dy. Director General (NRM), Dr. A. K. Singh in addition to the support received from staffs of all categories in the institute and its regional centres.

(S. V. Ngachan)
Director

CONTENTS

उत्तर पूर्वी पर्वतीय क्षेत्रों के लिए भा.कृ.अनु.प. का अनुसंधान परिसर, उमियम अपने मेघालय, अरुणाचल प्रदेश, मणिपुर, मिजोरम, नागालैंड, त्रिपुरा तथा सिक्किम में स्थित क्षेत्रीय केन्द्रों के साथ कृषि विज्ञान सम्बन्धी अनेक विषयों जिनमें पशुविज्ञान और मत्स्यिकी भी शामिल हैं, पर मूलभूत, कार्यनीतिक, व्यव्हारिक तथा अनुकूली अनुसंधान कार्यों में संलग्न रहा है। वर्ष 2010-11 में किए अनुसंधान कार्य के प्रमुख परिणामों एवं प्रगति का संक्षिप्त विवरण निम्नलिखित है।

फसल सुधार कार्यक्रम में मेघालय और मणिपुर के लिए चावल की 5 किस्मों जैसे भाल्युम -3 व 4 (उपराऊ), मेघालय चावल 3 व 4 (निचली भूमि के लिए बढ़िया चावल) तथा आर सी मनिफॉ-11 (फटन रोग व तना बेधक कीट की प्रतिरोधी) को जारी/अधिसूचित किया गया। इस प्रकार, इस क्षेत्र के विभिन्न स्थानों के लिए चावल की जारी की गई कुल 21 किस्मों से क्षेत्र में चावल की उत्पादकता को बढ़ाने में सहायता मिली है। दलहनों में त्रिपुरा और मेघालय के लिए टी आर सी पी-8 किस्म को जारी किया गया। सब्जी फसलों में, मेघालय राज्य के लिए मेघा टमाटर-3 किस्म को जारी/अधिसूचित किया गया। स्थानीय देसी चावल के जननद्रव्य के मूल्यांकन से पता लगा कि वंशक्रम एम ई-एस आर-1, एस-ई-एम आर-6, एम एन-एम आर 24 तथा एम एन-एस आर-14 में सेलमोनेला, स्टैफाइलोकोकस आदि जैसे जीवों के प्रति जीवाणु रोधिता होती है।

पादप संरक्षण के अन्तर्गत चावल की किस्मों भालुम-1 तथा भालुम-2 को सामान्यतः पत्ती मोड़क तथा गाल मिज कीट के प्रति मध्यम श्रेणी का सहिष्णु पाया गया। ह्वाइट लेहरित में मूल एफिड का प्रकोप बहुत कम रहा। आई आर-64, रमिनद एस टी आर 3, एन पी 125, सी 101 एल ए सी तदुकन तथा सी 105 टी टी पी-4-एल 23 को फटन रोग का प्रतिरोधी पाया गया।

उपराऊँ स्थिति के अन्तर्गत परम्परागत जुताई (2.56 टन/हे.) की तुलना में न्यूनतम जुताई (2.80 टन/हे.) वाले धान में उपज अधिक मिली। 50% आर.डी.एफ +यूपेटोरियम के ताजा बायोमास के उपयोग करने से अधिकतम अन्न उपज (3.07 टन/हे.) प्राप्त की गई और उसके बाद 50% आर.डी.एफ +चावल की भूसी 5 टन/हे. (3.05 टन/हे.) से मिली। निचली भूमि स्थिति के अन्तर्गत शून्य व न्यूनतम जुताई से परम्परागत जुताई की तुलना में क्रमशः 33 और 15% अधिक धान की उपज रिकार्ड की गई। चावल की खेती वाली भूमि में शून्य जुताई के अन्तर्गत मटर की विभिन्न किस्मों के प्रयोग करने पर आई पी एफ डी 99-13 से अधिकतम हरी फलियों की (4.1 टन/हे.) पैदावार रिकार्ड की गई, उसके बाद आई पी एफ डी 1-10 (3.295 टन/हे.) से रिकार्ड किया गया तथा मसूर की प्रयोग की गई किस्मों में डी पी एल-15 से बीज उपज (1.10 टन/हे.) और उसके बाद डी पी एल 62 (0.87 टन/हे.) से अधिकतम उपज रिकार्ड की गई।

पूर्व-खरीफ मौसम में सीधी बीज बुवाई के अन्तर्गत शाहसंरग 1 (4.7 टन/हे.) और आई आर (4.5 टन/हे.) जैसी किस्मों से अच्छी पैदावार हुई। धान की पूर्व-खरीफ सीधी बीज बुवाई से रैटून उपज पौधरोपण फसल की तुलना में बेहतर रही। धान में कटाई के समय 25 से. मी. ऊंचाई होने से 15 से.मी. ऊंचाई की अपेक्षा अधिक पैदावार मिली। दलदली भूमि में मूंगफली-शिमलामिर्च की कुल प्रणाली उत्पादकता (15.91 टन/हे.) सर्वाधिक रिकार्ड की गई और उसके बाद उठाई गई क्यारियों में मूंगफली-फूलगोभी प्रणाली से रिकार्ड की गई। फ्रेंचबीन-तोरिया से 5.85 टन/हे. की कुल प्रणाली उत्पादकता का आकलन किया गया तथा सबसे कम (2.482 टन/हे.) मक्का-तोरिया में आंकी गयी। दलदली भूमि में फूलगोभी की समकक्ष पैदावार (सी ई वाई) के सन्दर्भ में कुल प्रणाली उपादकता उठाई गई क्यारियों से फूलगोभी+4 मटर (31.3 टन/हे.) में अधिकतम रही। बिलम्बित पौधरोपण (15 अगस्त तक) के अन्तर्गत वी एल-धान 61 और विवेक धान -82 से काफी अच्छी पैदावार दर्ज की गई। पोषक तत्व आपूर्ति के जैविक स्रोतों के अन्तर्गत चारा फसलों जैसे झाड़ू घास, कंगोसिगनल, नैपियर और गुनिया घास की उत्पादकता अधिकतम रही।

चावल, मक्का, सोयाबीन, मूंगफली, सरसों, फ्रैंचबीन और अदरक के लिए जैव-कार्बनिक को सामान्य अवस्था की तुलना में 10-30% तक उत्पादकता बढ़ाने के लिए अनुकूल पाया गया। एफ. वाई. एम वर्मिकम्पोस्ट और पंचगव्य के एकीकृत उपयोग से मक्का, तोरिया और फ्रैंचबीन के दानों की अधिकतम उपज रिकार्ड की गई और उसके बाद 1/2 एफ. वाई. एम +1/2 वी.सी के उपयोग से प्राप्त की गई। जैविक खाद के बाद एकीकृत क्रियाओं के अन्तर्गत

मिट्टी में राईजोबियम, पीस्यूडोमौनस और एक्टिनोमिसेट्स जैसे लाभदायक सूक्ष्म जीवों की संख्या अधिकतम पायी गयी। मक्के में डेरिसोम 3 एम एल/लीटर तथा गोमूत्र के साथ पंचगव्य के प्रयोग से मक्के के दानों की उपज अधिक पायी गयी (3.74 टन/हे.)। जैविक उत्पादन में टमाटर के गुणवत्तापूर्ण प्राचलों जैसे फल, भार, विशिष्ट गुरुत्व और फल व्यास अन्य उपचारों की तुलना में उत्कृष्ट रहा।

अपशिष्ट के उपयोग से शून्य जुताई से अनाज की उपज (4563 कि.ग्राम/हे.) सर्वाधिक पाई गई जबकि पारम्परिक जुताई में भूसे का प्रयोग न करने से न्यूनतम अनाज पैदावार (4093 कि.ग्राम/हे. रही। शून्य जुताई के अन्तर्गत मक्का+मुंगफली को जोड़े की कतारों में बिना अपशिष्ट के साथ अन्त: फसल में अधिकतम डब्लू यू ई (42.9 कि.ग्राम/हे. एम एम) रिकार्ड की गई। स्ट्रॉबेरी में स्ट्रा पलवार के उपयोग से अधिक पैदावार रिकार्ड की गई। 1.0 पी ई टी के साथ-साथ बाद में 1.2 पी ई टी के अन्तर्गत बेरी की उपज सर्वाधिक रही। कुल 18 किसान प्रशिक्षण और 4 प्रशिक्षु प्रशिक्षण कार्यक्रमों का आयोजन किया गया।

मक्के में टी आर जी-4 (4.4 टन/हे.) और आर सी एम-76 (4.3 टन/हे.) को उन्नत पाया गया। बड़ापानी की स्थिति में मक्के की संकर किस्म एफ एच 3356 (7.9 टन/हे.) को अत्यधिक अनुकूल पाया गया। स्थानीय येलो और विवेक क्यू पी एम में न्यूनतम और अधिकतम कौब बौरर का प्रकोप क्रमश: 4.09 और 14.40% पाया गया। जून में बोये गये मक्के में अधिकतम कॉब बोरर का प्रकोप देखा गया। इन नाशी जीवों के लिए क्लोथिऐनिडिन 50% डब्लू डी जी का उपयोग 0.25 ग्राम/ली. के हिसाब से, फलूबेंडिएमाइट 39.35 मी/मी. एस सी का 0.5 मि ली./ली के हिसाब से, इंडोक्सेकैर्ब 14.5 एस सी का 1 मि.ली./ली. के हिसाब से कार्बोफ्यूरैन 3 जी का 5-6 ग्रेन्यू/हर्बल और स्पाइनोसैड 45 एस सी का 0.75 मि.ली/ली के हिसाब प्रयोग करने पर प्रभावी पाया गया। मक्के के टर्सिकम लीफ ब्लाइट के प्रति परीक्षित, 103 जीनोटाइपों में से 42 प्रतिरोधी और 18 साधारणतया प्रतिरोधी थे।

कृषि वानिकी के अन्तर्गत, छ: फल वृक्षों पर आधारित मक्के की अन्त: फसल को बागवानी -कृषि प्रणाली में ढलाऊं भूमि क्षेत्र में उनकी उत्पादकता के लिए मूल्यांकन किया गया, ये फलवृक्ष हैं, जैसे आडू (प्रूनस पर्सिका), अमरूद (पी सीडियम गौजावा), असमी नींबू (सिट्रस लाइमन), नासपाती (पाइरस कॉम्यूनिस), प्लम (प्रूनस डोमेस्टिका), मीठा संतरा (सिट्रस सिनेंसिस)। आडू+मक्का (आर सी एम आई-1) से सर्वाधिक उत्पादन (5.73 टन/हे, मक्का के समकक्ष उपज) रहा।

पैर्किया रॉक्सबर्गी के वृक्ष सुधार कार्यक्रम में, वृक्ष की सर्वाधिक लम्बाई (4.37 मी) तथा आधारतभूत व्यास (7.57 से.मी) केजेंगल्वा उद्गम स्थान में प्राप्त हुआ। मेघालय में जैट्रोफा क्यूर्कस के 13 उद्गम स्थानों/बीज स्रोतों में से पी जे एस-2(495 कि.ग्रा./हे) से सर्वाधिक बीज उपज प्राप्त हुई और उसके बाद मावहाटी (485 कि.ग्रा/हे) से मिली तथा अधिकतम तेल तत्व मावहाटी (40.67 प्रतिशत) से मिला और उसके बाद तुरा (39.67 प्रतिशत) से प्राप्त हुआ। वृद्धि और उपज सम्बन्धी विशेषताओं के सन्दर्भ में म्यूकाना प्रुरीन्स के उन्यासी जीनोटाइपों में काफी ज्यादा विविधता पायी गयी। संकलन यू पी एम पी-11(792 ग्रा.) में प्रति पौधा सर्वाधिक बीज उपज रिकार्ड की गई और उसके बाद डब्लू बी एन एम पी -3 (667 ग्रा.) से की गई। मूल्यांकित 79 संकलनों में से 32 उन्नत संकलनों को पूर्ण पारपत्र आंकड़ों सहित अभिगमन संख्या प्राप्त करने हेतु राष्ट्रीय पादप आनुवांशिक संसाधन ब्यूरो, नई दिल्ली को भेजा गया।

हेज की उत्पाती 5 प्रजातियों जैसे फ्लेमिंगिया, मैक्रोफिला, क्रोटोलैरिया टेट्रागोना, इंडिगोफेरा टिन्क्टोरिया, टेफ्रोसिया कैंडिडा और कैजेनस कैजान की सड़न प्रक्रिया से पता लगा कि अपक्षय स्थिरता, टी-अर्धता में विविघता पायी गई जो क्रोटोलैरिया टेटैगोना में 0.0363 फ्लोमिंगिया मैक्रोफिला में 0.1338 तक पायी गई।

सघन समेकित खेती प्रणाली के 5 विभिन्न नमूनों में फसल-मछली-वर्मिकम्पोस्ट बागवानी हेडगेरो पद्धति में मछली की उत्पादकता सर्वाधिक (1.62 टन/हे) रिकार्ड की गई। पशुधन में, सर्वाधिक दैनिक भार वृद्धि शूकर (0.28 कि.ग्रा/दिन) में देखी गई। सर्वाधिक मांस उत्पादन फसल-मछली-मुर्गीपालन-बहु-उद्देश्यीय वृक्षों (0.64 टन/हे) से रिकार्ड किया गया। इन 5 मौडलों में, फसल-मछली-मुर्गीपालन-बहु-उद्देश्यीय वृक्ष मौडल सबसे अधिक लाभदायक रहे।

प्रकाश-असंवेदनशील राइसबीन पी आर आर २ को आर बी एल-1 की तुलना मे उत्कृष्ट पाया गया। परती भूमि वाले धान में यूटेरा खेती के अन्तर्गत मसूर के निष्पादन से पता लगा कि एल 305 किस्म (1.2 टन/हे) से अपेक्षाकृत अधिक बीज पैदावार रिकार्ड की गई और उसके बाद एल 304 (1.0 टन/हे) और एल 303 (0.96 टन/हे) से प्राप्त हुई। अरहर की बहार किस्म में 35 से अधिक कीटों की प्रजातियों रिकार्ड की गईं जिनमें कुछ प्राकृतिक शत्रु कीट भी शामिल हैं।

खेती प्रणाली अनुसंधान के अन्तर्गत डेरी आधारित भूमि उपयोग में निवेश-उपज का अनुपात 2.57 पाया गया। लोबिया की बुन्देल लोबिया किस्म-1 (31.05 टन/हे) तथा जई की ए ओ एस सी -7 किस्म (32.58 टन/हे) से हरी फली की बेहतर पैदावार दर्ज की गई। वन्य चारे वाली भूमि उपयोग में 11 बकरियां, 300 ब्रॉइलर मुर्गी से एक वर्ष में 56,016.00 रुपये का शुद्ध लाभ दर्ज किया गया। कृषि-चारा प्रणाली में 2,00,818.00 रुपये की समग्र वसूली 1:39 के अनुपात से निवेश-उपज दर्ज की गई यह देखा गया कि हल्दी+खीरा/लौकी से अधिकतम कुल प्रणाली उत्पादकता दर्ज की गई। कृषि-बागवानी-वन्य चारा प्रणाली से 1.80:1 के लाभ-लागत अनुपात सहित 1,10270 रुपये की समग्र वसूली प्राप्त हुई। सब्जी आधारित फसल से समग्र एवं शुद्ध वसूली में अधिकतम योगदान दर्ज किया गया। बागवानी-वानिकीय प्रणाली में 610 मी² भूमि ही मसाला फसल को आवंटित थी जबकि अमरूद के लिए 4313 मी² क्षेत्र उपलब्ध है। इस प्रणाली से 17,667.00 रु की कुल उत्पादकता रिकार्ड की गई।

संकर सोयाबीन के 2-1, आर सी एस 1-9 और आर सी एस 1-10 जीनोटाइपों से 3.2-2.9 टन/हे. पैदावार प्राप्त हुई। पत्ती मोड़क कीट के लिए जैविक कीटनाशक बी.टी. किस्म कुर्स्तकी (2 ग्रा./ली.) को उत्कृष्ट पाया गया तथा उसके बाद एन.एस के ई 5% + गौमूत्र (1:1 मिश्रण) रहा जिससे सामान्य की तुलना में क्रमश: 42.85 तथा 35.71% क्षति कम हुई। सोयाबीन की के एस 103 और ई सी 241778 किस्मों को रतुवा रोग के प्रति बहुत अधिक प्रतिरोधी किस्में पाया गया। रतुवा के कारण 9% से 47% तक पैदावार का नुकसान आंका गया। मूंगफली में ब्लिस्टर बीटलों और पत्ती मोड़क कीटों की रोकथाम के लिए एन एस के ई का 5% सत कारगर पाया। सरसों के ऐफिड सम्बन्धी एक सक्षम प्रिडेटर कोक्सिनेल्ला सेप्टैम्पुन्क्टेटा का जीव वैज्ञानिक अध्ययन किया गया।

वर्मिकम्पोस्ट और जैविक अपशिष्ट से खाद बनाने के लिए देसी केंचुआ (पेरिऑनिक्स ऐक्सकैवैटस) पर अध्ययन किया गया। पादप रोगजनकों की विविधता के अन्तर्गत प्रूनस नेपैलेंसिस, पर क्लैडोस्पोरियम औक्सिस्पौरम, कौरियोप्सिस प्रजा. पर पौडोस्फैरिया प्रजा. जैसी कुछ नई रिपोर्ट बनाई गयी।

ओयस्टर खुम्भी प्ल्यूरोटस सजोर कैजू के स्ट्रेन कोड पी 6 तथा पी 9 से अधिकतम पैदावार रिकार्ड की गई जो ग्रीष्म में धान के 100 कि.ग्रा. सूखे पुआल से क्रमश: 91.4 तथा 87.2 कि.ग्राम थी। शीत ऋतु में सूखे पुआल से पी. फ्लोरिडा स्ट्रेन पी 1 से अधिकतम पैदावार यानि 80.6 कि.ग्रा. प्रति 100 कि.ग्रा. पुआल से प्राप्त हुई।

नींबू वर्गीय फलों में खासी संतरे के 6-7 वर्षीय न्यूसेलर पौध ऊत्तक सम्बर्धित तथा कलमी पौधों की वृद्धि, उपज और गुणवत्ता प्राचलों की दृष्टि से मूल्यांकन किया गया। ऊत्तक सम्बर्धित पौधों की अधिकतम लम्बाई (294 से.मी.) देखी गयी तथा उसके बाद कलमी पौधों में सी. रेश्नी मूलवृन्त पर (278.3 से.मी.) देखी गयी।

क्रोटोलेरिया टेट्रागोना पलवाल में अधिकतम पौध-लम्बाई (2.60 मी.) तथा शाखा-छत्र फैलाव (97.5 से.मी.) रिकार्ड की गयी। तने का व्यास (6.26 से.मी.) तथा शाखा/पौधे की संख्या (31 सं) क्रमश: टेफ्रोसिया कैडिंडा पत्तियों और राइसबीन पलवाल में सर्वाधिक रहे। अमरूद के 11 जीनोटाइपों जैसे आर सी जी-1, आर सी जी-2, आर सी जी-3, इलाहाबाद सफेदा, एल-49, ललित, संगम, आर सी जी-11, आर सी जी एच-1, आर सी जी एच-4 तथा आर सी जी एच-7 के प्रोटीन प्रोफाइलों/बैडिंग पैटर्नों को निर्धारित करने के लिए एस डी एस-पेज किया गया। बीज प्रोटीन के इलेक्ट्रोफोरग्राम (बैडिंग पैटर्न) से अलग-अलग पोलिमॉर्फिज्म का पता लगा और 23 पोलिपेप्टाइड बैंडों की पहचान हो पायी।

प्रयोग में लाए जा रहे सोहिओंग फल के विभिन्न जीनोंटाइपों का भौतिक व जैव रासायनिक अध्ययन किए गए। सोहिओंग के कलमी और बीज से बने पौधों का वृद्धि निष्पादन सम्बन्धी अध्ययन भी किया गया। पोलिहाउस में मेघा टमाटर-2 के प्रति पौधा (3.5 कि.ग्रा.) अधिकतम उपज और औसत फल भार (70.00 ग्रा.) रिकार्ड किया गया। खेत पर टमाटर के जिन सात (इंडिटर्मिनेट) जीनोटाइपों का मूल्यांकन किया गया। उनमें से सर्वाधिक उपज वाला वी टी जी-93 (37.50 टन/हे.) तथा अधिकतम औसत फल भार (120 ग्रा.) रिकार्ड किया गया। मेघालय टमाटर-1 में न्यूनतम झुलसा रोग (6.94%) तथा अधिकतम उपज (58.01 टन/हे.) रिकार्ड की गई।

बैंगन में जीनोटाइप आर सी एम बी एल-2 (35.84 टन/हे.) से सर्वाधिक उपज रिकार्ड की गई। इन जीनोटाइपों में से भोलानाथ में सबसे कम झुलसा रोग प्रकोप (6.75%) तथा औसत उपज 28 टन/हे. रिकार्ड की गयी। फैंचबीन में अर्का सुविधा (10.250 टन/हे.) से सर्वाधिक उपज रिकार्ड की गई। गाजर के शीतोष्ण संकरों में सर्वाधिक उपज न्यू कुरोडा (16.94 टन/हे.) से रिकार्ड की गई। बन्द गोभी के संकर-4 में अधिकतम फसल कटाई सूची (0.80) के साथ सर्वाधिक उपज (80.64 टन/हे.) रिकार्ड की गई।

कोलोकैसिया में एम एल-1 (22.13 टन/हे.) सर्वाधिक उपज रिकार्ड की गई और लीफ ब्लाइट का प्रकोप सबसे कम 20.17% रहा। कौरमलों को कार्बेंडेजिम (0.05%) से उपचारित करने से 192.66 दिनों तक गड्ढों में सुरक्षित रखा जा सकता है।

हल्दी के जीनोटाइप लकाडौंग, देहरादून लोकल, कुचिपुड़ि, वी के-17 दुग्गिरिला रेड, मधुकर, मणिपुरी नं 1, प्रतिभा, केदारम, एम एल टी-57 और एस के एम 61 को टैफ्रिना पत्ती धब्बा रोग के लिये प्रतिरोधी पाया गया। एन.बी.पी.जी.आर, नई दिल्ली से अदरक के 43 जनन द्रव्य आई सी नम्बर (आई सी-584322 से आई सी 584364) प्राप्त किये गये। हल्दी के 32 जीनोटाइपों के पारपत्र आंकड़े पौध सामग्री के साथ आई सी संख्या के सत्यापन के लिए एन.बी.पी.जी.आर क्षेत्रीय केन्द्र शिलांग को भेजा गया। सिंबीडियम जिगेनटियम एक दुर्लभ उद्यान प्रजाति के पीस्यूडो-तने के भागों से कली/पी एल बी समावेशन पर टी डी जेड के प्रभाव का अध्ययन किया गया। प्रोटोकॉर्म के ट्रांसवर्स खंडों के प्रयोग से टी डी जे (4 मि.ग्रा/ली) सप्लिमेंटेड बैसल माध्यम पर पी एल बी (30.16) की अधिकतम संख्या रिकार्ड की गई। डिब्बाबन्द स्ट्राबेरी को पोटेसियम परमैंगनेट से उपचारित करने पर उसको लम्बे समय तक सुरक्षित रखने के कार्य को निर्धारित किया गया। शिमला मिर्च का उचित प्रसंस्करण और अमरूद की गुणवत्ता बढ़ाने की प्रक्रिया का मानकीकरण किया गया।

जैंतिया हिल्स के तीन प्रमुख कोयला क्षेत्रों (बपंग, सुत्नगा और ख्लिहरिएट) की प्रयोग में आने वाली अलग-अलग भूमि क्षेत्रों (जैसे गैर-खनित, कोयले की खान वाले और 4 वर्षों से अलग-थलग पड़े खान वाले स्थल) से कुछ मिट्टी के नमूने एकत्र किए गये और मृदा की गुणवत्ता तथा चावल की उत्पादकता से सम्बन्धित विभिन्न विशेषताओं के लिए उनका विश्लेषण किया गया। सामान्य अवस्थाओं में किए गए प्रयोग से पता लगा कि खान से बरबाद हुई मृदाओं में धान फसल (डंठल) की जैविक उपज अप्रभावित मृदाओं (7.90 ग्रा प्रति गमला) की तुलना में बहुत ही कम (2.75 ग्रा प्रति गमला) हुई। तथापि, अलग-थलग पड़े स्थलों से संकलित मृदाओं में सक्रिय खनन के प्रभाव वाली मृदाओं की तुलना में धान की जैविक उपज में विशेष रूप से (>2 गुना) सुधार देखा गया। सक्रिय खनन (पी. एच 4.35) से मुक्त मृदा की तुलना में कोयले की खानों से प्राप्त मृदा के पी.एच में लगभग एक यूनिट तक कमी आयी है।

शून्य जुताई वाली स्थिति में धान, सरसों, मसूर और मटर के पौधे रोपण/ड्रिलिंग के लिए हाथ से संचालित किया जाने वाला शून्य जुताई पौध रोपक एक प्रोटोटाइप विकसित किया गया। मूंगफली और मक्के के पौधे लगाने के लिए हल्के पावर टिलर से संचालित पौधा रोपक यंत्र तैयार किया गया। आंतरिक तथा बाह्य मांग पर आधारित विपणन अवसर को देखते हुए हल्दी, अदरक, अन्नानास, खासी संतरा, टमाटर, शिमला मिर्च जैसी 6 फसलों की पहचान की गई तथा सस्योत्तर क्षतियों को आपूर्ति शृंखला प्रबंधन तथा मूल्य शृंखला प्रबंधन कम करने हेतु सुझाव दिए गये। भूमि उपयोग प्रतिमान, फसल प्रतिमान तथा तीन चयनित जनपदों जैसे-उत्तरी सिक्किम (सिक्किम) द्यलाई (त्रिपुरा) ईस्ट गारो हिल्स (मेघालय) की उत्पादकता और उसका तुलनात्मक अध्ययन खेती बनाम झूम के अर्थशास्त्र का विश्लेषण किया गया। यह पाया गया कि कृषि से बागवानी फसलों की ओर प्रमुखता से हस्तांतरण हो गया है। एन ए आई पी घटक-1 परियोजना के अन्तर्गत एस ए एस पर पांच प्रशिक्षण कार्यक्रम आयोजित किए गए और इनमें पूर्वोत्तर के 10 से अधिक संस्थानों को शामिल किया गया जिनमें 89 से अधिक एन ए आर एस कार्मिक सम्मिलित हुए।

पशु उत्पादन में, शीतीकरण और द्रवणोत्तर प्रक्रियाओं के दौरान शूकर के शुक्राणुओं की क्षति के मूल्यांकन का अध्ययन किया गया और यह पाया गया कि अधिकतम क्षति 5^{0} से. कम तापमान पर शीतीकरण एवं द्रवण की प्रक्रिया के दौरान होती है। 120 दिनों तक हर रोज आहार में जिंक (200 पी पी एम) और तांबे (20 पी पी एम) की खुराक बढ़ाने से संकर नस्ल की हैम्पशायर शुकरियों में 234±17 दिनों की तुलना में शीघ्र ही अर्थात 178±11 दिनों में यौन परिपक्वता लाने की प्रक्रिया से विशेष सुधार किया गया तो सामान्य अवस्था की अपेक्षा उनके शरीर में बेहतर सुडॉलता वृद्धि दर और प्रतिदिन बढ़ता हुआ वजन देखा गया। शूकरियों में पी एम एस जी से न्यूनतम लीटर आकार के ऐस्ट्रस का समावेश सफलतापूर्वक किया गया और उसके बाद एच सी जी नयाचार अपनाया गया। डूयूरोक शूकर में मादाओं की तुलना में नर शूकरों में शरीर के वजन में अधिक वृद्धि रिकार्ड की गई। एन जेड डब्लू खरगोश को यदि स्थानीय रूप से उपलब्ध आहार संसाधनों से खिलाये गये आहार की तुलना में सांद्रित आहार देने से वृद्धि दर बेहतर पायी गई किन्तु उनमें कोई महत्वपूर्ण परिवर्तन नहीं दिखाई दिया। समेकित सूअर-मछली पालन में 6 महीने की अवधि तक 468 वर्ग मीटर तालाब से कुल मछली उत्पादन 51.31

किलोग्राम प्राप्त हुआ। उर्वरता के मामलों में गांव तथा राज्य सरकार के पशु प्रजनन फार्मों में प्रजनन पुनरावृत्ति और ऐनोइस्ट्रस पाये गए जो जनन संबंधी मुख्य विकार हैं जो क्रमशः 43.38% और 33.90% पाये गए। असमी पहाड़ी बकरियों में जन्म के समय औसत वजन नरों में 1.58±0.04 किलोग्राम तथा मादाओं का 1.39±0.04 पाया गया। शीतकाल में जन्मे असमी पहाड़ी बकरियों के बच्चे जनन संबंधी लक्षणों के सन्दर्भ में अधिक सक्षम पाये गए किन्तु सभी ऋतुओं में गर्भावधि एक ही जैसी होती है। असमी पहाड़ी बकरियों में कृतिम गर्भाधान में 70.14% गर्भधारण दर पायी गयी।

पशुधन पोषण अनुसंधान में, खरीफ के मौसम में उगाए गये बाजरा और ज्वार 60 दिनों में कटाई के योग्य हो गये तथा इनसे क्रमशः 38.5 व 29.1 टन/हे. ताजे चारे की उपज प्राप्त हुई जिसमें डी एम तत्व क्रमशः 30.27 और 27.05% मिले। डेरी में गोशाला से पशुओं की घोवना/जलनिकासी नाली द्वारा खेत में पंहुचती है जहां सरसों, जई और बरसीम की मिश्र/अन्तः फसल में प्रयास किया गया। सरसों के चारे की कटाई (एकल कटाई) की गई तथा उसके पश्चात जई व बरसीम की कटाई हर 30 दिन की अवधि के बाद की गई। सरसों में चारे (ताजा चारा) की उपज 27 टन/हे., दूसरी व तीसरी कटाई में जई की क्रमशः 14 व 22.5 टन/हे. और बरसीम की 8.9 तथा 11.3 टन/हे. उपज प्राप्त हुई। सामान्य नमक युक्त (0.5/ताजा चारा) मक्के के चारे से लीन अवधि में जुगाली वाले पशुओं के आहार के लिए बढ़िया साइलेज तैयार किया गया। चावल की भूसी में फिकस पत्तियों के मिश्रण से तैयार आहार ब्लॉक (सी एफ बी) 3 बढ़ने वाली असमी पहाड़ी बकरियों के लिए अधिक स्वादिष्ट रहा। मक्के की कदाबी के सी एफ बी आहार संकर नस्ल के बछड़ों के लिए अधिक स्वादिष्ट रहा। दुधारू पशुओं के लिए मक्के की कदाबी से तैयार सी एफ बी आहार धान की भूसी से बने सी एफ बी आहार से बेहतर पाया गया, किन्तु मक्के की कदाबी को पीसकर बनाया गया सी एफ बी आहार लाभदायक नहीं रहा। वनराजा मुर्गी के आहार में पृथक लैक्टौबैसिलस मिलाकर देने से उनकी वृद्धि में सुधार देखा गया। सच्चरोमाइसेज प्रजा. के प्रयोग से भावी सुधार देखा गया। फील्ड स्थितियों में सूअरों के पारम्परिक आहार में फाइटेज मिलाकर देने से भी वृद्धि दर में सुधार पाया गया।

पशु स्वास्थ्य के अन्तर्गत पशुधन के फेकल नमूनों से ग्रुप 'ए' रोटावारस का पता लगाने के लिए एस डी एस-पेज और आर टी-पी सी आर का मानकीकरण किया गया और नैदानिक नमूनों की जांच की गई। दो नमूने एस डी एस-पेज द्वारा सकारात्मक पाये गये तथा आर टी-पी सी आर द्वारा 6 नमूने सकारात्मक मिले। विभिन्न खेती प्रणालियों से लिए गये फेकल नमूनों और तालाब के पानी के नमूनों की जांच प्रमुख आंत्र रोगजनकों के लिए की गई। फेकल नमूनों में सबसे सामान्य आइसोलेट ई. कोली तथा तालाब के पानी वाले नमूनों में ऐरोमोनस प्रजा. मिले। दोनों प्रकार के नमूनों में सिक्स 2 जीन सकरात्मक ई. कोली का पता लगा। पीरू में पॉक्सवायरस के प्रकोप के सन्देह की जांच की गई तथा 9 दिन के मुर्गे के भ्रूण पर सी ए एम के संचरण से बने घाव के लक्षणों के देखने के बाद निदान की पुष्टि हुई। सीरोग्रुप I(1/2ए, 1/2सी 3ए, 3सी) II(1/2सी, 3सी), III(1/2बी, 4बी, 3बी, 4डी, 4ई) तथा IV(4बी, 4डी, 4ई), के लिए सीरोवार्स विशिष्ट जीनों का पता लगाने पर लिस्टेरिया मोनो साइटोजीन्स आइसोलेटों के सीरोसमूह बनाए गये। विभिन्न सूत्रों से एल मोनोसाइटोजीन के आइसोलेटों में नस्ल सम्बद्धता/एकरूपता देखने के लिए ओ पी ए और ओ पी बी प्रमुख क्रम के प्रयोग से नयाचारों का मानकीकरण किया गया। 16 एस आर एन ए जीन (220 बी पी) तथा ग्रुप बी स्ट्रेप्टो कोक्सी जी (बी जी एस) के सी एक बी जीन (153 बी पी) के विशिष्ट जीन के प्रति एस. ऐगैलैक्टी का आणविक विशिष्टीकरण किया गया। पशुचिकित्सा में औषधीय पौधों के उपयोग के प्रयोजन से मेघालय और मणिपुर के विभिन्न गांवों में सर्वेक्षण किया गया। औषधीय पौधे छांटकर सूक्ष्मजीव रोधी गतिविधियों का अध्ययन करने हेतु सत बनाया गया। आवश्यकतानुसार पशु रोगों का नियमित निदान किया गया।

इस क्षेत्र में हीमोप्रोटोजोन संक्रमण के अध्ययन से पता लगा कि गायों में बबेसिया बिगेमिना के संक्रमण और कुत्तों में बबेसिया केनिस एवं बबेसिया गिब्सोनी का संक्रमण आम बात है। बबेसिया बिगेमिना के संक्रमण से रिकार्ड किया गया कि एक महीने की अवधि में 51.6 लीटर दूध कम हो गया। मृत्यता के दौरान खरगोश के फेकल नमूनों में ईमीरिया अर्थात ई. मैग्ना, ई. ऐग्जिगुवा, ई. पिरिफौर्मिस, ई. कोसिकोला, ई. इंटेस्टाइनलिस तथा ई. मीडिया के 6 अलग-अलग प्रजातियों की पहचान की गई। इस क्षेत्र के गो पशुओं के फेकल नमूनों में नेमाटोडिरस हेल्वेटियनस के अंडों की उपस्थिति रिकार्ड की गयी। सूअरों की त्वचा की खुरचनों के सूक्ष्म दर्शी परीक्षण के बाद देखा गया कि 11.11% सूअरों मे सैर्कोप्टस स्कैबी वार-स्यूस का प्रकोप है। व्यवस्थित और अव्यवस्थित सूअर फार्मों से रिकार्ड किया गया कि

उनमें क्रमश: 30.26% और 46.10% गैस्ट्रो इन्टेस्टाइनल परजीवीय संक्रमण विद्यमान है।

मुर्गीपालन विज्ञान में टर्की के विभिन्न बाह्य और अंतरिक अंडे की विशिष्टताओं तथा टर्की की मांस विशिष्टता एवं जापानी बटेरों की विपणन आयु से सम्बन्धित अध्ययन किये गये। मेघालय की कृषि जलवायु स्थितियों के अन्तर्गत जापानी बटेर का गहन लीटर प्रणाली से और टर्की का अर्ध-गहन प्रणाली से वृद्धि के विभिन्न स्तरों पर प्रबंधन क्रिया-विधियों का मानकीकरण किया गया है तथा उनके कार्य-निष्पादनों को रिकार्ड किया गया। बढ़िया ब्रॉयलर चिकन उत्पादन के लिए निष्पादन तथा हीमैटोबायो कैमिकल विशेषताओ पर आहार में 0.5% तथा 1% के स्तरों पर वानस्पतिक पाउडरों के पांच अलग-अलग संयोजनो को मिलाने से पता लगा कि सामान्य समूह की तुलना में ऐसे आहारित समूहों वाले मुर्गी के शरीर भार में कोई विशेष अन्तर (पी <0.05), नहीं मिला। तथापि सामान्य समूह की तुलना में ऐसे आहारित समूहों में विशेष रूप से (पी <0.05) निम्न सीरम कोलेस्ट्रोल स्तरों को रिकार्ड किया गया।

मात्स्यिकी में कौमन कार्प अमूर (हंगेरियन प्रजा.), का प्रवर्तन वर्ष 2010 की शुरूआत में पहली बार भा.कृ.अ.प., पू.प.क्षे.अ.प., बड़ापानी मेघालय में किया गया। प्रारंभिक 14.5 ग्रा. के प्रजनक बीजों को संस्थान के मछली फार्म में मध्य तापमान स्थिति के अन्तर्गत पोषित किया गया। कुछ मछलियों का वजन 14 माह की पोषण अवधि में अधिकतम 1.5 कि.ग्रा. हो गया।

अरुणाचल प्रदेश में झूम के लिए चावल की 14 प्रविष्टियों की पहचान की गई जो उपज की दृष्टि से और उपज में योगदान देने सम्बन्धी विशेषताओं के लिए सर्वोत्तम थीं। एस ए आर एस-1 (4400 कि.ग्रा.) से अनाज की सर्वाधिक उपज, हे. रिकार्ड की गई। उसके बाद जर्ली, किमिन (4400 कि.ग्रा.) से पायी गई विभिन्न प्रकार के मूलवृन्त-कलम के संयोजनों में से टैनियम + खासी सन्तरे से पौध लगाने के 9 वर्ष बाद सर्वाधिक फलों (232 सं) का उत्पादन हुआ और उसके बाद टैनियम+पहाड़ी सन्तरे + सिक्किम संतरे से सर्वाधिक फल भार (147.80 कि.ग्रा.), फल ब्यास (7.12 से.मी) गूदे का भार (105.95 ग्राम), तथा अम्लटा (1.94%) रिकार्ड की गई। सर्वाधिक रसतत्व (75.80 मि.ली) टेनियम+पहाड़ी संतरे में तथा सर्वाधिक 1010 बी टी एस एस, सी. वॉल्कैमैरियाना + खासी संतरे में देखा गया। गैर-मौसम के दौरान पोलिहाउस के अन्तर्गत (अप्रैल-जुलाई) टमाटर की अर्जुन किस्म अच्छी रही और उसके बाद अविनाश व पी एस 225। अविनाश विलम्बित अंगमारी की प्रतिरोधी पायी गई। चावल की सर्वाधिक अनाज उपज (3.78 टन/हे.) लुइट+टेफ्रोसिया से मिली और उसके बाद वन्दना + टेफ्रोसिया से प्राप्त हुई। मटर की टी आर सी पी 8 से टेफ्रसिया के साथ सर्वाधिक फली उपज (1.88 टन/हे.) रिकार्ड की गई, उसके बाद टेफ्रोसिया के साथ आजाद पी-1 (1.77 टन/हे.) से तथा क्रोटोलैरिया के साथ ही आर सी पी 8 से (1.72 टन/हे.) प्राप्त हुई।

पश्चिमी सियांग जनपद में सूअर पालन सम्बन्धी क्रियाविधियों और किसानों द्वारा वैज्ञानिक प्रबंधन वाली क्रियाविधियों को अपनाने सम्बन्धी सर्वेक्षण किया गया। डारिंग और बसार क्षेत्र से वैज्ञानिक सूअर पालन क्रियाविधियों के बारे में 12 किसानों को प्रशिक्षित किया गया।

मणिपुर में चावल की दो किस्मों आर सी एम-23 तथा फौगक को बाली फटन रोग की प्रतिरोधी (राष्ट्रीय पह: आई जी 0584772 तथा रेसिस्ट सं. आई एन जी आर 10153) तथा (राष्ट्रीय पह: आई सी 0583654 तथा रेसिस्ट सं आई एन जी आर 10154) स्रोत के रूप में राष्ट्रीय आनुवंशिक संसाधन ब्यूरो नई दिल्ली में पंजीकृत कराया गया। चावल की क्रमश: आर सी मनिफौ-10 (7073 कि.ग्रा/हे.), आर सी मनिफौ-7 (6953 कि.ग्रा/हे.), तथा के डी -2-6-3 (5490 कि.ग्रा/हे.), किस्मों को मुख्य खरीफ के लिए विकसित किया गया। ये किस्में खास तौर से बाली फटन और पत्ती फटन जैसे रोगों की प्रतिरोधी हैं। अरहर में फली के रंग और बीजों के रंग हेतु इसके जननद्रव्य वंशक्रमों में विविधता का अध्ययन किया गया। पहाड़ी स्थिति के अन्तर्गत मूंगबीन तथा उड़दबीन के अन्त: -विशिष्ट संकरण से प्राप्त एक 4 परिणामों का मूल्यांकन किया गया। मूंगफली में आई सी जी एस-76 से अधिकतम उपज (3.78 टन/हे.) रिकार्ड की गई। मूंगफली के बौरोन पोषक तत्व का अध्ययन किया गया तथा पाया गया कि अच्छी उपज के लिए मिट्टी में सौल्युबोर 10 कि.ग्रा. टन/हे. के हिसाब से उपयोग करना सर्वोत्तम है। मक्के के 40 देसो वंशक्रमों में देखा गया कि आर सी आर टी-10 (38) में अधिकतम संख्याओं में गरी/कतारें थीं। आर्टैमिसिया पर्विफ्लोरा, गोनियोथैलमस सीस्क्वीडेडैलिस, प्लेक्ट्रैन्थस टर्निफोलियस तथा विटैक्स नेगुन्डो जैसी वनस्पतियों से चावल, मक्का, सोयाबीन, तोरिया तथा मटर में भंडार के समय नाशीजीवों के प्रकोप में कमी आयी। हल्दी में कर्क्यूमिन की सर्वाधिक प्रतिशतता (8.50%) आर सी एम टी-7 से रिकार्ड की गई तथा इसकी उपज क्षमता 28.00 टन/हे. थी। देसी क्यूर्कुमा जननद्रव्य में आर सी एम आई एम आई टी-1 में पाया गया कि इसमें छाती/(30%) फेफड़े (33%), सी एन एस

(39%), तथा प्रोस्टेट (41%) की कैंसर कोशिकाओं की प्रतिरोधक क्षमता होती है। आर सी एम आई टी-3 में कोलोन कैंसर कोशिकाओं की 38% प्रतिरोधकता दिखाई दी तथा आर सी एम आई टी-4 व आर सी एम आई टी-5 में ए जी एस व पैंसिज कैंसर कोशिकाओं की क्रमश: 35% व 42% प्रतिरोधकता होती है। खासी संतरे के संग्रहण में देखा गया कि जेड ई सी सी पर संग्रहित फल सबसे अधिक दिनों (12 दिन) तक सुरक्षित रह सकते हैं तथा इनमें कुल उच्च अम्लता (0.89%) घटती हुई शर्करा (2.14%) तथा न घटती हुई शर्करा (089%) पायी गयी। कच्यई नींबू में भी शून्य ऊर्जा शीत चैम्बर पर सर्वाधिक सुरक्षा (17 दिन) पायी गई।

पैसन फल में फौलिकर व मौनसेरेन से फ्यूसेरियम सोलेनी, फौमोप्सिस टर्सा और ग्लोमेरेला सिंगुलैटा का 100% नियंत्रण पाया गया, उसके बाद सामान्य की तुलना में बैबिस्टीन द्वारा पाया गया। तमेंगलौंग जनपद की नदियों से बी. डेरी की उन्नत छोटी मछलियों की 35 प्रजातियों का संकलन किया गया जिनकी कुल लम्बाई 6.5 ± 2.1 से.मी. तथा शरीर का वजन 2.70 ± 4.5 ग्रा. था। देसी सजावटी मछलियों की 20 प्रजातियों का संकलन किया गया। प्यूंटियस विजोनैटस को प्रयोगशाला में रखकर सफलतापूर्वक प्रजनित किया गया। इन मछलियों को संतुलित आहार देकर अलग-अलग वातावरण स्थितियों में रखा गया।

मिजोरम में चावल की आर सी पी एल-10 से अधिकतम उपज (4.31 टन/हे.) रिकार्ड की गई, तथा उसके बाद आई आर 60080-46 ए (4.22 टन/हे.) प्राप्त हुई। उपरांऊ स्थिति वाले चावल की परीक्षित 9 किस्मों में से बेहतर अनाज उपज आर सी पी एल आई-90 और आई आर 60080-46 ए से रिकार्ड की गई। तथापि उपराऊं चावल की चावल अनुसंधान निदेशालय, हैदराबाद वाली किस्मों जैसे आई बी टी 3108 आई वी टी 3110 तथा आई वी टी 3109 में अधिक अनाज उपज देखी गई। निचली भूमि वाली किस्म आर सी पी एल-1-300 से अधिकतम अनाज उपज का उत्पादन हुआ। मक्के की विवेक क्यू पी एम-9 किस्म में अधिकतम अनाज उपज देखी गई। मोटे बीज वाली मूंगफली में 500 ली. पानी में 2 कि.ग्रा/हे. के हिसाब से कोलेमेनाइट के छिड़काव करने से अधिकतम उपज प्राप्त हुई। रबी मक्के में आर सी एम-76 बीज उपज और भुट्टे के औसत भार की दृष्टि से सबसे अधिक पायी गई और उसके बाद बी ए-61-ए तथा आर सी एम-75 में देखी गयी। उपज क्षमता के लिए फैंच बीन की बैंगनी रंग की फली वाली दो नवीन किस्मों का मूल्यांकन किया गया। कोलासिब में पूर्वोत्तर के विभिन्न भागों से चो-चो के जिन 13 जीनोटाइपों का परीक्षण किया गया, इनमें से तीन स्थानीय जीनोटाइप (स्थानीय-1, स्थानीय-2 तथा स्थानीय-3) का निष्पादन थोड़े ज्यादा तापमान पर सन्तोषजनक रहा। चो-चो के पौधों की पुरानी और सूखी पत्तियों की काट-छांट करने से फलों की संख्या में 11.5% की वृद्धि पायी गयी।

वनराजा मुर्गियों को चारे में नीम के पत्तों की भूसी मिलाकर देने से उनकी वृद्धि दर पर प्रभाव के लिए अध्ययन किया गया तो पाया गया कि 0.2% नीम के पत्तों की भूसी से उपचारित समूह और सामान्य समूह में उनकी वृद्धि दर पर कोई विशेष अन्तर नहीं आया। आहार सम्बन्धी परीक्षण पड़े सफेद यौर्कशायर सूअरों पर भी किए गये। इन सूअरों को 1:3 सान्द्रित चारे के साथ स्थानीय रूप से उपलब्ध कोलोकैसिया, शकरकन्दी की पत्तियां और स्पिलैंथस प्रजा. जैसी आहार सामग्री मिलाकर दी गयी। यह पाया गया कि 25% सान्द्रित आहार के स्थान पर स्थानीय रूप से उपलब्ध आहार सामग्री देने पर सूअर की वृद्धि दर पर कोई प्रभाव नहीं पड़ता। मिजोरम में 14 गो पशु फार्मों में डेरी गो पशुओं में परिशोधित कैलिफोर्निया स्तन-शोथ परीक्षण के प्रयोग से स्तन शोथ सम्बन्धी चिकित्सकीय व उपचिकित्सकीय जांच की गई। इसी प्रकार ई. कोलि तथा सल्मोनेला की मौजूदगी के लिए सूअर के बच्चे के फेकल नमूनों की भी जांच की गयी तथा चूचुक सम्वेदन जैवरोधी उपचार किया गया।

नागालैंड केन्द्र में चावल की कुल 21 किस्मों का परीक्षण निचली भूमि स्थिति के अन्तर्गत किया गया। इन किस्मों से टी आर सी 87-251 और उसके बाद आर सी एम-22 से क्रमश: 5.78 टन/हे. तथा 5.70 टन/हे. सर्वाधिक उपज रिकार्ड की गई। आर सी आर टी परीक्षण के अन्तर्गत मक्के की अधिकतम उपज क्रमश: आर सी एम-75 (2.67 टन/हे.), तथा उसके बाद आर सी एम-76, विजय, टी आर सी-5 और टी आर सी-3 से प्राप्त हुई। मूंगफली की 24 किस्मों से अधिकतम उपज एम-335 (3.24 टन/हे.), रिकार्ड की गई और उसके बाद क्रमश: एम-13 (2.89 टन/हे.), तथा टी जी 37 ए (2.80 टन/हे.) से रही। मूंग की सर्वाधिक उपज के एम-8-102 और के एम-8-228 से रिकार्ड की गई और उसके बाद के एम 8-202 से प्राप्त की गई।

मेगा बीज परियोजना के अन्तर्गत 76 ब्याने किये गये जिनसे 563 सूअर के बच्चे पैदा हुए। जिनमें से 336 सूअर के बच्चे किसानों को वितरित किए गए। बड़े काले और गुंग्रू सूअरों की उत्पादक और प्रजनक निष्पादन सम्बन्धी अध्ययन किए गए। मुर्गीपालन बीज परियोजना के अन्तर्गत, मुर्गीपालन परियोजना हैदराबाद से वनराजा और ग्रामप्रिया

के नर-मादा स्टॉक खरीदे गये और उनकी उत्पादक और अंडे सेने की प्रक्रिया सम्बन्धी निष्पादन पर अध्ययन किया गया तथा उनसे उत्पादित बच्चों को किसानों में वितरित किया गया। इस कार्यक्रम में जिन चूजों का उत्पादन किया गया, इनमें से 12,839 चूजे किसानों को वितरित किए गये। एक्सोन की सूक्ष्मजीवीय गुणवत्ता का अध्ययन किया गया तथा इसके जैविक प्रभाव तथा ऐक्जोन के अर्थशास्त्र को सूअर के आहार के साथ समायोजित करके मूल्यांकन किया गया।

सिक्किम केन्द्र में, जैविक खेती के अन्तर्गत चावल की उपज 3 बार यूरिया के उपयोग से धान अनाज की उपज जहां 2.05 से 3.87 टन/हे. रही, इसकी तुलना में मिश्रित कम्पोस्ट के साथ 2.21 से 3.73 टन/हे. की श्रृंखला में रही, मिश्रित कम्पोस्ट व नीम की खली के प्रयोग से 2.38 से 4.27 टन/हे. तक रही। मूल्यांकित मक्के की संकर किस्मों में से विवेक संकर किस्म-21(118.28 ग्रा) से प्रति पौधा सर्वाधिक अनाज उपज रिकार्ड की गई और उसके बाद विवेक संकर-25 (114.95 तथा एफ एच-3356 113.52) से प्राप्त हुई। सिक्किम संतरे के कीटों व नाशक जीवों की रोकथाम के लिए 6 कीटनाशकों का मूल्यांकन किया गया। परिणामों से पता लगा कि बैसिलस थ्यूरिंजिएंसिस (डेल्फिन 3 जी) 7 ग्रा./ली. नींबू की बटरफ्लाई के नियंत्रण के लिए सबसे अधिक कारगर पाया गया तथा सिक्किम संतरे के बाग में एफिड व लीफ माइनर के लिए ऐग्रो स्प्रे (सर्वो) 7 मिली/ली कारगर पाया गया।

सामान्य रूप से उपलब्ध जंगली घास और औषधीय या शोभाकारी पौधों की प्रजातियों, क्षेत्र प्रमुख मसाला फसलों के वानस्पतिक भागों, तीन सुगन्धित पौधों पांच वृक्ष फलों जिनमें औषधीय गुण हैं तथा 8 सामान्यतया प्रयोग में आने वाली पौध प्रजातियों पर यथास्थान किण्वन सम्बन्धी अध्ययन किए गये। जब ओवन से सुखाये गये नमूनों को गाय के ताजे गोबर में 96 घंटे तक लपेट कर रखा गया तो मिथेन बनने का स्तर लगभग 5.8 से 14.5 तक और कार्बन-डाइ-औक्साइड 58.9 से 79.5% तक देखा गया। सल्मोनेला की मौजूदगी देखने के लिए पशु मूल के 175 आहार नमूनों की जांच की गई और पाया गया कि 22 (12.5%) नमूने से सल्मोनेला प्रजा. के मामले में सकारात्मक निकले।

मूंगफली की जी जी-11 और उसके बाद जी जी-2, जी जी-13, आई सी जी एस-76 और जी जी-8 किस्में सर्वाधिक फली उपज देने वाली रिकार्ड की गई। चावल के जीनोटाइप आर सी पी एल-114 अदुमा, भलुम-1 तथा आइ सी-50429 में रोग प्रतिरोधिता का कुछ स्तर दिखाई दिया जो 0-9 रेटिंग स्केल में 1-2 रोग स्कोर रहा। वोल्वेरिला वोल्वेसिया के परीक्षित सात विभिन्न प्रजातियों में से वी.वी-02, वी.वी -08 तथा वी.वी-09 अन्यों की अपेक्षा ज्यादा उत्पादक पायी गई। पानी में लोहे की सान्द्रता 8.53 मि.ग्रा./ली. तक अलग-अलग पायी गई। भू-जल में तांबे की मात्रा 0.11 मि.ग्रा./ली. तक अलग-अलग रहा एवं भू-जल पानी में जस्ते की मात्रा भी 0.12 मि.ग्रा/ली तक अलग-अलग रही। इससे पता लगता है कि भूतल पानी में मैग्निशियम, तांबा और जस्ते की मात्रा कम है। इसके अलावा मैग्नीज जिसके लिए पीने के पानी में आवश्यक सीमा 0.1 से 0.5 मिलीग्राम/ली. तक अलग-अलग है।

आनुवंशिक सुधार कार्यक्रम के अन्तर्गत जापानी बटेर का वृद्धि एवं उत्पादन सम्बन्धी निष्पादन पर अध्ययन किये गये। रंगीन बटेर की वृद्धि दर सामान्य वंशक्रमों की अपेक्षा अधिक रही। अखिल भारतीय समन्वित मुर्गी पालन अनुसंधान परियोजना के अन्तर्गत किसानों को कुल 5442 चूजे उपलब्ध कराये गये। एन जी संकर नस्ल की मुर्गियों की प्रतिशत उर्वरता और अंडे देने की क्षमता तथा त्रिपुरा ब्रॉउन के स्थानीय जननद्रव्य का अध्ययन किया गया तथा अलग-अलग आयु समूहों में उनकी वृद्धि दर निष्पादन का भी अध्ययन किया गया।

EXECUTIVE SUMMARY

ICAR Research Complex for NEH Region, Umiam, Meghalaya along with its six regional stations located at Arunachal Pradesh, Manipur, Mizoram, Nagaland, Tripura and Sikkim has been engaged in conducting basic, strategic, applied and adaptive research on a variety of agricultural sciences including animal sciences and fishery. The salient findings and progress of the research work done during 2010-11 are summarized below:

In the crop improvement programme, five rice varieties namely Bhalum -3 & 4 (Upland), Megha Rice 3 & 4 (quality rice for low land) and RC Maniphou - 11 (resistant to blast and stem borer) for Meghalaya and Manipur was released/notified. Hence, a total of 21 rice varieties released for different locations in the region have helped in increasing rice productivity and production in the region. Among the pulses, TRCP-8 was released for Tripura and Meghalaya. In the vegetable crops, Megha tomato – 3 variety, was released/notified for the state of Meghalaya

Evaluation of local indigenous rice germplasm revealed that lines ME-MR-1, ME-MR-6, MN-MR-24 and MN-MR-14 possessed antibacterial property against organisms like *Salmonella*, *Staphylococcus* etc.

Screening of rice varieties revealed that Bhalum-1 and Bhalum-2 were moderately tolerant against leaf folder and gall midge. Incidence of root aphid was very low in White Lehrit followed by Red Manipur. Rice varieties IR 64, Tetep, Raminad str 3, NP 125, C101 LAC, Tadukan and C105 TTP-4-L23 were found to be resistant against blast disease.

Different cultural practices were experimented to enhance crop productivity and improve resource use efficiency of hill agriculture. The rice yield was higher under minimum tillage (2.80 t/ha) compared to conventional tillage (2.56 t/ha) under upland condition. Application of 50 % RDF + fresh biomass of *Eupatorium* @ 10 t/ha recorded maximum grain yield (3.07 t/ha) followed by 50 % RDF + rice straw @ 5 t/ha (3.05 t/ha). Under lowland conditions, zero and minimum tillage recorded 33 and 15% higher rice grain yield over conventional tillage, respectively. Among various pea varieties tried under zero tillage in lowland rice fallow, IPFD 99-13 recorded maximum green pod yield (4.1 t/ha) followed by IPFD 1-10 (3.29 t/ha) and among the lentil varieties tried, DPL-15 recorded maximum seed yield (1.10 t/ha) followed by DPL 62 (0.87 t/ha).

Varieties like Shahsarang 1 (4.7 t/ha) and IR 64 (4.5 t/ha) performed well under direct seeded condition during pre-*kharif* season. Direct seeding of pre-*kharif* rice gave higher ratoon yield compared to transplanted crop. Cutting height of 25 cm gave higher yield of rice compared to 15 cm. In marshy land, groundnut – capsicum recorded highest total system productivity (15.91 t/ha) followed by groundnut – cauliflower system on raised beds. The total system productivity of 5.85 t/ha was estimated with French bean-toria while lowest (2.48 t/ha) with maize - toria. The total system productivity in terms of cauliflower equivalent yield (CEY) was maximum with cauliflower + pea (31.31 t/ha) on raised beds in marshy lands.

Bio-organics for rice, maize, soybean, groundnut, mustard, French bean and ginger were found to increase productivity to the tune of 10-30 % over control. Integrated application of FYM, vermicompost and panchagavya recorded maximum grain yield of maize, toria and French bean followed by ½ FYM + ½ VC. Population of beneficial microorganisms *viz*., *Rhizobium*, *Pseudomonas* and *Actinomycetes* were found maximum in the soil under organics followed by integrated management practices. Application of panchagavya along with Derisom @ 3 ml/L and cow urine produced higher grain yield (3.74 t/ha) in maize. Quality parameters of tomato such as fruit weight, specific gravity and fruit diameter in organic production were superior over other treatments.

Zero tillage with residue retention produced the highest rice grain yield (4.56 t/ha) while, conventional tillage with residue removal recorded the lowest grain yield (4.09 t/ha). The Water Use Efficiency (WUE) was highest (42.9 kg/ha-mm) under maize + groundnut paired row intercropping along with residue removal under zero tillage. The strawberry yield was higher under polythene mulch than straw mulch. The berry yield was highest under 1.0 PET closely followed by 1.2 PET.

In maize, TRC-4 (4.4 t/ha) and RCM-76 (4.3 t/ha) were found promising. Hybrid maize FH3356 (7.9 t/ha) was found highly potential for Barapani condition. Minimum and maximum cob borer infestation was found in Local yellow and Vivek QPM-9 with 4.09

and 14.40% cob infestation, respectively. Maize sown during June showed maximum cob borer infestation. Clothianidin 50% WDG @ 0.25 g/l, flubendiamite 39.35 m/m SC @ 0.5 ml/L, indoxacarb 14.5 SC @ 1 ml/L, carbofuran3G @ 5-6 granules/whorl and spinosad 45SC @ 0.75 ml/L were found effective against these pests. Among 103 genotypes tested against Turcicum leaf blight of maize, 42 were resistant and 18 moderately resistant.

Photo-insensitive ricebean, PRR-2, recorded significantly higher yield than check RBL-1. Performance of lentil varieties under *utera* cultivation in rice fallow revealed that L305 (1.2 t/ha) recorded higher seed yield followed by L304 (1.0 t/ha) and L303 (0.96 t/ha). In pigeon pea, var. Bahar more than 35 insect species including some natural enemies were recorded.

Under agroforestry, six fruit trees based systems having maize as inter crop with the fruit trees such as peach (*Prunus persica*), guava (*Psidium guajava*), Assam lemon (*Citrus limon*), pear (*Pyrus communis*), plum (*Prunus domestica*), sweet orange (*Citrus sinensis*) were evaluated in the horti-agri system for their productivity in the slopy terrain. Peach + maize (var RCM1-1) was the most productive (5.73 t/ha maize equivalent yield).

In the tree improvement programme of *Parkia roxburghii*, highest tree height (4.37 m) and basal diameter (7.57 cm) was obtained in provenance from Kezanglwa. Among the 13 provenances/seed sources of *Jatropha curcas* evaluated at Meghalaya, highest seed yield was obtained from the PJS-2 (495 kg/ha) followed by Mawhati (485 kg/ha) and oil content was maximum for Mawhati (40.67 %) followed by Tura (39.67 %). Wide range of variability was observed among seventy nine genotypes of *Mucuna pruriens* with respect to growth and yield traits. Highest seed yield per plant was recorded in the collection UPMP-11 (792 g) followed by WBNMP-3 (667 g) and UPMP-2 (604 g). Out of the 79 collections evaluated, 32 promising ones along with complete passport data were submitted to National Bureau of Plant Genetic Resources, New Delhi for obtaining accession number.

Decomposition pattern of five hedge row species *viz., Flemingia macrophylla, Crotolaria tetragona, Indigofera tinctoria, Tephrosia candida* and *Canjanus canjan* revealed that the decay constant, t-half, varied from 0.0363 in *Crotolaria tetragona* to 0.1338 in *Flemingia macrophylla*.

Among the five different intensive integrated farming system models, fish productivity was recorded highest in Crop-fish-dairy-vermicompost-horticulture-hedgerow system (1.62 t/ha). Among the livestock, daily weight gain was recorded highest in pig (0.28 kg/day). Highest meat production was from crop-fish-poultry-multipurpose trees (0.64 t/ha). Among these five models, Crop-fish-poultry-multipurpose trees model was the most profitable.

In farming system research, the output-input ratio of dairy based land use was 2.57. Cow pea variety Bundel lobia –1 (31.05 t /ha), and oat variety AOSC – 7 (32.58 t/ha) registered higher green fodder yield. In Silvi-pastoral land use, 11 nos. of goats, 300 nos. of broiler chicken registered a net profit of Rs. 56,016/- in a year. Agro-pastoral system registered gross return of Rs. 2,00,818/- with input-output ratio of 1:3.9. It was observed that turmeric + cucumber/ bottlegourd registered maximum total system productivity. Agri-horti-silvi-pastoral system, gave a gross return of Rs. 1, 10,270/- with benefit cost ratio of 1.80:1. Maximum contribution in gross as well as net return was registered from vegetables based cropping system.

Soybean genotypes 'Cross 2-1', RCS 1-9 and RCS 1-10 yielded 2.9- 3.2 t/ha. Biopesticide, *B.t* var. *kurstaki* (2 g/l), against leaf folder, was found to be superior followed by N.S.K.E. 5% + cow urine (1:1 mixture) and it reduced 42.85 and 35.71% damage, resspectively as compared to control. Soybean varieties KS 103 and EC241778 were found highly resistant to rust disease. Estimated yield losses ranged from 9% to 47%, due to rust. N.S.K.E. 5% extract was found to be most effective against blister beetles and leaf folders in groundnut. Biology of *Coccinella septempunctata*, a potential predator on mustard aphid, was studied.

Indigenous earthworm (*Perionyx excavatus*) was studied for vermicompost and dynamics of decomposition of organic wastes was worked out. Under biodiversity of plant pathogens, few new reports i.e. *Cladosporium oxysporum* on *Prunus nepalensis*, *Podosphaera* sp. on *Coreopsis* sp. were made.

Oyster mushroom strain codes P6 and P9 of *Pleurotus sajor-caju* recorded the highest yields *viz.* 91.4 and 87.2 kg /100 kg of dry paddy straw, respectively in summer; *P. florida* strain P1 gave the highest yield i.e. 80.6 kg/100 kg of dry paddy straw in winter.

In citrus, evaluation of six-seven years old nucellar seedling, tissue cultured and grafted plants of *Khasi* mandarin for growth, yield and quality parameters was done. The maximum plant height (294 cm) was observed in tissue cultured plant followed by grafted plant on *C. reshni* rootstock (278.3 cm).

The plant height (2.60 m) and canopy spread (97.5 cm) was recorded maximum in *Khasi* mandarin under *Crotolaria tetragona* mulch. Stem diameter (6.26 cm) and no. of branch/plant (31 Nos.) were highest in *Tephrosia candida* leaves and ricebean mulch, respectively. SDS-PAGE was carried out to determine the protein profiles/banding patterns of 11 guava genotypes *viz.* RCG-1, RCG-2, RCG-3, Allahabad Safeda, L-49, Lalit, Sangam, RCG-11, RCGH-1, RCGH-4 and RCGH-7. The electrophoregram (banding patterns) of seed protein revealed the distinct polymorphism and led to the detection of 23 polypeptide bands.

In polyhouse, the highest yield per plant (3.5 kg) with highest fruit weight (70 g) was recorded in Megha Tomato – 2. Among the seven (indeterminate) genotypes of tomato evaluated in field, the highest yield was recorded in the genotype VTG-93 (37.50 t/ha) with maximum fruit weight (120 g). The minimum bacterial wilt (6.94%) with maximum yield was recorded with Megha Tomato-1 (58.01 t/ha).

In brinjal, highest yield was recorded in the genotype RCMBL-2 (35.84 t/ha). Among the genotypes, the least bacterial wilt infestation (6.75%) with an average yield of 28 t/ha was recorded in Bhola Nath. In French bean, the yield was recorded highest from in Arka Suvidha (10.25 t/ha). Among temperate carrot hybrids, the maximum yield was recorded in the New Kuroda (16.94 t/ha). Highest yield was recorded for cabbage hybrid-4 (80.64 t/ha) with maximum harvest index (0.80). In colocasia, the maximum yield was recorded from ML-1 (22.13 t/ha) with least incidence of leaf blight 20.17%. The shelf life of 192.66 days was observed when the cormels were treated with carbendazim (0.05 %) and stored in pits.

Turmeric genotypes *viz.*, Lakadong, Dehradun local, Kuchipudi, VK-17, Duggirila Red, Madhukar, Manipuri No-1, Pratibha, Kedaram, MLT 57 and SKM 61 were found resistant against *Taphrina* leaf blotch. Forty three ginger collections from Meghalaya has been assigned IC number. Thirty two genotypes of turmeric along with their passport data has been submitted to the NBPGR to obtain IC numbers. Effect of TDZ on bud/PLB induction from pseudo-stem segments of *Cymbidium giganteum*, a rare orchid species, was studied. Maximum number of PLBs (30.16) was recorded on TDZ (4 mg/l) supplemented basal medium using transverse sections of protocorms. Shelf life extension of peach and strawberry by using $KMnO_4$ treatments was worked out. Minimal processing of capsicum and value addition in guava and *Sohiong* fruits were standardized.

Representative soil samples from different land uses (*viz.* non-mined, coal-mined and 4 years abandoned mining sites) of the three major coal belts (Bapung, Sutnga and Khliehriat) of Jaintia Hills were collected and analyzed for various properties related to soil health and rice productivity. Experiment conducted under controlled conditions revealed that biological yield of rice crop (shoot) in mine spoil soils was significantly lower (2.75 g per pot) compared to the unaffected soils (7.90 g per pot). However, biological yield of rice improved significantly (>2 times) in soils collected from abandoned sites compared to that under the influence of active mining. Coal mining decreased the soil pH by about one unit compared to the soil free from mining activity (pH: 4.35).

A prototype of manual zero till planter was developed for planting/drilling of paddy, mustard, lentil and pea. A light weight power tiller operated planter was fabricated for planting of groundnut and maize.

Based on the internal marketing opportunity and external demand, six crops *viz.*, turmeric, ginger, pineapple, *Khasi* mandarin, tomato, capsicum were identified. The comparative study of land use pattern, cropping pattern and productivity of three selected districts *viz.* North Sikkim (Sikkim), Dhalai (Tripura), East Garo Hills (Meghalaya) and economics of *Jhum* vs. Settled cultivation was analyzed. It was found that there had been a major shift from agriculture to horticultural crops. Under NAIP Component 1 Project, five numbers of training programmes on SAS were organized covering more than 10 NARS institutes in the NEH region in which 89 NARS personnel were imparted training.

In animal production, assessment of boar sperm damage was studied during the process of freezing and post thawing and it was found that maximum damage occured during the process of freezing below 5 ^{0}C and thawing. A significant improvement in facilitating sexual maturity in cross-bred Hampshire gilts i.e. as early as 178 ±11 days as compared to 234 ±17 days using Zn (200 ppm) and Cu (20 ppm) supplementation in basal diet daily for 120 days was observed. Estrus was induced successfully with optimum litter size in anoestrous female pigs with PMSG followed by HCG protocol. In case of Duroc pig, higher body weight gain was recorded in males as compared to females. In integrated pig-fish culture, total fish production from 468 sq m pond area was found to be 51.31 kg within a period of six months. Among infertility cases, repeat

breeding and anoestrous were found to be major reproductive disorders in village as well as on State Govt. Cattle Breeding Farms, which comprised of 43.38% and 33.90%, respectively. The average birth weight of Assam hill goat were 1.58±0.04 kg in male and 1.39 ±0.04 kg in female. The winter borne kids of Assam Hill goats were found to be more efficient in regards to the reproductive traits; however, the gestation period remained same for all the seasons. Artificial insemination in Assam hill goats were carried out and 70.14% conception rate was achieved.

In animal nutrition research, bajra and jowar grown in *kharif* season yielded 38.5 and 29.1 t/ha fresh fodder at 60 days of harvesting with dry matter contents of 30.27 and 27.05%, respectively. In the field receiving the washings/drainage from the dairy cattle shed, mixed/inter cropping of mustard, oats and berseem was attempted. Mustard fodder was harvested (single cut) and the oats and berseem were harvested subsequently after every 30 days period. The fodder (fresh basis) yields were 27 t/ha for mustard, 14 and 22.5 t/ha for oats and 8.9 and 11.3 t/ha for berseem in second and third cut, respectively. Maize fodder (29.75% dry matter) with common salt (0.5%, fresh basis) produced good quality silage for feeding of ruminants during the lean period. Incorporation of *Ficus* leaf meal in the rice straw based complete feed block (CFB) increased the palatability in the growing Assam hill goats. Feeding maize kadabi in the form of CFB increased the palatability and growth in crossbred calves. In lactating cattle, feeding CFB having chopped maize kadabi was found better than CFB having chopped paddy straw, but grinding of maize kadabi was not beneficial for feeding in form of CFB. Supplementation of isolated *Lactobacillus* strain in the diets of Vanraja chicks improved the performance. Addition of *Saccharomyces* sp., showed further improvement. Phytase supplementation in the traditional swine ration also improved the growth performance in the field conditions.

Under Animal Health**,** standardized SDS-PAGE and RT-PCR for detection of group "A" rotaviruses from faecal samples of livestock and screened clinical samples, two samples were found positive by SDS-PAGE, while 6 samples were found positive by RT-PCR. Faecal samples and pond water samples from different farming systems were screened for important enteric pathogens. Most common isolates were *E. coli* in faecal samples and *Aeromonas* spp. in pond water samples. *Stx2* gene positive *E. coli* were detected in both samples. An outbreak of poxvirus suspected in turkey was investigated and diagnosis was confirmed after observing the characteristic pock lesion by CAM inoculation on 9 day old chick embryo. *Listeria monocytogenes* isolates were serogrouped based on the detection of serovars specific genes for serogroups I (1/2a, 1/2c, 3a, 3c), II (1/2c, 3c), III (1/2b, 3b, 4b, 4d, 4e) and IV (4b, 4d, 4e). The isolates in serogroups 1 and 4 were 2.9% and 10.3%, respectively. To observe strain relatedness/similarity among *L. monocytogenes* isolates from different sources, RAPD protocols were standardized using OPA and OPB primer series. Molecular characterization of *S. agalactiae* was carried out against specific gene of 16S rRNA gene (220 bp) and *cfb* gene (153 bp) of Group B Streptococci (GBS).

The study on detection of haemoprotozoan infections in this region revealed the presence of *Babesia bigemina* infections in cow; *Babesia canis* and *Babesia gibsoni* infections in dogs. Due to *Babesia bigemina* infection, decrease of 51.6 liter of milk for a period of one month was recorded. Six different species of *Eimeria i.e., E. magna, E. exigua, E. piriformis, E. coecicola, E. intestinalis* and *E. media* were identified from faecal samples of rabbit during mortality. The presence of eggs of *Nematodirus helvetianus* was recorded in faecal samples of cattle of this region. *Sarcoptes scabiei* var. *suis* infestation was recorded in 11.11% pigs after microscopic examination of skin scrapings. The prevalence of gastrointestinal parasitic infection was recorded as 30.26% and 46.10% in organized and unorganized pig farms, respectively**.**

In Poultry Science**,** the different external and internal egg quality traits of Turkey and the carcass qualities of Turkey and Japanese quails at marketeable age were studied. Management practices of Japanese quail under deep litter system and Turkey under semi-intensive system during different stages of growth was standardized under agro-climatic condition of Meghalaya. Supplementation of five different combinations of herbal powders at 0.5% and 1% levels as feed additives on the performance as well as haematobiochemical traits for quality broiler chicken production revealed no significant ($p<0.05$) difference in body weights among the supplemented groups compared to control group. However, significantly ($p<0.05$) lower serum cholesterol levels were recorded in two supplemented groups compared to control group.

In fishery, Common carp –Amur (Hungarian strain) was introduced in the ICAR RC-NEH Region fish farm, Umiam, Meghalaya. The breeder's seeds of initial average weight 14.5 g reared under the mid

altitude condition at the institute fish farm complex attained maturity in about 14 months period. A few fishes attained a maximum weight of 1.5 kg in a culture period of 14 months.

At Arunachal centre, the highest grain yield of rice was obtained by Luit + *Tephrosia* (3.78 t/ha) followed by Vandana+*Tephrosia*. Highest pod yield of pea was recorded in TRCP8 with *Tephrosia* (1.88 t/ha) followed by Azad P1 with *Tephrosia* (1.77 t/ha). In *Khasi* mandarin, GA_3 50 ppm recorded the highest fruit weight (104.37 g), size (4.8 x 5.1 cm^2), segment weight (71.02 g) with minimum flower drop (22%) at 3 m x 3 m spacing whereas, highest no. of fruits per tree was recorded in NAA 150 ppm (331.4) which was at par with GA_3 50 ppm (328.7). In INM studies on *Khasi* mandarin, treatment combination of 50% RDF + pig manure (15 kg) + Sunhemp (12.5%) + *Azotobactor* (20 g) + PSB (20 g) recorded highest fruits per plant (604.4), fruit wt. (102.9 g) and fruit yield (63.8 kg/ tree). The drying and dehydration technique for cauliflower and bamboo shoots were standarized. Survey of pig rearing practices and adaptation of scientific management practices by the farmers was conducted in West Siang district. Twelve framers were trained from Dirang and Basar circle about scientific pig husbandry practices.

In Manipur, two rice varieties *viz.*, RCM-23 and Phougak were registered in NBPGR, New Delhi as a source of neck blast resistance (National Id: IC 0584772 & Resist No. INGR 10153) and (National Id: IC 0583654 & Resist No. INGR 10154). Rice varieties RC Maniphou-10 (7.07 t/ha), RC Maniphou -7 (6.95 t/ha) and KD-2-6-3 (5.49 t/ha) were developed for main *kharif* season. Variability in pigeon pea germplasm lines for pod colour and seed colour was studied. Evaluation of F_4 progenies derived from inter-specific cross of mung bean and urd bean under hill condition was done. One ricebean genotype BKSB-48 was found drought tolerent. In groundnut, ICGS-76 recorded maximum pod yield (3.78 t/ha). Boron nutrition of groundnut was studied and soil application of Solubor @ 10 kg/ha was best for higher yield (3.76 t/ha). Evaluation of 40 indigenous maize lines indicated that maximum number of kernel/row was found in RCRT-M-10. Botanicals *viz*., *Artemisia parviflora, Goniothalamus sesquidedalis, Plectranthus ternifolius* and *Vitex negundo* reduced storage pests in rice, maize, soybean, rapeseed and peas. In turmeric, the highest curcumin percentage (8.50%) was recorded with RCMT-7 with a yield potential of 28 t/ha. In indigenous *Curcuma* germplasm, RCMIT-1 showed inhibitory activity against cancer cells of breast (30%), lung (33%), CNS (39%) and prostate (41%). RCMIT-3 showed 38% inhibition in colon cancer cells; whereas, RCMIT-4 and RCMIT-5 have shown 35% and 42% inhibition in AGS and Panceas cancer cells, respectively. In storage study *Khasi* mandarin stored at ZECC had the longest shelf life (21 days) with high total acidity (0.89%), reducing sugar (2.14%) and non-reducing sugar (0.89%). Kachai Lemon at Zero Energy Cool Chamber was also found to have longest shelf life (17 days).

Folicur and monceren gave 100% control of *Fusarium solani, Phomopsis tersa* and *Glomerella cingulata* in passion fruit followed by bavistin as compared to control . Thirty five advanced fries of *B. dero* having a total length of 6.5±2.1 cm and body weight of 2.70±4.5 g were collected from the rivers in Tamenglong district. Twenty indigenous ornamental fish species were collected. *Puntius bizonatus* was bred successfully in captivity in the laboratory.

In Mizoram, maximum grain yield of rice was recorded in RCPL-90 (4.31 t/ ha) followed by IR 60080-46A (4.22 t/ha). Among nine upland rice varieties tested, higher grain yields were recorded for RCPL1-90 and IR 60080-46A. However, the upland rice varieties from DRR, Hyderabad, higher grain yield was observed in IVT 3108, IVT 3110 and IVT 3109. In low land, the variety RCPL-1-300 produced maximum grain yield. The highest maize grain yield was observed in Vivek QPM 9. Spraying of colemanite @ 2 kg/ ha in 500 litre water gave maximum yield of bold seeded groundnut. The seed yield and average cob weight of *rabi* maize were highest in RCM-76 followed by BA-61-A and RCM-75. Two novel variants of French bean bearing purple colour pod were evaluated for their yield potential. Among 13 genotypes of chow-chow from different parts of NEH Region tested at Kolasib, the performance of three local genotypes (Local-1, Local-2 and Local-3) was satisfactory at slightly higher temperature. The number of fruits increased by 11.5 % by the pruning of old and dead leaves of chow-chow.

Effect of supplementation of chaffed neem leaves on growth performance of Vanaraja chicks was studied and no significant difference was observed on growth performance between treatment and control groups upon supplementation of 0.2% of chaffed neem leaves. Large White Yorkshire pigs were fed with locally available feed stuffs like colocasia, sweet potato leaves and *Spilanthus* sp. Along with concentrate feed in the ration of 1:3, it was found that 25% of the concentrate

feed can be successfully replaced by locally available feed stuffs without affecting the growth performance of pig. Screening of dairy cattle for clinical and subclinical mastitis was done at 14 cattle farms in Mizoram using Modified California Mastitis Test. Piglet faecal samples were also examined for the presence of *E. coli* and *Salmonella* and antibiotic sensitivity teat was conducted.

In Nagaland Centre, among the 21 rice varieties tested under low land condition, TRC 87-251 recorded the highest yield (5.78 t/ha) followed by RCM-22 (5.70 t/ha). Under RCRT trial, the maximum maize yield was recorded in RCM-75 (2.67 t/ha) which was followed by RCM-76, Vijay, TRC-5 and TRC-3. Out of 24 varieties of groundnut, the maximum yield was recorded in M-335 (3.24 t/ha) which was followed by M-13 (2.89 t/ha) and TG-37A (2.80 t/ha). The highest green gram yield was recorded by varieties KM-8- 102 and KM-8- 228 which was followed by KM-8- 202.

Under Mega seed project on pig, 76 numbers of farrowing was taken up producing 563 no. of piglets out of which, 336 nos of piglets were distributed to the farmers. Productive and reproductive performance of Large Black and Gungroo pigs were studied. Under poultry seed project, parent stock of Vanaraja and Gramapriya were procured from PDP Hyderabad and their productive and hatching performance were studied. From the chicks produced in the programme, 12,839 chicks were distributed to the farmers. Microbiological quality of Axone was studied and its probiotic effect as well as economics of its incorporation in pig feed was evaluated.

In Sikkim Centre, the rice grain yields under organic farming ranged from 2.21 to 3.73 t/ha with mixed compost; 2.38 to 4.27 t/ha with mixed compost and neem cake as compared with 2.05 to 3.87 t/ha rice grain yield with 3-split dose urea application. Among hybrid maize varieties evaluated, the highest grain yield per plant was recorded in Vivek hybrid-21 (118.28 g) followed by Vivek hybrid-25 (114.95 g) and FH-3356 (113.52 g). Six bio-pesticides were evaluated against insect pests of Sikkim Mandarin. The result revealed that *Bacillus thuringiencis* (Delfin 3G) 7 g/l was found to be the most effective bio-pesticide to control lemon butter fly while Agrospray (Servo) 7 ml/L was found effective against aphids and leaf miner in Sikkim Mandarin orchard.

In vitro fermentation study of commonly available jungle grass and other plant species of medicinal or aesthetic use, vegetative parts of three major spices crops of the region, three aromatic plants, five tree fruits having medicinal values and eight commonly used species were conducted. The level of methane production was about 5.8 to 14.5 % and carbon dioxide 58.9 to 79.5 % when oven dried samples were incubated with fresh cow dung inoculums for 96 hours. One hundred seventy five food samples of animal origin were screened for the presence of *Salmonella* and 22 (12.5%) samples were positive for *Salmonella* spp.

In Tripura Centre, groundnut variety producing the highest pod yield was GG-11 followed by GG-2, GG-13, ICGS-76 and GG-8. The rice genotypes, RCPL-114, Aduma, Bhalum-1 & IC-50429 showed certain level of resistance with disease score of 1-2 in 0-9 rating scale. Among seven different strains of *Volvariella volvacea* tested, VV-02, VV-08 and VV-09 were more productive than the others. The concentration of iron in water had a variation from trace to 8.53 mg/l. Manganese contents in ground water showed a variation from trace to 2.50 mg/l. Copper in ground water showed a variation from trace to 0.11 mg/l and Zinc in ground water also showed a variation from trace to 0.12 mg/l. This indicated that ground water contained less amount for all the elements studied except for manganese for which the permissible limit for drinking water is from 0.1 to 0.5 mg/l.

Growth and productivity performance of Japanese quail was studied under genetic improvement programme. The growth performance of coloured quail line was superior to control lines. Under All India Coordinated Research project on poultry breeding, a total of 5442 no. of chicks were supplied to the farmers.

1. INTRODUCTION

ICAR Research Complex for NEH Region was established on 9th January 1975 as a premier research institute in the field of agriculture and allied sectors for the benefit of the north eastern hill region of India. The institute has completed 35 years of rendering its service to the farmers, development departments, NGOs and other stakeholders. The institute was first set up at Shillong, Meghalaya under the aegis of Indian Council of Agricultural Research, New Delhi, an apex body for agriculture and allied sector research, education and extension in India. In 1989, the institute moved to its present location at Umiam in Ri-Bhoi district of Meghalaya where the entire set up is housed in a land of 101 ha. The institutes' research programmes had been action-oriented and location-specific, thus striving to solve farmers' problems associated with agriculture, agroforestry, fishery and livestock management. The institute was initially set up to undertake basic and applied research for delivering technologies for sustainable farming under different agro-climatic regions and practices of farmers with diverse socio-economic conditions. Later, the institute took up research and extension in various other areas of agriculture and allied sciences and collaborated with Central Agricultural University, Imphal in imparting post graduate education.

The institute encompasses all major disciplines of agriculture and allied sciences like crop sciences, horticulture, agroforestry, natural resource management, animal sciences and fisheries, farming system research, agricultural extension and social sciences. The institute has one centre in each of the component states of north eastern hill region located at Basar (Arunachal Pradesh), Imphal (Manipur), Kolasib (Mizoram), Jharnapani (Nagaland), Tadong (Sikkim) and Lembucherra (Tripura). KVK(s) is also attached to every centre to help in adaptive research and technology refinement and dissemination.

As per the last QRT recommendations, the then existing 18 sections have been clubbed into 10 divisions, including bio-technology and fisheries. Out of 10 divisions, the scientists of six divisions are engaged not only in technology generation and dissemination, but also in teaching and guiding of post-graduate students of CPGS, CAU, Umiam. To promote the open and distant mode of education, the institute has also signed MoU with IGNOU in 2007 and established a programme study centre for agriculture and allied sciences. Six new courses were initiated in 2008-09 under the IGNOU partnership programme with ICAR-RC-NEH Region. Presently, 10 students are enrolled in two courses, namely, Diploma in Value Added Products in Fruits and Vegetables and a Certificate course in Organic Farming. IGNOU is also making efforts to convert the programme study centre into a regular study centre in agricultural sciences.

The strength of scientists has increased in the recent recruitment drive to cope with the new challenges in frontier research and technological backstopping for ensuring farmers' livelihood security. Several in-house and ongoing research projects, mostly of inter-disciplinary nature, have been initiated. As on the date, about 20 sponsored funded projects (including DST, DBT, NAIP, NABARD, NHB, etc.), 12 AICRP, 5 Network, and 13 collaborative projects are in operation under ICAR-RC-NEH region. Recently, strategic research on climate change adaptation and mitigation has also been initiated under NICRA scheme.

Thrust areas

- To evolve sustainable integrated farming systems for *jhum* improvement and restoration of degraded lands.
- To increase the overall productivity of different crops through research in cereals, pulses, oilseeds, horticultural crops, agroforestry species, fisheries and other economical crops.
- Improvement of citrus plantation to reinvigorate the citrus industry.
- Development of feed and fodder resources including locally available fodder for livestock.
- Animal health coverage and improvement of livestock production system.

Mandate

- To undertake basic and applied research for delivering technologies based on sustainable farming system for different agro climatic and socio-economic condition.
- To improve the productivity of crops, livestock and fishery.
- To act as a repository of information on natural resources, different farming and land use systems.
- To impart training in research methodology and application of improved technologies for enhancing agricultural productivity.
- To collaborate with the State Departments for agricultural development in the region and testing and promotion of improved farming and land use systems.
- To collaborate with National and International agencies.
- To provide consultancy.

Human resources

Category	Sanctioned post	Filled post	Vacant post
RMP	7	6	1
Scientific	184	110	74
Technical	253	237	16
Administrative	130	122	8
Supporting	114	107	7
Total	688	582	106
KVK			
Scientific	13	4	9
Technical	152	147	5
Administrative	26	15	11
Supporting	28	28	0
Total	219	194	25

Budget

Head	Allotted (Rs. in Lakh)	Expenditure (Rs. in Lakh)
Plan	1000.00	999.72
Non-Plan	4781.00	4780.14

Library

Nature of publication	No. of copies available
Books and reports	25187
Back issues	11063
Foreign journals	15
Indian journals	85
Hindi books	2010

IT facilities

The institute has developed strong IT infrastructure along with a rich computer database of library resources. An AC lab with computers (installed with SAS) along with projector and UPS backup of 2.30 hrs with internet facility has been created. A general purpose Statistical Software Package SAS (Standalone as well as internet based) consisting of all modules for perpetual use by different NARS organizations is also available. An online system for NET/ARS Prelim Examination for ASRB, ICAR was established and scheduled to be commissioned soon.

Linkages

The institute has developed strong linkages with different NARS organizations within and outside the region. Linkages has been developed with line departments, state universities, KVKs and NGOs for evaluation and effective dissemination of improved agriculture practices. Implementation of the projects like Livelihood improvement through Integrated Farming System (NAIP-III) and National Initative on Climate Resilient Agriculture are some of the examples of linkages with above organizations. Biennial Regional Committee Meeting and interface meetings are held to discuss different problems of agriculture and related matters for research and development engaging all the stake holders.

Important events

Industry meet

The ICAR-Industry meet- 2010 was held from 18th to 19th Nov 2010, organized at Umiam by the Institute Technology Management Unit, ICAR Research Complex for NEH Region and Zonal Technology Management-Business Planning and Development Unit, NIRJAFT, Kolkata. During the meet various institutes of the eastern zone viz. CRIJAF, Barrackpore, CIFA, Bhubaneswar, DRWA, Bhubaneswar, ICAR RC for ER, Patna, IINR&G, Ranchi, CIFRI, Barrackpore, NRC on Pig, NRC on Mithun, NRC on Orchid, NRC on Yak, Directorate of Research, AAU, Jorhat, Director of Research (Vet.), AAU, Khanapara, NIRJAFT, Kolkata, and ICAR RC for NEH participated along with representatives of sixteen industries. Various sessions were planned for the farmers and entrepreneurs in terms of knowledge and business. During the session, industries viz. North East Biotech Pvt. Ltd, Androson Biotech, Shibha Welfare, Gouri Food Processing, Green Makers came forward to enter in public-private collaboration with ICAR, Umiam, Barapani.

His Excellency Mr R.S. Mooshahary, the Governor of Meghalaya, addressing the gathering at the inaugural session

Nature Fest and Agri-Expo 2010 Exhibitions

The Institute participated in the: "Nature Fest' organized by NRMC–NABARD at Karunamayee, Salt Lake Kolkata from 25th Oct to 3rd Nov 2010. 'Agri Expo – 2010' held at 4th Mile Dimapur, Nagaland from 15th to 19th Dec 2010. The fair had attracted a large number of farmers as the institute had displayed a good number of farmer friendly technologies. The scientists of the institute actively participated in the technical sessions and interacted with farmers of the entire region.

ICAR NEH stalls at the Agri Expo 2010 Dimapur Nagaland

Pineapple Festival

A one day "Pineapple festival" was organized by ICAR Research Complex for NEH Region, Nagaland Centre and KVK Dimapur on the 3rd February, 2011 in the pineapple village, Molvom of Dimapur district, Nagaland, where twelve institutes participated. Dr. S. Ayyappan, Secretary DARE, Govt. of India and DG, ICAR, while inaugurating the pineapple festival, stated that pineapple farming in the state has a very high potential. He appreciated and congratulated the farmers for the high productivity of pineapple which was higher than the whole of the northeast region. He lauded the efforts made by the farmers for the impressive pineapple farms and the quality of pineapple produced by them.

Chicks distributed to the farmers by Honorable Secretary DARE & DG, ICAR

DG with farmers at Molvom village; Director, explaining the exhibits; DG, releasing books

North East Agri-fair

The North East Agriculture fair was held at ICAR RC, Umiam from 28th February to 2nd March 2011. Altogether, 500 farmers participated in this event.

The theme of the event was "Bio-Diversity Conservation and Entrepreneurship Development". Various Institutes from all over India participated in this event.

The objective of the fair was to showcase the various technologies developed by different universities/ institutes/ NGO's highlighting the bio-diversity and its conservation. The fair encouraged the people related with bio-industries and agro-based industries. A Souvenir was also released on the occasion. Welcoming the delegates Dr. S.V.Ngachan, Director, ICAR Research complex for NEH Region, Umiam said, by conducting such fairs, we provide platform for promotion of biological diversity, encourage knowledge sharing among stakeholders, and provide current facts, latest trends in entrepreneurship development.

National Advisory Council Member Dr. Pramod Tandon as the guest of honour stated that we have a multiplicity of life forms here in the Northeast. The diversity of flora and fauna here is not found anywhere else in the world.

The Chief Guest, his Excellency, the Governor of Meghalaya, Shri. Ranjit Shekhar Mooshahary, urged agricultural scientists and farmers to come together

His Excellency Mr R.S. Mooshahary, Governor of Meghalaya, releasing the souvenir

His Excellency Mr R.S. Mooshahary Governor of Meghalaya addressing the gathering

and work synergistically for providing food security to the country. The country has increased production to a very large extent, producing millions of tonnes of food grains every year, but unfortunately what we produce is not enough. Adaptability is the key to growth. In the North Eastern Region, we have rain-fed areas, humid areas, alpine areas, so the technologies should suit all these including different climatic conditions.

Stalls at the exhibition

The three day event had five thematic sessions on different topics including buyer seller meet on medicinal plants, where a large number of farmers representing the entire North East region including Sikkim took active part in the discussions.

The fair ended with a valedictory function where Mr. U.K. Sangma, Secretary, North Eastern Council in his presidential address said that North East as a region is still facing food insecurity. ICAR research complex has a major role to play to solve this problem. Concerted efforts are needed to develop ways and means to balance the demand and supply. He also distributed the prizes to farmers and the participating organizations.

Farmers-scientist interaction

National Seminar cum Workshop

A three days National Seminar cum Workshop on "Developing the Potential of Underutilized Horticultural Crops of Hill Regions" was organized at ICAR Research Complex for NEH Region, Manipur Centre, Imphal from 14-16 Feb, 2011. The seminar was inaugurated by Shri P. Parijat Singh, Hon'ble Minister of Agriculture, Govt. of Manipur. A number of delegates including scientists, officials, NGOs and farmers from different parts of India in general and

Shri P. Parijat Singh, Minister of Agriculture, Govt. of Manipur attending the inaugural programme of seminar

Secretary North Eastern Council Mr U. K. Sangma chief guest for the occasion addressing the gathering and giving away the prizes to the farmers in the closing function

North Eastern Region in particular, participated in the seminar. Speakers like Dr. A. K. Singh, Deputy Director General (NRM), ICAR; Dr. K. V. Peter, renowned Horticulturist, Ex-Vice Chancellor, KAU & Director, World Noni Research Foundation and Dr. S. P. Ghosh, Ex-Deputy Director General (Horticulture), ICAR shared their expertise, experience and knowledge with the participants. Most of the speakers emphasized on protection and conservation of the fragile ecosystem and biodiversity of the potential underutilized crops of hill regions especially North East India. The valedictory function, held on 16th February, was graced by Dr. N. K. Tyagi, Member (ASRB) and Dr. S. P. Ghosh, Ex-DDG (Horticulture), ICAR as Chief Guest and Guest of Honour, respectively.

Visit of Prof. M. S. Swaminathan at ICAR, Manipur Centre

Dr. H.P Singh (DDG, Horticulture) visited ICAR Sikkim centre

Dr. H.P Singh (DDG, Horticulture) made a visit to Sikkim centre on February 19, 2011 and interacted with the scientists of various disciplines and took an elaborate note of their on-going research activities. He also visited the Institute's farm and discussed about various strategies to be adopted and reorientation of some of the research programmes to meet the needs of the people for technologies.

Field Day on Conservation Agriculture Observed

A farmer's field day on Conservation Agriculture was organized on 9th March in the lowland farm of Division of Agronomy, ICAR Research Complex for NEH Region, Umiam. About 100 farmers from various Districts of Meghalaya attended the programme along with members of NGOs like CASA, MRDS (IFAD), RRTC etc. Practical demonstration on cultivation practices of pea, lentil, toria etc under zero tillage along with implements required were demonstrated to the farmers. An interaction programme between the scientists and farmers were also organized. The programme was covered by the DD (NE) channels.

Farmers, scientists, NGO & media people attending the field day on Conservation Agriculture

Field Day on Rice and Pulses

Shri Joygobinda Deb Roy, Hon'ble Minister for Science and Technology, Govt of Tripura, attended the field Field Day on rice at Tripura Centre, Agartala. During field day on rice and pulses, demonstration on

Shri Jogobinda Deb Roy, Hon'ble Minister of Science and Technology, Govt. Of Tripura, observing operation of paddy transplanter during Field Day

paddy transplanter and field visit were organized for the benefit of farmers.

Sports and Community Events

The complex has participated in zonal tournament held at CRRI, Cuttack during 1-5 February 2010 and bagged two champion's trophy, 4 gold, 6 silver and 3 bronze medals. Women from the complex also won best athlete award. The winner in zonal tournament participated in inter-zonal tournaments held at CAZRI, Jodhpur during 9-13 November, 2010 and bagged 4 silver medals and one runner up trophy (Basket ball).

In addition to ICAR sports, the complex also organizes sports/ community events during Independence and Republic days every year, where many events were conducted and family members of the staff actively participated in it. In addition to scheduled events, few matches were played between CPGS and ICAR complex as friendly match. The events are conducted every year to make these auspicious days memorable. The winners and runners up in each event were given prizes. The prizes were distributed after completion of Independence Day events.

2. RESEARCH ACHIEVEMENTS

MEGHALAYA

WEATHER REPORT

The weather of Umiam (Barapani), Meghalaya during April 2010 to March 2011 was quite normal. The mean monthly maximum temperature was varying between18.86 -29.44^{0}C. The highest temperature in a single day was 32.5^{0}C which was recorded on 7th April. The mean monthly minimum temperature was varying between 5.06-20.13^{0}C with a lowest minimum temperature in a single day was 0.7^{0}C which was observed on 20thJanuary. The mean monthly variation of maximum and minimum temperature has been depicted in the Fig 1. The total annual rainfall was 2568.4 mm with monsoon rainfall (June to September) l739.7 mm. The monsoon rainfall was 195.75 mm more than the normal monsoon rainfall i.e.1543.95 mm. The highest rainfall in a single day was 110.8 mm on 27th June. The total number of rainy days was 142 days (more than 2.5 mm rain per day) which was 13 days more than the normal annual rainy days (129 days).

The annual total evaporation was 875.8 mm and the highest evaporation in a single day was 7.3 mm (on 23rd April). The mean monthly variation of rainfall and evaporation were depicted in the Fig 2.The relative humidity of morning hour was between 67.3 to 89.3% with a mean value of 82.3% whereas, evening hour relative humidity was varying between 48.0 to 78.2% with a mean value of 65.2%. The total annual sunshine hours were 1949 hours with a mean daily sunshine

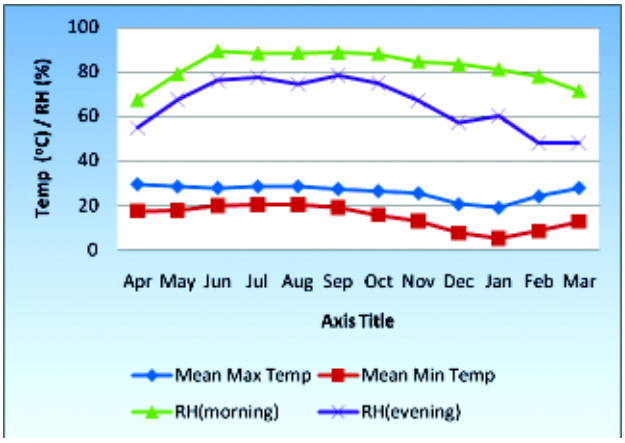


Fig 1 Mean monthly variation of max and min temp

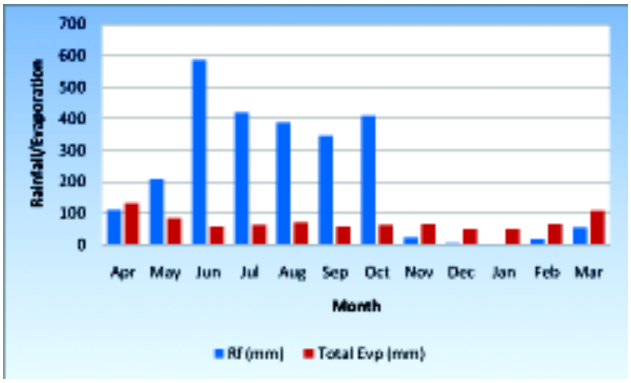


Fig 2 Mean monthly trend of rainfall and evaporation

hour of 5.69 hours. The highest sunshine hour (9.8 hour) during a single day was recoeded on 23rd April and 11th May. The highest total monthly sunshine hour was 218.6 hrs during January. The highest wind speed in a single day was 12.1 kmph on 3rd April followed by 9.5 kmph on 12th May with a mean monthly speed of 2.8 kmph.

The mean soil temperature at 5 cm depth during morning and evening hour was varying between 12.86-24.75^{0}C and 10.6-30.76^{0}C, respectively whereas, in 10 cm depth, it was between 13.29-24.96^{0}C and 18.89-29.08 ^{0}C, respectively. The mean soil temperature at 30 cm depth during morning and evening hour varied between 15.49-26.45^{0}C and 15.49-26.75^{0}C, respectively. The mean monthly variation of soil temperature is shown in the Fig 3. It was observed that soil temperature at 5 cm depth during evening hour of winter season was significantly lower than the

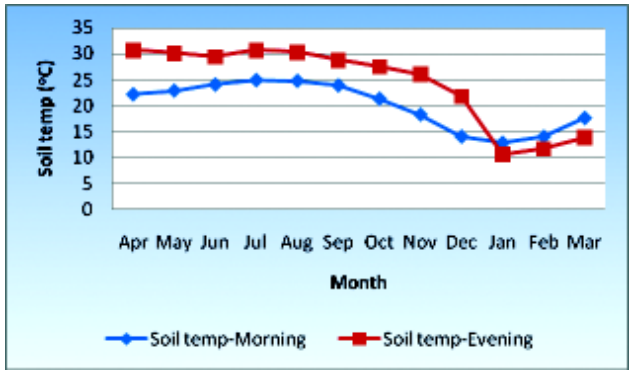


Fig 3 Mean monthly variation of soil temp during morning and evening at 5 cm depth

morning hour. The mean monthly soil temperature at 10 and 20 cm depth during morning and evening hours followed the similar trend (Fig 4 and Fig 5). The Fig 6 indicates that mean monthly soil temperature at 30 cm depth during morning and evening hour were same in all the seasons.

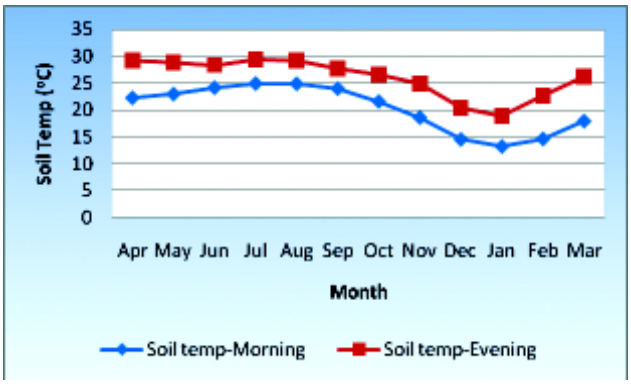


Fig 4 Mean monthly variation of soil temp during morning and evening hour at 10 cm depth

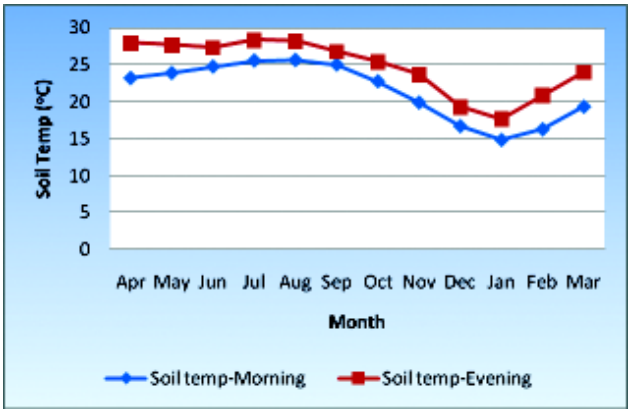


Fig 5 Mean monthly variation of soil temp during morning and evening hour at 20 cm depth

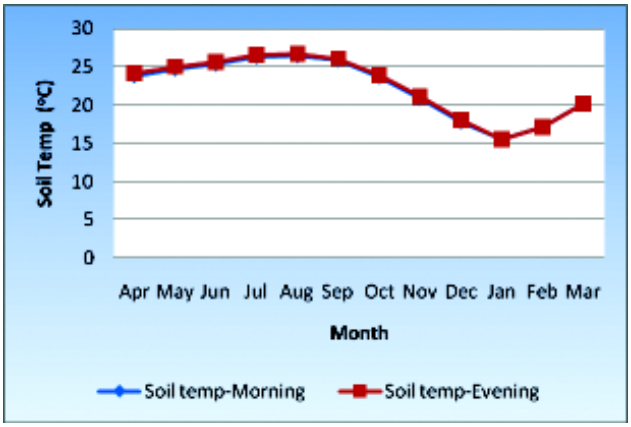


Fig 6 Mean monthly variation of soil temp during morning and evening hour at 30 cm depth

CROP SCIENCE

RICE

Variety release

Four genotypes *viz.*, RCPL1-115 (Bhalum 3), RCPL1-116 (Bhalum 4), RCPL1-76 (Megha SA1) and RCPL1-160 (Megha SA2) were released/notified by the Meghalaya State Seed Sub-Committee.

