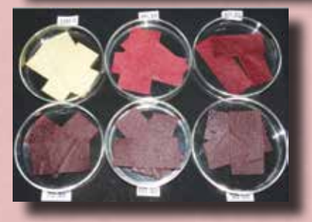

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भारतीय कृषि अनुसंधान परिषद

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वार्षिक प्रतिवेदन ANNUAL REPORT 2016

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ANNUAL REPORT
2016

उत्तर पूर्वी पर्वतीय कृषि अनुसंधान परिसर
(भारतीय कृषि अनुसंधान परिषद)
उमियम – ७९३ १०३, मेघालय

ICAR Research Complex for NEH Region
(Indian Council of Agricultural Research)
Umiam - 793 103, Meghalaya

भाकृअनुप
ICAR

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Annual Report 2016

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PREFACE

ICAR Research Complex for NEH Region is a premier institute of ICAR, which has glorious history in promoting and conducting research, extension and capacity building activities in agricultural and allied sectors for hills agriculture in northeastern region of the country.

The institute has developed various research and extension activities to meet the current demands of the NEH region.

A medium duration high yielding aromatic rice line RCM 34, was identified for high aroma and cooking quality traits. To enhance the pulses production in northeastern states, field demonstrations were undertaken in sixty three villages in Manipur state alone. Participatory seed production programme of cereals, pulses and oil seeds were undertaken on farmer's field. A web based software *SFAR (Soil Fertility Assessment and Recommendation)* has been developed for assessing the status of soil fertility based on 12 soil parameters. Molecular tools have also been developed for rapid and reliable identification of taxonomically difficult insect species and diseases of animals and plants. The institute has also made commendable progress in development of various products such as; 'Tree Bean Crunch' from tree bean pods, 'Museli' and 'Chewda Snax' from *Prunus nepalensis* and antioxidant rich 'Prunus Health Mix' from Prunus fruit pulp. Technologies on preparation of various products from meat and poultry have been commercialized. Licensing of technology for seed multiplication of Megha Turmeric 1 was also completed.

The institute is effectively using its well-developed network of reginal centers and KVKs and efficiently providing the technological support to the farmers of the north eastern hill region of India. Four KVKs namely; Peren, kiphire, West Tripura and Longdeng have also been established under the institute in 2016-17.

The tribal farmers of the region are also immensely getting benefitted through the special financial support from the Govt. of India under the Tribal Sub Plan, over 18,000 farmers were benefitted during 2016-17. The outcome of basic and strategic research is evidenced from the quality research publications came out during the year.

I compliment the editorial board for their efforts in compilation of annual report. I wish to place on record my deep sense of gratitude to the secretary DARE and Director General ICAR, Dr T. Mohapatra, the Deputy Director General, Natural Resources Management, Dr K. Alagusundaram for their constant support and guidance that enabled the institute to achieve the success presented here in the report.

(S. V. Ngachan)
Director

Contents

कार्यकारी सारांश

वर्ष 2016 के दौरान उमियम में कुल वार्षिक वर्षा 2202.4 मि.मी (129 घटनाएँ) हुई जिसमें मानसून के दौरान 74 दिनों में बरसात 1495 मि.मी हुई। मासिक अधिकतम तापमान 27^0C से 30.2^0C तथा न्यूनतम तापमान 25.7^0C से 19.8^0C के बीच पाया गया। औसतन मासिक आपेक्षिक आद्रता (सुबह) 75% से 89.3% और आपेक्षिक आद्रता (सायं) 42% से 79.1% के बीच पायी गयी। झरनापानी को छोड़कर न्यूनतम तापमान में 0.1^0C की वृद्धि हुई, जबकि मासिक अधिकतम तापमान 0.1^0C इम्फाल में और लगभग 1.4^0C प्रति दशक झरनापानी में वृद्धि हुई है। भारत के आठ उत्तर-पूर्वी राज्यों मे लंबी अवधि तक मानसून एवं वार्षिक वर्षा की प्रवृत्ति विश्लेषण से पता चला है कि केवल मेघालय और मणिपुर में बढ़ती हुई प्रवृत्ति पाई गयी है जबकि अरुणाचल प्रदेश, त्रिपुरा, मिजोरम, और सिक्किम में घटती प्रवृत्ति का अनुभव किया गया।

अरुणाचल प्रदेश से कुल 42 स्थानीय चावल के जर्मप्लाज्म का मुल्याकन किया गया जिसमें 23 डब्लूआरसी और 19 झूम के चावल के लैंडरेस शामिल थे। मध्यम अवधि और उच्च उपज देने वाली सुगन्धित चावल लाइन आरसीएम ३४ की पहचान उच्च सुगंध और उत्कृष्ट खाद्य गुणों के लिए की गई। चावल में सूखे की सहिष्णुता के् लिए, नई मैपिंग आबादी भालुम 3 x नवीन को क्यूयूटीएल (QTL) अध्ययन के लिए बनाया गया और त्रिपुरा में एफ ५ तक उन्नत किया गया। सूखा तनाव हालत के तहत अनाज उत्पादन में सुधार के लिए सात सूखा सहिष्णु QTLs (qDTY 1.1, qDTY 12.1, qDTY 2.1, qDTY 2.2, qDTY 3.1, qDTY 4.1 और qDTY 9.1) की उपस्थिति वाले 34 चावल जीनोटाइप की पहचान की गई। एक छोटी अवधि (111 दिन) सीधी-वरीकृत चावल के जर्मप्लाज्म (दुलार) की पहचान सिक्किम की वर्षा की अवस्था में नमी तनाव से सहिष्णु के रूप में की गयी है। आरसीआरटीटी (ऊपरी भूमि) में, चावल की उच्चतम उपज आरसीपीएल 1-413 (29.4 क्विं/हेक्टेयर) दर्ज किया गया और आरसीआरटी (निचला भूमि) में तीन प्रविष्टियां अर्थात आरसीपीएल - 300, आरसीपीएल 1-459 और आईयूरोन (IURON) 210 में उपज उमियम के चेक की तुलना में काफी अधिक दर्ज की गयी। मणिपुर में अग्रिम विविधता परीक्षण में, एमसी 41-2-2-11 (8.80 टन/हे) और एमसी 45-2-2-11 (8.08 टन/हे) को चेक से अधिक आशाजनक पाया गया। चावल की किस्म, भालूम -1, और गोमती में मिजोरम की ऊपरी और निचले इलाकों में क्रमशः सबसे अधिक अनाज की ऊपज दर्ज की गई। त्रिपुरा में, 34 क्रॉस में से 1406 एकल पौधे चयन किए गए जिसमे चावल के उपज और अन्य विशेषताओं के लिए विश्लेषण किया गया। त्रिपुरा में सूखे के तहत चावल की उपज के लिए प्रमुख क्यूटीएल की पहचान, क्षेत्र के चावल की झूम (स्थानांतरण खेती), सूखा सहिष्णुता के कार्यात्मक जीनोमिक्स और चावल के चयनित जीनों के एलील खनन द्वारा की गई।

मध्य-ऊंचाई मेघालय में नमी तनाव सहिष्णुता के लिए मक्का के तीन जर्मप्लाज्म अर्थात् वीक्यूपीएम 9 (अनाज की पैदावारः 3800 किलोग्राम/हेक्टेयर), उसके बाद आरसीएम 1-75 (3233 किलोग्राम/हेक्टेयर) और विजय कम्पोजिट (2733 किलोग्राम/हेक्टेयर) की पहचान की गई। उमियम में एक नियंत्रित अध्ययन के द्वारा जड़ और तना वृद्धि के आधार पर मक्का के तीन जीनोटाइप, अर्थात् आरसीएम जीपी 47, आरसीएमजीपी 63, आरसीएमजीपी 105 को गर्मी सहिष्णु के रूप में पहचान की गई। एक DREB2A cDNA क्लोन को *Pennisetum glaucum* से निकाला गया जिसे मक्के में नमी तनाव सहिष्णुता के लिए व्यक्त किया गया। बसार में, संरक्षण कृषि के तहत बेबी कॉर्न मकई की उत्पादन तकनीक विकसित की गई और VL बेबी कॉर्न-1 में आरसीएम 1-2 से ज्यादा उपज मिली।

पूर्वोत्तर राज्यों में दाल उत्पादन को बढ़ाने के लिए, मणिपुर के पांच जिलों के 63 गांवों में अरहर, राजमा,

मूँग, उरद, चावलबीन, लोबिया और सोयाबीन पर क्षेत्रीय प्रयोग किए गए। मिजोरम में विभिन्न किस्मों अर्थात, सीपी-5 (cowpea), उरद-3 (काली उरद), अमान (मटर), आईपीसी 97-67 (चना), डीपीएल 62 (मसूर), एचएम-12 (ग्रीन ग्राम), आईसी-18553 (चावलबीन) और जीपी एचबी-40 (एफबीए बीन) मे उच्चतम अनाज उपज दर्ज कि गयी। मेघालय में 780 से भी अधिक किसानों के खेतों में अनाज, दाल एवं तिलहन फसलों का भागीदारी पर आधारित बीजोत्पादन कार्यक्रम आयोजित किया गया। सिक्किम की परिस्थितियों में जलवायु तन्यक फसल प्रणालियों में मक्का (हरा भुट्टा) - उड़द-मोथा ने अन्य मौजूदा प्रणालियों की अपेक्षा अधिक उत्पादक (8.83 टन/हेक्टेयर), अधिक लाभ (बी. सी अनुपात 2.55) एवं रोजगार सृजनात्मक (282 आदमी दिवस) सिद्ध हुई। यह पूर्व सिक्किम के 195 प्रगतिशील किसानों के खेतों में, जिसका क्षेत्रफल 30 हेक्टेयर था, प्रर्दशित की गई। धान-ब्रोकोली-सेसबेनिया फसल प्रणाली के पालन से सिक्किम में मौजूदा धान/मक्का आधारित फसल प्रणालियों की अपेक्षा 19.8 प्रतिशत अधिक धान उत्पादन होता है। सिक्किम की परिस्थितियों में मक्का+लोबिया-सब्जीमटर से सर्वाधिक प्रणाली उत्पादकता (17.0 टन/हेक्टेयर) तथा उत्पादन दक्षता (46.5 किलोग्राम/हेक्टेयर/दिन) दर्ज की गयी। इसके बाद मक्का+लोबिया-राजमा द्वारा सर्वाधिक उत्पादकता एवं उत्पादन क्षमता दर्ज की गई।

एकीकृत पोषक प्रबंधन (आईएनएम : 50 प्रतिशत कार्बनिक+ 50% (अजैविक) अथवा 100%जैविक) के परिणाम स्वरूप ब्रोकोली-सब्जियाँ फसल प्रणाली द्वारा अधिकतम चावल समकक्ष उपज (>37.4 टन/हेक्टेयर) प्राप्त हुई। अजैविक प्रबंधन की तुलना में 100% जैविक प्रबंधन के तहत मिट्टी में सूक्ष्म पोषक सामग्रियों (लोहा, मैंगनीज, जिंक एवं कॉपर) मे 17.5 से 36.6% की वृद्धि हुई। मध्यम ऊँचाई वाले मेघालय के अम्लीय मिट्टी (पीएच : 4.5) में चार साल के प्रयोग से एकीकृत पोषक प्रबंधन एवं क्रियाओं का मूँगफली के लिए मानकीकृत किया गया जिससे उत्पादकता में दो गुना वृद्धि हुई। पूरक सब्जी आधारित अनुक्रमों में गाजर-भिंडी फसल से अधिकतम चावल उपकक्ष उपज (36.5 टन/हेक्टेयर) दर्ज की गई। घाटी भूमि के लिए एकीकृत जैव खेती प्रणाली मॉडल (आईओएफएस) मेघालय में विकसित की गया जिससे रूपये 1,66,144/प्रति वर्ष/हेक्टेयर का शुद्ध लाभ दर्ज किया गया। वर्ष 2016-17 के दौरान, मेघालय के मावकिरदेप गाँव में समूहबद्ध दृष्टिकोण को बढ़ावा दिया गया।

मेघालय में 32.4% की औसत ढलान वाले 0.064 हेक्टेयर क्षेत्र पर स्थापित कृषि-पशुधन प्रणाली के परिणाम स्वरूप 9.98 टन धान समकक्ष उपज (गिनी घास को छोड़कर) प्राप्त हुई। 245 मानव-दिन के रोजगार सृजन के अलावा इस प्रणाली ने सफल एवं शुद्ध आय (रूपए 3.14 और 1.17 लाख क्रमश :) का भी सृजन किया। फसलों, पशुधन, मत्स्य एवं वृक्ष घटकों से निर्मित छ : एकीकृत कृषि पद्धति (आईएफएस) मॉडल के व्यवहार्यता अध्ययन से पता चला कि मुर्गीपालन-मछली आधारित मॉडल (उत्पाद : निवेश अनुपात 9.32) से अधिकतम राजस्व प्राप्त होता है इसके बाद डेयरी आधारिक (पशु-मछली-एमपीटी-फसल-वर्मीकम्पोस्ट) मॉडल (उत्पाद : निवेश अनुपात 3.69) एवं अन्य संयोजनों का स्थान आता है। बसार में कंद की फसल आधारित फसल प्रणाली, जिसमें आच्छादन फसलों के रूप में दहलनों का सामावेश हो, विकसित की गई। नागालैंड के छोटे एवं सीमांत किसानों के लिए उपयुक्त आईएफएस मॉडल का मूल्यांकन किया गया तथा मॉडल 3 (जिसमें कृषि+बागवानी+सुअर पालन+मत्स्य पालन घटक शामिल है) ने उच्चतम शुद्ध लाभ (1.09 लाख रूपए) दर्ज किया।

उमियम में अदरक को फल-वृक्षों/*Parkia roxburghii* (आच्छादन फसल) के साथ लगाने पर अदरक की वृद्धि एवं उपज मे बिना आच्छादन की तुलना मे कमी पाई गयी। छ : फल-वृक्षों एवं अदरक आधारित प्रणालियों की उत्पादकता को अदरक समकक्ष उपज में परिवर्तन करने पर अधिकतम उत्पादकता तब प्राप्त हुई जब अदरक को खुले क्षेत्र में एकमात्र फसल (14.45 टन/हेक्टेयर)

के रूप में लगाया गया, तत्पश्चात आडू-अदरक (11.31 टन/हेक्टेयर) एवं अमरूद-अदरक (9.74 टन/हेक्टेयर) का स्थान आया। मुकुना के ग्यारह भरोसेमंद प्रजातियों की वृद्धि एवं उपज मापदंडों के लिए एक जाँच प्रजाति (आई सी 83195) के साथ मूल्यांकन किया गया। आई सी 83195 (98 दिन बुआई के पश्चात) तत्पश्चात UKD 11 (101 दिन बुआई के पश्चात) में शीघ्र पुष्पण देखा गया जबकि MZR 16 (153 दिन बुआई के पश्चात) में विलंबित पुष्पण पाया गया। उमियम संस्थान के अनुसंधान फार्म में 28 पूर्व स्थापित प्रणालियों (एफएस) मॉडल की मिट्टी-गुणवत्ता का अध्ययन किया गया। वानिकी आधारित फसल प्रणाली (एफएस) के तहत मिट्टी की गुणवत्ता सबसे ज्यादा थी, इसके बाद प्राकृतिक वन (पाइन) आधारित एफएस, बागवानी आधारित एफएस, कृषि-बागवानी-वन आधारित एफएस, कृषि-वानिकी एफ एस, गौशाला आधारित एफएस कृषि आधारित एफएस एवम् परित्यक्त झूम भूमि का क्रमशः स्थान आता है।

बाराक घाटी, असम के लिए रिमोट सेंसिंग, जीआईएस और सहायक जानकारी का एकीकृत उपयोग कर मृदा अम्लता, उर्वरता, प्रोफाइल कार्बन स्टॉक और संयुक्त मिट्टी गुणवत्ता सूचकांक (एसक्यूआई) की मैपिंग 1:50 के स्थानिक पैमाने पर किया गया। घाटी में अधिकांश मिट्टी (>76% जीए) मध्यम श्रेणी के माइक्रोन्यूट्रेंट-एनपीकेएस स्थिति (एम-एम-एम-एम) और गुणवत्ता में औसत (एसक्यूआई: 0.4-0.6) हें जिससे निरंतर कृषि जारी है। जयंतिया पहाड़ियों की कोयले की खदान की मिट्टी के सर्वेक्षण और विश्लेषण से पता चला है कि मिट्टी प्रकृति में रेतीले, लाल भूरे रंग से पीले भूरे रंग, बहुत अम्लीय (पीएच <4.90) और उसमें बहुत अधिक घुलनशील लवण (768 पीपीएम) थे। मिट्टी में अवशेष धातुओं (आर्सेनिक, कैडमियम, क्रोमियम, सीसा, पारा, जस्ता, निकल, फ्लोराइड, एल्यूमीनियम, लोहा, मैंगनीज आदि) की मात्रा भी अधिक थी। मिजोरम में झूम कृषि मिट्टी के जल जाने के बाद मृदा कार्बन पूल के विश्लेषण ने संकेत दिया कि सक्रिय सी पूल कम हो गए, जबकि निष्क्रिय सी पूल में वृद्धि परती अवधि (>10 वर्ष) के वृद्धि के साथ हुई।

मेघालय की मुख्य भूमि उपयोग प्रणालियों के सूक्ष्म वाटर शेड से पानी के बजट घटकों के आंकलन के तहत ये पाया गया कि वर्षा के बहाव (10.9 से 21.5 :), वास्तविक फसलों के वाष्पन-उत्सर्जन (33.5 से 62.2 :) और पुनर्भरण योगदान (32.5 से 50.6 :) में काफी विभिन्नता थी। तूरा में मुख्य झूम सुधार कार्यक्रम के 82 घटनाओं में 2189.3 मि.मी. बारिश और 48.2 टन/हेक्टेयर/वर्ष गाद का प्रभाव देखा गया। कुल 847 एएएस बुलेटिन और 28,507 एसएमएस तैयार किए गए और जीकेएमएस सर्विस के तहत एम किसान पोर्टल के जरिए किसानों को वितरित किए गए। पृथ्वी ट्यूब ताप एक्सचेंजर के साथ स्थापित पॉलिहाउस के ठंडा/गर्म करने के लिए बिजली की खपत का अनुमान लगाया गया था। उमियम में उन्नत औजारों के अग्रिम प्रदर्शन के तहत धान की थ्रेसर कम क्लीनर के बनावट मे सुधार, पावर टिलर के व्यवहार्यता परीक्षण, बीज ड्रिल और पहाड़ियों के संकीर्ण सीढीदार खेत में उपयोग होने वाले हल्के वजन के पावर टिलर में सुधार को आरंभ किया गया।

कम जुताई के कारण मक्का की उत्पादकता (3.79 टन/हे.), परंपरागत जुताई (3.18 टन/हे.) से काफी अधिक दर्ज की गयी थी, लेकिन शून्य जुताई (3.67 टन/हे.) के बराबर बनी हुई रही। पूर्व सिक्किम के 35 प्रगतिशील किसानों के 10.5 हेक्टेयर क्षेत्र पर धान की खेती के बाद परती जमीन पर शून्य जुताई के सब्जी मटर का प्रदर्शन हुआ। सीढीदार खेत के तहत, शून्य जुताई के मक्का समकक्ष उपज (एमइवाई) में परंपरागत जुताई के मक्का समकक्ष उपज (एमइवाई) में परंपरागत जुताई के मुकाबले अधिक वृद्धि देखी गई। परंपरागत जुताई प्रथाओं की तुलना में संरक्षण कृषि (शून्य खेती) ने जीएचजी (सीओ$_2$ CO_2, सीएच$_4$ CH_4 और एन$_2$ओ N_2O) का रिसाव काफी हद तक कम किया है। पोषक प्रबंधन प्रथाओं में, एफवाईएम का उपयोग, खरपतवार जैव भार और रॉक फॉस्फेट के साथ-साथ करने पर जीएचजी के रिसाव को

अधिक किया जबकि अकार्बनिक खाद (आरडी के 50: एनपीके) ने जीएचजी के रिसाव को कम किया। ताजा चावल के अवशेषों का बायोचार (0.5-1.0) में रूपांतरण से CO_2 के उत्सर्जन को 30-40: तक घटा दिया और मिट्टी के जैविक कार्बन के अधिग्रहण में काफी सुधार किया। हालांकि, तापमान में वृद्धि से, CO_2 प्रवाह के उत्सर्जन में 1.5 गुना बढ़ोतरी दर्ज की गई।

एनआरएम डिवीजन द्वारा 12 मृदा मापदंडों के क्षेत्र परीक्षण के परिणामों से मिट्टी की उर्वरता (खराब/मध्यम/ऊच्च) की स्थिति का आंकलन करने के लिए एक वेब आधारित सॉफ्टवेयर एसएफएआर (मिट्टी उर्वरता आंकलन और अनुशंसा) विकसित किया गया। सॉ फ्टवेयर में 10 महत्वपूर्ण फसलों के लिए सिफारिश मार्ग दर्शकों, जिसमें स्थान विशेष के अनुकूल मिट्टी अम्लता और पौधे पोषक प्रबंधन को सम्मलित किया गया है। इसी तरह, जैव भौतिकीय मॉडल (कृषि उत्पादन सिस्टम सिम्युलेटर-एपीएसआईएम) का उपयोग करते हुए विभिन्न प्रबंधन स्थिती और जलवायु परिवर्तन परिदृष्यों के तहत निची भूमि के चावल प्रजाति का आनुवंषिक गुणांक को दीर्घकालिक सिमुलेषन अध्ययन के लिए अंशशोधित किया गया।

मेघालय में पतन वाले खासी मंडारिन बगीचों में फलों के गुण जैसे, फलों के वजन (76-112 ग्राम), फल की आयतन (80-180 सीसी), टीएसएस (9.16-11.80), लघुकारक चीनी (3.17-5.87) और कुल चीनी (5.27-7.67) में स्वस्थ बागों की तुलना में कमी आई है। छ: साल पुराने सिक्किम मंडारिन पौधों पर जिन्हें विभिन्न रूट स्टॉक्स पर कलम बांधा गया था, नैनो-पोषक तत्व का 2 मि.ली. प्रति ली. को 45, 90 और 135 दिनों पर उपयोग से फलों की गुणवत्ता पर सकारात्मक प्रभाव देखने को मिला।

पांच अमरूद किस्मों, मेघा अमरूद (कटु प्रकार X स्थानीय लाल गुदा), मेघा सॉप्रियम (लाल गुदा X इलाहाबाद सफेदा), मेघा खोंगफेराम पौड़ीक (लखनऊ - 49 X नाषपाती आकार), इलाहाबाद सफेदा और लखनऊ 49 को मीडो रोपण प्रणाली (2 मीटर X 1.5 मीटर) के अंतर्गत छ: क्षेत्रीय केन्द्रों पर मूल्यांकन किया गया। अमरूद के मेघा खोंगफेराम पौड़ीक (आरसीजीएच 7) प्रजाति फल उत्पादकता (12.0 किलो/पौधे) और फलों के वजन (148.6 ग्राम) के मामले में बेहतर पाया गया। मिजोरम में अमरूद की इलाहाबाद सफेदा लाइनों में उच्च उत्पादकता दर्ज की गई। नागालैंड की स्थिति में अमरूद की आरसीजीएच 4 ने अधिकतम फल वजन (172.4 ग्राम) और उपज (18.3 किग्रा/पेड़) दर्ज किया जबकि आरसीजी 11 में सबसे अधिक टीएसएस (12.2 ब्रिक्स) दर्ज किया गया। सिक्किम की स्थितियों के तहत प्रति पौधा फल की कुल संख्या आरसीजीएच 7 में अधिकतम (140) थी, उसके बाद एल 49 (105) था।

मेघालय की स्थिति में लाल गुदा वाले अमरूद की किस्म मेघा सॉप्रियम (आरसीजीएच 4) का 5 अप्रैल को कली हटाने से फलों की परिपक्वता में 22 दिनों की देरी हुई जबकि 15 मार्च को कली हटाने के कारण उच्च बिक्री योग्य फल उपज (7.1 किलोग्राम/पौधे) का उत्पादन हुआ।

नागालैंड की निचली पहाड़ी स्थिति में वाणिज्यिक खेती के लिए कम द्रुतशीतन सतालू किस्मों में, फ्लोरडास का प्रदर्शन सबसे अच्छा था, इसके बाद टीए - 170 और शान-ए-पंजाब ने किया। सिक्किम में किवी फलों में प्रति टहनी 2 फलों का विरलन करने से सबसे ज्यादा फल की लंबाई, वजन और टीएसएस पाया गया। सिक्किम में आंशिक संरक्षण के तहत हाथ से परागण करने पर 'ए' ग्रेड के किवी फलों (70-80%) में काफी वृद्धि हुई। सिक्किम में अन्य की तुलना में तीन वर्षीय सतलुज बैंगनी बेरमें अधिकतम पौधे की ऊँचाई (3.2 मीटर), पौधे की छत्र (4.85 मीटर^2) और तना के व्यास (11.14 सेमी) दर्ज की गई। मिजोरम की स्थिति के लिए ड्रैगन फल और स्ट्रॉ बेरी उपयुक्त पाए गए।

पायरस पशिया में 15 से 30 अक्टूबर के दैरान जीभ की कलम करने पर अधिकतम अंकुरण (100%) और उच्चतम जीवित दर (86.7%) दर्ज की गई। टमाटर में अंतर-विशिष्ट संकर, एस सरासिफोर्मे X सेल 9 ए, एस.

सरासिफोर्मे X एमसीटीआर 4 बी और एस सरासिफोर्मे X डीएमटीटी 1 ने ब्लाइट के खिलाफ सहनशीलता दिखाई, जो की भारत के पूर्वोत्तर क्षेत्र में एक गंभीर समस्या है। ककरोल में, आरसीएसजी 15 (9.3 किलो) में उच्चतम उपज प्रति पौधे दर्ज की गई, जबकि आरसीएसजी 14 में फलों के वजन 149.4 ग्राम था। लाइकोपीन तत्व को छोड़कर अधिकांश लक्षणों के लिए परिपक्व हरे और परिवर्तन के चरण के बीच ककरोल का उत्पादन श्रेष्ठ पाया गया। सेम की एक नई जीनोटाइप चयन 1 की पहचान की गई जो कि अनिश्चित, छोटी अवधि (60-90 दिन) की है जिसमें 12.18 की संख्या में पॉड्स प्रति पौधे और उपज 150-180 ग्राम/पौधे होते है। फ्रेंच बीन के झाड़ी प्रकार के बीच, सेल - 17 सर्वश्रेष्ठ पाया गय जिसकी उपज प्रति पौधे (158 ग्राम) और पॉड की लम्बाई (16 सेंटीमीटर) थी। पोल प्रकार, में, मणिपुर से जीनोटाइप का एक नया संग्रह पाया गया जिसमे उल्लेखनीय पॉड की लम्बाई (18.0 सेमी) और पौड उपज प्रति पौधा (310 ग्राम) थी। शकरकंद में, टीएसपी 12-12 किस्म ने उच्चतम बिक्री योग्य उत्पाद (19.2 टन/हेक्टयर) और कुल उपज (27.8 टन हेक्टयर) दर्ज किया जबकि स्थानीय किस्मों में अधिकतम सूखा पदार्थ (33.3%), स्टार्च (19.6%) और चीनी (4.3%) दर्ज की गई। अरवी की किस्म मुक्ताकेशी ने अधिकतम कोर्मल संख्या (25.3), वजन (533 ग्राम/पौधे), उपज (16.9 टन/हेक्टेयर) और कुल उपज (21.33 टन/हेक्टेयर) पायी गयी। उमियम में प्याज के जीनोटाइप ओएन 15-45, ओएन 15-37 और ओएलआर - 1347 का प्रदर्शन आशाजनक पाया गया। अधिकतम हल्दी उपज (50.97 टन/हेक्टेयर), 100% जैविक खपत, सूक्ष्म पोषक तत्वों में दर्ज किया गया।

मेघालय के किसानों को आलू, हल्दी और अनानास फसलों के लिए पूर्व-बुवाई के पूर्वानुमान दिए गए। संस्थानों से बाजार सूचना सलाह प्राप्त करने वाले किसान ने पिछले वर्ष की तुलना में हल्दी पर 4% अधिक शुद्ध मुनाफा प्राप्त किया। मेघालय राज्य के लिए बागवानी फसलों के विपणन रणनीतियों को विकसित किया गया है और अनानास, आलू और अदरक की पहचान मेघालय में संभावित विपणन योग्य फसलों के रूप में की गई है।

जरबेरा में जैविक पलवार करने से शारीरिक विशेषताओं में सुधार और उपज देखी गई। जरबेरा संकर आरसीजीएच 12, 22, 114 और 117, खुले अवस्था, कम लागत वाले पॉलीहाउस और पंखा और पैड पॉलीहाउस के तहत आशाजनक प्रतीत हुए। जरबेरा आरसीजीएच 28 की पहचान छोटी जरबेरा जीनोटाइप के रूप में की गई थी, जो गमले और घर के अन्दर लगाने वाले पौधों के लिए उपयुक्त है।

चाउचाउ के गुदे को सोहिओंग रस के साथ 80:20 और 70:30 के अनुपात में मिश्रित करने पर चमड़े और आरटीएस पेय को सबसे अच्छे पेय के रूप में मूल्यांकन किया गया। बीन पेड़ के फलों के उत्सारण तकनीक द्वारा एक अनूठा उत्पाद 'ट्री बीन क्रंच' को विकसित किया गया था। उत्सारित उत्पाद जैसे "प्रुनुस नेपालसिस" द्वारा मूसली एवं चेवडा स्नैक्स और प्रुनुस फल के गूदे से बहुल ऑक्सीकरण रोधी प्रुनुस स्वास्थ्य मिश्रण एवं निर्जलित उत्पाद विकसित किए गए। कंद फसलों के लिए विशेष कोष के तहत उखुरुल जिला में दो सागू प्रसंस्करण इकाइयां "माया कंद फसल उत्पादक क्लब, रिहा" एवं लिंग्संस किसान क्लब, थोई" में सफलतापूर्वक स्थापित की गई।

उमियम में प्याज के लिए "थ्रिप्स" और "कटवोर्म (एग्रोटिस इप्सिलों)" प्रमुख कीटों के रूप में पाए गए है। उच्चतम थ्रिप्स जनसंख्या अप्रैल (42/संयंत्र) के महीने में पाया गया था। टमाटर में फलों के मक्खियों के प्रबंधन के लिए 15 पारा फेरोमोन जाल के साथ नीम (नींबेसीडाइन) के तेल आधारित संरूपण का 15 दिनों के अंतराल पर 5 मी.ली. प्रति ली. पानी में मिलाकर फल अवस्था में फुहारा बहुत प्रभावी था। मेघालय में बैंगन शूट बोरर्स के खिलाफ नई कीटनाशक अणु क्लोरानट्रानिलिप्रेल 40 ग्रा. ए.आई. प्रति हेक्टेयर और फ्लुबेन्डाइमेड @ 48 ग्रा ए.आई. प्रति हेक्टेयर अत्यधिक प्रभावी थे। सिक्किम मे मक्का के प्रतिशत अंकुरण (92%) को बनाये रखने एवं बीज मे कीटों के प्रकोप को कम करने मे स्पाइनोसाइड 45 SC

0.1% काफी प्रभावी पाया गया। मेघालय में नॉल-खोल को "बैक्ट्रोसेरा टाऊ" के एक नए होस्ट के रूप में सूचित किया गया है। सिक्किम में पहली बार (2016 में) कीवी पर "चाय मच्छर बग" दर्ज किया गया है। मिजोरम में मिर्च और कैप्सिकम पर फल मक्खी - "बैक्ट्रोसेरा टाउ" द्वारा आर्थिक नुकसान को पहली बार प्रतिवेदित किया गया। एंटीमोपैथोजेसिक बैक्टीरिया ("सेरेटिया मार्ससेन्स") से प्राप्त लाल रंगद्रव्य पॉलीफेगस कीट "स्पोडोपेटरा लिट्यूरा" के खिलाफ घातक पाया गया था।

सिट्रस ट्रंक बोरर "स्यूडोनेमोफस वर्स्टीगी" (रीत्सोमा) का पूरा मायटोकॉन्ड्रियल जीनोम अनुक्रमित और वर्णित किया गया। जीनोम का आकार 15,685 बीपी लंबा और गोल था। पीसीआर आधारित आणविक उपकरण, फल मक्खियों की चार संबंधित प्रजातियों की तेजी से पहचान के लिए विकसित किया गया था। अनाज फसल पारिस्थितिकी तंत्र के 30 कीट और प्राकृतिक दुश्मनों के लिए डीएनए बारकोड का विकास किया गया था।

प्रतिक्रियाशील ऑक्सीजन प्रजातियों के प्रति संभावित एजेंट को खोज करने के लिए, 15 विविध स्वदेशी फसलों के पानी के अर्क की जांच डीपीपीएच रैडिकल स्केजेनिंग गतिविधि के लिए की गई। प्राप्त किए गए पानी के अर्क में, "फिलांटस यूरेनियम" ने अधिकतम गतिविधि (0.24 मिलीग्राम आईसी 50 मूल्य) दिखायी, इसके बाद "रीस सेमीयालाटा" (0.40 मिलीग्राम आईसी 50 मूल्य) और "पेरिस पॉलीफाइला" (0.73 मिलीग्राम आईसी 50 मूल्य) ने स्थान प्राप्त किया।

अपशिष्टचिकन पंख के प्रोटीन हाइड्रोलाइजेड (एफपीएच) का "क्रिस्टीबेक्टेरियम प्रजाति" आरसीएम-एसएसआर - 7 के उपयोग से प्रतिक्रिया की सतह पद्धति को मानकीकृत किया गया था। आरसीएम-एसएसआर - 7 पंख कचरे से अमीनो एसिड के उत्पादन के लिए एक अच्छा प्रत्याशी हो सकता है। कारपेंटर कृमि ("प्रियोनॉ स्टिकस्टस रोबिनयिा" पेक) जो की नागालैंड की स्वदेशी आबादी के बीच एक लोकप्रिय व्यंजन है उसका जैव रासायनिक और पोषण मूल्य भी निर्धारित किया गया था।

मेघालय में गोभी के ऑफीड ("ब्रेविकोरिनी ब्रैसिकी") को संक्रमित करने वाले कवक की पहचान आणविक स्तर पर "लेकिनिसिलियम लान्जीस्पोरम" के रूप में की गई थी। आईवीटी में, तीन सोयाबीन जीनोटाइप (कोड संख्या 2, 9 और 33) उमियम में रस्ट के लिए अत्यधिक प्रतिरोधी पाए गए थे। सोयाबीन के पॉड ब्लाइट कॉम्प्लेक्स के प्रबंधन में थियॉफानेट मिथाइल का फुहारा रोपने के 55 एवं 75 दिनों के बाद या "ट्रायकोडर्मा विरीडी" 5 ग्रा प्रति ली. के उपयोग को अधिक रूप से प्रभावी पाया गया। नागालैंड की स्थितियों के तहत लहसुन की सभी पंक्तियों पर स्टेमफिलियम ब्लाइट सबसे प्रमुख बीमारी थी। सिक्किम में टमाटर की लेट ब्लाइट एवं जड़ सड़न के प्रबंधन के लिए कॉपर ऑक्सीक्लोराइड बहुत प्रभावी पाया गया। मणिपुर में किसानों के बीच मशरूम की खेती को लोकप्रिय बनाने के लिए अलग-अलग हित धारकों के लिए "प्लयूरोटस प्रजातियों" एवं शिताके (लेंतिनुला एडोदेस) के उत्तम बीज का उत्पादन और आपूर्ति की गई। जंगली केले पर उगाए गए मशरूम सूक्ष्म पोषक तत्वों में समृद्ध थे। नागालैंड केंद्र में पंद्रह जंगली खाद्य मशरूम एकत्र और संरक्षित किए गए थे। पूर्वोत्तर क्षेत्र में केले को संक्रमित करने वाले बनाना स्ट्रीक मोजेक वायरस (बीएसएमवायवी) का पता लगाया गया है और पुष्टि की गई है।

540 साइट्रस नमूनों को डबल एंटीबॉडी सैंडविच-एलिसा (डीएएस-एलिसा) और रिवर्स ट्रांसक्रिप्शन-पीसीआर (आरटी-पीसीआर) का उपयोग करके सीटीवी का परीक्षण किया गया और 62.7% नमूने सही पाए गए। मणिपुर के दस सीटीवी आइसोलेट्स में 86-94% पहचान थी और कोट प्रोटीन (सीपी) के न्यूक्लियोटाइड अनुक्रमों के लिए 89-98% अन्य भारतीय सीटीवी आइसोलेट्स केपीजी 3 के साथ और फयलोजेनेटिकली केपीजी 3 जीनोटाइप से संबंधित था। लगभग 38% सीटीवी और हंग्लोंगविंग (एचएलबी) के मिश्रित संक्रमण का पता चला है, जो संकेत देते हैं की मणिपुर में साइट्रस गिरावट के

लिए ये दोनों रोग जिम्मेदार थे।

आरके - 13 सेल लाइन में अनुकूलित सीएसएफवी पी - 25 का इस्तेमाल करके क्लासिकल सूअर बुखार वायरस (सीएसएफवी) एंटीबॉडी का पता लगाने के लिए अप्रत्यक्ष एलिसा को मानकीकृत किया गया। पूर्वोत्तर क्षेत्र से लैक्टिक एसिड बैक्टीरिया (एलएबी) को वर्णित करने के लिए नए आइसोलेट को पहचाना गया लैक्टोबैसिलस ब्रेविस, लैक्टोबैसिलस प्लांटारस और लैक्टोबैसिलस पोबोजिही। माइकोबैक्टीरियम प्रजाति को मनुष्य, जानवर और पर्यावरण के नमबनों से पृथक कर के आणविक वर्णन किया गया जिसमे 29 नॉटसबेर्क्युलस मायकोबैक्टेरिया (एनटीएम) और 23 माइकोबैक्टीरियम ट्यूबरकुलोसिस बेसिलस कॉम्प्लेक्स (एमटीबीसी) का पता चला है। सूअरों में जापानी एन्सेफलाइटिस एंटीबॉडी का पता लगाने के लिए पेप्टाइड आधारित निदान परख का मानकीकृत किया जा रहा है। ओंकोजेनिक वायरस जैसे मारेक रोग वायरस (एमडीवी), एवियन ल्यूकोसिस वायरस (एएलवी) और रेटिंकुलो एन्डोथिलियोसिस वायरस (आरईवी) को पोल्ट्री में पाया गया। सूअर के गस्त्रोइन्तेस्तिनल प्रोटोजोअन परजीवी की छ : प्रजातियां तीन फायलमय सिलीओफोरा, सरकोमास्तोफोरो, एपिकॉम्पलेक्सा के तहत पहचाने गए थे। सेरो-सर्विलांस ने पोर्सीनरेस्पिरेटरी और रिप्रोडक्टिव सिंड्रोम वायरस (पीआरआरएसवी), क्लासिकल सूअर बुखार वायरस (सीएसएफवी), पोर्सीनसिर्को वायरस (पीसीवी), फुट एंड माउथ डिसीज (एफएमडी), बोवाइन वायरल डायरिया (बीवीडी), हामोराजिक सैप्टिसीमिया (एचएस), ब्लैक क्वार्टर (बीक्यू) पूर्वोत्तर भारत के विभिन्न राज्यों में मूल्यांकन किया गया।

रसोई के कचरे में 7% मोल्लासेस मिलाकर बनाये गये नये खाने को खिलाकर सूअरों में 109 ग्राम/दिन की बेहतर वृद्धि दर हासिल की गई। हीट शॉक प्रोटीन (एचएससी 40) की तुलनात्मक अभिव्यक्ति स्तर खासी स्थानीय सूअरों में अदिक था, जो तनाव की स्थितियों में उन्हें सहन करने में सक्षम बनाता है। देशी सूअरों के संकर के लिए संग्रहीत तरल वीर्य की अपेक्षा 0-3 दिनों के लिए संग्रहीत तरल वीर्य अधिक प्रभावी है। गर्मियों के महीनों में क्रॉसब्रेड सूअरों से एकत्रित किए गए स्खलन में शुक्राणु की संख्या कम पाई गई। अरुणाचल प्रदेश के बसार में अलग-अवग जमीन सामग्री वाले शेड में किए गए प्रयोगों मे पाया की लकड़ी के बुरादे वाले शेड में सूअरों के वजन मे आशातीत वृद्धि होती है।

सिक्किम के विभिन्न कृषि-जलवायु क्षेत्रों में खनिज की कमी से उत्पन्न पोषकतत्वों विकारों से पता चला की डेयरी पशु के संगठित और असंगठित डेयरी फार्म में inter-calving अंतराल के बीच कोई महत्वपूर्ण अंतर नहीं दिखा। पोर्सीन भ्रूण को इन-विट्रो परिपक्वता के बाद रासायनिक सक्रियण और रोर्सीन ज्योगोटे मीड्यम (पीजेडएम) करके बूचड़खाना के अंडाशय से कृत्रिम तरीके से उत्पादन किया गया। उद्यमिता विकास के लिए एक मांस प्रसंस्करण इकाई को एक व्यवसाय मॉडल के रूप में उमियम, मेघालय में स्थापित किया गया है।

मिलाटोनिन से उपचारित बकरी के समूहों ने एस्ट्रस (100%) दिखाया और सफलतापूर्वक उपजाऊ बकरे के साथ प्रजनन किया। सभी इलाज समूहों में 50% के मामले में जुड़वां/तिहरा का जन्म हुआ था, जबकि सिक्किम में केवल 14.3% नियंत्रण समूह में जुड़वा जन्म हुआ। मुर्गी में जलवायु के तनाव को कम करने के लिए सुधारात्मक रणनीतियों के तहत खाने में स्थानीय रूप से उपलब्ध जड़ी-बूटियों (हल्दी और रोजेल) को देकर अध्ययन किया गया। मेघालय में वनराजा और श्रीनिधि मुर्गी किस्मों के प्रदर्शन पर तुलनात्मक अध्ययन से पाया गया की श्रीनिधि पक्षियों का गहन रख रखाव और किसानों के खेत में बेहतर प्रदर्शन था। नागालैंड केंद्र में वनराजा और श्रीनिधि के अभिभावक वंश में पाया गया की श्रीनिधि मुर्गी ने 72% अंडे का उत्पादन किया और वनराजा पक्षियों में 63% अंडे का उत्पादन किया। पोल्ट्री बीज परियोजना के तहत, कुल 2146 किसानों में 56418 वनराजा (एक दिन की चूजों को) सिक्किम के 487 गांवों में वितरित किया गया।

रिगर घोल (ई 1) और 10% डीएमएसओ को

गोल्डन महशीर (टोर पिटिटारा) के शुक्राणुओं के क्रायो प्रिजर्वेषन के लिए अच्छा माना गया। बारिलस मछली के ओस्टीओजी अद्ययन से पता चला है कि, *Opsarius barnoides* 42 सेंट से मिलकर बनता है, जिनमें से २१ पेट के कशेरुक है और बाकी २१ कंडल कशेरुक हैं। मछली आहार में अजोला का सम्मिलन काफी महत्वपूर्ण है *Cirrihinusmrigala* फिंगरलिंग्स में वृद्धि को बढ़ाया, जो मृगल फिगरलिग्सं के पारंपरिक आहार में प्रभावी रूप से इस्तेमाल किया जा सकता है। मेघालय में टिकाऊ मत्सपालन के लिए बायोफ्लॉक प्रौद्योगिकी का सफलतापूर्वक मूल्यांकन किया गया है। *O. bimaculatus* के पालन में 5% आहार पर अजोला (0.046 ग्रा/दिन) और लोम्ना (0.047 ग्रा/दिन) का इस्तेमाल किया जा सकता है। मिस्टस केवासियस के लिए कैप्टिव प्रजनन और लार्वल पालन प्रोटोकॉल का विकास त्रिपुरा में किया गया है।

दो प्रौद्योगिकियों का व्यवसायीकरण किया गया अर्थात् मांस और पोल्ट्री उत्पादों। मेघा हल्दी 1 के बीज गुणन के लिए प्रौद्योगिकी का लाइसेंस री-भोई मिहिंगी बहुउद्देशीय सहकारी सोसाइटी लिमिटेड को दिया गया। मेघालय के दो उद्यमियों को एबीआई केंद्र के तहत कृषि छोटे खेत के औजारों के निर्माण के लिए प्रशिक्षित किया गया। मेघालय में शिक्षित युवाओं के लिए विज्ञान आधारित सुअर और मुर्गी उत्पादन के माध्यम से छोटे पैमाने पर ग्रामीण उद्यमिता विकास शुरू किया गया है।

जनजातीय उप योजना (टीएसपी) के अंतर्गत आयोजित विभिन्न आजीविका सुधार कायक्रमों द्वारा 2016-17 के दौरान पूर्वोत्तर राज्यों के करीब 18000 जनजातीय किसानों का फायदा हुआ है। विभिन्न भौतिक संपत्तियों की 270 संख्याएं, बीज की तरह कृषि इनपुट (लगभग 40 टन), रोपण सामग्री, उर्वरक, जैव उर्वरक, जैविक खाद, पोषक तत्व, जड़ी-बूटियों, कीटनाशकों और जैव कीटनाशकों, कई पशुधन, मछली के फिंगरलिंग और एंटीबायोटिक, छोटे कृषि उपकरण और औजार आदि, पूर्वोत्तर क्षेत्र के आदिवासी किसानों के बीच किये गये गया, इसके साथ ही, विभिन्न प्रशिक्षण और जागरूकता कार्यक्रम (232 अंक), 22196 हेक्टेयर क्षेत्र में FLD (>1300) कृषि के विभिन्न क्षेत्रों में क्षमता विकास के लिए आयोजित किए गए थे, (फसल उत्पादन, पषु उत्पादन और प्रबंधन, मशरूम उत्पादन, बागवानी फसलों आदि का उत्पादन एवं प्रबंधन)। पूर्वोत्तर भारत के विभिन्न राज्यों में आदिवासी किसानों के लाभ के लिए घरेलू स्तर पर भोजन और पोषण संबंधी पूरक, किसानों के क्लब और एसएचजी की स्थापना पर भी प्रशिक्षण किया गया।

EXECUTIVE SUMMARY

The total annual rainfall at Umiam was 2202.4 mm in 129 events with monsoon rainfall of 1495 mm in 74 rainy days during 2016. The mean monthly maximum temperature varied between 27°C to 30.2°C and minimum temperature from 25.7°C to 19.8°C. The mean monthly RH $_{(morning)}$ varied from 75% to 89.3% and RH $_{(evening)}$ from 42% and 79.1%. Mean monthly maximum temperature increased from 0.1°C at Imphal to about 1.4°C per decade in Jharnapani whereas minimum temperature increased by 0.3^0C in all places except at Jharnapani. Trend analysis of long period (1971-2015) monsoon and annual rainfall across eight North Eastern states of India revealed that only Meghalaya and Manipur experienced an increasing trend while Arunachal Pradesh, Tripura, Mizoram and Sikkim experienced a decreasing trend at varying magnitudes.

A total of 42 local rice germplasm comprising 23 WRC and 19 *jhum* rice landraces were characterized under Arunachal Pradesh condition. RCM 34, a medium duration high yielding aromatic rice line was identified for high aroma and excellent cooking quality traits. For drought tolerance in rice, new mapping population Bhalum 3 x Naveen for QTL studies were created and advanced to F5 in Tripura. Presence of seven drought tolerant QTLs (qDTY 1.1, qDTY 12.1, qDTY2.1, qDTY 2.2, qDTY 3.1, qDTY 4.1 and qDTY 9.1) in 34 rice genotypes were identified for improving grain yield under drought stress condition. A short duration (111 days) direct-seeded rice germplasm (Dular) has been identified as moisture stress tolerant under rainfed condition of Sikkim. In the RCRT (upland), highest yield of rice was recorded in RCPL1-413 (29.4 q/ha) and in the RCRT (lowland), three entries *viz.,* RCPL-300, RCPL1-459 and IIRON210 had significantly higher yield than the checks at Umiam. In advance varietal trial at Manipur, MC 41-2-1-10 (8.80 t/ha) and MC 45-2-2-11 (8.08 t/ha) showed superiority over check. Rice varieties of Bhalum-1 and Gomati recorded the highest grain yield under upland and lowland conditions of Mizoram, respectively. In Tripura, 1406 promising single plant selections from 34 crosses were characterized for yield and other attributes in rice. Identification of major QTLs for yield under drought stress in rice using *jhum* (shifting cultivation) rice of NEH region and Functional genomics of drought tolerance and allele mining of selected genes in Rice at Tripura was done.

Three maize germplasms namely VQPM 9 (grain yield: 3800 kg/ha), followed by cv. RCM 1-75 (3233 kg/ha) and Vijaya Composite (2733 kg/ha) were identified as moisture stress tolerant at mid-altitude of Meghalaya. From a controlled study at Umiam, three maize genotypes namely RCMGP 47, RCMGP 63, RCMGP 105 were identified as heat tolerant for root and shoot growth. A *DREB2A* cDNA cloned from *Pennisetum glaucum* over expressed in maize for increased moisture stress tolerance. At Basar, production technology of baby corn under conservation agriculture was developed and baby corn variety VL Baby Corn-1 gave the highest yield followed by RCM1-2.

For enhancing pulse production in NE states, field demonstrations on Arhar, Rajma, Moong bean, Urd bean, Rice bean, Cowpea and Soybean were undertaken in sixty three villages of five districts of Manipur. Different cultivars *viz*., CP-5 (cowpea), Urd-3 (black gram), Aman (pea, IPC 97-67 (chickpea), DPL 62 (lentil), HUM-12 (green Gram), IC-18553 (rice bean) and GP HB-40 (faba bean) recorded highest grain yield under Mizoram condition. Participatory seed production programme of cereals, pulses and oil seeds were undertaken on more than 780 farmer's field in Meghalaya. Year round programme on promotion of pulses in NE region comprising field demonstration of quality seeds, participatory seed production, training awareness, stake holder workshop etc. were organized by the institute as a part of celebration of international year of pulses 2016. A climate resilient cropping system of Maize (Green cob) - Urd bean - Buckwheat under Sikkim condition was identified with higher system productivity (8.83 t/ha), profitability (B: C ratio of 2.55) and employment generation (282 man days) compared to other existing system. It was demonstrated in 195 nos. of progressive farmers' field covering 30 ha area in East Sikkim. Adoption of rice-broccoli-*Sesbania* cropping system leads to 19.8% higher rice grain yield over existing rice/maize based cropping systems in Sikkim. Maize + cowpea - vegetable pea recorded the highest system productivity (17.0 t/ha) and production efficiency (46.5 kg/ha/day) followed by maize + cowpea – rajmash under Sikkim conditions.

Integrated nutrient management (INM: 50% organic + 50% inorganic or 100% organic) resulted in maximum rice equivalent yield (>37.4 t/ha) of broccoli-vegetables cropping system. Micronutrient contents (Fe, Mn, Zn & Cu) of soil increased by 17.5 to 35.6 % under 100% organic management compared to inorganic management. From a four year long field experiment in acid soils (pH: 4.5) of mid-altitude Meghalaya, Integrated Nutrient Management package and practice was standardized for groundnut, which

resulted in two fold increase in productivity. Among the complementary vegetable based sequences, maximum rice equivalent yield was recorded under carrot – okra cropping (36.5 t/ha). Integrated Organic Farming System model (IOFS) for valley lands has been developed in Meghalaya and a total net return of Rs. 1,66,144/- per year/ha was recorded. During 2016-17, IFS in cluster approach was promoted in Mawkyrdep village of Meghalaya.

An agro-pastoral system established on 0.64 ha area along the average slope of 32.4 % at Meghalaya resulted in a production of 9.98 tonnes of rice equivalent yield (excluding guinea grass). In addition to 245 man-days employment generation, this system also produced gross and net incomes of Rs. 3.14 and Rs. 1. 17 lakhs, respectively. Feasibility studies of six Integrated Farming System (IFS) models comprising crops, livestock, fish and tree components revealed that maximum revenue was generated from poultry-fish based model (output: input ratio of 9.32) followed by dairy based (cattle-fish-MPTs-crops-vermicompost) model (output: input ratio of 3.69) over other combinations. Tuber crop based cropping system by including pulses as a cover crops developed at Basar. IFS models suitable for small and marginal farmers of Nagaland were evaluated and Model 3 (comprising Agriculture + Horticulture + Piggery + Fishery components) generated highest net profit (Rs. 1.09 lakh).

Growing of ginger with fruit trees/ *Parkia roxbughii* (as shade tree) reduced the performance of ginger (growth and yield) substantially compared to control condition (fresh soil under open conditions) at Umiam. On converting the productivity of 6 fruit trees and ginger based systems into ginger equivalent yield, maximum productivity was observed in ginger grown as sole crop in open area (14.45 t/ha) followed by peach-ginger (11.31 t/ha) and guava-ginger (9.74 t/ha) based system. Eleven promising genotypes of *Mucuna* were evaluated for 8 different growth and yield parameters with one check (IC 83195). Early flowering was observed in IC 83195 (98 DAS) followed by UKD 11 (103 DAS) whereas late flowering was observed in MZR 16(153 DAS). Soil quality of 28 years old, 8 different farming systems (FS) models in the research farm of the Institute, Umiam was analysed. Quality of soil under forestry based FS was in the highest order followed by natural forest (pine) based FS, horticulture based FS , agri-horti-silvi-pastoral based FS, agro-forestry based FS, dairy based FS, agriculture based FS and abandoned *jhum* land, respectively.

Using integrated approaches of remote sensing, GIS and ancillary information, variability in soil acidity, fertility, profile carbon stock and composite soil quality index (SQI) mapping at spatial scale of 1: 50K was done for Barak Valley, Assam. Majority of the soils (>76% GA) in the valley falls under medium category macronutrient -NPKS status (M-M-M-M) and average in quality (SQI: 0.4-0.6) for continuing agricultural practices. Field survey and analysis of the coal mine spoilt soils of Jaintia hills revealed that soils were sandy in nature, reddish brown to yellow brown in color, strongly acidic in reaction (pH<4.90), with very high total dissolved salts (768 ppm). The soils were also high in concentration of trace metals (arsenic, cadmium, chromium, lead, mercury, zinc, nickel, fluoride, aluminum, iron, manganese, etc.). An analysis of soil carbon pools in post burned shifting cultivated soils of Mizoram indicated that the active C pools decreased while passive C pools increased with the increase in fallow periods (> 10 years).

Estimation of water budget components from farming system micro-watersheds revealed wide variation of runoff (10.9 to 21.5%), actual crop evapo-transpiration (33.5 to 62.2%) and recharge contribution (32.5 to 50.6%) under predominant land use systems of Meghalaya. Flagship *Jhum* Improvement Programme at Tura witnessed 2189.3 mm rainfall in 82 events and 48.2 ton/ha/yr of sediment yield. Total 847 AAS bulletins and 28,507 SMS were prepared and disseminated to the farmers through *mkisan* portal under GKMS service. Cost of electric power consumption for cooling/heating of polyhouse installed with earth tube heat exchanger was estimated. Design improvement of paddy thresher cum cleaner and feasibility testing of power tiller, seed drill and light weight power tiller in narrow terraces of hills were undertaken with FLD under improved implements at Umiam.

Reduced tillage recorded significantly higher maize grain yield (3.79 t/ha) over conventional tillage (3.18 t/ha) but remained at par with zero till sown maize (3.67 t/ha). No-till vegetable pea in rice fallow was demonstrated to 35 nos. of progressive farmers covering an area of 10.5 ha in East Sikkim. Under terrace condition, zero tillage resulted in higher maize equivalent yield (MEY) compared to conventional tillage. Conservation agriculture (zero tillage) significantly reduced efflux of GHG's (CO_2, CH_4 and N_2O) compared to conventional tillage practices. Among the nutrient management practices, application of FYM along with weed biomasses and rock phosphate increased the efflux while inorganic fertilization (50% NPK of RD) decreased the efflux of GHG's. Conversion of fresh rice residue to biochar (0.5-1.0%) reduced the

emission of CO_2 flux by 30-40% and improved the soil organic carbon sequestration substantially. However, increase in temperature increased emission of CO_2 flux by 1.5 fold.

A web based software *SFAR (Soil Fertility Assessment and Recommendation)* for assessing the status of soil fertility (poor/medium/high) from the field test results of 12 soil parameters was developed by NRM division. Recommendation guide covering location specific soil acidity and plant nutrient management for 10 important crops have been provided in the software. Similarly, genetic coefficients of lowland rice cultivar (cv. Shahsarang) was calibrated for long term simulation studies under different sets of managements and climate change scenarios using biophysical model (*Agricultural Production Systems Simulator- APSIM).*

In declined *Khasi* mandarin orchards in Meghalaya, fruit characteristics such as fruit weight (76 – 112 g), fruit volume (80 – 180 cc), TSS (9.16 – 11.80%), reducing sugar (3.17 – 5.87%) and total sugar (5.27-7.67%) decreased compared to healthy orchards. Application of nano-nutrient formulation @ 2 ml per liter at 45, 90 and 135 days on six year old Sikkim mandarin plants grafted on different rootstocks showed significant positive effect on fruit quality.

Five guava varieties *viz*., Megha Guava (Sour type X Red fleshed local), Megha Saw Priam (Red fleshed X Allahabad Safeda), Megha Khongpheram Paudiik (Lucknow-49 X Pear shaped), Allahabad Safeda and Lucknow-49 evaluated under meadow orchard planting system (2 m x 1.5 m) exhibited very satisfactory performance across six regional stations. Guava variety Megha Khongpheram Paudiik (RCGH 7) was found superior with respect to fruit yield (12.0 kg/plant) and fruit weight (148.6 g). Guava, *Allahabad Safeda* lines produced highest yield in Mizoram. Guava variety RCGH 4 recorded maximum fruit weight (172.4 g) and yield (18.3 kg/tree) under Nagaland condition while highest TSS was recorded in RCG11 (12.2 Brix). The total number of fruits per plant was maximum (140 no.) in RCGH 7 followed by L 49 (105 no.) under Sikkim conditions.

Bud removal during 5th April on red fleshed guava *var*. Megha Saw Priam (RCGH 4) under Meghalaya condition delayed fruit maturity by 22 days and bud removal on 15th March produced higher marketable fruit yield (7.1 kg/plant).

Among low chilling peach cultivars, Flordasun was the best performer followed by TA-170 and Shan-e-Punjab under lower hill condition of Nagaland for commercial cultivation. Hand thinning of 2 fruits per shoot in kiwi fruit recorded the highest fruit length, weight and TSS in Sikkim. Hand pollination significantly increased percentage of 'A' grade kiwi fruits (70-80%) under partial protection at Sikkim. Three year old Satluj Purple plum recorded maximum plant height (3.2 m), plant canopy (4.85 m^2) and trunk diameter (11.14 cm) as compared to others at Sikkim. Dragon Fruit and straw berry were found suitable for Mizoram condition.

In *Pyrus pashia*, tongue grafting during 15th to 30th October recorded maximum sprouting (100%) with highest survival rate (86.7%). The inter-specific hybrids in tomato, *i.e*. *S. cerasiforme* × Sel 9A, *S. cerasiforme* × MCTR 4B and *S. cerasiforme* × DMT1 also showed tolerance to early and late blight which is a serious problem in NE region of India. In spine/sweet gourd, highest yield/ hill was recorded in RCSG 15 (9.3 kg) while fruit weight in RCSG14 (149.4 g). Harvesting of kakrol between mature green and turning stage were found superior for most of the traits except lycopene content. Selection-1, a new indeterminate, short duration (60-90 days) genotype of Dolichos bean was identified, which produced 12-18 number of pods/plant and yielded 150-180 g/plant. Among bush type of French bean, Sel-17 was the best performer for yield per plant (158 g) and pod length (16 cm). Among the pole type, a new collection of genotype from Manipur produced remarkable pod length (18.0cm) and pod yield per plant (310 g). In sweet potato, var. TSP 12-12 recorded the highest marketable yield (19.2 t/ha) and total yield (27.8 t/ha) while local cv. recorded maximum dry matter (33.3 %), starch (19.6%) and sugar (4.3%) contents. Colocasia cv. Muktakeshi showed maximum cormel numbers (25.3), weight (533 g/ plant), yield (16.9 t/ha) and total yield (21.33 t/ha). Onion genotypes ON15-45, ON15-37 and OLR-1347 were found promising in performance at Umiam. Maximum turmeric yield of 50.97 t/ha was recorded in 100% organic manure + micronutrients.

Pre-sowing forecasts were given to the farmers of Meghalaya for potato, turmeric and pineapple crops. Farmers who received market information advisory from the institutes gained 4% more net returns on turmeric than previous year. Marketing strategies for horticultural crops have been developed for Meghalaya state and pineapple, potato and ginger have been identified as potential marketable crops in Meghalaya.

Organic mulching improves physiological characteristics and yield of gerbera. Gerbera hybrids RCGH 12, 22, 114 and 117 were promising for growing under open conditions, low cost polyhouse and fan and pad polyhouses. Gerbera RCGH 28 was identified as miniature gerbera genotype**,** suitable for growing in pot and as indoor plants.

Leather and RTS beverage prepared from chowchow pulp blended with sohiong juice in ratios of 80:20 and 70:30 were rated as the best. Carambola candy of 20 mm thickness was found to be the best. A unique product 'Tree Bean Crunch' was developed from tree bean pods using extrusion technology. Extruded products such as Museli and Chewda Snax from *Prunus nepalensis* and antioxidant rich Prunus health mix and dehydrated products from *Prunus* fruit pulp were developed. Two numbers of Sagoo Processing Units were successfully established at Maya Tuber Crops Growers' Club, Riha and Lingsang Farmers Club, Thoyee of Ukhrul district under special funds for tuber crops.

Thrips and cutworms (*Agrotis ipsilon)* were found as the major pests of onion at Umiam. Highest thrips population was found in the month of April (42/plant). Module consisting of para pheromone traps @ 15 traps/ha plus spraying of oil based formulation of neem (nimbecidine) @ 5ml/liter of water at 15 days intervals during fruiting was very effective for management of fruit flies in tomato. New insecticide molecule chlorantraniliprole @ 40g a.i./ha and flubendiamide @ 48g a.i./ha were highly effective against shoot borers and fruit borers of brinjal and tomato at Meghalaya. Spinosad 45 SC @ 0.1% was effective to reduce the infestation of seed/grain retaining and percent germination (92.0%) in maize at Sikkim. Knol-khol has been reported as a new host of *Bactrocera tau* in Meghalaya. Tea mosquito bug has been recorded on kiwi for the first time (in 2016) in Sikkim. First report of economic injury by fruit fly- *Bactrocera tau* on chilli and capsicum were reported in Mizoram. Red pigment derived from the entomopathogenic bacteria (*Serratia marcescens*) was found lethal against polyphagous pest, *Spodoptera litura*.

The complete mitochondrial genome of citrus trunk borer *Pseudonemophas versteegi* (Ritsema) has been sequenced and characterized; the size of the genome was 15,685 bp long and circular in shape. PCR based molecular tool was developed for rapid identification of four closely related species of fruit flies. DNA barcodes for 30 numbers of insect pest and natural enemies of cereal crop ecosystem were developed.

For searching potential agent against reactive oxygen species, water extracts of 15 diverse indigenous crops were screened for DPPH radical scavenging activity. Among the extracts, *Phylantus uranium* showed maximum activity (0.24 mg IC_{50} value), followed by *Rhus semialata* (0.40 mg IC_{50} value) and *Paris polyphylla* (0.73 mg IC_{50} value).

Optimization of feather protein hydrolysate (FPH) from chicken feather waste using *Chryseobacterium* sp. RCM-SSR-7 by response surface methodology was standardized. RCM-SSR-7 could be a good candidate for production of amino acids from feather waste. Biochemical and nutritional values of Carpenter worm (*Prionoxystus robiniae* Peck), a popular delicacy among the indigenous population of Nagaland was also determined.

Fungus infecting cabbage aphid (*Brevicoryne brassicae)* in Meghalaya was identified as *Lecanicillium longisporum* at molecular level. In IVT, three soybean genotypes (code nos. 2, 9 and 33) were found highly resistant to rust at Umiam. Application of thiophanate methyl spray @ 1g/L at 55 and 75 DAS or *Trichoderma viride* @ 5g/L were found more effective and economical in management of pod blight complex of soybean. Stemphyllium blight was the most prominent disease on all the lines of garlic under Nagaland conditions. Copper oxychloride was found very effective for the management of late blight and root rot of tomato in Sikkim. Quality spawn of different *Pleurotus* species and shitake (*Lentinula edodes*) were produced and supplied to different stakeholders in Manipur for popularization of mushroom cultivation among farmers. Mushroom grown on wild banana was rich in micronutrient contents. Fifteen wild edible mushrooms were collected and conserved at Nagaland Centre. *Banana streak Mysore virus (BSMYV)* infecting banana in North Eastern region has been detected and confirmed.

Based on the combined results of double antibody sandwich-ELISA (DAS-ELISA) and reverse transcription-PCR (RT-PCR), 62.7% of the indexed citrus samples (out of a total of 540 samples) were positive for CTV. Ten representative CTV isolates sampled from Manipur were characterized for coat protein (CP) gene sequences, which shared a sequence identity of 86-94% among them. Manipur CTV isolates had 89-98% sequence similarity with already reported Indian CTV genotype Kpg3 and segregated to Kpg3 phylogroup. Nearly 38% were detected to have mixed infection of CTV and huanglongbing (HLB), indicating these two pathogens were responsible for citrus decline in Manipur.

An Indirect ELISA for *Classical Swine Fever Virus* (CSFV) antibody detection using CSFV P-25 adapted in RK-13 cell line was standardized. Characterization of lactic acid bacteria (LAB) from NE region identified new isolates; *Lactobacillus brevis*, *Lactobacillus plantarum* and *Lactobacillus pobuzihii*. Molecular characterization of *Mycobacterium* spp. isolated from man, animal and environmental samples identified 29 Nontuberculous

mycobacteria (NTM) isolates and 23 *Mycobacterium tuberculosis* bacillus complex (MTBC). Peptide based diagnostic assay for Japanese Encephalitis antibody detection in pigs is being standardized. Oncogenic viruses such as *Marek's disease virus* (MDV), *Avian leukosis virus* (ALV) and *Reticulo endotheliosis virus* (REV) were detected in poultry. Six species of gastrointestinal protozoan parasites of pigs were identified under three Phylum Ciliophora, Sarcomastigophora, Apicomplexa. Sero-surveillance diagnosed *Porcine Respiratory and Reproductive Syndrome Virus* (PRRSV), *Classical Swine Fever Virus* (CSFV), *Porcine Circo Virus* (PCV), *Foot and Mouth Disease* (FMD), *Bovine Viral Diarrhoea* (BVD), *Haemorrhagic Septicaemia* (HS), *Black Quarter* (BQ) etc in different states of NE India.

Feeding of the new formulated fortified feed from kitchen waste with 7% molasses in pigs achieved better growth rate of 109g/day. Relative expression level of the Heat shock proteins (HSP40) was higher in *Khasi* local pigs, which enables them to tolerate stress conditions. Liquid semen stored for 0-3 days is more efficient than frozen thawed semen for crossbreeding native pigs. Ejaculates collected from crossbred boars in the summer months had less number of spermatozoa. The performance of pigs reared in sheds with different flooring materials in Basar, Arunachal Pradesh attained higher body weight in saw dust flooring.

Reproductive disorders of dairy cattle in relation to mineral deficiency in different agro-climatic zones of Sikkim showed no significant difference between inter-calving interval between organized and unorganized dairy farm. Porcine embryos were produced parthenogenetically from abattoir ovaries after *in-vitro* maturation followed by chemical activation and subsequent culture in porcine zygote medium (PZM). Meat Processing Unit has been set up as a business model for entrepreneurship development at Umiam, Meghalaya. Melatonin treated groups of goat showed estrus (100%) and successfully bred with fertile rams. Twins/ Triplets were born in case of 50% of the does in all treated groups, whereas, only 14.3% gave twin birth in control group of does in Sikkim. Amelioration strategies to reduce climate stress in poultry by supplementing locally available herbs (Turmeric and Roselle) in the feeds were studied. A comparative study on the performance of Vanaraja and Srinidhi chicken breed showed better performance of Srinidhi birds in both intensive and farmers' field of Meghalaya. Parent stock of Vanaraja and Srinidhi at ICAR, Nagaland Centre recorded 72% hen day egg production in Srindhi and 63% in Vanaraja birds. Under Poultry Seed Project, a total of 56418 numbers of Vanaraja (one day old chicks) were distributed among 2146 farmers covering 487 villages of Sikkim.

Ringer's solution (E1) and the 10% DMSO was found to be good for cryopreservation of spermatozoa of Golden mahseer (*Tor putitora*). Osteology study of barillus fish reveled that, *Opsarius barnoides* consist of 42 centra, of which 21 are abdominal vertebrae and rest 21 are caudal vertebrae. Incorporation of Azolla in fish diet significantly enhanced the growth in fingerlings, which could effectively be used in conventional diet of mrigal fingerlings. Biofloc technology has been successfully evaluated for sustainable aquaculture in Meghalaya. *Azolla* (0.046g/day) and *Lemna* (0.047g/day) could be used as substitute fish meal at 5% diet in rearing of *O. bimaculatus.* Captive breeding and larval rearing protocols for *Mystus cavasius* have been developed at Tripura.

Two technologies have been commercialized *viz*., meat & poultry products. The licensing of technology for seed multiplication of Megha Turmeric 1 was given to Ri-Bhoi Mihngi Multi-Purpose Co-Operative Society Ltd. Two entrepreneurs from Meghalaya were trained for manufacturing of agricultural small farm tools and implements under ABI center. Small scale rural entrepreneurship development through scientific pig and poultry production for educated youth was initiated in Meghalaya.

Nearly 18000 tribal farmers of North Eastern States were benefitted during 2016-17 by various livelihood improvement programmes conducted under Tribal Sub Plan (TSP). Various activities like over 270 numbers of different physical assets, agricultural inputs like seeds (around 40 tons), planting materials, fertilizers, bio-fertilizers, organic manures, nutrient solutions, herbicides, pesticides, and bio-pesticides, several number of livestock, fish fingerlings and antibiotics, minor agricultural tools and implements etc. were distributed among the tribal farmers of NE Region. Simultaneously, several trainings and awareness programmes (232 nos), front line demonstrations (>1300 nos) covering an area of 2219.6 ha were organized for capacity building in various fields of agriculture (crop production, animal production and management, mushroom production, production and management of horticultural crops etc.) and animal husbandry. Training on household level food and nutritional supplement, formation of farmers club and SHGs were also carried out for the benefit of tribal farmers in different states of NE India.

INTRODUCTION

ICAR Research complex for NEH Region has been serving the North Eastern Hill Region of India since 1975. The institute has been constantly endeavoring to develop location specific technologies through its ten divisions at the headquarter at Umiam, Meghalaya and its six regional centers at the six hill states of the NE region. The institute is delivering its technologies to a large number of farmers' in the remote localities through its 19 KVKs distributed in different states including recent one at Peren.

Institute is also taking significant role in teaching and guiding students from Central Agricultural University, Assam Agricultural University and other central and state universities. The institute has been working on three flagship programmes *viz*, improvement of *jhum* cultivation, temperate horticulture and trans-boundary diseases during the XII Five Yearly Plan. A multi institutional and multi-disciplinary project on medicinal plants has been initiated to tap the rich medicinal resources of the NE region. Some competitive projects such as DBT, DST, NICRA, NHB and NMSHE, TSP, KIRAN, Agri-Consortia on Water etc. are operating in the region. The institute has been disseminating modern technologies for livelihood and nutritional security in the region that include truthfully labeled seeds, quality planting materials, improved animal breeds, poultry and fish seeds including proto-type implements and tools suitable for hill agriculture, soil health testing kits, diagnostic kits for animal parasites, diseases and critical inputs. Several in-house projects, mostly of interdisciplinary nature, are being pursued. The strategic and frontier research on climate change adaptation and mitigation under NICRA is a major research thrust area of the institute. About 15 AICRPs, 5 network and 15 collaborative projects are in operation. The institute has strong linkage with other ICAR Institutes and Universities, International organizations like IRRI, ICRISAT, ILRI, and IWMI. The Institute also collaborates with government sponsored agencies like NERCOMP, MRDS, NABARD and IFAD; several NGOs and farmers bodies and co-operative societies for technology dissemination.

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 including temperate horticulture, agroforestry, fisheries and other economical crops.
- Development of feed and fodder resources from locally available fodder for livestock.
- Improvement of citrus plantation to reinvigorate the citrus industry
- Animal health coverage and improvement of livestock production system including trans-boundary diseases.

MANDATE

- Develop and improve sustainable farming systems for different agro-climatic and socio-economic conditions of NEH region, including organic agriculture.
- Improve crops, horticulture, livestock and fishery and to impart training for development of local competence for efficient management of resources.
- Collaborate with State Departments for testing and promotion of improved farming technologies.

LABORATORIES

The headquarters of the institute at Umiam is well equipped with laboratory facilities in all the divisions. Besides, a centre of Biotechnology and central laboratory at headquarter also has the state of art instruments for catering of research needs in different agricultural and horticultural crops. A post-harvest processing unit and well-equipped workshop at the division of Agricultural Engineering is in place for research and development, value addition, fabrication and repair of agricultural implements and tools. A State of art facilities such as FATE, CTGC, Biochar, TOC, DNA sequencers, Flow cytometer, HPLC, GC, AAS, bio-safety cabinet for isolation works under containment condition, seven environmental control chambers, rainout shelters, transgenic facilities have also been developed at headquarters. The laboratories in all the six centers of the Institute are also being strengthened with basic and advanced instrumentation facilities.

HUMAN RESOURCES

Category	Sanctioned post	Filled post	Vacant post
Institute			
Scientific	181	144	37
Technical	252	178	74
Administrative	129	87	42
Skilled Support	114	96	18
Total	676	505	171
Krishi Vigyan Kendra			
Scientific	19	12	07
Technical	209	147	62
Administrative	38	16	22
Skilled Support	38	27	11
Total	304	202	102

LIBRARY

Nature of publications	No. of copies available
Books & Reports	30322
Back volumes of journals	12363
Foreign journals	Nil
Indian journals	80
News papers	16x
Hindi books	4478
Magazines	7

IT FACILITIES

IT facility of the institute includes computer Lab having SAS installed on 10 computers. The institute has perpetual license for SAS, SPSS and STATISTICA. ARC GIS software with a workstation is also in place to carry out data analysis and processing on GIS and remote sensing. Online ARS-NET examination facilities developed at Umiam are functional since 2012. KIRAN, a dedicated website managed by the Institute, is providing much needed service and knowledge sharing including integrated agro-advisory services through SMS. The institute has internet connectivity through NKN and more than 200 computers are provided with net connectivity.

IMPORTANT MEETINGS

RAC Meeting

The Research Advisory Committee (RAC) meeting of ICAR Research Complex for NEH region was held on 21st and 22nd September, 2016 at Umiam under the chairmanship of Dr. S.P. Ghosh, Ex-DDG (Horticulture), ICAR. Dr. Chandan Rajkhowa, Dr. Mathura Rai, Dr. S.K. Dhyani and Dr S. Bhaskar as the members were present in the meeting. Dr. S. V. Ngachan, Director presented the achievements and future programmes of the Institute. He highlighted that, 2016 being the International Year of Pulses, incorporation of pulses in cropping system would play a key role in achieving food security in the north eastern region of India. As of now, the institute has released 58 improved crop varieties including horticultural crops and development of more varieties in vegetables were recommended by the committee. All the completed projects of the institute were reviewed and suggestions were made for future research work.

Fig 1. Members of Research Advisory Committee 2016

IRC Meeting

The IRC meeting was held on 23rd - 24th September, 2016. The meeting was chaired by Dr S. V. Ngachan. RAC members also attended the IRC meeting and gave valuable suggestion.The Director reviewed a total of 60 numbers of on-going and new project proposals of the Institute and made valuable suggestions and recommendations. Thirty six new projects from the centres and different divisions of the headquarter were approved. Dr. Ngachan encouraged promotion of entrepreneurship development with processed products and emphasized the scope in value addition of underutilized crops.

Fig 2. Institute Research Committee, 2016

Midterm Review of 22nd Regional Committee Meeting of Zone III, 2015

The Midterm Review of 22nd Regional Committee Meeting of Zone III was held at ICAR RC for NEH region, Umiam, on 19th July 2016. Dr S. V. Ngachan, Director, ICAR RC for NEH, Umiam and Member Secretary RCM-Zone-III, welcomed and felicitated Dr. N. S. Rathore, Deputy Director General (Education,) and Chairman of the Mid Term Review Meeting, RCM Zone-III and Dr. Premjit Singh, Hon'ble Vice Chancellor, Central Agricultural University, Imphal. He highlighted that the NE region has currently achieved self-sufficiency in food grain production with active collaboration between ICAR NEH and IIPR, Kanpur for enhancing the pulse production in NER. Directors of the different ICAR institutes located in the NE region and officers from the state line departments also participated in the meeting. Progress of the recommendations made in the RCM meeting held at Tripura was reviewed by the Deputy Director General (Education) and the Nodal Officer RCM.

Fig 3. Members of the Midterm Review of 22nd Regional Committee Meeting of Zone III.

Meeting on Technology Exchange and Joint Research among ICAR Institutes of Hill Region held at ICAR RC for NEH Region, Umiam.

Fig 4. Meeting of directors of 10 ICAR institutes of Hills Region on technology transfer and joint research.

As per the suggestion of the Hon'ble Secretary, DARE & Director General, ICAR during the foundation day celebration of ICAR-VPKAS, Almora, a meeting of the ICAR Institutes working in the hill region was held on 12th December, 2016 at ICAR Research Complex for NEH region, Umiam, Meghalaya. The meeting was chaired by Dr. S. V. Nagachan, Director, ICAR Research Complex for NEH region, Umiam. In his remarks, he expressed that technology sharing among the Institutes working in the hill region is very important so that the developed technologies may reach to the farmers at the earliest. Ten (10) institutes of the Hill Region across the country attended and presented technologies available with them, which were ready for sharing and the areas in which they required new technology/ collaboration. A list of the agreed technology sharing and collaborative research/training programme to be achieved within 2017 was chalked out.

Special Meeting on Promotion of Pulses in NEH Region & State Level Farmers Meet on Promotion of Pulses in Tripura

The 3rd Special Meeting on Promotion of Pulses in NEH region was organized during 19-20 September, 2016 by ICAR Research Complex for NEH Region, Tripura Centre jointly with ICAR-IIPR, Kanpur. Special efforts were initiated for promotion of pulses in NE region by ICAR-IIPR in collaboration with ICAR-ICAR Research Complex for NEH Region, Central Agriculture University, Assam Agricultural University, other Agricultural Colleges in the region and the State Agriculture departments of all the states. Shri Naresh Jamatia, Hon'ble Minister (Forest, Rural Development & Election), Govt. of Tripura, was the Chief Guest in Inaugural Session. The meeting was attended by Dr. S. V. Ngachan, Director, ICAR Research Complex for NEH Region; Dr. N. P. Singh, Director, ICAR –IIPR, Kanpur and 57 scientists/ delegates from DAC & FW, CAU and SAUs of the region, Centres of ICAR Research Complex for NEH

Fig 5. Shri Naresh Jamatia, Hon'ble Minister (Forest, Rural Development & Election), Govt. of Tripura, (2nd from right) in Tripura

BUDGET & EXPENDITURE FOR 2016-17

S. No	Head	R.E 2016-17 Non-Plan	Expenditure 2016-17 Non-Plan	R.E 2016-17 Plan	Expenditure 2016-17 Non-Plan
1	2	3	4	5	6
A. Non-	**Recurring (Grants for creation of Capital Assests)**				
1	**Works**				
	(A) Land				
	(B) Building				
	i. Office Building			437.41	436.56
	ii Residential Building				
	iii. Minor Works				
2	**Equipments**	25.00	20.63	93.92	93.92
3	**Information Technology**			75.73	75.73
4	**Library Books & Journals**			16.99	16.99
5	**Vehicles & Vessels**				
6	**Livestock**				
7	**Furniture & Fixtures**	6.71	4.87	0.95	0.95
8	**Others**				
A.	**Total-CAPITAL (Grants for creation of Capital Assests)**	31.71	25.50	625.00	624.15
	B. Recurring (Grants in Aid-Salaries)				
1	**Establishment Expanses**				
	(A) Salaries				
	i. Establishment Charges	4316.46	4267.31		
	ii. Wages	1110.00	1091.61		
	iii. Overtime Allowance				
	(B) Total Grants in Aid-Salaries	5426.46	5358.92		0.00
B.1	**Recurring (Grants in Aid-General)**				
2	**Travelling Allowance**				
	(A) Domestic TA/ Transfer TA	55.00	54.99	42.00	42.00
	(B) Foreign TA				
	Total-Travelling Allowance	55.00	54.99	42.00	42.00
3	**Research & Operational Expenses**				
	(A) Research Expenses	282.00	281.82	436.47	436.45
	(B) Operational Expenses	61.00	60.75	120.66	120.66
	Total-Res.& Operational Exp.	343.00	342.57	557.13	557.11
4	**Administrative Expenses**				
	(A) Infrastructure	201.42	201.42		0.00
	(B) Communicaiton	7.00	2.89		
	(C) Repairs & Maintenance				0.00
	i. Equipments, Vehicles & Others	51.83	51.83		
	ii. Office Building	40.00	39.96		
	iii Residential Building	40.00	39.32		
	iv. Minor Works	82.75	83.52		
	(D) Others (excluding TA)	390.00	389.96	154.19	154.18
	Total-Administrative Expanses	813.00	808.90	154.19	154.18
5	**Miscellaneous Expenses**				
	(A) HRD	1.44	1.44	16.68	16.68
	(B) Other Items (Fellowship, Scholarship etc.)	0			
	(C) Publicity & exhibitions	1.50	1.42		
	(D) Guest House - Maintenance	4.80	3.26		
	(E) Other Miscellaneous	4.09	4.88		
	Total-Miscellaneous Expenses	11.83	11.00	16.68	16.68
B. 1	**Total-Grants in Aid-General**	1222.83	1217.46	770.00	769.97
6	**Loans & Advances**	50.00	10.67		
7	**Pension & Other Retirement benefits**	450.00	447.74		
GRAND TOTAL					
	B. + B.1 Total Revenue (Grants in Aid Salaries + Grats in Aid General)	6649.29	6576.38	770.00	769.97
	A+B+B.1Grand Total (Capital+Revenue)	6681.00	6601.88	1395.00	1394.12
	Tribal Sub-Plan			1385.00	1384.98
	Loans & Adv + Pension	500.00	458.41		0.00
	GRAND TOTAL	7181.00	7060.29	2780.00	2779.10

Region, ATARI, KVKs, AICRP-MULLaRP and Pigeonpea centres in the region.