Yield evaluation trials- Upland

Under upland conditions four yield trials (two RCRT and two AICRP trials) and one observation nursery (IURON) were conducted. In RCRT- 1 (medium duration) trial, RCPL 1-413 (4.0 t/ha), RCPL 1-130 (3.9 t/ha) and RCPL 1-115 (3.0 t/ha) performed significantly better than checks *viz.*,, Bhalum-1 (2 t/ha) and Bhalum-2 (2.1 t/ha). The increase in yield ranged from 60-100%. In RCRT-2 trials (early to medium duration), the genotypes RCPL 1-90 (2.4 t/ha), RCPL 1-92 (2.4 t/ha) and RCPL 1-116 (2.2 t/ha) were fond better with a yield advantage of 40-70% over checks. In AVT-1-UH, Sl.No 3004 (5.0 t/ha), and in IVT-UH, Sl.No 3109 (2.8 t/ha) were the top yielding genotypes. Significant differences were observed in days to 50% flowering. Ninetysix test entries were evaluated (IURON) in which superior performance was shown by test entries IR 82589-B-3-4-4-2 (3.9 t/ha) and IR 82589-B-B-2-3 (3.4 t/ha). Basal dose of NPK (30:60:40) was applied to all the genotypes.

Yield evaluation trials- Lowland

Three RCRTs and five co-ordinated yield trials which included 2 IVTs and 3 AVTs, and 4 international observation nurseries from IRRI, Philippines namely IRFAON, IRLON, IRTON and IRCTN were conducted. In the AICRIP trials for lowland conditions, Sl.No 2803 (AVT-1-MH) was the best genotype and yielded 5.0 t/ha. In IRFAON, BM9855 performed significantly better then best checks. In IRTON, the genotype ZAKHA ACC67859 performed better then best checks Megha rice-1, Megha rice-2 and PSB RC-2. In IRLON, sixteen genotypes performed significantly better than best checks and reference material. In IRCTN, none of the genotypes performed better than local check Megha rice-1.

Research Complex Regional Trial (RCRT)

Five rice RCRTs *viz.*, two upland trials and three lowland trials were conducted at five regional centres of the institute and one research centre of the

government of Meghalaya. Complete data for all the trials were received from Manipur, Meghalaya and Arunachal Pradesh. In upland trial 1, RCPL1-413 (3.06 t/ha) and RCPL1-115 (2.52 t/ha) were the best genotypes for Meghalaya, Manipur and Arunachal Pradesh while RCPL1-128 (3.07 t/ha) was best for Manipur and Arunachal Pradesh. In trial 2, RCPL1-113 (2.05 t/ha) was best for all the three locations and RCPL1-93 (2.63 t/ha) was best for Manipur and Arunachal Pradesh.

In lowland trial 1, RCPL 1-144 (2.34 t/ha) was the best genotype for Meghalaya and Arunachal Pradesh while RCPL 1-149 (5.25 t/ha) and RCPL1-131 (5.51 t/ha) were good for Manipur and RCPL 1-147 (2.95 t/ha) was the best genotype for Arunachal Pradesh. In lowland trial 2, RCPL 1-417 (3.29 t/ha) was the best genotype for Meghalaya, Manipur and Arunachal Pradesh while RCPL1-410 (7.0 t/ha) was the best genotype for Manipur and RCPL1-401(2.95 t/ha) was the best for Arunachal Pradesh. In trial 3 of lowland, RCPL1-160 (5.20 t/ha) was the only one best genotype for all the locations (Meghalaya, Manipur and Arunachal Pradesh).

Evaluation of introgression lines

Fifty true breeding introgression lines derived from elite x wild advanced backcross (Swarna - *O. nivara* BC_2F_7 and KMR3 - *O. rufipogon* BC_3F_7) population were tested for yield, flowering duration and resistance to blast. In Swarna - *O. nivara* BC_2F_7 lines 230S and 166S have performed well whereas, lines 501 and 467 were found superior in KMR3 - *O. rufipogon* BC_3F_7.

Evaluation of segregating and advanced generations

Under upland condition, 200 individual plants from 8 crosses were selected based on panicle weight (15.23 - 34.76 gm) and fertility parentage (71.05 - 87.31%) and the selected plants will be further advanced to the next generation. At Upper Shillong, out of 173 crosses grown in Augmented Design (Table 1), 61 crosses were found promising and yielded more than the checks. These promising genotypes will be grown in station trials for further evaluation.

Screening for cold tolerance

A selected set of genotypes were screened for cold tolerance. Cluster analysis using Ward's minimum variance method revealed that Miyang-93, 8F8-10-IP-5-6 and RCPL 1-11C constituted the out-group (Fig 1). In the main cluster, there were two groups. One group consisted of 3 genotypes (K-39, Kal Brer and Koshar) and the other group consisted of rest 9 genotypes.

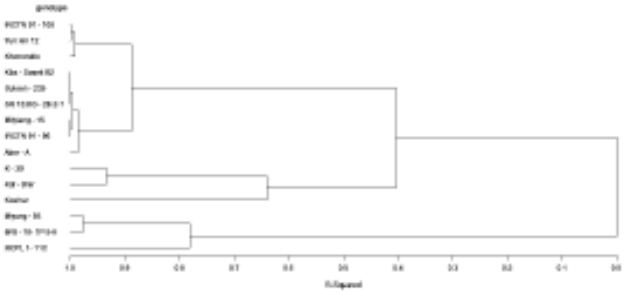


Fig 1 Dendogram of cold tolerant lines grown at the Upper Shillong farm

Principal components analysis performed on quantitative traits revealed that the first three most informative components accounted for 86.67% variance. This was also visible in the scree-plot indicating the significant components (Fig 2). Important characters with greater weightings in principal component axis I included healthy grain and

Table 1 Comparison of different crosses at upper Shillong farm

Crosses	DFF	PH	EBT	PL	PY
3C x Newli -3-3-2	122.0	114.2	9.2	22.6	3.759
Newli x Megha Rice 2-9-3	120.0	118.6	5.2	22.8	3.720
Megha Rice 2 x Newli- F_6B-5-5	121.0	120.2	7.4	24.0	3.632
RCPL 1- 3C x 1-7C-23-47-Bulk 6	121.0	105.6	5.4	21.6	3.620
Megha Rice 2 (check)	123.0	99.6	5.4	20.8	3.238
Mean	124	103.48	5.94	21.97	1.37
Range	118-130	88.0-135.0	3.2-10.4	18.6-27.2	0.12-3.759

Where DFF= Days to 50% flowering, PH= Plant height (cm), EBT= Ear bearing tillers, PL= Panicle length (cm), PY= Yield (t/ha)

panicle weight. Important characters with greater weightings in principal component axis II included straw weight, chaffy grain and ear bearing tillers. Days to 50% flowering had greater weightings in principal component axis III.

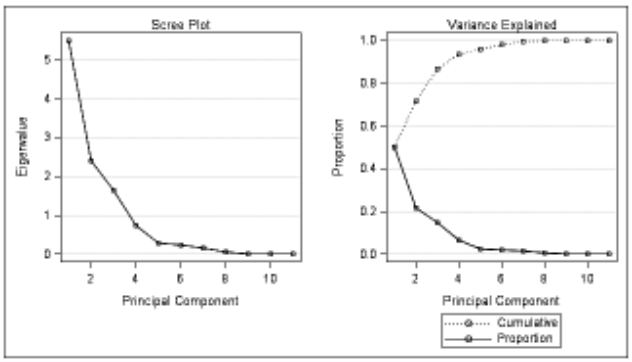


Fig 2 A Scree plot of cold tolerant lines grown at Upper Shillong farm

Studies on medicinal properties of indigenous rice

Seventy three indigenous samples were collected from Meghalaya, Manipur and Nagaland and analysis of 41 of them for their anti bacterial activity against *Staphylococus aureus, Listeria monocytogenes, Aeromonas hydrophila, E. coli* and Salmonella *typhimurium* were completed. ME-MR-1, ME-MR-6 (both from Meghalaya) and MN-MR-24 (from Manipur) showed antibacterial activity against *Staphylococus aureus.* MN-MR-14 (from Manipur) showed activity against *Listeria monocytogenes* and MN-MR-24 showed activity against *Salmonella typhimurium.*

Conservation agriculture in rice based cropping systems

Upland rice based cropping system

Upland rice-toria system was evaluated under conservation and conventional tillage practices with the objective to conserve soil and moisture. In conservation tillage, residue of all the crops grown in the system along with weed biomass was incorporated. In conventional tillage, crop residues and weeds were removed. The growth and yield of all crops (*kharif* and *rabi* season) under conservation tillage was higher than that under conventional tillage. The productivity of toria (TS 36) in rice fallow under conservation tillage was significantly higher (12%) compared to conventional tillage. This might be due to the effect of incorporation of plant biomass under conservation tillage which enhanced water retention capacity of soil during crop growing season. Quick build-up of organic matter in conservation tilled plots was possible through incorporation of crop residues and weed biomass. Based on soil moisture profile, it revealed that upland rice grown during rainy season under conservation tillage could support second crop of toria without any protective irrigation.

The rice (Bhalum 1) yield was higher under minimum tillage (2.80 t/ha) compared to conventional tillage (2.56 t/ha). *In-situ* green manuring with *Crotolaria tetragona* (Fig 3) could produce about 5.40 t/ha of green biomass which was recycled in the system.

Fig 3 *In-situ* green manuring in upland rice with *Crotolaria* spp.

However, there was significant effect of residue (nutrient) management practices on rice yield. Among the residue management practices, application of 50 % recommended dose of fertilizer (RDF) + fresh biomass of *Eupatorium* @ 10 t/ha (applied 2 months before sowing and incorporated) recorded maximum grain yield (3.07 t/ha) followed by 50 % RDF + rice straw 5t/ha (3.05 t/ha). The productivity of succeeding toria was better under plots where minimum tillage was done for *kharif* rice followed by zero tillage in *rabi* (535 kg/ha) compared to conventional tillage in *kharif* followed by zero tillage in *rabi* (476 kg/ha). Among the subplot treatments, *toria* yield was maximum under 50 % RDF + rice straw 5t/ha (615 kg/ha) (Fig 4) followed by 50 % RDF + green manuring (593 kg/ha).

Fig 4 Zero tillage *Toria* (TS 38) in terrace after rice

Lowland rice based system

Harvesting of rice at ground level is common practice in North East region and rice straw is mostly used for fodder. Those farmers who do not keep any livestock usually burn residue after its harvest. Similarly, in traditional rice cultivation farmers plough the field several times before sowing, particularly during puddling which leads to destruction of soil structure and loss of organic carbon from the soil. As soil carbon is designated as *blank gold* of soil, an optimum level of soil organic carbon (SOC) is needed to conserve soil, water and nutrient; favour biological activity and high productivity in any system. Many a times, sowing of *rabi* crops is not possible after harvest of puddled rice because of poor soil structure and soil fertility. Tillage affects soil physical, chemical and biological properties and can play an important role in enhancing the yield potential of crops. Resource conserving practices like zero tillage can help farmers to grow crops soon after rice harvest so that the grain matures before the onset of pre-monsoon shower.

Fig 5 Transplanting of rice with manual dibbler under zero tillage

A field experiment was conducted to study the effect of tillage and plant biomass management practices on productivity of lowland rice (var. Shahsarang 1). The main plot treatments included tillage practices *viz.*, conventional (4 ploughings), minimum tillage (2 ploughings) and zero tillage (application of glyphosate @ 4ml /l, 15 days before transplanting), while the sub-plot treatments were plant biomass management *viz.*, 50 % NPK, 50% NPK + fresh weed biomass @ 10 t/ ha (*Ambrossia* + *Eupatorium*), 100 % NPK (80: 60: 40 kg/ha), 50% NPK + green leaf manure (fresh *Tephrosia* biomass @ 10t/ha) and 50% NPK + *in-situ* residue management (rice straw 6 t/ha approx.) and FYM 10t/ha + weed biomass 10 t/ha + 30 kg P_2O_5/ha through rock phosphate (100 % organic). Among the three tillage practices, zero tillage gave the higher yield (5.09 t/ha) of rice followed by minimum tillage. On an average, zero and minimum tillage recorded 33 and 15% higher grain yield over conventional tillage. Among the nutrient management practices, 50 % RDF + fresh biomass of *Eupatorium* 10 t/ha recorded highest grain yield (4.66 t/ha) followed by 50% NPK + green leaf manuring (4.63 t/ha).

Direct dry seeded rice

Direct seeding has advantages of faster and easier planting, reduced labour and drudgery, earlier crop maturity (by 7-10 days), more efficient water use and high tolerance of water deficit, less methane and often higher profit in areas with an assured water supply. Direct seeding of rice using manual furrow opener was tried under unpuddled field. Seeding depth was kept at 2-3 cm. For comparison purposes transplanting was also done under conventional puddling. The rice varieties used were IR 64, Sahsarang 1 and Krishna Hamsha. Direct seedling was done in the third week of April and on the same day rice nursery was sown for transplanting. For weed control, cono-weeder and hand weeding was practised. Varieties like Shahsarang 1 (4.7 t/ha) and IR 64 (4.5 t/ha) performed well. This technology (Fig 6) can overcome the problem of water supply for rice transplanting during pre-*kharif* season and thereby save resources.

Coal mining effects on soil properties and rice productivity

In the northeastern state of Meghalaya, particularly in Jaintia Hills district, unscientific coal mining has been practiced extensively for so many decades. As a

Fig 6 Direct dry seeded pre-*kharif* rice (Shahsarang 1)

result, over the years, significant chunk of productive lands (agriculture and forest) has been degraded by this practice (Figs 7-10). Keeping in view the adverse consequences of coal mining on soil health and rice productivity, the present study was conducted in the hilly ecosystem of Jaintia Hills of Meghalaya.

Representative soil samples from different land uses (*viz.*, non-mined, coal-mined and 4 years abandoned mining sites) of the three major coal belts (Bapung, Sutnga and Khliehriat) of Jaintia Hills were collected and analyzed for various properties related to soil health and rice productivity. Experiment conducted under controlled conditions (in pots) revealed that biological yield of rice crop (shoot) in mine spoil soils was significantly lower (2.75 gm per pot) compared to the unaffected soils (7.90 gm per pot). However, biological yield of rice improved significantly (>2 times) in soils collected from abandoned sites compared to that under the influence of active mining. Coal mining decreased the soil pH by about one unit compared to the soil free from mining activity (pH: 4.35). The exchange acidity, exchangeable aluminium content and aluminium saturation in clay complex increased by >15% while percent base saturation decreased by 39%. Reduction in biomass yield of rice could be attributed to very high level of aluminium saturation in clay complex that was reflected by a very strong negative correlation (r=-0.91*). Soil fertility as

Fig 7 Overburden dumps near paddy field

Fig 8 Overburden from mining pit causing spillage to productive lands

Fig 9 Paddy field affected by acid mine drainage from adjacent mining sites in Jaintia Hills, Meghalaya

Fig 10 Degradation of forests due to open cast mining in Jaintia Hills, Meghalaya

well as hydro-physical properties also changed significantly. However, mining on steep slopes encouraged detachment and deposition of silts in the valleys. Available P and K were low in mined soils and medium in non-mined soils. Soil organic carbon and available sulphur contents were 2-6 folds higher in mined soils as compared to the non-mined soils. DTPA extractable Fe, Mn and Cu were significantly higher in mined soils while Zn content was found to be less than the critical limit of 0.6 ppm. However, improvement in soil properties and crop performance were observed when mining activities were discontinued for four years. This suggests that if mining is abandoned for longer duration, mined soils may regain its productivity to a great extent.

Phosphate and water use efficiency of different rice cultivars

Field experiment under rainfed condition on varietal response of four lowland rice cultivars (namely Shahsarang, Ngova, RCPL 75 and RCPL-1-160) to phosphatic fertilizers in *kharif*, showed that under natural fertility condition (absolute control), cultivar Ngova produced highest grain yield (4.2 t/ha) while RCPL 1-160 produced lowest yield (3.39 t/ha). However, under fertilized condition, cultivars Shahsarang and RCPL 1-160 demonstrated consistent increase in grain yield with the increase in rates of phosphorous application from 0 up to 90 kg/ha (Fig 11). The grain yield of Shahsarang and RCTPL 1-160 increased from 4.27 to 5.97 t/ha and 3.89 to 5.90 t/ha, respectively. On the contrary, cultivar Ngova responded only up to 30 kg while cultivar RCPL 1-75 responded up to 60 kg/ha of applied phosphorous in producing maximum grain yield (Fig 11). Significant effect of cultivars and rate of P application on plant growth, yield attributing characters and nutrient uptake was observed.

Quantification of different components of water balance (through field water balance approach) showed

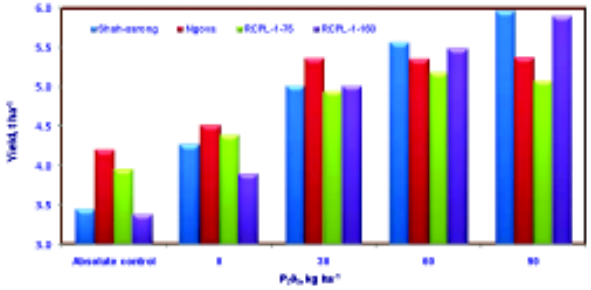


Fig 11 Differential response of low land rice cultivars to phosphorous fertilization

that a total of 936 mm of water input was needed to grow the rice. During crop growth period, total evapo-transpiration (ET) loss was 41% while percolation and seepage losses were 59% of total water input. Similarly, varietal and phosphorus doses had significant influence on crop water productivity (WP_{ET}) which varied from 1.05 to 1.55 g grain per kg of water, much higher than some of the most productive rice growing areas of India (IGP and others).

Fig 12 Ngova

Fig 13 RCPL-160

INSECT-PESTS

Varietal screening against major insect pests

Seven varieties of rice *viz.*,Mangoi, Saimara, White Lehrit, Red Manipur, White Mynri, Bhalum-1 and Bhalum-2 were screened against major insect pests. Out of these, Bhalum-1 and Bhalum-2 were found moderately tolerant against leaf folder (*Cnaphalocrosis*

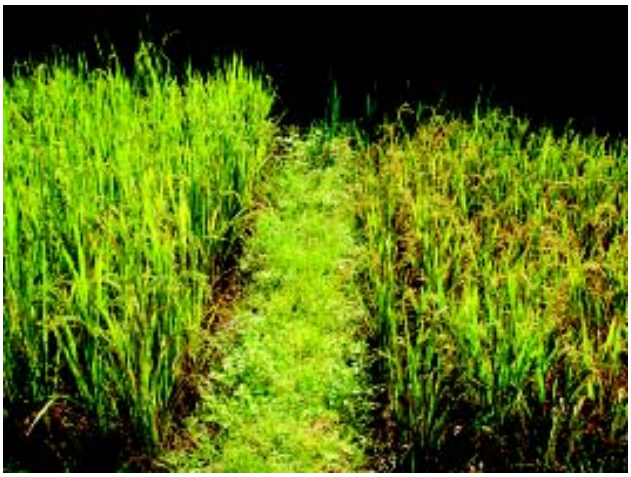


Fig 14 Varietal difference in plant height of low land rice cultivars

Fig 15 Rice field view at glance, Division of Soil Science

madinalis) and gall midge (*Orseolia oryzae*). Incidence of root aphid (*Tetraneura nigriabdominalis*) was very low in White Lehrit followed by Red Manipur.

Evaluation of different bio-pesticides against major insect pests of rice

Whorl maggot, leaf folder, rice hispa, green leaf hopper and earhead bug were recorded as major pests during the season in lowland rice ecosystem. Among all the biopesticides applied, *Bacillus thuriengiensis* var. *kurstaki* (3g/L of water) was found effective against leaf folder and whorl maggots. *Metarhizium anisopliae* (1 x 10^8 CFU/g) @ 1.5, 2.0, 2.5 and 3.0 kg/ha was found at par with carbofuran 3G (33 kg/ha) against the white grub on rice.

DISEASES

Screening trial for identifying resistant lines against blast disease (pathogen- *Pyricularia oryzae*) was conducted following uniform blast nursery pattern. Out of 928 entries tested against rice blast disease, 258 entries were found to be resistant (Table 2). In Donor screening nursery many entries *viz.*,, RP Patho-2 to 5, RP Biopatho 3, 4 etc. and many other lines were resistant.

Table 2 Screening for rice blast

Name of the nursery	Total entries	Resistant entries
National Hybrid screening nursery	82	44
National screening nursery -1	136	34
National screening nursery -2	557	89
Donor screening nursery	92	48
National screening nursery-Hills	61	43

Field monitoring of virulence of *Pyricularia oryzae*

The nursery included twenty-five cultivars consisting of international differentials, donors and commercial cultivars. IR 64, Tetep, Raminad str 3, NP 125, C101 LAC, Tadukan and C105 TTP-4-L23 were found to be resistant against blast disease. Virulence pattern was found to be different from the previous year's reaction.

MAIZE

Research Complex Regional Trial (RCRT)

RCRT was constituted with five composites from Tripura centre TRC-1, TRC-2, TRC-3, TRC-4 and TRC-5 and two lines *viz.*,, RCM 76 and RCM 75 from Umiam. At Umiam, Meghalaya, the trial was laid in RCBD in 10 m^2 plot. Comparison of average yield of all the composites showed that TRC-4 (4.4 t/ha), TRC-5 (3.7 t/ha) and RCM -76 (4.3 t/ha) performed better than the check, Vijay composite (3.2 t/ha).

Hybrid evaluation

Twelve hybrids from VPKAS, Almora were evaluated for their performances; all the hybrids were of short duration (80-90 days). The estimated kernel yield ranged from 4.8 -7.9 t/ha in Vivek hybrid 5 and FH 3356.

Germplasm maintenance and characterization

Sixty seven local germplasm lines from different parts of Nagaland, Meghalaya and Manipur were maintained. The characters recorded are presented in the Table 1.

Table 1 Different characters of local maize germplasm

Characters	Average	Range
Days to 50% tassel	73±6.5	51-80
Days to 50% silk	76±7.1	52-86
Days to 75% maturity	116±7.1	92-126
Plant height (cm)	279.5±60.4	153-356.7
Ear height (cm)	158.4±51	46-236
Stem diameter (cm)	8.38±1.83	5-10.8
Cob length (cm)	16.7±2.8	12-24.6
Cob diameter (cm)	13.7±1.7	11.8-23.6
Rows/cob	12.2±1.0	10-14
Seeds/cob	332±117	150-994
Kernel yield/plant (g)	103±42	32.5-36.7

Three plants from every line were selfed to study the grain qualities. The grain colour varied from white to black (Fig 1) in these selfed plants which could serve as rich source of desirable grain qualities.

Fig 1 Kernel colour variation and special cob characteristics in local maize

AICMIP Trials

Ten co-ordinated trials received from All India Co-ordinated Maize Improvement Project (AICMIP) were evaluated for the yield performances. Four IET, four AVT and two zonal trials were conducted during *kharif* -2010 (Table 2).

Screening maize for water logging tolerance

Cup screening

Initial germination test for water logging tolerance was taken up for four set of trials using cup screening method in green house. Germination percentage in trial 1 (13 x 13 diallel) was 87%, trial 2 (8 X 8 diallel) 35%, trial 3 (landraces) 28 % and in trial 4 (inbreds) 39 %.

Table 2 List of superior lines in AICMIP trials

Trial no and duration	Lines
IET 61 (Late)	X35A 175, KMH-2559, HP-222, CMH08-287, GK 3090, NMH-713, S 6668/NH 6668, S 6718/NH 6718, PRO 380, PFMH-97 I 40
IET 62 (Medium)	HM 8, HKH – 414, BIO-151, KH-B55, KH-B52, VMH-4106, S 6304, Hy. P3396
IET 63 (Early)	X8B561, Sun – Vaaman, REH 2009-11, REH 2009-12, WH-2051
IET 64 (Extra Early)	Hy. P 1453. KH-9888
AET 65 (Late)	BIO-265, MCH 40
AET 66 (Medium)	Sarpunch-171, X8B557, CMH 08-156, BIO 9637, KDMH 017
AET 67 (Early)	BIO-605, REH 2001, REH 2003
AET 68 (Extra Early)	Vivek QPM 9, FH 3487, DH-179
ZR 102 (Late)	214, 209, 205, 207
ZR 103 (Late)	121, 119, 131, 124, 105

Field condition

Water logging tolerance screening was done for 13 x 13 diallel, 8 x 8 diallel, 132 land races and 180 inbreds in field condition. The water level was maintained up to 10 cm above ground level after ten days of germination up to 20 DAS. Most of the genotypes were highly susceptible to water logging, with germination percentage of 47.3% in 13 x 13 diallel and 21.9 % in 8 x 8 diallel. The landraces and inbreds failed to germinate. However, mortality rate was high in 8 x 8 diallel and seed set was found only in few plants of 13 x 13 diallel 9 (Fig 2).

Fig 2 Effect of water logging on maize cobs

Development of QPM lines by MAS backcrossing

Fifty seven cob of BC_1F_1 from the cross CML 173 X V 398 were planted in ear to row method. Leaf

samples of 590 plants of these BC_1F_1 were collected for DNA analysis. Fore ground selection was carried by screening 590 DNA samples for presence of *opaque* 2 gene using four *SSR* markers. These plants were selfed to develop BC_1F_2 generation. Based on polymorphism for the parents, 27 SSR markers were selected to take up background selection in BC_1F_2 generation. This would assist in selection of plants with QPM gene and the desirable characters of elite parent.

Soil amendments and fertilizer effect on maize productivity and soil health: an integrated approach

Residual effects of agricultural lime applied at varying rates (from 12.5 % LR up to 75% LR) were prominent on the productivity of maize that varied between 1.25 and 3.8 t/ha (Fig 3). Lime dose of 12.5% LR (applied in previous season) along with 100% recommended NPK in the current season could able to produce comparable yield (2.95 t/ha) to that of 25-50% LR + 100% recommended dose of NPK (3.0-3.15 t/ha). However, residual effect of lime (12.5% LR) was most effective in increasing the yield up to maximum of 3.65-3.8 t/ha when poultry manure @ 2.5 t/ha, FYM @ 5t/ha along with 100% NPK was applied. Poultry manure was very effective, even better than FYM when it was applied in combination with lime (12.5% LR). Thus, it could be inferred that instead of application of higher doses of lime (=25% LR) with NPK every year, proper combination of FYM/poultry manure with NPK and lesser amount of lime (12.5% LR) once in two years could be effective in producing optimum yield of maize.

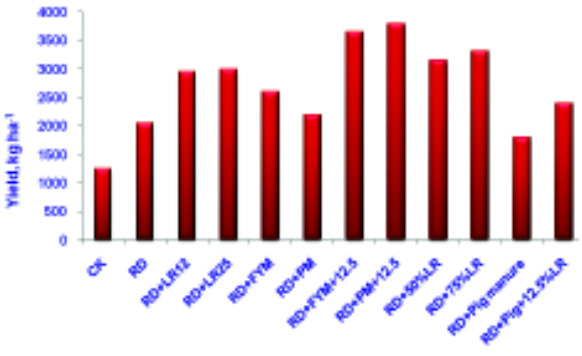


Fig 3 Effect of amendments (organic and inorganic) and fertilizer on maize productivity

Application of weed biomass along with organic manures and agricultural lime significantly improved the soil health, particularly hydro-physical (soil aggregation, water transmission, retention etc.) and soil microbial (biomass carbon, dehydrogenase activity etc.) properties up to sub-surface level (0-30 cm depth).

INSECT PESTS

Varietal trial for resistance against maize stem borer and cob borer

Twelve maize varieties were screened against maize stem borer (*Chilo partellus*) (Fig 4) and cob borer (*Stenachroia elongella*) (Fig 5). Infestation of stem borer ranged from 0.67 to 5.33% on different varieties. Stem borer infestation was lowest in Vivek Hybrid Maize-15 (0.67%) whereas, highest in Vivek Hybrid Maize-21, Vivek Hybrid Maize-23, HIM-129 and Vivek Hybrid Maize-5 with 5.33% infestation in each variety. Cob borer infestation varied from 4.09-14.40%. Minimum and maximum cob borer infestation was found in Local yellow (4.09%) and Vivek QPM-9 (14.40%). Lower yield (3.70 t/ha) was recorded in

Fig 4 Maize stem borer damage

Fig 5 Cob borer damage on maize

HIM-129 and higher (6.36 t/ha) in Vivek Maize Hybrid-25.

Effect of date of sowing on population build up of stem borer and cob borer in maize

Maize variety Vijay composite was sown at fortnightly interval starting from 1st May up to 1st July. Stem borer infestation was found more on early sown crop as compared to late sown crop. Stem borer damage was recorded from 2.67 to 10.67% while cob borer damage ranged from 1.35 to 13.92%. Maize sown during June showed maximum cob borer infestation.

Bio-efficacy of different insecticides against maize stem borer and cob borer

Maize variety RCM-1-2 was sown to evaluate the efficacy of nine insecticides against stem borer and cob borer. One spraying was given at boot leaf stage when stem borer infestation was noticed and another spraying (except Carbofuran) was done at silking stage for cob borer. Among tested insecticides, clothianidin 50% WDG @ 0.25 g/L, flubendiamite 39.35 m/m SC @ 0.5 ml/l, indoxacarb14.5 SC @ 1 ml/l, carbofuran3G @ 5-6 granules/whorl and spinosad 45 SC @ 0.75ml/l were found effective against these pests.

DISEASES

Trap nursery

Ten genotypes of maize were evaluated for naturally occurring diseases. *Turcicum* leaf blight occurred in HK1- 1344, HK1- 193-1, HK1- 1352, LM -5, JCY 2-7-1), *Maydis* leaf blight occurred in HK1- 193-1, HK1-1105, HK1- 1352, HK1 -323, LM -5, JCY 2-7-1 and common rust in LM -5, HK1- 1344, HK1-163.

Screening for *Turcicum* leaf blight resistance

Five (#75, 76, 77, 78 & QPM) screening trials were conducted. Altogether, 103 genotypes were screened for resistance/susceptibility. Of these genotypes, 42 were resistant, 18 moderately resistant, 20 moderately susceptible, 16 were susceptible and 7 were highly susceptible to *Turcicum* leaf blight of maize under Barapani conditions.

Management of *Turcicum* leaf blight by foliar application of nutrients

A trial with seven combinations of nutrients (N, P, K, Zn), one control (Mancozeb) and one absolute control applied as foliar spray, was conducted. N from KNO_3 @ 0.1M, P from KH_2PH_4 @ 0.1M, K from K_2HPO_4 @ 0.1M, Zn from $ZnSO_4$ @ 1% and control (Mancozeb 75% WP @ 2.5 g/L). N+P+K+Zn combination recorded less disease as well as maximum yield followed by N+Zn combination (Fig 6).

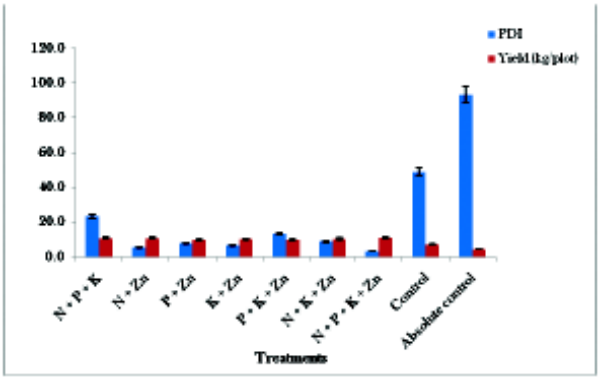


Fig 6 Effect of foliar application of nutrients on *turcicum* leaf blight of maize

Banded blight in maize

Sporadic cases of banded blight caused by *Rhizoctonia solani*, was observed in few pockets of north east. The disease is more prominent in the the valley and plains where the climte is warmer. The severity is less in the cooler regions at higher elevations of the north eastern hills.

Fig 7 Banded blight in maize

PULSES

Mungbean

Under upland condition two yield trials (IVT and AVT) were conducted in *kharif* season (2010). In IVT, 23 entries were planted in random block design and KM – 10 –1050 (0.613 t/ ha), KM – 10 –1072 (0.575

t/ ha), KM – 10 –1041 (0.554 t/ ha), KM – 10 –1050 (0.613 t/ ha), KM – 10 –1074 (0.513 t/ ha) and KM – 10 –1071 (0.503 t/ ha) were identified as the high yielding lines. In AVT, data of 5 genotypes were recorded. Two lines KM – 10 –1011 (0.395 t/ ha) and KM – 10 –1015 (0.309 t/ ha) were found promising.

Urdbean

Eight genotypes of urdbean were grown in upland condition and data was recorded for desired traits. The performance of the four superior genotypes is presented in Table 1.

Ricebean

A set of hundred germplasm lines of ricebean were maintained in upland condition. Thirty-one spreading type ricebean assembled from different parts of North East India were evaluated in augmented design. Three ricebean varieties developed through institutional breeding programmes *viz.*, PRR- 2, RBS- 16 and RBL- 1 were included as controls. BKSB – 170, CHALNKI and BKSB – 245 were found promising as depicted in Table 2.

The clustering pattern as revealed by Ward's minimum variance dendrogram classified the accessions into two distinct groups. Thirteen genotypes were clustered with the three control varieties.

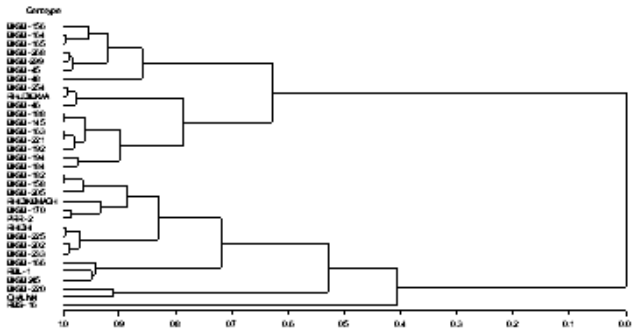


Fig 1 Ward's minimum variance dendrogram of 31 ricebean lines

Evaluation of photo-insensitive F_9 single plant progenies of ricebean

Based on the yield performance of the F_8 population of a cross between PISRB 3 X RBS 24, twenty two single plant selections were made. Individual F_9 plant progenies of these selected plants were evaluated during *kharif* with RBL 1 and PRR 2 as checks (Table 3).

Lentil

A set of seven genotypes were sown for multiplication in lowland ecology. An AVT was conducted and observation and performance was recorded. Entries

Table 1 Comparison of performances of four promising urdbean genotypes

Genotype	Days to 50% flowering	Days to maturity	Plant height (cm)	Branches / plant	Pods/ Plant	Yield/ plot (g)
PD - 4	40	78	21.8	1.2	21.6	100.3
KU5- 527	44	97	25.2	4.1	15.2	94.5
KU5- 505	43	96.3	24.6	4.2	13.7	88.8
KU5- 503	43	97.3	20.6	4.2	11.1	81.5
Mean	43	89.19	24.15	3.35	17.30	84.25

Table 2 Evaluation of spreading type ricebean genotypes in upland ecosystem

Genotype	PH	NOB	NOP	PL	SPP	DFF	DM	YLD
BKSB - 163	136.6	6.2	49.2	10.2	7	67	124	0.99
BKSB - 245	123.8	4.8	16	10.8	8.4	65	129	1.12
RBS - 16	174	5.8	28.8	11	8.8	69	124	1.17
CHALNKI	100.8	6.6	72.2	9.1	8	68	134	1.41
BKSB - 170	109.6	3.6	31.2	9.62	7.4	67	134	1.51
Mean	108.06	4.89	29.6	9.37	7.35	64.75	125.75	0.922
CD(*P*= 0.05)	13.19	1.11	14.11	0.73	0.71	1.75	9.36	0.37
CV (%)	16.02	17.29	14.32	6.74	8.42	2.35	6.45	18.74

PH: Plant height (cm); NOB: Number of branching; NOP: Number of pods; PL: Pod length (cm); SPP: Seed per pod; DFF: Days to 50% f1owering; DM: Days of maturity; YLD: yield (t/ ha)

Table 3 Comparison of performance of three promising lines of photo insensitive rice bean

Selection	Plant height (cm)	Branches/ Plant	Pods/ Plant	Pod length (cm)	Seed / pod	Days of 50% flowering	Days of maturity	Yield (q/ha)
5.19.25	29.53	3.73	9.00	8.93	7.47	49.00	94.00	3.96
121-5.32.20	33.40	4.33	13.60	8.32	7.33	49.00	97.00	3.87
151.5.4.1	39.60	4.40	11.73	8.49	7.13	49.00	88.67	3.78
PRR-2	52.67	5.47	16.00	9.51	8.47	52.00	95.00	9.15
RBL-1	56.07	4.53	19.60	9.83	8.73	55.33	99.33	7.93
Mean	34.29	4.19	11.81	8.59	7.45	48.87	93.50	3.56
CD (*P*=0.05)	6.90	0.8	1.94	0.7	0.77	0.33	1.74	0.78
CV (%)	20.20	18.91	16.43	8.09	10.31	0.65	1.85	21.86
Pr > F	0.0001	0.127	0.0001	0.156	0.174	0.0001	0.0001	0.0001

were found significantly different from each other for all the characters except for plant height and number of branches. Promising entries like L 9 -752 (1.12 t/ha) and L 9 – 753 (0.998 t/ha) yielded significantly better than the average value (0.63 t/ha).

Zero tillage – a viable option for pulse production in rice fallow

Conventionally after *kharif* rice, fields remain fallow in lowland, mainly due to excess moisture owing to seepage from surrounding hillocks. Draining water from rice field at physiological maturity creates favorable condition for cultivation of a successful *rabi* pulses like pea, lentil etc. A simple drainage around the rice fields/plots with appropriate outlets creates the desirable conditions. To study the performance of pulses like pea and lentil, 4 varieties each of pea and lentil were obtained from IIPR, Kanpur, UP. Pea and lentils (Figs 2a-d) were grown under zero tillage in lowland rice fallow using recommended dose of NPK (20:60:40 kg/ha). One weeding cum hoeing was given manually at 30 DAS. In another trial, different lentil

Fig 2 a. Opening narrow furrow by manual furrow opener, placing fertilizer, seeds and covering of seeds b. Lentil crop in between rice stubbles, c. Pea crop under zero tillage d. Lentil as utera crop in rice fallow

varieties were also grown as utera crop. The lentil seeds were broadcasted a day before rice harvest and the seeds were partially incorporated into the soil during harvesting, carrying of rice etc.

Among various pea varieties tried, IPFD 99-13 (Fig 3) recorded maximum green pod yield (4.1 t/ha) followed by IPFD 1-10- (3.29 t/ha), IPFD -99-25 (3.03 t/ha) and HUDP (1.7 t/ha). Among the lentil varieties tried, DPL-15 (Fig 4) recorded maximum seed yield (1.10 t/ha) followed by DPL 62 (0.87 t/ha) and IPL 406 (0.4 t/ha). Therefore, pea and lentil increased the system productivity and farm income. With appropriate agronomic interventions and varietal screening, pea and lentil could be popularized at mid altitude for food and nutritional security of small and marginal farmers.

Fig 3 Pea variety IPFD 99-13 (left) under zero tillage in rice fallow

Fig 4 Lentil var. DPL 15 under zero tillage in rice fallow

INSECT PESTS

Pest complex study on pigeon pea

A study was conducted to record the insect pest complex on pigeon pea (Variety-Bahar). More than thirty five insect species including some natural enemies were recorded on pigeon pea. These insect species belonged to eight insect orders comprising *Coleoptera*, *Lepidoptera*, *Hemiptera*, *Diptera*, *Hymenoptera*, *Thysanoptera*, *Orthoptera* and *Isoptera*. Among the insect pests recorded, pigeon pea pod boring weevil, *Apion clavipes* (Curculionidae: *Coleoptera*) was observed as major pest causing on an average 67.5% pod damage.

Insect pests on different varieties of mung bean

Ten varieties of green gram were sown to study the incidence level of insect pests on different varieties. White spotted flees beetle (*Monolepta signata*), aphid (*Aphis craccivora*), thrips (*Megalurothrips* spp) and blister beetle (*Mylabris pustulata*) (Fig 5) were the common insect pests on all the green gram varieties. Among them, aphids and blister beetles were found as major pests whereas, White spotted flees beetle was found on all the varieties during early crop growth stage. Aphid population varied from 1.40-10.81/flower bud and 16.94-66.78/pod, blister beetle was 1.00-3.08 per plot and thrips population was very less, only 0.11-1.11/leaf.

Fig 5 Blister beetle on green gram flower

DISEASES

Survey and surveillance of diseases of mung and urdbean (under AICRP on MULLaRP)

Survey and surveillance of diseases of mung and urdbean was done at the Plant Pathology field during the *kharif* season. Six diseases were recorded on urdbean and five diseases were recorded on mungbean (Table 4).

Table 4 Diseases recorded in urdbean and mungbean

Name of the disease	% incidence	
	Urdbean	Mungbean
Powdery mildew	40-50	35-50
Mung bean Yellow mosaic virus	2-5	1-3
Web blight	5-10	3-5
Ascochyta leaf blight	60-70	40-50
Sclerotium leaf spot	5-7	-
Anthracnose	30-35	25-30

Ascochyta leaf blight (Fig 7) was most severe (60-70% incidence) followed powdery mildew (40-50% incidence) and anthracnose (30-35% incidence), web blight (*Rhizoctonia solani*) (5-10%), *Sclerotium rolfsii* leaf spot (5-7%) (Fig 6) and least incidence was of Mung bean Yellow mosaic virus disease (2-5%).

Fig 6 Leaf spot of Urdbean caused by *Sclerotium rolfsii*

Fig 7 Ascochyta leaf blight of Urdbean

On mung bean, incidence of ascochyta leaf blight was 40-50%, powdery mildew 30-50% and anthracnose 25-30%, web blight 3-5% and mung bean yellow mosaic virus 1-3% but there was no record of sclerotium leaf spot. On both the crops ascochyta leaf blight, powdery mildew and anthracnose were the major diseases in the area.

National mungbean nursery for evaluation of AVT entries against important diseases

Thirty AVT line of mungbean were evaluated under Barapani field conditions against four major diseases (MYMV, powdery mildew, web blight and ascochyta leaf blight) of mungbean. All the entries were resistant to MYMV. Twenty eight entries were resistant to web blight and two entries namely P105 and P122 were moderately susceptible. Twenty five entries were immune to resistant but five entries (P106, P107, P108, P124 and P 122) were moderate to highly susceptible to ascochyta leaf blight. Fifteen entries were highly susceptible and rests were free or resistant to powdery mildew.

Thirty eight AVT urdbean entries were evaluated under field condition of Barapani against four major diseases (MYMV, powdery mildew, web blight and ascochyta leaf blight) of urdbean. All were resistant to MYMV and Web blight but most of the entries were moderate to highly susceptible to powdery mildew and Ascochyta leaf blight. AVT Line P174, P163, P151, P167, P172, P169, P176, P170, P162, P171, P153, P184 and P182 were immune to resistant, whereas, P164, P166, P151, P167, P172, P168, P178, P176, P162, P153, P184, P185, P186, P183, P190 and P192 were resistant to ascochyta leaf blight.

OILSEEDS

Soybean

Two coordinated trial (IVT and AVT- I) and one station trial were conducted. Code 02, Code 09 and Code 31 were found superior in IVT trial whereas, entry RKS 54 was found promising from AVT- I - 2010 trial. ANOVA for the station trial of nine genotypes revealed that overall model was significant for all traits except yield and number of branches. Cross 2-1 (3.21 t/ha), RCS 1-9 (3.16 t /ha) and RCS 1-10 (2.91 t/ha) performed better than checks *viz.*,, Bragg (2.38 t/ha) and JS335 (1.88 t/ha) (Table 1).

Table 1 Comparison of different soybean genotypes developed at ICAR RC NEH Umiam

Characters	Cross-1-1	Cross-1-2	Cross - 2-1	Cross-2-2	RCS 1-1	RCS 1-10	RCS 1-9	Bragg (check)	JS-335 (check)	Mean	CV (%)	Pr > F
DDF	79.67	77.00	79.33	77.67	84.00	78.67	84.33	82.00	75.33	79.64	4.38	<.0001
PLH	46.80	50.47	65.33	47.73	53.33	76.13	58.73	65.67	42.33	55.33	17.21	<.0001
NOB	5.47	5.73	5.93	6.27	6.93	5.93	6.80	5.53	5.73	6.07	13.26	0.4152
NOP	63.07	63.47	92.40	73.6	86.93	82.47	80.40	74.00	61.60	75.87	16.59	<.0001
NOC	17.00	16.47	22.98	18.87	24.80	24.33	25.93	19.80	15.87	20.66	17.32	0.0035
YLD	2.10	2.57	3.21	2.41	2.59	2.91	3.16	2.38	1.88	2.57	19.68	0.1084

Where DDF = days to 50 % flowering, PLH = plant height (cm), NOB= number of branches, NOP= number of panicles, NOC = number of clusters, YLD = yield (t/ha)

Toria

Four composites created from M-27, RCT- 1, RCT-2 and SCRT 1-2 (one composite each) were evaluated under upland conditions to complete the first cycle of composite formation. Superior plants from the first cycle composites were selected for increasing the genetic advance. Five advanced composites were grown with genotypes M-27 and Local white and the performance of superior genotypes for various agronomic traits are presented in table 2.

Fig 1 Syrphid fly larvae feeding on aphids

Fig 2 Parasitized aphids by *D. repae*

INSECT PESTS

Diversity of natural enemies in mustard ecosystem

Coccinellid beetles, syrphids fly (Fig 1) and spiders were recorded as major predators of aphids, *Dietiriella repae*, a major nymphal parasitoid of aphids (Fig 2). *Hyposoter ebeninus*, *Cotesia glomerata*, larval parasitoids of cabbage butterfly and numerous ichneumonid wasps were also found during flowering stage in mustard ecosystem.

Commonly found coccinellid beetles observed in mustard ecosystem were *Coccinella septumpuncata* L. (Fig 3), *Coccinella transversalis* F. (Fig 4), *Micraspis discolor* (F.) complex, *Oenopia kirbyi* M. (Fig 5) and

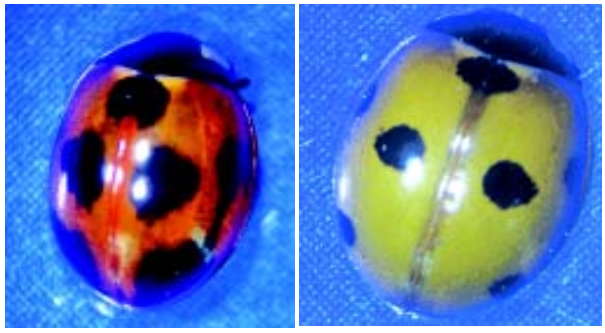


Fig 3 *Coccinella septempuncata* L.

Table 2 Evaluation of different toria composites grown at Umiam

Genotype	PH	NPP	NOB	RL	PL	NSPP	YLD
M-27	63.50	82.20	4.80	10.00	5.02	17.20	0.73
SCRT-1-2	59.60	76.45	4.00	9.32	5.16	14.78	0.69
RCT-2	62.88	63.58	4.24	8.81	5.10	15.81	0.66
RCT-1	62.20	68.20	4.60	10.44	4.69	15.52	0.61
LOCAL WHITE	62.20	85.30	4.30	10.61	5.11	15.83	0.53
SCRT -1-1	62.90	111.90	4.80	9.89	5.01	16.26	0.51
SCRT-1-3	68.20	108.45	5.80	11.54	5.08	14.14	0.47
Mean	63.07	85.15	4.65	10.09	5.02	15.65	0.60
CD (*P*= 0.05)	8.01	27.81	0.94	1.02	0.42	2.43	0.105
CV (%)	11.13	19.00	17.95	9.00	7.68	13.86	19.55

PH= Plant height (cm), NPP= No of pods per plant, NOB= No of branches, RL= Root length (cm), PL= Pod length (cm), NSPP= No of seeds per pods, YLD= Yield (t/ha)

Oenopia sexareata M. (Fig 6). Among all, *Coccinella septempuncata* L. and *Coccinella transvarsalis* F. complex were recorded as most dominant predators.

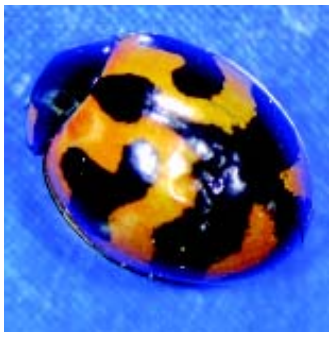


Fig 4 ***Coccinella transvarsalis*** F.

Biology of *Coccinella septempunctata*

Biology of *Coccinella septempunctata*, a potential predator on mustard aphid was studied and observed that eggs were laid in a batches consisting of 13 to 47 eggs in 3 to 5 rows and hatched in 4.4 ± 0.82 days. The period of first, second, third and fourth instar grubs were 3.25 ± 0.63, 2.95 ± 0.68, 5.7 ± 0.86 and 11.35 ± 1.42 days, respectively. The adult longevity of *C. septempunctata* (Fig 3) was 57.65 ± 8.62 days.

Fig 5 ***Oenopia kirbyi***

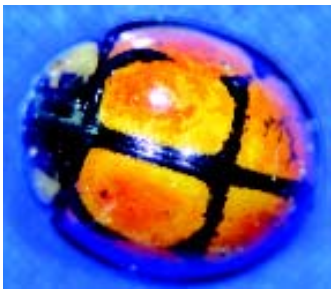


Fig 6 ***Oenopia sexareata*** M.

Feeding potential of *Coccinella septempunctata*

First, second, third and fourth instars grubs of *C. septempunctata* were found to consume an average number of 3.84 ± 0.9, 10.53 ± 1.53, 27.34 ± 2.18 and 34.05 ± 2.64 of aphids/ 24 hours, when provided with 10, 20, 40 and 60 numbers of aphid, respectively. It was observed that an adult *C. septempunctata* consumed 44.9 ± 4.8 of aphids/ 24 hours when provided with 100 mustard aphids. The feeding potential in adult male was 41.66 ± 3 aphids/ 24 hours, which was lower than the female beetle (48.6 ± 3.12 aphids/ 24 hour). However, total number of aphids consumed by different individual instars *viz.*, first, second, third and fourth instars grubs was 15.05 ± 3.73, 32.7 ± 3.6, 152.15 ± 26.2 and 366.75 ± 33.28 aphids, respectively. The female and male were found to consume 1459.4 ± 93.7 and 1269.6 ± 163.88 numbers of aphids, respectively in adult stage. The total number of aphids consumed during the entire development period of larvae (first to fourth instar) was 566.65 aphids and in individual adult it was 1347 ± 146.87 aphids in 30 days.

Eco-friendly management of major insect pest of soybean

Leaf folder (*Nacoleia vulgalis*) was recorded as a major pest of soybean, whereas, incidence of stem fly (*Omphiomyia phaseoli*), white spotted flee beetle (*Monolepta signata*), jassids (*Empoasca parathea*) and tobacco caterpillar (*Spodoptera litura*) was low. Different biopesticides were applied against leaf folder, *B.t* var. *kurstaki* (2 g/L)) was found to be superior over all the treatments followed by N.S.K.E. 5% + cow urine (1:1 mixture) and both the pesticides reduced 42.85 and 35.71% damage, respectively as compared to control.

Eco-friendly management of major insect pest of groundnut

Blister beetle (*Mylabris pustulata*), leaf folder (*Nacoleia* spp), flea beetle (*Monolepta signata*), jassids (*Empoasca parathea*) and aphids (*Aphis craccivora*) were observed in groundnut ecosystem. Population of blister beetle was observed to be higher during early September. Among various biopesticides applied, NSKE 5% extract was found to be most effective against both blister beetles and leaf folders. It reduced 52.94% and 39.55% damage of blister beetles and leaf folder, respectively compared to control.

DISEASES

Screening for rust resistance

Under AICRP on soybean, 42 genotypes including check (var. JS 335) were screened under field conditions at Umiam against rust disease caused by *Phakopsora pachyrhizi*. Only two entries *viz.*, KS 103 and EC241778 were found highly resistant. Seven genotypes *viz.*, PS 1476, KDS 344, PS 1477, NRC 88, MACS 1336, PS 1477 and EC241780 were rated as moderately resistant. Ten genotypes were moderately susceptible.

Evaluation of soybean genotypes for tolerance against rust

Ten genotypes were grown under fungicide protected and unprotected conditions and yield losses were estimated. Yield losses ranged from 9% to 47%. Based on yield potential and loss, genotypes MACS1140 (2124 kg/ha) and NRC80 (1721 kg/ha) were identified as high yielding resistant genotypes.

Genotypes MACS1188 (1953 kg/ha) and MACS1184 (1853 kg/ha) were identified as tolerant genotypes.

RODENT CONTROL

Bamboo flowering in Meghalaya

Quarterly survey conducted in all the districts of Meghalaya showed sporadic to mass bamboo flowering in Garo Hills and West Khasi Hills. Some isolated instances of a slight upsurge in rodent population and a slight increase in damage to rice crops was observed only in East Garo Hills.

A total of seven rodent species *viz., Bandicota bengalensis, Niviventtor niviventor, Rattus rattus, Rattus nitidus, Mus musculus, Rattus sikkimensis* and *Cannomys badius* were identified from bamboo flowering areas in Meghalaya. However *B. bengalensis* was the predominant species.

Damage assessment and evaluation of rodenticides

Rodent damage to rice, maize and groundnut crop was observed to the tune of 7.25%, 9.45% and 10.25%, respectively. However, damage was negligible in different vegetable crops *viz.*, broccoli, cabbage and cauliflower. The *Bandicota bengalensis* was recorded the predominant species. Bromadiolone (0.005%) and zinc phosphide (2%) were used for the rodent control by burrow and field placement methods. Zinc phosphide proved effective by reducing rodent activities between 70.51 – 78.00% by burrow placement method whereas bromadiolone reduced the active burrows upto 35%. Use of zinc phosphide followed by bromadiolone to control the residual rodent population proved effective in reducing the rodent population upto 87%. Consumption of rodenticide increased with bamboo bait stations for poison bait placement which resulted increase in the control efficiency.

VERMICOMPOST

Biological studies of indigenous earthworm (*Perionyx excavatus*)

Biology of *Perionyx excavatus* was studied and found that eggs (Fig 1) hatched in 16-21 days and worms (Fig 2) attained sexual maturity in 28-56 days. The life cycle of this species was completed in 44 to 71 days.

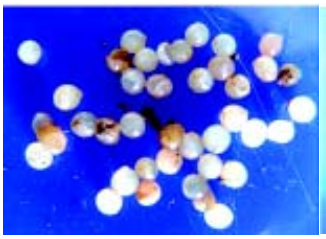


Fig 1 Eggs of *Perionyx excavatus*

Fig 2 Adult worms of *Perionyx excavatus*

Dynamics of decomposition of organic wastes by indigenous earthworms

Two earthworm species, *Eisenia foetida* and *Perionyx excavatus* were evaluated for the production of vermicompost from waste materials *viz.*,, paddy straw, waste paper, forest liter, vegetable waste and cow dung (control). It was observed that the *E. foetida* multiplied 4.16 times on forest liter and 2.17 times on cow dung. The multiplication of *P. excavatus* was the highest on waste paper (3.01) and the lowest on cow dung (1.71). *E. foetida* produced the highest fine grade vermicompost (140 kg) from waste paper and produced 130 kg of fine grade vermicompost from forest liter.

FRUITS

CITRUS

Evaluation nucellar seedling, tissue cultured and grafted plants of *Khasi* mandarin

Tissue cultured and grafted plants of *Khasi* mandarin (rootstocks like *Citrus volkamariana, C. latipes, C. taiwanica, C. jambhiri, Dancy Tanzelo* and *C. reshni*) of 6-7 years old and nucellar seedling of five years old were evaluated for their growth, yield and quality. The maximum plant height (294 cm) was observed in tissue cultured plant followed by grafted plant on *C. reshni* rootstock (278.3 cm). The rootstock and scion diameter (6.65 & 6.21 cm) was found maximum in *C. jambhiri* rootstock and canopy spread (90x86.66 cm) in *C. reshni* rootstock, while maximum fruits/plant (60 Nos.) was recorded in *C. latipes,* and *C. reshni* rootstock and minimum (10 Nos.) in *Dancy Tanzelo* rootstock.

Fruit weight ranged from 46.25 g in *C. jambhiri* to 93.75 g in *Dancy Tanzelo* rootstock. The maximum fruit length (46.68 mm), fruit diameter (52.54 mm), TSS (9.80%) and minimum peel thickness (2.92 mm) and acidity (0.70%) was recorded in *C. volkamariana,*

while least number of seed/fruit (10.75 Nos.) was recorded in tissue cultured plant. However, juice content (42.45%) and acidity (1.74%) were found maximum under *C. reshni* rootstock. The ascorbic acid content (32.14 mg/100 ml) was found highest in *C. latipes* followed by tissue cultured plant (31.98 mg/ 100 ml) and lowest in nucellar seedling (30.12 mg/ 100 ml).

Performance of nucellar, budded and grafted plants of *Khasi* mandarin

Three years old *Khasi* mandarin plants (rootstocks *Citrus volkamariana, C. jambhiri, C. latipes,* Rangpur lime, *Dancy Tanzelo* and *C. grandis*) were evaluated for growth performance. The maximum plant height was recorded on *Rangpur lime* rootstock (216 cm) followed by *C. jambhiri (*207.5 cm) and *Citrus volkamarian* (204.16 cm) and minimum in both *Dancy Tanzelo* and nucellar seedling (150 cm). Rootstock and scion diameter was maximum in *C. volkamariana* (76.35 mm, 48.59 mm) and *C. latipes* (55.19 mm, 47.59 mm) rootstock, respectively and minimum in *Dancy Tanzelo* (29.79 & 21.64 mm) rootstock while canopy spread was maximum in *C. jambhiri* (120.87 cm) rootstock.

Khasi mandarin budded on *C. jambhiri,* rangpur lime and grafted on *C. jambhiri,* rangpur lime, *C. grandis, C. latipes* of two years old were evaluated for growth performance. The grafted plants showed the vigorous growth as compared to budded plants. Maximum plant height (180.33 & 139.16 cm), scion diameter (47.67 & 25.15 mm) and canopy spread (84.16x83.33 & 72.5x59.16 cm) were recorded under grafted and budded plant of *Khasi* mandarin on rangpur lime and *C. jambhiri* rootstock, respectively.

Intercropping with *Khasi* mandarin

Six crops *viz.*,, French bean, cow pea (Kashi Kanchan), groundnut (ICGS-76), soybean (JS 335), rice bean (RCRB-1-6) and urd bean (T-9) were grown during *kharif* season in five years old *Khasi* mandarin orchard. The result showed that the maximum yield was recorded in cow pea (36.55 q/ha) followed by groundnut (29.8 q/ha), French bean (24.44 q/ha), rice bean (5.59 q/ha), soybean (5.5 q/ha) and urd bean (3.65 q/ha).

Effect of mulching on plant growth, weed population and soil moisture status

An experiment on mulching *viz.*,, black polythene, pine tree leaves, farm grass, leaves of rice bean, *Flemingia macrophylla*, *Crotolaria tetragona* and *Tephrosia candida* along with control (without mulch) was conducted on six years old *Khasi* mandarin. The leaves and grass were applied @ 2 kg/m^2 twice in a year i.e. Jul and Nov. Maximum plant height (2.60 m) and canopy spread (97.5 cm) was recorded in *Crotolaria tetragona* mulch. Stem diameter (6.26 cm) and no. of branch/plant (31 Nos.) were highest in Khasi mandarin mulched with *Tephrosia candida* leaves and rice bean mulch, respectively. Flowering was noticed in all the treatments. Minimum weed density was recorded in black polythene mulch (0.133 kg/m^2) followed by pine leaves (0.28 kg/m^2) and maximum in control (0.70 kg/m^2). Whereas, the maximum moisture content was noticed in black polythene mulch (37.85%) followed by *Flemingia macrophylla* (26.94%), *Tephrosia candida* (23.91%) and minimum in control (17.22%) during Jan.

INSECT PESTS

Seasonal incidence studies of citrus trunk borer (*Anoplophora versteegi*) on *Khasi* mandarin

The adult beetles were first noticed on 19th April with an initial population of 0.01 beetles/plant and reached the highest population of 1.6 beetle/plant on 8th May. Thereafter, beetle population declined till the end of July and no beetle population was further observed.

Monitoring of fruit flies

The fruit flies were found as major insect pests of fruits. The fruit fly species, *Bactrocera dorsalis* was recorded on plum (*Prunus domestica*), guava (*Psidium guajava*), peach (*Prunus persica*), black berry (*Prunus nepalensis*) and *Soh phie* (*Myrica esculenta*) whereas, fruit fly species, *B. zonata* was recorded only on peach causing severe damage to the fruits.

DISEASES

Citrus scab (*Elsinoe fawcettii*)

***In vitro* efficacy of native bio-agents and botanicals**

Bio-control agents: Seven native *Trichoderma* spp. were isolated and two *T. harzianum* isolates (PB2 & PB4) tested against eight *E. fawcettii* isolates.

Both isolates (PB2 & PB4) were found effective in inhibiting the growth of mycelium of *E. fawcettii* within 50 hours of incubation. However, the more inhibition was achieved with PB4 isolate (Figs 2&3).

a) **Effect of Tricure (Azadirachtin 0.03%):** Two field application doses viz, full dose (5ml/ L)

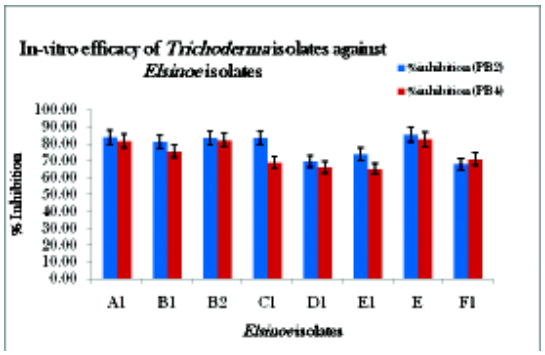


Fig 2 *In-vitro* efficacy of *Trichoderma* isolates against *Elsinoe* isolates

Fig 3 Dual culture of *Trichoderma* isolate (PB-4) against *Elsinoe* isolate (C1)

and half dose (2.5 ml/L) were evaluated in-*vitro* for efficacy against *E. fawcettii* isolates. It was recorded that half dose of Tricure was effective against B1 and H1 isolates, whereas full dose was effective against all the isolates (Fig.4).

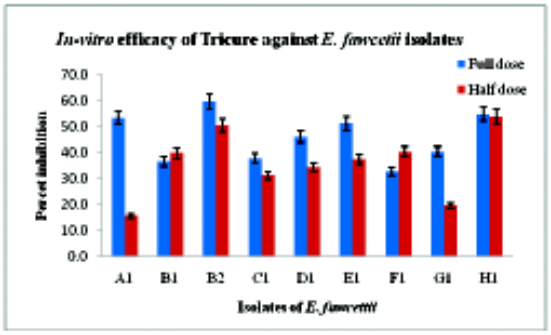


Fig 4 *In-vitro* efficacy of Tricure against *Elsinoe* isolates

b) Field efficacy of fungicides, bio-control agents and botanicals against citrus scab: Field efficacy trial for management of citrus scab using seven treatments (Table1) was conducted. The spraying was done at 15 days interval. Among the treatments, commercial formulation Nisarga (*Trichoderma viride*) @ 5 g/L was found effective followed by Bavistin (Carbendazim) @ 2 g/ L in the first year trial.

Table 1 Field efficacy of fungicides, bio-control agents and botanicals against citrus scab

Treatments	PDI
Nisarga (*T. viride*) @ 5 g/L	15.60
Tricure(Azadirachtin 0.03%) @ 5 ml/L	26.40
Lantana seed extract @ 200g/L	28.00
Bhoomika (*T. viride*) @ 5 g/L	23.53
Bavistin (Carbendazim) @ 2 g/L	19.60
Kavach @ 2.5 g/L	26.00
Control	40.40
CD (*P*=0.05)	2.28

Citrus foot/root rot and gummosis (*Phytophthora* spp.)

a. Survey for collection of isolates and isolation of pathogen (s)

Survey was conducted in citrus orchards of Government and progressive farmers of Meghalaya, Tinsukia district of Assam and Lohit district of Arunachal Pradesh. Infected root, wood and soil samples were collected from root/crown rot and gummosis affected plants. Pathogen (*Phytophthora* spp.) was isolated on Corn meal agar medium amended with antibiotics/fungicides and purified in V8 Juice Agar.

b. Morphological identification of *Phytophthora* spp.

A protocol for sporangial formationof *Phytophthora* spp was standardized. Hyphal swelling and bulging was recorded with distorted shape of sporangia. Different shapes (papillate, non papillate, spherical, pyriform, ovoid, obovoid.) and size of sporangia were observed. Additionally, chlamydospore formation was also recorded. The *Phytophthora* species were morphologically identified with Waterhouse key and Stamp's Key for Phytophthora identification.

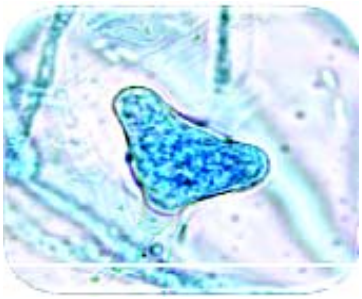


Fig 5 Distorted sporangia of *P. citropthora*, causing foot/ root rot of citrus

c. Molecular identification of *Phytophthora* spp.

Ten isolates from Assam and Arunachal Pradesh were confirmed as *P. parasitica* using species specific ITS1 and ITS4 primers (Fig 6).

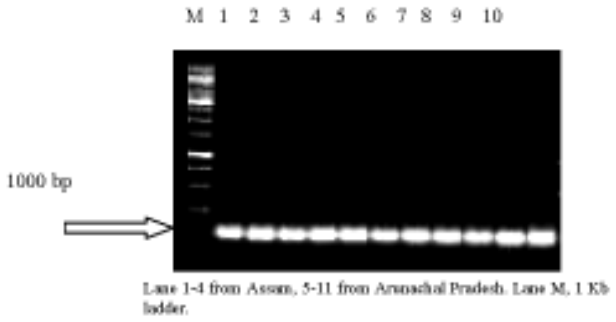


Fig 6 Molecular identification of *Phytophthora* spp. by ITS primers

d) Isolation and bio-efficacy of native bio-control agents for *Phytophthora* spp.

Fungal bio-agents were isolated from healthy citrus rhizosphere soil samples collected from Meghalaya, Assam and Arunachal Pradesh. Based on the morphological characters seven species of *Trichoderma* were identified as *T. viride, T. virens, T. harzianum, T. pseudokoningii, T. crassum, T. longibrachiatum* and *T. reesei*. These species were tested against four representative *Phytophthora* isolates using dual culture technique, effect of volatile compounds and non-volatile compounds.

(i) In dual culture test, *T. harzianum* and *T. longibrachiatum* were found effective against all four isolates of *Phytophthora* spp (Fig 7).

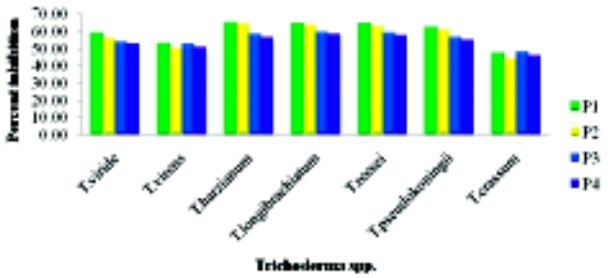


Fig 7 Dual culture of *Trichoderma* spp. and four isolates of *Phytophthora* spp.

(ii) In volatile compound effect experiments, four ways experiments (inoculation of bio-agent and pathogen on '0' day, bio-agents 1, 2 and 3 days ahead to pathogen) were conducted. In all experiments, *T. crassum* followed by *T. longibrachiatum* was found superior over other species against all four isolates of *Phytophthora* spp (Fig 8).

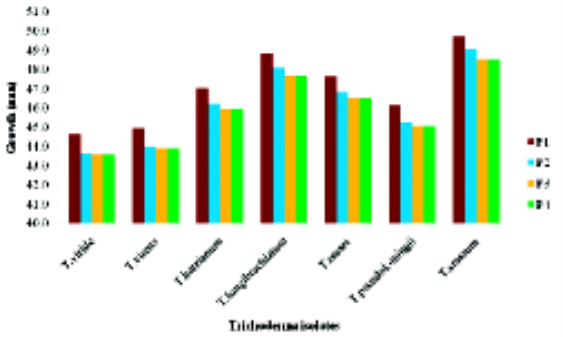


Fig 8 Effect of volatile compounds of *Trichoderma* spp. on four isolates of *Phytophthora* spp.

(iii) In non-volatile compound effect experiment with 10, 20 and 30% culture filtrate, *T. crassum* followed by *T. harzianum* were found superior against all four *Phytophthora* spp. of citrus (Fig 9).

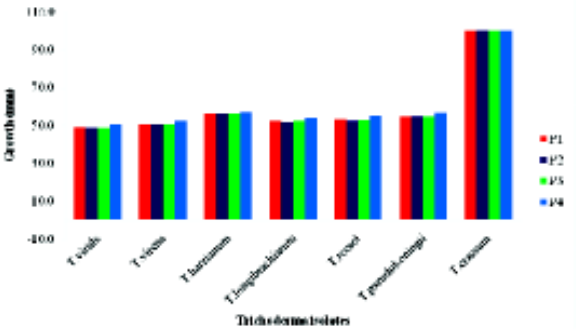


Fig 9 Effect of non-volatile compounds of *Trichoderma* spp. on four isolates of *Phytophthora* spp

GUAVA

Seed protein polymorphism in guava genotypes

The sodium dodecyl sulphate polyacrylamide gel electrophoresis (SDS-PAGE) was carried out to determine the protein profiles/banding patterns of 11 guava genotypes *viz.*, RCG-1, RCG-2, RCG-3, Allahabad Safeda, L-49, Lalit, Sangam, RCG-11, RCGH-1, RCGH-4 and RCGH-7. The electrophoregram (banding patterns) of seed protein presented in Fig 10 showed distinct polymorphism and led to the detection of 23 polypeptide bands.

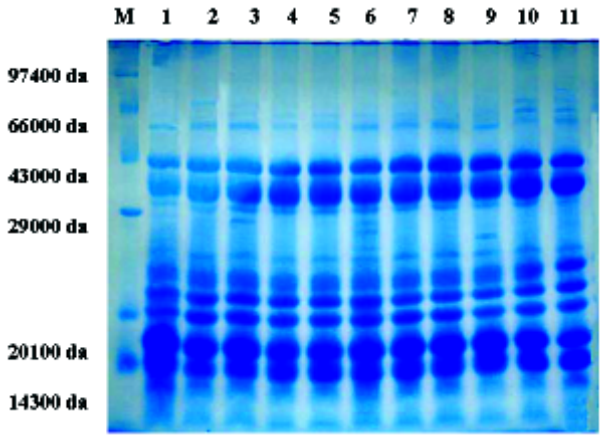


Fig 10 SDS-PAGE of guava genotypes (M -medium range protein marker; 1- RCG-1; 2- RCG-2; 3-RCG-3; 4-RCGH-1; 5- Lalit; 6- Sangam; 7- L-49, 8- Allahabad Safeda; 9- RCGH-4, 10. RCGH-7; RCH-11)

UNDERUTILIZED FRUITS

Variability in different *Sohiong* (*Prunus nepalensis*) genotypes

Sohiong fruit of 10 genotypes were collected from different parts of Meghalaya to study the variability in physico-chemical parameters. Fruit weight, seed weight, pulp and dry matter content ranged from 4.74 to 8.83 g, 1.69 to 3.14 g, 53.53 to 71.89% and 24.68 to 34.07%, respectively. However, TSS, acidity, ascorbic acid, total sugar, anthocyanin content, 'b' carotene and total antioxidants varied from 10.2 to 24.2%, 1.15 to 1.79%, 24.44 to 52.20 mg/100g, 3.64 to 10.0%, 193.38 to 407.73 mg/100g, 0.78 to 1.16% and 7.88 to 12.25 m mol trolox/g, respectively among the genotypes.

Mineral composition of *Sohiong* fruit

Two genotypes (bigger and smaller size) of *Sohiong* fruit were analyzed and results revealed wide variation between both the genotypes. The bigger size fruit recorded the total nitrogen content 70 mg/100g, total phosphorus 115 mg/100 g, total potassium 485 mg/100 g, sulphur 1362.5 mg/100g, iron 9.6 mg/100 g, copper 1.56 mg/100 g, zinc 2.42 mg/100 g and manganese 7.70 mg/100 g. Whereas, smaller fruit size genotypes recorded the total nitrogen content 70 mg/100g, total phosphorus 87.5 mg/100 g, total potassium 530 mg/100 g, sulphur 787.5 mg/100g, iron 2.32 mg/100 g, copper 1.0 mg/100 g, zinc 2.10 mg/100 g and manganese 5.62 mg/100 g.

Performance of grafted and seedling plant of *Sohiong*

One year old grafted plants of *Sohiong* showed the better growth performance with respect to rootstock diameter (18.33 mm), no. of branch/plant (6.5 Nos.) and canopy spread (52.83x50.17 cm), whereas, maximum plant height was recorded in seedling plant (122.4 cm).

Physico-chemical profiling of *Sohshang* fruit

Sohshang (*Elaegnus latifolia*) recorded the fruit weight of 16.38 g, fruit length and diameter 39.23 mm and 25.91 mm, TSS 11.9%, acidity 2.69-2.82%, ascorbic acid 16-19.2 mg/100 ml juice, total sugar 6.06%, 'b' carotene 1.04 mg/100g, anthocyanin 16.21 mg/100g, fibre 5.48%, ash 0.58%, antioxidants 10.06 m mol trolox/g, total nitrogen 1022 mg/100g, total phosphorus 95 mg/100 g, total potassium 487 mg/100 g, total sulphur 712.5 mg/100 g, iron 16.82 mg/100 g, copper 1.90 mg/100 g, zinc 4.90 mg/100 g and manganese 4.50 mg/100 g.

VEGETABLE CROPS

TOMATO

Evaluation of genotypes

Eight genotypes of tomato (determinate) were evaluated for yield and related traits. The highest yield was recorded in the genotype Co-3 (315 q/ha) followed by HADT-294 (310 q/ha) and least yield was recorded in the genotype VR-35 (162.50 q/ha). The highest fruit weight was recorded in the genotype HADT-294 (100 g) followed by CO-3 (96.0 g). However, the TSS (^{0}B) was maximum in the genotype PAU-3271(5.50) followed by ATL-01-19 (5.25). Among the seven (indeterminate) genotypes of tomato, the highest yield was recorded in the genotype VTG-93 (375.00 q/ha) with maximum average fruit weight (120 g) followed by Megha Tomato-1 (343.75 q/ha) (Fig 1) with the average fruit weight of 110 g.

Evaluation of tomato cultivars under medium cost polyhouse

Three cultivars of tomato *viz.*,, Megha Tomato- 1, Megha Tomato- 2 and Megha Tomato -3 were evaluated in medium cost polyhouse (Fig 2). The highest yield per plant (3.5 kg) with highest fruit weight (70 g) was recorded in Megha Tomato -2. However, the maximum numbers of fruits were recorded from the cultivar Megha Tomato- 3.

Fig 1 Megha tomato-1

Fig 2 Tomato cultivation under protected condition

DISEASES

Screening of cultivars/lines against bacterial wilt

Out of six genotypes of tomato (Table 1), the least wilt infestation (8.5%) was recorded in Megha Tomato-1 with a yield of 34.37 t/ha followed by in the genotype US-625 (10.67%) with a yield of 39.15 t/ha. The wilting was highest (65 %) in the genotype Pusa Ruby with an average yield of 18.75 t/ha.

BRINJAL

Evaluation studies (long type)

Fifteen genotypes of brinjal (long type) were evaluated for yield and related traits. The highest yield was recorded in the genotype RCMBL-2 (35.84 t/ha) followed by Arka Nidhi (32.16 t/ha) and Singh Nath (30.56 t/ha). However, least yield was recorded in the genotype Pongal Pink (23.91 t/ha).

DISEASES

Screening of cultivars/lines against bacterial wilt

Among the genotypes (Table 2) the least bacterial wilt incidence (6.75%) with an average yield of 28 t/ha was recorded in Bhola Nath followed by RCMBL-3 (7%) with an average yield of 35.65 t/ha. The wilting (72%) was highest in the genotype PPL with an average yield of 7.50 t/ ha.

Table 1 Performance of tomato genotype against bacterial wilt

Entries	Fruit length (mm)	Fruit breadth (mm)	Average fruit wt (g)	TSS (^{0}B)	Yield (t/ha)	Wilt (%)
US-625	53.10	69.50	108.33	4.55	39.15	10.67
BT-317	42.58	54.47	55.00	4.25	25.62	35.00
BMZ-21	53.69	43.77	47.00	4.75	30.00	23.25
Megha Tomato-1	49.47	54.45	110.00	4.80	34.37	8.50
BT-1(C)	54.84	56.32	95.00	5.00	33.12	13.67
Pusa Ruby (C)	55.00	45.35	45.00	4.60	18.75	65.00

Table 2 Performance of brinjal genotypes against bacterial wilt

Entries	Plant height (cm)	Fruit length (cm)	Average fruit wt (g)	Yield (t/ha)	Wilt (%)
RCMBL-3	68	14.00	120	35.66	7.00
BB-54	65	10.25	105	30.94	10.00
Singh Nath	72	22.00	145	30.56	8.00
Bhola Nath	66	12.75	115	28.00	6.75
Utsav	75	14.33	110	31.44	10.50
SM-6-6 (C)	57	10.45	85	25.16	12.25
Arka Nidhi (C)	64	15.71	88	32.16	9.20
PPL (SC)	55	12.55	110	7.50	72.00

CHILLI

Evaluation under low cost polyhouse

Four collections of King chilli (*Capsicum chinense*) were evaluated for the different characteristics (Fig 3). The average fruit weight and length varied from 1.25-3.8 g and 3.5-7.5 cm, respectively. The maximum fruit weight was recorded from RCKC-1(3.40 g). The plant height varied from 85-150 cm. The fruit yield per plant ranged from 650-1250 g.

Fig 3 Diversity in King Chilli collections

A molecular diversity analysis was carried out with 38 chilli accessions. Thirty five accessions were King chillies collected from Assam, Arunachal Pradesh, Nagaland and Manipur, and one accession each of *Capsicum annum* (g7), *C. fruitescence* (g25) and *C. baccatum* (g23). Twenty IISR markers were used for analysis of diversity. Based on amplification pattern, similarity values were calculated, genotypes were grouped using cluster analysis and the results are presented below as a dendogram (Fig 4). Average similarity ranged from 65 – 94%. Two major groups were identified. One group included 16 King chilli genotypes along with *C. annum* and *C. fruitescence*. The other group included 18 King chilli genotypes and *C. baccatum*. The distances of *Capsicum annum*, *C. fruitescence* and *C. baccatum* from King chilli was almost similar.

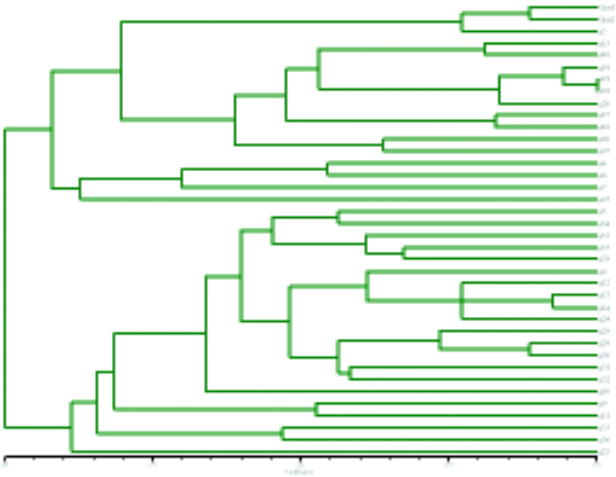


Fig 4 Dendogram showing similarity coefficients (J) and clustering (SHAN) pattern of King chilli genotypes and three species of chilli

FRENCH BEAN

Evaluation studies (bush type)

Twelve genotypes of French bean (bush type) were evaluated during 2010 (rainy season). The highest yield was recorded from the genotype Arka Suvidha (10.25 t/ha) followed by Contender (9.75 t/ha) and FBBVAR-2 (9.7 t/ha), however, least yield was obtained in the genotype FBBVAR-4 (6.25 t/ha). The maximum pod length was recorded in Arka Anoop (15.7 cm) followed by FBBVAR-4 (15.4 cm).

ASH GOURD

Evaluation of genotypes

Five entries of ash gourd were evaluated for yield and related traits. The highest yield (41.0 t/ha) was recorded in the genotype RCAG-15 (Fig 5) followed by RCAG-28 (36.8 t/ha). However, least yield was redorded in the genotype KAG-1 (28.2 t/ha). The average fruit weight was recorded maximum in the RCAG-28 (4.7 kg) followed by RCAG-15 (3.60 kg)

Fig 5 RCAG-15

CARROT

Evaluation of carrot genotypes

Out of six genotypes, highest yield was recorded in the New Kuroda (16.94 t/ha) followed by Nantes (15.0 t/ha), whereas least yield was obtained in the genotype No-286 (10.56 q/ha). The root length was also maximum in the genotype New Kuroda.

ONION

Varietal performance

Four genotypes of *kharif* season onion (Source: Directorate of Onion and Garlic Research, Rajgurunagar) were evaluated. The seeds were sown on 15th June and seedlings were transplanted during 1st week of August. The highest yield was recorded in cultivar Bhima Super (33.50 t/ha) followed by Bhima Raj (31.75 t/ha). However, the average bulb weight was highest in the cultivar Bhima Raj (61g) followed by Bhima Red (54.4 g).

OKRA

Multilocation trial

Under MLT of okra germplasm (NBPGR New Delhi), 135 genotypes were evaluated during the *kharif* season. The highest average yield per plant was recorded from the genotype IC-117140 (633.87 g) followed by IC- 013664 (557.30 g) and VRO-6 (479.35 g).

CABBAGE

Evaluation studies

Eight hybrids of cabbage were evaluated for different traits. The highest yield (80.64 t/ha) was recorded in the cabbage Hybrid-4 with maximum harvest index (0.80) followed by check Hybrid-139 (70.30 t/ha). The lowest yield was recorded in the genotype Kranti (23.8 t/ha). The earliest maturity was seen in check Hybrid-139 (66.67 days). The head compactness was highest in the hybrid Kranti (77) followed by cabbage Hybrid-4 (75.64).

INSET PESTS

Bio-intensive management of cabbage butterfly

Eco-friendly pesticides were evaluated against cabbage butterfly (*Pieris brassicae*) under field conditions, spinosad @ 0.01% was found to be very effective followed by Lipel 8 SP @ 2g/L, *B. bassiana* ($1x10^9$ cfu/ml) @ 6 ml/l and NSKE 5%. The reduction in damage by spinosad, Lipel (*Bt* var. *kurstaki*), *B. bassiana* ($1x10^9$ cfu/ml) and NSKE 5% were 60.82%, 50.16%, 41.82% and 40.38%, respectively as compared to control.

TUBER CROPS

Evaluation of sweet potato

Twenty three sweet potato genotypes were evaluated for yield and other characters. The highest tuber yield of (29.41 t/ha) was recorded in the genotype S-107. The maximum tuber length (24.90 cm) was recorded in Meghalaya Local, whereas, tuber diameter was highest (9.98 cm) in the variety Pol 21 – 1.

Under MLT, out of six genotypes (Table 1), the highest yield was recorded from Kokrajhar Local (29.41 t/ha) followed by S 107 (28.23 t/ha). However, the dry matter percentage was highest in the genotype Sree Bhadra (30.33%) followed by S 107 (28.67%) with least weevil damage (10%).

Table 1 Performance of sweet potato genotypes under multi location trials

Varieties	Tuber yield (t/ha)	Dry matter (%)	Weevil damage (%)	Harvest index (%)
S-107	28.23	28.67	10.00	40.33
Kokrajhar local	29.41	26.00	12.67	40.33
Kokrajhar red	25.55	27.00	14.00	46.67
Sree Bhadra	26.90	30.33	11.33	52.33
Meghalaya local	21.02	24.67	12.33	48.33
S.E. (m)	2.00	0.81	0.83	1.26
CD (*P*=0.05)	6.22	1.87	1.91	2.91

Evaluation of colocasia genotypes

Forty genotypes of colocasia were evaluated for their yield and yield attributing characters. Plant height was highest in IG Coll-5 (76.33 cm). The maximum number of side shoots per plant (8.50) was found in ARCol-8. The variety Nainital recorded the highest number of cormels/plant (30.33) followed by BCC-2 (26.00). The variety BCC-1(A) exhibited the lowest number of cormels/plant (3.67). The highest cormel yield (15.38 t/ha) and total yield (26.01 t/ha) was recorded in the variety White Gauriya.

Standardization of storage techniques for taro seed tuber

This experiment was conducted with the genotype ML-1 during 2010 and minimum sprouting % was recorded in the treatment T_4 (cormels treated with carbendazim (0.05 %) and stored in pacca floor) which varied from 27.33% in 30 days to 52.67% in 120 days after storage followed by T_5 (cormels treated with *Trichoderma viride* (0.05 %) and stored in *pacca* floor). Similarly, minimum rotting percentage and minimum reduction in starch content was recorded in the treatment T_4 followed by T_5. However, maximum shelf life (192.66 days) was observed in the treatment T_7 (cormels treated with carbendazim (0.05 %) and stored in pits followed by T_4 (183 days) and T_5 (181 days).

Similarly, the weight losses of cormels were least in (T_7).

DISEASES

Study on severity of leaf blight in colocasia

Out of six colocasia (taro) genotypes (Table 2), the highest yield was recorded from ML-1(22.13 t/ha) followed by ML-9 (19.13 t/ha) with least incidence of leaf blight 20.17% and 20.83%, respectively. However, the disease severity was highest in the genotype Megha-1 throughout the growing season.

Table 2 Severity of leaf blight in colocasia

Varieties	Yield (t/ha)	Leaf blight (%)	Disease severity index		
			2 (60 DAP)*	4 (120 DAP)	6 (180 DAP)
ML-1	22.13	20.17	14.58	22.92	35.42
ML-2	18.68	22.92	12.50	18.75	27.08
ML-9	19.13	20.83	10.42	18.75	29.17
Megha-1	17.51	45.83	20.83	33.33	50.00
BCC-1	12.51	31.25	14.58	25.00	39.58
Meghalaya local	17.00	22.92	12.50	18.75	27.08
S.E. (m)	1.28	2.90	3.18	1.86	2.46
CD (*P*=0.05)	2.85	6.46	7.09	4.14	5.48

* DAP: Days after planting

SPICES

TURMERIC

Genetic diversity studies using PCR-Based markers

A set of 72 genotypes comprising varieties and local cultivars from North East India were analyzed using random amplified polymorphic DNA (RAPD) markers. Polymerase chain reactions were carried out using forty operon 10 bp random primers. Of the 40 primers tested, 26 showed reproducible polymorphic bands. The 26 decamer primers amplified 326 distinct fragments and the number of fragments per primer ranged from 1-33 in the size range of 0.2-3.5 Kb (Fig 1). Specific polymorphic bands were identified and the gel eluted DNA extracts were sent for sequencing. Sequences will be further developed into SCAR markers.

Evaluation of turmeric genotypes for growth and quality traits

In order to study the interaction of genotype and environment (GxE) on growth and quality characters,

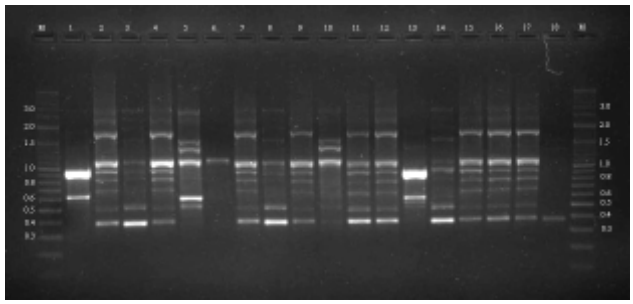


Fig 1 RAPD profile of turmeric genotypes with OPN 02 primer

10 different varieties/genotypes of turmeric (*Curcuma longa*) were evaluated. Roma produced the heaviest rhizomes per plant (750.0 g /plant). Dry matter recovery was the highest in Rashmi (23.79%) followed by Kedaram (22.67%) and Allepy Supreme (22.33%) while lowest recovery (14.33%) was in Rajendra Sonia. Highest curcumin content was recorded in Megha Turmeric-1 (7.70%) followed by Pratibha (6.99%) and Roma (6.94%) while BSR-2 had lowest curcumin (3.80%).

DISEASES

Screening against *Taphrina* leaf blotch

Forty-five diverse genotypes of turmeric were evaluated against *Taphrina* leaf blotch (Fig 2). Genotypes Lakadong, Dehradun local, Kuchipudi, VK-17, Duggirila Red, Madhukar, Manipuri No-1, Pratibha, Kedaram, MLT 57 and SKM 61 were found to be resistant.

Fig 2 Screening of turmeric genotypes against *Taphrina* leaf blotch

Eco-friendly management of turmeric diseases

RCHE221 (a product developed by Agronomy Division of ICAR-RC-NEH), *Trichoderma viride*, Panchagavya and Mancozeb 63% + carbendazim 12% were evaluated against foliar diseases of Turmeric.

Only Mancozeb 63% + carbendazim 12% @ 4 g/L was effective in managing the *Taphrina* leaf spot disease but yield differences were non significant when compared to untreated check (Table1).

Table 1 Management of *Taphrina maculans* leaf spot disease of turmeric

Treatment	PDI (arc sine values)	Yield of fresh rhizome (t/ha)
RCHE221 @ 2ml/L	53.70	15.2
Trichoderma viride @ 5g/L	63.50	15.8
Panchagavya @ 30mL/L	54.50	15.0
Mancozeb 63% + carbendazim12% @ 4g/L	47.10	17.9
Untreated check	66.30	16.3
CD (*P*= 0.05)	12.04	NS
CV (%)	13.70	16.4

GINGER

Study on genotype x environment interaction on quality

Ten ginger (*Zingiber officinale*) genotypes were evaluated. All the genotypes were affected by soft rot. Among the genotypes, highest plant height was found in Himgiri (62.30 cm) followed by Nadia (56.50 cm). The yield per plant was highest in Suprabha (255.0 g) followed by Mahima (225.0g) with lowest crude fibre content (2.93%). Highest dry matter recovery was recorded in genotype V_3S_1-8 (25.20%) followed by *Khasi* Local (22.54%) and Suruchi (21.96%). The crude fiber content was highest in the genotype Himgiri (5.0%) followed by Suruchi (4.25%).

Cataloguing of ginger and turmeric collections

IC number (IC-584322 to IC-584364) for 43 ginger germplasm collections (MLG-1 to 43) has been received from the NBPGR, New Delhi. The passport data of 32 genotypes of turmeric along with planting materials has been submitted to the NBPGR Regional Station, Umiam for granting of IC number. All the collected genotypes are maintained at experimental farm, Division of Horticulture, ICAR (RC) for NEH Region, Umiam.

DISEASES

Eco-friendly management of ginger diseases

Two ecofriendly methods along with a fungicide check were evaluated. *Trichoderma* based formulations *viz.*, Trichostar and copper oxychloride were used for rhizomes treatment and Panchgavya was used as soil drench after germination. Total three sprays were at an interval of approximately one month. There was no difference in yield and given diseases a severity of *Phyllosticta* and *Cercoseptoria* leaf spots when compared to untreated check.

Soft rot of ginger - survey and surveillance

Various districts of Meghalaya, Mizoram, Sikkim, Arunachal Pradesh and Manipur were surveyed. The pathogen (*Pythium myriotylum*) was isolated on *Pythium* specific media.

***a) In–vitro* testing of fungal antagonists:** Among the seven native *Trichoderma* spp. tested in dual culture against *Pythium* isolate (114), *T. harzianum, T. viride, T. atroviride* and *T.virens* were found effective after 4 days of inoculation.

b) Management of soft rot of ginger: Two sets of trials (containing a variety of treatment combinations) were conducted at two sites (one at the general field and the other at the soil science section) at Umiam to evaluate field efficacy of different treatments against soft rot of ginger.

i) At soil science, the highest germination (95.83%) was achieved in plots having ginger treated with hot water at 49^{0}C for 20 minutes (Table 1). The lowest per cent infection, highest yield and minimum yield loss was recorded in the plot treated with Poultry Manure (PM) @ 2.5 t/h + Mulching (*Ambrosia* spp.) + Ridomil MZ-72 @ 2 g/L.

ii) At the general field**,** the highest germination (84.62%) was achieved in Bhoomika (*T. viride*) @ 5 g/L treated plots. The lowest infection and minimum yield loss was recorded in treatment of ginger treated with hot water at 49^{o}C for 20 minutes. However, the plots having ginger treated with Ridomil gold @ 2.5 g/L yielded maximum yield (Table 2).

Bacterial wilt (*Ralstonia solanacearum*) of solanaceous crops and ginger

Survey for collection of samples and isolation of pathogen: Survey was conducted and 195 farmers were interacted. The villages were selected based on random sampling technique. Samples were collected for isolation of pathogen and their control by bio-control agents (BCAs). The pathogen (*Ralstonia solanacearum*) causing wilt disease of solanaceous crops and ginger was isolated. BCAs, *Bacillus subtilis*

Table 1 Field efficacy of combination of nutrients, mulching and fungicides, bio-control agents & botanicals against soft rot of ginger at soil science field

Treatments	Germination (%)	Infection (%)	Total yield (t/ha)	Yield loss (%)
Hot water	95.83	40.07	4.24	27.57
FYM +Indofil M-45	83.33	66.64	4.41	37.97
PM+Sanit	86.67	42.31	3.50	39.71
NPK+ FYM+ Bavistin	74.17	57.40	2.90	36.22
NPK+ PM+ Ridomil MZ-72	88.33	47.19	3.84	36.96
FYM+ Lime + Bhoomika	75.83	40.34	3.19	34.10
PM+Lime +Bhoomika	76.67	60.66	2.95	37.91
NPK+Lime +Agnee Plus	83.33	64.24	4.93	33.13
NPK + Mulching+Ridomil MZ-72	87.50	48.43	2.77	36.75
NPK + Mulching+Lime+ Bavistin	88.33	44.47	5.99	32.42
NPK + Mulching+ Indofil M-45	75.00	45.03	2.95	39.51
PM+Mulching+Ridomil MZ-72	94.17	39.88	6.75	27.07
Control	55.83	70.19	2.47	60.34
SE (d)	2.35	4.22	1.16	6.09
CD (*P*=0.05)	5.11	9.20	2.53	13.27

Table 2 Field efficacy of combination of nutrients, mulching and fungicides, bio-control agents and botanicals against soft rot of ginger

Treatments	Germination (%)	Infection (%)	Total yield (t/ha)	Yield loss (%)
Indofil M-45	68.38	71.46	2.68	36.60
Sanit	66.67	82.04	2.51	46.34
Bavistin	70.09	73.45	2.56	42.75
Ridomil MZ 72	69.23	78.67	3.70	40.91
Agnee	70.94	78.40	2.72	42.16
Ridomil gold	78.63	62.24	5.52	26.34
Bhoomika	84.62	54.85	3.64	20.73
Agnee plus	81.20	58.98	4.49	13.79
Hot water	61.54	46.15	3.09	10.27
Control	82.05	67.72	1.64	68.45
SE (d)	5.85	5.53	0.32	3.60
CD(*P*=0.05)	13.24	12.50	0.73	8.15

and *Pseudomonas fluorescens* were isolated from collected soil samples.

Identification of *R. solanacearum* by PCR based molecular tools: *R. solanacearum* was identified using specific 16SRNA OLI1 and Y2 primers. The amplification of *R. solanacearum* was noted at 288 bp (Fig 3).

Biovar test of collected *R. solanacearum* isolates: Forty-three representative isolates (12 from tomato, 7 from brinjal, 3 from capsicum, 6 from chilli and 15 from ginger) were subjected to Biovar test and grouped under Biovar-3, which indicated that *Ralstonia* from NEH states fall under Biovar-3 category (Fig 4).

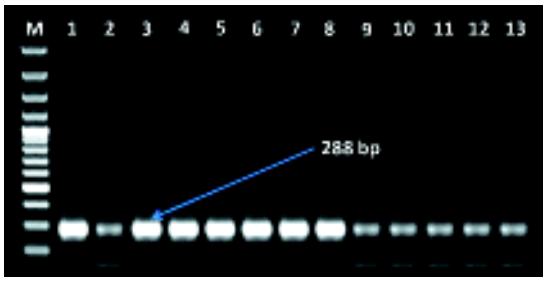


Fig 3 Identification of *R. solanacearum* by 16S RNA primers Lane 1-13 representative samples from Meghalaya, Manipur and Sikkim; Lane M -100 bp ladder

Isolation of bio-agent (s) for *R. solanacearum:* Rhizosphere soil samples of healthy tomato, maize, soybean, rice, groundnut, brinjal, cucumber, pumpkin,

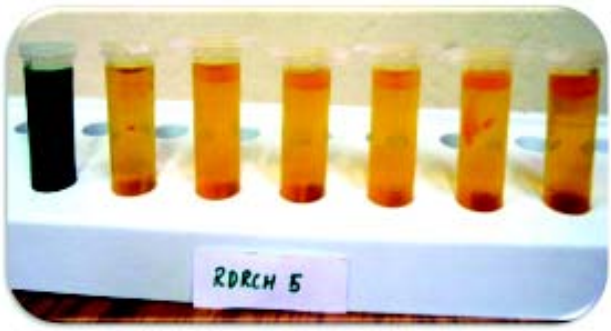


Fig 4 Biovar test of *Ralstonia* isolate RDRC-5

banana, chilli, pepper, and colocasia as well as fern plants along with the uprooted plants were collected from fields subject to various cultural practices, across Meghalaya, Assam and Arunachal Pradesh. The *Pseudomonas fluorescens* was isolated on KMB and *Bacillus subtilis* on LB medium.

In- vitro* bio-efficacy of bio-agents against *R. solanacearum: The *in-vitro* bio-efficacy test of bio-agents was tested following agar diffusion method and paper disc method. *P. fluorescens* isolates 404, was found producing clear zone of inhibition against *R. solanacearum* (Fig 5) followed by 403 and 408. Similarly *Bacillus subtilis* isolates 507, was found producing clear zone of inhibition against *R. solanacearum* followed by 516 and 518.

Fig 5 Inhibition of *Ralstonia* isolate by *P. fluorescens* isolate 404

Management of bacterial wilt of ginger, tomato and capsicum: Three field trials were conducted for the management of bacterial wilt of ginger, tomato and capsicum.

i) In ginger, the highest germination (82.14%) was achieved with treatment Agnee @ 5g/L, Lantana seed extract @ 40 ml/l, Streptomycin @ 0.2 g/L and Agnee plus @ 5 g/L (Table 3).

Table 3 Efficacy of antibiotics, bio-control agents and botanicals against bacterial wilt of ginger

Treatments	Germination (%)	Infection (%)	Yield (t/ha)	Yield loss (%)
Agnee	82.14	29.02	16.36	29.06
Lantana seed extract	82.14	33.44	14.15	34.94
Hot water	77.38	29.33	12.97	37.21
ATW	80.95	24.97	12.67	33.10
Streptomycin	82.14	31.94	12.88	34.22
Agnee plus	82.14	29.02	14.17	40.08
ATWC	77.38	32.40	14.67	39.43
Control	54.76	58.47	9.33	62.54
CD (*P*=0.05)	3.47	1.91	0.53	1.31

The lowest per cent infection of disease was recorded in ATW (1:3:5) followed by Agnee @ 5g/L which was at par with Agnee Plus @ 5g/L followed by hot water (49°C for 20 minutes). The maximum yield was recorded with treatment ATWC, whereas minimum yield loss was recorded with Agnee @ 5g/L.

ii) In the tomato var.Pusa Ruby (Fig 6), HEYC (1.2:4.0:8.0:8.0) was most promising followed by HEY (1.2:4.0:8.0) and Lantana seed extract (25 g/L of water).

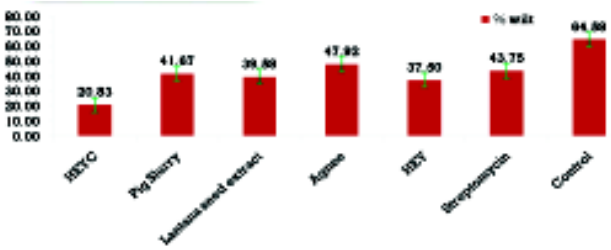


Fig 6 Field efficacy control agents against bacterial wilt of tomato

iii) In the capsicum var. Thai Wonder, pig slurry @1.5kg/15 L of water was found better, followed by HEYC (1.2: 4.0: 8.0: 8.0) at par with Lantana seed extract (25g/L of water).

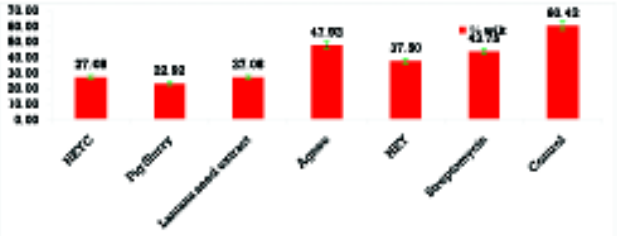


Fig 7 Field efficacy of control agents against bacterial wilt of capsicum

Screening of tomato genotypes against bacterial wilt

Altogether, 13 genotypes were screened against bacterial wilt under inoculated sick plot conditions. The observations reveald that the incubation period in resistant genotypes ranged from 46.67 to 30.33 days, in moderately resistant 16.33 to 12.83, in moderately susceptible 14.00 and in susceptible 9.33 days (Fig 8). 'Pusa ruby' recorded maximum (75%) disease incidence (DI) and lowest yield (18.40 t/ha). The minimum (6.94%) DI with maximum (58.01 t/ha) yield was recorded with Meghalaya Tomato-1.