Annual Review Meeting of AICRP on Poultry Breeding and Poultry Seed Project organized at ICAR-NOFRI, Sikkim

ICAR-National Organic Farming Research Institute, Tadong, Gangtok formerly ICAR Research complex for NEH Region, Sikkim Centre organized two days 'Annual Review Meeting of All India Coordinated Research Project (AICRP) on Poultry Breeding and Poultry Seed Project' to review the progress made in poultry breeding and poultry seed project operating at 24 Centres across the country. A total of 35 scientists from various ICAR institutes and state veterinary colleges participated and presented annual progress report. The programme was inaugurated by Dr. P. Senthil Kumar, IFS, Special Secretary, RMDD, Govt. of Sikkim in the presence of Dr. R. S. Gandhi, ADG (AP & B), ICAR, New Delhi; Dr. R. N. Chatterjee, Director, Directorate of Poultry Research, Hyderabad; Dr. R. K. Avasthe, Joint Director, ICAR-NOFRI and Dr. Vineet Bhasin, Principal Scientist, ICAR HQ, New Delhi.

DISTINGUISHED VISITORS

Hon'ble Prime Minister visited Agricultural exhibition organized by ICAR in 65th Plenary celebration of North Eastern Council in Shillong

Hon'ble Prime Minister, Shri Narendra Modi, during the inaugural programme of 65th NEC plenary held on 27th May, 2016 at Polo Ground, Shillong, visited the agricultural exhibition organized by ICAR RC for NEH Region, Umiam. He was accompanied by Dr. Jitendra Singh, Hon'ble Minister of State for Development of North Eastern Region (DoNER) & Chairman, NEC along with members of the NEC, Secretary, DoNER and Secretary, NEC. Appreciating the impressive display of the exhibition, Hon'ble Prime Minister, Shri Narendra Modi interacted with Dr. S. V. Ngachan, Director, ICAR RC for NEH Region regarding the rich biodiversity of the region. He showed keen interest on organic farming and traditional crops of NEH region like dragon fruit of Mizoram while making a short visit in the exhibition stall.

Fig 6. Inaugural address by Dr. P. Senthil Kumar, IFS, Special Secretary, RMDD, Govt. of Sikkim

Visit of Shri Radha Mohan Singh, Hon'ble Union Minister for Agriculture and Farmers Welfare, to Regional Agri-Fair held at CAU, Imphal

Hon'ble Union Minister for Agriculture and Farmers Welfare, Shri Radha Mohan Singh inaugurated the 3 days Regional Agri-Fair 2016-17 organized by Central Agricultural University, Iroisemba, Imphal on 10th November, 2016. He highlighted the unlimited potential of agriculture in the North Eastern states and that the Government of India is focusing exclusively on the development of agricultural sector in the region. He also elaborated on the benefits of various Centrally Sponsored Schemes *viz*. *Mera Gaon, Mera Gaurav*, *Rashtriya Fasal Bima Yojana*, Soil Health Card and Mission for Integrated Development of Horticulture.

Fig 7. Shri Radha Mohan Singh, Hon'ble Union Minister for Agriculture and Farmers Welfare, visiting the ICAR stall during Regional Agri-Fair at CAU, Imphal

Visit of Hon'ble Member of Parliament, *Lok Sabha*, Shri Prahlad Singh Patel at ICAR RC for NEH Region, Manipur Centre, Lamphelpat, Imphal

Hon'ble Member of Parliament, Lok Sabha, Shri Prahlad Singh Patel and MLA of Narsinghpur (Madhya Pradesh), Jalam Singh Patel visited ICAR Research Complex for NEH region Manipur Centre, Lamphelpat, Imphal on 5th April 2016. Hon'ble MP Shri Prahlad Singh Patel appreciated the efforts and dedication of the scientists in developing various improved varieties of Rice and Tomato and farmer friendly technologies like RC Seed Bin. He also appreciated the scientists for their efforts in making value added products of the locally available indigenous crops.

Fig 8. Hon'ble Member of Parliament, Lok Sabha, Shri Prahlad Singh Patel at ICAR Manipur Centre

Dr. Trilochan Mohapatra, Secretary (DARE) and DG (ICAR) visited ICAR RC for NEH Region

Dr. Trilochan Mohapatra, Secretary (DARE) and DG (ICAR) and Sh. Sunil Kumar Singh, Additional Secretary and Financial Advisor, ICAR visited ICAR Research Complex for NEH Region, Umiam, Meghalaya during 13 -14th May 2016. A review and interactive meeting of the finance heads of ICAR Institutes of the eastern zone was held on

Fig 9. Dr. T. Mohapatra, Secretary (DARE) and DG (ICAR) at ICAR RC for NEH region

13th May and with the scientists & staffs of ICAR RC for NEH region on the following day. About 100 participants comprising Directors, Joint Directors, Heads of the Divisions, Scientists, technical staff, officials from Administration and finance of various ICAR institutes of the eastern region of India participated the review meeting. The Secretary (DARE) and DG (ICAR) stressed upon the scientific community to focus its research efforts towards the food, nutrition and environmental security of the region. He appreciated the Institute's commendable work in agriculture and allied subjects. He stressed upon strengthening coordination among different stakeholders/ institutes in agriculture and allied sectors through regular interfaces.

Fig 10. Hon'ble Members of Parliamentary Standing Committee on Agriculture with ICAR Scientist

Visit of Parliamentary Standing Committee on Agriculture to ICAR RC for NEH region, Umiam

The Parliamentary Standing Committee on Agriculture headed by Member of Parliament, Shri Hukmdev Narayan Yadav visited ICAR Research Complex for NEH Region, Umiam on 21st June 2016. He said that the north eastern region has an important role to play in the second green revolution in the country under which the government desires to increase the production of agricultural and horticultural products from 256 million tonnes to 300 million tones. He commented that the constraints in marketing of agricultural produce which is profound in this region can be solved by introduction of refrigerated trucks and refrigerated bogies in trains connecting the north eastern states to the rest of the country. The committee attended a stakeholder's meet on National Horticulture Mission held in Pinewood hotel in Shillong on 22nd June where Director, ICAR RC for NEH Region and other scientists of the institute also participated.

Shri Sudarshan Bhagat, Hon'ble Union Minister of State for Agriculture and Farmers' Welfare, Government of India, visited ICAR RC for NEH Region, Umiam

Fig 11. Dr. S. V. Ngachan, Director, ICAR RC for NEH Region, Umiam felicitating Shri Sudarshan Bhagat, Hon'ble Union Minister of State of Agriculture and Farmers Welfare

Shri Sudarshan Bhagat, Hon'ble Minister of State for Agriculture and Farmers Welfare, Government of India, visited ICAR RC for NEH Region, Umiam on 8th November, 2016. During the visit, the Hon'ble Minister launched the Farmers First Programme of ICAR Research Complex which is to be implemented in Marngar and Sarikuchi cluster of Ri-Bhoi district. He also presided over the signing of MoU between ICAR RC for NEH Region, Umiam and Ri-Bhoi Mihngi Multi Purpose Co-Operative Society Ltd. and licensing for seed multiplication of Megha Turmeric-1. Sh. Vineet Kumar Verma, Director, Ministry of Agriculture and Farmers' Welfare, Government of India and Sh. Manoj Kumar Tripathi, PS to MoS accompanied the Hon'ble Minister.

Hon'ble Governor of Meghalaya, Shri. V. Shanmuganathan visited ICAR RC for NEH region, Umiam

Hon'ble Governor of Meghalaya, Shri. V. Shanmuganathan inaugurated the Conference on Linking Prospective Food Entrepreneurs with Government Schemes and Markets held on 15th December, 2016 in Swaminathan Hall, ICAR RC for NEH Region, Umiam, Meghalaya in collaboration with Associated Chambers of Commerce and Industries of India (ASSOCHAM) and Ministry of Food & Processing Industries (MoFPI), Government of India. The purpose of the conference was to provide a platform to aspiring food entrepreneurs, existing SMEs in food, agriculture professionals & students, progressive farmers, Self Help Groups, etc. for sharing their views and learn about latest initiatives and opportunities available in the field of Agro Food Industries. Other important dignitaries who addressed the conference were Dr. S. V. Ngachan, Director, ICAR RC for NEH Region, Umiam, Shri Osmand E J Nongbri, Managing Director, Meghalaya Co-operative Apex Bank and Dr. Om S. Tyagi, Senior Director, ASSOCHAM. A technical session was also held where speakers from different stakeholders groups spoke about the issue.

Fig 12. Hon'ble Governor of Meghalaya, Dr. V. Shanmuganathan inaugurating the Conference on Linking Prospective Food Entrepreneurs with Government Schemes and Markets

Hon'ble Union Minister of State Agriculture Interacted with scientists of ICAR-NOFRI, Sikkim

Shri Parshottam Rupala, Hon'ble Union Minister of State for Agriculture and Farmers' Welfare and Panchayati Raj, Ministry of Agriculture and Farmers Welfare, Government of India reviewed the progress of various Central Government Schemes in Sikkim on 27th December, 2016. During the program, Dr. R.K. Avasthe, Joint Director, briefed the Hon'ble Union Minister about the importance of sound organic research support in the country. Hon'ble Union Minister advised Sikkim Government for intensive marketing of organic produce to capture the organic market at the national and global levels.

Fig 13. Hon'ble Union Minister being presented the book "Transforming Rural Sikkim: Year Round Organic Crop Production" by Joint Director, ICAR-NOFRI

IMPORTANT EVENTS

Farmers' fair cum awareness programme on *Pradhan Mantri Fasal Beema Yojana* organized by KVKs of ICAR

A one day Farmers' Fair Cum Awareness Programme on *Pradhan Mantri Fasal Beema Yojana* (*PMFBY*) was organized by KVK, Ri-Bhoi, East

Fig 14. Shri. Vincent H. Pala, Hon'ble MP, Shillong, addressing the gathering during the programme in Umiam

Sikkim and Tura under ICAR Research Complex for NEH Region on 5th April, 2016. The programme was inaugurated by the Chief Guest, Shri Vincent H. Pala, Hon'ble Member of Parliament, Shillong. The programme was attended by Jt. Director, Directorate of Agriculture and Horticulture, Government of Meghalaya, Project Director-ATMA, DDM-NABARD, Father James, Director- RRTC Umran, representatives of different Insurance Companies, scientists and staff of ICAR, Umiam as well as about 300 farmers of Ri Bhoi district. In KVK, East-Sikkim, Ranipool, more than 270 farmers and dignitaries from line depts. and various financial institutions like NABARD, SISCO, SBI *etc*. participated. The programme was inaugurated by Chief Guest Shri Somnath Poudyal, Hon'ble Minister of FSADD & AHLFVS, in the presence of Guests of Honour, Shri P. D. Rai, Hon'ble MP, *Lok Sabha* and Shri B. B. Rai, Hon'ble MLA, Namcheybong, East Sikkim and other dignitaries. At KVK, Tura campus, Shri Noverfield R. Marak, MLA, North Tura was the Chief Guest of the programme. A total number of 283 farmers from West Garo Hills, South West Garo Hills, South Garo Hills and East Garo Hills districts participated in the programme.

Fig 15. Showcasing of technologies to the farmers in exhibition in KVK Tura

Fig 16. Hon'ble Minister of Agriculture and Animal Husbandry, Shri Somnath Poudyal in KVK East Sikkim

Workshop cum brainstorming session organized to Celebrate International Year of Pulses 2016 at ICAR Complex, Umiam

The year 2016 has been declared as International Year of Pulses (IYP) by the 68th United Nation General Assembly. ICAR Research Complex for NEH Region, Umiam organized two day workshop cum brainstorming session on 'Status and strategies for promotion of pulses in North East India to celebrate the International Year of Pulses with a motive towards developing technologies, conducting technology demonstrations to create awareness among farmers and to come up with new ideas in the pulse production to bridge the large gaps of demand. Dr. S.V. Ngachan, Director of the Institute and Chairman of the programme emphasized on developing crop calendar, proper monitoring, winning confidence of farmers, addressing marketing and processing constraints and developing capacity of the farmers to improve pulses scenario in the region. Ms. S. Tariang, Deputy Director (Agriculture), Govt. of Meghalaya was the guest of honor of the occasion. Dr. D.J. Rajkhowa, Joint Director (I/C), ICAR Nagaland Centre, Dr. N. Prakash, Joint Director, ICAR Manipur Centre, Assistant Director Agriculture, Nongpoh Mr. B. Shylla and Farmers' representative Mr. Wallang were other dignitaries present in the programme.

Fig 17. Dignitaries on dais during International Year of Pulses celebration

Swachhata Pakhwada observation in ICAR RC for NEH region, its six regional centers and KVKs

Swachhata Pakhwada was observed during 16 – 25th May and 16 - 31st October, 2016 in ICAR Research Complex for NEH Region, Umiam, Meghalaya including in its six regional centers and KVKs spread across the

Fig 18. Pledge taking by ICAR staffs at Umiam during Swacchhta Pakhwara

seven states of North East India. The *Swachhata* pledge was administered to all the employees of the institute by Dr. S. V. Ngachan, Director, ICAR Research Complex for NEH Region, Umiam. He emphasized on the importance of cleanliness and urged all the staff to join hands for transforming the institute and subsequently the country into clean country.

Orientation Training Programme of KVKs SMS and Programme Assistants

Seven days orientation training under human resource development programme was organized by ICAR RC for NEH Region from 27th August to 2nd September 2016 for the newly joined Subject Matter Specialists (SMSs) and Programme Assistants (PAs) of the KVKs working under ICAR RC for NEH Region. Dr. K.M. Bujarbaruah (Former Director, ICAR and VC, AAU, Jorhat), Chief Guest, inaugurated the orientation training programme where he emphasized the vital role played by KVKs in increasing productivity and bringing the second green revolution into reality. The training was attended by 25 numbers of SMSs and PAs from various KVKs in different states under the aegis of ICAR RC for NEH Region, Umiam.

Fig 19. Orientation training programme of KVKs SMS and Programme Assistants with Dr S. V. Ngachan, Director, ICAR RC for NEH Region, Umiam and Dr. P. Das, (former DDG Extension, ICAR, New Delhi)

Krishi Siksha Diwas (Agriculture Education Day) observed at ICAR RC for NEH Region, Umiam

ICAR RC for NEH Region, Umiam celebrated the *Krishi Siksha Diwas* (Agriculture Education Day) on 3rd December, 2016 in the D.N Borthakur conference hall, to commemorate the significance of agricultural education in the country. Dr. Satish Chandra, Director (I/C), ICAR RC for NEH Region chaired over the event and highlighted the growing importance of a good education in different agriculture and allied subjects. Various events like slogan writing, poster making and debate competition with topics relevant to the present scenario of agricultural education were held during the day. Students B.Voc - Agriculture from Tata Institute of Social Sciences, School of Vocational Education, Guwahati and research associates of ICAR RC for NEH Region participated in the various events. More than 80 participants have brought out innovative ideas from young minds on enhancing the effectiveness of agricultural education.

Fig 20. Students from TISS, Guwahati with ICAR staffs during Agricultural Education Day

MEGHALAYA

WEATHER REPORT

Umiam received total annual rainfall of 2202.4 mm in 129 events with monsoon rainfall of 1495 mm (68% of annual rainfall) in 74 rainy days (57% of annual). Monthly and annual rainfalls have been depicted in Fig 1. April, May and October months have contributed 46 rainy days. The rainfall received in February, October and November recorded considerably lower than the long period average (LPA). The rainfall was deficient by over 50% during August but September received higher than normal rainfall. During the whole year, the total rainfall was about 8% lower than normal and monsoon rain was also lower by about 40 mm. This year the pre-

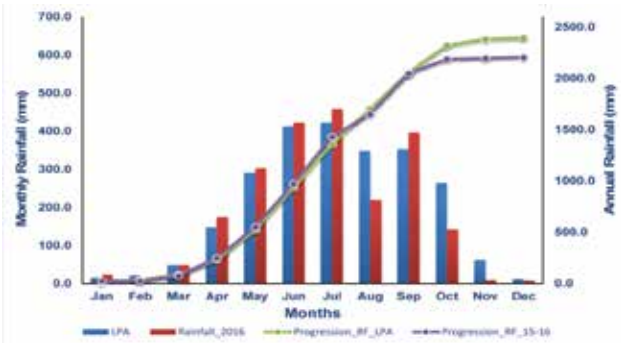
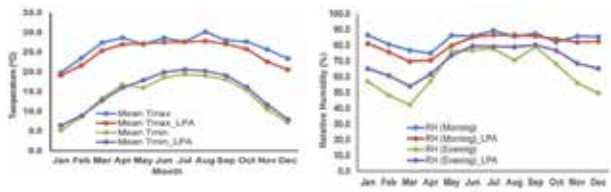


Fig 1. Monthly & annual rainfall pattern

monsoon and first two months of monsoon (June & July) received normal and higher than normal rainfall followed by almost 50% deficient rainfall in August but September rainfall of 11% more than normal have managed to keep the monsoon deficit up to 3%. There were 13 rainy days in August which were distributed all over the month, hence, deficit in rainfall amount of 50% have not impacted the crop growth during the period. Three months i.e. October to December have received much lower rainfall than the normal, indicating towards a drier winter.

The mean monthly maximum temperature (Mean T_{max}) and mean monthly minimum temperature (Mean T_{min}) showed a similar pattern of change throughout the year [Fig 2 (a)]. The mean T_{max} varied between 27.0°C to 30.2°C for all the months except November to February when it varied from between 25.7°C to 19.8°C. The figure indicates that the T_{max} was either similar or more than its LPA value for all the months. This phenomenon of higher T_{max} than normal T_{max} was also observed in the last few years, indicating towards a slow but persistent increase in T_{max} over the region. The mean monthly T_{max} of August was 30.2°C which was highest for this month in history of the region. The rainfall for the month of August was much lower than the normal, which may have attributed towards high temperature during the period. The Mean T_{min} was highest for the month of July (19.4°C) and lowest for the month of January (5.1°C). It is clearly seen that the mean monthly minimum temperature increased from January to July and therefore decreased. The mean monthly T_{min} value was either similar or lower than its LPA value like previous years for all the months, indicating towards the decrease in the T_{min} over the years.



(a) *(b)*

Fig 2. Monthly values of (a) mean maximum & minimum temperature and (b) mean relative humidity during 2016.

The variation in the morning relative humidity ($RH_{morning}$) is much less as compared to the evening relative humidity ($RH_{evening}$) [Fig 2 (b)]. The $RH_{(morning)}$ varied from 75.0 % to 89.3% in April and July, respectively and $RH_{(evening)}$ varied between 42.0% and 79.1% in March and September respectively. Due to heavy rainfall the relative humidity were high in the month of July.

The $RH_{(evening)}$ was much lower than its LPA value throughout many months of the year which is mainly due to increase in T_{max} of the region. The total annual pan evaporation was 965 mm. It was found that the pan evaporation was lower than the LPA in all the months except April & August, due to higher temperature or lower normal rainfall. The average wind speed was lower than normal by 27% to 52% for all the months except April when it was 4.7 km/hr close to the normal. It has been observed that the wind speed over the years in the place has decreased persistently.

CROP SCIENCES

Rice Improvement

Development of phosphorus efficient rice by marker assisted backcross breeding

Twelve (12) different sets of parents (Donors and recipients) were selected after phenotyping and

genotyping screening of large number of rice varieties/ germplasm grown in uplands of NEH region of India. F1 crosses were attempted from all the ten sets for Marker assisted backcross breeding program for transfer of Pup1 QTL to develop phosphorous efficient rice.

Confirmation of true F_1 plants (~ 15-20 Nos.) through marker analysis was performed and crossing of true F_1 plants with the respective recurrent parent (s) and generation of BC_1F_1 plants are in progress. An initiative was also taken to identify germplasms from NEH India, with increased Internal Phosphorous Use efficiency by proper phenotyping and genotyping.

Pup 1 DONOR (S)	RECURRENT PARENT (S)
Bhalum 3	Bhalum 1
Bhalum 3	Bhalum 4
Bhalum 3	Bhalum 2
Sahbhagi Dhan	Bhalum 1
Sahbhagi Dhan	Bhalum 4
Sahbhagi Dhan	Bhalum 2
Sahbhagi Dhan	Naveen
Sahbhagi Dhan	Samba Mahasuri
Swarna	Bhalum 1
Swarna	Bhalum 4
Swarna	Bhalum 2
Swarna	Naveen
Swarna	Samba Mahasuri
Bhalum 3	Samba Mahasuri
Bhalum 3	Naveen

Functional genomics studies of acid soil tolerance in rice

Being the single largest constraint to crop productivity in North East India, soil acidity often result in Aluminum (Al) toxicity. Although, metallic Aluminum is non-toxic to plants, its ionic form (Al^{3+}), prevalent in acid soil conditions is toxic to all living cells. An attempt was made to screen a core set of germplasm of rice growing in this region to study Functional genomics of Aluminium tolerance in rice. Few tolerant and susceptible genotypes were identified on the basis of root tolerance, shoot tolerance and root/shoot ratio (R/S) upon exposure to 200 µM Aluminum chloride (Fig. 3). Four highly tolerant (N-861, Yimyu, Motodhan and Vietnam-1) and 4 considerably susceptible genotypes (Lespah, VL31329, RCPL 1-13, UPR 2919-14-1-1) were identified. F1 crosses will be developed with tolerant donor lines and susceptible recipient lines Double haploid population will be generated from the promising crosses. Double haploid population generated from the selected crosses will be the source material for studying functional genomics for Aluminum toxicity tolerance.

Fig 3. Effect of aluminum toxicity on root growth of rice varieties/genotypes/landraces in hydroponics culture

1. Lespah, 2. Chankimaso, 3. Anjali, 4. Moiramsbhi, 5. Col- 4, 6. Rcpl- 13, 7. Ching 8. Ir1552, 9. Shaku 10. Ioro, 11. Skau-390, 12. Vr-14, 13. Vl31329, 14. Vl 31331, 15. Upr 2919-14-1-1, 16. Upr 2992-17-3-1, 17. Pancoas, 18. Asukni maghowa, 19. Assam, 20. Longpa tsuk, 21. Michiying, 22. Bang nayk, 23. Yimya mapok, 24. Sang chang, 25. Meyisao, 26. Nung khum, 27. Akiyiuti ashe, 28. Bhalum -2, 29. Bhalum -3, 30. Ching moiramsbhi 31. Vl – 31329, 32. Khasha, 33. Kalojeera, 34. Khougjai phou, 35. Posimot, 36. Upr 2919-141-1, 37. Sanri fiirii, 38. Motodhan, 39. Tsamu fiirii, 40. Bhalum – 1, 41. Merangkong, 42. Konpemo, 43. Chihg, 44. Bhalum – 4, 45. Likhamo, 46. Dhao tipnuakulon, 47. Vietnam – 1, 48. Aaha, 49. Silky rice, 50. Kenasu kedowa, 51. Koyabo, 52. Mange, 53. Tsaknak, 54, epyo, 55. Hahsho, 56. Yimyu, 57. Momching, 58. Ir 72, 59. Satabdi, 60. N-861, 61. Mtu - 7029, 62. Gobindobhog, 63.idaw

Study of rice yield under low light intensity

Field phenotyping, 300 genotypes (100 from Meghalaya, 100 from NRRI, Cuttack and 100 from BCKV) were sown under ambient and two shade-net conditions (30% and 50% shading), respectively, during kharif 2016 at Upland Plant Breeding farm (Fig 4). The following checks were sown in each block under all treatment conditions following augmented block design *viz.,* Swarna Prabha (Tolerant check), IR-8 (Susceptible check), Shasarang (Local Check), Swarna. Shading was initiated from transplanting, and sampling was done at 50% flowering. Light and weather data was recorded daily during the crop period (Fig 5). Agronomic evaluation of growth traits is presented in Table 1.

Fig 4. Low light experimental area

Increases in both plant height and leaf area under low light conditions are adaptive phenomena to increase light capture and photosynthetic area in almost all genotypes. A decrease in specific leaf weight (SLW), which is indicative of thinner leaves to enhance light penetrating into mesophyll cells, is also observed. Under low light the relative proportion of blue light is higher and Chl b has higher efficiency in utilizing blue light thereby maximizing light absorption rate. While the total chlorophyll content increases under low light, Chl a:b ratio decreases due to the surge in Chl b. This decreasing trend has also been observed as presented in Fig 6.

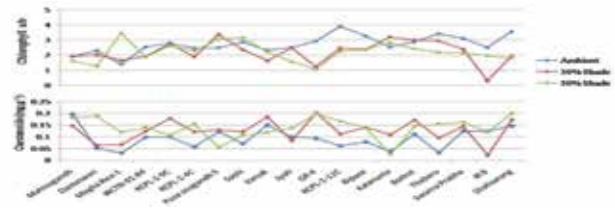


Fig 5. Light Intensity during crop growth kharif 2016

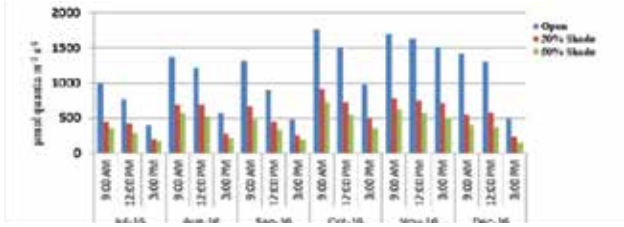


Fig 6. Variations in photosynthetic pigments in selected genotypes across different low light conditions

Table 1. Agronomic traits in selected genotypes across different low light conditions

Category	Genotype	Plant ht (cm)			Leaf area (cm^{-2})			SLW (mg dm^{-2})			Spklt fert (%)		
		Amb	30%	50%	Amb	30%	50%	Amb	30%	50%	Amb	30%	50%
Relatively tolerant genotypes	Mahisugandh	84.7	95.4	99	44.66	66.12	62	444.9	313.0	320	78	79	78
	Danteswari	78.2	86.2	81	28.11	36.52	49.28	666.7	374.3	309	83	72	42
	Megha Rice-1	91	95	68.5	20.10	30.58	15.44	643.6	311.1	381	94	90	75
	IRCTN- 91-84	88.6	84.7	94	32.16	27.83	32.47	400.3	432.2	439	93	96	60
	RCPL-1-9C	88.2	96.3	101	21.28	31.55	46.84	437.8	869.3	369	96	94	91
	RCPL-1-4C	74.8	102	-	23.44	37.58	24.61	336.1	370.6	332	97	98	91.5
	Pusa Sougandh 5	115.3	138.9	141	19.67	48.58	73.71	624.8	534.7	306	76	83	-
	Sashi	89.7	106.5	105	75.38	74.6	59.35	271.3	405.6	337	71	90	92.8
	Vaisak	91.1	111.1	94	39.44	63.87	55.22	472.7	268.7	350	82	98	76
	Jyati	81.7	91.4	88.4	73.99	34.65	68.83	565.5	976.8	229	81	72	88
Relatively susceptiple genotypes	GR-4	80.2	71.1	74	19.24	46.73	48.56	587.1	323.4	351	94	95	86
	RCPL-1-12C	77.2	100.4	89	51.10	29.63	12.79	476.6	912.0	383	97	98	86
	Bipasa	58	103.9	100	43.04	75.51	47.82	463.4	315.7	431	65	91	83
	Kalanunia	99	123.8	128	50.83	74.14	82.96	480.5	420.2	425	81	89	88
	Borkot	100.6	104.9	74	33.64	29.29	17.93	442.8	337.8	413	92	96	84
	Theberu	88.2	88.3	75	29.68	35.57	14.58	469.4	360.5	438	96	91	92
Checks	Swarna Prabha	105.3	120.4	114	42.92	91.7	-	612.3	295.7	-	74	76	-
	IR 8	66.2	68.2	71	51.38	74.2	67.02	184.8	384.9	367	72	70	62
	Shahsarang	69.6	103.4	102	34.54	53.61	90.86	507.7	479.5	336	72	77	55
	Swarna	49	77.8	73	38.12	58.04	15	592.8	418.1	407	54	59	79

Rice evaluation trial

In the RCRT (upland) highest yield was recorded in RCPL1-413 (29.4 q/ha) (Table 2). In the RCRT (lowland), three entries *viz.,* RCPL-300, RCPL1-459 and IIRON210 have shown significantly better yield than the checks.

Table 2. Performance of advance lines of rice in RCRT trials

Rank	RCRT (upland)	RCRT (lowland)
1st	RCPL1-413 (29.4 q/ha)	RCPL 1-300 (37.2 q/ha)
2nd	RCPL1-429 (26.7 q/ha)	RCPL1-459 (36.6 q/ha)
3rd	Bhalum 3 (24.6 q/ha)	IIRON210 (36.2 q/ha)
Check 1	Bhalum 3 (25.1 q/ha)	Megha SA1 (32.8 q/ha)
Check 2	Bhalum 1 (16.37 q/ha)	Shasarang (32.6 q/ha)
CD (5%)	2.14	2.36

AICRIP trial

Under upper Shillong conditions 3 AICRIP trials were conducted. In entry no. 2704, 2903 and 2813 were the top yielders in AVT-1 (M) H, IVT (U) H and IVT (M) H trials, respectively.

Rice Pathology

All India Coordinated Rice Improvement project

One thousand three hundred seventy six lines were screened against rice blast in uniform blast nursery pattern (Table 3). Two hundred and seventy four entries were found to be resistant. Variety HR-12 was used as susceptible check.

Table 3. Reaction of rice entries against blast disease

Screening trial	No. of Lines	Resistant lines
National Screening Nursery- 1	373	78
National Screening Nursery-Hills	86	33
National Hybrid Screening Nursery	145	66
Donor Screening Nursery	109	18
National Screening Nursery- 2	663	79
Total	**1376**	**274**

MAIZE

Cloning of stress inducible *DREB-2A* transcription factor from *Pennisetum glaucum* (*Pg-DREB-2A*) and over expression in maize for increased tolerance to moisture stress

Pennisetum glaucum (*P. glaucum*), commonly known as 'Pearl millet', a C4 plant, owing to its stress resistant nature, is contemplated to be equipped with better defense mechanisms to combat different abiotic stresses. In the present study, we have isolated a DREB2A gene from *P. glaucum*, referred to as *Pg - DREB2A* and over-expressed in maize.

The Open Reading Frame (ORF) of *Pg -DREB2A* cDNA was PCR amplified using forward 5'-CCGCT CGAGATGCAGTCCTTGACTGATGG-3'andreverse 5' TGCTCTAGACAGTTCC CTGACTACAGGC-3' primers with the flanking restriction sites Xho1, Xba1, respectively (Fig 7). The digested *Pg-DREB2A* gene

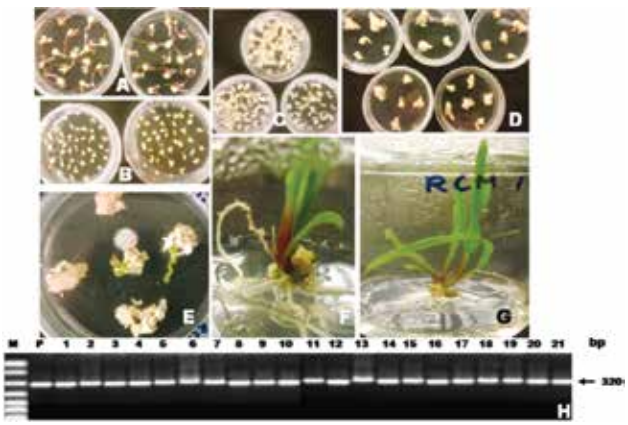


Fig 7. Different stages of development of transgenic maize (rcm-1-12) from excised embryo axis using the gene construct pg-dreb2a and molecular characterization by PCR

was cloned as an XhoI/ XbaI fragment in pRT101 vector. There after the entire cassette with CAMV 35S constitutive promoter, *Pg - DREB2A* gene and terminator was cloned in pCAMBIA130 at the *HindIII* site and mobilized into the *Agrobacterium* strain LBA4404 by freeze-thaw method. The *hpt* gene (*hygromycin phospho transferase*) serves as the plant transformation selection marker. Positive clones were selected on the kanamycin selected plates and also by PCR. The constructs carrying *Pg-DREB2A* gene in LBA4404 strain was used for *Agrobacterium* – mediated transformation of maize line (RCM-1-2). Embryogenic calli of obtained from mature seeds were co-cultivated with LBA4404 *Agrobacterium* strain caring *Pg-DREB2A* gene. Putative transgenic calli were subjected to regeneration and presence of the gene was confirmed in the putative transgenic plantlets by polymerase chain reaction (PCR) with gene specific primers. Further molecular analysis and analysis for moisture stress tolerance of the putative transgenic plants is in progress.

DISEASES

All India Coordinated Maize Improvement project

One hundred seventeen lines in replicated trials (two) were evaluated for Turcicum leaf blight resistance (Table 4). Forty nine lines were found to be resistant.

Table 4. Reaction of maize entries against turcicum blight

Screening trial	No. of Lines	No. of resistant lines
Trial 75 Late (AVT-I-II)	24	9
Trial 77 Early (AVT- I-II)	8	0
Baby corn I-II-III	14	7
Pop corn I-II-III	14	0
Sweet corn I-II-III	13	7
QPM I-II-III	27	24
Trial 76 Medium (AVT I-II)	17	2
Total	**117**	**49**

UNDERUTILIZED CROPS

Job's tears

Biochemical and molecular characterization was done in a set of 65 Job's tears collected from North-East region

Biochemical characterization

The amount of total phenol was determined with the Folin-Ciocalteu reagent. Gallic acid was used as a standard compound and the total phenols were expressed as mg/g gallic acid equivalent using the standard curve equation: y = 0.0022x 0.0155, R^2= 0.999, Where y is absorbance at 760 nm and x is total phenolic content in the different extracts of Job's Tears expressed in mg/gm (Fig 8). Phenolic compounds are a class of antioxidant agents which acts as free radical terminators. The total phenol varied from 5.55 to 10.18 mg/g in the extracts (Fig 9).

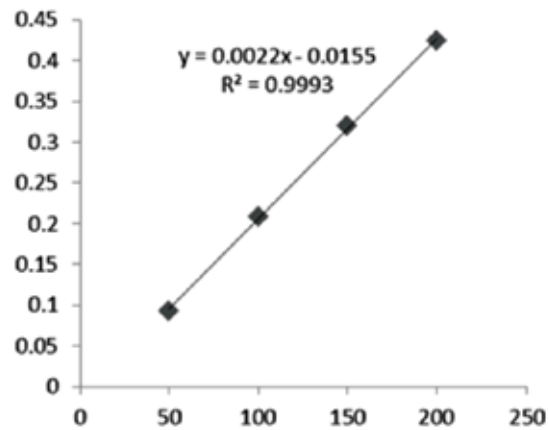


Fig 8. Standard curve of Gallic acid

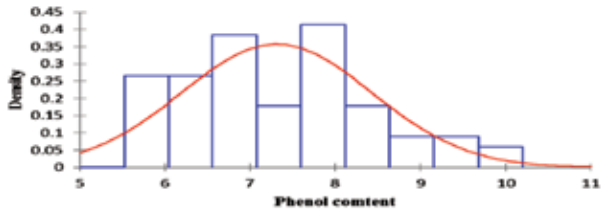


Fig 9. Frequency distribution of phenol content in the aqueous extracts of Job's tears

The maximum phenolic content was found in the aqueous extract (10.18 mg/g) of IC–416868 genotype.

Flavonoid content

The amount of total flavonoid was determined with the Quercetin reagent. Quercetin was used as a standard compound and the total flavonoid were expressed as mg/g Quercetin equivalent using the standard curve (Fig 10) equation: y = 0.738x+0.076, R^2= 0.990, Where y is absorbance at 510 nm and x is total Flavonoid content in the extracts of Job's Tears expressed in mg/gm. The total flavonoid varied from 4.6 to 23.6 mg/g in the extracts (Fig 11). The maximum flavonoid content was found in the aqueous extract (23.6 mg/g) of IC - 521341genotype.

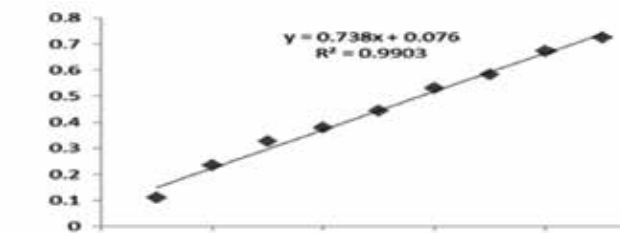


Fig 10. Standard curve of Quercetin

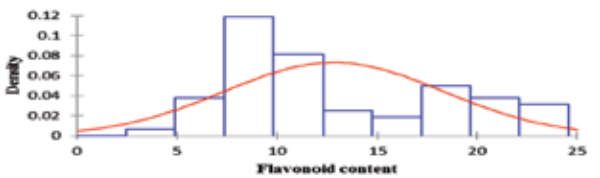


Fig 11. Frequency distribution of flavonoid content in the aqueous extracts of Job's tears

Total antioxidant content

Ascorbic acid was used as a standard compound and the total antioxidant content were expressed as mg/g ascorbic acid equivalent using the standard curve (Fig 12) equation: y = 0.0035x - 0.252, R^2= 0.996, Where y is absorbance at 695 nm and x is total antioxidant content in the different extracts of Job's Tears expressed in mg/gm. The total antioxidant content varied from 20 to 72 mg/g in the extracts (Fig 13). The maximum antioxidant content was found in the aqueous extract (72 mg/g) of JTN-3 genotype.

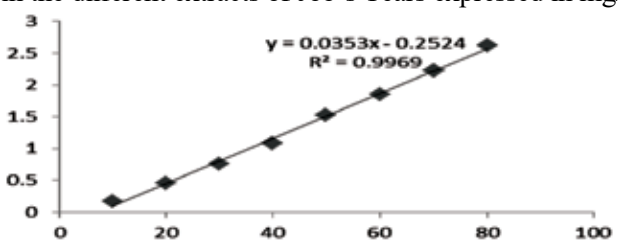


Fig 12. Standard curve of Ascorbic acid

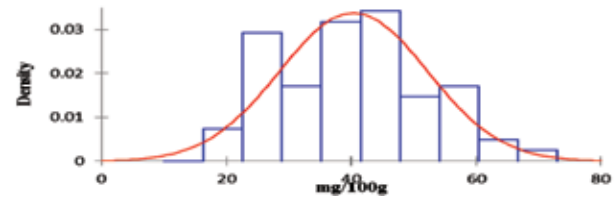


Fig 13. Frequency distribution of antioxidant content in the aqueous extracts of Job's Tears

Molecular Characterization

Sixteen SSR primers were used for molecular characterization of 65 Job's Tears landraces. The summary of genetic variation statistics for all 16 microsatellite loci and annealing temperature are given in Table 5. The locus GBssrJT198 was found the most informative marker among all the loci.

Table 5. Summary of genetic variation statistics for all 16 SSR loci and annealing temperature

Locus	na*	ne*	I*	T (^{o}C)
GBssrJT25	4	1.92	0.91	59
GBssrJT31	2	1.36	0.43	59
GBssrJT32	2	1.17	0.27	59
GBssrJT41	4	2.66	1.06	52
GBssrJT68	5	2.29	1.02	53
GBssrJT130	3	2.04	0.79	57
GBssrJT136	5	4.04	1.50	57
GBssrJT149	4	2.77	1.15	58
GBssrJT161	3	2.91	1.08	58
GBssrJT164	3	1.94	0.79	59
GBssrJT170	5	4.15	1.48	60
GBssrJT174	4	2.21	0.93	59
GBssrJT181	5	3.19	1.30	57
GBssrJT183	5	3.62	1.42	57
GBssrJT185	3	2.84	1.07	59
GBssrJT198	5	4.23	1.52	61
Mean	3.88	2.71	1.05	
St. Dev	1.18	1.00	0.37	

* na = Observed number of alleles, * ne = Effective number of alleles [Kimura and Crow (1964)], * I = Shannon's Information index [Lewontin (1972)]

PULSES

Development of pod borer resistant chickpea

Embryonic axis obtained from aseptically germinated seedlings of chickpea *(Cicer arietinum* L.) Variety Pusa 372, were wounded and infected with *Agrobacterium* strain (LBA4404) harboring the construct, ***cry1Aabc*** for 30 min (OD_{600} 0.8). After 9 weeks on regeneration medium containing 30 mg/l of

hygromycin, the surviving healthy putative transgenic plants were transferred to a greenhouse. The transgenic plants were initially verified by PCR with *cry1Aabc* gene-specific primer, using genomic DNA isolated from young leaves. PCR amplification was performed with 100 ng of genomic DNA as template using the primer pairs (Bt F-5′-CGGATCCGATCTTCACCTCAGCGTGCTT-3′ and Bt R-5′-CGAGCTCGGGCACATTGTTCT GTGG-3′). Further molecular analysis of putative transgenic plants is in progress (Fig14).

Fig 14. Different stages of development of transgenic chickpea (Pusa-372) from excised embryo axis using the gene construct cry1A abc , establishment of the plants in soil and molecular characterization by PCR

In lentil seed multiplication was done for PL-8, Hul-57, PL-6, IPL-81 and L-4174 under upland conditions. For enhancing the quality seed production, participatory seed production of lentil (HUL-57) and pea was done in Purangang village and Nongthymmai village of Ri-Bhoi District respectively (Fig. 15).

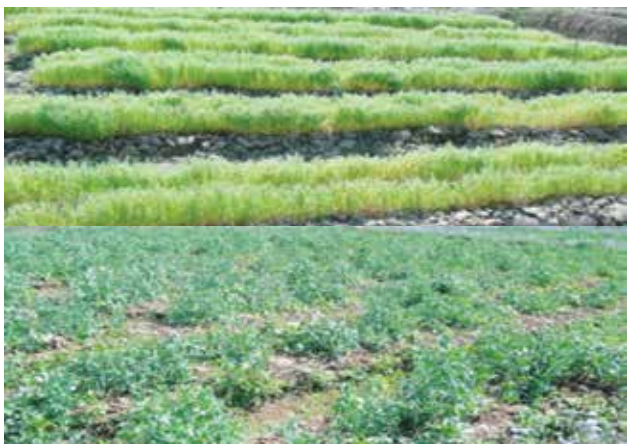


Fig 15. Participatory seed production of lentil and pea

OILSEEDS AND PULSES

SOYBEAN

Under upland conditions coordinated yield trial (IVT, AVT-1 and AVT-2) was conducted. TS-80, DSb-32 and KDS-1045 were found superior in IVT trial whereas entry JS 20-116 was found promising from AVT-1 trial. In AVT-2 trial RCS-10-46 was found as most promising. For enhancing the quality seed production, participatory seed production of soybean (DSb-19 variety) was done at Borkhatsari village of Ri-Bhoi District (Fig.

Fig 16. Participatory seed production of soybean at Borkhatsari village, Ri-Bhoi

DISEASES

Monitoring of soybean diseases

Occurrences and severity of soybean diseases were monitored on a set of 16 susceptible soybean genotypes. Four fungal *viz.,* rust, frog eye leaf spot (FLS), purple seed stain (PSS) and pod blight caused by *Colletotrichum truncatum* (PBct) were recorded. Rust and pod blight were the major fungal diseases and percent disease index (PDI) ranged 10.37 to 46.69 for rust and 5.67 to 55.67 for pod blight. Two bacterial diseases i.e. bacterial pustule (BP) and bacterial leaf blight (BLB) caused by *Xanthomonas campestris* pv.*glycines* and *Pseudomonas savastanoi* pv. *glycinea* and one virus disease i.e. yellow mosaic virus (YMV) were recorded with low severity. Rhizoctonia aerial blight (RAB) did not appear in this trial.

Management of pod blight complex of soybean

Eight treatments (Tables 6 and 7) were tested for managing pod blight complex disease of soybean. All the treatments were effective in reducing the pod blight compared to untreated check. Spray with thiophanate methyl @ 1g/L at 55 and 75 DAS or Spray with *Trichoderma viride* @ 5g/L were found more effective and economical. Seed treatments alone were not as effective as sprays for managing the disease and increasing 100-seed weight.

Screening for rust resistance

Fifty eight soybean genotypes were screened against rust (C.O. *Phakopsora pachyrhizi*) under three trials *viz.,* initial varietal trial (IVT), advance varietal trial 1(AVT 1) and advance varietal trial 2 (AVT 2).The genotypes were categorized as absolute resistant (AR), highly resistant (HR), moderately resistant (MR), moderately susceptible (MS), susceptible (S) and highly susceptible (HS).The number of genotypes under various categories of resistance is presented in Table 8.

Table 6. Trap nursery trial for monitoring of diseases (infection index) Umiam, 2016

Varieties	Rust	BP	BLB	RAB	FLS	PB(Ct)	YMV	PSS
JS 72-44	44.44	7.06	0.00	0.00	0.00	55.67	0.00	0.00
JS 75-46	22.78	2.41	0.00	0.00	0.00	14.73	0.00	1.43
JS 71-05	21.50	0.00	1.67	0.00	0.00	36.67	2.78	4.29
JS 72-280	46.69	5.95	0.00	0.00	0.00	12.39	0.00	0.00
PK 262	42.60	4.45	6.48	0.00	0.00	50.00	4.08	0.00
PK 472	32.24	5.17	0.00	0.00	0.00	52.22	0.00	2.86
MACS 58	10.37	0.00	0.00	0.00	0.00	24.17	4.28	0.00
JS 93-05	17.62	5.72	0.00	0.00	0.10	9.89	0.00	0.00
Punjab-1	23.89	0.00	3.89	0.00	0.00	30.61	0.00	10.00
Bragg	40.17	6.69	0.00	0.00	0.00	16.83	0.00	2.86
Monetta	40.76	2.95	0.00	0.00	0.00	15.11	0.95	0.00
KHSb-2	29.82	0.00	3.15	0.00	0.00	5.67	0.00	1.43
NRC 7	26.30	10.72	3.34	0.00	0.00	11.83	0.00	0.00
VLS 58	34.26	2.78	0.74	0.00	0.00	13.11	0.00	1.43
JS 335	35.76	2.78	0.00	0.00	0.00	28.45	1.67	10.00
Shivalik	37.77	0.00	0.00	0.00	0.00	18.56	0.00	1.43

DOS 29/6/2016

Table 7. Effect of various treatments on pod blight complex of soybean

Treat	Description	PDI	Pod infected (%)	100 seed wt.	Seed yield (kg/ha)	Plant stand/ ha
T1	ST with carboxin +thiram @ 2g/kg seed	14.07	71.45	8.29	729	383333.3
T2	ST with carbendazim + mancozeb @ 2g/kg seed	12.16	70.63	7.94	620	295925.9
T3	ST with *Trichoderma viride* @ 5g/kg seed	13.64	79.42	7.46	418	228888.9
T4	T1 + spray with thiophanate methyl @ 0.1% at 55 and 75 DAS	5.31	43.66	8.15	644	331851.9
T5	T2 + spray with thiophanate methyl @ 0.1% at 55 and 75 DAS	6.79	51.46	7.52	609	298148.1
T6	T3+ spray with thiophanate methyl @ 0.1% at 55 and 75 DAS	5.31	42.99	7.71	619	251481.5
T7	Spray with thiophanate methyl @ 0.1% at 55 and 75 DAS	7.47	54.92	8.08	606	313333.3
T8	Spray with *Trichoderma viride* @ 5g/l	9.20	59.36	7.65	574	288888.9
T9	Control	17.96	82.54	6.95	498	284814.8
	CD (p=0.05)	3.66	16.66	0.69	NS	NS

DOS 23/8/2016

Table 8. Number of soybean genotypes under various categories of rust resistance in different trials

Date of sowing	Trial	AR	HR	MR	MS	S	HS
15/7/2016	IVT	0	3	15	17	0	0
22/7/2016	AVT 1	0	0	1	3	7	2
08/8/2016	AVT 2	0	0	2	5	2	1

In IVT, three genotypes (code nos.2, 9 and 33) were found highly resistant to rust. In AVT 1, one genotype (DSb21) was moderately resistant. In AVT 2, two genotypes (KDS753 and KDS869) were moderately resistant. Resistant check genotypes (EC 241778 and EC 241780) continued to maintain their resistance level.

MUSTARD

150 Germplasm of NEH Region had been collected from NBPGR New Delhi, in 2015. In which 50 Germplasm of Toria, 50 Germplasm of yellow Sarson, 50 Germplasm of Indian mustard were. In Toria IC-23014 (Five plant weight) 40.5 gram, IC-23044 (Five plant weight) 27.09 gram and IC-23072 (Five plant weight) 16.2 gram performed well in among of Toria Germplasm. In Yellow Sarson IC-520760 (Five plant weight) 13.2gm, IC- 334283 (Five plant weight) 12.1 gm and IC-355343 (Five plant weight) 11.29 gm performed well in among of Yellow Sarson Germplasm. In Indian Mustard IC-122170 (Five plant weight) 8.04 gm, IC- 121726 (Five plant weight) 6.18 gm and IC-122458 (Five plant weight) 5.66 gm performed well in among of Indian Mustard Germplasm.

AICRP on Rapeseed and mustard

Two trials IVT Timely sown (rainfed) and AVT-1 Timely sown (rainfed) were conducted during Rabi 2015-16 at our station. In IVT Timely sown (rainfed) MCNR-15-21 (1.04 t/ha) was the best yielder followed by MCNR-15-5 (0.95 t/ha). In AVT – 1 Timely sown (rainfed) MCNR-15-29 (1.09 t/ha) was the best yielder followed by MCNR-15-30 (Kranti,NC) (1.02 t/ha).
Beside above seed multiplication of Toria (Variety TS-67) and Indian mustard (Variety Pusa Mustard-25, Pusa Mustard – 26, Pusa Mustard-27) was also done during Rabi 2015-16.

ICAR SEED PROJECT AND TSP PULSES

Rice Seed Multiplication

Seed multiplication was done for Bhalum-3, Bhalum-5, Bhalum-4, Bhalum-1 (Upland rice), Shahsarang (Lowland rice), Megha Rice-1 and Megha Rice-2 (cold tolerant). For enhancing the quality seed production, participatory seed production of rice varieties were done in Tyrso village of Ri-Bhoi District

Area expansion of kharif cereals

Rice (Var. Shahsarang and RCM-10) and Maize (DA-61A) seeds were distributed among 50 tribal farmers from villages Tyrso, Mynsain, Mawthei and Marngar of Ri-Bhoi District. About 5 tonnes of quality rice seed was bought back from the farmers of Tyrso village under the agreement made between Division of Crop Production, ICAR-RC-NEH Region and Tyrso farmers' welfare association.

Area expansion of Kharif Pulses

A total of 250 kg black gram (Var. Kalindi), 100 kg of Soybean (Var. JS-335), 150 kg French bean (S-9) 100 kg of groundnut (ICGS-76) and 120 kg of Rajmash (Tripura rajmash) were distributed among 180 tribal farmers of villages Mawthei, Mynsain, Pynthor, Marngar and Nongthymmai of Ri-Bhoi district. The kharif pulses seed production has been accomplished and buyback processes are under processing with farmers' welfare associations of the respective villages.

RABI PULSES

A total of 4.0 tons of lentil (var.HUL-57) and 3.8 tones pea seeds (var. Arkel & Vikash) were distributed among 550 tribal farmers in the villages viz. Maw pun, Kyrdem, Marngar, Sarikhusi, Borgang, Lalumpam, Umtham, Nalpara, Barkhatsari, Jaigang, Mawtnum, Pahamrinai, Nongagang, Parangang, Umori Labansoro, Umroi Madan, Jaiawpdeng, Liarsluid, Mynsain, Mawthei, Mawkyrdep, Tyrso and Pynthror of Ri-Bhoi district. Fertilizers such as Urea (350 kg), SSP (500kg) and DAP (350 kg) and powdered lime (140 kg) were distributed to selected farmers. Two (2) nos. of zero tillage furrow opener was also distributed to Liarsluid village. Ten (10) nos. of Assam lemon saplings was also given to a farmer of Umroi Labansaro who is having a fish pond for planting around the pond dyke.

Promotion of organic farming in participatory approach

Mynsain village in Ri-Bhoi district of Meghalaya has been adopted since 2013 for promotion of organic framing through cluster approach. During 2016-17 two more villages namely, Pynthor and Umden has been adopted under the programme. During 2016-17 total 6 number of training and various input distribution programmes were organized covering different aspect of organic farming by which more than 600 tribal farmers benefitted. On an average 35-45% income enhancement of farmers has been recorded over the base line income of 2013. New technologies like growing of pulses/vegetables under rice fallows, no-till technology, raised and sunken bed etc. were popularized. Before organic farming interventions, most of the farmers of the village remained idle after rice harvest, but now the farmers are adopting no-till practices to grow pulses after rice and maize harvest. Similarly, farmers are cultivating vegetables especially during dry season with harvested rain water from farm pond and *jalkund*. Backyard poultry farming, piggery along with cultivation of food-feed crops are being adopted by the farmers which are proving beneficial for improving income and livelihood.

FRUITS

MANDARIN

Variation in physico-chemical characteristics of fruit; soil and leaf nutrient status from non-declined and declined orchards of Khasi mandarin

Variations in physical and biochemical characteristics of *Khasi Mandarin* fruits in declined and non-declined orchards were studied. Characters such as fruit weight (76 – 112 g), fruit dimension (length, 4.8 -5.4 cm; width, 5 – 6.3 cm), fruit volume (80 – 180 cc), TSS (9.16 – 11.80%), reducing sugar (3.17 – 5.87%) and total sugar (5.27-7.67%) decreased in declined orchards as compared to healthy orchards, while fruit acidity (0.86 – 1.72%) and ascorbic acid (32.32 – 57.33 mg / 100 g) increased in declined orchards. Healthy Khasi mandarin orchards showed significantly higher leaf nitrogen (1.413-3.614%), phosphorous (0.087-0.230%) and potassium (1.38-2.63%) over declined orchards. Soil pH (3.14 – 5.33) and soil organic carbon (0.90 – 1.37%) reduced in declined orchards as compared to healthy orchards.

Raising of citrus seedlings under mid hills of Meghalaya

Experiment was conducted to identify suitable technique for raising citrus seedling under mid hills of Meghalaya (Fig 17). The seed were sown in raised bed in open field and in plastic crates inside the polyhouse during 1st week of December and uniform cultural practices were followed. Seedlings raised in plastic crates inside the polyhouse recorded minimum days to sprouting (35 days); highest germination percentage (88.22%) and plant survival (80.0%) while maximum days to sprouting (62 days) was recorded in seedlings raised at open field with lowest germination (66.5%) and survival (58.5%).

Fig 17. Rough lemon seedlings in plastic crates

Propagation of *Khasi* mandarin

Protocol for wedge grafting and T-budding was standardized for the vegetative multiplication of *Khasi* mandarins depicted in Table 9.

Table 9. Protocol for vegetative propagation of *Khasi* mandarin

Particulars	Wedge grafting	T-budding
• Type of rootstock	Vigorous	Vigorous
• Sowing of rootstock seeds in primary nursery	Plastic tray (Size: 60 x 40 x 12 cm)	Plastic tray (Size: 60 x 40 x 12 cm)
• Time of seed sowing	November-December	November-December
• Raising rootstock in secondary nursery	Polythene bag	Polythene bag
• Size of polythene bag	30 cm x 15 cm	30 cm x 15 cm
• Age of rootstock	6-7 months	11-12 months
• Diameter of rootstock	4-6 mm	3-3.5 cm
• Age of scion shoot	3-4 months	5-6 months
• Length of scion	8-10 cm	-
• Vertical cut on rootstock	1.5-2.0 cm	-
• Length of slanting cut on both the sides at lower end of scion	1.5-2.0 cm	-
• Length of bud wood	-	2.0-2.5 cm
• Length of cut on the rootstock for inserting bud on T-point	-	2.0-2.5 cm
• Grafting/budding height	12-15 cm above the soil surface/ polybags	20-22 cm above the soil surface/ polybags
• Time of grafting/budding	July-August	February

GUAVA

Guava production under meadow orchard planting system

Guava production under meadow orchard planting system for mid hills of Meghalaya has been standardized. In this system, planting should be done at a spacing of 2.0 x 1.5 m (plant population: 3333 plants/ha) during June-July. Then tree is topped at 40 to 50 cm above the ground, 2-3 months after planting *i.e.* in August-September to develop single trunk. Retain only 3-4 shoots to develop strong framework. As these shoots mature 3-4 months after emergence, prune terminal shoot up to 50% of its length during November-December to develop desired canopy architecture. New shoots start emerging during February-March on which flowering takes place in April-May. In July- August terminal shoot pruning should be done by keeping 2 to 3 cm distance above fruits bearing shoots to increase light penetration and aeration inside the tree canopy. The fruits are ready for harvesting in October-November. In this system, fruiting starts in the 2nd year. At 6th year, among the guava varieties, Megha Khongpheram Paudiik (RCGH-7) was found superior under meadow orchard with respect to fruit yield (12.0 kg/plant), fruit weight (148.60 g), fruit length (6.31 cm) and diameter (6.52 cm).

Effect of bud/shoot removal on fruit maturity in guava variety Megha Saw Priam

Experiment on effect of bud/shoot removal on fruit maturity of red fleshed guava variety Megha Saw Priam (RCGH 4) planted at spacing of 2 m x 1 m was conducted. Selected plants were completely defoliated by removing buds/shoots at ten days interval *viz*., T1 (5th March), T2 (15th March), T3 (25th March), T4 (05th April) and T5 (control). Results revealed that fruit maturity was extended by 19 to 22 days compared to control. The maximum delay in fruit maturity was recorded in T4 (22 days) with significant ($P = 0.05$) drop in fruit yield (4.22 kg/plant). However treatment T2 and T3 delayed the fruit maturity by 21 to 19 days, respectively, with a higher marketable fruit yield i.e. 7.11 kg/plant and 6.50 kg/plant, respectively, compared with control (4.80 kg/plant). Fruit weight was recorded maximum in T2 (175.0 g) followed by T3 (171 g). The highest TSS (9.15%) and lowest acidity (0.65%) was recorded in T4 which was at par with T3 . The ascorbic acid content was recorded highest in T2 (170.12 mg/100g). This indicated that bud/shoot removal during 15th to 25th March was suitable for extending the fruit maturity in guava.

Regional trial on advance breeding lines of horticultural crops- Guava

Five guava varieties *viz*., Megha Guava (Sour type X Red fleshed local), Megha Saw Priam (Red fleshed X Allahabad Safeda), Megha Khongpheram Paudiik (Lucknow-49 X Pear shaped), Allahabad Safeda and Lucknow-49 were planted under meadow orchard planting system (2 m x 1.5 m) during 2014. The experiment being conducted in six regional stations *viz.,* Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Tripura Sikkim and Nagaland. The results of the two years of testing are encouraging; at 2nd year highest plant height was recorded in RCGH-1 while plant spread in RCGH-7 across all the locations. Number of fruits was recorded highest in RCGH-4 (12 nos.) in Arunachal Pradesh and in Meghalaya RCGH-7 recorded maximum fruits (15 nos./ plant).

PEARS

Standardization of grafting techniques in *Pyrus pashia*

Experiment was conducted to find out the techniques and time of grafting in *Pyrus pashia*. Two methods of grafting, *viz*., Tongue grafting (TG) and Wedge grafting (WG) in six time of operations, *viz*., 15th & 30th August, 15th & 30th September, 15th & 30th October. Result revealed that Tongue grafting recorded maximum spouting (100%) during 15th to 30th October with highest survival rate (86.67%) (Fig 18).

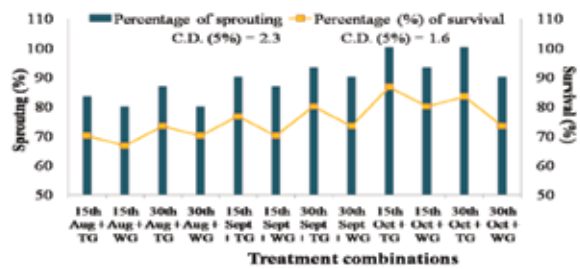


Fig 18. Effect of methods and time of grafting on sprouting and survival of Pyrus pashia

VEGETABLES

TOMATO

Selection and evaluation of F_2 population of tomato

Experiment was carried out with an objective to identify suitable variety of tomato for rainfed areas using seeds of 64 selected F_1 hybrids during January-

April, 2016 under rainfed conditions. Individual plants were selected in the segregating population and the best performing genotype for yield and related traits. Among the selected lines, highest yield per plant (1.77 kg) was obtained from the progeny of HADT-294 × Sel-9A followed by S. *cerasiforme* × DMT-1 (1.71 kg) which were statistically at par with HADT-294 × Sel-11 (1.68 kg). However, maximum fruit weight (74.28g) was recorded in (Sel-11 × DMT-1) and MT-11 × MCTR-4B (74.20 g). Among the lines, progeny of *S. cerasiforme* × DMT-1 was identified as superior for yield per plant (1.77 kg), shelf life of the fruits (17 days) and TSS (5.2%). The interspecific hybrids *i.e.*, *S. cerasiforme* × Sel-9A, *S. cerasiforme* × MCTR-4B and *S. cerasiforme* × DMT-1 also shown tolerance to early and late blight which is a serious problem in north eastern region of India. The segregating population showed wide variability for fruit size especially in inter-specific hybrids over parents and F_{1s}.

INSECT

Efficacy of bio-rational insecticides against tomato fruit borer (*Helicoverpa armigera*)

Bio-rational insecticides *viz*. flubendiamide 39.35SC (48 and 96 g a.i./ha), indoxacarb 14.5SC (75 and 150 g a.i./ha), novaluron 10EC (75 and 150 g a.i./ha) and conventional insecticide, cypermethrin 10EC (50 and 100 g a.i./ha) were evaluated against tomato fruit borer (*Helicoverpa armigera*). Among the insecticidal treatments, flubendiamide (5.74 to 5.89% fruit damage) and indoxacarb (5.65 to 7.46% fruit damage) were found to be effective insecticides against this pest. Both these insecticides also recorded higher marketable fruit yield as compared to other treatments.

SWEET GOURD

Evaluation of Spine/Sweet gourd germplasm

About 38 germplasm of spine/sweet gourd were collected from different parts of NEH region and evaluated for yield and related traits during March-September, 2016. The plants were raised from tubers planted in pits (60 x 60 cm) at 2.5 x 2.0 m spacing in the month of March. The wide range of variability was observed for the leaf, flower and fruit characteristics (Fig 19). Range of fruit length (5.6-10.3 cm), fruit weight (41.2-149.4 g), number of fruits/plant (12-810 and yield (0.5-9.3kg/plant). Variability was also observed for the quality attributes such as vitamin-c (26-74 mg) and protein (10.7-14.4%) content. Among the genotype, highest yield per hill was recorded from the RCSG-15 (9.3 kg) followed by RCSG-14 (8.6 kg) and RCSG-13 (7.5 kg). The highest fruit length (11.3 cm) was recorded in RCSG-20 and RCSG-32. However, the maximum fruit weight was observed in RCSG-14 (149.4 g).

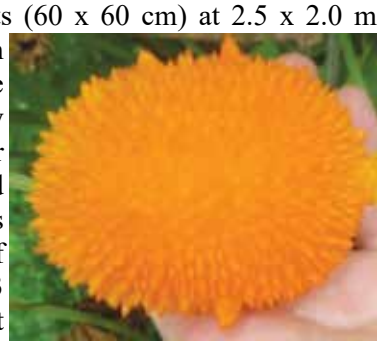


Fig 19. RCSG-15

KAKROL

Physicochemical changes in Kakrol at different stage of maturity

Eight genotypes of kakrol were used for the experiment and fruits were harvested at five maturity stages *i.e.*, mature green, turning, yellow, ripe and fully ripe). A wide variability of fruit quality was observed among different germplasm. Regarding quality traits, vitamin-c has shown decreasing trends from 36-58 mg (mature green) to 12-15 mg (fully ripe stage). Similarly, β-carotene (27.12-45.39 mg to 4.30-8.77 mg) and anthocyanin (1.10-1.25 mg to 0.33-0.56 mg) showed decreasing trends from mature green to fully ripe stage. However, lycopene content showed increasing trend from 2.50-4.86 mg (mature green) to 13.18-14.11 mg (fully ripe stage) and protein content was also recorded highest (14.35%) at ripe stage. Considering all the quality parameters of fruits, harvesting between mature green and turning stage were found superior for most of the traits except lycopene content (Fig 20).

Fig 20. Different stage of fruit maturity and ripening in kakrol

DOLICHOS BEAN

Performance of Determinate Dolicos bean

New indeterminate genotype of Dolicos bean (Selection-1) identified from the selection of local collection was used for carried out the experiment. This genotype was identified as a short duration variety and harvesting period ranged from 60-90 days and found suitable for the rainfed cultivation. This genotype having white flowers, green pod, length ranged from 12-15 cm, width (3-4 cm), raceme length (25-30 cm), number of pods/plant (12-18), yield per plant(150-180 g/plant). This genotype is also suitable for legume vegetable and pulse as well.

CAPSICUM

Performance of *Capsicum species* under low-cost polyhouse

Experiment was carried out during March - August, 2016 under low-cost polyhouse using 6 genotypes of *Capsicum spp*. Among genotypes, highest yield was recorded in long type hot pepper hybrid Angel (4.14 kg/m^2). However, among capsicum hybrids, highest yield was recorded in Pusa Deepti F1 (2.68 kg/m^2) followed by Mahabharat (1.56 kg) and among varieties, California Wonder was highiest in yield (1.34 kg).

BITTER GOURD

Performance of improved varieties of bitter gourd under low-cost polyhouse

To study the performance of bitter gourd under low cost polyhouse, 4 genotypes *i.e*., Pusa Rasdar, Pusa Ausadhi (predominantly gynoecoius line), Pusa Hybrid-2 and Local collection were planted used at spacing 1 x 1 m in trellis. Among genotypes, maximum and fruit weight was recorded in Pusa Rasdar (80 g) and minimum in Pusa Aushadhi (49.15g). However, highest yield was recorded from the predominantly gynoecious line Pusa Ausadhi (1.01 kg/plant) followed by Pusa Rasdar (0.9 kg/plant) and Pusa Hybrid-2 (0.58 kg/ plant).

FRENCH BEAN

Evaluation of French bean germplasms for yield attributes

About 175 genotypes (145 pole type and 30 bush type) were evaluated for yield and related traits during July-November, 2016. Out of 30 bush type, the best performing genotype was Sel-17 for yield per plant (158 g) and pod length (16 cm) and followed by Arka Komal (148.9 g), RCFB-3 (113 g) and Arka Anoop (112 g) for yield per plant. Among the pole type, a new collection from Manipur with pod length (18.0cm), pod yield per plant (310g) was the best performing genotype.

COWPEA

Collection and evaluation of Cowpea germplasm

About 35 genotypes of cowpea were collected and evaluated for yield and related traits. Days to first flowering ranged (30-37) and average pod length (19.40-49.70 cm). Genotypes, MZCPC-1 (429.50 g), RCCPC-2 (380 g) and RCCPC-2(360 g) were identified as high yielding genotypes.

TUBER CROPS

SWEET POTATO

Nine sweet potato varieties were evaluated for yield and related parameters. Var. TSp 12-12 recorded highest marketable yield (19.23 t/ha) and total yield (27.81 t/ha). Local cv. recorded maximum dry matter content (33.33 %), starch (19.56%) and sugar (4.34%, Table 10).

COLOCASIA

Six genotypes of colocasia were evaluated for physical parameters and quality parameters . Result showed that maximum cormel number (25.33), weight (533 g/ plant), yield (16.88 t/ha) and total yield (21.33 t/ha) were found highest in Muktakeshi. While, lowest calcium oxalate (170mg/100g) was found in Megha Taro-1 (Table 11).

Table 10. Yield and quality parameters of sweet potato lines

Genotype	Yield (t/ha)	Marketable Yield (t/ha)	Sugar (%)	Dry matter (%)	Starch (% dry weight)	Sweetness	Flesh colour
TSp12-4	22.48	13.60	3.77	29.15	18.94	Slightly sweet	Creamish white
TSp12-6	16.56	10.65	4.16	31.66	18.75	Sweet	Creamish white
TSp12-7	13.43	13.31	4.08	30.33	17.64	Moderately sweet	White
TSp12-8	8.8	5.59	4.01	32.07	17.82	Moderately sweet	White
TSp12-9	14.79	13.01	4.08	30.02	18.36	Slightly sweet	Light yellow
TSp12-10	15.97	11.24	3.84	29.23	17.3	Slightly sweet	Creamish white
TSp12-12	27.81	19.23	3.77	28.71	17.64	Slightly sweet	Light yellow
ShreBhadra	8.50	7.39	3.92	24.6	18.36	Moderately sweet	White
Local	13.31	13.31	4.34	33.33	19.56	Sweet	White
C.D. (0.05)	0.60	0.35	0.05	0.45	0.59	-	-

Table 11. Performance of Colocasia lines at Barapani

Varieties	No. of cormels/ plant	Weight of corms/ plant (g)	Weight of cormels/ plant (g)	Total yield (t/ha)	Calcium oxalate (mg/100 g)	Taro leaf blight	Keeping quality
TTr12-2	17.67	133.3	523.33	17 .11	240	1-10%	long >30 days
TTr12-4	11.33	118.3	158.33	7.3	210	>25 to 50%	long >30 days
TTr12-7	15.67	115.0	288.33	13.77	250	>25 to 50%	long >30 days
TTr12-8	11.67	128.3	160.00	11.55	220	>10 to 25%	long >30 days
Muktakeshi	25.33	136.7	533.3	21.33	180	No symptom	long >30 days
Megha Taro-1	17.67	143.3	396.67	15.33	170	No symptom	long >30 days
CD (0.05)	2.56	15.57	27.28	7.44	8.75	-	-

ONION

Forty three genotypes of onion were evaluated for yield and other parameters during 2015-16. Plant height was found highest in ON15-45 (79.67 cm) followed by ON15-33 (66.00 cm) whereas lowest in OLR-1213 (14.43 cm). OLR-1347 recorded maximum diameter (polar, 65.88 mm; equatorial, 86.78 mm) and neck thickness (124.74 mm). ON15-45 produced highest marketable (66.41q/ha) and total yield (85.45q/ha). TSS was found highest in ON15-37 (14.60 %) and lowest in OLR-1343 (6.13 %).

All India Network project on onion and garlic

Thrips incidence in different onion genotypes at Umiam, Meghalaya

Incidence of thrips in different trials varied from 35 to 56% in different genotypes, (Tables 12-13) it was highest in genotype ON-15-01 (56% foliage damage) and lowest in genotype ON-15-45(35% foliage damage). In AVT I, thrips damage was ranged from 29.67 to 53.67% in different genotypes. Percent foliage damage was maximum in genotype ON-14-01 (53.67%) and lowest in genotype ON-14-04 (29.67%). In AVT II (varietal trial), thrips incidence varied from 28 to 62% in different genotypes, being highest in genotype OLR-1354 (62%) and lowest in genotype OLR-1359 (28%). In AVT II (Hyrbid trials), thrips infestation ranged from 15.67 to 30.67% in different genotypes. Percent foliage damage was higher in genotype OLR-1372(30.67%) and lowest in genotype OLR-1381 (15.67%). Besides thrips, the cutworm, *Agrotis ipsilon* was found to be a major pest of onion during 2015-16.

Population dynamics of onion thrips during 2015-16

Thrips population was started appearing in the field from March end (4.5 thrips/plant), being highest during the third week of the April (42.15/ plant). Thrips population was started declining from the second week of the May and found to be minimum at the end of the May. Data on weather parameters during the experimental period are presented in Tables 12-14. Incidence of thrips was found to have significant positive correlation with rainfall (r=0.528), temperature (r=0.616 for max. temperature and r=0.724 for minimum temperature) and wind speed (r=0.849); whereas significant negative correlation with morning relative humidity (r=-0.546).

Assessment of yield loss due to thrips infestation

Thrips incidence was significantly reduced in protected plots compared to unprotected plots. Since the thrips population was observed to be for the shortest period i.e. only during April and May, therefore considerable variation was not observed in thrips numbers and yield in different dates of planting under both protected and unprotected conditions. However, percent yield loss was found to be minimum (9.19%) in crop planted during 1st November; while it was maximum in crop planted during 1st December.

DISEASES

Screening against purple blotch revealed that out of 19 lines only six were moderately susceptible.

Table 12. Thrips incidence in onion genotypes under different trials at Umiam, Meghalaya

IET 2015			AVT I 2015			AVT II 2015 (variety)			AVT II 2015 (Hybrids)	
Entry code	Thrips incidence (% foliage damage)	SN	Entry code	Thrips incidence (% foliage damage)	SN	Entry code	Thrips incidence (% foliage damage)	SN	Entry code	
ON-15-01	56.00	1	ON-14- 01	53.67	1	OLR-1323	37.33	1	OLR-1367	19.67
ON-15-04	42.00	2	ON-14- 04	29.67	2	OLR-1341	38.00	2	OLR-1370	18.33
ON-15-06	48.67	3	ON-14- 06	49.33	3	OLR-1343	44.00	3	OLR-1372	30.67
ON-15-11	43.33	4	ON-14- 09	**	4	OLR-1344	53.33	4	OLR-1374	30.00
ON-15-13	54.33	5	ON-14- 11	31.67	5	OLR-1347	53.00	5	OLR-1377	14.67
ON-15-16	43.67	6	ON-14-15	48.00	6	OLR-1349	56.00	6	OLR-1381	15.67
ON-15-18	48.00	7	ON-14- 17	**	7	OLR-1352	42.67	7	OLR-1388	**
ON-15-20	42.33	8	ON-14- 23	42.67	8	OLR-1354	62.00			
ON-15-23	54.00	9	ON-14- 25	37.33	9	OLR-1357	35.67			
ON-15-27	50.00	10	ON-14- 27	43.33	10	OLR-1359	28.00			
ON-15-33	53.67	11	ON-14- 29	**	11	OLR-1362	33.33			
ON-15-37	55.67				12	OLR-1364	58.33			
ON-15-39	54.33				13	ALRO -1213	57.67			
ON-15-42	53.67									
ON-15-45	35.00									
ON-15-48	49.33									
C.D. 5%	16.72			12.86			11.42			12.18
C.V.	20.46			17.50			14.70			31.14

*Note: ** Genotypes could not be evaluated due to non-availability of sufficient plants*

Table 13. Reaction of onion entries against purple blotch

Entries	PDI (%)	Reaction
ON-15-45	34	Moderately susceptible
ON-15-33	36	Moderately susceptible
ON-15-37	36	Moderately susceptible
ON-15-16	41	Susceptible
ON-15-18	42	Susceptible
ON-15-42	42	Susceptible
ON 15-04	48	Susceptible
ON-15-11	55	Susceptible
ON-15-13	56	Susceptible
ON 15-01	62	Highly Susceptible
ON-15-06	66	Highly Susceptible
ON-15-27	66	Highly Susceptible
ON-14-09	36	Moderately susceptible
ON-14-06	37	Moderately susceptible
ON-14-15	40	Moderately susceptible
ON-14-04	42	Susceptible
ON-14-01	44	Susceptible
ON-14-11	46	Susceptible
ON-14-23	48	Susceptible

Table 14. Thrips damage in different date of plantings and their effect of Onion yield

Date of Planting	Treatment	Thrips number/plant	TY t/ha	MY t/ha	Percent yield loss
15th Oct	Protected	1.83	20.00	18.97	10.01
	Unprotected	18.83	17.90	17.07	
1st Nov	Protected	2.33	18.67	17.73	9.19
	Unprotected	26.83	17.23	16.10	
15th Nov	Protected	4.67	19.17	18.33	10.53
	Unprotected	35.73	17.83	16.40	
1st Dec	Protected	6.00	18.83	18.20	13.74
	Unprotected	35.67	16.70	15.70	
15th Dec	Protected	5.03	18.67	17.50	12.40
	Unprotected	33.33	16.37	15.33	
Mean		3.97	18.97	18.15	-
C.D. 5%	Protected	3.37 (NS)	1.75 (NS)	1.61 (NS)	-
C.V.		45.04	4.91	4.71	-
Mean		30.08	17.20	16.12	-
C.D. 5%	Unprotected	17.93 (NS)	1.39 (NS)	1.26 (NS)	-
C.V.		31.67	4.28	4.16	-

GARLIC

About 16 genotypes of garlic were collected from Assam and Arunachal Pradesh in the month of July through joint exploration with Directorate of Onion and Garlic, Pune. These collections were planted in pots for recording data as per DUS testing guidelines.

SPICES

TURMERIC

Source-sink relationship in turmeric

Six genotypes of turmeric were taken for evaluation the source-sink relationship in turmeric. Observations were recorded at 60, 120, 180 DAP (days after planting) and at harvest stage. The dried samples were sent to IISR for further analysis. Mydkur variety recorded highest fresh rhizome weight at 60 DAP (18.79 g/plant), 180 DAP (350.04 g/plant) and at harvest (409.26 g/plant), whereas at 120 DAP Rajendra Sonia recorded highest fresh rhizome weight (250.39 g/plant).

Organic production of Turmeric

Maximum yield of 50.97 t/ha was recorded in T_3 (100% organic manures + micronutrients) followed by 44.4 t/ha in T_5 (75% N requirement of turmeric + micronutrients). Dry recovery (22.49%) was recorded highest in T_2 (100% organic manures equivalent to 75% N requirement of turmeric) and lowest (21.05%) in T_8 (Farmers practice). Treatment T_7 (NPK 120:90:90 NPK kg/ha) recorded highest curcumin content (6.35%) and highest oleoresin (14.35 %).

GINGER

Source Sink relationship in ginger

Three genotypes, *viz*., Himgiri, Nadia and Mahima were evaluated to study the source-sink relationship in ginger. Observations were recorded at 60, 120, 180 DAP and at harvest stage. Highest fresh rhizome weight at 120 DAP (110.63 g/ plant), 180 DAP (187.35 g/ plant) and at harvest (305.85 g/ plant) was recorded in Himgiri, whereas at 60 DAP Nadia recorded highest fresh rhizome weight (14.78 g/plant).

Organic production of Ginger

Maximum yield (48.37 t/ha) was recorded in T_6 (75% N requirement of ginger + vermiwash 10%) followed by T_5 (75% N requirement of ginger + micronutrients, 26.54 t/ha). Dry recovery (20.55%) was recorded highest in T_3 (100% organic manures + micronutrients) and lowest (19.44%) in T_8 (Farmers' practice). T_6 (75% N requirement of ginger + vermiwash 10%) recorded highest fibre content (4.33%) while lowest was recorded in T_3 (100% organic manures + micronutrients, 3.49%). Oleoresin content was recorded highest in Treatment T_7 (NPK 100:90:90 NPK kg/ha) and lowest in T_3 (100% organic manures + micronutrients) with 3.93%.

INSECT

Infestation of Oriental leafworm, *Spodoptera litura* on ginger

The Oriental leafworm *Spodoptera litura* was found infesting ginger plants in Meghalaya. To establish the correct identity, pest samples were collected from the field and charectorized morphologically as well as at molecular level. The first incidence was observed in July 2013 and subsequently their population dynamics and bionomics were studied under field condition. *S. litura* is a polyphagus pest and known to damage many agricultural and horticultural pests across the globe. Female moth laid eggs on the ginger leaves (Fig 21) and larvae were found defoliating leaves (Fig 22 and Fig 23) and in later stage few larvae were also found attacking rhizome portion of ginger. As per primary scientific literature, this is the first report of *S. litura* damage to ginger plants from India.

Fig 21. Egg

Fig 22. Larva

Fig 23. Damage symptoms

FLOWERS

GERBERA

Effect of different growing conditions on physiological and yield characteristics of gerbera hybrids

Experiment was conducted to find out the effect of growing conditions (open field conditions; organic mulch under open field conditions and low cost polyhouse) on physiological and yield performance of gerbera. Result revealed that organic mulching gave maximum *A* (21.13 **µmol**/ m^2/s), *E* (3.46 mmol /m^2/s) and *gs* (87.60 mol / m^2/s), while highest *Ci* (402.71 ppm) was recorded in low cost polyhouse. However, number of flower was recorded maximum in low cost polyhouse

(23.20) which was at par with organic mulch (21.63). Therefore, growing gerbera under organic mulch under open field condition is an option for resources poor farmers.

Evaluation of gerbera hybrids/ varieties under fan and pad polyhouse and open field

Experiment was carried out to find the most suitable conditions for growing gerbera. Result revealed that significance variation in flowers characteristics among hybrids, growing conditions and their interaction (Table 15a). Hybrid RCGH-117 showed maximum flower stalk length (47.10 cm), stalk diameter (5.27 mm), flower diameter (10.60 cm). While, RCGH-114 produced maximum number of flowers per month (4.42) which was *at par* with RCGH-117 (4.32). Regarding growing conditions, hybrids growing under fan and pad polyhouse showed maximum value for all the parameters recorded. In the interaction effect, hybrid RCGH-22 + fan and pad polyhouse had maximum flower stalk length (55.47 cm). Hybrid RCGH-117 + fan and pad polyhouse showed maximum flower stalk diameter (5.44 mm) and flower diameter (10.73cm). Maximum number of flower was observed in RCGH-114 + fan and pad polyhouse (4.89 /plant/month).

Miniature gerbera genotypes

Among 32 gerbera genotypes, RCGH-28 was identified as miniature gerbera suitable for growing in pot and indoor plant. Flower characteristics of RCGH-28 are given in Table 15b & Fig 24.

Fig 24 RCGH-28

ORCHID

Evaluation and maintenance of Orchid germplasm

Evaluation of 33 species of orchids were carried out for growth and flowering under net house. Regarding growth characteristics, *Phaius tankervilleae* recorded maximum plant height (148.2 cm) and plant spread (107.2 cm), while *Coelogyne flaccid* showed maximum leaf (95 nos.). Flowering characteristics showed that *Coelogyne flaccid* produced maximum no. of flower spikes/ pseudobulb (6.0). Number of flowers/ spike was maximum in *Phaius tankervilleae* (14.67), inflorescence diameter (17.77 cm) and inflorescence length (19.33 cm) in *Phaius woodfordie.*

Table 15a. Evaluation of promising gerbera hybrids under open field conditions

Hybrids/ variety(s)	Flower stalk length (cm)			Flower stalk diameter (mm)			Flower diameter (cm)			Number of flower/plant/ month		
	FPP	OFC	Mean	FPP	OFC	Mean	FPP	OFC	Mean	FPP	OFC	Mean
RCGH-7	44.04	37.09	40.57	4.84	4.64	4.74	9.33	8.87	9.10	3.64	3.33	3.48
RCGH-9	43.08	28.11	35.60	5.01	4.21	4.61	9.57	9.46	9.52	3.31	2.21	2.76
RCGH-12	42.30	39.01	40.65	5.14	4.88	5.01	9.88	9.57	9.73	4.57	2.58	3.57
RCGH-19	39.43	35.55	37.49	4.35	4.78	4.57	9.56	8.60	9.08	2.83	2.29	2.56
RCGH-22	45.32	44.29	44.81	5.22	4.97	5.10	10.03	9.31	9.67	4.34	3.83	4.08
RCGH-23	48.08	32.50	40.29	5.40	5.14	5.27	8.92	8.77	8.85	3.36	2.66	3.01
RCGH-33	51.30	37.15	44.23	5.04	4.92	4.98	9.10	8.44	8.77	3.92	2.82	3.37
RCGH-42	44.31	31.25	37.78	5.08	4.28	4.68	8.00	7.78	7.89	2.92	2.36	2.64
RCGH-51	48.14	35.93	42.04	5.05	4.94	5.00	9.25	9.04	9.15	4.33	3.39	3.86
RCGH-76	45.43	25.62	35.53	5.03	4.54	4.79	8.85	8.69	8.77	4.34	2.43	3.385
RCGH-89	45.49	29.48	37.49	5.27	4.22	4.75	8.70	8.16	8.43	2.8	2.42	2.61
RCGH-95	41.73	38.75	40.24	4.89	4.64	4.77	8.42	8.94	8.68	2.83	2.98	2.91
RCGH-100	41.6	41.27	41.44	4.87	4.89	4.88	10.43	9.64	10.04	3.99	3.22	3.61
RCGH-113	52.81	42.82	47.82	5.11	4.30	4.71	7.89	7.62	7.76	4.08	4.00	4.04
RCGH-114	48.84	41.38	45.11	5.24	5.15	5.20	10.34	10.14	10.24	4.89	3.95	4.42
RCGH-117	48.47	45.73	47.10	5. 44	5.27	5.35	10.73	10.46	10.60	4.56	4.08	4.32
RCGH-128	37.71	33.34	35.53	4.86	5.13	5.00	6.79	7.46	7.13	3.06	2.61	2.83
RCGH-226	51.00	34.35	42.68	4.12	3.85	4.49	9.77	8.96	9.37	2.85	2.38	2.62
Alesmera	50.15	46.50	48.33	6.46	6.12	6.29	10.54	10.04	10.29	3.42	2.94	3.18
Mean	46.11	36.40		5.05	4.78		9.26	8.99		3.68	2.97	
Factors	H	G	HxG	H	G	HxG	H	G	HxG	H	G	HxG
CD (p=0.05)	0.62	0.60	1.06	0.04	0.02	0.07	0.63	0.75	1.23	0.28	0.33	0.72

Table 15b. Flower characteristics of RCGH-28

Days to bud burst	Days to first flower opening	Flower stalk length (cm)	Flower stalk diameter (mm)	Flower diameter (cm)	Disc diameter (cm)	Number of flowers per plant per month	Vase life (Days)
13.00	25.00	22.30	5.46	8.94	1.36	5.60	7.00

VALUE ADDITION

Chow chow and *sohiong* blended leather and RTS (ready to serve) beverage

Chowchow pulp was blended with *sohiong* (*Prunus nepalensis* Serr.) juice for preparation of leather and RTS beverage in ratios (100:0, 90:10, 80:20, 70:30, 60:40 and 50:50). Leather of different combination ratios was prepared by addition of sugar (20%) and acid (0.2%), and dried in thin layer of 4 mm thickness at 50 °C. RTS ble nded beverages were adjusted to 15 °B and 0.5% acidity according to the specific measurements given in Table 16. Based on the organoleptic evaluation 80:20 and 70:30 ratios were rated to be the best for leather (Fig 25) and RTS respectively (Fig 26).

Table 16 Ingredients for *chow- chow* and *sohiong* blended RTS

Ingredients	Quantity
Chow-chow and *sohiong* blended juices	1 L
Sugar	700 g
Citric acid	13 g
Water	3.5 L

Fig 25 Chow chow and sohiong blended leather

Fig 26 Chow chow and sohiong blended RTS

Value added products from Carambola

Carambola candy of 10, 20 and 30 mm thickness were prepared by steeping in sugar syrup (30 °B) for 5 days and gradually raising the strength of syrup to 70 °B (Fig 27). The fruit pieces were drained and dried at 55±5 °C. Based on the uniformity of drying and sensory testing, 20 mm thickness candy was found to be the best. Firm ripe carambola fruits were used for making carambola squash containing 25% fruit pulp, 1% acid and 45°B TSS.

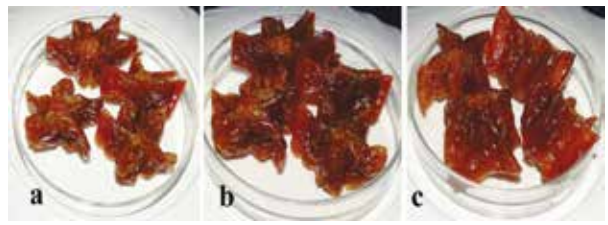


Fig 27. Carambola candy- a, 10 mm; b, 20 mm; c, 30 mm thickness

Peach value addition

Value added products such as peach spread and spiced peach were prepared (Fig 28). For peach spread, pulp of ripe fruits was cooked in sugar (70 °B) to smooth consistency. Spiced peach was prepared by light cooking firm mature fruit pieces in spices (black peppercorn, cinnamon, red chili, clove, bay leaf) infused sugar syrup.

Fig 28. Peach spread & spiced peach

TRANSFER OF TECHNOLOGY

FLD on canopy management and rejuvenation in peaches was conducted at Ummulong, Niriang and Nargboh villages of West Jaintia Hills district in collaboration with KVK Jaintia Hills, Meghalaya. Model *Khasi mandarin* orchard was developed at Mawryngkneng Village, East Khasi Hills Meghalaya with technical support from Horticulture division, ICAR, Umiam. Farmer is having 300 (nos.). *Khasi mandarin* plants producing an average 400-600 fruits per plant. One *Julkund* was constructed for supply of water during lean period. Farmer is following the standard package of practices prepared by the division (i.e. Bordeaux paste; mulching; removal of diseased/dry shoots; nutrient applications schedule; weed management; insect pest and diseases control and maturity indices for harvesting etc). Under

improvement of *jhum* farming for natural resource conservation and livelihood security in NEH Region one citrus nursery was established at Sonidan village. At site mother plants were identified and tagged from nearby orchards serving as scion source. One rootstock block (rough lemon and rangpur lime) was also established.

Five days training programme on 'Landscaping and fruit tree plantation' from 1st to 5th August, 2016 was organized to the of Army Cantonment,Umroi, Ri Bhoi, Meghalaya.


A three days training programme on "Production technology in Khasi Mandarin to improve livelihood security of farmers" was conducted under Tribal Sub Plan in collaboration with the Special Purpose Vehicle Society, Shillong from 10th – 12th August, 2016 at ICAR Research Complex for NEH Region, Umiam. The training was mainly to impart theory as well practical experiences to farmers on various technologies relating to Khasi mandarin cultivation for improving livelihood security among growers. The programme was attended by ten (10) "Master Trainers" selected from Nongtrai village, South West Khasi Hills. During the programme, the trainees were addressed on various issues concerning Khasi Mandarin including propagation and nursery management, cultural practices, nutrition and water management, harvesting and post management, pest and diseases management and rejuvenation techniques. These "Master Trainers" will be also an instrument in disseminating knowledge on scientific management of Khasi Mandarin in their own village and nearby.


An Awareness-cum- Demonstration Programme on 'Entrepreneurship in Floriculture' was conducted on 3rd Sept, 2016 under Tribal sub Plan at Eastern Ri-Bhoi College, Bhoirymbong. The main aim of the programme was to create awareness among the college students on taking floriculture as an attractive prospect for entrepreneurship. About 120 participants including students and teachers were actively involved in the programme. The participants were highlighted on the scope of floriculture in the NEH Region, recent advance technologies in floriculture and also marketing of flowers. Gerbera suckers were also distributed to the Principal of the College as part of demonstration during the programme. An interactive session was very productive as participants have come forward with several queries to clear their doubts.

One day Hands on training programme on "Techniques of gerbera hybrids cultivation under open cultivation" in the farm of Horticulture division under TSP for farmers on 8th September, 2016 in the Horticulture division. The programme was attended by about 40 farmers /participants from nearby villages. In addition, planting materials of gerbera was also distributed.

A four (04) days farmers' training programme on Integrated Farming System to improve livelihood of tribal farmers was organized from 14th - 17th December, 2016 under Tribal sub Plan. The farmers were imparted hands-on training on horticultural crops such as cultivation of flowers, fruits, vegetables and mushroom as well as pig rearing. Planting materials of gerbera were distributed among the farmers.

CROP PROTECTION

ENTOMOLOGY

Eco-friendly management of fruit flies in vegetables

Field trials on fruit fly management were conducted in tomato and *chow-chow* crops. Module consisting of parapheromone traps @ 15 traps/ ha along with spraying of oil based formulation of *neem* (nimbecidine) @ 5ml/litre of water at 15 days intervals during fruiting was found to be the most effective against fruit flies with significantly higher marketable yield ($p \leq 0.05$) in tomato during rainy season. In *chow chow*, mass trapping of fruit flies @ 20 traps/ha along with sprays of Anonin 1 EC @ 2ml/ litre of water at 15 days interval during fruiting stage was found very effective against fruit flies.

Management of fruit fly complex in peach

Maximum reduction in fruit fly damage (61.12%) over control was observed in Module II (which consists of male trapping @ 15 pheromone traps/ha + four sprays of Deltamethrin @ 0.5 ml/lit of water during fruit setting at 20 days interval + soil application of *M. anisopliae* during early September (15 days before fruit maturity) @ 15 kg per ha ($1x10^9$ cfu/gm). Module III reduced 51.24% fruit fly damage compared to control; which is at par with Module I (41.27% reduction).

Knol-khol as a new host of fruit fly, *Bactrocera tau*

Incidence of *Bactrocera tau* (Fig 29) on knol-khol was initially observed in December 2014. As per existing scientific literature, this is the first report of *B. tau* damage to knol-khol. Subsequently, a study on its bionomics and seasonal incidence was initiated. Female fly lays eggs on top tender portion of the knol-khol plant and complete larval stage inside by feeding on internal content. Infested portion cracks near the oviposition punctures (Fig 30). The infested produce loose the market quality due to cracks and rottening. About 5-8% field damage was observed during peak season. Mass trapping was found to be the best method of reducing fruit fly damage in knol-khol.

Fig 29. Bactrocera tau adult

Fig 30. Damage of B. tau on knol-khol

Insecticidal activity of bacterial pigment Prodigiosin on *Spodoptera litura*

Red pigment derived from the entomopathogenic bacteria, *Serratia marescens* is being evaluated against polyphagus pest, *S. litura*. In preliminary experiments, the pigment was found insecticidal against larvae of *S. litura.* Infected larvae stop feeding within 24 and 48 hours and eventually die within 72 hours. Detail machanism of action is being studied.

Insecticidal activity of *Zanthoxylum armatum* extract against *Spodoptera litura*

Different fractions *viz*., ethanolic, methanolic, hexane, ethyl acetate and aqueous fraction of various plant parts of medicinally important indigenonus plant, *Zanthoxylum armatum* are being evaluated against polyphagus pest, *Spodoptera litura.* Results indicated that, hexane fraction of pericarp was found highly insecticidal to the second instar larvae of *S. litura*. Different fractions of leaf of *Z. armatum* are being evaluated.

Molecular characterization and Biology of Cacao Tussock Moth, *Orgyia australis postica* Walker infesting Rosaceae Plants in northeast India

The caterpillars of *O. australis postica* were found feeding voraciously on leaves and tender portion of apple (Fig 31) and rose plants at Basar, Arunachal Pradesh and Sohphoh (*Docynia indica*) plants at Umiam, Meghalaya. Interestingly, maize (*Zea mays*), pomegranate (*Punica granatum*) and Mexican heather (*Cuphea hyssopifolia*) plants grown nearby the orchard at Basar were also found infested by this pest. Adult moths were found to be sexually dimorphic (Fig 32). The adult males were grey-brown with pectinate antenna which lived for 8.25±2.1 days. In natural condition, they form a silken cocoon (pupa) on the leaves. The mean pupal period was observed to be 7.2 ± 1.1 days. The female, after emerging from pupa, was wingless, observed sticking to the pupal coverings and laid eggs on

Fig 31. Caterpillars of O. australis postica feeding on apple leaves

Fig 32. Male moth of *O. australis postica*

the hairs of the pupal remains. The mean lifetime fecundity of the female was found to be 198 ± 13 egg per female under laboratory conditions, which hatched in 3.2 ± 1 days. The larvae molted for the four times and the larval period was completed in 18.5 ± 2days. Since identification of lymantrid moths is difficult or complex due to considerable overlapping morphological characters within and in between species. We have established the identity of *O. australis postica* through DNA barcoding by using partial cytochrome oxidase I gene of mitochondrial DNA. The DNA barcode (680 bp) of *O. australis postica* has been deposited to the NCBI vide accession number KU682728.

Evaluation of new insecticides against brinjal shoot and fruit borer (Leucinodes orbonalis)

Three new insecticides *viz.* chlorantraniliprole 18.5SC (40 and 80 g a.i./ha), indoxacarb 14.5SC (75 and 150 g a.i./ha), chlorfenapyr 10SC (100 and 200 g a.i./ha) and chlorpyriphos 20EC (standard check) were evaluated against shoot and fruit borer (*Leucinodes orbonalis*) during kharif season. All the insecticidal treatments were effective and superior over untreated control in reducing shoot and fruit infestation. Among the treatments, chlorantraniliprole was found to be most effective treatment with 6.15 to 6.98% shoot infestation and 7.65 to 9.22% fruit infestation followed by indoxacarb and chlorfenapyr. All these new insecticides recorded higher marketable fruit yield over conventional insecticide.

Development of DNA barcodes for insect pest and natural enemies of cereal crop ecosystem

DNA barcodes of insect pests and natural enemies of major cereal crops in mid hills of Meghalaya were developed. A total of 35 insect species belonging to insect orders; Hemiptera (13), Coloptera (8), Lepidoptera (6), Odonata (6), Hymenoptera (1) and Orthoptera (1) were collected, identified and documented. Out of 35 species, 23 species were insect pests and 12 species were natural enemies. Six species of insect *viz.*, *Chilopartellus*, *Helicoverpa armigera*, *Leptocorisa vericornis*, *Nilaparvata lugens*, *Cnaphalocrocis medinalis* and *Parapoynx stagnalis* were found to be major pest of rice and maize in the region. The natural enemies consisted of four ladybird beetles, six dragon flies and one predatory bug and one larval parasitoid *Cotesia* sp. DNA was successfully extracted from multiple specimens of 35 species. Sequencing of partial COI gene of mtDNA was done successfully for 30 insect species. The sequence quality for five insect species *viz., Diplacodes nebulosa*, *Palpopleura sexmaculata*, *Orthetrum sabina*, *Cofana lineata* and *Cotesia* sp. were not good and hence they were not used in the analysis. Molecular identity of the 30 insect species was established through NCBI BLASTN search. The DNA barcodes for all 30 insect species have submitted to the international Genbank (NCBI) vide Accession Numbers KX351377-KX351408.

Sequencing and characterization of complete mitochondrial genome of citrus trunk borer *Pseudonemophas versteegi* (Ritsema)

Significant genetic variation was detected in geographically separated populations of citrus trunk borer (*Pseudonemophas versteegi*) collected from different states of Northeastern India. Therefore there was an urgent need to sequence and characterize the complete mitogenome of *P. versteegi* for understating speciation and evolutionary relationships between populations *P. versteegi*. The DNA library was prepared from the adult of *P. versteegi* using TruSeq Nano DNA HIT Library sample preparation kit. The mean size of the library was 594 bp and it was sequenced in Illumina Platform and 3GB data per samples were generated. The complete mitochondrial genome of *P. versteegi* (India) was successfully sequenced and assembled. Based on the preliminary analysis, the size of complete mitochondrial genome of *P. versteegi* was determined to be 15685 bp long and circular in nature (Fig 33), the detail characterization of the genome is being undertaken.

Fig 33. Circos plot of P. versteegi mitogenome (15,685bp). The abbreviation COI COII and COIII refer to cytochrome oxidase subunits, CytB refer to cytochrome b, and ND1-6 refers to NADH dehydrogenase components. Yellow and grey colour represents protein coding genes (PCGs) and red colour represents large and small subunits ribosomal RNA.

PCR based molecular tool for rapid identification of different species of fruit flies of the genus *Bactrocera*

The PCR based molecular tool was developed based on informative microsatellite loci boms3a for rapid and stage independent identification of *Bactrocera* species. The microsatellite loci originally developed for

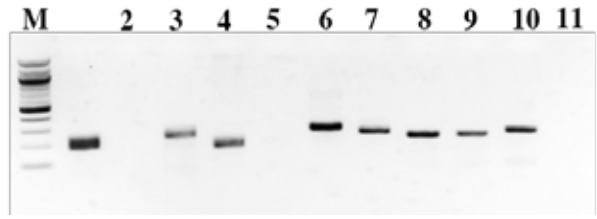


Fig 34. 100bp ladder (M), B. zonata (1), B. tuberculate (2), B. cucurbitae (3), B. ruiliensis (4) B. carambolae (5), Bactrocera sp.1 (6), Bactrocera sp.2 (7), B. scutellaris (8), B. dorsalis (9), B. tau (10), Negative Control (11)

Bactrocera oleae were cross amplified in ten different species of *Bactrocera*. The microsatellite locus boms3a was found to be very informative and could differentiate four closely related species of *Bactrocera* namely, *B. dorsalis, B. ruiliensis, B. carambolae and Bactrocera* sp1. This locus/marker gave consistent results even tested on different populations of the same species (Fig 34). The microsatellite locus boms3a was also validated on different life stages (egg, grub, pupa and adult) of individual species of *Bactrocera*. Given the difficulties in taxonomic identification and importance of fruit flies as an economically important pest of fruits and vegetables which have export potential, this PCR based tools ccould be easily employed for discrimination of taxonomically similar species of fruits flies of the genus *Bactrocera*.

PLANT PATHOLOGY

Biodiversity of plant pathogens in northeast India

Brassica juncea var *rugosa* known as cabbage leaf mustard or more commonly as *lai-patta* in this region is cultivated for vegetable purpose. Molecular and morphological characterisation was done for ascertaining the species responsible for causing white rust of *B. juncea* var. *rugosa. Cox2* and ITS region were used for phylogenetic analysis using Maximum likelihood criteria. The sequences were deposited in GenBank with accession numbers (*cox2*: KJ700640 and ITS: KJ700641). Phylogenetic analysis placed our sequences in the clade containing *A. candida* sequences with 100% bootstrap support confirming the identity of the fungus as *A. candida*.

Exploration and utilization of hyperparasites (of plant pathogens) and entomopathogens in Meghalaya

Infected aphids (*Brevicoryne brassicae* L.) (Hemiptera: Aphididae) (nymphs and apterous adults) were spotted and collected from cabbage plants. Morphological and molecular analysis was also conducted for confirmation of the fungus. For molecular analysis large subunit (LSU) of nrDNA containing D1 and D2 domains and the ITS region comprising ITS1-5.8S-ITS2 was amplified using different primers. Based on morphological characters the pathogen was identified as *Lecanicillium longisporum*. It was also found to be associated with green peach aphid (*Myzus persicae*) on cabbage plants. Pathogenicity tests were also conducted which yielded positive results. This fungus is being evaluated for its pathogenicity on other aphids.

Extension activities under AICRP on Mushroom

Mushroom day with the theme "Mushroom for nutrition and health" was celebrated at ICAR Research Complex for NEH Region, Umiam, Meghalaya on 23rd Dec, 2016 (Fig. 35)

Two trainings and eight demonstrations/visit/ lecture were conducted on mushroom cultivation which included farmers, entrepreneurs etc. Trainings were oriented towards spawn production, mushroom cultivation and post harvest management.

Fig 35. Mushroom day celebration

Recognition of seed film coating polymers for efficient and health friendly seed treatment operations for certified seeds of soybean

The field evaluation experiment of soybean treated with seed film coating polymers have taken up during *kharif* of 2016. Morpho-physiological parameters recorded at active vegetative growth of crop indicate non-significant changes in leaf area, chlorophyll pigment content and significant changes in carotenoid content across seed treatments. The data on biomass indicate T_1 (Seeds treated with Polymer DISCO AG SP RED L-200 + Thiram+Carboxine) and T_4 (check variety DSB 19) whereas T_3 (seeds

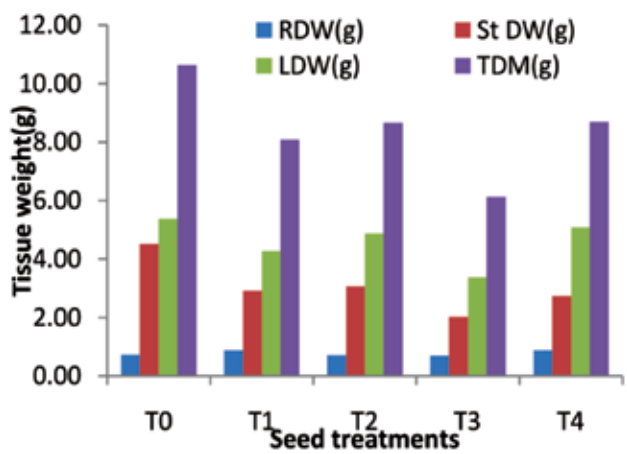


Fig 36. Effect of seed film coating on plant grown of soybean

treated with Polymer DISCO AG SP RED L-200 + Thiram +Quick roots) have recorded higher leaf to stem ratio and T0 (seeds treated with water and thiram) have indicated leaf dry weight and total dry matter (TDM) (Fig 36).

T_2 (treated with Polymer DISCO AG SP RED L-200 + Thiram+ Genius coat) have recorded significantly higher grain yield (t/ha) as compared to the other treatments and the least grain yield (t/ha) was noticed in T0 where seeds were treated with water +Thiram alone (Fig 37). With regards to the stover yield, T_4 (Variety DSB 19) recorded significantly higher stover yield (t/ha) as compared to the other treatments. It was found that T_4 and T_2 (which was on par with T_3) have indicated improved growth and physiological parameters, better yield and yield attributes at hilly ecosystems of Meghalaya.

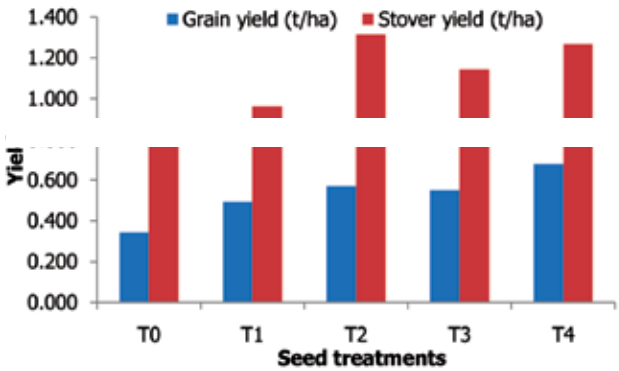


Fig 37. Yield parameters of soybean as influenced by seed film coating polymer

Physiological evaluation of chick pea genotypes for morpho-physiological growth and yield performance at mid altitudes of Meghalaya

A field experiment was carried out during *Rabi* season of 2016 to evaluate physiological and yield performance of chickpea genotypes. Results revealed that the contents of chlorophyll and carotenoid pigment levels in fully matured leaves significantly varied with mean chlorophyll a and chlorophyll b content of 0.98 and 0.36 mg/g, respectively. The average carotenoid content was ranging from 10- 71.3 µg/plant. The cultivar D-7 has retained highest total chlorophyll content of 2.68 mg/g and D-17 producing significantly higher root weight of 1.53 g/plant which was followed by D-8 with root weight of 1.44 g/plant. The root to shoot ratio and total dry matter (g/plant) was recorded maximum in D-2. The highest seed yield is 8295 kg/ha was recorded by D-12 chickpea genotype and lowest seed yield of 205 kg/ha was recorded by D-11. Among 34 genotypes tested, D-7, D-12, D-18, D-20, D-22, and D-17 performed better in relative improved leaf pigmentation, increased biomass, harvest index and increased seed yield at mid altitude of Meghalaya.

Seed priming improves germination and seedling vigour of pea (*Pisum sativum* L.) at mid altitudes of Meghalaya

Among all tested priming substances, PEG, $ZnSO_4$ and H_2O_2 were assessed most suitable priming substances to increase germination percentage and seedling vigour at low moisture conditions in hill slopes of Meghalaya**.** Relationships between seedling vigour index and metabolic efficiency as influenced by different seed priming substances was found to be positive with high correlation value (Fig. 38) elucidating increased seedling vigour index, increases metabolic efficiency of pea seed for better seedling establishment.

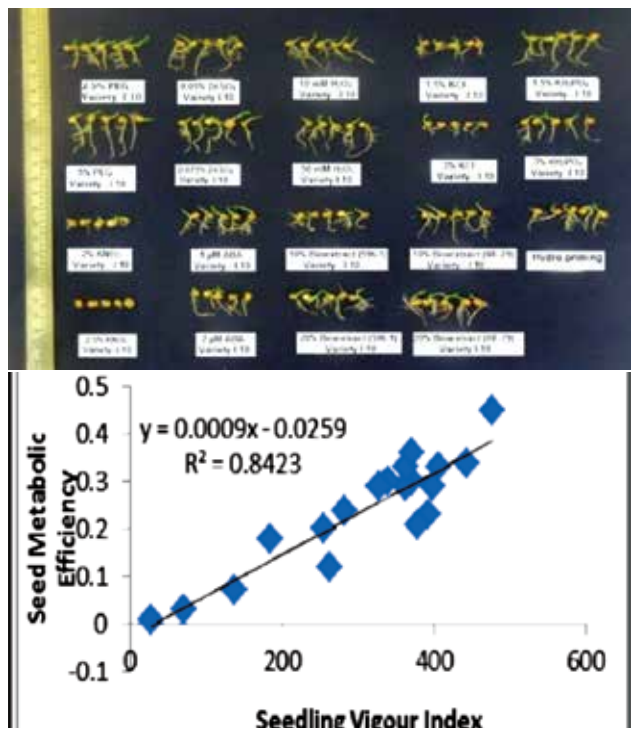


Fig 38. Effect of seed priming substances on germination and relationship between seedling vigour and metabolic efficiency in pea

FARMING SYSTEM RESEARCH

Micro watersheds comprising of dairy based land use (FSW-1), mixed forestry (FSW-2), silvi-pastoral land use (FSW-3), agro-pastoral system (FSW-4), agri-horti-silvi-pastoral (FSW-5), silvi-horticultural system (FSW-6), natural forest block (FSW-7) and timber-based farming system (FSW-8)

are being evaluated on long term basis (since 1984) at ICAR Research Complex for NEH region, Umiam, Meghalaya.

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 of forest land (Fig 39). The area under planned land use was 0.94 ha of which 0.447 ha terrace area was under annual fodder crops and the remaining under broom and guinea grass production. Three numbers of milch cow along with their calves were maintained in 0.50 ha area. Analysis of fodder production and requirement revealed that total green fodder from forage crops and slopping land was 34.1 t, while the requirement for dairy animals was 30.86 t, showing a surplus of (+) 3.25 t/ annum. The feed concentrate, paddy straw and medicine were arranged from

Fig 39. Overview of the Dairy based farming system at Umiam

nearby market costing to Rs. 1,40,458. The milk yield obtained from the system was 4,550.00 litres amounting to Rs.1,69,438. The net annual income from the system was calculated as Rs. 40, 230.00.

Mixed forest block (FSW-2)

Mixed forest block had been established in 3.89 ha area, where 3.05 ha area was apportioned under natural forest and 0.84 ha area under planned land use. The average slope of the micro-watershed was 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. The plant height and girth of the trees were 1.31 m and 1.18 m for *Acacia auriculiformis*, 1.16 m and 1.08 m for *Michelia oblonga* and 1.35 m and 1.20 m for *Symingtonia populnea,* respectively.

Silvi-pastoral system (FSW-3)

Silvi-pastoral system was established on 2.94 ha area of forest land of which 2.05 ha was under planned land use. The average slope of the area was 32.18%. Twenty seven goats (9 males, 18 females) were maintained in this system by demarcating 0.5 ha area in the system. The system was not generating profit and hence, poultry (375 no. broilers) chicks were also integrated in three cycles on the dyke of fish pond of 500 m^2 of area as a subsidiary source of income. The fish weight of 45 kg was recorded, which together with broiler poultry increased income of the system. The gross income from this system was Rs. 1,03,250 with input cost of Rs. 94,520 on feed, concentrate and procurement for day old chicks resulting into a net profit of Rs. 8,730.0 from the micro-watershed. The lower half portion of the watershed was planted with fodder trees species comprising of *Symingtonia populnea*, *Bauhinia purpurea, Ficus* spp, *Schima wallichii, Indigofera indica* and wild cherry to provide green leaf fodder to the goats during lean period. Mixed perennial grasses had been planted between the fodder trees to conserve soil and water and to provide supplementary source of fodder for grazing.

Agro –pastoral system (FSW-4)

Agro-pastoral system was established in 0.64 ha area having an average slope of 32.42 %. The hill slopes is having forest land of 0.06 ha and a planned land used area of 0.58 ha. About 75 % of the total area was utilized with 200 % cropping intensity which results in production of 9,976.0 kg of rice equivalent yield (REY) excluding guinea grass from the system. An integrated approach with crops and livestock showed that maximum income was obtained from cow milk (Rs.1,77,004). This system could generate 245 man-days employment amounting to Rs. 49,000 adding the cost of other inputs amounting to Rs. 3,14,191. The gross and net income of Rs. 3,14,191 and Rs. 1,16,584 were obtained, respectively. 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.

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

Agri-horti-silvi-pastoral system was developed in 1.58 ha for *jhum* improvement of NEH Region. Out of the total area 0.55 ha was under forest while 1.03 ha under planned land use system (Fig. 40). The system

Fig 40. Crops in Agropastoral System

was standardized in 0.80 ha area. In this system 0.10 ha of foothill was used for agriculture use, 0.25 ha for horticulture use and 0.44 ha for silvi-pastor crops. The Agri-horti-silvi-pastoral system produced 17,645 kg REY. The highest REY of 3405 kg was estimated with cow milk followed by Capsicum-Frenchbean-Pea (293 kg REY).

Cost of cultivation analysis indicated gross return of Rs. 77,760 from the system while net return of Rs. 26,348.0 was obtained from one cow dairy unit. Vegetable component registered a net income of Rs. 2,614 while fruit orchard (guava and pineapple) gave a net income of Rs. 1,555 amounting to a total net income of Rs. 30,517 from the system.

Silvi-horticultural system (FSW-6)

The total area of Silvi-horticultural system was 3.13 ha with a forest land of 2.17 ha and planned land use of 0.96 ha of which 0.50 ha area was kept for system study. The average slope of the area was 53.18%. Lower terraces covering an area of 490 m^2 was utilized for growing spices like turmeric. The middle portion of the system was utilized for fruit crops of guava. Upper portion of the system was covered with the forest tree spp. *Alnus nepalensis*. A gross income of Rs. 63,750 was recorded from this system.

Natural forest block (FSW-7)

A total of 1.03 ha area in natural forest block was divided under forest (0.08 ha) and under planned land use (0.95 ha). The average slope was 45.87 %. The watershed area was dominated by common weed flora viz. *Fumaria parvifolia, Ciprus irri*, *Eupatorium adenophorum, Arundinella bengallensis, Solanum khasianum* and *Ageratum* spp. Two tree species were commonly grown on the natural forest in the watershed area. The growth and development attributes of these tree species revealed that *Pinus kesiya* (1.6 m) attained more plant height and other developmental attributes as compared to *Schima wallichii* (1.25 m).

Timber –based farming system (FSW-8)

The area of timber-based farming system was 0.52 ha of 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* with a plant height of 1.81 m and 1.14 m.

Integrated farming system model for livelihood improvements (1.0 ha area) (AICRP-IFS)

Among the various components of IFS, agri. / vegetable based cropping system registered highest total income of Rs. 1, 92,534.00. Rice-toria-frenchbean system was allotted 2300 sq m area which gives income of Rs. 20.46/sq m. The maize based cropping system involving soybean, black gram, green gram, french bean, toria were planted in 2500 sq m which recorded income of Rs. 31548.00 with income potential of Rs. 12.62/sq m. The spices crops were grown in 900 sq m area on which cucumber, bottle gourd, sponge gourd and squash were grown as vertical crop. The income from spice based cropping system was recorded to Rs. 77,166.00 with income potential of Rs. 85.74/ sq m. The vegetable based cropping system adopted in 700 sq m area with 300% cropping intensity registered income of Rs. 31,520.00 with income potential of Rs. 45.03/sq m. The lowest area and income was recorded from groundnut-toria cropping system. The system as a whole registered a total income of Rs.1, 92,534.00 with income potential of Rs. 27.50/sq m. The orchard component is having 2000 sq m area in which four fruits species *viz.* Assam lemon, guava, peach and orange were planted in an area of 270, 675, 335 and 720 sq m, respectively. The saplings of fruit plants were planted during 2010. In livestock component of integrated farming system, 575 broiler chicks were reared in 5 rotations of 115 birds each for a cycle of 35-40 days. The total cost of broiler production was Rs. 95,800.00 with gross return of Rs.1, 02,680.00 and hence net profit of Rs.6, 880.00 was realized from broiler production. Besides, 130 layer birds of Vanaraja poultry birds were maintained on the farm for egg production. From layer bird component, Rs. 63,100.00 was obtained while the gross income was Rs. 67,440.00. The net return from layer poultry was Rs. 4,340.00. The third livestock component of farming system was pig. The pig breed of Hampshire X Khasi local was reared for 304 days and the initial weight of piglet was 18 kg/piglet. The total cost of production was worked out to be Rs. 44,330.00, while the gross return was

Rs. 46,000.00. The net return of Rs. 1670.00 was therefore realized from three pigs. The fish pond in 500 sq m area was lined with polythene sheet and tested for water storage continuously for two years. Five hundred (500) fingerlings were released during the year of experimentation. The harvested water was utilized for giving one pre-sowing irrigation to french bean and one supplementary irrigation to standing crop of toria. The dyke occupied 322 sq.m area and was utilized for cultivation of vegetables, fruit crops and fodder crops. Cucurbitaceous crops like bottle gourd, pumpkin and cucumber were grown during *kharif* season on the bamboo *machan* and cole crops like cabbage and broccoli are grown during *Rabi* season. The cost of cultivation involved in vegetable production was of Rs. 3547.00 with a gross return of Rs 10,469 and hence the net income was Rs. 6919.00. From this harvested water fish weight of 80.10 kg was recorded. The harvested fish gave a gross return of Rs. 8010.00 with the cost of cultivation of Rs. 4500.00 and hence the net income was Rs. 3510.00/ annum from fishery unit.

Impact of organic farming on soil health and productivity under raised and sunken bed system

In 12th year of study integrated management practices produced significantly higher rice equivalent yield (REY) compared to all other treatments. Among the management practices, integrated management (50% organic+50% inorganic) resulted in maximum REY (37.63 t/ha) of broccoli-vegetables cropping system followed by 100% organic (37.45 t/ha) and 75% organic (33.14 t/ha) farming. Among cropping sequences, broccoli – tomato cropping system recorded maximum REY (37.50 t/ha) followed by broccoli - french bean, broccoli-carrot and broccoli -potato cropping system (Table-17). With regards to the soil health, bulk density in both raised and sunken bed slightly decreased compared to initial year (1.19 g/cm^3 and 1.25 g/cm^3, respectively). Micronutrient content (Fe, Mn, Zn, Cu) of soil increased by 20.9, 35.6, 29.6 and 17.5% under 100% organic management and 20.2, 28.9, 24 and 13.1% under integrated management practice in raised bed compared to inorganic management. Soil organic carbon (SOC) in raised beds was higher as compared to sunken beds. Under raised bed condition, 100% organic management practice (3.31%) recorded maximum SOC followed by integrated (3.20 %) treatment as compared to inorganic and 75% organic. Available nitrogen (N), phosphorus (P) and potassium (K) in raised beds were increased in all management practices from the initial values.

Maximum available N and P was observed under 100% organic (259.6 kg/ha and 22.8 kg/ha, respectively) whereas, maximum K was found under integrated management (292.2 kg/ha). In case of sunken beds, available N and K were found maximum under organic (241.8 kg/ha and 287.9 kg/ ha, respectively) while available P was maximum under integrated (22.2 kg/ha) treatment. Similarly, Soil microbial biomass carbon (SMBC) was maximum under 100% organic treatment in both raised beds (184.7 µg/g dry soil) and sunken beds (152.5 µg/g dry soil) followed by 75% organic and integrated treatment as compared to inorganic treatment.

Table 17 System productivity in terms of Rice Equivalent Yield (REY) (t/ha) as influenced by various cropping systems and management practices in raised beds

Treatments	REY (t/ha)
A. Cropping systems	
CS_1: Broccoli-Carrot	35.05
CS_2: Broccoli –Potato	32.77
CS_3: Broccoli -French bean	35.14
CS_4: Broccoli –Tomato	37.50
SE(m)±	0.58
LSD *(P=0.05)*	1.70
B. Management practices	
NS_1: 75 % Organic	33.14
NS_2: 100% Organic	37.45
NS_3: Integrated	37.63
NS_4: Inorganic	32.24
SE(m) ±	0.64
LSD (P=0.05)	2.22
C. Interaction	
SE(m)±	1.16
LSD (P=0.05)	NS

Evaluation of major crop varieties under organic farming

Performance of maize: Among the eleven tested varieties/ land races, the longest cob length was recorded with DA 61-A (14.4 cm) followed by local yellow. Cob weight was maximum in DA 61-A (223.9 g) followed by RCM-75 (219.5 g). Green cob yield was recorded maximum in DA 61-A (5.85 t/ ha) followed by RCM-75 (5.76 t/ha). With respect to kernel yield among the tested varieties DA 61-A

(3.57 t/ha) recoded maximum followed by RCM-75 (3.47 t/ha) (Fig 41). However, lower kernel yield was recorded with local white (2.85 t/ha).

Performance of French bean varieties: In French bean, the highest green pod yield was recorded in Naga local (8.77 t/ha) followed by RCM-FB-18 (7.88 t/ha) and RCM-FB-19 (5.57 t/ha) (Table 18). The lowest green yield was recorded in Maram (1.05 t/ha) followed by Nagaland local 1 (2.16 t/ha) and RCM-FB-61 (3.57 t/ha). Seed yield also shown the similar trend as in green pod which had recorded highest in Naga local (4.23 t/ha) and lowest in Maram (0.69 t/ha). On the other hand, stover yield was highest in Naga local (7.53 t/ha) followed by Nagaland local 3 (6.30 t/ha) and RCM-FB-18 (6.26 t/ha). Lowest stover yield was recorded in Maram (1.35 t/ha) followed by Nagaland local 1 (3.28 t/ha) and RCM-FB-61 (4.86 t/ha) which was closely followed by RCM-FB-80 (4.87 t/ha).

Table 18 Yields of French bean varieties under organic farming

Variety	Green pod yield (t/ha)	Seed yield (t/ha)	Stover yield (t/ha)
RCM FB 18	7.88	3.69	6.26
RCM FB-19	5.57	3.12	5.44
RCM FB-37	5.38	2.35	5.14
RCM FB 61	3.57	2.34	4.86
RCM FB-62	5.54	2.43	5.22
RCM FB-80	5.71	2.87	4.87
Nagaland local 1	2.16	1.50	3.28
Nagaland local 3	5.00	2.93	6.30
Maram	1.05	0.69	1.35
Naga local	8.77	4.23	7.53
SEm ±	0.36	0.25	0.26
LSD (P=0.05)	1.07	0.75	0.77

Evaluation of tomato cultivars against insect pest infestation: Among the tested varieties least pod borer incidence was reported in cultivar MT 2 (9.97%). Other less infested cultivars were 0-17 (10.0%), pant T-10 (11.07%) and MT 11 (11.67%). With regard to the economic yields among the twenty cultivars evaluated under organic production system, MT 2 recorded the highest yield (22.59 t/ha), however, it was statistically at par with cultivars 0-17 (22.28 t/ha).

Evaluation of bio-intensive complimentary cropping systems

Four rice varieties namely Shahsarang-1, Lampnah, IR 64 and *Vivek Dhan*-82 were transplanted

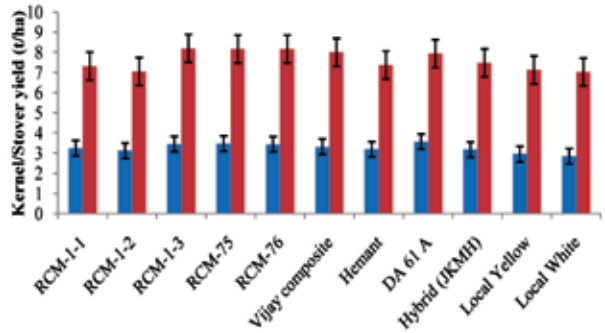


Fig 41. Kernel and stover yield of maize under organic farming

in sunken beds during *kharif* season. Similarly, potato (*cv.* Kufri Jyoti), french bean (Naga local) and carrot (New Kuroda) were grown on raised bed during pre-*kharif* season (January to May) followed by *okra* in *kharif* season (June to August/Sept). *Kharif* rice was harvested by leaving about 20 cm standing stubble during last week of November. Thereafter lentil was grown under zero tillage in sunken beds. For growing lentil in sunken beds, the fields were drained at physiological maturity of rice crop.

Yield of vegetables on raised bed: The yield of okra during *kharif* season ranged from 8.5 to 9.1 t/ha and the yield was highest under french bean- okra cropping sequence (9.1 t/h) whereas, rice equivalent yield was recorded highest under carrot –okra cropping (36.5 t/ha).

Yield of crops on sunken bed: In rice based cropping sequences in sunken beds, rice productivity ranges from 3.39 to 4.64 t/ha under various sequences with mean productivity of 4.06 t/ha and 3.96 t/ha under rice-lentil and rice-pea cropping sequence, respectively. Among the rice varieties, Shahsarang-1 recorded the highest yield (4.64 t/ha) under rice-lentil cropping sequence. During *rabi* season, lentil yield ranged from 1.09 to 1.22 t/ha. The highest lentil and, pea yields was recorded following *Vivek Dhan*-82 variety of rice (1.22 t/ha). However, the highest rice equivalent yield was recorded under Rice (Lampnah) – pea (13.32 t/ha) followed by rice (VD-82) – pea 13.04 (t/ha).

Development of integrated organic farming system model (IOFS) for valley lands (0.43 ha area)

Climbing vegetables such as bottle gourd, *chow-chow*, cucumber and ridge gourd were grown on a structure created above water bodies on one side of the pond dyke for vertical intensification. Pumpkin was raised on the other side of the pond and allowed to crawl on the ground (Fig 42).

Fig 42. Components of IOFS model

The total cost of cultivation was recorded as Rs. 56,654/- per year under the IOFS model with an area of 0.43 ha. Maximum expenditure was incurred in crop component of the model with 46.6% of the total cost of cultivation. Dairy unit with one adult cow and one calf registered 37.7 % of the total cost of cultivation, while fishery component recorded 8.7 % of the total cost of cultivation. For maintaining vermicomposting unit of 72 m^2 area and other important operations like hedgerow planting, residue recycling, rock phosphate application and liming, the expenditure incurred was Rs. 3950/- which accounted to 5.5 % of the total cost. A total net return of Rs. 71,442/- per year was achieved under the IOFS model which is much higher than the region's common practice of rice monocropping rice-vegetables cropping system. The highest contribution towards the total net return was by crop component of the model (66.5%) followed by dairy (23.9%) and fishery component (15.2%). About 96% of the total N requirement, 83% of the total P_2O_5 requirement and total K_2O requirement could be met within the model itself and only 4% of the total N requirement, 17 % of the total P_2O_5 requirement was met from the external sources to sustain the model.

SOIL SCIENCE

Long term management effect on soil quality of different farming system

Soil quality of 28 years old established 8 different farming systems (FS) models in the research farm of ICAR RC for NEH region, Umiam were studied. The 8 different FS models were livestock based (W1), forestry based (W2-mixed plantation), agro-forestry based (W3), agriculture (W4), agri-horti-silvi-pastoral (W5), horticulture based (W6), natural fallow i.e pine forest (W7) and shifting cultivation (abandoned jhum land - W8) (Fig. 43). The chemical soil quality attributes viz pH, organic carbon, particulate organic matter (POM), potentially mineralizeable N (PMN), available N, available P_2O_5, available K_2O, exchangeable Ca and exchangeable Mg of soils of different land use systems across the slope and depth of sampling varied from 4.49 to 5.10, 0.72 to 2.54%, 1.40 to 12.66 g/kg, 26.8 to 138.6 mg N/kg, 247 to 405 kg/ha, 9.75 to 20.75 kg/ha, 93 to 202 kg/ha, 1.31 to 3.19 meq/100g and 1.72 to 2.12 meq/100g, respectively. The microbial biomass carbon (MBC) varied from 286 to 926 µg per g soil. The activities of soil enzymes viz. dehydrogenases, acid phosphatase and β-glucosidase varied between 6.91 and 17.62 µg TPF per g, 60.87 and 193.32 µg PNP per g and 19.06 and 38.43 µg PNP per g soil, respectively. Soil bulk density, micro-aggregate, macro-aggregate and mean weight diameter (MWD) of the soils varied between 1.14 and 1.31 Mg/m^3, 22.15 and 43.6%, 15.66 and 50.63% and 2.39 and 3.02 mm, respectively. Land use systems affected the quality of acidic *Inceptisols* in the sub-tropical hill zone of Meghalaya. The values of different soil quality attributes were relatively higher in forestry based FS (W2) compared to other FS models and results revealed that the adopted management practices induced significant changes in soil quality. Conversion of forest land to other land uses significantly reduced the soil quality attributes. Principal component analysis and analysis of similarity (ANOSIM) revealed significant variability among the farming systems with respect to soil quality. Soil quality index was developed and reported in Table 19. Quality of soil under forestry based FS was found to be the highest in order followed by natural forest (pine) based FS, horticulture based FS, agri-horti-silvi-pastoral based FS, agro-forestry based FS, dairy based FS, agriculture based FS and abandoned jhum land, respectively.

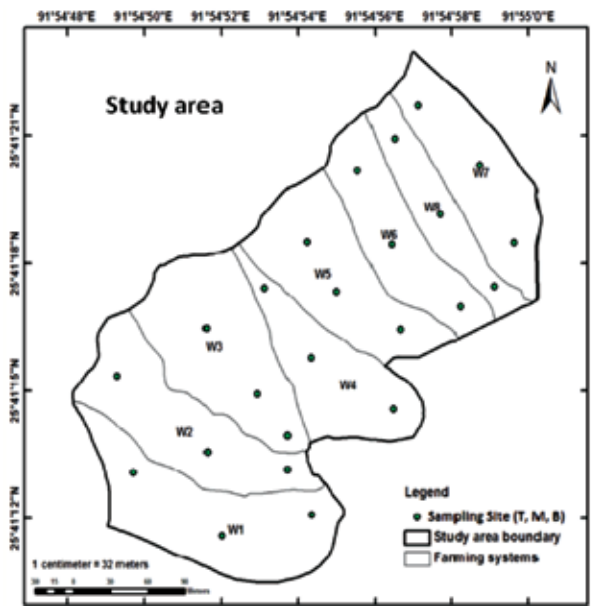


Fig 43. Different Land use studies for soil quality index

Table 19 Soil quality index of different farming system

Farming System	SQI
Dairy based (FS1)	83.4±0.7[c]
Forestry (FS2)	118.2±1.2[g]
Agro-forestry (FS3)	92.4±0.8[d]
Agriculture (FS4)	81.0±0.6[b]
Agri-horti-silvi-pastoral (FS5)	96.3±0.7[e]
Horticulture (FS6)	99.0±0.8[f]
Abandoned Jhum land (FS8)	78.2±1.2[a]
Natural forest-pine (Reference site, FS7)	100.0

System-wise SQI index was determined using the average factorial deviation from the reference values scaled to 100 for Natural pine forest. SOI values followed by different letters were significantly different as determined by one-way ANOVA incorporating Tukey's Honestly Significance Difference for pair-wise comparisons.

dairy based FS, agriculture based FS and abandoned jhum land, respectively.

Development of integrated nutrient management package for groundnut in acid soils of Meghalaya

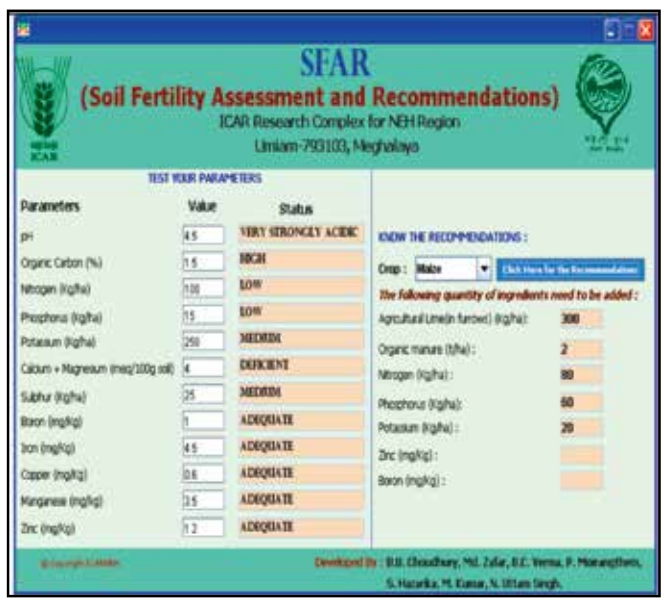
From a four year long periods of field experiment on ground nut productivity and soil carbon sequestration potential in an acid soils (pH: 4.5), an INM package and practices has been developed. The suggested recommended package is "application of inorganic fertilizers-NPK @ of 20-26-30 kg ha^{-1} with organic manures (vermicompost @ 5 t/ha) and agricultural lime (500 kg/ ha)". This package improved ground nut productivity by two fold from 15 q/ha under control (NPK- 0-0-0 kg/ ha). Similarly, it also reduced the degree of soil acidity (pH) by 0.3-0.5 units while at the same time, substantially improved organic carbon concentration (55% up) and microbial properties.

SFAR (Soil Fertility Assessment and Recommendation) web based-software

A web based software - *SFAR (Soil Fertility Assessment and Recommendation)* covering 12 important soil parameters (soil acidity, carbon, macro- and micronutrients) for acid soils of NE region of India was developed. Use of this software will facilitate in assessing the status of soil fertility (poor/medium/high) from the field test results, and accordingly, a recommendation guide covering location specific soil acidity and plant nutrient managements for 10 important crops (rice, maize, pulses & vegetables) have been provided in the software. The potential user will be farmers, KVKs, NGOs, State agricultural departments etc. for maintaining land productivity across NER of India. The preliminary validity has been tested by scientists from the Division of Social Science, ICAR (RC) for NEH region, Umiam, Meghalaya. Options kept for further validation and recommendation/ improvement / extension in coverage (nutrients /crops / locations) once it come in user domain carrying feedbacks.

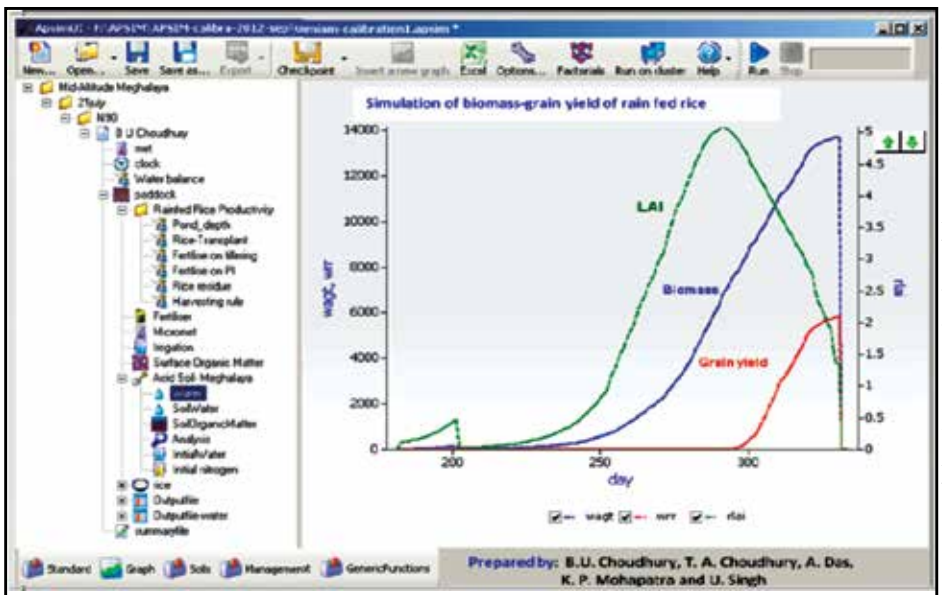
Calibration of genetic coefficient of lowland rice (cv. *Shahsarang*) for validation of simulation (APSIM) model

Calibrated genetic coefficient (growing degree days) for different growth stages of lowland rice cultivar (cv. *Shahsarang*) grown in the lowland experimental field of NRM division for validation of Agricultural Production Systems Simulator (APSIM) model and further long term simulation studies under different sets of managements and climate change scenarios. Crop development rate was calculated using the observed crop phenology parameters *viz.*, dates of sowing, transplanting, panicle initiation, flowering and physiological maturity for rice cultivar *Shahsarang* at mid-altitude Meghalaya. The calibrated model using the derived genetic coefficients could predict major plant genetic parameters like growth stage wise leaf area, biomass production and simulated grain yield within a satisfactory level (RMSE: 0.48 t ha^{-1} and normalized RMSE was 5.6% of the observed yield).



E-learning lesson on simulation of rainfed rice productivity at Mid-altitude Meghalaya

Using a biophysical model (*Agricultural Production Systems Simulator- APSIM)*, the soil science section of the division of NRM has developed an **e-learning lesson** on "*simulation of single season rainfed transplanted rice productivity under varied climate change scenarios, specific to mid –altitude Meghalaya*". This model (APSIM) is a dynamic, daily time-step modelling platform that combines biophysical and management modules within a central engine to simulate biophysical processes in diverse cropping systems, rotations, fallowing, crop and environmental dynamics, particularly those relating to the production and ecological outcomes of management practices in the face of climate risk. It contains a suite of modules which enable the simulation of systems that cover a range of plant, animal, soil, climate and management interactions. These modules include a diverse range of crops, pastures and trees, soil processes including water balance, N and P transformations, soil pH, erosion and a highly-flexible range of management controls.



E-Learning lesson : APSIM

Methodology for soil resource mapping (at 1:50k scale) using remote sensing and geographic information system (GIS)

In a collaborative project between Division of NRM (Soil Science) and Northeastern Space Applications Center (NESAC) on "soil resource mapping (at 1:50 k scale)", a methodology was developed for soil mapping from integration of ancillary information (climate, physiography, geology, landscape, land use pattern, slope etc.) with remote sensing and GIS in spatial format. Landscape and physiographic boundaries were delineated using base maps. Land usesland cover map was prepared using multi-temporal satellite imagery of Resources at-1 LISS-III geo-coded

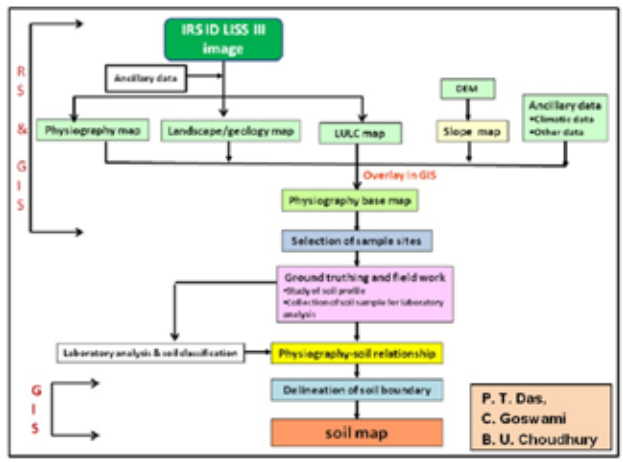


Fig. 44. Methodology for soil resource mapping using ancillary information with RS and GIS

satellite imagery. The variation of image with respect to tone, texture, size, shape, pattern, association and shadow etc. were correlated with geology, physiography, slope and land use to generate map units. An interpretation key was developed to segregate discernable image units for each soil mapping unit using tone, texture, size, shape, pattern, association and shadow etc. Sample strips covering all the landscapes and physiographic unit were selected for intensive study in order to establish soil series and their association. Sample areas were selected for ground truth verification to establish correlation between spectral signature of the image with soil and its associated land features. This methodology helps in capturing maximum inherent field variability in the soil units while reducing the sample size substantially (>40%) over traditional or grid based soil sampling and mapping. The methodology is schematically depicted below (Fig 44).

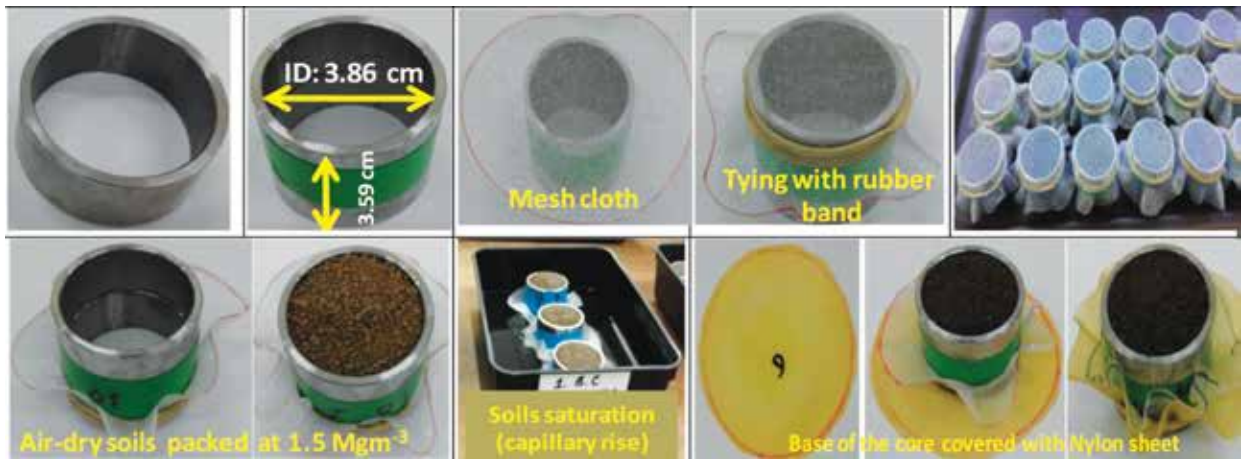
Methodology for deriving soil water drying (evaporation) curve for studying soil hydraulic properties

A laboratory based cost effective and simple method of generating soil water drying (evaporation) curve in soil cores of different dimensions have been standardized. This methodology enables generating base line information on soil water evaporation curve for further studying the soil water dynamics (transmission, retention, conductivity, diffusivity etc.) through simulation approaches. This method also enables in studying the effect of stimulation and suppression of microbialactivity on the movement of water in soil for a wide range of moisture gradients including extreme dry soils (wilting point to air drying). Below is the schematic representation of the step-wise depiction of the methodology (Fig 45).

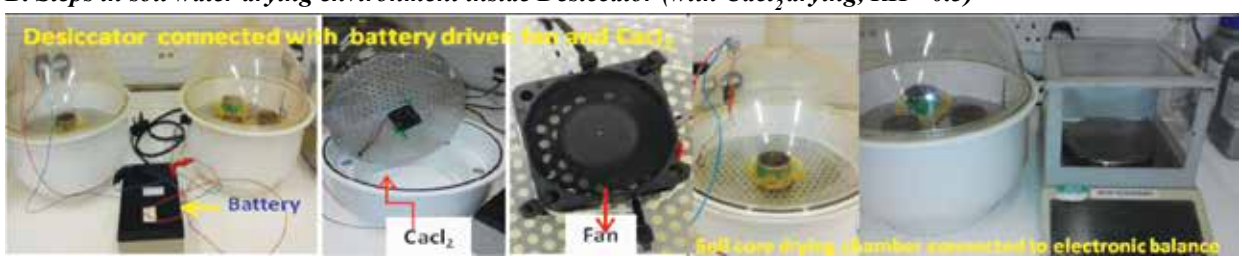
Spatial database management of soil resources and mapping

Soil survey and selection of nearly 100 master profiles, 15 mini profiles (based on multi-layer analysis of land use land cover map from satellite data, geology, physiography, elevation, slope etc.) using remote sensing and GIS (RS & GIS) at 1: 50, 000 scale were carried out across 6922 sq. km area of Assam (Barak Valley). The soil profiles were excavated up to a depth of about 1.5 meters or up to water table depth/lithic or paralithic contact. The selected geo-referenced profiles were exposed, horizonation was done and then horizon-wise soil samples were collected for laboratory analysis of 16 soil properties (physical, acidity and fertility parameters). Soil (surface and profile) mapping was done at 1:50 K scale for the entire valley representing an area of 6922 sq.km. Majority of the soils (64-70%

a. Steps in soil core preparation (dimension- 3.59 cm height, 3.86 cm diameter)



B. Steps in soil water drying environment inside Desiccator (with $Cacl_2$ drying, RH <0.3)



C. Soil core drying and generation of drying (evaporation) curve

Fig 45 Cost effective simple method (laboratory) of deriving soil evaporation (drying) curve

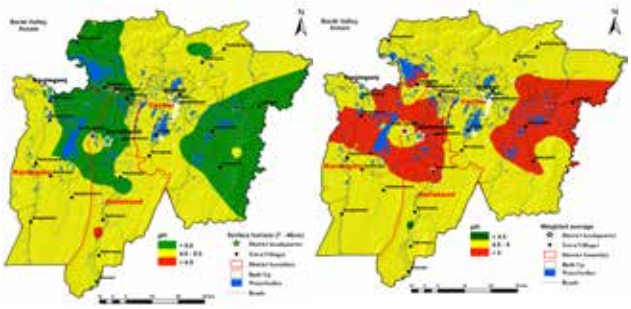


Fig 46. Soil acidity mapping at 1:50 K scale of Barak Valley, Assam

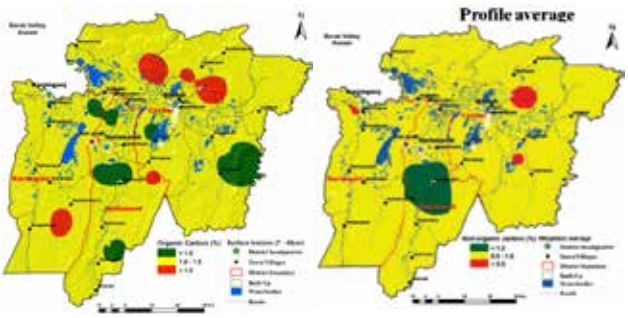


Fig 47. Soil organic carbon mapping at 1:50 K scale of Barak Valley, Assam

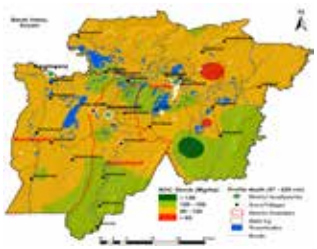


Fig 48. Spatial variability of Profile SOC-density (Mg/ha) at 1:50 K scale of Barak Valley, Assam

area) were acidic in reaction (pH <5.0) while only 23-29% soils had pH value of >5.0 (Fig 46). More than 90% area of the valley had high soil (surface & profile) organic carbon concentrations (SOC>1.0%) (Fig 47). Soil profile (average depth: 133 ± 28 cm) SOC density was 80-120 Mg/ha in nearly 60% area while another 31% area had higher SOC-density (120-160 Mg/ha) (Fig 48).

Development and spatial mapping of soil quality index (SQI) in GIS environment

Following standard procedure, a composite soil quality index (SQI) was developed using multi-criteria decision-making approach and the step-wise procedures followed in developing SQI. Indicators were selected and using principal component analysis, minimum datasets were generated. Indicators were given scores and accordingly, boundaries and shape of the scoring functions were set. This step scales and normalizes soil acidity, fertility and physical parameter measurements with different units so that they can be combined into unit less composite indices. The above soil parameters were transformed into unit less (0 to 1 scale) by using three types of standardized scoring functions (i) More is better (ii) Less is better (iii) and Optimum is better. Similarly, proportion of variance of variables was estimated using community test followed by assigning of weights for each indicator. SQI was estimated from the assembling of weight and score of each indicator and finally, spatial mapping of SQI variability in GIS environment was carried out across Barak valley, Assam. Surface soils (7 - 45 cm thickness) across the valley of 6922 sq.km falls under two major categories: average - high in 54.2% GA (SQI: 0.5-0.6) and average-low in 38% GA (SQI: 0.4-0.5) (Fig 49). Similarly, profile (weighted average of 57-225 cm) soils were average-low (in 43%GA) to average-high (in 47%) in SQI values (Fig 50).

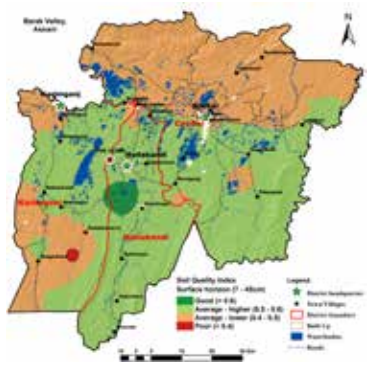


Fig 49. Spatial variability in surface soil SQI

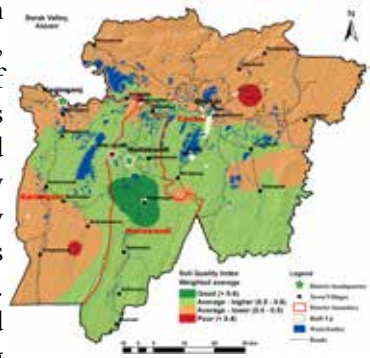


Fig 50. Spatial variability in profile soil SQI

Spatial zoning of macro-nutrients category of Barak valley, Assam in GIS environment

Based on soil survey and laboratory estimation of soil macronutrients (N, P, K & S) status across and following critical threshold limits (Tandon, 2005), spatial variability in fertility status of surface soils were mapped at 1:50K scale across 6922 sq.km area of Barak Valley. Three categories such as high (H-

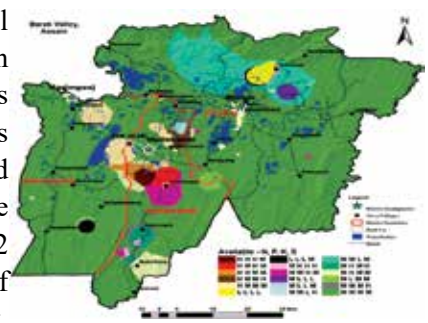


Fig 51. Spatial mapping of soil macro-nutrients zoning across Barak valley, Assam

available soil N>300 kg/ha, P>20 kg/ha; K> 300 kg/ha; S>40 kg/ha), medium (M-available N: 200-300 kg/ha, P: 10-20 kg/ha; K: 200-300 kg/ha; S: 20-40 kg/ha) and low (L-available N: <200 kg/ha, P<10 kg/ha; K<200 kg/ha; S<20 kg/ha) were considered for demarcation of zones in multi-layer GIS mapping. Majority of the soils (>76% GA) in the valley falls under medium category macronutrient-NPKS status (NPKS: M-M-M-M) followed by medium NPS and low K levels (M-M-L-M) in 6.57% GA (Fig 51).

Technology for improving carbon sequestration under climate change scenarios- use of biochar

From a incubation study on carbon mineralization pattern from rice residue *vis--a-vis* biochar at two different hydro - (50% of field capacity and 100% field capacity) thermal (24°C and 28°C) regimes, conversion of fresh rice residue to biochar (0.5-1.0%) reduced the emission of CO_2 flux by 30-40% while improved the soil organic carbon sequestration substantially (Fig. 52). However, increase in temperature by 4°C from 24°C, emission of CO_2 flux increased by 1.5 folds. Moisture regime had marginal effect on emission of CO_2 flux. Hence, instead of using fresh residue, conversion into biochar and application in soil can serve as potential

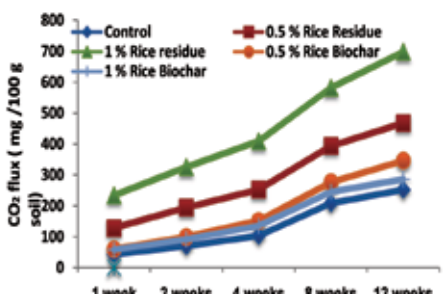


Fig 52. Emission of CO2 flux from rice residues and biochar over a period of 12 weeks

amendment to sequester carbon while reducing the emission *vis-à-vis* environmental pollution in the changing climate scenario. However, the extent of benefit depends upon the nature and properties of biochar as well as agricultural management practices

Upward revision of Zinc critical availability in acidic soils of northeast india

Zinc is the most deficient micronutrient in Indian soils (49%), and its deficiency afflicts nearly 1/3rd of the acid soils of the country. Adequate Zn fertilization is therefore crucial to exploit the yield

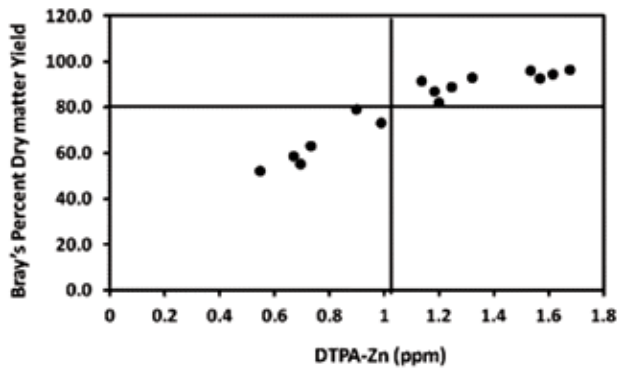


Fig 53. Critical limit of DTPA extractable Zn

potential of crops. Although the commonly used Zn extractants (0.005M DTPA reagent) was originally not recommended for acid soils, it is being frequently used even in the acid soils of northeast India. In order to evaluate the suitability of available zinc extractants and to determine the critical limits of Zn availability in acid soils, an experiment was conducted where in Pea (*Pisum sativum* L.) as a test crop was grown in 15 different soils, with and without Zn fertilization (Fig. 53). The suitability of four extractants was assessed by correlating the amount of extractable Zn to plant response and Zn uptake. Zn uptake as well as chemical indices of Zn availability increased due to Zn application in all the experimental soils. The results indicated that 0.1 N HCl extracted the highest amount of Zn while least amount was extracted by ammonium acetate. Across all experimental soils, DTPA showed highest correlation with 0.1 N HCl and Mehlich-3. A nearly perfect correlation between DTPA and 0.1 N HCl (0.988) and between DTPA and Mehlich-3 (0.917) suggest that both 0.1 N HCl and Mehlich-3 can be safely adopted as alternative to DTPA extractant. Mehlich-3, being a multi-nutrient extractant, can improve the rapidity of soil testing, saving substantial amount of time, cost and labour involved therein. The critical Zn concentration in plants was found to be 36 ppm across the soils. The critical value of Zn in soil was found to be 1.02 ppm for DTPA, 4.5 ppm for 0.1 N HCl and 2 ppm for Mehlich 3 extractants for the acid soils of northeast India. Thus, a critical limit of 1.02 ppm instead of 0.6 ppm (presently used) is recommended for evaluation of Zn availability in acid soils of northeast India.

Assessment of soil contamination in coal mine affected areas in Jaintia Hills district of Meghalaya

The present study is being carried out to assess the level of soil degradation and heavy metal contamination due to coal mining in Jaintia hills.

It was observed that coal mining makes notable influence on soil properties, the influences varying in severity depending on whether the mine is working or abandoned, the mining methods used, and the geological conditions. Precipitates of iron hydroxides and oxides occurring on streambeds as yellow–orange jelly-like coatings, called ochre are commonly observed in AMD-affected areas near the mining sites and the stockpiles. Coal mine spoil soils have poor physical properties; abrupt textural change often encountered mostly due to the loss of top soils. Colliery (excavated coal and overburden dumped) soil lack soil structure and altered elemental concentration. Dominance of coarser fragments resulted in very low water holding capacity of mine spoil soils which is one of the major limiting factors for plant growth and development in coal mine spoils. Soil is sandy in nature, reddish brown to yellow brown in color, acidic in reaction (pH 2.67-4.89), EC and TDS was found to be highest in mined area with 1636 µS/cm and 768 ppm, respectively) while lowest was recorded in paddy fields in undisturbed area with 13.39µS/cm and 6.6 ppm respectively. In addition to extreme acidity and other associated nutrient imbalance, high salinity in coal-mined soils, heavy metal (arsenic, cadmium, chromium, lead, mercury, selenium, lanthanum, Zinc, Nickel, fluoride, aluminum, iron, manganese, etc.) contamination at toxic level is also major concern.

EXTENSION ACTIVITIES

Popularization of diagnostic kit- RAPID Soil health test kit- Farmers' training cum awareness programme on "Soil Health Card for better crop productivity"

Three days Farmers' training cum awareness programme on "Soil Health Card for Better Crop Productivity" was organized by the division of Natural Resource Management, under Tribal Sub Plan (TSP). A total of 26 farmers from three districts of Meghalaya participated in this programme. Hand on exercise on low cost rapid soil health diagnostic kit developed by the division, soil health card- its importance and relevance, soil health card for improving crop productivity in Northeastern India, soil testing and results interpretation, use of soil health card based upon on soil testing report etc. had been imparted at length.

Popularization of technology- Farmers' training cum awareness programme on "Soil moisture stress management through in-situ soil physical modification".

A three day's residential farmers' training programme during November 2016 was organized under Tribal Sub Plan (TSP) by the Division of Natural Resource Management (Soil Science). A total of 30 farmers from four districts of Meghalaya participated in the training. Several cost effective i*n-situ* soil moisture conservation practices through soil physical modifications developed by the Institute namely mulching (hydrothermal regimes), raised bed and furrow system, inter-plot water harvesting, soil pit, modification of tillage practices (zero, minimum, deep tillage), sunken bed system, land leveling, vegetative barrier, seed priming, cover crops, agricultural liming, and biochar application etc. had been demonstrated. Extension leaflets with detail procedure along with field scale implementation had been distributed among farmers'.

Farmers' training cum awareness programme on popularization of Diagnostic Kit (RAPID Soil health test kit)

A three day's residential farmers training programme during December 2016 was organized under Tribal Sub Plan (TSP) by the Division of Natural Resource Management. A total of 30 farmers from Ri-Bhoi district of Meghalaya participated in the said training. Hand on exercise on low cost rapid soil health diagnostic kit developed by the division, nutrient deficiency symptoms identification at field, soil tests using the kit and diagnosis cum recommendation had been imparted among the farmers. Extension leaflets with detail procedure along with field scale implementation as well as soil testing kits were distributed among farmers'.

WATER MANAGEMENT

Residue management and conservation tillage in rice-based cropping system

Field experiment was conducted to evaluate the effect of tillage and residue management in rice based system for increasing production and resource conservation (Fig 54). Significantly higher grain yield of rice (33.8%) and succeeding *rabi* crops, *viz.*, pea (14.6%), toria (50.5%) and buckwheat (21.3%) as well as the water use efficiency were estimated under conservation (zero tillage with residue retention) for both crops as compared to conventional tillage practices (with residue removal). Similarly, conservation tillage had better water saving, yield and income enhancements for all the crops over conventional tillage. During *rabi* season (2015-16), *toria* recorded the highest water saving (50.0%), yield (50.5%) and income enhancement (164%) under zero tilled compared to the conventionally tilled crop. *Toria* followed by buck wheat and pea followed the order in all the aspects. During *kharif* season (2016), rice also performed best under zero tilled condition with 34.7% water saving and 33.8% and 81.4% yield and income enhancements, respectively, over the control.

Conventional tillage (Residue removal)

Zero tillage for all crops (Residue retention)

Fig 54. Performance of rice under different tillage and residue management practices

Resource conservation practices in lowland rice cropping system

A field experiment was conducted to assess different tillage practices and planting methods on growth and yield of rice and to study the influence of different tillage practices on the succeeding *rabi* crops. Puddled transplanted (3831 kg/ ha) rice recorded higher yield, with an increase of 52.1% as compared to puddled wet seeded rice. Also, the seed yield and water use efficiency of succeeding lentil was found significantly higher (26%) under zero tillage along with straw mulching.

Among the various methods of rice establishment, the puddled transplanted rice was found best,. During *rabi* season (2015-16), lentil under no tillage with application of straw mulch cover increased crop productivity by 42.1%, water productivity by 12.8% and net income by 27.4%. During *kharif* 2016, rice performed better under puddled transplanted condition with 8.8 and 168.1% yield and income enhancement, respectively, over control (puddled wet seeded). However, the water saving was found higher under puddle transplanted condition only (Table 20)

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

Field experiment was conducted to find out water efficient maize based cropping system for terrace condition. Zero tillage resulted in higher maize equivalent yield (MEY: 6103 kg/ha) compared to conventional tillage. Among the intercropping system/residue management treatments, the MEY was highest under maize + groundnut paired row (residue retention) (7181 kg/ha) which was 32.7% more compared to sole maize. The yield of succeeding

Table 20. Summary of results on experiment 'Rice resource conservation' (Rabi 2015-16 & Kharif 2016)

Year (Season)	Crop (s)	Yield (kg/ha)	WUE (kg/ha/ mm)	B:C	Water saving* (%)	Yield enhancement* (%)	Income enhancement* (%)
					Lentil		
2015-16 (*Rabi*)	Best treatment	1383	17.6	1.07	12.8	42.1	27.4
	Control	973	15.6	0.84	-	-	-
					Rice		
2016 (*Kharif*)	Best treatment	3831	6.4	1.26	52.1	8.8	168.1
	Control	2518	4.2	0.47	-	-	-

Over control; For Lentil: Best treatment- No tillage with mulch, Control: Puddled transplanted with no mulch; For Rice: Best treatment- Puddled transplanted, Control: Puddled wet seeded

toria was also found higher under maize + groundnut paired row (residue removal) (725 kg/ha) compared to sole maize. During *rabi* season (2015-16), *toria* intercropped with maize performed better under conventional tillage with residue retention (15.5, 15.6 and 636% higher water saving, yield and income enhancement) compared to conventional tilled with residue removal treatment (Fig 55).

Maize + Groundnut ***Maize + Soybean***

Fig 55. Crop performance under different intercropping practices

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

Field experiment was conducted to develop simple and low-cost technique of *in–situ* moisture conservation for the Second crop during winter season. Maize grown under zero tillage recorded highest grain yield (5803 kg/ha) as compared to conventional tillage. Whereas, among the residue management practices, the grain yields of maize (6549 kg/ha) and toria (1249 kg/ha) were highest under maize stalk cover + poultry manure + ambrosia @ 5 t/ha, and 34.1% and 81.3% higher than the yield recorded under the control, respectively.

Under in situ residue management experiment with maize and *toria as* test crops, tillage practices resulted in differential results under maize and toria (Fig 56). During *rabi* 2015-16, toria recorded highest water saving (100%), yield (99.8%) and income (137.5%) enhancements under conventional tillage, whereas, during *kharif* 2016, rice recorded highest water saving (43.4%), yield (43.1%) and income (71.2%) enhancements under zero tillage.

Effect of manures and straw mulching on turmeric under terrace condition

Field experiment was conducted to evaluate the most suitable manure along with straw mulch for higher productivity of turmeric and better soil moisture conservation under terrace condition. Turmeric grown under terrace condition with FYM + straw mulching recorded significantly higher rhizome yield (10.15 t/ha) compared to other treatments. There was an increase of 176.7% rhizome yield and 179.5% water saving under Farm yard manure @ 5 t/ha + Mulching @ 5 t/ha compared to the control (Table 21).

Table 21. Effect of manures and straw mulching on turmeric (Kharif 2016)

Year (Season)	Crop	Yield (kg/ ha)	WUE (kg/ha/ mm)	B:C	Water saving* (%)	Yield enhance-ment* (%)	Income enhance-ment* (%)
2016-17 (*Kharif*)	Best treatment	10148	10.9	1.43	179.5	176.8	921
	Control	3666	3.9	0.14	-	-	-

Over control; Best treatment: FYM+ straw mulching; Control: Farmers practice

Multi-storied cropping of ginger and bottle gourd in upland terraces

A field experiment was conducted to assess economic benefit of multi-storied cropping of ginger and bottle gourd over sole ginger in upland terraces (Fig 57). The results suggested that growing ginger alone under shade was highly uneconomical, but if planted with bottle gourd on *chang* over it, than the economic benefit improved (Table 22). This also ensured 231.5% water saving and 99.2% income enhancement over the sole ginger (Table 22). Hence, multi-storied planting of ginger and bottle gourd can be adopted as a very good practice of cultivation to maximize net economic return in upland terraces.