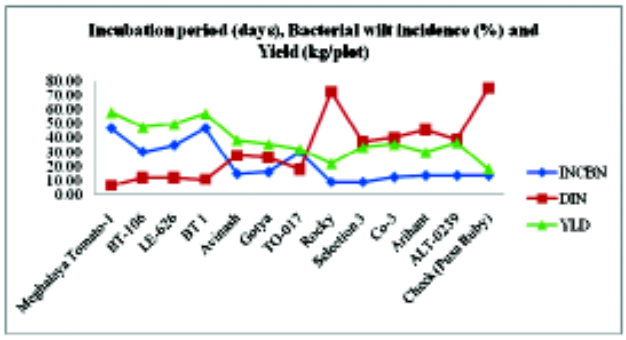


Fig 8 Screening of tomato genotypes against bacterial wilt of tomato

Areca nut bud rot (*Phytophthora* spp)

The pathogen (*Phytophthora spp*) was isolated from bud rot samples collected from various districts of Meghalaya.

***In-vitro* bio-efficacy of native *Trichoderma* spp. against *Phytophthora* spp**

Six isolates of *Trichoderma* spp. were isolated from different Arecanut habitats and tested in dual culture. Of these *T. viride* isolated from phylloplane area of arecanut was found effective in inhibiting (92.1%) mycelial growth of pathogen followed by *T.harzianum* (Fig 9).

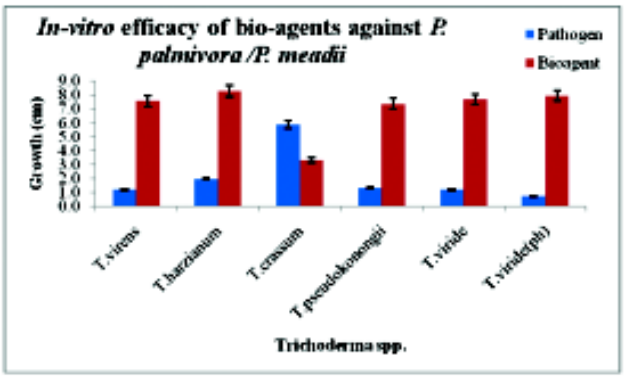


Fig 9 *In-vitro* efficacy of bio-control agents against *P. palmivora/P. meadii*

FLORICULTURE

GERBERA

Evaluation under low- cost polyhouse

Fourteen varieties of gerbera hybrids were planted in the bamboo made low-cost polyhouse during 1st week of Nov, 2010. Out of these, 8 varieties *viz.*,, Dubai, P. Intezz, Ice Queen, Rich, Torbin, Jaffana, Lion and Rising Sun started flowering. The earliest flowering (126 days) after planting was noticed in Ice Queen. The maximum no. of leaves/plant (12.4) and stalk length (45.4 cm) was recorded in Dubai hybrid while stalk dia.(8.03 mm), plant spread (43.2 cm^2) and flower diameter (8.51 cm) was found maximum in Rising Sun, Cantida and P. Intezz hybrid, respectively at 130 days after planting.

ORCHIDS

Effect of TDZ on bud/PLB induction from pseudo-stem segments of *Cymbidium giganteum*, a rare orchid species

The potential of TDZ (thidiazuron; n-phenyl-N 1, 2, 3-thidiazol-5-ylurea), a potent cytokinin in *in vitro* propagation of a rare orchid species *C.giganteum* was explored. The seed derived pseudo-stem segments were cultured in ½ MS solid and dual phase media (solid + liquid) supplemented with different strengths of TDZ (0.2-4.4 mg/L). Irrespective of culture conditions, maximum number of shoot buds/Protocom like bodies (PLBs) was recorded at 4.4 mg/L, but the differentiation rate from bud/PLB to shoot stage was very poor. At lower concentration (0.2 mg/L), though the frequency of shoot bud/PLB proliferation rate was comparatively less, subsequent shoot regeneration was high. At this concentration, irrespective of culture conditions, maximum number of buds differentiated to shoots and developed into healthy plantlets.

Influence of different explant sources and cytokinins on *in vitro* induction of PLBs and plantlet development of *Cymbidium mastersii*

Successful initiation of protocorm like bodies (PLB) and *in vitro* plantlet regeneration was achieved using various explant sources *viz.*,, whole protocorm, protocorm longitudinal sections and protocorm transverse sections and cytokinin types (BAP, IP and TDZ) of various concentrations that supplemented half MS basal medium with 1.5 mg/L activated charcoal. The highest percentage of PLB proliferation was found when whole protocorm was taken as explant irrespective of plant growth regulators. Maximum number of PLBs (30.16) was recorded on TDZ (4 mg/L) supplemented basal medium using transverse sections of protocorms. However, the quality of regenerants in terms of growth and shoot differentiation was much more superior to TDZ when cultured with IP (0.5 mg/L) which recorded 27.66 numbers of PLBs. The regenerated PLBs were sub-cultured on half MS plain medium with tryptone to evaluate the residual

effect of these cytokinins with respective concentrations. It was found that the PLBs continued to proliferate and simultaneously some of them differentiated to shoots upto four subcultures (8 weeks/ subculture).

POST HARVEST TECHNOLOGY

Shelf life extension of peach varieties by $KMnO_4$

Three varieties of peach *viz.*, Floradasan, TA 170 and Shan-e-Punjab were harvested at optimum maturity stage and the best quality ones sorted out. Pouches of 1% and 2 % $KMnO_4$ were prepared wherein 5 g of silica was added. About 500 g of each variety of peach was weighed and put in non-perforated polypropylene (200 gauge) packets. To six packets of each variety, $KMnO_4$ pouches of a particular concentration was added and sealed. Then, they were placed at room temperature storage (Temp: 18°C, RH: 80%) and refrigerated storage (Temp: 4.0°C, RH: 50%). On the basis of the visual and textural quality, best result was given by peach cv. TA-170 which showed a shelf life of 40 days in refrigerated condition, packed in non perforated polypropylene (200 gauges) packets with 2% $KMnO_4$ pouches. It retained highest beta carotene (1.82 mg/100 g) as compared to other $KMnO_4$ treated peach varieties, at the end of 40 days of storage. However 2% $KMnO_4$ treated cv. Shan-e Punjab peach showed a lesser percentage of PLW compared to cv. TA 170 and its visual and textural quality was also within marketable acceptability, at the end of 40 days of storage.

Shelf life extension of packaged strawberry by $KMnO_4$

Packed strawberry (var. Festival) boxes were purchased from the market and the best ones selected. Each box contained 250 g of the sample. 1% and 2% $KMnO_4$ pouches were prepared to which 5 g of silica was added. To each of the boxes, $KMnO_4$ pouch of a particular concentration was added. Half of the whole lot was then packed in 200 gauge polypropylene (PP) packets. In another case, strawberries were directly put into polypropylene (200 gauge) packets and sealed after adding $KMnO_4$ pouches of particular concentrations. Then, they were kept both at room temperature storage (Temp: 18°C, RH: 80%) and refrigerated storage (Temp: 4.0°C, RH: 50%). On the basis of the visual and textural quality the best result was given by the strawberry boxes containing 2% $KMnO_4$ pouches packed in PP packets. It showed a shelf life of 30 days in refrigerated condition, against 5 days at room temperature storage. PLW % was minimum (5.02%) compared to the other treatments. Its visual and textural quality was also within marketable acceptability. However, in chemical study, it was observed that strawberry boxes with 2% $KMnO_4$, kept at refrigerated condition showed better result since it retained ascorbic acid of 98.5 mg/100 g and high anthocyanin content (29 mg/100 g) at the end of 30 days of storage. But, it scored less in textural and visual quality, compared to the boxes packed in PP. For the rest of the observed chemical parameters, a uniform trend of change during the 30 days storage period was not found.

Minimal processing of capsicum

Capsicum cv. California wonder after harvest were washed and cut into four pieces and subjected to chemical blanching by dipping for 5 minutes in either of the four types of chemical solutions *viz.*, potassium metabisulphite (KMS) 0.4%, KMS (0.5%), sodium benzoate (0.6%) + KMS (0.3%) and ascorbic acid (1.5%). Each kind of chemically blanched capsicum pieces were then packed in polypropylene (200 gauge) packets, perforated with 4 pin holes. The sealed packets were put in at room temperature storage (Temp: 25°C, RH: 85%) as well as refrigerated storage (Temp: 4.0°C, RH: 40%) and the shelf life was determined. On the basis of the visual and textural quality, it was found that the packed capsicum, treated with ascorbic acid (1.5%) showed the best result. It could be stored for a period of 20 days in refrigerated condition and 5 days in room temperature storage.

Extension of shelf life of guava

Guava (Cv. RCGH 7) was harvested at optimum maturity stage and stored in refrigerated as well as room condition. About 500 gm of Guava (3-4 Nos) was weighed and put in polypropylene (200 gauge) packets having 4 pin holes perforation. To each packet $KMnO_4$ pouches of 1-2 % concentration was added, sealed and kept in room temperature storage (Temp: 15°C, RH: 75%) and refrigerated storage (Temp: 8.0°C, RH: 60%). On the basis of the visual and textural quality it was found that the fruit, packed in perforated polypropylene (200 gauge) packets with 2% $KMnO_4$ pouches recorded a shelf life of 50 days in refrigerated condition and 25 days in room temperature storage.

Standardization of protocols for preparation of guava leather

Dropped guava fruits were collected and washed properly with sanitized water. The fruits were blanched for 10-15 minutes and pulped in a mixer. On the basis of the TSS (%) of the pulp, sugar was added at calculated amounts to the pulp, to maintain final TSS concentration of 12%, 15% and 20%. Each kind of sugared pulp was spread into PP sheets on the aluminum trays (4-5 mm thickness) and dried at a temperature of 55-60°C for 12-15 hours. The guava leather formed, on drying, was gradually peeled out from PP sheets on the aluminum trays. These leathers were made into small pieces and sealed in polypropylene packets. On sensory evaluation of the three kinds of guava leather (12%, 15% and 20% TSS) at a 9 point Hedonic scale, it was found that leather of 20% TSS concentration was the most appealing to the panel members in terms of its taste, colour, flavor and overall acceptability. This product packed into PP packets (Fig 1) may be stored for more than six months at room temperature.

Fig 1 Guava leather

Post harvest technology and value addition of *Sohiong*

Value added products like RTS beverages, squash, jam and wine were prepared from the fruits. For preparation of RTS, 10% fruit juice was adjusted to 10°B, 12°B and 15°B. On the basis of organoleptic test done by ten panel members on 9 point Hedonic scale, it was found that RTS with TSS level 15°B was the most appealing. Similarly, *Sohiong* squash prepared by adjusting TSS of 25% fruit juice to 40°B, 45°B and 50°B. Squash of TSS value 45°B when diluted 3 times with water, was found to be the most preferred one amongst the panel members. In case of *Sohiong* jam preparation, 45% of fruit pulp was adjusted to 68°B, 70°B and & 72°B. After sensory evaluation, it was observed that Sohiong Jam having 68°B TSS was most acceptable.

For preparation of *Sohiong* wine, 24 hr old yeast culture (*Saccharomyces cerevisiae)* was added to 50%, 75% and 100% diluted *Sohiong* juice. In each case, TSS was adjusted to 20°B. Fermentation was carried out for 10-12 days. The wine thus obtained was filtered, bottled, sealed and sterilized. On the basis of sensory evaluation, it was found that wine obtained from the 50% diluted juice was most appealing in terms of taste and colour.

Development of different packaging design for long distance transport of ginger

Five different capacity CFB boxes *viz.*, 5 kg, 10 kg, and 20 kg with tray packing (3 ply) and 20 kg with Honey comb packing (3 ply) and two types of standard plastic crates of capacity 10 kg and 15 kg were used for transportation study (Table 1). Fresh gingers were packed in the packaging materials and transportation study (1000 km distance in the Meghalaya) was carried out to evaluate the best packaging design for quality retention with minimum loss. Out of all packaging

Table 1 Dfferent packaging design for long distance transportation of ginger

Capacity (kg)	Packaging materials	No. of 25 mm holes	External dimension (mm)	Internal dimension (mm)	Remarks
5	CFB, 5 ply without tray	2	365x255x155	360x250x150	Maximum 6 % PLW but no breakage was recorded
10	CFB, 5 ply with 2 tray	4	525x370x 160	520x365x 155	Less than 2 % breakage & 3 % PLW was noticed
15	CFB, 5 ply with 3 tray	6	780x 370x 160	775x 365x 155	Less than 6.5% breakage & 5% PLW was noticed
20	CFB, 5 ply with 4 tray	8	530x380x 325	525x 370x 320	Less than 5% breakage & 5% PLW was noticed
20	CFB, 5 ply with Honey comb	8	525x370x 320	520x 365x 315	Less than 5% breakage & 10% PLW was noticed
15	Plastic Crates	Perforated	580x380x 230	560x360x 220	No breakage and 5% PLW was recorded
20	Plastic Crates	Perforated	530x360x 300	500x330x 280	No breakage loss was noticed but 8% PLW was recorded
Control	Gunny bag	20	600x400	-	Maximum 10% PLW with 15% breakage was recorded

materials tested, the minimum loss (3% PLW) was recorded in 10 kg capacity CFB box without tray followed by 15 kg capacity plastic crates.

Changes in post-harvest phytochemical qualities of broccoli florets

The effect of ambient and refrigerated storage temperature on post-harvest phytochemical qualities of broccoli floret was investigated during storage. Fresh broccoli florets were packed in polypropylene (PP) micro-perforated film bags and stored, under open ambient storage conditions (15 ± 1 ^{0}C, 55 ± 2% RH), and laboratory refrigerated storage (4 ± 0.5 ^{0}C, 50 ± 2% RH) for a total period of 144 h. Samples packed in PP micro-perforated film showed significantly (P < 0.05) lower losses of PLW, ascorbic acid, chlorophyll, â-carotene and total antioxidant activity (5.51%, 4.53%, 18.9%, 4.04% and 16.4%, respectively), during storage for up to 144 h under refrigerated conditions. For better phytochemical retention, the broccoli florets should be packed in PP micro-perforated film bags and stored under refrigerated conditions.

Production of minimal processed ready-to-cook green jack fruits

Green jackfruits (45-60 days after flowering) were collected from the experimental field, Govt. of Meghalaya, Ri-bhoi district in the month of April-June, 2010. Fruits were peeled manually and made into slices. Slices were treated with different blanching time and dipped in different concentration of brine solutions with or without addition of potassium metabisulphite (KMS). These fruit slices along with brine solutions were packed in glass jars and stored at room temperature (24±5°C and 70% RH) for six months (Figs 2 & 3). These slices were evaluated at 30 days interval for six months for its quality and shelf life. Best quality slices were recorded at 8% NaCl + 0.2% KMS during storage at ambient condition.

Fig 2 Jack fruit slices during blanching

Fig 3 Minimally processed slices

CROPPING SYSTEM RESEARCH

Influence of organic and inorganic nutrient sources on fodder yield

Field experiment was conducted during 2010 to study the effect of organic and inorganic sources of nutrient supply on productivity of fodder crops. The nutrient sources were organic (FYM 10 t/ha supplemented with 30 kg P_2O_5 /ha through rock phosphate), inorganic (80:60:40 N, P_2O_5, K_2O) and control (no manure and no fertilizer). During the reporting year, 4 cuttings were taken and green fodder yields were recorded. The entire fodder crop yielded maximum under organic sources of nutrient supply followed by inorganic (Table 1). Among the fodder crops, Napier recorded highest fodder yield (159.0 t/ha) followed by Guinea (128.8 t/ha).

Table 1 Effect of nutrient management on fodder yield (t/ha)

Treatments	Control	Organic	Inorganic	Mean
Broom	18.7	21.0	20.0	20.0
Congo	104.9	118.3	110.7	111.3
Napier	125.1	196.7	155.2	159.0
Guinea	113.4	150.2	122.7	128.8
Mean	90.5	121.6	102.1	-

Performance of lentil under utera cultivation in rice fallows

The experiment was conducted during 2010 in *kharif* season with four varieties *viz.*, Shahsarang 1, IR 64, Lampnah and Vivek Dhan 82 under organic management practices (Fig 1). Shahsarang 1 yielded maximum (4.4 t/ha) grain yield followed by Lampnah (4.17 t/ha) and other varieties.

Four varieties (L 303, L 304, L 305 and L 307) of lentil were tested under *utera* cultivation. Among the

Fig 1 Lentil crop under *utera* cultivation in raised and sunken bed technology

four varieties, L305 (1.2 t/ha) yielded higher seed followed by L304 (1.0 t/ha) and L303 (0.96 t/ha).

Effect of varieties, establishment methods and cutting height on ratoon yield

Field experiment conducted at ICAR Research Complex for NEH Region, Umiam, Meghalaya during 2010 revealed that Shahsarang 1 and FYM as nutrient sources has the best potential for ratooning followed by IR 64 (Table 2 & 3). Establishment of pre-*kharif* rice also influenced the ratoon yield. Direct seeding of pre-*kharif* rice gave higher ratoon yield (Fig 2) compared to transplanted crop. Cutting height of 25 cm was found to give higher yield of rice compared to 15 cm (Fig 3).

Fig 2 Shahsarang 1 ratoon under direct seeding

Fig 3 Shahsarang 1 ratoon crop under two cutting heights

ORGANIC FARMING

Soil fertility management using organic inputs in field crop based systems

A field experiment was laid out under Network Project on Organic Farming with two maize based cropping sequences *viz.*,, CS_1: Maize (seed)-Toria and

Table 2 Performance of pre-*kharif* rice varieties under different establishment methods and effect of cutting height on ratoon yield (t/ha)

Nutrient source	Establishment of pre –*kharif* rice		Cutting height of pre-*kharif* rice			
	Direct seeded	Transplanted	Direct seeded		Transplanted	
			15 cm	25 cm	15 cm	25 cm
FYM	4.19	4.28	2.50	2.89	2.33	2.78
Vermicompost	4.06	4.13	2.12	2.49	1.84	2.49
Pig manure	4.24	4.48	2.23	2.62	2.16	2.66
Paddy straw	3.88	4.19	1.98	2.36	1.71	2.22
Control	3.34	4.16	1.38	1.81	1.20	1.58

Table 3 Productivity (t/ha) of pre-*kharif* and ratoon rice as influenced by different sources of nutrients, establishment methods and cutting height

Varieties	Establishment of pre –*kharif* rice		Cutting height of pre-*kharif* rice			
	Direct seeded	Transplanted	Direct seeded		Transplanted	
			15 cm	25 cm	15 cm	25 cm
IR 64	3.82	4.19	2.20	2.60	1.85	2.47
Shahsarang 1	4.27	4.35	2.32	2.71	2.05	2.56
Lampnah	3.94	4.26	2.13	2.58	1.85	2.36
Krishna Hamsa	3.73	3.76	1.52	1.83	1.39	1.69

CS_2: Maize (Green cob) – Frenchbean and six nutrient sources *viz.*, N_1:FYM+ vermicompost, N_2:FYM + VC + Panchagavya, N_3:Panchagavya (3%) spray, N_4: Biodynamic manure, N_5: Panchagavya + Biodynamic manure and N_6:Control to evaluate the efficacy of various on farm and off farm produced organic sources of nutrients/formulations on productivity and soil health. Integrated application of ½ FYM + ½ Vermicompost was selected as base and applied on N-equivalent basis. P requirement was adjusted by applying mussorie rock phosphate (MRP). Maize + soybean intercropping was adopted in 1:1 ratio during *kharif* season (Fig 1). Soybean crop was intercropped as *in-situ* green manure at earthing up in standing maize crop. Maize crop grown in maize- frenchbean cropping sequence was harvested as green cob to facilitate timely sowing of succeeding frenchbean whereas, under maize- toria cropping system it was harvested as grain crop. Maize stalk was recycled back into the same plot under both the cropping systems. Results revealed that combination of FYM, Vermicompost and Panchagavya recorded maximum grain yield of maize, toria and frenchbean followed by ½ FYM + ½ VC whereas, integrated application of FYM+ Vermicompost+ Panchagavya and FYM + Vermicompost recorded comparable green cob yield of maize, seed yield of toria and pod yield of frenchbean (Table 1).

Fig 1 Maize and French bean crop under Maize + Soybean (GM) – French bean cropping system

Improvement in physico-chemical properties of soil was observed due to application of organic manures. Population of beneficial microorganisms *viz, Rhizobium, Pseudomonas* and *Actinomycetes* were found more in FYM + Vermicompost + Panchagavya treatment.

Soil fertility management using organic inputs in important vegetable crop based systems

Field experiment was conducted with treatment combinations consisting of three cropping systems *viz.*,, CS1: Maize + soybean (2:2)- tomato, CS2: Maize + soybean (2:2) - potato and CS3: Maize + soybean (2:2) – Frenchbean in main plot and four organic sources of nutrient *viz.*,, Farmyard Manure (FYM), Vermicompost (VC), integrated nutrient sources (½ of FYM+ ½ of VC) and control in sub plots (Fig 2) to study the performance of vegetables under different cropping systems and to evaluate efficiency organic sources of nutrients and their effect on soil fertility and crop production.

Fig 2 Vegetable based cropping system under organic farming

Significant increase in crop growth and grain yield of maize was recorded in all the cropping sequences and nutrient management sources over control (Table 2). Combination of FYM and Vermicompost recorded maximum increase in grain yield of maize and green pod yield of frenchbean, however, sole application of FYM produced comparable yield with that of

Table 1 Yield (t/ha) of crops under maize based cropping systems as influenced by various sources of nutrient supply

Nutrient sources	Maize-Toria (Seed)		Maize-French bean (Green cob/pod)	
	Maize	Toria	Maize	French bean
FYM + Vermicompost	4.08	0.36	8.93	9.67
FYM + VC + Panchagavya	4.15	0.45	9.33	10.28
Panchagavya (3%) spray	1.34	0.10	2.58	4.18
Biodynamic manure	1.52	0.13	3.12	4.10
Panchagavya + Biodynamic manure	2.38	0.26	4.32	5.16
Control	1.01	0.015	1.21	1.32
CD *(P*=0.05*)*	0.48	0.09	1.07	0.32

Table 2 Yield (t/ha) of crops under different cropping systems as influenced by various sources of organic nutrient

Nutrient sources	Maize + Soybean-Tomato			Maize + Soybean- Potato			Maize + Soybean-Frenchbean		
	Maize	Soybean	Tomato	Maize	Soybean	Potato	Maize	Soybean	French bean
FYM	5.28	0.70	27.35	5.28	0.66	11.52	4.70	0.68	17.65
VC	5.09	0.62	26.81	5.08	0.61	11.83	4.46	0.65	16.99
FYM+VC	5.54	0.74	27.08	5.26	0.71	11.33	5.10	0.77	18.53
Control	3.04	0.48	9.42	2.54	0.50	4.63	2.41	0.50	3.39
CD *(P*=0.05*)*	0.49	0.11	1.10	0.45	NS	1.31	0.48	NS	0.99

integrated nutrient source in case of maize and tomato. Maximum yield of potato was recorded with sole application of vermicompost and was found at par with sole application of FYM.

The highest organic carbon content was recorded 2.36 % with application of ½ FYM + ½ VC (integrated nutrient supply) after 5th year of the experimentation. Likewise, available nutrients (N, P & K) in the soil also increased from the initial status. Maximum SMBC (220.33 µg/g) was recorded with integrated nutrient supply. Dehydrogenase enzyme activity of soil was also recorded maximum (109.8 µg/g soil) under integrated nutrient source.

Comparative efficiency of organic, inorganic and integrated management practices on soil and crop productivity

Upland rice under 100% organic management practice exhibited better yield over inorganic and integrated (50 % N through organic + 50 % N through inorganic) management (Fig 3). Rice- Frenchbean cropping systems recorded highest yield (3.13 t/ha) of rice compared to other cropping systems. All the vegetable crops *viz*, carrot, potato, frenchbean and tomato registered highest economic yield in integrated nutrient management practices and was found significantly superior over all other nutrient sources.

There was improvement in soil health in terms of soil physico-chemical and biological properties. Porosity (58.0 %) and maximum water holding capacity (56.8 %) increased from the initial value of porosity (50.2 %) and water holding capacity (45.2%) due to application of organic manures in raised bed. However, higher porosity (63.75 %) and maximum water holding capacity (62.80 %) was recorded in sunken bed compared to raised bed. This might be due to organic matter from raised bed washed into sunken bed.

Population of beneficial microorganisms *viz.*, *Rhizobium*, *Pseudomonas* and actinomycetes are presented in the Fig 4. Population/activity of all the three groups of organisms were found maximum in the soil under organic followed by integrated management practices. Increased microbial populations in the organics and integrated treatment probably mineralized the unavailable form of nutrients and thus enhanced their avaibility and subsequently improved the plant growth and productivity. Maximum

Fig 3 Rice and vegetables under rice–vegetables cropping system in raised sunken bed technology

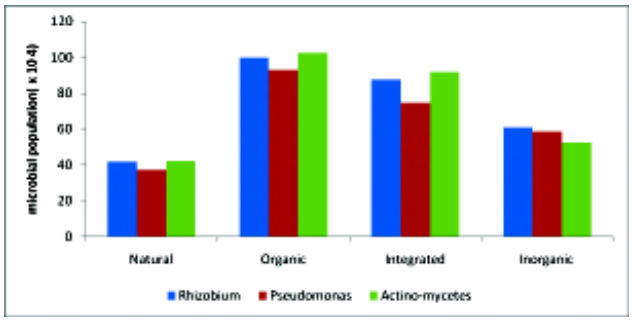


Fig 4 Microbial population (cfu/g dry soil) as influenced by various sources of organic nutrients

value of Soil Microbial Biomass Carbon (SMBC) was under organic (173.50 µg/g dry soil) nutrient management practices followed by integrated (141.34 µg/g dry soil) and inorganic (131.1 µg/g dry soil) nutrient management practice which is depicted in fig 5.

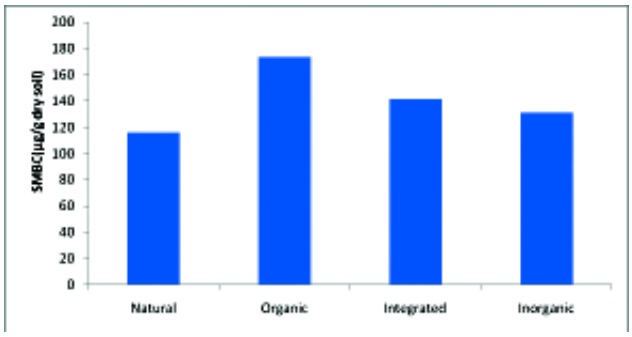


Fig 5 Soil microbial biomass carbon as influenced by nutrient management practices

Quality parameters of tomato such as average fruit weight and fruit diameter were recorded 50 and 50 respectively in organic treatment which was found superior over other treatments (Table 3). TSS, acidity, ascorbic acid and lycopene content were also found maximum (4.72, 0.67, 28.32, respectively) in organic treatment whereas reducing sugar and total sugar content were found maximum (2.53 and 6.38) in inorganic treatment.

Quality parameters of carrot such as root diameter, TSS, ascorbic acid, acidity, bita-carotene, total carotenoides, total sugar and reducing sugar are presented in table 4. The maximum root diameter, specific gravity, total sugar and reducing sugar were recorded (33.07,1.98 ,5.94 and 4.32 respectively) in integrated treatment, where as TSS, ascorbic acid, acidity, beta carotene and total carotenoides (8.33, 40, 0.22, 8.03 and 69.06, respectively) were found maximum in organic treatment followed by integrated treatment.

Insect-pest and disease management under organic farming

Application of Panchagavya along with Derisom @ 3ml/L and Cow urine produced higher grain yield (3.74 t/ha) in maize compared to other pest management practices. Maximum fruit yield of tomato (19.91 t/ha) was recorded when Panchagavya was applied in combination with Lantana leaf extract 10% + Vermiwash 10% followed by sole application of *Trichoderma* (19.76 t/ha) compared to other treatments.

Table 3 Quality parameters of tomato at maximum ripening stage

Treatment	Average fruit weight (g)	Average fruit diameter (mm)	TSS (%)	Acidity (%)	Ascorbic acid (mg/100 g)	Reducing sugar (%)	Total sugar (%)	Lycopene (mg/100g)
Natural	12.30	34.00	3.53	0.40	19.90	1.37	2.81	11.85
Organic	50.50	50.50	4.72	0.67	28.32	2.50	4.10	16.35
Integrated	44.55	49.08	4.17	0.61	27.47	2.49	5.72	15.49
Inorganic	42.97	42.97	4.22	0.65	26.43	2.53	6.38	13.86
CD *(P=0.05)*	2.83	4.36	0.33	0.08	3.06	0.15	0.70	1.35

Table 4 Quality parameters of carrot at harvesting stage

Treatment	Root diameter (mm)	TSS (%)	Ascorbic acid (mg/100g)	Acidity (%)	Beta carotene (mg/100g)	Total carotenoides (mg/g)	Total sugar (%)	Reducing sugar (%)
Natural	15.53	7.63	35.00	0.14	7.27	57.07	4.27	3.70
Organic	28.23	8.33	40.00	0.22	8.03	69.06	5.82	4.11
Integrated	33.07	7.30	39.50	0.16	7.42	61.96	5.94	4.32
Inorganic	24.80	6.63	35.20	0.14	6.23	58.60	5.13	3.97
CD *(P=0.05)*	3.45	NS	NS	NS	NS	NS	1.87	NS

Lowest PDI of early blight of tomato was recorded with the application of Panchagavya @ 3% followed by Anonine @ 3ml/L. Fruit borer and leaf miner are the two major pests of tomato. Due to less incidence of leaf miner attack only fruit borer incidence was given priority and no. of infested fruits/plants and % fruit damage was recorded for testing the effectiveness of various insect pest management practices. Panchagavya + Lantana leaf extract + vermiwash and *Trichoderma* treatments were found better in minimizing the fruit borer attack in tomato.

Weed management in maize-toria cropping system

Experiment on weed management under organic farming in maize-toria cropping systems was carried out during *kharif* season. Mulching with fresh *Ambrosia/ Eupatorium* @ 10 t/ha after earthing up was found effective in reducing weed growth and produced significantly higher grain yield (3.94 t/ha) of maize compared to all other treatments. Mulching with fresh *Eupatorium/Ambrosia* showed a positive effect on yield of succeeding crop toria and recorded significantly higher seed yield (0.67 t/ha) which might be due to carry over nutrients and moisture from the previous crop.

Organic farming on rainfed terraces

Ginger and turmeric

Ginger and turmeric was grown in rainfed terraces following two methods of cultivation i.e. flat bed and *bun* (raised bed of 30 cm height, 1 m width) along with four organic nutrient management practices. Soybean as green manure crop was grown in the inter row spaces of ginger and turmeric and was incorporated during earthing up operation (Fig 6). Experimental results (Tables 5 & 6) revealed that integrated (1/2 FYM + ½ VC) application of nutrients

Fig 6 Ginger and turmeric in flat bed and *bun* under organic farming

Table 5 Yield (t/ha) of turmeric as influenced by different nutrient management sources

Treatments	Turmeric rhizome		Dry matter (%)		Powder yield	
	Flat bed	*Bun*	Flat bed	*Bun*	Flat bed	*Bun*
FYM	19.82	20.66	2.02	2.08	3.68	4.03
Vermicompost	17.45	16.54	1.99	2.09	3.18	3.21
FYM +VC	22.29	26.11	2.07	2.12	4.45	5.20
Farmers practice	15.12	15.27	1.90	1.90	2.50	2.78
CD *(P*=0.05*)*	0.49	0.50	NS	0.14	0.48	0.38

Table 6 Yield (t/ha) of ginger as influenced by different nutrient management sources

Treatments	Ginger rhizome		Dry matter (%)		Powder yield	
	Flat bed	*Bun*	Flat bed	*Bun*	Flat bed	*Bun*
FYM	18.16	19.61	1.79	1.88	3.24	3.43
Vermicompost	15.18	16.04	1.64	1.84	2.32	2.65
FYM +VC	19.31	20.31	1.92	1.93	3.33	3.55
Farmers practice	12.85	15.09	1.58	1.72	1.88	2.34
CD *(P*=0.05*)*	0.43	0.47	0.13	NS	0.42	0.33

along with soybean *in-situ* green manuring produced significantly higher yield in ginger (20.31 t/ha) and turmeric (26.1 t/ha) compared to control in *bun* system of cultivation. The powder yield of turmeric (5.21 t/ha) and ginger (3.55 t/ha) was also recorded higher in integrated sources (1/2 FYM +1/2 VC) in *bun* system of cultivation. Yield of these two crops was found more in *bun* beds compared to flat bed system of cultivation, probably because rhizome development of these two crops needs more soil depth which was espaced by the *bun* beds.

A field experiment was laid out in a randomised block design with different doses of *Tephrosia* green leaf manure with or without mulching. Experimental results showed that *Tephrosia* @ 20 t/ha produced significantly higher rhizome (28.30 t/ha), dry matter percentage (58.0 %) and powder (5.80 t/ha) yield of turmeric followed by *Tephrosia* @ 15 t/ha.

Black gram

A field experiment was carried out in randomized block design with four organic sources of nutrient *viz.*,, Farmyard Manure (FYM), Vermicompost (VC), integrated nutrient sources (½ of FYM+ ½ of VC) and control. Results revealed that integrated treatment recorded maximum stover and seed yield of blackgram followed by FYM, Vermicompost and control treatment (Table 7).

Table 7 Yield of black gram (t/ha) as affected by various organic nutrient management practices

Treatment	Seed yield (t/ha)	Stover yield (t/ha)
FYM	1.18	0.47
Vermicompost	0.98	0.39
½ FYM + ½ VC	1.36	0.54
Control	0.95	0.30
CD *(P*=0.05*)*	NS	0.13

Rice

Six organic nutrient management combinations were tested in direct seeded rice (var. Bhalum 1) under rainfed terrace condition. Integrated application of FYM + VC+ Rock phosphate produced highest grain yield (3.30 t/ha) and was found at par with FYM (15 t/ha) + RP compared to all other treatments (Table 8). Incorporation of fresh biomass (weed / hedgerow) of *Indigofera, Ambrosia* + *Eupatorium* 15 days before sowing resulted significantly higher grain yield in rice over control.

Table 8 Yield of rice (t/ha) as affected by various organic nutrient management practices

Treatment	Grain yield (t/ha)	Straw yield (t/ha)
FYM @ 15 t/ha + RP	3.20	3.70
Vermicompost @ 7.5 t/ha + RP	2.66	3.26
½ FYM + ½ VC + RP	3.30	3.75
Indigofera green leaf biomass @ 15 t/ha	2.52	3.25
Ambrosia + *Eupatorium* green leaf biomass @ 15 t/ha	2.69	3.14
Farmer's practice (control)	2.06	2.95
CD *(P*=0.05*)*	0.44	0.34

Groundnut

Sixteen organic nutrient management combinations were tested to find out suitable organic nutrient source for groundnut in mid hills of Meghalaya during *kharif* season. Application of FYM (15 t/ha) along with rock phosphate (150 kg/ha) and lime produced maximum pod yield (33.4 t/ha) followed by Ambrosia green biomass @ 15 t/ha (Table 9).

Table 9 Groundnut productivity (t/ha), chlorophyll and oil content as affected by source of nutrient supply

Treatment	Pod yield (t/ha)	Chlorophyll index at 45 DAS	Oil content (%)
Control	2.62	40.4	37.0
FYM @ 10 t/ha	2.98	43.6	38.0
FYM @10 t/ha + RP 150 kg/ha	3.09	40.4	38.5
FYM @ 15 t/ha + RP + lime	3.34	44.7	38.8
Vermicompost @ 5 t/ha	2.77	43.7	35.5
Vermicompost @ 5 t/ha + RP 150 kg/ha	2.83	43.1	36.4
Vermicompost @ 10 t/ha + RP 150 kg/ha + lime	3.23	44.4	35.0
Eupatorium green biomass @ 15 t/ha	3.05	44.7	37.0
Ambrosia green biomass @ 15 t/ha (FW)	3.27	42.27	36.5
FYM @ 5 t/ha + *Eupatorium* green biomass @10 t/ha	3.15	42.63	38.5
FYM @5 t/ha + *Ambrosia* green biomass @ 10 t/ha	30.6	41.7	36.0
Improved Bun with FYM @ 10 t/ha	32.5	44.1	38.2
FYM 7.5 t/ha+Vermicompost 3.75 t/ha+RP 150 Kg/ha	32.0	44.0	37.5
Tephrosia 15t/ha (FW)	31.32	42.27	37.5
FYM 5 t/ha + *Tephrosia* 10 t/ha (FW)	30.4	42.9	37.0
Vermicompost 2.5 t/ha + *Tephrosia* 10t/ha (FW)	29.8	44.1	36.4
CD *(P=0.05)*	NS	2.28	2.4

DEVELOPMENT OF MARSHY LAND FOR CROP PRODUCTION

Evaluation of groundnut based cropping on permanent raised bed

Groundnut based cropping system comprised of seven winter/ summer vegetables grown after groundnut were compared with groundnut fallow. The total system productivity was markedly improved in different cropping sequences as compared to groundnut –fallow system. Amongst the cropping sequences, groundnut – capsicum recorded highest total system productivity (15.91 t/ha) followed by groundnut – cauliflower system. The remaining cropping sequences remained in between 7.0-12.7 t/ha, which were 2 - 4 times higher than groundnut-fallow system (Table 1). Groundnut was also grown in sequence with field crops, indicated that wheat crop significantly reduced groundnut yield followed by *toria*. However, lentil and rice bean registered higher pod yield of groundnut as compared to other cropping sequences but it remained significantly inferior to the pod yield recorded in monocropping of groundnut. Maximum total system productivity of (6.88 t/ha) was recorded with groundnut- lentil followed by groundnut- rajmash (6.26 t/ha) and latest was with *toria* and wheat crop.

Response of sunken bed rice to width and crops of raised bed

The yield of rice grown in sunken bed affected by the width of raised beds and types of crops grown on the raised bed. This effect was assessed by keeping raised bed width, 1, 2, 3 and 4 meter and four different stature of crops viz. maize, rice, soybean and groundnut. The yield of rice variety Shahsarang-I in sunken bed significantly reduced with high stature crops like maize and upland rice variety Bhalum-I, while short statured crops like groundnut and soybean did not effect rice yield in sunken beds significantly. Highest yield rice (4.02 t/ha) in sunken bed was recorded with groundnut (Table 2). The width of raised bed found to influence the yield of sunken bed rice. Maximum yield reduction was with 1 meter width and lowest was with 3 meter width. The yield of rice further improved at 4 meter width but the extent was not significant. The effect of height of raised bed on crops was also assessed with four levels of raised bed height i.e. 20,30, 40 and 50 cm on maize, rice, groundnut and frenchbean in split plot design with three replications. The results reveals that all crops except rice could not perform well at 20 cm height. At 30 cm height of raised bed, rice and maize registered economic optimum yield, while maximum yield was observed at 50 cm height of raised bed (Table 3). Amongst the crop

Table 1 Production potential of groundnut based cropping system on raised beds in lowland area

Cropping system	*Kharif* crop yield (t/ha)	Summer crop yield (t/ha)	Groundnut equivalent yield (t/ha)	Total system productivity (t/ha)
Groundnut-potato	2.50	16.46	5.76	8.26
Groundnut-tomato	2.60	18.28	9.14	11.74
Groundnut-capsicum	2.45	13.46	13.46	15.91
Groundnut-frenchbean	2.87	13.69	4.79	7.66
Groundnut-cauliflower	2.50	19.12	9.56	12.86
Groundnut-carrot	2.45	20.63	10.31	12.76
Groundnut-radish	1.84	26.16	5.23	7.07
Groundnut-fallow	2.84			2.84
CD *(P=0.05)*	0.11			0.56

Table 2 Effect of raised bed width and grain yield (t/ha) of sunken bed rice

Crop	Raised bed width				Mean
	1 meter	2 meter	3 meter	4 meter	
Maize	2.90	2.48	2.26	2.33	2.49
Rice	3.52	3.83	3.32	3.41	3.52
Soybean	3.86	3.63	3.43	3.56	3.62
Groundnut	4.12	4.02	3.95	3.96	4.01
Mean	3.60	3.49	3.24	3.32	

CD *(P=0.05)* Crop 0.24 , Raised bed width 0.35, C x R 0.87

Table 3 Effect of height of raised bed from moisture levels on yield (t/ha) of crops

Crop	Raised bed width					REY
	20 cm	30 cm	40 cm	50 cm	Mean	
Maize	1.52	2.57	3.13	3.56	2.69	3.23
Rice	3.43	3.63	3.27	3.02	3.34	3.33
Groundnut	0.55	1.48	2.23	2.86	1.78	3.56
Frenchbean	2.54	6.55	11.52	14.53	8.78	6.15

maximum rice equivalent yield (REY) was recorded with frenchbean followed by groundnut, while maize remained inferior in terms of REY. During winter season, pea, *toria*, lentil, and linseed were grown which revealed that at 40 cm raised bed height maximum production could be obtained. Raised bed height of 20 cm remained very poor yielder during the course of experimentations

Performance of *toria* in different ecologies

Toria based cropping sequences were evaluated on raised beds in marshy land as well as on upland dry terraces ecosystem. The treatments were tested in split plot design with three replications. Amongst the two environments, maximum *toria* yield (1.13 t/ha) was recorded in marshy land area which was 50.13 % higher than that of dry terraces. Amongst the *kharif* crop, highest *toria* equivalent yield (TEY) was recorded with frenchbean (4.82 t/ha) followed by groundnut (2.45 TEY /ha). The yield of *toria* was was highest (1.12 t/ha) when grown after groundnut followed by frenchbean. The total system productivity of 5.85 t/ha was estimated with frenchbean-*toria* while lowest (2.48 t/ha) with maize - *toria* (Table 4). The lowland area registered maximum system productivity of 3.76 t/ha, which was 9.90 % higher than that of upland terraced area indicated suitably of permanent raised bed for obtaining higher yield of *toria* as compared to upland dry terraces.

Development of cole crop based cropping system

The interspaces of wide spaced cole crops was utilized by growing suitable intercrops. The crops like pea, methi, coriander, radish and carrot was grown in between two lines of cauliflower and broccoli. All the crops were also grown as sole crop for comparison. The data revealed that all the inter crops significantly reduced the yield of main crop of cauliflower. Maximum and minimum yield reduction of 109.921 and 18.54 % was observed with radish and pea, respectively. The total system productivity in terms of cauliflower equivalent yield (CEY) was maximum with cauliflower + pea (31.31 t/ha) followed by the lowest CEY with cauliflower + radish (15.09 t/ha) which was 53.30 % lower than even cauliflower sole crop indicating that radish yield could not compensate the cauliflower yield reduction. In broccoli, lentil and mustard were grown as intercrop and tested with pea, methi, radish and carrot. It was observed that broccoli yield decreased markedly in intercropping system. Maximum yield reduction was noticed with radish and mustard while minimum was observed with methi,

Table 4 Performance of *toria* based cropping system in two environments

Treatment	*Kharif* crop yield (t/ha)	*Kharif* crop productivity (t/ha) as *toria* equivalent yield (TEY)	*Toria* yield (t/ha)	Total system productivity (t/ha)
Environment				
Upland	5.75	2.69	0.75	3.44
Lowland	7.69	2.63	1.13	3.76
CD (P=0.05)	-	NS	0.11	0.13
Cropping system				
Rice – *toria*	3.69	1.64	0.86	2.50
Maize – *toria*	3.17	1.73	0.75	2.48
Groundnut – *toria*	2.45	2.45	1.12	3.57
Frenchbean – *toria*	13.77	4.82	1.027	5.85
Rice – fellow	-	0.15	0.102	0.09

lentil and pea. Maximum total system productivity of 14.66 t/ha was recorded with broccoli + methi which was almost similar to broccoli + pea (14.61 t/ha) (Table 5).

Development of technology of pre-*kharif* rice

Agronomical evaluation of rice variety suitable for pre-*kharif*, *kharif* and late *kharif* was carried out by planting of Krishna Hamsha, IR-64, VL Dhan 82, VL Dhan 61 and Shahsarang 1 at 15th March, 1st July and 14th August. Data presented in Table 6 revealed that Krishna Hamsha and IR-64 were the highest yielder during pre-*kharif* season, while Shahsarang1 registered maximum yield (5.48 t/ha) during *kharif* season. However, under late transplanting VL Dhan 61 and Vivek Dhan 82 registered highest yield. In another experiment, maximum total system productivity of 8.15 t/ha was recorded with Vivek Dhan 82-Shahsarang-1 , followed by IR-64 – Shahsarang –1 (7.94 t/ha). The production efficiency was maximum with Krishna Hamsha – IR-64 (27.39 kg/ha/day) followed by VL Dhan 61 - Shahsarang 1 (27.00 kg/ha/day).

Determination of seedling age for pre-*kharif* rice

The experiment was continued for the third conservative years with four seedling age i.e. 30, 45, 60 and 75 days old of seedlings of varieties viz., Krishna Hamsha, IR-64, VL Dhan - 61 and Vivek Dhan -82. It is found that seedling age of 45 days registered maximum rice yield, which was followed by the yield recorded with 60 days old seedling. Lowest seed yield was recorded with 30 and 75 days old seeding. Transplanting of seedling on 30th March registered highest yield (3.17 t/ha) followed by 15th March (2.99 t/ha). The interaction effect indicated that transplanting of 45 days old seedlings on 30th March registered highest seed yield (4.04 t/ha), which was 70.68 % higher over the seed yield recorded with 30 days old seedlings on the same date of planting. The seedlings age with respect to varieties were evaluated in split plot design with three replications. It was observed that 45 days old seedlings registered highest seed yield followed by 60 days old seedlings. Amongst the varieties, IR-64 and Krishna Hamsha recorded maximum yield of 2.92 and 2.66 t/ha respectively).

Table 6 Response of rice (t/ha) varieties to date of transplanting

	Date of transplanting			Mean
	15th March	1st July	15th August	
Krishna Hamsa	4.17	3.32	2.66	3.39
IR-64	4.03	3.75	2.95	3.57
VL Dhan 82	3.27	3.46	3.46	3.40
VL Dhan 61	3.18	3.66	3.56	3.46
Sahasarang 1	1.87	5.48	2.26	3.20

Development of rice + fish system for sunken bed

Rice + fish system was standardized keeping five rice + fish system while rice and fish were also was kept alone for comparison. It was observed that rice yield significantly improved with rice + fish system. Maximum rice yield (5.22 t/ha) was recorded with rice + fish + azolla followed by rice + fish + food system. The yield further improved when rice + fish + azolla was integrated with fish feed (5.44 t/ha).

Amongst the fish species, the growth of both species were on per. Depending upon the fingerlings density common carp yield was more. The total yields of both species of 40.35 q/ha was recorded with rice + fish + azolla + food system which was 37.10 and 50.72 percent higher than rice + fish + food and rice + fish + azolla respectively. However highest of 77.55 t/ha were observed with fish alone during the course of expenditure.

Table 5 Effect of broccoli based intercropping system on system productivity on raised bed

Cropping system	Broccoli yield (t/ha)	Intercrop yield (t/ha)	Broccoli equivalent yield (BEY t/ha)	Total system productivity (t/ha)
Broccoli + Pea	11.04	3.57	3.57	14.61
Broccoli + Methi	11.58	1.76	3.08	14.66
Broccoli + Radish	3.53	8.57	1.71	5.24
Broccoli + Mustard	7.56	1.43	1.44	9.00
Broccoli + Lentil	11.14	1.54	2.67	13.84
Broccoli + Carrot	10.56	7.59	3.80	14.35
Broccoli + Sole	12.56	-	-	12.56
CD *(P=0.05)*	0.97	-	-	1.04

BIOORGANICS FOR CROP PRODUCTION

Upland rice

At Barapani, rice variety Shahsarang-1 was tested in upland field with promising four formulations. Seed soaking for 8 hrs @ 10% solution in water before sowing along with one foliar application @ 2% at 35 days after planting were undertaken. All the formulations *viz.*,, RF 79L, R-9, RCHE 686L and RCHE C-12L gave significantly higher yield in comparison to no treatment. The grain yield increase was 64.2, 49.1, 43.5 and 36.7 per cent, respectively over control (2.34 t/ha).

Lowland rice

Five different formulations were tested in lowland transplanted rice (var. Bhalum 1). Seed for nursery was soaked for 12 hrs in formulations @ 10% concentration and one foliar application @ 2% concentration was applied at 30 days after transplanting. The plant growth varied with different bioorganics. Four different formulations, *viz.*, R-9, RCHE C-12L, RF 37, and RF 79 were found to be significantly increasing grain yield. The percent increase in grain yield was in order of 26.8, 22.3, 21.1 and 19.6 over control (4.73 t/ha). Formulation RF 37 treated plot attained physiological maturity a week ahead of all other treatments.

Maize

Five different herbal formulations were tested in maize crop; seed was treated @ 10 % concentration with botanicals and one foliar application (2% concentration) was undertaken at 30 days after sowing. The formulations MF129, RCHE 620L, MF18, and MF 98 resulted in yield increase of 22.3, 18.75, 14.3, and11.6 percent over control (2.81 t/ha). The highest yield was recorded in formulation MF 129 (3.47 t/ha); however, the total biomass was highest in RCHE 620L (5.49 t/ha).

Wheat

Wheat (var. UP 262) was treated with three formulations RCHE 572 L. RCHE 724 L and RCHE 442 L (Seed treatment @ 8 % conc for 4 hrs before planting and one foliar application @ 2 % at 30 days after sowing). The treatments resulted in significantly higher biomass accumulation and increased grain yields of 26.7, 23.2 and 19.6 per cent respectively over control (2.72 t/ha).

Groundnut

Groundnut seed (var. ICGS 76) was treated with formulations before planting @ 8% conc. Also, one foliar application @ 2 % was applied at 40 days after planting, The formulations *viz.*, GF3, RCHE641FL, RCHE 490L and RCHE 694L increased pod yield by 33.7, 30.3, 25.3 and 22.5 per cent over control (2.15 t/ ha). The no. of branches per plant was highest in RCHE641FL treated plot whereas, the no. of root nodules was maximum in RCHE 694L treated plot.

Soybean

Four different formulations, *viz.*, RCHE 397L, SF 4, 681L and 538L were selected for soybean (seed treatment @ 8% for 2 hrs before planting and one foliar application @ 2 % were applied at 40 days after planting). The formulations RCHE 538L and 681L treated seeds germinated two days ahead of all other treatments. Whereas, the root volume and root nodules were the highest with RCHE 538L. The increase in grain yields was 24.1, 27.5, 25.8, and 22.6 percent over control (1.84 t/ ha), respectively.

Toria

Toria (variety M-27) was selected, and four different formulations *viz.*, RCHE 681 L, MSF 4 and MSF 5 and MSF 6 were tested @ 6% conc. with 5 hrs seed soaking and subsequently drying in shade before sowing. The crop was given one foliar application @ 2% conc at 30 days after sowing. Dry matter accumulation was 20.3, 22.1, 24.6 and 31.9 percent over control at 60days after sowing. The grain yields were 16.2, 15.2, 26.1 and 27.8 percent respectively more over control (0.49 t/ha).

FARMING SYSTEM RESEARCH

Dairy based farming system (FSW-1)

Dairy based farming system was evaluated on a micro watershed of 1.39 ha area including 0.45 ha forest land. The area under planned land use is 0.94 ha of which 0.22 ha terrace area is under annual fodder crops and remaining under broom and guinea grass. The average slope of the watershed is 32.02%. The bottom 1-10 terraces were utilized for production of annual fodders with maize + cowpea – cowpea and maize – cowpea cropping sequence. The riser area was utilized for the production of guinea grass while 2500 m^2 sloppy area was put under broom grass which gave

15.06 t green leaves and tender shoots during lean period. Four milch cows along with their calves were maintained in the system. Fodder crops/ grasses grown in the micro-watershed, produced sufficient fodder for the whole year for the dairy animals. The crop wise green fodder yield presented in Table-1 revealed total 37.50 t green fodder production form the watershed of which maximum green fodder of 15.06 t recorded from broom leaves followed by mixed grass (13.58 t).

Table 1 Fodder production in the dairy based farming system

Name of fodder	Yield (t)
Maize	3.75
Cowpea	0.54
Rice bean	0.59
Guinea grass	4.24
Broom grass	15.06
Mixed grass	13.58
Oat	2.65
Total green fodder	37. 50

Cultivated fodder crops like maize, cowpea, rice bean and perennial guinea grass were utilized as green fodder from June to November. During lean period, broom grass was available for 4 months i.e, December to March. The remaining 1 month was without green fodder, only paddy straw and few amounts of new shoots coming from guinea grass was used to feed the animals. During May, 50% green fodder requirement was available from guinea grass. An analysis of fodder production and requirement revealed that total green fodder from forage crops was 37.5 t, while the requirement for the dairy animals was 31 t showing a surplus of 6.5 t. Total concentrate and paddy straw was arranged from open market costing about Rs. 78,810.00. Keeping in view farmer's family in the watershed, all labour were considered as farmer's works, only concentrate and paddy straw was procured from the market and milk yield was considered to be the farmer's income.

The milk yield obtained from the system was 8,462 litre (assuming farmer's requirement was 415 litre) giving gross return of Rs. 2, 09,328/-. Besides milk, 35 tonnes of FYM was produced from cow dung, urine, crop residues, and weed biomass in the system. The production of 90 kg of broom spikes and two calves (sold) increased income of the dairy based system. Considering family labour as a system of employment for dairy based farming, total cost of feed, concentrate and medicine was Rs. 78,810/- with annual income of the system registered net income of Rs. 1,20,518/- showing output– input ratio of 2.57. To increase nutritional quality of fodder, cowpea varieties were evaluated in the watershed. Among them, Bundel lobia-1 registered the highest green fodder yield of 31.50 t / ha followed by Bundel lobia-2 (25.46 t/ha) and UPC-9202 (24.07 t/ha). The lowest green fodder yield of 12.55 t/ha was obtained with UPC-5286 followed by UPC-622 (18.07 t/ha). Seven varieties of oats for green fodder grown during February and March in the watershed showed highest green fodder yield of 32.58 t/ha with AOSC –7 followed by AOSC –3 (28.05 t/ ha). Lowest green fodder was obtained with AOSC –

Table 2 Balance sheet of dairy based system

Particulars	Area	Production (t)	Requirement (t)	Surplus/Deficit	Value(Rs)
A. Green fodder					
a) Annual fodder	0.12 ha	4.45	-	-	-
b) Perennial grass	1.27 ha	33.86	-	-	-
Total (A)	**1.39 ha**	**37.5**	**31.00**	**(+) 6.50 t**	**(+) 6,500**
B. Feed, dry fodder and medicine					
(a) Concentrate	-	-	7.00	(-) 7.00 t	(-) 71,301
(b) Paddy straw	-	-	4.29	(-) 4.29 t	(- 6,509
(c) Medicine	-	-	-	-	(-) 1000
Total (B)	**-**	**-**	**11.29**	**(-) 11.29 t**	**(-) 78,810**
C. Output					
a) Milk	4 cows	8,462 lit	415.00	(+) 8,047	(+) 1,93,120
b) Calves (sold)	2 calves	-	-	(+) 8,800	(+) 8,800
c) Cowdung		90 kg	-	(+) 90 kg	(+) 900
Total (C)					(+) 2,02,828
Gross income (A + C)					(+) 2,09,328
Net income (A + C – B)					**(+) 1,20,518**

6 followed by AOSC – 1 (Table-3). The yield obtained by AOSC – 2, 4 and 5 remained in between 11 – 21 t/ha green fodder under mid-hill altitude in Meghalaya which indicated that proper management of forage crop can provide quality nutritious fodder round the year.

Table 3 Green fodder yield of oat varieties

Variety	Productivity (t/ha)
AOSC 1	8.45
AOSC 2	21.07
AOSC 3	28.05
AOSC 4	11.53
AOSC 5	17.04
AOSC 6	8.10
AOSC 7	32.58

Mixed forest block (FSW-2)

Mixed forest block was established in 3.89 ha area with 3.05 ha area under natural forest and 0.84 ha area under planned land use. The average slope of the micro-watershed is 38 %. The area under micro watershed was utilized for plantation of forest tree species *viz. Acacia auriculiformis*, *Michelia oblonga* and *Symingtonia populnea* for timber and fuel purpose. Among these species, maximum plant height was attained by *Symingtonia populnea* (27.60 m) and lowest was recorded with *Michelia oblonga* (19.60 m). The circumference of tree trunk also followed the similar trend. However plant- spread was maximum with *Acacia auriculiformis* followed by *Symingtonia populnea* (Table 4).

Silvi-pastoral system (FSW-3)

Silvi-pastoral system was established on 2.94 ha area in forest land of which 2.05 ha was under forest and 0.90 ha under planned land use of silvipastoral system. The average slope of the area is 32.18%. The top portion of the micro-watershed was utilized for broom grass to fulfill the requirement of fodder for the animals during lean period and to get broom sticks as well as fuel woods in the form of stick. An area of 0.74 ha was planted with broom which recorded green fodder of 35.50 t out of which 4.625 t green leaves were used for cow and goat from November to February.

Eleven goats (4 adult males, 3 adult females, 3 male kids and 1 female kid) were maintained in this system. The goats were allowed to graze for 3 hours per day and green fodder @ 3 kg per adult along with 250 g of concentrates per adult were given. The goats consumed a total of 3.6 t guinea grass, 2.16 t *Symingtonia* leaves and 0.46 t of concentrate. Poultry (300 broilers) chicks were also reared in two cycles as subsidiary source of income (Table 5). The total body weight was 770 kg with average body weight 1.9 kg per bird during 1st cycle while during 2nd cycle the average body weight was recorded to be 2.1 kg per bird. The gross income from system was Rs. 89,100/-. The expenditure of Rs. 33,084/- was incurred on feed, concentrate and price of day old chicks resulting into a net profit of Rs. 56,016/- from the watershed.

The lower half portion of the watershed had been planted with fodder trees species of *Symingtonia populnea*, *Bauhinia purpurea* and *Ficus* spp, *Schima wallichii*, *Indigofera indica* and wild cherry to provide green leaf fodder to the goats during lean period which was observed to be 2.68 t green leaf fodder from all the tree species. The growth and development attributes of tree species shown in Table 6 revealed that the tallest plants were in tree species of *Bauhinia purpurea* (11.60 m) while lowest plant height was recorded with *Symingtonia populnea* (2.85 m), which might be due to frequent lopping of plants for green leaf fodder for goats. The circumference at basal height was maximum with *Bauhinian purpurea* and *Schima wallichii*. While at breast height the circumference was more with *Bauhinia purpurea* followed by *Symingtonia populnea*. Mixed perennial grasses had been planted in between the fodder trees to conserve the soil and water by covering the surface and to provide fodder for goats for grazing/ browzing purpose.

Table 4 Growth and development attributes of tree species in W-2

Name of tree species	Plant height (m)	Girth at basal height (m)	Girth at breast height (m)	Spread (m)	
				N- S	E-W
Acacia auriculiformis	26.44	1.00	0.88	8.52	10.16
Michelia oblonga	19.60	0.80	0.61	6.75	7.20
Symingtonia populnea	27.60	1.11	0.92	7.52	8.57

Table 5 Cost benefit analysis of agri-pastoral model

Sl.No.	Particulars	No.	Weight	Value (Rs.)
A. Output				
1.	Goat	11	220 kg	19,800
2.	Poultry	300	770 kg	69,300
			Total	89,100
B. Input				
1.	Feed and concentrate for goat	-	0.41 t	4,920
2.	Feed for broiler	-	1.338 t	17,064
3.	Price for day old chicks	300	-	10,000
4.	Medicine	-	-	500
			Total	33,084
			Gross income	89,100
			Net income	**56,016**

Table 6 Growth and development attributes of trees species in W-3

Name of tree species	Plant height (m)	Girth at basal height (m)	Girth at breast height (m)	Spread (m)	
				N- S	E-W
Bauhinia purpurea	11.68	0.53	0.47	5.98	5.74
Schima wallichii	8.08	0.55	0.43	3.80	3.82
Indigofera indica	6.60	0.29	0.24	4.66	4.60
Prunus nepalensis	5.45	0.26	0.20	2.87	3.29
Symingtonia populnea	2.85	0.44	0.39	-	-

Agro –pastoral system (FSW-4)

Agro-pastoral system was in 0.64 ha area having an average slope of 32.42 % with forest land 0.06 ha and planned land used area of 0.58 ha. Terracing enhanced surface area by 28.2 %, resulting in 0.49 ha area of terraced land and 0.33 ha terrace risers. The terrace area was utilized for growing cereals, oilseeds, spices and vegetables. About 75 % of the area was brought under 200 % cropping intensity which resulted into production of 1.99 t rice equivalent yield (REY) excluding guinea grass from the system (Table 7). It was observed that turmeric + cucumber / bottlegourd registered maximum total system productivity followed by rice-toria. The lowest yield of ginger and groundnut resulted in minimum values of total system productivity. Output per sq/m in the W-4 watershed revealed that amongst crop component, maximum output of Rs. 25.95/ sq m was realized with turmeric followed by bottlegourd (Rs.21.44 /sqm). In general maximum output was realized from vegetables/spices crop. Rice crop registered Rs. 5.93/sq m output (Table 8). Lowest output of Rs. 1.59 /sq m was observed with black gram and toria (Rs 1.32/sq m) followed by ginger (Rs. 5.56/sq m) due to poor yield in the watershed.

Table 7 Cropping pattern and production in agro-pastoral system

Terrace No.	Cropping system	Area (m^2)	Production		System Productivity REY (kg)
			Kharif (kg)	*Rabi*(kg)	
1-16	Rice – Toria	1,100.00	261.00	78.00	417
19 – 23	Ginger + Frenchbean	370.00	109.00	103.00	212
24- 31	Maize - Blackgram	374.00	218.40	39.69	259
32 – 36	Groundnut – Toria	200.00	35.50	7.80	86
37 – 40	Turmeric+ Cucumber	160.00	197.00	188.90	582
41 – 44	Turmeric+Bottlegourd	132.00	182.00	283.00	435
44 – 60	Guinea grass	3500.00	31,000.00	3,100.00	
T.Risers	Guinea grass	2,700.00 rmt	21,000.00	2,100.00	
				Total REY	7,191

In an integrated approach, crops and livestock income revealed that maximum income realized from cow milk (Rs. 1,54,625/-), which was 65.76 % of the total income of the system. The crop component contributed only 34.24 %. The system could generate 520 mandays employment costing to Rs. 52,000/- and it was added with the cost of other input amounting to Rs. 1,43,937/- (Table 8). With gross and net income of Rs. 2,00,818/- and Rs. 56,844/-, respectively giving an output – input ratio 1.39. The cow dung produced in the Agro-pastoral system (32.5 t.) was utilized for the production of crops. Production of guinea grass on terrace risers in the lower and middle part of the watershed and broom on the top portion of the watershed provided green fodder sufficient for 8 months for the dairy unit without any extra input/ management cost. Production of grasses on terraces risers, although reduced the yield of main crop but the yield reduction was compensated with the continuous availability of green fodder for the animals in the micro-watershed**.**

Table 8 Input output relationship in W-4 watershed

Particulars	Yield / unit (kg)	Values (Rs.)	Output (Rs. / sq m)
A. Crop			
Rice	261.00	6,525	5.93
Toria	85.80	1,716	1.32
Ginger	109.00	2,180	5.56
Frenchbean	103.00	1,030	2.78
Maize	218.04	7,207	19.27
Blackgram	39.69	595	1.59
Groundnut	35.50	710	3.55
Turmeric	379.00	7,580	25.95
Cucumber	188.90	945	5.90
Bottlegourd	283.00	1,415	10.72
Guinea grass	31,000.00	15,500	4.42
Total	=	44,693	7.90
B. Animals			
Milk	6185 lit	1,54,625	-
Sale of calves	1 No.	1,500	-
Total B	1,56,125	-	
Grand Total (A + B)		2,00,818	-
C. Input Cost			
Fertilizer	0.35 t	2,100	-
Concentrate	5.48 t	76,664	-
Paddy straw	5.5 t	12,210	-
Medicine		1,000	-
Labour charges	520 mandays	52,000	-
	Total C Rs	1,43,974	-
Gross Income (A + B)	Rs	2,00,818	-
Net Income (A + B – C)	**Rs**	**56,844**	**-**

Agri-horti-silvi-pastoral system (FSW-5)

Total area of this system was 1.58 ha. Out of this, 0.55 ha was under forest while planned land use area was 1.03 ha. The average slope of the micro-watershed is 41.77 %. In this system, 0.10 ha of foothills was used for agricultural use, 0.25 ha for horticulture use and 0.44 ha for silvi-pastoral crops. In the lower terraces, crops like capsicum, frenchbean and bhindi were grown during *kharif* season and frenchbean, pea, cauliflower and cabbage were grown during *rabi* season. The middle portion of the system was utilized for fruit crops like Assam lemon, orange and guava. On terrace risers, *guinea* and *congosignal* grasses were planted to arrest soil erosion and to get green fodder. Pineapple was planted in double row system as an inter crop with Assam lemon. Forest block of the system consisting of *Alnus nepalensis* and *Schima wallichi* for timber and fuel wood were also used as staking trees for black pepper plants, while *Ficus* and *Symingtonia populnea* were used for green leaf fodder during lean period and in between tree species, broom grass was grown as companion crop to conserve soil and water and to get fodder. The system productivity was 11.03 t rice equivalent yield (REY) registering a gross return of Rs. 1,10,270/-. The cropping pattern of the system depicted in Table 9 revealed maximum REY 1.68 t with tomato-bhindi - colecrops followed by guinea grass on terrace risers and horticulture as well as forestry unit of the system (1.76 t REY). Lowest REY was recorded with frenchbean – bhindi - pea sequence which might be due to less area allotted to the sequence. Among the fruit crops, maximum REY of 1.2 t was estimated with pineapple followed by guava (330 kg). Input: output relationship (Table 10) indicated maximum net return with vegetable section by registering net income of Rs. 39,109/- followed by fruit component (Rs. 13,740/-). The net returns of Rs. 9,100/- were obtained from three numbers of pigs. Total income from the system was Rs. 1,10,270/-, while the net income was Rs. 70,919/- giving benefit cost ratio of 1.80:1 from the system.

Silvi-horticultural system (W-6)

The total area of this system was 3.13 ha with forest land of 2.17 ha and planned land use of 0.96 ha. The average slope of the area is 53.18 %. Lower terraces having an area of 510 sqm were utilized for growing spices and vegetables based cropping system like turmeric + bottle gourd and turmeric alone. The middle portion of the system was utilized for fruit crops of pineapple and guava. Upper portion of the system was

Table 9 Area, production and total system productivity of cropping sequence and fruit crops

Cropping system	Area (m^2)	Production (kg)		System productivity REY (kg)
		Kharif	*Rabi*	
Capsicum – Frenchbean - Pea	285.25	456.25	292.00	1831.88
Tomato – Bhindi - Colecrop	1080.00	288.40	310.00	1678.70
Frenchbean-Bhindi – Pea	343.75	228.70	220.00	1122.45
Guinea grass on terrace risers of fruit + forestry unit	17,600	-	-	1760.00
Assam lemon	160 nos.	-	-	160.00
Orange	12 nos	-	-	24.00
Guava	330 nos.	-	-	330.00
Pineapple	1200 nos.	-	-	1200.00
Total REY				**8107.03**
Piggery (03) nos.		292 kg		2920.00
		Total REY		11027.03
		Gross return		**Rs. 1,10,270/-**

use. The average slope is 45.87 %. The watershed area was dominated by common weed flora *viz.*, *Fumaria parvifolia*, *Ciprus irri*, *Eupatorium adenophorum*, *Arundinella bengallensis*, *Solanum khasianum*, and *Ageratum* ssp. Two tree species were commonly grown in the natural forest in the watershed. The growth and development attributes of tree species revealed that *Pinus kesyia* attained more plant height and other developmental attributes as compared to *Schima wallichii* (Table 12). The plant spread was also highest with *Pinus kesyia*.

Timber –based farming system (FSW-8)

The area of timber-based farming system was on 0.52 ha in which 0.02 ha was under forest and 0.50 ha under planned land use. The average slope was 41.35 %. The planned land use system was covered by tree species of *Michelia champaka* and *Michelia oblonga*. The growth performance of planted trees

Table 10 Input: output relationship

Component	Area/ No.	Input Cost (Rs)	Mandays cost (Rs.)	Total cost (Rs.)	Total production (REY)	Gross income (Rs.)	Net income (Rs.)
Vegetables	1000 m^2	2,721	4,500	7,221	4,633	46,330	39,109
Fruits	2000 m^2	900	2,500	3,400	1,714	17,140	13,740
Pigs	3 nos.	17,980	2,250	20,230	2,920	29,200	8,970
Grasses	-	-	850	8,500	1,760	17,600	9,100
Total	**=**			**39,351**		**1,10,270**	**70,919**

covered with forest trees *Alnus nepalensis*. The productivity of the system depicted in the table 11 showed a gross income of Rs. 17,667/- from the system.

Natural forest block (FSW-7)

There was 1.03 ha area in natural forest block with 0.08 ha under forest and 0.95 ha under planned land

and their developmental attributes shown in Table 13 showed better growth and development of *Michelia champaka* by registering plant height of 16.15 m and plant spread of 5.06 x 5.44 (m) in (N – S) x (E – W) direction while, *Michelia oblonga* could attain plant height of 15.53 m with plant spread of 5.44 x 5.77 (m).

Table 11 The productivity and economics of silvi-horticultural system

Cropping system	Area (m^2)	Production (kg)		Value(Rs.)
		Turmeric	Bottle gourd	
Turmeric + bottlegourd	253.05	128.00	224.52	5,807
Turmeric	256.00	383.00	-	7,660
Guava	4,313.00	170		1,700
Pineapple	2,400.00	250 *		2,500
Total				**17,667**

***** *Pineapple fruits were damaged by rats and hence were given to pig for consumption.*

Table 12 Growth and development attributes of tree species in W-7

Name of tree species	Plantheight (m)	Circumference at basal height(m)	Circumference at breast height (m)	Spread (m)	
				N-S	E-W
Pinus kesyia	22.60	1.20	1.15	9.97	9.84
Schima wallichii	18.75	1.41	1.41	7.99	9.00

Table 13 Growth and development attributes of tree species in W-8

Name of tree species	Plantheight (m)	Circumference at basal height(m)	Circumference at breast height (m)	Spread (m)	
				N-S	E-W
Michelia champaka	16.15	0.92	0.73	5.06	5.44
Michelia oblonga	15.53	0.91	0.76	5.44	5.77

AGRICULTURAL MECHANIZATION

Farm implement and machinery

Manual zero till planter

A prototype of manual zero till planter was developed for planting/drilling of paddy, mustard, lentil and pea in zero tillage condition. It consisted of cell type vertical seed and fertilizer metering rollers, tine, frame, seed box, chain type driving mechanism, ground wheel, leveling wheel and a handle. The metering roller was different for each type of crop. It picks up single seed in each circular hole from the auxiliary seed chamber and drops in the delivery pipe mounted behind the tine. Holes on the roller edge were so made that it can maintain 5 cm seed to seed spacing while in operation. It was made of cast iron to reduce cost and to protect it from rusting. The same principle was applied for the fertilizer metering roller. It was designed for a target rate of application of 350 kg/ha (considering 40 kg N, 30 kg P_2O_5 and 40 kg K_2O-recommended dose of fertilizer for mustard). Seed box has capacity of holding approximately one kg of seed and fertilizer each. Tine is provided to open a furrow of 2-3 cm wide and 4-6 cm deep to place seed and fertilizer at different depths. The draft requirement to operate this implement was calculated as 100 N which a person can easily develop by pushing by two hands. The leveling wheel was provided for two purposes-to keep the implement level in operation to maintain a constant planting depth and press the tilled soil over the planted seed. It also helped in balancing the implement. The machine will be tested for the performance and further development of the components will be carried out if needed.

Prototype manufacturing

A light weight power tiller operated planter was fabricated for planting of groundnut and maize. It has two tines which can be adjusted for spacing and depth. The size and weight of the implement was selected after matching it with the light weight power tiller. Its weight was 42 kg which was same as that of rotary tiller that came as an attachment with the power tiller. The implement can be attached with the tiller after removing the rotary attachment. One person can easily handle it. The implement is yet to be tested for its accuracy and efficiency.

Frontline demonstration of improved farm tools and implements

Frontline demonstration was conducted (Fig.1) on wire loop thresher (15 h), self propelled vertical conveyor reaper-walk behind type (2.5 ha), Paddy drum seeder (1 ha), hand operated winnower (50 h) and horticultural tools (5 demos).

Fig 1 Demonstration of improved farm tools and implements

Commercialization of farm tools and machinery

Through AICRP FIM and Revolving Fund Scheme, a number of improved tools and implements were commercialized in the NEH Region. To meet the local

requirements, the improved farm tools and implements (Fig 2) are being fabricated in the research workshop and supplied to different government and non-government organizations and individual farmers. The manually operated tools and implements include maize sheller, long handle weeders, cono weeder, wheel hoe, fruit harvester, groundnut decorticator, winnower, SRI row marker, adjustable row marker, seed drills and paddy thresher. Animal drawn implements fabricated are MB plough, light ridger plough and bund former. The implements worth Rs. 2, 44,305/- were fabricated and supplied during April, 2010 to March, 2011.

Pneumatic seed metering device for power tiller operated planter

A roller type pneumatic seed metering unit was designed and developed for picking up single seed. It was different from the previous design in the aspect of nozzle placement. In a common pneumatic planter, cells are drilled on a plate and another plate is used to maintain the vacuum. In this new design, nozzles were drilled on the periphery of a roller. The concept behind this invention was to lower the vacuum pressure requirement and reduce the multiple seed pick up and increase the accuracy in seed singulation. Initially the operational parameters of the roller will be standardized for maize then some other crops will be selected which are directly planted. This roller was made of cast iron to reduce cost as well as to increase the self life as cast iron does not rust easily. This unit is under testing for its performance.

Application of plastic in agriculture

Standardization of agro-techniques for cut flower production of gerbera in low cost polyhouse

Statistically designed experiments in two polyhouses were laid and data pertaining to vegetative growth, flower yield were monitored. Treatments were: Soil + FYM; Soil + Leaf mould; Soil + Sand; Soil + Leaf mould + Sand; Soil + FYM + Sand + Cocopeat; Soil + FYM + Perlite; Soil + FYM + Perlite + Vermiculite; Soil + FYM + Perlite + Vermiculite + Cocopeat; Soil + Leaf mould + Perlite + Vermiculite. Replications: 3; Plant density: 9 plants per m^2; plot size: 1 m^2. The most appropriate growing media identified was Soil + FYM + Sand + Cocopeat (T5) followed by Soil + FYM + Perlite + Vermiculite + Cocopeat (T6). Plant height was 40.66 cm in polyhouse in T5 followed by 32.33 cm in T6 as compared to 21.2 cm in open conditions. No. of leaves were 32 in T5 in polyhouse followed by 28 in case of T6 compared to 16 in case of open conditions. Leaf area was 302.83 cm^2 in polyhouse in T5 followed by 287.5 cm^2 in T6 as compared to 75.44 cm^2 in open. Flower size observed was 10.37 cm (diameter of flower) in case of T6 in polyhouse followed by 10.2 cm in T5 and 7.45 cm in open. Root density (nos. of roots / primary root length) was found to be 10.02 in T5 in polyhouse followed by 9.33 in T6 in polyhoude compared to 5.62 in open conditions. Root length obtained was 50 cm in case of T6 and 47 cm in case of T5 in polyhouse compared to 27 cm in open conditions.

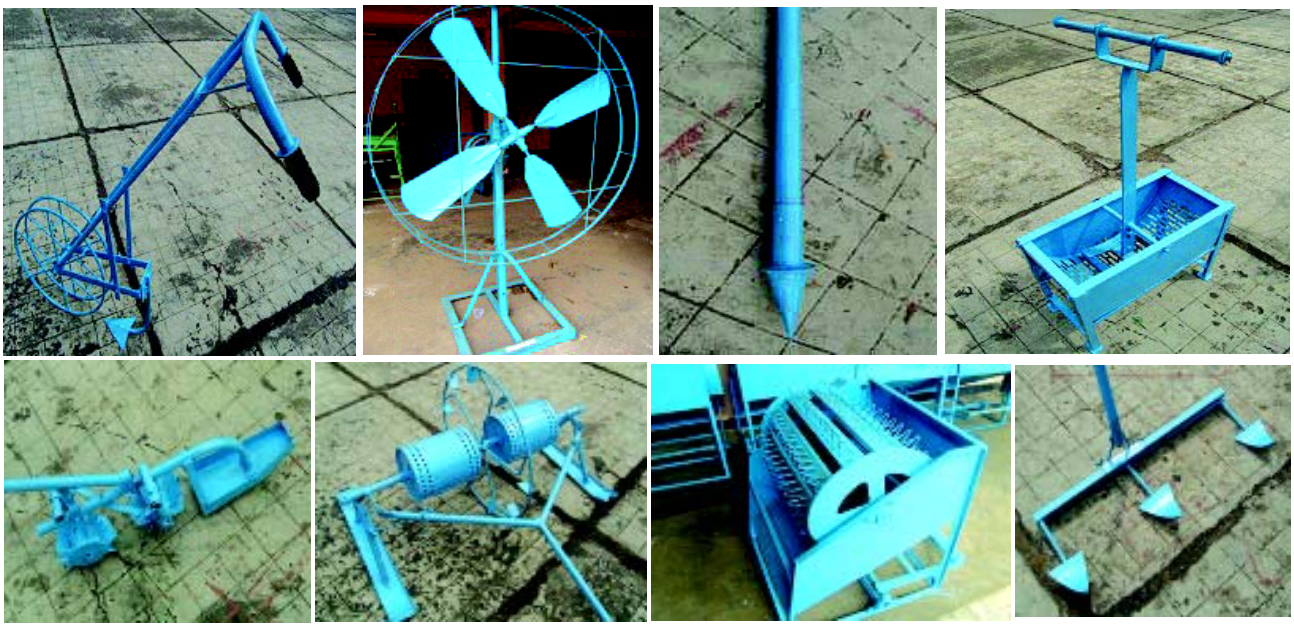


Fig 2 Tools and implements manufactured in the workshop

Powdery mildew was observed in August in polyhouse. Spray of Carbendazim @ 0.1% two times at 15 days interval controlled the disease. In open conditions leaf miner, powdery mildew and root rot were observed. The most suitable micro climate in polyhouse was observed when the air temperature was 22 to 24 ºC and relative humidity at 2 PM 70–80%. The B:C ratio for gerbera cultivation in the low cost poly house was obtained as 4.5:1.

Development of vegetative and structural management strategies for Eastern Himalayan Hilly Watersheds using field measurements and a physically based model

Considering the soil erosion problems associated with agriculture on sloping land, availability of infrastructure for measuring field data, and availability of meteorological and other collateral data, one small untreated watershed namely, Umroi watershed (MW) depicted in Fig 3 and two adjacent treated micro watersheds namely, WS1 and WS2, and eight research plots with different land use treatments were selected as the study areas. The study areas is located in Umsning block of Ribhoi district of Meghalaya state of India and lie between 91° 57' 31" and 91° 58' 37" E longitude and 24° 42' 32" and 24° 43' 42" N latitude. Toposheet number 78/O 14 of survey of India on 1:50,000 scale covers the entire study area. Location of the MW watershed is shown in figure 3. The area of the MW watershed is 239.44 ha and its elevation ranged from 900 to 1240 m above the mean sea level.

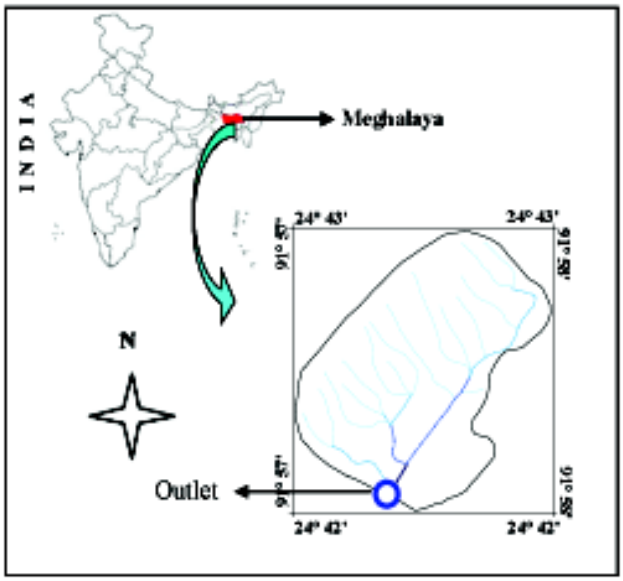


Fig 3 Location map of the MW watershed

In Eastern Himalayan region of India, traditional method of crop cultivation (*bun* agriculture) with tuber crops followed by upland paddy in the same *bun* field in the subsequent year is quite prone to soil erosion, yielding sediment at an average rate of 48.70 Mg ha^{-1} during the first year and 76.47 Mg ha^{-1} during the subsequent years. Graded bunding in the *bun* field at 1 m vertical interval along with water harvesting tank at lower reaches of the hill slope was noted to reduce sediment yield by 74.91%. Therefore, graded bunds along with the siltation tank at the downstream end are recommended for hill agriculture on steep slopes in high rainfall conditions to reduce soil erosion due to traditional cultivation along the slope.

In the present study, the land use and land cover map, and digital elevation model (Fig 4 & 5) were developed with the help of GIS tools. The WEPP model was tested for its efficacy to predict runoff and sediment yield in high rainfall and steep slope conditions of eastern Himalaya. The model was used to develop vegetative and structural control measures to enhance agricultural sustainability in the Umroi watershed representing the typical agro-climatic conditions of eastern Himalaya. Based on results of the study the following conclusions were drawn:

1. The WEPP model simulates runoff and sediment yield satisfactorily in high rainfall and high slope conditions of eastern Himalaya with Nash–Sutcliffe coefficients > 0.87 and percent deviations < ±5.23. Comparison between WEPP–simulated and measured values of runoff and sediment yield revealed that the model tends to under-predict the values of higher magnitude. Future studies on

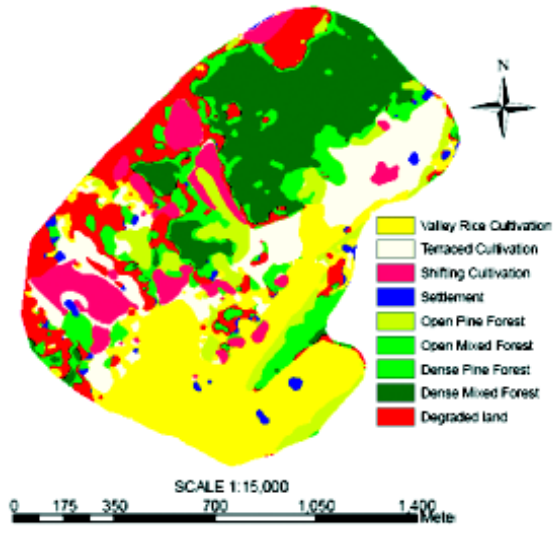


Fig 4 LU/LC map of the MW watershed

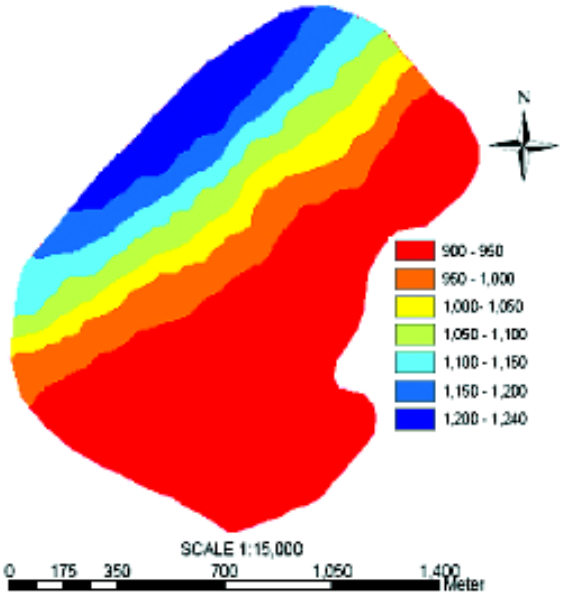


Fig 5 DEM of the MW watershed

subsurface components of the model parameters may be useful to enhance model predictability particularly in case of high subsurface flow.

2. Simulation results indicated that soybean and peanut crops have the potential to replace paddy crop in upland for reducing sediment yield by 29.60 and 27.70%, respectively.
3. Simulation results indicated that replacing existing tillage practice of spading with drill-no-tillage system and field cultivator may reduce the sediment yield by 13.14 and 21.88%, respectively.
4. Simulation results showed that installation of 26 porous rock-fill check dams and trash barriers in the Umroi watershed can reduce the sediment yield by 54.67%.
5. The results clearly indicated that crop and tillage management practices and structural controls individually are not capable of reducing sediment yield to less than 5 Mg ha^{-1}. Simulation of combinations of crop, tillage and structural control scenarios revealed soybean–drill-no-tillage–with structural controls combination has potential to reduce sediment yield by 78.40% i.e. to 4.74 Mg ha^{-1}. Maize intercropped with soybean may be adopted in place of upland paddy to reduce soil loss and to meet food and nutritional requirement.
6. The calibrated, validated WEPP model can be successfully used to develop crop and structural management strategies in high rainfall and high slope conditions of eastern Himalaya.

EXTENSION AND DISSEMINATION OF TECHNOLOGY

Intellectual property rights

According to the ICAR guidelines for Intellectual Property Management and Technology Transfer/ Commercialization, an effective three-tier mechanism for IP management and technology transfer has been laid down. The scheme shall adhere to a review and monitoring procedure and ensure to keep an up-to-date database of IP assets and other activities/records related to Intellectual Property Management and Technology Transfer/Commercialization in various ICAR institutes.

Patent related information

Patent was filed on "A process for producing tuity-fruity from chow-chow". Numbered as 1114/KOL/ 2010 dated 05/10/2010.

Patent sent for filing

"Development of a novel toxiod-vaccine for salmonellosis"

Number yet to be allotted

Information related to technologies for commercialization

1. Instant ginger candy: Process to develop candy
2. PCR based diagnosis for parasitic infection in animals : PCR based technique has been standardized for identification of species specific gastrointestinal parasites from faecal samples of cattle and goat.

Facilitation centre on medicinal plants

Training programmes, stake holders meet, medicinal garden, package of practices for cultivation of medicinal and aromatic plants, technical appraisal are the important aspects of the project. The main activity of the project was to impart training to the farmers (Fig 1).

More than 500 farmers and nursery growers have been trained since the start of the project. Some of the training programmes were conducted in collaboration with State and Central Government agencies and NGOs like Rural Resource and Training Centre (RRTC), Meghalaya Rural Development Society-Livelihood Improvement finance Company of Meghalaya (MRDS-LIFCOM); Bio-resource and Development Centre, BSI, Shillong.

Fig 1 Medicinal plant training in the village and a local healer displaying his herbal medicine

Fig 2 Director of the institute interacting with the trainees

A medicinal garden was developed where important medicinal plants were multiplied and maintained. The garden is equipped with polyhouse, shednet house etc. for raising seedling and cuttings. Emphasis is being given on 10 species of MAPs suitable for NEH region. Besides these, around 75 other species of medicinal plants are also maintained in the garden. Facilitation Centre provided the following quality planting materials to farmers.

- *Cymbopogon flexousus*
- *Cymbopogon winteranus*
- *Alpinia galanga*

Some special achievements under the projects are-

- Training Program conducted for nursery growers on raising quality planting materials for commercialization of medicinal and aromatic plants in Meghalaya.
- Compiled a catalogue and developed webpage on "Decision Support System on Medicinal Plants".
- Developed agro technique and gave training on *Aloe vera*, *Alpinia galanga* and *Curcuma longa.*
- Developed and maintained Herbal Garden with more than 75 species of medicinal and aromatic plants.
- Provided quality planting material to farmers.

Protection of plant varieties and farmers rights authority

ATIC facilitated in conducting Training cum Awareness programmes on Protection of Plant Varieties & Farmers Right Act where a good number of farmers were trained about their rights and how they can protect their plants which are unique to their locality/area.

Role of rural based institutions in technology dissemination

The survey conducted under the project revealed that most of such organizations (86%) were tribal based and structure and functions vary across different tribes. They were mostly endogenous and 85% of them were having top to down information flow. Generally, grapevine communication (92%) got strong impact among the female members of these organizations. Under the project, organisational set up and their functions, nature and type of linkages with other institutions, information flow analysis, suggested the ways and means to accelerate the dissemination of agricultural technologies and the role of women in decision making in rural institutions. The data were collected from Nagaland, Manipur and Meghalaya and covered 18 rural based organisations. It was found that all the organisations had properly designed organisational structure with delineated hierarchy. They all played gate keeper, facilitator and legitimiser roles. Some of the variables like achievement motivation, management orientation, risk taking ability were positively and significantly related with diffusion of the agricultural technologies. During reporting period the institute was visited by 955 people from 42 different organizations belonging to various categories such as students, farmers etc.

WATER MANAGEMENT

Residue management and conservation tillage in rice-based system

In the present study, four tillage and residue management practices *viz*., conventional tillage (residue removal), zero tillage for all the crops (residue

retention), zero tillage for *rabi* crops (residue retention) and reduced tillage (residue incorporation) in main plot along with two mulching treatments *viz*., no mulch and mulching with straw in *rabi* crops in sub-plots were evaluated in lowland rice (Figs 1-4). Zero tillage with residue retention produced the highest grain yield (4563 kg/ha) while, conventional tillage with residue removal recorded the lowest grain yield (4093 kg/ha). The grain yield obtained under reduced tillage with residue incorporation was also higher than conventional tillage with residue removal (Table 1)

Table 1 Growth, yield attributes and yields of rice as influenced by various tillage practices

Treatment	Chlorophyll index	Grain yield (kg/ ha)	Straw yield (kg/ ha)	Harvest index
Conventional tillage (Residue removal)	40.3	4093	6240	39.6
Zero tillage for all crops (Residue retention)	39.6	4563	6578	41.0
Zero tillage for *rabi* crops (Residue retention)	39.4	4188	6033	41.0
Reduced tillage (Residue incorporation)	39.5	4388	6776	39.3

Conservation agriculture in rice for enhancing resource use efficiency and crop diversification

An experiment was conducted with four main plot tillage treatments (conventional (*kharif*)-conventional (*rabi*), Furrow and Raised Bed (FRB) in *kharif* – FRB in *rabi*, conventional (*kharif*)- FRB (*rabi*) and conventional *(kharif*)-zero tillage (*rabi*), along with two sub-plots treatments (straw mulch and no mulch), to conserve natural resources, recycle residues and promote crop diversification for improving productivity and income (Figs 5-8). Results (Table 2) revealed the highest grain yield under conventional - zero tillage system followed by conventional – conventional and conventional- zero tillage. The straw yield was highest under conventional – zero tillage system.

Fig 1 Conventional tillage, residue removal

Fig 2 Zero tillage for all crops, residue retention

Fig 3 Zero tillage for *rabi* crops, residue retention

Fig 4 Reduced tillage residue, incorporation

Fig 5 Conventional - FRB

Fig 6 FRB - FRB

Fig 7 Conventional – Conventional

Fig 8 Conventional – Zero tillage

Table 2 Yield attributes and yield as influenced by various tillage practices

Treatment	Chlorophyll index	Grain yield (kg/ ha)	Straw yield (kg/ ha)	Harvest index
Conventional - Conventional	37.5	4250	6244	40.5
FRB – FRB	37.2	3850	5382	41.7
Conventional - FRB	32.9	4125	6378	39.0
Conventional – Zero Tillage	31.1	4750	7144	40.3
CD (*P*=0.05)	-	310	465	NS

Effect of *in situ* residue management on carry over soil moisture and crop growth under hill agriculture

An experiment was conducted to develop simple low cost technique of *in-situ* moisture conservation for raising second crop during winter season. Treatments consisting of conventional tillage, zero tillage in the main plot and residue management – control, Maize stalk cover (MSC), MSC + *Ambrosia* sp. @ 5t/ha, MSC + *Ambrosia* sp. @ 10 t/ha, MSC + *Ambrosia* sp. @ 5t/ha + Poultry manure, and MSC + FYM @ 10t/ha in sub plots were evaluated in maize-mustard cropping sequence (Fig 9). The grain yield of maize under zero tillage and conventional tilllage was statistically at par. However, there was significant

Fig 9 Crop performance under different residue management practices

effect of *in-situ* moisture conservation practices on performance of maize. The interaction effect between tillage and moisture conservation practices was significant. The highest grain yield of maize was recorded with MSC + Poultry manure + *Ambrossia* @ 5t/ha under conventional tillage followed by MSC + FYM 10t/ha under conventional tillage. The highest water use efficiency (WUE) followed the trend similar to that of grain yield (Table 3).

Evaluation of resources conserving option on productivity and water use efficiency (WUE) of maize - toria cropping system under terrace condition

The experiment was conducted to find out water use efficient maize-based cropping system for terrace situation. Treatments comprised of (A) conventional tillage and zero tillage in main plot and (B) intercropping/residue management - maize (residue removal), maize (residue retention), maize + soybean paired row (residue removal), maize + soybean paired row (residue retention), maize + groundnut paired row (residue removal), maize + ground nut paired row (residue retention), maize + *in-situ* green manure (residue removal), maize + *in-situ* green manure (residue retention) in sub plots (Fig 10). Results revealed that the maize + groundnut paired row (residue retention) recorded maximum MEY followed by maize + groundnut paired row (residue removal). The maximum WUE (42.9 kg/ha-mm) was recorded under maize + groundnut paired row intercropping along with residue removal under zero tillage (Table 4). The data on seasonal soil profile moisture has been presented in (Fig 11)**.** In general, the soil moisture status was marginally higher under residue retention compared to residue removal. Soil moisture did not show any trend up to 60 DAS, but thereafter, decreased gradually up to 90 DAS.

Table 3 Seed yield and water-use efficiency of maize under different tillage and residue management treatments

Treat.	Tillage Treatments (T)					
	Zero tillage	Conventional tillage	Mean	Zero tillage	Conventional tillage	Mean
	Seed yield (kg/ha)			Water-use efficiency (kg/ha-mm)		
M_1	3744	3638	3691	25.9	25.2	25.6
M_2	3916	4139	4028	27.1	28.7	27.9
M_3	4761	4333	4547	33.0	30.0	31.5
M_4	4971	5028	4999	34.4	34.8	34.6
M_5	4927	5344	5136	34.1	37.0	35.6
M_6	4894	5250	5072	33.9	36.3	35.1

Table 4 Maize equivalent yield and water-use efficiency as influenced by tillage and intercropping / residue management

Treat.	Tillage Treatments (T)					
	Zero tillage	Conventional tillage	Mean	Zero tillage	Conventional tillage	Mean
	Seed yield (kg/ha)			Water-use efficiency (kg/ha-mm)		
M_1	5147	4800	4974	30.9	33.1	32.0
M_2	4513	4700	4607	28.8	27.8	28.5
M_3	5149	5721	5435	36.8	33.2	35.0
M_4	5439	5667	5553	36.5	35.0	35.8
M_5	6260	6666	6463	42.9	40.3	41.6
M_6	6493	6467	6480	41.6	41.8	41.7
M_7	4853	4533	4693	29.2	31.2	30.2
M_8	4880	4533	4707	29.2	31.4	30.3

Maize + Soybean

Maize + Groundnut

Maize + *In-situ* green manure

Fig10 Maize crop under different tillage and residue management practices

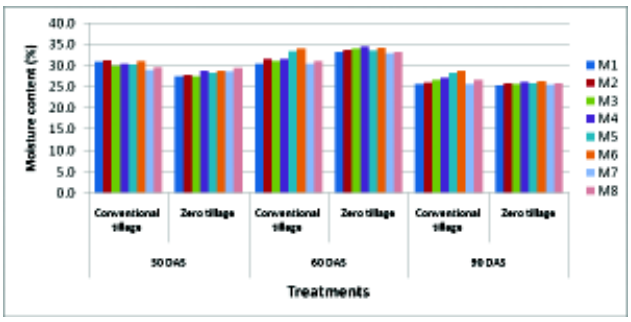


Fig 11 Profile moisture regime in residue management treatments under conventional and zero tillage during growth of maize crop

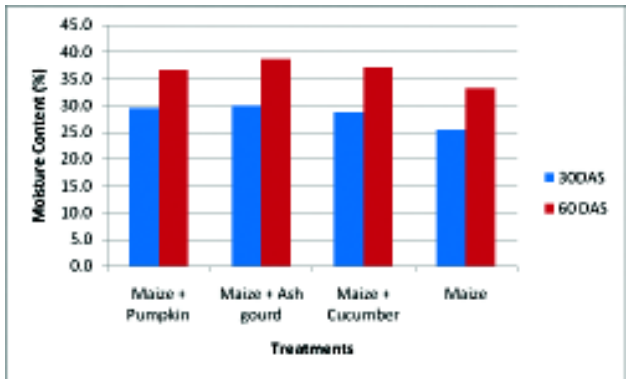


Fig 12 Moisture content (%) in 0-45 cm under various intercrops

Conservation measures through broad leaved vegetables and maize intercropping in terrace situation

Field experiments were conducted to evaluate three broad leaved vegetables *viz*., pumpkin, ash gourd and cucumber as intercrop in maize and compared with sole maize during *kharif* season. Results revealed that among the broad leaved intercrops, pumpkin as intercrop reduced grain yield of maize by 20% followed by cucumber by 13%. Maize intercropped with ash gourd was found as the best system for the terrace conditions of mid altitude of Meghalaya as this system recorded maximum soil moisture (Fig 12) and grain yield of maize (Table 5).

Efficient water management in strawberry through micro irrigation

An experiment was conducted to find out the efficient utilization of water through micro irrigation with and without mulching. Results revealed that the soil moisture content at 0-45 cm depth was generally higher under plastic mulch over straw mulch (Fig 13). Among the irrigation levels, highest soil moisture content was recorded under irrigation at 1.2 PET followed by 1.0 and 0.8 PET. In general, the yield attributes and berry yield was recorded higher under polythene mulch than straw mulch. The berry yield was recorded highest under 1.0 PET closely followed by 1.2 PET indicating the need for providing adequate

Table 5 Performance of maize as influenced by intercropping with broad leaved vegetables

Treatment	Chlorophyll Index	Grains /cob	1000 grain wt. (g)	Grain yield (t/ ha)	Straw yield (t/ ha)	Harvest Index
Maize + Pumpkin	27.6	379.3	290.5	3.45	5.04	39.4
Maize + Ash gourd	27.7	388.3	296.4	3.93	5.84	40.2
Maize + Cucumber	28.4	389.3	305.4	3.77	5.51	40.6
Maize sole	29.6	410.0	308.2	4.33	6.35	40.5

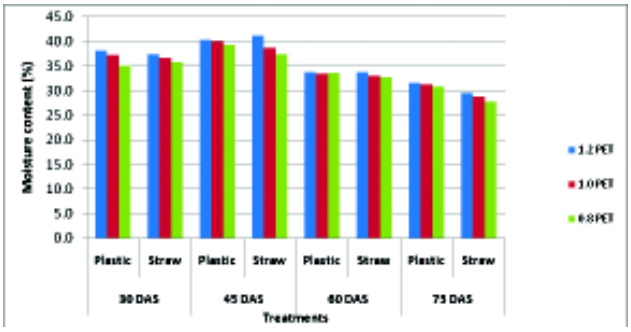


Fig 13 Moisture content (%) in 0-45 cm under different types of mulch in strawberry

water to the crop. Excess water over 1.0 PET is a waste especially under mulching (Table 6), the berry yield was also found to be best under 1.0 PET (Table 7).

Fig 14 Overview of experimental plots

Scaling-up of water productivity in agriculture for livelihood

The pilot project "Scaling up of water productivity in agriculture for livelihood through teaching cum demonstration" has been implemented at ICAR Research Complex for NEH Region, Umiam under Water Management division since 2007. Ever since the programme started, it has achieved good results in imparting trainings and demonstrations on various aspects of water management. It has also involved in up-scaling knowledge and upgrading skills of the trainers and farmers from the entire NEH Region. The farmers' and trainers' training were organized on various aspects of water management and multiple use of water as mentioned below:

- Community based rain water harvesting
- Water resource management for increasing agricultural productivity and improving livelihood of the farming community
- Water harvesting and its multiple use
- Efficient use of water resources under integrated farming system for improving livelihood of farming community
- Scaling of water productivity through soil health improvement.
- Soil and water conservation in different land forms
- Conservation and efficient management of water
- Integrated water management with special reference to rain water harvesting

Table 6 Effect of irrigation levels and mulching on performance of strawberry

Treatment	No. of berry/plant			Berry wt. (g)			Berry yield (t/ha)		
Irrigation levels (PET)	Plastic mulch	Straw mulch	Mean	Plastic mulch	Straw mulch	Mean	Plastic mulch	Straw mulch	Mean
0.8	17.0	15.3	16.2	165.7	156.3	160.6	5.71	5.24	5.48
1.0	20.1	16.8	18.5	192.7	184.5	188.1	6.13	6.01	6.07
1.2	23.4	17.0	20.2	211.2	195.7	203.1	6.03	6.02	6.03
Mean	20.2	16.4	-	189.3	178.3	-	5.96	5.76	-

Table 7 Effect of irrigation levels and mulching on quality of strawberry

Treatment	Specific gravity			Acidity (%)			Total sugar (%)		
Irrigation levels (PET)	Plastic mulch	Straw mulch	Mean	Plastic mulch	Straw mulch	Mean	Plastic mulch	Straw mulch	Mean
0.8	19.8	20.8	20.27	0.128	0.128	0.128	6.06	5.0	5.53
1.0	22.6	22.5	22.54	0.141	0.141	0.141	5.41	4.65	5.03
1.2	20.3	19.8	20.03	0.125	0.135	0.130	5.41	4.55	4.98
Mean	20.9	21.0	-	0.131	0.134	-	5.63	4.73	-

- Rain water management and system of rice intensification (SRI)
- Multiple uses of water for diversified cropping system, animal husbandry and fisheries

During the year 2010-2011, a total of 18 farmers training (50 farmers and 7 days duration for each training) and 4 trainers' training (25 trainers and 14 days each) programme was successfully conducted. These training programmes, both for farmers and trainers, were conducted in different states of North Eastern Region i.e. Meghalaya, Manipur, Tripura, Sikkim and Arunachal Pradesh. Out of 18 farmers training, 10 trainings were conducted at three different districts of Meghalaya, 4 trainings at Manipur, 2 at Tripura and 2 at Arunachal Pradesh. For trainers training programme, 2 trainings were conducted at ICAR Research Complex for NEH Region, Umiam, Meghalaya, one training at ICAR Research Complex, Manipur Centre, and one at ICAR Research Complex, Sikkim Centre. Pictorial view of some of the farmers and trainers training programme conducted at different centres are presented below (Figs 1 to 14):

Farmers training programme

Fig 1 "Integrated Farming System for Livelihood Security" at Mawkyrdep, Ri-Bhoi District, Meghalaya from 19th – 25th October, 2010

Fig 2 "Natural Resource Management Under Moisture Stress and Climate Change Scenario" at KVK Churachandpur from 10th – 17th August, 2010

Fig 3 "Community Based Rain Water Harvesting" at ICAR-RC, Manipur Centre, Lamphelpat, Imphal from 25th to 31st October, 2010

Fig 4 "Scaling-up of Water Productivity through Soil Health improvement" at Wahlang village, East Khasi Hills, Meghalaya from 14th – 20th Feb, 2011

Fig 5 "*In-situ* water management techniques in hill agriculture" at KVK, ICAR, Tura from 22nd -28th March, 2011

Fig 6 "Rain water harvesting and its efficient use for Agriculture" at ICAR RC, AP Centre, Basar from 25th - 31st March, 2011

Fig 7 "Integrated water management with special reference to rain water harvesting" at Tripura

Trainers training programme

Fig 8 "Integrated Watershed Management Approach for Livelihood Improvement" at ICAR-RC, Manipur Centre, Lamphelpat, from. 18th January- 2nd February, 2011

Fig 9 "Technology Interventions for Resource Conservation and Mechanization in Hill Agriculture" at ICAR Research Complex, Umiam, Meghalaya from 8th -21st February, 2011

Farmers' field visit

A number of farmers' field visit (Fig 10) were arranged as a part of the training programme in order to make the farmers aware of the different new technologies available at ICAR, KVKs.