Table 22. Yield, water use efficiency of multistoried cropping of Ginger and Bottle gourd in upland terraces (Kharif 2016)

Year (Season)	Crop (s)	Yield (kg/ha)	WUE (kg/ha/mm)	B:C	Water saving* (%)	Income enhancement* (%)
2016 (*Kharif*)	Ginger sole in open (Control)	24728	23.5	2.39	-	-
	Ginger under shade of *Chang*/ bower/ pargola	16296	15.5	0.41	-34.0	-82.8
	Bottle gourd sole	65714	106.2	2.54	351.9	6.3
	Ginger + Bottle gourd multistoried	82010	77.9	4.76	231.5	99.2

*Over control

Fig 56. Maize and toria under different tillage and residue management practices

Fig 57. Improving jhum sustainability through micro-climate guided interventions

The studies were conducted in two jhum fields at Mawpun and Umeit villages of Ri-Bhoi district of Meghalaya. Treatments on land configuration and crop geometry (improved and conventional) were imposed and compared with traditional practices of the farmers. Constructed water harvesting structures at hill top, and harvested water was recycled for irrigation during lean period and for off season vegetable cultivation. The study suggests that the South West (SW) exposure of *jhum* field was more productive than North West (NW) exposure. Absorption of photosynthetically absorbed radiation by rice was found higher in the SW exposure and at the middle part of the slope by 26.2 and 13.6% over top and bottom of the field, respectively. The improved land configuration and crop geometry enhanced conservation of soil organic carbon and soil moisture by 44 and 38%, respectively, over the farmer's practice (cultivation along the slope). The economic yield of rice was found highest (4.2 t/ha) in the middle of the field. It was found lower in the top and bottom of the field by 68 and 20%, respectively. The imposed improved treatments (raised beds across the slope and closer line spacing) were found to facilitate smooth operational management in steep jhum fields, improving soil health, including soil carbon, and economic returns from crops.

EXTENSION PROGRAMME

Training cum awareness program on '*Rabi* vegetable production in rice and maize fallows utilizing available soil moisture and harvested rainwater to improve cropping intensity and livelihood of tribal farmers'

To increase the cropping intensity and income of the farmers by growing high value *rabi* crops such as pea, capsicum, cauliflower, cabbage, beans, broccoli etc. immediately after the harvest of rice and maize, using the residual soil moisture and harvested water from *Jalkund,* a one day training cum input distribution (seeds) was organized at Mawlasnai village on the 5th November 2016. A total of 10 progressive farmers (6 female and 4 male) from Mawlasnai and Khyndewso village attended the programme.

AGRO FORESTRY

Development of genetically superior variety of *Mucuna pruriens*

Twelve genotypes of *Mucuna pruriens* were evaluated in replicated trial for *nine yield* and yield contributing traits. Significant variation was found among the genotypes for all the nine traits (Table 23). Heritability broad sense varied from 0.54 (clusters/plant) to 0.97 (100 seed weight and Flowers per inflorescence). Seed yield was highest for MPWBN-03 (1.91 t/ha) followed by MPUP-06 (1.63 t/ha). For yield, h^2_{bs} was recorded to be 0.83 which can be useful for selection and trait improvement. Correlation between growth traits (Table 23) revealed that genotypic correlation was negative and statistically significant between inflorescence length and 100 seed weight (-0.51), pod length (-0.48), and pod width (-0.62).

Yield is negatively correlated with pod length (-0.43) and number of seeds per pod (-0.34). Therefore, it might not lead to better yield performance if indirect selections are made on higher pod size or inflorescence. However, study of traits in segregating generations and resolving the correlations into direct and indirect effect would give more conclusive evidence on the nature of genetic control and association of the yield traits with the observed parameters.

Flagship programme on *Jhum* improvement in Ri-Bhoi of Meghalaya

Jhum in the short fallow cycle has been widely considered as an unsustainable land use practice that leads to severe land degradation. Productivity of the *Jhum* land is very low after one or two years of cultivation. Since, *Jhum* is closely linked with the culture, beliefs and lifestyle of the indigenous people of the NE hills, an attempt was made to improve the existing *Jhum* system in terms of productivity, restorative capacity and improve livelihood of the *Jhum* practitioners. It is hypothesised that pressure on Jhum cultivation would reduce if economic conditions of farmers improve though *Jhum* and with some ancillary agricultural production activities. The concept was implemented in a village Sonidan, in Ri-Bhoi district of Meghalaya which is 80 km away from Shillong. The village has 230 households with 1610 persons. Nearly 80% of people depend on agricultural activities for their livelihood. *Jhuming* is practiced by almost all the farmers of the village.

Therefore, a holistic approach was adopted where soil and water conservation measures (bench terracing, contour bunding, hedgerow inter cropping, micro water harvesting structures), improved crops varieties, agronomic practices, crop rotation and cropping sequences, agroforestry, fruit and vegetable cultivation, improved housing and breed in piggery, backyard poultry, mushroom cultivation etc were implemented on selected farmers field. The results of the various interventions are summarized below.

Intervention on field crops, vegetable and spices

In the Ri-Bhoi district of Meghalaya, most of the farmers cultivate ginger as a cash crop along with colocasia, chilli, pumpkin etc in the first year of *Jhum* followed by rice, in the subsequent years. Therefore, the farmers practice was improved by introduction of good varieties and/or good cultivation practices such as nutrient supplementation, spacing, seed treatments etc. It was observed that the productivity has increased in a range of 12.37 % (in ginger) to 60.84% (in Chilli) (Table 24, Fig 58).

Table 23. Variability in growth and yield attributes in *Mucuna pruriens*

Genotypes	Inflorescence length (cm)	Flowers/ inflorscence	Pod length (mm)	Pod width (mm)	Seeds / pod	Pods/ cluster	Clusters / plant	100 seed weight (g)	Yield (t/ha)
ASM-27	16.13	23.30	71.99	12.67	4.20	5.93	22.78	28.20	0.66
IC-83195	8.47	12.30	95.64	15.01	5.27	4.47	51.33	42.04	1.52
MGH-06	25.63	24.40	76.18	12.24	5.00	7.40	39.45	27.02	0.98
MZR-16	58.47	61.13	62.93	10.69	3.93	12.27	86.67	24.66	1.48
NGL-25	31.33	42.20	66.54	12.13	4.00	8.67	52.45	32.21	1.35
NGL-41	45.10	50.29	75.67	11.00	4.97	7.47	39.44	26.94	1.17
SKM-02	20.47	27.23	68.77	12.02	4.37	10.53	48.67	28.14	1.56
UKD-11	6.97	9.10	70.68	10.69	4.50	4.55	47.89	23.78	0.55
UP-04	7.23	9.80	100.25	16.03	5.50	3.07	20.89	76.32	0.64
UP-06	12.33	17.57	60.81	13.05	4.77	6.27	52.11	60.31	1.63
WBN-03	29.20	40.90	65.95	12.74	4.20	7.00	65.56	30.38	1.91
WBN-07	29.10	40.40	65.05	11.89	4.07	9.87	68.11	34.13	1.50
C.D. (0.05)	5.38	4.97	5.48	1.02	0.54	2.93	25.48	4.51	0.32
h^2_{bs}	0.96	0.97	0.94	0.87	0.70	0.68	0.54	0.97	0.83

Table 24. Increase in productivity of field crops and vegetables on the *Jhum* land through adoption of improved cultivation practices

Crop	Improved Practice		Farmers Practice		Increase in Productivity (%)
	Variety	Yield (t/ha)	Variety	Yield (t/ha)	
Ginger	Nadia	13.16	Nadia	11.71	12.37
Upland paddy	Local	2.01	Local	1.40	43.84
Chilli	Tejaswini (MHP1)	3.45	Local	2.15	60.84
Cucumber	Malini	5.00	Local	3.13	59.74
Maize	DA61A	2.116	Local	1.684	25.65

Fig 58. Cultivation of Ginger with MPTs in Jhum field

It was observed that, the local rice varieties responded very well to line sowing and fertilizer application and the yield has increased by 43.83%. Since, the cultivar was a glutinous one and was preferred by the villagers, the intervention was well accepted and adopted by the farmers.

Agroforestry and fruit trees

Agroforestry and fruit tree plantations are one of the important interventions which do not require tilling of soil for quite a long period of time. Therefore, after the *Jhum* cultivation of the land for few years, multipurpose tree species like *Michelia oblonga*, *Chukrasia tabularis*, *Khasi Mandarin*, Peach, Assam lemon etc were planted (Fig 59). Some of the fruit trees were also planted in the home gardens. The average growth of the trees are presented in Table 25. Among the trees *Chukrasia tabularis* had better survival percentage than the other tree species. *Khasi mandarin* had more mortality with a survival percent of 53.33 %. Within a period of three years, *Michelia oblonga* attained an average height of 3.35 m and *Chukrasia tabularis* attained an average height of 3.56 m. In terms of farmers' preference, *Michelia oblonga* is preferred for timber purpose whereas *Chukrasia tabularis* is preferred for fuel wood or selling in the market especially for plywood.

Fig 59. Agroforestry plantation on abandoned Jhum land

Income generation through production of quality planting materials in nursery

Looking at the demand of quality *khasi mandarin* seedlings, it was planned to establish a local nursery at Sonidan village. The seeds were sown on nursery beds in open conditions in Jan 2015. However, the growth was too slow for which one *Jhum* farmer, Shri Drem Shadap, was provided with a poly-house of 15 m x 5 m x 3 m size to raise the seedlings (Fig 60). The first poly-house was constructed in 2015 with complete funding of Rs 56000 from ICAR Research Complex for NEH region. About 4000 seedlings in medium sized polybags were then transferred to the polyhouse.

Table 25. Growth of the MPTs and *Khasi mandarin* in farmers field.

Species	Year of Transplanting	Survival (%)	Avg Plant ht (m)	Avg collar dia (cm)
Michelia oblonga	2014	77.6 (n=1630)	3.35 ± 0.54	8.37 ± 0.97
Chukrasia tabularis	2014	85.5 (n=1650)	3.56 ± 0.45	8.35 ± 0.78
Michelia oblonga	2015	77.20 (n=430)	1.05 ± 0.26	1.52 ± 0.37
Chukrasia tabularis	2015	79.70 (n= 345)	1.20 ± 0.38	1.66 ± 0.62
Citrus reticulata (Khasi Mandarin)	2014	53.33 (n= 90)	1.85 ± 0.183	2.51 ± 0.28

Fig 60. Khasi mandarin seedlings in Polyhouse of the farmer

Fig 61. The two polyhouses constructed by the farmer

The farmer sold about 3500 seedlings at an average selling price of Rs 25/seedling and earned a gross return of Rs 87500. With the income, the farmer established another polyhouse (Fig 61) for which he contributed 40% of the cost and the rest was contributed by the institute under the TSP programme. Out of the total expenditure of Rs 62100, the farmer contributed Rs 24840 for the nursery. Now the farmer has two polyhouses to grow the *khasi mandarin* seedlings. The farmer has about 4500 seedlings (in large polybags) ready to be sold in 2017 from which an estimated gross income of Rs 1.12 lakhs is expected. The same polyhouse can be utilized for raising seedlings of other tree species also if the demand so arises.

Mushroom cultivation by *Jhumias*

Mushroom was introduced as an ancillary enterprise or micro-enterprise especially for the ladies who can devote sometime at home to produce mushrooms and generate some additional income.

Table 26. Income generated by cultivation of Mushroom

No of farmers	Plastic bags (after mixing mushroom spawn with rice straw)	Total mush-room (kg) produced	Gross income per farmer (Rs)
16	12 to 32 per farmer	11 to 40.5 kg per farmer	2200 to 8100 per farmer

Initially, the farmers were trained at the institute (Fig 62 & 63) and only four selected farmers were provided with all inputs including a temporary shed for mushroom cultivation. In 2016-17, about sixteen farmers came forward to cultivate mushroom and they constructed mushroom sheds on their own and a participatory production has started. About 12 to 32 bags of paddy straw/famers (3 kg capacity) were inoculated with spawn. The farmers could earn a gross income of Rs 2200 to 8100 (Table 26) within a period of two to three months at their home itself. This enterprise could generate employment for the ladies of the household at their doorstep.

Fig 62. Preparation of paddy straw by ladies for mushroom cultivation

Fig 63. Mushroom produced by the lady farmers in Sonidan village

Pig husbandry by *Jhum* farmers

Pig is a much sought after animal which are reared by the farmers for meat purpose. Farmers usually rear the local breeds of pigs which is fattend to about 40 to 50 kg in a year. Therefore, improved breed of pigs (Umsniang) were supplied during 2014 – 2016 to the farmers to improve productivity and generate additional family income without much investment.

Table 27. Income of farmers from rearing of improved breed of Pig in Sonidan

SN	Farmer name	Year	No. of piglets given	Piglets survived after live birth	Piglets sold	Grown up Pigs sold	Total amount (Rs)
1	Sainkur Shadap	2014	1 M + 1 F	5	5		12500
		2015		5	3		7500
		2016		2		2	25000
2	Kyrshan Lyngkhoi	2014	1 M + 1 F	9	7		14000
		2015		9	9		18000
		2016		2	0		0
3	Spar Shadap	2014	1 F	10	10		20000
		2015		9	7		14000
		2016		6	4	2	28000
4	Romes Warjri	2015	1 F	3	3		6000
5	Riful Dorphang	2015	1 F	3	3		6000
6	Wandar Khymdeit	2015	1 M + 1 F	3	3		6000
7	German Shadap	2015	1 F	4	4		8000
8	Don Shadap	2015	1 M + 1 F	7	7		14000

Fig 64. Pig rearing by the Jhum farmers

A representative list of few selected farmers who were supported with the improved piglets is given in table 11. It was observed that the farmers who continued to expand the pig herd by not selling all the newborn piglets earned Rs 11,000 to 21,000 per annum in three years and still continuing with the rearing of piglets. Those, who did sold all the newly born piglets and did not expand their herd size earned Rs 6000 to 14000 per annum. However they have still retained the parent stock provided to them. In 2016, five farmers were given (one male and one female) improved breed of pigs (Umsniang) and one farmer one female piglet for rearing (Fig 64). Improved pig husbandry could reasonably improve the family income of the farmers.

Backyard poultry by *Jhumias*

As a means of supportive livelihood option, selected *Jhum* farmers were provided with 20 Kroiler birds of two weeks old for backyard poultry. Performance of backyard poultry in 10 sample farmers is given in the table 28. After rearing for about 75 to 90 days, the grownup chickens were sold at an average rate of Rs 180 per kg of live weight.

Table 28. Performance of backyard poultry in Sonidan village

Birds Survived	Feed cost (Rs)	Total live wt (kg)	Input cost (Rs)	Gross Returns (Rs)	Net Returns (Rs)	B:C Ratio
15 - 18	3600-4000	35-45	4550-4950	6660-8100	2110-3550	1.27-1.54

Selling price/ kg live wt = Rs 180. Observations were recorded in ten farmers (Sample size=10)

The average cost of medicine was Rs 150 for the whole period of rearing, cost of two weeks old chicks was Rs 75 per chick and cost of feed was variable which varied according the number of live birds and farmers' capacity to spend on feed. Cost of chicks, medicine and feed constitutes the total input/investment cost. It was observed that a farmer could earn Rs 1750 to 3550 within three months which is sufficient to support the education cost of two school going children for three months. The enterprise did not involve any additional mandays as the farm family would spent only an hour or so in a day to manage the flock.

Long term evaluation of growth behaviour of Multipurpose tree species after 29 years of transplantation in arboretum

More than 20 multipurpose tree species (MPTs) were planted in 1988 in the arboretum of the institute to evaluate their performance. Some of the species were indigenous species whereas others were not native to the region.

After 29 years, only nine species could survive and maintain a reasonable population and the others did not survive in long run. All the nine species except *Cryptomeria japonica* continued to grow and remained healthy (Fig. 65).

Fig 65. Growth pattern in dbh of the MPTs over a period of 29 years

Evaluation of agro forestry system under hill ecosystem

Ginger and turmeric were grown in the terraces along with six fruit trees and in the open for comparison as control. Crop performance was compared with ginger-ginger two year rotations grown with the application of recommended dose of fertilizers. The growth and yield parameters were observed and presented in Table 29.

Yield calculated on the basis of plant density 66,666 /ha in terraces with tree (T)* and 83333/ ha in terraces without tree (WT) and control

Perusal of table reveals the reduction in growth and yield attributes of ginger when grown in combination with shade tree compared to open condition (control), particularly in the freshly cultivated site (Control I). However, in the 2nd year of continuous cultivation in open areas (control II), plant growth and yield of the crop declined. Maximum yield of ginger was observed in control (260 g/plant) followed by *khasi mandarin* without tree (153.9 g/plant) and *khasi mandarin* with tree (136.8 g/plant) which was higher than control II (133.7 g/plant). Thus, ginger yield can be sustained in fruit tree based agro forestry system. To compare the productivity of different systems, ginger and fruit yield were converted in to rice equivalent yield. Maximum productivity was observed in ginger grown on virgin soil in open area (14.45 t/ha). In agri-horti systems, better productivity was recorded in peach (11.31 t/ha) and guava based system (9.74 t/ha).

Progeny evaluation of plus trees of tree bean (*Parkia roxburghii*)

To develop genetically superior planting materials of *Parkia roxburghii*, progenies of plus trees from seven of its natural range of distribution were evaluated for the biomass and growth traits in uniform environment in replicated trial. Survival and growth parameters were recorded for evaluation. Survival percentage ranged between 16.2 to 90% and was recorded maximum in the provenance Bilkhawthir (90%) and Kanpokpi (90%) followed by Kenanglwa (80%) and Kawnpai (80%). Plant survival was recorded minimum (16.2%) in the provenance Thingkhangphai. Plant height was recorded maximum in the provenance Kenzanglwa (15.1 m) followed by Kanpokpi (13.2 m). Diameter at breast height (DBH) was recorded maximum in the provenance Kezanglwa (15.1 cm) followed by Kawnpai (12.1 cm) provenance. Canopy length was recorded maximum in the provenance Kenanglwa. Based on these growth parameters studied, the provenance Kenanglwa could be a better seed source.

Being a leguminous tree, the tree is beneficial for growth of shade tolerant crops. Two shade tolerant and commercially important crops, ginger and turmeric were grown in *Parkia roxburghii* terraces in the plot size of 3 m × 1m at spacing of 30 cm × 30 cm. The growth and yield parameters of these two crops were recorded. The rhizome yield of ginger (87.8 g/ plant) grown as shed tree under *Parkia* was reduced by 2/3rd compared to ginger grown in fresh soils in open condition. Turmeric grown as shed tree under *Parkia* produced rhizome yield of 106.7 g/plant.

Harvesting, processing and value addition of natural resins and gums

Pinus kesiya (*khasi pine*) resin was tapped from trees of three different diameter classes *viz.* 30-40 cm, 40-50 cm and > 50 cm and month wise resin yield was estimated across the diameter classes. Resin was processed and turpentine and rosin was estimated at three intervals- within one month after tapping, 6 months after tapping and one year after tapping. Turpentine oil is essential oil lighter than water and specific gravity of oil was found to be 0.90. Fresh

Table 29. Growth and yield of ginger grown under agro forestry systems

Parameter/ Fruit trees	Assam lemon		Guava		Peach		Khashi mandarin		Plum		Pear		Control (II)	Control (I)
	T*	WT	T	WT	T	WT	T	WT	T	WT	T	WT		
Plant height (cm)	31.8	35.3	38.27	34.87	47.38	50.63	35.43	53.17	42.78	43.54	42.94	48.60	41.50	62.25
No of shoots	4.2	2.4	3.33	3.33	3.50	4.38	3.33	6.33	3.92	4.00	3.33	4.25	3.28	6.63
Rhizome length (cm)	2.2	2.3	2.13	2.06	2.06	1.85	2.03	2.10	1.98	4.76	1.92	2.04	2.15	
Rhizome width (cm)	1.6	1.8	1.77	1.54	2.63	2.08	1.91	2.01	1.90	2.01	1.66	1.88	1.91	
Ginger yield /plant (g)	76.1	97.8	101.33	133.56	101.66	92.41	136.83	153.91	126.58	157.91	123.33	86.33	133.66	260
Yield, t/ha	5.1	8.2	6.76	11.87	6.78	8.21	9.12	13.68	8.44	14.04	8.22	7.19	11.14	21.67

distillation of resin yielded very high amount of turpentine oil: 23.9- 54.2% across different tree diameter sizes with a mean value of 36.8%. The turpentine oil reported in these samples was very high compared to other species of pine. However, the turpentine oil content decreases with the increase in storage periods. In the samples distilled after 3 months, the turpentine oil content ranged between 20.5 – 24.6% with a mean value of 22.1%. In the samples stored for 1 year, turpentine yield further decreased to 10.4-21.7% with a mean value of 15.1%.

Development of self sustainable integrated farming system (IIFS) through crop, livestock and forestry integrations under rainfed condition for productivity enhancement

In IIFS system comprising crops,, livestock, fish and tree components, revenue generated from different models have been evaluated and monetary input and output from the system has been estimated (Table 30). Maximum revenue was generated from poultry based model followed by dairy based model.

Table 30. Monetary Output /Input pattern from IIFS models

IIFS Model	Components (revenue generated) Rs./ year	Total Input	Total Output	Labour Cost (Rs.200/day)	Output: Input (Incl. labour)	Output: Input (excl. labour)
Duck-fish-hedge row-vegetables- annual crops	Ducks (5291) Vegetables (9212)	7280	14503	17000	0.85	1.99
Poultry-fish	Broiler birds (365260)	253680	365260	39200	9.32	1.44
Pig-fish-MPTs-crops	Pigs (21000*2) Crops (7435)	17920	49435	36500	1.35	2.76
Goat-fish-MPTs-crops	Goats (43425) MPTs (4060)	15560	47485	28800	1.65	3.05
Cattle-fish-MPTs-crops-vermi compost	Cattle (90000) Milk (219906) Paneer (21500) Crops (6400)	171550	336656	91250	3.69	1.96
Upland crops-Fish without integration (Control)	Crop (5250)	4850	5250	62400	0.08	1.08

Input includes: Cost towards labour, seed/planting material, feed, fish fingerlings, green fodder, FYM, Pond preparation etc. ;* Output includes: production of egg, meat, milk, dung, fish, crop produce etc. (Rs. 818589 from 1.82 ha (1.03 ha of Land and 0.79 ha Pond area); * The livestock manure from all the models is not included in its equivalent cost; * Crop/Livestock produce priced at institute price (50-60% lesser price than in the market)

AGRICULTURAL ENGINEERING

Evaluation of conservation efficiency of grasses on hill slopes of Meghalaya region

The project was initiated during 2014-15 for assessing conservation efficiency of grasses in natural resources management and economic importance. The aims can be fulfilled by studying the hydrological behaviors of degraded lands under selected local grass covers with their conservation efficiencies and production potentials. During the period under report (2016) ten numbers of runoff plots (ROPs) were renovated for desired slope of 45% with renovation of gauging stations and installation of gauging devices. *Congo signal*, hybrid napier, broom, guinea, lemon grass and citronella grass saplings were transplanted in recommended 30 - 45 cm spacing in 6 numbers of ROPs. ROPs were monitored for their hydrological behaviors by installing automatic water stage level recorders on 1ft H-flumes. Sediment samples were monitored through 1' dia Coshocton wheel silt samplers (N-1 type). The area received 2202.4 mm average annual rainfall in 129 events with runoff of 1579 mm from 47 events. The hydrological behaviors and production potential of different ROPs are presented in table 31. Soil conservation efficiencies were estimated at 27.7, 25.06, 37.7, 39.8, 20.41, 32.22, and 22.2 % with water conservation efficiency of 20.5, 22.98, 25.94, 29.03, 25.16, 18.52 and 46.91% respectively. The overall soil & water conservation efficiencies of *congo signal*, hybrid napier, broom, *guinea*, lemon, citronella, cultivated weeds and natural weeds were 24.1, 24.02, 31.82, 34.4, 22.78, 25.36 and 34.56% respectively.

Estimation of water budget components for predominant farming systems of Meghalaya region

The project was initiated during 2014-15 for evaluation of farming system impact on water budget parameters, development of relationship between water budget components and hydro- meteorological parameters, evaluation of suitability of different models/ methods/ approaches for modeling water

Table 31. Hydrological behaviors and production potential of different ROPs under grass land use in 2016

ROP (s)	Grass	Runoff (% rainfall)	Sediment yield (t/ha)	Yield (fresh biomass) (t/ha)
1	Congo Signal	15.46	12.26	51.75
2	Hybrid Napier	14.08	11.59	223.56
3	Broom grass	13.66	11.24	151.52
4	Guinea grass	13.96	11.49	23.20
5	Lemon grass	12.93	9.76	12.5
6	Citronella grass	11.92	9.53	25.0
7	Weed biomass in cultivated fallow	13.34	6.15	18.18
8	Weed biomass in natural fallow	12.00	6.02	26.52

budget components with assessment of biological and economical productivity of water under different land use options. Five farming system micro-watersheds i.e. Agriculture (W_1=0.64 ha), Agri-Horti-Silvi-pasture (W_2=1.03 ha), Agro-Forestry (W_3= 2.94 ha), Forestry (W_4=3.89 ha) and Natural fallow (W_5=1.03 ha) were delineated, demarcated and calibrated for their hydrology during 2015. The soil is of sandy loam and lies in class VII_e. The average slope of micro-watersheds lies in the range of 32.02 to 45.87% with relief of 89-110 m. The maximum length and width varies from 250-320 m and 65-230 m respectively.5 gauging stations equipped with 1' H-flumes were renovated and installed with automatic stage level recorders. The area received 2202.4 mm annual rainfall in 129 events with runoff producing storms of 889.6 mm from 17 events during 2016. The hydrological behavior of FSR Micro-watersheds is presented in Table 32. Runoff was estimated using standardized SCS-CN method for the region and actual evapotranspiration by following the method of FAO-56 Penman-Monteith using multiple crop option. Using the water balance approach, recharge contribution was estimated. Estimated water budget components for predominant land uses individually and combining composite land use system are presented in the table 33and monthly water budget components is presented in Table 34.

Table 32. Hydrological behavior of FSR Micro-watersheds (2016)

FSR Micro-watershed No.	Runoff (%)	Sediment yields(ton/ha-yr)	Water Conservation Efficiency (%)	Soil Conservation Efficiency (%)	Soil and Water Conservation Efficiency (%)
W_1	11.46	7.307	25.42	34.79	30.11
W_2	10.87	6.905	38.39	40.51	39.45
W_3	11.40	7.164	28.03	35.06	31.55
W_4	13.15	8.201	19.27	18.80	19.04
W5	21.50	12.853	Control	Control	Control

Table 33. Estimated contribution of water budget components under prominent land uses (2016)

Land uses	Contribution		
	Runoff (%)	AET (%)	Recharge (%)
Agril (W_1)	11.46	37.95	50.59
Agri-Horti-Silvi-Pasture (W_2)	10.87	62.23	26.90
Agro forestry (W_3)	11.40	49.60	39.00
Forestry (W_4)	13.15	54.35	32.50
Natural fallow (W_5)	21.50	33.51	44.99
Composite	13.68	47.52	38.80

Table 34. Estimated monthly water budget components for the year 2016

Month(s)	Rainfall (mm)	Runoff (mm)	AET (mm)	Recharge Contribution (mm)
January	23.4	0	32.9	0.0
February	0.3	0	34.3	0.0
March	48	0	51.6	0.0
April	174.2	20.6	173.4	0.0
May	302.5	43.7	187.8	41.0
June	422.3	114.6	163.1	144.0
July	457.4	76.3	171.3	209.8
August	219.2	43.6	131.3	44.3
September	396.4	88.3	124.5	60.6
October	142	12.2	116.5	13.3
November	9	0	75.6	0.0
December	7.7	0	27.9	0.0
% Contribution	100	18.13	58.58	23.29

Flagship programme on *Jhum* improvement

A gauging station was installed and made functional at demonstration farm of KVK ,Tura during 2016. *Ramie* (a perennial hardy best fibre yielding crop) was planted and hydrological behaviors were monitored. During the period under report-82 rainfall

event occurred with annual rainfall of 2189.3 mm. 21 runoff producing storms were recorded with 31.8% runoff and 48.20 t/ha/yr of sediment yield from a gauged Jhum cultivated area at KVK, Tura, West Garo hill of Meghalaya.

Analysis of historical weather variables and accuracy assessment of the weather forecast

Climate change is global, but its nature, extent & intensity being localized, needs quantification at a proper scale. Hence, weather data analysis has taken the centre stage for understanding the quantitative direction of the change. Temperature (maximum and minimum) data of seven north eastern states recorded at the *GKMS* agro-met observatories of the respective centers of ICAR Research Complex for NEH region were used for analysis. There were several changes in the maximum (T_{max}) and minimum (T_{min}) temperature over the region, the pattern of which also varied from region to region. T_{max} has increased unanimously (fig 66) in all the months over all the region. The increase in mean annual T_{max} varied from 0.1°C per decade in Imphal to about 1.4°C per decade in Jharnapani. The changes were significant for all the stations except, Gangtok. Maximum number of statistically significant increasing changes in monthly T_{max} were observed in Umiam (12), *i.e.* T_{max} increased significantly for all the months in a year, followed by Jharnapani (11), Basar (10), Imphal (7), Kolasib (6) and Kailasahar (6). Gangtok was the only place where T_{max} was found to be significantly decreasing for the months of November and December. If we see from seasonal point of view, the T_{max} increased significantly over five places (except Gangtok and Kailasahar) in winter, over six places (except Imphal) in pre-monsoon, over five places (except Gangtok and Kolasib) in monsoon and over six places (except Gangtok), where it was decreasing in post-monsoon. It signifies that the T_{max} has increased over the whole north-eastern India. Unlike T_{max}, the trend in T_{min} was much varied over the region, somewhere it has shown increasing trend (Basar, Imphal & Gangtok) somewhere it decreased (Jharnapani and Umiam). The mean annual T_{min} increased significantly for Imphal and Gangtok at a rate of about 0.3°C and 0.6°C per decade respectively while it decreased significantly in Umiam and Jharnapani at a rate of 0.3°C and 1.4°C per decade respectively. The T_{min} has significantly increased in Imphal and Gangtok for all the months whereas it has decreased significantly at Jharnapani. In Basar it has also shown increase for seven months while at Umiam, it decreased in five months.

Form the seasonal point of view, Gangtok and Imphal have witnessed increasing trend in T_{min} in all the four season while at Jharnapani it decreased. During monsoon, it increased in Basar while decreased in Umiam and in post-monsoon it has increased significantly in Kailasahar. Overall, the T_{min} had a mixed response over the region, in climatologically cooler places like Gangtok, Imphal and Basar it has increased but in comparatively at hotter places like Jharnapani and Umiam, it has decreased. The trends of both the T_{max} and T_{min}, has changed the daily temperature range (DTR) over the region. DTR has increased significantly over Jharnapani and Umiam while decreased over

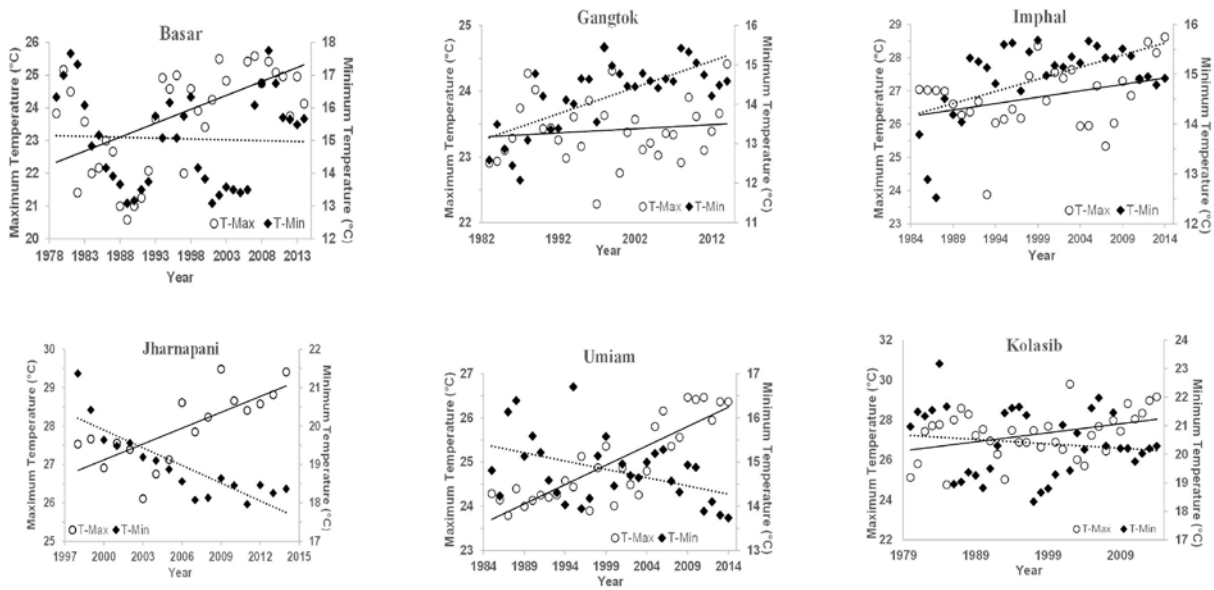


Fig 66. Trends in annual maximum and minimum temperature over different places of Northeast India.

Gangtok, Basar and Imphal during the study period. The changes in maximum, minimum temperature along with DTR, is bound to perturb the thermal regime of the region, which may impact the ecology & environment of the region in general and the agricultural crops in particular.

AICRP on Plasticulture Engineering and Technology

Feasibility and economic evaluation of heating and cooling of poly house using earth heat exchange.

The study was conducted during 2012 - 2016 to evaluate the performance of closed loop geothermal cooling of poly house and techno-economic feasibility of the geothermal cooling system in poly house for high valued crops production system. The designed and fabricated earth air tube heat exchanger was operated round the year 2016 with blower speed of 12.5 m^3/h to heat or cool the polyhouse. The optimum length of heat exchanger for a flow rate of 12 m^3/h was found to be 36m. The average maximum and minimum temperature inside the polyhouse were 24.67°C and 18.28°C in comparison to outer temperature of 23.99°C and 13.11°C respectively. The respective relative humidity during morning and evening periods were 72.66 and 63.33 (inside) as compared to 87.45 and 73.18% (outside) respectively. The blower was run for 10hrs/day. Considering the price for electricity consumption in the Meghalaya state @ Rs.2.25/kwh under agril practice, the cost comes up to Rs.22.5 day and fixed charge @ Rs.50/- month. If it is considered under industrial use, the cost of operation per day @ Rs 5.2 as Rs.52/- + fixed charge @ Rs.90/- month.

Modeling the micro climate of vegetable based cropping system under poly house in mid hills of Meghalaya

The project was initiated in January 2015 to model the vegetable grown poly house. One net house and one polyhouse were renovated for initiation of project. Offseason vegetable crops like capsicum, brinjal and tomato seedlings were transplanted during the month of October 2015 and growth and yields parameter were monitored. Harvesting was made in the month of February 2016. Vegetative growth of crops in polyhouse was more luxuriant, than net house. Yield of capsicum, brinjal and tomato were recorded as 28, 58 & 34 t/ha in polyhouse whereas the same were 22, 41.5 and 30.2 t/ha in net house. Under farmers practice, the yield were 19.2, 30.1 & 26.5 t/ha. It is observed that growth and yield of crops were more in polyhouse as compared to net house and farmers practice due to rise in temperature by 2.5°C during winter and relative humidity was less by 2.1%. Harvesting of gerbera flower indicated increase of flowers numbers 38.09% and 26.4% under polyhouse and net house condition as compared to farmers practice.

Development of package of practices for pisciculture in poly housed – plastic lined pond for mid- hills of Meghalaya

The project was initiated during monsoon season of the year 2016. Two numbers of lined ponds of the division were equipped with two numbers of low cost poly houses. Fish fingerlings were procured and placed in polyhouse-plastic lined ponds. 100 nos of *Catla* are being reared in 20m^2 pond. Average water surface temperature rose by 1.3^{0}C during the month of July to December, 2016.

Development of low cost seed storage system using plastics

Seeds of rice and maize were dried to the recommended moisture levels (8-10%), packed in single layered LDPE packets of 10kg and sealed. The packets were stored under ambient conditions. Maize seeds stored in this condition with acephate showed no deterioration in quality and resulted 96% germination and without acephate 89% germination. Rice seed without acephate resulted with 96% germination.

AICRP on Farm implements and machinery

Testing and modification of power paddy thresher cum cleaner

A lightweight power paddy thresher cum cleaner was designed and developed for threshing paddy in hills. It consists of main frame, threshing unit, bower, sieving unit and power transmission unit equipped with single phase one HP electric motor. Threshing unit consists of cylinder fitted with wire loops. A blower is used to blow off the chaff, dust and other light foreign materials from the grain. The developed power paddy thresher cum cleaner was tested and modified to reduce the vibrations in the equipment by changing the belt and pulley to reduce the speed of cylinder. A cover made of wire mesh was fitted to cover the belt and pulley for safety purposes. The specifications and test results are given below.

Specifications of thresher cum cleaner	Test Results
Overall Dimensions (l×w×h), mm: 1080 x 730 x 1310 Weight: 105 kg (without motor) Type of threshing cylinder: wire loop Length of threshing cylinder: 610 mm Diameter of threshing cylinder: 400 mm Sieving tray size: 480x530 mm	Number of person required: 2 Average threshing efficiency: 99.4% Grain output capacity: 158 kg/hr Threshing losses due to shattering: 1% Unthreshed earhead/plant: Nil Breakdown of equipment: Nil

Fig 67. Testing of paddy thresher cum cleaner

Prototype feasibility testing of farm machinery

Sowing of seeds is normally undertaken manually or in few cases with animal drawn implements. Since the power tiller is becoming popular at NEH region for land preparation in valley land and terraces, the same can be utilized for sowing operation with suitable attachment. Hence the power tiller drawn seed drill was taken for feasibility testing. The hitch point and hopper link on both side of the seed drill were modified to make it suitable for being operated with *KAMCO* power tiller being used in the region. The equipment was tested for sowing of lentil in the farmer's field (Mawpat and Mawsinram village of East Khasi Hills district). It was equipped with fluted feed roller type seed metering mechanism with three numbers of furrow openers. Depth of seeding achieved was 45-50 mm at a row spacing of 280 mm and the pattern of seed placement in row was continuous. Effective field capacity achieved was at 0.08 ha/hr. The equipment was found suitable for sowing of lentil in terraces and valley lands. A light weight (69 kg and 4.1 kW engine) power tiller with attachments (rotavator, cultivator and ridger/furrower) was tested for terrace cultivation. The whole unit could easily be shifted from one terrace to another and easily operated in narrow terraces due to small turning radius (< 1 m) and light weight. Feasibility trial of power tiller operated potato digger (*TNAU* design) was conducted to reduce the drudgery of work and labour requirement. It was found suitable for the potato grown along the length of terrace or in valley land. Prototype feasibility testing of grass brush cutter with crop harvester attachment was undertaken in ICAR farm for harvesting of paddy crop. The equipment was fitted with 1.3 kW petrol engine and the dry weight of the equipment was 7.7 kg which made it handy for operation on hills. A disc type blade and crop diversion board was fitted for harvesting paddy. It was not suitable for harvesting lodged crop and sometimes chocking of blade with plant also occurs.

Fig 68. Prototype feasibility testing of different farm machinery

Frontline demonstration of farm tools and machinery

Manually operated direct paddy seeder made of plastic body was demonstrated in the farmers' field for direct sowing of paddy in line. The equipment fitted with 2 drums for sowing 4 rows at 20 cm spacing in one pass. Its weight is approx 9 kg which makes it easy to operate and can be used in narrow terraces. VST make self-propelled VCR having 1000 mm cutter bar length, 4 Nos. of crop divider and 5 hp diesel engines was demonstrated for harvesting paddy in terraces and valley lands. Manually operated cono-weeder was demonstrated for weeding in low land paddy sown in line. STIHL make engine operated posthole digger having 635 mm length and 150 mm diameter augur was demonstrated for digging holes. Farmer's opinion about the equipment was that it is time saving but costly equipment and difficult to repair in case

of any breakdown. Hand operated winnower was demonstrated for cleaning threshed paddy. It is time saving and need not be dependent on natural wind breeze. Horticultural tools (hand fork, Grafting/ Budding knife, Tree pruner and Hedge Shear) were also demonstrated in the farmers' field.

Fig 69. Frontline Demonstration of farm tools and machinery

Prototype manufacturing of farm tools and equipments

Prototypes of farm tools and equipments (779 numbers) were fabricated during April to December, 2016 under AICRP on FIM and Revolving Fund Scheme on "Commercialization of farm tools and Machinery for Hill Agriculture" and supplied to government, non-government organizations, KVKs and individual farmers of NEH states.

Table 35. Prototypes of farm tools and equipments manufactured and supplied during 2016

Prototypes Fabricated and Supplied	Quantity/No.	Prototypes Fabricated and Supplied	Quantity/No.
Maize sheller	134	Zero till furrow opener	86
Sri row marker	3	MB plough	2
Garden rake	45	V-blade weeder	17
Wheel hoe	112	Briquette chulah	3
Grass slasher	36	Briquetting mould	14
Cono weeder	6	Groundnut decorticator	98
Straight blade weeder	12	Metallic tip dibbler	12
Hand Fork	62	Hand operated winnower	10
U-blade weeder	46	Manual Trolley	2
Adjustable Row Marker	74	Paddy thresher pedal type	5

Forecasting Agricultural output through Space, Agro-meteorology and Land based observations (FASAL)

Field experiments on maize (*cv. RCM 76*) and upland rice (*cv. Bhalum 1*) were conducted in 2016. Maize was sown in 1st week of April, while rice was direct seeded in 3rd week of June. Rainfall during 2016 maize growing period (April-July) was 1356.4 mm against water requirement of 750 mm with 78 nos. of rainy days whereas during rice growing period (June-October), amount of rainfall was 1637.3 mm against requirement of 1000 mm with rainy 85 nos. of days. The crops did not suffer from any water stress during its growth periods. Maize and rice took 103 and 117 days to attain physiological maturity, respectively. DSSAT (Ceres-Maize) simulated maize yield was 2239 kg/ha against observed yield of 2054 kg/ha with over estimation of 9%. In case of rice, simulated yield was 2178 kg/ha against observed yield of 1973 kg/ha with over estimation of 10.4%. Considering acreage of maize and rice in Meghalaya as 18,025 and 63,539 ha, respectively, expected (simulated) production of *Kharif* maize and rice in Meghalaya in 2016 may be 40.4 and 138.4 thousand tons, respectively.

Agri-consortia Research Platform on Water

The project "Development and Management of Integrated Water Resources in different Agro-ecological Regions of India" under Agri Consortia Research Platform on Water was approved by NRM division of ICAR on 11-11-2015. The Institute is one of the consortia partner and is working in the theme "Conservation and augmentation of Water resources" with sub theme on "Development & management of integrated water resources". The hydrological data of farming system research (FSR) micro-watersheds having land uses of agril, agri-horti-silvi-pasture, agro-forestry, forestry and natural fallow were collected for the duration of 1991-2006. Based on the historical data compilation design and construction of *Jalkund* and solar gravity fed drip irrigation system have been installed. Land use treatments works like vegetable cultivation and establishment of Piggery unit on hill slope is being undertaken.

Gramin Krishi Mausam Sewa (GKMS)

Agro-advisory bulletin service was started from May 1996 at AMFU, Umiam with the objectives of preparing AAS bulletin based on weather forecast from IMD, Guwahati (medium range of 3-5 days) every tuesday and friday after consultation with the Agro-Advisory bulletin

board, providing weather forecast to the farmers along with Agro-Advisory guidelines for economic management of farm operations, taking feedback from farmers and analyzing for improvement of AAS, assessing the feasibility of the forecast and communicating daily recorded meteorological data to regional meteorological station, Guwahati for improvement of weather forecast. Agro-met advisories are prepared by expert groups (Scientists of ICAR, Umiam) based on the weather forecast received from Regional Meteorological Centre, Guwahati along with Tools & techniques like Normalized Difference Vegetation Index (NDVI) &the Standardized Precipitation Index (SPI) for 11 district of Meghalaya received from Agromet Pune. Agro-advisories are disseminated to media like AIR, DDK, Local newspapers, etc. through e-mail, SMS, Fax and Telephonic conversation. The agro-advisory bulletin prepared are uploaded in IMD Agromet website (www.imd.agrimet.gov.in), (www.farmer.gov.in) & (www.kiran.nic.in) for dissemination. This AMFU is sending the advisory bulletin as well as SMS to all the KVKs of the state, State Agril/Horti officers for forwarding the SMS to beneficiary farmers. 847 numbers of AAS bulletins were prepared and disseminated to the farmers during 2016. In addition, 28507 numbers of SMS were sent to the farmers through *mkisan* portal of Ministry of Agriculture, Government of India.

Agri Business Incubation Project

Two incubaties having interest in manufacturing of farm tools and equipments were admitted for training. During two and a half weeks training on manufacturing of implements the participants were exposed to basic manufacturing technology of tools and machinery required for fabrication. Practical training was given to the participants on use and operation of workshop tools and machinery for measuring, marking, cutting, welding, etc. During the process of training implements such as adjustable row marker, single tyne wheel hoe and grass slasher were fabricated by incubatec trainees.

TRANSFER OF TECHNOLOGY

Demonstration of soil and water conservation and water harvesting technologies, improved farm tools and post harvest processing equipments

Soil and water conservation technologies, water harvesting techniques, protected cultivation methods, improved farm tools and equipments suitable for hill agriculture were demonstrated to the Nagaland state department officials, farmers from Assam, Arunachal Pradesh (Anjaw) and Meghalaya, Army personnel from Umroi Cantonment, students of college of Post Graduate Studies (CAU), Umiam, students of Kendriya Vidyalaya, Umroi Cantonment and Shillong.

Machinery for post harvest processing of farm produce was also demonstrated to the farmers, students and state department officials of the region. A demonstration on manually operated farm tools for hill agriculture (long handle weeders, manual seed drill, maize sheller, winnower, pedal paddy thresher and horticultural tools) was given to the 36 farmers of Umroi Nongrah village of Ri-Bhoi district, Meghalaya.

Fig 70. Demonstration of Water harvesting, protected cultivation technology and improved farm tools and implements

List of demonstrations/ field days organized

1. Rain water harvesting technologies, improved farm tools and equipment suitable for hill agriculture were demonstrated to 20 numbers of farmers of Nagaland under ATMA programme on 18th August 2016.
2. Soil and water Conservation Technologies, Improved hand tools were demonstrated to the 15 farmers of Assam during August, 2016.
3. Water harvesting techniques, Soil and water Conservation Technologies, improved farm tools and equipment suitable for hill agriculture were demonstrated to 11 numbers of the farmers of Jorhat, brought through DAO Jorhat, Assam on 27th July 2016.
4. Mechanized banana fibre extraction was demonstrated to 15 Nos. of women farmers of Ri-Bhoi district, Meghalaya on 21st July, 2016 in collaboration with KVK, Ri-Bhoi district, Meghalaya.
5. Demonstration of Water harvesting techniques,

improved farm tools and implements to the 50 farmers of Wakhaw RVP, Meghalaya on 9th May, 2016.

6. Demonstration of soil and water conservation technologies, improved farm tools and implements to a group of 52 students and teachers from Spring Time Secondary School, Sadew, Shillong on 1st October, 2016.
7. Demonstration of water harvesting techniques, improved farm tools and implements to the 30 progressive farmers from ATMA, Jowai on 4th October, 2016.

Fig 71. Demo of banana fibre extraction to the women farmers

Fig 72. Demo of improved farm tools and Jalkund Construction to the farmers

SOCIAL SCIENCE

Network project on market intelligence

The secondary data source for the price and arrivals of the selected commodities in Meghalaya were taken from AGMARKNET and Meghalaya state agricultural marketing portal. The primary data were collected from farmers from six villages *viz*, Nongthymmai, Nongrim-Nongladew, Mawtneng, Mawbri, Mawphrew and Umsning in Ri-Bhoi district of Meghalaya for six selected crops i.e., potato, tomato, ginger, turmeric, pineapple and banana respectively. Data from traders of the respective commodities were collected from different markets of Meghalaya *viz.,* Mawiong, Umsning, Nongpoh, Jowai and Iewduh for potato, tomato, ginger, turmeric and banana respectively. For the selected commodities, the market for each specified commodity was selected based on highest arrivals among the top five markets in the state. Prices of the commodities were forecasted for the selected respective markets and additionally, Nongpoh market was selected for forecasting the prices of pineapple.

Price forecasts were prepared using various methods of forecasting namely ARIMA, SARIMA, ARCH and GARCH. During 2016, pre-sowing forecasts for Meghalaya state were given on potato for October-November, on tomato for November-December and on turmeric for April-June. During the same year, the pre-harvesting forecasts were also given on crops like pineapple for June-September, on ginger for November-December, on turmeric for November-January, on potato for February-March and on tomato for March-April. The forecasted results were disseminated through the Local Newspaper *i.e.* Mawphor as well as through the KIRAN website (www.kiran.nic.in). As per the preliminary market survey there was 70-75 % usability and reliability in the price forecasts of the selected commodities. The prices of the agricultural produce in Meghalaya depend on arrivals of the agricultural produce - in a particular day in the wholesale market. The prices also largely depend on the weather conditions which influences the production of the agricultural produce. Price forecasts are useful for taking decisions regarding the choice of crop to be cultivated, selection of crop variety, planting/harvesting dates, when and where to sell the agricultural products and investments in farm inputs. The pre-harvest forecast (80-85%) is better than the pre-sowing (70-75%) forecast and the usability of pre-harvest forecast was found to be significant in case of all the crops chosen for the study.

Farmers who received market information advisory have received increase in gross returns and net returns for their various crop produce from the previous years. The highest increase in gross returns (5.1 per cent) and net returns (4 per cent) was observed in ginger

followed by turmeric which had increased by 4% in gross returns and 3.5 % in net returns. The farmers were also able to store their produce for a certain period of time till they fetched a higher price in the market. Market Intelligence has benefited those farmers who have adopted it and has improved their livelihood due to their increased returns from production.

Developing Marketing Strategies for horticultural crops in Meghalaya

The diverse agro-climatic nature of the state makes it conducive for cultivation of large number of horticultural crops. To develop marketing strategies of horticultural crops in Meghalaya, some crops were prioritized. Based on the interaction with experts and officials from different state departments, a list of ten leading horticultural crops (4 Fruits, 4 Vegetables and 2 Spices) was prepared for detailed analysis considering their potential to integrate with national and international market, agricultural marketing investment, consistent prices, ability to have socio-economic impact and scope for future expansion (Table 36). The aspects/dimensions like social, economic, input use/availability, ease of production and market access and availability are considered important for framing market oriented policies so as to ensure remunerative price by enhancing access to market by farmers.

The analysis was based largely on secondary information collected from reports/ documents/ online resources published by different organizations of the state government and central government like State Agricultural Marketing Board, Department of Agriculture, Directorate of Economics and Statistics and National Horticultural Board. Relevant primary information on important variables considered under the study has also been collected through interaction with different stakeholders.

Table 36. Crops advised by the experts

Sl No	Name of the crop	Type of crop
1	Ginger	Spice
2	Turmeric	Spice
3	Banana	Fruits
4	Pineapple	Fruits
5	Papaya	Fruits
6	Orange	Fruits
7	Cabbage	Vegetable
8	Cauliflower	Vegetable
9	Tomato	Vegetable
10	Potato	Vegetable

The index values which represents the relative positioning of different crops with value of (1) showing as the most suitable and value of (0) as the least suitable is presented in the Table 37. Equal weights are assigned to each dimension considered in the study like social, economic, market and ease of cultivation. The table reveals pineapple to be the most suitable crops over all the variables considered followed by potato, orange, turmeric, ginger and tomato. Within each crop categories, pineapple and orange were found to be most suitable fruits while most suitable vegetables were potato and tomato. Of the two spices considered, ginger was observed to have shown greater potential over various other fruits and vegetables considered for analysis.

Table 37. Index-value based position of different crops in Meghalaya (Unit Index Value)

Crops	Social	Eco-nomic	Ease	Market	Overall
Pineapple	0.70	0.70	0.90	0.75	0.76
Potato	0.85	0.65	0.80	0.70	0.75
Orange	0.80	0.85	0.50	0.35	0.63
Tomato	0.25	0.85	1.00	0.35	0.61
Ginger	0.80	0.60	0.10	0.80	0.58
Turmeric	0.50	0.55	0.70	0.50	0.56
Banana	0.60	0.20	0.30	0.80	0.48
Cauliflower	0.50	0.65	0.40	0.20	0.44
Papaya	0.25	0.10	0.60	0.55	0.38
Cabbage	0.25	0.35	0.20	0.50	0.33

Value chain analysis of ginger, citrus, king chilli, cassava, large cardamom and pineapple in North-East

Value chains encompass the full range of activities and services required to bring a product or service from its conception to sale in its final markets—whether local, national, regional or global. Value chain includes input suppliers, producers, processors and buyers. They are supported by a range of technical, business and financial service providers. Ginger, Citrus, King Chilli, Cassava, Large Cardamom and Pineapple were given emphasis for harnessing the benefit of agribusiness opportunities in North-East region and ICAR Research Complex for NEH Region have identified these crops as potential crop for diversification of farmers' income. According to regional importance and interaction with experts and officials from different state departments, it was decided to study Ginger in Arunachal Pradesh, Citrus (Kachai Lemon) in Manipur, King Chilli

in Nagaland, Cassava in West Garo Hills, Large Cardamom in Sikkim and Pineapple in Tripura. Questionnaire has been prepared for data collection from various stakeholders viz. farmers, traders and consumers involved in production and marketing of different crops.

Development of Strategies for improving effectiveness of convergent model of extension services in meghalaya

An interview schedule has been developed to assess existing nature and extent of convergence along with the need of different extension services (information, advisory and information) which will help in identifying the problems and constraints related to effectiveness of extension organizations in delivery of extension services to the farmers. Data from 200 farmers respondents randomly selected from three districts of Meghalaya (Ri-Bhoi, West Khasi Hills and East Khasi Hills) along with the different public, private and Non-Governmental Organization working in these areas will be collected. The data collection procedure has been started and expected to be completed by April, 2017.

Livelihood Improvement of Hill Farmers through Sustainable Farming Systems in North Eastern Hill Region (FARMERS' FIRST Project)

The Farmers' FIRST Programme was officially launched on 8th November, 2016 with Shri. Sudarshan Bhagat, Hon'ble Union Minister of State for Agriculture and Farmers' Welfare as the Chief Guest. The project is a module based technological intervention towards sustainable integrated farming system in the farmer's field. The project will be operated in the 10 villages of Marngar Cluster Borgang, Parangang, Lalumpam, Barkhatsari, Nalapara, Jaigang, Umtham, Nongagang, Sarikhusi, Mawttnum and Pahamrinai targeting 1000 beneficiaries under different modules. There are 7 modules proposed under Farmers' First Project: Promotion of pulses (pea and lentil) in rice fallow, Promotion of vegetables in rice & maize, Organic ginger and turmeric production, Artificial insemination of pigs and deep litter housing model for pigs, Agri-business venture of ginger Candy, ginger powder, dehydrated ginger, turmeric powder, Integrated nutrient management (INM) and Acid soil amelioration and Pig based integrated farming system and Fish based integrated farming system. Demonstration on pulses (Pea & Lentil) cultivation in rice fallow have been conducted for 65 numbers of farmers for which necessary seeds, bio-fertilizers and small farm implements were distributed to encourage the farmers to increase the cropping intensity. In another module, demonstration on vegetable cultivation in rice and maize fallow have been taken up for which seeds of cauliflower, cabbage, capsicum, beans, tomato, potato etc. were distributed. Along with demonstration on improved agriculture and allied technologies, information of individual farmers are also being collected to develop the database for available resources, crops grown, problems faced and other related parameters of the farmers which will help in devising improved technological intervention suitable for their farm enterprise.

Convergence and Network Analysis of Extension Organizations for Enhancing Their Effectiveness in Pluralistic Extension Regime (NASF Project)

The project was formally launched on 21st November, 2016 at ICAR-IARI, New Delhi where a workshop was conducted about the roadmap of the project. In the said workshop, it was decided to conduct the benchmark survey to assess the existing nature and extent of convergence in the project area for which interview schedule has been developed and data collection from the farmers and other extension organizations are in process.

Climatic trends and changes in livestock production

Research on climate change impact is aimed at finding the effect that future changes in climate could have on human activities and the natural state of the world. It is necessarily conjectural as impacts cannot usually be experimentally confirmed or verified. Economic model of climate change impact study will be used to estimate the second order effects and beyond such as livestock production and patterns in livestock disease occurrence. As a preliminary exploration of the project, the district wise monthly temperature data for five years (2009-2013) were analysed to check the maximum variability, measured by Coefficient of Variation. The result showed that Ri-Bhoi District had maximum variability in average monthly temperature among the districts. According to this result, Ri-Bhoi district will be chosen as the study area for the project.

Table 38. Average Coefficient of Variation (CV) of monthly temperature of the districts of Meghalaya over the years 2009 - 2013

Sl No.	District	Mean (°C)	Standard Deviation	CV
1	East Khasi Hills	18.51	1.8	0.10
2	West khasi Hills	18.59	1.64	0.09
3	Jaintia Hills	19.50	2.16	0.11
4	Ri-Bhoi	23.12	3.94	0.17
5	East Garo Hills	-	-	-
6	West Garo Hills	24.00	2.17	0.09

The trend in different categories of livestock products was worked out. Overall milk production in the state had an increasing trend of 1.44 during the period 1983 to 2014 (Fig. 73 to 75). The milk productions from cross-bred and indigenous cow have increasing trends with the trend value higher in cross-bred (1.25) than in indigenous cow (0.27). However, a negative trend was observed in buffalo milk production, mainly due to the decrease in population. Total egg production had a significant increasing trend, with desi egg having higher trend value than improved egg. This trend is due to the higher market value of desi egg which sends price signal to the producers. One reason for their preference to keep desi varieties is the low maintenance cost and self-sustainability. All the meat category *viz.,* beef, pork, mutton and chicken have significant increasing trends. With a significant increasing trend of 0.01, mutton is becoming a popular meat in Meghalaya and its market is developing.

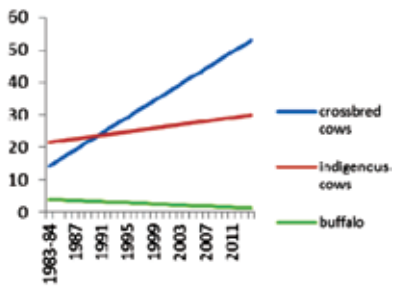


Fig 73. Trend in milk production of Meghalaya

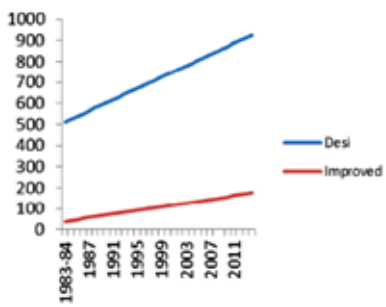


Fig 74. Trend in egg production of Meghalaya

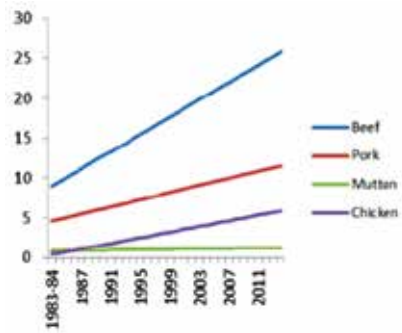


Fig 75: Trend in meat production in Meghalaya

Market Survey in Aquarium Fish Trade in Shillong

Case study methodology was chosen for the study of aquarium shop owners available at Ri-Bhoi district of Meghalaya. It was observed that the shop owners mostly dealt in exotic species of ornamental fish in businesses which are procured from Kolkata. The ornamental fish varieties that are being dealt in the shops are guppy (Poecilia reticulata) (Rs. 20/pair), molly (Poecilia latipinna), (Rs. 30/pair), platy (Xiphophorus maculates) (Rs. 40/pair), gold fish (Carassiusauratus) (Rs. 60/ pair), red cap oranda gold fish (Rs. 450/pair), gold fish celestial variety (Rs. 50/pair), gold fish telescopic variety (Rs. 50/pair), gold fish calico gold variety (Rs. 70/pair), gold fish shubunkin variety (Rs. 40 / pair), red-gilled violet shark (Labeoboga) (Rs. 40/pair), angel fish (Pterophyllum scalare) (Rs. 200/pair), black tip tail shark (Labeobata) (Rs. 80/pair), milky fish (Rs. 60/pair), Oscar (Rs. 400/pair), parrot (Rs. 600/pair), Indian rosy barb (Puntius conchonius) (Rs. 50/pair), dwarf gourami (Colisalalia) (Rs. 70/pair), arrowana (Rs. 1000/pair), black knife fish (Notopterus notopterus) (Rs. 80/pair), stone fish (Garragoty lagotyla) (Rs. 60/pair), red-eye tetra (Rs. 50/pair), widow tetra (Rs. 60/pair). However, the shop owners had no idea about sex identification in the pairs that they sell to customers. All the shop owners procured fish from Kolkata. However, they had no idea about the fish being caughtwild or farm raised. 100 per cent of the traders were of the opinion that gold fish was the variety most demanded by customers. It was also reported by 66.67 per cent of the shop owners that sales of aquarium fish decreased during winter. This is mainly because aquarium keepers goes on holidays in winter and are unable to take care of aquarium fish. All the shop owners provided after-sales service to the customers whenever necessary for aquarium maintenance activities such as aquarium cleaning, water quality maintenance, fish disease treatment etc. The marketing constraints stated by the shop owners were difficulties in renewing licenses for aquarium fish business, competition from other pet business and transportation problems. More

professional services and a well organized marketing system need to be in place for ornamental fisheries in Shillong.

Participatory Decision Support System – a recent approach towards designing farmers friendly DSS for horticulture crops in Meghalaya

Most of the farmers of the selected villages were growing vegetables in *rabi* season and fruit crops, maize and rice in *kharif* season in both upland and lowland ecosystem having acidic soils. The farmers had mostly small land holdings, lacked awareness about soil testing. As far as irrigation is concerned, rainfall was used for *kharif* crops and jalkund for *rabi* crops, furrow method for vegetables and drip method for fruit crops. Good quality Seed or planting material for horticulture crops are being provided by the ICAR. The villagers followed multi cropping where fruits and vegetables had maximum yield potential, in spite of which the farmers were not satisfied with the yield of the fruit and vegetables. Products were sold in the local market and Shillong, though the prices fetched were not satisfactory.

The Institute Technology Management Unit (ITMU)

The Institute Technology Management Unit (ITMU) was established in 2008 under ICAR plan scheme entitled "Intellectual Property Management and Transfer/Commercialization of Agricultural Technology Scheme (Up-scaling of existing component i.e. Intellectual Property Rights (IPR) under ICAR Headquarters Scheme on Management and Information Services)" funded by ICAR. ITMU acts as a facilitating and supporting unit to identify the emerging technologies and to manage the IP portfolios of the institute. ITMU is also engaged in capacity building in IP Management (Training, Workshop, Seminar, etc) and has organized 19 meetings from August 2015 to December 2016 related to IPR Technology Commercialization and developing collaboration research, plant variety registration, etc. ITMU also facilitates the documentation of the Institute's IP assets, plays an advisory role for various projects undertaken by ICAR, analyses the commercial potential of IP Assets, technology transfer and commercialization including making reports and monitoring. Five patents have been applied under patent, copyrights, plant variety by the ITMU unit of our institute which is under various stages for the grant of patent. Under Commercialization of Technologies, two numbers of technologies have been commercialized viz. meat & poultry products. Multiplication of variety Megha Turmeric 1 and Fruit Fly Trapping Kit RC1: Technology for management of fruit flies in Fruits and Vegetables are under process of commercialization. Facilitating a Memorandum of Agreement under Agri Business Incubation Program – "Arise, Launch Pad for Agri-Startup of ZTM & BPD Unit, ICAR-IARI" along with M/s Jeev Anksh Eco Products Private Limited which has requested for incubation at ZTM & BPD Unit, IARI for the project on "Setup of Certified Organic Food Processing unit in Northeast India". The Unit has facilitated signing of MoU between ICAR RC for NEH Region, Umiam and Ri-Bhoi Mihngi Multi-Purpose Co-Operative Society Ltd. and licensing for seed multiplication of Megha Turmeric1 was done on 8th November, 2016 in the presence of Shri Sudarshan Bhagat, Hon'ble Union Minister of State of Agriculture and Farmers Welfare.

Fig 76. Signature of MoU between ICAR RC for NEH Region, Umiam and Ri-Bhoi Mihngi Multi-Purpose Co-Operative Society Ltd. for licensing seed multiplication of Megha Turmeric1

Agri- Business Incubation (ABI)

The ABI centre in ICAR RC for NEH region, Umiam has conducted a three months training programme on Entrepreneurship Development of Manufacturing of Agricultural Small Farm Tools and Implements in the Division of Agricultural Engineering, ICAR Research Complex for NEH Region, Umiam. Two incubates recently graduated under ABI whose trainings commenced from 29th September to 3rd December while two other incubates are still pursuing the said programme awaiting successful completion. After the completion of the training, ICAR will provide them the license for commercialization of approved technologies developed by the institute. A national cold chain summit was organized by ICAR Research Complex for NEH Region, Umiam under Agri- Business Incubation (ABI) Centre in collaboration with the ASSOCHAM, Ministry of AYUSH, Government of India on 4th and 5th October, 2016 in Shillong, Meghalaya wherein 67 participants attended the said programme. The aim of the summit was on developing entrepreneur's skill on food processing industry for boosting food industry in North Eastern Region.

ANIMAL HEALTH

Genetic characterisation of *Aeromonas* spp.

Aeromonas spp. is a food borne pathogen generally affecting fish, humans and other animals. A comparative genomic study of publicly available whole genome sequences of *Aeromonas* spp. was done to deduce phylogenomic relationship and possible evolutionary trends (Fig 1). Results revealed that there were Open pan-genome for all three species with pan-genome sizes of 11345, 7589 and 6884 genes for *A. hydrophila*, *A. veronii* and *A. caviae*, respectively. Core-genomes of *A. hydrophila*, *A. veronii* and *A. caviae* consisted of 3508, 3344 and 3380 genes, respectively. A new indicator - RCP for estimating genomic diversity in a collection of pathogens was developed. RCP was highest for *A. caviae* (0.49), followed by *A. veronii* (0.46) and *A. hydrophila* (0.38). Phylogenomic network analysis highlighted influence of homologous recombination and lateral gene transfer in the evolution of *Aeromonas* spp.

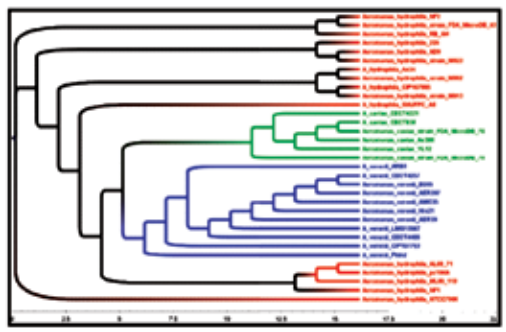


Fig 1. Evolutionary tree of Aeromonas spp. showing early divergence of A. hydrophila into two separate clades possibly due to homologous recombination

Antimicrobial resistance at the interface of human and animal health

ESBL isolates of diverse origin were analysed for molecular traits and phenotypic characters. PCR screening of isolates targeting genes for tetracycline and chloramphenicol resistance revealed highest incidence for *tetB* and *cmlA* gene, respectively. Source comparison of isolates by Tukey Post hoc analysis identified pork as high risk source for ESBL genes ($P<0.01$) than beef and mutton. On the other hand beef samples were most prolific source for fluoroquinole resistance genes as compared to chicken, mutton and pork ($P<0.01$). Similarly, chroramphenicol resistance genes had higher incidence in isolates of mutton origin ($P<0.01$). However, year-wise comparison by Kruskal-Wallis tie did not reveal any significant difference (Fig 2).

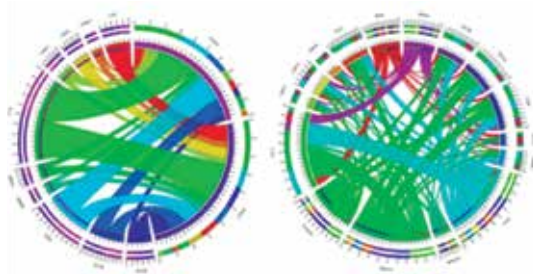


Fig 2. Circos plots of incidence of antibiotic resistance genes in yearwise (left) and sourcewise (right) manner

Analysis of resistance property of Pseudomonas sp. against various heavy metals

A study for isolating bacteria from environmental niches with regard to stress adaptation was initiated. Sampling was done from effluent discharge points and isolates were selected on their ability to grow at enhanced concentrations of Copper, Lead and Cadmium. Ten *Pseudomonas* sp. isolates were selected for analysis of heavy metal resistance potential. The heavy metals selected were Copper sulfate ($CuSO_4.5H_2O$), Lead Nitrate ($PbNO_3$) and Cadmium chloride ($CdCl_2$) and the concentrations used were 5mg, 10mg and 15mg. 10 isolates showed complete resistance towards copper sulfate and lead nitrate whereas 6 isolates were sensitive towards cadmium chloride and 2 isolates showed complete resistance. Another 2 isolates were resistant to 5mg Cadmium Chloride but sensitive towards the 10mg and 15mg concentration. Cadmium resistance was relatively lower than resistance to copper and lead. Four of the *Pseudomonas* sp. showing resistance to the selected three heavy metals was used for studying the effect of lead nitrate against bacterial growth. It was observed that the bacterial isolates were resistant to the heavy metal which was indicated by the increase in population density with time.

Molecular characterization of fermented food bacteria

Characterization of lactic acid bacteria (LAB) from NE region by biochemical (Phoenix 100), molecular (16SrRNA gene sequencing) and functional characters was done. Newly identified isolates were *Lactobacillus brevis* (11), *Lactobacillus plantarum* (5) and *Lactobacillus pobuzihii* (4). Riboflavin production potential was present in 87% isolates and Amylase production was exhibited by 77% isolates. Of these LABs, 61% was resistant to bile salts indicating their putative use as probiotic.

Sero-surveillance of important viral diseases in animals

A total of 2,524 porcine serum samples from Meghalaya (1713), Assam (202), Tripura (305), Nagaland (150) and Manipur (154) were received for viral disease screening such as Porcine Respiratory and Reproductive Syndrome virus (PRRSV), Classical swine Fever virus (CSFV), Porcine Circo virus (PCV). The ELISA based results revealed 88 (3.48%), 538 (21.3%) and 1290 (51.1%) porcine serum positive for PRRSV, CSFV and PCV, respectively. Samples of caprine serum (5), caprine nasal swabs (28), porcine tissue samples (25) and canine serum (2) were received from disease diagnostic laboratories of Meghalaya for screening of various diseases. Six (18.1%) caprine nasal swabs were positive for Peste des Petits Ruminant Virus (PPRV). All the porcine tissue samples were positive for CSFV. Bovine serum (567) collected from different districts of Meghalaya were also screened for Bovine Viral Diarrhea virus (BVDV) and bovine herpes virus 1 (IBR). 8.8% and 40.2% of bovine serum were positive for BVDV and IBR, respectively.

Cell lines for isolation of viruses

Fifteen different cell lines are maintained in the cell culture laboratories for various research purposes. Among these, MDCK, Vero, RK-13, BHK-21, Pk-15, MCF-7, HeLa, QT-35 cell lines are supplied to different institutes of North East Region (IIT Guwahati, NEIGRIMHS, C.V.Sc. Aizawl, C.V.Sc. Khanapara, NRC on Pig Guwahati) and NIVEDI, Bengaluru. In addition, MDCK cell line is used for isolation of CSFV and Mareks Disease Virus (MDV) and RK-13 cell line for CSFV. Peste des Petis Ruminant Virus (PPRV) isolation is carried out in B95a and Vero cell line (Vero/h SLAM). Vero cell line is also used for isolation of Goat Pox Virus (GPV). QT-35 cell line is used for isolation of Duck Pox Virus (DPV).

Development of an indigenous RK-13 cell line adapted CSFV isolate

Classical Swine Fever Virus was isolated from Field outbreak samples and the virus was adapted in RK-13 cell line (Fig 3). Presence of virus in RK13 cell line was confirmed through conventional PCR and Real Time PCR by targeting the E2, NS5B and 5'NTR genes of CSFV, respectively (Fig 4-6).

The presence of CSFV in RK-13 cell line was also confirmed by an Indirect Immunoperoxidase test

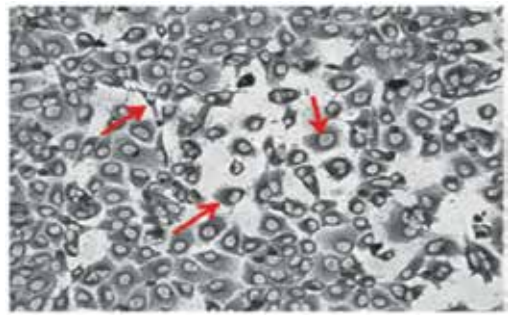


Fig 3. CSFV infected RK-13 cells (P-25) showing cytoplasmic staining in I-IPT

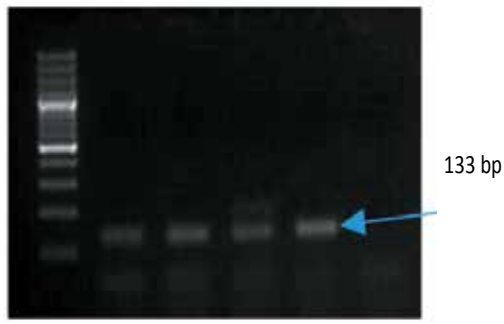


Fig 4. Detection of CSFV in RK13 cell line with partial 5'NTR gene primer

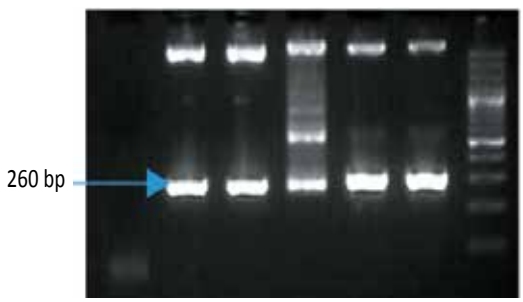


Fig 5. Detection of CSFV in RK13 cell line with partial E2 gene primer

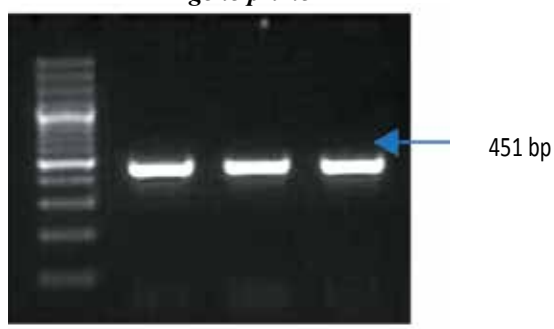


Fig 6. Detection of CSFV in RK13 cell line with partial NS5B gene primer

(I-IPT) as per the method described in the European Union diagnostic manual with slight modification. The Indirect-IPT was performed in various passages (P21-P25) of CSFV infected RK-13 cell line. The presence and viral load of CSFV in RK-13 cell line was also confirmed by flow cytometer (BD Fortessa). It was observed that there was 52.0% increase in viral load/count in stained treated/infected RK-13 cells as compared to unstained treated/infected cells (Fig 7).

This indicates the presence of Classical swine fever virus within the RK-13 cells.

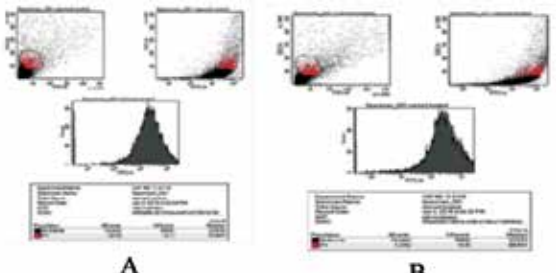


Fig 7. Comparison between stained control (A) and stained treated (B) by Flow cytometer

Development of in-house indirect ELISA kit for detection of CSFV antibody in serum

An Indirect ELISA for CSFV antibody detection using CSFV P-25 adapted in RK-13 cell line was developed and standardized. The virus containing media was precipitated and purified. The precipitated cell lysate was used as antigen to formulate in-house indirect ELISA for the detection of CSFV antibody status in serum samples. The concentrated cell culture antigen was diluted in coating buffer and 100µl of the diluted antigen was added to the plate and incubated at 37°C for one hour. 1:40 antigen and 1:100 antibody dilutions is optimal concentration for the standardization of the kit. For the validation of the in-house ELISA kit, 22 serum samples each from Department of Microbiology, AAU, Khanapara and ICAR, Umiam were tested. The result of each sample from ICAR was cross checked with commercial IDEXX CSFV Ab ELISA kit.

Diagnostic services rendered

Different clinical samples including swab and tissue samples were collected/received from various states (Meghalaya, Nagaland, Assam, Uttar Pradesh) for screening of bacterial pathogens. The major bacterial pathogens observed were *E. coli*, *Pseudomonas* sp., *Staphylococcus* sp. and *Pasteurella multocida*. A major outbreak of *Haemorrhagic septicaemia* (HS) in buffaloes of Nagaland was diagnosed and *P. multocida* belonging to serogroup B was identified as the causative organism (Fig 8a-b). *E. coli* (74), *Klebsiella* sp. (28), *Aeromonas* spp. (4) and *Staphylococcus* sp. (1) were also isolated from tissues (12), water (27), feces (16), milk (13) and swabs (72). Four pond water samples harbored *Aeromonas hydrophila*, *Klebsiella pneumonia*, *E. coli* and *Enterobacter cloacae*. Fecal sample of pigs (113), cattle (77), goats (46), sheep (106) and yaks (270) collected from different places were examined for diagnosis of gastrointestinal parasitic infections. The

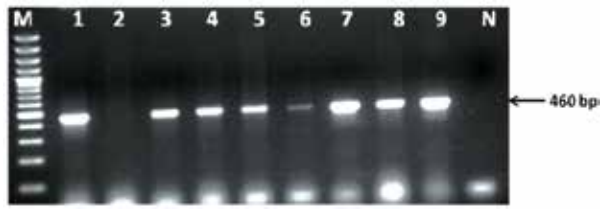


Figure 1: Amplifiation of P. multicida specific KMT1 gene (460 bp). Lane M : 100bp plus DNA ladder; Lane 1-9: Samples; Lane N : NTC

Fig 8a. Amplification of P. multocida specific KMT1 gene (460 bp). Lane M: 100bp DNA ladder; lane 1-9: samples; lane N: NTC

Figure 2: Amplifiation of P. multicida serogroup B (bcbD gene, 760bp) Lane M : 100bp plus DNA ladder; Lane 1-8: multocida isolates; Lane N : NTC

Fig 8b. Amplification of P. multocida serogroup B (bcbD gene, 760bp). Lane M: 100bp DNA ladder; Lane 1-8: P. multocida isolates; Lane N: NTC

percentage of infections in pigs, cattle, goats, sheep and yaks were 64.60%, 28.57%, 28.26%, 22.64% and 35.55%, respectively. In pigs *Balantidium coli* (26.54%), *Ascaris suum* (21.23%), Strongyle spp. (20.35%) and *Eimeria* spp. (12.38%) were recorded. In cattle *Eimeria* spp. (12.93%), *Strongyle* spp. (11.68%) and Amphistome (3.89%) were recorded. In goats Strongyle (15.21%) was the predominant species followed by *Eimeria* spp. (10.86%), *Moniezia* sp. (8.69%), *Strongyloides* sp. (6.52%) and *Trichuris* sp. (4.34%). In sheep only *Eimeria* spp. (16.98%), Strongyle sp. (4.71%) and *Trichuris* sp. (0.94%) were found. However, in yaks *Eimeria* spp. (19.25%), *Neoascaris* sp. (11.92%), Strongyle spp. (5.92%), *Trichuris* sp. (1.85%) and *Strongyloides* sp. (0.74%) were recorded. *Babesia bigemina* infection was recorded in blood samples of cattle from Meghalaya. High rate of infections with coccidia (*Eimeria* sp.) were also observed in buffalo calves of Meghalaya.

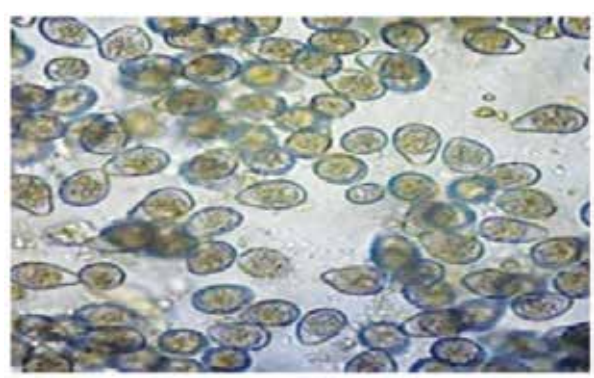


Fig 9. Coccidiosis in Buffalo

AICRP on Animal Disease Monitoring and Surveillance (ADMAS)

The major livestock diseases reported from different districts of Meghalaya are Haemorrhagic Septicaemia (HS), Black Quarter (BQ), Foot and Mouth Disease (FMD) and Classical Swine Fever (CSF) (Fig 10). Few cases of Anthrax, Goat pox, Contagious ecthyma and Infectious Keratoconjunctivitis were also reported. Highest sero-positivity of swine and bovine brucellosis were seen in West Jaintia Hills and Ri-Bhoi districts, respectively. Sero-positivity for Infectious Bovine Rhinotracheitis (IBR) and Bovine Viral Diarrhoea (BVD) was highest in West Khasi Hills and West Garo Hills, respectively. In case of caprine diseases, the highest sero-positivity of PPR and Bluetongue were recorded in East Khasi Hills and East Jaintia Hills, respectively. In swine, highest sero-positivity of CSF and PRRS were recorded in East Jaintia Hills and East Khasi Hills, respectively.