Fig 10 Farmers visiting experimental fields on water

Demonstration at farmers' field

During each training programme, technologies on low cost rain harvesting structure (Jalkund), *in-situ* residue management for moisture conservation and mulching, roof water harvesting etc. were taught to the farmers for water conservation. The farmers however after being trained in the training, were very much interested with the different technologies and were ready to adopt and practice in their own field/ farm.

The following photos show the technologies adopted and practiced by the farmers of different villages (Figs 11-14)

Fig 11 Excavation of Jalkund in progress

Fig 12 Monitoring the Jalkund after the excavation

Fig 13 Farmers' participation during lining of Silpaulin

Fig 14 Jalkund filled with rain water Mawkhap village

Climate change impact and adaptation strategies in hill agriculture of Northeast India

The analysis of 29 years (1982-2010) annual rainfall data of Umiam revealed that the year 1998 was the most dry year (1808 mm) followed by 2006 (1828.7 mm) whereas, the year 1988 (3321 mm) was the wettest year. Abnormalities in rainfall distribution with comparatively lesser rainfall in July (planting season) and higher in Oct and Nov (harvesting) was also observed**.** The number of rainy days analysed for 29 years as per IMD (with rainfall more than 2.5 mm per day) was recorded the highest in the year 1997 with 146 days and lowest in the year 2008 with 106 days.

A close look at the long term (1983-2010) monthly rainfall distribution pattern (Fig 1) revealed that June and July are the wettest month and the period between May to October is the water surplus period compared to evapo-transpiration. January and February are the

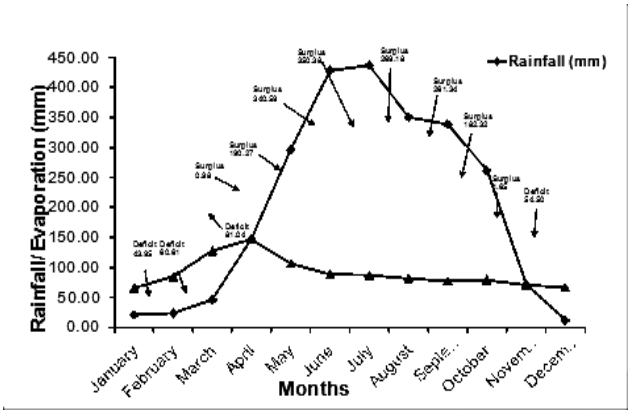


Fig 1 Monthly water flux of Umiam, Meghalaya

driest months and period between December to April are the water deficit periods considering rainfall and evapo-transpiration.

From the graph, it is evident that at Umiam, Meghalaya (Fig 2) the maximum temperature is increasing linearly over the years whereas, the minimum temperature showed a gradual decreasing trend. Thus there is a widening gap between maximum and minimum temperature.

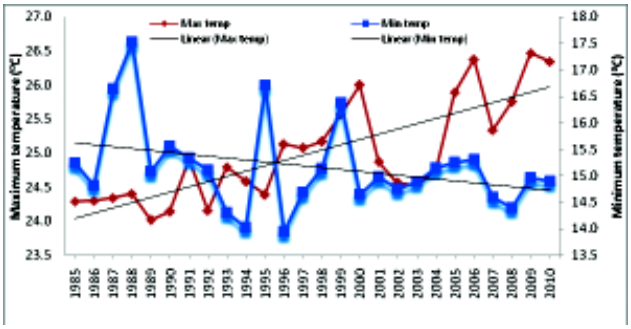


Fig 2 Long term annual variation of temperature at Umiam, Meghalaya

Following are the salient achievements under the project during reporting period-

- About 100 ITK's in relation to weather prediction, resource conservation, forecasting pest and disease problems including productivity were collected and compiled.
- Long term climate data of different ICAR NEH Centers were compiled and trend analysis carried out for temperature, rainfall, evaporation etc.
- *In-situ* residue management to carry over soil moisture in maize-toria cropping system through the retention of maize stalk cover and mulching with locally available weed *Ambrosia* species to form a double mulch and growing *toria* with residual moisture was found most effective practice for soil

moisture conservation that significantly increased soil moisture content, water use efficiency and increased productivity by more than 3 times compared to no residue management.

- Short duration rice varieties *viz*., Vivek dhan 82 and IET 20957 was identified for late planting (upto mid August) to overcome early season drought problem.

Crops like rice, maize and cabbage were grown under ambient and elevated temperature (1.5 ± 0.25^0C) and growth and yield parameters were recorded. Rice, maize, cabbage and cauliflower produced marginally higher yield under elevated temperature. However, the ascorbic acid content in cabbage was lower under elevated temperature. In general, the incidence of pest and disease problem in rice was higher under elevated temperature.

SOIL HEALTH MANAGEMENT

Impact of *jhum* cycles and land use practices on soil health in Manipur

Traditional farmers of North Eastern region of India widely practice shifting cultivation in undulating landscape using long (>10 years) fallow periods. However, in the recent past, shifting cultivation has become unsustainable due to reduction in fallow period to 2-3 years, resulting in large scale soil degradation and ecological imbalances. This study examined the relationships between length of fallow cycles (0-1, 3-4, 5-7, 8-10 and 12 years), different improved/alternate land use practices (e.g. intermittent agriculture, agro forestry and abandoned *jhum* land) and soil health in *jhum* lands of Chandel district of Manipur (Figs 1a, 1b, 2 & 3). Results revealed that in all the land use systems, short term fallow cycle (3-4 years) resulted in significant reduction in soil pH, exchangeable bases, availability of major nutrients (N, P, K, Ca, Mg and S), organic carbon concentration, soil water retention and availability, microbial biomass carbon, dehydrogenase activity etc. Al^{3+} saturation in clay complex and susceptibility of soil to erosion increased many folds. However, increase in fallow cycles from 5-7 years onward resulted in regeneration and restoration of soil health except in intermittent agriculture where irregular crop-fallow rotation was practiced. Among the land uses, abandoned *jhum* lands (under pastures) for 5-7 or more years (Fig 2) were relatively stable in restoring soil health due to efficient surface coverage, internal regulation and lack of anthropogenic intervention. Eight to ten years old Agro-forestry system (Fig 3) involving soil enriching pulse crops (*Vigna* spp., *Cajanus* spp., *Glycine max*) and deep rooted nitrogen fixing leguminous trees (*Parkia, Albizia* etc.) restored the soil health considerably and rapidly, even better than 25 years old undisturbed secondary *Pinus kesiya* dominant forest ecosystems. Thus, adoption of appropriate land uses in conjunction with optimum fallow cycles, preferably 5-7 years or more with proper combination of soil enriching crops and trees complimentary to each other have the potential to restore the soil health and sustain the production in *jhum* lands of north-eastern regions of India.

Soil amendments and fertilizer on crop productivity and soil health-an integrated approach

The residual effect of agricultural lime used with different combinations of fertilizers and organic manures (e.g. FYM, poultry manure, pig manures and weed biomass) in acid soil was found to be significant.

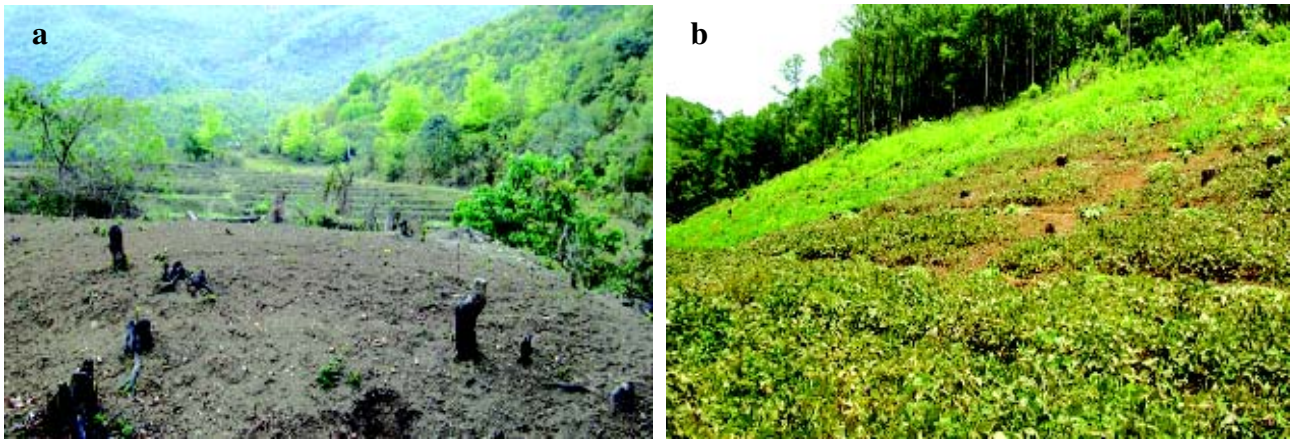


Fig 1 (a) Freshly cleared vegetation and (b) Cowpea (*Vigna unguiculata*) in shifting cultivated area of Chandel District, Manipur

Fig 2 Abandoned *Jhum* land in shifting cultivated area of Chandel District

Fig 3 Agro-forestry system adopted in shifting cultivated area of Chandel district, Manipur

Turmeric

There was significant effect of treatments (Fig 4) on rhizome yield (fresh weight) of turmeric. Application of 100% recommended dose of NPK, FYM (@ 5t ha^{-1}) and poultry manure (@ 2.5 t ha^{-1}) either alone or in combinations, increased the rhizome yield significantly to the tune of 50-129% over absolute control (4.13 t ha^{-1}) (Fig 5). Rhizome yield increased by over 300% (17.8 t/ha) when weed biomass (*Ambrosia* spp.*)* was used as mulch along with 100% recommended dose of NPK. However, with the same treatment combination, an additional increase of 150% (rhizome yield: 22.8 t/ha) was obtained when applied in plots where lime (@ 20% LR) was used in the previous year. Thus, the residual effects of lime (once applied in every two years @ 20% LR) can be exploited through application of 100% recommended dose of NPK along with 1.5 t ha^{-1} of weed (*Ambrosia* spp.) biomass for getting higher productivity of turmeric in the acid soils of Meghalaya.

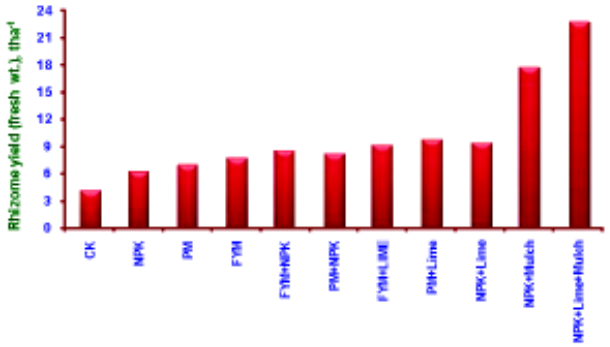


Fig 4 Effect of amendments (organic and inorganic) and fertilizer on turmeric productivity

Fig 5 Absolute control

Fig 6 Lime +100%NPK+ Weed biomass

Ginger

Rhizome yield (fresh weight) of ginger under different treatments varied between 3.5 and 9.8 t ha^{-1} (Fig 7). Sole application of FYM (@ 5 t/ha), poultry manure (@ 2.5 t/ha), lime (@ 20% LR) and 100% NPK could produce 30-65% higher rhizome yield than the absolute control (3.5 t ha^{-1}). When weed biomass (*Ambrosia* spp. @ 1.5 t ha^{-1}*)* was added either with poultry manure or FYM or Lime, rhizome yield

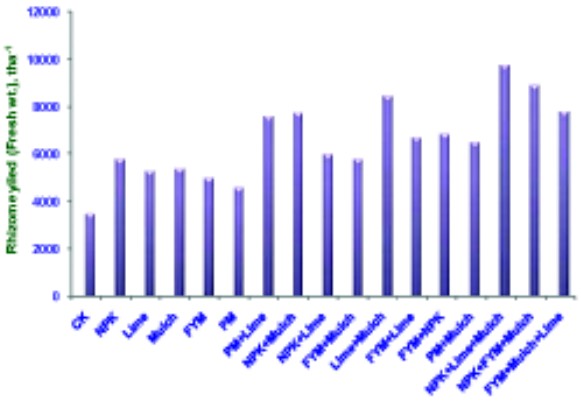


Fig 7 Effect of amendments and fertilizer on ginger productivity

increased (85- 141% over control). However, the maximum yield of rhizome (9.8 t ha^{-1}) was obtained when lime @ 20% LR, 100% NPK and weed biomass was applied in integrated manner. Thus, inclusion of weed biomass and its proper combination with lime @ 20% LR and fertilizers/organic manures can substantially increase the productivity of ginger in the acid soils of Meghalaya.

Soil-Plant-Animal continuum in relation to mineral status and fertility of dairy cattle in Meghalaya

In order to establish a correlation between mineral status in soils and plants, and its effect on nutritional status and fertility of dairy animals in Meghalaya, soil samples from the three districts *viz*. East, West and South Garo Hills, were collected, processed and analyzed for its mineral contents. Correlation of the soil mineral contents with that in plant (fodder) and blood samples are being developed. Samples from the remaining four districts of Meghalaya are also to be collected and analyzed shortly; this will give a complete understanding of the soil-plant-animal health correlation at state level.

AGROFORESTRY

Evaluation of agroforestry systems in the mid hills of Meghalaya

Six fruit trees peach (*Prunus persica*), guava (*Psidium guajava*), Assam lemon (*Citrus limon*), pear (*Pyrus communis*), plum (*Prunus domestica*), sweet orange (*Citrus sinensis*) were evaluated in the horti-agri system for their productivity in the slopy terrain. Maize (var. RCM 1-1) was cultivated in the inter row and inter terrace spaces of the tree species. Out of these six species, three were bearing fruits and other three i.e. pear, plum and sweet orange have not yet started bearing fruits. Therefore, performance of the three systems that produced fruits is summarized (Table1).

Table 1 Economic productivity of the different horti-agri systems

Landuse	Fruit yield (t/ha)	Maize yield (t/ha)	Total yield (MEY)* (t/ha)	Economic return (Rs/ha)
Assam lemon + Maize	2.1	0.67	4.87	48,700
Peach + Maize	5.2	0.53	5.73	57,300
Guava + Maize	3.3	0.58	5.43	54,300

*MEY=Maize equivalent yield

It was observed that peach + maize was the most remunerative followed by guava + maize and Assam lemon + maize in the mid hills of Meghalaya. Reduction in yield of maize was maximum under peach as compared to the other tree crops. Among the three fruit trees, peach performed best producing highest fruit yield (Fig 1).

Fig 1 Fruiting of peach in the agroforestry systems

Evaluation of *Parkia roxburghii* collections from the north eastern hill region

Seeds were collected from seven different places covering the states of Mizoram, Nagaland, Manipur and Meghalaya. After six years of transplantation, the collection Kezanglwa recorded highest plant height (4.37 m) followed by Kanpui (4.0 m) and Kanpokpi (3.6 m). However, the maximum diameter was recorded by Kezanglwa (7.57 cm) followed by Bilkhawthlir (7.31 cm) and Kanpui (7.18 cm).

Collection and evaluation of *Mucuna pruriens* germplasm

Seeds were collected from individual plants of *Mucuna pruriens* from the north eastern hill region and few other states of the country such as Assam, West Bengal, Uttarakhand, Rajasthan, and Uttar Pradesh. Seventy nine representative collections were evaluated for different growth and yield traits against five checks. These five checks include three (IC 385298, IC 83195, IC 385925) from National Bureau of Plant Genetic Resources, New Delhi, one (IIHR MP-5) from Indian Institute of Horticulture, Bengaluru and one local collection (MGH-11) from Meghalaya. Wide range of variability was observed in all the traits evaluated. The most promising collections along with their phenotypic character for some of the most important traits such as early flowering (less than 55 days), inflorescence length (more than 50 cm), 100 seed weight (more than 90 g), number of clusters per plant (more than 90 clusters per plant) and seed yield per plant (more than 500 g per plant) are presented in Table 2. The coefficient of variability for these traits varied from 27 % (days to flower initiation) to 75 % (seed yield per plant). Highest seed yield per plant was recorded in the collection UPMP-11 (792 g) followed by WBNMP-3 (667 g), UPMP-2 (604 g), NGLMP-25 (572 g), WBNMP-6 (532 g) and WBNMP-7 (512 g). Seed yield from all these collections were higher than that of the best check, IC 385298 (503 g). All the collections were evaluated for resistance against *rust* disease. Nine collections such as ASMMP-30, NGLMP-25, NGLMP-28, UPMP-2, UPMP-11, WBNMP-1, WBNMP-3, WBNMP-6 and WBNMP-7 were resistant against *rust*. Out of the 79 collections evaluated, 32 promising ones were submitted to National Bureau of Plant Genetic Resources, New Delhi to get accession number.

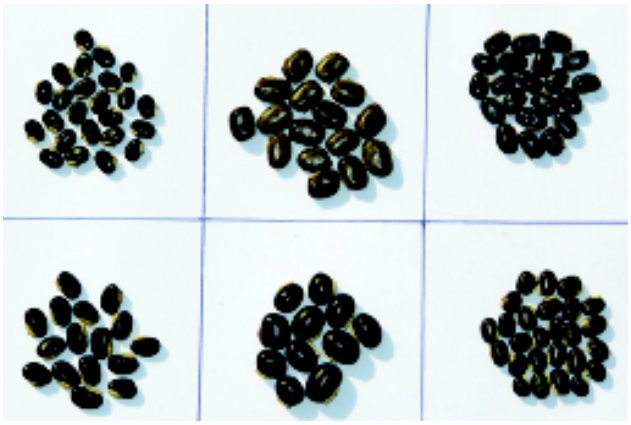


Fig 2 Variability in the seed morphology of *Mucuna pruriens* collections

Table 2 Range, mean and CV of important agro-morphological traits of promising genotypes of *Mucuna pruriens* and their characterization

Traits of importance	Range	Mean	C.V. (%)	Collection Name	Phenotypic characteristics							
					Days to flower initiation	Inflorescence length (cm)	Pod length (cm)	Seeds per pod	Pods per cluster	100 seed weight (g)	Number of clusters per plant	Seed yield per plant (g)
Days to flower initiation (< 55 days)	48-190 days	94 days	27	UKDMP-7	48	9.6	7.90	4.2	3.8	40.75	2	3.1
				RJSMP-4	52	26.2	8.01	5.2	8.6	33.40	52	231
				RJSMP-10	52	5.9	8.64	6	4.2	34.34	22	123
				ASMMP10	53	29.4	7.35	5.2	13.2	22.28	54	215
				RJSMP-15	53	8.4	8.64	5.2	5.8	34.55	48	168
				RJSMP-7	55	25.7	8.01	5.2	8.6	37.69	68	350
Inflorescence length (> 50 cm)	3.25 – 51.7 (cm)	25 cm	47	NGLMP-41	105	50.5	7.43	4.4	9.8	18.72	14	72
				NGLMP-25	123	51.7	7.18	5.6	16.8	24.38	62	572
100 seed wt (> 90 g)	16-95 (g)	29 g	55	UPMP-4	75	6.7	9.58	5	4.2	95.00	15	91
Number of clusters per plant (>90)	2-99	43	45	SKMMP-2	87	20.0	7.00	4.8	8.6	24.30	97	334
				WBNMP-6	122	37.0	7.10	4.9	8.4	31.10	99	531
Yield per plant (> 500 g)	35-792 (g)	201 g	75	NGLMP-25	123	51.7	7.18	5.6	16.8	24.38	62	572
				UPMP-2	107	12.3	6.82	5	7.4	61.67	16	604
				UPMP-11	67	5.3	7.01	5.7	8.0	70.54	45	792
				WBNMP-3	97	40.6	7.63	5.1	12.0	31.13	77	667
				WBNMP-6	122	37.2	7.10	4.9	8.4	31.00	99	532
				WBNMP-7	121	35.2	7.40	4.8	14.2	31.00	38	512
Mean value of checks		Check-1		IC 385298	62	8.3	12.70	5.4	3.5	187.5	19	503
		Check-2		IIHR MP-5	59	3.3	11.80	5.1	3.3	150.0	22	392
		Check-3		IC 83195	58	13.3	10.10	5.5	5.2	50.10	79	446
		Check-4		IC 385925	57	3.5	13.60	5.5	3.0	201.0	21	390
		Check-5		MGHMP-11	108	44.8	7.60	5.6	11.4	24.00	37	179

Cluster analysis was also carried out based on the quantitative traits which revealed some patterning and minor grouping of collections from geographically contiguous locations. However, molecular analysis would reveal more clear picture on the clustering pattern.

Tree borne oil seeds: Evaluation of performance of *Jatropha curcas* provenances

Plantation was raised from the seeds collected from six provenances of the north eastern states and seeds received from different participating centers in the project on tree borne oil seeds. Highest seed yield was obtained from the PJS-2 (495 kg/ha) followed by Mawhati (485 kg/ha) and PJS-1 (475 kg/ha). Oil content (Table 3) was maximum for Mawhati (40.67 %) followed by Tura (39.67 %) and TFRI-2 (39.46 %).

Fig 3 *Jatropha curcas* provenances evaluated at the institute farm

Screening of *Jatropha* collections against powdery mildew

Thirteen provenances *viz*. TFRI 1, 2, Mawlasnai, Brynihat, PJS 1-2, Nagpur, Mendipatthar, Rahuri, PDKV Akola 2, Mawhati, Dimapar and Tura were screened against powdery mildew. Provenances from Mawlasnai and Brynihat were susceptible to powdery mildew based on single year observation. Berries and petioles were also found to be heavily infected.

Development of self sustainable integrated farming system through crop livestock integration.

Composite fish culture was practiced and fish farming was integrated with different animal components. Productivity of five different agroforestry models was estimated. Among these models, fish productivity was recorded highest in crop-fish-dairy-vermicompost-horticulture-hedgerow system (1.62 t/ha). Among the livestock, daily weight gain was recorded highest in pig (0.28 kg/day). Highest meat production was from crop-fish-poultry-multipurpose trees (0.64 t/ha). Among these five models, crop-fish-poultry-multipurpose trees model was the most profitable.

Crop production

Ginger and turmeric were grown with multipurpose trees *Alnus nepalensis* and *Gmelina arborea*, respectively. Yield of ginger was 11.82 t/ha and turmeric was 14.01 t/ha. In the *kharif* season, maize,

Table 3 Growth and development traits of different provenances of *Jatropha curcas*

Name of provenance	Plant height (cm)	No. of Primary branches	No. of secondary branches	Canopy (cm)	Collar diameter (cm)	Seed yield (kg/ha)	Oil content (%)
Rahuri	260	6	7	157	6.64	142.5	38.78
TFRI 2	373	6.2	4	115	8.52	100	39.46
TFRI 1	314	6.4	11.2	181	7.36	145	35.32
PDKV	185	4.4	3.8	105	3.16		
Akola 2						37.5	34.45
PJS 2	367	7	15.2	230	8.48	495	34.64
PJS 1	301	5	14	261	7.20	475	37.46
Nagpur	248	6.6	10.8	172	6.36	180	31.94
Byrnihat	268	7.2	15	196	6.20	365.5	37.12
Mawhati	259	7	11.6	166	6.46	485	40.67
Mawlasnai	228	6	5.4	146	5.92	60	35.33
Tura	249	5	9.6	162	6.62	47.5	39.67
Mendipathar	250	6.8	8.8	141	6.70	107.5	36.00
Dimapara	264	6.8	9.8	186	7.64	77.5	37.00

upland paddy and lowland paddy were grown. The productivity of maize, upland paddy and lowland paddy was 3.21 t/ha, 1.95 t/ha and 2.83 t/ha, respetively. In *rabi* season toria, cabbage, cauliflower, knoll-khol and carrot ware grown and productivity of these crops were recorded to be 0.49 t/ha, 10.71 t/ha, 10.40 t/ha, 2.46 t/ha and 2.34 t/ha, respectively.

Rate of decay of leaf biomass of different hedge row species

Experiment was conducted to evaluate the rate of decay of five different hedge row species *viz*., *Flemingia macrophylla, Crotolaria tetragona, Indigofera tinctoria, Tephrosia candida* and *Canjanus cajan*. To estimate decay rate, nylon mesh bag technique was used. Seven samples of each species were taken out after 15 days, 30 days, 75 days, 135 days and 195 days. Decay rate was maximum in *C.tetragona* (15.5 per cent left after 15 days of incorporation) and *I.tinctoria* (17.95 per cent left after 15 days of incorporation). Decay rate was slowest in *F.macrophylla* (61.65 per cent remained after 30 days of incorporation) and in all other species more than 60 percent biomass decayed after 30 days of incorporation. The 't'-half (on average year basis) varied from 0.0363 in *C.tetragona* to 0.1338 in *F.macrophylla*. Based on the decay constant, it appeared that *C.tetragona* is a better hedge row species followed by *I.tinctoria*, *T.candida*, *C.cajan*, and *F.macrophylla*.

Production of maize and toria under hedge row intercropping

Leaf biomass of two hedge row species was pruned and incorporated in the soil twice a year to supplement nutrients. First pruning was done in the month of February and second pruning was done in the month of September. Total leaf biomass production was estimated for *Flemingia macrophylla* and *Indigofera tinctoria* and it was recorded to be 2.6 t/ha and 1.3 t/ha, respectively. Pruning was done twice a year and pruned biomass was incorporated in the soil to supplement nutrients. First pruning was done during Feb-March, 2010. Maize was grown as Pre-*kharif* crop. Fertilizers were applied @ 75:60:40 NPK along with poultry manure @ 3.3 t/ha. Total yield of maize was recorded to be 3.21 t/ha. Leaf biomass was pruned again in the month of September and incorporated in the soil. Toria was sown in the last week of October. Fertilizers were applied @ 60:80:40 NPK. Total yield of mustard was recorded to be 0.79 t/ha.

BIODIVERSITY

Biodiversity of plant pathogens in NEH Region

Under a project on biodiversity of plant pathogens, few new reports i.e. *Cladosporium oxysporum* on *Prunus nepalensis*, *Podosphaera* sp. on *Coreopsis* sp. have been made, many diseases have been documented, and Institute herbarium (ICARHNEH, ICAR Herbarium for North eastern hills) is being maintained and enriched. *Rhizoctonia solani* anastomosis group AG 2–2 IIIB was identified on *Canavalia ensiformis*, *Sechium edule*, *Glycine max* and *Dolichos lablab*, AG 1–1A on *Zea mays*, AG 4HG-II on a weed, *Galinsoga parviflora*. True identity of powdery mildew pathogens on citrus, tomato, sowthistle and papaya has been established using light and scanning electron microscopy. Transmission electron microscopy has also been used for viral disease. Molecular characterization of fungal pathogens is also being done. Diseases of plants in medicinal garden are being investigated.

MUSHROOM

Strain evaluation of oyster mushrooms (*Pleurotus sajor caju* and *P. florida*)

Five strains of *Pleurotus sajor caju* were tested. Strain codes P6 and P9 recorded the highest yields *viz*. 91.4 and 87.2 kg /kg of dry paddy straw, respectively. Of the five strains of *P. florida* tested, the strain P1 gave the highest yield i.e.80.6 kg/ kg of dry paddy straw.

DISEASES

A green mould (*Trichoderma* sp) disease was recorded on paddy straw substrate containing mushroom bags. The disease intensity (DI) was lowest (0.28) on 1-9 scale in *P.sajor caju* strain code P7 and P9. The highest DI 3.05 was noted in P6. Strain codes P8 and P10 had DI 0.35 and 2.13, respectively. The disease could be managed with dusting of agricultural lime powder over affected portions of straw.

INSECT PESTS

Fruit fly is not a pest, but it was noticed on mushroom crop for the first time (Fig 1)

Fig 1 Fruit fly on mushroom

AGRICULTURAL ECONOMICS AND STATISTICS

Economic dynamics of changes in *jhum* system in North Eastern Hills Region

The comparative study of land use pattern, cropping pattern and productivity of three selected districts namely North Sikkim (Sikkim), Dhalai (Tripura), East Garo Hills (Meghalaya) and economics of *Jhum* vs. Settled cultivation was analyzed and compared.

North Sikkim districts having 4.93% area under irrigation as compared to the state average of 10.57%. This indicates that the district is mainly dependent on rain fed farming (Table 1). Area under forest in North Sikkim is about 13.24% in compared to the 13.76% of state level which is very low as compared to the other hilly states. The cardamom is the main source of income in North Sikkim. Area shared by this crop is 37.51% compared to the 16.38% of the area occupied by this crop in Sikkim State. It indicates that the farmers are mostly depended on cardamom crops and livelihood of the farmers is influenced by the success of the cardamom. Share of cereals crops in total cultivated area in North Sikkim district is estimated to be 28.76% as compared to the state average of 33.59% (Table 2). The district is more deficit of the food requirement in comparison to the Sikkim state.

Table 1 North Sikkim Vs Sikkim State land use pattern (2006-07)

Land type	Area (ha)			
	North Sikkim	% of total area	Sikkim state	% of total area
Irrigated land	886.97	4.93	12643.23	10.57
Unirrigated land	3959.84	22.00	39304.49	32.87
Non Agri. land	1903.13	10.57	9966.67	8.34
Forest/Jungle/Bushes	2383.77	13.24	16448.85	13.76
Cardamom field	6752.15	37.51	19587.91	16.38
Grass land	63.29	0.35	4144.77	3.47
Barren land	1023.01	5.68	8817.26	7.37
Uncultivated fallow land	1030.21	5.72	8661.61	7.24
Total	18002.37	100.00	119574.79	100.00

Productivity of cereals crops including maize is around 1258.35 kg/ha against that state average of 1509.76 kg/ha. The productivity of all crops except fruit crops was found lower when compared to state average.

Table 2 Area (000 ha) of important crops in North Sikkim and Sikkim (2006-07)

Crops	North Sikkim	Percentage	Sikkim	Percentage
Cereals	4.49	28.76	68.66	33.59
Pulses	0.08	0.51	5.96	2.92
Oil seeds	0.96	6.15	8.97	4.39
Fruits	0.15	0.96	8.99	4.40
Vegetables	0.88	5.64	9.82	4.80
Potato	0.36	2.31	7.56	3.70
Spices	4.12	26.39	19.81	9.69
Total	11.04		129.77	

Table 3 Yield (kg/ha) of important crops of North Sikkim and Sikkim State (2006-07)

Crops	North Sikkim	Sikkim
Cereals	1258.35	1509.76
Pulses	1250.00	914.44
Food grains	1258.20	1462.22
Oil Seeds	729.17	812.71
Fruits	1052.00	1489.00
Vegetables	12981.00	13911.00
Potato	3956.00	4411.00
Spices	388.00	2058.00

The productivity of all crops except fruit crops was found lower in compared to state average. The spice crop, cardamom is main source of the farmers' livelihood. The average yield realized by the farmers is very low at 388 kg/ha as compared to the state yield of 2058 kg/ha which needs to be addressed to enhance the overall productivity of the spices in the district.

Coefficient of variations of important crops in North Sikkim and Sikkim State

Coefficient of variation is one of the important indicators to access the variation over the periods for formulating policy measure for sustainable agriculture development. Spices are the main source of livelihood of farmers in Sikkim. The coefficient of variation in the area of spices crop in the North district was estimated to be 30.62 % in compared to the state average of 25.50 during the period 2004 to 2007 (Table 4). The data indicates that the coefficient of variation in the spices crops was found highest in the spices of North Sikkim which was estimated 30.62 as against 25.5% of the state as whole. The higher fluctuation in yield was observed due to occurance of disease in cardamom crops and ginger.

Table 4 Coefficient of variation in yield of important crops of North Sikkim and Sikkim

	Yield (kg/ha)	2004-2005	2005-2006	2006-2007	CV
North Sikkim	Total fruits	825.00	860.00	1052.00	13.40
	Total vegetables	4221.00	4233.00	4097.00	1.80
	Total potato	3247.00	3293.00	3956.00	11.34
	Other root & tuber crops	3363.00	3369.00	4580.00	18.59
	Total spices crops	223.00	252.00	388.00	30.62
Sikkim	Total fruits	1482.00	1483.00	1489.00	0.26
	Total vegetables	4625.00	4633.00	4580.00	0.62
	Total potato	4345.00	4350.00	4411.00	0.84
	Other root & tuber crops	4362.00	4367.00	4681.00	4.09
	Total spices crops	1262.00	1495.00	2058.00	25.50

A comparative study of important agricultural crops in Dhalai district of Tripura is presented in Tables 5 and 6. The result indicated that the share of rice crop in the total crop area was estimated to be 85.18% as compared to the state average, which was worked out to be 91.69% which indicates that rice is the major crop, although the area under rice cultivation is marginally less in Dhalai district.

Table 5 Comparative study of area (ha) under important crops in Dhalai district and Tripura (2007-08)

Crops	Dhalai	Percentage	Tripura	Percentage
Rice	28752	85.18	252897	91.69
Maize	533	1.58	2123	0.77
Wheat	238	0.71	1023	0.37
Pulses	915	2.71	5361	1.94
Arhar (Tur)	326	0.97	1221	0.44
Groundnut	304	0.90	679	0.25
Sesamum	509	1.51	1776	0.64
Rape seed & Mustard	313	0.93	1451	0.53
Potato	705	2.09	5800	2.10
Mesta	329	0.97	949	0.34
Cotton	533	1.58	1109	0.40
Jute	68	0.20	458	0.17
Total	33525	99.32	274847	99.60

The pulses, potato and cotton are the major crops in Dalai District and the share of this crop under cropping system ranges 1.85% to 2.9%, which is more or less similar to the state average baring pulses area, which is marginally higher at state level. The productivity of all major crops of the district is almost similar except groundnut, sesamum having lower yield as compared to the state average. The average yield of rice in Dalai district was estimated to be 2228 kg/ha as compared to the state average of 2532 kg/ha (Table 6).

Table 6 Comparative study of productivity (kg/ha) of major crops of Dhalai and Tripura (2007-08)

Crops	Dhalai	Tripura
Rice	2228	2532
Maize	977	1001
Wheat	1941	1847
Pulses	604	652
Arhar (Tur)	742	722
Ground nut	928	1012
Sesamum	406	505
Rapeseed & Mustard	754	732

The productivity of all major crops of the district is almost similar except groundnut, sesamum having lower yield when compared to the state average.

Table 7 Comparative study of land use pattern in East Garo Hills and Meghalaya for the year 2006-07 (area in ha)

Particulars	East Garo Hills	Land use pattern in East Garo Hills (%)	Meghalaya	% land use pattern in Meghalaya
Forest	124797	41.42	944108	36.81
Area under non-agri uses	5689	1.89	90910	3.54
Barren and uncultivated land	4712	1.56	136029	5.30
Land under miscellaneous tree crops and groves etc.	23409	7.77	159752	6.23
Cultivable waste land	43165	14.33	435000	16.96
Fallow lands other than fallows	21190	7.03	163168	6.36
Current fallows	4949	1.64	61358	2.39
Net area sown	31389	10.42	236755	9.23
Area sown more than ones	5289	1.76	50419	1.97
Total crops area	36678	12.17	287194	11.20
Total	301267	100.00	2564693	100.00

The percentage irrigated area under net area sown in East Garo Hills is 22.49% as compared to 24.02% of the state (2006-07). Net area sown in East Garo Hills is 31389 ha which occupies 10.42% of the total district area as compared to 236755 (9.23%) of the state. In East Garo Hills, cereals occupy 49.31% area when compared to the state level (48.57%).

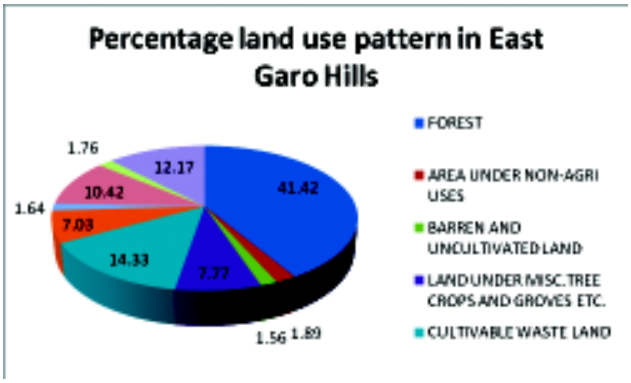


Fig 1 Percentage land use pattern in East Garo Hill

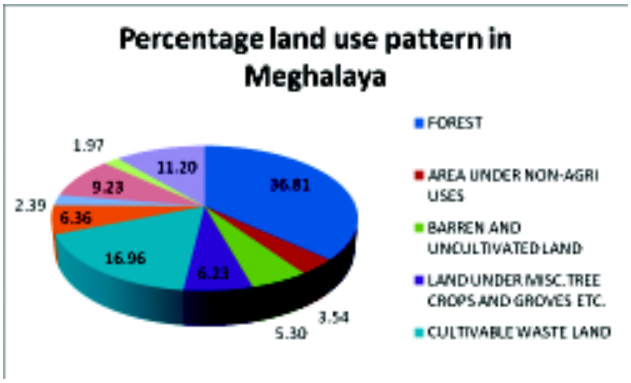


Fig 2 Percentage land use pattern in Meghalaya

Table 8 Comparative study of land use pattern in East Garo Hills and Meghalaya for the year 2006-07 (area in ha)

Particulars	East Garo hills	Meghalaya
Geographical area	260300.00	2242900.00
Reporting area	259300.00	3337100.00
Gross irrigated area	9817.40	72015.24
Net irrigated area	7060.10	56869.38
Net area sown	31389.00	236755.00
% irrigated sown area	22.49	24.02

The comparative study on share of crops is presented in the Table 9. In East Garo Hills and Meghalaya the result indicated that there was not much difference in the cropping pattern and major share of the crops were occupied by cereals, fruits and vegetables. However, the spices crops had the higher (13.23 %) share as compared to 5.11% in the state of Meghalaya which indicated that the spices play a very vital role for the livelihood of farmers.

Table 9 A comparative study of important crops of Meghalaya during 2007-08 (area in ha)

Crops	East Garo Hills	% of the total area	Meghalaya	% of the total area
Fruits	3052	8.08	25929	10.13
Tuber	2026	5.36	26881	10.50
Plantation	1293	3.42	20741	8.10
Spices	4996	13.23	13088	5.11
Vegetables	2517	6.66	12398	4.84
Cereals	18624	49.31	124290	48.57
Other cereals and small millets	430	1.14	2627	1.03
Fiber crops	2965	7.85	15563	6.08
Sugarcane	32	0.08	92	0.04
Tobacco	222	0.59	696	0.27
Oilseeds	1056	2.80	10050	3.93
Pulses	554	1.47	3561	1.39
Total	37767	100	255916	100.00

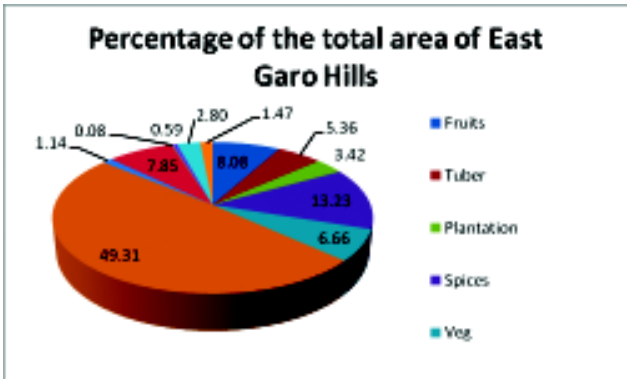


Fig 3 Percentage of the total area of East Garo Hills

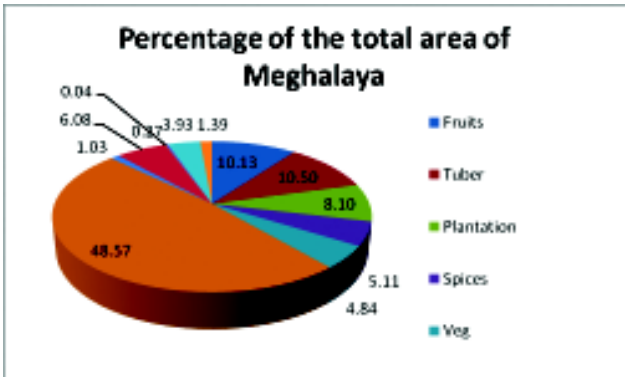


Fig 4 Percentage of the total area of Meghalaya

In this district fiber crop's share was 7.85% against the state share 6.08%. Productivity under vegetable in the district was 8875 kg/ha and that of state was 10816 kg/ha. In the district rice productivity was 1233kg/ha as compared to state productivity 1882 kg/ha. Tobacco production in the district was 653 kg/ha and that of state was 667 kg/ha (Table 10).

Table 10 A comparative study of yield under important crops in East Garo Hills and Meghalaya during the year 2007-08

Crops	Yield (kg/ha)	
	East Garo Hills	Meghalaya
Fruits	11917	8053
Tuber	5011	7919
Plantation	1252	1682
Spices	4562	4915
Vegetable	8875	10816
Rice	1233	1882
Wheat	1104	1801
Maize	1235	1475
Other cereals and small millets	856	856
Fiber crops	711	851
Sugarcane	2719	2739
Tobacco	653	667
Oilseeds	525	673
Pulses	634	871

Economics of *jhum* vs settled agriculture: Tamenglong District (Manipur)

Under low population density condition where land is abundantly available, the 12-year cycle *Jhuming* was found to be most profitable as compared to 5 year *jhuming* and other conservative systems such as bench terrace and contour bunding. But in high population density conditions where the *jhum* cycle is 5 years, the conservative systems such as bench terrace system become more profitable. Under high population density conditions at higher discount rate contour bunding become more economical as compared to bench terrace. This occurs mainly because of high establishment cost of the bench terrace system. More studies will be undertaken to suggest for better options for maintaining *jhum* land in order to conserve that natural resources and improve livelihood of the *jhumias*.

Marketing opportunities and scope of diversification in agricultural sector of the northeastern region

It is known that agriculture development in crop diversification goes hand in hand. If the diversification is properly implemented it can be used as a tool for increasing the farm income, generate employment alleviate poverty and conserve precious soil and water resources.

The North East Region, the agriculture production system is complex, diverse and risk prone. The main objective of the production system is to produce the crops to meet the immediate demand of foods for the livelihood. However, due to the emerging changes in the agriculture on account of the globalization and liberalization there is a need for the development of suitable policy for taking advantage of diversification of agriculture crops being the socio-economic status of the farmers and marketing and another infrastructure available in the North East region.

Agriculture and allied activities account for over a quarter of region's GDP, and their share has been declining (Table 11). Among the states the share of GDP was lowest in Mizoram (13.9%) and highest in Nagaland (28.5%) Except in Nagaland it has declined considerably in all the states since the early 1990s.The performance of agriculture in the region had been quite impressive during the past one decade. At the regional level, the sector grew at an annual rate of 3.12%, slightly higher than the national level of 2.8%. It is well known fact that agriculture in North East is in transition stage due to the various efforts made by the

Table 11 Growth of agricultural sector of North-Eastern states *(Per cent)*

States	Share of agriculture in GDP		Annual growth rate, 1993/94 to 2008/09	
	1993/94	2008/09	Agricultural GDP	GDP
Arunachal Pradesh	43.4	25.8	1.25	5.34
Assam	39.4	27.9	2.48	6.29
Manipur	35.5	23.6	3.30	5.80
Meghalaya	25.3	19.5	4.08	7.35
Mizoram	29.6	13.9	0.58	6.19
Nagaland	24.4	28.5	9.21	6.43
Sikkim	34.3	17.0	2.63	7.78
Tripura	35.3	22.4	4.84	8.67
North East	36.8	25.9	3.12	6.55

Source: Estimated using data National Accounts Statistics (www.mospi.gov.in)

Government of India and State Government as well. On the basis of secondary data and primary data it is clear that the agriculture in North East is more diversified due to the agro-climatic condition, food habit and socio-economic status.

Horticulture is the key sector for the development of North Eastern region of India. Due to various efforts made by the Central and state Government, the area under horticultural crops has been increased significantly and so marketable surplus has also increased. In Meghalaya, different varieties of crops are grown but farmers are not getting desired return from their investment due to post harvest losses at different stages of marketing of their produce. To assess the post harvest losses a study was conducted for the 5 major horticultural crops in Ri Bhoi district of Meghalaya. Data were collected from the 120 farmers residing in various parts of the district. Estimates of the post-harvest losses of pineapple, tomato, capsicum, orange and ginger were studied in Meghalaya and found that mishandling, spoilage and pest infestation were the major cause of post harvest losses. The loss was estimated 4.83, 15.4, 12.5, 9 and 5.6 percent of total production in case of pineapple, tomato, capsicum, orange and ginger, respectively at the farmer's level. The loss was found to be 5.72, 11.45, 8, 10.09 and 11.02 percent in case of pineapple, tomato, capsicum, orange and ginger, respectively at the market middle man's level (Table 12).

Fruit, vegetables and root crops are perishable, and if care is not taken in their harvesting, handling and transport, they will soon decay and become unfit for human consumption. Reduction in this wastage, particularly if it can economically be avoided, would be of great significance to growers and consumers. If we can reduce the post harvest losses at farmers' level, the ultimate income of the farmer will increase which will lead to the socio-economic development of this region.

The production of oilseeds decreased from 263.67 thousand tonnes in TE 2003 to 258.16 thousand tonnes in TE 2010. During this period oilseed production decreased with the annual compound growth rate of 0.44% and it is a matter of great concern. However the production of pulses is showing positive growth trend in NEH Region. In North-East production of pulses has increased at the growth rate of 1.34% per annum. Production of cereals declined from 5896.13 thousand tonnes in TE 2003 to 5828.59 thousand tonnes in TE 2010 with negative growth rate of -0.11% per annum. Fruits and vegetables production showed an increasing trend with compound growth rate of 3.15% and 8.86%, respectively, whereas production of spices decreased at the rate of -1.28% per annum (Table 13)

Table 13 Compound growth rates (Production in '000 tons) of agricultural and horticultural sector in NE region

Commodity	TE 2003	TE 2010	CGR
Cereals	5896.13	5828.59	-0.11%
Pulses	123.63	147.20	1.34%
Total food grains	6019.83	6049.64	0.02%
Oilseeds	263.67	258.16	-0.44%
Fruits	1968.6	3119.19	3.15%
Vegetables	5258.49	5048.66	8.86%
Spices (2007-10)	150,45	140,65	-1.28%

Source: DES, Ministry of Agriculture, Govt. of India. (Various issues)

Table 12 Extent of post harvest losses of selected commodities in Meghalaya

	1. At farmers level	Pineapple	Tomato	Capsicum	Orange	Ginger
	Assembling	1.83	4.2	2.3	2	1
	Grading	0.4	3.2	2.6	1.5	0.9
	Storage	0.3	0.5	0.4	0.2	1
	Transportation	0.8	2.5	2.2	3.25	0.9
	Loss in Market	1.5	5	5	2.05	1.8
2.	**Total loss at farmers level**	4.83	15.4	12.5	9	5.6
3.	**At market middle man**					
	Assembling	0.6	0.95	1.1	1.75	1.5
	Grading	0.62	3.2	1.3	2	0.6
	Storage	1	0.5	2.02	2.75	5.02
	Transportation	1.5	4.5	1.98	1.89	0.9
	Loss in market due to moisture and rotting	2	2.3	1.6	1.7	3
4.	**Loss at market middle man**	5.72	11.45	8	10.09	11.02
Total post harvest loss		10.55	26.85	20.5	19.09	16.7

The production performance of fish, meat, milk and eggs in the northeastern states are quite impressive. Among the four sectors meat showed the highest growth trend with the annual compound growth rate of 3.21% followed by fish and eggs. Production of milk was also showing positive growth trend in NEH Region with the growth rate of 0.72% per annum (Table 14).

Table 14 Performance of livestock and fishery sector in North Eastern States

	Production in '000 tons		
Commodity	**TE 2002**	**TE 2009**	**CGR**
Fish	221.47	260.3767	1.02%
Meat	107.14	165.29	3.21%
Milk (2007-10)	1173.00	1183.333	0.72%
Egg (in lakh nos)	8775.667	9830.333	1.01%

Source: Basic Statistics of North Eastern Region

Strengthening statistical computing for NARS

The salient achievements under the project during reporting period are-

a. An AC lab of 10 computers (installed SAS) along with projector and UPS backup of 2.30 hrs with internet facility.
b. Available a general purpose Statistical Software Package SAS (Standalone as well as internet based) consisting of all modules for perpetual use by different NARS Organizations (ICAR Institutes/ NRCs/ PDs/ SAUs/CAUs/Agricultural Colleges with Post Graduate Education, etc.). Anybody in NARS can install the software in their official machines free of cost. The software is also distributed to all the nodal centres of this centre and users also can get the software from the nodal centres and can be used for all the time to come.
c. Available books and manuals to use different modules of SAS (each copy of these books and manuals are also distributed to the Nodal Centres, Regional Centres and other NARS Organizations in NE Region)
d. We have six Nodal Centres namely: NRC Pig, Guwahati; NRC Mithun, Nagaland; NRC Yak, Arunachal Pradesh; AAU, Guwahati; NRC Orchid, Arunachal Pradesh and CAU Imphal for the establishment of close linkages with scientific and technical personnel of research organizations of the concerned region for proper assessment of their training and other technical support requirements.
e. Five training programmes have been organized under this project.

Developing, commissioning, operating and managing an online system for NET/ARS prelim examination for ASRB

The salient achievements are-

- Renovation of Agricultural Extension Block "D" of the Institute Building with Wall partition for UPS & server Room, Examination Hall with Dias.
- Location of the hall: D block, ground floor, Division of Agricultural Extension, ICAR Research Complex for NEH Region, Umroi road, Umiam, Meghalaya -793103.
- Dimension of the hall: Length = 84 ft, Breadth = 20 ft, Height = 9 ft.
- Dimension of server room (located inside the hall): Length = 12 ft., Breadth = 5 ft., Height = 9 ft
- Dimension of UPS room (located inside the hall): Length = 8 ft., Breadth = 5 ft., Height = 9 ft
- Two entrances on the right side of the corridor while coming from the main entrance.
- 100 connected computer tables partitioned individually beneath the table with keyboard drawers and CPU shelf in five rows along the length of the hall. Size of each table is 2.6X1.8 sq. ft. with height 2.6 ft.
- 103 revolving chairs for each table (including for the tables in server room and dais)
- Five Air Conditioners: three in the hall and one each in server room and UPS room.
- Two iron racks of size 6.6X3.6X1.6 cu. ft. including 7 decks each for putting batteries in the UPS room
- Electric and network cabling for each node.
- Dais of size 10X6.6 sq. ft. with height 1.6 ft. It has a table of 9X2.6 sq. ft. with height of 2.6 ft.
- One white board of size 8X3.6 sq.ft. behind the dais.
- Two notice boards of size 7X3.6 sq. ft. on the wall along the corridor of the hall.
- Wall and ceiling are panelled with pine wood and ply wood with painting and varnishing.
- 50 light points with CFL bulb of 20 watt each put underneath the ceiling.
- PVC flooring inside the hall
- Windows are curtained with blending blind.
- Two godrej almirah of size 4X2.6X1.6 cu. ft. placed on the side of dais.
- Glazed ceramic floor tiles on the corridor outside the hall.

ANIMAL PRODUCTION

Cryo-preserevation of boar semen

Assessment of motility and membrane integrity of porcine spermatozoa at different stages of freezing and post thawing

The objective of the study was to investigate the stage which is most susceptible to spermatozoa and the extent of damage during the process of freezing of boar semen. A total of 24 sperm rich fraction of ejaculate were collected from mature Hampshire boar in a plastic bottle kept inside an insulated thermos flask. The semen was immediately brought to the laboratory and routine examination was done. The samples having more than 75% initial motility was frozen using BTSLEYG (Beltsvilli Thwing Solution + Glycerol Egg Yolk) extender with 3% glycerol and 1 hour equilibration. After equilibration, the straws were filled with the semen and the open end was sealed with PVA and kept in liquid nitrogen vapors. Immediately after vapour freezing, the straws were transferred into the goblet containing liquid nitrogen and transferred to liquid nitrogen container for freezing and storage. Thawing of straw was done at 50 ^{0}C water for 20 sec. Small aliquot of semen is drawn after holding, before equilibration at 5 ^{0}C, after equilibration and post thawing. Sperm motility, live sperm count, acrosomal integrity and HOST reacted spermatozoa were estimated as per the standard methods. Results have shown that there was a gradual decline in sperm motility, live sperm count, acrosomal integrity and HOST reacted spermatozoa as the temperature decreased from 35 ^{0}C to 5 ^{0}C but there was a sudden decline in all the parameters after thawing. Highest motility, live sperm count, acrosomal integrity and HOST reacted spermatozoa were found after holding (81.04 ± 1.42, 88.29 ± 0.49, 88.87 ± 0.57 and 61.50 ± 1.04, respectively) and the lowest were reported after thawing (51.38 ± 0.87, 56.83 ± 0.74, 54.83 ± 0.74 and 43.79 ± 0.83, respectively). However, there was no significant difference in sperm parameters before and after equilibration (sperm motility, 75.00 ± 1.09 vs. 72.70 ± 1.04; live sperm count, 82.37 ± 0.44 vs. 80.00 ± 0.50; acrosomal integrity, 82.25 ± 0.48 vs. 80.00 ± 0.50 and HOST reacted spermatozoa, 53.04 ± 0.78 vs. 50.54 ±0.89 respectively). It may be concluded that maximum damage of spermatozoa occurs during the process of freezing below 5 ^{0}C and during thawing.

Ultrastructural changes in porcine spermatozoa during freezing and post-thawing

The study was aimed to find out the ultrastructural changes in porcine spermatozoa at different stages of processing while freezing, viz. after holding at 24 ^{0}C, after cooling to 5 ^{0}C, after equilibration and after thawing, using transmission electron microscopy (TEM). Fresh semen was taken as control. A total of 36 sperm rich fraction of ejaculates having more than 75 per cent initial motility were frozen in liquid nitrogen using BTSLEYG (Beltsvilli Thwing Solution + Glycerol Egg Yolk) extender with 3% glycerol and 1 hour equilibration. Thawing was done by putting the straw at 50 ^{O}C water for 20 sec.

Aliquot of sample was drawn from fresh semen, after holding, after cooling, after equilibration and after thawing and were subjected to Transmission Electron Microscopy (TEM). Results showed that most of the spermatozoa in fresh semen had intact plasma membrane over head and mid piece. Acrosome and acrosomal apical ridge were normal and intact. Both outer and inner acrosomal membranes were clearly visible. Nucleus was electron opaque. Few cells showed swollen acrosome after cooling. In many spermatozoa examined after equilibration, the plasma membrane over the head and middle piece was swollen and ruptured. Few cells showed swelling of acrosome and loss of acrosomal contents. Majority of the cells showed swollen, separating and ruptured plasma membrane over the head region. Fusion of plasma membrane with outer acrosomal membrane and formation of large spaces between plasma membrane and outer acrosomal membrane were commonly seen. Most of the cells showed swollen acrosome while, few cells showed loss of acrosomal contents and dissolution of acrosomal apical ridge. Thinned mitochondrial matrixes were also seen. It was concluded that not much damage to spermatozoa happened up to 5 ^{0}C, but maximum damage to spermatozoa occurred during the process of equilibration and thawing.

Augmentation of fertility in female pigs

Facilitation of early sexual maturity in cross-bred gilts

The local pig germplasm suffers from poor growth rate, delayed maturity and other poor production traits. The present investigation was done to facilitate early sexual maturity in cross-bred Hampshire gilts (Hampshire x *Khasi* Local) using Zn (200 ppm) and Cu (20 ppm) supplementation in basal diet daily for

120 days (60-180 days of age) and were compared to control (n=10) .The gilts were observed for estrus, ovarian activity and other reproductive traits including biometry of genital tract after slaughtering. The results showed a significant improvement not only in facilitating sexual maturity as early as 178 ±11days as compared to 234 ±17 days thereby reduction of 56 days indicating a good potential for efficient reproduction capacity but also showed good body score, growth rate and more daily weight gain as compared to control.

Induction of estrus and artificial insemination in anoestrous pigs

The study was conducted to initiate cyclicity in clinically anoestrous crossbred female pigs (n=06) and were compared with controls (n=06). In group –I, the animals were treated with PMSG 1000 IU followed by HCG 500 IU after 96 h of PMSG. In Group-II, the animals were injected with normal saline solution placebo. The animals were observed for onset of estrus, estrus behavior, estrus period, response to treatment etc. The animals were inseminated artificially with extended liquid semen and examined for pregnancy and the pregnant animals were followed up to parturition. The 83.40% of the treated animals responded to treatment with 67.75 conception rate as compared to 33.25 % from the control group. However, the difference in litter size was found to be non-significant between treated and control groups. The results showed that estrus can be induced successfully with optimum litter size in anoestrous female pigs with PMSG followed by HCG protocol.

Ovulatory response to exogenous gonadotropins in pubertal gilts

Crossbreeding along with early attainment of early sexual maturity are the possible strategies for getting more piglet crop per sow during her life time. Hence, the investigation was done to assess the capabilities of pubertal cross-bred gilts for successful reproduction by inducing early sexual maturity for maximising the piglet crop. The pubertal cross-bred Hampshire gilts (Hampshire x *Khasi* Local) (n=10) aged 5-6 months with average live body weight 56.320 ± 4.725 kg were administered with PMSG 1000 IU(I/M) followed by 500 IU HCG (I/M) after 88-92 h. of PMSG and were examined for standing estrus and inseminated artificially. The observations for onset of estrus, estrus duration and intensity of estrus and other reproductive traits were recorded. The animals were slaughtered on day 03 post insemination and the observations for ovarian activity *ie*. weight of ovaries, number of CL, number of anovulatory follicles present on the ovaries were recorded. The oviducts and each uterine horns were flushed separately using DBPS with 0.4% BSA and antibiotics and the flushings were examined for embryos/ova under steriozoom microscope. The embryos collected were evaluated for morphology as well as quality. The results showed that 80% animals responded to treatment and the time of onset of estrus from PMSG administration was 61.30±3.22 h. with estrus duration of 38.5± 4.25 h. The average weight of the ovaries was 6.245± 2.154 g.Total no.of CL including both the ovaries were 21.5±3.25, unovulatory follicles averaged 3.30±1.30 . Total no. of embryos/ ova recovered from both the oviducts and uterine horns averaged 10.25±3.50 showing a recovery rate of 47.67%.The unfertilized ova averaged 2.15± 0.18. The morulla, 8 cell, 4 cell and 2 cell embryos recovered were 72.33,17.49, 5.25 and 2.68% , respectively. As per gradation of embryos are concerned, 65.35% embryos were graded as very good quality (A Grade), 23.85 % as good quality (B grade) and 11.25% as poor quality. The results showed that pubertal gilts may attain the capability of successful reproduction with acceptable response as early as at 06 months of age with a body weight of 60 kg if managed properly.

Growth performance of Duroc pig under agro-climatic conditions of Meghalaya

A study was conducted to evaluate the growth performance of Duroc breed under agroclimatic conditions of Umiam, Meghalaya. A total 16 grower Duroc pigs (10 females and 6 males) were brought from National Research Centre on Pig, Guwahati, to study the productive and reproductive performance under hilly condition of Meghalaya (Fig 1). The study

Fig 1 Duroc pig maintained at livestock farm of animal production division

was conducted from 3 months to 9 months of age. All the pigs were reared under semi-intensive system. Balanced grower ration was provided based on the body weight and age of the animal. Body weight gain was recorded at monthly interval and average daily body weight gain was also calculated at monthly interval. Average body weight of both males and females at 120, 150, 180, 210, 240 and 270 days were found to be 18.90 ± 2.60, 24.45 ± 5.15, 31.70 ± 3.01, 39.30 ± 3.20, 48.50 ± 5.30 and 56.78 ± 4.65 kg, respectively. However, higher body weight gain was recorded in males as compared to females.

Average daily body weight gain of male and female were found to be 178.33 ± 5.15, 175.65 ± 6.85, 246.67 ± 9.10, 248.33 ± 9.95, 288.33 ± 10.40 and 312.54 ± 13.45 g between 90-120, 120-150, 150-180, 180-210, 210-240 and 240-270 days, respectively. However, the daily body weight gain in males was non-significantly higher than in females. Six, out of 10 females exhibited first estrus. The average age at puberty was found to be 264.45 ± 8.64 days. The study revealed that the performance of Duroc breed is at par with other genetic groups maintained under same condition.

Pig-Fish integrated system

Crossbred (Hampshire x *Khasi* local) pigs were integrated with composite fish culture in a 468 sq m pond area at Livestock farm under Animal production Division in order to increase the profitability per unit area by reducing the feeding cost of fish through addition of fresh dung into the pond (Fig 2). Fish species combination and ratio was 2:1:1 for Mrigal:Gonius:Bata. The fingerlings was stocked at the rate of 10,000/ha pond area. The pig (5 months) was integrated at the rate of 40 grower pigs / ha. The fresh dung of two grower piglets were collected and dropped into the pond daily at four corners of the pond. The productive performance of fish was studied for six months during July to December (Tables 1-2). Total fish production from 468 sq m pond area was found to be 51.31 kg during six months. In integrated pig-fish culture, under above mentioned conditions, the fish yield was 2150 kg /year/ ha water area. It was observed that the growth of Gonius was significantly higher than Mrigal and Bata. During the six months study period, the pig gained 70 kg body weight. Feeding cost of pig was also reduced by replacing 20% of the concentrate feed with vegetables grown by addition of pig manure.

Table 1 Weight and length increment of fishes in pig-fish integration

Parameters	Mrigal	Gonius	Bata
Weight increment			
Initial weight (g)	11.23	15.5	10.58
Final weight (g)	91.02	118.02	72.85
	± 8.48	± 9.79	± 15.02
Absolute growth (g)	79.79	102.52	62.27
Growth increment (g/fish/day)	0.44	0.57	0.34
Length increment			
Initial length (cm)	8.64	8.55	8.12
Final length (cm)	23.18	20.75	18.51
	± 0.87	± 0.75	± 0.66
Absolute length (cm)	14.54	12.20	10.39
Length increment (cm/fish/day)	0.08	0.06	0.05

Fig 2 Harvesting of fish under pig-fish integration system at livestock farm, division of animal production

Table 2 Fish productivity under pig-fish integrated system (6 months of growth)

Fish species	Survival %	Average weight (kg/fish)	Fish harvested from 468 m^2 pond area (kg)	Productivity (t/ha/yr)
Mrigal	94.5	91.02 ± 8.48	23.66	2.150
Gonius	96.0	118.02 ± 9.79	16.99	
Bata	97.7	72.85 ± 15.02	9.66	

Assessment of fertility and reproductive disorders of dairy cattle in Meghalaya

A total of 200 dairy cattle have been screened for the fertility status in East, West and South Garo Hill Districts of Meghalaya. Out of total animals screened, 140 (70 %) were normal cyclic/ pregnant and rest 60 animals (30 %) showed some sort of reproductive disorders. Fertility status of dairy cattle was assessed in terms of age at puberty, age at first conception, gestation period, age at first calving and inter-calving interval etc. Out of total infertility cases, repeat breeding and anoestrous were found to be major reproductive disorders in village as well as on State Govt. Cattle Breeding Farms, which comprised of 43.38% and 33.90%, respectively. Fertility status of dairy cattle was assessed based on the analysis of the data obtained from Govt. Cattle Breeding Farms as well as from farmer's field, which is presented in table 3.

Table 3 Reproductive parameters in crossbred dairy cattle in Meghalaya

Parameters	No. of observations	Days (mean ± SE)	Range (days)
Age at puberty	95	798.45 ± 24.75	644-1115
Age at first conception	116	886.54 ± 31.23	720-1185
Gestation period	95	278.40 ± 0.30	270-282
Age at first calving	165	1160.23 ± 27.32	1027-1465

Reproductive disorders in dairy cattle were assessed on the basis of gynaecological examination of cows and reproductive history of the animal. Animals were classified into normal cyclic/ pregnant, repeat breeder, anoestrous and infertile. Animals showing some sort of reproductive disorders were further classified into different categories (Table 4).

Table 4 Incidence of reproductive disorders of dairy cattle in RiBhoi and East Khasi Hill Districts of Meghalaya

Reproductive disorders	Incidence (%)
Animals examined	200
Animals with rep. disorders	30 % (140/200)
A. Anestrous	41.66 % (25/60)
B. Repeat breeding	26.66 % (16/60)
C. Retained placenta	15.0 % (9/60)
D. Abortion	11.60 % (7/60)
E. Pyomettra	6.66 % (4/60)
F. Dystocia	5.0 % (3/60)

Morphometric characteristics of Assam Hill goat

The morphometric characteristics of Assam hill goats are being studied under standard management conditions (Table 5). The predominant colours are black, black and white, and brown with patches of different colours in the body. Three types of ears are observed in which the percentage of horizontal medium-sized ear is dominant over the erect and pendulous. The thick and small sized (7.7 cm) black horns in female shows upward and backward

Table 5 Body measurement of Assam Hill goat

Physical parameters	Mean ± S.E (in cm)	Physical parameters	Mean ± S.E (in cm)
Live body weight (adult)	21.18 ± 1.00 Kg	**Neck**	
Head		i. Length	36.50 ± 1.02
i. Length	17.50 ± 0.90	ii. Circumference	28.50 ± 0.90
ii. Breadth of forehead	3.80 ± 0.25	**Barrel**	
iii. Eye to eye	9.80 ± 0.34	i. Body length	84.23 ± 1.30
Horn		ii. Oblique body length	49.35 ± 1.80
i. Horn Length	7.70 ± 0.80	iii. Height at wither	55.50 ± 0.86
ii. Distance between horn	6.12 ± 0.32	**Girth**	
iii.Circumference	5.50 ± 0.28	i. Heart girth	63.85 ± 1.15
Ear length	12.59 ± 0.42	ii. Abdominal girth	77.80 ± 1.21
		iii. Paunch girth	69.26 ± 1.84
		Tail length	10.25 ± 0.86

orientation. But in male the orientation is straight upward.

Productive and reproductive parameters of Assam Hill goat

The body weight of Assam Hill goats are being recorded in every 30 days interval up to 360 days. The average birth weight was found to be 1.58±0.04 kg in male and 1.39 ±0.04 kg in female (Table 6). The average body weight of male and female kids were14.2± 0.87 kg and 11.91±0.8 kg, respectively at 360 days. The body weight of male kids was significantly higher as compared to the female kids (P<0.05). Some of the reproductive parameters of Assam Hill goat under semi-intensive managemental condition are given in tables 7 & 8.

Table 6 Average monthly body weight of Assam Hill goat

Age (days)	Male (kg)	Female (kg)	Overall
At birth	1.58 ± 0.04	1.39±0.04	1.48±0.03
30	3.83 ± 0.13	3.7±0.11	3.77±0.09
60	5.56 ± 0.28	5.19±0.21	5.38±0.18
90	6.87 ± 0.31	6.1±0.22	6.48±0.19
120	8.26 ± 0.38	7.44±0.26	7.85±0.23
150	9.15 ± 0.36	8.13±0.31	8.66±0.25
180	10.26±0.39	8.93±0.37	9.32±0.29
210	10.25±0.76	8.34±0.31	9.51±0.39
240	11.1 ± 0.67	8.83±0.43	9.91±0.46
270	11.73±0.79	9.45±0.54	10.41±0.51
300	12.38±0.82	10.2±0.59	11.12±0.53
330	12.88±0.82	11.0±0.68	11.84±0.56
360	14.20±0.87	11.91±0.8	12.93±0.64

Table 7 Reproductive parameters of Assam Hill goat

Traits	Mean ± SE
Twinning percentage	38.45 %
Triplet percentage	2.98 %
Singe birth percentage	58.56 %
Inter kidding period (days)	257.2 ± 1.95
Gestation period (days)	147 ± 0.21
Age at first kidding (days)	439 ± 0.54

Table 8 Birth weight of kids under different types of birth

Type of birth	Male	Female
Single	1.71±0.06	1.52±0.06
Twin	1.49±0.05	1.35±0.07
Triplet	1.30±0.13	1.19±0.05

Effect of season on reproductive traits of Assam Hill goat

A study is being carried out to observe the effect of seasons and types of birth on reproductive traits. Study on the effect of season on reproductive traits revealed a season-wise variation of age at 1st conception, age at puberty, age at 1st kidding and gestation period (Table 9). However, the winter borne kids of Assam Hill goats were found to be more efficient in regards to the reproductive traits. However, the gestation period was same for all the seasons.

Table 9 Season-wise variation of reproductive traits in Assam Hill goat (days)

Reproductive parameters	Seasons		
	Summer	Monsoon	Winter
Age at 1st conception	295 ± 1.07	289 ± 1.33	279 ± 1.20
Age at puberty	270 ± 1.05	266 ± 1.54	261 ± 1.85
Age at 1st kidding	447 ± 1.56	442 ± 1.08	437 ± 1.48
Gestation period	147 ± 0.22	146 ± 0.19	147 ± 0.21

Effects of types of birth on reproductive traits are also being studied and revealed that age at puberty, age at 1st conception and age at 1st kidding came earlier in single born group than in twins and triplets (Table 10).

Table 10 Birth-wise variation of reproductive traits in Assam Hill goat (days)

Reproductive parameters	Type of birth		
	Single	Twin	Triplet
Age at 1st conception	287 ± 1.42	290 ± 1.49	295 ± 1.25
Age at puberty	258 ± 1.37	262 ± 1.26	269 ± 1.54
Age at 1st kidding	434 ± 1.30	437 ± 1.22	443 ± 1.85
Gestation period	147 ± 0.52	148 ± 0.44	147 ± 0.76

Estrus synchronization and AI in goat

Studies on sexual maturity, estrus induction, estrus synchronization and artificial insemination in Assam hill goats were carried out (Figs 3,4 &5). The sexual maturity in males was observed as early as 224 ±16 days with a body weight of 11.245 ± 1.320 kg whereas in females the sexual maturity was recorded at 289± 23 days with a body weight of 10.875± 1.355 kg. The kids born single showed sexual maturity earlier by about 45-50days as compared to kids born as twins.

Fig 3 Removal of vaginal sponge after 12 days of insertion

Fig 4 Artificial insemination in synchronized goat

Fig 5 AI born kid with dam

Estrus was induced (n=16) using tiaprost trometamol (225µg/animal I/M) in randomly selected anoestrous goats with 62.50% success rate (n=10) in treated group compared to 16.66 % (n=01) in control group (n=06).

Estrus synchronization in goats was attempted (n=10) using intra vaginal progesterone sponge for 12 days followed by removal of sponge and subsequent administration of 225µg/animal I/M injection of tiaprost trometamol. 70.00% (n=7) animals responded to treatment and were inseminated artificially with 70.14% (5/7) conception and 55.55 % (4/7) kidding rate with one abortion.

Growth performance of broiler rabbit fed with locally available resources

A total of 30 New Zealand White (NZW) rabbits were selected after weaning for feeding trial at Livestock farm of ICAR Complex, Umiam. All animals were randomly distributed in to 5 groups *viz.*, C, T-1, T-2, T-3 and T-4, each group consisting of 6 rabbits. The group C was solely fed on concentrate feed while groups T-1, T-2, T-3 and T-4 were given locally available fodder (cauliflower and cabbage leaves) replacing concentrate feed @ 20%, 30%, 40% and 50% in the respective groups. The body weight was recorded at weekly interval for all rabbits individually. The growth performance of rabbits (NZW) at weekly interval has been given in the table 11. The growth performance was found to be superior in control followed by T-1, T-4, T3 and T-2 respectively. However, average body weights were significantly not different amongst the groups.

Table 11 Growth performances of NZW rabbit fed on locally available feed resources

Age of rabbit in weeks	Average body weight (kg)				
	C	T-1	T-2	T-3	T-4
8	0.89	0.93	0.82	0.94	0.81
9	1.00	1.03	0.87	1.06	0.93
10	1.14	1.15	0.99	1.20	1.03
11	1.25	1.27	1.15	1.30	1.13
12	1.30	1.34	1.26	1.40	1.23
13	1.46	1.45	1.48	1.58	1.47
14	1.57	1.57	1.48	1.58	1.47
15	1.60	1.60	1.50	1.65	1.60
16	1.77	1.67	1.57	1.74	1.70
17	1.90	1.74	1.68	1.85	1.80
18	1.97	1.80	1.70	1.80	1.80
19	2.04	1.87	1.77	1.80	1.80
20	2.04	1.90	1.80	1.85	1.87

ANIMAL NUTRITION

Yield of feeds and fodder under agroclimatic conditions of Meghalaya

i. **Fodder production under cultivable lowland:** Nine years old parari plants (2500 plants per ha density), recorded average yield of leaf fodder 17.5

Fig 6 Feeding of locally available feeds to NZW rabbits

kg/plant with 21.45% DM. Additional fodder yield from native grass which was grown between the parari plants was 32.35 t/ha with 13.27% DM in three cuttings. From cultivable plain lowland area, the improved varieties of perennial grasses *viz.* congosignal, napier, hamil and guinea collectively yielded on average 62.47 t/ha fodder with average DM content of 15.21%in four cuttings. Similarly, from terraced area at the Dairy Unit, cumulative fresh fodder yield was 55.61 t/ha in three cuttings.

ii. **Fodder yield from upland terraced area:** Soybean, rice bean and sunhemp were grown as annual legume whereas, maize as annual non-legume fodder in *kharif* season. At 60 days, the fodder yields were 21.63, 25.11, 12.52 and 44.34 t/ha from soybean, ricebean, sun hemp and maize, respectively. Additional bio-mass yields of 19.98 t/ha as fodder from sun hemp and 2.47 t/ha as grain from soybean at 145 days were recorded.

iii. **Legume fodder production under the trees in lowland plain area:** Total fodder yield was 41.23 t/ha (3 cuttings) with average 21.68% DM from the 9 year old perennial groundnut forage, transplanted in the shed under the trees in cultivable plain lowland.

iv. **Production of fodders during *kharif*:** The bajra and jowar were grown as fodders. In upland terraced land, bajra and jowar have yielded 38.52 and 29.15 t/ha fresh fodder at 60 days of harvesting with DM contents of 30.27 and 27.05%.

v. **Production of fodders during *rabi*:** An attempt has been made to grow the best quality of leguminous fodders in the upland terraced area during the winter season under the climatic condition of Meghalaya. The Berseem and Lucerne have yielded 6.2, 11.3 and 8.7, and 5.0, 9.4 and 13.1 t/ha green fodder on fresh basis in three cuts respectively.

In the field receiving the washings/drainage from the dairy cattle shed, mixed/inter cropping of mustard, oats and berseem was attempted. Mustard was harvested (single cut) as major fodder after the 50 days of sowing and the oats and berseem were harvested subsequently after every 30 days period (Fig 1). The fodder yields on fresh basis were 27.0 t/ha for mustard, 14.0 and 22.5 t/ha for oats (2 cuts) and 8.9 and 11.3 t/ha for berseem (2 cuts).

vi. **Jackbean:** In general the plant of jackbean is of 2-3 feet in height but a plant with a height of about 20 feet was observed in the Animal Nutrition Farm. In total it was having 33 pods with 9-12 seeds per pod (Fig 2).

Fig 1 Mixed cropping of oats and berseem for winter fodder production

Fig 2 Jackbean plants with normal and creeping habit

Conservation of green fodder as silage

Maize fodder was harvested at milky stage. Before chopping it was kept for two days under the shed. About 6 tonnes of chopped maize (29.75% DM) along with lactobacillus culture was filled in pucca silo without (T-1) or with common salt (0.5% level, fresh basis; T-2). The contents were thoroughly pressed and packed tightly. The silos were opened after three and half months and the quality parameters of the silage were determined. The silages were found to have excellent characteristics (Table 1 and Fig 3) and it was also found that addition of common salt improved the silage preparation. Therefore, it is recommended that

Fig 3Appearance of prepared silage and its feeding by dairy cattle

surplus green fodder available during the months of August and September can be ensiled to get the excellent quality silage to feed the dairy cattle during winter season when there is shortage of green fodder in the NEH region.

Table 1 Characteristics of silage prepared from the maize fodder

Particulars	T-1 (Fodder maize with *Lactobacillus* culture)	T-2 (Fodder maize with *Lactobacillus* culture + 0.5% common salt)
Silage DM (%)	28.85	27.66
pH	4.2	4.1
Color	Greenish yellow to brown	Greenish yellow
Aroma	Good	Good
Palatability	Excellent	Excellent

Performance of crossbred dairy animals

During the year 2010-11, in the existing experimental dairy unit of Animal Nutrition Division, about 34 crossbred animals (lactating-14 and heifers & calves-20) were maintained on the fodder produced from 1.0 ha area and feeds like- paddy straw and concentrates procured from outside to a tune of about 30 and 40 tones, respectively. Out of total production area under fodder, improved perennial grasses and annual fodder crops were grown in 0.7 and 0.3 ha, respectively. The lactation performance is given in the table 2.

Table 2 Lactation performance of herd comprising of crossbred cows

Attributes	Value
Number of cows	14
Total cows in lactation (average/month)	10.42
Total milk production of herd (l)	37,357
Herd average (milk yield in l/d/head)	7.31

Goat nutrition

During the lean season, tree leaves can be good fodders for the goats. Moreover, if these are fed in compact feed block form, may provide an alternate balanced feeding strategy. With this hypothesis, a study was planned to evaluate the complete feed blocks (CFB) having different proportions of *Ficus* leaf meal in goats (Fig 4). Three types of CFB (12% CP and 57% TDN) with roughage and concentrate in equal

Fig 4 Feeding of complete feed blocks to goats

proportion having 0, 20 and 40% *Ficus* leaf meal were prepared. Growing goats (Assam hill) of 9.5 to 10.75 kg average BW were randomly allotted to different dietary treatments. Preliminary results indicate a good palatability of CFB having either proportion of *Ficus* leaf meal.

Dairy cattle nutrition

Growing crossbred calves (3-5 months age) were offered three diets having 10% CP and 55% TDN (estimated). First ration was given as concentrate mixture with maize kadabi separately (T-1) and other ration was in mash form containing chopped maize kadabi and concentrate mixture (T-2) and CFB prepared from chopped maize kadabi (T-3). The intake was improved in both mash and CFB with concurrent improvement in digestibility and growth. The ADG (g/d) was 365, 392 and 426 during 2 months feeding on respective treatments.

Another experiment was conducted to observe the efficacy of maize kadabi based CFB (12% CP, 57% TDN) in dairy cattle. Three groups of two animals each were randomly given different treatments. Control group was given CFB comprising of chopped paddy straw and concentrate (T-1), while other groups were given CFB comprising of chopped (T-2) and ground (T-3) maize kadabi and concentrate. Apart from above all the animals were given 2 kg of green fodder of mixed grasses. Complete investigation was extended for 3 observation periods and each period lasted for 15 days of preliminary feeding followed by a digestion trial of 7 days plus 3 days of sampling for rumen fermentation study. The results (Table 3) indicated an increase in the daily average milk production and intake of DM.

Development of probiotics for livestock and poultry

Isolation and *in vitro* probiotic evaluation of bacterial isolates was carried out. Thirty-three fecal samples from swine (17) and birds (16) were used for

Table 3 Effect of feeding different compound feed blocks on average DMI, nutrient digestibility, rumen parameters and milk production in crossbred lactating cows

Attributes	T-1	T-2	T-3
BW (kg)	368.40	372.2	369.80
DMI (kg/d)	10.02	11.76	10.63
Digestibility (%) of nutrients			
DM	59.15	62.81	63.86
CP	62.11	60.32	60.98
CF	59.37	62.41	62.27
EE	59.66	63.17	63.84
Rumen liquor pH	6.85	6.94	6.88
TVFA (meq/dl SRL)	13.02	15.67	15.23
NH_3-N(mg/dl SRL)	15.22	12.82	13.65
Milk Yield (FCM; kg/d)	9.80	11.04	10.61

isolation of bacterial strains lactobacillus by selective culture technique. The samples were suspended in the phosphate buffer (pH 6.8). MRS agar plates were inoculated with 100 ml aliquot of each suspension and incubation was carried out under anaerobic conditions for 72 hr at 37°C. Circular and creamy-white colonies (total 51) were picked up and grown overnight in MRS broth. To maintain their purity, a loop full of individual culture was again inoculated on MRS agar plates and single colony was multiplied in MRS broth. Eleven fast multiplying isolates were tested for gram reaction, shape, catalase reaction, pH and ox bile tolerance.

One isolate of lactobacillus was grown on large scale for feeding to the Vanraja chicks. Experimental feeding was initiated after the age of 2 weeks. The experimental diets having 21% CP and 3100 Kcal/kg ME were comprised of yellow maize, soybean meal, groundnut cake, fishmeal, mineral mixture, vitamin premix and supplement in the proportion of 68, 8, 19, 8, 2.5, 0.1 and 0.4. The diet was free of probiotic supplement (G-1, control) whereas the diets of other groups of chicks contained lactobacillus (G-2) and lactobacillus plus saccharomyces sp (G-3). The experimental feeding was continued for 11 weeks. From the data (Table 4) and blood parameters it is noticeable that the isolated organism had beneficial impact on the performance of the indigenous chicks.

Pig nutrition

Performance of CB pigs supplemented with phytase enzyme under field conditions

Under the resource poor farmer's field conditions an 'on farm trial' was conducted for 4 months on 10

Table 4 Average values of different parameters of Vanraja chicks on supplementation with lactobacillus isolate (probiotics)

Particulars	Groups of chicks		
	G-1	G-2	G-3
Initial BW (g)	110	121	117
Final BW (g)	1947	1916	1810
Gain in BW (g)	1837	1795	1693
Gain in BW (g/week)	167	163	154
Total feed consumption (kg, in each group)	43.56	44.29	45.74
Feed conversion efficiency	2.45	2.48	2.63
Dressing (%, with skin, excluding giblet)	73.35	72.64	70.59
Wt of gizzard (g/kg BW)	29.67	27.12	25.39
Wt of heart (g/kg BW)	10.53	10.17	9.28
Wt of liver (g/kg BW)	29.33	27.03	30.27
Cost of feed (Rs/kg)	21.00	21.00	21.00
Cost of feeding (Rs/kg BW)	51.51	52.06	55.20

Hampshire crossbred piglets in Nongthymai and Umdihar villages of Ri-Bhoi district in collaboration with KVK, Barapani to study the impact of supplementation of phytase in swine ration. The average daily weight gain was 145g in control and 175g in animals supplemented with phytase @ 20g/100kg concentrate feed.

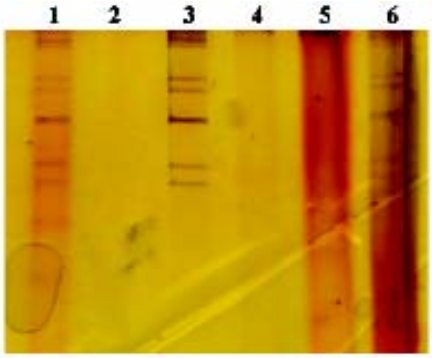
ANIMAL HEALTH

Rotavirus infection in livestock

Standardization of SDS-PAGE and RT-PCR for detection of group "A" rotaviruses from fecal samples of livestock

Two fecal samples positive in the earlier studies were used for standardization of SDS-PAGE and Reverse Transcription-Polymerase Chain Reaction (RT-PCR) methods for detection of rotavirus. Initially, the dsRNA of rotavirus was extracted with phenol: choloroform: isoamyl alcohol (25:24:1) method. The RNA extracted was then subjected to SDS-PAGE to determine the presence of rotavirus. During standardization, separating gel of varying concentrations *viz.*, 5%, 7.5%, 10.0% and 12.5%, and stacking gel of different concentration *viz.*, 4.0%, 5.0% and 7.5% were prepared and used for the detection of rotavirus from the two positive control samples. Finally, separating gel of 7.5% and stacking gel of 5.0% with different concentrations of the reagents/ ingredients were selected and used in further study for

the detection of rotavirus from field fecal samples by SDS-PAGE (Fig 1). RT- PCR conditions were standardized using rota1 rota2 primers targeting partial *VP7* gene for detection of group "A" rotaviruses.

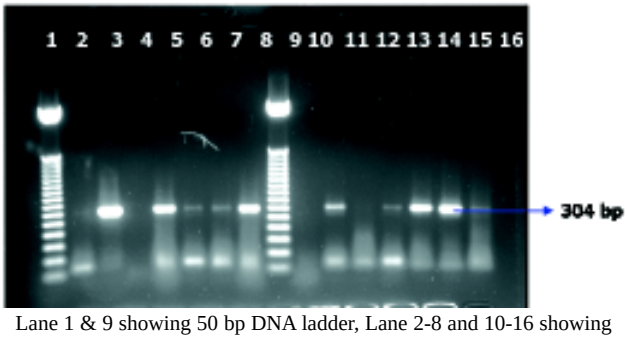


Lane 1 – Control positive fecal samples (rotavirus positive) Lane 3 & 6 : Positive fecal samples from piglets

Fig 1 SDS-PAGE showing 11 bands of dsRNA of rotavirus

Screening of fecal samples for detection of rotavirus using standardized SDS-PAGE and RT-PCR

A total of 42 fecal samples comprising 35 from piglets and 7 from goatswere collected from different farms located in and around ICAR Research Complex, Barapani and screened for detection of rotavirus. The dsRNA of rotavirus from fecal samples were extracted by phenol:chloroform:isoamyl alcohol method and subjected to SDS-PAGE. Only 2 samples were found to be positive by SDS-PAGE while 6 samples were found to be positive by RT-PCR (Fig 2) including the two, which were found positive by SDS-PAGE.



Lane 1 & 9 showing 50 bp DNA ladder, Lane 2-8 and 10-16 showing PCR products of samples (304 bp in positive cases)

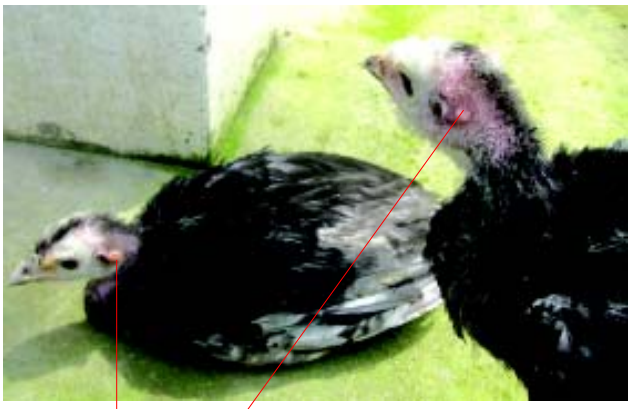
Fig 2 Detection of rotavirus by RT-PCR showing positive fecal samples using Rota 1 and Rota 2 primers

Isolation and characterization of zoonotic pathogens in different integrated livestock farming systems

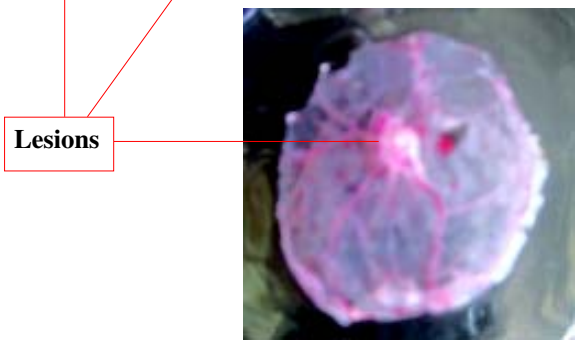
A total of 60 faecal samples (cattle, pig, goat and poultry) and 30 pond water samples from different farming systems were screened for zoonotic pathogens. Samples were screened for important enteric pathogens such as *Salmonella, E.coli, Aeromonas* and *Vibrio* spp. A total of 26 *E. coli* from animal faecal and pond water samples and 2 *Aeromonas* spp. from pond water samples were isolated. *Stx2* gene positive *E. coli* were detected in pond water samples as well as from animals. The antibiotics sensitivity pattern of the isolates showed high resistance to tetracycline followed by co-trimoxazole and sulphafurazole and high sensitivity to ofloxacin and nitrofurantoin.

Poxvirus infection in turkey

An outbreak of poxvirus suspected in turkey was reported from the organized poultry farm. The scab samples of the affected birds were collected and inoculated into chorioallantioc membrane (CAM) of 9 day old chicken embryonated eggs. After the third passage in CAM, characteristic pock lesions (Fig 3) were identified that confirms the poxvirus infection.



Lesions of poxvirus infection in turkey



Pock lesions in CAM

Fig 3 Detection of poxvirus infection

Standardization of RAPD protocols for *Listeria monocytogenes*

Random Amplification of Polymorphic DNA (RAPD) protocols were standardized using OPA and

OPB primer series, for studying strain relatedness/ similarity among *L. monocytogenes* isolates from different sources (Fig 4).

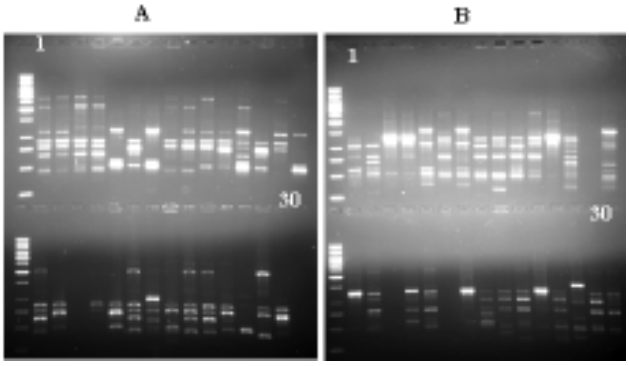


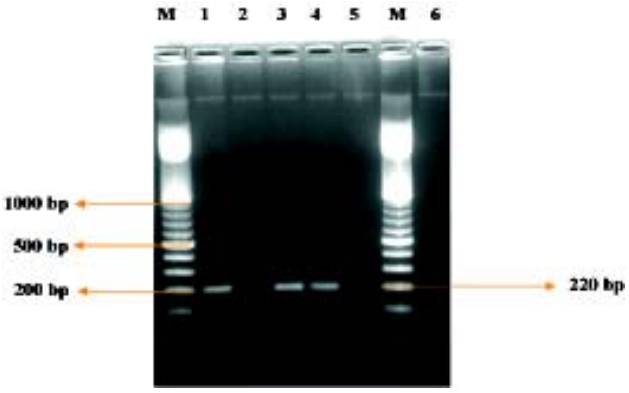
Fig 4 RAPD analysis of 30 isolates of *L. monocytogenes* with primers OPA9 (A) & OPB18 (B)

PCR serogrouping of *Listeria monocytogenes* isolates

A total of 68 *L. monocytogenes* (4.7% isolation rate) were isolated from animal, food and environmental samples. These isolates were used for PCR serogrouping studies, based on the detection of serovars specific genes. PCR conditions for serogrouping were standardized using published primers for *lmo*0737 gene (specific for serovars 1/2a, 1/2c, 3a, 3c), *lmo*1118 gene (specific for serovars 1/ 2c, 3c), ORF2819 gene (specific for serovars 1/2b,3b, 4b, 4d, 4e) and ORF2110 gene (specific for serovars 4b, 4d, 4e). The *prs* gene, specific for strains of the genus *Listeria* was amplified for confirmation of *Listeria* species. Out of the 68 *L. monocytogenes* isolates, *lmo*0737 gene (691bp) was amplified in 2 isolates, ORF2819 gene (471bp) in 35 isolates, both *lmo*0737 and ORF2819 genes together in 16 isolates, ORF2819 and ORF2110 genes in 7 isolates, and *lmo*0737, ORF2819 and ORF2110 genes combined in 8 isolates. The *lmo*1118 gene was absent in all the isolates. Our studies indicated that 2.9% and 10.3% of the isolates falls in serogroups 1 and 4, respectively. This rapid PCR method can be employed for serogrouping studies of *L. monocytogenes*, as an alternate to more expensive and laborious methods.

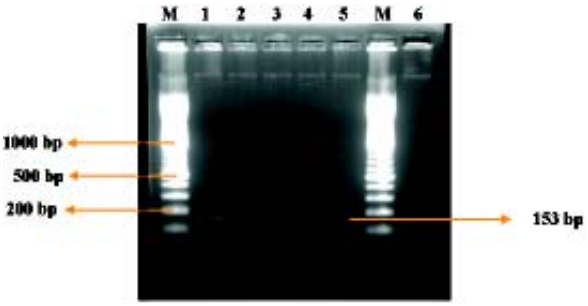
Detection of *Streptococcus agalactiae* by PCR

S. agalactiae, gram positive cocci inhibits ducts and cisterns of the mammary gland leading to inflammation and decreased milk production. There is an increased somatic cell count and eventually the involution of cistern. The PCR method was standardized for the detection of 16S rRNA gene (220 bp) (Fig 5) and *cfb* gene (153 bp) (Fig 6) of Group B Streptococci (GBS). A total of 72 milk samples (20 clinical mastitis case and 52 from apparently healthy) were tested. Out of 52 apparently healthy, 24 were CMT positive, in which 15 isolates were *S. agalactiae*, 4 were *Staphylococcus* and 7 were *E. coli*. From 20 clinical samples, 7 were *Staphylococcus*, 5 were *E. coli* and 2 were *S. agalactiae*. Molecular characterization of *S. agalactiae* was carried out against specific gene of 16S rRNA gene (220 bp) and *cfb* gene (153 bp) of Group B Streptococci (GBS).



Lane M: 100 bp DNA ladder; Lane (1-4): isolated *S. agalactiae* cultures. Lane 5 – Negative control culture

Fig 5 PCR based detection of 16S rRNA gene (220 bp) of *S. agalactiae*



M: 100 bp DNA ladder; Lane (1-4): isolated *S. agalactiae* cultures. Lane 5 – Negative control culture

Fig 6 PCR based detection of *cfb* gene (153 bp) of Group B Streptococci (GBS)

Screening of medicinal plants and preparation for antimicrobial activity

The survey and personal interview was conducted in some villages of Meghalaya using prepared interview module. Forty villagers were interviewed including the village headman in Ri Bhoi District (Mawpun village and Kyrdem Village), 15 villagers in East Khasi Hills (Mawkhan Village, Upper Shillong)

and Imphal West, Manipur. As per the information based on personal interview of villagers in Meghalaya it was opined that they rarely depend on indigenous plants for treating ailing animals, which may be due to accessibility of veterinary healthcare. In Imphal West, Manipur, use of some plants for treatment of animals were noticed. For example *Blumea hieracifolia* (Ching tera paibi) used in cuts and wounds, *Centella asiatica* used in indigestion, *Allium porrum* (Maroinakupi) for debilitation, *Spilanthes oleiracea* (Angkasa-Mizo local name) used in dental problem in animals, *Adhatoda vesica Nees* (Nongmangkha) used for fever in animals. Screening of plants and preparations were initiated for its antibacterial properties both by agar diffusion test and minimum inhibitory concentration.

Sero surveillance of brucellosis and IBR

A total of 35 sera samples of yak were collected from West Kameng District of Arunachal Pradesh for screening of brucellosis and IBR. None of the samples was found positive for brucellosis by Rose Bengal Plate Test (RBPT) while 18 samples were positive for IBR by indirect ELISA kit (IBR).

Treatment of curl-toe paralysis in chicks

Treatment of two ailing chicks suspected for curl toe paralysis, were initiated with 0.2 ml of Neurobion injection (i/m) for three consecutive days, supplemented by oral feeding of Ambiplex (half tea spoon) and water. After successful treatment these birds were sent back to farm on the 5th day.

Service activities

Work done	Service rendered	Total number
Diagnostic reports	Disease diagnosis/pathogen identification	84
Autopsies (P.M.)	Disease diagnosis	147
Treatment rendered	Disease amelioration	35
Sample surveys	Surveillance	238

VETERINARY PARASITOLOGY

Detection of *Babeisa* spp. infections in animals

A total of 97 blood samples of cattle were collected from organized cattle farms and slaughter houses of Meghalaya for detection of haemoprotozoan infections. Blood samples from 104 dogs were also collected from Assam. These blood samples were screened for detection of haemoprotozoan infections by examination of Giemsa stained blood smears and polymerase chain reaction (PCR) using specific primers. One clinical case, suspected for haemoprotozoan infections in a cross bred cow maintained in cattle farm of ICAR Research Complex for NEH Region, Umiam, Meghalaya, were observed. The cow in its 3 months of lactation was found

Fig 7 Suspected for curl toe paralysis

Fig 8 Recovery on 3rd day of post treatment

suffering from high rise of temperature (106.4^{0}F), haemoglobinurea, anorexia, decrease milk production, anaemia and diarrhoea. Blood samples of this cow was collected for detection of haemoprotozoan infections.

All blood samples of cattle collected from organized cattle farms were found negative for haemoprotozoan infection except the cross bred cow maintained in cattle farm of ICAR Research Complex for NEH Region, Umiam, Meghalaya, which was found positive for *Babesia bigemina* infection after examination by Giemsa stained blood smears (Fig 1) and by PCR using specific primer. An expected 1124 bp size band specific for *B. bigemina* observed after PCR and electrophoresis (Fig 2). The tick *Boophilus microplus* was found to present in the body of the cow. The animal was treated successfully with a single injection of 4,4' Diamidine diazoamine benzene diaceturate with recommended doses and no parasite was detected either by examination of Giemsa stained blood smears or PCR after a period of 48 hours post treatment onwards (Fig.2). Out of 104 blood samples of dogs 40 were found for *Babesia canis* and *B. gibsoni* infection after microscopic examinations. Molecular diagnosis by PCR using specific primers detected 63 dogs infected with *Babesia canis* and *Babesia gibsoni* either single or mixed infections. In case of *B. canis* an expected PCR product of 450 bp band size (Fig 3) and in case of *B. gibsoni* an expected PCR product of 671 bp band size (Fig. 4) were observed. Simultaneous molecular detection of *Babesia* spp. and *Theileria* spp. using PCR (Fig 5) were done in two blood samples of cattle collected from cattle slaughter houses of Meghalaya, which were found negative after examination of Giemsa stained blood smears.

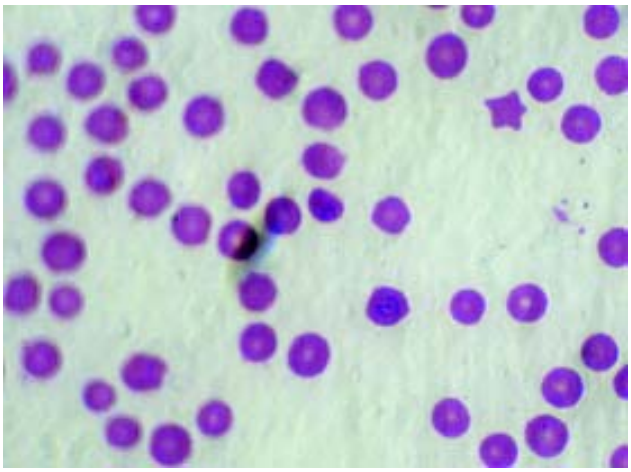


Fig 1 *Babesia bigemina* in RBC of Giemsa stained blood smears of infected cow

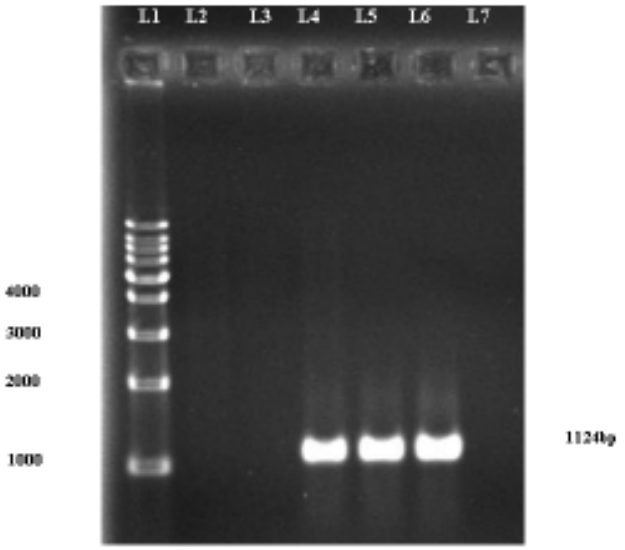


Fig 2 Electrophoresis gel (0.8% agarose, stained with ethidium bromide), showing lanes from left to right : Lane 1- 1kb DNA ladder, Lane 2- Negative after 9 days post treatment (PT), Lane 3- Negative after 48 hours PT, Lane 4 to Lane 6- PCR product showing positive during infection (1124 bp), Lane 7 - Negative control - sample contains water and no template DNA

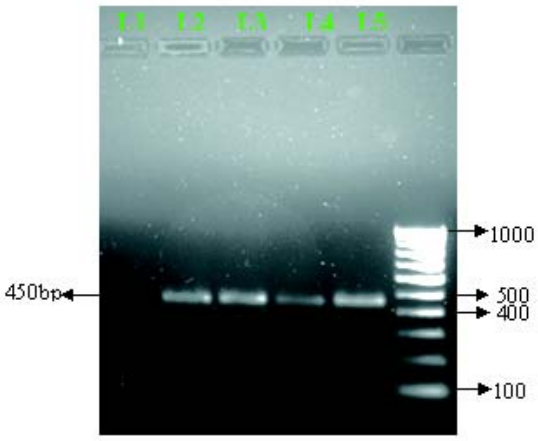


Fig 3 Electrophoresis gel (1.5% agarose, stained with ethidium bromide), showing lanes from left to right : L1, Negative control; L2 to L5, PCR product showing positive for *Babesia canis* (450 bp) ; L6, 100 bp DNA ladder

Effect on milk production due to *Babesia bigemina* infections in cow

A study was undertaken to observe the effect on milk production due to *Babesia bigemina* infections in cow, as there is a lack of such type of study. For this the cow maintained in cattle farm of ICAR Research Complex for NEH Region, Umiam, Meghalaya, which

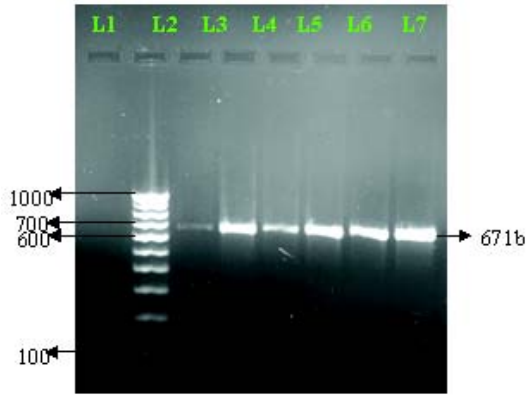


Fig 4 Electrophoresis gel (1.5% agarose, stained with ethidium bromide), showing lanes from left to right : L1, Negative control; L2, 100 bp DNA ladder; L3 to L8, PCR product showing positive for *Babesia gibsoni* (671bp)

was found positive for *Babesia bigemina* infection was taken. The average milk production (in litre) per week before infection, during infection and after treatment was recorded (Fig 6). It was observed that there was significant decrease in milk production throughout May in comparison to April and June which were considered as months of normal milk yield of the cow.