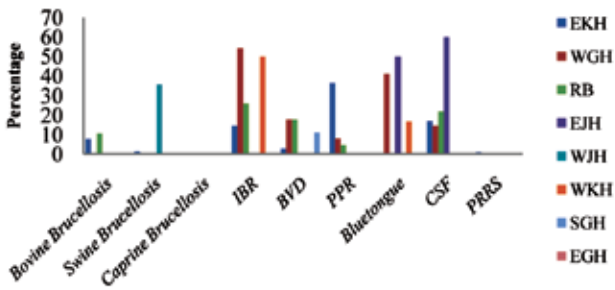


Fig 10. Seropositivity of important livestock diseases in Meghalaya (April to December 2016)

Listeria in food and environment

A total of 415 samples from dry fish (87), pork (45), raw/fermented fish samples (18), milk/milk products (59), vegetable/ fruits (26), soil (9) and water (26) samples were collected and screened for *Listeria* spp. On basis of phenotypic and genotypic identification, 13 presumptive *Listeria* spp. were isolated and all these 13 isolates were positive for genus specific *prs* genes and are non pathogenic.

Molecular characterization of *Mycobacterium* spp. isolated from man, animal and environmental samples

52 (9.18%) Mycobacterial isolates recovered from 566 samples (232 animal, 120 human, 214 environment) were processed for molecular characterization. DNA was extracted and partial sequence of 441bp fragment was amplified using *Mycobacterium* genus specific *hsp65* gene primer. Purified amplimers of *hsp65* gene were sequenced. Altogether, there were 29 NTM isolates (26 from animal sources; 2 from human and 01 from environmental sources) and 23 were Mycobacterium tuberculosis bacillus complex (MTBC) (22 human origin and 01 animal source).

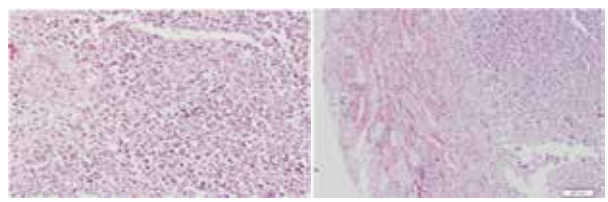
Japanese encephalitis (JE) peptide ELISA and epidemiological investigation

Peptide based diagnostic assay for Japanese Virus Encephalitis antibody detection in pigs is being standardized. Two synthetic peptides have been found to be effective in the ELISA test namely NS1_sam (EHRAW) and E-khu-KDKQINHHRHKAGS. The standardization is carried with pooled field positive sera and negative sera. The 5000ng peptide/well was the optimized peptide antigen concentration and 1:100 was the sera dilution. Porcine sero-surveillance in Lakhimpur district of Assam by indirect ELISA revealed 3.85% JE infections. Analysis of retrospective human JE cases (2013, 2014, 2015) revealed that there is an association between the cases of human JE and sero-positivity of porcine serum. It also showed that majority of JE cases were during the monsoon months especially in July. The epidemiological investigation of these blocks shows that few blocks were more affected with JE and the proximity of water bodies, close association of pig-human with adequate exposure of mosquitoes are the contributing reasons.

Studies on oncogenic viruses of Poultry

Detection of oncogenic viruses by molecular based PCR method targeting specific genes. Marek's disease virus (MDV) - 7 nos., Avian leukosis virus (ALV)- 4 nos. and Reticuloendotheliosis virus (REV)- 3 nos. were detected during the reported period. Histopathology of tumour showed the infiltration of immature lymphocytes

(a) Tumor in lung ***(b) Tumor in Kidney***



Tumor lung tissue infiltrated with lymphomas. H&E stain (20X) ***Kidney tissues infiltrated with lymphomas. H&E stain (10x)***

Fig 11. Histopatrology of tumour

into the tissues of kidney and lungs (Fig 11a-b). Sero-screening of oncogenic ALC and REV viruses by ELISA method showed 59 samples were positive for REV while 51 samples were positive for ALC out of 92 random samples tested in poultry.

Studies on therapeutic effects of Indigenous plant (*Roselle sabderiffa*)

The Proximate analysis of Roselle calyces was done (AOAC, 1980) to determine the nutritive content and found the Dry matter (DM) content to be 90.47%, Crude protein (CP) - 08.31%, Crude fiber (CF) - 11.53%, Ether extract (EE) - 00.80%, Total ash (TA) - 05.69% and the Nitrogen free extract (NFE) was calculated to be 64.14%. The fold change expression of genes regulating apoptotic pathway (Fig 12) and regulatory proteins genes (Fig 13) in the roselle treated Hela and MCF-7 cells were studied. The apoptosis in Hela cells is likely induced both by intrinsic and extrinsic pathways. However in MCF cells, the pathway seems incomplete may be due to inhibition of expression of regulatory proteins.

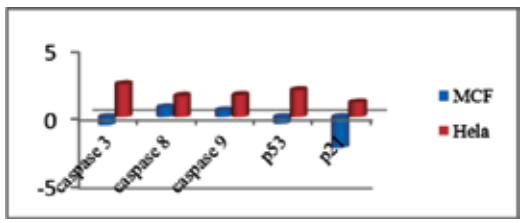


Fig 12. Fold change expression of genes regulating apoptotic pathway

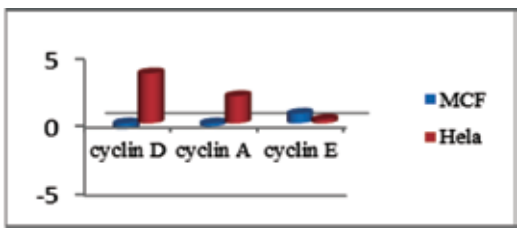


Fig 13. Fold change expression of regulatory proteins genes

Fold change expression of nine pro and five anti apoptotic genes (Fig 14-15) in Hela and MCF cells treated with Roselle aqueous extract were studied and found the variation in the expression. However no expression of Puma gene in Hela cells and bclw gene in MCF cells may indicate the lack of receptors in these cells and warrants further studies to validate the findings.

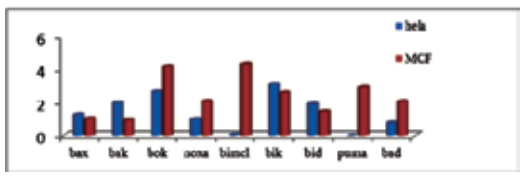


Fig 14. Fold change expression of pro apoptotic genes

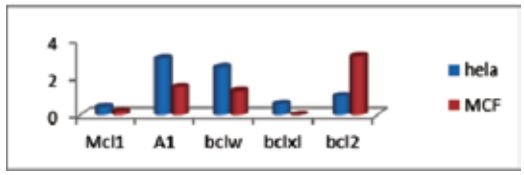


Fig 15. Fold change expression of anti apoptotic genes

Surveillance of Brucellosis

A total of 2055 sera sample from three states *viz*., Meghalaya (n=1870), Tripura (n=48) and Nagaland (n=137) were screened by ELISA. Sero-positivity of bovine brucellosis and porcine brucellosis was 4.85% and 3.44%, respectively in Meghalaya. In Nagaland sero-postivity of porcine brucellosis was 6.57%. Nine isolates were confirmed as *Brucella abortus* and one as *Brucella suis*. Two presumptive colonies of *Brucella* were isolated from placenta of two aborted cows, identified and confirmed as *Brucella abortus* by Real time PCR (Fig 16).

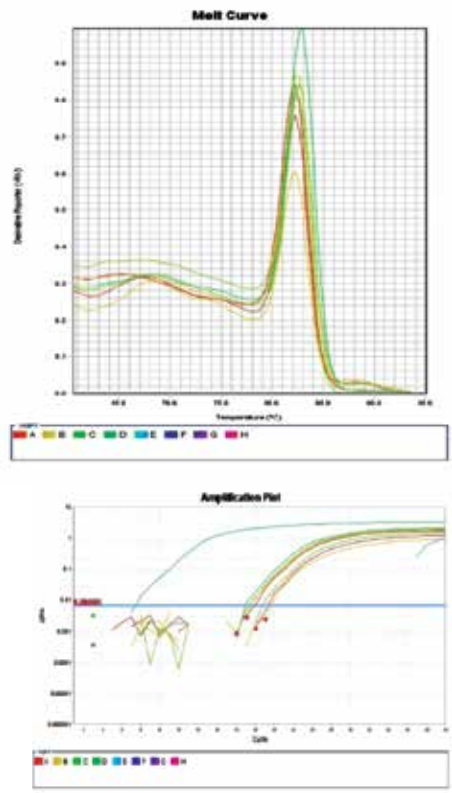


Fig 16. Melting curve and Amplification plot of bcsp gene of Brucella isolates

Protozoan parasitic infections of swine in Meghalaya

Fecal samples of pigs from three districts of Meghalaya *viz*. Ri Bhoi, East Khasi Hills and Jaintia Hills (Fig 17) were collected and examined for presence of any

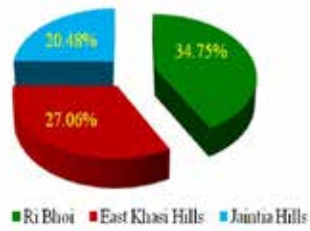


Fig 17.District wise prevalence

gastrointestinal (G.I.) protozoan parasites. Age wise, infections was recorded in all age groups of pigs *viz.*< 6 months (34.29%), 6-12 months (35.61%) and >12 months (15.66%) and was comparatively lower in >12 months old pigs. Six species of G.I. protozoan parasites were identified under three Phylum (Ciliophora, Sarcomastigophora, Apicomplexa). Under Phylum- Ciliophora, *Balantidium coli* (13.38%); under Sarcomastigophora - *Entamoeba polecki* (1.40%) and *Giardia* sp. (0.47%) while under Apicomplexa - *Cryptosporidium* sp. (2.62%), *Eimeria* spp. (10.02%) and *Isospora suis* (1.69%) were identified (Table 1). Different species of *Eimeria* were identified and species wise *E. debliecki* (42.99%) infection was highest followed by *E. suis* (27.10%), *E. porci* (15.89%), *E. perminuta* (10.28%), *E. spinosa* (2.80%) and *E. cerdonis* (0.93%) (Table 2). The oocyst per gram (OPG) of feces ranges from 50-1450.

Table 1. Age wise prevalence of G.I. protozoan parasites in pigs of Meghalaya

Age (months)	Sample examined	Sample positive	Ciliophora	Sarcomastigophora		Apicomplexa		
			B. coli	*E. polecki*	*Giardia* spp.	*Eimeria* spp.	*I. suis*	*Cryptosporidium* spp.
<6	417	143 (34.29)	46 (11.03)	1 (0.24)	4 (0.96)	34 (8.15)	7 (1.68)	28 (6.71)
6-12	351	125 (35.61)	62 (17.66)	14 (3.98)	1 (0.28)	43 (12.25)	10 (2.85)	-
>12	300	47 (15.66)	35 (11.66)	-	-	30 (10)	1 (0.33)	-
Total	1068	315 (29.49)	143 (13.38)	15 (1.40)	5 (0.47)	107 (10.02)	18 (1.69)	28 (6.71)

Figures in parentheses indicates percent positivity

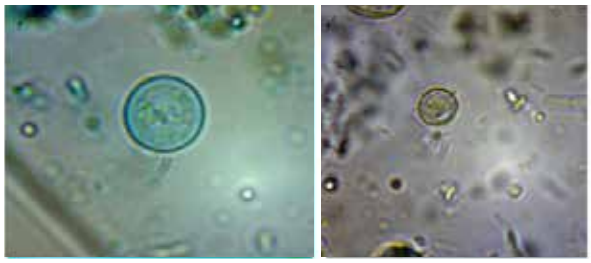
Table 2. Percent prevalence of different species of *Eimeria* in pigs of Meghalaya

***Eimeria* spp.**	**Age groups**			**Total**
	< 6 months	6-12 months	>12 months	
E. debliecki	17 (36.96)	16 (34.78)	13 (28.26)	46 (42.99)
E. porci	4 (23.53)	8 (47.05)	5 (29.41)	17 (15.89)
E. suis	11 (37.93)	13 (44.83)	5 (17.24)	29 (27.10)
E. perminuta	2 (18.18)	2 (18.18)	7 (63.63)	11 (10.28)
E. cerdonis	-	1 (100)	-	1 (0.93)
E. spinosa	-	3 (100)	-	3 (2.80)

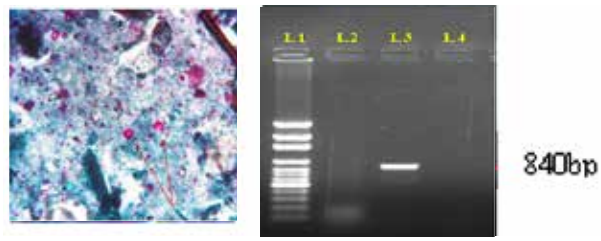
Figures in parentheses indicates percent positivity

Differential diagnosis of Cryptosporidiosis in pigs

Diagnostic sensitivity for detection of *Cryptosporidium* sp. in faecal samples of pigs varies with different techniques. Malachite green stain (0.2%) (Fig 18a), Sheather's sugar solution (Fig 18b), Modified Ziehl Neelsen stain (Fig 18c) and



a ***b***



c ***d***

Fig 18 Diagnosis of Cryptosporidiosis

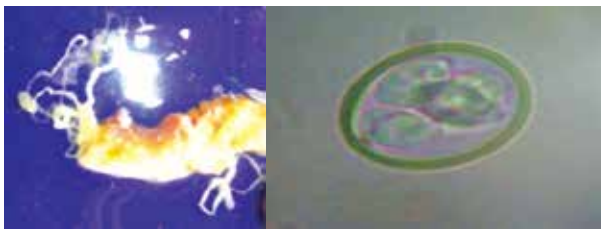
Nested PCR (Fig 18d) detected *Cryptosporidium* spp. with 100%, 100%, 92.85% and 96.42% specificity, respectively.

Gastrointestinal parasitic infections in poultry of North Eastern Region of India

Among poultry birds that are maintained in different villages of Meghalaya in unorganized way, 53.12% fecal samples of those poultry birds were recorded as positive for GI parasitic infections. Oocysts of *Eimeria* spp. and eggs of *Ascaridia galli* were identified in fecal samples of these poultry birds. The poultry birds maintained in organized farms of Meghalaya revealed 19.64% G.I. parasitic infections. Infections with different species of *Eimeria* and *Ascaridia galli* were recorded in organized poultry farms. Thus, overall 35.09% fecal samples of poultry birds of Meghalaya were recorded as positive for G.I. parasitic infections. Molecular diagnosis using PCR identified different species of *Eimeria* as *E. maxima*, *E. praecox* and *E. acervulina* .

The fecal samples collected from both organized and household poultry farms of Manipur, revealed overall 57.43% as positive for GI parasitic infections. Coccidia infections caused by different species of *Eimeria* were found to be predominant (52.02%) and among positive, 90.58% infections were recorded as coccidian infections. Infections with *Strongyloides* spp. were recorded in 22.29% fecal samples. Mixed infections with *Eimeria* spp. and *Strongyloides* spp. were recorded in 15.54% fecal samples (Fig 19).

Post mortem examination of G.I. tracts of poultry birds of both local birds and organized farms collected from butcher shops of Meghalaya and organized farm revealed overall 23.88% as positive for G.I. parasitic infections. Indigenous poultry birds were found as 44.61% positive whereas birds maintained in farm condition were found 4.34% as positive for G.I.



(a) Raillietina spp. ***(b) Eimeria tenella oocyst***

(c) Distension of caeca of chicks due caecal coccidiosis ***(a) Haemorrhage in caeca due to caecal coccidiosis***

Fig 19. G.I. parasites of poultry

parasitic infections. Among positive, *Raillietina* spp. (75.00%) and *Ascaridia galli* (15.62%) were identified after postmortem examination of G.I. tracts collected from butcher shops and caecal coccidiosis caused by *E. tenella* were diagnosed in 9.37% poultry birds collected from organized farms. Causes of mortality in an organized poultry farm of Ri-Bhoi district of Meghalaya was diagnosed as due to caecal coccidiosis caused by *E. tenella*. Administration of anticoccidial agent containing a mixture of Amprolium and sulfaquinoxaline to apparently sick birds and rest of the flock, controlled mortality in this poultry farm.

Standardization of fractionation of *Zanthoxylum armatum* extracts for nanoemulsion synthesis

Standardization of essential oil synthesis, fractionation from non-polar to polar solvents (Ether, ethyl acetate, methanol and aqueous extracts) of *Zanthoxylum armatum* has been initiated. These extract fractions were checked for antibacterial and insecticidal activities and have shown to be very promising. The oily fractions will be used for nanoemulsion synthesis for better bioavailability and functions.

Training/Health camps organized under TSP

For improving the livestock farming, training programmes and health camps (Fig 20-21) were organized in different villages of Meghalaya *viz*. Umshorshor, Umsawkhwan and Mawnosynrum under TSP (MGMG programme). A total of 155 nos. of farmers were benefited with the programmes. Inputs in the form of improved breeds of backyard poultry (Kuroiler), poultry feeds and veterinary medicines such as antibiotics, anthelmintics, anticoccidials, mineral mixtures, vitamin supplements and topical cream were distributed to these farmers.

Fig 20. Training programme at Umshorshor village

Fig 21. Animal health camp

ANIMAL PRODUCTION

Life time productivity traits of developed-upgraded pig variety

The length of productive life and life time production traits are important in commercial swine

production system because of their association with stability, productivity and cost of production. The length of productive life is the numbers of days between sow age at first farrowing and sow age at weaning of her last farrowing, while life time production traits are the sum of all individual measurements of each trait during the life time of a pig. The life time production traits was calculated from the record for the upgraded pigs developed in the pig breeding farm of the institute which has 75% of Hampshire inheritance and 25% Khasi local inheritance. The details of life time productivity traits are given in Table 3. Life time productivity traits of the pig like total litter size at birth (51.83±2.70), average litter size at birth (9.13±0.17), total litter weight at birth (44.07±2.29), average litter weight at birth (7.75±0.14), total litter size at weaning (47.17±2.69), average litter size at weaning (8.29±0.20), total litter weight at weaning (446.19±25.43) and average litter weight at weaning (78.46±1.91) is comparable to other breeds.

Increasing a sow's length of productive life results in higher sow life time productivity and lower gilt replacement costs. The commercial swine producers could control the proportion of sows in the herd with long length of productive life. Thus, the developed upgraded pig would be profitable in the north eastern region of India.

Table 3. Life time productivity traits of developed-upgraded pig variety

Sow no	Average Litter size at Birth	Total Litter Weight at Birth	Average Litter weight at Birth	Total Litter size at weaning	Average Litter size at weaning	Total Litter weight at weaning	Average Litter weight at weaning
1	9.5	48.5	8.08	54	9	510.84	85.14
2	9.7	49.3	8.21	52	8.66	491.92	81.98
3	9	45.9	7.65	50	8.33	473	78.83
4	9.2	46.75	7.79	49	8.16	463.54	77.25
5	8.6	36.55	7.31	38	7.6	359.48	71.89
6	8.8	37.4	7.48	40	8	378.4	75.68
Mean ±SE	9.1± 0.1	44.0± 2.2	7.7±0.1	47.1±2.6	8.2±0.2	446.1±25.4	78.4±1.9

Formulation of innovative fortified feed from kitchen waste for pig to combat stress

Supplementing poor quality feed like kitchen or vegetable waste with molasses will improve palatability of feed and increase feed intake as well as overcome feed scarcity. Experimental group-1 was fed with kitchen waste (60%) mixed with standard concentrate mixture (40%) and group-2 was fed kitchen waste (53%) and 7% molasses mixed with standard concentrate mixture (40%) while the control group-3 was fed solely with standard concentrate mixture. The body weights of animals were recorded fortnightly and blood samples were collected at monthly interval for estimation of stress parameters. The details of the growth performance and concentration of blood stress biomarkers are presented in the Table 4. The results showed that the pigs (group-2) which were fed with kitchen waste with 7% molasses have higher growth rate (109g/day) as compared to control (Table 4). Similarly lowest serum cortisol level was observed in group-2 as compared to control and group-2 (Table 4). The study conclude that feeding of the new formulated fortified feed from kitchen waste with 7% molasses had better growth rate and may help in protecting the pigs from climatic stress.

Table 4. Effect of fortified feed from kitchen waste on growth performance and stress biomarkers in pigs

Parameters	Group -1	Group -2	Group -3
Av. Initial body weight (kg)	5.25	5.45	5.6
Av. Final body weight(kg)	37.0	40.0	35.0
Total weight gain (kg)	31.75	34.55	29.4
Weight gain per/day (g/d)	100	109	93
Av. DMI (kg/day/animal)	0.76	0.88	0.65
DM intake/100kg b.wt (kg)	2.05	2.2	1.85
Cortisol (µg/dl)	38.40	32.5	44.25
Superoxide Dismutase (Units/ml)	1.08	1.12	1.04

Relative RNA expression of heat shock protein (HSP) in different breeds of pigs

Heat shock proteins (HSP) expression is increased when cells are exposed to elevated temperatures or other stress. The relative expression of different heat shock protein (HSP) *viz*., HSP20, HSP70 and HSP90 in the different pig breeds were

studied using real time PCR. The relative expression of heat shock proteins *viz.,* HSP20, HSP70 and HSP90 of the target genes were determined by quantitative real time PCR in indigenous pigs, and compared with crossbred pigs. Beta-actin was used as a housekeeping gene/internal control to normalize the expression of target genes. Relative expression level of the HSP40 was higher in Khasi local pig as compared to Hampshire and crossbred pigs. Whereas the expression level of HSP70 and HSP90 differ among the pig breeds. The study indicates that the Khasi local pigs may be stress tolerant as compared to other pig breeds.

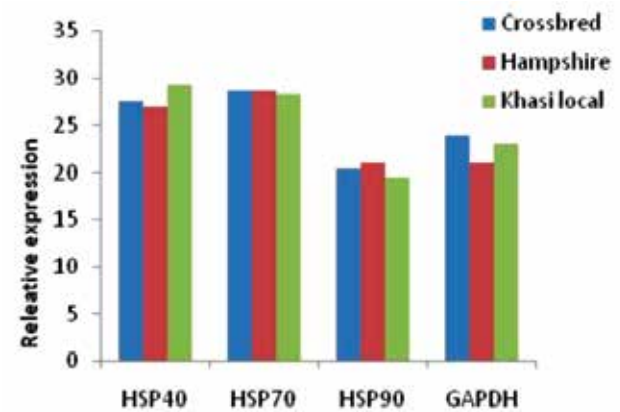


Fig 22. Relative RNA expression in different breeds of pigs

Pregnancy rate, farrowing rate and litter size of liquid semen and frozen thawed boar semen

A total of 93 sows/gilts were inseminated with three billion sperm in 95 ml of liquid semen stored up to 3 days. For frozen semen a total of 10 straws of capacity 0.5 ml were thawed and mixed with 60 ml pre-warmed (Beltsville Thawing Solution) extender very slowly and 65 ml thawed semen was inseminated per sow/gilt within 5 min of thawing. Double cervical artificial inseminations were carried out using disposable golden AI pig catheter (IMV Technologies, France) in sows at 30 and 42 hours following onset of oestrus with a dose of 4-5x10^9 frozen thawed sperm per insemination. The Pregnancy rate, farrowing rate and litter size at birth following AI with liquid semen on different days of preservation are shown in Table 5. There was no significant difference in days regarding pregnancy rate, farrowing rate and litter size from day 0 to day 3. However, the litter size at birth was significantly reduced after day 3 ($P<0.05$). However, the pregnancy rate, farrowing rate and litter size in frozen thawed semen were significantly lower than liquid semen stored from day 0 to 3. It may be concluded that liquid semen stored for 0-3 days is more efficient than frozen thawed semen in terms of preservation of sperm characteristics and fertility and may be used effectively in crossbreeding native pigs of north-eastern India.

Table 5. Pregnancy rate, farrowing rate and litter size of liquid semen and frozen thawed boar semen

Parameter	Liquid semen				Frozen thawed semen
Days	Day (0)	Day (1)	Day (2)	Day (3)	
Sperm motility	83.2 ±0.3	80.7 ± 1.5	79.3 ± 1.7	77.6 ± 1.8	58.2 ±2.9
Number of animal inseminated	27	25	21	20	32
Pregnancy rate (%)	81.00	79.40	74.00	75.56	51.25
Farrowing rate (%)	77.77	76.00	68.75	66.66	40.62
Litter size at birth	9.3 ± 0.3	9.5 ± 0.6	8.2 ± 0.5	8.6 ± 0.8	6.8 ± 0.18

Effect of season on semen quality in crossbred boars with different level of Hampshire and indigenous inheritance in North Eastern India

Four healthy sexually matured fertile boars aged about 2-4 years of different genetic groups of Hampshire crossbred *viz* 50%, 75%, 87.5% exotic inheritance and indigenous pig of Meghalaya (Sniang Megha) routinely used for breeding programs on the pig breeding farm were utilized to investigate the effects of season and crossbreeding of local indigenous pig with different level of Hampshire inheritance on semen quality, quantity and freezabilty (Table 6).

Table 6. Semen volume (ml) after ejaculation from crossbred boars with different level of Hampshire and indigenous local inheritance in different seasons

Season	Crossbred pigs with level of inheritance			Pure Hampshire
	50%	75%	87.50%	
Spring	121	172	236	238
Rainy	125	167	223	215
Autumn	132	168	251	247
Winter	138	178	259	256

Table 7. Post-thaw sperm motility after freezing of semen samples from crossbred and Hampshire boars in different seasons (Mean ±SE)

Seasons	Crossbred with level of Hampshire inheritance			
	50%	75%	87.5%	Hampshire
Spring	63.67	59.94 ± 0.54	56.76 ± 0.73	56.34 ± 0.77
Rainy	61.76 ± 0.56	60.53 ± 0.57	52.56 ± 0.61*	51.23 ± 0.65*
Autumn	63.42 ± 0.61	58.49 ± 0.49	57.46 ± 0.57	57.67 ± 0.56
Winter	62.50 ± 0.37	59.71 ± 0.37	56.45 ± 0.52	57.89 ± 0.53

The study concluded that ejaculates collected in the summer months had the less number of spermatozoa and yielded the least amount of insemination doses than in the autumn and winter period and crossbred boars with 75% Hampshire inheritance and 25% Khasi local produced ejaculates with the greatest number of spermatozoa with better quality for AI (Table 7).

Enhancing reproductive and productive performance of Assam hill goat through selective breeding

A nucleus-breeding flock of selected Assam Hill goats (n=28) as foundation stock based on twinning and triplets kidding of dam, phenotypic characteristics *viz*. body size, conformation, weight for age, their ancestral history on production and reproduction was established.

Resilience/adaptability with round the year cyclicity and high milk production of Murrah buffaloes under agro-climatic conditions of Meghalaya

The studies on adaptability of Murrah buffaloes in this region showed a marked loss of body score and weight loss up to 12-15% in the initial 30 days but recovered well in the next 30-60 days period with improved feeding and managemental adjustments and showed a remarkable resilience to adapt to climatic conditions of North East as validated by haemato-biochemical evaluation. The pooled data of 3 years generated from 12 clinically healthy Murrah buffaloes showed increase in growth rate with average daily weight gain over and above 514.52 gm/day. The age and weight at puberty in buffalo heifers was 727.5 ± 28 days and 430 ± 26 kg, respectively, age at first service 689 ± 35 days, gestation period 309 ± 05 days, birth weight of calf 34.66±02 kg and resumed reproductive cyclicity within 60 ± 18 days postpartum, respectively

Murrah buffaloes showed regular cyclicity as evaluated by haemato-biochemical parameters and validated by ultrasonography even in the months of March to July, in contrast to the buffaloes in its home tract in North India where they show higher incidence of summer anoestrus during these months indicating that Murrah buffaloes may be a part of integrated farming system of North Eastern region. Among all the breeds of buffalo, Murrah is considered best in term of milk production with average milk production range from 2000-2500 litre/lactation and per day milk yield @ 8-12 litre with long lactation length of 300 to 350 days. The average lactation length of 260 days producing total milk yield 1839.83 kg/lactation in Murrah buffaloes reared in North Eastern Region needs more scientific attention for better productivity in terms of milk production.

(a) *(b)*

Fig 23. a) Fetal Fibroblast Cell culture from ear tissue of porcine fetus b) Blastocyst with distinct ICM

Effect of method of isolation of Inner Cell Mass (ICM) from Porcine embryos for preparation of embryonic stem cells

The porcine embryos were produced parthenogenetically from abattoir ovaries after *in-vitro* maturation for 44hrs followed by chemical activation and subsequent culture in porcine zygote medium (PZM). The inner cell mass (ICM) from naturally hatched blastocysts, mechanically removed zona and trophectoderm and enzymatically removed zona and trophectoderm were compared for attachment to feeder layer (mitomycin treated) and cultured with either LIF, bFGF or LIF+bFGF and different concentration of FCS. The results showed that ICM from naturally hatched blastocysts was best for culture (35.30%) followed by mechanical isolation (20.50%) and chemically isolated ICM had lowest (15.75%) attachment and subsequent culture. LIF is must for growth of porcine embryonic stem cells (PESCs) and 5% FCS was found suitable for culture of PESC.The addition of LIF+ bFGF did not

have any significant improvement (P>0.05) than LIF alone in the culture medium.

Enhancing the livelihood security of farm women through livestock technologies

The study was carried out to improve the livelihood security of farm women through livestock technologies. An interview schedule and PRA was conducted in these villages and randomly 50 numbers of farmers from Umlyngka and 58 from Nongsangu were selected. Three -days training programme was conducted in both the villages on the scientific livestock and poultry farming. In Umlyngka, 20 farm women were provided with 400 birds of 6-8 weeks age @ 20 birds per beneficiary along with feed and medicine**.** Fifteen farm women also received minor farm implements to ease the drudgery burden while doing agricultural operations. Out of the 400 birds, a total of 240 birds were sold @ Rs. 180 per kg when they attained an average body weight of 3 kg in the first lot and each farm women earned on an average Rs. 6152/- (Rs. 4420 to 11900) through the sale of birds. Of the 20 farm women, 11 beneficiaries utilized a part of their income in repurchasing new birds. In the second cycle, these farm women repurchased 550 birds of which, 476 numbers of birds were sold @ Rs. 180 per kg after attaining an average body weight of 3.0 kg, thus earning a total income of Rs. 16,696 (Rs. 5,000 to 35,145). The profit earned by the women was Rs. 3356/- (Rs. 700 to 4780) after the cost related to purchase of birds, feed cost and other cost were deducted from the total earning. A part of the profit earned was deposited into bank, paying school fees and buying goods needed for daily use at home. The other beneficiaries, who did not go for repurchase of birds, utilized the income in providing the needs of their children and other household requirements. Again, from these 11 beneficiaries, 5 made another round of repurchase (third cycle) of 210 birds, thus making backyard poultry as a sustainable enterprise for their livelihood. These birds are still remaining with them as they are yet to attain the required body weight for sale in the market. Five farm women have also retained some birds for egg laying for household consumption and occasional sale @ Rs. 10 per egg. Considering the benefits in keeping backyard poultry birds, farm women have decided to continue with this enterprise as a subsidiary activity to supplement household income and nutrition. The success of these women has also motivated others encouraging many farm women and other unemployed youths to come forward and start this enterprise in their village. Whereas in Nongsangu village, out of the 400 birds distributed, only 50 number of birds were sold @ Rs. 180 per kg after attaining an average body weight of 2.5 to 3 kg. The amount from sale of these birds ranges from Rs. 1700 to 3258 and was utilized only for daily family expenses. The reasons for mortality of poultry birds in Umlyngka were mainly due to cold, fever and diarrhoea whereas that in Nongsangu was mainly due to attack of predators and wild birds.

Out of the 20 piglets distributed, 8 numbers of pigs weighing approximately in the range of 60 to 100 kg were sold at an average rate of Rs. 10000 (Rs. 7000 to 12000) in Umlyngka. The profit gained after deducting all the feed cost and other costs ranges from Rs. 2000 to 3000 per beneficiary. This profit however was utilized for purchasing essential commodities at home. The reasons of mortality in Umlyngka were mainly due to diarrhoea and emaciation whereas that in Nongsangu was mainly due to fever and diarrhoea.

Fig 24. Critical Input support to farmers

An Animal Health camp cum Awareness Programme on "Scientific Management of Dairy, Piggery and Poultry Farming to Enhance Livelihood Security" and an awareness Programme cum Input Distribution on "Scientific Dairy Intervention**"** were also conducted on the 20th December, 2016 and 25th January, 2017 in Umlyngka Village. During these programmes, discussions and input distribution were made regarding the feeding and management practices that should be followed while rearing livestock.

Documentation of traditional meat products in the North Eastern region of India

Northeast India harbours a number of traditional meat products which have immense potential for commercialization. In Meghalaya, the popular products identified were *Doh Jem, Tungrymbai, Achar Doh Sniang (Pork Pickle), Doh Snam, Dohkhlieh* and *Jadoh* (Fig. 25). In Mizoram the popular products identified were *Bongsha Rep, Bongsha Rep But, Vawksha Rep, Vawksha Rep But* and *Bongsung***.** The meats used to prepare these products are primarily chicken or pork. In Manipur, people were found to prefer the traditional fish

products. The most popular fish products identified in the State were *Ngari, Hentak, Khazing.* In Sikkim the popular products identified were *Goyang, Chhwelaa* and *Falki.* The meat used to prepare *Goyang* is primarily beef or yak, for *Chhwelaa* is buffalo and for *Falki* legs and head of sheep. These traditional products were found to be more palatable and nutritious than the general meat preparations. The techniques employed for making such products were partially responsible for imparting the characteristic flavour to the products. The most common ones were fermentation, smoking, drying, etc. A step forward for commercializing the products will require standardized technique for each product. Moreover, it was observed that the native meat handlers were ignorant about the importance for maintaining hygiene and quality specifications during preparation of such traditional products. Intervention of certain institutional support mechanisms will enhance the prospect of commercializing.

Doh snam of Meghalaya

Bongsung of Mizoram

Stuffed Doh Snam of Meghalaya

Fig 25. Traditional meat productions in NEH region

Small scale rural entrepreneurship development through scientific pig and poultry production for educated youth

To promote the rural small scale entrepreneurship development, 7 days residential training programmes on the scientific piggery and poultry rearing were given to 83 youths. The youths were divided into two groups (piggery/poultry). Accordingly, each group were given 3 piglets and 100 poultry birds along with feed and medicines. Regular monitoring was also made and supports were given to those poor youth who needed help in constructing pigsty or poultry shed. It was observed that 60% of the rural youth rearing pigs have gone for breeding while the rest 40% for fattening. The pig obtained body weight of 85-97 kg within 12 months. Average litter size was 8.47 in breeding pigs. The mortality rate was 11%. After 3-4 months, the piglets were sold @ Rs. 3000 to 3500. The youths who have gone for fattening have sold the pigs @ Rs. 10000 to 12000 after attaining a body weight of 70 to 80 kg. The profit gained from selling the piglets and pigs was utilized in repurchasing new piglets and household expenses. 50% of the rural youth rearing poultry (vanaraja breed) have sold the birds @ Rs. 220 to 230 when they have attained a body weight of 2-3 kg. The profit gained after selling the birds was utilized in repurchasing new flock of birds and also in purchasing essential commodities at home.

Fig 26. Successful entrepreneur in pig production

Business model for entrepreneurship development in meat processing and innovative value addition

Fig 27. Marketing of the meat products

The Meat Processing Unit has been set up as a business model for entrepreneurship development. The Unit has been set up as per FSSAI norms. The license no. of the unit is 11716003001 95 as given by the licensing authority of FSSAI. Its primary objective is to develop innovative value added meat products, provide hands on training and technical knowledge on meat processing to the educated rural youth for entrepreneurship development in the region. The small scale modern unit includes raw meat area, processing area, cold storage facilities, laboratory and equipment like portioning machine, meat slicer, meat mincer, planetary mixer, sausage filling machine, Bowl chopper, Microwave machine, deep fry pan, Tray sealing machine, Deep-fridge, ice flaking machine, vacuum packaging machine, etc. An extensive work is ongoing for development of innovative meat products. Some of the innovative products made in this unit are ready to eat concentrated pork curry, chicken and pork sausage with fibrous and nutritious vegetables and herbs like beet root, bamboo shoot, etc. and smoked chicken sausage. Different packaging systems are being experimented with different products like vacuum packing, plastic tray packing and polypropylene box packing. The marketing of the meat products were carried out by public-private partnership mode. The meat processing unit provided non-exclusively licensing with M/S Tynrai Farms, Dongktieh, Nongrah, Shillong- 793006 for marketing of the meat products to Meghalaya.

Association of growth hormone gene polymorphism with carcass traits in indigenous chicken of north east India

The association of growth hormone gene polymorphism with carcass traits in indigenous Normal Feathered and Naked Neck chickens of north east India was studied. The PCR-RFLP revealed 3 genotypes in Naked Neck (A1A1, A1A3 and A3A3) and 2 genotypes in Normal Feathered (A1A1 and A1A3) chicken. Although, there was no significant difference among the three genotypes of Naked Neck chicken, the A1A1 homozygous genotype showed better results than the other two genotypes (Table 8) and in Normal Feathered chicken, the A1A3 heterozygous genotype showed better results than the homozygous genotype (Table 9) in terms of carcass traits. Polymorphism of the cGH gene may be useful in phylogenetic analysis, as well as in the designing of selective breeding programs.

Table 8. Carcass traits of Naked Neck chicken according to genotype

Parameters	Genotype		
	A1A1	A1A3	A3A3
Live Weight	1.251±0.211	1.012±0.026	1.059±0.084
Weight after bleeding	1.194±0.200	0.973±0.026	1.013±0.079
Defeathered weight	1.139±0.186	0.931±0.027	0.967±0.075
Dressed weight	1.061±0.171	0.856±0.021	0.896±0.068
Eviscerated weight	0.856±0.171	0.735±0.031	0.746±0.061
Weight of shank	0.039±0.010	0.036±0.003	0.039±0.003
Weight of head	0.039±0.006	0.038±0.004	0.040±0.004
Liver weight	0.025±0.002	0.018±0.002	0.018±0.001
Heart weight	0.008±0.001	0.008±0.001	0.008±0.001
Gizzard weight	0.030±0.004	0.024±0.002	0.024±0.002
Neck weight	0.057±0.013	0.041±0.004	0.042±0.003
Wings weight	0.098±0.019	0.091±0.006	0.094±0.007
Back weight	0.152±0.032	0.129±0.009	0.135±0.10
Breast weight	0.249±0.040	0.219±0.008	0.235±0.014
Thigh weight	0.159±0.030	0.129±0.006	0.133±0.010
Drumstick weight	0.134±0.033	0.119±0.012	0.117±0.011

Table 9. Carcass traits of Normal Feathered chicken according to genotype

Parameters	Genotype	
	A1A1	A1A3
Live Weight	1.113±0.057	1.199±0.143
Weight after bleeding	1.076±0.052	1.167±0.137
Defeathered weight	1.007±0.046	1.092±0.127
Dressed weight	0.929±0.040	1.005±0.118
Eviscerated weight	0.760±0.024	0.847±0.095
Weight of shank	0.040±0.004	0.049±0.006
Weight of head	0.395±0.003	0.049±0.007
Liver weight	0.020±0.001	0.022±0.002
Heart weight	0.008±0.001	0.008±0.001
Gizzard weight	0.032±0.002	0.027±0.003
Neck weight	0.044±0.002	0.045±0.004
Wings weight	0.101±0.004	0.104±0.008
Back weight	0.139±0.006	0.156±0.018
Breast weight	0.253±0.010	0.271±0.029
Thigh weight	0.125±0.007	0.133±0.014
Drumstick weight	0.129±0.006	0.125±0.016

Amelioration strategies to reduce climate stress in poultry by supplementing locally available herbs in the feeds

Feeding trials were conducted to study the effect of supplementation of Turmeric and Roselle powders in indigenous Naked Neck, Normal Feathered and Vanaraja grower birds during peak winter month in Meghalaya. Basal commercial grower mash in control and basal grower mash plus Turmeric @ 1% and Roselle @ 0.5 % in treatment groups were offered for 4 weeks. Blood Cortisol, Superoxide Dismutase (SOD) and Heat Shock Protein (HSP 20, 40, 70 and 90) levels were measured as bio-indicators of stress in the birds. Feeding of Turmeric and Roselle powders resulted in decrease of Cortisol and increase of SOD levels in the blood serum of the birds, indicating the ameliorative effects of cold stress in the birds. The expression of HSP20 was highest in indigenous normal feathered birds followed by Naked Neck and Vanaraja. The expressions of HSP 40, 70 and 90 were found to be more in indigenous Naked Neck compared to Normal Feathered and Vanaraja birds. However, no significant effect on HSP expressions were recorded on supplementation of Turmeric and Roselle powders in the birds (Table 10).

Table 10. Effect of Turmeric and Roselle supplementation on blood Cortisol and Superoxide Dismutase (SOD) levels in birds during peak winter

Parameters	Naked Neck		Normal Feathered		Vanaraja	
	Control	Treatment	Control	Treatment	Control	Treatment
Cortisol (µg/dl)	3.30±2.14	1.38±0.52	3.50±1.41	2.19±1.07	4.05±1.69	1.28±0.69
SOD (Units/ml)	0.030±0.003	0.033±0.003	0.030±0.004	0.037±0.003	0.029±0.005	0.034±0.005
HSP20 (ng/ml)	1.62 ± 0.78	1.18 ± 0.52	2.26 ± 0.68	1.48 ± 0.53	1.2 ± 0.35	2.46 ± 0.87
HSP40 (ng/ml)	2.03 ± 0.28	1.27 ± 0.12	1.7 ± 0.29	1.57 ± 0.52	1.4 ± 0.15	2.03 ± 0.29
HSP70 (ng/ml)	21 ± 5.89	17.83 ± 3.24	18.67 ± 8.84	15.5 ± 6.17	8 ± 1.32	14.83 ±1.83
HSP90 (ng/ml)	2.03 ± 0.34	1.63 ± 0.39	1.83 ± 0.57	1.67 ± 0.47	1.17 ± 0.21	2.17 ± 0.13

Studies on comparative performance of Vanaraja and Srinidhi birds under intensive and backyard systems of rearing

Under the AICRP on Poultry Seed Project, dual purpose Srinidhi chicken varieties developed by Directorate of Poultry Research, Hyderabad was introduced for rural poultry production in Meghalaya. A comparative study was done on the performance of Vanaraja and Srinidhi chicken varieties under intensive system of rearing in Institute Poultry Farm and in the Backyard system of rearing in the farmers' fields. The results showed overall better performance of Srinidhi compared to Vanaraja birds both in the intensive and farmers' field in the agroclimatic condition of Meghalaya (Table 11).

Table 11. Performance of Vanaraja and Srinidhi birds under intensive and backyard systems of rearing

Traits	Intensive		Backyard	
	Vanaraja	Srinidhi	Vanaraja	Srinidhi
Feed consumption per bird up to 40 weeks (Kg)	33.35	31.32	16.20	13.73
Average body weight at 40 weeks (Kg)	M-3.85 F-2.74	M-4.31 F- 1.86	M-2.69 F-1.83	M-2.81 F-1.53
Age at first egg (Days)	126	130	154	161
Egg production per bird up to 40 weeks	59	63	40	42
Fertility (%)	86	82	-	-
Hatchability (%)	71	69	-	-

(a) Farm condition

(b) Farmers' field

Fig 28. Vanaraja and Srinidhi birds

Cryopreservation of Golden mahseer (*Tor putitora*) milt

The spermatozoa of Golden mahseer (*Tor putitora*) collected from the farm ponds of ICAR-RC-NEH Region, Umiam were utilized for cryopreservation study, in an effort to conserve the germplasm of this endangered fish species. The collection of milt was performed by following standard milt collection protocol. All the milt samples were brought to the laboratory and motility test were performed. Those samples which showed more than 80% motility were utilized for the freezing study (Fig 30).

Based on the available literatures, four different extenders were used in the freezing study while DMSO was used at two concentrations (10% and 20% of the aliquot) as cryoprotectant to obtain the best result.

After two days of freezing the initial post thaw motility test was performed. A combination of different thawing temperatures (37°C, 45°C and 55°C) and duration (15 sec, 30 sec, 40 sec and 50 sec) was tested. The best motility was observed at 37°C for 15 sec (Fig 29). During the study it was observed that out of all the four extenders, the modified fish ringer's solution (E1) and the DMSO concentration at 10% showed the best result for cryopreservation of fish spermatozoa.

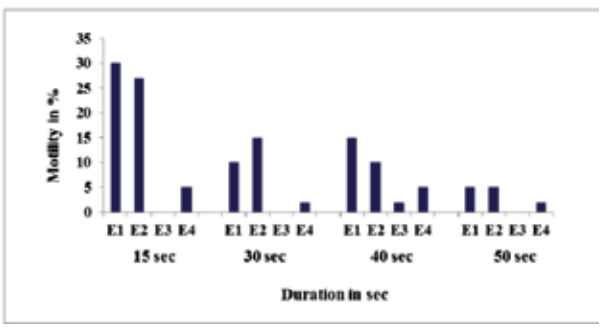
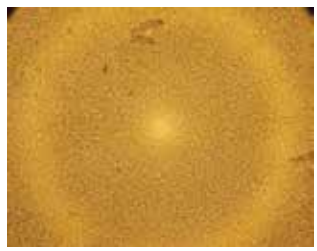


Fig 29. Performance of different extenders (E1, E2, E3 & E4) at 37ºC with various thawing durations

Fig 30. A. Stripping milt from mature male Mahseer brooder

B. Storing milt in ice for transportation

C. Frozen straw kept in canister



D. Motile sperms observed under the microscope (20X)

Fig 30. Different steps of mahseer cryopreservation study

Osteology study of Barilius fish, *Opsarius barnoides*- an indigenous ornamental fish

An osteology study was undertaken on an important indigenous ornamental barilius fish species of the Northeast India, *Opsarius barnoides* belonging to family Cyprinidae. The species was collected from the Chindwin River Basin, Manipur and the study was carried out to confirm the taxonomic characters. For osteological study, fishes kept in preservative were cleaned and muscles were removed carefully. The fishes were then transferred to trypsin digestion solution. Osteological data were taken from cleared and Alizarin stained specimens. Disarticulations of bones, without damaging their structure, were done by treating the fresh specimens directly in 2% KOH solution without any preservative. In this study it was observed that the total vertebrae of *Opsarius barnoides* consist of 42 centra, of which 21 are abdominal vertebrae and rest 21 are caudal vertebrae (Fig 31).

Fig 31. Total vertebrae of *Opsarius barnoides*

Growth assessment of Mrigal (*Cirrihinus mrigala*) fingerlings fed with Azolla as an alternate protein source under mid hill aquaculture in Meghalaya

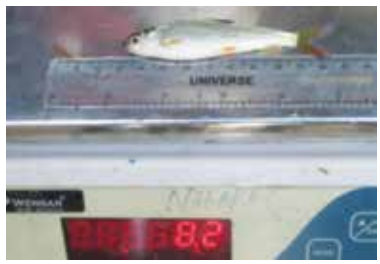


Fig 32. Cirrihinus mrigala fingerling

A 60 day indoor feeding trial was conducted to investigate the growth of Mrigal (*Cirrihinus mrigala*) fingerlings- an Indian major carp species (average length 2.57±0.04 cm and weight 0.42±0.02 gm) under mid hill condition (900m above msl) in Meghalaya. Three isonitrogenous experimental diet were made of rice polish & mustard oil cake (T0), used as control against two diets, rice polish, soybean & mustard oil cake (T1); rice polish, azolla and mustard oil cake (T2) as 50 per cent partial replacement of mustard oil cake with azolla which is available in northeastern region of India. The physio-chemical parameters were found in the normal range throughout the experimental period. The results revealed that the test animals fed with diet T2 containing Azolla showed better growth (366±7.26 %) than T1(167± 4.86%) and control diet, T0 (117±2.44%) in terms of weight. The specific growth rate (SGR) was found highest in T2 group (0.76±0.01) followed by T1 group (0.64±0.01) which was ($P < 0.05$) higher than T0 the control group. The food conversion ratio (FCR) also varied significantly ($P<0.05$) among the treatment group. The better FCR was observed in T2 group followed by T1 & T0 group (Table 12). These results suggest that incorporation of Azolla can enhance growth in *C. mrigala* fingerlings (Fig 33) and can effectively be used in conventional diet of mrigal fingerlings without any adverse effect on their growth and survival in order to reduce the cost of fish feed.

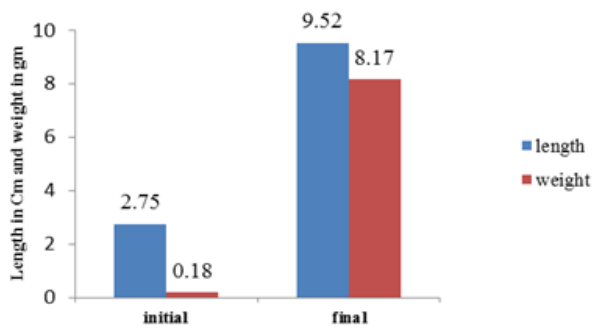


Fig 33. Growth performance of Mrigal fry with stocking density 2 lakh/ha

Table 12. The growth parameters and survivability of Mrigal fingerlings fed with different experimental diets

Growth parameters	T_0	T_1	T_2
Percentage weight gain	117±2.44	167± 4.86	366±7.26
Specific growth rate	0.52±0.01	0.64±0.01	0.76±0.01
Food conversion ratio	4.10±0.06	3.35±0.04	2.88±0.01
Survival (%)	70	80	90

Fingerling raising in water harvesting ponds (Jalkund) during post monsoon

To utilize the water of existing water harvesting tank (Jalkund) for culturing mrigal fry (Fig 34) to the stage of fingerling, a farmer participatory research was conducted to raise fingerling of mrigal (*Cirrihinus mrigala*) during the post monsoon month (Aug-Dec) in the Ri-bhoi district of Meghalaya. The mrigal fry were stocked at three different stocking density and the best growth and survival were recorded at a stocking density of 2 lakh per ha with an average of 65% survival.

Fig 34. Fish growth evaluation in Jalkund

Evaluation of Biofloc Technology for Sustainable Aquaculture in Meghalaya

A study on biofloc technology was initiated to investigate the effects of different locally available carbohydrate sources on biofloc production, fish growth, soil and water quality in fresh water fish farming system under the mid hill condition of Meghalaya (Fig 35). The study has successfully optimized the C:N ratio

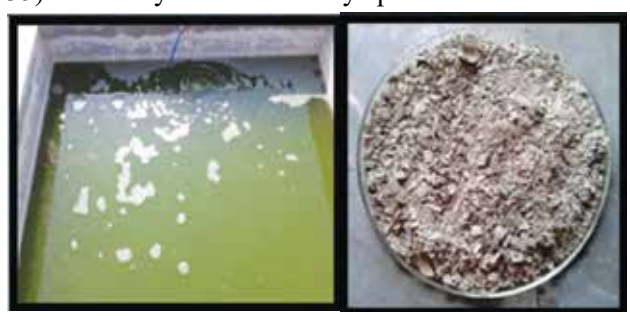


Fig 35. Biofloc Production

Table 13. Nutritional analysis of produced Biofloc

	Crude protein	Crude Fiber	Crude Fat	Nitrogen free extract	T. ash
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
C	0	0	0	00	0
T1	14.05±2.93	3.93±0.44	3.77±1.05	60.21±2.22	18.04±2.74
T2	15.02±2.63	3.09±0.20	3.10±1.08	61.69±2.42	17.10±1.90

for production of biofloc in fresh water with different inorganic and organic substances. Green and brown Biofloc were also produced through fertilization and locally available carbon sources (T1 & T2), eg. rice polish, wheat flour, sweet potato, yam, tapioca, rice husk etc. The study revealed that the soil and water quality can be improved through biofloc technology (Table 13). The growth performance of common carp fingerlings reared under the system is encouraging.

Three day long training cum seed distribution programme in West Jaintia Hills, Meghalaya

The Division of Fisheries, ICAR-RC-NEH Region, Umiam, Meghalaya in collaboration with the District Rural Development Organization, conducted a 3 days long training cum seed distribution programme from 26th to 28th of July 2016 at three blocks of Jowai i.e. Thadlaskein, Laskein and Amlarem, West Jaintia Hills, Meghalaya under TSP. Altogether 170 trainees from line department, NGOs, and a large no. of farmers participated in the training programme; where they were imparted training on scientific fish culture, economic analysis of nursery raising and analysis of water quality in fish ponds. Fish seeds were also distributed to potential farmers after the training. Further, water quality of farmer's pond (6 nos.) was analyzed to provide remedial measures for maintaining optimum water quality for fish farming (Fig 36).

Workshop cum fish seed distribution and fish ranching programme at Jowai, West Jaintia Hills in connection with World Fisheries Day

A workshop cum fish seed distribution and fish ranching programme was conducted on the 21st of November 2016 under TSP in collaboration with the ICAR-CIFT, Kochin at Jowai, West Jaintia Hills in connection with World Fisheries Day (Fig 37). The basic objective of the workshop was to highlight the importance of fish farming and fish products in human diet. About 50 participants including officials from the various Government departments attended the workshop. Fish seeds were distributed to selected farmers of Jowai area which was followed by a fish ranching programme in the Thadlaskein lake for fish stock enhancement in the lake.

Fig 36. Farmers' training and quality fish seed distribution in West Jaintia Hills, Meghalaya

Fig 37. World fisheries day celebration at Jowai, Meghalaya and Ranching of Fish seeds in Thadlaskein lake, Jowai

ARUNACHAL PRADESH

WEATHER REPORT

Climatically the year 2016 was very unusual as compared to the last 37 years as per the meteorological observation recorded at ICAR Research Farm, Gori, Basar. The rainfall was exceptionally below normal in the months of July and August (Fig. 1), which leads to unprecedented dry spell during the period. It adversely affected agriculture and allied activities. The numbers of rainy days were less during the month of August (Fig. 2). The month of August depicted the highest average monthly maximum temperature of 31.2 °C which is unprecedented in the last 37 years (Fig. 3). The average minimum temperature did not significantly varied from the normal temperature (Fig. 4).

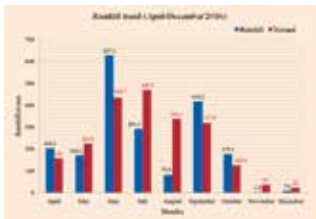


Fig 1. Rainfall status during the period compared to normal

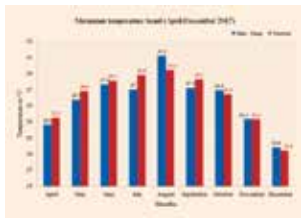


Fig 3. Average Monthly maximum temperature during the period compared to normal

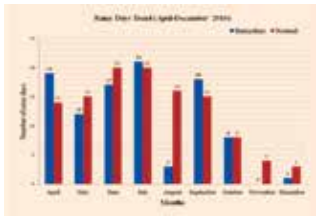


Fig 2. Number of rainy days compared to normal during the period

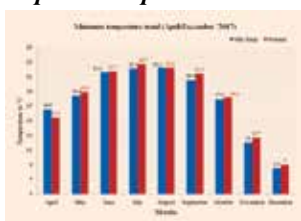


Fig 4. Average monthly minimum temperature compared to normal

AGRONOMY

Development of baby corn *(Zea mays)* production technology under conservation agriculture

A total of 12 varieties of baby corn including local landraces, *viz.,* VL baby corn-1, HM 4, RCM 1-1, RCM 1-2, RCM 1-2, RCM 75, RCM 76, DA 61 A, local maize (Sago), Vijay composite (Fig. 5) were collected and evaluated for their suitability and performance under Arunachal Pradesh conditions. The experiment was laid out in RBD experimental design with 3 replications and spacing of 40 cm x 20 cm. All the recommended package of practices were followed in the experiment. The experimental findings revealed that there is difference in characters among the varieties evaluated (Fig. 5-6).

Among varieties, VL Babycorn-1 matured at the earliest where the first picking was attained at just 45 days after sowing (DAS) followed by HM 4. Whereas in other varieties, RCM 1-1, RCM 1-2, Sago Local etc. reached the first date of pickings at comparatively same time (55-60 DAS). The highest baby cob yield was registered in VL Baby corn-1 (23.6 t/ha) RCM 1-2 (23.2 t/ha) and Sago local (local landrace) respectively. Although VL Baby corn 1 produced the highest baby cob yield, however other characters like baby cob length, girth and colour are not desirable and appealing as per the marketing characteristics. Among the varieties, HM 4 followed by RCM 1-2 and Sago local has the preferable characters with slight yellow creamy colour (Fig 7). Those varieties having baby cob length (9.5 cm-10.2cm), baby cob girth (3.5-4.1 cm), baby cob weight (10.2-12.8 g), number of baby cob/plant (2.4-2.98) are preferable. After evaluation of varieties, the best two varieties (HM 4 and RCM 1-2) was then taken for main experiment conducted during 2016 where different nutrient management and conservation techniques were imposed.

Fig 5. Different varieties grown in the experiment

The effect of variety, conservation agriculture and nutrient management on the performance of cultivation of baby corn-baby corn-pulse

cropping system was studied during *kharif* season of 2016. The first crop of baby corn was sown in the month of May, followed by second baby corn crop in the month of August and lentil was sown in the month of November after following all the nutrient management combinations and conservation techniques. It was observed that there was no significant effect of tillage on performance of baby corn as well as on soil qualities. Among different nutrient treatments for first and second baby corn crop no concrete conclusion can be made during the first year of the experiment. However, 125% RDF registered the highest yield and yield attributing characters (Table 2).

Fig 6. Characteristics of different varieties

Table 1. Performance of different baby corn maize varieties

Weight of baby cob with husk (g/ cob) Days to silking Variety			Weight of baby cob without husk (g/cob)	Length of baby cob (cm)	Diameter of baby cob (cm)	Number of cobs per plant	Baby corn yield (q/ha)	Fodder yield (q/ ha)
RCM 1-1	59.4	41.2	11.4	9.5	1.7	2.3	18.0	238.3
RCM 1-2	60.6	48.5	11.2	10.2	1.5	2.7	23.2	362.8
RCM 1-3	58.6	49.5	9.2	9.2	1.6	2.2	14.4	375.7
RCM 1-75	62.0	52.1	9.3	8.8	1.8	2.3	14.8	381.7
RCM 1-76	60.8	57.0	12.5	9.7	1.5	2.4	20.6	380.2
DA 61 A	58.8	48.2	11.3	9.8	1.6	2.3	18.5	270.5
Vijay composite	59.6	47.4	10.4	10.3	1.5	2.3	16.5	366.0
VL babycorn 1	45.2	39.7	12.8	8.6	1.8	2.8	23.6	275.8
Sago local	61.0	42.4	12.1	10.1	1.6	2.6	23.1	267.8
HM 4	60.4	47.2	7.9	9.5	1.3	3.0	16.3	341.7
CD (5%)	-	-		-	-	-		74.1

Table 2. Yield and yield attributes of baby corn as influenced by varieties, conservation tillage and nutrient management.

Treatments	Cob length with husk (g)	Cob length without husk (g)	Cob diameter without husk (cm)	Weight of baby cob with husk (g)	Weight of baby cob without husk (g)	No of cobs/ plant	Baby corn yield (q/ha)	Fodder yield (t/ha)
T1 V1N1	22.2	9.4	1.36	52.3	8.40	2.76	18.3	36.3
T1 V1N2	24.4	10.6	1.45	52.5	8.79	2.65	18.3	34.0
T1 V1N3	25.2	9.6	1.48	37.7	6.43	2.47	12.6	26.0
T1 V1N4	24.5	11.1	1.44	49.8	7.11	2.99	16.8	35.0
T1 V2N1	22.6	9.4	1.86	51.2	10.55	2.39	20.3	36.3
T1 V2N2	21.9	9.9	1.94	47.6	9.96	2.38	18.6	34.1
T1 V2N3	22.4	9.7	1.88	52.0	10.58	2.37	19.8	30.2
T1 V2N4	24.3	10.7	1.86	53.5	11.42	2.58	23.4	37.0
T0 V1N1	23.3	9.2	1.59	44.6	7.57	2.55	15.2	35.1
T0 V1N2	26.2	9.8	1.39	48.9	6.75	2.50	13.4	28.7
T0 V1N3	22.6	8.8	1.33	48.3	7.86	2.38	14.8	32.0
T0 V1N4	23.4	9.5	1.47	46.6	7.37	2.98	17.4	36.5
T0 V2N1	25.5	10.4	1.99	56.6	10.16	2.48	19.8	34.0
T0 V2N2	23.8	9.6	1.74	53.6	8.91	2.28	16.0	32.1
T0 V2N3	22.2	10.9	1.80	43.7	9.47	2.15	16.2	29.7
T0 V2N4	23.8	8.7	1.66	47.3	7.40	3.00	16.9	36.9

V1 ***HM 4,*** **V2** ***RCM 1-1,*** **T1-*Conventional tillage,*** **T0-** ***Minimum tillage***
N1:*100 % RDF-100%RDF,* **N2:*100% RDF-50% RDF,*** **N3:*50% RDF+5 t/ha FYM-50% RDF+5 t/ha FYM,*** **N4:*125%RDF+10 t/ha FYM-Nil***

Conventional tillage, RCM 1-2, 100%RDF-50% RDF

Conservation tillage, RCM 1-2, 50%RDF+10t/ha FYM-50% RDF+5t/ha

Conventional tillage, sago local, 100%RDF-100% RDF

Fig 7. Attributes of the varieties with different treatments

Effect of irrigation and zinc sulphate levels on performance of pea in a zinc deficient soil of Basar

The effect of zinc sulphate as foliar spray application under different of irrigation levels was studied. Majority of soils of Arunachal Pradesh in general and Basar in particular are deficient in most micronutrients especially zinc. Which is affecting the performance of crops especially *rabi* crops that grown under limited irrigation facilities and moisture stress conditions. The crops that mostly affected due to nutrient deficiency are pea, capsicum, cauliflower, knol khol, brocolli etc. The efforts were undertaken to minimize the problems due to zinc deficiency on crop by application of zinc sulphate under different irrigation intervals with the hypothesis that at higher soil moisture availability with more irrigation intervals, crop will develop slighter or no micronutrient deficiency symptoms (Fig. 8).

Fig 8. Micronutrient deficiency symptoms in pea (Zn)

For this study Pea (variety Azad pea 1) was sown on 5th October 2016 with recommended package of practices including fertilizer (20:50:40 kg/ha NPK) and FYM (5 t/ha FYM) maintaining a spacing of 45 cm x 5-10 cm. The treatments imposed were 3 (three) irrigation intervals (Main plots), *viz*., i) at 5 days interval ii) 10 days interval accompanied with paddy straw mulching (PSM) and iii) 2 (Two) irrigations at pod formation stage and four levels of zinc sulphate foliar spray (sub plots) concentration (control, 0.25%, 0.5 % and 0.75 %).

Results revealed that, plant growth and yield attributes like plant height, number of pods per plant, pod length, pod weight etc. were higher in the case of 10 days irrigation interval with PSM with a mean value of 45.2 cm, 12.4, 12.1 cm, 10.9 g, respectively and which was at par with irrigation at every 5 days interval when compared to treatments with only 2 irrigations at pod formation stage. Crops with assured irrigation and moisture conservation measure like PSM tends to show minimal moisture stress thus gave better growth with lesser micronutrient deficiency occurrence. However, in case of $ZnSO_4$ foliar spray the different level concentrations has no effect under assured irrigation, *i.e.,* under 5 days irrigation intervals and 10 days interval with PSM, but under water stress situation with limited watering (2 irrigations at pod formation stage) the symptoms of micronutrient (Zn) was found to be more noticeable and conspicuous. It is observed that crop perform better in terms of growth parameters and yield attributes with increasing levels of $ZnSO_4$ concentrations (Fig. 9a-b).

a. Pea with two irrigations at pod formation stage and no zinc sulphate foliar spray

b. Pea under 10 days irrigation interval with PSM and 0.75 % zinc zulphate foliar spray

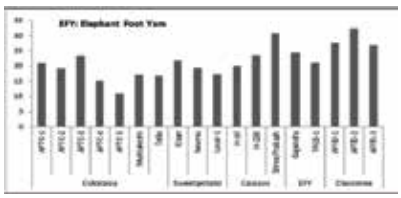
Fig 9a-b. Comparison of pea under different treatments

Development of tuber crop based cropping system

Considering the importance and mandatory practice of

growing tuber crops in the *jhum* field by the local farmers of the state, the present study was carried out to evaluate the yield performance of different local and improved cultivars of tuber crops as crop model in *jhum* field and to quantify the economic profitability for developing suitable and sustainable tuber crop based cropping system model for achieving better livelihood in Arunachal Pradesh (Fig. 10). Different local and improved varieties of tuber crops, *viz.* colocasia, sweet potato, cassava, elephant foot yam, diascorea etc. were grown at ICAR Research Farm, Gori, Basar, Arunachal Pradesh. Under this model, on farm evaluation for yield of different varieties of tuber crops were recorded and presented (Fig. 11). The model tuber based cropping system comprises of growing of cover crops like cowpea, green gram and other leguminous crops at the various intervals across the slope (Fig. 12). Hedge row planting of teprosia, crotolaria and flamingia soil conservation measures were of the model.

Fig. 10 Tuber crops in the hill slopes



Y-axis=Yield (t/ha), X-axis=Tuber crop varieties

Fig 11. On farm evaluation on yield of different varieties of tuber crops

The yield data from different tuber crops were recorded. The cost of cultivation, gross return, net return and benefit cost ratio were computed by keeping in view of the present market price. In Colocasia, the net return was Rs. 2,15,600/- with benefit cost ratio of 4.64. Sweet potato and cassava recorded a net return of Rs. 2,43,400/- and Rs. 2,28,675/-, respectively. Among the tuber crops, Diascorea recorded the highest net return of Rs. 3,43,700/- and benefit cost ratio of 5.98 followed by Elephant Foot Yam with net return and benefit cost ratio of Rs. 2,72,050/- and 5.86, respectively.

Farming system model for sustaining hill agro ecosystem in Arunachal Pradesh

Farming System model was developed at ICAR Research farm, Gori, Basar, with an area of about 0.25 ha under upland situation. It comprises of various cropping systems or crops, *viz*., cereal based cropping systems, pulse based, vegetables, oilseed based, tuber and spice based. Fruit crops like citrus, guava, pine apple and banana were kept in upper portion of the land-use system. Spice (ginger and turmeric), oilseeds (mustard/toria, groundnut, soybean), pulses (green gram, black gram, pea, rajmash), vegetables, tuber crops and cole crops, etc (Fig 13) were maintained in middle terraces, whereas cereal-based cropping system like rice, maize and millets were kept in lower terraces. Maize, being the important upland crop of NE region; Maize equivalent yield (MEY) was computed for comparison.

Fig 12. Different cultivars of tuber crops Growing of pulses (cover crops) in between tuber crops

Fig 13. Different crops and cropping systems in a farming system model

With this approach, very high MEY of 8.6 tonnes can be achieved from a farm holding of 0.25 ha whereas just 1.02 tonnes if kept under maize mono-cropping. Thus, this farming system model shows that farm profit can be enhanced up to 8 times or more when compared to maize mono-cropping. It can be concluded that a marginal farmer with a small farm land holding can enhance his farm income and crop productivity with inclusion of various crops/ cropping systems comprises of cereals, vegetables, pulses, spices, fruits etc. as to reduce the risk factor and more importantly increase better land use systems and sustainability.

PLANT BREEDING

Characterization and evaluation of local rice germplasm of Arunachal Pradesh

An experiment on characterization and evaluation of local rice landraces was conducted for the second consecutive year during *kharif* 2016. A total of 42 local rice germplasm comprising of 23 WRC and 19 *jhum* rice landraces were characterized. Various qualitative and quantitative characters were studied at different growth stages. The *jhum* rice genotypes, recorded plant height ranging from 105 to 161 cm, panicle length (22.8 to 35cm), number of filled grain per panicle (90 to 203) and test weight ranging from 1.9 to 3.18 gm. The highest mean yield was recorded in Bali red (30.2 q/ha) followed by Pumik (28.3 q/ha), Jarli (26 q/ha), Chipu (25q/ha) and Mingpong (24.3 q/ha). While the lowest yield of 9 q/ha was recorded in Amchiriri. Among the low land rice genotypes, plant height ranges from 70 to 141 cm, panicle length (10 to 29.2 cm), number of filled grain per panicle (120 to 270) and test weight range from 1.73 to 2.8 gm. The highest mean yield of low land rice genotypes was recorded in Amham (35.3 q/ha) followed by Amlum (31 q/ha), Pumde (29.9 q/ha) and Riew Amo (28 q/ha). Lowest yield was recorded in Ame Amli (6 q/ha).

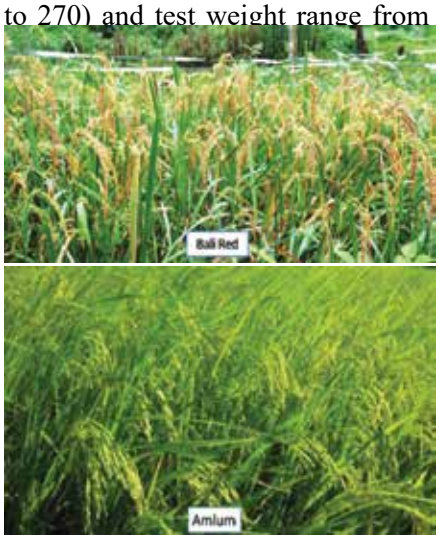


Fig 14. Performance of local rice varieties.

Performance evaluation of foxtail millet

Varietal evaluation for identification of best performing varieties of foxtail millet (*Setaria italica)* was conducted in two different seasons during *rabi* 2015 and *kharif* 2016 in mid hill condition of Arunachal Pradesh. The varieties under trial consist of 12 high yielding improved varieties, *viz.,* Sia 326(PRASAD), Sia 3086, K221-1, Sia 2644, Sia 3156, Sia 2622, SR 16, HMT 100-1, PS 4, Sia 2593, Arjuna and Surya Nandi. The highest average yield of two seasons was recorded in Sia (9 q/ha) followed by Arjuna (8.6 q/ha), Sia 3156 (8q/ha), SR 16 (7.8 q/ha) (Fig. 15).

Fig 15. Performance of foxtail millet var. SiA 3156 (kharif) and SiA 326 (rabi)

Performance of soybean and groundnut

A study was conducted to assess to performance of soybean (var. JS 335) and Groundnut (var. ICGS 76) both in research farm and farmers field at various locations during *kharif* 2016. In soybean (var. JS 335), average plant height of 76.2 cm, number of branch/plant (6.7), number of seeds/ pod (2.5), test weight (10.07gm), duration 146 days and average yield of 18 q/ha were recorded. Whereas in groundnut (var. ICGS 76), an average plant height of 47.5 cm, no. of pods/plant (46.5), test weight (44.5 gm), maturity duration 152 days and average yield of 9 q/ha. Major causes of reducing yield in groundnut were found to be due to pod borer and rats.

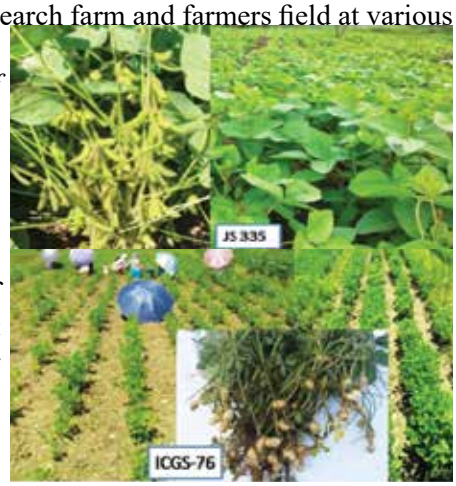


Fig 16. Performance of Soybean var. JS 335 and Groundnut var. ICGS76

HORTICULTURE

Flagship programme on "Improvement of *Jhum* through Horticulture Interventions"

With the objective to improve the *jhum* through horticulture interventions, a total of 39 ha area were covered under the project during 2016 (Fig. 17). Under different crop modules, orange seedlings (3000 nos.), banana suckers (2000 nos.), pineapple suckers (3000 nos.), tuber crops (colocasia, sweet potato, tapioca, yam etc.), paddy including different pulse crops, kharif/rabi vegetables and pig unit (24 nos. i.e. 3 units) were distributed to *jhum* farmers along with training/demonstration on scientific agro-techniques and soil/water conservation measures.

Fig 17. Intervention under jhum improvement

Effect of different planting dates on growth, yield and quality of strawberry var. *Chandler* under mid hill condition of AP

Field experiment was conducted at ICAR Research Farm, Gori, Basar to investigate the optimum planting dates on yield and quality attributes of strawberry cv. *Chandler*. The experiment was laid out under RBD with six treatments replicated four times. The treatment includes T_1: 1st of September, T_2: Mid of September, T_3: 1st of October, T_4: Mid of October, T_5: 1st of November and T_6: Mid of November. Among the different planting dates, runners transplanted on mid-October recorded the highest number of fruits per plant (22.08), fruit yield (185.42 g) and TSS (9.33°Brix). Highest ascorbic acid content (56.16 mg/100g) was recorded in fruits of 1st November transplanted runners (Fig. 18).

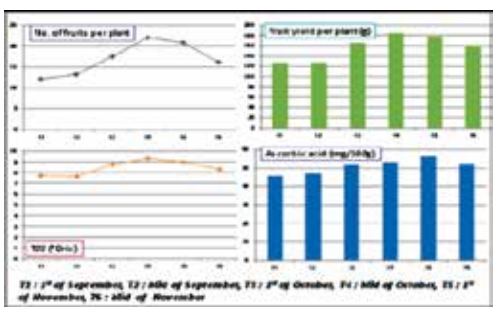


Fig 18. Performance of the Strawberry var. Chandler under mid-hills of A.P.

Nutrient and total Antioxidant characterization in star anise

Considering the economic values of star anise, the centre has initiated & conducted the study on its biochemical analysis (Table 3) to assess the potential values of star anise for nutritional and pharmaceutical properties (Fig. 19).

Table 3. Average nutritional composition, TAC & phenol content of star anise

Sample (dry star anise fruit)	Values
Fe	147.05 ppm
Mn	157.18 ppm
Zn	12.32 ppm
Cu	4.94 ppm
Al	252.96 ppm
Ca	1.00 %
Mg	0.60 %
N	1.2 %
P	0.0053 %
K	0.52 %
Total antioxidant capacity (TAC)	78.82 µg/g Ascorbic acid
Phenol content	29 µg/g gallic acid
Ascorbic acid	4.5 mg/g

Fig 19. Stages of Star anise

Manipulation of fruit size, yield and quality of Kiwifruit through hand thinning

Crop load is one of the major factors influencing the size and weight in Kiwifruit, thus thinning is required to obtain better size and quality fruits. Keeping in view the above points, the present investigation was undertaken at Sago village, West Siang district, Arunachal Pradesh situated at an altitude of 1200 m above msl to study the effect of hand thinning on size, yield and quality of Kiwifruits cv. Allison. The results revealed that T_1 (fruit thinning to 2 fruit per shoot) recorded the highest fruit length, breadth, weight and TSS. The treatment T_2 (fruit thinning to 4 fruit per shoot) exhibited the maximum ascorbic acid (Table 4).

2 fruits per shoot 4 fruits per shoot 6 fruits per shoot

Fig 20. Hand thinning of kiwi

Productivity maximization and quality improvement of tissue culture banana var. Grand Naine through improved agro-techniques in mid hills of Arunachal Pradesh

An experiment on different level of fertilizers and liming on growth, yield and quality of banana var. Grand Naine was carried out at ICAR Research Farm, Gori. It was found that out of 12 treatments, the treatment 50% Lime + 100% RDF application recorded the highest bunch weight (24.83 kg), total no. of fingers per bunch (161.00) and TSS (23.07 °Brix). The highest ascorbic acid content (14.45 mg/100g) was recorded in the treatment 100% Lime + 75% RDF application.

The advanced lines of Guava *viz*., RCGH 1, RCGH 7, RCGH 4 from ICAR, Umiam along with two improved varieties *viz*., L 49 and Allahabad Safeda were planted as regional trials to study its performances under mid hill condition of AP. The lines RCGH 4 recorded the highest plant height (1.80 m) and no. of leaves per shoot (27.6). Meanwhile, in terms of fruit set, no. of fruits per plant and days required from flowering to fruit set, the line RCGH 7 exhibited better results as compared to others lines and varieties.

Table 5. Regional trial of advanced Guava lines

Varieties	Plant height (m)	Canopy spread (m^2)	No of leaves/ shoot	Days from flower-ing to fruit set	Fruit set (%)	No. of fruits/ plant
RCGH 1	1.62	0.77	20.0	12.1	84.06	11.3
RCGH 7	1.74	1.24	12.6	11.5	92.42	13.6
RCGH 4	1.80	1.19	27.6	12.5	90.38	12.7
L 49	1.47	1.16	15.8	12.7	77.67	4.8
Alla-habad Safeda	1.45	0.75	17.4	12.3	86.89	9.5
SEM (±)	0.07	0.07	2.72	0.44	3.28	0.42
CD *(P=0.05)*	0.21	0.21	8.15	1.31 (NS)	9.83	1.27

Table 4. Effect of hand thinning on biological parameters of Kiwi

Treatments	Fruit length (cm)	Fruit breadth (cm)	Fruit wt. (g)	TSS (°Brix)	Acidity (%)	Ascorbic acid (mg/100 g)
T_1 (fruit thinning to 2 fruit per shoot + CM)	6.08	4.34	68.87	12.26	0.88	91.59
T_2 (fruit thinning to 4 fruit per shoot + CM)	6.02	4.22	67.75	12.06	0.85	91.85
T_3 (fruit thinning to 6-8 fruit per shoot + CM)	5.92	4.02	64.23	12.10	0.92	88.83
T_4 (no thinning + CM)	5.48	3.80	51.26	10.92	1.23	80.27
T_5 (no thinning and no canopy man-agement)	5.12	3.62	43.60	10.58	1.31	77.15
CD (*P*=0.05)	0.39	0.29	5.89	0.84	0.09	12.72

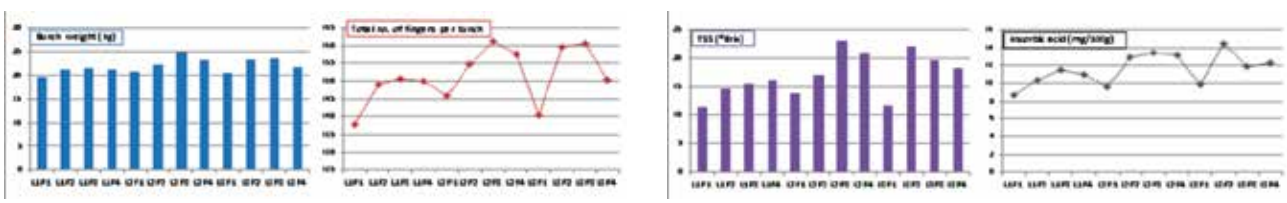


Fig 21. Yield attributes of the tissue cultured banana

PLANT PATHOLOGY

Leaf blight disease incidence of colocasia under *jhum* cultivation

A set of 12 colocasia germplasm were screened against leaf blight (*Phytopthora colocasiae*) incidence, under natural epiphytotic conditions of infection. Out of 12 colocasia germplasm screened against leaf blight, least PDI was recorded in Muktakeshi (16.81) and the maximum PDI was in Zindakachu (42.73).

ANIMAL SCIENCE

Evaluation of improved backyard and nondescript poultry birds its impact under farmers field condition of Arunachal Pradesh.

The performance and impact of improved backyard and nondescript poultry birds were determine at farmers' field conditions. Pre structure questionnaire and PRA data was collected before the staring of the project and after introduction of birds. The impact was measured on 03 rating scale, *viz*., positive, negative and no impact. A total of eight items related to production and management of poultry was addressed. The data revealed that majority of the respondents had positive perception and adopted improved practices. Around 85.18% respondents informed increase in protein intake through consumption of eggs whereas (74.37 %) enhancement of household income through sale of eggs and poultry birds. 70.37% of the respondent adopted improved poultry housing, (51.85%) procured poultry inputs and 59.25% purchased household items from poultry. In terms of mortality of birds 50.92% responded that mortality was reduced and increase in employment through rearing of poultry birds (44.44 %). Degree of association (p> 0.05) between 8 independent variables with income, it was found that education (0.255), family size (0.355), social participation (0.414) and extension agent contact (0.416) had positive and significant relation with income whereas age was negatively correlated.

Fig 22. Performance of poultry under farmer's field condition

FISHERY SCIENCE

A comparison study was carried out at Basar (650 meter msl) and Ziro (1524 meter msl) paddy-fish plot. Where, it has been recorded that "*paddy-fish culture using mustard oil cake as a feed*" recorded the average length (21.1±1.68 cm) and weight (330±1.75 gm) of the fishes, respectively (in Basar situation). Whereas, in "*paddy-fish culture without mustard oil cake as a feed*" exhibited average length (20.5±1.12 cm) and weight (328±1.25 gm) of the fishes, respectively (in Ziro situation). In Basar, relatively higher fish productivity (1125 kg/ha/yr) was observed compared to Ziro (987 kg/ha/yr). Due to the unavailability of external feed (*mustard oil cake*) at Ziro, the fish productivity was relatively low. In Ziro, total alkalinity (56±0.55 ppm) and total hardness (83.2±2.22 ppm) of water were slightly higher than Basar. The source of water at Ziro is mainly from river stream. Organic carbon (4.21±0.25%) and available phosphorus (8.54±0.16ppm) were higher in Ziro as compared to Basar.

To enhance the fish productivity in paddy plot, application of supplementary fish feed or any other feed ingredient is necessary. Water temperature

Table 6. Disease reaction of colocasia germplasm against leaf blight disease

Colocasia germplasm	Leaf blight incidence (PDI)	Calculated yield (t/ha)	Colocasia germplasm	Leaf blight incidence (PDI)	Calculated yield (t/ha)
TRC-1	23.18	10.83	APTC-10	28.63	08.75
TRC-2	28.64	08.32	APTC-11	39.54	07.95
TRC-3	18.64	17.92	APTC-12	21.81	14.75
TRC-4	19.54	10.33	Muktakeshi	16.81	17.08
TRC-5	26.82	09.42	Telia	19.54	16.67
TRC-6	20.91	12.25	Zindakachu	42.73	07.75

Parameter	p^H	Temperature (°C)	Total Hardness (ppm)	Turbidity (TNU)	Total alkalinity (ppm)	Dissolved oxygen (ppm)
Basar	7.83±0.05	25±0.05	73.5±5.12	7.8±1.12	32.5±0.65	7.8±0.06
Ziro	7.92±0.03	10±0.08	83.2±2.22	6.5±0.12	56±0.55	8.2±0.02

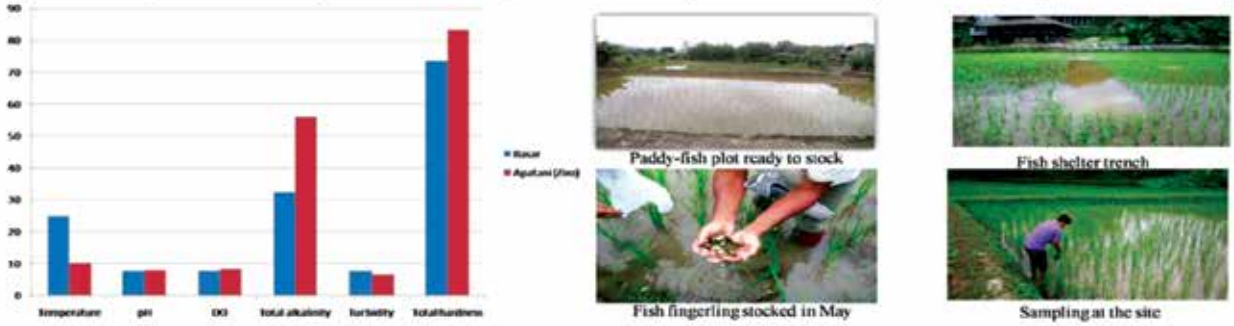


Fig 23. Evaluation of water quality parameters of paddy-fish field at Basar and Ziro

Parameter	p^H	Temperature (°C)	Organic C %	Available P (ppm)	Available N (%)	Texture
Basar	6.05±0.04	23±0.02	3.02±0.59	8.04±1.06	0.02±0.01	Clay
Ziro	6.01±0.02	10±0.04	4.21±0.25	8.54±0.16	0.08±0.05	Clay

Fig 24. Evaluation of soil quality parameters of paddy-fish field at Basar and Ziro

is vital for achieving higher growth of the fishes. Maintenance of quality of water and soil in fish-paddy plot is in an important aspect for successful paddy-fish culture. Application of supplementary fish feed is essential, at Ziro traditional paddy-fish culture.

Fig 25. Training programmeat Dechengthang village, Menchukha, West Siang District, Arunachal Pradesh

Fisheries Training and Extension activities

One day awareness-training programme was organized by Young Mission Adventure Club (YMAC)-Yomcha sponsored by NABARD, in technical assistance with the resource person of ICAR RC for NEH Region A.P. Centre Basar and KVK West Siang District of Arunachal Pradesh under the banner of "Scientific Cultivation Training on Fisheries, Tomatoes & Potato" at Yomcha village on 4th May' 2016. In the programme total 84 numbers of agri-horti-fish growers from the villages of Yomcha circle participated. Thorough discussion were carried out regarding critical management aspects of low cost input fish culture technology (composite fish and duck-fish culture); envisages the usage of liming, manuring, feeding, and water-soil quality parameters for higher fish production. Water pH was demonstrated and tested using waterproof pH Testr-10 kit. Training cum demonstration programme was also organized at Dechengthang village, Menchukha, West Siang District of Arunachal Pradesh. Around

Fig 26. Fisheries training cum water quality testing demonstration at Disi and Bam villages

30 resource poor farmers from Dechengthang East, Dechengthang West and Singber village attended the programme. Various management aspects of cold water fish culture technique (NFDB, Hyderabad sponsored) in terms of liming, stocking, feeding, fish health care were thoroughly discussed.

Another multi-disciplinary training cum demonstration programme was organized at Disi and Bam villages, West Siang District, Arunachal Pradesh by the scientists of ICAR RC for NEH Region, Arunachal Pradesh Centre Basar.

AGROFORESTRY

Performance of different intercrops in combination with different MPTs evaluated. Among 31 combinations of 51 species of MPT and 5 species of cane, *Alnus nepalensis* + *Takek* was reported best in terms of basal girth (37.4 cm) followed by *Pinus khasiana* + *Takek* (32.5 cm).

Among 28 combinations of MPT species and Guinea grass, the combination *Terminalia myriocarpa* + *Guinea* recorded the highest guinea grass yield (24.1 kg/row) followed by Kobolaxo + *Guinea* (19.7 kg/row). In all combinations of MPTs and other crops, the length of row was 30 meters.

***T. myriocarpa* + Guinea grass**

***Alnusnepalensis* + Takek**

Among 22 combinations of MPT species and broom grass, the combination *Gravelia robusta* + broom grasss recorded the highest yield (24.8 kg/row) followed by *Bombax ceiba* + *Broom* (18.2 kg/row) and *Lagerstroemia speciosa* + *Guinea* (14.9 kg/row).

Effect of tree densities on the growth performance of *Ghamari* (Gmelina arborea)

The spacing trial of *Ghamari* was established in 1999. In 17th year of establishment, *ghamari* obtained highest plant height (18.9 m) in the spacing 2m x 3m followed by the height (18.4m) in spacing 4m x 3m. The girth at breast height was found highest (123.1 cm) in the spacing 4m x 4m followed by 104.7 cm in 6m x 3m spacing.

***Graveliarobusta* + Broom grass**

Spacing Trial of 13 Bamboo species

Out of 13 species of bamboo grown under three spacing, maximum clump circumference was recorded in *Bambusa cacharensis* (16.08m) at 5 m x 5 m spacing followed by the same species (13.9 m) planted at spacing 6 m x 6 m. But in spacing 7 m x 7 m, *Bambusa nutans* recorded the highest clump circumference (11.4 m) (Fig. 28). Highest number of culms per clump was recorded in *Bambusa pallida* (77) at 7 m x 7 m spacing followed by *Dendrocalamus sahnii* (67) at 6 m x 6 m spacing and *Dendrocalamus hamiltonii* (63) at 5 m x 5 m spacing.

Fig 27. Spacing trial of *Gmelina arborea* (Ghamari)

GRAMIN KRISHI MAUSAM SEWA

During the period 99 weather-based SMS advisories were send to 789 farmers and other stake holders across the state of Arunachal Pradesh. Regularly on every tuesday and friday, the agromet advisory bulletins were prepared for 16 districts of

the state and disseminated through different media and KVKs. During the reporting period 5 farmers awareness programmes were conducted in different districts of the state (Fig. 28). Also an interface cum awareness programme was organised on 6th October 2016 with Centre for Agriculture and Bioscience International (CABI) under *Gramin Krishi Mausam Sewa* (*GKMS*) at ICAR Research Complex for NEH Region, Arunachal Pradesh Centre Basar (Fig. 29). To increase the reach and impact of the existing agromet advisory services under *GKMS* through interactive voice mail service under collaboration with CABI.

Fig 28. Awareness programme for farmers and other stakeholders

Fig 29. Interface cum awareness programme in collaboration with CABI

TRAINING PROGRAMMES CONDUCTED

1. Training programme on "Innovative Technologies for increasing rice production through simplified SRI in context with climate change" was conducted under NICRA (Research) project on 21st May, 2016 at Conference Hall of Farmer's Hostel at ICAR Research Farm, Gori, Basar. The training was attended by 40 farmers.

Fig 30. Awareness cum training on participatory seed production of Pulses and oil seeds

Fig 31. Awareness cum training on animal health, aquaculture and temperate horticulture at Mechuka

2. Training programme on water conservation technologies (*Jalkund*) was conducted under NICRA (Research) project on 22nd July, 2016 at Barfu village, Hayuliang circle Anjaw district in coordination with the KVK-Anjaw. The training was attended by 50 farmers.
3. The farmer's awareness training programme on agro-meteorological advisory services under *GKMS* was conducted on 29th March, 2016 at Conference Hall of Farmer's Hostel at ICAR Research Farm, Gori, Basar. The training was attended by 60 farmers.
4. The farmer's awareness training programme on Agro-meteorological Advisory services under GKMS was conducted for officers of the line departments on 15th June, 2016 at conference hall of administrative building of ICAR AP centre, Basar. The training was attended by 25 officers of line departments of state government of Arunachal Pradesh.
5. Training programme under "*Pradhan Mantri Fasal Bima Yojna* (PMFBY)" on 25th June, 2016 at conference hall of farmer's hostel at ICAR Research Farm, Gori, Basar. The training was attended by 30 farmers.
6. The three days awareness cum training programme on climate resilient technologies for farmers was conducted during 29th – 31st August, 2016 at Conference Hall of Farmer's Hostel at ICAR Research Farm, Gori, Basar. The training was attended by 30 farmers.
7. One day training cum visit programme was conducted on 11th August, 2016 at Conference Hall of Farmer's Hostel at ICAR Research Farm, Gori, Basar in coordination with the Department of Agriculture, Government of Arunachal Pradesh. Training was attended by 20 farmers of Aalo.

MANIPUR

WEATHER REPORT

During the period of April to December 2016, the monthly average maximum and minimum temperature was 28.6°C and 18.6°C, respectively (Fig 1). The day with highest maximum temperature was on 29th June 2016, recording 34.6°C and lowest minimum temperature recorded on 10th December 2016, was

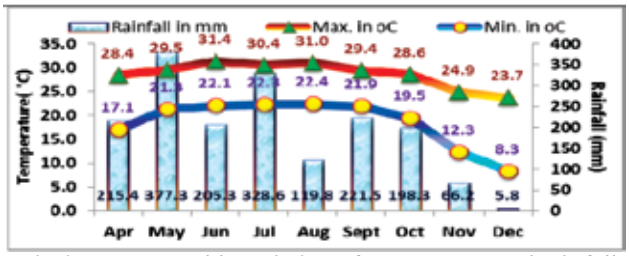


Fig 1. Mean monthly variation of temperature and rainfall

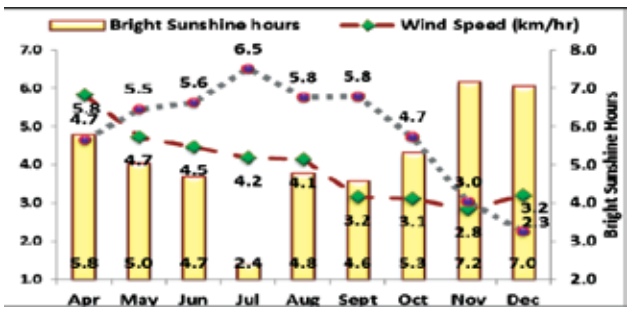


Fig 2. Mean monthly variation of wind speed, cloud cover and sunshine hours

5.8° C. Total rainfall observed during the period was 1732.4 mm with highest monthly rainfall of 377.3 mm observed in July 2016. The day with highest rainfall was observed on 18th May 2016 with 103.1 mm of rainfall. Monthly average wind speed during April during the period was 4.0 Km/hr (Fig 2). The Bi-weekly district level agromet advisory bulletin of Manipur were disseminated 82 times during the period through e-mail to IMD Delhi & Pune, KIRAN, Press, DDK, AIR, ISTV, IMPACT TV. The bulletin was also uploaded in website www.imdagrimet.gov.in. The agromet advisory SMS were also disseminated to 246 progressive farmers through mkisan portal.

CEREAL CROPS

RICE

Identification of high yielding long slender aromatic advanced line (RCM 34)

RCM 34, a medium duration high yielding aromatic rice was identified for high aroma and excellent cooking quality traits (Fig 3). The yield potential of the line under normal agronomic practices is 4.5 t/ha. RCM 34 is a semi-tall (130cm) plant and bears 7-9 effective tillers/plant. The husk colour is black which is transferred from female parent (*Chahao amubi*) while kernel colour is white, similar to male parent (*Basmati 370*). The kernel length is long slender (KL: 6.6 mm) with length breadth ratio of 3.14. It has been observed to be moderately tolerant to stem borer and blast under natural conditions of Manipur. The identified line will under go IVT trials under AICRIP-2017 for multi-location testing.

Fig 3. Aromatic Rice: RCM 34

Breeding and maintenance of superior rice varieties for lowland and upland of Manipur State

Breeding of rice for multiple spikelets

Multiple spikelets have been reported in very few traditional land races of rice. Phougak, a land race of Manipur has been reported for multiple spikelets. However, commercial production of Phougak is very limited due to late maturing, tall plant, susceptibility to blast and stem borer and poor grain quality. Phougak was exploited in breeding programme to develop a series of multiple spikelets genotypes with improved plant type (Table 1).

Table 1. Performance of different breeding lines

Genotypes	Origin	Nature of Spikelets	Days to 50% Flowering (days)	Plant Height (cm)	Yield (t/ha)	Reaction to Blast
Phougak	Land race	Clustered	117	188.67	5.20	S
MC 45-2-2-11	IR 64 x Phougak	Clustered	110	108.67	8.08	MR
MC 45-6-1-14	IR 64 x Phougak	Clustered	102	115.33	7.58	R
MC 41-8-7-8	KD 2-6-3x Phougak	Clustered	80	108.67	6.42	MR
MC 41-36-1-25	KD 2-6-3x Phougak	Clustered	95	179.00	8.00	MR
MC 41-2-1-10	KD 2-6-3x Phougak	Clustered	111	121.00	8.80	R

R: Resistant, MR: Moderately Resistant, S: Susceptible

Selection of promising lines from segregating generation

Individual plant selection in three populations, (RCM 23 x *Chahao amubi, Chahao amubi* x RCM 9 * RCM10, *Chahao amubi* x RCM 9) of black rice in F_4 generation, showed promising improvement in yield parameters *viz*., no. of filled grains/panicle, panicle size, test weight, yield per plant and plant architecture over the parent *Chakhao amubi*. Some of the selected lines were found to have deeper pigmentation than *Chahao amubi.*

Preliminary station trial of rice

Under second year of testing, a preliminary station trial containing fourteen advanced lines of rice along with four different checks were evaluated during *kharif*, 2016 under *rainfed* transplanted lowland conditions. The advanced lines have been emanated from six different crosses of rice. Six advanced lines namely, MC 41-36-1-25-1 (8.10 t/ha), MC 40-10-1-2 (7.76 t/ha), MC 40-10-1-1 (7.58 t/ha), MC 49-4-3-2 (7.42 t/ha), MC 49-4-4-1 (7.42 t/ha), MC 41-18-3-3-1 (7.25 t/ha) were found promising than the best check, RC Maniphou 10 (5.70 t/ha).

Advanced station trial of rice

During *Kharif*, 2016, three advanced station trials were conducted. Under advanced station trial-1, four lines namely, MC 41-2-1-10 (8.80 t/ha), MC 45-2-2-11 (8.08 t/ha), MC 45-7-2-17 (7.75 t/ha) and MC 41-2-1-1 (7.50 t/ha) were found promising than the three different checks. Under advanced station trial-II, two lines, MC 35-60-5-52 (7.05 t/ha) and MC 35-52-41-3-7 (6.92) were found at par with checks, RC Maniphou 13 (6.42 t/ha) and CAUR 1 (6.75 t/ha). Under advanced station trial-III, ten lines emanated from RCM 9 x *Manuikhramui* cross were evaluated for yield and yield components under normal agronomic practices. Three advanced lines, MC 35-2-3-70- 4 (7.39t/ha), MC 35-7-2-42-48 (7.15 t/ha), MC 35-10-5-52 (7.24 t/ha) were found promising.

Characterization and Development of Rice Plant Ideotypes for Improved Yield Under Upland Conditions of Manipur

Selection of lines from segregating generation under upland conditions

97 families of segregating populations generated from two different crosses (Bhalum1 x RCM 9 & Bhalum 3 x RCM 9) were evaluated for yield and plant vigour under direct seeded conditons of upland rice at Langol research farm. 17 promising lines were selected based on yield, yield components and plant vigour.

Multilocation yield trials of upland rice

A multilocation yield trials consisting of eight advanced lines and three checks (Bhalum 1, RC Maniphou 6 & CAUR 1) were conducted at three locations (Chandel, Ukhrul and Imphal West-Langol) in the view of identification of stable high yielding genotypes. In Chandel, advanced lines, MC 43-13-1 (3.2 t/ha) and MC 45-5-10 (3.08 t/ha) were found promising than the best check Bhalum 1 (2.86 t/ha). However, in Ukhrul none of the entry was found promising than the check Bhalum 1. In Langol hill research farm, entries, MC 45-3-2 (3.3 t/ha) and MC 45-5-10 (2.90 t/ha) were found promising than the best check, Bhalum 1 (2.76 t/ha).

DUS testing and grow out test (GOT) of farmers' varieties of rice from north eastern region

DUS characterization of 41 farmers' varieties and 7 reference varieties of rice of north eastern states, received from PPV & FRA, New Delhi were carried out at the centre in randomized block design. Two farmers' varieties namely *Idaw* and *Langphou chahao* were found to be distinct by 27 morphological characters and these varieties need to be further revalidated.

Screening of rice entries under National Screening Nursery-Hills (NSN-H) and Donor Screening Nursery (DSN) for leaf and neck blast diseases

A total of 195 rice entries constituting NSN-H (86 entries) and DSN (109 entries) received from IIRR, Hyderabad were screened for leaf and neck blast diseases under modified uniform blast nursery (UBN) and natural disease pressure respectively. High disease pressure was recorded during *Kharif* 2016. In NSN-H trial, only one entry exhibited low disease score (0-3) for leaf blast and 27 entries for neck blast. In DSN, 32 entries showed resistant reaction (score of 0-3) for leaf blast and 55 entries for neck blast. 26 entries in DSN trial showed resistance to both leaf and neck blast.

Field monitoring of virulence of *Pyricularia oryzae* under Manipur valley conditions

The virulence spectrum of rice blast pathogen population was monitored on 25 cultivars consisting of international differentials, donors, and commercial

cultivars during *Kharif* 2016. Only one genotype, Tetep showed resistant reaction; and four genotypes (RIL 29, Raminad STR 3, Zenith and Tadukan) showed moderate reaction. Remaining all genotypes in the differential set showed highly susceptible reaction to leaf blast pathogen.

Studies on false smut of paddy (*Ustilaginoidea virens*) and its management

Intensity of false smut disease on nine different varieties including two hybrids was studied under Manipur conditions during *Kharif* 2016. Based on the pooled results of three consecutive seasons (2014, 2015 and 2016), percentage of false smut infected plants varied from 6-79% in different varieties surveyed (maximum in hybrids and minimum in Phouoibi Phou). Among all varieties surveyed, RCM 10 had lowest percent infected tillers (9.27%) in infected hills. Efficacy of different fungicide molecules in management of false smut disease was tested (Fig 4). Out of 16 chemicals tested, two sprays (spraying at booting stage and 20 days after first spray) of chemicals azoxystrobin 18.2 % + difenoconazole 11.4 % (w/w) SC (Amistar Top), flusilazole 25% + carbendazim 12.5% (Lusture 37.5 SE), azoxystrobin 25 SC (Amistar), hexaconozole + captan (Taqat) and trifloxystrobin 25 % WP + tebuconazole 50% WP (Nativo) were effective in management of false smut (per cent infected panicles/m^2 were 1.2 to 9.2% in treated plots).

Fig 4. Management module for false smut of rice

Standardization of best sowing time to escape blast disease under Manipur conditions

A staggered sowing experiment (15 days interval) was undertaken during *Kharif* 2016 with 8 popular varieties of rice (RC Maniphou 7, 10, 12, 13, CAU R 1, 2, 3 and 4) to standardize best time to escape rice blast disease under Manipur valley conditions. The percent infection of leaf and neck blast disease were observed to be very high if the sowing was done in second fortnight of July or thereafter. Early sowing in June to first fortnight of July could help escaping the infection of blast disease.

Frontline Demonstration under NFSM in collaboration with IIRR, Hyderabad

RC Maniphou 9, 11and 13 were demonstrated in 40 ha area of Imphal West, Imphal East and Thoubal districts in 13 villages comprising 54 farmers. The average state yield of rice is 2.2 t/ha. The grain yield under improved practice through RC Maniphou 9, 11and 13 was 5.95, 4.22 and 5.56 t/ha respectively.

Evaluation of rice germplasm under NICRA

510 germplams of rice obtained from ICAR Tripura Centre were evaluated for yield, yield components and reaction towards disease and insect pest at ICAR Lamphelpat farm, Imphal. The 15 successful lines were selected that includes, TRC 16-118, TRC 16-455, TRC 16-293, TRC 16-19, TRC 16-604, TRC 16-1, TRC 16-646, TRC 16-498, TRC 16-350, TRC 16-43, TRC 16-329, TRC 16-324, TRC 16-20, TRC 16-29 and TRC 16-142.

All India Coordinated Rice Improvement Programme, 2016

Three trials were conducted during *kharif* 2016 namely, AVT-1 MH irrigated, IVT-MH irrigated and IVT-UH under randomized bock design at ICAR Lamphelpat (Medium Hill trials) and Langol research farm (Upland hill trial). Under AVT-1 MH, thirteen entries were tested including checks and none of the entry was found superior than the check RC Maniphou 13. Under IVT-MH, nineteen entries were tested including checks and three entries namely, IET 2807 (6.91 t/ha), IET 2805(6.85t/ha) and IET 2818 (6.63 t/ha) were found promising than the local check, RC Maniphou 13 (6.63t/ha). Under, IVT-UH (Direct seeded) trial, three entries, IET 2909 (2.57t/ha), IET 2902 (2.54 t/ha) and IET 2913 (2.40 t/ha) were found promising than the check RC Maniphou 6 (1.87 t/ha)

MAIZE

Biomass management in cropping systems for enhancing productivity and resource use efficiency under hill regions of Manipur

Green manuring of sesbania, cowpea and greengram significantly (*P=0.05*) enhanced the grain yield of maize and groundnut, nutrient uptake, water use efficiency and soil quality as compared to control. The highest system productivity in terms of maize equivalent yield (MEY) was recorded in Maize + Groundnut-Pea (13.94 ± 0.66) as compared to Groundnut-Pea (12.86 ± 0.65) and Maize-Pea (9.19 ± 1.09) system. The soil, nutrient and water loss were maximum under maize sole cropping (Fig 5).

The system residual biomass of green manuring and crop residue were recycled under Sesbania (GM)-Maize stalk + Groundnut haulms + Pea residues, which significantly enhanced the enzymatic activities (Acid phosphatase and Dehydrogenase), microbial biomass-C, microbial biomass-N, nutrients (macro and micro), C-stock as compared to other system.

Fig 5. Maize sole, groundnut sole and Maize + Groundnut crops sown under various green manuring

Promoting improved technology of maize production among tribal farmers of Manipur in collaboration with IIMR, New Delhi

Nine maize based intercropping systems were demonstrated in five districts *viz*. Chandel, Churachandpur, Imphal West, Ukhrul and Tamenglong districts of Manipur. Altogether 75 beneficiaries were covered for demonstration from twenty seven villages of said districts (Fig 6). The average maximum maize equivalent yield was found in Maize + groundnut (R) (6.33 t/ha) followed by Maize + Soybean (A) and Maize sole cropping (3.4 t/ha). Maize + Groundnut (A), Maize + Greengram (A), Maize + Urdbean (A), Maize + Rajma (R), and Maize + Ricebean (R) have fetched higher economic returns as compared to sole cropping of maize.

Fig 6. Maize based intercropping with pulses and groundnut

PULSES

Enhancing pulses production in NE states for nutritional security, sustainable production system and livelihood improvement of tribal farmers

Pulses like Arhar, Rajma, Moongbean, Urdbean, Ricebean, Cowpea and Soybean were demonstrated in sixty three (63) villages of five districts *viz*. Chandel (23), Churachandpur (18), Imphal West (7), Ukhrul (12) and Tamenglong (7) districts of Manipur (Fig. 7). Altogether 263 beneficiaries' were covered for demonstration in 163 ha area in *Kharif* season (Fig. 7). The beneficiaries especially from *Jhum* cultivated areas received net returns of Rs 45,000 to 73000/ ha, where, rice mixed farming is dominant with low productivity (0.5 to 0.9 t/ha) and less economical. Demonstration of pulses including Pea, Lentil and Broadbean were demonstrated in *Rabi* season on 155 ha area comprises 156 beneficiaries.

Fig 7. Demonstration of different pulse crops

POTENTIAL CROPS

Seasonal incidence of insect pests of rice bean

A field trial was conducted at Langol farm to study the seasonal incidence of insect pests of rice bean crop in the month of June, 2016. Pheromone traps for gram pod borer, *Helicoverpa armigera* and tobacco caterpillar, *Spodoptera litura* were installed after one month of planting. The population of *H. armigera* showed positively significant correlation (at P=0.05) with temperature (r=0.392) and relative humidity (0.437). Likewise, the population of *S. litura* also showed positively significant correlation (at P=0.05) with temperature (r=0.792) and relative humidity (0.143). The population of *S. litura* was found to be trapped higher as compared to *H. armigera* in the month of early August, 2016. Except for the early week of August, *S. litura* level did not reach ETL. Minor pests like leaf webber and leaf roller were observed more in rice bean maybe due to favourable weather conditions. Bihar hairy caterpillar (*Spilarctia obliqua*) was found to be more in density compared to *Spodoptera litura.*

All India Coordinated Network project on Potential Crop

Genotype screening trial on Perilla: Among 33 local germplasm**,** four lines recorded maximum yield namely RC Thoiding 15 (IC 0615376) 4.2 t/ha, RC Thoiding 8 (IC 0615369) 4.01 t/ha, RC Thoiding 6 (IC 0615367) 3.89 t/ha and RC Thoiding 21(IC 0615382) 3.25 t/ha.

Genotype Screening Trial on Ricebean: Among 36 local genotypes, five lines recorded more yield namely RC Chak hawai 24 (4.1 t/ha), RC Chak hawai 10 (3.3 t/ha), RC Chak hawai 33 (2.9 t/ha),

RC Chak hawai 32 (2.95 t/ha) and RC Chak hawai 26 (2.7 t/ha). Among the 24 genotypes for initial screening including 4 checks PRR 1, PRR 2, RBL 1 and RBL 6 received from NBPGR Regional station Shimla, EC 16136 gave maximum yield (1.34 t/ha) as compared to better performing check RBL 1 (1.2 t/ha). Among 2 genotypes for IVT including 1 checks VRB 3 of NBPGR Regional station Shimla, VRB 3 check gave maximum yield (1.89 t/ha) as compared to other 2 genotype RBHP 117 (1.5 t/ha) and IC 108858 (1.2 t/ha). Among 10 other genotypes, RBHP 307 gave maximum yield (2.2 t/ha) as compared to other genotypes.

SEED TECHNOLOGY

Maintenance breeding of locally released varieties of rice and other recommended crop varieties

Rice varieties released from the centre are being maintained through panicle row selection and basic seeds are being produced. Seeds were supplied to the farmers either directly under different demonstration programmes or seed production programme (Fig 8). During the year, altogether 3.83 tonne basic seeds in rice were produced. In *kharif*, RC Maniphou 6, RC Maniphou 7 and RC Maniphou 10 were raised getting

Fig 8. Basic seed production at ICAR Farm

99.67%, 99.98% and 99.95% purity, respectively. In addition to this, 380 local rice germplasm having different crop durations were also maintained.

Participatory development of quality seed production practices under seed village concept

The project involving KVKs, NGOs, Self Help Groups and farmers clubs under famers' participatory seed production approach was taken up in different crops including rice, maize, groundnut, rapeseed mustard, soybean and blackgram in nine different districts of Manipur. Participatory Seed Production of rice covered 250ha with 140 farmers on rice varieties RC Maniphou 7, RC Maniphou 10, RC Maniphou 12 and RC Maniphou 13. The selected farmers were trained and demonstrated with technologies like line planting, use of conoweeder and Leaf Colour Chart (LCC) and low cost seed production, RC seed bin, *etc.*

Altogether 1300 tonne of rice seed were produced with an average seed yield of 4.5 t/ha in pre *kharif* and 5.6 t/ha in main *kharif* rice, respectively. Similarly, 21.4 tonne of labelled seeds of groundnut (ICGS 76) were produced from 12ha and 3 tonne of soybean (JS 335) were produced from 5 ha of farmers' farm respectively. Production of 5.6 tonne of black gram (T 9) from 10 ha and 82.5 tonne of maize from 15 ha were made from different districts of the state.

NATIONAL SEED PROJECT (AICRP on Seeds)

Experiments under recognition of seed film coating polymers for efficient and health friendly seed treatment operations for certified seed of soybean (JS 335), rice (MTU 1010) and maize (HEMA) under NSP-STR (AICRP)

During 2016, experiments in three crops *viz.,* soybean, rice and maize were taken up with treatments *viz*., T_0 -no treatment or water+thiram only, T_1 - polymer DISCO AG SP RED L-200 + thiram+carboxine, T_2-polymer DISCO AG SP RED L-200 + thiram+ genius coat, T_3- polymer DISCO AG SP RED L-200 + thiram+ quick roots/ mycorrhiza. Seed viability was noticed in all the three tested crops. In soybean variety JS 335, significant differences among the treatments were found for all the characters studied. Among the different treatments, T_1 was found to give better performance as compared to the others. Among the characters studied, grain yield, number of branch per plant and number of pods per plant were found to differ significantly. In rice variety MTU 1010, significant differences among the treatments were found for all the characters studied. Among the treatments, T_2 gave better performance from the other. Maize variety Hema was also found to perform better with treatment T_2.

Fig 9. (a) Soybean Variety JS 335

(b) Rice variety MTU 1010

(c) Maize variety Hema

Sweet Sorghum trials at ICAR RC NEH Region Centre under Trials & Nurseries (AICRP)

Ten varieties of sweet sorghum were put on trial. Among the varieties CSV 24 SS was found to perform better in respect to plant height (204.73 cm), stem girth (11.18 mm) and weight of stem (162.82 g). Leaf length and leaf breadth were found to be highest in SSV 84 (83.80 cm and 6.06 cm, respectively). Total soluble salt was found to be the highest in variety CSV 21 F with 15.50% of TSS. The variety CSV 20 was found to be highest in the leaf weight with 26.54 g.

SOIL SCIENCE

A total number of 511 soil samples (275 for KVKs, 106 for farmers, 88 for students, 42 for other departments) were analyzed at the Soil Science Laboratory of ICAR, Manipur Centre. Thirteen soil chemical parameters, *viz.,* soil pH, EC, organic carbon, N, P, K, S, Ca, Fe, Mn, Cu, Zn and B, were included in the analysis. Awareness about the importance of soil testing and methodology for soil sample collection from the fields were demonstrated time to time.

HORTICULTURAL CROPS

VEGETABLES AND TUBERS

Identification of novel disease resistance gene *Oleosin1* in tomato *var.* MT 3

Whole genome expression analysis was conducted on resistant (MT 3) and susceptible (Pusa Ruby) tomato cultivars to identify genes associated with bacterial wilt resistance. A major induction in gene expression was detected in resistant cultivar at 5 DAI with 374 genes differentially expressed (DEGs); 151 being induced and 223 being repressed (Fig 10a). The up regulated genes are involved in various metabolic process (*viz*., lipid and carbohydrate), signal transduction, transcriptional regulation and response to various stresses (both biotic and abiotic). The most highly up regulated tomato gene *Oleosin-1-like Protein* exhibited 12.96-fold induction upon *R. solanacearum* infection. In the susceptible reaction, only 11 genes were differentially expressed; out of which 9 were up and 2 were down regulated. MapMan analysis (Fig 10b) was performed to understand the host's involvement in defense response on the transcriptome level upon *R. solanacearum* attack. This is the first-time report of Global Transcriptomics studies on tomato to isolate the resistant genes at the onset of wilting (5 DAI) against bacterial pathogen

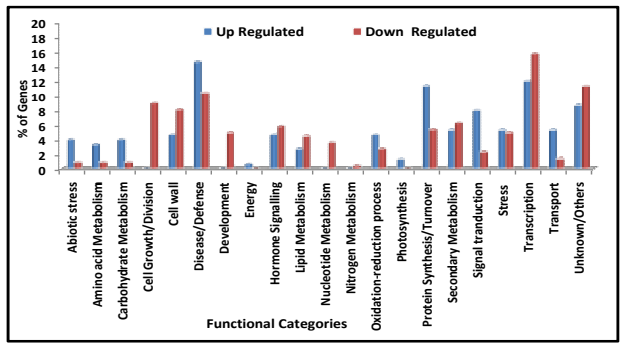
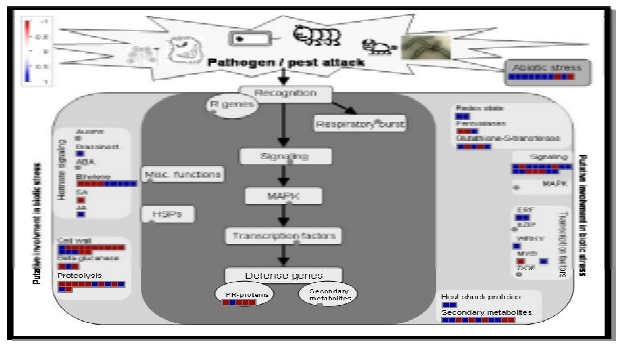


Fig 10. (a) Functional categories of DEGs (up and down regulated) upon R. solanacearum challenge in resistant reaction



(b) Changes in expression of defense gene during resistant response of tomato upon R. solanacearum infection

Ralstonia solanacearum.

Strong anti-inflammatory activity revealed in indigenous crops of Manipur

All total 24 indigenous plants were screened for their inhibitory activity against Cyclooxygenase-I (COX-I) and -II (COX-II) enzyme. COX-I is constitutively expressed in cells involved in normal physiological functions, whereas COX-II is induced by various cytokines, growth factors and carcinogens (Fig 11). The COX-II enzyme is over-expressed in several types of cancers. Among the plant extracts, maximum inhibition of COX-I enzyme was observed with *Cuscuta reflexa* (92.50%), followed by *Cephalotexas* (90.30%). Interestingly

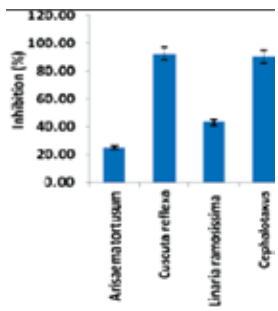


Fig 11. Cyclooxygenase-I Inhibition by Different Plant Extracts of Indigenous Crops

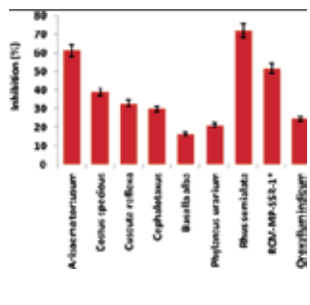


*Fig 12 Cyclooxygenase-II Inhibition by Different Plant Extracts of Indigenous Crops (*RCM-MP-SSR-1 : Yet to be identified)*

some plant extracts have shown selective COX-II inhibitory activity (Fig 12). Maximum inhibition (71.98%) was found in *Rhus semialata*; followed by *Arisaema tortusum* (61.35%) and RCM-MP-SSR-1 (51.69%). The RCM-MP-SSR-1 has been collected from Hungdung village, Ukhrul district of Manipur. All these three plants showed the potential for development of non-steroidal anti-inflammatory drugs (NSAIDs).

Antidiabetic potential discovered in *Litsea cubeba*

To look for more effective means for treatment of diabetes from plant source, methanolic extracts of seven underutilized plants were screened for their inhibitory activity against α amylase enzyme, which is involved in the breakdown of long chain carbohydrates and plays role in intestinal absorption (Fig 13). Among the plant extracts, *Litsea cubeba* has shown maximum inhibition with 7.19 mg IC_{50} value; followed by *Aegle marmelos* (11.40 mg IC_{50} value) and *Rhus semialata* (13.24 mg IC_{50} value).

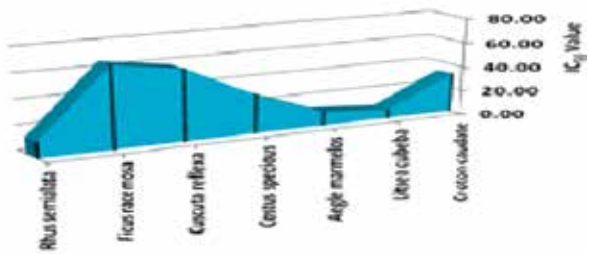


Fig 13. α-Amylase Enzyme Inhibitory Activity by Different Plant Extracts of Underutilized Crops

Radical scavenging and anti-cancer activity of *Rhus semialata,* an indigenous fruit of Ukhrul District, Manipur

For searching potential agent against reactive oxygen species, water extracts of 15 diverse indigenous crops were screened for DPPH radical scavenging activity. Among the extracts, *Phylantus uranium* has shown maximum activity (0.24 mg IC_{50} value), followed by *Rhus semialata* (0.40 mg IC_{50} value) and *Paris polyphylla* (0.73 mg IC_{50} value). The *Rhus semialata* was further investigated for bioactive compounds present in stem bark extract and three compounds have been isolated and identified.

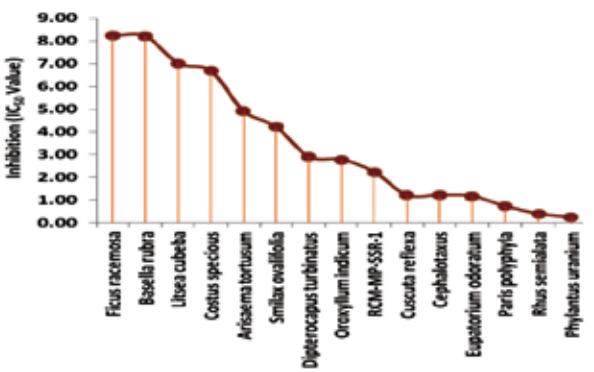
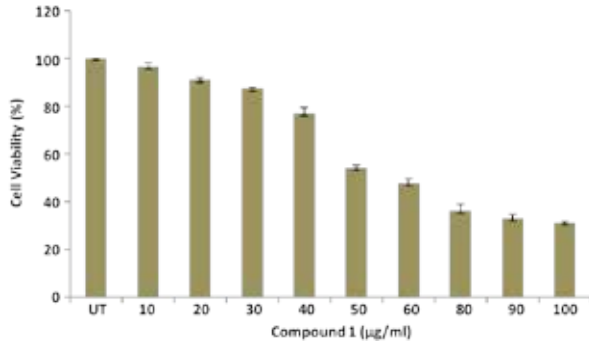


Fig 14. (a) Effect of Compound 1 Isolated from Rhus semialata on Cell Viability of U937 Breast Cancer Cells

The Compound 1 and 2 have been identified as Gallic acid and Methyl gallate (Fig 14a). Another compound was also isolated and is showing close resemblance with Gallotannin. These compounds were tested for their anti-cancer activity against U937 breast cancer cell line using MTT assay. Compound 1 (Gallic acid) significantly reduced the cell viability in a dose-dependent manner (Fig 14b).



(b) DPPH Radical Scavenging Activity of Different Plant Extracts

Optimization of Feather Protein Hydrolysate Production from Chicken Feather Waste using Multifaceted Bacterium *Chryseobacterium* sp. RCM-SSR-7

Optimization of feather protein hydrolysate (FPH) from chicken feather waste using Chryseobacterium sp. RCM-SSR-7 was standardized using response surface methodology. After overall analysis it was found that optimum soluble peptide released (295 mg/g feather) occurred at pH 7.5, 5% feather concentration and 84 h of incubation. From 100g of feather 80± 3g of feather

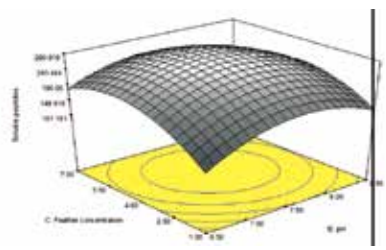
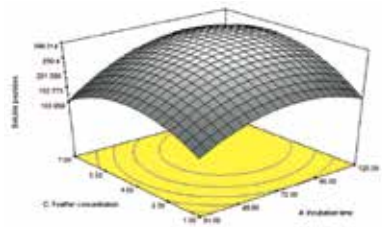
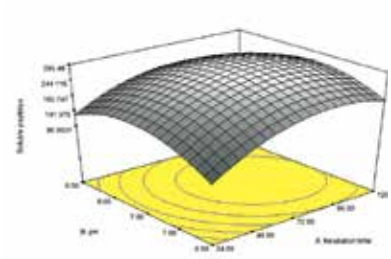


Fig 15. (a) 3D response interaction between feather concentration and pH



(b) 3D response interaction between feather concentration and incubation time



(c) 3D response interaction between pH and incubation time

meal (i.e. 80% recovery) could be obtained after final processing. However, the strain RCM-SSR-7, could degrade very high concentrations of feathers within 72 h of incubation at 30^0 C. Even at 10% (w/v) feather concentration, 74% feather weight loss was achieved.

The FPH contains crude protein (75%), ash (11%), fat (3%), nitrogen (12 g/100g), phosphorous (840 mg/100g), potassium (450 mg/100g), calcium (114 mg/100g), iron (13.7 mg/100g), zinc (10.3 mg/100g), manganese (0.52 mg/100g) and copper (0.48 mg/100g). It has also been found to be rich in essential amino acids such as Histidine (90 mg/g FPH), Leucine (106.3 mg/g FPH), Lysine (43.1 mg/g FPH), Threonine (86.1 mg/g FPH), Isoleucine (17.9 mg/g FPH)) and Methionine (56.3 mg/g FPH) as compared with raw feather. Hence, strain RCM-SSR-7 could be a good source for production of amino acids from feather waste.

Feather protein hydrolysate is rich in amino acid and has higher digestibility (80%) and can also be used as animal feed additives. The DPPH radical-scavenging activity of FPH showed that the feather protein hydrolysate exhibited radical scavenging activity with an IC_{50} value of 0.102 mg/ml. The bacterial strain RCM-SSR-7 can also produce IAA from 24 h of incubation in chicken feather medium with or without tryptophan supplementation..

Detection of *Turnip mosaic virus* (TuMV) infection

Broad leaved mustard (*Brassica juncea* var. *rugosa*) plants in different locations of Manipur were observed to exhibit typical symptoms of puckering and leaf deformation with an estimated disease incidence of 38%. Electron microscopy confirmed the association of a flexuous virus. Upon mechanical inoculation, the virus was successfully transmitted to different cole crops (cauliflower, broccoli, knol khol), radish and spinach. Based on amplification and sequencing of CP gene, the incitant virus was identified as *Turnip mosaic virus* (TuMV). Two TuMV isolates (from broad leaved mustard and cabbage) had 95% identity among them and 89-94% with other Indian TuMY isolates for CP nucleotide

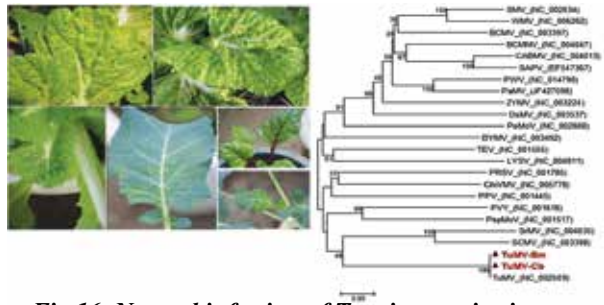


Fig 16. Natural infection of Turnip mosaic virus on broad leaved mustard, mechanical transmission to different hosts and CP based phylogeny

sequences (Fig 16) . This is first molecular evidence for association of TuMV infection from Manipur.

Evaluation of taro hybrid progenies for growth and TLB resistance

About 200 seedling progenies of taro comprising of OP and hybrids were successfully raised *in vitro* and maintained in poly house for morpho-physio-biochemical characterization for growth and resistance against *Phytophthora* leaf blight disease. The hybrid line RCMC-5 x Jhankri performed better with lower disease score (0-4 point scale) while compared with its parental lines and other hybrid progenies (Fig 17).

Jhankri *RCMC-5* *RCMC-5 x Jhankri*

Fig 17. Morpho-physio-biochemical Characterization of hybrid progenies of taro

FRUITS AND PLANATATION CROPS

Prevalence and genetic diversity of *Citrus tristeza virus*: development of robust diagnostics for routine indexing

Extensive surveys were conducted in different citrus growing groves of Manipur (Churachandpur, Chandel, Tamenglong, Ukhrul and Imphal West) covering 36 locations to identify the prevalence and distribution *of Citrus tristeza virus* (CTV) on citrus species like mandarin, oranges, mosambi, *Citrus macroptera* and *Kachai* lemon (Fig 18). Out of total 540 samples tested using double antibody sandwich-ELISA (DAS-ELISA) and reverse transcription-PCR (RT-PCR), 62.7% samples were tested positive for CTV. Ten CTV isolates from Manipur had 86-94% identity among them and 89-98% with other Indian CTV isolate *Kpg3* for nucleotide sequences of coat

Fig 18. Diversity of CTV and HLB symptoms observed onvarious citrus species at different locations of Manipur

protein (CP) and were phylogenitically related to *Kpg3* genotype. Out of the tested samples 38% were detected to ave mixed infection of CTV and huanglongbing (HLB), indicating these two pathogens to be responsible for citrus decline in Manipur.

PASSION FRUIT

A recombinant *Potyvirus* associated with yellow mottle disease of passion fruit in North East India

A novel *Potyvirus* identified to be associated with yellow mottle disease of passion fruit was analysed for possible recombination in coat protein (CP) gene (Fig 19). Two isolates, PFPV-1 (sampled from yellow passion fruit cultivar) and PFPV-3 (sampled from Brazilian golden cultivar) were identified to be recombinant. Two recombination events viz. R1: nucleotide coordinates 104-197 (PFPV-1)/125-187 (PFPV-3) and R2: nucleotide coordinates 109-695 (PFPV-1)/188-697 (PFPV-3) in CP sequences were identified, supported by three and five algorithms respectively. The R1 recombination event was contributed by *Passion fruit woodiness virus* (PWV)-SYd isolate and *East Asian Passiflora virus* (EAPV)-Twn isolate as minor and major parent respectively.

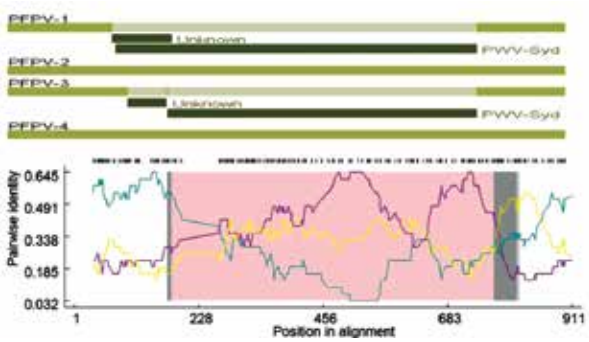


Fig 19. Recombination break points in CP region of passion fruit infecting Potyvirus

Similarly R2 recombination event was contributed by *Passion fruit woodiness virus* (PWV)-SYd isolate and *Cowpea aphid-borne mosaic virus (*CABMV)-PE4 isolate as minor and major parent respectively. This indicated that the recombinant genomic region in these passion fruit infecting potyviruses was derived from PWV. The recombinant isolates were pathogenically also distinct suggesting biological implications of the recombination phenomenon.

SPICES

Characterization of viral complex of chilli and development of ecological engineering based integrated disease management module

A high incidence of viral disease complex on king chilli was recorded under Manipur conditions. Surveys in different pockets of Manipur were

Fig 20. Symptom diversity of viral complex in king chilli and detection of associated viruses

conducted for the viral complex of king chilli and an incidence of 64% was recorded based on symptoms. Out of 240 symptomatic samples showing symptoms of leaf puckering, shoestring, veinal mottling, yellowing, small leaf lamina etc. collected from different districts of Manipur, 50.44% were tested positive for CMV and 21% for ChiVMV in reverse transcription PCR (RT-PCR). Out of the tested samples 17% were having mixed infection of CMV and ChiVMV (Fig 20). Present study indicated that CMV and ChiVMV are the most commonly associated viruses with viral complex of king chilli in Manipur.

An ecological engineering integrated viral disease management module was developed for the field management of viral disease complex of king chilli. Seed treated with carbendazim were sown under insect-free poly house covered with insect-proof net for raising the healthy seedlings of king chilli (Fig 21). Initial experiment was carried out with seedling dip treatment of bare rooted king chilli seedlings with (i) Crusier (thiamethoxam 5S) and (ii) Actara (thiamethoxam 25WP) for 6 hours to overnight. Treated seedlings were transplanted in different plots where barrier crops (maize, sunflower, buck wheat, foxtail millet and barnyard millet) around 20-25 days earlier to transplanting. Mulching with silver plastic mulch or paddy straw was done separately in different plots.

After 20-25 days post-transplanting, one foliar spray of respective insecticide and micronutrient mixture was given to the transplanted king chilli. Significantly lower viral disease incidence (0-4% after 30 days of transplanting and 9-10% after 60 days of transplanting) was observed as compared to untreated plot (78% after 30 days of transplanting and 95% after 60 days of transplanting). Based on the combined results of three seasons, treatment with Crusier (thiamethoxam 5S) or Actara (thiamethoxam 25WP), followed by transplanting in plots having 20-25 days old maize plants as barrier crop and silver plastic mulch or paddy straw mulch protected the king chilli plants from any secondary viral infection carried through vectors for at least for 60 days post-transplanting and gave significantly higher yield (63% higher yield) over the untreated control.

SECONDARY AGRICULTURE

MUSHROOM

In order to popularize mushroom cultivation among farmers of Manipur, quality spawn of different *Pleurotus* species (*P. ostreatus, P. eous, P. sapidus, P. flabellatus, P. sajorcaju, P. florida*and *P. eryngii*) and shitake (*Lentinula edodes*) were produced and supplied to different stakeholders. Different training programmes (174 participants) on scientific mushroom spawn production and cultivation technology and 'National Mushroom Day' (40 participants) were organized for farmers, farm women, women self help groups, entrepreneurs etc. Under AICRP-Mushroom, four oyster mushroom strains were evaluated during winter 2016. Strains PL-16-02, and 04 were found to be superior.

VALUE ADDED PRODUCTS

Development of Unique value added products from Tree bean and *Prunus nepalensis*

Different value added products from underutilized Tree bean and *Prunus nepalensis* were developed under DBT twinning project in collaboration with PJTSAU, Hyderabad. A unique product 'Tree Bean Crunch' was developed from tree bean pods using extrusion technology. Extruded products such as Museli and Chewda Snax from *Prunus nepalensis* and antioxidant rich Prunus health mix and dehydrated products from Prunus fruit pulp were developed (Fig 22).

The products were assessed by the sensory descriptors following 9 point Hedonic scale for acceptance of colour, flavor, texture, taste and overall acceptability. The nutritionally rich processed products would be able to mitigate hidden hunger and malnutrition among the people of this region.

Fig 22. (A) Tree bean crunch; (B) Prunus Museli and Prunus Chewda; (C) Prunus Health Mix; (D) Dehydrated Prunus nepalensis

Establishment of Sagoo Processing Unit

Two numbers of Sagoo Processing Units were successfully established at Maya Tuber Crops Growers' Club, Riha and Lingsang Farmers Club, Thoyee of Ukhrul district under special funds for tuber crops. Preparation of Raw Sagoo and Sagoo pappads were demonstrated among the club members. The Sagoo processing units will boost additional income generation among the tribal population through tuber crop incubation centres.

Empowering Farm Women and Unemployed Rural Youths through Community Processing Unit

With the aims of empowering farm women and unemployed rural youths through food processing; reducing the post harvest spoilage and promotion of indigenous horticultural crops; nine community food processing units were established involving women self help groups, widow organization and NGOs in collaboration with KVKs (Fig 23a). Among the nine processing units, two are for spice processing (in Churachandpur and Imphal East) and seven are based on fruits and vegetables (in Chandel, Churachandpur, Imphal West, Senapati and Ukhrul). All the products being manufactured by these units was given a regional branding.

For the first time in Manipur one "Organic Spice Processing Unit" was established in collaboration with Grassroot Syndicate Producer Co. Ltd., Imphal. The unit has already obtained organic certification. All nine processing units have obtained FSSAI license. One processing unit in Ukhrul district was developed as Model Training Centre for Community Based Value Addition to provide need based and comprehensive hands-on training for the aspiring agripreneurs and tribal women. The value added products developed at ICAR, Manipur Centre have

Fig 23 (a) Women self help group with processed food

(b) Value added products from local horticultural crops

been disseminated to these processing units. All these processing units are producing more than 50 diverse value added products from local horticultural crops. This is a significant initiative to harness the potential of underutilized horticultural crops as well as to sustain the livelihood of the resource poor farming community.

ANIMAL SCIENCE

VETERINARY PUBLIC HEALTH

Clonal analysis of Multidrug resistant ***Escherichia coli*** from clinical cases, sewage and foods of animal origin

Multidrug resistant *Escherichia coli* isolates (n=35) from clinical cases of animals, foods of animal origin and sewage were characterized with ERIC-PCR and $(GTG)_5$-PCR to explore the clonality among these isolates. With ERIC-PCR, the CTX-M positive isolates are grouped in two main clusters revealing high clonality among these isolates. $(GTG)_5$ fingerprinting showed similar clonality among dog diarrhoeal isolates (Fig 24).

Characterization of novel conserved genes of field isolates of ***Salmonella*** Typhimurium

A total of eighty field isolates of *Salmonella* Typhimurium were characterized with oligonucleotide primers targeting serotype-specific "*typh*" gene and Biofilm-Associated Protein (*Bap*A: *Bap*AFI, *Bap*AFII and *Bap*AFIII, *Bap*B and *Bap*D). On silico analysis, it was found that these genes are conserved in all the tested *Salmonella* Typhimurium.

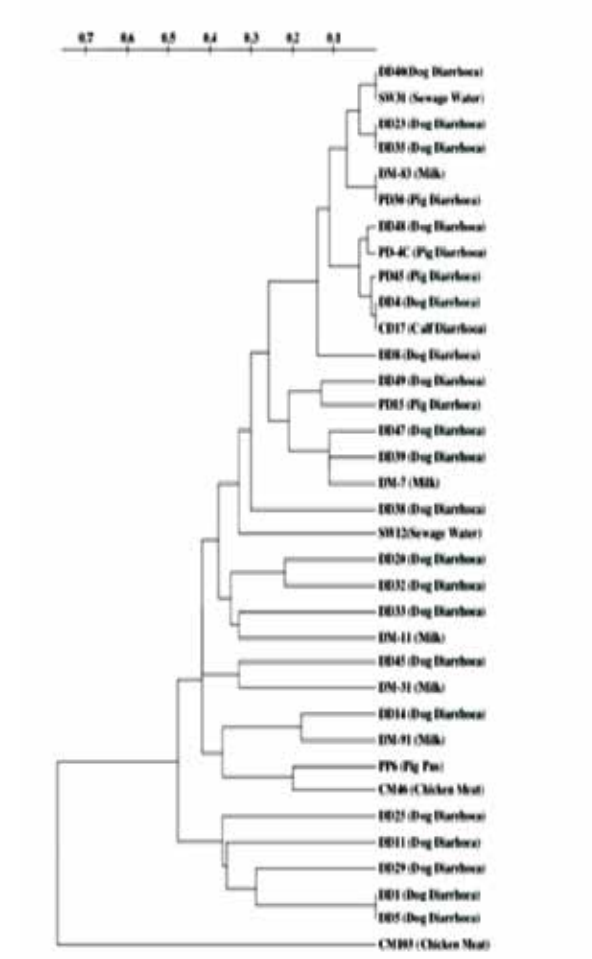
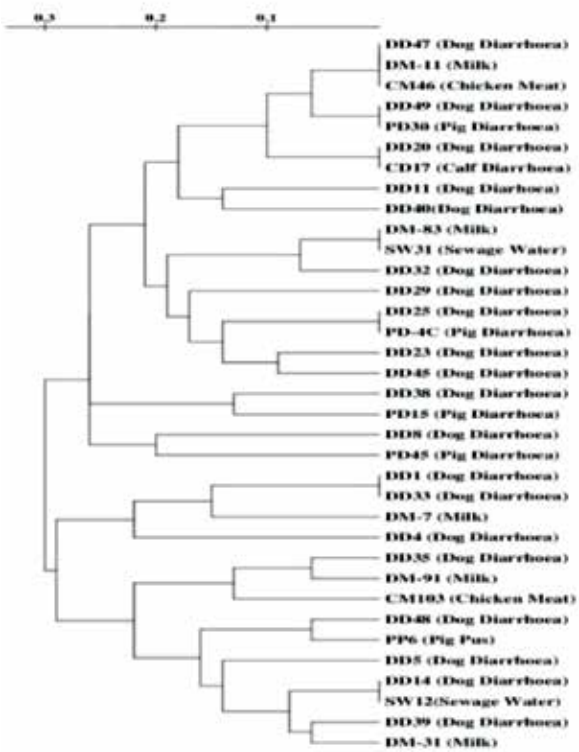


Fig 24. Dendrogram generated from (a) ERIC



(b) Fingerprinting with (GTG)5

POULTRY SCIENCE

Poultry Seed Project (PSP)

The parent stock of Vanaraja and Srinidhi poultry birds were maintained in this project and the total number till December 2016 are 1327 birds (including the pullets). During the reporting year, a total 33170 numbers of eggs are laid and 27424 numbers of chicks in the form of DOC chicks was supplied and chicks were distributed to the beneficiaries in various district of Manipur during April to December 2016. Altogether 150 numbers of farmers, 11 families and 6 villages were benefitted under TSP under Poultry Seed Project. Besides, six training programmes were also organized.

Performance of Vanaraja and Srinidhi under Backyard conditions (at household levels)

The data were collected randomly from some of the farmers which are benefited under TSP for analysis. The main reason of mortality in farmer's field was due to diseases like coccidiosis, respiratory infection, cannibalism, parasitic infestation and poor electric supply.

FISHERY SCIENCE

Effect on growth and survival rate of *Ompok bimaculatus* using formulated aquatic plant based diet

Four different formulated feeds were fed to fifteen days old fries of *O. bimaculatus* @ 5% body weight/day for 30 days. All the tested feed were having 28% crude protein level based and 5% crude protein (CP) from *Azolla*, *Lemna* and fish meal. From the result, it was observed that the best growth was from fish meal based diet (0.05g/day). However, good growth were observed using either 5% CP *Azolla* and *Lemna* and found better than control diet (rice bran: oil cake) (0.041g/day). Hence, *Azolla* (0.046g/day) and *Lemna* (0.047g/day) can be used as substitute fish meal at 5% diet in *O. bimaculatus* rearing and has great potential as an inexpensive and readily available protein supplement.

Effect on growth and survival of *Tor species* reared in ponds

Tor fries were fed with a mixture of rice bran and oil cake @ 5% body weight per day in two different locations of Manipur (ICAR, Lamphelpat and Nungba). Fishes reared in ponds at Lamphelpat gained higher body weight than at Nungba (Fig 25). From this preliminary study it was evident that, this fish can be a potential fish species for farming in the valley.

Physico-chemical characteristics of water in cultured ponds of both locations were monitored. Water temperature was found more or less similar. However pH, free carbon-dioxide (CO_2), dissolved oxygen (DO), alkalinity, ammonia, chlorides, nitrites, nitrate, iron, magnesium and phosphate contents were quite different. High alkalinity, Mg, Cl- NH4, hardness, etc were found higher in ponds of ICAR Lamphelpat; however, NO_2, NO_3, Fe, phosphate content in pond water were higher at Nungba.

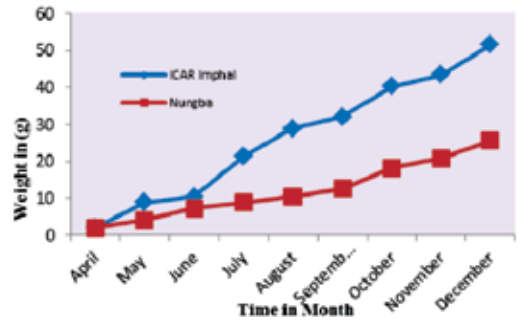


Fig 25. Growth of Tor tor reared in ponds at Lamphelpat & Nungba

Studies on molecular phylogenetic of *Bangana dero* and two *Labeo* species :

Molecular phylogenetic study of *Bangana dero*, an endemic fish species and two *Labeo* species i.e. *Labeo bata* and *L. rohita* were conducted by using mitochondrial 16S rRNA gene sequences (Fig 26). Molecular phylogenetic tree (NJ tree) shows that Bangana dero is a distinct species.

Demonstration Programme under MASTEC-ICAR joint Project on Pisciculture and its Allied Activities for Socio-Economic Development in Manipur:

Off-campus demonstration on short duration aquaculture practices were conducted in two locations (pond depths=2.3-2.5m and water depth at 2.0m). Stocking density @ 40,000 fingerlings/ha using mixed carps of IMCs, exotic carps and indigenous minor viz., *Bangana dero* and *Osteobrama belangeri* in different

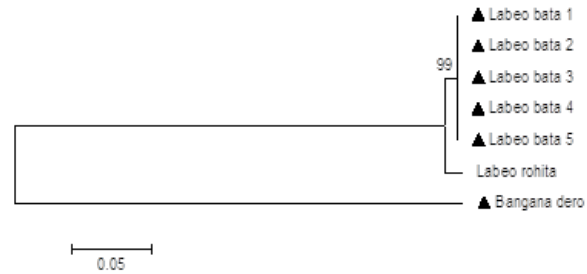


Fig 26. Phylogenetic tree of two genera, Labeo and Bangana based on mitochondrial 16S rRNA gene sequences

ratio. The fish productions ranged from 1300 to 1700 kg/0.25ha in 7 months with benefit cost ratio range 3.0 to 3.5 (average 3.09). The profit was much higher when more number of indigenous carps *viz*. *Bangana dero* and *Osteobrama belangeri* where included in stocking. Under this short duration aquaculture practices 25 farmers were covered in >40 ha in 2016.

Table 2. Fish seed production in 2016

Species	No. of Brooders	Spawn production	Fingerlings
Cyprinus carpio	11kg	15 lakh	75,000
Ctenopharyngodon idellus	5 kg	5 lakh	40,000
Osteobrama belangeri	10kg	5 lakh	30,000
Bangana dero	2 kg	2 lakh	45,000
Clarias magur	3 kg	0.10	1,000
Others	5 kg	5 lakh	25,000
Total	36 kg	**32.10 lakhs**	**2,16,000**

SOCIAL SCIENCE

Farmers field school integral farmers club-Transfer of Technology approach for enhancing percolation of technologies at field level and improve technology adoption

Four farmers club namely Sangaithel, Heikrujam, Khabam Bamdiar and Khumbong were taken up for the present study on technology dissemination and demonstration. During *Kharif* season 2016 emphasis was given on scientific cultivation practices of paddy using high yielding improved variety and new technology. For this, training and demonstration were conducted in all the four selected farmers' club right from the seed selection and soil preparation stage. Through training and interaction programme farmers were appraised on the benefit of systematic line transplanting, use of optimal dose of fertilizer, biosafety plant protection measures, use of conoweeder and direct paddy seeder machine (Fig 27). For the first time, low cost direct paddy seeder machine was demonstrated and introduced at farmers' field. Direct paddy seeder save labour cost by 80 % and reduce seed requirement up to 50% per hectare area. Weeding and intercultural operation becomes very easy on the field where direct paddy seeder is used and yield is almost the same as line transplanted paddy.

In order to monitor and control the insect pest in paddy, pheromone trap were introduced in farmer's field through farmers club programme. Regular observations of insect pest found trapped in pheromone trap helps to determine the ETL level and act as a guideline for pest

Fig 27. (a) Farmer's Training Programme

(b) Demonstration of Direct Paddy Seeder

(c) Installation of Pheromone trap at Farmer's Field

control recommendations. For solving the problem of credit, the farmer club were linked with the financial agencies ie NABARD for getting loan and financial assistance. Through NABARD assistance farmer club member start getting Kisan Credit Card loan to the tune of Rs.30,000 per annum at the nominal interest rate of 7%. During the *rabi* season, initiative were taken for cultivation of winter crops for round the year crop cultivation.

Adoption of Integrated Farming System for Livelihood Improvement of the Farmers in Manipur

Five different models of IFS have been established in hill districts of Manipur (Fig 28). The major components included in the IFS are cropping systems (*Kharif*: paddy, groundnut, beans and maize; *Rabi*: pea and mustard), vegetables (tomato, cabbage, cauliflower, chilli, cucurbits), fruit cultivation (orange, Kachai lemon and gooseberry), piggery (cross breed Hampshire), goatry (Black Bengal), backyard poultry (Vanaraja), duckery (Khanki Campbell), fishery (common carp and grass carp), agroforestry (Tree bean), residue management (composting and vermicomposting), soil management (liming, bench terracing), water harvesting (Pond, *Jalkund*) etc. The net farm income was realized by farmer who maintained "*crop-livestock-fish-vegetable-fruits-water harvesting"* integration on their field (Table 3).

Table 3. Net farm income was realized by farmer

Name of the Participatory Farmers and Location	Components	Area (ha)	Water body (ha)	B: C ratio
Shri A. S. Somi Nungshangkhong Village Ukhrul district (1435 m above MSL) Sub-tropical	**Model A :** Field crops (2 ha) + Horticultural Crops (3 ha) + Agro-forestry (2 ha) + Apiculture (10 hives) + Fish hatchery (1 unit) + Fishery (80 brooder) + Goatery (5 nos.) + Poultry (520 nos.) + Mushroom (1 unit) + Vermicomposting (1 unit) + Polyhouse (1 unit)	8	0.75	3.98
Shri R. D. Peter Purul Akutpa Village Senapati district (1723 m above MSL) Sub-temperate	**Model B :** Field crops (1 ha) + Horticultural Crops (1 ha) + Agro-forestry (10 ha) + Fishery (100 brooders) + Carp hatchery (1 unit) + Piggery (2 nos.) + Poultry (80 nos.) + Vermicomposting (3 unit) + Apiculture (2 hives) + Fruit processing (1 unit) + Polyhouse (1 unit)	13	1.00	7.93
Shri V. Tuime Lolly Kachai Village Ukhrul district (1371 m above MSL) Mild Sub-tropical	**Model C:** Field crops (2 ha) + Horticultural Crops (8 ha) + Agro-forestry (2 ha) + Fishery (100 brooder) + Piggery (10 nos.) + Dairy (5 nos.) + Poultry (80 nos.) + Sericulture (1 unit) + Vermicomposting (1 unit) + Fruit processing (1 unit) + Polyhouse (1 unit)	13	1.0	3.85
Shri Hemkhopao T. Champhai Village, Churachandpur district (808 m above MSL) Mild tropical	**Model D :** Field crops (2 ha) + Horticultural Crops (1 ha) + Fishery (25 brooders) + Piggery (7 nos.) + Poultry (120 nos.) + Vermicomposting (1 unit) + Apiculture (2 hives)	4.0	0.20	4.32
Shri H. B. Starson Chandel Khullen Village (899 m above MSL) Mild tropical	**Model E:** Field crops (1.25 ha) + Horticultural Crops (0.75 ha) + Fishery (80 brooders) + Piggery (14 nos.) + Poultry (60 nos.)	2.5	0.60	3.45

Fig 28. IFS models developed in Ukhrul, Senapati and Churachandpur districts of Manipur

The performance of each models consisting of agri, horti, livestock, fisheries and secondary horticulture was evaluated for five consecutive years. The cropping intensity was increased up to 180 to 300% compared to 120% in traditional farming system. The farming intensity has also been increased 300 to 500%, as compared to 150-200% in traditional farming system. On an average, 409 to 570 days employment was generated against 110 days in traditional farming system. The average return rupee per rupees investment of various farming systems varied from 3.45 to 7.93.

NATIONAL MISSION ON SUSTAINING THE HIMALAYAN ECOSYSTEM

Pilot studies: The pilot studies under the project were undertaken at Chandanpokpi village, Chandel district. Pigeonpea (UPAS-120), *Urd* bean (PU-31), rice (R C Maniphou 7), organic turmeric, maize + groundnut/ pulses intercropping, INM, IPM and SRI were introduced through tribal sub plan. Cultivation of *Rabi* vegetables and especially legumes (Lentil, pea and broadbean) were undertaken to increase the cropping intensity and enhance the soil fertility. In this pilot studies, *Jalkund* were successfully established and farmers harvested > 60000 litres of water/unit. Introduction of improved bred of poultry strain (Vanaraja) and cross breed of pig as well as timely vaccination, feed supplement and improved housing was undertaken. Climate smart technologies like preparation of early vegetable nursery under low cost polytunnel were introduced. Income generating secondary agricultural activities like mushroom production, bee keeping and community based fruit processing were popularized with an aim for agri-preneurship development. One awareness programme, five training programmes were organized. One state level workshop-cum-brainstorming session on sustaining the Himalayan ecosystem in North Eastern India under changing climate (Fig 29) was successfuully organised.

Monitoring indicator studies: Under soil health indicator, soil samples were collected from ten different land use system from three altitudes [low < 800 m (Orange Orchard (3 years old); Banana Orchard (3 years old); Vegetable cropping system (Tomato/ Brinjal- Potato/Veg. pea); Rice-Fallow (Lamphelpat, Imphal); Rice-Tomato (ICAR Farm), mid 800-1600 m (Improved Jhum (3 years); Pine forest (>10 years) and high altitudes > 1600 m (Kiwi orchard (4 years old); Tree bean plantation (8 years) and Oak plantation (10 years)] from 6 soil depths (0.00-0.15 m, 0.15-0.30 m, 0.30-0.45 m, 0.45 -0.60 m, 0.60-0.75 m and 0.75 -1.00 m) and tested for its various soil physical, chemical and biological properties (Fig 30)

During mid fortnight of July to August, the soil loss recorded 0.24 t/h at 37% slope in Chandel district, while 0.50 t/ha at 32 % slope of ICAR Langol Farm. The soil loss was 150% more in 67.3% sand dominated soil texture than 52.7% sand texture soil. Similarly, water samples were collected from three different altitudes Low (<800 m): Imphal (Thangmeiband pond and langol bore well); Bishnupur (Loktak and Thongjaorok river), Medium (800-1600 m): Chandel (Maha river, stream and pond), High (>1600 m): Senapati (Stream, Chuya spring and Kulu canal) and tested for different water quality parameters (Table 4).

Fig 29. Technological Interventions under NMSHE (TF-6) at Chandanpokpi Village, Chandel Manipur

Table 4. Quality of wter samaples collected from different sites

Sites	Tem. (°C)	pH	Alkalinity (ppm)	Dissolved oxygen (ppm)	NO_3^- (ppm)	NO_2^- (ppm)	NH_4^+ (ppm)	PO_4^{-3} (ppm)	Cl^- (ppm)
Thangmeiband pond	22	7.4	80	3.8	<10	<10	<0.5	<2	15
Langol bore well	20	7.2	160	3.4	<10	<10	<0.5	<2	10
Maha river	18	7.8	70	6.4	<10	<10	<0.5	<2	10
Stream	16	7.4	80	6.6	<10	<10	<0.5	<2	10
Pond	20	6.8	40	6.0	<10	<10	<0.5	<2	20

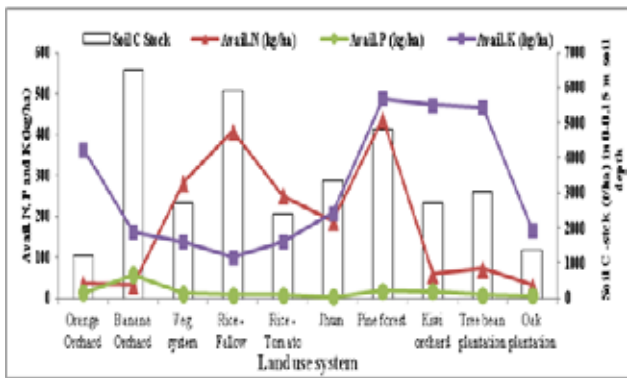


Fig 30. Fig. C stock, Available N, P and K under 10 different land use system

ICAR-Kachai Villagers joint initiative on Community Plantation brought recognition to Kachai village, Ukhrul

For conservation of Kachai lemon as well as to improve the lemon productivity, the villagers of Kachai village in Ukhrul district, Manipur under the technical guidance of ICAR, had initiated Community Conservation Programme where every household in the village maintains 50 to 100 numbers of plants. ICAR, Manipur Centre provided the technical guidance for improving the productivity and rejuvenation of lemon orchards. ICAR team also developed one Kachai lemon based integrated farming system in the village. All these unique efforts have created significant impact among the villagers. As recognition to this noble initiative Kachai Village Community has been awarded "Plant Genome Savior Community Award" by Protection of Plant Varieties and Farmers Right Authority, Government of India in 2016 (Fig 31). This award has motivated the villagers and boosted up the confidence of ICAR.

Fig 31. Kachai Village Community accompanied by Joint Director, ICAR Manipur Centre receiving 'Plant Genome Savior Community Award' from Hon'ble Minister of Agriculture & Farmers Welfare, GoI

MIZORAM

WEATHER REPORT

Daily weather observations were recorded during April to December 2016 (Fig. 1). The total amount of rainfall received during the period was 3157.40 mm in 132 rainy days and 4 extreme rainy days (more than 100 mm rainfall per day). The highest T_{Max} was observed on 11th April, 2016 (31.9°C) and the lowest T_{Min} was observed on 14th December, 2016 (12.9°C). The variation of morning RH was lesser than the evening RH which varied from 86% (May) to 96% (August and September), while the evening RH varied between 53% (January) to 82% (August), respectively. Southerly to South-Easterly wind directions was most prevalent throughout the year. The average bright sunshine hours varied from 3.48 to 4.06 hrs during monsoon months (June to September) and 6.98 to 7.93 hrs during winter months.

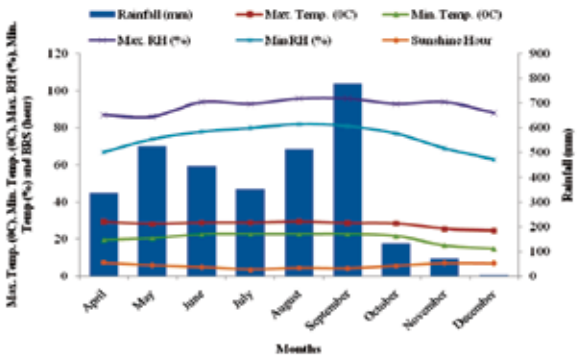


Fig 1. Mean monthly weather variables recorded during April 2016 to December 2016 at ICAR Research Complex for NEH region, Mizoram Centre, Kolasib Mizoram

Trend analysis of past weather events

Long term weather data (1986-2014) recorded at surface observatory of Mizoram centre was analyzed. The rainfall data of 35 years (1980-2014) and temperature data of 29 years (1986-2014) were analyzed. The analysis showed that the winter month of February is becoming warmer due to significant increase in both maximum and minimum air temperature ($P < 0.1$), along with significant rise in monthly minimum temperature during March ($P<0.05$). Monthly rainfall trend analysis showed an abrupt increase in 1 month SPI during August at Kolasib, with lower annual variability. This increase indicated by a significant rise in 1 month August Standardized Precipitation Index (SPI) at $P < 0.01$. The results confirmed that Kolasib was becoming wetter during last 35 year for experiencing more monsoonal rainfall in August. The pattern of the existing environmental change suggested a significant rise in 3 months Standardized Precipitation Evapotranspiration Index - SPEI ($P<0.05$) from July to October due to increasing moistness which coincides with the dominant *Jhum* cultivation period (May to September) across the state. Consequently, the negative trend of 3 months SPEI values during January and February month affirmed the increasing dryness during the post monsoon and winter months. *Rabi* agriculture in Mizoram may be adversely affected due to this environmental change driven increasing water scarcity problem in future.

Variability of soil carbon pools in post burning condition of shifting cultivation

Surface soil (0-10 cm) samples were collected before burning the slash vegetation, 45 days after burning from different *Jhum* fallow periods in Kolasib District of Mizoram to relate the time of upland rice sowing and immediately after harvesting of paddy (Table 1). Different carbon pools such as very labile, labile, less labile and non labile carbon pools were determined by different concentrations of H_2SO_4. Very labile and labile pools consist the active pools whereas less labile and non labile constitute the passive pool. Results revealed that the active carbon pools decreased after burning and further to harvesting stage which was attributed to the loss of biomass due to burning and other operations. The active carbon pool was significantly higher due to fallow period above 10 years (Fig. 2). The passive pools increase after burning and similarly fallow period above 10 years maintained higher passive carbon pool.

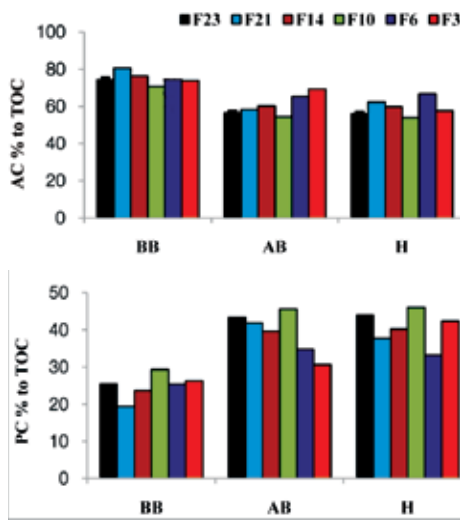


Fig 2. Percent contribution of active and passive carbon pool to total organic carbon

Table 1. Dynamics of active and passive carbon pools as affected by cultural operations and fallow period

FA	Active carbon pool (mg/ g)				Passive carbon pool (mg/ g)			
	BB	AB	H	Mean	BB	AB	H	Mean
F_{23}	25.1±0.3	17.3±0.5	15.4±0.6	19.3^{AB}	8.6±0.5	13.3±1.0	12.1±0.3	11.4^{A}
F_{21}	27.8±0.7	16.3±0.3	15.2±0.4	19.8^{A}	6.7±0.6	11.8±0.6	9.2±0.1	9.2^{B}
F_{14}	23.0±0.6	16.2±0.7	15.0±0.8	18.1^{B}	7.1±1.0	10.7±1.2	10.1±0.6	9.3^{B}
F_{10}	17.0±0.2	11.6±0.7	10.2±0.5	13.0^{D}	6.6±0.6	7.5±0.9	5.8±0.7	6.6^{C}
F_{6}	18.1±0.2	14.2±0.3	13.4±0.5	15.2^{C}	6.2±0.8	7.6±0.2	6.7±1.0	6.8^{C}
F_{3}	17.8±0.6	15.3±0.3	11.5±1.1	14.8^{C}	6.3±0.7	6.8±0.4	8.5±1.3	7.2^{C}
Mean	21.5^{A}	15.2^{B}	13.5^{C}		6.9^{B}	9.6^{A}	8.7^{A}	

Note: Means followed by ± numbers represent standard error (SE). Different letters along the column and rows are significantly different (P<0.05) according to Duncan's test. FA: Fallow period; BB: Before burning; AB: After burning; H: Harvesting; F_{23}: 23 year fallow; F_{21}: 21 year fallow; F_{14}: 14 year fallow; F_{10}: 10 year fallow; F_{6}: 6 year fallow; F_{3}: 3 year fallow.

Effect of land uses on soil quality in different land use of mizoram

Soil samples were collected from different land uses and depths (0-15; 15-30; 30-45 cm) to study the impact of practiced land uses on soil quality. Secondary forest (F), abandoned *Jhum* field after first year cultivation of upland rice (J), oil palm (O), areca nut (A), lowland rice (P), rubber (R) and teak (T) were selected from adjacent area and analyzed for different soil biological parameters *i.e.* acid and alkaline phosphatase enzyme, dehydrogenase, urease, β-glucosidase and arylsulphatase enzyme activity (Fig. 3). To sum up the effect of soil enzymes, geometric mean (G Mea) of the entire soil enzyme was analyzed as an indicator of soil quality. Results suggested that β-glucosidase (GLU), an important enzyme involved in C cycling varied in the studied soil following R>F>A>O>P>J>T (P < 0.05) due to land use changes. The effect of land use on geometric mean of soil enzymes was in the order F>R>A>O>T>J>P (P < 0.05) and decreased with the increase in soil depth, respectively. The results suggest that the soil quality parameters were least for paddy soils which may be attributed to the intensity of disturbance and tillage operations and among the plantations teak was inferior.

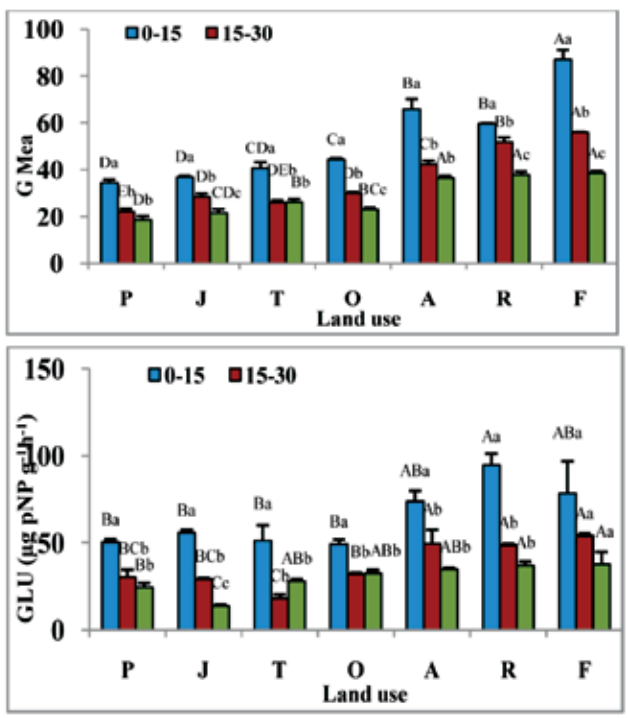


Fig 3. Variability of geometric mean (±SE) of soil enzyme activities and β-glucosidase as affected by land use.