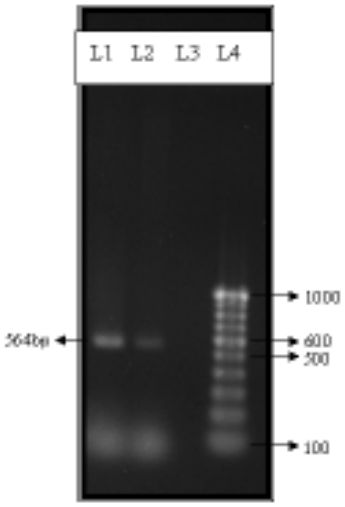


Fig 5 Electrophoresis gel (1.5% agarose, stained with ethidium bromide), showing lanes from left to right : L1 & L2, PCR product (564 bp) showing simultaneous detection of *Babesia* spp. and *Theileria* spp. infection; L3, Negative control; L4, 100 bp DNA ladder

On 14th May, the cow showed acute clinical symptoms and on this day *B. bigemina* infection was diagnosed and treated. After treatment the milk production gradually increased and reached to normal production after 17 days of post treatment. Average daily decrease in milk production as observed was 1.72 litre. This decrease in milk production was noticed for 30 days. Hence, total decreased in milk production during disease condition was calculated as 51.6 litre.

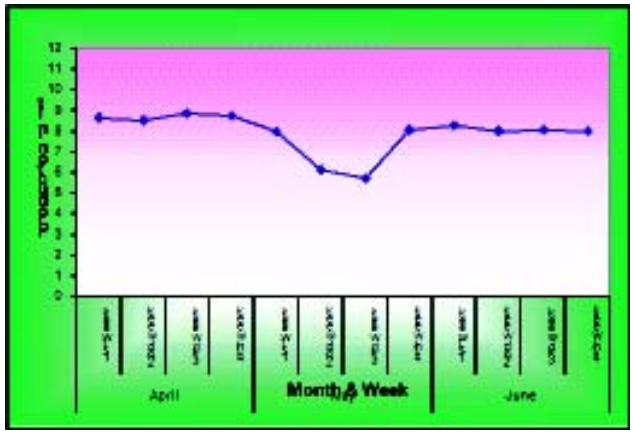


Fig 6 Average milk production (in litre) per week

Detection of mange infestation in pigs of Meghalaya

A total of 63 skin scrapings of pigs were collected from pig farm of Animal Production and Animal Nutrition of ICAR Research Complex for NEH Region, Umiam, Meghalaya, Mawphlong village and from pigs brought for slaughter house of Shillong. Out of these seven (11.11%) pigs were found infested with *Sarcoptes scabiei* var. *suis* after microscopic examination of skin scrapings.

Fig 7 Skin lesion of pig suspected foe mange infestation

Anthelmintic efficacy against gastrointestinal parasites of pigs in Meghalaya

Incidence of gastrointestinal parasitism of pigs

For epidemiological and seasonal incidence of gastrointestinal parasitic infection, a total of 589 faecal samples of pigs were collected per rectum from

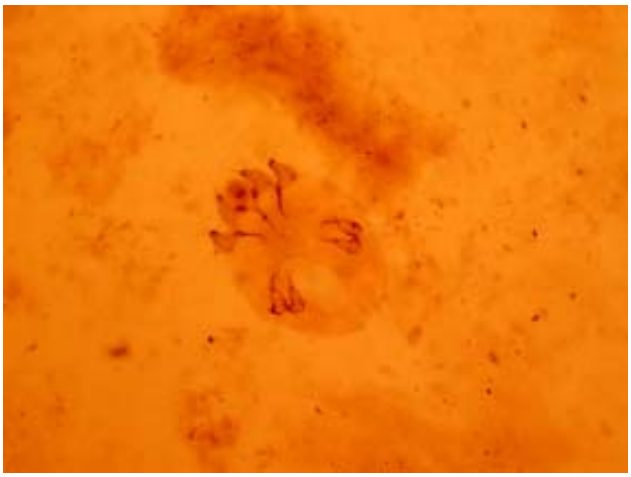


Fig 8 Diagnosis of *Sarcoptes scabiei*

organized and unorganized pig farms of Ri-Bhoi district of Meghalaya and examined by using modified Mc Master technique. The prevalence of gastrointestinal parasitic infection was recorded as 30.27% and 46.10% in organized and unorganized pig farms, respectively. In organized and unorganized pig farms the percentage of infection of *Strongyle* sp. 28.33% and 43.16%; *Strongyloides ransomi* 7.05% and 1.87%; *Ascaris suum* 32.08% and 17.15%; *Trichuris suis* 0.83% and 3.21% and *Eimeria* sp. 23.75% and 12.33%, respectively (Fig 9). 7.50% and 22.25% mixed infection was also recorded in organized and unorganized farms, respectively.

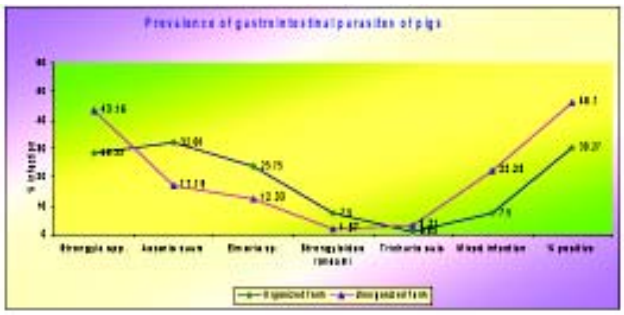


Fig 9 Prevalence of gastrointestinal parasites of pigs in organized and unorganized farms of Meghalaya

Studies on incidence of gastrointestinal parasitic infection in pigs from Apr'2010–Mar'2011 revealed prevalence of gastrointestinal parasitism in pigs throughout the year in both organized and unorganized farms. In organized farms lowest and highest percentage of infection was recorded in Jan (19.4%) and Jul (37.5%) whereas, in unorganized farms it was recorded in Feb (35.2%) and Jun (58.2%), respectively (Fig 10). Based on these findings pigs should be dewormed with anthelmintics at least once during Apr/May and again during Sep/Oct.

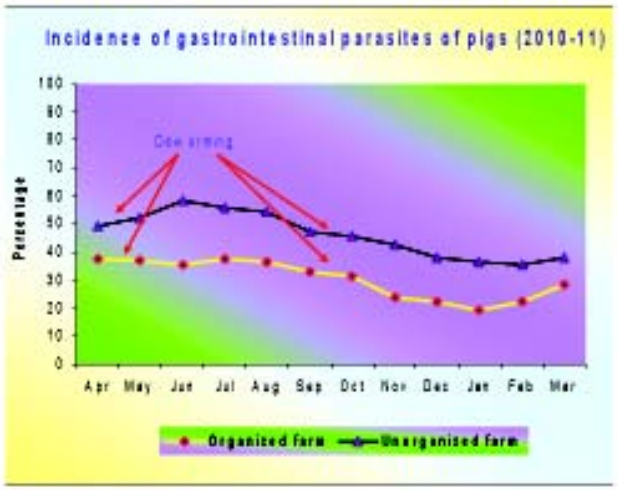


Fig 10 Incidence of gastrointestinal parasites of pigs

Anthelmintic efficacy of plants against parasites of livestock and poultry

Extracts of five locally available plants were evaluated *in-vitro* against *Haemonchus contortus* larvae of goats for larvicidal activity. Aqueous and methanolic extracts of two plants showed 80% and 60% larvicidal activity at different concentration i.e., 100µl, 200µl, 300µl, 400µl and 500µl, respectively (Fig 11).

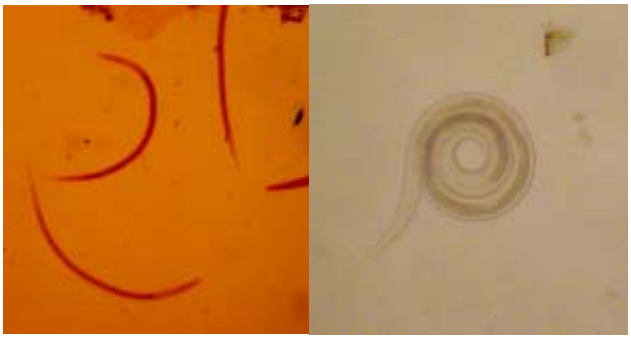


Fig 11 Effect of plant extracts on *H. contortus* larvae

Studies on gastrointestinal parasitism in cattle

A total of 105 faecal samples of cattle were collected from different cattle farms of Meghalaya. Out of these 35 cattle were found positive for parasitic infections. The eggs or ova of *Strongyle* spp., *Moniezia* spp., *Eimeria* spp., *Strongyloides* spp. and *Nematodirus helvetianus* (Fig 12) were detected from these faecal samples.

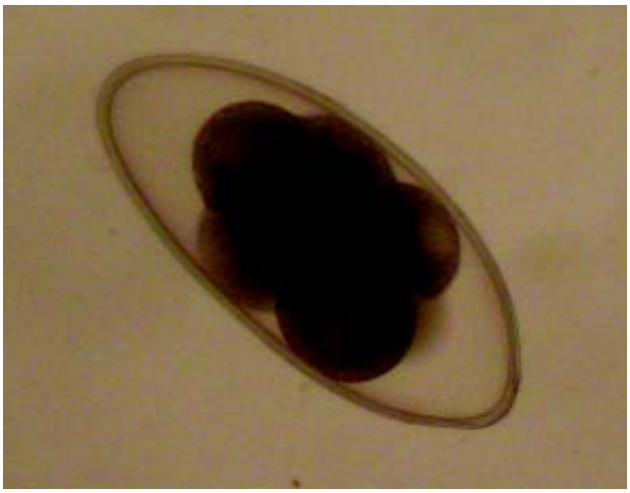
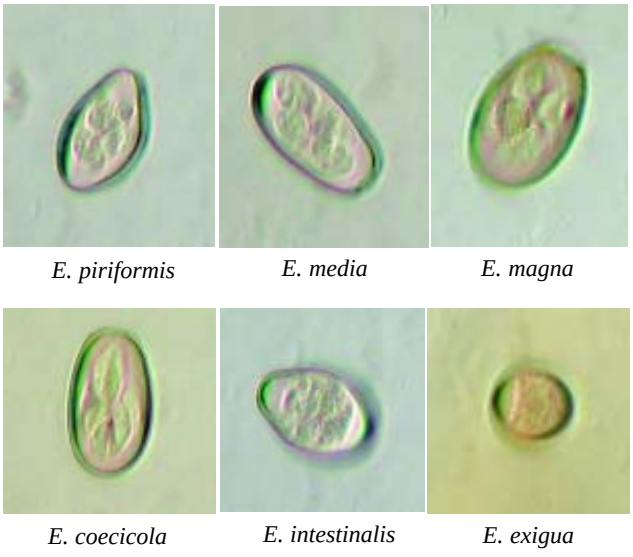


Fig 12 Egg of *Nematodirus helvetianus*

Study on mortality in rabbits

Coccidian infections in rabbits cause heavy economic losses to the livestock owners in terms of morbidity and mortality. Young rabbits mostly suffer from this disease. The rabbit population of this hilly area have been observed to harbor coccidial infection throughout the year in sub clinical form with an average range of 150 to 5100 oocysts per gram (OPG) of faeces except in monsoon season when clinical form of coccidiosis have been observed. Mortality in rabbits maintained in the rabbit farm of ICAR Research Complex for NEH Region, Umiam, Meghalaya, were observed in the month of August, 2010. It was diagnosed that coccidiosis caused by different *Eimeria* spp. were responsible for such mortality with an average of 50,000 to 60,000 OPG. Six different species of *Eimeria* i.e., *E. magna, E. exigua, E. piriformis, E. coecicola, E. intestinalis* and *E. media* were identified. Mortality was controlled after treatment Amprolium soluble powder 20% w/w @ 0.1% in water for 10 days. Individual drenching was found more effective to control the mortality.



E. piriformis *E. media* *E. magna*

E. coecicola *E. intestinalis* *E. exigua*

Fig 13 Six different species of *Eimeria* identified from rabbit

POULTRY

Studies on egg and meat quality traits of Turkey and Japanese quails

The different external and internal egg quality traits of Turkey and the carcass qualities of Turkey and Japanese quails at market age were studied and presented in the Tables 1 & 2.

Table 1 Egg qualities (at 40 weeks) of Turkeys in agro-climatic condition of Meghalaya

Parameters	Values
Egg weight (g)	68.95±0.75
Shape index	75.99 ± 2.47
Specific gravity	1.090 ± 0.001
Whole egg volume (ml)	60.62 ± 0.71
Albumen volume (ml)	40.71 ± 0.45
Yolk volume (ml)	19.92 ± 0.47
Albumen to egg yolk ratio	2.055 ± 0.049
Egg liquid weight (g)	62.14 ± 0.72
Albumen weight (g)	40.87 ± 0.70
Yolk weight (g)	21.26 ± 0.46
Shell weight (g)	6.81 ± 0.34

Table 2 Carcass qualities of Turkey and Japanese quail at market age

Traits	Values	
	Turkey	Japanese quail
Live weight (g)	3460±199.00	180.00±8.56
Dressed yield (%)	75.35±1.00	71.30±2.53
Giblet yield (%)	3.29±0.29	4.75±0.12
Cut-up yields (%)		
Breast	26.70±1.41	33.18±0.89
Back	17.80±1.01	25.43±0.85
Thigh	16.70±0.94	13.49±0.78
Drumstick	14.10±0.82	9.09±0.52
Wing	15.80±0.98	8.96±0.43
Neck	8.90±0.75	9.85±0.69

Performance of Turkey and Japanese quail in Meghalaya

Management practices of Japanese quail under deep litter system and turkey under semi-intensive system during different stages of growth has been standardized under agro-climatic condition of Meghalaya and their performances have been presented in Table 3.

Fig 1 Japanese quails under deep litter

Fig 2 Turkeys under net house

Table 3 Average performance of turkey and Japanese quail in Meghalaya

Parameters	Japanese quail	Turkey
Age at first egg (days)	50	200
Annual egg production (nos.)	200	100
Egg weight (g)	10	70
Body weight at marketeable age (g)	180-200	3000-5000

Supplementation of herbal feed additives for quality broiler chicken production

Feeding trial with one hundred and eighty straight run commercial broiler chicks was conducted to study the effects on supplementation of five different combinations of herbal powders at 0.5% and 1% levels as feed additives on the performance as well as haematobiochemical traits. Two different combination of herbal powders were prepared and designated as Formulation-1 (garlic, ginger and turmeric powder combination at the ratio of 1:1:1) and Formulation-2 (*Occium sanctum*, *Menta arvensis*, and *Emblica officinalis* powders at the ratio of 1:1:1). The chicks were randomly allotted to five dietary treatments *viz.*, T0 (Basal diet), T_1 (Basal diet plus 0.5% Formulation-1), T_2 (Basal diet plus 1 % Formulation-1), T_3 (Basal diet plus 0.5% Formulation-2), T_4 (Basal diet plus 1 % Formulation-2) groups with three replicates of twelve chicks in each and reared on deep litter system under standard management condition up to 49 days of age. No significant (P<0.05) difference in body weights were recorded among the supplemented groups compared to control group. Although significantly (P<0.05) lower serum cholesterol levels were recorded in T2 and T4 supplemented groups compared to control group (T_0) but other haematobiochemical traits evaluated remained nonsignificant (Table 4).

Table 4 Performance and haemato-biochemical traits of broilers under different treatment groups

Traits	Treatment groups				
	T_0	T_1	T_2	T_3	T_4
A. Performance					
1st week body weight (g)	97.40±2.35	99.60±3.16	104.40±2.19	99.20±2.01	96.80±3.72
2nd week body weight (g)	202.20±5.56	231.00±8.98	246.60±8.20	202.00±4.13	235.80±9.25
3rd week body weight (g)	417.80±8.76	414.60±11.47	415.80±12.40	403.80±10.70	430.43±16.44
4th week body weight (g)	752.20±26.04	773.60±22.05	783.80±21.96	728.20±22.99	705.22±28.37
5th week body weight (g)	1101.04±55.87	1175.00±30.58	1250.00±29.90	1077.08±37.68	1101.19±35.50
6th week body weight (g)	1560.42±55.10	1606.00±39.09	1635.00±51.60	1552.08±55.66	1526.25±37.10
7th week body weight (g)	1934.78±60.58	1980.00±52.60	1992.08±48.07	1872.92±52.21	1857.50±46.63
Mortality (%)	10.00±5.78	10.00±5.78	6.67±6.67	10.00±5.78	6.67±6.67
Cumulative FCR	2.01±0.04	2.06±0.07	2.01±0.04	2.01±0.04	1.96±0.03
B. Haemato-biochemical					
GPO (mg/dl)	153.33±2.51	151.00±2.32	152.44±1.92	150.22±2.11	151.33±2.54
SGOT (U/L)	34.67±2.99	34.33±2.10	33.56±2.29	34.56±2.24	32.78±1.96
GPT (U/L)	33.22±2.21	34.89±2.02	32.89±2.49	32.67±2.06	34.67±1.50
Alkaline ahosphatase (U/L)	252.78±4.91	251.33±6.09	249.44±4.37	250.67±3.60	249.33±6.38
Serum protein (g/dl)	5.60±0.41	5.51±0.44	5.71±0.63	5.52±0.39	5.78±0.66
Serum cholesterol (mg/dl)	191.44^{a}±4.79	182.78^{ab}±5.79	167.00^{c}±5.79	179.67^{ab}±5.80	165.78^{c}±6.10

T_0: Basal diet, T_1: Basal diet plus 0.5% Formulation-1, T_2: Basal diet plus 1 % Formulation-1, T_3: Basal diet plus 0.5% Formulation-2, T_4: Basal diet plus 1 % Formulation-2

FISHERIES

Introduction of Amur- Common carp

A genetically improved variety of Common carp – Amur (Hungarian strain) was introduced for the first time in the ICAR NEH Region fish farm, Barapani, Meghalaya in early 2010. The breeder's seeds of this variety were procured from the Fisheries Research and Information centre of Karnataka Veterinary, Animal and Fisheries Sciences University, Bangalore. Initial trial on this variety had shown encouraging results. In a culture period of six months, the fish attained an average weight of 300 g under mono culture condition at the farm complex of the institute. Currently, the division is working on production of quality seeds of improved strain/variety Common carp following planned breeding programme with two lines (paternal & maternal). Evaluation of growth performance of the improved strain/ varieties in comparison with the local strain in mid altitude condition is under progress. The study is being funded by the R & D wing of NABARD, Mumbai.

First breeding trial under mid hill conditions

The breeder's seeds of initial average weight 14.5 g reared under mid altitude condition at the institute fish farm complex attained maturity in about 14 months period. A few fishes attained a maximum weight of 1.5 kg in a culture period of 14 months (Fig 1-3). Male matured earlier than the female. The first breeding trial with this new variety was conducted successfully in March'2011 when the atmospheric temperature varied between 16^0C to 18.3^0 C. The fertilized eggs took about 78 to 83 hours to hatch. Water temperature ranged between 19^0 C to 22.8^0 C while water pH varied from 6.5 to 6.8.

Fig 1 Pond reared Amur – Common Carp

Fig 2 Selection of brooders for quality seed production

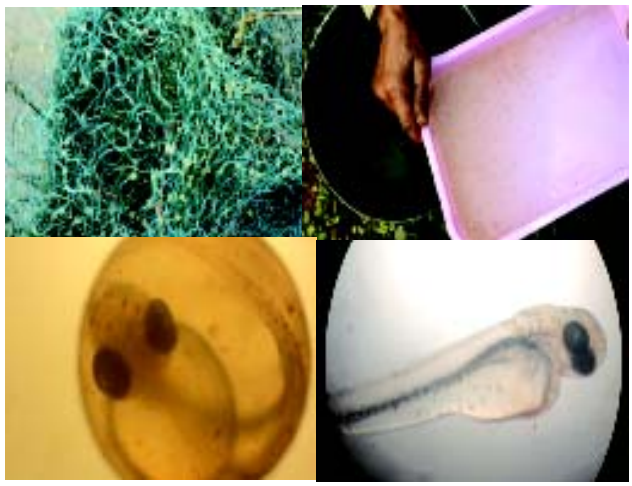


Fig 3 Seed production of Amur- Common carp (eggs, larval development and spawn)

Rice + fish farming

Rice - fish is the basic diet for most people of northeast India. A low lying area connected with a perennial stream was selected jointly with the Soil science division of the institute for conducting the experiment. Under mid hill condition, Common carp in rice field (plot size: 61 x 12 m^2=732. m^2) yielded encouraging results. The paddy plot was designed with perimeter canal (size: 1 m width & 0.75 m depth) and a centre pond (size: 5m diameter & 0.75 m depth) for rearing only Common carp, *Cyprinus carpio* at a stocking density of 5,000 nos/ha. Common carp seeds of average size 7 cm in length and 6 g in weight were introduced after 21 days of paddy plantation on 10.08.2010. In a rearing period of 237 days a production of 683 kg of common carp per hectare could be obtained without supplementary feeding. An average fish growth of 177.5 g was recorded during the period, while the maximum growth of an individual fish was 435 g (Figs 4-5).

Fry nursing of Golden mahseer, (*Tor putitora,* Ham)- An endangered species in pond based cage culture system

Golden mahseer is one of the most important fish species of the northeast especially in the hill states.

Fig 4 Paddy plot with perimeter canal

Fig 5 Growth of fish after 237 days

However, the population of this important indigenous fish species has been reduced to a great extent over the years due to several factors. Since the species now constitutes a negligible fishery of the hill streams and rivers, it has been categorized under the endangered fish species. Recently, an effort has been made to rear the juveniles of this species at the fish farm complex of the institute. The seeds of Golden masher were provided by the Directorate of Cold Water Fisheries Research, ICAR, Bhimtal, Uttarakhand. Golden mahseer juveniles of average size 2.36 cm was stocked in a 1 cubic meter low-cost bamboo cage at a stocking density of 100 nos per square meter in September 2010. The cage of size 1x1x1 m was fabricated with bamboo and nylon net material which was fixed in a pond with the help of bamboo poles for evaluation of survivality and growth over a period of 60 days from September to November 2010. The experiment recorded 70 % survival and a growth increment 2.39 cm in terms of length and 11 g in terms of weight under pond based cage culture system (Figs 6-8). During the study period water temperature varied between 17 – 28 ^{0}C while average water pH was 7.

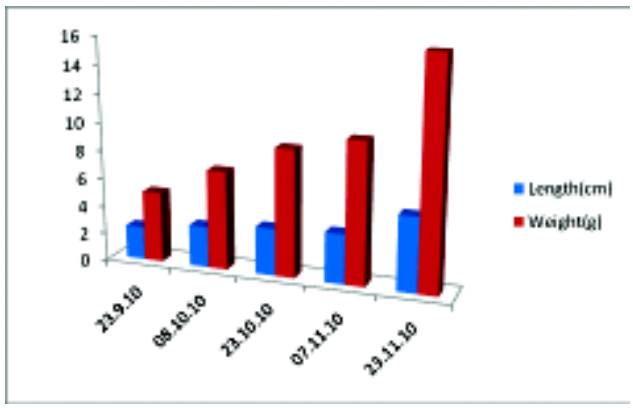


Fig 7 Performance of Golden mahseer, *Tor putitora* fry in pond

Fig 6 Pond based cage culture

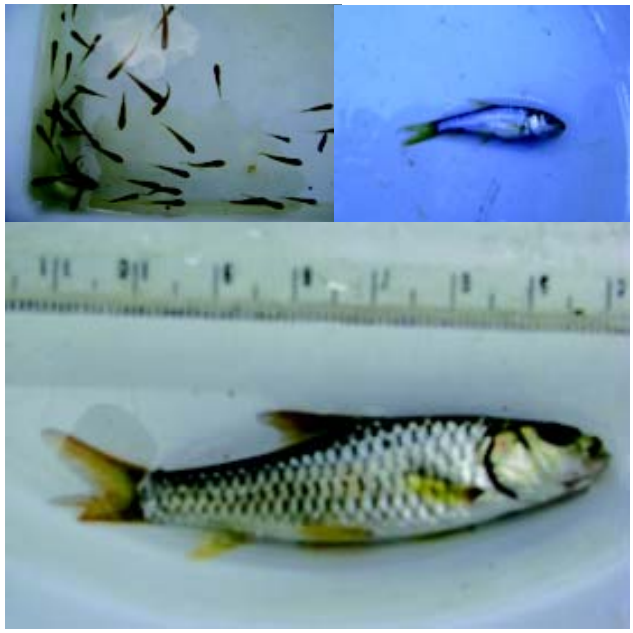


Fig 8 Juveniles of Golden mahseer reared under pond based cage culture system

Thermal tolerance of potential native fish species *Brachidanio rerio* and *Danio dangila* acclimatized to four different temperatures

Recent studies have shown that exposure to warm water can adversely affect the growth, survibility and reproduction of fishes inhabiting the hill streams. This study was designed to determine the species specific variation in thermal tolerance and metabolic activity, critical thermal maximum (CTMax) and lethal thermal maximum (LTMax) of *Danio dangila* and *Brachidanio rerio* adults acclimatized at four temperatures. For this purpose, fish were reared continuously at constant temperatures of 20, 25, 30 and 35°C for 45 days. The results implicate CTMax (36.4±0.05, 37.2±0.04, 38.7±0.03, 39.8±0.01); LTMax (39.8±0.03, 40.4±0.02, 41.2±0.06, 42.2±0.03), increased significantly (p<0.05) in *B. rerio* with increasing acclimation temperatures. Similarly, CTMax (36.2±0.02, 37.7 ±0.31, 39.6±0.07, 40.9±0.10); LTMax (38.1±0.08, 39.8±0.06, 40.0±0.07, 41.1±0.04) increased significantly (p<0.05) in *D. dangila* with increasing acclimation temperatures. Inter species specific variation (between *B. rerio* and *D. dangila*) was evident at 30 and 35°C. Oxygen consumption rate increased (p<0.05) with increasing temperatures in both the species. However, temperature quotient (Q10) was more in *B. rerio* (1.52) in comparison to *D. dangila* (1.43). Overall results suggest that *B. rerio* is more thermal tolerant and show better adaptation in comparison to *D. dangila* (Fig 9).

Fig 9 *Brachidanio rerio* (left top panel) and *Danio dangila* (right top panel). Damaged fish morphology at lethal temperature (bottom panels)

Feed utilization and reproductive competence of *H. fossilis* males reared in comparatively high temperature

In general, fishes cannot maintain a constant body temperature like mammals do. Their body is exactly at the same temperature as the water they are living in. Fishes can live in very cold or very hot water, but each species has a range of preferred temperatures. Most fish can't survive in temperatures too far out of this range. When fishes encounter water that is too cold for them, their metabolic activities slow down and become lethargic. On the contrary, as the surrounding water warms up, metabolic activities speed up and they digest food more rapidly, grow more quickly, and eventually have more energy for reproduction. But fish need more food and more oxygen to support this higher metabolism. On this backdrop, the current experiment was conducted to study the feed utilization efficiency by *H. fossilies* at ambient (17±0.5°C) and comparatively higher water temperature (32±0.5°C). Experimental feeds were prepared using viscera of pig and goat and were fed twice daily at 5% body weight. The growth parameters and gonado-somatic index was recorded at 15 days interval from the beginning of experiment. The study implicates goat viscera based feed utilization is better at higher temperature (32±0.5°C) with significant increase in GSI than other tested feeds at same and/or lower temperature (Table 1).

Cryopreservation of Chocolate mahseer milt

The Chocolate Mahseer is one of the endangered fish species in northeast India. Recent studies have revealed that the natural stock of Chocolate mahseer in various water bodies of the region has taken a declined trend. This might have happened due to various factors such as change in habitat, irresponsible fishing and climate change. Besides, it is also reported that the attainment of sexual maturity in male is earlier

Table 1 Variation in weight gain (g) and GSI (%) by feeding 3 experimental diets to the *H. fossilis* at elevated and ambient water temperature

Experimental	Tanks					
	Tank 1	Tank 2	Tank 3	Tank 4	Tank 5	Tank 6
Temperature (°C)	32±0.5	32±0.5	17±0.5	17±0.5	32±0.5	17±0.5
Feed type	Pig based	Goat based	Pig based	Goat based	Control	Control
Initial weight (g)	110	130	130	110	100	100
Final weight (g) after 30 days	160	190	160	155	135	130
Initial GSI (%)	0.31	0.28	0.33	0.34	0.36	0.25
Final GSI (%) after 30 days	1.40	1.90	0.82	0.97	1.11	0.48

(8-12 months) than the female counterpart (2-3 years) that pose severe difficulty in achieving captive breeding. In this backdrop it is paramount to conserve the gametes of this important fish species through *in situ* measures. One of the proven technologies for *in situ* conservation appears to be cryopreservation. It provides flexibility of long term preservation under ultra-low temperature and timely utilization of such preserved gametes as and when required for mass-scale propagation. This approach might overcome the problem of irregular sexual maturity that currently existing in nature.

In a preliminary trial, toxicity test was conducted using four extenders incorporating various cryoprotectants i.e. DMSO, Glycerol, Methanol and Ethylene glycol (Table 2). The extenders were prepared by diluting cryoprotectans in modified ringer solution (Table 3). Survibility of spermatozoa were observed under light microscope at different time interval such as 5, 10, 15 and 20 minutes. It was found that DMSO at 1M concentration with modified fish ringer solution gave maximum up to 50% survibility for 20 minutes where as survibility of spermatozoa was significantly lower is other extender solutions.

were *C. mrigala, L. gonius and L.bata* at a ratio of 2:1:1. Stocking density of fish was 10,000 fingerlings/ha and pig was 40 no/ha. At the end of six month trial, 51.31 kg of fish was harvested which is equivalent to 2150 kg/ha/year (Fig 10).

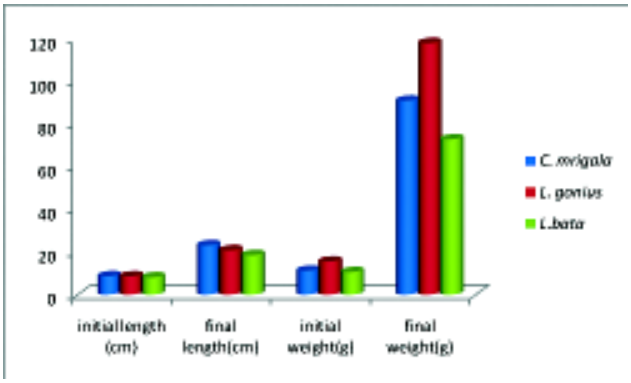


Fig 10 Growth performance of fish in fish cum pig integrated system

Table 2 Chemical composition of extenders (µl/10ml ringer's solution)

Chemicals	E1 (0.5M)	E2 (1M)	E3 (2M)	E4 (3M)	E5(4M)	E6(5M)
DMSO	390.5	781	1562	2343	3124	3905
Glycerol	460	920	1840	2760	3680	4600
Methanol	160	320	640	960	1280	1600
Ethylene glycol	310	620	1240	1860	2480	3100

Table 3 Chemical composition of modified ringer solution

Chemicals	Grams/100ml distilled water
NaCl	0.75
KCl	0.01
$CaCl_2$	0.016
$NaHCO_3$	0.02
pH	7.5

Growth performance of fish in fish cum pig integrated system

An integration of fish with pig was done in pond area of 468 sq m to increase the profitability by nullifying the feeding cost for fishes by application of fresh pig dung in to the pond. Fish species stocked

Human resource development

The Fisheries division conducted one major training programme with financial assistance from the National Fisheries Development Board (NFDB), Hyderabad for the benefit of Fisheries officers of Govt. of Meghalaya in January 2011. The five day long training was conducted on a topic entitled *Enhancement of fish production through fish based farming system in the hill state of Meghalaya*. An exposure visit cum training on ornamental fish culture was organized for the entrepreneur and extension officials at the request of Directorate of fisheries, Govt. of Assam. In addition, the staff of division imparted training to visiting farmers / entrepreneurs and also participated as resource person in various training programmes conducted by the Department of Fisheries, Govt. of Meghalaya and institute's SWPAL programme.

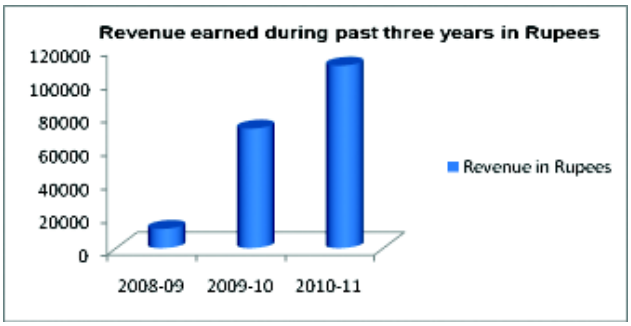
Fish seed production and distribution

The fisheries division has intensified the seed production programme in the past year and the produced seeds were distributed to the aspiring fish farmers of the state at fair price. Thus, the revenue

Fig 1 Training programmes organized by the Fisheries Division

Fig 2 Fish seed production and distribution

generated is principally based on sale of fish seeds. During the period 2010-11, an amount of 1,09,756.00 (Rupees One lakh nine thousands and seven hundred fifty six only) was generated. Fish seeds of major as well as minor carps and exotic carps have been produced along with two varieties of ornamental fishes, Gold fish and Koi carp.



Livelihood Improvement and Empowerment of Rural Poor through Sustainable Farming Systems in North East India, NAIP Component 3 (SRLS)

Zero tillage in toria- a success in Tamenglong, Manipur

Toria (var. M-27) was introduced in 50 ha area through Zero tillage technique in the 3 selected villages (Fig 1). Higher productivity (0.84 t/ha) of toria obtained under zero tillage as compared to local practice (0.54 t/ha). Farmers are also extracting the oil from their own seeds with the oil expeller provided by the ICAR. The zero tillage cultivation of toria is gaining popularity in the adjacent districts also. The advantages of zero tillage in toria are timely sowing is possible (October-November), conserve soil moisture and require less water, saves tillage cost and the soil is protected from erosion due to the retention of surface residues and reduce organic matter depletion.

Fig 1 Toria (M-27) under zero tillage, Tamenglong

SRI and ICM method of paddy cultivation- a great success in Dhalai, Tripura and South Garo Hills, Meghalaya

A total of 1103 nos. of farmers in Marachera and Balaram cluster under Dhalai district (Tripura), were given seeds of Pusa-44, Samba Mashuri and Naveen @ 1kg/kani (0.16 ha) for SRI cultivation (Fig 2). Similarly, a total of 95 farmers were provided with Ranjit variety of paddy in South Garo Hills (Meghalaya). Farmers followed the SRI method of rice cultivation right from raising of nursery. About 90% farmers were satisfied with the SRI method due to the increase in productivity. Average productivity of local variety in South Garo Hills district was 1.5 t/ha and in Dhalai District it was 2.1 t/ha. After introduction of Ranjeet variety through SRI average productivity went up to the 4.8 t/ha in South Garo hills whereas, in Dhalai (Tripura) after the introduction of Naveen variety through SRI the productivity went upto 3.7 t/ha. In the two sites (Dhalai & South Garo Hills) the average enhancement in income/ha/yr due to the introduction of HYV rice + SRI technology increased by Rs 6700/ha/yr. A total of 1200 farmers were benefited.

Fig 2 SRI in Garo Hills and Dhalai

Fish + duck + pig based farming system in South Garo Hills, Meghalaya

Sixty household in 11 villages of Sibbari cluster, South Garo Hills were selected for Fish + duck (Sonali) + pig (Hampshire) based farming system (Fig 3). A total of 10 new ponds were constructed and renovated old small ponds (30 nos) scientifically. Due to this intervention farmers fish productivity has increased by about 1.5 t/ha and individual farmers are earning about Rs.10,000 from their pond (25m x 25m). Duck give about 150 eggs/annum as compared to 110-120 from local one and villagers are selling egg @ Rs. 6-7/egg. The improved Hampshire breed is giving two furrowing in a year with 7-8 piglets/furrowing. Farmers are selling the piglets after 3 months @ Rs. 1500/piglet. Some farmers are also selling vermicompost @ Rs. 6/kg. Banana (var. Malbhog) started giving fruits for some farmers. Arecanut, citrus and guava are in vegetative stage. Altogether the farmers are very happy and they are earning a net income of about Rs. 15,000/annum from such integrated farming.

Fig 3 Pond + Pig + Duck based IFS, Garo Hills

Terracing for Panikheti in Mon, Nagaland

Under natural resource management, terracing for panikheti (Fig 4) in Lampong Sheanghah village (Mon District) was done not only to enhance rice productivity but also to introduce second crop which otherwise used to be kept fallow by the farmers. A total of 9 households were involved covering an area of 6.2 ha with a net cultivable area of 4.9 ha under terrace cultivation. Terracing was followed in the lower part of the hillock with slope of about 30%. All the terraces were made at a vertical interval of 1m keeping the topmost soil intact. Irrigation channels were prepared to divert water from the stream. For nutrient management, a thick row of hedgerow species like *Tephrosia candida* and *Crotolaria* spp. were planted and the green biomass was mulched into the terraces. Two rice varieties Shahsarang and Lampnah were cultivated which showed the productivity enhancement by 3 fold (3.39

t/ha) as compared to the indigenous landraces, i.e. Rakchu having the productivity of 1.2 t/ha in wet land condition.

Fig 4 Terrace Wet Rice (*panikheti*), Mon

Turmeric processing at Saiha, Mizoram

For the first time a turmeric processing unit (Fig 5) was established at Saiha, Mizoram to boost value addition to locally produced turmeric. Thus, farmers of Saiha where market for sale of fresh turmeric was not adequate could now sell their produce with higher price in different markets in the state. A total of 3 SHGs (32 members) in Saiha district (Mizoram) are involved in Turmeric processing unit. An average of 400 kg of dried turmeric is being processed per month and is sold @ Rs. 10/100gms packet. Due to the installation of turmeric processing unit employment and income of SHG members is enhanced.

Fig 5 Turmeric processing unit

Year round production of high value vegetables at North Sikkim

Year round cultivation of high value vegetables; tomato (Avinash, Anup, Romeo and All Rounder), capsicum (Indra and Orebelle), cauliflower (Suwashini and Girija), broccoli (Everest and Aishwarya) etc under polyhouse has increased the income of the farmers (Fig 6.) in North Sikkim. More than 10 SHGs of Lingdong, Passingdang, heegyathang, Tinvong and Samdong are engaged in the cultivation of vegetables. Under this project 29 low cost polyhouses have been constructed, more than 1 lakh seedlings have been distributed and the area under protected cultivation has been increased to 0.5 ha from 0.02 ha. Farmers are earning a net income of Rs. 4880 to Rs.11800 from 0.02 ha area from year round vegetable cultivation in North Sikkim.

Fig 6 Year round vegetable production in polyhouse, North Sikkim

Arunachal Pradesh

WEATHER REPORT

The centre is acting as nodal agency to provide weather forecast for all the sixteen districts and to release weather based agro-advice bulletin at three days interval for the crops of importance. The period from Apr 2010 to Mar 2011 recorded the highest rainfall. The Agromet Advisory Services has been working since 2008 for the welfare of the farming community of the State of Arunachal Pradesh. The Agrometeorological Field Unit, Basar has been publishing the Agromet Advisory Bulletin of the 14 districts *i.e.*, Tawang, West Kameng, East Kameng, Lower Subansiri, Papumpare, East Siang, West Siang, Upper Subansiri, Upper Siang, Dibang Valley, Lower Dibang Valley, Lohit, Tirap and Changlang of Arunachal Pradesh through local daily Arunachal Times, Doordarshan Kendra, Itanagar, KVKs through e-mail and disseminated to the farmers through the local administration of the concerned district as well as through the District Agriculture Officers of different districts of the state.

The mean monthly maximum temperature varied from 19.9 ºC in Dec to 31.4 ºC in August (Table 1). The mean monthly minimum temperature varied from 7.6 ºC in the month of Jan to 24.7 ºC in July. August was the hottest month. Highest maximum temperature recorded for a single day was 36.2ºC on 6th August and lowest temperature recorded was 4.5 ºC on 11th January 2011. The total rainfall recorded during April 2010 to March 2011 at Basar was 3088 mm distributed over 152 days. The total number of rainy days was about 141 days which was 3 days less than the normal.

CROP PRODUCTION

RICE

Effect of cultural management practices under low input production system for wetland rice

An experiment was laid (Fig 1) out to evaluate the performance of four rice varieties (Lachit, Puja, VL-61 and VL-225) with three cultural management practices (i) One spading at the time of transplanting (CP1) (ii) Two spading-1st before 20 days of planting and other at the time of transplanting (CP2) and (iii) Puddling (CP3). All four varieties were transplanted at spacing of 25 cm x 10 cm. The FYM was applied @ 5t/ha at the time of field preparation and 20 kg N/ha was given at the time of panicle initiation stage. The highest grain yield was obtained from VL-61 + puddling (3.81 t/ha) followed by VL-61 + 2 spading (3.67 t/ha) and Puja + puddling (3.63 t/ha).

Fig 1 VL-61+Puddling at PI stage

Table 1 Weather data recorded at Agro-meteorological observatory, Gori Research Farm, ICAR, Basar for the year 2010-11 and compared with normal

Parameter	Months											
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Mean max. temp. (ºC)	24.5	26.6	27	29.2	31.4	30.7	26.3	23.2	19.9	17.7	17.6	20.8
Normal max. temp. (ºC)	22.6	25.8	27.5	28.1	28.8	27.9	26.3	23.5	19.7	16.9	17.4	20.1
Mean min. temp. (ºC)	18.1	19.5	23	24.7	22.5	21.4	18.5	14	8.6	7.6	9.2	14.6
Normal min. temp. (ºC)	14.9	17.5	20.4	21.6	21.2	20	17.4	11.4	8.2	6.8	8.9	11.1
Total rain (mm)	200	412	440	626	524.5	418.5	90	100.5	18.2	97.9	27.8	131.6
Normal rain (mm)	169.5	227.4	463.7	514.4	345	357.9	149.8	46.5	29.1	52.8	95.3	106.5
Total rainy days	14	20	21	22	15	19	10	3	3	0	3	11

Maximum number of grains per panicle was observed in VL-61 + puddling (217) followed by Lachit + puddling (214.66) and VL-61 + 2 spadings (213.33). Highest test weight 31.56 g was recorded in VL-61 + puddling followed by Puja + puddling (31.34 g) and VL-61 + 2 spading (31.00 g). Maximum plant height was measured in Puja + puddling (102.7 cm) followed by Puja + 2 spading (96.20 cm) and Puja + 1 spading (92.16 cm). Highest weed biomass (21.33 kg) was recorded in VL-225 + 1 spading followed by Lachit + 1 spading (20.00 kg /plot). Highest gundhi bug infestation was observed in Puja followed by Lachit and VL-61.

Evaluation of organic sources of nutrients supply for rice-pea cropping system in wetland condition

A field experiment was laid out with different organic sources of nutrients for rice-pea cropping system under wetland rice cultivation. Two varieties of rice (Luit and Vandana) and two varieties of pea (TRCP 8 and Azad P1) were evaluated with the treatment of control, green manure of *Tephrosia*, green manure of *Crotolaria*, green manure of weeds and farm yard manure (FYM). All the organic manures were applied @ 80 kg N/ha and the amount was calculated on the basis of respective nitrogen percentage content (*Tephrosia candida*=3.57%, *Crotolaria tetragona*=3.23%, weeds=1.87% and FYM=0.52% N) to make the equivalent. All green manure crops/weeds were chopped into pieces and applied into respective plots in allotted treatment 15 days before transplanting and FYM also applied at the same time.

Results revealed the highest grain yield in Luit + *Tephrosia* (3.78 t/ha) followed by Vandana + *Tephrosia*. However, Luit + *Crotolaria* has recorded 3.48 t/ha and Vandana + *Crotolaria* yielded 3.23 t/ha. Test weight (1000 grain weight) was obtained highest from Luit with *Tephrosia* (25.18 g) followed by Luit with *Crotolaria* (24.86 g). Number of grains/panicle was observed highest in Luit+*Tephrosia* (181.3) followed by Luit + *Crotolaria* (146.6) and 128.3 in Vandana + *Tephrosia* and 118.33 in Vandana + *Crotolaria*. Highest plant height was observed in Vandana + *Tephrosia* (101.16 cm) followed by Vandana + *Crotolaria* (88.83 cm) and Luit + *Tephrosia* (82.53 cm). Two varieties of pea (Azad P1 and TRCP8) were sown during *rabi* in specified plot and green pod yield were recorded in both varieties. Highest pod yield was recorded in TRCP8 (1.88 t/ha) with *Tephrosia* followed by Azad P1 with *Tephrosia* (1.77 t/ha) and TRCP8 with *Crotolaria* (1.72 t/ha).

Studies on suitable cropping sequence

A field experiment with rice (var. Vandana) based crop sequence *viz*. rice-wheat (HS-240), rice-pea (var. Azad P1), rice-French bean (var. Anupama), rice-potato (var. K.Jyoti), rice-mustard (var.TS-38), rice-winter maize (All-rounder), rice-tomato (var. Suraksha), rice-cabbage (var. Pride of India) was conducted and tested for performance with three replication in fixed plot of 4m x 3m area. Different crops and their varieties with respective fertilizer doses were applied in upland rice [5t FYM+50% RDF (60:40:40-N:P:K)], maize (120:60:40), wheat (40:30:30), pea (20:60:30), French bean (80:60:40), mustard (50:60:40), tomato (76:60:75), potato (125:120:60) and cabbage (60:60;40). The upland rice variety Vandana was sown on 16th April, 2010 in 24 plots of 4m x 3m size for recording the performance. The grain yield obtained from Vandana (Fig 2) was in the range of 3.17-3.66 t/ha. Plant height was recorded from 96.4 cm-107.4 cm. The crop matured at 102 days. Crop sequence rice-French bean was found more remunerative than other crop sequences *viz.*, rice-cabbage, rice-tomato, rice-pea, rice-potato, rice-maize, rice-wheat and rice-mustard.

Fig 2 Vandana attaining maturity

Cultural management practices for enhancing grain yield and soil health of rainfed upland rice

Upland rice (var. Anjali) was sown with Dhaincha (Fig 3) and compared under various treatments. The maximum number of panicles/m^2 (246.6) was recorded

Fig 3 Performance of rice under Dhaincha in field

in rice + Dhaincha + 60:60:40 (N:P:K) followed by rice + Dhaincha + 60:40:40 (N:P:K) *i.e.,* 224.6. The panicle weight/m^2 was observed maximum in Rice + Dhaincha +60:60:40 (N:P:K) (381.6 g) followed by rice alone + 60:60:40 (N:P:K) i.e. 341.0 g. Maximum grain yield (3444 kg/ha) was obtained from Rice + Dhaincha + 60:60:40 (N: P: K) followed by rice alone + 60:60:40 (N:P:K) *i.e.,* 3263 kg/ha whereas, rice alone with control produced 1241 kg/ha and rice+ Dhaincha in control yielded 1595 kg/ha.

Collection, screening and improvement of *jhum* rice for increasing production and productivity of *jhum* cultivation

Fourteen *jhum* rice germplasm collections were identified based on yield performance (1.0-4.4 t/ha yield) in an experiment with RBD in ideal *jhum* field without any external inputs like chemical nutrients *etc.* during 2010-11 season (Fig 4). A minicore of rice germplasm was screened during *kharif*-2010. Out of them 14 accessions were identified as best performer for yield and other yield contributing traits. The highest grain yield/ha was recorded for SARS-1 (4400 kg) followed by Jarli, Kimin (4000 kg) and Bamtare (3750 kg). Similarly, Bamtare (145 cm) was observed as tallest followed by Bali Lite (135 cm) and Pupi III (132 cm). Highest number of panicle/m^2 was exhibited by SARS-5 (93) followed by Pumik (74) and Jarli (72). For the number of effective tillers/plant, Jora (12.2) produced highest no. of effective tillers followed by SARS-5 (9.4) and Ampu (8). Genotype SARS-1 showed highest number of grains/panicle (405.8) followed by SARS-2 (359.6) and SARS-5 (262). All the identified rice germplasm accessions were also characterized according to DUS Testing guideline of PPV& FR Authority (Govt. of India).

Evaluation of different groups of rice varieties in different land situations (aromatic, fine grain, upland, lowland varieties)

Different groups of rice varieties (aromatic and fine grain) were evaluated in *Kharif* -2010 under upland condition with two replication and two checks in trial I and three checks in trial II. Results of trial I showed that RCPL 1- 115 followed by RCPL 1-114 and RCPL 1-413 performed best for most of the characters (days to 50% flowering, panicle/m^2, plant height, grain yield and disease incidence). In trial II, RCPL 1-113 followed by IR60080-46A and RCPL1-116 exhibited superiority over checks for yield and related traits with less disease incidence.

Different groups of rice varieties (aromatic and fine grain) were evaluated in *Kharif* -2010 under lowland condition with two replication and four checks in trial I and three checks in trial II and III. Results of trial I showed that RCPL 1-145 followed by RCPL 1-147 and RCPL 1-149 performed best for yield and contributing traits along with least disease incidence. RCPL 1-401 followed by RCPL 1-187 and RCPL 1-403 exhibited best performance with less disease in trial II. In trial III, RCPL 1-300 followed by RCPL 1-160 and RCPL 1-304 produced superior characteristics over the checks with least disease incidence.

SARS-1 **Kimin** **Bamtare**

Fig 4 Performance rice germplasm in *jhum* fields

DISEASES

Screening of rice germplasm collections/varieties against rice leaf blast

Eighty two varieties of rice were collected from different institutes and local sources and were screened under UBN pattern for leaf blast resistance. The disease pressure was moderate at Basar condition with 3.96 LSI. Eighteen varieties showed resistant reaction, 32 were as tolerant, 12 entries as susceptible and 20 entries were highly susceptible. Another 28 rice entries were received from IARI and screened in UBN pattern for leaf blast resistance under Basar condition. There was very low disease pressure and almost all entries showed resistant reaction against rice leaf blast with LSI of 1.32 (very low disease pressure).

National screening nurseries for host plant resistance against leaf blast under AICRP on Rice

One hundred seventy one (171) entries of National Screening Nursery 1 (NSN1) were evaluated in UBN pattern for their blast resistance. Disease pressure was low with LSI of 2.98. Similarly, 79 entries of National Screening Nursery Hills (NSN-H) were also evaluated in UBN pattern and showed moderate disease pressure with LSI of 3.90.

MAIZE

Effect of different sources of nutrients on maize

Maize received from Advanta var. *PAC-746* was sown on 18th June, 2010 and its performance was recorded with the treatment of control, FYM (10 t/ha), RDF (120:60:40), DAP (P-60 kg/ha through DAP) and MOP (40 kg K/ha through MOP). The highest plant height (170.46 cm) was recorded with RDF followed by DAP treatment i.e.156.63 cm and FYM 150.16 cm. Maximum fresh cob yield (5.32 t/ha) was obtained with the treatment of RDF followed by with DAP treatment (4.5 t/ha) and with MOP (3.53 t/ha). Maximum cobs/plant was recorded with RDF and MOP (3 Nos.).

Effect of different leguminous crops on growth and yield of maize

Legumes like cowpea, French bean and black gram were intercropped in maize with various combinations (Figs 5-8). The highest maize yield was recorded with sole maize (4800 kg/ha) followed by maize + cowpea (1:2 ratio). However the lowest yield (2100 kg/ha) was recorded on maize + French bean (1:5 ratio). The

Fig 5 General view of intercropping experiment

Fig 6 Maize and cowpea with 1:5 ratio

Fig 7 Maize and black gram with 1:5 ratio

Fig 8 Cobs of maize cowpea with 1:5 ratio

highest Maize Equivalent Yield (MEY) was recorded when the maize was intercropped with cowpea at 1:5 ratio followed by maize black gram (1: 5 ratio) but was comparable to sole cowpea. Similarly land equivalent ratio was recorded higher on maize + cowpea with 1: 5 ratio (1.40) and maize + black gram with 1:5 ratio (1.37). The weed dry weight was recorded lowest and highest weed control efficiency on sole cowpea followed by maize cowpea with 1: 5 ratio.

Evaluation of locally available manure on maize

Five locally available manures along with control was imposed in maize. The growth and yield attributes was recorded highest when crop was supplied with 2.5 t/ha of vermicompost followed by 1.25 t/ha of poultry manure. The yield of grain and stover was recorded highest in vermicompost (3.92 and 6.25 t/ha, respectively) followed by poultry manure (3.75 and 6.12 t/ha, respectively). However, the lowest yield was recorded on control (1.9 and 4.65 t/ha, respectively). Similarly, physical and chemical properties of soil were improved with vermicompost and nutrient use efficiency was recorded higher on vermicompost followed by poultry manure.

MUNGBEAN

Effect of varieties and date of sowing on yield

Four varieties of mungbean were sown on last week of May at 10 days interval (3 dates of sowings) in 36 plots. The maximum seed yield (1.09 t/ha) was

obtained by var. IPM-02-03 (Fig 9) with 1st date of sowing followed by IPM-02-03 with 2nd date of sowing (07/06/10) (0.97 t/ha). Variety PDM-139 yielded 0.88 t/ha at 1st date of sowing and yield in all dates of sowing were less than 1st date of sowing. The maturity period 66 days was observed by var. IPM-02-03 and 68 days in IPM-99-125 whereas, lowest maturity (65 days) period was observed in PDM-139. IPM-06-5 was low yielder in all dates of sowing 0.59 t/ha (at 1st date of sowing) with maturity period 77 days. Pod length was recorded maximum in IPM99-125 (7.24 cm) at 2nd date of sowing (07/6/10) followed by IPM 02-03 (7.13 cm). Number of pods/plant was observed maximum in IPM 02-03 (51.33) followed by PDM-139 (28.0) and SM 06-5 (25.33) at 1st date of sowing. Lowest pod/plant was recorded in IPM-99-125 (18.66) at 3rd date of sowing (18/6/10). 100 seed weight was recorded highest in IPM 02-03 (4.05 g) followed by IPM 99-125 (3.66 g) at 1st date of sowing. The test weight decreased with 2nd and 3rd date of sowing in all the four varieties. The growth, plant height was recorded maximum (74.60 cm) by var. IPM99-125 at 1st date of sowing followed by the same variety in 2nd date of sowing i.e. 72.90 cm at harvest. IPM-02-03 attains 71.20 cm height at maturity.

Fig 9 Performance of mungbean (IPM-02-03)

Evaluation of AVT-summer mungbean (*Phaseolus radiatus* L.)

Three varieties of summer mungbean (Fig 10) received from ICAR RC NEH Region, Tripura Centre were sown on last week of May, 2010 in six replications. The highest seed yield (1.44 t/ha) was obtained by IPM-02-03 followed by PDM-139 (1.21 t/ha) and IPM 99-125 (0.67 t/ha). The straw yield of IPM-02-03 was 3.26 t/ha.

The IPM-02-03 was superior in maximum pod length, no. of seeds per pod and no. of pods per plant (7.42 cm, 11.10 and 48.66, respectively) followed by PDM-139. Plant height was measured highest at 30 DAS in IPM-02-03 (39.25 cm) followed by PDM-139 (36.11 cm). At 60 DAS, highest plant height was found in IPM-99-125 (70.23 cm) followed by IPM-02-03 (65.68 cm). The maturity period was found 63 days of PDM-139, 66 days of IPM-02-03 and 68 days of IPM-99-125.

COWPEA

Nutrient management in cowpea

Nitrogen was applied in recommended dose (25 kg/ha) and phosphorus and potassium (60 and 50 kg/ha, respectively) was applied with various doses in combinations (Fig 11 & 12). The highest green pod and stover yield of cowpea was recorded on 100% P + 100% K (4.9 and 14.2 t/ha, respectively) followed by 100% P + 75% K (4.7 and 13.7 t/ha, respectively). Similarly, all the growth and yield attributes followed the same trend for the above said treatments. However, lowest green pod and yield was recorded on 50% P and 50% K (3.0 and 10.1 t/ha, respectively). The nutrient uptake was also recorded highest when cowpea received 100% P + 100% K followed by 100% P + 75% K.

Evaluation of locally available manure on cowpea

The growth and yield attributes were recorded highest when crop was supplied with 2.5 t/ha of

Fig 10 Performance of summer mungbean varieties in Arunachal Pradesh

Fig 11 Cowpea cv. CP-04 with 100% P and 100% K (flowering stage)

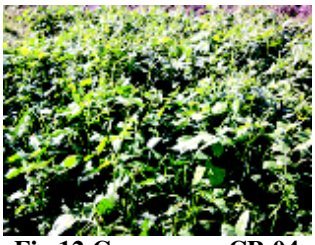


Fig 12 Cowpea cv. CP-04 with 100% P and 100% K (harvesting stage)

vermicompost followed by 1.25 t/ha of poultry manure. The yield of green pod and stover was recorded highest on vermicompost (4.73 and 5.05 t/ha, respectively) followed by poultry manure (4.05 and 4.82 t/ha, respectively). However, the lowest yield was recorded on control (2.4 and 4.05 t/ha, respectively). Similarly physical and chemical properties of soil were improved with application of vermicompost and nutrient use efficiency was recorded higher on vermicompost followed by poultry manure.

Evaluation of locally available mulches in pea

The highest yield was recorded in paddy straw mulch (3.2 t/ha) followed by maize stubbles (3.07 t/ha). Initial growth parameters were recorded highest on *Flemengia* mulched treatment. However, the moisture retention and availability to the crop plant was recorded highest on thatch grass *(Imperata cylendrica*). Similarly weed control efficiency was recorded highest on *Imperata cylendrica* followed by paddy straw mulch.

DISEASES

Evaluation of field pea varieties against location specific diseases at Basar condition

Two varieties namely Azad Pea -1 and Arkel were taken for screening at Basar condition (Fig 13). The experiment was conducted at three different date of sowing each at a difference of 15 days. Seeds were sown in two different spacing that are, S1- (25 x 15 cm) and S2- (35 x 20 cm). The first sowing was done on 27th Oct, 2010. It was found that no disease occurred in the plants of the first sowing till the second harvest of the pods i.e. after 94 DAS. However, symptom of anthracnose was observed in pods of Arkel after 102 DAS in the first sowing.

Disease pressure was low in the first sowing, high in the second, and third sowing. Arkel showed high susceptibility to white rust and anthracnose. Pod filling was poor in Azad Pea-I in the first sowing. Mid-October was found best for Arkel with low disease intensity and high yield i.e 0.86 t/ha and late November sowing showed high disease intensity in both varieties in Basar conditions. Leaves and pods showed severe blight symptoms. The spread of disease was enhanced by rainfall during pod formation and maturation stage.

BLACK GRAM

Weed management

The growth and yield attributes were recorded higher when black gram was completely free from weeds. The grain yield (1.43 t/ha) was recorded when crop was imposed weed free followed by two hand weeding (1.37 t/ha). However, the lowest yield was recorded on weedy check. The B:C ratio was recorded higher when pendimethalin @ 1.5 l/ha followed by one hand weeding at 25 DAS was done. Weed control efficiency was recorded 100% on weed free, followed by two hand weeding and pendimethalin @ 1.5 l/ha and one hand weeding. However, the lowest weed control efficiency was recorded on weedy check. Highest weed dry weight was recorded on weedy check and lowest on weed free treatment.

Fig 13 Evaluation of field pea varieties against diseases at Basar conditions

DISEASES

Screening of green gram varieties against location specific diseases

This varietal trail against location specific disease at Basar included four varieties of green gram namely; PDM-139, IPM-02-03, IPM-99-125 and SM-06-5. Treated seeds of these four varieties of green gram were sown in 2 x 3 m^2 plot at a spacing of 30 x15 cm under RBD. Sowing of seeds was done on 10th May, 2010. During the germination of seed heavy rainfall was received and hence very poor germination was observed. Re-sowing was done on 25th May 2010. PDM-139 and IPM-02-03 germinated earliest among the four varieties *i.e.* after 5 DAS. No disease was observed during the vegetative growth. Highest plant height was obtained by PDM-139 (48.3 cm) whereas, shortest plant height was observed in SM-06-5 (35.6 cm).

Flowering was first observed in PDM- 139 and IPM-99-125 *i.e.* in 39 DAS. Pod formation was also early in these two varieties *i.e.* 43 DAS. Cercospora leaf blight, web blight and anthracnose were observed during flowering in IPM-02-03 and IPM-99-125. The spread of disease was enhanced by the high rainfall. However, no disease was observed in PDM-139. Highest yield was obtained from IPM-99-125 (2527 kg/ha) followed by IPM-02-03 (1850 kg/ha) and PDM-139 (1520 kg/ha). Shattering of pods was prominent in all the four varieties and highest shattering loss was observed in PDM-139.

Screening of black gram varieties against location specific diseases

Varietal screening of black gram against location specific diseases was carried out at Basar with three varieties namely; IPU-94-1, Pant-U-31 and T-9. Treated seeds of these three varieties of black gram were sown in 2 x 3 m^2 plot at a spacing of 30 x15 cm under RBD on 10th May, 2010. Early germination was observed in IPU-94-1 *i.e.* in 6 DAS. Plants of Pant-U-31 attained highest plant height (46.7 cm). Pod formation was early in IPU-94-1 and Pant –U-31 *i.e.* 42 DAS. No disease occurrence was observed in any of these varieties. However, due to heavy rainfall shattering of pods was observed which lowered down the yield. Among the varieties highest yield was obtained from Pant-U-31 (0.56 t/ha) followed by T-9 (0.44 t/ha) and IPU-94-1 (0. 26 t/ha).

TORIA

Effect of tillage and mulch

Toria var. TS-38 was grown under three tillage practices *viz.*, conventional, minimum and no tillage and four mulches *viz*. paddy straw, maize stubble, *Imperata cylendrica* and no mulch. Growth and yield attributes were recorded better on minimum tillage (1.28 t/ha) followed by conventional tillage (1.17 t/ha) and lowest yield on no tillage (Figs 14 & 15). Among the mulches, maize stubbles recorded highest yield of 1.29 t/ha followed by paddy straw. However, the lowest yield was recorded on no mulch. The root length, root dry weight and volume were recorded higher on conventional tillage followed by minimum tillage but root number was recorded highest on no tillage. Similarly, maize stubble has recorded better root attributes. Weed control efficiency was recorded higher on no tillage and with *Imperata cylendrica* mulch.

Fig 14 View of mustard under tillage and mulch experiment

Fig 15 Mustard under no-till and maize stalk mulch

Evaluation of toria varieties against location specific diseases at Basar condition

M-27 and TS-36 were sown (Fig 16) in two different sowing dates (difference of 10 days). Plant growth as well as yield was found better in the first sowing i.e mid November. But disease intensity was high in first sowing. The highest plant height was observed in TS-36 (83.5 cm) with 91.2 number of siliqua per plant. White blight and anthracnose was first noticed in M-27 with all leaves infected (scoring 7.0). TS-36 also showed symptoms of anthracnose and white blight but disease intensity was scored 3.0. The plant height in M-27 was 71.5 cm and numbers of siliqua per plant was 67.9. The highest yield was obtained from TS-36 (1.23 t/ha) while M-27 yield 1.0 t/ha. The plants of the second sowing showed poor flowering and low yield.

Fig 16 Evaluation of toria varieties against diseases at Basar condition

TUBER CROPS

TAPIOCA (*Manihot esculentus*)

Twelve varieties including local check were tested and it was recorded that all the crop parameters were better in Shree Rekha followed by H-1687. The local varieties grew well and recorded the maximum height, more numbers of nodes and length of inter node. However, yield attributes *viz.*, no. of tuber/plant, tuber length and girth and weight of tuber/plant was recorded highest on Shree Rekha. Yield of Shree Rekha was 35.5 t/ha followed by H-1687 (32.3 t/ha). However the lowest yield attributes and yield was recorded on Shree Jaya.

COLOCASIA (*Colocasia esculentus*)

Thirteen different varieties of *colocasia* were evaluated and observed that growth parameters were recorded better on local varieties. But yield attributes *viz.*, No. of tubers/plant, length, girth and weight was recorded higher on APTC-5 with the yield of 16.5 t/ha followed by Muktakeshi (15.3 t/ha). However, the no. of tubers was more on APTC- 1 and 2.

SWEET POTATO (*Ipomea batata*)

Ten varieties of sweet potato were evaluated. The no. of vine/plant, length of vine, vine weight/plant and number of tuber/plant was recorded higher in local varieties. But, the highest yield parameter like tuber weight, girth of tuber and yield was recorded maximum on ST-12 (23.4 t/ha) followed by Sourin (22.4 t/ha).

Evaluation of potato varieties against location specific disease

Four varieties of potato namely Kufri Jyoti, Kufri Kanchan, Kufri Shilja and Kufri Giriraj were evaluated against location specific diseases at Basar. Tubers were planted at spacing of 50 x 20 cm in 2 x 3 m^2 plot under RBD. Among the four varieties the tubers of Kufri Jyoti showed the earliest shoot emergence i.e. 10 DAS. Kufri Kanchan sprouted the last among the varieties. It was observed that vegetative growth of Kufri Jyoti was very fast in early stages. At 29 DAS leaf curl was observed in Kufri Jyoti and Kufri Shilja. Plants of Kufri Giriraj showed stunted growth as well as poor tuber formation.

Appearance of late blight was first noticed in Kufri Jyoti with highest blight incidence scoring of 7.0 with all leaves and stem infected while Kufri Giriraj and Kufri Shilja had scoring 5.0 with all leaves infected. Kufri Kanchan showed resistance with disease score of 3.0 and also highest yield. Tuber size varied from 4 cm to 7 cm. Tubers of Kufri Jyoti were found to be larger than the other varieties. The number of tubers per plant was highest in Kufri Shilja ranging from 7 to 14. Red ant infestation was very severe in Kufri Jyoti whereas tubers of Kufri Kanchan were less infested by red ants.

ELEPHANT FOOT YAM (*Amorphophyllus paeoniifolius*)

Two varieties *viz.*, Gajendra and TRCB-1 (Figs 17 - 19) were evaluated. Plant height and number of plant/ tuber, stem girth were recorded higher in Gajendra. Similarly, the yield attributes *viz.*, horizontal and vertical girth, tuber weight/plant were recorded higher on Gajendra with 45.5 t/ha followed by 40.2 t/ha in TRCB-1.

Fig 17 TRCB-1

Fig 18 Gajendra

Fig 19 Plant of Gajendra var of elephant foot yam

DIOSCOREA (*Dioscorea* spp.)

Nine varieties were collected and evaluated at research farm (Fig 20- 21). APTD-2 was recorded the highest yield attributes *viz*. length, girth and tuber weight/plant with the yield of 55.6 t/ha followed by APTD-1 (50.6 t/ha).

Fig 20 Evaluation of *Dioscorea* varieties

Fig 21 Vegetative growth of APTD-1

Assessment of technology on watershed based integrated farming system under AP condition

Different crops were grown on FSRP and the yield and/or output are converted to per hectare basis. The details of different components are given below:

a. Maize based cropping sequences were evaluated on two terraces having area of 342 and 332 m^2. Maize recorded the average yield of 3.4 t/ha during rainy season. Post rainy season crops like pea, French bean, tomato, potato, cabbage, cauliflower, okra etc. were planted on the terrace. The highest MEY was recorded on maize-tomato cropping system. Turmeric and ginger were also planted in area of 262 and 228 m^2, respectively. Turmeric recorded the yield of 19.2 t/ha and ginger 22.1 t/ha.

b. Under WRC land of FSRP with area of 605 m^2, nine varieties of rice were planted. It was recorded that plant height was higher on Kala Joha followed by Joha. However, the no. of tillers and effective tillers were recorded higher on Bahadur followed by Ranjeet. The highest grain yield was recorded on Bahadur (3.4 t/ha) followed by Ranjeet (3.3 t/ha).

c. Weed management in pineapple under area of 2570 m^2 revealed that the highest yield was recorded on weed free condition (42.0 t/ha) followed by glyphosate @ 1.5 l/ha (36.3 t/ha) with 70.7% of weed control efficiency.

d. Hedge rows *viz*. *Crotoleria*, *Flemengia* and *Tephrosia* were planted on terrace raiser and these hedge crops were harvested and incorporated on terrace. The highest biomass/m running length was recorded on *Crotoleria* followed by *Tephrosia*. But the nutrient status was recorded better on *Flemengia*. Though the biomass yield is not comparable to *Crotoleria* and *Flemengia* it is a potential source of nutrients. The lopped hedge row plants were composted on pit and manures were supplied to the crops grown on site.

e. *Stylosanthus hamata* was also grown on slope of the terrace to prevent soil erosion and provide the additional fodder to cattle.

f. Among the various sources of nutrients (Hedge plant, weeds, cow dung and legumes, crop residues) 56% of the crop requirement was fulfilled and rest of the nutrients were supplied though the fertilizer.

g. On the terrace riser *Crotoleria*, *Tephrosia*, *Flemengia* were harvested (11.2, 5.8 and 3.4 kg/m^2, respectively). Similarly *Stylosanthus hamata* was recorded 6.3 kg/m^2, which was used to feed the dairy livestock. From the terrace slope *Stylosanthes* along with guinea grass was harvested and it was supplied to five cattle for 6 months and rest of the time livestock were fed by crop residues and additional concentrate feeds and mineral mixtures purchased from market.

h. Among the five livestocks, 5 t of cow dung was retained along with 3000 liters of urine within 6 months. Cow dung and urine was collected and composted and recycled as a source of nutrients.

i. From the sloppy land, guava (24 nos), peach (20 nos) and *khasi* mandarin (19 nos) was harvested. Among the fruit plants peach recorded 1090 fruits/plant, guava (256 fruits/plant) and *khasi* mandarin have just started bearing and individual plant retained hardly 15-25 fruits/plant. Among the

planted fruit trees, peach was harvested first (April-June), followed by guava (Aug-Oct) and *khasi* mandarin (Nov-Jan). Thus it was possible to get fruits throughout the year.

j. Around 3.5 ha of area was covered under bamboo (Bamboositum). It was recorded that there was 400 nos of bamboo clump/ha, which gave 15-20 bamboo/clump. Single bamboo costs Rupees 50-100 depending on the size and use. Overall 6000-8000 bamboo can be harvested/year from well established bamboo plantation.

FRUITS

CITRUS

Maintenance of citrus germplasm

Evaluation of germplasm showed that maximum plant height was observed with Mediterranean orange which was at par with King theppi followed by Zigardio mandarin, while the minimum in Wilking orange (Table 2). Hill mandarin, Sikkim mandarin and Nagpur mandarin were smaller in length and recorded the smaller leaf length where as the leaf breadth was smaller in Hill mandarin and Nagpur mandarin followed by Sikkim mandarin. Flesh colour of the oranges varied from deep orange in *Khasi* mandarin to yellow in Wiliking orange. The rind was very thin in cultivars *viz*., Kara mandarin, Sikkim mandarin and Wilking orange. Among sweet orange maximum plant height was observed with Washington malta followed by Valencia Newton, while the minimum in Vanilla malta. Among the different sweet orange cultivars and races, Italian large and Vanilla malta recorded the highest leaf length and breadth while the least length was recorded with ruby blood red followed by *Tasi* which was at par with Washington malta. Higher fruit weight was noticed in Washington malta followed by Vanilla malta. Mosambi Australia and *Tasi* were at par with each other for fruit weight. Washington malta was observed with the thicker rind followed by local race *Sohning riang*. The seed number varied from as low as one in Washington malta to as high as fifty five in *Tagu* which is the local race concentrated in Along belt of west Siang district of Arunachal Pradesh. Among different rootstock species *Tanyum* was bushy type with very long and sharp thorns. Flowers were very big and had creepy branches. *C. jawanica* recorded the highest leaf length and breadth followed by *C.latipes* which was at par with *Karnakatta* on leaf length. However, the leaf breadth was very small for *C.latipe*. Cleopatra mandarin was smaller in size followed by trifoliate orange. However, the highest fruit breadth was recorded with *Karnakatta* followed by *C.latipes*. Rough lemon had a peculiar suppression in their naval region.

Evaluation of high density plantation and growth regulators in *Khasi* mandarin

GA_3 (25, 50, 75 ppm) and NAA (100, 150, 200 ppm) were sprayed on HDP (2x2 m; 2x2.5m; 3x3m; 4x4m; 5x5m) orchard. It was observed that minimum flower drop (22%) was recorded with GA_3 50 ppm spray. 3m x 3 m spacing, sprayed with GA_3 50 ppm recorded the highest fruit weight (104.37 g), size (4.8 x 5.1 cm^2),

Table 2 Growth and fruit characteristics of different mandarin cultivars in mid hill condition

CV No*	Tree height (m)	Leaf length (cm)	Leaf breadth (cm)	Presence of thorn	Fruit weight (g)	No of segments	Flesh colour	No of seed	Appearance of seed
1	5.4^{bc}	6.50^{d}	2.93^{f}	A	97.67^{def}	11.33^{ab}	O	9.67^{cd}	R, Y, S
2	6.2^{a}	8.87^{ab}	4.17^{b}	P, S	162.33^{a}	10.29^{bcd}	Y	2.33^{f}	VS, Pl, I,Y
3	4.8^{c}	6.16^{d}	2.93^{f}	A	133.61^{bc}	9.31^{d}	O	17.00^{a}	S, Y
4	6.2^{a}	8.07^{bc}	3.54^{cd}	P, S	114.38^{cde}	9.34^{d}	Y	8.67^{de}	I, Y-B
5	4.8^{c}	6.26^{d}	3.00^{ef}	A	97.00^{def}	10.07^{cd}	O	10.66^{cd}	S, Pl
6	4.4^{cd}	8.50^{abc}	3.43^{de}	A	90.14^{ef}	11.12^{abc}	O	6.68^{e}	S, I, W-Y
7	5.9^{ab}	10.00^{a}	4.77^{a}	A	113.25^{cde}	11.15^{abc}	DO	13.31^{b}	I, L
8	4.2^{d}	7.23^{cd}	3.10^{def}	A	82.57^{f}	9.33^{d}	DO	3.69^{f}	I, Y, F
9	5.3^{bc}	9.50^{ab}	3.93^{bc}	P, S	141.62^{ab}	11.66^{a}	DO	11.57^{bc}	S, Ov
10	4.6^{cd}	7.31^{cd}	3.1^{def}	A	123.68^{bcd}	10.35^{bcd}	Y	9.85^{cd}	Y, R
CD (5%)	0.87	1.50	0.49	-	26.71	1.24			

P. Present; A. Absent; S.Small; L. Long; M. Medium; VS. Very Small; VL. Very Long; B. Big; O. Orange; Y. Yellow; G. Green; DO. Deep Orange; LG. Light Green; R. Round; I. Irregular; Pl. Plumpy; B. Brown; W. White; F. Flat; Ov. Oval, *1. Hill mandarin; 2. Mediterranean orange; 3. Nagpur mandarin; 4. King theppi; 5. Sikkim mandarin; 6. Kara mandarin; 7. Zigardio mandarin; 8. Wilking orange; 9. *Khasi* mandarin; 10. Kinnow mandarin

segment weight (71.02 g). Highest no. of fruits per tree was recorded with NAA 150 ppm (331.4) which was at par with GA_3 50 ppm (328.7).

Integrated nutrient management in *Khasi* mandarin

A field trial was executed to standardize the integrated nutrient supply system for *Khasi* mandarin (Fig 22) through various organic, inorganic and biological sources like FYM, pig manure and poultry manure along with different doses of Sunhemp, *Azotobactor*, PSB and in combination. Results indicated that plant growth and yield parameters like fruits per plant (604.4), fruit wt (102.9 g) were recorded higher with 50% RDF + pig manure (15 kg) + Sunhemp (12.5%) + *Azotobactor* (20 g) + PSB (20g). Highest fruit yield (63.8 kg/tree) was also recorded with the same treatment. Peel weight (31.09 g) and thickness (4.2 mm) were more with full dose application of NPK while segment weight (88.08 g) and fruit weight (114.4 g) were highest with pig manure along with other nutrient sources. However N substitution by FYM resulted in higher B: C ratio than vermicompost due to its lower cost of production.

Fig 22 *Khasi* mandarin orchard under INM

Establishment of agro techniques for strawberry

Strawberry (*Fragaria* × *ananassa* Duch) cv. 'Chandler' was grown in the field to study the effect of different mulches and irrigation level on growth and physico-chemical parameters. Three irrigation level *viz*., I_1 (1.0 *IW/CPE ratio*), I_2 (0.8 *IW/CPE ratio*) and I_3 (0.6 *IW/CPE ratio*) and four mulch materials *viz*., black polyethylene (BPM; 40 µm), transparent polyethylene (TPM; 50 µm), paddy straw (PSM 4 t/ha) and pine needles (PM 4 t/ha) were tried. The I_1 favoured plant growth, enhanced flowering (67.5 days), resulted in production of significantly larger fruit and higher yield (175.15 g/plant) with higher root numbers, fruit having higher TSS, and ascorbic acid content with lesser incidence of albinism (17.9%) and botrytis rot than other irrigation levels. Plants mulched with BPM showed better growth, flowered and fruited early, produced larger fruit and higher yield, with slightly higher incidence of albinism (19.8%), but with lower incidence of botrytis rot (14.9 %) than other. Irrigation level x mulching interaction significantly influenced plant growth; flowering and fruiting; fruit yield and quality, albinism and botrytis rot. Plants have best growth parameters like plant height, crown spread and leaf area with I_1 x M_1 interaction. Strawberry produced larger fruit (13.1 g) and higher yield (185.8 g/plant) with fruit having higher TSS, and higher ascorbic acid content with a slightly higher incidence of albinism, but comparatively lower incidence of botrytis rot when irrigated at I_1 level with BPM than other irrigation level and mulched with TPM, PSM and PM .

Evaluating the grape varieties under mid hill condition

Nine different grape genotypes *viz*., B-1-3, B- 24-1, Italia, B-50-1, Gimson, Red globe, PH-2, B9-3, B-7-3 cuttings were collected from NRC for Grapes, Pune and planted during 2008. In spite of continuous care and adoption of scientific cultural practices the well established cuttings in the polyhouse failed to survive in the field. The failure in establishment might be due to unsuitable climatic conditions in Basar during the reported period.

VEGETABLES

Evaluation of cropping sequences for year round production of vegetables under polyhouses

Tomato-French bean- Cabbage; Tomato- Chilli-Broccoli; Tomato-Okra- Knol Khol and Tomato- Bottle gourd-cauliflower combinations were tried to evaluate the best cropping sequence planted in Mar- Jun; Jul-Oct and Nov-Feb. It was observed that Tomato-French bean-Cabbage combination performed well under polyhouse. In addition kept the soil status intact and recorded less incidence of pest and diseases. Net return Per Rupee (NPR) invested was recorded (1:2.1).

Standardization of organic growing of ginger

Ginger was sown during June under six treatments *viz*., T_1: Vermicompost (VC; 2.5 t/ha), T_2: Poultry manure (PM; 1.25 t/ha), T_3: Swine manure (SM; 3.0 t/ha), T_4: Cow dung manure (CDM; 10.0 t/ha), T_5: Farm yard manure (FYM; 10.0 t/ha) and T_6: control and

replicated thrice to study the effect of applied organic nutrients on growth and yield attributes of ginger. The physical parameters like porosity, maximum water holding capacity (MWHC), field capacity (FC), permanent wilting point (PWP), bulk density (BD) and moisture releasing pattern was measured better for FYM followed by CDM. Chemical parameters like pH, Soil organic carbon (SOC), available N, P and K were recorded better on VC followed by PM over control. The gross and net return was recorded higher on VC followed by PM. B:C ratio was recorded higher on PM followed by CDM. However, the lowest economic returns were recorded on control.

Performance of radish varieties

Two radish varieties *viz*., Japanese white and Chinese pink were evaluated. Japanese white recorded the root length of 27.4 cm, root girth 6.7 cm and root weight of 1.24 kg whereas, Chinese pink recorded the root length of 25.4 cm, root girth of 5.4 cm and root weight of 755.34 g.

FLORICULTURE

Standardization of agro techniques for galdiolus

Eight varieties *viz*., Promise, Red Majesty, Candyman, Rosared, Pusa Chandhini, Pusa Josna, Snow Princess and Novalux were evaluated for their performance under mid hill condition. Result showed that cv. Pusa Josna performed better followed by Promise, and Pusa Chandhini. Highest plant height (112.5 cm), spike length (73.7 cm) and rachis length (44.8 cm) and number of florets per spike (14.1) were recorded with Promise.

Standardization of agro techniques for gerbera

Nineteen different gerbera lines were grown in both open and closed condition. Polyhouse grown plants were early in flowering irrespective of cultivars. Alsemera recorded more plant height (25.8 cm) while no of leaves was more in black heart (29.3). Leaf length and breadth was more in Alsemera which also recorded more stalk length (53.1 cm).

POST HARVEST TECHNOLOGY

Standardization of drying and dehydration techniques for fruits and vegetables

Cauliflower and bamboo shoots were dehydrated with different drying conditions *viz.*, cabinet drier (CD), low temperature drier (LTD), solar drier (SD) and Sun drying. They were analyzed for different physico- chemical parameters. It was observed that cabinet drying 8 hrs for cauliflower and 13 hrs for bamboo shoots was superior to other mode of drying. Further, drying ratio and rehydration ratio was also superior in CD followed by LTD. Descriptive analysis on sensory score (8.2) was also found best with CD while the NEB, which is undesirable character on dried product, was more with solar drier (0.43).

Effect of some process variables on osmotic dehydration of bamboo slices

A study was conducted to find out the optimum osmotic concentration, temperature, slice thickness and fruit to syrup ratio for better osmo-dehydration of bamboo slices. Response surface design (RSM) was used with four factors on five levels. The slices of various thickness (2, 4, 6, 8 and 10 mm) were dipped into various sucrose concentrations (*viz*., 20°B, 30°B, 40°B, 50°B and 60°B and temperature *viz.,* 30°C, 40°C, 50°C, 60°C and 70°C) for six hours in various fruit to syrup ratio *viz*.,. 1:1, 1:2, 1:3, 1:4 and 1:5. Water loss (WL) and solid gain (SG) increased linearly with the increase in sugar concentrations and temperatures of the solution during osmosis process. Optimization of various parameters revealed that slice thickness and fruit to syrup ratio recorded least effect on mass transfer of slices. With high concentration and temperature, peak gain in solids was observed. Similarly, all the process variables had significant effect on sensory attributes of bamboo slices. The regression analysis and ANOVA showed that the process variables have significant effect on osmosis (Fig 23).

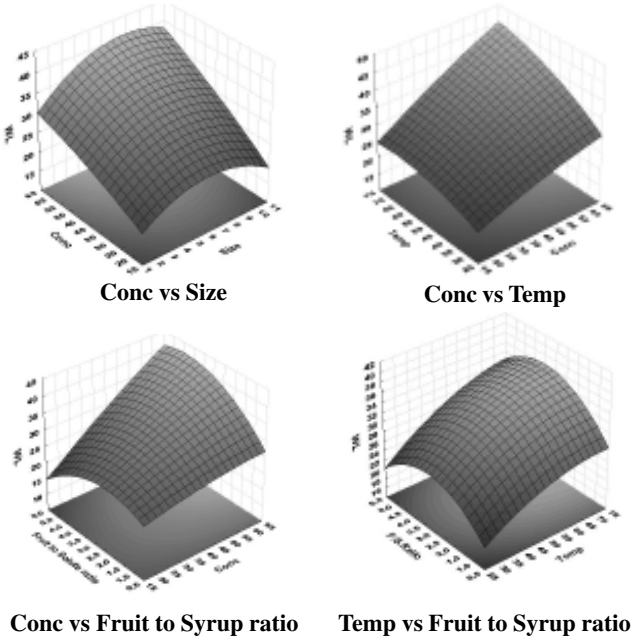


Fig 23 Response surface and contour plots showing the effect of processing variables on WL

Standardization of squash making from taktir

Taktir fruits were harvested from second fortnight of April to mid of May to adjudge the best maturity time for fresh consumption and processing. The fruits harvested during 1st week of May (H_4) recorded the fully matured fruits, rich in sugar, ascorbic acid (16.54 mg/100g), overall acceptability (7.46) and edible portion (79.35%). Different combinations of juice percentage (22.5, 25 and 27.5%) and TSS (37.5, 40 and 42.5°B) were tried for the development of squash. A drink with 22.5% juice and 40°B was found best by a panel of semi-trained judges. Most of the chemical attributes were also found best for the same treatment. Taktir drink was further analyzed for chemical composition and microbial safety during three months of storage under room temperature (RT) and low temperature in day light and dark condition packed in pet and glass bottles. Reducing sugar, total sugar and acidity increased with the storage period while pH and ascorbic acid reduced. Anthocyanin degraded with the increase in storage period. The 'a' value was found to be decreasing as the storage interval increased. 'L' value increased as the temperature increased under light condition. However yeast, mould, *E.coli* and total plate counts were absent in the beverage.

Training and demonstrations

To disseminate the developed technologies, various training and demonstrations were conducted. Trainings were sponsored by TM, NABARD and ITBP while the demonstrations were conducted from the financial assistance of Horticulture Mission (MM I). Training covered various topics like improved production technology for kiwi fruit, orange, pineapple and banana; rejuvenation of old senile orchard of *Khasi* mandarin; off season production of vegetables; post harvest processing and value addition of different horticultural produces including mushroom. Demonstrations were conducted on mulching of *Khasi* mandarin; FLD on cabbage, banana and pineapple (Figs 24-26).

ANIMAL SCIENCE

Pig farming practices and adoption level of pig farmers in West Siang District of Arunachal Pradesh.

Collection of primary data from Department of Animal Husbandry and Veterinary Sciences, Govt. of Arunachal Pradesh was done. Twelve farmers were appraised from Daring circle and Basar circle about scientific pig husbandry practices and data were collected. It was found that majority (98.6%) of the farmers were rearing pig on low input based system (Fig 27). Rearing of pig was mainly scavenging type (89.5%) followed by intensive type for castrated boar. Feeding was done on available household waste (92.7%) and locally available feeds except few farmers at Basar circle who were giving concentrate feeds. No vaccination was done. Breeds available were local variety (92.5%) and crossbred of Hampshire breeds (7.5%) at Basar circle. The major constraints were unavailability of medicine and vaccine (89.17%) and high cost of feeds (87.6%) in the study area.

Establishment of indigenous feed plots and fodder block

Three plots were prepared for plantation of tuber crops which are locally available in the area for feeding of pigs to decrease the cost of production. Plot No.1 with an area of (8 x 13 m) and Plot No 2 (4 x 13 m) was developed, sweet potato var. *chini* and local variety was planted with a spacing of 60 cm between plants to

Fig 24 Training on mushroom cultivation

Fig 25 Hands on exposure on processing

Fig 26 Training on processing and value addition

Fig 27 Traditional housing system for pigs (A) Wooden type (B) Bamboo type

plant. Under plot no.3 (4 x13 m) banana var *Kodum* was planted with a spacing of 4 x 3 m. Efforts are made to establish fodder block at Gori farm. Different indigenous and improved leguminous crops were collected and maintained in the field.

Manipur

WEATHER REPORT

The highest maximum temperature of 32.0 ^{0}C was recorded on 8th Aug, 2010 against the previous year record of 33.2 ^{0}C that was recorded on 30th May, 2009. The lowest maximum temperature of 18.8 ^{0}C was recorded on 6th Feb, 2010 against the data of 18.8 ^{0}C that was recorded on 6th Feb, 2010. The highest minimum temperature of 24.1 ^{0}C was recorded on 10th Aug, 2010 against 23.8 ^{0}C that was recorded on 20th Jun, 2009 and the lowest minimum temperature of 2.0 ^{0}C recorded on 21st Jan, 2011. Annual rainfall recorded during the year 2010-11 was 1658.3 mm against 1076.6 mm recorded last year (2009-10). The monthly rainfall was highest in Jul 2010 (296.1 mm) whereas Nov, 2010 was the driest month with 2.8 mm rain. (Table 1)

CROP PRODUCTION AND PROTECTION

RICE

Breeding for high yielding, disease resistance quality rice

A preliminary advance yield station trial was conducted for 14 advanced lines of rice with three checks under lowland transplanted conditions of Manipur Valley during *kharif*. Five promising lines *viz.*, MC-34-1-30-74-10-5, MC-34-7-1-6-15-61-47, MC-34-7-5-2-75-33-19, MC-34-4-9-3-25-47 and MC-34-4-9-3-25-45 showed higher yield (8026 kg/ha, 7853 kg/ha, 7470 kg/ha, 7356 kg/ha and 7326 kg/ha) as compared to local three checks i.e. RC Maniphou-10 (7073 kg/ha), RC Maniphou -7 (6953 kg/ha) and KD-2-6-3 (5490 kg/ha). The lines were also moderately resistant to neck blast and leaf blast.

Breeding for short and medium duration rice genotypes

Nine short duration cultivars including two checks were sown in station trial during pre- *kharif* 2010. Among them, entry MC-34-1-10-6-1-26 (RCM-13) flowered in 67 days and matured in about 95-105 days. The average yield was recorded 4800 kg/ha and found suitable for pre-*kharif*, early *kharif*, main *kharif* (contingency variety). This cultivar escapes the blast reaction because of its short duration nature. On the basis of yield performance, grain quality and earliness, this has been proposed for IVT (VE) for all India testing under AICRIP trial in year 2011.

A preliminary yield trial in 37 advanced lines of medium duration rice along with two checks was conducted in a replicated advanced trial under low land transplanted conditions. Among them six lines *viz.*, MC-34-4-13-45-82-70, MC-34-4-13-45-82-69, MC-34-4-98-48-24-22, MC-34-4-1-8-34-8, MC-34-4-106-46-54 and MC-34-5-12-2-38-02-27 were found promising in term of yield performance (6916 kg/ha, 6883 kg/ha, 6640 kg/ha, 6333 kg/ha, 6146 kg/ha and 6116 kg/ha, respectively).

Breeding for high yielding, disease resistant quality rice for paddy cum fish culture

A station trial was conducted for evaluating the fifty advance lines of rice along with two checks, majority of them were tall types for the purpose of paddy cum fish culture. The lines were tested in replicated station trials under low land rainfed transplanting conditions for yield performance, tallness, strong culm and reaction to disease and insect-pests. On the basis of performance for three consecutive years (2008, 2009

Table 1 Agro-meteorological data (monthly average) from Apr'10 to Mar'11

Month	Temp (^{0}C)		RH (%)		Wind direction (deg)		Wind speed (km/h)	Cloud cover (Okta)		Total rainfall (mm)
	Max	Min	Morning	Afternoon	Morning	Afternoon		Morning	Afternoon	
Apr	29.0	18.4	88.2	80.6	203.0	241.3	6.3	6.2	4.0	229.5
May	27.9	20.1	89.7	83.8	153.2	218.7	3.9	7.0	5.6	193.7
Jun	27.3	22.0	94.5	75.5	116.6	187.8	2.5	7.0	7.0	238.4
Jul	29.0	22.7	92.9	83.3	160.9	227.6	4.3	7.5	6.4	296.1
Aug	29.6	22.6	92.8	86.2	141.9	248.7	3.5	6.8	6.0	103.6
Sep	28.6	21.6	93.6	87.4	102.2	241.2	2.4	7.3	5.8	262.3
Oct	27.6	18.5	92.4	87.2	102.9	183.9	2.0	5.7	5.2	195.0
Nov	25.3	12.7	90.1	83.8	173.5	223.5	1.8	4.7	2.6	12.6
Dec	21.6	7.3	83.5	79.8	147.2	241.1	1.7	4.0	1.7	59.2
Jan	20.8	5.4	80.8	77.8	154.0	244.4	3.0	4.2	2.6	17.5
Feb	23.2	7.2	77.5	69.0	197.2	233.3	3.6	3.9	2.2	2.8
Mar	26.0	11.8	82.8	76.2	169.2	232.3	4.9	5.0	4.1	47.6

& 2010) twenty-five outstanding lines were selected for testing in next year under transplanting conditions.

Newly released variety of rice - RC Maniphou-11 (RCM-21)

RC Maniphou-11, a derivative of Prasad/IR 24 was developed under low land transplanted conditions at ICAR Manipur Centre, Lamphelpat, Imphal, notified by Central Subcommittee on Crop Standards, Notification and Release of Varieties in 2010 (Fig 1, Table 2). It is recommended for valley and terraced areas of Meghalaya and Manipur up to an altitude of 1000 MSL. The average yield was 5680 kg/ha. It possesses desirable characters such as long slender grain, soft cooking quality, impressive yield gain and resistant to leaf blast etc. It matures in 130-135 days and showed resistance to neck blast and moderate resistance to brown plant hopper.

Table 2 Description of the RC Maniphou-11 (RCM-21)

Plant height	100-105 cm
Plant type	Semi-dwarf
No. of effective tillers/plant	7-8
No. of panicle/sq.m.	240-250
Day to 50% flowering	100 days
Seed to seed duration	130-135 days
Panicle type	Compact
Panicle exsertion	Well exerted
Awning	Absent
Apiculus colour	Purple
Lemma Palea colour	Straw
1000- grain weight	27 g
Kernel length	6.84 mm
Kernel breadth	2.15 mm
L/B ratio	3.18
Grain type	Long slender
Kernel appearance	Very occasionally chalkiness
Milling recovery	73.1%
Head rice recovery (HRR)	59.0%
Alkali spreading value (ASV)	7.0
Amylose content (AC)	24.39%
Gel consistency	45.0 mm

Registration of germplasm

RCM-23 (IET 20810)

RCM-23 was registered in NBPGR, New Delhi as a source of neck blast resistance (National Id: IC 0584772 & Resist No. INGR 10153) in 2011. It was developed by the cross between Leimaphou and Akhanphou during *kharif* 2000. The line may be used as a donor parent to develop high yielding and neck blast resistance lines in breeding programme.

Fig 1 New rice variety RC Maniphou-11

Phougak

This germplasm line was registered in the NBPGR, New Delhi (National Id: IC 0583654 & Resist No. INGR 10154) in 2011 for its unique character as multi-spikelet's in single cluster (Fig. 2). All the spikelets possess fertile and fully developed seeds. The potential yield was 4.0 t/ha. This germplasm line is being utilized in breeding programme at this centre for transferring its unique character in high yielding genetic background of IR-64 and KD-2-6-3. This trait can be useful to boost the yield by increasing the number of spikelet's/panicle.

Fig 2 Phougak a unique germplasm with multiple spikelet

Selection from segregating and subsequent population

A large number of F_3 populations were evaluated from the crosses namely IR-64/SARS-9, IR-64/

Phungphamah, IR-64/SARS-1, IR-64/Phougak, KD-2-6-3/Yungra Makrei, KD-2-6-3/Wang shim Makel and KD-2-6-3/Phougak with the objectives of high yield, disease and insect resistance, tolerance to abiotic stresses and quality characters. About 130 lines have been selected from F_3 segregating population under low land transplanting condition.

A huge population of F5 generation from four crosses *viz.*, RCM-9 x Manuikharamui, RCM-10 x Akhanphou, Taothobi x RCM-10 and Akhanphou x RCM-10 was raised in low land rainfed area and evaluated for high yield, resistance to disease and insect-pests and quality parameters. Selection was done in consultation with farmers representing different areas and ecologies of Manipur. About 315 outstanding lines were selected for yield and yield contributing characters.

RESEARCH COMPLEX REGIONAL TRIAL (RCRT)

Lowland rice

Three trials of RCRT-Lowland (Transplanted) *viz.*, RCRT LL-1(14 entries), RCRT LL-II (11 entries) and RCRT LL-III (11 entries) were tested under low land transplanted conditions in Manipur valley during *kharif* 2010. In LL-1 three entries namely, VL-31335, RCPL-1-149 & RCPL-1-126 exhibited better performance over check. In LL-II trials four entries *viz.*, RCPL-1-417 (7044 kg/ha), RCPL-1-410 (6733kg/ha), Sahasarang (6403 kg/ha) and RCPL-1-408 (6270 kg/ha) exhibited better performance over check RCM-21(5760 kg/ha). In LL-III trials five entries *viz.*, RCPL-1-160 (6574 kg/ha), RCPL-1-302 (5986 kg/ha), RCPL-1-300 (5940 kg/ha), RCPL-1-304 (5833 kg/ha), RCPL-1-302 (5986 kg/ha) were observed for higher yield over checks RCM-9 (4076 kg/ha) and IR-64 (5337 kg/ha).

Upland rice

Two trials of RCRT- upland (direct seeded) *viz.*, RCRT UL-I (9 entries) and RCRT UL-II (15 entries) were tested under upland conditions at Langol farm of ICAR Research Complex for NEH Region, Manipur Centre during *kharif* 2010. In UL-I trial , RCPL-1-128 and RCPL-1-115 performed better as compared to checks and gave yield of 3600 kg/ha and 3933 kg/ha, respectively. In case of UL-II, RCPL-1-180, RCPL-1-93 and RCPL-1-103 performed better as compared to checks and gave yield of 3816, 3830 and 3820 kg/ha, respectively.

AICRP trials on rice

Six trials of AICRP *viz.*, AVT-1-IM (20 entries), AVT-1-IME (31entries), IVT-IM (61 entries), IVT-IME (62 entries), AVT-1-U-H (13 entries) and IVT-U-H (12 entries) were tested under low land transplanting conditions in Manipur valley during *kharif* 2010. Most of the entries in AVT-1-IM and AVT-1-IME trials exhibited better performance over check. In IVT-IME, 37 entries were observed for higher yield as compared to local check variety. In IVT-IM, 52 entries were observed for higher yield as compared to local check. In case of IVT-U-H two entries namely IET No. 3110, 3109, 3105, 3104, and 3112 were observed for slightly higher yield as compared to check variety. In case of AVT-1-U-H, IET No. 3070 exhibited better performance over the check and this entry was also least affected by the infestation of leaf blast as compared to other.

INGER nurseries

INGER Nursery of 36th IIRON, Module-I (2010) was conducted at ICAR Research Complex for NEH Region, Manipur Centre, Langol Farm, and Imphal. Forty entries including one local check were tested in augmented design. Out of these, ten entries showed better performance and higher phenotypic acceptability at maturity over the check in lowland conditions of Manipur. Three entries showed high susceptibility to the neck blast.

INSECT PEST

Stem borer was observed as the major pest of rice in late transplanted crop. Incidence of stem borer was noticed in most of the lines of AICRP trials (AVT & IVT), RCRT trials (low land) and also in released varieties. However, RCM-9 recorded the highest infestation and the least was observed in RCM Maniphou-11 followed by RCM-10.

DISEASES

Evaluation of rice germplasm against fungal diseases

Two hundred and fifty lines / varieties of rice germplasm were evaluated under field conditions under the project "Rice improvement through participatory plant breeding" for their reaction against blast, sheath blight and brown spot diseases. For neck blast, the disease score varied from 1 in Drumphou, Kazizhum, Athormah, Runya, Ratkhara, Mayamasitangto to 5 in Saras 9. In the case of brown spot disease, lowest disease score of 1 was recorded in Teruntssok, Basmati

370, Ngoloharia, Maisagang, China 1, Tsushruri, Kwangohai Mioun-AP, Wesheioru, Thumpak-TS, Moroephyo to 6 in Chingchakhao, SARS-1. In the case sheath blight disease the disease score varied from 1 in Chakhao kumbi, KD phou, Talui, Talinamah, Chingphourel Amubi and Saras 2 to 9 in Dramphou, Prakash. In the case of sheath rot, the disease score varied from 1 in Talinamh, Mayamasitang, Jaksa, Phoutumah, Chingphaorel amubi, Saras 2, Talui to 9 in Mahakalwa.

Screening of rice entries under national screening nursery (NSN –Hill) against multiple diseases

Seventy nine entries (NSN-H) sent by DRR Hyderabad were screened for multiple diseases. The disease score for leaf blast varied from 1 in entries having IET number 21747, 21748, 21750, 21752, 21754, 21755, 21756, 21757, 21319, 20958, 21323, 20961, 21320, 21738, 20803, 21375, 21377, 21382, 21759, 21966, 20820, 21384, Rasi and IR-8 to highest score of 6 in IR-50. The lowest disease score for neck blast was 1 in entries having IET number 21757, 21758, 21326, 20957, 21741, 21762, 21766, 20820, 20826, 21392, Vivekdhan 82 and Rasi, whereas, it was 5 in 21755, 21320, 21745, 21760, 21767, 20822, 20819 and IR 50. For sheath blight, the disease score varied from 1 in entries 21759 to 9 in 21953, 21755, 21757, 21358, KD263, 21320, 21767 and 20819. The disease score for brown spot varied from 1 in 21749, 21754, 20955, 21738, 20826, KD 263, Vivekdhan 62, Swarnadhan, Nidhi to 6 in 21745. Against sheath rot, the entries bearing IET no. 21747, 21750, 21757, 20955, 21739, 21746, 21377, 21759, 21767, 21768, 21769, 20820 exhibited disease score of 1 whereas, it was 3 in 21755, 21320, 21767, 21393. All entries were free from bacterial leaf blight and rice tungro virus.