Performance of different rice varieties under upland condition

Fifteen different rice varieties were evaluated for yield potential in upland condition. *Gomati* recorded the highest number of tillers whereas *IURON-519* recorded the lowest (4.84) (Table 2 and Fig. 4). The maximum number of panicles was observed in variety *Gomati* (20.13) and the tallest plant was observed in *Partei Buh* (144.66 cm). The highest grain and biological yield was observed in variety *Bhalum-1* (32.9 q/ ha grain yield and 81.4 q/ ha biological yield). The maximum harvest index was recorded under variety *IURON-514* (48.82) and the highest test weight was attributed to *Bhalum-4* (8.05 g).

Fig 4. Performance of upland rice varieties *CAUR-2, BHALUM-1 and BHALUM-2*

Performance of different rice varieties under lowland condition

Among the 15 varieties the tallest plant was observed under *NLR-6* (162.88 cm) followed by *Chhunpawlh* (158.45 cm) and *Buhmawi* (157.75 cm) (Table 3 and Fig. 5). *Gomati* and *CAUR-1* produced more numbers of tillers/ hill and panicles/hill whereas *NRL-5* and *Khawbung Buh* produced the least,

Table 2. Growth and yield of different rice genotypes under upland condition of Mizoram

Varieties	Tillers /hill	Panicles / hill	Plant height (cm)	Grain yield (q/ha)	Biological yield (q/ ha)	Harvest index	Test weight (g)
Bali Red	8.26	7.45	128.45	25.7	71.3	36.23	22.61
Bali White	7.26	6.04	118.99	28.6	65.4	44.04	22.34
Kimin Red	6.65	6.24	114.76	24.7	56.5	43.97	21.76
Khoujai Phou	11.49	9.87	127.85	25.0	64.3	39.15	22.60
Bong Bhutial	8.47	7.85	127.25	30.2	75.7	40.19	22.15
Partei Buh	6.05	4.83	144.26	28.3	65.3	43.71	22.34
Pu Ruata Buh	11.29	9.26	142.35	30.3	75.7	40.26	22.03
Idaw	10.88	6.64	131.88	26.8	67.9	24.90	21.62
Bhalum-1	7.66	5.03	129.26	32.9	81.4	40.64	23.78
Bhalum-2	7.05	6.44	127.04	24.2	69.6	40.84	23.46
Bhalum- 4	6.65	5.84	125.03	21.7	65.6	33.30	22.05
CAUR-2	14.11	14.70	79.93	25.0	67.3	37.47	22.62
Iuron-514	4.84	2.82	93.22	26.6	54.9	48.82	22.60
Gomati	23.99	20.13	111.74	28.2	66.9	42.42	23.69
SE(m)±	0.11	0.09	0.35	0.9	1.9	1.13	0.33
CD(p=0.05)	0.31	0.26	1.03	2.6	5.4	3.28	1.01

respectively. The highest grain and biological yield was recorded from *Gomati* which produced 46.7 and 98.0 q/ ha, respectively under lowland condition of Mizoram. However, the highest harvest index was observed under *Shasarang* (49.20) and the 1000 seeds weight was attributed to *Gomati* (23.85g).

Fig 5. Performance of upland rice varieties, Gomati, CAUR-1 and RCM-10

Table 3. Yield and yield attributes of different rice varieties under lowland condition of Mizoram

Varieties	**Tillers per hill**	**Panicles per hill**	**Plant height (cm)**	**Grain yield (q/ ha)**	**Biological yield (q/ ha)**	**Har-vest index**	**Test weight (g)**
Chhunpawlh	7.25	6.44	158.45	35.5	90.2	39.65	22.23
Buhmawi	8.15	7.55	157.75	30.2	74.9	40.32	22.77
Khawbungbuh	6.74	6.34	149.90	32.7	79.9	40.93	22.09
Shasarang	8.44	8.86	109.93	37.0	75.2	49.20	23.75
RCM-9	9.84	9.05	114.06	42.2	92.0	43.96	23.44
RCM-10	7.45	8.86	115.67	37.9	78.3	48.40	23.06
CAUR-1	10.85	10.25	119.90	43.8	92.4	46.96	23.08
Gomati	10.87	10.47	110.94	46.7	98.0	47.65	23.85
NLR-1	10.07	9.66	124.83	30.7	82.3	37.30	21.57
NLR-2	9.87	8.86	115.17	34.3	73.2	46.86	22.18
NLR-3	8.05	7.45	118.19	37.7	79.2	47.60	22.28
NLR-4	8.46	7.85	115.77	38.6	85.5	45.15	22.96
NLR-5	6.64	6.44	124.02	38.7	79.6	48.62	22.80
NLR-6	9.47	9.46	162.88	32.3	75.2	42.95	22.07
NLR-7	8.36	7.25	140.33	34.4	83.7	41.10	22.33
SE(m)±	0.30	0.26	1.39	0.9	1.2	0.53	0.16
CD(p=0.05)	0.80	0.75	4.13	3.1	3.8	1.64	0.49

Performance of Different Cowpea (*Vigna unguiculata*) Cultivars in Mizoram

Among the seven varieties tested, higher numbers of pods per plant was recorded in CP- 4 (15.17) whereas the number of seeds per pod was attributed to CP-3 (13.37) (Table 4 and Fig. 6). The highest 100 seeds weight was observed under CP-5 (10.93 g) cultivar. The highest grain yield was received under CP-5 (9.31 q/ ha) whereas the highest biomass production was found under CP-6 (34.42 q/ ha).The highest harvest index was recorded in CP-2 (34.06) followed by CP-1 (32.07).

Fig 6. Performance of cowpea varieties, CP-1, CP-3 and CP-5

Table 4. Yield and yield attributing parameters of cowpea cultivars under Mizoram conditions

Varieties	Plant height (cm)	Days to 50% flowering	Days to 80% maturity	Pods / plant	Seeds / pod	100 seed weight (g)	Grain yield (q /ha)	Biological yield (q/ ha)	Harvest index
CP-1	33.10	35.33	55.67	10.90	11.72	8.66	8.02	25.22	32.07
CP-2	32.23	36.67	54.67	8.83	11.51	9.74	8.77	25.78	34.06
CP-3	34.37	37.33	55.67	13.40	13.37	9.93	8.39	27.68	30.32
CP-4	32.60	35.33	57.67	15.17	12.38	10.52	8.51	31.63	26.97
CP-5	31.53	35.67	55.33	13.13	11.58	10.93	9.31	31.86	29.34
CP-6	33.87	36.67	56.33	14.30	11.83	8.94	8.95	34.42	26.03
CP-7	31.77	35.33	55.33	14.87	13.20	9.53	8.74	33.89	25.87
SE(m)±	0.29	0.15	0.14	0.41	0.09	0.01	0.08	0.68	0.64
CD (p=0.05)	0.89	0.45	0.42	1.25	0.29	0.02	0.25	2.10	1.96

Performance of different black gram (*Vigna mungo*) cultivars in Mizoram

The least days taken to reach 50% flowering was attributed to Urd-1 (33.33 days) among the five cultivars (Table 5 and Fig. 7). The number of pods per plant was observed under Urd-4 (24.33) which was at par with Urd-3 (24.10). The highest number of seeds per pod was observed in Urd-4 (5.98) and the least being recorded in Urd-1 (5.50). Higher weight of 100 seed was recorded under Urd-3 (4.73 g). The highest grain yield and biological yield was observed under Urd-3 (6.30 q/ ha) and Urd-2 (31.78 q/ ha), respectively. The maximum harvest index was found under Urd-3 (23.31).

Fig 7. Performance of black gram varieties Urd-1, Urd-3 and Urd-5

Table 5. Yield and yield attributing parameters of black gram cultivars under Mizoram conditions

Varieties	Plant height (cm)	Days to 50% flowering	Days to 80% maturity	Pods/ plant	Seeds/ pod	100 seeds weight (g)	Grain yield (q/ ha)	Biological yield (q/ ha)	Harvest index
Urd-1	43.10	33.33	54.00	11.20	5.50	4.50	6.00	27.52	22.10
Urd-2	43.57	34.67	51.33	15.03	5.74	4.62	6.16	31.78	19.44
Urd-3	44.93	36.00	51.33	24.10	5.69	4.73	6.30	27.26	23.31
Urd-4	46.37	34.67	51.67	24.33	5.98	4.45	5.93	31.59	18.79
Urd-5	44.23	36.67	52.00	20.57	5.72	4.18	5.57	29.74	18.77
SE(m)±	0.24	0.15	0.26	0.40	0.03	0.01	0.01	0.39	0.30
CD(p=0.05)	0.73	0.45	0.80	0.87	0.08	0.03	0.04	1.20	0.92

Performance of different Pea (*Pisum sativum*) cultivars in Mizoram

VL 42 required the least number of days for 50% flowering (61 days) among all the varieties, while Aman and IPFD 6-3 needed the highest number of days (68 days) (Fig. 8 and Table 6). The highest grain yield was recorded under Aman (18.13 q/ha) followed by HUDP 15 (17.35 q/ ha). Higher performance in these varieties was mainly attributed to significant higher yield attributing characters such as number of pod per plant (16.7-21.2), seeds per pod (5.3-6.5) and 100 seed weight (16.1-16.5g).

Fig 8. Performance of HUDP 15 (P 01), Adarsh (P 02) and IPFD 6-3 (P 06)

Table 6. Performance of different pea varieties

Varieties	Days to 50% flowering	Days to 80% maturity	Pods / plant	Seeds / pod	100 seed weight (g)	Seed yield (q/ ha)
HUDP 15	68	107	21.2	5.29	16.09	17.35
Adarsh	63	110	15.9	5.45	14.39	15.98
Aman	68	109	16.67	6.45	16.51	18.13
Vikas	64	112	8.73	4.79	12.81	12.43
Prakash	62	108	13.8	5.52	16.05	13.23
IPFD 6-3	68	107	12.27	4.53	13.56	16.07
TRCP 8	62	108	15.77	4.46	16.27	14.82
TRCP 9	61	108	17.7	5.48	13.68	14.43
SE(m)±	1	1	0.95	0.14	0.43	0.69
CD(p=0.05)	3	NS	2.87	0.43	1.31	2.08

Performance of different chickpea (*Cicer arietinum*) cultivars in Mizoram

IPC 97-67 required the least number of days to 50% flowering (66 days) among the varieties (Fig. 9 and Table 7). The highest grain yield was recorded in IPC 97-67 (14.72 q/ha) followed by Pant G186 (14.33 q/ha) and Rajas (14.07 q/ha). Higher grain yield in these varieties was attributed to higher number of pods per plant (35.2 to 45.5) and 100 seed weight (20.5 to 24.5 g).

Fig 9. Performance of gram variety, IPC 97-67 (G01), PANT G186 (G14), and RAJAS (G12)

Table 7. Performance of different chickpea varieties

Variety	Days to 50% flowering	Days to 80% maturity	Pods / plant	Seeds / pod	100 seed weight (g)	Seed yield (q/ ha)
IPC 97-67	66	118	35.2	1.41	20.67	14.72
KWR 108	75	119	28.03	1.41	21.47	13.37
KPG 59	72	121	35.1	1.42	21.57	11.13
Subra	67	123	26.27	1.42	28.47	11.28
DCP 92-3	67	121	20.77	1.35	15.33	11.15
JG 11	69	121	21.2	1.37	26.43	10.63
JG 16	68	119	20.97	1.33	20.5	12.37
JAKI 9218	67	121	21.3	1.33	26.37	11.18
JSC 55	69	119	23.93	1.47	24.53	12.53
JSC 56	68	120	21.43	1.44	23.43	13.87
PUSA 372	67	121	28.8	1.42	15.43	10.63
RAJAS	68	120	45.53	1.45	15.37	14.07
JG 14	67	121	34.03	1.43	22.53	12.5
PANT G186	73	121	42.43	1.45	17.6	14.33
SE(m)±	1	1	1.74	0.06	0.14	0.82
CD(p=0.05)	4	NS	5.06	NS	0.41	2.39

Performance of different lentil (*Lens culinaris*) cultivars in Mizoram

All the varieties (Fig. 10 and Table 8) required the same number of days both for 50% flowering (67 - 71 days) and 80% maturity (117 - 121 days). The highest grain yield was recorded in DPL 62 (17.02 q/ ha) followed by Tripura L.S.1 (16.67 q/ha). These two varieties performed significantly superior in terms of grain yield over the rest of the variety. Higher grain yield recorded under these two varieties were mainly attributed to number of seeds per pod and 100 seed weight.

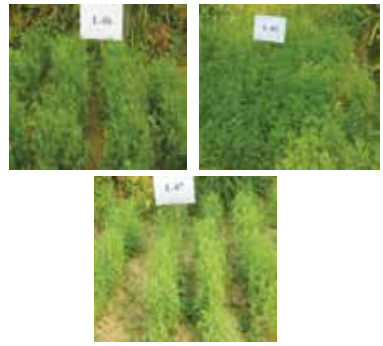


Fig 10. Performance of lentil variety, IPL 81(L06), Pant lentil 7(L09) and Tripura L.S.1 (L07)

Table 8. Performance of different lentil varieties

Variety	Days to 50% flowering	Days to 80% maturity	Pods / plant	Seeds / pod	100 seed weight (g)	Seed yield (q/ha)
HUL 57	67	119	55.1	1.83	2.3	13.52
IPL 316	68	119	54.37	1.81	2.6	13.95
IPL 406	69	121	53.5	1.72	4.43	13.72
DPL 62	71	120	55.03	1.86	3.33	17.02
DPL 15	70	121	55.8	1.78	3.63	10.3
IPL 81	70	121	55.33	1.78	2.47	14.08
Tripura L.S.1	68	117	49.33	1.83	2.37	16.67
Moitri	68	118	52.23	1.74	2.2	12.07
Pant Lentil 7	67	118	47.9	1.74	3.27	14.85
SE(m)±	1	2	6.45	0.01	0.13	0.6
CD (5%)	NS	NS	NS	0.03	0.39	1.8

Performance of different green gram (*Vigna radiata*) cultivars in Mizoram

Among the varieties HUM 12 required the most number of days for 50% flowering, however, HUM16 required the least number of days (Table 9 and Fig. 11). But number of days to 80% maturity was similar for all the varieties. Variety HUM 12 (10.17 q/ ha) followed by Meha (10.11 q/ha) produced significantly higher grain yield over the rest of the varieties. Higher yield in above varieties was primarily attributed to the highest number of pod per plant (21.3 and 20.7, respectively) and seeds per pod (10.6 and 10.3, respectively).

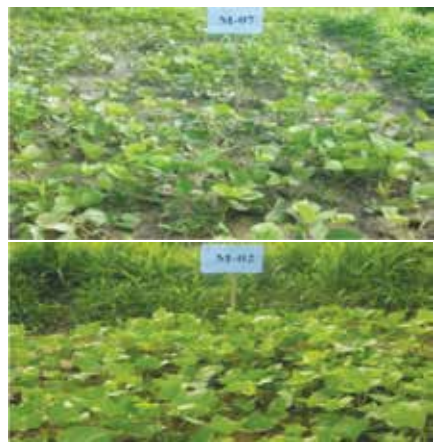


Fig 11. Performance of green gram variety, IPM 02-3 (M07) and HUM 12 (M02)

Table 9. Performance of different green gram variety

Variety	Days to 50% flowering	Days to 80% flowering	Pods / plant	Seeds / pod	100 seed weight (g)	Seed yield (q /ha)
DGGS 4	33	60	19.7	8.7	3.47	9.63
HUM 12	37	61	21.3	10.6	3.43	10.17
HUM 16	32	60	20.7	9.4	3.63	9.55
Narendra mung 1	35	61	19.8	8.7	3.37	8.37
Meha	36	60	20.7	10.3	3.2	10.11
IPM 2-14	33	60	20.3	9.6	3.27	9.87
IPM 2-3	34	59	19.8	9.7	3.57	9.53
Samrat	36	60	19.4	10	3.43	8.80
Tripura mung 1	35	59	18.5	8.5	3.21	8.66
SE(m)±	0.8	1.3	0.3	0.2	0.12	9.3
CD(p=0.05)	3	NS	0.8	0.5	0.36	28.2

Evaluation of rice bean in Mizoram

Forty three lines of rice bean were evaluated for agro-morphology and their yield attributes in Mizoram (Fig. 12). *IC-18553* recorded the highest yield (11.80 q/ha), followed by *RBHP 304* (11.47q/ha), and *RBHP 104* (11.31q/ha) (Fig. 13). The least yield recorded in line, *IC 2567* in tune at 2.05q/ha but check line *VRB-3* recorded the yield of 9.18q/ha. Rice bean matured in range of 108-118 days after sowing.

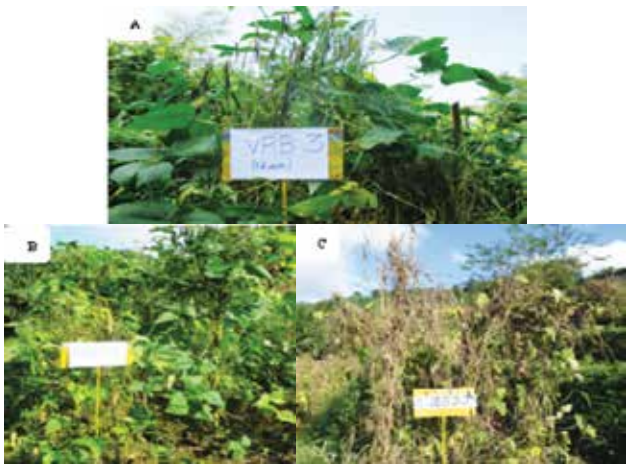


Fig 12. Performance of rice bean lines a) VRB 3 (check), b) RBL-6 and c) IC 18553

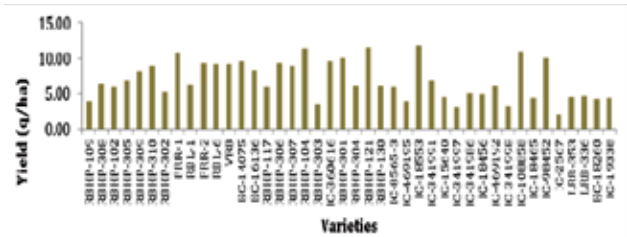


Fig 13. Yield attributes of different rice bean (Vigna umbellata) lines in Mizoram

Evaluation of faba bean in Mizoram

Among the 51 genotypes of fababean, the tallest crop was observed in GP EC 108 (112.46 cm), whereas the genotype GP NDF 121 recorded the least plant height (Fig. 14). Numbers of pods/plant was highest under the genotype GP IC 243770 (41.13) and the least number of pods/plant was found in PRT 12 (c) genotype (18.63). GP EC 243624, GP EC 243782, GP HB 64, NDFB 13 and GP NDF 9 were attributed to similar least number of days to reach 80% maturity (135 days). The number of branches/plant, pod length, 100 seeds weight and number of seeds per pods were similar among the yield attributing parameter. The highest seed yield were attributed to the genotype GP HB 40 (17.49 q/ha), GP NDF 121 (16.61 q/ha), GP DFB 91 (15.28 q/ha), GP FB 102 (14.61 q/ha), GP IC 243770 (14.44 q/ha) and GP EC 10845 (13.57 q/ha) which

Fig 14. Performance of different faba bean (Vicia faba) under Mizoram condition

are statistically similar to each other while the least yield was recorded in GP RFB 8 (7.02 q/ha).

Evaluation of purple french bean performance

An unique type purple french bean (MZFB-48) having attractive colorful purple pod was identified from 52 land races collected from Mizoram and evaluated for its yield potential (Fig. 15). The pods are green in colour for first 5-7 days from pod formation, and then turned into complete purple colour in next 8-10 days. The immature tender fresh pods are rich in anthocyanin content (7.08 mg/ 100 g) which is higher than the normal green-podded genotypes. This is pole type in growth habit and bears flower at 35-40 days after sowing (DAS) and pods become ready to first harvest at around 60-65 DAS with a crop duration of 95-100 days. On an average, the weight and length of each tender pod is 16.5 g and 17.1 cm, respectively. Each pod contains approximately 8 seeds. The yield potential (tender pods) of genotype is 1.4 kg/ stake.

Fig 15. Performance of French bean (var. MZFB-48) under Mizoram condition

Evaluation of insect pest infestation on cole crops

The highest infestation (75%) by cabbage butterfly was with broccoli compared to cabbage, cauliflower and knol-khol. The highest infestation (60%) by tobacco caterpillar was with cauliflower and the lowest was with knol-khol (25%). The highest infestation (40%) by diamond back moth was with cauliflower compared to cabbage, broccoli and knol-khol. The highest infestation (35%) by aphids was with broccoli and the lowest was with cabbage (25%).

Evaluation of insect pest infestation on okra

An experiment was conducted to study the incidence of chewing pests populations in okra ecosystem. The results revealed that a peak population of *Nodostoma* spp. noticed during July (56.46 per 5 plants). Maximum relative humidity had a significant positive correlation with *Nodostoma* spp. ($r = 0.672^{*}$) (Table 10). A peak population of *M. pustulata* recorded during July (3.81 per 5 plants). The highest population of *A. affaber* observed during July (2.57 per 5 plants). A peak population of *A. affaber* was recorded when maximum and minimum temperatures crossed 24 and 32^{0}C, respectively and minimum and maximum relative humidity was below 80 and 95%, respectively.

Table 10. Correlation between meteorological parameters and chewing pests populations on okra

Weather parameter	Chewing pests of okra		
	Nodostoma spp.	*Mylabris phalerata*	*Alcidodes affaber*
Min. temp. (^{0}C)	0.445ns	0.162ns	0.105ns
Max. temp. (^{0}C)	0.098ns	-0.262ns	-0.448ns
Min. RH (%)	0.196ns	0.393ns	0.440ns
Max. RH (%)	0.672*	0.427ns	0.443ns
Rainfall (mm)	0.124ns	0.523ns	0.485ns

Species diversity of fruit flies on cucurbit ecosystems

The overall survival from pupal to adult stage was also significantly high in ridge gourd (84.7 %) and sponge gourd (83.5 %) (Table 11). Abundance of female fruit flies was the highest among the cucurbits. Sex ratio was the highest in sponge gourd (1: 1.36) and the lowest in bitter gourd (1 : 1.01). *B. tau* was more abundant, its proportion being (98.8-100 %) in all cucurbits, while *Bactrocera cucurbitae* (Coquillett) affected were ranged from 0.0-1.2 % among cucurbits. Ridge gourd, sponge gourd, bottle gourd and bitter gourd recorded only *B. tau*.

Table 11. Percent infestation by fruit flies on different cucurbits fruits

Crops	% infestation
Pumpkin	57.14
Bitter gourd	26.32
Bottle gourd	35.29
Snake gourd	11.11
Chilli	12.94
Capsicum	50.00

Effect of shading environment on growth and yield of bird eye chilli landraces

The bird eye chilli was grown in three conditions, open condition (Control), 75% shade net and 50% shade net condition at Kolasib Centre, Mizoram. Results (Table 12) revealed that the maximum plant height was recorded in 75 % shade net condition (83.0 cm) and minimum in open condition (51.6 cm). In open condition, maximum, no. of fruit per plants (89), fruit weight per plant (73 g), no. of leaves (352.2) and yield (0.073 kg).

Table 12. Effect of shading on growth and yield of bird eye chilli

Varieties	Plant height (cm)	Fruit/ plant	Fruit weight (g)	Leaves / plant	Yield (kg/ plant)
Open condition	51.6	89	73.0	352.3	0.073
75% shade net	83.0	40	36.0	137.0	0.036
50% shade net	62.8	53	44.0	80.0	0.044

First Report of economic injury by fruit fly- *Bactrocera tau* on chilli in India

Percent infestation by fruit flies in cultivars spread over a wide range (Fig. 16). The highest and lowest percent infestation by fruit flies was in cv. Guntur Hope and cv. Mohini respectively. An effect of chilli cultivars on biology of fruit flies was studied. The results revealed that the level of maggot infestations and puparia varied in cultivars. The cv. Guntur Hope had the most fruit fly puparia/20 fruit. The fewest fruit fly puparia/20 fruit was in cv. Mohini. The overall survival from pupal to adult stage varied with cv. King chilli exhibiting the highest percent adult emergence. The lowest percent adult emergence

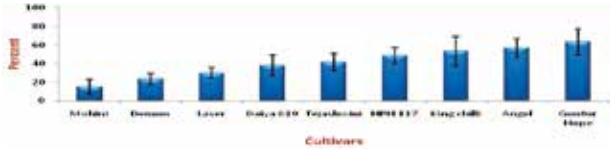


Fig 16. Percent infestation by fruit flies in different cultivars

was in cv. Guntur Hope. The highest number of adult emerged was in cv. Angel and the lowest in cv. Mohini. The highest male and female populations were in cv. Angel. The lowest male and female populations were in cv. Mohini. *Bactrocera tau* was more abundant, its proportion being (39.21 %) in all cultivars of chilli. Other species (*B. correcta*, *B. dorsalis* or *B. latifrons*) composition ranged from 11.17 to 35.33 % among all cultivars of chilli.

Report of economic Injury by fruit fly- *Bactrocera tau* (Walker) on capsicum in NEH Region

Population fluctuation and seasonal incidence of fruit flies- *B. tau* on capsicum crop using cuelure traps revealed that the highest fruit flies adults were attracted during April and May. An effect of capsicum cultivars on biology of fruit flies was studied and the results revealed that the fruit fly puparia recovered from cultivars ranged from 67 to 103. *Cv. 'Indra'* yielded the highest fruit flies puparia/20 fruits (103). *Cv. 'Indra'* had the highest percent adult emergence (50.5) than cv. 'Picador' (44.8). The highest male (30) and female (20) population was with *cv. 'Indra'*. Sex ratio of *B. tau* was the highest in *cv. 'Picador'* (1: 1.25), and the lowest in *cv. 'Indra'* (1 : 0.75). *Bactrocera tau* was more abundant, its proportion

a. Bactrocera tau b. Bactrocera correcta c.Bactrocera dorsalis

being (66.67 to 85.71 %) (Fig. 17). Other species (*B. correcta*, *B. dorsalis* or *B. latifrons*) composition ranged from 4.00 to 18.00 %.

Evaluation of guava lines under Mizoram condition

Three guava lines *viz*., *RCGH-1, RCGH-4* and *RCGH-7* developed at ICAR Research Complex for NEH Region, Umiam along with two standard check *L-49* and *Allahabad Safeda* were evaluated at spacing of 2 x 1.5 m. Results revealed that the *L-49* recorded maximum plant height (2.49m) and canopy spread (2.38 m^2) (Table 13 and Fig. 18). Plant girth was recorded maximum in *RCGH-1* (37.25 cm) followed by *RCGH-7*. The *RCGH-4* recorded the maximum fruit weight (237.33g) and followed by *RCGH-7* (157.67). The highest yield was recorded in *Allahabad Safeda* (3.99 kg/tree) followed by *L-49* (3.63 kg/ tree). The maximum TSS (14.10) was recorded in *RCGH-1* followed by *Allahabad safeda* (12.93).

Evaluation of dragon fruit under Mizoram condition

Dragon fruit (*Hylocereus undatus*) is highly valued for its reported nutraceutical properties. Dragon fruit variety, Commercial Red, was planted at ICAR- Research farm, Kolasib at different spacing,

Table 13. Evaluation of guava lines for growth, yield and quality attributes

Varieties	Plant height (m)	Stem diameter (cm)	Canopy spread (m^2)	Fruit weight (g)	Yield (kg/ plant)	TSS (^{0}B)
RCGH-1	2.48	37.25	1.45	154.33	1.09	14.10
RCGH-7	1.81	33.92	1.48	157.67	1.30	11.93
RCGH-4	1.75	31.36	1.62	237.33	3.00	11.33
L-49	2.49	31.43	2.38	151.00	3.63	12.40
Allahabad Safeda	1.49	27.63	1.69	140.00	3.99	12.93
SEm (±)	2.00	32.32	1.72	168.07	2.60	12.54
CD *(P=0.05)*	0.24	3.77	0.19	10.64	0.67	0.66

Fig 18. Performance of guava lines (RCGH-1, RCGH-7, RCGH-7, L-49 and Allahabad Safeda) under Mizoram condition

2 × 2 m, 2 × 3 m and 2 × 3.5 m. Three plants were planted in one pit, around the cement pole. Studies on economically important insect pests and diseases of dragon fruit showed that hairy caterpillar, hopper, aphids, mealy bug, scale, pentatomid bug, white leafhopper were the important insect pests whereas soft rot and wet rotting disease typically infects the ends of dragon fruit branches (Fig. 19).

Fig 19. Emerging insect pests (hairy caterpillars) and diseases (soft rot disease) of dragon fruit

Evaluation of strawberry varieties under Mizoram condition

Two strawberry varieties *viz*., *Festival* and *Nabila* were evaluated at spacing of 60 × 25 cm (Fig. 20). Results revealed that the *Nabila* recorded maximum plant height of 14.5 cm, fruit weight of 33.95g, fruit length of 5.9 cm and TSS content of 12.88. In *festival*, maximum number of leaves (104) and fruit width (5.0 cm) were observed.

Fig 20. Performance of two strawberry varieties namely Nabila and Festival

Effect of cucurbitaceous vegetable shading environment on growth and yield of turmeric

The partial shading effect (for initial 3 months of crop establishment) from different local cucurbit landraces (bottle gourd, ridge gourd, pumpkin and bitter gourd) and continuous shading effect from passion fruit canopy were assessed on turmeric rhizome yield (variety: *RCT-1*) (Fig. 21). Plant height increased significantly, with a marginal decrease in leaf chlorophyll content with increasing degree of shading. Turmeric rhizome yield was significantly higher (9.61%-21.6%) with the increasing degree of partial shading from cucurbit canopy applied for initial three months of crop establishment; however continuous shading from passion fruit canopy significantly depressed (23.6%; P< 0.05) the turmeric rhizome yield of *RCT-1* (Table 14).

A. Passion fruit- turmeric integration ***B.Pumpkin-turmeric integration.***

Fig 21. Effect of canopy shading on turmeric yield

Table 14. Effect of canopy shading on growth and yield of turmeric (variety: RCT-1)*

Particulars	Plant height (cm)	Number of leaves/ (plant)	Leaf chlorophyll content (mg/ g)	Rhizome yield (t/ ha)
Turmeric (Sole crop) 67.9		9.6	14.16	9.01
Bitter gourd - turmeric integration	71.6	11.4	11.01	10.11
Sponge gourd- turmeric integration	77.3	10.5	10.16	9.86
Bottle gourd- turmeric integration	80.2	18.2	13.41	10.67
Pumpkin - turmeric integration	85.3	17.9	15.24	11.03
Passion fruit - turmeric inte-gration	99.6	16.3	13.1	6.91
LSD (*P* <0.05)	4.95	3.91	0.54	2.68

(*Note: represents the average value of three observations)

Evaluation of antagonist and botanical against bacterial leaf blight (*Xanthomonas axonopodis* pv. *Dieffenbachiae*) of anthurium and their effect on plant growth parameters

The maximum disease control of 66.48% and 59.80% was recorded in *T. viride* and *P. fluorescens* treated plants, respectively and followed by *T. harzianum* (56.82%), Streptocycline + Copper hydroxide (40.81%). Neem solution was found to

Table 15. Effect of different antagonists on various plant growth parameters of Anthurium *cv. Pistache* in Mizoram

Treatments	Growth parameters						
	Plant height (cm)	Stem length (cm)	Flower/ plant/year	Flower /spathe size (cm)	Spadix length (cm)	Flower stalk length (cm)	Days to flowering
T1-*Trichoderma viride* @ 1%	35.12	31.70	5.13	10.23	3.93	15.31	163.21
T2-*Trichoderma harzianum* @ 1%	35.33	32.12	6.19	12.75	5.71	17.23	157.11
T3-*Pseudomonas fluorescens* @ 1.5%	25.33	28.36	5.42	10.12	3.02	12.36	160.93
T4-Streptocycline (0.05%) + Copper hydroxide (0.2%)	30.12	26.31	3.63	9.03	3.02	11.23	160.33
T5-Neem solution @ 2%	23.65	23.53	3.19	9.23	3.13	16.52	158.63
T6-Strobulurin @ 0.01%	34.19	27.63	4.02	11.03	2.61	14.32	159.37
T7- Control	20.23	15.91	3.96	8.54	3.11	11.02	162.37
S.Em±	0.3	0.9	0.5	0.31	1.10	2.32	15.6
C.D. (P=0.05)	1.1	1.9	1.5	0.89	2.96	5.20	35.12

be the least (35.15%) effective for minimizing the blight. The highest disease incidence (90.7%) was recorded in control plots. Antagonist *T. harzianum* was found statistically significant the plant growth and resulted the maximum plant height (35.33 cm), stem length (32.12 cm), number of flower per plant per year (6.19), spathe size (12.75 cm), spadix length (5.71), flower stalk length (17.23 cm) and least number of days (157.11 days) for first flowering as compared to control plant showed poor plant health and flower quality (Table 15).

Utilization of wild banana leaves for cultivation of Oyster Mushroom (*Pleurotus florida*) in Northeastern Hill of India

Wild banana (WB) leaves were used as substrate for cultivation of oyster mushroom (*Pleurotus florida*) and evaluated yield components and proximate composition. Paddy straw (PS) was used as control. Different ration of WB and PS combinations were prepared and replicated five times. WB recorded the fastest substrates colonization (13.30 days) primordial initiation (5.60 days after colonization), nos. of primordial (9.922) but stipe length was the higher in combination of WB25:PS75 and WB50:PS50. The highest economic yield and biological performance in tune of 1300.00 gram and 130%, respectively was recorded in 100 WB substrate. The basic nutrient (macro and micro) content of oyster mushroom (*Pleurotus florida*) grown on different substrates were studied. This study revealed that a mushroom cultivated on WB was in rich of micronutrient content (Table 16). The highest nutrient content like Mn, Fe, Zn, Cu, Ca recorded in WB in tune to 65.38, 281.03. 69.33, 15.07 and 1251.00 mg/kg, respectively (Table 17). Hence, these yield components and nutrients content of mushroom is superior when WB used as substrate either sole or supplemented with paddy straw, therefore, it may be recommended for commercial cultivation oyster mushroom in hill of Mizoram.

Table 16. Different growth parameters of oyster Mushroom (*Pleurotus florida*) grown wild banana (WB) leaves as substrate

Treatment (Subs-trates)*	SC (Days)	PI (Days)	NOP (Nos.)	Cap Size (cm)		Stipe length (cm)	Weight of 10 mush-room (g)	Average Yield (g)	BE (%)
				Length	Breath				
WB100: PS00	13.30	5.60	9.92	68.80	65.55	8.27	101.00	1300.00	130.00
WB0: PS100	14.30	6.90	7.50	62.67	51.72	7.65	97.96	1016.65	101.67
WB25: PS75	13.90	5.80	9.92	77.22	75.00	10.38	144.00	1220.00	122.00
WB50: PS50	15.60	5.80	16.14	78.60	78.16	9.02	182.00	1110.00	91.00
WB75: PS25	15.01	6.02	14.55	74.20	69.44	8.10	125.00	1100.00	90.50
SE±	1.02	0.04	1.23	3.52	2.61	0.25	5.23	12.31	
CD (p=0.05)	2.010	1.02	3.21	7.23	5.10	1.96	10.13	26.30	

WB Wild banana, PS Paddy straw, SC Substrate colonization, PI Primordia initiation, NOP Number of primordial, BE Biological Efficiency

Table 17. Nutritional content (micronutrient) of oyster mushroom *Pleurotus florida* grown wild banana leaves (WB) as substrates

Treatment (Substrates)*	Mn (mg/kg)	Fe (mg/kg)	Zn (mg/kg)	Cu (mg/kg)	Ca (mg/kg)
WB100:PS00	65.383	281.033	69.333	15.067	1251.000
WB0: PS100	34.62	205.35	56.68	16.10	692.37
WB25:PS75	35.45	199.40	68.33	7.28	581.77
WB50:PS50	49.92	167.70	46.12	3.95	829.60
WB75:PS25	49.53	162.98	35.87	9.00	610.33
SE±	3.25	23.61	1.63	2.31	101.01
CD (p=0.05)	7.23	49.63	3.25	5.81	254.37

WB Wild banana, PS Paddy straw,

Biodiversity, predatory potential and field efficacy of predaceous coccinellids and Syrphids

Totally 32 species of coccinellids and 12 species of syrphids were collected from different agroecosystems in Mizoram. Assessment of biology and feeding potential of 12 species of coccinellids and 2 species of syrphids on aphids (*A. gossypi* and *L. erysimi*) were undertaken. The mean consumption of early stage larvae of syrphid on *Lipaphis erysimi* was the lowest. The late stage larval consumed more *L. erysimi* as compared with the early stage larvae. The mean consumption of first instar larvae of *P. dissecta* on *L. erysimi* was the lowest (13.47). The second instar larval *P. dissecta* consumed more *L. erysimi* (22.74) as compared with the first instar larvae but significantly less than the other development stages of *P. dissecta*. A similar feeding trend was observed with the third and fourth instar larval stages as well as adult beetles of *P. dissecta*, where each development stage consumed significantly more *L. erysimi* than the previous stage. The durations of egg, first, second, third and fourth instar of *P. dissecta* grub averaged 2.00, 2.16, 2.00, 2.05 and 2.58 days, respectively. The pupal period averaged 3.63 days. The average longevity of females and male was 34.44 and 23.90 days, respectively (Fig. 22). The mean consumption of 1st instar of *C. bissellata* on *A. gossypii* was the lowest (17.4±1.990). The second instar larval *C. bissellata* consumed significantly more *A. gossypii* (27.2±2.590) as compared with the first instar larvae but significantly less than the other development stages of *C. bissellata*. A similar feeding trend was observed with the third and fourth instar larval stages as well as adult beetles of *C. bissellata*, where each development stage consumed significantly more *A. gossypii* than the previous stage. The durations of first, second, third and fourth instar of *C. bissellata* grub averaged 3.10±0.233, 2.50±0.167, 2.80±0.133 and 4.90±0.433 days, respectively. The pupal period averaged at 8.10±0.100 days. The average longevity of females and male was 29.10±3.923 and 19.20±2.417 days, respectively. Artificial diet for promising coccinellids was developed.

Fig 22. Life cycle of four promising coccinellids

MEETING/TRAINING/SEMINAR/ KISAN MELA ORGANIZED

Conducted 14 training programmes under TSP, NICRA, AICRP Mushroom at ICAR Research Complex for NEH region, Mizoram centre, Kolasib and other parts of Kolasib district. 705 farmers were benefited from these training programmes.

Fig 23.Glimpse of Training Activities

NAGALAND

WEATHER REPORT

The mean monthly maximum and minimum air temperature varied from 26.5^{0}C to 34.0^{0}C and 11.1^{0}C to 24.8^{0}C, respectively. Highest maximum temperature for a single day was recorded on the 4th August (37.1^{0}C) and the lowest on 7th November (21.2^{0}C) (Fig. 2). Highest minimum temperature for a single day was 26.7^{0}C recorded on 17th August whereas the lowest was 8.7^{0}C on 30th December. A monthly relative humidity ranged from 51% to 95% with the highest monthly maximum relative humidity was recorded during the month of November (95%) and the lowest during April (84%). Total rainfall received during April to December was 1643.2 mm and about 95 total rainy days (considering precipitation of more than 2.5mm). Monthly rainfall was maximum during August (398.9 mm) followed by September (283.7 mm) (Fig. 1). Highest amount of rainfall in a single day was recorded on 7th November (67.7 mm) and followed by 11th September (61.8 mm). Cloud cover was observed during morning and evening. Mean monthly wind speed ranged from 0.088 km/h during the month of July to 0.868 km/h in April. Highest mean wind speed (3.033 km/h) in a single day was recorded on the 14th April. Soil temperature was recorded both in the morning and evening at 5 cm, 15 cm and 20 cm depth, which showed an increasing trend along with the depth. Highest monthly evaporation was recorded in April (125.0 mm) and lowest in December (53.3 mm).

Fig 1. Rainfall and evaporation

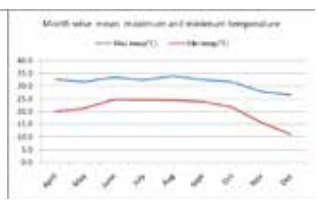


Fig 2. Mean maximum and minimum temperature

CROP SCIENCE

Comparative evaluation of integrated farming system models suitable for small and marginal farmers of Nagaland

An integrated farming system (IFS) research was started at ICAR Nagaland Centre, Medziphema during 2012-13. The objective was to improve the livelihood of small and marginal farmers, based on the land availability and topography. Four IFS models were established *viz.,* Model 1: Horticulture + Piggery + Fisheries, Model 2: Agriculture + Horticulture + Duckery + Fishery, Model 3: Agriculture + Horticulture + Piggery + Fishery, Model 4: Agriculture + Horticulture + Poultry + Fishery + Azolla + Mushroom (Fig 3). Vermicompost unit was incorporated in all the models. Each IFS model was allocated a minimum area of 0.4 ha (1.0 acre). Results revealed that Model 3 generated highest net profit (Rs. 1,09,064.50) and Model 4 gave highest B:C ratio, 2.86 (Table 1).

Soil nutrient profiling of different land use system

A total of 189 soil samples were collected from different land use system at different soil depths (0-20, 20-40 and 40-60 cm) from Longleng block (3 villages), Sakshi block (3 villages) and Tamlu block (1 villages). Soil samples from two (2) more villages of Tamlu block is yet to be collected. Result are presented in Table 2.

Evaluation of Low Chilling Peach Cultivars for their performance in Nagaland

Low chilling varieties of peach *viz*., TA170, Flordasun and Shan-e-Punjab were evaluated to find out a suitable cultivar for commercial production under low hill condition of Nagaland. Result revealed that cultivar TA170 accounted for the maximum yield (15.58 kg/tree), fruit weight (40.27 g), fruit length (5.50 cm) and fruit diameter (4.50 cm) followed by Flordasun. The maximum total sugars (13.71 %), reducing sugar (6.67 %) and TSS (17.35° Brix) along with lowest acidity (0.27 %) content was observed in cultivar Flordasun. Maximum ascorbic acid (76.17 mg/100g) content was found in the cultivar Shan-e-Punjab (Table 3).

Evaluation of guava hybrids and varieties for their performance in Nagaland

The variety (RCG11) and hybrids (RCGH1, RCGH4 and RCGH7) developed at ICAR Research Complex for NEH Region, Umiam along with two standard checks L49 and Allahabad Safeda were evaluated at ICAR Nagaland Centre for their performance. Result revealed that RCGH4 recorded the maximum fruit weight of 172.44 g, followed by 148.12 g in RCGH7. The maximum fruit size was observed in RCGH4 (6.55/6.74) cm followed by RCGH7 (5.64/5.00) cm. Similarly, the highest yield was recorded in RCGH4 (18.34 kg/tree), which was closely followed by Allahabad

Table 1. Benefit cost ratio of IFS models

Models	Components	Gross income (Rs)	Cost of cultivation (Rs)	Net income (Rs)	B:C Ratio*
Model 1	Horticulture	1,310	220	1,050	1.52
	Fishery	-	-	-	
	Piggery	31,500	9,968	21,532	
	Vermicompost	1,200	500	700	
	Total	34,010	9,688	23,322	
Model 2	Agriculture	29,960	12,500	17,460	1.69
	Horticulture	21,611	4,010	17,601	
	Fishery	-	-	-	
	Duckery	880	5,850	4,970	
	Vermicompost	7,500	1,000	6,500	
	Total	36,748	10,200	26,608	
Model 3	Agriculture	6,162	600	5,560	2.30
	Horticulture	26,102	8,800	17,302	
	Fishery	11,340	3,000	8,340	
	Piggery	87,500	38,640	48,860	
	Vermicompost	30,000	1,000	29,000	
	Total	16,1104	52,040	10,9064	
Model 4	Agriculture	15,680	280	15,400	2.86
	Horticulture	17,260	1,110	16,150	
	Fishery	2,680	-	2,680	
	Poultry	11,400	3,000	8,400	
	Mushroom	1,890	935	955	
	Azolla	390	-	390	
	Vermicompost	900	300	600	
	Total	50,100	5,025	44,575	

*B:C Ratio excluding fixed cost

Fig 3. Components of IFS models

Safeda (16.52 kg/tree). Highest TSS was recorded in RCG11 followed by RCGH1 (Table 4).

Varietal evaluation and screening of Garlic lines for diseases and insect pest under open field condition in Nagaland

Varietal evaluation and screening for pest and diseases of 11 IET and 11 AVT lines (supplied by Directorate of Onion & Garlic Research, Nashik) with local germplasm (Poilwa Local) as checked varieties were conducted**.** Result showed that all the lines were significantly different with respect to the vegetative characters, exception for plant height (Fig. 4). Poilwa local recorded maximum plant height (38.13 cm), whereas, maximum number of leaves (9.05), leaf length (32.55 cm) and

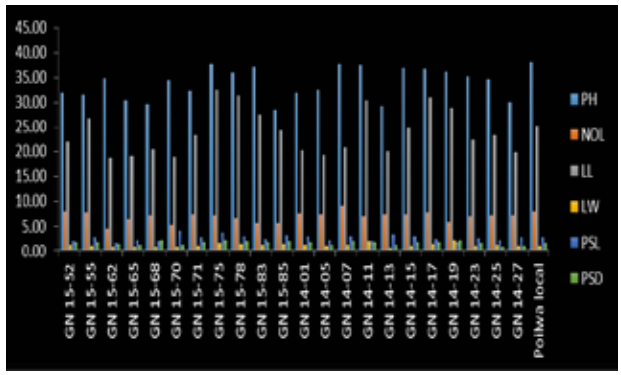


Fig 4. Vegetative growth of garlic lines. *PH= Plant height; NOL= Number of leaves; LL= Leaf length; LW= Leaf Width; PSL= Pseudostem length; PSD= Pseudostem diameter

leaf width (2.13 cm) were recorded in GN-14-07, GN-15-75 and GN-14-19, respectively. Maximum pseudostem length, and diameter were observed significantly higher in GN-15-70 (4.20 cm) and GN-15-68 (2.26 cm), respectively. Among the lines screened for diseases, *Stemphyllium* blight was found to be the most prominent disease. Maximum per cent disease index was recorded in Poilwa local (65.5%), which was followed by GN-15-83 (45%) and GN-14-15 (43%). The lowest disease index (16%) was recorded in GN-14-23. In addition, a symptom of Onion yellow dwarf disease was also observed in few lines, but not in severe form. Leaf roller infestation was also found in the field in few lines, which was below the economic threshold level (Fig. 5).

Table 2. Soil nutrient level of various land use systems

Land use system	pH	EC	SOC (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)	S (kg/ha)
Jhum 1st Year	4.97	0.08	2.25	384.68	21.35	236.43	65.77
Jhum 2nd Year	4.94	0.07	2.26	329.87	21.19	232.21	63.37
Large cardamom based agro forestry system (4th year)	5.02	0.04	1.93	342.87	18.77	219.52	81.85
Orange based farming system (15 yr)	4.94	0.04	1.87	403.22	17.32	223.95	82.36
Jhum Fallow (4th year)	4.96	0.10	2.43	310.33	16.18	275.52	69.76
Forest >20 year)	5.32	0.04	2.68	380.50	19.63	286.80	58.43

Horticulture

Table 3. Fruit yield and quality of peach genotypes at 4th year after planting

Variety	Fruit				TSS (°Brix)	Titratable acidity (%)	Total sugars (%)	Reducing Sugars (%)	Ascorbic acid (mg/100g)
	weight (g)	length (cm)	diameter (cm)	yield (kg/ tree)					
Flordasun	38.07	4.77	3.81	13.64	17.35	0.27	13.71	6.67	75.57
TA-170	40.27	5.5	4.5	15.58	15.51	0.29	11.03	6.21	70.04
Shan-e-Punjab	35.64	4.33	3.62	14.60	16.99	0.32	12.07	6.63	76.17

Table 4. Physical and biochemical composition of guava varieties and hybrids

Varieties/ hybrids	Fruit weight (gm)	Fruits size (Length/ Width) (cm)	Fruit yield (kg/tree)	TSS (°Brix)
RCGH1	144.35	4.64/5.25	10.28	11.84
RCGH4	172.44	6.55/6.74	18.34	10.12
RCGH7	148.12	5.64/5.00	10.10	10.94
RCGH11	125.52	4.24/4.30	15.24	12.20
L49	126.64	4.85/4.78	12.86	10.55
Allahabad Safeda	120.75	5.10/4.89	16.52	10.43

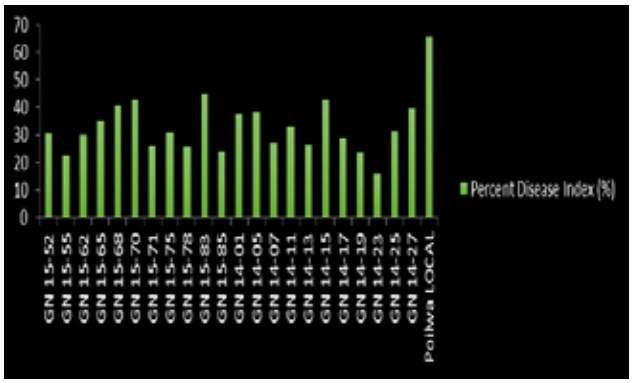


Fig 5. Percent disease index of Stemphyllium Blight in 23 garlic lines

Five bacterial endophytes (KEB2, KEB5, KEB6, KEB7, KEB15) isolated from healthy King chilli fruits and bio-agent *P. fluorescens* were tested for their efficacy against major diseases of King chilli from April to August, 2016 at Nagaland Centre, Medziphema and also for their effectiveness on growth and yield of chilli plant with Dithane M-45 as negative control. Result indicated that DGP recorded maximum plant height (85.10 cm). Maximum fruit weight was recorded in HGP (5.14 g). Maximum number of fruits were recorded from T6 (75 nos.) and highest yield in T6 (7895.5g) (Table 5). Regarding disease incidence, Bacterial wilt, anthracnose and dieback and viral disease were observed. DGP and HGP showed no sign of bacterial wilt with zero incidences. ARP and DGP were recorded with zero disease incidence of anthracnose of chilli (Table 6).

PLANT PATHOLOGY

Evaluation of effective bacterial endophytes against major soil borne diseases of King chilli under field condition

Table 5. Growth and yield of King chilli

Treat ment	Plant Height (cm)				Fruit weight (g)	No. of fruits / plant	Yield/ plot (g)
	30 DAT	60 DAT	90 DAT	120 DAT			
Control (T0)	23.5	49.5	73.3	80.2	4.59	54	4037. 62
ARP (T1)	22.5	49.1	71.1	80.1	4.21	36	3316. 12
CGP (T2)	23.7	42.3	62.8	68.5	5.06	36	4215. 5
CRP (T3)	24.6	47.5	64.7	70.5	4.17	24	4472. 37
DGP (T4)	22.9	55.2	78.4	85.1	4.33	57	5893. 87
HGP (T5)	23.8	49.5	72	77	5.14	65	3970. 75
P. fluorescens (T6)	25.3	54.5	76.8	84.8	4.62	75	7895. 50
Chemical (T7)	23.7	50.2	70.9	73.9	4.19	54	5426. 62

Table 6. Per cent disease incidence in king chilli (%)

Treatment	Bacterial wilt	Anth racnose	Die back
Control (T0)	7.5	15	17.5
ARP (T1)	7.5	0	30
CGP (T2)	7.5	7.5	10
CRP (T3)	7.5	12.5	15
DGP (T4)	0	0	10
HGP (T5)	0	5	15
P. fluorescens (T6)	5	15	20
Chemical (T7)	2.5	12.5	22.5

ANIMAL SCIENCE

Poultry Seed Project, ICAR Nagaland Centre

Parent stock of Vanaraja and Srinidhi were maintained at ICAR, Nagaland Research Farm during the current year. Hen day egg production was recorded up to 72% in Srindhi whereas 63% in Vanaraja birds. A total four training were conducted and about 38,256 chicks were distributed to 547 beneficiaries under the Project.

Mega Seed Project on Pig

Parent stock of Ghungroo, Hampshire, and crosses of Ghungroo and Hampshire breeds of pigs were maintained. A total of 782 piglets were farrowed, of which 559 piglets were distributed to the beneficiaries, NGOs, KVKs and GOI sponsored programs in all the districts of Nagaland and neighboring districts of Assam and Manipur. Increased demand for piglets and liquid boar semen was observed during the year. The coverage area for artificial insemination (AI) was also expanded. Total revenue for the year, April-December 2016 was Rs.19.44 lakhs.

The introduction of AI for enhancing production of piglets from superior breeding stock available under Mega Seed Project on Pig is growing popularity among the farmers. The quality of AI at field level has also been improving (Table 7). It was observed that at farm level, the conception rate and average litter size were 75.45% and 9.42 piglets, respectively following double insemination. The slightly reduced conception rate and average litter size in the farm can be attributed to the retention of old sows in the herd, some of which were farrowed as early as 2009. However, the younger sows have performed satisfactorily, with a maximum litter size of 20 piglets. Natural servicing has also been phased out in the farm and only AI is practiced for breeding. MSP-Pig, in collaboration with KVK Dimapur also conducted a vaccination drive in the month of September against classical swine fever in Jharnapani and Kukidolong villages. Improved performance at field level is a result of distributing improved germplasm to the farmers along with imparting training in AI technique and improved pig husbandry methods. Several capacity building programs were undertaken to popularize the improved pig breed for establishment of pig breeding unit and to popularize artificial insemination technique in Nagaland.

FISHERIES

Several baseline surveys were under taken in different parts of Nagaland (Nihokhu village, Zutoi village, Pihekhu village, Benrue village, etc.) to assess the present status, constraints and potential of fish farming. Survey revealed that availability of fish seed and feed is the major constraints. Demand for indigenous fish is more as compared to cultivable fish and hence more thrust is needed on diversification of fish species and research on the biology and feeding behaviour. Further, indiscriminate killing of the local fishes has also caused threat to the population especially the indigenous ornamental fishes and hence a trial on breeding and rearing of some of the ornamental fishes is immediately required. In Zutoi and Benrue village, the prospect for paddy cum fish culture is very high. Pihekhu village may be well adopted for nursery raising of fish. In another village near Medziphema, preparation of plot for paddy cum fish culture is in progress. Another survey was conducted to acquire information on the available fishes in the major market of Dimapur and adjacent areas as well as fish import in wholesale market with special reference to locally available species and to obtain first-hand information on the marketing channel. A major chunk of fishes is being imported from Andhra Pradesh, West Bengal and Bihar. Fresh fishes are mostly imported from Assam. Fishes are sold as fresh, frozen, dried and smoked form. In fact, the demand for smoked product is more as compared to dried fishes. Several fishes having ornamental value are sold in the market in the form of smoked fish products, which indicate the need for conservation of the fishes in natural habitats. Apart from fish, other aquatic animals like frog, crabs, snails, mussels etc are also sold, indicating their high preference among the local people. The thrust areas identified are; 1. Adoption of model nursery village to meet demand for fish seed, 2. Popularise paddy cum fish culture, 3. Popularize integrated fish farming to reduce feed and fertilizer cost, 4. Undertake research on the breeding and rearing of indigenous ornamental fishes and 5. Explore the possibility of introducing indigenous fishes under culture system.

NATIONAL MISSION FOR SUSTAINING HIMALAYAN ECOSYSTEM (NMSHE)

Jhum improvement through Integrated / Agro-forestry farming system

An IFS model was developed in the farmer's (Mr. Angmet) field of Hukphang village in an area

Table 7. Performance of AI conducted at farm and field level

Location of AI adopted	No. of inseminations	No. of animals conceived	Conception rate	Service per conception	Litter size average
MSP Pig Farm	110	83	75.45 %	1.32	9.42 (1-20)
Medziphema Area	46	40	86.96 %	1.115	8.75 (6-15)
Kohima Area	44	41	93.18 %	1.07	8.42(6-10)
Dimapur Area	36	34	94.44 %	1.05	10(7-13)
Diphu	7	5	71.43 %	1.4	9.6 (7-13)
Jalukie	8	4	50 %	2	yet to farrow
Total in field condition	141	124	88 %	1.13	9.19

of 2.5 ha (Fig. 6). The components included were rice, horticulture (Orange, Mango, litchi, guava, kiwi, black pepper and lemon), piggery, mushroom, vermicompost and water harvesting structure (storage capacity: 8.75 lakh liter). The water harvested was used for irrigation purpose during water scarcity as a life-saving irrigation for crops and animals. Tree bean was planted along the border of the farm.


Site before intervention


After intervention


General view of IFS


Rice sowing at IFS


Rice field under IFS


Mushroom unit


Vermicompost unit


Piggery unit

Fig 6. Components of IFS model at Hukphang village

All India Coordinated Research Project on Mushroom, Nagaland Centre

Collection, identification and conservation of wild edible mushrooms

The following are the mushrooms collected and conserved at Jharnapani, Dimapur, Nagaland (Fig. 7 & 8).


1. Unknown Jharnapani (12.09.2015) Wood stump


2. Unknown Jharnapani (06.09.2015)


3. Unknown Jharnapani (06.09.2015) Litter


4. Unknown Jharnapani (06.09.2015) Wood stump


5. Unknown Jharnapani (06.09.2015) Litter


6. Unknown Jharnapani (06.09.2015) litter


7. Unknown Jharnapani (21.09.2015) Road side


8. Unknown Jharnapani (21.09.2015) Litter


9. Unknown Jharnapani (23.06.2016) Wood stump


10. Unknown Jharnapani (10.08.2016) Garden


11. Unknown Jharnapani (14.07.2016) Soil


12. Unknown Jharnapani (26.07.2016) Wood

Fig 7. Wild mushrooms

13. Paddy straw Jharnapani (28.07.2016) Vermicompost unit

14. Oyster Jharnapani (28.09.2016)

15. Wild Edible (09.08.2016)

Fig 8. Wild edible mushrooms

EXTENSION

On Farm demonstration on black gram and green gram cultivation

Hands on training programme of black gram variety (KU 301) and green gram variety (Pratap) was conducted in 0.4 ha of *Jhum* field (rice fallow) on 31st August, 2016 at Mongtikang village. Seven farmers attended the programme (Fig. 9).

Fig 9. Training programme on Black gram and Green gram

Demonstration units

Two demonstrations unit on poultry were established to enhance awareness among farmers. One rabbit farming and one low cost mushroom production unit were also established (Table 8).

Table 8. Demonstration units established in farmers field

Name of the unit	Name of the farmer/SHG	Year of establish ment	Size of the unit	Name of the village
Poultry demon stration unit	Woman dept. MBC (SHG)	2016	15x10 sq. ft	Mongtikang
Poultry demon stration unit	Hukphang Unionla (SHG)	2016	20x15 sq. ft	Hukphang
Rabbit farming unit	Noken Phom	2016		Hukphang
Low cost mush room produc tion unit	Shri. Angmet Phom	2016	15x10 sq. ft	Hukphang

National Mushroom day celebration

ICAR Research Complex NEH Region, Nagaland Centre observed the **"National mushroom day"** on 23rd December, 2016 at ICAR Research Complex Nagaland Center, Medziphema. The state of Nagaland is having a large scope for the recycling the paddy waste for the mushroom cultivation by utilising these wastes for growing mushrooms to enhance income. Effort has been made towards the improvement of livelihood and nutritional security by promoting the mushroom cultivation for the rural youths and women self-help groups. During the programme, awareness about the importance of mushroom in human diet and its nutritional and medicinal importance for all age group people was created. The Joint Director, felicitated a young innovative spawn producing entrepreneur from Dimapur, Nagaland (Fig. 10). This is to encourage commercial mushroom spawn production to mitigate the problem of spawn availability.

Fig 10. Joint director Dr. D. J. Rajkhowa felicitated the young mushroom entrepreneur

Gramin Krishi Mausam Sewa (GKMS)

AMFU (Agro Met Field Unit), ICAR Nagaland Centre, Medziphema have been issuing district wise Integrated Agro Advisory Service (IAAS) biweekly based on the weather forecast and the crop information available from districts to the eight districts of Nagaland. The information helps the farmers in planning their agricultural operations by taking advantage of the favorable weather and mitigating the effects of adverse weather.

Kisan Mobile Advisory Service (KMAS) an initiative of GKMS provides location specific farm advisory services on agriculture and allied sectors to the farming community through short message service (SMS). It improves farmers' decision making ability and help in increasing farm production and productivity. More than 6,400 farmers of the state are benefiting from the SMSs services, which are provided twice in a week.

Farmers' awareness programmes were also organized for sensitizing the role played by the project for improving the agriculture and allied sectors of the state (Table 9).

Table 9. Awareness / Training programme conducted under GKMS project

Sl. No.	Name of the programme	Date	Venue	No. of farmers
1	Awareness programme	18.05. 2016	ICAR Research Complex for NEH, Nagaland Centre	43
2	Awareness programme	24.05. 2016	Piphema , Dimapur district	39

EVENT / MEETING

Stakeholder meet on Agriculture Development and Agromet Advisory Services in Nagaland

ICAR Research Complex for NEH Region, Nagaland Centre organized stakeholder meet entitled "Stakeholder Meet on Agriculture Development and Agromet Advisory Services in Nagaland" on 21st November, 2016 at its campus. The meeting was attended by officials representing different line departments, organizations, institutions. Moreover, farmers from different districts and representative from farmers' associations and NGOs also participated the event. The event was jointly sponsored by Ministry of Earth Sciences, IMD, New Delhi and ICAR Research Complex for NEH Region, Umiam, Meghalaya. The inaugural session was attended by Shri M K Mero, Commissioner and Secretary (Veterinary & Animal Husbandry), Govt. of Nagaland as Chief Guest. Dr. Kripan Ghosh DDGM (Agrimet), Regional Meteorological Centre, IMD, Guwahati; Dr. S V Ngachan, Director, ICAR Research Complex for NEH Region, Umiam, Meghalaya; Dr. Abhijit Mitra, Director, ICAR- NRC on Mithun; Captain G Dhananjaya Rao, Dean, Veterinary College, CAU; Professor R C Gupta, Dean. NU-SASRD and Shri I P Khalla, Director, Department of Veterinary & Animal Husbandry, Govt. of Nagaland were the Guest of Honours. Various issues related to the role of weather and climatic phenomena in agriculture and the advisory services through convergence and linkages with different stakeholders (Fig. 11).

Fig 11. Stakeholder meet on Agriculture Development and Agromet Advisory Services in Nagaland

Field day cum Farmer-Scientist interaction

ICAR Research Complex for NEH Region, Nagaland Centre organized field day cum farmer –scientist interaction on 27st October, 2016 at its Research farm. The aim of the event was to demonstrate improved technology on agricultural and allied field and addressed the farmer's problems through farmer-scientist interaction. The event was inaugurated by the Honourable Chief Guest, Shri Dr. Benjongliba Aier, Parliamentary Secretary, Agriculture, Govt. of Nagaland in the presence of Rongseninla, Director, Department of Agriculture, Kevisa Kense, Director, Department of Fisheries, Dr. Lallan Ram, Director, CIH, Professor R. C. Gupta, Dean, NU-SASRD, Dr Abhijit Mitra Director, NRC on Mithun, other dignitaries and farmers. Several technologies and products were showcased in the exhibition by several organizations. The event was attended by more than 150 farmers from across the state. Various critical farm inputs including saplings, agricultural farm implements, soil health card, seeds, and poultry chicks were also distributed to the farmers during the occasion (Fig. 12).

Fig 12. Field day cum Farmer - Scientist interaction

Entrepreneurship development through spawn production and mushroom cultivation

Mushroom cultivation is a commercial enterprise for small and marginal farmers of Nagaland to increase their income and livelihood security. The cultivation of oyster mushroom round the year give an impact on profitable agri-business for the rural poor. A young innovative spawn producer and mushroom cultivation entrepreneur, Mr. Rajib Mondal from Dimapur, Nagaland has been practicing mushroom cultivation in large scale. Today, he is able to supply the spawn packets to the farmers of Nagaland on payment basis (Fig. 13).

Fig 13. a) Spawn lab *b) Mushroom unit*

c) Mushroom cultivation

LIST OF VISITORS

Fig 14. Dr. Benjongliba Aier (Parliamentary Secretary- Agriculture) visited during Field day cum Farmer- Scientist interaction 27th October, 2016

Fig 15. Dr. Harsh Vardhan, Hon'ble Union Minister for Science & Technology & Earth Science visited on 18th April, 2016

Fig 16. Shri. T. R. Zeliang, Chief Minister, Govt. Of Nagaland visited during Farmers fair cum Exibition programme- 6th August 2016 Jalukie, Peren

Fig 17. Piglet distribution by Chief Minister of Nagaland Shri. T R Zeliang

Fig 18. Shri. Radha Mohan Singh Hon'ble Union Minister Agriculture, Farmers welfare Govt. of India laid foundation stone of KVK Peren on 6th August 2016

Fig 19. Dr. Trilochan Mohapatra Hon'ble Secretary DARE & Director General ICAR Krishi Bavan New Delhi Govt. of India- 7th August 2016 visited to MSP-Pig farm

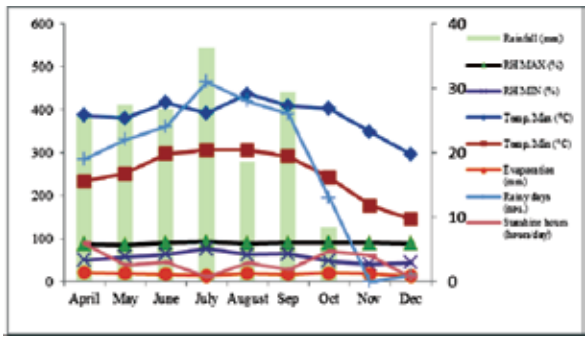
Training conducted by ICAR Research Complex for NEH Region, Nagaland Centre

Title of the training programme	Date/ period	Number of days	Number of beneficiaries			District's covered
			Male	Female	Total	
Training on scientific backyard poultry farming	22- 25, June, 2016	4	0	30	30	Dimapur, Kohima
Promotion of pig breeding through Artificial insemination and scientific management technique	20- 22, July, 2016	3	28	3	31	Dimapur, zunheboto, Wokha, Mon, Kohima, Mokokchung
Hands on training on Mushroom Cultivation	13-14, October , 2016	2	12	22	34	Peren
Sustainable crop production, protection and value addition of citrus in NE Region	18- 25, October, 2016	8	13	7	20	All districts of Nagaland, Tinsukia- Assam
Livelihood Improvement through aquaculture practices in Nagaland	9-11, November, 2016	3	12	8	20	Dimapur, Kohima
Training on Scientific pig and poultry production- Avenues for entrepreneurship development.	15-18 , November, 2016	4	18	5	23	Kohima, Dimapur, Karbi Anglong, Golaghat
Entrepreneurship development through Mushroom cultivation	5 - 7, December , 2016	3	8	22	30	Dimapur, Pasighat- Arunachal Pradesh
National mushroom day and Training cum demonstration on mushroom cultivation	23rd December, 2016	1	12	15	27	Dimapur, Peren
Production & Cultivation Practices of Large Cardamom & Orange	23.08.16 (Farmers)	1			27	Mongtikang
Training on insect pest and disease management on orange and large cardamom	23.08.16 (Farmers)	1			27	Mongtikang
Disease management of pig	20.01.17 (Farmers)	1			41	Mongtikang
Food processing and preservation	20.01.17 (Farmers)	1			41	Mongtikang
Training of oyster mushroom production	20.01.17 (Farmers)	1			41	Mongtikang
Demonstration of oyster mushroom production	20.01.17 (Farmers)	1			41	Mongtikang
Disease management of poultry	20.01.17 (Farmers)	1			41	Mongtikang
Value addition of broom grass	20.01.17 (Farmers)	1			41	Mongtikang

SIKKIM

WEATHER REPORT

The total amount of rainfall received during April 2016 to December 2016 was 2591.1 mm. During the crop growing period, maximum rainfall (544.2 mm) and maximum rainy days (31 no.) was recorded in the month of July 2016, whereas, there was no rainfall recorded in the month of November 2016.



The maximum average temperature (29.12°C) was observed in August, 2016 and the minimum (15.6 °C) was in April 2016. The maximum evaporation (1.38 mm) and sunshine hours (5.33 hr/day) was observed in the month of October, however, minimum evaporation (0.95 mm) and sunshine hours (0.75 hr/day) was observed in the month of July.

AGRONOMY

Effect of cropping system on system productivity and production efficiency

Diversification of rice through inclusion of leguminous crops was tested in a fixed plot field in Completely Randomized Block Design (CRBD) comprising seven cropping systems *viz*., rice-maize, rice-fenugreek (leafy vegetable)-maize (green cobs), rice-broccoli-*Sesbania* (green manuring), rice-vegetable pea-maize (green cobs), rice-coriander (green leaf)-cowpea (vegetable), rice-fenugreek (leafy vegetable)-baby corn and rice-buckwheat. The results of the study revealed that among the diversified cropping systems, significantly higher values of yield attributing parameters and grain yield of rice (4.51 t/ha) were recorded with rice-broccoli-*Sesbania* cropping system. Thus, adoption of rice-broccoli-*Sesbania* cropping leads to 19.8% higher rice grain yield as compared to existing rice-maize systems in irrigated ecosystems of Sikkim Himalayas.

Effect of biochar on crop productivity

Impact of biochar on crop productivity was assessed in factorial randomized block design, assigning three levels of biochar *viz*., control, 1 t/ha and 2 t/ha as factor A and five levels of FYM (control, 100% RDN, 75% RDN, 50% RDN and 25% RDN) as factor B. Results of the study revealed that among the different treatment combinations, application of 2 t/ha along with 100% RDN through FYM recorded higher grain yield of maize (3.68 t/ha).

Diversification of maize-based cropping system through *in situ* moisture conservation practices for improving water and crop productivity

Among the cropping sequences, maize + cowpea - vegetable pea recorded the maximum values of system productivity (17.0 t/ha) and production efficiency (46.5 kg/ha/day) followed by maize + cowpea - rajmash (Fig. 1). With respect to the moisture conservation practices, *insitu* retention of maize stalks + weeds biomass proved its superiority over the other methods of moisture conservation (Fig 1).

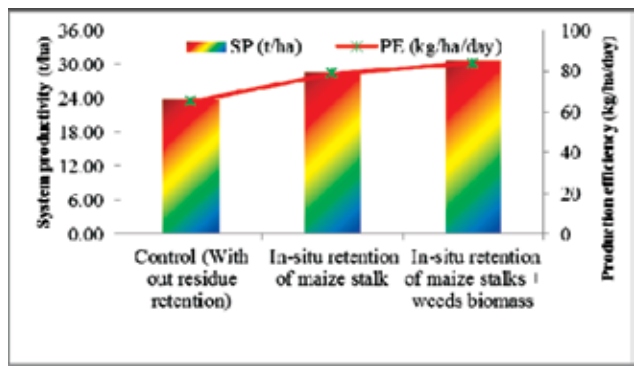


Fig 1. Effect of In-situ moisture conservation measures on SP and PE

Resource conservation techniques for improving productivity and resource-use efficiency of maize-pea cropping system.

The experiment consisted of three tillage practices *viz*., conventional, reduced and zero tillage and four organic sources of nutrients *viz*., farmer practices, recommended dose N through organic sources, 75% of RDN of organic source + maize stalk/pea stover, 50% RDN of organic sources + maize stalk/pea stover and replicated thrice. The result showed that reduce tillage recorded significantly higher maize grain yield (3.79 t/ha) over conventional tillage (3.18 t/ha) but remained at par with zero till sown maize (3.67 t/ha). The organic sources of nutrients also showed significant effect on maize yield and recommended dose N recorded the maximum value (3.98 t/ha) followed by 75% of

RDN of organic source + pea stover (3.82 t/ha) and the lowest value was with farmers practice (3.01 t/ha).

Effect of tillage practices and organic sources of nutrients on productivity of rice - vegetable pea - maize (green cob) cropping system

Rice-vegetable pea-maize (green cob) cropping system was evaluated under different tillage practices and organic nitrogen sources. The results were significantly influenced by different tillage and organic nutrient sources, the highest on maize green cob yield (Fig 2). Similarly, rice yield was also influenced by tillage practices and organic N sources and recorded maximum grain yield with RT (3.20 t/ha) followed by NT (3.19

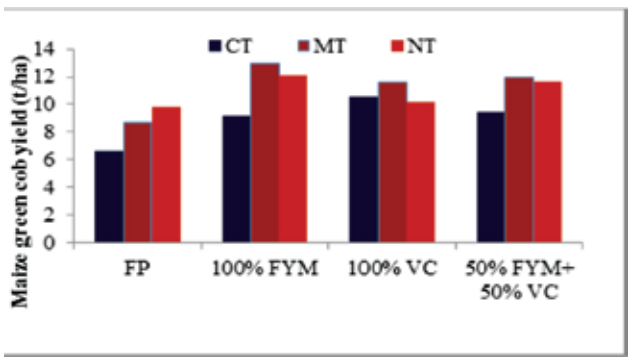


Fig 2. Effect of tillage practices and organic nutrient sources on maize green cob yield in rice-vegetable pea -maize (green cob) system

t/ha) and lowest in CT (2.97 t/ha). With regard to organic sources of nutrients, application of 50% FYM+50% VC+biofertilizers recorded significantly higher grain yield (3.70 t/ha) over other organic sources. Vegetable pea was sown 13 days earlier than conventional and reduced till in the same experiment.

Development of climate resilient maize-based cropping system for mountain ecosystem under organic management

In order to increase the cropping intensity in the state up to 300% under rainfed ecosystem through intensification of maize-based cropping sequences with inclusion of leguminous crop an attempt has been made at ICAR experimental farm. Three cropping sequences *viz*., CS_1- maize-fallow (FP), CS_2- maize-urd bean (*pahenlo dal*)-buckwheat and CS_3- maize-urd bean (*pahenlo dal*)-mustard were kept in main plot and four organic sources of nutrients *viz.,* control (farmers practices); 50% FYM + 25% VC + 25% MC + biofertilizers; 50% MC + 25% FYM + 25% VC + biofertilizers and 25% FYM + 25% MC + 25% VC + 25% PM + biofertilizers in subplots with three replications. The results revealed that among the organic sources of nutrients application, 25% FYM + 25% MC + 25% VC + 25% PM + biofertilizers recorded higher grain yield (3.74 t/ha) of maize over the other sources on nutrients. The grain yield of maize was higher in CS_2 (3.57 t/ha) followed by CS_3 (3.55 t/ha). Similarly, maize responded to the mulching applied in *Rabi* season crops and recorded significantly higher grain yield (3.57 t/ha) over without mulching (3.45 t/ha) (Fig. 3).

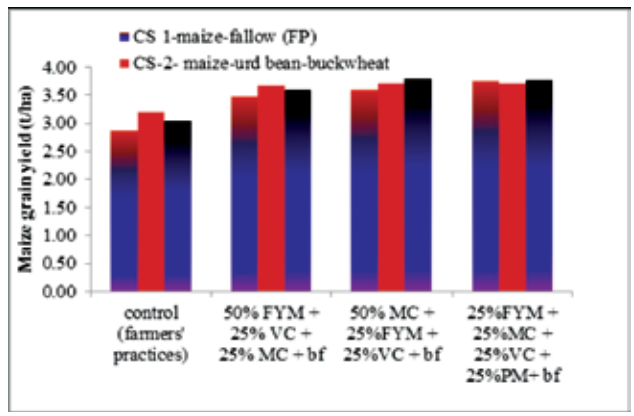


Fig 3. Effect of different cropping system and organic N sources on maize grain yield in maize-based cropping system

Effect of local land races of rice (*Oryza sativa* L.) under different planting methods in mid hills of Sikkim Himalayas

In order to evaluate the effect of local land races (scented) on productivity of rice under different methods of planting, an experiment was laid out in split plot design, assigning two methods of rice production *viz.,* system of rice intensification (SRI) and conventional planting (CP) in main plots and three local cv. *viz., Kalonunia*, *Bhrimphul* and *Krishna Bhog* allocated in subplots. The results revealed that SRI recorded 18.9 per cent higher grain yield over the CP. Among the local cv., *Krishna Bhog* recorded significantly higher grain yield (3.13 t/ha) over others.

Effect of tillage practices on productivity of rajmash and black gram in mid hills of Sikkim

To reduce the labour cost, energy use and enhancing the soil quality and crop productivity of maize fallow areas an experiment was conducted on rajmash and blackgram cultivation under no-till based conservation practices at ICAR Research Farm.

The results of the study showed that both the crops (rajmash and black gram) recorded higher grain yield under no-till (NT) practices over conventional tillage (CT). The grain yield of rajmash (1.37 t/ha) was 17.8 per cent higher in no-till practice over CT (Fig 4). Similarly, the black gram yield was also higher under NT planting (0.98 t/ha) over CT.

Fig 4. No till rajmash crop

Production of seeds and planting materials under ICAR Seed Project

Under ICAR seed project cereals, pulses and oilseeds and other crops has been undertaken for seed production during *Kharif* 2016. The detail quantity has been given in Table 1.

Table 1. Seed production during 2016 in Institute and as participatory mode at farmers' field

Crop	Variety	Breeder seed (q)	Foundation seed (q)	Truthfully labelled seed (q)
		Cereals		
Maize	MA 8-1	0.18		
	MS 4-1	0.11		19.6
	MS 1-1	0.12		
	Vivek Sankul 31		2.21	2.27
	RCM 1-3		1.26	2.38
		Pulses		
Urd bean	SK PD 3	1.28		21.78
Rajmash	SKR 57	1.26		3.6
	Tripura Rajmash Sel. 1		3.7	
		Oilseeds		
Soybean	RCS 1-10		2.18	14.52
		Others		
Sesbania				0.72
Ginger	*Gorubathane/ Bhaise*			34.2
Turmeric	Megha Turmeric-1			13.6
Large cardamom	Seremna/ Sawney			20500 sapling

Fig 5. Seed cleaner cum grader

Screening of Rajmash (*Phaseolus vulgaris* L.) varieties under organic management condition

In order to meet the demand of pulses in the state, short duration pulse crop rajmash (*Phaseolus vulgaris* L.) is an option for the farmers in the state. A short duration rajmash variety which can escapes the drought during early winter season may enhance the cropping intensity after harvest of maize crop in the state. Hence, varietal evaluation of rajmash was conducted in four time replicated randomized block design at research farm of ICAR-NOFRI and KVK-East Sikkim Farm during *rabi* season. Among the different varieties tested, Raj 2 recorded significantly higher grain yield (1.73 t/ha) over Raj 1 (1.02 t/ha), SKR 57 (1.11 t/ha) and Tripura Raj Sel 1 (1.47 t/ha) but at par with Raj 3 (1.62 t/ha) and Raj 4 (1.56 t/ha).

Fig 6. General view of crop and seed colour of different varieties

SOIL SCIENCE

Soil organic carbon dynamics and fertility in response to organic nutrient sources under maize based cropping system

Field experiment was conducted on clay loam soil during three consecutive years 2014-16 (pre-*kharif*) to evaluate SOC dynamics and fertility status in maize based cropping system. Five treatments, *viz*., T_1, control; T_2, 75% N through FYM + green manure; T_3, 50% N through FYM + 25% VC + GM ; T_4, 33% N FYM + 33% N VC + GM; T_5, 25% N FYM + 25 % N VC + 25% N poultry manure + GM were laid

out in FRBD design and replicated thrice. The three year pooled analyses showed that T_4 resulted in highest grain yield for RCM 1-3 (3.87 t/ha) and RCM 1-76 (4.21 t/ha). T_4 registered significantly higher available N, P and K content in soil as compared to other treatments. The higher available nitrogen, phosphorus and potassium in T_4 could be due to increased activity of micro-organisms leading to greater mineralization of applied and native nutrients.

Characterization of biochar derived from weed biomass for physico-chemical properties

ICAR-National Organic Farming Research Institute, Tadong, Gangtok has identified six weeds species around their research farm *viz.*, *Ageratum* spp., *Lantana* spp., *Artemisia vulgaris*, *Chromolaena odorata*, *Bidens* spp., *Neyraridia* spp. and utilized their biomass to prepare biochar. The biochar products derived from six different weed biomass has been characterized for different physico-chemical properties (Table 2).

Table 2. Chemical properties of biochar derived from weed biomass

Sources	Volatile organic content (%)	pH	Moisture content	Total N (g/kg)	Total P (g/kg)	Total C (g/kg)	C:N ratio	Ash (%)	CEC (cmol kg^{-1})	Alkalinity
Lantana spp.	15.7	9.21	10.3	7.2	1.81	735	102	25.7	29.7	121.3
Agera tum spp.	16.9	9.02	9.9	8.3	1.95	750	85	27.9	26.2	110.5
Neyraridia spp.	19.6	8.87	10.2	7.8	1.78	730	94	30.5	23.4	102.7
Artemisia vulgaris	19.1	8.53	10.1	7.7	1.81	715	93	33.2	22.7	99.7
Bidens spp.	17.8	8.11	9.7	9.5	1.92	708	74	36.4	21.6	94.7
Chromolaena odorata	18.4	8.02	10.6	8.9	1.83	727	82	39.6	20.7	90.6

Effect of integrated sources of organic nutrient on soil microbial indicators (after 4th upland direct seeded rice-pea sequence)

The results revealed that MBC ranged from 295.9 to 471.1 mg/kg among the various treatments. Application of organic nutrients significantly improved the MBC over control. However, vermicompost and neem cake along with BF showed more build up of MBC (471.1 mg/kg). Similar results were observed in the case of MBN content. The MBN content among the treatments varied from 81.8 to 158.3 mg/kg. Like MBC and MBN, T_7 showed greater buildup of MBP in the soil rhizosphere (Table 3).