PULSES

PIGEON PEA

Evaluation of F_2 population of inter-specific crosses of pigeon pea

The present investigation involved the field screening of F_2 progenies of inter-specific hybrids along with their parents namely, UPAS-120, ICPL-88034, and one wild relative i.e., *Cajanus scarabaeoides*. These progenies were screened for the characters *viz.*, plant height (cm), primary branches/ plant, pod length (cm), pod borer damage (%) and undeveloped seeds/pod (%) in protected and unprotected set at field level. In unprotected set of material, the pod damage range among parents was observed 0.1% to 23.91%. Least damage was noticed in *C. scarabaeoides* (0.1%). *C. scarabaeoides* also showed fully developed seeds/pod. In unprotected set, forty six interspecific progenies in F_2 generation derived from the cross UPAS 120 x *C. scarabaeoides* showed a large range of variation for pod damage (0.0 to 31.25%) and undeveloped seeds/pod (5.8 - 88%). Out of them, 17 progenies showed the least percentage of pod damage (0.00%) by pod borer. Hairy and wild type nature of the pods was exhibited by ten progenies, which indicates that these characters were transmitted from *C. scarabaeoides*. One progeny possessed the highest undeveloped seeds/pod (88%) and climber plant type. One desirable F_2 progeny of UPAS 120 x *C. scarabaeoides* showed plant height (100 cm), primary branches (13), pod length (4.46 cm), pod damage (3.70%) and sterility (0.00%) while another progeny of the same cross had promising traits as long primary branches and hairy pods, although undeveloped seeds/pod (19.05%) and pod damage (1.96%) was increased. In protected set, pod damage ranged 0.0% to 22.12% among parents whereas no pod damage was observed in *C. scarabaeoides*. Fifty five F_2 progenies of the cross UPAS 120 x *C.scarabaeoides* revealed the range of pod damage from 0.0% to 25%. Out of them, 36 progenies showed the desirable traits for selection of the plant. Two progenies exhibited the highest undeveloped seeds/pod (90% and 92.59%) together with least pod damage (0.0-3.08%) and more number of primary branches/plant (18). Among the F_2 progenies of ICPL 88034 x *C. scarabaeoides* only 13 progenies were selected in unprotected set. Out of thirteen, 4 four progenies exhibited less pod damage and undeveloped seeds/pod. One progeny expressed towards cultivated plant type with green and long pod (5.58 cm), while three progenies had wild plant type. Another one progeny also showed desirable traits namely, highest primary branches (21), lesser pod damage (3.03%), but increased undeveloped seeds/pod (22.73%). Field screening was also made in protected set for F_2 progenies of interspecific crosses namely UPAS 120 x *C. scarabaeoides* and ICPL 88034 x *C. scarabaeoides*. In protected set, F_2 progenies and their parents were sprayed with Endosalphan 0.07 @ 500g a.i per ha. Cultivated parents, namely UPAS 120 and ICPL 88034 showed pod damage 22.12% and 11.71%, respectively, whereas no pod damage was observed in *C. scarabaeoides*. Fifty five F_2 progenies of the cross UPAS-120 x *C. scarabaeoides* were selected in

protected set. Out of them, 37 progenies were promising for one or more traits. It was noted that five progenies were desirable for all the traits under study. One progeny exhibited the highest undeveloped seeds/ pod (90%), hairy pods, pod length (3.1%) primary branches/plant (6) and no pod damage (0.00%). One desirable progeny was observed for the characters *viz*., plant height (178 cm), long primary branches (69 to 88 cm), primary branches/plant (10), pod length (4.34 cm), hairy pods, lesser pod damage (1.96%) and undeveloped seeds/pod (19%). It is interesting to note that one progeny was found like soybean plant type that was erect, plant height (96 cm), primary branches (8), pod length (3.58 cm), pod damage (9.67 %) and undeveloped seeds/pod (4.55%). Some progenies showed synchronous maturity, which will be helpful for mechanical harvesting. Seventy F_2 progenies were studied in the cross ICPL 88034 x *C. scarabaeoides*. Out of them, ten progenies were observed desirable for all the characters under study. Two progenies showed long pods (6.68 to 6.72 cm), damage of pods (0.0 to 4.0%), undeveloped seeds/pod (0.00 - 4.0%) and brown seed colour.

Variability in pigeon pea germplasm

Thirteen germplasm lines were collected from Imphal East and Imphal West district of Manipur during *kharif* 2008-09. A large variation was observed for pod colour, shape and size (Figs 3 & 4). Pod colour was found green, purple, dark purple, mixed (green and purple), mixed (green with dark purple) and mixed (green with purple on constrict). Variation was observed for length of pod. Maximum seeds/pod was seven. Diversity was also observed in seed colour and size. Colour of seeds were noticed dark brown, brown, light brown, cream, white and mottled. Oval and pea seed shape was recorded while seed size was large in most germplasm lines.

Fig 3 Diversity in pod colour of pigeon pea land races

Fig 4 Diversity in seed colour of pigeon pea land races

INSECT PESTS

PIGEON PEA

During flowering stage incidence of blister beetles, *Mylabris pustulata*, was observed which fed on the flowers and cause severe damage. Incidence of pod borer was observed at pod forming stage. Larvae damage the buds, flowers and pods severely and enter into the pod by making a hole and feed on developing seeds. Population of pod borer was very high by the end of crop season and pods were damaged severely. An average damage observed to mature pods was 50%. Pod boring weevil (*Apion clavipes*) also appeared at flowering stage and fed on the flowers, young leaves and also on developing pods. Average 5 adults/ inflorescence were recorded in the field. Eggs were laid on the pods and after hatching grubs entered into pods and fed on the grains. Larvae damage the green seed in the pods. Pupation took place in the pods and adult emerge by making a hole in the pod. *Helicoverpa armigera* was also recorded as a major pest and its larvae eat up the floral parts, flowers, leaves and pods. Plume moth (*Exelastis atomosa*) was also noticed causing moderate damage. Their larvae chew the buds, flowers and pods. Small holes were seen in the buds and tender pods and it fed on the developing grains. Blue butter flies, *Lampides boeticus*, also caused moderate damage to the crop. Their larvae chew leaves, buds, flowers and pods. Incidence of aphids, jassids, pod sucking bugs and leaf folder was also observed at low density.

MUNG BEAN AND URD BEAN

Evaluation of F_4 progenies derived from inter specific cross of mung bean and urd bean under hill condition

The F_4 progenies of interspecific cross of *Vigna radiata* x *Vigna mungo* were grown in foot hills of Langol Farm, Imphal during *kharif* 2010. Fifty three mung bean type plants were selected for plant height (cm), branches/plant, number of clusters/plant, pods/ plant, pod length and seeds/ pod. A wide range for these

characters were recorded such as plant height (37-114 cm), branches/plant (0-5), number of clusters (3-19), pods/plant (5-63), pod length (5.74-8.62 cm) and seeds/pod (6.8-14.2 cm). One promising progeny exhibited the maximum pods/plant (63) along with pod length (7.5 cm) and seeds/pod (12.6), whereas another progeny had the highest number of clusters/pod (19).

RICE BEAN

Drought tolerant rice bean line

Eighty genotypes were sown in October, 2010. Most of the genotypes showed poor performance due to moisture stress. The trial was severely affected by powdery mildew. But one plant of genotype BKSB-48 showed high vigour, drought tolerance, full bloom with flower and no symptoms of powdery mildew disease in field condition. The plant height was 86 cm and 6 branches were recorded. Flower was noted on 21st April, 2011. During cultivation period, total rainfall was 98.6 mm. This plant will be used for further study in next year.

MAIZE

Evaluation of germplasm

Forty germplasm lines of indigenous maize were evaluated in augmented design with Pusa Composite-3 and Local Red as checks. The line RCRT-BC-3 showed the highest plant height (255.60 cm) followed by RCRT-BC-6 and RCRT-M-5. RCRT-BC-6 exhibited superiority over the local check for plant height (255 cm), number of cobs / plant (1.2), fresh cob weight (205g), cob weight without silk (189g), cob length (18 cm) and cob girth (14.9 cm) except kernel rows/cob (13.8) and number of kernels/row (17.66). The maximum number of kernels/row was found in RCRT-M-10 (38) followed by RCRT-M-5 (34.60) and RCRT-BC-8 (31.40).

SOYBEAN

Five entries including checks were evaluated under foot hill conditions of Langol farm, Imphal. Least days to 50% flowering was recorded for the genotype JS 335 (35 days), whereas it also showed the highest number of branches/plant (5.45) number of clusters/plant (26.5). The genotype H1 exhibited the maximum number of filled pods/plant (84.35) and yield/plant (18.02 g) while unfilled pods/plant was noticed minimum in local check and maximum number in the genotype H9.

NATURAL RESOURCE MANAGEMENT

Soil test based fertilizer recommendation for targeted yield of rice in acid soils of Manipur

Research work was initiated to develop soil fertility gradients at Langol Farm, ICAR Manipur Centre. For this, three types of terrace were selected. The upper, middle and lower terraces were fertilized with NPK fertilizers at the rate $N_0P_0K_0$, $N_1P_1K_1$ and $N_2P_2K_2$ (N_0, N_1, N_2 = 0, 100, 200 Kg N ha^{-1}; P_0, P_1, P_2 = 0, 80, 160 kg P_2O_5 ha^{-1}; K_0, K_1, K_2 =0, 60, 120 kg K_2O ha^{-1}), respectively. Upland rice (RCM-6) was grown as exhaustive crop in each terrace for homogenization. Low, medium and high fertility gradients with respect to NPK were established in the upper, middle and lower terraces, respectively.

Performance of groundnut varieties

Twelve bold seeded groundnut varieties (A series) were tested under ICAR Research Complex for NEH Region, Manipur Centre. ICGS-76 was found to be the best yielder (3.43 t/ha) followed by NRCG-CS-268 (2.84 t/ha) and TG-42 (2.80 t/ha). Lowest yield was observed in TPG-41 (1.07 t/ha).

Fourteen confectionary purpose large seeded groundnut (B-series) were evaluated at ICAR Research Complex for NEH Region, Manipur Centre to study the yield performance. Among the different varieties, maximum yield was recorded in TG-37-A (3.53 t/ha) followed by ICGS-76 (3.11 t/ha) as compared to lowest yield (1.78 t/ha) in GG-16.

Eighteen advanced groundnut varieties (C-series) of collaborative study were tested at ICAR Research Complex for NEH Region, Manipur Centre. Among the different varieties, ICGS-76 was found to obtain maximum yield (3.78 t/ha), followed by K-134 (3.57 t/ha) as against the lowest yield (1.18 t/ha) obtained in GG-14.

Eighteen varieties (D-Series) were evaluated at ICAR Research Complex for NEH Region, Manipur Centre. NRCG-CS-268 was found to obtain the highest yield (3.07 t/ha) followed by M-13 (2.94 t/ha) as compared to lowest yield (0.84 t/ha) in BG-3.

Boron nutrition on groundnut

The efficacy of different commercial formulations of boron on growth and yield of groundnut was studied. The results revealed that (Table 3) the soil application of Solubor @ 10 kg/ha was best in terms of obtaining maximum yield (3.76 t/ha), followed by soil application of Maxibore @ 10 kg/ha (3.45 t/ha) against the lowest yield (2.10 t/ha) in control.

Table 3 Effect of different formulation of boron on growth and yield of groundnut

Treatments	Plant height (cm)	No. of branches	No. of pods	Yield (t/ha)
Control	68.11	13.56	15.66	2.10
Borax-(Soil Application)	76.55	14.66	19.56	3.05
Agricol-(Soil Application)	80.55	11.44	11.11	2.65
Chemibor-(Soil Application)	72.33	11.11	12.78	3.17
Chemibor-20(Foliar Spray)	66.78	11.89	15.55	2.95
Solubor-(Soil Application)	70.67	16.00	16.55	3.76
Solubor-(Foliar Spray)	78.22	12.89	11.22	2.45
Borosol-(Soil Application)	76.89	11.67	15.11	3.37
Borosol-(Foliar Spray)	76.89	11.00	11.55	2.22
Maxibore-(Soil Application)	72.56	12.89	14.11	3.45
CD (P = 0.05)				0.13

Agromet Advisory Services (IEAS)

The Agrometeorological Field Unit (AMFU), Imphal Unit covers the Agro-Advisory Services for the state of Manipur. There are six observatories in five districts (*viz.*, Imphal West, Ukhrul, Chandel, Tamenglong and Churachandpur districts) under this centre. The weather data recorded at Agrometeorological Observatory of AMFU-Imphal Unit at ICAR Research Complex along with other districts data were sent daily to India Meteorology Department, Pune and Delhi, NCMRWF, FICCI and Regional Meteorological Centre, Guwahati, Doordarshan Kendra, KVKs Imphal, Manipur Regional Web-site, All India Radio (AIR), and to both morning and evening local newspapers through e-mail, sms and phone. 'The Manipur Bulletin' containing past few days' weather summary, weather forecast for next five days and agro advisories for the farmers are weekly provided to these media. For the year 2010-2011, ninety bulletins covering nine districts were furnished. Observed data and weather forecast were supplied to DDK news unit and to others like governmental, non-governmental organizations, research scholars, students, farmers, etc. as per demand and telecast daily by the DDK, Imphal in the local News.

Four ordinary rain gauges were distributed to the selected farmers from four districts for installation at their fields (Fig 5). They have been guided with steps for management of the apparatus and procedure for recoding and maintaining the rainfall data for self-use and comparative study of rainfall at different locations/ villages. This unit has translated the IMD Brochure to Manipuri which was released in the 4th Annual Meet of IEAS at Hyderabad.

Fig 5 Distribution of rain gauges by the Director of Agriculture, Manipur

SEED TECHNOLOGY

Feasibility study on scientific production and storage of farmers' saved seed in major crops of Manipur

Quality levels of the farmers' saved seeds under scientific supervision (T) were much superior in all the standard components over the traditionally produced ones (t). In rice varieties RC Maniphou-10, the off types present was as low as 0.76%, respectively under *T* as compared to 14.50% under farmers' conditions *t*. The yield advantage due to seed quality was as high as 22.65% over those using locally saved

seeds. Rice seeds in the experimental seeds plots were found 99.15% pure as compared to 73.67% in adjoining fields (Table 4). Seed moisture in RC-Seed Bin was maintained at 10.5% in rice, 10.7% in maize and 8.25% in rapeseed.

Table 4 Quality of farmers own produced rice seed under supervision

Standards under Indian minimum standard	Seed produced under supervision	Check
Pure seed (98%)	99.15%	73.67%
Inert matter (2.5%)	0.76%	8.54%
Weed Seed (10/kg)	1.88	13.20
Germination (80%)	87.52%	78.54%
Moisture content (%)	10.60%	13.22%

In rapeseed and maize, time isolation could avoid out crossing. In maize, the variety Pusa Composite-3 produced with time isolation by *rabi* sowing at Kakching village (Thoubal District) and Imphal West was maintained upto 6th generation and farmers could obtain certifying level quality saved seeds through selection (Fig 6). In M27, rapeseed early sowing during Sep-Oct maintained the purity level within permissible limit under Indian Minimum Seed Certification Standards with, the off types present as low as 2.34% in T as compared to 20.27% under traditional open pollinated seed saving (t). Seeds stored inside RC Seed Bin maintained the minimum standards and seed health quality for more than 2 sowing seasons when compared to the ambient traditional storage (ambient) practice which maintained hardly for one season. Thus, small famers could produce quality seeds for their use or sale at higher price with some extra efforts, care and participatory approach.

Fig 6 Pusa composite- 3 maize with high purity at 6th generation being maintained with time isolation (*rabi* sowing) under farmers' field at Kakching Village, Thoubal District

Maintenance and breeding of locally released/ recommended varieties of important crops

Rice varieties released from the centre are being maintained through panicle row selection and basic seeds are produced every year. Seeds were supplied to the framers under Front Line Demonstration programmes/sale or through state Agriculture Department for Seed production programme. The varieties for pre *kharif* are RC Maniphou 4 and RC Maniphou-5. The main *kharif* varieties are RC Maniphou-6, RC Maniphou-7, RC Maniphou-10. Breeder seed of newly released RC Maniphou-11 (RCM 21) (Fig 7) was also maintained. In maize, composite variety, Pusa Composite-3 was maintained since 2005 with time isolation by sowing during *rabi* (Fig 8). Rapeseed variety M 27 was maintained for 5 years with 96.54% purity level (Table 5).

Table 5 Basic seed production during 2010-11 at Manipur centre

Crop	Variety	Basic seed produced (kg)
Rice	RC Maniphou 4 (RCM 7)	1100*
	RC Maniphou 5 (RCM 8)	20*
	RC Maniphou 6 (RCM 5)	210
	RC Maniphou 7 (RCM 9)	6875
	RC Maniphou 10 (Lungnilaphou)	2500*
	RC Maniphou 11(RCM 21)	90
Maize	Pusa Composite 3	20
	HQPM-1 (at KVK Chandel)	55
Rapeseed	M 27 (Breeder seed)	50
	M 27 (Foundation Seed)	350
Groundnut	ICGS 76	108
	ICGV 86590	50
	JL 24	20
	TG 37-A	25
Soyabean	JS 335	170
Total		**11,673***

** Flood affected the seed production*

Fig 7 Newly released rice variety RC Maniphou-11

Fig 8 Maize variety Pusa composite-3 with time isolation

Development of low cost seed storage practice

Efforts were made to develop low cost medium seed storage technology for different crops *viz.*, rice, maize, soybean, rapeseed and peas to assess the effect of botanicals in seed storage (Table 6). There was reduction in storage pests with application of locally available botanicals *viz.*, *Artemisia parviflora*, *Goniothalamus sesquidedalis*, *Plectranthus ternifolius* and *Vitex negundo*. These botanicals, when applied to the storage pests exhibited knock down effects showing repellent action but no lethality on the insects were noticed. Efficacy period was hardly for a few weeks. Seed viability too declined beyond the permissible limit after the second sowing season. However, storage of treated seeds with powders of the above plants under desiccated conditions through charcoal could reduce the moisture and thereby the infestation of macro and microorganisms too. Desiccated conditions could maintain seed quality upto two sowing seasons.

Development of seed production packages in important crops

The major problem of seed production in the region is small size land holdings coupled with lack of expertise among the local stake holders. Techniques suitable to small and poor farmers need to be developed for the region. For self-pollinated crops like rice, peas, legumes, not much problem were noticed if some practices are adopted for seed source, site selection, rouging, handling and storage. In outcross crops like maize, rapeseed and mustard, time isolation were more practicable than the distance isolation. For maize (open pollinated varieties), time isolation by *rabi* planting (Oct-Jan) was found suitable both for pollination and post-harvest operations. Early planting (Aug to Oct depending on soil moisture) was suitable for rapeseed, M-27 in the uplands. For this variety, seed produced under zero tillage practice was also suitable for time management to outcrossing with the respective commercial crops besides maintaining a high seed quality.

Table 6 Germination percentages after storage of different crop seeds treated with plant powders

Crop (Variety)	Storage period (months)				
	4	8	12	20	32
Artemesia parviflora					
Rice (RC Maniphou 7)	91.75%	90.75%	85.25%	65.25%	42.5%
Maize (Pusa Composite 3)	89.5%	89.5%	65.25%	23.5%	14.0%
Soybean (JS 335)	87.25%	88.75%	67.5%	31.5%	12.25%
Rapeseed (M 27)	86.25%	88.25%	80.75%	76.5%	65.25%
Goniothalamus sesquipedalis					
Rice (RC Maniphou 7)	94.75%	91.50%	84.25%	67.5%	45.25%
Maize (Pusa Composite 3)	91.5%	92.25%	67.5%	26.75%	12.5%
Soybean (JS 335)	88.25%	88.5%	66.5%	22.75%	10.25%
Rapeseed (M 27)	87.5%	86.5%	82.5%	78.25%	64.75%
Plectranthus ternifolius					
Rice (RC Maniphou 7)	92.75%	91.25%	83.25%	64.5%	38.25%
Maize (Pusa Composite 3)	90.5%	89.5%	55.25%	32.75%	11.5%
Soybean (JS 335)	85.5%	84.5%	65.5%	24.25%	10.25%
Rapeseed (M 27)	87.25%	85.5%	81.25%	77.75%	55.25%
Vitex negundo					
Rice (RC Maniphou 7)	90.5%	91.25%	87.5%	65.25%	46.25%
Maize (Pusa Composite 3)	91.5%	92.5%	66.25%	22.5%	14.5%%
Soybean (JS 335)	83.68	82.45	66.5%	30.5%	13.25%
Rapeseed (M 27)	86.5%	86.5%	83.75%	72.5%	54.25%

INSECT PEST

MUSTARD

Mustard saw fly, *Athalia lugens proxima*, was the major pest in early vegetative stage. There larvae feed voraciously on leaves and their infestation increased with the age of crop till seed setting. Mustard aphid, *Lipaphis erysimi*, was also recorded as the major pest of mustard. Aphid infestation started from the flowering stage of the crop and continued till maturity of the crop. The predatory coccinelid beetle, *Cocccinela septempunctata* appeared simultaneously with aphid infestation. The adults and larvae of *Cocccinela septempunctata* were found predating on these pests. The population of these beetles was high at maturity in comparison to flowering stage. Incidence of cabbage butter flies, *Pieris brassicae* and *Pieris canidia*, was observed at vegetative stage while the pea pod borer, *Lampides boeticus* appeared at flowering stage. Larvae of these butterflies feed voraciously on the leaves, branches and pods of the crop. Bihar hairy caterpillar appeared at late vegetative stage. The newly hatched caterpillars remain in clusters on the lower surface of the leaves and feed on the epidermis. The grown up larvae disperse and feed in isolation. They eat away entire leaf tissues leaving only the midribs.

PEA

Leaf miner, aphids, cabbage butterflies and blue butter flies were the major insect pest infesting pea crop. Leaf miner was observed from vegetative stage. Aphids start infesting crop from vegetative stage and simultaneously the predatory coccinelid beetles were found predating on these pests. Aphid population reached to its peak at flowering stage. Pea pod borer was another serious pest of the crop. It appears at flowering stage and their larvae feeds on the developing pods causing severe damage. Cabbage butterfly also appeared at vegetative stage and there larvae started damaging the crop severely.

HORTICULTURE

VEGETABLES

TOMATO

The release proposal for Selection 9A was sent to State Variety Release Committee. Another high yielding line, Selection 11, is under pipeline (Figs 9 & 10). Among the other promising lines such as RCMT-4B (uniform colour development), RCT-9 (Resistant to water logging) and RCT-3 (High yielding and resistant to bacterial wilt) will be proposed for inclusion in All India Coordinated Research Project on Vegetable Crops (AICRPVC) for multi location field trial.

Fig 9 Selection 9A

Fig 10 Selection 11

BRINJAL

Ten promising genotypes of brinjal (long purple type) were evaluated at Manipur for resistant to bacterial wilt. The released variety Arka Keshav was used as control. Among the 10 genotypes, highest yield (32.40 t/ha) was recorded with RCMB 10, as compared Arka Keshav (24.75 t/ha). RCMB 10 is moderately resistant to bacterial wilt. The line was proposed for inclusion in the AICRP on Vegetable Crops. Other lines namely RCMB 5, RCMB 6 and RCMB 9 were found free from bacterial wilt and can be effectively used as doner parent in future breeding programme.

COLOCASIA

The experiment was conducted with 5 clonal selections (RCMC 1 to 5) of F_7 generation. The released variety Muktakeshi was taken as control. The maximum yield (32.66 t/ha) were recorded in RCMC 3 (Fig 11), followed by RCMC 2 (30.33 t/ha) and

Fig 11 High yielding clone of colocasia

RCMC 1 (29.50 t/ha) as compared to 18.00 t/ha in Muktakeshi.

SPICES

TURMERIC

The experiment was undertaken to develop suitable variety of turmeric for Manipur by clonal selection from potential indigenous germplasm. A total of 26 advance breeding line of F_7 generations were evaluated based on different horticultural parameters. Accession RCMT-14 (Fig 12) performed best (34.33 t/ha), followed by RCMT-10 (32.90 t/ha), RCMT-9 (31.00 t/ha) and RCMT-11 (30.66 t/ha). But highest curcumin percentage (8.50%) was recorded with RCMT-7 with a yield potential of 28.00 t/ha.

Fig 12 High yielding clone of turmeric

BIOACTIVE NATURAL PRODUCTS CHEMISTRY

Collection, evaluation, characterization and documentation of local French bean, dolichos bean and cow pea germplasm of NEH region using morphological and protein marker

All total 25 local germplasm line of French bean, 12 local germplasm line of dolichos bean and 15 local germplasm line of cow pea were collected from different parts of Manipur. The protocol for extraction of protein from mature seeds was standardized. Electrophoresis for SDS-PAGE protein profiling was carried out in which maximum variation was recorded in 13% gel concentration. The SDS-PAGE protein profile showed variation among the different genotypes (Fig 13).

The bioassays were done to select some French bean genotypes with functional food quality

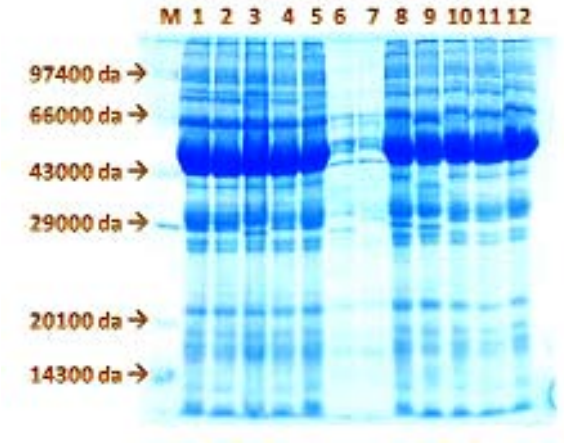


Fig 13 SDS-PAGE protein profile of French bean germplasm

(bioactive). The study was conducted on selected bean accessions (RCMF 8, RCMF 9, RCMF 11, RCMF 19, RCMF 22, RCMF 25, RCMF 35, RCMF 35B, RCMF 36 and RCMF 46) to determine their bioactive properties. MTT (Thiazolyl Blue Tetrazolium Bromide) assay (Fig 14) of the water and methanolic extracts of the selected accessions at 37^0C revealed that methanolic extracts of RCMF 11, RCMF 22 and RCMF 35 have bioactive properties (Antioxidants). These three accessions (Methanolic extracts) were subjected to Cyclooxygenase Assay commonly known as COX Assay (Based on biological oxygen monitoring system) to evaluate their anti-inflammatory activity. It was observed that none of the accessions were active against COX-I enzyme, but RCMF 22 and RCMF 35 revealed low to medium activity against COX-II (This enzyme helps in proliferation of tumor cell). The Thin Layer Chromatography (TLC) of the ten accessions (Methalonic extracts) was carried out in Chloroform-Methanol solvent system (4:1 and 8:1). Not much difference was observed in both solvent systems.

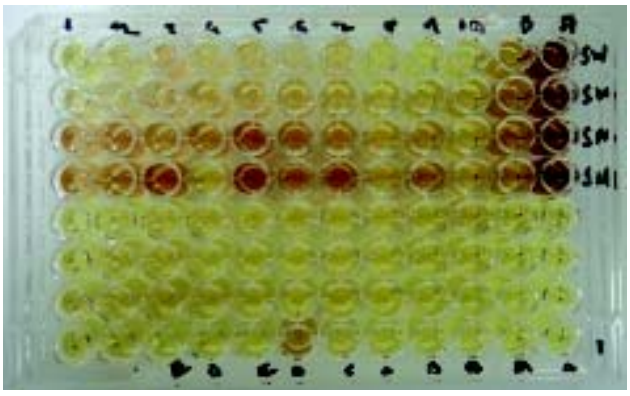


Fig 14 MTT assay on French bean germplasm

Identical trend was noticed for almost all the accessions except RCMF 35B, 36 and 46. Expression of these three accessions was not much as compared to other accessions. Expression of RCMF 8, 11, 22 and 35 was better in TLC. From the result, accessions RCMF-11, RCMF-22 and RCMF-35 were found to be the best in terms of yield and bioactive properties and these accessions should be carried forward to evolve better varieties.

Evaluation of bioactivity of indigenous *Curcuma* germplasm

Four indigenous *Curcuma* germplasm collections collected from Tamenglong district of Manipur is extensively used in folk medicine by the local people. These are unique in terms of their flesh colour (white, grey, deep blue and black). The collection number is given namely RCMIT-1 (Dark blue), RCMIT-3 (Grey), RCMIT-4 (White) and RCMIT-5 (Black) and evaluated for functional food quality and bioactive properties in collaboration with Michigan State University, USA.

The MTT (Thiazolyl Blue Tetrazolium Bromide) assay was done for hexane, ethyl acetate and methanolic extracts of the selected germplasm at 37^0C taking ascorbic acid and TBHQ as control. It was revealed that methanolic extracts of RCMIT-5 is highly active, followed by RCMIT-4, RCMIT-3 and RCMIT-1. The result indicated the presence of high antioxidants in the samples.

Based on MTT assay, the methanolic extracts were subjected to Cyclooxygenase Assay commonly known as COX Assay (Based on biological oxygen monitoring system) to evaluate their anti-inflammatory activity. It has been observed that none of the accessions are active against COX-I enzyme, but highly active against COX-II (This enzyme helps in proliferation of tumor cell and other diseases). The best inhibition of COX-II has been observed in RCMIT-3 (84.38%), followed by RCMIT-4 (80.40%), RCMIT-5 (81.25%) and RCMIT-1 (63.68%). In the Lipid Peroxidation Inhibitory Assay or LPO Assay, the samples did not show high activity indicating that the antioxidants in the samples react through redox reaction not through radical scavenging reaction.

Both the hexane and methanolic extracts were subjected to Anticancer Assay or Anti-tumor Cell Proliferation Assay (Fig 15). The extracts were applied in 6 types of cancer cell line (Lung, Colon, Breast, CNS, Pancreas, Prostate and AGS) to observe the inhibitory action on the cell proliferation. The result was highly significant. RCMIT-1 showed inhibitory

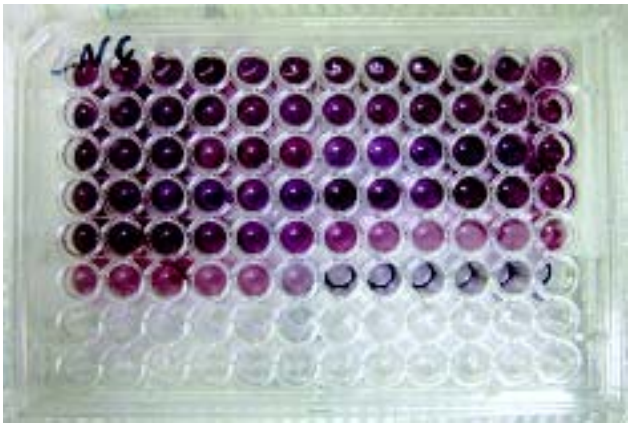


Fig 15 Anti-tumor cell proliferation assay

activity against cancer cells of breast (30%), lungs (33%), CNS (39%) and prostate (41%). RCMIT-showed 38% inhibition in colon cancer cells; whereas RCMIT-4 and RCMIT-5 showed 35% and 42% inhibition in AGS and Panceas cancer cells respectively.

The Thin Layer Chromatography (TLC) of the extracts was standardized and best separation was observed in Hexane-Acetone (4:1) solvent system. The TLC profile revealed a number of compounds present in different extracts. The hexane extract of RCMIT-5 was subjected to fractionation and two compounds have already been purified through preparative liquid chromatography. The purification of other compound is going on, after that the compounds will be detected with the help of NMR. The Anti-cancer Assay will be repeated for each compound to identify the active compounds and also to observe the dose response. Overall result indicated an enormous opportunity for commercial exploitation of these neglected species.

Fig 16 TLC profile of *Curcuma*

POST HARVEST TECHNOLOGY AND VALUE ADDITION

Standardization of low-cost storage technique for fruits and vegetables

In storage study *Khasi* mandarin stored at ZECC had the longest shelf life (21 days) with high total acidity (0.89%), reducing sugar (2.14%) (Fig 17) and non-reducing sugar (0.89%) whereas, highest TSS (11.83°Brix) was found in the fruits stored at RC storage bin. Kachai Lemon at Zero Energy Cool Chamber was also found to have longest shelf life (17 days) while the fruits stored at RC storage bin kept for 13 days.

The pineapple fruits could be stored up to 28 days in refrigerated condition (RC) and ZECC, followed by RC storage bin (21 days) and room temperature (14 days). Pineapple stored in RC showed the best result with moderate change in the physico-chemical characteristics and was at par with ZECC. After 28 days of storage, maximum TSS (15.30^{0}B), Acidity (0.38), pH (2.77), and Total sugar (5.86%) were found in RC, followed by ZECC (15.02^{0}B TSS, 0.36 acidity, 2.40 pH, and 5.79% total sugar).

Fig 17 Storage of fruits under different storage condition

But, the maximum ascorbic acid content after 28 days of storage (15.41 mg/100 g) was recorded in ZECC as compared to 15.30 mg/100 g in RC. Therefore, refrigerated storage condition and ZECC seems to be more appropriate for short-term storage. However, considering the cost and power crisis in Manipur, storage of fruits in ZECC is the most feasible storage condition for the farmers in Manipur.

Standardization of spray drying technology for *Prunus nepalensis*

The protocol of spray drying of *Prunus* juice was standardized (Fig 18). The full ripe fruits were found best for spray drying due to maximum juice content. The 50% dilution of juice with water was found best in terms of powder yield. The parameters like inlet and outlet temperature, flow rate, pressure as well as percentage of starch were standardized to obtain maximum powder yield. The powder can be mixed with water to prepare RTS or can be used in different value added preparations. The storage study revealed that the powder could be stored up to 2 months at room temperature in air tight container or zipper plastic pouch without any chemical preservatives.

Fig 18 Spray drying of *Prunus nepalensis*

PASSION FRUIT

The protocol of spray drying of passion fruit juice was standardized. Fruit at 1/3rd ripening stage was found best for spray drying due to maximum juice content. Maximum powder yield (40.12 g/100 ml fruit juice) was obtained with 40% Maltodextrin. The parameters like inlet and outlet temperature, pressure, flow rate etc. were standardized for spray drying. The powder can mixed with water to prepare RTS or can be used in different value added preparations. The storage study revealed that the powder could be stored up to 3 months at room temperature in airtight container or zipper plastic pouch without any chemical preservatives.

DISEASES

Survey and management of important diseases of passion fruit

In vitro evaluation of five fungicides *viz.*, Bavistin 50WP (carbendazim), Antracol (propineb 75 WP), Sectin (fenamidone 10%+mancozeb 50%WG), Monceren 250SC (pencycuron 22.9SC) and Folicur 250 SC (tebuconazole 25.9 EC) was done against *Fusarium solani*, *Phomopsis tersa* and *Glomerella cingulata*. Folicur and Monceren gave 100% control of *Fusarium solani*, *Phomopsis tersa* and *Glomerella cingulata* followed by Bavistin as compared to control.

TECHNOLOGY MISSION

Offseason production of vegetables

The experimental results revealed that crop cycle involving King chilli (Oct-Apr) → Cucurbits + Okra (May-Sep) → Capsicum + Beans (Oct-Jan) →Lettuce + Chilli (Feb-May) → Cowpea + Palak + Tomato (Jun-Sept) is the best combination for off-season production of vegetables under low cost polyhouse in Manipur. Among the different capsicum variety Thai Wonder was found best for off-season cultivation under low cost poly-house. On an average, 8 fruits were observed per plant with 108 g of average fruit weight per plant. The projected yield was 13 t/ha which is quite high as compared to open condition.

Standardization of life-saving irrigation technology by water harvesting and micro-irrigation on different horticultural crops

Experiment on low cost drip irrigation in cauliflower var. White Flash (Fig 19) in which crop was irrigated for 2 hours daily at an interval of 2 days, 3 days and 4 days. Maximum curd formation was recorded with irrigation at 3 days interval. Maximum yield (16.90 t/ha) was observed with daily irrigation, followed by irrigation at 2 days interval (16.20 t/ha), but the difference was statistically non-significant. So, drip irrigation for 2 hours at two days intervals can be recommended for cauliflower under Manipur valley.

Table 7 Transfer of technology under Technology Mission (MM-I)

Topic of the Training/Demonstration	Number
Improved production technology of *Khasi* mandarin and kachai lemon	3
Replanting/rejuvenation of unproductive *Khasi* mandarin and kachai lemon orchards	4
Propagation of citrus	1
Improved production technology of passion fruit	1
Improved production technology of banana	2
Improved production technology of papaya	1
Mushroom production technologies	4
Improved production technology of pea	1
Improved production technology of turmeric	3
Improved production technology of tomato var Sel 9A	1
Improved production technology of onion	2
Value addition of fruits and vegetables	8
Low-cost vermicomposting technique	2
Production and use of azolla in horticulture based farming system	1
Low-cost water harvesting technique for vegetable garden	1
Workshop on organic vegetable farming	1

Fig 19 Low cost drip irrigation in cauliflower

MEDICINAL AND AROMATIC PLANTS

Establishment of model nurseries of medicinal plants under national mission on medicinal and aromatic plants

Under the sponsorship of National Mission on Medicinal and Aromatic Plants (NMMP), three Model Nurseries were established by the ICAR-RC for NEH Region, Manipur Centre, at Lamphel, Imphal, Churachandpur and Ukhrul. Out of these, a main mother medicinal plant garden at Langol Hills was also developed. At the main model farm at Imphal, 3300 *Acorus calamus* are produced. 2800 *Stevia rebaudiana* plants and 100g seed was harvested. Forty grafted plants of *Emblica officinalis* were planted in the garden. 280 *Piper longum* stem-cuttings and 400 *Rauwolfia serpentina* procured from outside were also planted. For *Mucuna pruriens,* 1.75 kg seeds from outside were raised. For the Sub-tropical hill zone, nursery unit at Churachandpur, KVK (Pearsonmon Village), 1000 *Aloe vera* plants were produced. Temperate Model Nursery at KVK, Ukhrul (Hundung Village) was also started, and plants *viz.*, *Ginseng, Paris polyphylla, Taxus bacatta, Smilax lanceifolia* and *Swertia chirata* mother plants were raised.

National Network on Integrated Development of Jatropha

Survey and collection of superior local germplasm

The survey in different districts indicated large variation in the germplasm. Three collections (accession number is provided by NBPGR) *viz.*, MNJ 001, MNJ 006 and MNJ 0017 had seed oil content more than 40%. This indicates that there was a large scope for exploitation of superior genetic stock of Manipur for further improvement.

Performance of Jatropha germplasm under different trials

Progeny Trial: The highest seed yield was observed in genotype TFRI-04 (1111.1 kg/ha) whereas, TFRI-01 recorded the highest oil content (49.20%). The plant height was recorded maximum (310.00cm) in genotype JIP-17 and collar diameter was recorded highest (83.50 mm) in genotype MNJ-005 while, number of branches per plant (18.17) was recorded maximum in genotype DOR.

Local Trial : The genotype MNJ-002 was recorded maximum plant height (190.15 cm) whereas, collar diameter (67.45 mm) was recorded highest in genotype MNJ-011. The maximum number of branches per plant (9.00) was recorded in genotype MNJ-006 while, MNJ-002 recorded the highest oil content (40.87%).

Zonal Trial : The plant height (204.34 cm) and collar diameter (73.00.00 mm) was recorded highest in genotype PJ-01while, number of branches per plant (16.20) was recorded maximum in genotype JIP-13.

Multilocational Trial : The highest plant height (179.70cm) was recorded in genotype PDKV-NOV-3 and collar diameter (66.00 mm) was recorded maximum in genotype Orissa-2 while, highest number of branches per plant (14.70) was recorded in genotype JA-9.

National Trial I : The genotype TFRI-04 recorded highest plant height (184.40cm) while, number of branches per plant (16.15) and collar diameter (67.00 mm) were recorded maximum in genotype PJ-01.

National Trial III : The genotype RJ-92 was recorded highest plant height (132.20 cm) and collar diameter (67.00 mm) while, genotype TR-4 was recorded maximum number of branches per plant (9.10) .

Spacing Trial : The maximum plant height (359.20 cm), collar diameter (66.00 mm), number of branches per plant (14.70) were recorded in genotype MNJ 005 with 3m x 4m spacing, while, fruit yield (1010.00 g/plant) and seed yield (600.00 g/plant) was highest in genotype MNJ 002 with 3m x 3m spacing.

Pruning Trial : The percent increase in plant height (1.92%) was recorded highest in TFRI-07 with 30 cm topping height and maximum percent increase in collar diameter (6.12%) was found in NDJC-1 with 60 cm topping height while, percent increase in number of branches per plant (14.04 %) was recorded maximum in NDJC-1 with 60 cm topping height.

Fertilizer Trial : The percent increase in plant height (0.19%) was recorded maximum in MNJ-002 with 150g urea + 250g SSP + 50g MOP per plant and maximum percent increase in collar diameter (6.11%) was recorded in TFRI-02 with 150g urea + 250g SSP + 50g MOP per plant while there was no increase in number of branches per plant. It has been observed that with increase in quantity of urea the plant height and collar diameter increases in all the genotypes, the highest being observed with 150g urea + 250g SSP + 50g MOP per plant whereas, maximum number of branches per plant was observed with 100g urea + 250g SSP + 50g MOP per plant which was closely followed by 125g urea + 250g SSP + 50g MOP per plant.

Agri-silvicultural Trial: The trial has been conducted to select the suitable intercrops for jatropha plantation. During the years, performance of different crops namely sweet potato, French bean, dolichos bean, broad bean, soybean and ground nut have been evaluated. The main objective of selecting legume crops is to enhance the soil fertility as jatropha is mainly grown in waste land situation. Sweet potato has been selected in order to check soil erosion under hill slope condition. Sweet potato (var. Gauri) has been found to be the most suitable intercrops for jatropha under foothill condition of Manipur followed by Soybean (var. JS-335) and Ground nut (var. ICGS-76). French bean (var. Anupam) has also performed well. Dolichos bean and Broad bean were not found suitable for intercropping under jatropha plantation.

DISEASES

JATROPHA

Studies on diseases of jatropha (*Jatropha curcas*) in Manipur

In vitro evaluation of five fungicides *viz.*, carbendazim (bavistin 50WP), antracol (propineb 75 WP), sectin (fenamidone 10%+mancozeb 50%WG), monceren 250SC (pencycuron 22.9SC) and folicur 250 SC (tebuconazole 25.9 EC) was done against *Colletotrichum gloeosporioides* and *Glomerella cingulata*. Monceren was 100% effective against *Colletotrichum gloeosporioides* followed by bavistin. Bavistin, folicur and monceren gave 100% control of *Glomerella cingulata* as compared to control. Antracol and sectin were not effective against *Glomerella cingulata*.

Standardization of seed production and culture techniques of some potential indigenous fish species of north east hill for aquaculture

Bangana dero (Hamilton-Buchanan) known as *Ngaton* or *Khabak* (in Manipuri), *Khital* (in Tangkhul), *Ngatai* (in Myanamar) is an indigenous medium carp. Maximum standard length is 40 cm. Thirty-five advanced fries of *B. dero* having a total length of 6.5±2.1 cm and body weight of 2.70±4.5g were collected from the rivers in Tamenglong district of Manipur in Oct and Nov 2009. The fishes were reared in earthern ponds. The fishes were fed with a formulated feed containing 30% crude protein at the rate of 5% body weight per day.

Artificial breeding

B. dero male females were segregated by keeping in separate tanks one month before the breeding operation. Spawners were selected for induced breeding in the month of June 2010. Spawners were injected Ovatide @ 0.5ml/kg body weight. After the intra-muscular injection on the dorsal muscle above the latral line, the breeders were released in a breeding *hapa*. The fertilized eggs were spherical, translucent, slightly greenish in colour and demersal measuring 2.5±0.2 mm in diameter. Water absorbed fertilized eggs measured 4.5 ± 0.05 mm in diameter. Unfertilized eggs were paler and opaque. Fertilized eggs were hatched out between 24-48 hrs after fertilization. The water temperature ranged 25-26°C. The fertilized eggs underwent development and young hatched larvae measured 4.2 mm long and 1.5 mg in weight. They do not take exogenous food for about 72 hours at 25°C. The yolk sac is fully absorbed on the 4th day and the hatchlings grew to 5.5-6.0 mm long. After four days of hatching the spawns were released in to well manured nurseries.

Standardization of breeding and culture techniques for potential indigenous ornamental fishes of North East Region for commercialization

Twenty indigenous ornamental fish species were collected from different water areas of Manipur and maintained in the laboratory for further studies. Studies on bio-ecology, breeding biology for five selected species were continued (Table 8).

Fig 20 Different stages of artificial breeding of *Bangana dero*

Table 8 Food and feeding habit, size, sexual differentiation and breeding behaviour of selected indigenous ornamental fishes

Scientific Name	Habitat	Water quality	Food and feeding habit	Reproductive biology and breeding behaviour
Syncrossus berdmorei	Clear fresh water, demersal, swift flowing streams with rocky and sandy bottom. They prefer to hide under gravel	pH – 7.0-7.5; T – 24-26°C; Dissolved O_2 – 6-8 ppm	Omnivorous, feeds on worms, mollusc, benthic crustaceans and little amounts of algae	Females are larger, fuller with an apparent genital papilla during breeding season.
Puntius manipurensis	Bentho-pelagic, freshwater fish, inhabits in lakes, ponds, canals of Imphal Valley, Purul Akutpa Senapati.	pH-7.0-7.5, T-22-28°C, Dissolved O_2 – 6-8 ppm	Omnivorous, feeds on algae, small insects, crustaceans etc.	Males are larger and more colourful. Females are larger with a rounded belly and dark black dorsal fin.
Devario acuticephala	Pelagic, freshwater, inhabits in rice fields, ponds, canals, hill streams of Manipur	pH-6.2-7.5, T-20-26°C, Dissolved O_2 – 4-8 ppm	Omnivorous, feeds on algae, small insects, molluscs, worms etc .	Males are larger and colourful. During breeding season males develop a pinkish strip below a black strip from the operculum to the caudal fin along the whole.
Acanthocobitis zonaltrenus	Bentho-pelagic, freshwater, inhabits in sandy, rocky hill streams of Manipur. They prefer shades	pH- 6.0-7.5, T-20-26°C, Dissolved O_2 – 4-8 ppm	Omnivorous, feeds on algae, small insects like *Moina*, *Daphnia*, mollusc, worms	Females are large with rounded belly. Males are more slender. Pink coloration develop

***Puntius bizonatus* (an endemic barb) bred in laboratory**

Puntius bizonatus is an endemic fish of Lokchao River, a hill-stream of Indo-Myanmar border of Manipur. *P. bizonatus* normally spawn in running water only and does not breed in still water. However, the fishes were bred successfully in captivity in the laboratory when the fishes were provided with well balanced feed and its environment was manipulated. Forty five fish fries having 24-25 mm size were collected from Lokchao river and stocked in tank glass aquaria having dimension of 2 ½´ x 1 ½´x 1 ½´. The fishes reached 3.2- 3.5 cm in four months and matured. During culture period, the fishes were fed thrice in a day with the artificial diet and freeze-dried tubifex worms. Physico-chemical characteristics of water like pH, water temperature, dissolved oxygen, total alkalinity and free carbon dioxide ranged from 7-7.5, 24-26ºC, 5-7 ppm, 60-80 ppm and 0-4.0 ppm, respectively during the entire period of study. The matured males and females having 3.2-3.5 cm SL were selected for breeding and transferred to a plastic circular tank having 1m diameter and water depth of 80 cm. The sex ratio between male and female in all the experiments was 1:1. *Hydrilla* was provided as hiding place for young ones. Fishes were fed with diet mixed with Ovatide for 3 days. It was observed that the hormone incorporated feed could enhance the fishes to breed and lays eggs. Forty-sixty eggs were produced per female. Fertilized eggs hatched within 2-3 days at 26ºC. Five to six days old fishes were fed with fine powder of the artificial diet containing 30% crude protein.

***Puntius bizonatus* male brooder**

Courtship in breeding tank

Fig 21 Breeding of *Puntius bizonatus* in captivity

Livelihood improvement and empowerment of rural poor through sustainable farming systems in North East India (NAIP, component III)

The programmes taken up were–

- Quality seed production of rice varieties RC Maniphou-10 and RC Maniphou-6 in 63 ha area by 230 farm families with combined average yield of 4.07 tonnes / ha against the local check variety (16.28 % increase over the local check).
- Adoption of hybrid maize cultivation (PEMH-2) in 2.0 ha area by 10 farm families, soybean cultivation (JS 335) in 5.0 ha by 36 farm families and groundnut (ICGS-76) cultivated in 1.0 ha by 5 farm families with average productivity of 3.15, 1.5 and 1.2 tonnes /ha, respectively.

Upliftment of rural family income through enhanced cropping intensity, double cropping of rice fallows with zero tillage of M-27 and other suitable *rabi* crops

- M-27 zero tillage rapeseed cultivation in 65 ha area benefitting 165 farm families, pea cultivation (var. Arkel) in 10 ha area with 120 farm families, potato cultivation (var. Kufri Megha) in 2.8 ha area benefitting 184 farm families and introduction of vegetable cultivation (tomato, onion, cabbage) in 2.4 ha area with 107 farm families were taken up.
- The other crops taken up during *rabi*, 2010-11 were potato, peas, onion and cabbage. For potato an area of 2.8 ha was adopted by 184 farm families and recorded a combined average yield of 11.98 t/ha and per farm family operational area ranged from 100-300 m^2 and earned a gross return of Rs.1010 to Rs.3810 per farm family. For peas, both field (Rachana) and garden (Arkel) peas were taken up and 120 farm families were in 10 ha area with an operational area of 800-1000 m^2 per farm family. The crop performed well under minimum tillage practices with a combined average yield of 3.76 t/ha and fetched a gross income of Rs 12,000-25,800/ farm family (Table 9).

Table 9 Basic seed production during 2010-2011 under NAIP at Tamenglong District, Manipur

Crops	Varieties	Basic seed production (kg)
Rice	RC Maniphou-10	4070
	RC Maniphou-6	3770
Maize	PEMH-2	3105
Soyabean	JS-335	1500
Groundnut	ICGS-76	1200
Rapeseed	M-27	1020
Potato	Kufri Megha	12700
Pea	Arkel	4500
Cabbage	Rareball	17200
Tomato	Suwraksha	25600
Onion	N-53	3000

- To increase seed yield and for extra income, 30 apiary units were introduced to 30 farm families.
- **Improvement of livelihood through low volume high value crops**: High value crops *viz.*, ginger, turmeric and king chilli were taken up for better livelihood. Turmeric on 6 ha area produced 85 tonnes turmeric rhizomes, ginger of 5 ha area produces 70 tonnes ginger rhizome and king chilli in 1 ha area produced 1 kg king chilli per plant.
- **Scientific composite fish farming**: Seventy seven farmers adopted scientific composite fish farming and estimated fish production ranged from 4.1- 4.4 t/ha and farmers could get a gross profit of Rs. 9,846 to 15,581 per farm family depending on their available water area.
- **Scientific pig rearing**: To increase family income, 518 improved Hampshire pigs were reared by 251 farm families. A gross return of Rs 68,000 per farm family earning was achieved through improved Hampshire pig rearing that helped to improve the livelihood of poor farmer (Table 10).

Table 10 Gross return per farm family for rearing a unit of 2 females and 1 male improved breed Hampshire (2 years rearing period)

Particulars	Quantity	Return (Rs)
1. Sale of adult pigs @ Rs 8000/ pig	3 nos.	24,000
2. Sale of piglets @ Rs 2000/ piglet from 1st furrowing	10 nos.	20,000
3. Sale of piglets @Rs 2000/ piglet from 2nd furrowing	12 nos.	24,000
Total return (Rs)		68,000

- **Improvement of livelihood through sustainable farming system:** A total area of 3.5 ha was developed under sustainable farming system models involving Agriculture + Aquaculture + Horticulture + Animal Husbandry.
- **Introduction of 2 dairy units with improved breed Holstien Fresian to 2 farm families:** Two heifers dairy cattle of improved breed Holstien Fresian were reared by two farm families at Tupul and Reangkhong villages under NAIP project. Cattle were vaccinated against haemorrhagic septicaemia, black quarter and foot and mouth diseases.
- **Establishment of home scale oil expeller unit at Tupul and Noney**: Two units of home scale oil expellers were established at Noney and Tupul villages and 17.02 ('000 litres) of oil was produced in the cluster area.

Observation of field day on *rabi* crops

To demonstrate and disseminate the success of *rabi* crops in *kharif* rice fallows and to create awareness amongst the farmers of the state, particularly of the district, a Field Day on Rabi Crops was organized on 8th Febuary, 2011 at Marangching village, Tupul, Tamenglong. One hundred ten farm families from five different villages of the cluster *viz.*,Tupul Charoi Chagotlong, Noney (Longmai), Reangkhong, Awangkhul and Marangching participated in the awareness cum training programme.

Establishment of rural information kiosk centre

Rural information kiosk centre was established and rural unemployed youths were trained on accessing information on weather forecasting, early warning of disease and pest problems, information on cropping systems and planning, best and latest package of practices for agricultural, horticultural and commercial crops, soil testing and sampling, input prices, availability and farm business information and crop insurance and post- harvest technology etc.

Other Extension Activities

- State Level Field Day on Rice at Lamphelpat and Hon'ble Minister of Agriculture, Manipur released the new Rice variety RC Maniphou 11 for Manipur state on 16th November 2011.
- Seven days Farmers' Training Programme on Community based rain water harvesting was from 25-30th October, 2010 under SWPAL.

- Content Development Workshop of RKMP under NAIP on 10th December, 2010. Altogether 50 farmers from different districts participated in the training. Resource personnels from CAU, State Departments and KVKs shared their expertise in the programme.
- Fifteen days Trainers' Training Programme on Integrated Watershed Management Approach for Livelihood Improvement from 15th January to 2nd February, 2011 under SWPAL. Twenty six Officials from state Departments of Agriculture, Horticulture and KVKs participated in the programme. Resource persons from, CAU, Institute of Cooperative Management, Imphal, NABARD, ICAR, Umiam, State Departments took part in the programme.
- Training Programme on Production Seed Tuber from TPS in collaboration with IFAD, Ukhrul.
- A series of training and demonstration programme in collaboration with CRPF under Civic Action Programme.
- Training and Demonstration programme in collaboration with Indian Army; Department of Forest, Govt. of Manipur; State Departments, NGOs and NABARD etc.

Training programmes at Lamphelpat- pictorial depiction

Fig 22 Training programme on rain water harvesting

Fig 23 Farmers' Field Day on rice

Fig 24 Demonstration on community based value addition to fruits

Fig 25 Demonstration on mushroom production technology

Fig 26 Training programme on value addition to prunus plum

Fig 27 Demonstration on community based value addition to fruits

Mizoram

WEATHER REPORT

A preview of the meteorological data at Mizoram Centre (Table 1) showed that the mean monthly maximum temperature (31.7 ºC) was recorded in July 2010 and the mean monthly minimum temperature (13.1ºC) in January 2011. The mean monthly minimum relative humidity (20.8 %) was recorded in February 2011 and the mean monthly maximum relative humidity (96.1 %) was recorded in June 2010. The annual rainfall was recorded 3097 mm during 2010-11 along with 142 rainy days. In August 2010, there were 27 rainy days and rainfall was 693 mm.

CROP PRODUCTION

RICE

Performance of different varieties of rice under upland (RCRT)

Nine upland rice varieties were evaluated for their yield potential. The data presented in Table 2 revealed that variety RCPL 86 recorded maximum plant height, while minimum plant height was recorded for Bhalum-1. The longest panicle length was recorded in RCPL 93 (26.1 cm) and RCPL 412 (26.1 cm), while shortest for RCPL 86 (19.4 cm). The variety RCPL 90 took 92 days to achieve 50% flowering, while shortest duration of 79 days was taken by Bhalum-1. The maximum grain yield (4.31 t/ ha) was recorded with RCPL 90 which was at par with IR 60080-46A (4.22 t/ha) and RCPL 412 (3.64 t/ha), and significantly higher than other varieties.

Performance of Initial Varietal Trial (Early IVT) under upland condition

Eleven entries were received from DRR, Hyderabad and evaluated for yield potential under irrigated condition. The maximum plant height of 92.2 cm was recorded with IVT 3109 which was significantly superior over rest of the treatments except IVT 3112, IVT 3102 and IVT 3105 (Table 3). The entry IVT 3107

Table 1 Mean monthly weather parameters at research centre, Mizoram (2010-2011)

Month	Temperature (°C)		Relative humidity (%)		Rainfall (mm)	No. of rainy days
	Minimum	Maximum	Minimum	Maximum		
Apr	21.3	28.2	70.4	85.1	597	12
May	21.3	31.3	83.8	90.5	385	17
Jun	20.6	31.3	83.3	96.1	340	22
Jul	22.0	31.7	82.2	94.0	401	24
Aug	23.3	31.4	82.2	92.9	693	27
Sep	23.1	30.7	83.1	92.3	431	22
Oct	23.0	30.6	79.1	88.5	136	8
Nov	19.1	27.8	70.0	84.8	15	3
Dec	15.9	25.8	50.6	69.9	31	2
Jan	13.1	23.5	37.4	54.5	0	0
Feb	16.4	27.1	20.8	51.1	4	1
Mar	19.3	28.0	23.5	56.2	64	4
Total	3097	142				

Table 2 Performance of different varieties of rice under upland

Varieties	Height (cm)	No of tillers/ hill	Panicle length (cm)	No. of filled grains/ panicle	No of unfilled grains/ panicle	Days to 50% flowering	Grain Yield (q/ha)
RCPL 82	74.8	9.3	21.2	106.2	18.0	85.0	34.3
RCPL 86	82.2	9.2	19.4	131.2	17.2	87.0	30.7
RCPL 90	79.2	10.4	21.8	133.8	17.9	92.0	43.1
RCPL 93	78.1	17.0	26.1	118.0	31.1	87.0	34.4
RCPL 412	72.3	10.9	26.1	81.44	49.0	91.7	36.4
RCPL 413	67.3	8.8	24.7	91.67	64.0	87.0	34.4
IR 60080-46A	67.1	8.7	25.5	55.89	34.3	78.3	42.2
IET 20957 (VL 8167)	70.8	10.9	23.8	68.5	35.4	82.0	11.4
Bhalum-1	66.5	11.0	22.7	100.6	25.0	79.3	33.5
SE (m)	1.1	1.6	0.8	8.4	6.5	-	2.55
CD (*P*=0.05)	3.4	4.6	2.3	25.2	19.5	-	7.42

Table 3 Performance of Initial Varietal Trial (Early) under upland condition

Varieties	Height (cm)	Days to 50% flowering	Panicle length (cm)	No grains per panicle	Grain yield (q/ha)	No of panicles / m^2	Harvest index (%)
IVT 3102	89.0	82.3	17.4	56.0	26.2	288.6	23.3
IVT 3103	74.5	79.3	14.7	46.5	22.4	321.9	22.7
IVT 3104	72.5	83.3	12.8	62.3	37.0	333.0	19.7
IVT 3105	88.1	81.3	22.6	47.5	33.9	344.1	20.0
IVT 3106	85.7	81.3	24.3	46.3	30.8	255.3	24.0
IVT 3107	49.0	76.7	16.4	37.3	25.3	244.2	20.7
IVT 3108	87.9	77.3	25.5	65.8	48.2	421.8	28.3
IVT 3109	92.2	79.3	18.0	31.5	13.8	277.5	26.0
IVT 3110	72.6	82.3	26.1	84.1	35.1	255.3	27.7
IVT 3111	77.6	83.7	22.8	47.3	54.1	321.9	25.3
IVT 3112	90.7	83.7	27.6	65.8	47.7	399.6	23.7
SEm	0.05	-	0.19	0.72	0.18	0.11	0.14
CD (*P*=0.05)	3.93	-	2.85	17.83	3.96	26.83	2.89

came to flowering very early than rest of the entries. The highest number of panicle per square meter was observed with IVT 3108 which was significantly superior over rest of the entries. Significantly higher harvest index was observed with IVT 3108 (28.3 q/ ha) which was at par with IVT 3110 and IVT 3109. However, maximum yield was harvested for IVT 3111 (54.1 q/ha).

Performance of different varieties of rice under low land (RCRT-I)

In a varietal evaluation trial, ten varieties of rice were evaluated for their yield potential. The data presented in Table-4 revealed that maximum plant height of 111 cm was recorded with variety RCPL-1-306, which was significantly superior over rest of the varieties. The variety RCPL-1-300 produced maximum grain yield of 61.8 q/ ha which was significantly superior than RCPL1-308, RCPL1-303, RCPL1-308 and RCPL1-307.

Performance of different varieties of rice under low land (RCRT-II)

Fourteen varieties of rice were evaluated for their production potential. Maximum plant height (136.4 cm) was recorded in local collections (RCPL 1-147), which was at par with RCPL 1- 148 and RCPL 1- 131, and significantly higher than rest of the varieties. RCPL1- 134 and RCPL1- 140 took minimum days to 50% flowering, while Bia *rabi*-2 and Bia *rabi*-1 took maximum days to 50% flowering.The grain yield was higher in the variety RCPL1- 125 which was at par with RCPL1-126 and significantly higher than rest of the varieties (Table 5).

Table 4 Performance of different varieties of rice under low land

Varieties	Plant height (cm)	Panicle length (cm)	No grains / panicle	No. of un-filled grains/ panicle	No of panicles / hill	Grain yield (q/ ha)	Straw yield (q/ ha)	Harvest index (%)
RCPL 1- 300	88.2	26.9	151.3	53.6	11.2	61.8	208.0	22.8
RCPL 1- 302	78.7	28.0	160.0	47.6	12.4	47.1	192.7	19.4
RCPL 1- 303	74.3	28.6	188.0	42.9	12.6	54.0	166.3	24.6
RCPL 1- 304	66.6	27.9	181.2	33.1	10.9	46.7	117.7	28.5
RCPL 1- 306	111.0	28.1	176.0	57.2	11.8	37.8	145.7	20.3
RCPL 1- 307	59.6	28.6	180.6	30.2	10.7	51.2	216.0	18.9
UPLR 1-5	63.8	25.6	182.3	38.3	12.3	40.1	197.7	18.6
IR 64	57.9	27.0	145.8	27.9	9.0	40.0	110.7	27.3
RCPL 1- 72	89.4	29.4	144.4	47.9	10.4	44.9	111.2	29.1
RCPL 1- 308	82.4	29.1	213.6	65.4	11.8	56.0	202.3	21.1
SEm	4.24	0.43	0.37	4.08	3.14	0.33	3.87	5.99
CD (*P*=0.05)	12.5	1.3	1.1	12.1	9.3	1.0	11.7	17.6

Table 5 Performance of different varieties of rice under low land (RCRT-II)

Varieties	Height (cm)	Panicle length (cm)	Grains/ panicle	Unfilled grains / panicle	Panicles/ m^2	Days to 50% flowering	Yield (q/ ha)
RCPL 1- 131	133.0	26.4	271.1	74.4	362.6	95.0	46.33
RCPL 1- 134	89.7	27.5	191.1	55.8	374.0	85.0	46.13
RCPL 1- 140	88.2	25.8	108.4	81.2	330.0	85.0	16.67
RCPL 1- 144	88.3	23.7	138.2	50.7	282.3	95.3	15.33
RCPL 1- 145	122.3	25.3	137.3	30.0	319.0	119.0	20.00
RCPL 1- 147	136.4	23.4	108.1	43.2	381.3	94.7	29.17
RCPL 1- 148	135.1	24.9	107.4	62.9	359.3	94.0	17.50
RCPL 1- 149	77.4	26.9	89.9	50.0	374.0	99.7	13.17
RCPL 1-125	78.3	13.2	27.2	208.8	429.0	131.3	52.76
RCPL1- 126	77.2	11.8	26.8	219.3	344.7	132.0	48.71
RCM 11	65.9	12.3	25.2	130.9	311.7	127.7	46.44
Shasarang	66.2	10.9	23.5	142.0	304.3	128.3	35.64
Bia*rabi*-1 (Local)	76.4	10.8	22.7	166.3	392.3	151.3	28.63
Bia*rabi*-2 (Local)	122.9	9.1	22.4	122.0	333.7	152.3	10.67
SEm	3.25	0.93	5.83	14.6	8.78	-	2.05
CD (*P*=0.05)	9.45	2.66	16.9	42.9	25.7	-	5.94

Performance of different varieties of rice under low land (RCRT-III)

Ten varieties of rice were evaluated for their yield potential under low land. The maximum plant height (119.4 cm) was recorded in local collection, RCPL 1-187, which was significantly higher than rest of the varieties. RCPL 1-408 took minimum days (64 days) to 50% flowering, while Shahsarang (128 days) took maximum days to 50% flowering. The variety local cv. Khumhnuai produced significantly longer panicle length than others tested. The grain yield was higher in the variety RCPL 1- 305 which was at par with Shasarang and was significantly higher than rest of the varieties (Table 6).

Performance of Initial Varietal Trial (Early) under irrigated condition

Fourteen entries were received from DRR, Hyderabad and evaluated for yield potential under irrigated condition. The maximum plant height of 109.4 cm was recorded with IVT 2911 which was significantly superior over rest of the lines (Table 7). The entry IVT 2911 came to flowering very late (84.5 days) than other entries. The highest number of panicles/ m^2 was observed with IVT 2907 which was statistically at par with IVT 2908 and IVT 2914 and significantly superior over other entries. Highest grain yield was observed for IVT 2912 (45.8 q/ha) which was at par with IVT 2909, IVT 2906 and IVT 2902.

Table 6 Performance of different varieties of rice under low land (RCRT-III)

Treatment	Plant height (cm)	No. of panicles / hill	Panicle length (cm)	Days to 50% flowering	No. of grains / panicle	Yield (q/ ha)
RCPL 1- 167	83.1	9.0	24.2	74.0	116.0	24.4
RCPL 1- 187	119.4	11.7	25.5	90.0	168.3	38.6
RCPL 1- 400	76.4	11.2	25.0	85.6	132.2	30.0
RCPL 1- 401	82.9	10.7	26.4	85.0	139.8	40.1
RCPL 1- 403	77.3	11.2	28.2	86.0	170.2	30.4
RCPL 1- 408	95.1	10.8	25.1	64.0	153.9	43.1
RCPL 1- 410	85.1	10.7	23.1	73.0	151.8	43.9
RCPL 1- 305	66.4	12.5	27.2	74.0	157.1	50.0
Shash sarang	75.7	9.2	23.5	128.0	142.0	44.6
Khumhnuai	95.2	10.4	31.7	85.0	115.4	21.6
SEm	1.73	0.41	0.79		5.23	1.80
CD (*P*=0.05)	5.15	1.24	2.35		15.55	5.36

Table 7 Performance of different entries under IVT in lowland

Treatment	Plant height (cm)	No. of panicles/ m²	Panicle length (cm)	No. of grains / panicle	No. of unfilled grains/ panicle	Days to 50% flowering	Yield (q/ha)
IVT 2901	81.4	275	26.9	123.9	46.9	62.0	42.7
IVT 2902	86.4	279	26.2	115.3	24.8	62.0	43.9
IVT 2903	71.1	286	27.8	112.1	46.8	65.0	36.0
IVT 2904	77.3	293	28.8	124.6	75.3	62.0	43.1
IVT 2905	99.8	290	27.8	121.2	29.7	61.0	38.6
IVT 2906	76.4	290	25.0	176.4	43.9	71.0	44.8
IVT 2907	78.7	253	31.2	106.8	70.2	64.5	42.5
IVT 2908	77.9	297	29.1	124.7	35.9	59.0	42.7
IVT 2909	91.0	275	27.6	152.2	52.4	59.0	45.0
IVT 2910	88.9	290	24.6	93.67	25.3	59.0	27.2
IVT 2911	109.4	194	22.7	82.7	32.8	84.5	22.9
IVT 2912	98.6	242	28.8	102.9	34.0	61.0	45.8
IVT 2913	102.8	370	26.0	146.3	48.6	64.0	28.1
IVT 2914	100.4	235	29.1	92.22	40.4	61.0	32.8
SEm	1.48	9.58	0.96	6.95	2.22		0.71
CD (*P*=0.05)	4.3	29.7	2.9	20.7	6.4		2.2

Performance of Advance Varietal Trial (Early) under irrigated condition

Twelve entries from DRR, Hyderabad, were evaluated for yield potential under mountain irrigated condition. The maximum plant height of 109.1 cm was recorded for AVT 2803 which was significantly superior over rest of the entries (Table 8). The entry AVT 2806 came to flowering (58 days) very early than the other entries. The highest number of panicles/m² was observed with AVT 2803 (359) followed by AVT 2811 (345) and AVT 2804 (334). Significantly higher grain yield was harvested for AVT 2805 (50.1 q/ha) which showed non-significant difference with AVT 2808 and AVT 2809.

MAIZE

Performance of different maize varieties/ hybrids during *kharif*

Twelve hybrids and varieties of maize from VPKAS, Almora and one local landrace of Kolasib were evaluated for their yield potential. The maximum plant height was recorded for Vivek QPM 9 (200 cm) which was at par with Vivek Sankul Makka 31 (186 cm), Vivek Hybrid 5 (183 cm) and Vivek Sankul Makka 35 (182 cm) (Table 9). The grain yield was highest for Vivek QPM 9 (97.8 q/ha) which was significantly superior over rest of the entries except Vivek Maize Hybrid 25.

Table 8 Performance of Advance Varietal Trial (Early) under irrigated condition

Treatment	Plant height (cm)	No. of panicles / m²	Panicle length (cm)	No. of grains / panicle	Days to 50% flowering	Grain yield (q/ ha)
AVT 2801	61.9	315	25.2	138.7	60	42.2
AVT 2802	62.9	279	27.4	91.7	60	36.4
AVT 2803	109.1	359	26.8	149.9	65	19.9
AVT 2804	85.4	334	29.9	142.2	66	38.5
AVT 2805	72.3	297	26.6	150.9	65	50.1
AVT 2806	75.0	290	28.4	124.6	58	41.9
AVT 2807	71.3	297	25.4	128.4	60	31.1
AVT 2808	69.7	293	27.1	123.9	63	47.3
AVT 2809	65.8	271	27.3	110.9	66	47.1
AVT 2810	88.1	301	29.8	118.9	65	35.1
AVT 2811	95.2	345	31.7	115.4	85	19.9
AVT 2812	71.7	301	30.2	143.1	65	38.5
SE (m)	3.1	-	0.9	3.2	-	1.2
CD (*P*=0.05)	9.8	-	3.0	9.7	-	3.6

Table 9 Performance of different varieties/ hybrids of maize during *kharif* 2010

Varieties/ hybrids	Days to 50% pollen shed	Days to 50% silking	Plant height (cm)	Ear length (cm)	Cob weight (g)	No. of lines/ cob	No. of grains / lines	Grain yield (q/ ha)
Him 129	44.0	47.0	175	16.1	118.9	15.4	41.5	67.6
Vivek Hybrid 5	44.3	48.0	183	17.5	277.9	15.7	42.8	60.8
Vivek Hybrid 9	44.3	47.3	179	16.3	160.5	20.1	49.4	59.0
Vivek Maize Hybrid 15	44.0	47.3	162	17.2	188.5	15.1	42.5	80.1
Vivek Maize Hybrid 21	45.7	48.7	163	17.9	211.2	14.8	38.3	70.2
Vivek Maize Hybrid 23	47.7	49.7	150	17.6	201.9	14.5	45.5	79.5
Vivek Maize Hybrid 25	51.0	53.3	153	17.8	202.4	14.9	51.2	84.7
Vivek Maize Hybrid 33	45.3	48.7	172	18.0	184.3	18.4	46.7	71.8
FH 3356 (New Hybrid)	44.7	46.7	152	16.6	179.4	15.2	45.9	45.6
Vivek QPM 9	44.3	46.3	200	18.4	194.3	14.8	44.2	97.8
Vivek Sankul Makka 31	46.0	48.3	186	16.6	180.0	16.6	39.5	72.1
Vivek Sankul Makka 35	49.3	51.0	182	17.6	120.2	9.5	42.9	60.7
Local (Kolasib)	66.0	66.3	170	14.6	233.9	16.7	27.1	51.2
SEm	0.75	0.65	6.36	0.67	14.86	2.05	2.63	4.81
CD (*P*=0.05)	2.23	1.95	19.00	2.01	44.34	6.11	7.82	14.31

Seed production of maize during *rabi* season

Three maize varieties *viz.*, RCM-75, RCM-76 and BA-61-A were evaluated for seed yield during *rabi* season. The cob length was maximum for BA-61-A followed by RCM-76 and RCM-75 (Table 10). The seed yield and average cob weight was recorded highest in RCM-76 followed by BA-61-A and RCM-75.

Table 10 Maize seed production during *rabi*

Variety	Cob length (cm)	No. of lines / cob	No. of seeds / line	Cob weight (g)	Yield (q/ ha)
RCM-75	11.93	12.8	23.5	98.4	35.7
RCM-76	12.27	13.5	23.7	195.3	69.4
BA-61 A	15.45	13.0	24.6	154.2	65.4

SOYBEAN

Performance of different varieties during *kharif* 2010

Five soybean varieties were evaluated for their yield potential in *kharif*. The local variety had tallest plant height and more number of branches/ plant which was significantly higher than other varieties. The maximum grain yield (16.1 q/ ha) was recorded with H-10 and was at par with H-9, and significantly higher than other varieties (Table 11).

GROUNDNUT

Effect of different source of boron on yield

The performance of bold seeded groundnut variety ICGS-76 was evaluated with different boron sources

Table 11 Performance of different varieties of soybean during *kharif* 2010

Varieties	Height (cm)	No of branches	No of pods per plant	Seeds per pod	Days to 50% flowering	Grain yield (q/ha)
H1	34.7	5.44	205.0	3.00	61.0	13.3
JS 335	34.4	8.22	140.0	2.33	34.5	11.7
H9	34.3	4.33	60.7	2.67	47.5	13.9
H10	36.1	5.78	171.0	2.44	55.5	16.1
Local	56.6	5.44	176.0	4.44	92.0	7.2
SEm	2.5	0.87	8.9	0.43	9.3	1.2
CD (*P*=0.05)	7.8	2.72	27.8	1.36	27.9	3.8

to determine the boron nutritional requirement of bold seeded groundnut during *kharif* 2010. The maximum pod yield (21.52 q/ ha) was recorded with spraying of Colemanite (2 kg/ ha) which was at par with basal applications of borax (20 kg/ ha), boric acid (20 kg/ ha) and Colemanite (20 kg/ ha) (Table 12).

Integrated nutrient management (INM)

The INM trial having 11 treatment combinations was conducted at Siphir, Aizawl, Mizoram to evaluate the effects of various sources of nutrients on plant growth and fruit yield. The fruit quality and yield was found to be better by application of organic sources of nutrients (vermicompost @ 10 kg/ pit and pig manure @ 10 kg/ pit) and bio-fertilizer (PSB @ 25-50 g/ plant along with N @ 250 g/ pit, P_2O_5@ 150 g/ pit, K_2O @ 300 g/ pit and Trichoderma @ 25 g/ pit.

Table 12 Effect of different source of boron on yield of groundnut

Treatment	Plant height (cm)	No. of branches / plant	No. of pods / plant	100 pod weight (g)	100 kernel weight (g)	Pod yield (q/ ha)
Colemanite @ 20 kg/ ha as soil application	28.3	9.56	12.31	187	72.82	20.32
Colemanite @ 10 kg/ ha as seed dressing	22.6	8.63	12.46	174.98	49.57	17.42
Colemanite as foliar spray (2 kg/ ha)	27.5	9.02	15.34	243.44	109.63	21.52
Solubur @ 20 kg/ ha as soil application	25.8	10.07	9.79	143.35	55.57	15.7
Solubur as foliar spray (2 kg/ ha)	27.6	9.46	11.88	147.84	60.95	17.95
Borosol @ 20 kg/ ha as soil application	24.4	7.9	11.11	122.83	52.38	15.83
Borosol as foliar spray (2 kg/ ha)	20.3	7.51	13.6	177	67.92	17.5
Borax @ 20 kg/ ha as soil application	22.5	10.8	11.96	225.9	113.05	20.97
Boric acid @ 20 kg/ ha as soil application	28.5	9.15	12.88	184.5	87.4	20.91
Control (no boron)	20.3	7.22	9.41	121.32	47.34	14.1
SEm	1.7	0.55	4.65	1.81	0.646	1.22
CD (*P*=0.05)	5	1.6	13.9	5.4	1.94	3.67

HORTICULTURE

CHOW-CHOW

Evaluation of germplasm and standardization of agro-techniques of chow-chow

Among 13 genotypes tested, the growth and yield of two genotypes i.e. Kolasib (Local-1) and Kawnpui (Local-2) was found to be satisfactory with a yield potential of 40-50 t/ha and number of fruits / plant varied from 45-60 during first year. Moreover, another genotype from Aizawl (Local-3) having dark-green colour fruits recorded only 20-25 fruits/ plant during first year. All these three local materials (Local-1, Local-2 and Local-3) are being multiplied at ICAR Kolasib (Figs 1 and 2).

Fig 1 View of experimental site

Fig 2 Diversity of chow-chow in Mizoram

Leaf pruning

The pruning of old and dead leaves, after 1st harvest improved the sun light penetration and fruit setting especially in old vine-yard. The number of fruits was increased by 11.5 %. However, there was no effect of leaf pruning on fruit weight, fruit size and fruit density.

FRENCH BEAN

Genotypic variation for economic traits in French bean germplasm

Seventy seven genotypes of vegetable French bean (*Phaseolus vulgaris* L.) were collected from NBPGR, New Delhi, Division of Horticulture, ICAR-RC-NEH Region, Barapani, and Mizoram local and were evaluated for qualitative and quantitative traits. Among them, 20 genotypes were not included for final data analysis because of non-germination of seeds, or flowering or bush type plant growth. The genotypes varied significantly (Table 13) for days to 50 % flowering (33-66 days), plant height (80-408 cm), number of nodules (15-443/ plant), fresh pod length (9-18 cm), pod numbers (10.0-38.0/ plant), fresh pod

Table 13 Variability for quantitative traits among 57 genotypes of pole type French bean

Sources of germplasm	Days to 50 % flowering	Plant height (cm)	No. of nodules / plant	Fresh pod length (cm)	Number of pods / plant	Fresh pod weight (g/ pod)	Pod yield (q/ ha)
Range of NBPGR	32.1-55.8	80.3-268.0	15.3-357.0	8.7-15.6	10.0-36.0	3.358-7.634	32.4-146.6
Average of NBPGR	43.9	172.3	87.6	10.8	15.4	4.594	56.9
Range of Barapani	41.9-66.4	169.0-360.3	52.5-443.3	9.5-17.5	11.0-36.0	4.118-12.691	41.6-179.2
Average of Barapani	49.0	246.7	147.2	13.0	18.7	6.900	95.0
Range of Mizoram	30.9-47.8	189.5-408.5	43.5-197.0	12.5-15.5	11.0-38.0	6.659-12.818	57.0-199.4
Average of Mizoram	41.1	284.9	99.0	14.1	19.5	8.869	132.4
Range of all germplasm	30.9-66.4	80.3-408.5	15.3-443.3	8.7-17.5	10.0-38	3.358-12.818	32.4-199.4
Average of all germplasm	45.4	225.1	113.6	12.4	17.6	6.395	87.7

weight (3.4-12.8 g/ pod) and pod yield (33-200 q/ ha). Among 57 genotypes, 17 were categorized under vegetable types.

Purple French bean: A new variant collected from Sherkhan and Saiha

Two variants of French bean having purple colour pods, i.e. MZPF-1 and MZPF-2 were collected from markets of Sherkhan (Kolasib) and Saiha districts of Mizoram, respectively. Only one pod, having 5 seeds, of each collection was found in market, and now is being multiplied and evaluated at ICAR Complex, Kolasib. Both genotypes have purple color pigmentation on stem, leaf petiole, flower and pod. The pod color remained green up to 5-8 days after pollination, and thereafter purple pigmentation started and pods became fully purple at physiological maturity. The pod of genotype MZPF-1 is light purple colour and straight to slightly curved, while there was dark purple pigmentation and curve to S-shape pods in MZPF-2 (Fig 3).

BROCCOLI

Effect of boron (B) and molybdenum (Mo) on plant growth and head yield

An experiment was conducted to evaluate the effects of B and Mo on growth and yield of broccoli in alfisols soil under mild-tropical agro-climatic conditions. One month old seedlings of F_1 hybrid 'Pushpa' bred by Seminis India were transplanted on 12th November 2010 at the spacing of 45×40 cm. The yield and yield contributing parameters, namely gross plant weight, length, leaf area, specific leaf weight, harvest index and head weight were significantly effected by application of B and Mo (Table 14). The increase in head weight was recorded up to 44 % by application of various doses of borax and ammonium molybdate. Application of borax @ 20 kg/ ha and ammonium molybdate @ 1 kg/ ha (T2) was found to be best over other treatment combinations. The results revealed that B and Mo are very much essential for growth and yield of broccoli in alfisols soil under mild-tropical conditions.

MZPF-1 MZPF-2 Flower and pod MZPF-1 MZPF-2

Fig 3 Purple French bean

Table 14 Effect of application of micronutrients on growth and yield of broccoli

Treatment	Gross plant wt (kg)	Leaf number	Leaf area (cm^2)	Specific leaf wt. (mg/cm^2)	Harvest index (%)	Head weight (kg)	Increase in yield over control (%)
T1	0.726	14.0	317	1.28	25.7	0.187	43.8
T2	0.790	13.4	382	1.21	23.8	0.188	44.3
T3	0.683	13.3	356	1.16	24.9	0.170	30.9
T4	0.781	13.4	329	1.44	21.9	0.171	31.3
T5	0.707	12.6	319	1.34	20.3	0.143	10.4
T6	0.770	14.8	314	1.55	17.7	0.136	4.8
T7	0.755	12.9	318	1.37	19.6	0.148	13.6
T8	0.711	13.3	317	1.52	19.9	0.142	9.1
T9	0.698	13.2	303	1.40	19.0	0.133	2.2
T10	0.681	13.0	306	1.42	19.4	0.132	1.6
T11	0.676	13.2	280	1.51	19.0	0.130	0
T12	0.636	13.4	254	1.67	20.5	0.130	Control
Average	0.718	13.4	316	1.41	21.0	0.151	-
SEm	0.005	0.1	4	0.02	0.2	0.001	-
CD (*P*=0.05)	0.015	0.2	12	0.05	0.6	0.004	-

CABBAGE

Effects of boron and molybdenum levels on growth, and yield of cabbage

Thirty days old seedlings of F_1 hybrid 'Bahar', bred by Nunhems India Pvt. Ltd., Hyderabad, were transplanted on 4th Dec 2010. There were significant effects on gross plant weight, net head weight, leaf area, specific leaf weight, harvest index and yield through application of B and Mo (Table 15). Maximum yield was realized by application of borax @ 20 kg/ ha and ammonium molybdate @ 2 kg/ ha (T-1) followed by T2, T4, T3 and T5 indicating the significant role of B and Mo. The increase in yield was recorded upto 98 % more as compared to control for T-12 treatment. The results reveal that boron as well as molybdenum is very much essential for cabbage.

CARROT

Effects of micronutrients on growth and yield of carrot

The carrot seeds cv. INDAM Kuroda was sown on ridges spaced at 25 cm on 12.11.2010, and plant population was maintained at 4-5 cm. The highly significant improvement in gross plant weight, root weight, number of leaves, root length, root diameter

Table 15 Effect of borax and ammonium molybdate on plant growth and yield of cabbage

Treatment	Gross plant weight (kg)	Net head weight (kg)	Leaf weight (kg)	Leaf area (cm^2)	Specific leaf weight (g/ cm^2)	Harvest index (%)	Yield (q/ ha)
T1	2.525	1.724	0.774	567	1.365	68.3	560
T2	2.309	1.511	0.729	538	1.356	65.4	491
T3	2.258	1.490	0.693	536	1.295	66.0	484
T4	2.288	1.502	0.719	519	1.386	65.6	488
T5	2.162	1.406	0.684	467	1.466	65.0	457
T6	2.107	1.311	0.633	513	1.234	62.2	426
T7	1.873	1.219	0.609	412	1.480	65.1	396
T8	1.724	1.080	0.593	425	1.398	62.6	351
T9	1.612	0.930	0.616	445	1.386	57.7	302
T10	1.574	0.909	0.623	426	1.462	57.7	295
T11	1.553	0.885	0.628	399	1.576	56.9	287
T12	1.529	0.868	0.604	391	1.544	56.8	282
Average	1.960	1.236	0.659	470	1.412	62.4	402
SEm	0.029	0.027	0.011	16	0.041	0.6	9
CD (*P*=0.05)	0.084	0.079	0.033	48	0.120	1.8	26

and yield were recorded by the application of borax. The root yield was recorded highest by application of borax @ 20 kg/ ha + copper sulphate @ 2 kg/ ha (T1) which was at par with application of borax @ 20 kg/ ha + copper sulphate @ 1 kg/ ha and borax @ 20 kg/ ha + no copper sulphate (T2 and T3). The increase in root yield was recorded from 17-90 % in various treatments over treatment without borax.

AFRICAN EGGPLANT/ NIGHTSHADE

Solanum macrocarpon L. (African eggplant/ nightshade) locally known as *satinrem* is traditionally used as leafy vegetable among Mizo community. A glabrous, erect, branched, herbaceous plant, reaches up to 1.5 m tall with blackish violet stem having wood at the base. Leaves are oblong-lanceolate, very soft at young stage with size of 20-30 × 10-15 cm. (Fig. 4)

There are 2-5 flowers in each inflorescence. Fruits are depressed, globose, 6-8 × 8-10 cm, light-green at immature stage and yellow-brown at maturity. First harvest of leaves may be done after 50-60 days of transplanting. Morphologically and biologically, *S. macrocarpon* is very similar to brinjal (*Solanum melongena*). It could be popularized as a new leafy vegetable in other parts of India or could be used as a genetic resource for improving agronomic traits of brinjal.

Plant

Young

Inflorescence

Flower

Young

Immature fruit

Fig 4 Different parts of African eggplant

SPICES

TURMERIC

Evaluation studies

Twenty-seven genotypes, including 11 varieties and 16 local collections, were evaluated. Significantly higher yield was recorded for Local-13 followed by Narendra Haldi-1, Local-14, Suranjana, RCT-1, Local 15, Local-8, IISR Allepy Supreme and BSR-2. The dry matter content was highest in Local-15 followed by Rashmi, IISR Pratibha, Local-7, Roma, Local-11 and Local-12. None of the genotypes showed tolerance to two major diseases, i.e. leaf spot (*Colletotrichum curcumae* and *C. capsici*) and leaf blotch (*Taphrina maculans*). The incidence of leaf spot was more acute than leaf blotch. Both the diseases were noticed during Sep-Oct.

FARMING SYSTEMS

Assessment of technology on watershed based integrated farming systems in north eastern hills region

Five watershed based framing systems are being maintained in the FSRP block having various components like field crop, fruits, tree beans, spices, forest plants, dairy, fodder grasses, soil and water management etc.

W1: Agriculture based farming system

- Groundnut: Groundnut cv. ICGS-76 was sown during July 2010 and produced a pod yield of 27 q/ ha.
- Pigeon pea: Local pigeon pea sown in July, 2010 yielded 560 pods/ plant with seed yield of 10 q/ ha.

W2: Agri - Horti System

- Rice (cv. IURON 514) and maize (cv. QPM hybrid) were grown and the average yield of 1.4 t/ha and 3.0 t/ha, respectively was obtained.
- Turmeric: Turmeric var. RCT-1 produced yield of 20 t/ ha.
- Ginger: Ginger var. Thinglaidum produced rhizome yield of 16 t/ ha.
- Banana: Banana vars. Giant Cavendish and Grand Naine performed better with the yield of 22 t/ ha and 20.0 t/ ha, respectively.
- Peach: Peach var. TA-170 and Flordasun produced 55 and 64 fruits/ plant, respectively.
- Guava: About 150 plants of var. Allahabad Safeda produced on an average around 350-400 fruits / plant.
- Mandarin: Five year old plants of *Khasi* mandarin attained the height of 1.5-2.0 m.

W3: Horti - Silvi - Pastoral system:

- Pineapple: Suckers of cv. Kew were planted and maintained in row system. Average yield recorded was 23 t/ ha.
- Banana: Banana var. Giant Cavendish and Grand Naine performed better with the yield of 20 t/ ha and 28.0 t/ ha, respectively.
- Agro-forestry: Data on teak, tung, gamari and local multi-propose forest tree spices, planted during 1996–97, are recorded.
- Congo signal, guinea grass, setaria, local fodder grasses, broom grass were planted and are being maintained and fed to the cattle of dairy unit.
- Medicinal plants like *Alpinia galanga* and cooking oil palm plants of red oil palm are also maintained.

W4. TEPA (Technology Extension Programe on Agro-Forestry)

- Many local multi-propose tree spices were planted and are maintained for their performance
- Teak: A total 130 numbers of teak plants are being maintained for their performance.
- Tree bean: Altogether 30 plants are maintained. Maximum yield of 112 pods/ plant was recorded.
- Turmeric: Megha turmeric-1 was sown in the terraced lands and the maximum yield obtained was 23 t/ha.

W5. Dairy component

The herd strength of dairy unit is comprised of 9 cows, 6 heifers, 6 calves (3 male+3 female). Besides, 6 numbers of bulls are also maintained separately in bull shed. All the animals including the lactating and pregnant cows were stall fed with Napier, Para grass, Guinea grass, Congo signal, gamari, other tree fodder leaves, banana leaves etc. The animals are provided with ready made concentrate feed, salt etc.

PLANT PROTECTION

DISEASES

Disease surveillance was done in the *Rabi* maize. During crop period *Turcicum* leaf blight, *Maydis* leaf blight ("O" strain), *Septoria* leaf blotch and grey leaf spot were the major diseases recorded (Table 16) in terraced cultivation. The incidence of maize streak virus was very low. The severity of *Turcicum* leaf blight was observed after 30 days of sowing, it continued till harvest of the crop. Brown spot, *Phaeosphaeria* leaf

spot and **e**yespot of maize were also observed in the *Rabi* maize. Tassel-ear was noticed first time on some plants of *Rabi* Maize (RCM-76 and BA-61A) (Fig 5).

Table 16 Major and minor diseases of *rabi* maize

Major diseases	Minor diseases
Turcicum leaf blight, *Exserohilum turcicum* Maydis leaf blight, *Bipolaris maydis* Septoria leaf blotch, *Septoria maydis* Grey leaf spot, *Cercospora zeae-maydis*	Brown spot, *Physoderma maydis* Phaeosphaeria leaf spot, *Phaeosphaeria maydis* Eyespot of maize, *Kabatiella zeae* Maize streak virus

Fig 5 Tassel-ear (Inside full matured tassel-ear)

CITRUS DECLINE

In Mizoram *Khasi* mandarin is grown on commercial scale. However, most of them are in decline stage. The major causes of decline recorded were improper site selection with steep (50-70 °) slopes resulting in heavy soil erosion accompanied with nutrient depletion and also hindrance to cultural operations, heavy weed infestation by *Michania* spp. in most of the orchards, severe prevalence of insect-pests and diseases, deficiency of macro and micro nutrients, and occurrence of high rainfall from March to September followed by severe drought from October to February. Mandarin orchards in Lungdar village were surveyed in the month of February, 2011. It was observed that the infestation of trunk borer, bark eating caterpillar and aphid was very low while the leaf miner infestation was low to medium but decline was severe. The severity of powdery mildew, canker and phytophthora was in trace while scab was more severe. There was severe infestation of lichen and mosses and *Michania* spp. in all the orchards surveyed. Lichen was successfully controlled by the local farmers by paste of wood ash solution on trunk. But the infestation of *Loranthus* parasite was varied from low to medium. It was also observed that Hatkora and Mandarin were declining simultaneously in case of mixed planting. But sour pumelo (*Citrus metalaxycarpa*) were found unaffected.

ANIMAL SCIENCE

POULTRY

A systematic study on growth performance of Vanaraja chicks, procured from ICAR, RC for NEH region, Manipur centre, was conducted at Poultry unit of this centre. Two hundred Vanaraja dual purpose chicks (3 days old) were divided into two groups (group I and II). All the chicks were fed with standard starter mesh up to 4 weeks and then fed with finisher ration. The chicks in group I (100 Nos) were fed with chaffed neem leaves by replacing 0.2 % of concentrate feed, whereas the chicks in the group II (100 Nos) were fed with only standard feed. All the chicks were reared under common brooding, feeding, vaccination and other management conditions. No significant difference was found between the body weight gain of birds in control and treatment group. Further, the feed cost was slightly reduced in neem fed group than the control group and the birds were more resistant to infection in treatment group. The age at first laying of parent stock was 16 weeks with an average body weight 2.5 kg. The average body weight of parent stock males at 16 weeks was 3.66 kg.

PIGGERY

At present 1 Large White Yorkshire sow, 1gilt and 1 castrated male pig are being reared at piggery unit. These are reared to study the growth rate with different feeding combinations. They are being fed with mixture of concentrate feed and locally available feedstuff like colocasia, sweet potato leaves, *Spilanthus* sp. and banana pseudostem in the ratio of 3:1. It is found that there is no significant difference in growth rate of pigs fed with concentrate only and pigs fed with concentrate feed mixed with locally available green fodders. The feed cost is much reduced with the pigs fed with the mixture and that enhanced the palatability too.

The commonly encountered ailments in the piggery unit were piglet diarrhoea and maggoted wound. Diarrhoea cases were effectively treated after carrying out isolation, identification and antibiotic sensitivity test. Maggoted wound was effectively treated by removing the maggots applying turpentine oil and dressing with tincture iodine. Routine examination of the faecal samples was carried out and deworming was done accordingly.

Studies on piglet diarrhoea of bacterial origin in Mizoram

Twenty-three diarrhoeic faecal/rectal swabs were collected from Aizawl and Kolasib District. Out of which, 22 strains of *E. coli* and 1 Salmonella were isolated. *E.coli* strains were subjected to antibiotic sensitivity and the isolates were sensitive to Gentamicin, Norfloxacin (76.92) followed by Enrofloxacine, Cefotaxime and were resistant to Cloxacillin, Nitrofurantoin, Ampicillin, Amoxycillin, and Sulphamethoxazole (Figs 6 & 7).

Fig 6 *E. coli* in EMB

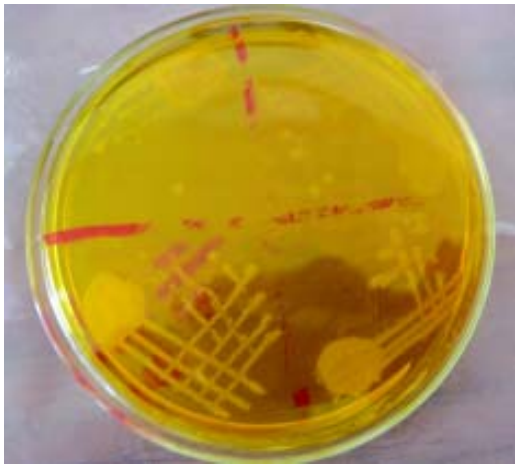


Fig 7 *E. coli* in BGA

DAIRY

Studies on bovine bacterial mastitis in Mizoram

The incidence of clinical and sub-clinical mastitis in cows is studied in 14 different farms in Mizoram. Sixty-four animals were examined using Modified California Mastitis Test and 11 animals were found positive for sub clinical mastitis and 5 animals were found positive for clinical mastitis. The positive milk samples were inoculated in a media and *Staphylococcus* (16), *E. coli* (5) and *Streptococcus* (4) were isolated and the isolates were highly sensitive to Enrofloxacin and Gentamicin (Figs 8 & 9).

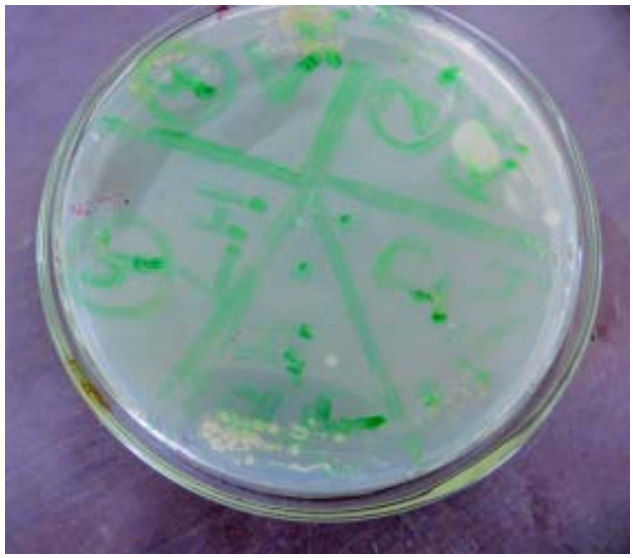


Fig 8 *Staphylococcus* in NA

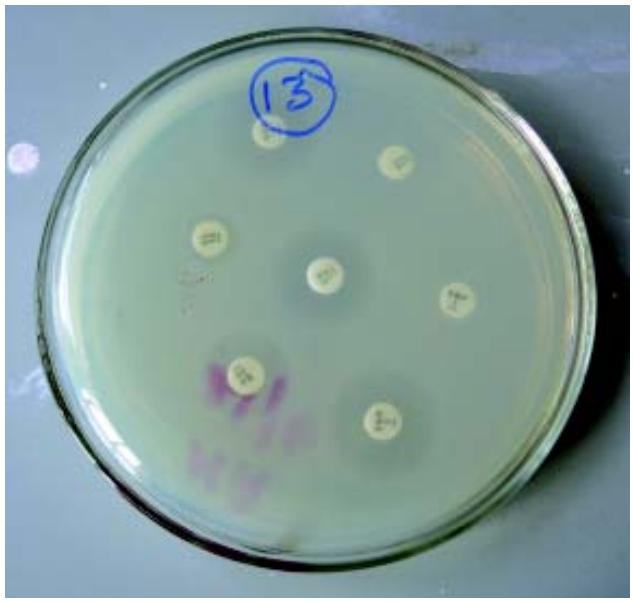


Fig 9 Antibiotic sensitivity test

Nagaland

WEATHER REPORT

The mean monthly maximum and minimum air temperatures were found to vary from 22.29^{0}C to 31.91 ^{0}C and mean monthly 8.17^{0}C to 25.20 ^{0}C, respectively (Table 1). The highest maximum temperature of 36.70 ^{0}C was recorded on 7th Apr. The lowest minimum temperature of 5.10 ^{0}C was recorded on 22nd Jan 11. Apr was the hottest month and Jan was the coolest month during the period. The average monthly maximum and minimum relative humidity (%) varied from 72.60% to 86.10% and 13.82% to 67.17%, respectively. The months from May to Oct showed the higher relative humidity. The total rainfall received during the year 2010 -11 (Apr 10 to Mar 11) was 1650.30 mm. The total rainy days were 98 days. The monthly rainfall was maximum in the month of Aug (376.90 mm) followed by Jul (366 mm). No rainfall occurred during Nov. Except during the month from Oct to Feb, the sky was clear. The average monthly wind speed varied from 9.8 kmph to 34.32 kmph. Mar and Apr months were observed to have high wind velocity. Soil temperature was recorded both in the morning and evening at 5, 15 and 20 cm depths. The soil temperature showed a decreasing trend along the depth. Total monthly evaporation was found to vary from 41.80 mm (Jan) to 126.70 mm (Apr).

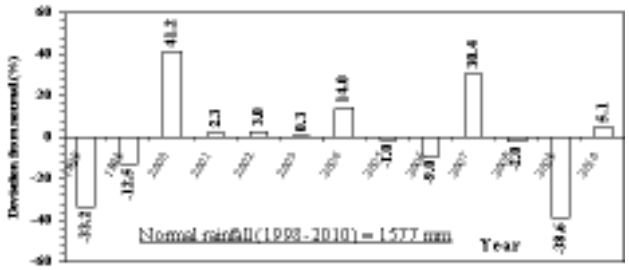


Fig 1 Deviation of rainfall from normal

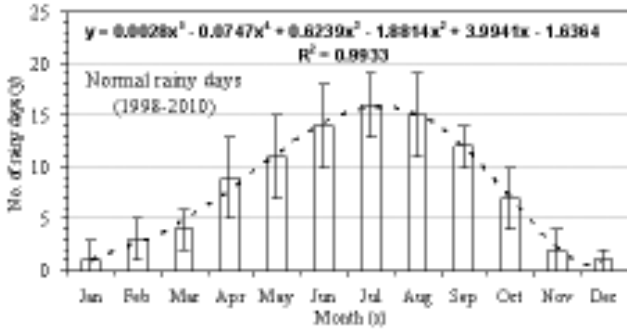


Fig 2 Monthly variation pattern of normal rainy days in Nagaland

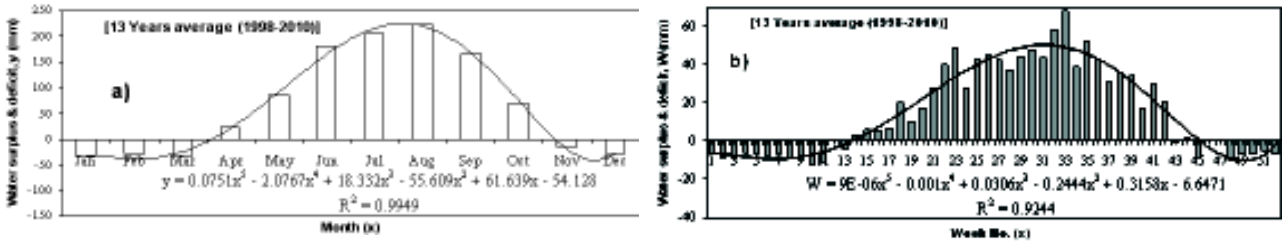


Fig 3a) Monthly and b) weekly water surplus and deficit model for Nagaland

Table 1 Average monthly weather data of Nagaland (the mean values are given in parentheses with bold letters)

Air temperature (^{0}C)		Relative Humidity (%)		Pan evaporation (mm)	Total rainfall (mm)	Soil temperature (^{0}C) (5 cm)		Soil temperature (^{0}C) (15 cm)	
Max	Min	Max	Min			Max	Min	Max	Min
22.29 (Jan 2011) – 31.91 (April 2010) **(27.04)**	8.17(Jan 2011) – 25.20 (Aug 2010) **(19.57)**	72.60 (April 2010) – 86.10(Oct 2010) **(80.01)**	13.82 (Feb 2011) - 67.17 (Sep 2010) **(46.93)**	41.80 (Jan 2011) – 126.70 (April 2010) **(987.90)**	**1650.30**	13.3 (Jan'11) – 24.76 (July' 10) **(20.50)**	3.9 (Jan '11) – 17.97 (Aug'10) **(12.27)**	22.8 (Jan'11) – 33.50 (July'10) **(28.82)**	11.8 (April'10) – 29.33 (July'10) **(22.05)**

CROP PRODUCTION

RICE

INM in rice

An experiment was conducted on integrated nutrient management for rice (RCM 9) productivity during the *kharif* season. The soil of the experimental site was clay loam, acidic in reaction (pH = 5.2), high in organic carbon (1.95%), low in available nitrogen (236.20 kg/ha), moderate in phosphorous (12.30 kg/ha) and moderate to high in available potash (200.20 kg/ha). The main plot treatments consisted of four organic sources of nutrients such as crop residue (M_1), vermicompost (5 t/ha) (M_2), bio-fertilizers (M_3) and mixture of crop residue, vermicompost, bio-fertilizers (M_4). The sub-plot treatments consisted of different combination of chemical fertilizers, such as control (S_1), 50% NPK (S_2), 75% NPK (S_3), and 100% NPK (80:60:40 kg/ha) (S_4). Among the main plot treatments, the highest no. of effective tillers/hill, panicle length, no. of grains/panicle and the highest grain yield were recorded in M_4 which was closely followed by M_3, M_2 and M_1, respectively, except the no of grain/panicle (Table 2). Among the sub- plot treatments, the maximum plant height, no. of effective tillers/ hill, no. of grains/ panicle and grain yield were observed in S_3 which was closely followed by S_4, which may be attributed to appropriate combination of organic and inorganic sources of nutrients.

Table 2 Growth and yield attributes of rice under INM

Treatments	Plant height at harvest (cm)	No. of effective tillers/ hill	Panicle length (cm)	No. of grains / panicle	Grain yield (t/ha)
Main plots					
M 1	105.02	10.87	24.35	180.20	3.32
M 2	110.25	10.90	24.60	182.50	3.47
M 3	112.55	12.60	25.45	195.20	3.55
M 4	114.60	12.96	26.32	196.50	3.68
Sub plots					
S 1	108.15	11.20	26.32	184.00	3.30
S 2	109.05	11.45	26.80	194.30	3.55
S 3	114.00	12.47	27.50	213.30	3.85
S 4	111.80	12.30	25.90	210.10	3.70

M_1 = crop residue M_2 = vermicompost M_3 = Bio-fertilizers
M_4 = crop residue +vermicompost + Bio fertilizers
S_1 = Control S_2 = 50% NPK S_3 = 75% NPK
S_4 = 100% NPK

Varietal trial on aromatic rice

A varietal trial on aromatic rice was conducted under Research Complex Rice Trial (RCRT) in low land. The highest rice yield was recorded with the rice variety IET-16313 followed IET- 16313 (Table 3).

Table 3 Yield attributes and yields of aromatic paddy

Varieties	Plant height (cm)	No. of effective tillers /hill	Panicle length (cm)	Yield (t/ha)
RCM-11	129.50	21.30	28.20	5.00
IET - 17281	100.80	28.00	26.90	4.35
AR-3	110.00	25.60	28.90	4.80
Lampnah	132.00	19.60	31.20	4.50
IET 16332	128.40	16.60	31.10	5.11
Shasarang	112.10	21.60	26.70	4.94
IET-16313	123.80	22.00	28.00	5.20

Varietal trial on lowland rice

A total number of 21 rice varieties were tested under low land condition. Among the varieties, TRC 87-251 recorded the highest yield 5.78 t/ha followed by RCM-22 5.70 t/ha. (Table 4).

Table 4 Yield attributes and yields of lowland paddy varieties

Varieties	Plant height (cm)	Effective tillers /hill (No.)	Panicle length (cm)	Yield (t/ha)
RCM-13	118.80	13.00	27.70	5.45
RCM-14	115.00	13.30	25.10	3.52
RCM-15	116.50	12.30	28.40	3.32
RCM-16	108.30	14.00	27.60	4.50
RCM-17	117.50	12.00	27.30	3.20
RCM-18	137.10	18.30	28.10	4.60
RCM-19	118.70	15.30	26.90	5.20
RCM-20	106.10	12.00	28.00	5.00
RCM-21	107.50	13.00	31.00	5.00
RCM-22	113.50	13.00	28.20	5.70
IET-17276	116.30	12.00	28.30	4.30
IET-17278	102.20	15.30	29.80	4.20
IET-17281	101.20	16.60	28.40	3.70
IET-18564	120.00	13.60	27.50	5.30
IET-18572	122.60	14.30	28.00	5.05
TRC-87-251	113.00	9.30	28.00	5.78
BM-9820	104.30	10.30	28.30	5.30
IET-18564	133.10	16.00	27.30	5.20
IET- 18581	145.60	15.30	27.80	3.40
IET-18572	127.40	16.60	28.20	5.20
IET-18571	121.90	11.30	28.00	3.50

MAIZE

Integrated nutrient management in maize

A field experiment was conducted on integrated nutrient management for maize (Vijay composite) productivity during the *kharif* season. The main plot treatments consisted of four organic sources of nutrients such as crop residue (M_1), vermicompost (M_2), bio-fertilizers (M_3) and mixture of crop residue, vermicompost, bio-fertilizers (M_4). The sub-plot treatments consisted of different combination of chemical fertilizers, such as control (S_1), 50% NPK (S_2), 75% NPK (S_3), and 100% NPK (S_4). In the main plot treatments, the maximum plant height, no of rows/ cob, no of kernels/ row and the highest grain yield were observed in M_4 with yield of 2.24 t/ha. In the subplot, the treatment S_3 resulted the highest plant height, no. of plants/m^2, no. of rows/cob and no. of kernels/ row and grain yield (Table 5).

Table 5 Growth and yield attributes of maize under INM

Main plots	Plant height (cm)	No. of plants / m^2	No. of rows /cob	No. of kernels / row	Grain yield (t/ha)
Main plots					
M 1	223.30	8.30	12	34	1.64
M 2	226.20	8.30	13	34	2.00
M 3	232.40	8.40	13	35	2.15
M 4	234.80	8.50	13	35	2.24
Sub plots					
S 1	220.30	8.30	12	30	1.52
S 2	225.40	8.30	13	32	1.84
S 3	232.70	8.30	13	33	2.26
S 4	230.50	8.30	13	32	2.05

Varietal trials on maize

The RCRT yield trials on maize were conducted at ICAR Research Complex for NEH Region, Nagaland Centre during the kharif season. Altogether seven entries of maize were evaluated for their yield potential with Vijay composite as the local check. The days to 50% germination was found to be lowest in TRC-5 (5.2 days) followed by TRC-4 (5.8 days) and TRC-1, TRC-3 (6 days). The plant height at 60 DAS was highest for RCM-75 (267.12 cm) followed by the local check Vijaya (267.12 cm). The maximum final plant stand was recorded in Vijay (LC) followed by RCM-75, RCM-76 and TRC-5. The maximum yield was recorded in RCM-75 (2.67 q/ha) which was followed by RCM-76, Vijay, TRC-5 and TRC-3 (Table 6).

Table 6 Growth and yield attributes of maize varieties

Varieties	Days to 50% germination	Days to 75% dry husk	Height at 60 DAS (cm)	Ear ht. (cm)	Yield (t/ha)
Vijaya	7	78.2	226.92	59.5	1.92
RCM-75	8	80	267.12	57.4	2.67
RCM76	9	79.6	228.34	57.2	2.12
TRC -1	6	88.6	178.07	42.48	0.73
TRC-2	6.2	89.4	158.02	50.64	0.67
TRC-3	6	89	154.82	51.66	1.55
TRC-4	5.8	90.4	187.4	49.8	1.40
TRC-5	5.2	89.6	181.22	39.04	1.82

Evaluation of green gram and black gram varieties

A total 15 varieties of green gram entries were evaluated for their yield potential (Table 7) and the results showed that the highest yield was recorded by varieties KM-8-102 and KM-8-228 which was followed by KM-8- 202.

Table 7 Yield attributes and yields of green gram Varieties

Varieties	Yield (t/ha)
KM - 8 -207	0.36
KM - 8 -228	0.57
KM - 8 -152	0.50
KM - 8 -201	0.51
KM - 8 -102	0.57
KM - 8 -202	0.55
KM - 8 -225	0.33
KM - 8 -208	0.53
KM - 8 -217	0.40
KM - 8 -154	0.44
KM - 8 -226	0.43
KM - 8 -220	0.38
Meha	0.17
KM - 8 -105	0.47
KM - 8 -213	0.40

A total of 15 varieties of black gram were evaluated for their yield potential. The results (Table 8) showed that the highest yield was recorded in the variety KU-8-635, followed by KU-8-502 and KU-8-638.

Tables 8 Yield of black gram varieties

Varieties	Yield (t/ha)
KU - 8 -518	1.67
KU - 8 -632	1.50
KU - 8 -635	2.00
TRU 99 - 14	1.73
KU - 8 -640	1.87
KU - 8 -628	1.70
KU - 8 -527	1.80
KU - 8 -502	1.93
KU - 8 -638	1.90
KU - 8 -613	1.47
KU - 8 -620	1.60
TRU 99 - 17	1.67
KU-8- 613	1.73
KU-8- 634	1.67
KU-8- 512	1.40

Varietal evaluation trials in groundnut

A total of 24 varieties of groundnut were evaluated for their yield potential. The maximum yield was recorded in M-335 (3.24 t/ha) which was followed by M-13 (2.89 t/ha) and TG-37A (2.80 t/ha) (Table 9).

Table 9 Yield attributes and yields of groundnut varieties

Varieties	Shoot length (cm)	No of Pri. branches / plant	No. of pods / plant	Pod weight /plant (g)	Yield (t/ha)
TG-37A	66.60	11.00	44.70	71.70	2.80
ICGS - 86590	91.10	11.00	28.00	53.40	1.87
GG-7	68.60	8.40	19.70	43.40	1.96
GG – 16	71.50	10.70	27.70	41.70	2.04
TG – 26	47.40	10.00	42.00	86.00	2.47
TAG-24	77.90	9.40	23.00	43.00	1.62
LGN-2	53.70	11.00	24.00	38.40	1.61
SG-99	56.90	10.40	22.00	46.70	2.23
ICGS – 5	78.70	10.00	24.70	43.40	2.38
ARL – 2	72.50	8.00	25.00	46.70	1.79
CSMG-84-1	55.90	13.70	28.70	50.00	1.78
ICGS-76	70.60	10.40	25.00	43.40	1.87
NRCG-7599	60.00	8.40	12.70	28.40	0.34
Tirupati.	91.50	7.40	19.40	38.40	1.11
BG-13	76.90	12.00	24.70	50.00	2.46
NRCGCS -281	82.50	6.40	13.40	26.70	1.02
NRCG-268	58.60	7.40	23.70	55.00	1.96
Girner	51.70	12.00	18.40	33.40	2.47
GG-20	72.50	10.70	28.00	53.40	2.30
BAU-13	45.40	18.70	27.40	61.70	1.11
B-95	50.30	9.40	22.00	46.70	1.79
M-13	69.10	12.40	23.70	60.00	2.89
M-335	69.60	10.70	20.00	50.00	3.24

Effect of fertility levels on toria

A field experiment entitled "Response of fertility levels on toria (*Brassica campestris*) varieties under foothill condition of Nagaland in rainfed condition" was carried out at Nagaland Centre, Medziphema during *rabi* season (Fig 4). The soil of the experimental site was clay loam, acidic in reaction (pH=5.2), high in organic carbon (0.97 %), low in available nitrogen (236.20 kg/ha), potash (130.78 kg/ha) and moderate in phosphorous (12.04 kg/ha). The factors under study comprise four fertility levels (Control, 100% RDF, 125% RDF and 150% RDF, where RDF was 60: 40: 40: 30 kg N, P, K and S ha^{-1}). The RDF was in main plot and three varieties (M-27, TS-38 and TS-36) in sub plot treatment in a split-plot design replicated thrice. The maximum values of all the growth parameters were recorded with 150% recommended dose of fertilizer which was closely followed by 125% RDF and 100% RDF. Among varieties, TS-38 recorded the highest value of all the growth and yield attributes *viz.*, plant height, leaves per plant, number of branches per plant which was at par with TS-36 at all stages. The highest values for all the yield components were recorded in TS-38 which was closely followed by TS-36 and M-27. The maximum seed and stover yield of 0.65 and 1.41 kg/ha, respectively were realized at the highest fertility level *i.e.* F_3 (150% RDF). Amongst varieties, the maximum seed and stover yield of 0.59 and 1.16 t /ha were recorded with TS-38 which was at par with TS-36 and higher than M-27 (Table 10).

Fig 4 Toria crop at flowering stage under fertility trial

Integrated nutrient management in dwarf pea

The performance of dwarf pea under INM was evaluated at Medziphema during *rabi* season of 2010-11 (Fig 5). The soil of the experimental site was clay loam, acidic in reaction (pH=5.2), high in organic carbon (1.13 %), low in available nitrogen (239.20 kg/

Table 10 Effect of different fertility levels on growth and yield attributes of toria varieties

Treatments	Plant height (cm) 90 DAS	Leaves /plant (no.) 60 DAS	Pri. branch / plant (no.) 90 DAS	Sec. branch / plant (no.) 90 DAS	Siliqua length (cm)	No. of siliqua /plant	Siliqua Wt / plant (g)	Seed yield (t/ha)	Straw yield (t/ha)	Biol. yield (t/ha)
Main Plot										
F_0	66.86	16.62	3.92	9.48	4.73	73.24	9.11	0.33	0.66	0.99
F_1	69.04	16.48	4.07	9.70	4.93	100.23	11.29	0.61	1.27	1.88
F_2	69.05	17.47	4.14	10.47	4.87	119.60	11.62	0.64	1.28	1.92
F_3	75.28	20.74	4.19	11.20	5.28	124.75	11.84	0.65	1.41	2.06
Sub Plot										
V_1	79.03	14.83	3.80	8.14	4.88	99.97	10.20	0.52	1.14	1.66
V_2	65.21	19.94	4.53	11.15	5.0	107.86	11.78	0.59	1.16	1.75
V_3	65.93	18.72	3.91	10.47	4.98	105.54	10.92	0.56	1.15	1.71

F_0: Control, F_1: 100% RDF, F_2: 125% RDF, F_3: 150% RDF, V_1: M-27, V_2: TS-38, V_3: TS-36

ha), potash (127.31 kg/ha) and moderate in phosphorous (15.78 kg/ha). Five fertility levels, *viz.*, control (no application), 100% inorganic (N, P, K and S at 40: 20: 20: 20 kg/ha), 100% organic (N - 40 kg/ha through vermicompost), 100% inorganic + 50% organic and 100% organic + 50% inorganic were allotted to main plots. Four treatments *viz.*, control, biofertilizer (Rhizobium + PSB + PGPR), zinc and biofertilizer + zinc were allotted to sub- plots. Results reavealed highest seed yield for the treatment having 100% NPK + 50% N through organics (0.33 t/ha) followed by 100 N through organics + 50 % NPK (0.30 t/ha) (Table 11).

Fig 5 Dwarf pea (Azad pea) at vegetative stage in INM trial

Table 11 Effect of INM on growth, yield attributes and yield of dwarf pea

Treatment	Plant height (cm)			Pri. branch/plant (no.)		Dry matter/ plant (g) at harvest	Pods/ plant (No.)	Seeds/ pod (No.)	Seed yield (t/ha)	Straw yield (t/ha)	Biol. yield (t/ha)
	30 DAS	60 DAS	90 DAS	60 DAS	90 DAS						
Main Plot (Fertility level)											
M_0	11.63	26.32	36.05	8.43	13.00	213.33	2.67	5.67	0.19	0.37	0.56
M_1	12.21	26.47	38.31	9.00	13.72	278.75	3.47	6.89	0.26	0.52	0.82
M_2	11.83	22.65	37.43	8.83	10.31	272.92	2.84	6.44	0.21	0.48	0.69
M_3	12.78	27.49	38.99	9.14	13.08	399.59	3.30	6.73	0.33	0.72	1.05
M_4	12.47	31.05	45.48	9.22	13.33	311.67	3.72	6.60	0.30	0.57	0.87
Sub Plot (Biofertilizer + micronutrient)											
S_0	11.7	26.18	37.66	8.91	13.31	277.67	3.05	6.43	0.26	0.51	0.77
S_1	12.37	27.17	39.73	9.11	13.04	296.67	3.10	6.23	0.25	0.52	0.77
S_2	12.21	25.74	39.33	8.97	13.51	289.00	3.19	6.64	0.27	0.54	0.81
S_3	12.46	28.60	40.29	8.71	13.55	317.67	3.45	6.40	0.29	0.59	0.88

Main Plot (Fertility level): M_0: Control, M_1: 100% NPK, M_2: 100% $N_{organic}$, M_3: 100% NPK + 50% $N_{organic}$, M_4: 100% $N_{organic}$ + 50% NPK;
Sub Plot (Biofertilizers+micronutrients): S_0: Control, S_1: Biofertilizer, S_2: Zn @ 5 kg/ha, S_3: Biofertilizers + Zn.

Effect of fertility levels on linseed

To study the effect of fertility levels and seed rate on linseed under rainfed condition, a field experiment was carried out during *rabi* season of 2010-11. The treatment comprised 12 combinations, of which four levels of fertility *viz.*,control F_0 (NPKS are zero), F_1 (20 kg N, 10 kg P, 10 kg K and 10 kg S), F_2 (40 kg N, 20 kg P, 20 kg K and 20 kg S), F_3 (60 kg N, 30 kg P, 30 kg K and 30 kg S) ha^{-1} and three seed rates, S_1 (20 kg), S2 (30 kg), S_3 (40 kg) ha^{-1}. Each treatment was replicated three times in factorial RBD. The increase in fertility levels from F_0 to F_3 significantly increased all growth attributes at various growth stages. Increase in fertility levels from F_0 to F_3 also increased all yield attributes *viz.*, number of capsule per plant, number of seeds per capsule. Increase in fertility levels resulted in increase in seed and straw yield. The increase in seed rate decrease plant height, number of branches per plant. Number of capsule per plant, number of seed per capsule. Increase in seed rate significantly increased grain yield from 20 kg to 30 kg/ha but further increase in seed rate decreased grain yield.

HORTICULTURE

Sweet potato

The ten sweet potato cultivars including the local were evaluated (Fig 6). Among them maximum vine length was recorded in Sree Bhadra (606.37 cm), followed by Arun (592.63 cm), and minimum was recorded by Gouri (250.77 cm). The maximum number of leaves per plant was recorded by CIP-440127 (138.13) and minimum was recorded by Meghalaya Local (85.73). The maximum number of tubers was recorded by Kishan (6.00), followed by CIP-440038 (4.00) and minimum tubers was recorded by Sree Bhadra (1.67). The tuber length also varied significantly among the cultivars evaluated. The maximum length of 14.51 cm was recorded in CIP-440038, followed by Kishan (13.02 cm) and minimum length of 8.11 cm was recorded by CIP-440127. The maximum tuber diameter was found in CIP-440038 (6.08 cm) and minimum was recorded in CIP-187017 (2.67 cm). The highest tuber weight of 256.6 g was recorded in CIP-440038 and minimum weight of 26.70 g was recorded by CIP-187017. Among the cultivars evaluated for yield characters, the cultivar CIP-440038 performed well under Nagaland conditions.

Fig 6 Evaluation of sweet potato cultivars under Nagaland condition

Colocasia

Twenty-two colocasia germplasm lines were collected from various parts of Nagaland and evaluated (Fig 7). All the collenctions differed significantly for their morphological and yield characters. The maximum plant height was recorded by line 16 (161.40 cm), followed by line 14 (149.00 cm) and minimum plant height was recorded by line 5 (53.00 cm). The maximum suckers (3.60) was recorded in line 15 followed by the line 14 (3.40). The lines 3, 6, 8 and 20 did not produce any side suckers.

Fig 7 Evaluation of colocasia lines under Nagaland condition

The different lines varied significantly for corm and cormel characters. Among the lines evaluated, the line 3 recorded the maximum number of corms (3.20) and the lines 3, 4, 6, 7, 8 and 20 recorded the minimum number of corms (1.00). The maximum numbers of 13.00 cormels were found in line 21 and minimum of 2.00 cormels were found in the line 3. The maximum corm length of 16.10 cm was recorded by the line 21 which was closely followed by the line 20 (15.28) and the minimum length of 3.10 cm was recorded in the line 4. The maximum corm weight was recorded by the line 20 (806.9 g) and minimum corm weight was recorded by the line 2 (35.2 g). The maximum cormel weight of 50.5 g was recorded by line 12 and minimum of 7.7 g was recorded by line 10.

AGROFORESTRY

Evaluation of growth performance of *Jatropha curcas*

A total of 11 provenances were screened for the growth performance of *Jatropha curcas*. Among various provenances, the *Jatropha* collected from Molvum exhibited the highest height (2.58 m),

followed by Piphema (2.43 m). The lowest height was recorded in Rangapahar (1.45 m). The highest stem diameter was recorded in Piphema provenance (8.55 cm) followed by Ruzaphema (7.99 cm). The no. of branches per plant were also recorded highest in Molvum (13.80 nos.), followed by Dhansiripar (12.31 nos.). The seeds were analyzed for oil content (Table 12) by the National Oilseeds and Vegetable Oils Development (NOVOD) Board, Ministry of Agriculture, Govt. of India using Soxlet apparatus.

Among various provenances, the *Jatropha* collected from Molvum exhibited the highest seed yield (0.36 kg/plant), followed by Piphema and Dhansiripar (0.35 kg/plant). The lowest seed yield was, however, recorded in Tolbi basti with 0.31 kg/plant. As far as the no. of fruiting per branch is concerned, it was recorded the maximum in Molvum provenance (5.0) followed by Dhansiripar (4.6). Similar to no. of fruiting per branch, the no. of fruits per branch were also recorded the highest in Molvum (10.5 nos. per branch), followed by Dhansiripar and Piphema (9.5 nos. per branch).

Table 12 Growth and oil content of *Jatropha curcas* after four years of plantation

Genotypes	Height (m)	Average diameter (cm)	No. of branches /plant	Seed oil (%)
Jalukie	1.78± 0.02	7.37±0.32	7.35±0.10	32.12
Jharnapani	1.69±0.09	8.10±0.05	7.50±0.34	30.19
Medziphema	1.73±0.03	7.98±0.08	5.22±0.22	31.44
Molvum	2.58±0.01	6.99±0.12	13.80±0.32	38.99
Piphema	2.43±0.40	8.55±0.09	10.11±1.15	35.62
Rûzaphema	1.75±0.26	7.99±0.13	8.21±0.17	34.43
Seithekiema	1.62±0.05	6.12±0.19	6.17±0.12	28.19
Khatkati	1.68±0.03	6.93±0.06	6.66±0.15	33.37
Rangapahar	1.45±0.01	6.93±0.02	9.15±0.21	37.51
Dhansiripar	1.72±0.03	7.17±0.04	12.31±0.05	32.39
Tolbi basti	1.66±0.03	6.99±0.14	9.52±0.08	33.00

ANIMAL SCIENCE

Animal production

Mega seed project on pig

Parent stock of Large Black and Ghungroo breeds of pigs (Figs 8 & 9) are being reared under the project. In the reporting period two new pig sties were included in the project. Herd strength was increased from 99 in beginning of the year to 189 at end of the year. This year 76 number of farrowing has been taken place and 563 no. of piglets (326 male and 273 female) born. Total 336 no. of piglets were distributed as mentioned in Table 13.

Table 13 Beneficiaries of mega seed project on pig

Name of the beneficiaries	No.	No. of piglets distributed
Individual farmers	80	230
NGOs	8	44
KVKs	4	48
State/central dept.	6	62
Total		**336**

Comparative studies on productive and reproductive performances of different breeds of pig in Nagaland

In first year of the project, reproductive performances of 35 numbers of sows (17 Large Black cross and 18 Ghungroo) were evaluated. The detail of reproductive performances is presented in Table 14.

Total twenty two piglets were selected for replacement in the herd and were included for further study in the project. Their growth performances were monitored at monthly interval till six months of age. The growth performance is presented in table 15. Individual litter weight at birth is highest in Large Black crosses as compared to Ghungroo and litter of

Fig 8 Large black cross

Fig 9 Ghungroo sow

Fig 10 Distribution of piglet to the farmer

Table 14 Reproductive performance of Large Black cross and Ghungroo pigs

Particulars	Large Black Cross	Ghungroo
Litter size at farrowing	8.41 ± 0.75	8.11 ± 0.62
Sex ratio at farrowing (M:F)	1.014	1.281
Litter size at weaning	6.71 ± 0.71	6.11± 0.49
Farrowing to conception interval (days)	56.13 ± 4.14	56.75 ± 2.29
Gestation period (days)	114.18 ± 0.58	113.88 ± 0.41
Pre-weaning mortality	1.71 ± 0.46	2.0 ± 0.38

cross between local female and Ghungroo male pigs. Similarly, pre-weaning growth in terms of daily weight gain was also higher in Large Black crosses than the other two groups. However, at post weaning period the growth rate did not differed significantly in any of the three groups.

Table 15 Growth performances of different breeds of pigs in Nagaland

Particulars	Large Black cross	Ghungroo	Local X Ghungroo
Individual litter weight at birth (kg)	1.105 ±0.027	0.951 ±0.058	0.739
Individual litter weight at weaning (kg)	9.023 ±0.616	7.378 ±0.463	5.963 ±0.127
Pre-weaning daily weight gain (g)	176.0	143.0	116.0
Post weaning monthly body weight (kg)			
2nd month	11.483 ±0.775	10.42 ±0.719	10.13 ±0.818
4th month	27.555 ±3.295	28.869 ±1.205	28.953 ±1.182
6th month	52.55 ±2.650	49.082 ±1.854	

Poultry Seed Project

Performance of parent stock

Parent stock of Vanaraja and Gramapriya (Figs 11 -14) were procured from PDP, Hyderabad and reared in existing poultry sheds. Feeding regime was followed as per the formulation received from PDP, Hyderabad. The production performance, hatching performance and distribution of chick to the farmers are presented here.

The production performance represented in table 16 indicated the superior performance of Vanaraja birds as compared to Gramapriya in terms of age at first

Fig 11 Vanaraja parent stock (female 16 wks) old

Fig 12 Vanaraja parent stock (male 16 wks old)

Fig 13 Gramapriya parent stock (female, 16 wks old)

Fig 14 Gramapriya parent stock (male, 16 wks old)

laying, average hen-house production performance and average body weight at different weeks. The mortality in adult layer birds was low during the reporting period in both Vanaraja and Gramapriya.

Table 16 Production performance of Vanaraja and Gramapriya birds in Nagaland

Particulars	Vanaraja	Gramapriya
Age at first laying	142 days	163 days
Total egg production	34,378	28,410
Average 'Hen-House' eggs production (%)	35.60±3.34	29.83±3.81
Average eggs weight (g) from 26 wk to 66 wks	50.37±0.19 to 63.36±1.24	50.30±0.15 to 63.50 ±1.10
Mortality rate in parent stock from 30- 70 weeks (%)	1.065 ± 0.25	1.168 ± 0.34
Body weight of live birds (g)		
At 20 wks	2498.59 ±214.75	1398.87 ± 144.15
At 45 wks	2360.00 ±58.80	1406.25 ±47.36
At 60 wks	3385.60 ± 178.29	1942.20 ±109.03
Average daily feed intake (g/bird)	165.64 ± 1.99	120.02 ± 7.22

Hatching performance of Vanaraja and Gramapriya

Eggs produced in the centre were allowed to hatch in the hatchery unit having capacity of 15000 eggs for setting and 5000 eggs for hatching. The hatching performance and chicks produced are presented in Table 17.

Table 17 Hatching records of Vanaraja and Gramapriya birds

Particulars	Vanaraja	Gramapriya
Total no. of eggs set	14993	11573
Average fertility percentage	87.017 ± 2.74	84.245 ± 2.58
Average hatchability percentage	82.476 ± 2.65	83.409 ± 1.61
Total no. of chicks produced	10743	8207

Distribution of chicks

The chicks produced in the centre were either distributed (Fig 15) to the farmers at day old stage or reared in the nursery unit for a period of 30 days before giving to the beneficiaries at subsidized rate. Vaccination against diseases like Marek's, IBD and Ranikhet were given apart from routine de-worming

Fig 15 Chicks distributed to the farmers by Honorable Secretary DARE & DG, ICAR

and electrolyte – vitamin supplementation as and when required. The mortality was comparatively higher in the initial 1-2 week period than later weeks of rearing in the nursery unit. The average mortality rate was recorded 7.64 % in Vanaraja and 8.47 % in Gramapriya varieties from the period of January to November. Total 12839 no. of chicks were distributed to the farmers and different NGOs, KVKs and state department or central agencies working in the Nagaland state. The details of beneficiaries is presented in the table 18.

Table 18 Beneficiaries of poultry seed project

Particulars	Total No
Total no. of chicks distributed	12839
No. of benefited farmers	8613 chicks to 250 farmers in 5 districts
No. of KVKs collected chicks for OFT and FLD	1431 chicks. in 4 KVKs
No. of NGOs collected chicks for distribution to their members	725 chicks to 4 NGOs. in 4 districts
State and Central dept. (Assam Rifle, State Vety. Dept, SASRD, NRC-M)	2070 chicks in 3 districts

The improved varieties of Vanaraja and Gramapriya birds became very popular in the state though the remote areas are yet to get the benefit of this project. Vanaraja and Gramapriya birds are now replacing the Kuroiler varieties in the region. The feedback from different sectors of the state was very much encouraging. This project was able to met the demand of superior germplasm in the region to a certain extent. It could also generate subsidiary source of income and gainful employment to the unemployed youth in Nagaland.

ANIMAL HEALTH

Studies on microbiology of Axone

A total of 370 samples of Axone of different tribes (Angami, 76; Ao, 24; Chakesang, 72; Kukies, 6; Lotha,124; Manipuri, 2; Pochury, 2; Sempa, 64) collected from different markets were analysed for: coliform count, total aerobic count, aerobic spore count, anaerobic spore count, *Enterococcus* count, yeast and mould count, *Staphylococcus* count and for presence of *Salmonella.* Coliforms were detected in 47.3% samples (avg. 2.79±3.21 Log_{10} cfu g^{-1}, range 0.0-10.67 Log_{10} cfu g^{-1}). Most of the fresh preparations (94%) and about a third (38%) of matured preparations were positive for coliforms. Aerobic bacteria were detected in all the samples (avg. 9.42±0.89 Log_{10} cfu g^{-1}, range 6.44-12.98 Log_{10} cfu g^{-1}) and majority was of *Bacillus* spp. Aerobic spore were present in all the samples (avg. 8.03±0.77 Log_{10} cfu g^{-1}, range 5.60-10.55 Log_{10} cfu g^{-1}). However, anaerobic spore could be detected in 107 samples only but could not be counted due to low numbers (<200 per gm). *Enterococcus* was present in 94.2% samples (95% matured and 91% fresh) and they were positive for enterococci (avg. 5.42±1.95 Log_{10} cfu g^{-1}, range 0.00-8.26 Log_{10} cfu g^{-1}). Yeast and molds were detected in ~54% samples of Axone (avg. 2.73±2.64 Log_{10} cfu g^{-1}, range 0.00-7.41 Log_{10} cfu g^{-1}). All the samples were positive for *staphylococci* (avg. 6.79±0.48 Log_{10} cfu g^{-1}, range 5.79-7.56 Log_{10} cfu g^{-1}).

Common bacteria isolated from Axone samples

Aeromonads, Citrobacter spp., *Enterobacter* spp., *Klebsiella* spp., *Morganella* spp., *Proteus* spp., *Pseudomonas* spp., *Salmonella enterica* subsp. *enterica* (from 5 chakesang Axone samples), *Bacillus subtilis, B. anthracoides, B. badius, B. brevis, B. circulans, B. coagulans, B. lentus, B. marcerans, B. pantothenticus, Enterococcus caecorum, E. casseliflavus, Staphylococcus aureus, S. epidermidis and S. hyicus.* Average pH of axone samples was 7.44 ±0.73; however, ranged between 6.24 to 8.36, less in fresh Axone samples and more in semi-dry or dried preparations. Lower pH of matured Axone was recorded from Axone samples of Chakesang, Lotha and Angami tribes (<7.6) than that of Ao, Pochury and Sema tribes (>8). A total of sixteen Axone samples were analyzed for dry matter, crude fiber, crude protein, ether extract and ash content. The results revealed the following values (Table 19)

Table 19 Aproximate analysis of Axone samples

Particulars	DM	Crude fiber	Ash	CP	EE
Average	50.0	18.5	5.9	34.8	23.5
STDV	10.8	4.8	1.7	4.9	4.5

A total of 250 *Bacillus* species isolates from different Axone samples were tested against *Klebsiella pneumoniae, Escherichia coli* and *Salmonella enterica* serovar Typhimurium. Of these caps, 162 inhibited growth of one or more bacterial strains while 3 inhibited growth of all three pathogens tested, of which three strains (LP31, ABY103 and W6) selected for further studies to evaluate their probiotic potential in mice, rabbits and pigs. For pigs, ABY 103 appeared to be the best probiotic culture to be used for enhancing growth rate while for rabbits W6 appeared to be the best probiotic culture to improve the growth.

Economics of Axone feeding to grower Ghungroo pigs

Amount of Axone fed to six pigs (50×45g)	= 2.25 kg
Cost of Axone @ Rs. 100/ kg	= Rs. 225/-
Total extra weight gain by 6 pigs: 3.2×6	= 19.2 kg
Cost of extra live weight gain @Rs.50/kg	= Rs. 860/-
Total gain in 45 days	= Rs. 635/-

Economics of Axone feeding to mother sows

Two Ghunghru sows having 16 piglets were fed with Axone @ 50g/ sow daily while two sows with 16 piglets were kept as control and given grounded soybean instead of Axone for 30 days. In Akhuni group only one piglet had diarrhoea while in control group a total of 7 piglets suffered diarrhoea at one or more occasions and 4 died.

Weight gain of piglets	**Control group**	**Axone group**
Per day/piglet	90.0 g	151 g
Total/ piglet	3.04 kg	5.3 kg
Total live weight of piglets	36.48 kg	79.50
Extra cost involved for Axone	0	Rs. 300/-
Value of live weight @Rs. 50/kg	Rs.1824/-	Rs. 3975/-
Axone feeding benefit to farmer	Rs. 3975-1824-300 =Rs. 1851/-	

Sikkim

WEATHER REPORT

Maximum rainfall of 606.5 mm was received during the month of Aug, 2010 whereas, there was no rainfall in the month of Dec, 2010. The maximum average temperature (27.7^0 C) was observed in the month of Jun, 2010 and minimum (6.57^{0}C) in the month of Jan, 2011. The maximum relative humidity (92.2 %) was observed during the month of Jun, 2010 and the minimum of 39.1 % in the month of Mar, 2011 (Table 1).

CROP PRODUCTION

INM in soybean

Field experiment was conducted on soybean-toria rotation with integrated nutrient management in the main crop and evaluating the effect of residual nutrients on succeeding mustard with one irrigation. Treatment combinations consisting of chemical fertilizers as starter dose, mixed compost, neem cake and dolomite in nine combinations and one control (no nitrogen) were imposed on soybean var. PK-1024 during *kharif* season. N: P: K @ 30:40:30 in conjunction with dolomite @ 2 t/ha, Neem cake 1 t/ha + mixed compost 2.5 t/ha produced highest yield of soybean (3170 kg/ ha) which was statistically at par with integrated nutrient management through urea + SSP + MOP @ 30:40:30 + dolomite @ 2 t/ha + neem cake @ 0.5 t/ha (3025 kg/ha). Short duration, high yielding toria variety M-27 was sown in November 2010 in the same soybean plots and given one irrigation at the flowering stage. Conjunctive application of urea + SSP + MOP @ 30:30:30 + dolomite @ 2 t/ha + Neem cake @ 0.5 t/ha produced the highest grain yield (0.83 t/ha) followed by application of neem cake 1 t/ha + mixed compost 2.5 t/ha+ dolomite produced yield of (0.73 t/ ha) on the residual soil nutrients.

INM in rice

Studies were conducted during *kharif* season with three improved rice varieties *viz*., VL Dhan-61, Pusa Sugandh II, Pant Dhan-10 and one local check "Attey" under two organic sources of nutrition *viz*., mixed compost and neem cake to evaluate their performance in terms of yield attributes, yield and N-use efficiency in comparison with 3-split urea application. 25 days old seedlings were transplanted with 20 x 15 cm spacing, 2 seedlings/hill. The rice grain yields ranged from 2.21 to 3.73 t/ha with mixed compost; 2.38 to 4.27 t/ha with mixed compost and neem cake as compared with 2.05 to 3.87 t/ha rice grain yield with 3-split urea application. The no fertilizer control yield ranged from 1.14 to 1.57 t/ha.

Organic nutrition in buckwheat

Studies were undertaken on organic nutrition of buckwheat during *rabi* season with local cultivar "Mithe". The crop was sown in two spacing of 20 x 20 and 30 x 30 cm. Five treatment combinations of mixed compost, neem cake and seed treatment with azophos along with control were basally applied at sowing. The highest grain yield (1.48 t/ha) of buckwheat was recorded with combinations of mixed compost 5 t/ha and neem cake 0.5 t/ha.

Organic nutrition in toria

Studies were conducted on organic nutrition of toria during *rabi* season (Nov sowing) with var. M-27. The highest yield (1.23 t/ha) was recorded with mixed

Table 1 Average meteorological data for the period Apr 2010 to Mar 2011

Months	Max Temp. (^{0}C)	Min Temp. (^{0}C)	Max R/H (%)	Min R/H (%)	Rainfall (mm)	Evaporation (mm)
Apr 10	26.20	16.10	89.50	51.20	465.0	2.80
May 10	26.50	17.50	89.70	57.30	328.8	2.60
Jun 10	27.70	19.50	92.20	65.50	591.2	2.30
Jul 10	27.00	20.20	91.00	67.00	598.5	2.60
Aug 10	26.72	20.38	90.00	71.61	606.5	2.50
Sep 10	26.16	19.00	90.90	69.00	363.6	2.80
Oct 10	25.27	16.18	80.00	57.50	112.0	3.10
Nov 10	20.50	12.60	87.50	56.40	22.3	1.30
Dec 10	17.00	8.00	83.10	42.30	00.0	1.30
Jan 11	14.56	6.57	83.74	48.00	25.9	0.95
Feb 11	19.10	9.50	83.10	44.40	47.8	3.70
Mar 11	23.50	12.24	82.03	39.09	51.1	3.29

compost @ 5 t/ha + vermicompost @ 1 t/ha + neem cake @ 1 t/ha + dolomite @ 1 t/ha which was followed by application of mixed compost @ 5 t/ha + vermicompost @ 1 t/ha + dolomite @ 1 t/ha that produced 0.98 t/ha.

Screening of rajmash germplasm

Thirty two pole type Rajmash entries were evaluated in plot size of 0.75 m^2 in two replications (Spacing of 45x25 cm) during *rabi* season (Sep sowing) at ICAR Sikkim Farm. The Analysis of variance revealed significant differences in yield among the entries (Table 2). Maximum grain yield per plot was recorded in SKR-62 (415.65 g) followed by MS (302.55 g) and R-29 (292.50 g).

Genetic advancement and carry over of materials suitable for Sikkim conditions

Elite rapeseed

Three yellow sarson (SSY-1, SSY-2and SSY-3), two brown sarson (SSB-1 and SSB-2) and two toria (SKMT-1 and SKMT-2) improved material developed at the centre were sown in isolation for its pure seed production. Single plant selections have been made in yellow and brown sarson.

Hybrid maize

Eleven varieties of hybrid maize from VPKAS Almora were evaluated during *Kharif*-2010. Significant differences in yield were found among the varieties (Table 3). The trial was conducted in RBD

Table 2 Screening of rajmash germplasm

Entry	Days to 50% flowering	Plant height (cm)	No of pods /plant	Pod length (cm)	No. of seeds /pod	Days to maturity	Yield/ plot (g)
Kanchan	43	127.75	9.23	10.04	4.75	92.50	123.25
Nagaland-2	43	130.50	9.77	10.17	4.75	92.50	121.10
SKR-67	43	173.00	20.40	13.72	7.50	91.00	217.95
R-33	43	143.00	13.70	10.92	7.00	99.00	194.65
SKR-33	45	108.50	9.60	8.67	5.00	97.50	128.45
R-29	45	79.00	16.00	10.60	6.50	99.00	292.50
SKR-50	43	190.20	10.30	17.97	8.50	104.00	120.05
Kailash A	41	59.00	8.60	10.51	5.00	92.50	141.70
Kailash-B	41	43.50	13.10	10.80	4.50	92.00	167.20
MS	43	206.00	14.40	9.98	7.00	108.00	302.15
R-333	48	191.50	18.00	9.92	6.50	117.00	252.55
SKR-62	48	179.00	17.80	10.31	7.00	109.50	415.65
R-21	48	122.50	17.66	9.77	6.50	114.00	70.80
SKR-67	48	142.00	11.30	13.19	7.00	103.50	212.80
R-10	48	192.00	15.70	10.43	7.50	104.00	220.10
SKR-54	48	102.50	12.10	10.05	7.00	103.00	207.70
SKR-59	46	202.00	16.10	11.15	7.00	104.00	258.45
R-19	46	124.50	14.20	9.80	7.50	112.00	196.45
SKR-333	43	79.50	6.40	7.89	4.50	104.00	84.35
SKR-4	43	120.25	4.90	10.44	4.50	108.50	39.05
R-48	43	176.50	17.80	11.14	7.00	104.00	239.85
R-19	43	177.50	17.80	10.48	6.50	122.00	152.90
SKR-13	43	162.00	12.20	14.40	7.00	99.00	147.90
SKR-48	43	91.00	6.30	11.68	6.50	98.00	120.90
SKR-66	48	151.00	15.00	10.17	7.00	106.50	194.40
SKR -4B	43	143.50	9.30	11.16	5.50	104.00	178.45
R-40	48	169.00	16.80	10.81	6.50	124.00	240.70
R-48	44	190.00	13.20	11.24	7.00	104.00	291.15
R-28	43	79.80	10.70	13.30	5.50	99.50	149.95
Ghew Sibi C	43	106.25	9.75	9.65	4.00	96.50	117.50
Ghew Sibi B	43	140.80	7.97	9.77	4.50	96.50	90.50

with three replications having plot size each of 2.4m^2 (Spacing of 60x30 cm). The Analysis of variance showed significant differences among the varieties for grain yield per plant. The highest grain yield per plant was recorded in Vivek hybrid-21(118.28 g) followed by Vivek hybrid-25 (114.95 g) and FH-3356 (113.52 g).

Soybean

Five soybean entries including local cultivar were evaluated under Regional coordinated trial *kharif*-2010 in three replications with plot size of 1.8 m^2 each (spacing of 45x15 cm). The ANOVA showed significant differences among the varieties for grain yield per plot (Table 4). The highest yield per plot was recorded in H-9 followed by H-1.

HORTICULTURE

Germplasm evaluation in chilli

Germplasm lines were evaluated for growth, leaf character, fruit character, yield, quality and disease severity. Maximum fruit yield/plant was recorded in collection-6 (1100 g/plant) at the spacing of 1x1 m whereas, minimum fruit yield (27g/plant) was recorded in collection-11 after overall harvest.

Mulching in cherry pepper

To standardize mulching material black polythene, white polythene, forest leaf and *Schima wallichi* leaf mulch were used. The minimum plant wilting (20%) was observed in *Schima wallichi* mulched plants followed by forest leaf mulch and black polythene in cherry pepper. Maximum plant mortality (74%) was recorded in control plots with no mulching for cherry pepper. Chilli pepper showed very less wilting (12%) in *Schima wallichi* mulching. Late blight occurrence was observed irrespective of the mulching material.

Shelf life of cherry pepper

Cherry pepper storage at room temperature and 4^{0}C temperature indicated maximum shelf life of cherry pepper for 6 days at room temperature. Under 4^{0}C maximum shelf life recorded was 23 days without any quality deterioration.

Table 3 Performance of hybrid maize varieties under Sikkim condition

Variety	Plant height (cm)	Days to 50% tasseling	Days to 50% silking	Days to 75% maturity	Grain yield/ plot (g)	Grain yield/ plant (g)
Him-129	134.44	61.67	65.67	105.67	1333.33	69.38
Vivek hybrid-5	166.11	65.00	68.67	105.33	1300.00	72.43
Vivek hybrid-9	164.44	63.00	68.33	106.00	1933.33	95.08
Vivek hybrid-15	153.44	65.67	68.00	106.00	1933.33	101.52
Vivek hybrid-21	164.78	65.67	67.67	103.00	2366.67	118.28
Vivek hybrid-23	148.44	65.00	67.00	103.00	2200.00	108.92
Vivek hybrid-25	151.44	66.00	68.00	105.00	2300.00	114.95
Vivek hybrid-33	139.56	65.67	70.33	106.33	1933.33	100.91
FH-3356	144.89	65.67	69.67	107.00	2200.00	113.52
V.Sankul-31	135.78	63.33	65.00	106.00	1233.33	65.79
V. sankul-35	127.56	60.67	67.00	101.00	866.67	42.61

Table 4 Performance of soybean entries under Sikkim condition

Genotype	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of branches	No. of pods	No. of clusters/plant	Plot yield (g)
H-1	57.00	109.67	66.47	9.60	85.60	24.73	542.63
H-9	57.00	113.67	70.13	10.47	68.73	19.27	632.27
H-10	54.67	112.00	65.73	10.07	91.47	25.73	459.30
JS-335 (Check)	53.33	110.67	50.80	8.73	58.93	17.27	396.67
Local	54.33	111.00	56.87	10.53	74.20	21.87	252.93

PLANT PROTECTION

Molecular characterization and bio-intensive management of *Collectotrichum gloeosporioides* leaf blight in large cardamom

Survey was conducted in large cardamom fields during Nov and Dec 2010. The blight incidence ranged from 5 to 58.33%. Leaf samples were collected and the pathogen was isolated. On the basis of microscopic and cultural characteristics the causative fungus was identified as *Glomerella cingulata (*Stonem) Spauld & Schrink (Fig 2). Perfect stage of *Colletotrichum gloeosporioides* (Penz) Penz and Sacc. pathogenicity was established for the pathogen isolates using Koch's postulates. The pathogen was purified and cultured in Petri plates. The colonies on PDA were grayish white to dark grey (Fig 1). Aerial mycelium showed diurnal zonation of dense and sparse development with fructifications. Abundant pinkish pinhead like masses of conidia mostly appeared in sparse region of mycelial growth. Perithesia always formed in culture, more common in older ones often associated with stromatic structure and darker, or more tufted mycelium than acervuli. Reverse side of colony was unevenly white to grey, getting darker with age. Perithesia globose to obpyriform, with periphyses. Conidia cylindrical with obtuse ends, hyaline, aseptate with oil globule at the centre. The efficacy of various plant extracts *viz.*, chiloney, artimisia, garlic, onion, ginger, lantana, turmeric, marigold, colocassia, oxyspora , turmeric + garlic, turmeric + ginger, turmeric + onion at 2%, 5% and 10% was studied against the pathogen. Though the treatments were statistically non-significant the plant extracts like garlic, ginger and Turmeric at 10% concentration showed significant control (Fig 3) with less colony diameter of 6.466 mm, 6.783 mm, and 6.933 mm, respectively over control (7.406 mm).

Eco friendly management of insect pests in organic rice

An experiment was conducted to evaluate the location specific bio intensive IPM strategies for management of rice pest. Two plots were taken for this purpose. In one plot the rice crop was cultivated adopting all developed technologies *viz*., i. growing of tolerant high yielding variety like RC Manipho-10, ii. transplanting in line with spacing of 20 x 15 cm, iii. spraying of Nimbicidine @ 3 ml/L at 10 DAT followed by second spraying after 20 days, iv. installation of pheromone trap for yellow stem borer, v. one spraying of *Beauveria bassiana* (Biopower® @ 7g/lit) in the boot leaf stage to reduce gundhi bug population, and in case of the other plot the practices viz., i. growing of traditional variety like Attey, ii. Transplanting in traditional method was followed as adopted by the farmers in their own field. The observation on infestation of whorl maggot, stem borer, leaf folder and gundhi bug was recorded in both the plots at 30 and 50 DAT. Average natural enemy populations in both the plots were also recorded visually.

Yield record was taken from both the plots after harvesting separately. It was observed from the study that the yield of rice was significantly higher in IPM plot (4.02 t/ha) in comparison to farmer's practice plot (1.84 t/ha).

Bio rational management of insect pest in Sikkim Mandarin

The survey of insect pests population and natural enemies was done in various nurseries and orchards of Sikkim mandarin in which it was found that leaf miner, lemon butterfly, leaf roller, whitefly, scale insect, mealy bug and semi looper are some important pests in citrus nursery. In the orchard the incidence of trunk borer, bark eating caterpillar and shoot borer were

Fig 1 The colony growth of *Glomerella cingulata* on PDA plate

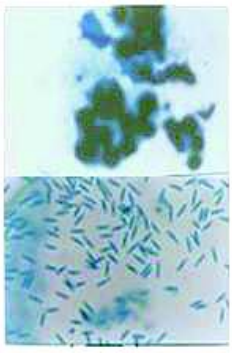


Fig 2 Perfect and imperfect stage of *Glomerella cingulata*

Fig 3 The colony growth of *Glomerella cingulata* on PDA medium amended with different plant extracts

common (Figs 4,5,6). The orchards of all the surveyed areas were infested (24 - 32%) by the fruit fly. The adults and grubs of lady bird beetle, *Menochilus sexmaculata* and *Coccinella septempunctata* were observed as potential predator in all the surveyed orchards.

Fig 4 Leaf miner

Fig 5 Bark eating caterpiller

Fig 6 Trunk borer infestation

Evaluation of bio-pesticides against insect pests of Sikkim Mandarin

Six biopesticides were evaluated against insect pests of Sikkim Mandarin. The result revealed that *Bacillus thuringiencis* (Delfin 3G) 7g/l was found to be the most effective bio-pesticides to control lemon butter fly while Agrospray (Servo) 7ml/l was found effective against aphids and leaf miner in Sikkim Mandarin orchard.

Another field experiment was conducted for management of trunk borer (Fig 7) in citrus orchard with six treatments *viz.*, **a.** cleaning of infested plants and insertion of iron wire to kill the larvae followed by Bordeaux paste (T1), **b**. Insertion of cotton soaked in kerosene and plastered with soil and cow dung mixture (T2), **c**. Insertion of cotton soaked in petrol and plastered with soil and cow dung mixture (T3), d. (T1 +T2), e. (T1 + T3) and control (T6). It was observed from the study that cleaning of infested plants and insertion of iron wire to kill the larvae followed by Bordeaux paste and insertion of cotton soaked in petrol or kerosene to the holes and plastered with soil and cow dung mixture are highly effective (77.9 – 85.5% larval reduction).

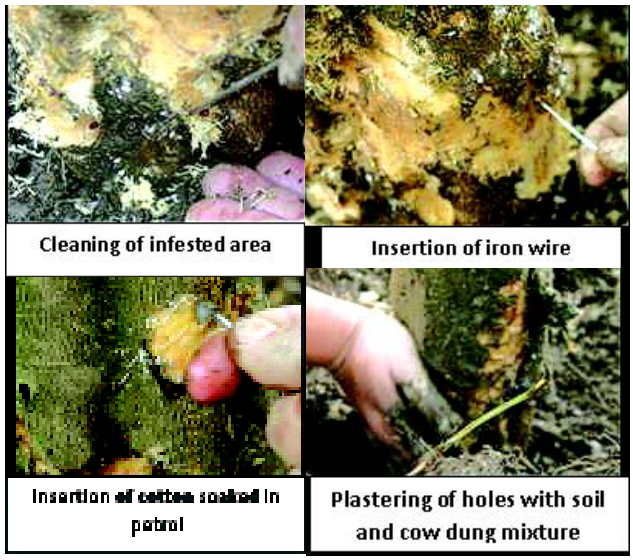


Fig 7 Management of trunk borer in Sikkim Mandarin

Bio-rational management of insect pests of major spices

The survey revealed that shoot borer, white grub, leaf roller and grasshopper are found to be economically important pests of ginger. *Apanteles* was found to be potential parasitoid for leaf roller larva. In case of chilli the infestation of cut worm, aphids, white fly and fruit borer was observed. Lady bird beetle, *Coccinella septempunctata* (adult and larva) was observed predating on aphid populations. Survey also revealed that leaf eating caterpillar, *Artona chorista* Jordon, shootfly, *Merochlorops dimorphus* Cherian and stem borer, *Glyphipterix* sp are some of the economically important pests in large cardamom in Sikkim.

Four different locally available insecticidal plants *viz*., Banmara, *Eupatorium odoratum*; Chelaone, *Schima wallichi*; Titepati, *Artemisia vulgaris* and Dhatura, *Datura stromanium* were evaluated against insect pests of ginger, chilli and large cardamom. Two spraying of aqueous extract of Titepati, *Artemisia vulgaris* (1:10) was found effective against shoot borer, leaf roller and grasshopper in ginger, aphids and white fly in chilli and leaf eating caterpillar in large cardamom. From the survey it was observed that the adults and grubs of lady bird beetle, *Menochilus sexmaculata* and *Coccinella septempunctata* were observed as potential predator.

LIVESTOCK PRODUCTION AND MANAGEMENT

Genetic improvement of Sikkim local goats for litter size

This study was initiated for genetic improvement of Sikkim local goats for litter size. For this purpose an elite herd of Sikkim local goats (48 female and 12 buck) were procured from different localities of the state. General management, productive and reproductive parameters, health control measures including deworming, anti tick bath and general treatment were taken. The growth and bio-metrical parameters were also studied.

Month wise kidding incidence

A total of 32 kiddings were recorded during the year. The highest kidding incidence was found in March and October (21.88%) followed by November (18.75%), January, February and April (9.38%).

Kidding incidence and sex ratio

A total of 32 kiddings were obtained from Sikkim local goats with a twinning and triplet incidence 34.38 and 3.13%, respectively. Out of 32 kiddings, 12 kiddings were first time kidding. The twin incidence was 16.67%. The overall sex ratio was 1:0.61. However, male and female ratio was slightly lower in twins (1:0.83) and slightly higher in triplets (1:0.50).

Reproductive performance of Sikkim local goats

Data on reproductive performance of Sikkim local goat was recorded during the study period. Gestation period, service period, inter-kidding interval, age at first service, weight at first service (kg), age at first kidding (d) and weight at first kidding (kg) were 145.59±0.39 days, 194.56±11.45 days, 254.86±17.26 days, 369.27±41.04 days, 15.74±0.35 kg, 511.27±37.55 days and 20.58±0.31 kg, respectively.

Productive performance of Sikkim local goats

The average body weight of male and female kids at birth was found to be 1.60±0.11 and 1.51±0.09 kg, respectively. The body weight at birth was highest in single male and female kids (1.81±0.04 and 1.74±0.05 kg) followed by twins male and female kids (1.56±0.08 and 1.63±0.10 kg). In twins, the body weight at birth was higher in female kids (1.63±0.10 kg) in comparison to male kids (1.56±0.08 kg). However, body weight at birth in triplet male and female kids was lower (1.43±0.15 and 1.16±0.00 kg). The average body weight at 3 months of age in male and female kids was 5.65±0.52 and 5.50±0.32 kg, respectively. The average body weight of single male kids was higher (6.40±0.08 kg) in comparison to twins and triplet kids. The body weight was lower in triplet kids. The litter size at birth was 1.41.

Biometrical performance of Sikkim local goats

The average body height, body length, hearth girth and abdominal girth in male kids at birth was recorded 23.58±0.56, 22.79±0.56, 23.21±0.67 and 23.17 cm, respectively and in female kids was 22.81±0.62, 22.56±0.61, 21.65±0.80 cm, respectively. The same parameters in male kids at 3 months of age were found to be 32.38±1.21, 32.08±0.83, 32.07±1.38 and 32.23±1.24 cm and in female kids 33.00±1.33, 31.14±0.88, 30.07±1.23 and 31.86±0.83 cm, respectively. The gain in body length, height, hearth girth and abdominal girth (cm) from birth to 3 months of age in male kids was 9.27±0.06, 9.80±0.04, and 8.86±0.06 and 9.06±0.05 cm and in female kids was found 8.56±0.04, 10.19±0.08, 9.06±0.06 and 9.42±0.07 cm, respectively.

ANIMAL NUTRITION

Evaluation of feeds and fodders of Sikkim in terms of their antimethanogenic activities

In-vitro fermentation study was conducted on twenty seven samples consisting of commonly available jungle grass and other plant species of medicinal or aesthetic use, vegetative parts of three major spices crops of the region, three aromatic plants, five tree fruits having medicinal values and eight commonly used species. Samples were incubated with fresh cow dung, buffered and fortified with minerals. Volume of total gas liberated during fermentation was recorded at various time intervals. The volume of carbondioxide and methane gas was estimated at the end of 96 hours of incubation period.

After 96 hours of incubation the volume of total gas, carbondioxide ranged from 30.8 to 111.1 cc/g and methane gas production varied from 21.5 to 183.8 cc/g sample on dry matter basis (Fig 8). Results showed a wide variability in gas production among samples after 24 hours of incubation. Methane production per gram sample fermentation was lowest about 2.8 to 3.2 cc/g in large cardamom (*Amomum* sp.), Buro okhati (*Astilde ridulari*) and one moss type (*Polytricum* sp.) followed by behra pulp (*Terminalia bellerica*), Ajwain

(*Trachysperimum copticum*) and bark of *Cinnamum* sp. However, the highest value (46.6 cc/g) was observed in Heing (Spices) followed by *Aloe vera* (31.3cc/g) and *Trigonella sp.* (28.6 cc/g).

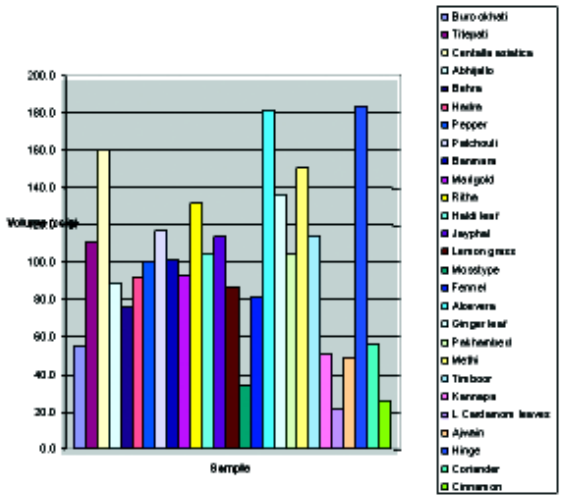


Fig 8 *In vitro* accumulated total gas after 96 hrs

In the samples with values varying from 5.82 to 14.48% for methane production was non- significant and the lowest values were in buro okati (*Astilde ridulari*) followed by Titepati (*Artemisia vulgaris*), *Centalla asiatica*, Abhijallo (jungle grass) behra pulp (*Terminalia bellerica)*, Hadra (*Terminallia chebula*), Black pepper, *Pogostemon patchouli*, *Eupatorium spp*, marigold leaves *(Cholendula officinalis*), Ritha (*Sopindus mulcorosis*), Haldi leaves (*Curcuma longa*), jayphal (*Myristica fragnonus*), Lemon grass (*Cymbopogon flexuosus*). The highest percent methane

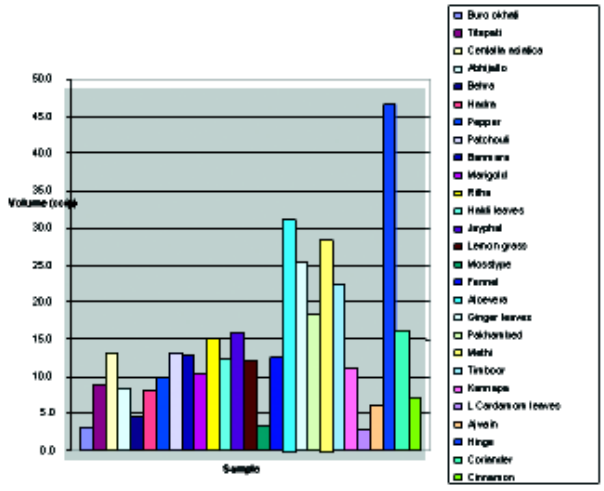


Fig 9 In vitro accumulated CH_4 gas after 96 hrs

production (41%) was found in bark of *cinnamum* sp. The level of methane production was about 5.8 to 14.5 % and carbon dioxide 58.9 to 79.5 % when oven dried samples were incubated with fresh cow dung inoculums for 96 hours.

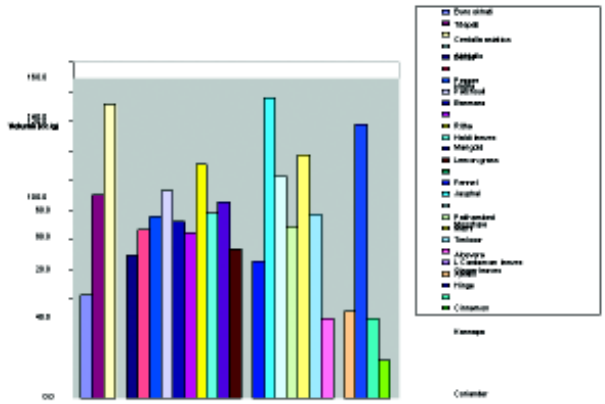


Fig 10 In vitro accumulated CO_2 gas after 96 hrs

ANIMAL HEALTH

Molecular characterization of *Salmonella* isolated from foods of animal origin

During the year 175 meat samples including chicken, chevon, pork, and beef were screened from the retail shops for the presence of *Salmonella* spp. Of the 175 samples comprising chicken (50), chevon (50), pork (50), and beef (25), screened for the presence of *Salmonella spp*., a total of 22 samples turned out to be positive for *Salmonella* spp, resulting in an overall incidence of 12.5%. Salmonella were recovered from 16% of chicken samples, 10% of chevon, 14% of pork and 8% of beef samples. All the isolates were confirmed as Salmonella by biochemical characterization (Table 5).

Table 5 Isolation of *Salmonella* spp. from different sources

Source	No of samples	No of samples + for Salmonella (%)
Chicken	50	8(16)
Chevon	50	5(10)
Pork	50	7(14)
Beef	25	2(8)
Total	175	22(12.5)

Antibiotic sensitivity testing of isolates showed significant resistance among the isolates. Most effective antibiotics were Colistin, Gentamicin and Ciprofloxacin

DNA fingerprinting and chemoprofiling of traditional ginger cultivars of North East India

Morphological characterization of 110 traditional collections of North east India has been evaluated for morphological characters in the field study at ICAR Sikkim centre. Protocol for DNA extraction has been standardized and molecular profiling of 110 collections of ginger was performed by RAPD. The essential oil of ginger was extracted and the oil samples were sent to Indian Institute of Integrative Medicine, CSIR, Jammu for chemo profiling. It was found that limalool content was maximum in NLG-3 (3.1%) followed by ASG-1 (2.33 %) whereas it was found least in ASG-3 (0.37 %) followed by ASG-5 (0.47 %).

Technology Mission-I

Prog 1 Production of nucleus/basic seed and planting material of horticultural crops

Table 6 Targets and achievements under programme 1

Crop	Target	Achieve-ment	Stock available	Sales proceed generated during April-September
Mandarin	10000	10000	10000	22500
Strawberry	20000	30000	30000	Nil
Passion fruits	1000	500	500	Nil
Kiwi fruits	500	300	300	Nil

Establishment of mother blocks for bud wood production during 2010-11

Citrus- New plantation established
Peach- Ready for bud wood production
Kiwi fruit- Ready for bud wood production

Establishment of rootstocks bank during 2010-11: Citrus- 750 nos.

Prog 2 Standardization of production and protection technologies

Standardization of package of practices of Peach under Sikkim condition

- Tatura training system in peach var. Shaan- e - Punjab gave a yield of 35 kg/plant in the 3rd year of plantation, whereas in modified leader system yield was 26 kg/plant.
- Leaf curl problem was organically controlled with the application of agro spray @ 1%.
- Pruning in the month of Dec-Jan gave good quality fruit with higher yield in peach var. Shaan-e-Punjab.

Standardization of package of practices of kiwifruit under Sikkim condition

- Pruning in the month of Dec-Jan and manure application in Nov-Dec gave better plant growth.
- Maximum of twenty three per cent success was recorded for the grafting of vines in kiwifruit.

Standardization of off season tomato and cole crop cultivation under polyhouse

- Tomato var. Anup performed better with the yield of 6.5 kg/plant.
- Cauliflower var. Girija performed better with the yield of 16.0 t/ha.
- Broccoli var. Aishwarya performed better with the yield of 8.0 t/ha.

Standardization of vermicompost production technology

Eisenia foetida and *Eudrillus euginea* are found effective converters. Twenty quintals of enriched vermocompost was prepared with bed methods.

Prog 3 Technology refinement and imparting training

Conducted six field level demonstration on improved production technology of Sikkim mandarin, protected cultivation of vegetables, improved production technology of vermicomposting and five trainings on improved orchard management of fruit crops.

Documentation, on-farm conservation of native and underutilized crops of Sikkim, promoting their cultivation by value addition, capacity building of farmers, in seed production and conservation of agro-biodiversity

FSAD-ICAR Collaborative Project under RKVY

Collection and maintenance of germplasm

Table 7 The germplasm maintained at ICAR Sikkim Centre

Crop	No. of collections	Crop	No. of collections
Food grains		**Vegetables**	
Rice	34	Chillies	37
Ragi	13	Pumpkin	19
Rayo saag	15	Cucumber	5
Yellow and brown sarson	10	Soybean	2
Pulses		Buckwheat	2
Black gram	55	Dolichus	7
French bean	48	Bottle gourd	5
Rajma	38	Bee	5
Rice bean	24	Radish	2

Evaluation of maize germplasm

Fourteen local maize germplasm were evaluated for cob characters and yield. The maximum seed yield/ m^2 was recorded in Seti Makai -1 and Sehrung (0.80 kg) followed by Paheli Makai-3 (0.70 kg), Paheli Makai-4 (0.65 kg), Putali Makai and Baiguney Makai (0.60 kg). Rato Makai -1 (0.50 kg), Tempo Rinzing, Kali Makai-2 and Rato Makai-1 had yield of 0.40 kg each followed by Paheli Makai-2 and Seti Makai-2 (0.35kg) and SP-2 (0.30kg). Paheli Makai-2 had the largest cob diameter (6.32cm). It was observed that SP-2 recorded maximum No. of cobs/plant (1.8), No. of rows/cob (14), and No. of kernels/row (592) while Seti Makai-1 and Putali Makai recorded 1.8 cobs/plant (Fig 11).

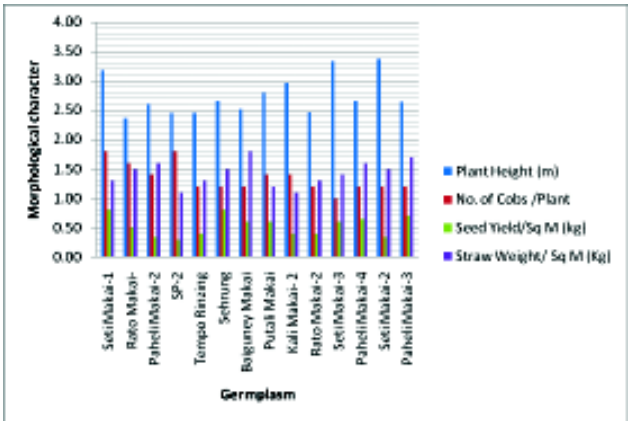


Fig 11 Growth and yield attributes of maize germplasm

Multi locational evaluation of Rayo Saag germplasm

A total of 15 varieties of local Rayo saag were planted at two different locations which also varied in the altitude. The two sites chosen were ICAR Sikkim Centre Farm, Tadong which is located at an altitude of 1350 mtrs and KVK Saramsa farm whose altitude is around 1125 mtrs. Transplanting was done in October in KVK and ICAR farm. Various morphological parameters were collected from both the sites and then compared. It was found that Chinese Saag recorded the highest total no. of leaves, with 46 leaves in KVK farm and 38 in ICAR Farm. RS-8 (8.33) and RS-9 (8.00) recorded the lowest no. of leaves/plant in ICAR and KVK farm, respectively. RS-1, RS-7 and RS-20 had almost the same values in both the sites. RS-16 showed a remarkable decrease in its no. of leaves when planted in KVK farm which was located in the lower altitude. The length of leaf was also recorded from both the sites. It was noted that Chinese Saag even though it had the highest no of leaves/plant; it also had the smallest leaves among all the local varieties. Its leaves had an average length of 17.51 cm and 17.96 cm in ICAR Farm and KVK farm, respectively. It was noted that change in the altitude did not have much effect on the length of the leaves as various varieties such as RS-4, RS-9, RS-19 and RS-21 had almost the same average leaf length in both the sites. RS-3 which was planted in the ICAR farm recorded the longest leaf (38.33 cm). The morphological parameter which showed the maximum difference in the data collected from the two sites was the total weight/plant. There was a marked decrease in the total weight of the plant in all the varieties which was grown in the KVK farm as compared to the ones grown in the ICAR farm. The difference could be seen when we compared the total weight/plant of RS-16 from both the sites. In ICAR farm it recorded 276.75 gm while in KVK farm it had a weight of 50.82 gm. From ICAR farm, RS-1 recorded the highest total weight/plant (279.45 gm), while the highest total weight/plant in KVK farm was of RS-9 (77.16 gm). RS-8 in both the sites had the minimum value with 135.18 gm and 30.38 gm which shows that this variety was not suitable for both the sites. Weight of single leaf was also evaluated. The Chinese Saag since it had the smallest leaves among all the local varieties also had the lowest weight of single leaf. It recorded 14.96 gm in ICAR Farm and 6.00 gm in KVK farm. It can be seen that there is a remarkable decrease in the values of the varieties planted in KVK farm. Comparative studies indicated that RS-7 of ICAR farm

had the highest weight of single leaf (43.44 gm). Apart from the Chinese Saag, RS-8 had lower weight in both the sites; it recorded 22.39 gm and 7.74 gm in ICAR and KVK farm, respectively. RS-4 with14.86 gm was the highest recorded weight of single leaf in KVK Farm. Almost all the varieties, upper and lower leaf colour was observed to be green and light green, respectively except RS-3 which had dark green with purple veins, RS-7 which had dark purple margin in the upper surface of the leaves and RS-8 which had purple colour in the upper surface of leaf with light purple colour in its lower surface. Serrated leaves with prominent leaf lamina were observed in all the varieties. RS-8 had pubescence in upper and lower surface of leaves whereas all the other varieties had smooth upper and lower leaf surface.

Evaluation of French bean

Among 22 IC and 18 EC collections of French bean, IC-199265 and IC-199246 had the highest values of pod length and diameter. IC- 199265 had pod length of 18.16 cm and its pod diameter was 11.26 mm. IC-199246 had 14.44 cm and 11.67 mm as its pod length and diameter, respectively. EC-530910 had the shortest pod length (8.83 cm) whereas EC-530909 had the smallest pod diameter (8.66 mm). Highest plant height was recorded in EC-328394 (218.33 cm) followed by IC-199277 and IC-262840 with 216.66 cm each, on the other hand, IC-199268 had the shortest plant (61.67 cm). Apart from the aforementioned morphological parameters, other characters were also recorded which include weight of pod, yield etc. IC-202497 had the maximum no of seeds/pod (7.34) which was followed by IC-199265 (7.33). With 3.34, IC-199268 and IC-265907 recorded the minimum no. of seeds/pod. Weight of pod was also noted; IC-199265 had the highest weight/pod (10.2 gm) followed by IC-262840 which had 7.83 gm. With just 0.96 gm, IC- 278579 had the lowest weight of pod among the entire collections of French bean. Highly significant difference was observed among the germplasm line under evaluation for yield parameters. IC-265935 recorded the highest yield of 155.2 q/ha, IC-199277 recorded 106.62 q/ha which was followed by EC-328394 (45.34 q/ha). IC-204751 had the lowest yield of 1.36 q/ha. White coloured flower was observed in IC-265907 whereas IC-199242 had purple colour flowers. The rest of the collections had flower colour ranging from Light purple pale type to white pale type. Few collections also had white dwarf and cream pale type.

Evaluation of Rajma

Various morphological data were collected among the 34 available varieties of Rajma and a comparative evaluation was done. The various parameters taken into consideration included plant height, pod length, pod diameter, yield etc. It was observed that SKR-33 had the highest plant height among the evaluated varieties which was 236.66 cm. It also had the highest pod diameter (27.13 mm). SKR-50 had the second highest plant with 228.37 cm plant height. The shortest plant was recorded in SKR-15 which had the height of 38.00 cm. SKR-2 and SKR-23 followed the SKR-33 in pod diameter with 13.96 mm and 13.33 mm, respectively. R6 recorded the smallest pod diameter with 7 mm. Upon observing the pod length, it was found that SKR-48 had the longest pod (18.8 cm) and the second longest pod of 16.9 cm was recorded for SKR-13. SKR-4 had the shortest pod (9.1cm). R-48 recorded the highest yield of 95.00 q/ha, following it with 67.60 q/ha was Kailash which recorded the second highest yield among the Rajma varieties. SKR-48 and SKR-13 had the lowest yield with 1.92 q/ha and 3.30 q/ha, respectively. Highest pod weight was found in R-15 (8.76 g) and Kanchan (8.1 g) whereas the lowest pod weight was recorded in Kailash (1.56 g). For the parameter, no. of seeds/pod, SKR-54 had the highest with 7.66; following it were R-19, R-6, R-48, R-29, SKR-48 with 7.33 each. Cream coloured flower was found in R-48 and Kanchan variety. R-19, R-28, R-26, SKR-67, SKR-5, SKR-18, SKR-21, R-15, SKR-54, SKR-59, SKR-13, SKR-44 and SKR-48 had white coloured flower whereas the remaining varieties had shades of purple and pink as its flower colour.

Evaluation of Rice bean

Nine collections/accessions of Rice bean was evaluated in which SKM RB-5 gave the highest yield of 41.76 q/ha, followed by SKM RB-14 (25.44 q/ha) and SKM RB-8 (19.78 q/ha) while the lowest yield was recorded in IC-176563 (3.42 q/ha), followed by Mizoram RB-1 (8.64 q/ha) and Manipur RB-1(9.69 q/ha). Grey seed colour was observed for SKM RB-5, Manipur RB-1 and Mizoram RB-1 while the other collections showed only cream coloured seeds. Bold seeds were found in RC-18181 (11.00 g/100 seed) followed by IC-176563 (12.00 g/100 seed), SKM RB-14 (14.20 g/100 seed) and SKM RB-8 (14.20 g/100 seed). Earliest flowering was found in IC-176563 (148 days to 50% flowering) whereas late flowering was observed in Mizoram RB-1(172 days to 50% flowering).

Network project on management of soft rot of ginger

Ginger is one of the second most important spice crops of Sikkim. It is affected by many diseases. Among them, soft rot is a major disease causing heavy yield loss to the farmers. Survey and surveillance was conducted at different districts of the Sikkim state *viz.*, Aho Yangtham, Sajong, Rey, Assam Lingzey, Pacheykhani, Sirwani, Ranka, Rumtek of East Sikkim, Ravangla and Soreng of West Sikkim, Dzongu, Heeygyathang, Pashingdong and Lingdong of North Sikkim and Namchi, Namthang, Karekbusty, Palitam, Lalshore, Lower Temi of South Sikkim. In 2009 survey, North Sikkim was free of disease infestation however, in 2010, the disease was seen in almost all the fields of the four districts. The disease incidence ranged from 10- 70%.

Disease diagnosis showed the prevalence of soft rot along with bacterial wilt and *Fusarium* yellow in the same field. The causal agent of soft rot *Pythium* spp. was isolated and sent for identification. The fungus has been confirmed as *Pythium* spp. The fungus produced coenocytic mycelium and sporangia. The bacteria *Ralstonia solanacearum* was also isolated and identified as the cause of bacterial wilt in ginger. A *Trichoderma* spp. was isolated from ginger field and identification is yet to be done upto species level.

Sustainable utilization of mountain fisheries resources

Representative water samples and data were collected periodically from various streams, rivers, natural lakes, Govt. fish tanks and farmer's fish ponds and tanks situated at varying altitude about 702 to 14000 ft amsl. Fish samples were collected through fishing with the help of hired fisher man and also procured from the local market (Fig 12). Meteorological parameters such as humidity and wind velocity, air and water temperature were recorded to identify agro climatic condition of the sampling site. The torrential streams of Sikkim have shallow clear cold water in the foothills. The frequency of fish species found in the river during sample collection by gill net fishing in the river tributaries was mostly *Neolisocheilus hexagonolepsis, Schizophorax progastus, S. richardsonii, Garra gotyla, Gara annandalei* and *Balilius* sp.

Fig 12 Collection of fish samples

The average air temperature observed irrespective of altitude was 9.1 - 22.4^0 C and water temperature recorded for river and at farm tank /pond was 3.3 to 4.2^0 C. The pH of water from various streams and rivers during Apr to Jun and Jan to Feb was 7.7 to 8.5 where as in the month of Jul and Aug pH was about 7.29 to 8.02. Comparatively lower pH value was observed when precipitation and runoff water was more. The lowest DO level, 2.93 mg / l, was recorded in the hot spring. However, the level of DO varie from 4.3 to 5.8 mg / l during Jul and Aug and 5.0 to 11.9 mg / l in the month of Apr, Jun, Jan and Feb. The average DO level in river water was 7.4 ± 2.0 mg /l measured during the reporting period. In Himalayan water, its maximum concentration remains near 100 mg/L in normal conditions. However, the TDS observed was 29.0 ± 12.3 mg/l in river water and 17.3 ± 6.2 mg/l in natural lakes. In river water the average value for Ca ions was 4.3 ± 2.3 mg/L, Mg was 9.4 ± 4.6 mg/L and Cl was 5.3 ± 3.1 mg/L and hardness was 14.1 ± 5.1mg/ L. the water in natural lakes contained Ca 3.2 ± 0.8 mg/L, Mg 5.7 ± 0.9 mg /l and Cl 4.1 ± 1.1 mg/L, and the hardness recorded was 8.9 ± 1.1 mg/L.

The percent availability of different species varied from one stream to another depending upon altitude, water temperature, water current and depth of water. The pH value was found environmentally suitable. Higher DO level at some places may be due to discharge of organic matter or sewerage into the river.

Poultry Seed Project

In order to establish poultry seed unit and to promote poultry production in the region the project work at ICAR farm premises was initiated in a temporary shed on deep litter system. At present, the construction works in all the three units, layer shed, brooder shed and hatchery, has been completed. Necessary implements for raising parent stock have been made available. Arrangements were made to procure incubators for hatching chicken eggs. Two number of Setter each with fifteen thousand (15,000) eggs loading capacity and one hatcher has been procured and installation has been completed. Miscellaneous necessary equipments and implements have been procured and some of them are under process.

Three hundred day old chicks, Vanaraja, for parent stock procured from Technology Transfer and Marketing Unit, PDP, Hyderabad during December 2009 are being maintained. Surplus male birds and females showing deficiency symptoms were separated and sold out. Further, total 600 nos. day old parent stock of Vanraja and Grampriya, 300 each have been procured in the month of December 2010 and are being raised to replace the old parent stock. Standard feeding and management with proper vaccination practices are being followed with the existing flock. During reporting period a total 6956 nos. of hen lay eggs was produced.

Total revenue collected during the reporting period was Rs 252818/- only. Poultry Seed Unit is ready for hatching eggs and arrangements are being made to hatch first batch of day old chicks during April 2011.

All India network programme on Gastrointestinal parasitism (GIP) in goat

Agroclimatic zone and animal-wise prevalence of gastrointestinal helminthes

A total of 6564 animals were examined during the study period. An overall prevalence of 37.32 % helminthic infestation was observed. Among the different animals examined, the occurrence of GI helminthic infestation was found to be higher in goats (63.67 %) than that of cattle (30.45 %) and yaks (8.12 %). The mixed infestation of trematode, cestode and nematodes with coccidian oocysts were found higher in goats than in other animals. The mean epg value was also higher in goats as compared to cattle and yaks. The prevalence of GI-helminthes was higher in subtropical and high humid zone (46.17 %) followed by temperate and humid area (39.41 %) as compared to subalpine low humid zone (22.66 %) and alpine dry area (7.59 %).

Month-wise prevalence of gastrointestinal parasites in goat, cattle and yaks in Sikkim

The helminthic infestation was higher during the month of June to October with the peak in August (79.52 %) in goats and cattle (37.59 %) as compared to yaks. This may be due to high rainfall and favourable temperature (26-27^0 C), which is congenial for the development of parasitic infestation. Monthly evaluation of the data revealed that strongyles especially *Haemonchus* was the most prevalent parasite in all three animals throughout the year in Sikkim.

Severity of gastrointestinal nematodiasis in goats, cattle and yaks as measured by epg in different months in Sikkim

The intensity of infestation in terms of eggs per gram of feaces (epg) ranged from 100-4500 in goats, 100-700 in cattle and 100-400 in yaks. The maximum epg in goats was recorded in the month of October (mean epg value 3600.50). In cattle, the intensity was maximum in the month of August to November (100-700), whereas in yaks, mean epg of 50.50 was found in the month of October. This indicated that during North- East monsoon maximum animals used to get infestation with various GI-helminthes in the pasture.

Study of prevalence of gastrointestinal parasites through faecal culture and pasture larval count in Sikkim

Pooled infested faecal samples of goat, cattle and yaks from various places were cultured for larval composition. Infested cultured larvae were separated using Bayermanns apparatus. The larvae were identified under light microscope and identified as *Haemonchus* spp., *Bunostomum, Nematodirus* and *Oesophagostomum*, spp., in all the zones in Sikkim.

One kilogram of grass with soil was collected bi-monthly from various pastures located at different district in Sikkim. The pasture larval count was assessed by standard procedure and was expressed as mean larval count per kilogram of grass. Maximum contamination of pasture with third stage larvae was recorded in the month of August to October. *Haemonchus contortus* and *Oesophagostomum* was the predominant species followed by *Bunostomum*, *Nematodirus* and *Trichostrongylus* sp.

Prevalence of gastrointestinal helminthes in goats as determined by necropsy examination

Of the 56 GI-tract of goats examined, helminthic infestation with an overall prevalence of 62.50 % were found. Among the various endoparasites, nematodes (60.71 %) were found higher followed by trematodes (33.92 %) and Cestodes (28.57 %). Among nematodes, *Haemonchus* spp. was predominant (60.71 %) followed by *Oesophagostomum* (39.28 %), *Bunostomum* spp. (32.14 %), *Nematodirus* spp. (19.64 %), *Trochostrongylus* spp. (16.07 %) and *Trichuris* spp. (14.28 %). Average worm burden (200.12- 277.21) was higher in the month of Jun- Aug followed by the month of Nov (220.54).

Season -wise prevalence of gastrointestinal helminthes in goat, cattle and yaks in Sikkim

Out of the four seasons, significantly higher helminthic infestation was observed during summer (June-August) in goats (74.05 %) and spring in cattle (36.80 %) and yaks (18.68 %). Comparatively low infestation was observed during winter (42.18 % in goats) and 20.62 % in cattle and 11.79 % in spring in yaks. Mixed infestation of trematode, cestode, nematode and coccidian oocysts were observed during all the seasons in Sikkim. The mean epg value was higher in monsoon and post-monsoon season in goats and cattle than spring and winter. The highest mean epg values of yaks were seen in autumn (50.50) as compared to spring (18.68).

Bioclimatograph of *Haemonchus* and *Trichostrongylus* spp

To see the effects of temperature, rainfall and relative humidity, bioclimatograph were prepared in which total rainfall (TRF) was plotted against the maximum temperature (Tmax) for *Haemonchus contortus* and average RH was plotted against Tmin (for *Trichostrongylus* spp. and *Nematodirus filicolis*) for each month and the resultant points were joined by a closed curve. On these graphs, lines indicating the limits of climatic conditions most suitable for development, survival and dissemination of pre-infective stages of GIN were superimposed. Based on published information the limits of suitable climatic conditions were taken as total monthly RF to the tune of 50 mm or more with average monthly Tmax ranging from 18 to 37°C for *H. contortus* and same rainfall with temperature ranging from 6 to 20°C for *Trichostrongylus*. The RH considered for optimum development of parasites was >50%.

Field progeny testing of frieswal bulls for genetic improvement, collection of semen and cryopreservation

A total of 2602 nos. of semen straws of 16 different bulls viz., -WAM 331 Kenu, NPK 341 Shyam, CLK 341 Ram , CJH 429 Tora, CLK 332 Ankit, WAM 334 Dona, SP 403 Naj, CMT 390 Seth, NPK 430 Shiv, CLK 346 Shanti, CLK 54 6 Ajju, WAM 554 Dara, CK 399 Harsh, CK 317 Nitin, CMT 525 Nahar and CMT 364 Zumka of Frieswal breed were collected from Project Directorate on Cattle, Meerut on three different dates i.e. 13th January, 2010, 21st September, 2010 and 9th March, 2011. Cryopresevation of semen straws have been maintained with regular checking of LN2 level in various cryocans and also evaluation of sperm under microscope on monthly basis.

Table 8 Prevalence of gastrointestinal parasites during April 2010-March 2011

Animal		Total
Goat	**Sample examined**	**2078**
	Positive	1323 (63.67)*
	Mean EPG	1650.50
	EPG Range	100-4500
	Trematode	197 (9.48)
	Cestode	790 (38.07)
	Nematode	1222 (58.81)
	Mixed infections	895 (43.07)
Cattle	**Sample examined**	**3415**
	Positive	1040 (30.45)
	Mean EPG	75.65
	EPG Range	100-700
	Trematode	148 (4.33)
	Cestode	470 (13.76)
	Nematode	937 (27.44)
	Mixed infections	624 (18.27)
Yak	**Sample examined**	**1071**
	Positive	87 (8.12)
	Mean EPG	30.50
	EPG Range	100-400
	Trematode	13 (1.21)
	Cestode	44 (4.11)
	Nematode	76 (7.10)
	Mixed infections	38 (3.55)

*Figures in parentheses indicates percent positive

Semen distribution

As per the registration of the farmers in Sikkim, distribution of semen straws have being made more in East District compared to rest of the districts, equal distribution to South and West districts and a bit less to North district. (Table 9)

Artificial insemination, pregnancy diagnosis and calf born

As per the registration of farmers of Sikkim, Artificial Inseminations (AI) of breedable cattles are going on. All together 1428 numbers of Artificial Insemination have been conducted in all the four districts of Sikkim up to the month of March, 2011.

Table 9 District wise distribution of semen straws

Bull Name & Bull No.	East	West	South	North	Total
Kenu331	75	75	75	75	300
Shyam341	75	75	75	75	300
Ram341	75	75	75	75	300
Tora429	75	75	75	75	300
Ankit332	80	50	50	30	210
Dona334	20	20	20	10	70
Naj403	20	20	20	10	70
Seth398	20	20	20	10	70
Shiv430	20	20	20	10	70
Shanti346	20	20	20	12	72
Ajju546	50	30	30	20	140
Dara554	50	30	30	20	140
Harsh399	50	30	30	20	140
Nitin317	50	30	30	20	140
Nahar525	50	30	30	20	140
Zumka364	50	30	30	20	140
Total	780	630	630	502	2602

Accordingly, Pregnancy diagnosis of almost 379 animals has been confirmed till March, 2011. Besides, a total of 47 numbers of calving have taken place during the reporting period and out of which 21 nos. are female (Table 10). Average conception rate of 40-42% (approx) was recorded after 1st insemination.

Table 10 Progeny confirmation and total calving against the total nos. of AI conducted

Bull Name/Bull No.	Set No	Total Number of AI		Pregnancy rate		Total calving			
		Current month	Total	Current month	Total	Normal		Female calves Born	
						Current month	Total	Current month	Total
RamCLK347	1st	5	244	13	85	6	13	2	6
ShyamNPK341	1st	6	222	9	88	9	16	5	8
ToraCJH429	1st	6	202	7	87	3	7	1	4
KenuWAM331	1st	8	270	8	85	4	11	1	3
AnkitCLK332	1st	11	98	2	6	-	-	-	-
DonaWAM334	1st	16	59	2	4	-	-	-	-
Naj SP403	1st	25	53	2	2	-	-	-	-
SethCMT398	1st	13	113	4	14	-	-	-	-
ShivNPK430	1st	19	55	3	3	-	-	-	-
ShantiCLK346	1st	15	50	5	5	-	-	-	-
AjjuCLK546	1st	14	14	-	-	-	-	-	-
DaraWAM554	1st	7	7	-	-	-	-	-	-
HarshCK399	1st	23	23	-	-	-	-	-	-
NitinCK317	1st	7	7	-	-	-	-	-	-
NaharCMT525	1st	8	8	-	-	-	-	-	-
Zumka CMT364	1st	3	3	-	-	-	-	-	-
Total		186	1428	55	379	22	47	9	21

Table 11 Details of registered farmers and registered animals with average milk yield

Sl. No	Name of the district	Total no. of farmers	Total no. of animals	Total no. of each type of animal under mentioned			Average Milk yield /animal/day (liters)		
				Local	JC	HF	Local	JC	HF
1	EAST	566	1200	188	723	289	2	7	8
2	WEST	280	600	60	492	48	2	5	8
3	NORTH	270	600	375	220	05	1.5	6	7
4	SOUTH	265	600	60	525	15	2.5	5	7
TOTAL		1381	3000	683	1960	357	2.0	5.75	7.5

Milk sampling: A total of 21 milk samples were collected from all over the state of recently calved cows inseminated with Frieswal bull semen and thus it was found to contain the following parameters on an average; milk fat: 3.54%±0.285 ; SNF: 8.625%± 0.0947; protein: 3.35%±0.1622 ; lactose: 4.77%± 0.051.

IMPORTANT EVENTS AND VISITORS

Prof. M. J. Modayil, Hon'ble Member ASRB

Hon'ble member of Agricultural Scientists Recruitment Board (ASRB) Prof. M. J. Modayil visited the ICAR Sikkim centre (Fig 13). Prof Modayil stressed on the need to undertake quality research work having direct influence on the farming community. He said that there is ample opportunity for young Scientists working in North Eastern states to develop their career. He applauded the facilities generated in the institute to carry out quality research work.

Fig 13 Prof. M. J. Modayil interacting with the scientists

Interactive workshop on Biopesticides

Prof. A.K Mukhopadhyay, Hon'ble RAC Chairman of ICAR Research Complex for NEH Region, Umiam, Meghalaya and ex-Vice Chancellor, Assam Agricultural University, Jorhat visited ICAR Sikkim center on 13th Nov. 2010 (Fig 14). He took a note of the research activities going in the institute and stressed upon the need to adopt various bio-rational approaches for management of pest and diseases. He inaugurated one day worksop on "Biorational Management of Pests and Diseases of Major crops with special reference to Large Cardamom" in which he gave an elaborative lecture on "Use of *Trichoderma* as a biological control agent".

Fig 14 Interactive workshop on Biopesticides

IGNOU sponsored farmers' training programme organised

ICAR Sikkim Centre, Tadong organised farmers' training programmes on important emerging areas like "**Marketing of agricultural produce**" (5-6 July, 2010) and another on "**Dairy farming"** (7-9 July, 2010) sponsored by ICRTA, IGNOU Regional Centre, Agartala for developing awareness and disseminating the knowledge and skill about the innovative technology among the farming community (Fig 15). The training programme on "**Dairy farming"** was inaugurated by Shri T. N. Takkarpa, Hon'ble Minister for FSAD and HCCD, Govt. of Sikkim as the Chief Guest. In his address Hon'ble Minister, highlighted the potential avenues for the farmers of the state in

Fig 15 Trainees in the Dairy farming training

different fields like food processing, spices preservation, value addition, dry flower, cut flower business in addition to dairy farming to make the agriculture more sustainable leading to livelihood security.

Group Meeting of Network Project on Management of Soft rot of Ginger

The second group meeting of Network Project on Management of Soft Rot of Ginger was organized at ICAR Research Complex for NEH Region, Sikkim Centre, Tadong, Gangtok on December 7, 2010 (Fig 16). The meeting was attended by representatives from all the coordinating centers like ICAR, CAU and YSPUHF. Dr. N.P. Dohroo, Joint Director of Research and PI of the project, Dr. Y.S. Parmar University of Horticulture & Forestry, Nauni, Solan (HP) in his speech, highlighted achievements of the project made so far and expressed satisfaction over the work done by the various centers. He stressed to exchange the isolated Trichoderma cultures amongst the centres. He also emphasized on the non chemical methods of disease control like hot water treatment and use of extract of botanicals like Lantana, Agave, Onion, Garlic etc.

Fig 16 Participants of the group meeting on soft rot of ginger

Scientific Advisory Committee (SAC) of KVK, Ranipool organised

Scientific Advisory Committee (SAC) meeting of Krishi Vigyan Kendra, ICAR Research Complex for NEH Region, Sikkim Centre, Rainipool was held on 6th July, 2010 at 10.30 a.m. at KVK, Ranipool under the Chairmanship of Dr. H. Rahman, Joint Director, ICAR Sikkim Centre, Tadong to review the activities of KVK and prepare its future action plan. Suggestions and recommendations were given by the honorary members after thorough review of the KVK activities (Fig 17).

Fig 17 Meeting of SAC of KVK

Interactive Workshop on Technology Backstopping in Sikkim

A state level Interactive workshop on Technology Backstopping in Sikkim was organised at ICAR Research Complex for NEH Region, Sikkim Centre, Tadong, Gangtok on 13th August 2010 with an objective to discuss about the suitable technological backstopping for agricultural development of Sikkim and to provide strategic recommendations for the KVKs and line departments for effective implementation of the technical programmes. Shri K.K. Singh, Principal Director, Deptt. of HCCD, Govt. of Sikkim and Shri S.K. Sinha, Principal Director, Deptt. of F S & AD, Govt. of Sikkim attended the workshop as invited guests. Besides, scientists and specialists from ICAR, all the four KVKs and line departments of Sikkim participated in the workshop as delegates.

Tripura

WEATHER REPORT

The average rainfall recorded during 2010-11 was 2645.8 mm indicating 20% increase as compared to the long term average annual rainfall of 2200 mm. The average monthly maximum and minimum temperature recorded were 30.9^{0}C and 20.5^{0}C, respectively (Table 1).

RICE

Rice Improvement Programme

Five entries were nominated to IVT trials in AICRP during 2010. The entries were TRC 2008-1 (IET 22167), TRC 2008-2 (IET 22221), TRC 2008-3 (IET 22111), TRC 2008 – 4 (IET 22112) and TRC 2008 – 5 (IET 22113). Four entries, except TRC 2008 – 2, performed very well in the trials. TRC 2008 – 4 (IET 22112) ranked 1st in IVT IME in national yield average (5576 kg/ha). TRC 2008-3 (IET 22111) ranked 5th in national average (5139 kg/ha) in IVT IME. TRC 2008 – 1 (IET 22167) ranked 3rd in all India average (4906 kg/ha).

AICRP on Rice Improvement

Five trials in *kharif* 2010 and one trial in *boro* 2010-11 were conducted at this centre. Due to limited availability of paddy lands at the centre all trials except boro 2008-09 were conducted on farmers' plot.

Table 1 Meteorological data of Lembucherra

Month	Rain fall (mm)	Evaporation (mm)	Temperature		Wind speed (kmph)	Wind direction (deg)	
			Max ^{0}C	Min ^{0}C		Morn	Even
Apr	218.1	139.7	34.1	24.5	3.1	W	NW
May	671.6	130.8	33.4	24.5	1.9	W	NW
Jun	494.7	103.9	32.4	25.1	2.6	SW	SW
Jul	314.7	129.2	32.9	25.8	1.7	SW	NW
Aug	266.5	125.2	32.7	25.4	0.9	SW	W
Sep	320.3	117.0	32.6	24.9	0.9	SW	NW
Oct	232.7	117.9	31.8	24.2	0.3	SW	NW
Nov	0.0	113.3	29.8	18.8	0.2	SW	NW
Dec	53.6	93.2	25.7	12.0	1.7	266	NW
Jan	0.0	98.7	23.7	9.0	1.5	W	NW
Feb	0.0	108.3	29.6	14.5	3.1	SW	NW
Mar	73.6	140.9	33.0	18.0	5.5	SW	NW

Conti..

Month	Sun shine (Hr)	Relative humidity (%)		Soil temperature (^{0}C)					
		Morn	Even	Morning			Evening		
				5 cm	10 cm	20 cm	5 cm	10 cm	20 cm
Apr	6.2	77	63	26.7	27.9	29.3	38.8	36.1	33.5
May	5.5	79	66	26.8	28.0	29.2	37.4	35.3	32.9
Jun	2.0	82	75	26.8	27.6	28.6	32.5	38.3	30.1
Jul	4.4	86	70	26.8	27.9	29.0	35.2	33.5	32.1
Aug	4.4	85	73	27.3	28.7	30.0	35.8	34.2	32.8
Sep	3.6	84	70	26.7	28.1	29.5	35.0	33.6	32.4
Oct	6.9	82	72	25.7	27.1	28.5	32.7	33.1	31.9
Nov	6.8	69	73	22.9	24.9	26.8	32.8	31.4	30.2
Dec	6.3	60	69	18.1	20.0	22.0	28.1	26.2	24.8
Jan	5.2	64	73	14.9	16.6	18.6	24.9	23.1	20.6
Feb	7.0	72	73	18.8	20.4	21.8	18.8	20.4	21.8
Mar	5.4	66	69	23.5	25.3	26.6	23.5	25.3	26.6

Table 2 Performance of TRC 2008 -3 in IVT IME 2010

Characters	Region	TRC 2008-3 (IET 22111)	NC (IR 64)	RC	LC	Yield adv (%) over NC/RC/LC
Grain yield kg/ha regional means	R2	4870	4515	5104	4342	16.83
	R3	4675	4119	4122	3870	12.96
	R4	4833	3700	3993	4419	
	R5	6012	5146	5322	5648	12.28
	Mean	5139	4400	4580	4577	National Rank: 5th

Table 3 Performance of TRC 2008 -4 in IVT IME 2010

Characters	Region	TRC 2008-4 (IET 22112)	NC(IR 64)	RC	LC	Yield adv (%) over NC/RC/LC
Grain yield kg/ha regional means	R2	4931	4515	5104	4342	26.72
	R3	5328	4119	4122	3870	21.75
	R4	4923	3700	3993	4419	
	R5	6537	5146	5322	5648	21.83
	Mean	5576	4400	4580	4577	

Table 4 Performance of TRC 2008 -5 in IVT IME 2010

Characters	Region	TRC 2008-5 (IET 22113)	NC (IR 64)	RC	LC	Yield adv (%) over NC/RC/LC
Grain yield kg/ha regional means	R2	5060	4515	5104	4342	10.34
	R3	4497	4119	4122	3870	6.00
	R4	5020	3700	3993	4419	
	R5	5121	5146	5322	5648	6.07
	Mean	4855	4400	4580	4577	

Table 5 Performance of TRC 2008 -1 in IVT Late 2010

Characters	Region	TRC 2008-1 (IET 22167)	NC (IR 64)	RC	LC	Yield adv (%) over NC/RC/LC
Grain yield kg/ha regional means	R3	4552	4359	4740	4382	12.03
	R4	4760	6376	5523	4820	6.58
	R5	5419	3399	4007	4350	10.07
	Mean	4906	4379	4603	4457	

BMGF – STRASA (Bill & Mellinda Gates Foundation Project – "Stress Tolerant Rice for Poor Farmers in Africa and South Asia)

Activities during 2010

Upland Rice Shuttle Breeding Network (URSBN)
Drought Breeding Network (DBN)
Participatory Variety Selection (PVS)
Seed production and dissemination of *sub1* seed

Trials conducted under Upland Rice Shuttle Breeding Network (URSBN) 2010

AYT 80-100 RNFHF (Rainfed High Fertility)

In Advanced Yield Trial (AVT) 80-100 days duration under rainfed high fertility yield levels ranged from as low as 430 kg/ha to 2923 kg/ha. Plant height of the entries ranged from 79 cm to 133 cm. Harvest index ranged from 0.13 to 0.46. The entries ranged from 57 days to 79 days to reach 50% flowering (Table 6).

Table 6 Summary statistics for measured traits: AYT 80-100 RN FHF

Variate	Minimum	Maximum	Mean	Std. dev.	CV (%)
Days to 50% flowering	57	79	67.2	4.6	3.19
Plant height (cm)	79	133	105.8	9.2	6.95
Yield (kg/ha)	430	2923	1491	610.5	30.6
Harvest index	0.13	0.46	0.29	0.08	14.1
Biomass/plot (g)	400	1093	689	142.6	19.9
Lodging (%)	0	33	5.3	12.2	
Days to harvest	90	113	101	4.6	2.1
No. of panicles / m^2	145	339	248	40.7	26.4

Variety RR 616 –B – 2 – 75 – 2 produced highest yield (2923 kg /ha) in this trial. The entry was 107 cm tall and required 71 days to reach 50% flowering. This was followed by RR 616 – B – 2 – 54 – 1 (2733 kg / ha), which was 100 cm tall and required 67 days to flower (Table 7).

AYT 80-100 RNFLF (Rainfed Low Fertility)

A total of 56 entries were tested under Alpha Lattice experimental design and replicated twice. The seed rate was 60 kg / ha with a spacing of 20 cm between rows under direct seeding condition. Fertilizer dose applied was 20:10:10 kg NPK/ha (Table 8).

Table 7 Performance of top 10 entries in AYT 80-100 RN FHF

Entries	Days to 50 % flowering	Height (cm)	Grain yield (kg/ha)	HI	Biomass (g)	Lodging (%)	Days to harvest	Panicles/ m^2
RR 616-B-2-75-2	71	107	2923	0.42	807	0	105	272
RR 616-B-2-54-1	67	100	2733	0.39	861	0	103	320
IR 84900-B-150-CRA-23-1	74	102	2597	0.43	673	0	109	219
RR 646-B-93-6-B-3	71	106	2493	0.38	827	0	101	226
IR 78908-193-B-3-B	70	98	2353	0.37	815	0	104	256
RR 617-B-47-3	70	98	2328	0.35	887	0	105	223
RR 617-B-3-3	75	100	2267	0.31	995	0	108	159
IR 84898-B-171-CRA-43-1	71	99	2250	0.36	789	0	105	231
BAU 446-06	74	107	2203	0.36	799	0	108	249
RR 616-B-2-75-1	67	118	2070	0.31	874	0	99	223
LSD (*P*=0.05)	4.35	18.63	762.6	0.56	246.2		2.3	21.8
CV (%)	3.19	6.95	30.6	14.1	19.9		2.1	26.4

Table 8 Summary statistics for measured traits in AYT 80-100 RNFLF

Variate	Minimum	Maximum	Mean	Std. dev.	CV (%)
Days to 50% flower	70	78	73	1.8	2.79
Plant height	72	125	103	10.1	9.4
Yield (kg / ha)	333	1854	970	368.3	29.5
Harvest index	0.13	0.41	0.29	0.07	13.6
Biomass/plot (g)	276	858	539	136.9	24.2
Lodging (%)	0	58	11	10.1	
Days to harvest	106	111	108	1.2	3.1
No. of panicles / m^2	110	359	245	57.4	21.1

In the low fertility trial RR 616-B-2-75-1 was the highest yielder (1854 kg / ha), which was 107 cm tall and required 72 days for flowering. This was followed by IR 82635-B-B-47-1 (1812 kg/ha) (Table 9).

OYT HF (Observational Yield Trial High Fertility)

A total of 84 entries were tried under alphalattice design. A seed rate of 60 kg/ha with row spacing of 20 cm was used. Direct seeding with a fertilizer dose of 60:30:30 kg/ha was used. Large variation was observed in yield of entries in this trial. Yield ranged from 258 kg to 4767 kg/ha, with the mean yield of trial 2017 kg/ha. Harvest index ranged from as low as 0.07 to 0.45. Plant height ranged from 61cm to 141cm (Table 10).

In OYT highest yield was produced by IR 83929-B-B-100-2, which produced 4766 kg/ha. This was followed by IR 83928-B-B-9-1, which produced 4237 kg/ha (Table 11).

Table 9 AYT 80-100 RNFLF Performance of top 10 entries

Entries	Days to 50 % flowering	Height (cm)	Grain yield (kg/ha)	HI	Biomass (g)	Lodging (%)	Days to harvest	Panicles/ m^2
RR 616-B-2-75-1	72	107	1854	0.39	705	0	109	304
IR 82635-B-B-47-1	71	110	1812	0.34	858	0	108	242
IR 82635-B-B-88-2	75	82	1542	0.38	609	15	111	210
IR 82589-B-B-7-2	73	117	1500	0.41	566	0	108	338
IR 82635-B-B-23-1	73	120	1479	0.30	843	0	108	308
IR 82589-B-B-84-3	73	101	1437	0.34	682	13	107	268
NDR 1131	73	113	1417	0.31	722	0	108	259
RR 646-IR 79971-B-12-B	73	94	1375	0.30	723	10	108	359
TRC-87-251	71	101	1333	0.35	589	30	108	325
IR 82639-B-B-70-4	75	100	1333	0.36	637	20	110	243
LSD (*P*=0.05)	3.67	21.2	917.4	0.06	231.4		2.34	19.3
CV (%)	2.79	9.4	29.5	13.6	24.2		3.1	21.1

Table 10 Summary statistics for measured traits in OYT HF

Variate	Minimum	Maximum	Mean	Std. dev.	CV (%)
Plant height (cm)	61	141	106	14.1	3.4
Yield (kg/ha)	258	4767	2017	919.4	33.1
Harvest index	0.07	0.45	0.28	0.08	5.9
Biomass/plot (g)	130	1170	582	161.0	17.2
Lodging (%)	0	40	9	12.5	
No. of panicles / m^2	60	644	337	97.0	22.6

Table 11 OYT HF Performance of top 10 entries

Entries	Height (cm)	Grain yield (kg/ha)	HI	Biomass (g)	Lodging (%)	Panicles/ m^2
IR 83929-B-B-100-2	87	4766	0.43	740	0	460
IR 83928-B-B-9-1	102	4237	0.41	730	0	523
IR 82635-B-B-25-4	103	3992	0.40	717	0	453
JDP-377-3-DGI-8	82	3875	0.38	745	0	471
IR 82589-B-B-2-2	98	3592	0.41	620	0	326
IR 82635-B-B-75-2	110	3342	0.45	490	0	323
IR 83928-B-B-56-1	111	3250	0.32	815	0	454
IR 82589-B-B-138-2	95	3175	0.39	595	0	377
IR 82589-B-B-51-4	97	3117	0.40	575	0	328
IR 82635-B-B-47-2	108	3100	0.38	610	0	294
LSD (*P*=0.05)	7.8	989.7	0.05	211.8		62.8
CV (%)	3.4	33.1	5.9	17.2		22.6

Trials conducted under Drought Breeding Network (DBN)

- AYT GT 120 Control
- AYT GT 120 REPST
- AYT GT 120 RNFSS
- OYT (Trial failed , data not reported)

AYT GT 120 control

A total of 56 entries were tried under alphalattice design. Seedlings per hill used were 2 with row spacing of 20 cm. Transplanting with a fertilizer dose of 80:40:40 kg/ha was used. The results of the trials are presented in table 12.

Highest yield in this trial was produced by IR 83376-B-B-24-2 (4115 kg/ha), which was 96 cm tall and flowered in 92 days. However, no other entry could surpass the check entry Lalat, which produced 3889 kg/ha (Table 13).

AYT GT 120 REPST

A total of 56 entries were tried under alphalattice design. Seedling per hill used were 2 with row spacing of 20cm was used. Transplanting with a fertilizer dose of 80:40:40 kg/ha was used. The results of the trials are presented in table 14.

Table 12 Summary statistics for measured traits in AYT GT 120 (control)

Variate	Minimum	Maximum	Mean	Std. dev.	CV (%)
Days to 50% flower	84	116	91	2.6	2.1
Plant height (cm)	76	134	98	13.7	6.7
Yield (kg/ha)	1194	4115	3175	689.2	28.4
Harvest index	0.36	0.48	0.45	0.02	6.8
Biomass/plot (kg)	0.34	0.77	0.61	0.11	22.7
No. of panicles /m^2	142	375	283	54.3	18.9

Table 13 AYT GT 120 control performance of top 10 entries

Entries	Days to 50% flowering	Height (cm)	Grain yield (kg/ha)	HI	Biomass (g)	Panicles/m^2
IR 83376-B-B-24-2	92	96	4115	0.5	0.8	300
LALAT	91	99	3889	0.4	0.8	375
IR 83377-B-B-42-3	93	86	3842	0.5	0.7	320
SWARNA	116	118	3822	0.5	0.7	371
IR 83387-B-B-125-2	92	86	3794	0.5	0.7	331
IR 83387-B-B-110-1	92	101	3746	0.5	0.7	285
IR 83373-B-B-25-3	90	92	3732	0.5	0.7	289
IR 83387-B-B-40-1	92	89	3707	0.5	0.7	281
IR 83388-B-B-108-3	87	89	3619	0.5	0.7	313
CPMB IR 20-110-238	92	134	3597	0.5	0.6	364
LSD (*P*=0.05)	3.13	10.42	1477.15	0.05	0.23	89.4
CV (%)	2.1	6.7	28.4	6.8	22.7	18.9

Table 14 Summary statistics for measured traits in AYT GT 120 REPST

Variate	Minimum	Maximum	Mean	Std. dev.	CV (%)
Days to 50% flower	80	116	89	8.4	0.8
Plant height (cm)	102	167	125	13.8	1.0
Yield (kg/ha)	669	2547	1723	470.4	26.7
Harvest index	0.08	0.40	0.29	0.07	18.2
Biomass/plot (g)	705	1633	845	180.3	18.4
No. of panicles / m^2	170	310	213	34.1	7.6

The same entries when subjected to reproductive stage drought stress, the highest yield level came down to 2547 kg/ha. Highest yield was produced by IR 82870-11, which was 147 cm tall and flowered in 90 days. No other entry could surpass the local check Naveen (Table 15).

AYT GT 120 RNFSS

A total of 30 entries were tried under alphalattice design. Seedlings per hill used were 2 with row spacing of 20 cm. Transplanting with a fertilizer dose of 80:40:40 kg/ha was used. The results of the trials are presented in table 16.

In rainfed drought stress highest yield was produced by Swarna (3303 kg/ha), followed by IR 83376-B-B-24-2, which produced 3089 kg /ha, flowered in 88 days and had plant height of 126 cm. Naveen was 3rd highest yielding entry in this trial (Table 17).

Table 15 AYT 120 REPST performance of top 10 entries

Entries	Days to 50% flowering	Height (cm)	Grain yield (kg/ha)	HI	Biomass (g)	Panicles/m²
IR 82870-11	90	147	2547	0.4	783	275
Naveen	90	122	2437	0.4	705	179
IR 84882-B-118-CRA-40 A-1-1	90	130	2399	0.4	747	186
IR 83387-B-B-110-1	92	135	2356	0.3	917	219
IR 83373-B-B-25-3	91	134	2222	0.4	733	195
IR 75417-R-R-R-R-267-3	90	121	2154	0.3	884	263
IR 83377-B-B-42-3	88	117	2143	0.4	739	191
IR 83387-B-B-125-2	83	112	2141	0.3	818	204
IR 83387-B-B-27-4	90	105	2072	0.4	717	174
SWARNA	114	117	2038	0.3	933	186
LSD (*P*=0.05)	1.3	2.0	757.6	0.09	254.9	26.6
CV (%)	0.8	1.0	26.7	18.2	18.4	7.6

Table 16 Summary statistics for measured traits in AYT GT 120 RNFSS

Variate	Minimum	Maximum	Mean	Std. dev.	CV (%)
Days to 50% flower	80	116	90	8.5	1.0
Plant height (cm)	102	168	126	14	1.3
Yield (kg/ha)	1156	3303	2280	523.6	33.5
Harvest index	0.26	0.39	0.31	0.03	11.6
No. of panicles / m²	161	280	212	28.1	13.9

Table 17 AYT 120 RNFSS Performance of top 10 entries

Entries	Days to 50% flowering	Height (cm)	Grain yield (kg/ha)	HI	Panicles/m²
SWARNA	115	117	3303	0.3	239
IR 83376-B-B-24-2	88	126	3089	0.3	264
Naveen	92	125	3014	0.4	251
IR 80461-B-7-1	87	123	2822	0.4	241
IR 75417-R-R-R-R-267-3	92	124	2811	0.4	244
IR 83387-B-B-110-1	92	139	2789	0.3	232
IR 83388-B-B-108-3	89	127	2778	0.3	212
IR 83387-B-B-40-1	90	111	2739	0.3	222
IR 84882-B-118-CRA-40 A-1-1	91	131	2739	0.3	221
BVD 203	91	143	2639	0.3	236
LSD(*P*=0.05)	1.44	2.66	1246.9	0.06	48.14
CV (%)	1.0	1.3	33.5	11.6	13.9

DISEASES

Influence of host resistance on the incidence of sheath blight disease in Tripura.

The rice genotypes *viz.*, NDR-97, Ful Badam, Garomaloti, Bati, Aduma, TRC-87-251, IC-504177, IC-540237, IC-504249**,** IC-540179, IC-526713, RCPL 1-115, RCPL 1-117, RCPL 1-114, RCPL 1-46, RCPL 1-116, RCPL 1-113, MTU-7029, Bhalum-1 and Bhalum-2 were evaluated. The field plots were inoculated with *Rhizoctonia solani* inoculum. The genotypes, RCPL-114, Aduma, Bhalum-1 and IC-50429 showed certain level of resistance with disease score of 1-2 in 0-9 rating scale.

This study was also done under pot conditions to further confirm the resistance against sheath blight disease under controlled condition giving the same amount of inoculum and similar environment. Results indicated that the smaller spots in genotypes Aduma (6.3 cm) and RCPL-115 (4.4 cm) were in agreement with their resistance in field.

Efficacy of biocontrol agents in minimizing sheath blight disease

This study was done in two steps. In the first step, the efficacy of different biocontrol agents was evaluated *in vitro* on petri plate medium with the use of cell free extracts, while, in the second step they were evaluated in field condition.

***In vitro* evaluation**

The effect of biocontrol agents *viz.*, *Trichoderma viride* (Guard, Amit biotech, Howrah), *T. viride* (Nagaland, personal collection), *T. viride* (ICAR, Tripura, personal collection), *T. viride* (Rubber Board, Tripura, personal collection), *T. harzianum* (Assam, personal collection) were studied in dual culture along with rice sheath blight pathogen i.e. *Rhizoctonia solani* grown on PDA medium. The isolates were identified from Indian Type Culture Collection Centre, IARI, Pusa, New Delhi. Both *T. viride* and *T. harzianum* of various companies and localities behaved differently against sheath blight disease. All the isolates of both the species showed hyperparasitization *in vitro*. *T. viride* isolates which were collected from Rubber Board and Amit biotech showed additional effect of antibiosis (Fig 1).

Field evaluation

Different biocontrol agents collected from various sources and isolated from soils were evaluated with

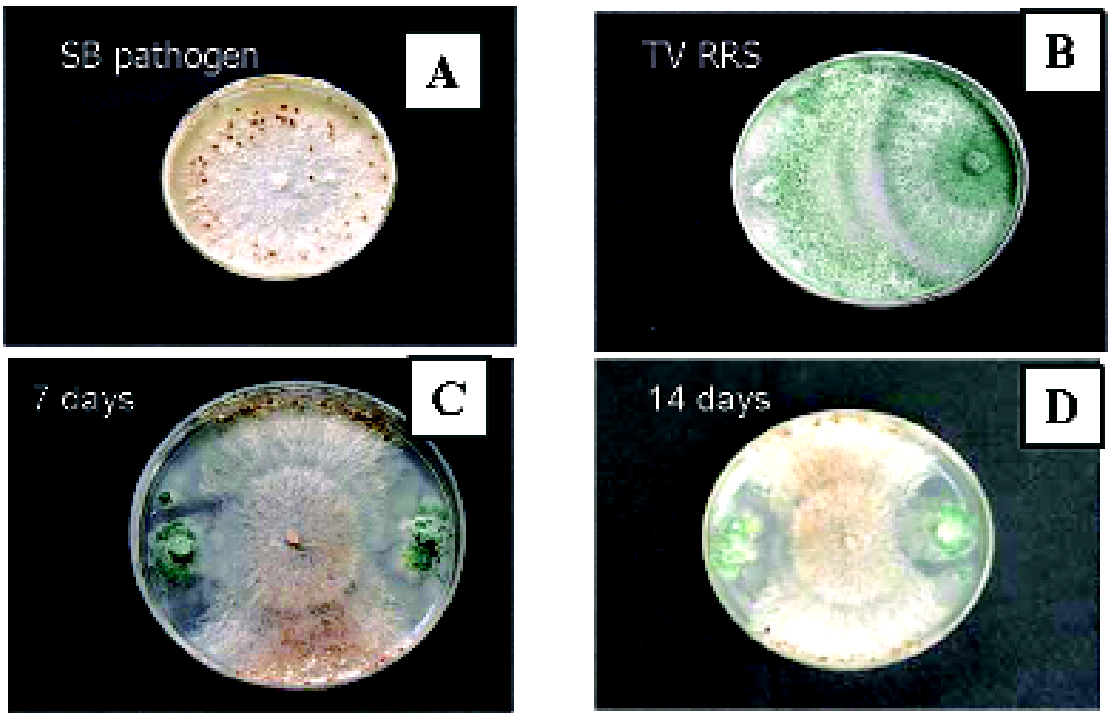


Fig 1 *Trichoderma viride* showing both hyperparasitization and antibiosis effects on *Rhizoctonia solani*. A. Sheath blight pathogen (control); B. *T. viride* showing hyperparasitization; C. *T. viride* showing antibiosis after 7 days of incubation; D. *T. viride* showing antibiosis after 14 days of incubation

the rice variety TRC-27-251. The results indicated that different strains of *Trichoderma viride* and *T. harzianum* were effective in minimizing the disease slightly when applied both in soil along with FYM @ 50 g culture in rice grain medium/ plot and as foliar spray @ 5% solution of 2×10^8 formulation in field.

Evaluation of fungicides to control sheath blight disease

Seven fungicides *viz.*, Carbendazim 0.05%, Chlorothalonil (0.2%), Mancozeb (0.2%), Benomyl (0.1%), Tricyclazole (0.1%), Hexaconazole (0.025%) and Propiconazole (0.025%) were tested in field which was inoculated by sheath blight pathogen spreading inoculum of *Rhizoctonia solani*. Under field condition, all the fungicides except mancozeb were effective in minimizing the disease. The effect was more promising with both propiconazole and hexaconazole, although, these two fungicides showed toxic effects by decreasing the plants' height.

OILSEEDS

GROUNDNUT

Evaluation of recently released varieties of groundnut

Fourteen varieties of groundnut *viz.,* ICGS-76, GG-2, GG-13, TG 37 A, FeESG-10, FeESG-8, K-134, GG-6, SB XI, GG-11, Kaushal, GG-4, GG-2 and GG-8 were grown. The fertilizers NPK (40:60:50) in combination with cow dung (5 t/ha) were applied. It was observed that the no. of pod and seed weight in groundnut varied form 9.40 to 16.96 and 4.77 to 21.22 g /plant, respectively. The groundnut variety producing the highest pod yield was GG-11 followed by GG-2, GG-13, ICGS-76 and GG-8.

Nutrition of bold seeded groundnut in acid soils

The experiment on nutrition of groundnut var. GG 7 was carried out with the treatments *viz.*, T_1- control, T_2- P_{50}, T_3- K_{100}, T_4-lime (2.5 t/ha), T_5-P_{50} + lime, T_6-P_{50} + K_{100} + Lime , T_7- P_{50} +K_{100} + Lime +13 kg boric acid/ha, T_8- P_{50} + K_{100} + lime + cowdung 10 t /ha. It was seen that the treatment T8 [application of phosphate (50 kg P_2O_5 /ha), potash (100 K_2O /ha), lime (2.5 t/ha) and cowdung (10 t/ha)] produced the highest pod yield of 0.42 t /ha with 27.83 no of pods and 40.53 g pod /plant.

Evaluation of germplasm and advance breeding lines of groundnut

Screening of groundnut germplasm against the soil acidity condition was carried out with 46 no of germplasm lines. The line NRCG 11276 recorded the highest seed wt /plant (10.67g). No of pods /plant was highest (21.66) in NRCG-5001.

Evaluation of core collection of groundnut germplasm for their performance in acid soils of NEH region

Sixty core collections of groundnut germplasm were evaluated for their disease reaction under natural conditions of Tripura. The diseases like leaf spot, rust, wilt/stem rot were found during *kharif* season. During this year, leaf spot disease appeared in all the genotypes of core collection with high intensity. However, its intensity was comparatively less in genotypes like NRCG 12174, NRCG 201, NRCG 12478, NRCG 12393, NRCG 12297, NRCG 12339, NRCG, 11693 NRCG 11985 and NRCG 12968 ranging from 3-5 score in 1-9 scale, both under fertilized and unfertilized conditions. Rust was more in the genotypes NRCG 10564, NRCG 11942 and NRCG 11236 in comparison to others.

Effect of micronutrient on bold seeded groundnut variety in acid soil.

The experiment on nutrition of groundnut var. GG 7 was carried out with the treatment M_1- control, M_2-$ZnSO_4$, M_3- Ammonium molybdate, M_4-boric acid, M_5-ammonium molybdate + boric acid; M_6- $ZnSO_4$ + boric acid. The productivity parameters are presented in Table 18. It is indicated from the table that the treatment combination M_3 could produce the highest pod weight /plant (29.43g), seed weight (17.55g) and no of seeds/ plant (39.32).

Initial varietal trial

Eleven varieties *viz.,* INS-I-2010-3, INS-I-2010-7, INS-I-2010-8, INS-I-2010-23, INS-I-2010-20, INS-I-2010-9, INS-I-2010-25, INS-I-2010-1, INS-I-2010-11, INS-I-2010-18 and INS-I-2010-6 were grown. The fertilizers (NPK 40:60:50) in combination with cow dung (5t/ha) were applied. The highest pod and seed wt./plant *i.e.* 15.94 g and 10.21 g, respectively were recorded in INS-I- 2010-5. Among test varieties, the no of pods and seed weight in groundnut varied from 1.00 to 11.49, 1.00 to 15.94, and 1.00 to 10.21 g /plant, respectively.

Table 18 Productivity parameters of groundnut in response to micronutrients

Treatments	No. of pods/plant	Pod weight (g/plant)	Seed weight (g/plant)	No of seeds /plant	Shelling percent
M_1- control	10.210	8.73	5.66	18.99	64.83
M_2	16.310	14.99	7.66	30.54	51.10
M_3	16.663	29.43	17.55	39.32	59.63
M_4	24.867	19.54	8.43	24.54	43.14
M_5	13.867	9.18	4.77	12.43	51.96
M_6	9.643	8.96	3.21	8.88	35.82
SEM (±)	3.48	2.008	0.53	1.16	26.39
CD (*P*= 0.05)	1.95	1.47	0.76	1.12	5.37

Groundnut in various intercropping option

Groundnut variety GG7 was grown in intercropping (2:2) with rice, sesamum, cowpea and maize. The NPK dose applied was 40:60:50 kg/ha in combination with cow dung (5t/ha). Treatment combinations were N_1- rice sole crop, N_2-sesamum sole crop, N_3-maize sole crop, N_4-groundnut sole crop, N_5 – groundnut : rice (2:2), N_6 - groundnut : sesamum (2:2), N_7 – groundnut : maize (2:2). The highest yield (1600 kg/ha) was recorded in N_5 treatment.

Evaluation of recently released varieties of groundnut under acid soil in NEH region

Seven recently released varieties were evaluated during *kharif* season for their performances under acid soils in NEH Region. The results revealed that leaf spot disease was comparatively low in GG-20 and ICGS-76 with disease scores 5.1 and 5.63 in 1-9 scale. While, the varieties like GG-5, GG-7, FeESG-8 and FeESG-10 showed high leaf spot disease incidence (disease score: 8.0 – 8.33). The rust was not found in any of the varieties. As regards the stem rot disease (*Sclerotium rolfsii*), both GG-20 and ICGS-76 showed some tolerance.

PULSES

VARIETAL IMPROVEMENT

Pulses Improvement

The following activities are ongoing under pulses improvement programme.

- Breeding superior varieties of pulses for NEH Region.
- AICRP on MULLaRP (Urdbean, Mungbean, Fieldpea, Lentil, Rajmash).
- Biodiversity & Integrated Gene Management Program (BIGMP) – Legume International Testing Program-Nurseries.
- SAARC Shuttle Breeding Project on Pulses.
- Identification of superior genotypes of lentil for utera condition in Tripura.
- Front Line Demonstrations.

AICRP on MULLaRP

In total 11 trials (IVT, AVT1 and AVT2 were conducted on mungbean, urdbean, fieldpea and lentil during the period under report.

SEED PRODUCTION

The rice seed produced is given in Table 20.

Table 19 Status of breeding lines in pulses

Crop	No. of genotypes developed	No. of genotypes nominated to AICRP	No. of genotypes identified / promoted by AICRP for satisfactory performance in one or more state	No. of genotypes sent to CVRC and SVRC	No. of varieties released by CVRC or SVRC
Field pea	230	2	TRCP – 8 and TRCP – 9 both qualified for VIC proposal in 2009	TRCP – 8 released by CVRC	TRCP – 9 for submission to SVRC is made ready
Greengram	678	2	—	—	—
Blackgram	6	—	—	—	—
Lentil	F3 and F5 nurseries from ICARDA are under selection				

Table 20 Production of Truthfully labeled (TL) seed on farmer's field

Variety	Quantity (kg) of TL Seed produced
TRC 2005-1	2600
TRC 2005-2	2200
MTU 1010	80
TRC 2008 -1	230
Swarna sub1	620
Sambha Mahasuri *sub1*	190
IR 64 *sub1*	35
Sahbhagi	175

FIELD PEA

Evaluation of released field pea varieties in Tripura for resistance against wilt disease

Five varieties of pea namely TRCP 8, TRCP 9, DMR 7, Rachana and IPFD 1 were evaluated during *rabi* season (2010-11) for resistance against *Fusarium* wilt. Among the varieties, the disease was highest in TRCP 9 and least was observed in Rachana.

Effect of bioagents for the control of wilt in field pea

Three different bioagents *viz.*, *Trichoderma viride*, *Pseudomonas fluorescens* and *Bacillus subtillis* were applied @ 100 g /12 m^2 plot along with cow dung manure during field preparation. In addition, the bioagents were sprayed @ 5 g /L on foliage after 30 days of sowing. It was found that amongst the three bioagents tested, *T. viride* showed some effect in minimizing the disease.

Efficacy of fungicides for the management of wilt in pea

Three different fungicides namely Chlorothalonil (2.5%), Mancozeb (0.2%) and Carbendazim (0.1%) were applied both as soil drenching and as foliar spray. All the test fungicides had some effects in minimizing the disease. However, amongst them, carbendazim was the most effective in minimizing the disease.

INTEGRATED NUTRIENT MANAGEMENT IN DIFFERENT CROPS

Tree species, *Gliricidia maculata, Indigofera tinctoria* and *Tephrosia candida* were raised on the terrace riser and green leaf (10 t/ha) with 50% before sowing of the crop and 50% as leaf mulch were applied in the crops grown on the terrace. The productivity of the crops after the application of green tree leaf is stated below:

(i) Green gram

Application of green leaf from *Indigofera tinctoria* increased the productivity of green gram (var. Ratna) from 381 to 1163 kg /ha over fertilizer application and on the other hand, leaf from *Tephrosia candida* produced the rise in pod yield from 875 to 1000 kg/ha (Table 21).

(ii) Sesamum

The productivity of sesamum (var. B-67) was also increased substantially from 540 to 1120 kg/ha and 481 to 1044 kg/ha after the application of leaf from *Indigoferra* and *Tephrosia* as compared to fertilizer application (Table 22).

Table 21 Effect of tree leaf application on productivity of green gram

Treatment	*Indigoferra*		*Tephrosia*		*Gliricidia*	
	Pod (kg/ha)	Seed (kg/ha)	Pod (kg/ha)	Seed (kg/ha)	Pod (kg/ha)	Seed (kg/ha)
Fertilizer without leaf (20:40:20)	381	194	875	531	875	551
Green tree leaf (10 t /ha)	1163	700	1000	619	570	343
Mean	772	447	938	575	722	447

Table 22 Effect of tree leaf application on productivity (kg/ha) of sesame

Treatment	*Indigoferra*		*Tephrosia*		*Gliricidia*	
	Seed	Haulm	Seed	Haulm	Seed	Haulm
Fertilizer without leaf (40:20:20)	540	1820	481	1775	653	2313
Greed tree leaf (10 t /ha)	1120	2054	1044	2562	387	2875
Mean	830	1937	762	2169	520	2594

(iii) Maize

Production of high quality protein maize (var. HQPM -1) was also increased after the application of tree leaf and the highest rise in yield was recorded (65 %) by the application of *Indigoferra* as compared to only fertilizer (Table 23).

Table 23 Effect of tree leaf application on productivity (t/ha) of maize

Treatment	*Indigoferra*	*Tephrosia*	*Gliricidia*
Fertilizer without leaf (80:40:40)	1.60	4.77	3.82
Green tree leaf (10 t /ha)	2.64	4.72	3.68
Mean	2.12	4.75	3.75

(iv) Radish

Leaf sources from *Indigoferra* and *Gliricidia* enhanced radish (var. Ivory white) yield from 27.5 to 41.3 t/ha and 49.4 to 55.0 t/ha over fertilizer (Table 24).

Table 24 Effect of tree leaf application on productivity (t/ha) of radish

Treatment	*Indigoferra*	*Tephrosia*	*Gliricidia*
Fertilizer without leaf (60:50:50)	27.5	56.3	49.4
Greed tree leaf(10 t /ha)	41.3	56.3	55.0
Mean	34.4	56.3	52.2

(v) Toria

The productivity of toria (var. TRC-1-1-5-1) increased from 733 to 775 kg/ha, 619 to 906 kg/ha and 346 to 806 kg/ha after the application of 3 different leaf sources as compared to fertilizer (Table 25).

Table 25 Effect of tree leaf application on seed yield (kg/ha) of toria

Treatment	*Indigoferra*	*Tephrosia*	*Gliricidia*
Fertilizer without leaf (50:40:40)	733	619	346
Greed tree leaf (10 t /ha)	775	906	806
Mean	754	763	576

(vi) Carrot

Leaf source from *Indigoferra* increased the carrot (var. King Kuroda) yield from 11.9 to 20.6 t/ha as compared to two other leaf sources (Table 26).

Table 26 Effect of tree leaf application on productivity (t/ha) of carrot

Treatment	*Indigoferra*	*Tephrosia*	*Gliricidia*
Fertilizer without leaf (50:40:40)	11.9	10.9	13.9
Greed tree leaf (10 t /ha)	20.6	14.3	14.4
Mean	16.3	12.6	14.2

Effect of INM on crop productivity

An experiment was conducted in sesamum and thereafter upland rice (var. NDR-97) was raised to find out the residual effect. It is indicated that ½ NPK + Manure + PSB could 84 % increase in yield of sesamum and 48 % increase in production of upland rice grown in-residual nutrients.

HORTICULTURE

Table 27 Production of nucleus/basic seed and planting materials

Crop	Target	Achievement	Stock available as on 31 March 2011
a) Fruits: Mango (graft)	5000	6700 4300 Amrapali & 2400 Himsagar	3600
Papaya seedling	—	1000 seedlings & 900g seed	We are capable to produce more 50000/ seedling if demand is there
Mosambi (sweet orange) budded	1500	4000 root stock prepared for budding	670
Rangpur lime seedling	2500	3500	3000
Banana (suckers)	3000	3300	3260
Pineapple (suckers)	35000	20000	20000
b) Tuber & Spices crops			
Black pepper		2000	2000
c) Floricultural items			
Tube rose (Bulb)	100000	40000	

Table 28 Development of Horticulture based farming system in Tripura

Crops	Area (m^2)	No. of plant
Mango (var. Amrapali)	6240	350
Aonla (NA-10, NA-4, NA-5, NA-7, Chakaiyya,Kanchan	1440	90
Bael (NA-6,NA-5,NA-9 and Tripura local)	720	45
Sweet orange (Mosambi)	200	50
Karonda	200	75
Litchi	2032	127

Table 29 New plantations created under horticulture based farming system

Mango / Variety	No. of plants	Mango / Variety	No. of plants
Chausa	15	Thai	15
Maldai Langra	15	Bombai	15
Totapuri (Bangalora)	15	HB -13	15
Vastara (Baramasi)	15	Ratna	15
Golabkhash	15	Mallika	20
Alfanso (Badami)	20	Siraj Tara (Baramasia)	15
Dasheri	35	Total	225
Guava / Variety	**No. of plants**	**Pomegranate/ Variety**	**No. of plants**
KG	7	Nagpuri	15
L- 49 (Sardar)	30	Bhagooa	15
Arkamol	15	Ber / Variety	
Baruipur local	15	Red Gol	15
Sweta	5	White	15
Lalit	5	Rose apple/Variety	
RCG -1	5	Calcuttai red	15
RCG - 7	5	Calcuttaia white	15
RCG – 11	10	Phalsa/Variety	
RCG – 6	5	Baruipur local	15
Allahabad Safeda	25		

Organic farming approach in pineapple

- New plantation created on an area of 1400 sq. m. for study on organic approaches in pineapple.
- Plantation of approximate 7000 suckers are completed.
- Various organic sources used include Poultry manure, FYM, *Gliricidia* leaves, VAM as Rhizogold, Annapurna, *Azospirlum* and *Azotobacter*.
- Plant height (95 cm) and fresh weight of D leaf (105g) was higher in Annapurna followed by *Gliricidia* leaves.
- Significant effect of organic sources on fruit weight over control was observed.

Standardization of production technologies for high value vegetable cultivation

The following trials were conducted —

- Management of shoot and fruit borer in Brinjal
- Standardization of production technology of capsicum under open, shed net, poly house and organic mode.
- Response of different fertilizer doses and spacing on broccoli.
- Effect of organic inputs on lettuce.
- Effect of organic input on beet root.
- Effect of organic input on carrot.
- Effect of different organic inputs on Pak-choi under Tripura condition.
- Effect of different organic inputs on Chinese cabbage under Tripura condition .
- Organic inputs on Basil (Sweet tulshi) under Tripura condition.

Management of shoot and fruit borer in brinjal

- The experiment was conducted with an objective to control of shoot and fruit borer in Brinjal (var. Bholanath and Singnath) under mechanical barrier

Fig 1 Flowering in Amrapali in 2011, 5 year old plants at Cocotilla farm

(net) and pheromone trap with treatments *viz.*, sanitation, bio-pesticide (Kalichakra) @ 2.5gm/L., chemical (Flubendamide) @ 1ml/L and all possible combinations.

- The data was taken regarding the shoot and fruit borer infestation and yield attributes at 15 days interval.
- After completion of 2 years trial it was found that under the mechanical barrier (net) condition shoot and fruit borer infestation was significantly lesser than under open condition with pheromone trap (Fig 2 & 3).
- Mechanical barrier coupled with sanitation and application of Flubendamide can give reasonable control from brinjal shoot and fruit borer.

Fig 2 Full grown brinjal plant under mechanical barrier

Fig 3 Full grown brinjal plants under open condition

Standardization of production technology of Capsicum under open, shed net, poly house and organic mode in Tripura

The experiment was conducted with an objective to standardize agro-techniques of Capsicum under open, shade net, net house and organic mode in Tripura. Performance of three varieties of capsicum *viz.*, Orebelle, Bomby and Indra with different treatments *viz.*, spacing, different organic, inorganic fertilizers and spraying of plant hormone NAA @ 50ppm under open, shed net and polyhouse was tested over 2 years. The data were recorded on yield and yield attributes. All the 3 varieties performed better under the open condition and performance was significantly better with spacing of 60 X 30 cm and fertilizer dose of 150:100: 225 (NPK) kg/ha (Figs 4 & 5)

Fig 4 Capsicum under different growing conditions under the project

Fig 5 Different coloured varieties of capsicum

Response of different fertilizer doses and spacing on broccoli

Considering the increasing importance of brocoli in the state the trial was conducted for standardizing production technologies for brocoli in Tripura. The trial consisted 3 fertilizer doses (N:P:K 100:80:100, 120:100:120 & 140:20:140) and 2 spacings on 2 varieties: Everest (Fig 6) and Aishwariya (Fig 7). It was observed that greater spacing 60 x 60 sq. cm with highest dose of fertilizer in Everest showed highest curd weight (535 g) and in Aishwariya greater spacing 60 x 60 sq. cm with fertilizer dose of 100: 80: 100 produced highest curd weight (604 g). Aishwariya appears to be more suitable variety under Tripura condition. Physical appearance of the curd also makes this variety more preferred.

Fig 6 Everest

Fig 7 Aishwariya

Effect of organic inputs on lettuce

The experiment was conducted with an objective to evaluate the performance of Lettuce under different organic inputs (variety –Ice berg & Revolution). The organic inputs were farm yard manure, vermicompost, poultry manure and Glyricidia leaf and the dose of inputs were 5 t/ha, 10 t/ha and 15 t/ha of each inputs. The data were taken on yield and different yield attributes. It was been found that poultry manure @ 10 t/ha produced maximum yield with average weight of 900 gm/head (Fig 8).

Fig 8 Lettuce under different organic inputs

Effect of organic inputs on beet root

The experiment was conducted with an objective to evaluate the performance of different organic inputs in beet root. The organic inputs were Farm yard manure (FYM), vermicompost, poultry manure and Glyricidia leaf @ 5 ton, 10 ton and 15 t/ha of each input and the data were taken on yield and different yield attributes. It was found that poultry manure @ 15 t/ha produced maximum yield with an average weight of 121.78g/ root, followed by Glyricidia leaf @ 15 t/ha.

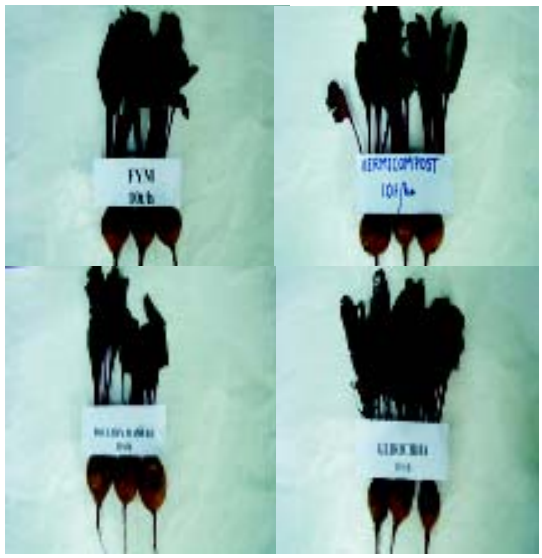


Fig 9 Effect of organic inputs on beat root

Effect of organic inputs on carrot

The experiment was conducted with an objective to evaluate the performance of carrot under different organic inputs. The organic inputs were farm yard manure, vermicompost, poultry manure and Glyricidia leaf and the doses of inputs were 5 t/ha, 10 t/ha and 15 t/ha of each inputs. Vermicompost @ 15 t/ha showed maximum yield with average weight of 58.78 g/root, followed by 55.95 g/root in 5t/ ha of FYM.

Effect of different organic inputs on Pak-choi under Tripura condition

Three organic inputs *viz*., Farm Yard Manure, Vermicompost, Poultry manure, Glyricidia leaf were tried. The doses were 5 t/ha, 10 t/ha, 50% of 5 t/ha, 50% of 10 t/ha and all their possible combinations. It was found that combination of 50% FYM 10 tones + 50% vermicompost 10 t/ha produced the maximum yield (Figs 10).

Fig 10 Pak-choi under organic inputs

Effect of different organic inputs on Chinese cabbage under Tripura condition

Four organic inputs *viz*., Farm Yard Manure, Vermicompost, Poultry manure, Glyricidia leaf were tried. The doses were 5 t/ha, 10 t/ha, 50% of 5 t/ha, 50% of 10 t/ha and all their possible combinations. It was found that combination of 50% FYM 10 tones + 50% vermicompost 10 t/ha produced the maximum yield (Fig 11).

Organic inputs on Basil (Sweet tulshi)

Three organic inputs *viz*., i) Farm Yard Manure, ii) Vermicompost, iii) Poultry manure, iv) Glyricidia leaf were tried. The doses were 5 t/ha, 10 t/ha, 50% of 5 t/ ha, 50% of 10 t/ha and all their possible combinations.

Fig 11 Chinese cabbage under organic input

It was found that combination of 50% FYM 10 tones + 50% vermicompost 10 t/ha produced the maximum yield.

PLANT PATHOLOGY

TOMATO

Influence of host resistance on the incidence leaf curl disease

Fifteen genotypes including 3 hybrids were sown in rows with earlier detected susceptible variety, BT-1, as infector row at every 4th row. Three replicates were kept in all cases, except BT-1. The disease was studied after 55 days of transplantation. It was found that all the tested genotypes were more tolerant than BT-1. However, the disease was least amongst the hybrid in Trishul and amongst the varieties in Tura Local with 46.67% and 49.44% disease, respectively. Considering the yield, the hybrids, Trishul and All rounder, and the varieties, CKVT-17, H-24, S-22 were better than others.

Effect of bio-pesticides on the control of leaf curl disease

The experiment was carried out with BT-1 tomato variety. Commercial neem oil (0.1%), neem leaf extract (10%), neem twig extract (10%) and control (without spray) were used as spray in 2 × 2.5 m plot. The biopesticides were sprayed four times at 10 days interval and disease was studied on 55 days after transplantation. It was seen that none of the materials was effective in minimizing the disease.

Effect of chemical pesticides on the control of leaf curl disease

The experiment was carried out with BT-1 tomato variety. Seven pesticides *viz.*, Benfuracarb (0.1%), Monochrotophos (0.1%, spray), Malathion (0.1%, spray), Dimethoate (0.1%, spray), Imidachloprid (0.1%, spray), Chloropyriphos + Cypermethrin mixture (0.1%, spray), Carbosulfan (0.1%, spray) were applied at 10 days interval for four times. The results indicated comparatively less disease intensity with increased yield in Benfuracarb, Malathion and Dimethoate treatments suggesting effectiveness of these pesticides in controlling the vector pest i.e. *Bemisia tabaci*.

Evaluation of company sponsored biopesticides (pilot study)

Three different biopesticides *viz.*, Ramederma (*Trichoderma viride*), Rameflora (*Pseudomonas fluorescens*) and Ramecide (*Beauveria bassiana*) of Ramel industries Ltd., Kolkata, were tested for their efficacy against major diseases and pests of tomato (var.- BT-10). The diseases like early leaf blight, wilt, leaf curl, mosaic, late blight and insect pest i.e. leaf miner were considered for this study due to their prevalence in the season. The disease and pest incidences in all the treatments were little low. The yield was highest in Ramederm (*T. viride*) treated field.

BRINJAL

Evaluation of company sponsored bio-pesticides (pilot study)

The biopesticides tested for tomato pests and diseases were also tested for their efficacy against major diseases and pests of brinjal (var.- Singnath). The diseases like leaf spot, wilt, stem rot, little leaf and pests i.e. shoot borer and mealy bug were considered for this study due to their prevalence in the season. No clear difference was observed in disease and pests incidence due to their fewer occurrences during the season. However, amongst the treatments, number of fruits was more in Ramederm (*T. viride*) treated plots.

MUSHROOM

Evaluation of different races of paddy straw mushroom

Seven different strains of *Volvariella volvacea viz.*, VV-01, VV-02, VV-07, VV-08, VV-09, VV-11 and VV-Tripura were cultivated during the favorable seasons. In each case, cube bed was prepared with 3 kg paddy straw. Mushrooms were harvested at button, egg and elongation stages at a time. The biological efficiency (%) recorded was 15.67 (VV-08), 11.96 (VV-09) and 9.93 (VV-02).

Fig 12 Paddy straw mushroom cultivation on cube bed

Evaluation of different races of oyster mushroom

The experiment was conducted with different races of *Pleurotus sajor-caju* (PSC), *P. florida* (FLO) and *P. flabellatus* (PF) during the favourable period. The mushrooms were grown both in autumn and winter seasons in poly bag method of cultivation. The results indicated that during autumn crop season, the races, like, PF, PSC and FLO were higher yielder with more than 50% BE, while, during winter crop season, FLO and FLO-02 races were better than the other tested races and species.

WATER QUALITY

Micronutrients in ground water of South Tripura

Ground water samples from deep tube well (350-500 ft.), hand pump (150-200 ft) and dug well (up to 50 ft.) were collected from different places in South Tripura and analyzed for Fe, Mn, Cu, and Zn. The data are presented in Table 30.

The concentration of iron varied from trace to 8.53 mg/L. The maximum allowable limit of iron as per ICMR specification is 1.0 mg/L for drinking water and WHO permits only 0.3 mg/L of iron in drinking water. This indicates that most of ground water samples contain very high quantity of iron unfit for drinking water. Manganese contents in ground water showed a variation from trace to 2.50 mg/L. Copper in ground water showed a variation from trace to 0.11 mg/L and Zinc in ground water also showed a variation from trace to 0.12 mg/L. This indicated that ground water contained less amount of Mn, Cu and Zn except manganese for which the permissible limit for drinking water was varying from 0.1 to 0.5 mg/L.

Table 30 Micronutrients in water samples from different types of well in South Tripura

Location	Nature of well	Fe (mg/L)	Mn (mg/L)	Cu (mg/L)	Zn (mg/L)
Silghati-1	Deep Tube Well	3.309	0.152	Trace	0.068
Silghati-2	Hand Pump	Trace	Trace	Trace	Trace
Silghati-3	Dug Well	0.204	Trace	0.020	0.090
kalirBazar-1	Deep Tube Well	0.060	0.193	Trace	Trace
kalirBazar-2	Hand Pump	3.542	0.115	Trace	0.339
kalirBazar-3	Dug Well	0.050	Trace	Trace	1.436
Pitra-1	Deep Tube Well	2.263	0.201	Trace	0.030
Pitra-2	Hand Pump	1.165	0.114	Trace	0.025
Pitra-3	Dug Well	1.578	2.501	Trace	0.033
Kedernal-1	Deep Tube Well	3.054	0.152	Trace	0.022
Kedernal-3	Dug Well	1.532	0.144	Trace	0.040
Killa-1	Deep Tube Well	4.200	0.306	Trace	0.022
Killa-3	Dug Well	4.138	0.188	0.108	0.412
Srinagar-1(South)	Deep Tube Well	0.088	0.020	Trace	Trace
Srinagar-2(South)	Hand Pump	0.563	0.327	Trace	1.369
Belania-1	Deep Tube Well	2.604	0.105	Trace	0.031
Belania-2	Hand Pump	0.136	Trace	Trace	Trace
East Bagafa-1	Deep Tube Well	0.064	0.010	Trace	Trace
East Bagafa-2	Hand Pump	7.267	0.115	Trace	Trace
East Bagafa-3	Dug Well	5.185	0.098	Trace	2.12
Rupaichari-1	Deep Tube Well	0.175	0.046	Trace	Trace
Rupaichari-2	Hand Pump	0.233	0.080	Trace	2.413
Rupaichari-3	Dug Well	0.063	Trace	0.011	0.169
Mirza-1	Deep Tube Well	3.227	0.033	Trace	0.041
Mirza-2	Hand Pump	6.651	Trace	Trace	0.021
Tebaria-1	Hand Pump	0.147	Trace	Trace	0.019
Tebaria-2	Dug Well	0.233	Trace	Trace	0.021
Maharani-1	Hand Pump	2.688	0.077	0.046	0.622
Maharani-3	Dug Well	0.175	0.426	Trace	Trace
Ompi-2	Hand Pump	2.099	0.149	Trace	0.486
Ompi-3	Dug Well	8.530	0.132	Trace	0.078
Haripur	Deep Tube Well	0.043	Trace	Trace	Trace
Bagbassa	Deep Tube Well	3.338	0.166	Trace	0.073
Amarpur	Deep Tube Well	7.410	0.398	Trace	0.031
Rajnagar	Deep Tube Well	3.749	0.099	Trace	0.049
Jolaibari	Artesian Flow	1.156	0.128	Trace	0.040
Rani	Dug Well	1.054	0.112	0.023	0.123
Paschim jalefa	Dug Well	1.183	0.017	Trace	0.064
Duluma	Dug Well	3.531	0.083	0.014	0.043
Pilak	Dug Well	0.234	0.033	Trace	0.028
Amlighat	Dug Well	0.143	0.308	Trace	0.103
Hadra	Dug Well	0.262	0.088	Trace	0.081

Network project on *Jatropha curcus*

Progeny trial

In the progeny trial, 18 seed sources were planted on 9th May' 06 and growth characteristics estimated up to November '10. *Jatropha* planted from seed samples of Mendipathar (East Garo hills) showed the maximum diameter of 11.74 cm with 3.00 primary branches, 11.00 secondary branches and 63.00 tertiary branches. The lowest basal diameter (8.57 cm) was noted in *Jatropha* planted from Khowai (West Tripura) with 3 nos of primary branches 10 nos of secondary branches and 57.00 nos of tertiary branches. *Jatropha* from south Tripura (Udaipur), North Tripura (Dharmanagar) and Rajasthan showed the maximum no. of primary branches (4 nos) and Bilashpur showed the maximum no. of secondary branches (18 nos). Male/Female ratio varied from 14.78 to 31.24 with fruit yield from 398.33 to 2378.00 g/plant. Seed yield was variable from 174.44 to 786.00 g/plant with the shelling percent from 25.44 to 59.75. First flowering was recorded in the month of April'10. After 4th year of plantation, *Jatropha* from Dimapara (South Garo Hills) showed the maximum fruit yield (2.378 kg/tree) with 33.05 % recovery and *jatropha* from Madhya Pradesh showed the lowest production of fruit yield (0.398 kg/tree) with 43.79 % recovery. Out of the progeny material from Tripura, *Jatropha* from Mohanpur (West Tripura) showed the maximum production of fruit (1.296 kg/ tree) with 38.08 % recovery. There was an increment of the pruning on the secondary branches of *Jatropha*. *Jatropha* from Dimapara (South Garo Hills) showed the maximum no of secondary branches (18-19) thus indicating the maximum fruit/seed yield after 4 years of planting.

Agri-silviculture trial

The agri- silviculture trial was planted in May' 06 with a spacing of 4 x 3 m. In the agri-silviculture trial, rice (TRC-87-251) was grown. *Jatropha* from Mendipather (East Garo Hills) had the maximum basal diameter of 12.98 cm with 13.88 no of secondary branches and 138.44 of tertiary branch. Fruit yield was also maximum (2.248 g/plant) in *Jatropha* from South Tripura (Udaypur). Male /Female ratio was variable from 15.26 to 29.43. Rice also showed the maximum production of 901 kg/ha in the interspaces of *Jatropha* from Dimapara (South Garo Hill).

Package of practices

In the package of practices trial with the fertilizer dose of 26 g urea, 100 g SSP, 16 g MOP and 1 kg cow dung, growth characteristics were estimated. Basal diameter was maximum (11.50 cm) in *Jatropha* from South Tripura (Udaypur) and lowest (8.80 cm) in *Jatropha* from North Tripura (Dharmanagar).

National Provenance Trial

A National trial with the following materials, 1) LBJJ-23 (Ranchi). 2) NDJC-1 (Faizabad) 3) TFRI -07 (Jabalpur) 4) JIP-12-520621 (Jammu) 5) JJ2 (Jabalpur) 6) Panth JCP-1 (Uttarakhand) 7) JCP-2 (Uttarakhand) 8) PDKVNOV -19 (Akola) was laid out in 2008. Growth characteristics were estimated up to November '10. *Jatropha* planted from seed samples of PDKVNOV-19 (Akola) showed the maximum basal diameter of 7.75 cm with one primary branch, 5.66 no of secondary branch and 3.00 no of tertiary branch. The lowest basal diameter (5.73 cm) was noted in *Jatropha* planted from Panth-JCP-1 with one primary branch, 6.50 no of secondary branch and 4.00 no of tertiary branch.

Propagation through stem cutting

Stem cutting collected from different places of Tripura were planted in 2007 in ICAR Research farm. Male /Female ratio of the materials varied from 12.60 to 102 with fruit yield from 23 to 258.33 g/plant.

***Jatropha* in undulated uplands**

It is indicated that the fruit yield of the *Jatropha* planted in undulated terrains varied from 398.00 to 650.00 g/plant. *Jatropha* from North Tripura (Dharmanagar) showed the highest production of *Jatropha* (650 g /tree).

Elite plantation of *Jatropha* plant

In the Elite plantation trial, five seed sources were planted on 6th July' 07. *Jatropha* was planted from seed samples. Trigunction showed the maximum nos of fruit and seed production per plant (447.13 g/plant fruit and 204.28 g/plant seed) after 3 years of plantation.

FARMING SYSTEM RESEARCH

FSR 1

A number of crop combinations were undertaken in FSR -1 where the cropping intensity was attempted to be made 300 % and the cropping sequence as undertaken with economic return is presented in Table 31 and 32.

Table 31 Productivity and economics of the cropping system in FSR1

Crop Sequence	Productivity (t/ha)	Cost of cultivation (Rs/unit area)	Gross return (Rs/unit area)	Net return (Rs/unit area)	Net return (Rs in lakh/ha)	BCR
Cowpea –Maize-Cabbage/ Broccoli	2.92 t (2.08 t Green cob + 0.84 t Dried) – 5.9 t -23.7 t / 16.2 t	10,550	24,228	13,678	2.89	2.28
Bhindi –Maize + Moong -Cauliflower	4.88 t -4.1 t + 1.0 t -17.2 t	4510	8454	3944	2.47	1.87
Maize + Groundnut- Capsicum	4.3 t + 2.0 t -2.5 t	2250	3235	985	0.55	1.43
Sesamum + Moong –Tomato	1.2 t + 1.05 t – 15.9 t	2560	4225	1665	0.85	1.65
Cowpea – Radish- Carrot	8.33 t -4.04 t – 15.74 t	1600	3045	1445	2.67	1.90
Green gram – Leafy vegetable -Cauliflower	1.75 t – 2.8 t – 11.5 t	1820	3100	1280	1.60	1.70
Green gram - Radish	1.72 t – 13.2 t	1040	1621	581	0.83	1.56
Black gram - Potato	1.10 t-20.83 t	2460	4775	2315	1.29	1.94
Cowpea – Potato + Capsicum	3.45 t – 21.1 t + 1.55 t	1260	1905	645	0.77	1.51
Cowpea –Leafy vegetable	5.15 t – 5.56 t	640	1200	560	0.83	1.87
Elephant foot yam + Cowpea , Cucumber + Pumkin	15.6 t +2.43 t , 5.4 t	1000	4005	3005	2.09	4.01
Ridge gourd – bitter gourd – bottle gourd	1.63 t – 1.09 t -10.15 t	2420	6180	3760	1.34	2.55
Duck cum fish culture	3.22 t fish /ha	6600	12,570	5970	1.83	1.90

Table 32 Economic returns from horticultural crops in farming system

Horticultural crops	Productivity (t/ha)	Cost of cultivation (Rs/unit area)	Gross return (Rs/unit area)	Net return (Rs/unit area)	Net return (Rs in lakh/ha)	BCR
Guava + Lemon	10 – 6.18 -3.36	200	294	94	0.039	1.47
Mango	1.46	280	375	95	0.039	1.88
Banana	5.01	1200	3616	2416	0.63	3.01
Broom grass	6.81	480	1470	990	0.92	3.06
Assam lemon	7.0	120	175	55	0.092	1.46

Maize grown in combination with various crops at 2 :2 intercrops ratio could produce the maize equivalent yield varying from 6.64 to 8.81 t/ha thus indicating that groundnut in combination with maize could produce the maximum yield. The benefit/cost ratio as estimated for various cropping systems studied in the farming systems research varied from 1.16 to 2.29 thus indicating that three crop rotations of cowpea /maize / cabbage or broccoli were economically viable. The total area brought under various cropping system in FRS 1 was 5287 m^2 and the net economic return was Rs 45,811/-. The BCR was 2 with a net return of Rs 86,648/ha.

Fig 13 Maize + moong and maize + black gram intercropping in farming systems

FSR-II

The thrust areas of the FSR-II model are of fruit crops, tuber crops, piggery and fishery which are interrelated to some extent. The special feature of this model is high value-low volume crops integrated with piggery and fishery which provide high return per unit area. (Table 33)

Fig 15 Ghungroo pig of North Bengal

Table 33 Productivity and economics of the cropping system in FSR2

Crop Sequence	Productivity (t/ha)	Cost of cultivation (Rs/unit area)	Gross return (Rs/unit area)	Net return (Rs/unit area)	BCR
Cowpea (green)	2.72	-	120	-	-
Brinjal	6.0	150	360	210	2.40
Tomato	28.0	430	760	330	1.75
Potato	14.74	1750	4380	1316	2.5
Cauliflower	22.0	-	240	-	-
Elephant foot yam	77.0	605	1386	781	2.29
Tannia	32.0	484	1050	566	2.16
Dioscoria	30.0	668	1530	862	1.99
Colocasia	9.0	484	937.50	435.50	1.93
Fish	0.082	8310	9940	1630	1.19
Banana	294 no	333	882	549	2.64
Papaya	0.038	242	570	328	2.35
Lemon	361no	121	182	61	1.50
Areacanut	270 no	-	-		-

ANIMAL SCIENCE

PIGS

Some phenotypic descriptors, productive and reproductive traits in indegenous pig breeds

Two indigenous pig breeds, namely 'Mali' and 'Ghungroo' along with crossbed (Hampshire X *Khasi* local) pigs were maintained at ICAR Research Complex, Tripura Centre during the period under report. Studies made on some phenotypic descriptors, productive and reproductive traits on those breeds as presented in Table 34 and 35 and depicted in fig (14,15,16).

Fig 16 Crossbred pig (Hampshire X *Khasi* local pig)

Fig 14 Mali pig of Tripura

GOAT

Generation of information on distribution of prolific Black Bengal Goats in Tripura

The highest number of prolific Black Bengal goats was found in South Tripura district followed by West Tripura and Dhalai district in the present study. In

Table 34 Phenotypic descriptors of different adult pig breeds

Parameter	Breed		
	Mali	**Ghungroo**	**Crossbred (Hampshire X *Khasi* local pig)**
Origin	Sub-Himalayan region (hilly tracts) of Tripura (Dhalai in particular)	Eastern Sub-Himalayan region of West Bengal (North Bengal in particular)	Hampshire- America Khasi local- Meghalaya
Colour	Black	Black	Black with a white broad band in heart girth region
Face	Narrow and short	Broad and flattened	Broad
Snout (long/ short and straight / concave/ convex)	Concave	Short, upwardly curved	Long
Ear (large/ small and erect/ pendulous/ horizontal)	Small and erect	Large, pendulous and heart shaped resembling those of elephant	Small and erect
Top (Back) line (straight/ concave/ convex)	Concave	Straight	Convex
Belly type (pot/ flat)	Pot-bellied	Flat	Flat
Body length (cm)	Female- 85, Male- 86	Female- 109, Male- 102	Female- 160, Male- 150
Chest girth (cm)	Female- 83, Male- 80	Female- 104, Male- 97	Female- 137, Male- 126
Body weight (kg)	Female- 54, Male- 51	Female- 109, Male- 89	Female- 277, Male- 220
Tail	Short	Long	Long
Hoof placement (full/ partial)	Full	Partial	Full
Bristle (long/ medium/ short and thick/ thin)	Thick, strong and erect	Thick, coarse and long	Thick, coarse and long
Number of teats	5- 6 pairs	5- 6 pairs	6- 7 pairs

Table 35 Productive and reproductive traits of different pig breeds

Parameter	Breed		
	Mali	**Ghungroo**	**Crossbred (Hampshire X Khasi local pig)**
Birth weight (kg)	0.4- 0.6	0.5- 1.0	1.0- 1.3
BW (kg) at 3 month	8- 10	12- 15	12- 15
BW (kg) at 6 month	30- 40	40- 50	60- 70
BW (kg) at 1 year	80- 90	100- 110	110- 120
Age at puberty (month)	6- 7	6-7	7- 8
Litter size at furrowing	8- 10	8- 12	8- 12

Tripura, 389 does gave birth TO 681 kids, averaging 1.75 kids per doe. An overall prolificacy rate of 175.07% was recorded in the present study. Some physical descriptors like hair coat colour, skin colour, neck length and ear length have shown to influence the kidding size in Black Bengal goats. 43.19% of the goats with black hair coat color and 34.88% of the goats with white skin colour were recorded to give twin birth and the association between black hair coat color/ white skin colour and the incidence of twin birth was significant (P<0.05). The goats with bigger ear as well as longer neck showed the tendency to give birth of more kids. The stepwise discriminant function results have been presented in Table 36. Body weight was recorded as a good indicator for higher kidding size only at 5th month of pregnancy and after delivery. Heart girth measurement was found to be a good indicator for higher kidding size at 3rd and 4th month of pregnancy and also after delivery as documented in Fig 17. Height at wither might be a good indicator for higher kidding size at 2nd month of pregnancy and in empty stage after delivery. Curved head- rump length was also registered as a good indicator for higher kidding size at 1st and 4th month of pregnancy. The fitted linear trend or simple regression lines for descriptors indicated that udder height from ground decreased significantly due to advancement in pregnancy (months) for kidding size 3 and 2 as shown in Fig 18.

Table 36 Stepwise discriminant function results for month wise discrimination of variables in Tripura

Variables	Month 1	Month 2	Month 3	Month 4		Month 5	Empty stage	
	Function 1	Function 1	Function 1	Function 1	Function 2	Function 1	Function 1	Function 2
	Canonical discriminant function coefficients							
Height at wither		0.323					0.006	0.035
Heart girth			0.187	0.155	-0.233		0.134	0.012
Curved head-rump length	0.187			0.041	0.335			
Body weight						0.207		
Constant	-11.833	-15.939	-11.625	-12.373	-6.093	-4.642	-11.764	-1.368
	Kidding sizeFunctions at group centroids							
1	-0.626	-0.546	-0.619	-0.659	-0.082	-0.678	-0.703	0.071
2	0.124	0.112	0.172	0.223	0.084	0.248	0.281	-0.115
3	1.149	0.753	0.956	1.046	-0.448	0.954	0.728	0.752
Eigenvalue	0.180	0.131	0.184	0.234	0.019	0.246	0.241	0.047
% of Variance	100.000	100.000	100.000	92.600	7.400	100.000	83.700	16.300
Cumulative %	100.000	100.000	100.000	92.600	100.000	100.000	83.700	100.000
Canonical Correlation	0.391	0.340	0.394	0.435	0.136	0.444	0.441	0.212

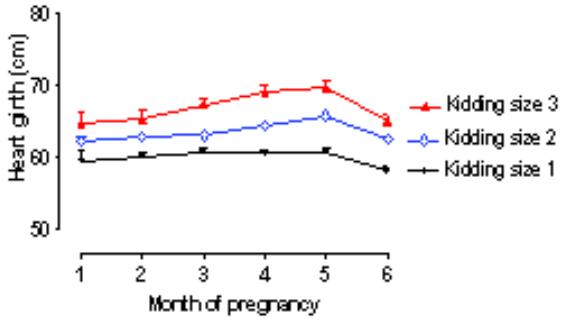


Fig 17 Mean (± SEM) heart girth (in cm) during pregnancy and after pregnancy in goats under different kidding size groups

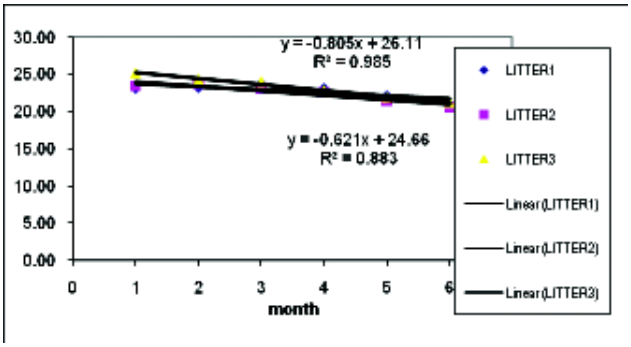


Fig 18 Regression line for 'udder height from ground' for kidding size 3 and 2

Black Bengal goats were found to have multiple ovulations in estrous cycle

The multiple (two or more than two) ovulations in one estrous cycle were recorded in 47.06% of goats, while the incidence of single ovulation was in 52.94% of goats. Since 52.94% of goats registered single ovulation in estrous cycle, Black Bengal goats were not multiple ovular in every estrous cycle. Number of kids born (1.67 ± 0.23) was lower (P<0.05) than the ovulation rate (2.33 ± 0.40) in Black Bengal goats**.** However, there was a significant (P<0.05) correlation (r= 0.72) between the kidding size and ovulation rate.

Prediction of number of fetus during pregnancy, but not ovulation rate in cyclic goats by plasma progesterone profiles

The plasma progesterone profiles in pregnant goats with different kidding size have been shown in Fig 19. Plasma progesterone values in goats were significantly higher (P<0.05) among triplet vs. twin vs. single pregnancy between day 77 and 35 prior to parturition (day 0 represented the day of parturition). The discriminant function result for discrimination of day of blood sampling during pregnancy indicated that day 63 prior to parturition was the most suitable day of

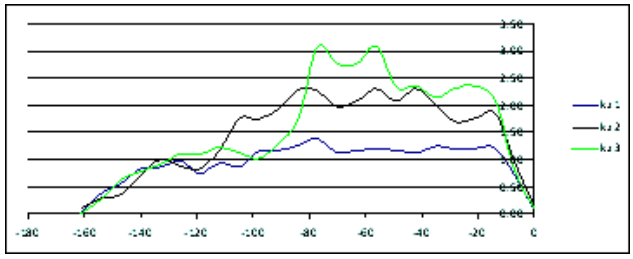


Fig 19 Plasma progesterone profile during pregnancy in Black Bengal does carrying single, twin and triplet fetuses. Day 0 represented the day of parturition

blood sampling for the prediction of kidding size by plasma progesterone estimation. The differences in plasma progesterone level in goats carrying single, twin and triplet kids during pregnancy were probably due to production of progesterone by the placenta during pregnancy in addition to corpus luteum and adrenal glands. Plasma progesterone concentration might be a predictive tool for determining number of fetus during pregnancy in female Black Bengal goats.

Plasma progesterone levels (0.95 +/- 0.08 ng/ml, 0.99 +/- 0.09 ng/ml and 1.05 +/- 0.10 ng/ ml for goats with one/ two/ three CLs, respectively) did not vary (P<0.05) among the goats with one/ two/ three CLs in ovary during estrous cycle. Plasma progesterone level might not be helpful for determining ovulation rate in cyclic Black Bengal goats.

Selection of prolific Black Bengal goats based on gonadotrophic releasing hormone (GnRH) challenge test

The responsiveness of FSH and/ or LH to GnRH challenge situation in Black Bengal goats is presented in Fig 20 and 21. The goats belonging to triplet kidding size groups showed highest (P<0.05) plasma FSH response in terms of hormonal peak and amplitude of hormone release as compared to the goats belonging to either twin or single kidding size groups. Plasma FSH response in goats under the twin kidding size group was higher (P<0.05) than the goats under single kidding size group. Interestingly, plasma LH response after GnRH challenge did not differ (P<0.05) in goats among three different groups.

Status of plasma micronutrients and gonadotrophin hormones in relation to puberty of female Black Bengal goat

The plasma samples harvested from the collected blood samples were utilized for the estimation of Cu, Mn, Zn, Fe by atomic absorption spectrophotometric method and FSH, LH following EIA technique. The female Black Bengal goats attained puberty at an average age of 157.40 ± 10.28 days with a mean body weight of 7.32 ± 0.87 kg. Plasma Zn, Fe and FSH levels increased (P< 0.01) during the months preceding puberty and particularly plasma FSH level was highest (P< 0.01) just few days prior to onset of puberty as shown in Fig 22 and 23. Plasma Zn, Cu and Mn levels remained higher (P<0.05) during the month of puberty. The significant correlation of FSH (p< 0.05), LH (P<0.05), Cu (P<0.05), Zn (P< 0.01) and Mn (P< 0.01) with body weight and significant correlation of Cu (P< 0.01) and Fe (P<0.05) with LH as well as between Mn and FSH (P<0.05) before puberty onset indicated that micronutrient levels are important for bringing changes in plasma hormone concentrations and thereby puberty onset in female Black Bengal goats.

Pig rearing for rural livelihood improvement (under NAIP, Component- 3)

Two training programmes on 'care and management of pigs' were organized on 30th and 31st March 2011 at Murracherra and Balaram, respectively. A total of 56 farmers participated in the training programme. A total of 12 pig houses (brick- cement made) at Balaram and Murracherra were established to make the farmers

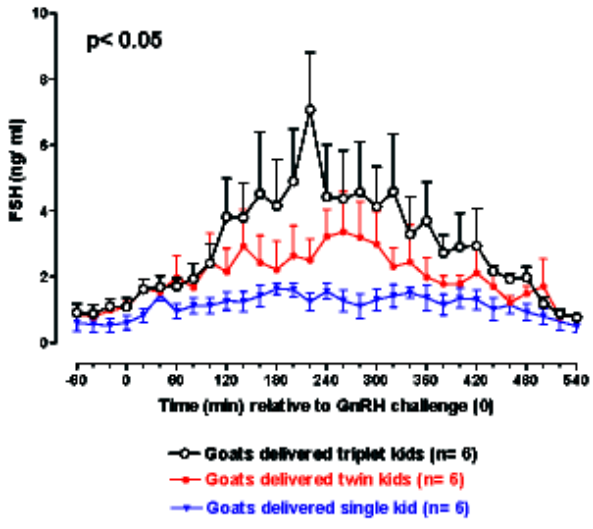


Fig 20 Plasma FSH response after GnRH challenge

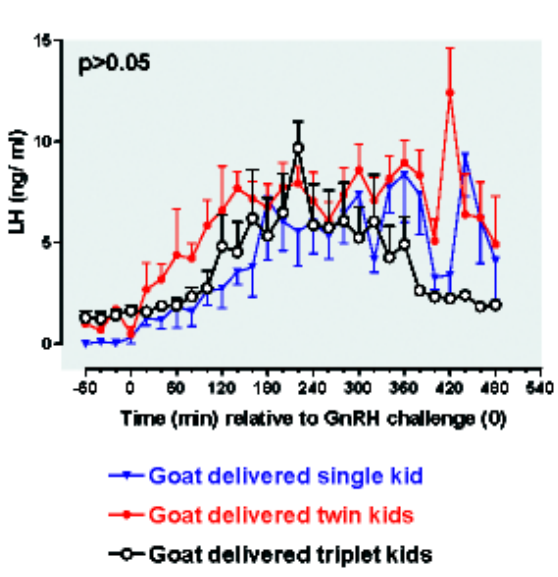


Fig 21 Plasma LH response after GnRH challenge

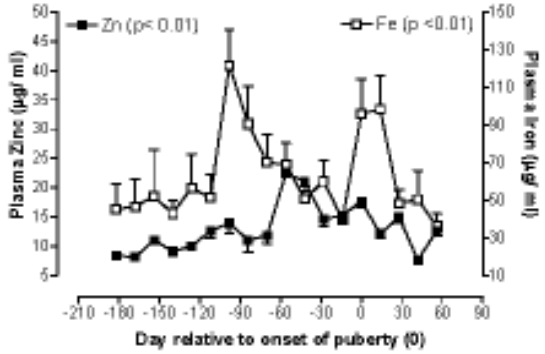


Fig 22 Mean (± SEM) plasma Zn and Fe levels (µg/ ml) in female Black Bengal goats from 180 days prior to puberty upto 60 days post-puberty

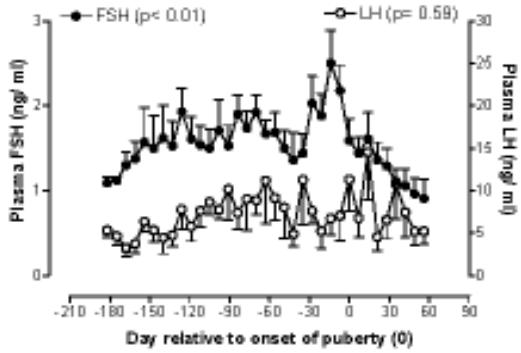


Fig 23 Mean (± SEM) plasma FSH and LH levels (ng/ ml) in female Black Bengal goats from 180 days prior to puberty upto 60 days post-puberty

aware about the pig house and improved managemental practices under NAIP programme. The farmers were financially supported (@ Rs. 10,000/- per house per farmer) for making improved type pig shelters (brick-cement made) for better management of pigs. Twenty crossbred (Large White Yorkshire x Landrace) piglets (1 male + 1 female for each farmer) were provided to ten farmers for rearing, breeding and production of piglets and subsequently selling of piglets to fetch money in a continuous manner. Two farmers were continuing the farm with the crossbred pigs which were provided earlier (Fig 24 & 25).

Fig 24 A tribal farm woman with a pair of crossbred piglets of NAIP

Fig 25 An improved pig shelter made under NAIP project

Goat raising for rural livelihood improvement (under NAIP, Component- 3)

The aim of the study was to educate and support the farmers for better animal husbandry and management of local natural resources to improve rural livelihood and secure foods for few more days utilizing goat resource in resource limited area. Eight deworming and treatment camps were organized during the period under report at Balaram and Murracherra under NAIP programme. A total of 405 goats along with 6 pigs, 7 cattle and 37 poultry birds were treated during the camps (Fig 27). A total of 141 farmers were benefited from the treatment camps. A total of 135 bamboo-made elevated goat houses (@ Rs. 2000- 2500/- per house) at the backyard of the farmer's house were made (Fig 26). This type of goat house concept was first introduced in the area. A total of 182 female Black Bengal goats were collected from West and South Tripura districts and provided to the farmers in Dhalai district for minimising inbreeding problem and increasing the new stock of Black Bengal

Fig 26 Goat house

Fig 27 Treatment camp organized under NAIP programme

goats in the area. Farmers showed keen interest for making goat house utilizing low-cost local materials and rearing goat with more care to fetch more income.

POULTRY

Genetic improvement of growth and production traits of Japanese quail in agro-climatic conditions of Tripura.

The evaluation of performance of third generation of Japanese Quail (Fig 28) was continued. The overall mean performance of body weights of the progeny of coloured quail line at 3, 4 and 5 weeks of age were: 117.06±0.91, 155.15±0.97 and 197.55±1.27 g, respectively and the corresponding body weights in control line were: 109.38±1.89, 147.072.29 and 177.61±2.15 g, respectively. Moreover, the overall mean performance of body weights of the progeny of white quail line at 3, 4 and 5 weeks of age were 110.37±0.63, 148.42±0.83 and 181.74±0.93, respectively and the corresponding body weights in Control line were: 104.45±1.26, 135.36±1.75 and 161.05±1.84, respectively. The weight gain in coloured and white quail lines from 3-5 weeks of age were 80.48±1.49 and 71.370.34 g, respectively and the corresponding weight gain in control lines were 68.23±1.77 and 56.59±0.69 g, respectively.

Fig 28 White Adult quail bird

AICRP on Poultry Breeding (Rural Poultry Production)

Germplasm supply

A total of 5,442 nos. of good chicks of different varieties / lines of poultry were supplied to the farmers of different villages of Tripura.

Performance of (Tripura black native germplasm male × Dahlem Red female) male × Dahlem Red female, (D75%), ND cross

A total of 2988 eggs of ND cross were set for hatching. The percent fertility was 81.72 % and the percent hatchability on total egg set and fertile egg set were 64.69 and 79.16 %, respectively. The mean performance of body weights of ND cross were measured from 2 to 20 weeks and then at 40 weeks of age in both the sexes at farm. The mean body weights of ND cross at 8 weeks of age were 538.07±7.42 g., 486.84±7.26 g and 511.90±5.51 g., respectively, for male, female and overall mean, respectively at farm. The mean body weights at 20 weeks of age were 1.721±0.037, 1.317±0.026 and 1.520±0.028 kg., respectively in male, female and overall mean at the farm. The age at first egg was 174 days at the ICAR Lembucherra farm. The egg weight at 28 weeks of age was 50.13±0.55g. The egg production upto 40 weeks of age was 54.93 eggs at the ICAR Lembucherra farm.

Mean performance of (Dahlem Red male × Tripura black native germplasm female) male× Dahlem Red female (D75%), DN cross

The 1686 chicks of DN cross were hatched out using 2403 fertile eggs of the cross. The percent fertility was 79.98 % and the percent hatchability on total egg set and fertile egg set were 70.16 and 87.72 %, respectively. The mean body weights of DN cross at 8 weeks of age were 517.39±9.74, 471.08±10.43 and 495.47±7.35 g, respectively, for male, female and overall mean at the farm. However, the mean body weights at 20 weeks of age were 1.764±0.033, 1.364±0.024 and 1.583±0.027 kg, respectively in male, female and overall mean at the ICAR Lembucherra farm. The age at first egg was 156 days. The egg weight

at 28 weeks of age was 50.09 g .The egg production up to 40 weeks of age was: 60.69 eggs at the farm. These two breeds are depicted in Fig 29.

Fig 29 Female and male birds of Dahlem Red (75%)× Tripura black native cross

Performance of Tripura Brown native germplasm at the Institute farm

A total of 2215 fertile eggs of Tripura brown native germplasm were set for hatching. The percent fertility was 77.25 % and the percent hatchability on total egg set and fertile egg set were 64.51 and 83.51 %, respectively. The mean body weights of Tripura brown were 313.12±9.02, 278.69±6.33 and 289.29±5.27 g, respectively, at 8 weeks of age at the farm. However, the mean body weights at 20 weeks of age were 1.279±0.029, 0.906±0.015 and 1.027±0.018 kg, respectively in male, female and overall mean at ICAR Lembucherra farm. The age at first egg was 143 days. The egg weight at 28 weeks of age was: 40.0±0.29 g The egg production up to 40 weeks of age was 34.50 eggs at the farm.

FISHERIES

Growth performance of Pabda, (*Ompak bimaculatus*) under polyculture system

Production potential of *Ompak bimaculatus* polyculture was assessed at a stocking density of 4000 ha^{-1} in 300 m^2 earthen pond at ICAR Research Farm, Tripura. The growth and production of fishes in terms of gain in length and weight were monitored fortnightly (Table 37). Final harvesting was done after 180 DOC by repeated netting followed by draining of pond water.

Nutrient composition of selected fish species of Tripura

A study was under taken to analyse and compare the nutrient content of some selected fish species commonly available in Tripura during the lean season through chemical analysis. The fish species were collected from the ICAR Research Farm and sun-dried before analysis. Proximate composition such as protein, macro-minerals such as K, Ca, P and micro-nutrients such as Cu, Zn, Fe and Mn were estimated and the obtained results are represented graphically (Fig 30).

An investigation was undertaken to evaluate the growth and survival of endanger *Ompak bimaculatus* fry at different stocking densities (Table 38). Considering the value of larval growth and survival, the stocking density of three larvae L^{-1} was identified as the optimum for the rearing of 14 days old *O. bimaculatus* fry.

Table 37 Growth and production of *O. bimaculatus* in polyculture system with Indian Major Carps

Parameters	*Catla catla*	*Labeo rohita*	*Cirrhinus mrigala*	*O. bimaculatus*
Number of stocked fishes	48	36	18	18
Mean initial TL (cm)	9.91±0.25	4.77± 0.13	11.25± 0.41	2.99±0.17
Mean final TL (cm)	25.67±2.08	23.58±1.26	18.18±0.31	14.26±0.44
Mean length gain (cm)	15.76±2.21	18.81±1.21	6.93±0.63	11.27±0.40
% length gain	61.15±3.41	79.72±1.03	38.08±3.00	79.02±1.08
Mean initial weight (g)	10.44±0.22	0.955±0.05	14.18±0.50	0.284±0.02
Mean final weight (g)	368.5±35.04	194.0±39.77	95.0±14.52	79.5±12.57
Mean weight gain (g)	358.06±35.17	193.04±39.75	80.82±14.63	79.21±12.57
% weight gain	97.14±0.30	99.48±0.11	84.77±2.27	99.6±0.05
SGR in %	1.97±0.05	2.94±0.11	1.05±0.08	3.12±0.09
% survival (numbers)	68.75 (33)	72.2 (26)	55.5 (10)	61.1 (12)
Production in kg ha^{-1}			619.0	

Data expressed as mean ± SD

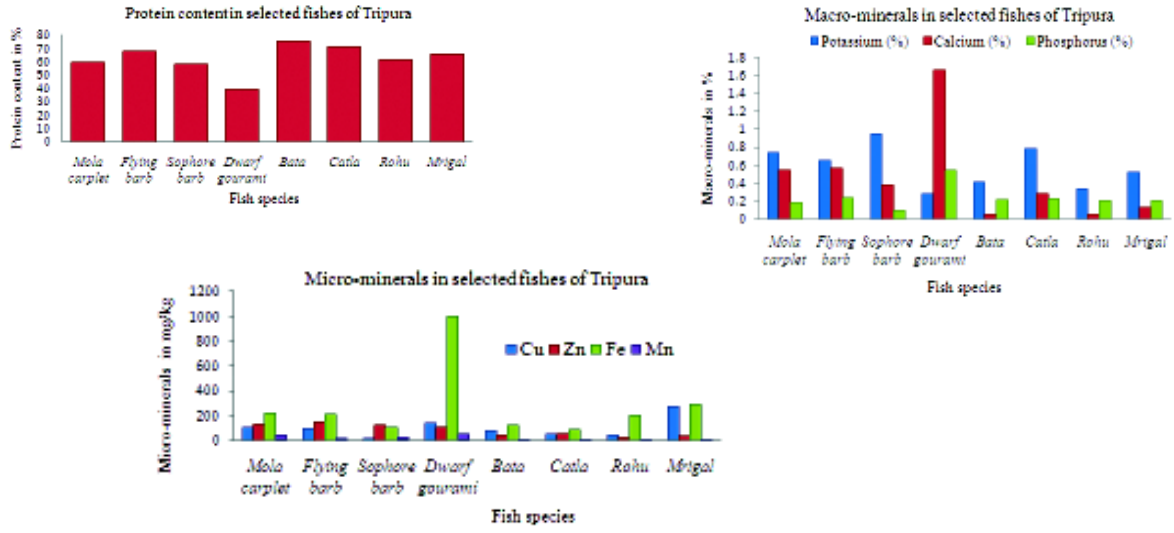


Fig 30 Stocking density-dependent growth and survival of endanger Pabda (*Ompak bimaculatus* Bloch, 1794) larvae

Table 38 Effect of stocking density on mean TL and weight, specific growth rate, percent weight gain and survival of 14 days old *Ompak bimaculatus* larvae (initial size: 16.36±0.47 mm and 33.97±3.35 mg) over four weeks of rearing

Stocking density (larvae L^{-1})	TL in 14 days (mm)	Wet weight in 14 days (mg)	Final total length in 28 days (mm)	Final wet weight in 28 days (mg)	Specific growth rate	Percent weight gain	Survival (%)
2	25.66±0.33^{a}	86.33±0.88^{a}	32.33±0.88^{a}	141±0.57^{a}	5.08±0.01^{a}	315.06±1.70^{a}	81.33±1.76^{a}
3	21.33±1.20^{b}	74±1.52^{b}	28±0.57^{b}	129±0.57^{b}	4.76±0.01^{b}	280.41±1.17^{b}	83.55±1.60^{a}
4	18.33±0.33^{c}	52.33±0.33^{c}	22.33±0.33^{c}	93±0.57^{c}	3.60±0.02^{c}	173.76±1.70^{c}	72.33±1.45^{b}
5	18±0.57^{c}	48.33±0.33^{d}	21±0.57^{cd}	90.33±0.88^{d}	3.48±0.04^{d}	165.91±2.59^{d}	71.2±2.80^{bc}
6	18±0.57^{c}	49±1.15^{d}	19.6±0.66^{d}	90.6±0.33^{d}	3.50±0.02^{d}	166.89±0.98^{d}	66.22±0.89^{c}

Data based on mean (± SE) of triplicate tanks for each density level. Mean values bearing different superscripts in a column differ significantly (P<0.05)

Livlihood improvement and empowerment of rural poor through sustainable farming system (NAIP component III)

Improvement of livelihood by mushroom cultivation

Mushroom cultivation at Balaram and Maracherra villages was introduced by giving training and demonstration (Fig 31 & 32). The spawn and other requisite materials were either supplied from this centre or supplied by purchasing from state Government laboratories. Low-cost mushroom houses were prepared in the houses of progressive and interested farmers. Considerable number of farmers learned the techniques and produced mushroom for the first time in their houses. The farmers earned money from selling of fresh mushroom @ Rs.80/- per kg in the local markets.

Fig31 Farmers showing mushroom production under NAIP

Fig 32 Training & demonstration of mushroom cultivation

Mushroom production at Balaram, Dhalai

Total 88 farmers of Balaram cultivated mushroom during the period starting from April, 2010 to March, 2011 (Table 39). They used 975 mushroom spawn packets (each 150g) and produced 396.7 kg of fresh mushroom. There expenditure was calculated as Rs. 11700/- @ Rs. 12 for a poly bag filling. The farmers sold their produce @ Rs. 80/- per kg fresh mushroom to the local markets and earned Rs. 31736/-, which resulted in Rs. 16468/- as net profit.

Mushroom production at Maracherra, Dhalai

Total 13 farmers of Maracherra cultivated mushroom during the period starting from April, 2010 to March, 2011 (Table 40). They used 775 mushroom spawn packets (each 150g) and produced 324.25 kg of fresh mushroom. There expenditure was calculated as Rs. 9300- @ Rs. 12 for a poly bag filling. The farmers sold their produce @ Rs. 80/- per kg fresh mushroom to the local markets and earned Rs. 25940, which resulted Rs. 15160/- as net profit.

Table 39 Mushroom production and profit observed in Balaram village, Dhalai

Period/Month	No. of Farmers	No. Spawn bag used (150 g each)	Total expenditure (Rs.)	Production of mushroom (kg)	Amount received on selling (Rs.)	Profit (Rs.)
Aprl	0	0	0	0	0	0
May	0	0	0	0	0	0
Jun	16	200	2400	74.6	5968	3568
Jul	10	150	1800	68.4	5472	3672
Aug	0	0	0	0	0	0
Sep	12	150	1800	63.8	5104	3304
Oct	0	0	0	0	0	0
Nov	10	50	600	22.8	1824	1224
Dec	10	75	900	34.35	2748	1848
Jan	15	250	3000	96.25	7700	4700
Feb	15	100	1200	36.5	2920	1720
Mar	0	0	0	0	0	0
Total	88	975	11700	396.7	31736	16468

Table 40 Mushroom production and profit observed in Maracherra Village, Dhalai Maracherra

Period/Month	No. of Farmers	No. Spawn bag used (150 g each)	Total expenditure (Rs.)	Production of mushroom (kg)	Amount received on selling (Rs.)	Profit (Rs.)
April	0	0	0	0	0	0
May	0	0	0	0	0	0
June	8	100	1200	33.5	2680	1480
July	7	100	1200	42.7	3416	2216
August	0	0	0	0	0	0
September	5	100	1200	45.7	3656	2456
October	0	0	0	0	0	0
November	5	50	600	49.6	3968	3368
December	6	75	900	25.9	2072	1172
January	15	200	2400	67.6	5408	3008
February	6	150	1800	59.25	4740	2940
March	0	0	0	0	0	0
Total	52	775	9300	324.25	25940	15160

Table 41 Trainings and workshops organized

Name of the training/ workshop	No. of types of participants	How is the relevant to the sub-project
Training on mushroom cultivation	One SHG (Panchina) and 150 beneficiaries at five locations (Three locations at Balaram and two locations at Maracherra).	Mushroom cultivation to increase livelihood at Balaram and Maracherra is the main subject to deal with in this sub-project. Thus the training and demonstration are directly related to be acquainted with the technical know-how of the mushroom cultivation
Distribution of spraying pumps	4 spraying pumps have been distributed among the beneficiaries of Balaram and 4 more sets are to be distributed shortly at Maracherra cluster.	

Distribution /Training of Soil Health Card

Fig 33 Dignitaries in the dias

Fig 34 Mr. Partha Das, Honble MLA distributing the card

Fig 35 Principal Secretary of Agriculture, Director of Agriculture, Govt. of Tripura inspecting rice varieties developed by ICAR Tripura Centre

Goat Day 2011 organized by ICAR, Tripura Centre at Dhalai

A one-day workshop, namely 'Goat Day 2011' was organized at Balaram village of Ambassa, Dhalai District by ICAR Research Complex, Tripura Centre, Lembucherra, West Tripura on 13th January 2011 to popularize goat rearing. A total of 78 goat keepers from the villages of Balaram and Murracherra participated in the workshop.

An interactive workshop on "development of animal resources in Tripura" organized by ICAR, Tripura Centre

An Interactive workshop on "Development Of Animal Resource In Tripura" was held on 9th March 2011 at ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra, Agartala, Tripura West. A total of 110 delegates including the ICAR scientists, KVK Personals, State ARDD and TTADC veterinary officers, Farmer club members, SHG leaders, Individual key farmers, Bank representatives and other activist engaged in development of animal resources in Tripura attended workshop.

Food Security through enhancement of Productivity and Production of Rice in Dhalai of Tripura (NAIP Sub Project, Component 3)

Higher productivity of rice through adoption of HYV: Naveen, Samba Mahasuri, TRC 2005-1, MTU 1010, Chandan.

- Application of improved production technologies like SRI & ICM
- Mechanization with use of 8 row machine operated paddy transplanter
- No of beneficiaries – 1103
- Total land area – 190.4 ha
- Average Yield Achieved– 3.772 t/ha
- Yield average of demonstration plots was higher by 1437 kg over the district average (2335).

Front line demonstrations on rice 2010

In all 663 FLDs were conducted Transplanter was demonstrated on 74 farmers' field, performance of the machine was very much satisfactory. Problems faced in earlier years were corrected, except more number of seedlings per hill. Varieties demonstrated included TRC 2005-1, TRC 2005-2, TRC 2005-3, MTU1010, Durga, Varshadhan and Swarna sub1. As this year no

Fig 36 Field visit of IRRI scientists at Lembucherra

check plots were used, yield advantages were not calculated. However, average performance of FLD plots were 5800 kg/ha for TRC 2005-1, 5950 for TRC 2005-2, 5570kg/ha for TRC 2005-3, 5360kg/ha for MTU 1010, 4360 kg/ha for Durga, 5700 kg/ha for Varshadhan and 5620kg/ha. Machine transplanted plots produced 5900 kg/ha.

Front Line Demonstrations on Pulses

During Spring 2010 in total 87 FLDs were conducted. Forty three FLDs were conducted on urdbean and 44 FLDs were conducted on mungbean. FLD plots consisted HYV + Sulphur @ 20 kg/ ha + 3 sprays of urea @ 2% during flowering. Yield advantage attained in different FLD plots and average yield advantage of urdbean and mungbean FLDs were 26.61% and 33.23% , respectively.

Fig 37 Shri Aghore Debbarma, Hon'ble Minister for Agriculture, visiting field

Fig 38 Shri Aghore Debbarma, Hon'ble Minister for Agriculture, visiting rice field

Rice and pulse day 2010 South Tripura

Boro rice field day and Rice and Pulse Day 2010 was held at Bagma on 1st June 2010. Hon'ble Minister for Agriculture, Tripura, Shri Aghore Debbarma, Naresh Jamatia, MLA, Bagma, Dr. S. N. Sen, Director of Agriculture, Govt. of Tripura, Dr. R. C. Samuhi, Principal, College of Agriculture, Tripura, Shri Dilip Datta, Vice Chairman, Matabari Panchayat Samiti, Dr. M. Datta, Joint Director, ICAR, Tripura Centre along with several senior officers from State Agriculture Department and scientists from ICAR first visited Magpuskarini and Dudhpuskarini and gone around the demonstration plots of TRC 2005-1, Chandan, MTU 1010. They also seen the machine transplanted fields with these varieties and discussed with happy farmers. Later the dignitaries visited the demonstration plots at Bagma. While interacting with press Hon'ble Minister expressed happiness over the fact that in recent years ICAR, Tripura centre is putting tremendous effort for helping the state in attaining self sufficiency in food grain. Already they brought lot of positive changes in the field of Agriculture in Tripura. He opined that the number of improved varieties of different crops developed and introduced by them helped the state to achieve higher productivity levels and the gap to self sufficiency is narrowing down. Later the dignitaries assembled in the Bagma Community Hall for Celebration of Rice and Pulse Day 2010. More than 400 farmers attended the Rice and Pulse Day.

Rice Transplanter Field Day

"Rice Transplanter Field Day" was organized at Mirza, South Tripura on 4 August 2010. Hon'ble Minister for Science and Technology, Govt. of Tripura, Shri Joygobinda Debroy was present on the occasion as the Chief Guest. Joint Director, ICAR, Tripura Centre, Dr. M. Datta, Programme Coordinator, KVK, Chebri, Dr. Pranab Kr. Datta, Mr. Haradhan Das, Vice Chairman, Panchayat Samiti, Mr. Parimal Majumder, Village Pradhan, Mirza Gram Panchayat witnessed the operation of the paddy transplanter on the field of Shri Jiten Majumder, Chief Coordinator, Arabinda Farmers Club, Mirza. Dr. M. Datta appraised the Hon'ble Minister about the activities of ICAR to increase the rice productivity and production in this part of the state. Hon'ble Minster observed and enquired in detail about the operation of the machine. He discussed merits and demerits as expressed by a group of about 200 farmers

Fig 40 Rice transplanter field at Mirza, South Tripua

gathered on the field to witness the operation of the paddy transplanter. Later the Hon'ble minister while interacting with print and electronic media expressed his confidence that the transplanter will be a common machine like power tiller in Tripura in a short period of time and will be very much helpful in reducing cultivation cost and drudgery of farm labours. He also expressed satisfaction for the way ICAR is putting effort in developing and bringing new crop varieties and technologies for the benefit of farmers in the state. On behalf of ICAR the demonstrations and Field Day was organized by Dr. S. P. Das, Sr. Scientist (Plant Breeding) in collaboration with Arabinda Farmers Club, Mirza.

"Paddy Transplanter Field Day"Maracherra on 10 September, 2010 and"Training cum Fertilizer Distribution"Balaram and Maracherra, Dhalai, 9 & 10 September, 2010

ICAR Research Complex for NEH Region, Tripura Centre, has taken up several activities at Maracherra and Balaram under the NAIP project "Livelihood Improvement and Employment of Rural Poor through Sustainable Farming Systems in North Eastern Region" Under the sub project "Food Security through Enhancement of Productivity and Production of rice in Dhalai District". In 2010 demonstrations are taken up on 380 farmers' plots.

Among number of technologies like new HYV, SRI, ICM etc, a mechanical 8 row Paddy Transplanter was also introduced in the district for the first time. To popularize the paddy transplanter a "Paddy Transplanter Field Day" was held at Maracherra on 10 September, 2010. The Field Day was attended by about 180 farmers from the cluster and was followed by fertilizer distribution among the NAIP Cluster farmers and training on different aspects of technologies under demonstration in rice project. The Field Day was graced by Mrs Pranati Das, Hon'ble Sabhadhipati of Dhalai as Chief Guest. Other dignitaries present were Shri Prankumar Das, Shri Bisheshwar Ahir, both Jila Parisad members , SDM of Kamalpur Shri Bimal Reang and Dr. M. Datta, Joint Director, ICAR, Tripura Centre.

Dr. Datta gave brief account of ICAR activities under the NAIP project and also highlighted the achievements already made. Hon'ble Sabhadhipati was delighted to see the operation of the paddy transplater for the first time along with a 250 strong crowd gathered to see the machine transplanting. She exclaimed that this can be very helpful in completing the transplanting in a very short time over a large area.

The Field Day was followed by fertilizer distribution and training to farmers by Dr. S. P. Das, Sr. Scientist (Plant Breeding), Principal Investigator of the NAIP, rice project at Dhalai. Fertilizer distribution and training at Balaram Cluster farmers was held on 9 September, 2010.

Multilocation yield testing of ICAR developed rice varieties through KVK, North Tripura, 26 September 2010

Enhancing the rice productivity and production is a priority area of work for ICAR Research Complex for NEH Region, Tripura centre for achieving food self sufficiency in the state. Keeping this as prime objective the centre is working on development of high yielding rice varieties suitable for the state. Sveral promising lines are also developed. Keeping this in view 10 newly developed promising lines were given for multilocation testing in North Tripura in collaboration with Dr. Sentru Acharjee, Programme Coordinator, KVK, North Tripura. The multilocation testing of following ICAR Tripura centre developed lines – TRC 2008 -1 , TRC 2008-2, TRC -4, TRC 2008-5, TRC 2008-6, TRC 2008-7, TRC 2008-9, TRC 2008-10, TRC 2008-11 and TRC 2005-1 were taken up in collaboration with Dr. S. P. Das, Sr. Scientist (Plant Breeding), ICAR, Tripura centre.

Seeing the excellent performance of some of the newly developed lines, KVK, North Tripura organized a Field Day on Aman Paddy on 26 September, 2010. Hon'ble Minister for Agriculture, Tripura, Shri Aghore Debbarma graced the Field Day as Chief Guest. Senior officials from the Dept. of Agriculture, Jila Saha Sabhadhipati, Panchayat Pradhan were also present. Dr. S. Biswas, Sr. Scientist (Plant Pathology) represented ICAR, Tripura centre on the occasion.

Hon'ble Minister and other dignitaries visited the promising lines along with large number of farmers present on the day. Hon'ble Minister hailed such collaborative activity by ICAR, Dept. of Agriculture and KVK, North Tripura for working together for the development of Agriculture in the state. He pointed out that in recent years ICAR's effort in the state is helping the department and farmers in a big way.

Participatory Variety Selection (PVS) of Upland Drought Tolerant Rice at ICAR, Tripura Centre, Lembucherra on 19 October 2010 and Visit of Scientists from Internatioanl Rice Research Institute, Philippines 19-21 October, 2010

Dr. Arvind Kumar, Sr. Scientist, Drought & Aerobic Rice, Dr. Amelia Henry and Dr. Benoit Clerget, Crop

Physiologists, International Rice Research Institute (IRRI), Philippines visited Tripura during 19- 21 October, 2010, in connection to ongoing Bill & Melinda Gates Foundation Project (BMGF) "Stress Tolerant Rice for Poor Farmers of Asia and Africa (STRASA)" in which ICAR, Tripura Centre is one of the cooperating centres.

ICAR, Tripura centre is one of the network partners of this prestigious project. Initially the centre got associated with IRRI through 'Upland Rice Shuttle Breeding Network (URSBN)" in 2006. Since 2008 the centre was included in the "BMGF – STRASA". The centre is now involved in Upland Shuttle Breeding Network for development of stress tolerant rice for upland ecology; Drought Breeding Network (DBN) for development of drought tolerant rice for rainfed lowland; conduct of Participatory Variety Selection (PVS) of promising lines for their greater adaptability by farmers and seed production of stress tolerant varieties for upland and lowland including *sub1* varieties that can tolerate submergence up to 18 days at vegetative stage.

Kharif Rice Field Day , 17 November 2010

Principal Secretary of Agriculture, Mr. K. V. Satyanarayana along with Director, Dept. of Agriculture, Govt. of Tripura, Dr. S. N. Sen and top officials from Department of Agriculture, visited rice variety testing and demonstration plots at Bagabasa and Magpuskarini, South Tripura on 17 November, 2010. The dignitaries first visited the demonstration plots of TRC 2005 -1 (Gomati), TRC 2005-2 and TRC 229-F-41 at Bagabasa. Dr. M. Datta, Joint Director, shown the demonstration plots of the varieties, which were comparatively demonstrated against most popular Swarna and hybrid Arize 6444. The Principal Secretary was very much satisfied by the performance of the ICAR Tripura Centre varieties. He opined that the Government should zero down to one or two varieties from these for release and wide scale cultivation in the state as Swarna needs to be replaced due to its severe susceptibility to Sheet blight disease. The Principal Secretary, Director and other senior officials were impressed by the performance of the ICAR varieties on par with the hybrid Arize 6444. Farmers informed the dignitaries that Gomati (TRC 2005-1) fetched highest sell price in the market presently due its very fine grain quality.

Later the Principal Secretary visited the ICAR rice variety testing plots at Magpuskarini. Due to non availability of paddy land at ICAR premises a major part of the rice breeding material are handled at this location on the field of Mr. Paramananda Sen. He along with officials from Dept of Agriculture closely inspected the Yield testing plots of promising entries developed by ICAR, Tripura centre as listed below. He also had a quick look at the 94 other advanced promising lines under evaluation in replicated trial. He was very happy about performance of at least 4 lines and suggested for their multi location yield trial. He also visited the paddy demonstration plots planted with mechanical 8 row paddy transplanter. By seeing the performance of the paddy transplanter he declared that the department will provide subsidy even up to 50 percent if any Farmers Club apply for purchase of the Paddy transplanter which was costing Rs. 2 lakh approximately. At Bagabasa he also discussed about the establishment of the modern rice mill at Bagma, which is being pursued by ICAR along with the Farmars Club Federation at Bagma and assured for maximum assistance.

Training Programme on "Cottage level Food Processing & Entrepreneurship Development for Farmers" 4 December 2010

A training programme on "Cottage Level Food Processing & Entrepreneurship Development for Farmers" was organized on 4 December, 2010, in collaboration with Indian Institute of Crop Processing Technology (IICPT), Tanjavur. The programme was attended by 84 aspiring entrepreneurs interested in setting up cottage level food processing industries. Director, Industries & Commerce, Govt. of Tripura, Mr. V. G. Jenner was the Chief Guest of the programme. Mr.S. Sunder, GM, NABARD, Agartala and Dr. C. R. Bandopadhyay, Director, Horticulture and Soil Conservation were present as Guests of Honour. Dr. M. Datta, Joint Director, ICAR, Tripura Centre was the Chairman of the training programme.

3. PUBLICATIONS

MEGHALAYA (HQrs)

AGRONOMY

Research Papers

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4. Das Anup**,** Patel D P, Munda G C, Ghosh P K, Ngachan S V, Choudhury B U, Ramkrushna G I, Saha R, Rajkhowa D J, Panwar A S, Kumar Rajesh, Kumar Manoj and Buragohain Juri. 2011. Conservation agriculture in rice and maize based cropping systems: package and practices for NEH Region. Research Bulletin no. 75. ICAR Research Complex for NEH Region, Umiam, Meghalaya. pp 36.
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Book Chapters

1. Das Anup, Munda G C, Ghosh P K, Patel D P, Tripathi A K and Gill S C. 2009. Shifting cultivation in north eastern region of India – status and strategies for sustainable development. pp 326-347, (In) *Food Security and Sustainable Agriculture.* Jain O K, Hansra B S, Chakraborty and Jayashree M Kurup. (Eds). Uday Publishers and Advertisers. New Delhi.
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Dr. M.H. Khan, Scientist
Dr. Rantu Basumatary, Scientist
Dr. P.K. Bharti, Scientist

ANIMAL NUTRITION
Dr. Pramod Singh, Senior Scientist & In-Charge
Dr. J.J. Gupta, Principal Scientist (Animal Nutrition; up to 30.05.2010)

VETERINARY PARASITOLOGY
Dr. R. Laha, Senior Scientist & In-Charge
Dr. Meena Das, Scientist

ANIMAL HEALTH
Dr. Arnab Sen, Principal Scientist & In-Charge
Dr. I. Shakuntala, Senior Scientist

Dr. Z.B. Dubal, Scientist
Dr. K. Puro, Scientist
Dr. R.K. Sanjukta, Scientist

POULTRY SCIENCE
Dr. Sunil Doley, Senior Scientist & In-Charge

FISHERIES
Dr. S.K. Das, Principal Scientist & In-Charge
Dr. S.K. Majhi, Scientist
Dr. K. Murmu, Scientist

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Dr. Magan Singh, Sr. Scientist (Agronomy)
Dr. P. Suresh Kumar, Scientist (Horticulture)
Dr. V.K. Choudhary, Scientist (Agronomy)
Dr. Joginder Singh, Scientist (Plant Breeding)
Dr. D. Jini, Scientist (Vet. Extension)

MANIPUR CENTRE
Dr. N. Prakash, Joint Director
Dr. I. Meghachandra Singh, Senior Scientist (Seed Technology)
Dr. Pawan Kumar Sharma, Senior Scientist (Plant Pathology)
Dr. Jogendra Singh, Senior Scientist (Plant Breeding)
Dr. D. Kumar, Senior Scientist (Agril. Entomology)
Dr. Ch. Basudha Devi, Senior Scientist (Fishery)
Dr. Subhra Saikat Roy, Scientist (Horticulture)
Dr. D. Sarkar, Scientist (Soil Science)
Mr. Sudhir Kumar, Scientist (Plant Breeding)
Mrs. Punitha P., Scientist (Agril. Extension)
Mrs. S.K. Raman, Programme Coordinator (KVK, Imphal West)
Dr. L. Loken Singh, Programme Coordinator i/c (KVK, Ukhrul)
Dr. W. Rajen Singh, Programme Coordinator i/c (KVK, Churachandpur)
Dr. A. Suresh Meitei, Programme Coordinator i/c (KVK, Tamenglong)
Mr. G.P. Kabui, Programme Coordinator i/c (KVK, Chandel)

MIZORAM CENTRE
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Dr B.K. Singh Scientist (Hort.-Vegetable Science)
Dr L.H. Puii Scientist (Veterinary Microbiology)
Mr. K. Rajakekar Scientist (Soil Science)
Mr. Raghuveer Singh Scientist (Plant Pathology)
Dr Y. Ramakrishna (Farm Manager)

NAGALAND CENTRE
Dr. Anupam Mishra, Joint Director, Incharge
Dr. B.P. Bhatt, Ex. Joint Director
Dr. B.R. Singh, Principal Scientist (Veterinary Microbiology)
Dr. B. Sahoo, Scientist (Soil Water Conservation and Engineering)
Dr. M.K. Patra, Kumar, Scientist (Animal Reproduction)
Shri Rakesh Kumar, Scientist (Agronomy)
Dr. A. Thirugnanavel, Scientist (Horticulture)
Dr. Lohit Kumar Baishya, Farm Manager
Dr. Ebibeni Ngullie,SMS, Animal science

TRIPURA CENTRE
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Dr. S. Biswas, Senior Scientist (Plant Pathology)
Dr. A. Haldar, Senior Scientist (Animal Reproduction)
Dr. S. Malik, Senior Scientist (Poultry Science)
Dr. S. P. Das, Senior Scientist (Plant Breeding)
Mr. B.L.Meena, Scientist (Plant Breeding)
Mr. C. Debnath, Scientist (Fishery Science)
Mrs. H. Ranebennur, Scientist (Plant Pathology)
Mrs. L. Sahoo, Scientist (Fishery Science)

SIKKIM
Dr. H. Rahman, Joint Director
Dr. R.K. Avasthe, Pr. Scientist (Soil Science)
Dr. (Mrs.) Saroj Toppo, Sr. Scientist (An. Nutrition)
Dr, H. Kalita, Sr. Scientist (An. Nutrition)
Dr. A.K. Mohanty, Prog. Coordinator, KVK
Dr. Ramesh Chandra, Sr. Scientist (LPM)
Dr. Kundan Kishore, Scientist (S.S) (Horticulture)
Dr. Ashok Kumar , Scientist (S.S) (Horticulture)
Dr. L. Chatlod, Scientist (An. Health)
Dr. R. Gopi, Scientist (Plant Pathology)
Sh. Chandan Kapoor, Scientist (Plant Breeding)