Table 3. Soil microbial biomass carbon, nitrogen and phosphorus dynamics

Treat-ments*	Microbial biomass C (mg/kg)	Microbial biomass N (mg /kg)	Microbial biomass P (mg/kg)
T_1	295.9	81.8	9.13
T_2	395.1	125.1	16.3
T_3	361.7	103.6	16.1
T_4	381.8	112.5	16.3
T_5	418.3	139.4	19.5
T_6	443.4	141.7	20.7
T_7	471.1	158.3	23.6
T_8	446.7	144.2	21.4
CD (*P=0.05*)	11.5	3.9	2.6

T1=Control, T2= FYM 100% + BF, T3= FYM 75% + NC 25% + BF, T4= FYM 50% + VC 25 % + NC 25% + BF, T5= FYM 25% + VC 50% + NC 25% +BF, T6= VC 75% + NC 25% + BF, T7= VC 100% + NC 25% +BF, T8= VC 100% + BF; BF @ 25 kg/ha

HORTICULTURE

Flagship Program on Temperate Fruits

KIWI FRUIT

Studies have been undertaken on hand pollination (HP) techniques and their effect on the percentage of fruit-set, fruit growth, fruit yield and fruit quality under partial protection along with control (C). Hand pollination significantly increased percentage of 'A' grade fruits (70-80%) under partial protection. The best time of hand pollination was observed at 10-12 am to get the maximum fruit set (80-90%). Pollen viability was observed up to 72 hr for hand pollination, however, maximum (100%) fruit-set was observed in hand pollination within 24 hrs after anther removal, and 90% fruit-set was observed after 48 hrs of anther removal. Hand pollination and organic nutrients (ON) management showed significant effect on fruit length {55.46 mm (C) to 70.26 mm (HP&ON)}, fruit breadth {40.20

mm (C) to 42.47 mm (HP&ON)}, fruit weight {50-60 g (C) to 100-120 g (HP&ON)}, and quality parameters - acidity {0.63% (HP&ON) to 1.35% (C)}, total sugars {8.23% (C) to 14.05% (HP&ON)} and Total Soluble Solids (TSS) contents {10.54° Brix (C) to 18.67° Brix (HP&ON)}. For maximization of 'A' grade organic kiwifruit production, vines should be mounted with 50% agro-shade net at the end of March for about sixty days, which are removed at the end of May.

Fig 7. Partial shade, hand pollination and fruit set in kiwifruit

PLUM AND POMEGRANATE

Three year evaluation studies after planting showed significant variations for vegetative growth parameters in plum and pomegranate. Maximum plant height (3.20 m), plant canopy (4.85 m^2) and trunk diameter (11.14 cm) was observed in var. Satluj Purple, however, minimum plant height (1.17 m), plant canopy (1.31 m^2) and trunk diameter (1.92 cm) was recorded in var. Maricoza. Satluj Purple and Santa Rosa plum came in to fruiting in third year of planting and yielded 13.27 kg/plant and 9.79 kg/plant, respectively under uniform cultural practices.

Fig 8. Plum in fruiting

The TSS content was noted as 10.78 °Brix in Satluj Purple and 9.35 °Brix in Santa Rosa (Fig. 9). Maximum plant height (1.62 m) was observed in var. Sinduri, however, lowest was noted in Bhagwa (1.34 m). Highest plant canopy (80.38 cm^2) was recorded in Mridula and lowest (50.50 cm^2) was found in Sinduri. Maximum trunk diameter (26.90) was observed in var. Kabuli Kandhari and minimum was observed in var. Sinduri (20.43 mm). So far none of the pomegranate cultivars entered in to reproductive phase (Fig. 10).

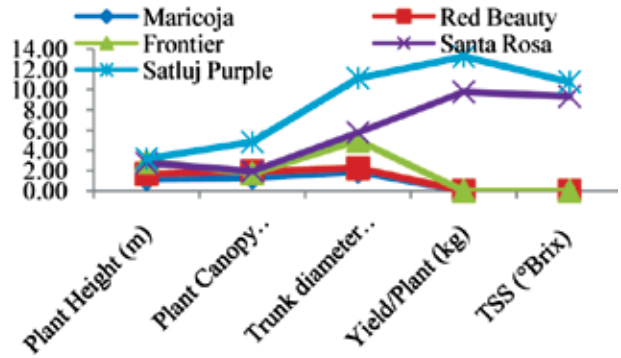


Fig 9. Comparative performance evaluations of plum varieties

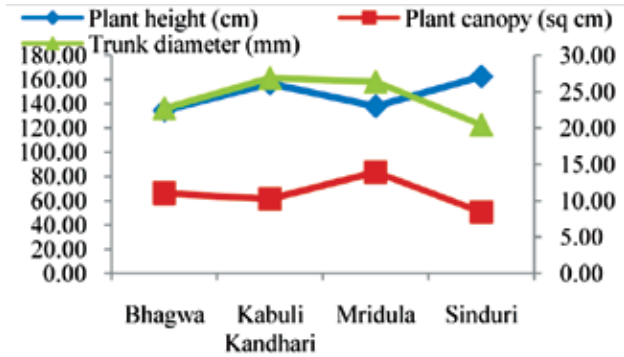


Fig 10. Comparative performance evaluations of pomegranate varieties

Evaluation of pear germplasm suitable for cultivation under Sikkim conditions

Evaluation of 11 pear cultivars (Asian pear: Punjab Nectar, Punjab Gold, Punjab Beauty, Patharnakh; Japanese pear: Kosui, Hosui, Sojuru; European pear: Bartlett, Starkrimson, Williams Quince C), after four years of planting under uniform management practices showed significant variations for vegetative growth parameters, *viz.*, plant height, trunk diameter, number of leaves per ft. branch, number of branches per plant, plant canopy measurements, no. of spurs per ft. branch and spur length was observed. Patharnakh attained maximum plant height (3.4 m) followed by Punjab Nectar (3.3 m), however, Quince C are slow growing and attained minimum plant height (1.6 m) followed by Bartlett (1.7 m). Plant canopy was maximum in Punjab Beauty (2.6 sq m) followed by Patharnakh (2.3 sq m) and the minimum plant canopy was observed in Sojuro (0.3 sq m). The maximum trunk diameter was observed in Patharnakh (52.5 mm) followed by Punjab Beauty (52.3 mm) and minimum trunk diameter was observed in Punjab Gold (4.0 mm). Highest no. of branch/plant was observed in Punjab Beauty (19) followed by Punjab Gold (16) and lowest no. of branch/plant was in Sojuro (3). The maximum no. of leaf per ft. branch was found in Punjab Beauty and Punjab Gold (23) and minimum was in William (7). So far none of the cultivars have fruited,

however, spurs formation has started and maximum no. of spurs was noted in Punjab Nectar (10.4) followed by Bartlett (9.0), however, no spur formation in Hosui, Starkrimson, Williams and Quince C (Fig. 11). Standardization of organic nutrient management and scheduling of biopesticide and biofungicide spray has also been undertaken. Application of well decomposed and dried cattle manure @ 20 t/ha in two split doses (*i.e.*, dormant stage in December and active vegetative growth stage in July), neem cake @ 2 t/ha, dolomite @ 2 t/ha, and vermicompost @ 2 kg/plant showed better growth response in all the pear varieties. Spray of petroleum-oil based mixed with neem oil in equal concentration @ 5 ml/l during April-May and July-August is effective to control aphids, leaf miner etc. and spray of copper oxychloride @ 0.25% during April-May and July-August at 15 days interval is effective for the management of blight disease.

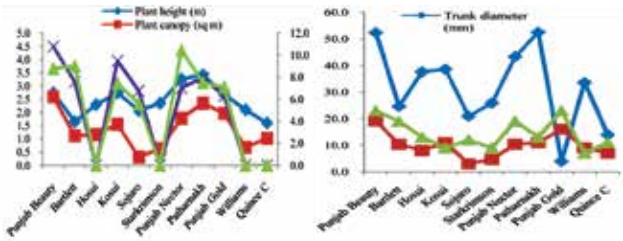


Fig 11. Comparative performance evaluations of pear varieties

Evaluation of nano fertilizers on mandarin

Nano nutrient formulation @ 2 ml per litre sprayed on six year old Sikkim mandarin plants grafted on different rootstocks at 45, 90 and 135 days showed significant effect on various fruit quality parameters. Sikkim mandarin grafted on Rangpur lime (SM+RgLi) showed maximum (11.8 °Brix) TSS followed by Sikkim mandarin grafted on Rough lemon (SM+RLe) (11.2 °Brix), however, in control (Sikkim mandarin) was minimum (8.0 °Brix). Acidity was minimum (1.44%) in SM+RgLi and highest (2.89%) in Sikkim mandarin grafted on Grapefruit (SM+GF).

Evaluation and screening of chow-chow/squash (*Sechium edule*) germplasm under varied climatic conditions

ICAR-NOFRI has a collection of 86 chow-chow accessions. Morphologically different types and colours of fruits were observed, *viz*., round, oblong, spiny, very spiny, without spine and creamy white to green, dark green fruits. High range of fruit phenotypic variations were observed among the chow-chow accessions for several parameters under study such as fresh fruit weight, fruit length, fruit width, spine density per unit area and spine length in spiny types and yield. The fresh fruit weight ranged from 91.67 to 789 g, fruit length from 62.85 to 183.8 mm, fruit width from 53.97 to 116.8 mm, spine density from 0.0 to 74.9 per square inch and spine length 0.0 mm to 8.00 mm in spiny types. The yield of chow-chow accessions varied from 1.0 to 160 kg per plant

Regional trial on advance breeding lines of horticultural crops – Guava

Five guava varieties, *viz*. RCGH-1 (Sour type X Red fleshed local), RCGH-4 (Red fleshed X Allahabad Safeda), RCGH-7 (Lucknow-49 X Pear shaped), Allahabad Safeda and Lucknow-49 (Sardar) have been planted in ultra high density system at 2 m x 1.5 m spacing during 2014-15. During the third year, all the guava varieties entered in to reproductive phase and observations on no. of fruits/plant, fruit growth in terms of length (mm) and width (mm), average fruit weight (g), yield/plant (kg) and TSS (%) was recorded.

Standardization of organic nutrient management and scheduling of biopesticide and biofungicide spray is being done. Maximum fruit length (63.28 mm) was noted in L-49, however, maximum fruit width (72.68 mm) was observed in RCGH-1 followed by L-49 (68.75 mm). The total no. of fruits per plant was maximum (140) in RCGH-7 followed by L-49 (105.33). The average fruit weight (197.10 g) and yield (20.76 kg/plant) was highest in L-49 followed by RCGH-7 (17.53 kg/plant) (Fig. 13).

Fig 12. Guava planting in ultra high density system

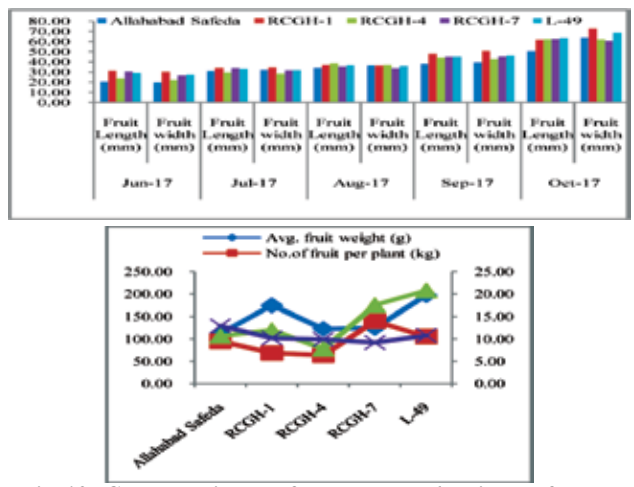


Fig 13. Comparative performance evaluations of guava varieties at ICAR-NOFRI

AGRO FORESTRY

Carbon sequestration potential and bio-economic appraisal of large cardamom based agroforestry systems in mountain region.

An experiment was conducted in large cardamom based AFS during 2016 at ICAR Sikkim Centre. Large Cardamom cultivar Sawney was planted in combination with multipurpose tree species as well as mixed forest system. Growth performance of three year old age plant of large cardamom recorded more number of average plant height and bearing tillers/clump under *Alnus nepalensis* based AFS followed by mixed forest system and minimum average plant height and bearing tillers/clump was recorded under *Ficus hookerii*. Dry wt. of capsules (g)/clump was obtained higher in combination with *Alnus nepalensis* based AFS followed by mixed forest system and minimum with under *Ficus hookerii* (Table 4).

Assessment of microbial biomass carbon and nitrogen under different agroforestry system

All agroforestry systems including control have shown higher microbial biomass carbon (MBC) on the surface layer as compared to subsurface layer and significantly higher over control in both layers. MBC was also found to be significantly higher between the soil layers of same type of agroforestry systems. Maximum MBC was recorded in mixed forest (847 mg/kg) followed by *Ficus* (801 mg/kg) and *Terminelia* (790 mg/kg), and the lowest was observed in control (398 mg/kg) at the surface layer. The same is followed also in the sub-surface layer for all agroforestry systems. The MBC obtained in both layers can be arranged in descending order as Mixed st>*Ficus*>*Terminalia*> *Schima*>*Leauceana*>control. Microbial Biomass Nitrogen (MBN) was significant between the soil layers of same type of agroforestry system. Like MBC, the surface soil has shown higher MBN than subsurface soil. Surface soil layer of *Alnus* had maximum MBN (416 mg kg^{-1}) followed by mixed forest (376 mg kg^{-1}), *Leauceana* (363 mg kg^{-1}), *Schima* (351 mg kg^{-1}), *Ficus* (310 mg kg^{-1}) and lowest for control (357 mg kg^{-1}) and the same trend at the sub-surface layer.

Table 4. Growth performance of large cardamom with different multipurpose tree species

Growth Parameters of Large Cardamom	*Schima wallichii*	*Alnus nepalensis*	*Terminelia myriocarpa*	*Ficus hookerii*	*Leauceana leucocephala*	Mixed Forest
Plant height (cm)	142.27±14.87	185.60±16.3	146.13±12.70	135.60±13.70	147.80±10.06	150.33±10.83
Diameter (mm)	9.27±0.19	8.40±0.03	9.33±0.64	9.15±0.42	9.46±0.09	10.73±0.33
Immature tillers/clump	6.13±0.13	2.87±0.47	4.00±0.83	4.07±0.75	3.87±1.07	3.40±0.46
Mature tillers/clump	11.67±0.55	9.60±1.62	6.53±1.27	10.80±1.80	17.20±2.14	8.07±0.58
Bearing tillers/clump	4.07±0.75	6.13±0.73	3.87±1.07	2.87±0.47	4.00±0.83	4.40±0.46
Av. no. Spikes/clump	6.20±0.69	3.13±0.73	2.33±0.84	2.00±1.62	5.00±0.58	4.20±0.53
Av. capsuels/spike	24.80±4.10	37.60±6.13	23.60±5.10	14.40±1.75	35.47±16.18	13.20±2.73
Fresh weight of capsule/clump (g)	73.33±19.54	99.33±22.28	46.00±9.02	31.00±2.08	94.00±50.48	82.33±4.74
Dry wt. of capsules (gm)/clump (g)	14.67±4.89	19.87±5.87	9.20±1.06	6.20±0.70	18.80±6.25	16.47±0.77

Sikkim Mandarin Based AFS

A field experiment was conducted to assess the growth performance of mandarin and yield of intercrop. As intercrop, maize and soybean were sown in *kharif* season, whereas mustard and buckwheat were sown in *Rabi* season in association with mandarin. The average yield of maize, mustard and soybean association with fruit tree was 31.7, 6.37 and 13.50 q/ha, respectively. The sole yield (without tree) 41.0, 9.0 and 17.5 q/ha, respectively. The height of mandarin was recorded 3.75 m, girth 26 cm and spread of canopy 1.77 m with intercrop and in control (without intercrop) height 4.5m, girth 30.65 cm and canopy spread 1.97 m was observed.

Guava Based AFS

The average yield of intercrops recorded in maize (35.0 q/ha), mustard (6.7q/ha) and soybean. The sole yield (without tree) 46.0, 9.0 and 17.5, respectively. The average fruit yield of guava was recorded (16.0 kg/tree) in control (without under storey crop) and with crop fruit yield of 8.5 kg/tree was obtained.

PLANT PATHOLOGY

Organic management of major tomato diseases under protected and unprotected conditions in Sikkim

Experiments were conducted in both protected and unprotected conditions to study the effect of different organic treatments against various diseases in tomato. A total of 10 treatments were used, *viz*., garlic 5%, onion 5%, mugwort 5%, *Trichoderma viride* 0.25%, *Pseudomonas fluorescens* 0.25%, copper oxychloride 0.25%, copper hydroxide 5%, Metalaxyl 0.1%, neem oil 0.3% and control with no spray. The diseases noticed were late blight (*Phytophthora infestans*), leaf curl and root rot (*Rhizoctonia solani*). Among the various treatments studied, copper oxychloride was found very effective for the management of late blight and root rot respectively in open conditions (21.3%, 5.0%), poly house (21.7%, 3.0%), rain shelter (16.3%, 2.3%) and high tunnel (19.7%, 4.3%). The next best fungicide was copper hydroxide. The biocontrol agent *Trichoderma harzianum* was found to be most effective among the biocontrol agents and botanicals tested in reducing the incidence of root rot caused by *Rhizoctonia solani* in open conditions (9.0%), poly house (7.3%), rain shelter (9.0%) and high tunnel (11.7%). Among the treatments, neem oil was found very effective in controlling the leaf curl incidence in tomato with per cent disease incidence of 4.0%, 7.0%, 6.0% and 4.0% in open conditions, poly house, rain shelter and high tunnel, respectively.

AGRICULTURAL ENTOMOLOGY

Evaluation of some non-edible oils and substances against pulse beetle, *Callosobruchus chinensis* (L) of pahenlo-dal in storage

Five non-edible substances, *viz*., neem oil, lemongrass and petroleum based horticultural oil @ 7 ml/kg of grain, spinosad 45 SC @ 0.1% solution and sesame oil @ 10 ml/kg were evaluated for their efficacy as grain or seed protectants against beetle, *Callosobruchus chinensis* (L) in storage based on grain damage %. The number of infested grains was recorded after 1 and 3 months of storage. Germination test of all treated seeds was done after 3 months of treatment with untreated and uninfested seeds as control. It was observed that among five treatments, grain damage was minimum in lemon grass oil (5.45%) followed by treated seeds of spinosad (6.75%) and sesame oil (8.25%) but in case of lemon grass oil the germination per cent of seeds was less (52.5% after 3 months) in comparison to spinosad and sesame oil. Spinosad 45 SC @ 0.1% was effective to reduce the infestation of seed/ grain retaining the germination (92.0%) followed by sesame oil (93.25%).

Evaluation of some biopesticides against insect pests of pahenlo-dal

Five different biopesticides *viz*., neem oil (1500 ppm) @ 4 ml/l, *Metarhizium anisopliae* @ 5 ml/l, petroleum oil based agrospray @ 10 ml/l, petroleum oil based horticultural spray 10 ml/l and spinosad 45 SC @ 0.3 ml/l was evaluated against legume pod borer in *Pahenlo dal*. First application of biopesticides was done during pod formation stage of the crop followed by the second spray at 15 day interval. The percent of infestation of pods was recorded at 7 and 14 days after treatment. Among the biopesticides, spinosad 45 SC @ 0.3 ml/l was found to be the most effective (82.46% reduction over control) followed by the treatment of neem oil (1500 ppm) @ 4 ml/l (72.84% reduction over control).

Fig 14. Pahenlo dal

Study on population build up of insect pests of maize and their natural enemies

The populations build up of insect pests of maize and natural enemies were studied in 2016. The crop was sown in the first fortnight of March and no application of insecticides was done during the whole crop growth period. The population data of insect pests and natural enemies was recorded starting from 10 days after sowing at 15 days interval till harvest. The study revealed that the cut worm population was maximum during seedling stage in the first fortnight of April.

The armyworm attack was maximum in the first fortnight of May whereas the semilooper population was maximum in the first fortnight of June. Cob borer and maize aphid infestation was maximum in the second fortnight of June. Throughout the growth period of the crop, the infestation of grasshopper was observed but maximum population was recorded in the second fortnight of May (Table 5).

Fig 15. Maize

Table 5. Study on population build up of insect pests of maize

Observation In different fortnights	% of incidence of different insects					
	Cut worm	Army worm	Semi looper	Cob borer	Aphids	Grass hopper
March-ll	8.00	2.00	0.00	0.00	0.00	2.00
April-l	14.00	8.00	0.00	0.00	0.00	6.00
April-ll	6.00	14.00	4.00	0.00	0.00	8.00
May-l	0.00	18.00	8.00	0.00	0.00	12.00
May-ll	0.00	12.00	12.00	2.00	2.00	14.00
June-l	0.00	8.00	16.00	6.00	6.00	10.00
June-ll	0.00	4.00	14.00	10.00	8.00	8.00
July-l	0.00	4.00	6.00	6.00	4.00	8.00

Tea mosquito bug, an emerging pest of kiwi

Tea Mosquito Bug, *Helopeltis theivora* Waterhouse has been recorded in kiwi for the first time in Sikkim in 2016. Already the pest has been recorded for the first time as emerging pest of Red Cherry pepper (*Dalle Khorsani*) and large cardamom in Sikkim. Both young and adult mosquito bugs, damage kiwi plants by sucking the sap from leaves.

The affected parts of the plant develop a circular stain that is dark brown. The young shoots become curled, dried and black reducing the growth of the plant and ultimately affects the yield. The female lays eggs inside the tender shoots. After hatching, nymphs complete its nymphal period through four instars. The size of spots produced by the initial instars is smaller in comparison to later instars and adult. The fully matured nymph or adult can produce more than 100 spots/day. It causes damage of leaves in the range of 20-55 per cent.

Pollinators' complex of some important crops of Sikkim Himalaya

Pollinators play a vital role for enhancing production of majority of the crops. The information regarding pollinator's complex of some important crops is of utmost necessity in organic state like Sikkim. The work in this line has been done for some important crops like large cardamom, mustard, buckwheat, sunflower, Pigeon pea, maize, bitter gourd, kiwi *etc*. During the year, the pollinator's complex of cucumber has been studied. In cucumber, *Bombus breviceps*, *Apis cerana indica*, rice skipper, cabbage butterfly, *Danaus chrysippus, Xylocopa* spp., lady bird beetle and blister beetle were recorded as frequent visitors but among these *Bombus breviceps*, *Apis cerana indica*, blister beetle and *Danaus chrysippus* were found as important pollinators.

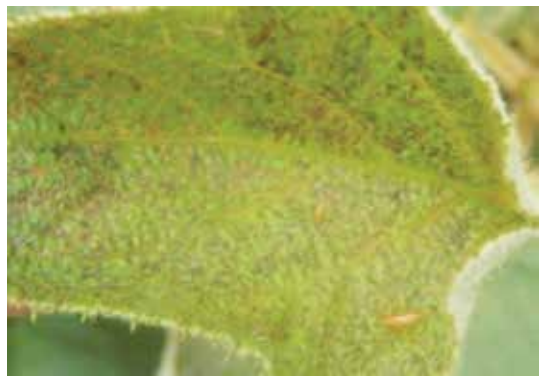
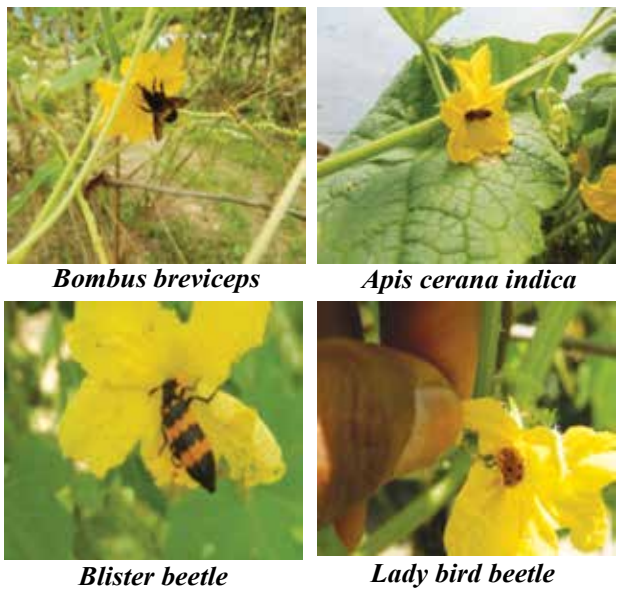


Fig 16. Tea Mosquito Bug on Kiwifruit Leaf



Bombus breviceps ***Apis cerana indica***

Blister beetle ***Lady bird beetle***

Fig 17. Common pollinators in cucumber

ANIMAL SCIENCE

Productive and reproductive performance of Singharey Goats in organized and conventional farms of Sikkim: effect of melatonin on the reproductive performance of Singharey goat

The reproductive performance of Singharey goat was studied using three different dose rates of melatonin, *i.e*., 10 mg, 20 mg and 40 mg. All the does under treatment groups, *viz*., T1, T2 and T3 were injected subcutaneously with 10 mg, 20 mg and 40 mg melatonin, respectively after dissolving each dose in 1 ml corn oil and control (C) does were treated with 1 ml corn oil. The kidding rate of the goats in various groups of melatonin was recorded in the month of August, 2016. All the does in the melatonin treated groups (T1, T2 and T3) showed estrus (100%) and successfully bred with fertile rams, whereas, only 42.85% could be bred in control group. Pregnancy

rate was 100% in T2 group followed by 83.33% in T1 and T3 and 28.57% in control group of does. Twins/Triplets were born in case of 50% of the does in all treated groups (T1, T2 and T3), whereas, only 14.28% gave twin birth in control group of does. Kidding percentage was highest in T2 group (166%) followed by T1 and T3 (150%) and lowest in control dose (42.85%).

Fig 18. Singharey female goat delivered triplets

Reproductive disorders of dairy cattle in relation to mineral deficiency in different agro-climatic zone of Sikkim

Survey regarding different reproductive disorder in dairy cattle in all four districts is going on and significant amount of blood, fodder and soil sample has been collected and estimation is underway. There was no significant difference between inter-calving interval between organized and unorganized dairy farm. However, it was slightly more in unorganized farm than organized farm. It was also observed that post-partum anestrum period was more in unorganized farm than organized farm (Table 6).

Table 6. Various reproductive parameters of dairy cattle

Reproductive Traits	East Sikkim		South Sikkim (Un-organized farm)
	Organized farm	Un-organized farm	
Age at first service (month)	24.3 ± 2.03	26.9 ± 2.23	25.4 ± 1.20
Age at first calving (M)	32.8 ± 3.2	35.6 ±1.5	34.9 ± 2.31
Inter Calving period (days)	456 ± 22.6	532 ± 24.1	436 ± 14.38
Post partum anestrum (month)	4.38 ± 0.75	5.46 ±0.68	4.25 ± 1.00
Calving to conception interval (days)	230 ± 10	245 ± 5	224 ± 6
No. of services per conception	1.8 ± 0.18	1.5 ± 0.21	1.68 ± 0.45

EXTERNALLY FUNDED PROJECTS

Network Project on Organic Farming (NPOF)

Evaluation of crop varieties under organic production systems

Evaluation of buckwheat varieties

Among the twelve tested varieties the maximum yield was recorded on IC 26600 from NPBGR, HP (15.33 q/ha) which was followed by local Teethey (14.62 q/ha) and IC 109433 from NPBGR, HP (14.05 q/ha).

Evaluation of maize composite

Among the tested varieties the maximum grain yield of maize was recorded with Vivek Sankul 35 (2.94 t/ha) over all the local landraces but remained at par with all the released varieties under organic management conditions. All the composite varieties matured in lesser time than the local landraces (Table 7).

Table 7. Screening of maize cv./ varieties under organic management conditions

Maize (Cv./ Var.)	Plant height (cm)	Days to 50% tasseling	Days to maturity (75%)	Grain yield (t/ha)
Setimakkai	305	72	134	2.12
PaheloMakkai	237	68	124	1.75
RatoMakkai	277	71	120	1.42
BaiguniMakkai	296	71	119	1.61
KaloMakkai	258	67	120	1.41
Sathiya	264	63	109	1.36
RCM 1-1	219	66	113	2.73
RCM 1-3	225	68	115	2.75
RCM 75	231	68	110	2.70
Vivek Sankul 31	149	62	103	2.78
Vivek Sankul 37	157	62	101	2.69
Vivek Sankul 35	138	61	103	2.94
SEm ±	9.71	0.93	1.44	0.17
CD (0.05%)	27.89	2.66	4.12	0.49

Intervention made at Timpyem village, East Sikkim

Survey was done for the collection of data regarding various inputs distributed in the previous year and their incomes generated by each farmer. Inspection of *Jalkunds* was done at the piloted site for their proper functioning and its maintenance. Since, it provides the opportunities for growing of winter crops which otherwise may not be possible during winter

season. During the month of July transplanting of rice was done in various farmers field from the nursery site. After a month of rice transplant (August) bunds were cleaned for sowing of soybean seed in order to utilize the bunds to generate extra income. Soybean being a leguminous crop helps to restore soil fertility as well as suppresses the weed growth. Timely monitoring of crops was done to check the incidence of disease and pests, thinning, weed management etc. Various cropping system under different land use have been implemented in farmers field such as rice-vegetable pea, maize- *Pahenlo dal*- buckwheat, large cardamom-turmeric, large cardamom-ginger, maize-soybean, mandarin-vegetable, *Alnus nepalensis*-turmeric, guava-cowpea. This has been monitored at regular interval to check its proper growth and development and also to combat against disease and pest through proper management practices. Integrated farming system was emphasized upon to generate higher income and self-employment. The programme also stressed on the importance of poultry manure in organic agriculture and advantages of rural poultry farming with Vanaraja birds, scientific housing, brooding management of chicks and treatment of poultry diseases.

Fig 19. Transplanted Rice at Timpyem

Rashtriya Krishi Vikas Yojana (RKVY)

During the year, different part of North, South, East and West Sikkim has surveyed and collected the local germplasm of different crops from various locations crops, *viz*., maize (13), rice (23), sorghum (02), French bean (06), Bee (04), Beans (12), Amranthus (02), Foxtail millet (02) and Porso millet (03). With regards to germplasm evaluation, ten previously collected germplasm of maize; twenty six germplasm of rice, two germplasm of sorghum, ten germplasm of French bean, two germplasm of foxtail millet and two germplasm of porso millet were evaluated at ICAR Research Farm. Apart from that, the work on nutritional profiling of collected germplasm is also under process to find out the most nutritive indigenous germplasm of different crops.

Studies on offseason organic zucchini production under low cost protected structures under MIDH

Offseason organic zucchini production studies were undertaken at ICAR-NOFRI, Tadong, Gangtok, Sikkim and crop was planted in different low cost protected structures, *viz*., low cost plastic tunnels, low cost plastic rain shelters, black/silver plastic mulch along with open conditions as control during first week of September under uniform cultural practices. Maximum no. of flowering buds (13.4) and flowers (11.8) was observed in black/silver plastic mulch followed by low cost plastic rain shelters (12.3 and 10.8, respectively), however, lowest flowering buds (9.4) and flowers (7.2) was observed in Zucchini planted under open conditions. Number of fruit set per plant was highest (9.2) in Zucchini planted under low cost plastic rain shelters, followed by black/silver plastic mulch (8.8), low cost plastic tunnels (7.8) and minimum (5.5) was under open conditions. There was no significant difference in average fruit weight was observed under different growing conditions, however, significant difference in maturity period was observed. The fruit grows faster and was harvested at 21 days after fruit set under low cost plastic rain shelters followed by black/silver plastic mulch (25 days). Crop under open conditions was harvested at 30 days after fruit set. Significant difference in fruit growth was observed, highest fruit length and width (41 cm and 81.6 mm, respectively) was noted on low cost plastic rain shelters followed by black/silver plastic mulch (40.5 cm and 78.40 mm), low cost plastic tunnels (31.6 cm and 68.62 mm) and lowest fruit length was observed in open conditions (27.0 cm and 53.3 mm) at 21 days after fruit set. The yield of Zucchini planted under low cost plastic rain shelters was significantly higher (12.9 kg/plant) as compared to control, *i.e.*, open conditions (5.5 kg/plant) and low cost plastic tunnels (9.2 kg/plant), however, the zucchini yield on black/silver plastic mulch (11.0 kg/plant) was at par with low cost plastic rain shelters.

Fig 20. Zucchini under low cost plastic rain shelter and plastic mulch

Comparative studies on offseason organic broccoli production under low cost protected structures under MIDH

Offseason organic broccoli production studies were undertaken at ICAR-NOFRI, Tadong, Gangtok, Sikkim and crop was planted in different low cost protected structures, *viz*., low cost plastic tunnels, low cost plastic rain shelters, black/silver plastic mulch along with open conditions as control during first week of August under uniform cultural practices. Observations on plant height (cm), number of leaves, average fruit weight (kg), crop duration (days) and yield (kg/ sq m) was recorded at 20 days interval. The difference in plant height and number of leaves at 20 days after transplanting (DAT) was non-significant among all the growing conditions. However, the difference in plant growth started at 40 DAT and was significantly higher in terms of plant height and no. of leaves under low cost plastic tunnels (72.4 cm and 18.3 no.) and low cost plastic rain shelters (70.4 cm and 16.8 no.) as compared to black/silver plastic mulch (65.3 and 15.8 no.) and control (open conditions) (58.8 and 14.9 no.), respectively at the time of harvest. The average fruit weight (700 g) was highest under low cost plastic tunnels and was lowest (500 g) under open conditions. Significantly higher broccoli yield was recorded under low cost plastic tunnel (6.2 kg/m^2) as compared to control followed by low cost plastic rain shelter (5.9 kg/m^2) and black/silver plastic mulch (5.6 kg/m^2) as compared to control (4.5 kg/m^2) *i.e.*, open condition. The crop duration from transplanting to harvest was found longest in open conditions (83 days) as compared to low cost plastic tunnel (75 days) low cost plastic rain shelter (76 days) and black/ silver plastic mulch (79 days), respectively.

Fig 21. Broccoli under low cost-structure

All India Network Research Project on Onion and Garlic-Garlic Trials

All India Network Research Project on Onion and Garlic for Garlic Trials was allotted with the objectives to evaluate, characterize and maintain garlic germplasm supplied by DOGR, Nasik. A total of 21 lines of garlic were evaluated during Rabi season 2015-2016 with check cultivar Sikkim Garlic (SG-01) as local check for both AVT-I and AVT-II trials. And storage trials for all the 21 lines were conducted during 2016-17. Per cent weight loss was evaluated at 30 days interval after storage. The maximum total percent loss after 180 Days in storage was recorded in GRL-1351 (77.17%) followed by GRL-1330 (72.47%) and lowest percent loss was recorded in SG-01 (23.54%) followed by GRL- 1337 (36.89%).

Poultry Seed Project

Vanaraja dual purpose bird is being promoted in the state of Sikkim since 2010 under Poultry Seed Project funded by ICAR-Directorate of Poultry Research, Hyderabad. During nine months (April to December, 2016) of this year, a total of 56418 numbers of Vanaraja day old chicks have been distributed to 2146 farmers covering 487 villages of Sikkim. Out of this, a total of 52678 birds have been distributed under tribal sub plan (TSP) to the 2115 tribal farmers covering 450 villages of Sikkim.

A total of 86120 numbers of eggs produced within a period of nine month starting from April 2016 to December 2016. Highest egg production in a particular month was recorded in the month of August 2016 (15605 nos.). During the period, the distribution of the birds reached a record peak in the month of September 2016 with the supply of 10481 numbers of chicks in the month. Since August 2016 till December 2017 continuously more than 80% hatchability was recorded with a peak hatchability of 88.46% achieved in the month of December 2016, which was much higher than the hatchability of the previous years (around 70%).

The people of Sikkim have well accepted the eggs of Vanaraja birds for consumption due to the resemblance with the local eggs. The egg production performance of Vanaraja birds varied from 50 to 70%

Fig 22. Training cum distribution of Vanaraja chicks

and Vanaraja adult bird weight ranged from 2.25 to 4.0 kg in females and 3.0 to 6.0 kg in males (Table 8).

Table 8. Performance of the Vanaraja birds in ICAR-NOFRI

Parameter		ICAR Farm, Tadong	Farmers Field
Age at first egg production		147th day (21st week)	157-172 days (25th week)
Peak egg production (% / day)		69.57% / 252nd day	65.00% / 260th day
Peak egg production period (week)		31-48	32-44
Egg Production (peak period) %		57.11-69.57%	42.05-65.00%
Fertility (%)		88-91	NA
Hatchability (%)		80.00-88.46	NA
Chicks weight (1 week)	Male	92.75	75 -88
	Female	76.75	
Grower Birds (16 weeks) weight (kg)	Male	*2.46 *1.70	2.00-3.5
	Female	1.5-2.5	
Adult body weight (kg)	Male	*3.0- 4.5 *2.50-	4.0-6.0
	Female	3.0	2.5-4.5
Rate of eggs (Rs.)		10.0	10.0-20.0
Rate of Vanaraja Live bird (per kg)		200	250-300
Mortality (%)	Up to 6 weeks	1.15%	3.00 - 30.00
	7 to 20 weeks	5.79%	2.00-20.00
	21-40 weeks	3.36%	2.00-10.00

*Feeding at ICAR Farm: Restricted feeding schedule; Farmers field: *Adlibitum* feeding

Fig 23. Vanaraja chicken in backyard condition of rural Sikkim

Characterization of Tibetan Sheep under Network Project on Animal Genetic Resources

In this year survey work related with sheep and shepherds socio-economic condition of West Kameng and Tawang District of Arunachal Pradesh partially has been completed (Table 9). Nomadic pastoralism or seasonal cyclic movements or transhumance and agro-pastoralism are practiced as primary means of livelihood at higher elevations of North Sikkim; Tawang and West Kameng District of Arunachal Pradesh. Although yaks characterized Tibetan pastoralism, sheep are usually more economically important. The wool from Tibetan sheep is also one of the best carpet wools in the world. Till about five years ago the valley had a population of around thousand sheep which now has declined drastically to 185 and due ICAR Sikkim Centre intervention in last two years the population is slowly increasing and reached to 255 in numbers.

Table 9. Body weight (kg) of Arunachali sheep

S. No.	Age	Male (kg)	Female (kg)	Overall (kg)
1.	At Birth	2.98± 0.12	2.80± 0.08	2.89± 0.09
2.	4 month	15.14 ± 1.55	14.14± 1.45	14.65 ± 0.51
3.	6 month	19.57 ± 0.92	14.93 ± 0.40	18.22 ± 1.29
4.	12 month	21.09 ± 0.69	18.89 ± 0.54	19.99 ± 1.10
5.	Adult > 2 year	39.10 ± 1.05	27.20 ± 0.53	33.15 ±5.95

a. Male ***b. Female***

Fig 24 a-b. Arunachali sheep

TRIBAL SUB PLAN

Integrated Organic Farming System (IOFS) for Livelihood Improvement of Tribal Farmers of Sikkim

Integrated Organic Farming System (IOFS) for Livelihood Improvement of Tribal Farmers of Sikkim has been initiated in Timpyem village in East Sikkim and in horizontal spread Thanka Martam village was adopted in 2016-17. The following technologies have been undertaken in adopted village.

- No-till vegetable pea in rice-fallow
- Maize – *Pahenlo dal* – buckwheat cropping system
- Year round vegetable cultivation under low cost poly tunnel/poly shed

- Low cost water harvesting structure (*Jalkund*) for supplemental irrigation and other activities under IOFS
- Demonstration on backyard improved poultry
- Improved organic manure production

ICAR-NOFRI Empowered North Sikkim Tribal Farmers on Organic Crop Production

The ICAR-NOFRI organized three day training program on organic crop production during 19th to 21st April 2016 at Ringhim, Mangan, North Sikkim in order to increase awareness and strengthen the progressive tribal farmers on organic crop production by dissemination of scientific knowledge along with input support system under Tribal Sub Plan (TSP). During the program a total of 55 progressive farmers of Ringhim, Upper Singhik and Kalow Wards representing Self Help Groups (SHGs) attended the program and benefited from the technical knowhow and various inputs distributed, *viz*., spray machines, organically permitted bio pesticides, fungicides, bio fertilizers, vermicompost units (vermibeds), polythene for mushroom production, vegetable seeds and mushroom spawn.

ICAR-NOFRI Empowered Tribal Farmers of South and West Sikkim through Technological Backstopping and Input Support

The ICAR-NOFRI organized four training programs, consequently two at South Sikkim and two at West Sikkim under Tribal Sub Plan (TSP) in order to strengthen tribal farmer's capacity by dissemination of scientific knowledge and input support. During all the four programs, a total of 252 progressive farmers of South and West Sikkim participated and benefitted with the technical know-how and various necessary inputs like spray machines, organic pesticides (neem oil, copper oxychloride *etc*), vermibed sets, biofertilizers, neem cake, polythene for mushroom production and untreated seeds of various *kharif* vegetables were distributed among the farmers of both South and West districts of Sikkim.

ICAR-NOFRI, Tadong Empowered Tribal Farmers of East Sikkim

The ICAR-NOFRI organized two days training of Progressive Farmers with 'Technological Empowerment through Training and Input Support System' on September 9th 2016 at 42-Dundung Thasa GPU, Ralap, East Sikkim and on September 13th 2016 at 20-Thekabong, Parakha GPU, Pakyong, East Sikkim under Tribal Sub Plan (TSP). During the program a total of 100 nos. of progressive farmers of Ralap and Parakha GPU, East Sikkim representing different Self Help Groups (SHGs) attended the program and benefited with the technical know-how and various inputs distributed *viz*., sprayers, organically permitted bio-pesticides, bio-fungicides, bio-fertilizers, untreated seeds, and plastic sheets for low cost plastic tunnels and shelters. Power point presentations were delivered to the farmers on scientific crop production technologies developed by ICAR-NOFRI for quick and easy learning of the techniques and farmers showed keen interest and appreciated the ICAR efforts.

ICAR-NOFRI Organized Skill Development Program for High Altitude Tribal Farmers of North Sikkim

ICAR-NOFRI organized three-day 'Skill Development cum Input Distribution Program on Livelihood Security through Organic Vegetable Cultivation under Tribal Sub Plan (TSP) and National Mission for Sustaining Himalayan Ecosystem (NMSHE) for the progressive high altitude tribal farmers of Nam-Panang, Lachen and Thangu areas of North Sikkim. During the program a total of 125 nos. of progressive farmers attended the program and benefited with the technical know-how and various inputs distributed *viz*., sprayers, organically permitted bio-pesticides, bio-fungicides, bio-fertilizers, untreated seeds, and plastic sheets for low cost plastic tunnels.

ICAR-NOFRI Organized Skill Development Program for Farmers of North Sikkim

ICAR-NOFRI organized 'Skill Development cum Input Distribution Program on Livelihood Security through Organic Vegetable Cultivation under Tribal Sub Plan (TSP) and National Mission for Sustaining Himalayan Ecosystem (NMSHE) for the progressive high altitude tribal farmers of

Fig 25. TSP Training Program at Ringhim, Mangan, North Sikkim

Lachung, North Sikkim on October 25, 2016. During the program a total of 49 nos. of progressive farmers and student attended the program and benefited with the technical know-how and various inputs distributed, *viz*., organically permitted bio-pesticides, bio-fungicides, bio-fertilizers, untreated seeds, and plastic sheets for low cost plastic tunnels.

ICAR-NOFRI Empowered Arunachal Farmers with Organic Vegetables and Spices Production Techniques

ICAR-NOFRI in collaboration with Young Mission Adventure Club, Itanagar, Arunachal Pradesh organized three-day training on 'Livelihood Security through Organic Vegetables and Spices Cultivation' under Tribal Sub Plan (TSP) for the progressive tribal farmers of West Siang District, Arunachal Pradesh at ICAR Tadong during 06-08 November 2016. A total of 16 nos. of progressive farmers of Darak Farmers Club of West Siang District on self-financed education program to learn the organic vegetables and spices production techniques.

ICAR-NOFRI Empowered Maharashtra Farmers with Organic Farming Techniques

ICAR-NOFRI organized training on 'Technology Demonstrations for Organic Crop Production and Animal Husbandry' under Tribal Sub Plan (TSP) for the progressive farmers of Maharashtra in collaboration with Maharashtra Agricultural Competitiveness Project (MACP), Shivajinagar, Pune at ICAR Tadong on November 24, 2016. A total of 26 nos. of representatives for various 'Farmers Producer Organizations' visited ICAR-NOFRI under MACP - ATMA, Pune to learn the organic crop production techniques at ICAR-NOFRI.

ICAR–NOFRI Observes Jai Kisan-Jai Vigyan Week

On the occasion, two-day Training cum Awareness Program on 'Organic Crop Production' was organized for the Tribal Farmers under TSP project by the ICAR-National Organic Farming Research Institute, Tadong, Gangtok in collaboration with ICAR-KVK East Sikkim at Khamdong VAC, East Sikkim during December 22-23, 2016. During the TSP training program, National Mushroom Day was also observed on December 23, 2016. Total of 63 nos. of progressive farmers from Khamdong GPU, East Sikkim participated in the program. Seeds of vegetable pea, mushroom spawn, plastics, organic pesticides and biofertilizers were distributed to the farmers.

Fig 26. TSP Training Program at Okhrey, West Sikkim

ICAR –NOFRI Trained Tribal Farmers on Organic Crop Production

In continuation of observation of Jai Kisan-Jai Vigyan week, two-day Training cum Awareness Program on 'Organic Crop Production' was organized for the Tribal Farmers of Assam Lingzey under TSP project by ICAR-NOFRI in collaboration with ICAR-KVK East Sikkim during December 27-28, 2016. During the TSP training program, a total of 48 nos. of progressive farmers participated in the program. Seeds of vegetable pea, mushroom spawn, plastics, organic pesticides and biofertilizers were distributed.

Fig 28. TSP Training Program at Assam Lingzey, East Sikkim

Pig farming under deep litter housing system for sustainable livelihood and nutritional security of tribal farmers of Sikkim

In this livelihood project, 12 deep litter units were established and 24 piglets have been distributed in all four districts of Sikkim and three field level trainings have been imparted on pig farming.

Swacchha Bharat Mission

Swacchha Bharat Mission programme were organized time to time at various locations in Sikkim for making awareness among the farming community for their health and hygiene. ICAR-National Organic Farming Research Institute, Tadong, Gangtok organized Swacchta Pakhwara during October 17-31, 2016. Various awareness activities were conducted amongst the farming community related to Swaccha Bharat Abhiyan in Sikkim. Shri Shakti Singh Chaudhary, Mayor, Gangtok Municial Corporation formally inaugurated the programme at ICAR-NOFRI, Tadong on October 22, 2016.

Mera Gaon Mera Gaurav (MGMG)

Under MGMG total sixteen villages across the Sikkim has been selected for training, demonstration and skill development by ICAR-National Organic Farming Research Institute, Tadong along with the KVK East Sikkim. Training cum input and various demonstration programmes were organised during 2016-17 to across the Sikkim.

TECHNOLOGY TRANSFER TO THE FARMERS FIELD

Maize-*pahenlo dal*- buckwheat a climate resilient cropping system

Fig 27. TSP Training Program at Ralap and Parakha, East Sikkim

The technology has been demonstrated as front line demonstration to the 195 nos. progressive farmers covering an area of 30.0 ha in Bhasme, Loosing, Tshlamthang, Sirwani, Ralap, Thanka and Amba village of East Sikkim and Mangle and Sripatam in South Sikkim.

Front Line Demonstration of oilseeds and pulses in East Sikkim

ICAR-National Organic Farming Research Institute, Tadong and KrishiVigyan Kendra (ICAR), East Sikkim demonstrated complete package of practices of black gram (var. SKPD-3) on 58 ha land to the 205 nos. of tribal farmers in Sikkm to the progressive farmers of the East District of Sikkim. Overall, the grain yield of black gram was 21.6 percent higher than farmers practice.

No-till vegetable pea in rice fallow

ICAR–National Organic Farming Research Institute, Tadong, Gangtok introduced zero tillage vegetable pea technology in puddled rice fallows has been demonstrated through KrishiVigyan Kendra (ICAR), East Sikkim to the progressive farmers of the East District of Sikkim. The technology has been demonstrated as front line demonstration to the 35 nos. progressive farmers covering an area of 10.5 ha in Timpyem, Nandok, Thanka, Upper Sirwani village of East Sikkim.

Low cost water harvesting structure (*Jalkund)*

ICAR–National Organic Farming Research Institute, Tadong, Gangtok in collaboration with the KVK East Sikkim started demonstration of *Jalkund* at farmer's field. Harvested water in *Jalkund* can be used as supplemental irrigation especially for winter vegetables (0.15 ha). The harvested water is utilised by the farmers for other purposes also. In the current year 2016-17, a total 40 nos. of *Jalkund* were demonstrated at various parts of Sikkim.

Front Line Demonstration of oilseeds and pulses in East Sikkim

ICAR-National Organic Farming Research Institute, Tadong and KrishiVigyan Kendra (ICAR), East Sikkim demonstrated complete package of practices of black gram (var. SKPD-3) on 58 ha land to the 205 nos. of tribal farmers in Sikkm to the progressive farmers of the East District of Sikkim. Overall, the grain yield of black gram was 21.6 percent higher than farmers practice. The demonstration of oilseeds has been taken on 35 nos. of progressive farmer's covering an area of 10.0 ha in Thanka, Timpyem, Upper Sirwani, Nandok and Loosing village of East Sikkim.

TRIPURA

WEATHER REPORT

The year 2016 was a normal monsoon year with 2107.9 mm rainfall in 88 days, and it was accompanied with total pan evaporation losses of 1217.5 mm at an average rate of 4.5 mm/day (Fig 1). The above normal and well distributed rains during March to June supported negligible moisture stress free rainfed *boro* rice in the state. However, almost 33% lower than normal rainfall and rainy-days during June-September caused moisture deficit for many upland rainfed crops, but 56% lower than normal rains during October resulting in longer bright in lower sunshine hours promoted better translocation of photosynthates to sink. In contrast, a total of 224 mm rainfall was received during November, which was highest rainfall ever recorded at Lembucherra during the month over the last 25 years. Heavy down pour caused lodging of maturing crops and incurred losses to farmers' at several places.

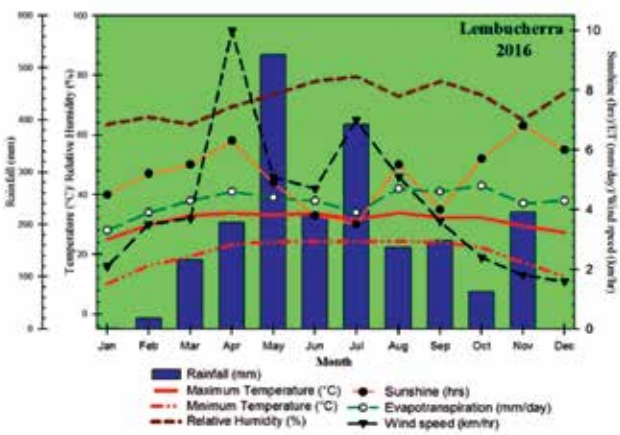


Fig. 1. Mean monthly meteorological data recorded at Lembucherra observatory during 2016

Throughout the year, the mean monthly temperature ranged from 17.6° C (January) to 29.1° C (August) and the mean monthly maximum temperature of 25.0-33.9° C with absolute maximum value of 36.4° C on May 1, 2016. The overall temperature across the year remained favorable for production of crops, livestock and fisheries, however occasional high temperatures in conjunction with high relative humidity (>80%) caused discomfort and uneasiness to livestock.

RICE IMPROVEMENT

During the year 2016, 1406 promising single plant selections from 34 crosses were characterized for yield and yield contributing attributes. Hundred seventeen entries were evaluated in replicated station trials. Ten out of 21 entries nominated to different AICRIP IVT trials were promoted to AVT1, while the entry IET 24665 - TRC 2014-14 / IR 82589-B-B-2-2 was promoted to AVT2 Aerobic, entry TRC2013-11 / IR84898-B-171-CRA43-1 (IET 24195) and TRC2014-8 / IR 83928-B-B-9-1(IET 24197) promoted and tested in AVT2 E (H). The entry TRC 2013-2 qualified for VIC proposal to CVRC under Early Transplanted (E-TP). Performances of the promoted entries in different trials are presented below in trial wise tables 1-4.

Table 1. Performance of TRC 2013-2 over 3 years of testing in E-TP

IET No. / Designation	Year	Overall mean yield	Yield advantage (%) over NC / ZC/ LC	% increase over best check				
				State &Rank	% BC	% HC	Zone	% BC
23947 TRC 2013-2	2015	5418 89 LS	6.84 11.12 5.88	UT-6 HA-7 OD-5 MP-5 KE- KA-9	19 18.2 14 12 7 11	- 7 12.0 - - 5.0	ZII ZIII ZIV ZV	8 12 14 8
	2014	4902 89 LS	4.7 19.9 -	HA-7 MP- MH-4	11.8 5 7	- - -	R4-4	6
	2013	4966 85	0.0 37 5.9 -	PU-2 HAR PU-9 PY	25.65 27.05 11.71 12.76			

Table 2. Performance of promoted entries in Hill Trials

IET NO	Trial /ecosystem	Designation	GY(Kg /ha)	Days to 50% flowering (DF)	% yield over (BC)
24195	AVT -1 EH Northern low	TRC2013-11 / IR84898-B-171-CRA43-1	3541	95	40.0
24196	AVT -1 EH Northern low	TRC 2014-6 / IR83929-B-B-132-2	3221	91	28.0
24195	AVT -1 EH Southern low	TRC2013-11 / IR84898-B-171-CRA43-1	5173	94	42.0
24196	AVT -1 EH Southern low	TRC 2014-6 / IR83929-B-B-132-2	5060	96	39.0
24195	AVT -1 EH Northern medium	TRC2013-11 / IR84898-B-171-CRA43-1	6794	92	18.0
24197	AVT -1 EH Southern medium	TRC2014-8 / IR 83928-B-B-9-1	10211	92	38.0
25818	IVT EH Northern low	TRC 2016-9 / IR 83399-B-B-52-1	5130	92	11.2
25826	IVT EH Northern medium	TRC 2016-2 (Fulbadam / Naveen)	5143	106	23.4
25836	IVT EH Northern low	TRC 2016-3 (Bhalum x Naveen)	4990	107	12.8
25833	IVT EH Northern low	TRC 2016-4 (Bhalum 3 x Naveen)	4889	109	10.5

Table 3. Performance of promoted entries in Aerobic trials

IET NO	Designation	Trial	Yield (kg/ha)	FD	% yield superiority over the best check (BC)					
					Overall	ZII	ZIII	ZV	Z VI	Z VII
24665	TRC 2014-14 / IR82589-B-B-2-2	AVT1 Aerob		81	--	--	--	11	--	--
25662	TRC 2015-12	IVTAerob	4464	84	16.0	10	--	9,20	--	7.0
25611	TRC 2015-8	IVTAerob	4519	95	--	--	7.0	--	--	--
25636	TRC 2015-15	IVTAerob	4886	89	--	--	15.0	--	--	--

Table 4. Performance of promoted entries in IVT Early Transplanted and IVT IM

IET NO	Trial	Designation	Mean Yield (kg/ha)	Days to 50%flowering	% yield advantage over best check		
					Zone II	Zone IV	Zone V &VI
25597	IVT E TP	TRC 2015-10	6127	92	-	14	9
25554	IVT E TP	TRC 2015 -17	5771	96	-	18	-
25355 IM	IVT IM	TRC 2015-7	5756	102	8.24	48.71	-

All India Coordinated Rice Improvement Project - AICRIP

During the period 2016, 404 rice entries were evaluated in 11 trials. The details of the trials conducted and the highest yielding entry in the respective trial is presented below.

Sl. No.	Trials conducted	Total entries	1st ranking entry No.	Yield (kg/ha)
1	AVT1 E DS	11	111, LC-Hakuchuk 1	4717
2	IVT E DS	42	240	4274
3	AVT 2 E TP	12	910	5800
4	AVT 2 E TP Zone IV	16	1036, LC - Tripura Nirog	6343
5	IVT IME	63	1434	6157
6	AVT1 IM	23	1614	6230
7	IVT IM	63	1708	7300
8	AVT1 Aerob	24	3305	7698
9	IVT Aerob	56	3447	8512
10	AVT 1 MS	31	3909	7292
11	IVT MS	63	4006	8464

Development of stress tolerant rice for Africa and south asia (STRASA)

During the period of 2016, 612 rice entries, including NILs in the background of Anjali, Vandana, Kalinga, Swarna and IR 64, were evaluated in 13 different trials to identify promising entries under drought stress. The details of trials conducted are summarized in table below 5 and the highest yielding drought tolerant entries in each trial are listed.

Fig 2. View of STRASA trials at Mirza

Identification of major QTLs for yield under drought stress in rice

Under this objective, phenotyping of mapping populations Bhalum 3 x Naveen and Fulbadam x Swarna was carried out in F5. Parental polymorphism survey with 314 SSR markers completed for the parents Bhalum 3, Naveen, Fulbadam and Swarna. Parental polymorphism was completed with 600 SSR primers for the Mapping population CT 9993-5-10-1-M/2 * SAMBHA MAHSURI, out of which 286 SSR primers were found to be polymorphic. Whole population genotyping of 311 RILs of the Mapping population CT 9993-5-10-1-M/2 * SAMBHA MAHSURI was completed with these 286 SSR markers. Drought phenotyping for the Mapping population CT 9993-5-10-1-M/2* SAMBHA MAHSURI was also completed. Potential high yielding lines with good drought tolerance were also selected from the bulk segregating populations of these crosses (Table 6).

AICRP MULLaRP

Thirteen coordinated trials (IVT & AVTs) were conducted during the period under report and 207 entries of mung bean, urd bean, lentil field pea and chickpea were evaluated in replicated trials. Details of trials are described below. In mung bean, IVT and AVT 2 + 1 in total 38 entries; in urd bean, IVT and AVT1 in total 24 entries; in field pea, IVT(Tall), IVT(Dwarf) and AVT1 (Tall) in total 40 entries; in lentil, IVT(SS), IVT(LS), IVT (EE), AVT1(SS) and AVT2 +1 in total 73 entries and in Chickpea,

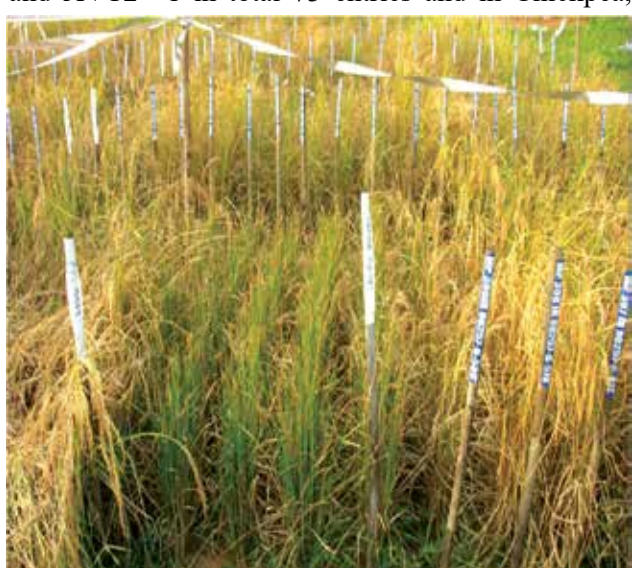


Fig 3. New Mapping population Bhalum 3 x Naveen for QTL studies on drought tolerance in rice

Table 5. Performance of rice entries under drought stress

Trial	No. of Entries	Design	Highest yielding entry	Yield (kg/ha) & Flowering days	Yield of best check (BC)	% over best check
AYT 80-100 (Rainfed)	42 + 3 checks	Alpha Lattice (5x9)	IR 97068-18-2-2-2	3279 71	2719 63	20.6
Anjali + Vandana NILs drought (Rainfed)	42 + 3 checks	Alpha Lattice (5x9)	IR 84984-83-15-481-B	3639 52	3119 63	16.7
Kalinga-III MAS (DSR, rain-fed)	3 + 1 check	RCBD.	IR 102612-31-B-1-1	5802 83	4302 82	34.9
OYT (RS Drought)	160 + 5 checks	Augmented Design	IR 93353:33-B-1-23-5-1RGA-2RGA-1-B-B	5987 91	4227 82	41.6
OYT (Control)	160 + 5 checks	Augmented Design	IR 93343:26-B-5-23-8-1RGA-2RGA-1-B-B	6978 92	5756 97	21.2
AYT 100-120 (Control)	57 + 6 checks	Alpha Lat-tice(7x9)	GSR IR1-DQ122-D2-D1	6774 88	5964 97	13.6
Swarna MAS (Control)	23 + 4 checks	Alpha Lattice (3x9)	IR 102777-18-128-2-1-4	7776 99	6518 109	19.3
IR64 MAS (Control)	20 + 4 checks	Alpha Lattice (3x8)	IR 99784-226-237-1-5-1-1	5670 87	4514 89	25.6
Harvest Plus MET1-	7 + 5 checks	RCBD.	IR 99704-22-1-1	6500 83	5475 84	18.7
Harvest Plus MET2-	16 + 4 checks	Alpha Lattice	BRRI dhan 62	6728 97		
Genotype x Environment Interaction:	57 + 6 checks	Alpha Lattice	Sahabhagidhan	6387 85		
PVS: On station Transplanted – Rainfed:	9 + 3 checks	RCBD	PR37956-3B-44-1	6680 92	5884 97	13.5
PVS: On farm Transplanted – Rainfed:	9 + 3 checks	RCBD	IR 93809-101-2-2-2	6686 90	5586 81	19.7

Table 6. Presence of different drought QTLs in jhum rice of Tripura and some RCPL lines as revealed from drought QTL linked SSR genotyping

QTL	Genotype	Total genotypes
qDTY1.1	America, Maivor, Taisanghar, Kaproc, RCPL-1-129	5
qDTY12.1	Beti-2, Berain-4, Beti-3, Charke, Maimi, Adhuma-1, Adhuma-2, Sang-pompa, Maimi-vattao-2, Bethi-2, Berain-6, Galong-4, RCPL-1-82, RCPL-1-129, RCPL-1-114, RCPL-1-90, RCPL-1-103	18
qDTY2.1	Berain-1, Unknown-1, Berain-3, Beti-1, Bdaiya, Rajadhan, Beti-2, Berain-4, Berain-5, Beti-3, Saree, Garua, Gajori, Aduma-2, Sang-pompa, Galong-2, Badia, Releng, Chinat small, Bethi-1, Rugnei, Maimi-vattao-2, America, Bethi-2, Berain-6, Sawite, Galong(bigsize)-5, Releng-2, Mybring-ha, Delong-kuphui (white), Unknown-2, Kataktara, RCPL-1-412, RCPL-1-129, TRC2005-1, Farbawr (Tai), Kungrei, Taibuh, RCPL-1-90, RCPL-1-103, RCPL-1-93	42
qDTY2.2	Berain-1, Berain-2, Unknown-1, Bdaiya, Beti-2, Beti-3, Maimi, Saree, Maimi-uattao-1, Gajori, Sang-pompa, Mai khomtai, Horipi, Copro, Badia, Releng, Bethi-1, Berain-6, Maivor, Taisanghar, Sawite, Releng-2, Beti-4, Mybring-ha, Maimi watchalu, Gir-jangima, Galong-4, Kataktara, RCPL-1-129, IR46A, TRC2005-1, Buhban (Kawnglawng), Farbawr (Tai), Taibuh, Buh Vubuk (Lubuk), Bhalum-1, Bhalum-3, RCPL-1-114, RCPL-1-90	39
qDTY3.1	Unknown-1,Berain-3,Beti-1,Beti-2,Adhuma-1,Sang-pompa,Galong-2,Copro,Galong-3,Chinatsmall,Rugnei, Maimi-vattao-2, Faretesen, Bethi-2, Berain-6, Maivor, Taisanghar, Kaproc, Beti-4, Gir-jangima, Galong-4, Unknown-2, IR46A, TRC2005-1, Buhban (Kawnglawng), Taibuh, Buh Vubuk (Lubuk), Bhalum-1, Bhalum-3	29
qDTY4.1	Unknown-1, Maimi, Saree, Mai khomtai, Badia, Galong-3, Releng, Maimi-vattao-2, Berain-6, Maivor, Kaproc, Beti-4, Mybring-ha, Maimi watchalu, Gir-jangima, Galong-6, RCPL-1-82, Farbawr (Tai)	18
qDTY9.1	Berain-1, Unknown-1, Berain-3, Beti-1, Bdaiya, Beti-2, Berain-4, Berain-5, Beti-3, Charke, Maimi, Adhuma-1, Saree, Maimi-uattao-1, Gajori, Adhuma-2, Mai khomtai, Horipi, Galong-3, Bethi-1, Maimi-vattao-2, Faretesen, Berain-6, Maivor, Taisanghar, Sawite, Chinat-2, Galong(bigsize)-5, Releng-2, Beti-4, Mybring-ha, Maimi watchalu, RCPL-1-82, IR46A, Buhban (Kawnglawng), Farbawr (Tai), Bhalum-1, RCPL-1-93	39

Physiology 32 entries were evaluated in replicated trials and data reported to AICRP MULLaRP. Promising entries were identified for Tripura.

Legume International Nurseries (BIGMP), ICARDA

Under Biodiversity & Integrated Gene Management Program (BIGMP) of ICARDA, the following nurseries were conducted during rabi season of 2016-17. Single plant selections (633 selections) were made from the segregating material of different crosses bulks. The details of nurseries evaluated in 2016-17 are listed in tables 7 - 8.

Seed production

In total, 23 tons of breeder seed of 11 rice varieties and 5.16 tons breeder seed of mung bean, urd and field pea varieties released by the Tripura Centre were produced during the year 2016; while 414 tons TL seed rice, mung bean, urd, lentil, rajmash and toria were produced through participatory seed production programme under ICAR Seed Project and Breeder Seed Project. Under pulses, seed hub 50.67 tons TL seed was produced in kharif and production in rabi is expected to be more than 70 tons TL seed.

Crop	Year	Trials and no. of entries			
Lentil	2017	LIEN-SS 36 entries	LIEN LS 36 entries	LIEN-E 36 entries	LIEN DT 36 entries
Grass-pea	2017	IGYT Low B ODAP 25 entries	IGYT E 25 entries	IGSP F5 10 entries	

Table 7. Quality seed production during 2016- 17 under ICAR seed project (ISP/BSP) in 2016: participatory seed production in farmers' field (in tons)

Crop	Breeder seed		TL seed	
	Target	Production	Target	Production
Summary of seed produced in 2016-17	20.6	23.1	592.4	414.4
Gomatidhan	8.0	9.3	500	319.1
Tripura Khara	0.4	0.51	1.0	1.29
Tripura Khara	0.8	0.31	2.5	0.0
Tripura Jala 1	0.3	0.22	1.2	0.2
Tripura Chikan Dhan	3.0	4.71	14.0	23.0
Tripura Sarat	0.8	0.46	2.5	0.40
Tripura Nirog	2.5	2.97	9.0	9.4
Tripura Hakuchuk 1	0.4	0.52	1.2	0.78
Tripura Hakuchuk 2	0.4	0.18	1.2	0.72
Tripura Aush	1.0	0.76	7.0	0.34
Tripura Maskolai 1	2.0	1.7	3.0	0.62
Tripura Mung 1	1.0	1.46	2.0	0.43
Participatory seed production in boro & expected production				
Fieldpea TRCP-8	1.7	2.0	2.0	2.0
Tripura Lentil Sel 1			5.0	3.5
Tripura Rajmash 1			40.0	22.0
TRC Toria			2.0	3.5

Table 8. Seed production under pulses Seed Hub *"Seed Hubs for increasing indigenous production of Pulses in India"* during 2016-17

Crop	Variety	Target	Achievement
Mungbean Urdbean	Tripura Mung 1 Tripura Maskolai	**300**	**506.8**
Lentil Fieldpea Rajmash	Tripura Lentil Sel 1 TRCP 8 Tripura Rajmash 1	**350**	**720 (expected)**

Revenue in excess of Rs. 24 lakh has been generated from sale of different seeds during the period

Effects of conservation tillage and weed control measures on toria

A field experiment was conducted to study the effect of three different weed control measures, *viz.,* control, straw mulch and manual weeding, on toria (cv. TRCT 1-5-1-1) under zero tillage (ZT) and conventional tillage (CT) practices. The experiment with six replications was laid out in an upland field by following split-plot technique, where tillage was imposed in main plots and weed control measures in the sub-plots. The weeds were cut at the ground level in the ZT plots; while in the CT plots, weeding were done by using *Khurpi*. The mean seed yield data showed that there was no significant difference between CT and ZT. This indicated that the farmer can save the land preparation cost by shifting from the conventional practice of ploughing to ZT seeding. Both straw mulch and manual weeding operations significantly increased seed yield over control, but they did not differ between themselves under CT practice (Table 9). That means the farmer may choose either of these two methods as per his convenience for controlling weeds under CT. Under ZT, however, straw mulch was statistically superior to manual weeding, indicating that straw mulching is to be preferred over manual weeding if ZT is to be practiced for toria cultivation. Overall, it is concluded that the expenditures incurred traditionally towards the costs of land preparation and manual weeding may be saved by cultivating toria under ZT with straw mulch.

Table 9. Effects of tillage and weed control measures on toria seed yield (t/ha)

Tillage (T)	Weed control measures (W)			
	Control	Straw mulch	Manual weeding	Mean
ZT	0.59	1.25	0.99	0.94
CT	0.52	1.15	1.11	0.93
Mean	0.56	1.20	1.05	
CD (0.05)	Tillage (T): NS; Weed control (W): 0.14; T x W = 0.20			

Effects of conservation tillage and live much on maize productivity

A field experiment was conducted on effects of conservation tillage on productivity of kharif maize. The experiment consists of five treatments: zero tillage (ZT), zero tillage + Live mulch (ZT+LM), reduced tillage (RT), reduced tillage + live mulch (RT+LM) and conventional tillage (CT). The crop was sown at 60 x 30 cm spacing apart. In treatments, where live mulch was used, the two rows of cowpea (var. kashi kanchan) were sown in between two rows of maize. Compared to CT, which showed a productivity level of 2.14 t/ha, the grain yield of maize significantly increased by 23.1% under ZT (2.63 t/ha). There was no significant difference between ZT and ZT+LM treatments in terms of grain yield (Fig 4). This showed that there was no yield penalty on maize due to intercropping with cowpea. Similarly, as compared to CT, significantly higher grain yield was recorded under RT (2.59 t/ha) and it was statistically similar to the value recorded with RT+LM (2.49 t/ha). The results indicated that by shifting from conventional tillage practice to ZT+LM or RT+LM, the farmer can be benefited in terms of savings in land preparation cost without any penalty on maize yield, besides obtaining green fodder (cowpea) as bonus.

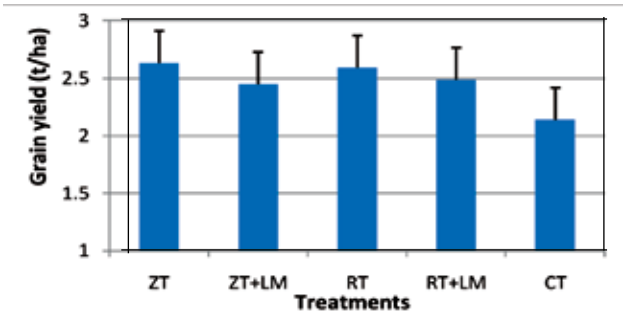


Fig 4. Effects of conservation tillage on kharif maize yield (Bars on mean are SD's)

Agronomic evaluation of lentil lines/varieties

Fourteen lentil lines/varieties were evaluated for their adaptability to upland condition of Tripura. The seeds were sown on 11th November, 2016. The seed yield of the tested varieties ranged from 214 to 1105 kg/ha (Fig 5). Compared to the seed yield of 895 kg/ha produced by the cultivar HUL-57, which is presently being cultivated widely in Tripura, the varieties SUBRATA, L-1112-07, WBL-77 and BM-7 have yielded 15.0, 21.3, 22.4 and 23.5% higher yields, respectively. It is worth mentioning here that these four lines/varieties of lentil also performed well during 2015-16. The seed yield recorded with these four varieties ranged from 1029-1105 kg/ha. The varieties L-1112-12 and ILL- 10893 were similar to HUL-57 in terms of seed yield. The remaining tested varieties, namely, ILL-10897, L-1112-18, ILL-6002, BM-6, L-4076, ILL-10951 and L-1112-20 performed poorly, in comparison to HUL-57. It is hence, concluded that the lentil varieties SUBRATA, L-1112-07, WBL-77 and BM-7 maybe popularized for cultivation under upland field condition of Tripura.

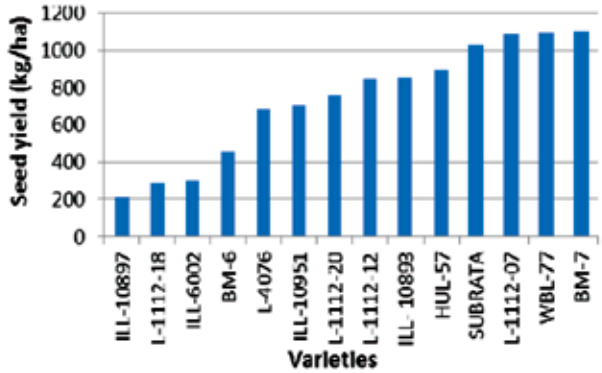


Fig 5. Performance of lentil lines in Tripura condition

Physiological evaluation of paddy varieties from North-East India for iron toxicity tolerance

To evaluate the iron toxicity tolerance, thirty six indigenous rice germplasm procured from NBPGR, Umiam at seedling stage were grown in hydroponic system. Homogenous seedlings were selected and transplanted into trays filled with half strength Yoshida nutrient solution. Experiment was performed in triplicate for each rice genotypes used. After four weeks of plant growth, half of the plants were exposed to excess iron stress of 1000 mg L^{-1} for 7 days. The seedlings were evaluated for leaf bronzing symptom and physiological parameters *viz*. chlorophyll a, chlorophyll b, chlorophyll a/b and relative water content (RWC) after 7 days (Table 10).

Based on the parameters studied, accessions EC-339880P, IC-146064, IC-207877, IC-540459 were found to be relatively tolerant with lower symptom score (2), higher chlorophyll a (5.75-6.91), chlorophyll b (7.24-10.96) & RWC (76.4-84.1) and lower chlorophyll a/b ratio (0.63-0.81). While the accessions IC-207949, EC-339888P, IC-207924, IC-200599, IC-0610256, IC-3178821P, IC-200599, IC-146079, IC-146063, IC-81388, IC-200649, IC-200595, IC-339882P, IC-207878 IC-206002 IC-139994, IC-200631, IC-85933, IC-146065, IC-146148, IC-206003 and IC-89152 have shown moderate tolerance with relatively higher symptom score (3-4) and lower chlorophyll a (3.27-4.63), chlorophyll b (3.16-8.29), although the values of RWC (68.2-88.6) and chlorophyll a/b ratio (0.6-1.31) not significantly different from relatively tolerant genotypes mentioned above (Fig.1). On the contrary, the accessions IC-146061, IC-146063, IC-200617, IC-144603, IC-0610268, IC-137492, IC-461710, IC-540523 and IC-200631, IC-139962 recorded higher symptom score (5-8), lower chlorophyll a (0.39-1.71), chlorophyll b (0.1-1.78), & relative water content (62-80.4) and higher chlorophyll a/b ratio (0.90-5.39), therefore, highly sensitive to iron toxicity.These observations needs to be substantiated further with yield data to ascertain the genotypic tolerance to iron toxicity.

PLANT PATHOLOGY

Detection and Confirmation of *Banana streak Mysore virus (BSMYV)* infecting banana in North Eastern region

Banana streak is an economically important disease of banana caused by a group of Badna viruses, collectively known as banana streak viruses (BSV). The virus has non-covalently closed double stranded DNA genome and has endogenous integrated counterparts integrated to host genome. The present study was undertaken to know the prevalence of the virus in North Eastern Region. The samples which exhibited the characteristic symptoms of leaf streak comprising of chlorotic and necrotic streaks (Fig 6) and green vein banding were collected from West Tripura Lembucherra, Manipur and Meghalaya. These three isolates were designated as Mgh1 (from Meghalaya), Mnp1 (from Manipur) and Trp1 (from Tripura). They were further used for the detection and confirmation of the BSV. In order to detect the BSV infection, immunological technique i.e. Antigen Coated Plate - Enzyme Linked Immuno Sorbent Assay (ACP–ELISA) was used. The samples which showed positive reaction in ACP–ELISA was further subjected to the Duplex-Immuno-Capture polymerase chain reaction (D-IC-PCR) using BSMYV specific primers (targeting RT/R Nase H region). The study revealed that in Antigen coated plate ACP–ELISA, all the three samples showed positive reaction to the polyclonal antibodies *of Banana Streak Mysore virus* (BSMYV). It was further confirmed when the test samples were subjected to D-IC-PCR, a specific amplicon of around 580 bp was deleted (Fig 7) in the sap preparation of all the three ACP-ELISA positive samples. The sequencing of the amplicons shared 98-99% identity amongst and with BSMYV from Australia (AY805074) which confirms the association of BSMYV with all the three isolates. Phylogenetically, all the three isolates were in the same cluster along with the BSMYV.

Fig 6. Chlorosis of the leaf caused by banana streak virus

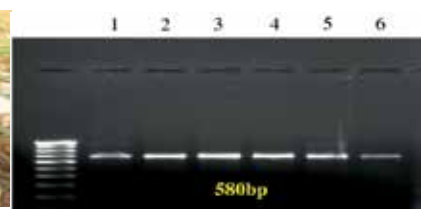


Fig 7.Gel photograph showing the bands at 580 bp. Lane 1,2 = Mgh1 ,lane 3,4= Trp1 ,lane 5,6 = Mnp1

Table 10. Effect of excess iron (1000 ppm Fe^{2+}) on chlorophyll a, chlorophyll b, chlorophyll a/b ratio and bronzing symptoms in 36 rice germplasm

Germplasm	Chlorophyll a (mg g^{-1}Fw)	Chlorophyll b (mg g^{-1}Fw)	Chlorophyll a/b (mg g^{-1}Fw)	RWC (%)	Leaf bronzing score
IC-146065	1.08^{d}	0.22^{a}	4.91^{f}	78	4
IC-146061	0.81^{bc}	0.21^{a}	3.85^{de}	75.6	6
IC-146063	0.62^{abc}	0.15^{a}	3.96^{de}	62	6
IC-200617	0.81^{bcd}	0.18^{a}	4.26^{ef}	80	7
IC-144603	0.60^{ab}	0.12^{a}	4.90^{f}	63.6	7
IC-0610268	0.77^{bcd}	0.14^{a}	5.39^{g}	74.6	5
IC-137492	0.39^{a}	0.10^{a}	3.56^{e}	64	8
IC-461710	0.94^{bcd}	0.22^{a}	4.31^{de}	72	6
IC-85933	1.37^{e}	0.33^{a}	3.96^{de}	78.3	4
IC-146148	1.93^{f}	0.24^{a}	8.03^{h}	81.6	4
IC-207949	4.30^{m}	3.28^{bc}	1.31^{bc}	85.3	3
EC-339880P	5.87^{q}	7.24^{j}	0.81^{bc}	84	2
IC-146064	6.91^{r}	10.96^{l}	0.63^{a}	76.4	2
IC-207877	5.85^{q}	7.60^{j}	0.77^{bc}	84.1	2
EC-339888P	4.11^{lm}	4.16^{def}	0.97^{bc}	85.8	3
IC-207924	3.86^{kl}	3.65^{bcd}	1.04^{bc}	75.8	3
IC-200599	5.12^{o}	8.13^{jk}	0.63^{a}	83.4	3
IC-0610256	4.63^{n}	3.40^{bc}	1.44^{c}	80.9	3
EC-31788821P	3.76^{jk}	4.31^{f}	0.88^{bc}	68.2	3
IC-200599	5.44^{p}	6.38^{i}	0.86^{bc}	83.1	3
IC-146079	5.56^{pq}	8.29^{k}	0.6^{a}	71.0	3
IC-146063	5.12^{o}	5.69^{h}	0.88^{bc}	88.6	3
IC-81388	4.30^{lm}	5.17^{h}	0.81^{bc}	80.9	3
IC-200649	3.27^{hi}	3.16^{b}	0.99^{bc}	80.8	3
IC-540523	1.71^{f}	1.78^{b}	0.96^{bc}	80.4	5
IC-200595	3.85^{k}	5.14^{h}	0.76^{b}	87.1	3
IC-339882P	3.18^{ghi}	4.10^{def}	0.78^{bc}	82.2	3
IC-207878	3.45^{ij}	4.55^{fg}	0.73^{bc}	84.4	3
IC-207883	3.45^{ij}	3.24^{b}	1.10^{bc}	86.4	3
IC-540459	5.75^{pq}	7.49^{j}	0.75^{bc}	83.1	2
IC-206002	4.34^{m}	5.13^{h}	0.83^{bc}	76.8	3
IC-139994	3.69^{ik}	5.09^{gh}	0.70^{b}	80.0	3
IC-206002	2.90^{g}	3.86^{cde}	0.75^{bc}	75.9	4
IC-89152	1.9^{1f}	2.31^{b}	0.82^{bc}	72.3	4
IC-139962	0.43^{a}	0.63^{a}	0.65^{a}	61.2	8
IC-200631	3.02^{gh}	4.71^{fgh}	0.63^{a}	85.7	3

** Different letters in column indicate significant differences among genotypes by LSD-test ($p < 0.05$)*

Management of Sigatoka diseases of banana in Tripura

The study was conducted for the management of Sigatoka disease complex at Cocotilla farm located in the ICAR Research Complex, Lembucherra from June 2015 to June 2016. Randomized Complete Block Design (RCBD) with five treatments and three replications with nine plants per replication were used. The cultivar Sabri was used because of its high susceptibility to Sigatoka disease in previous studies. The agronomic practices were carried out as recommended for the banana in the region including fertilization, desuckering and weeding. In the study, a total of four treatments and a control were evaluated. The evaluated treatments were namely T1- spray on only upper leaf with *Trichoderma viridae* 5 gms/L + *Pseudomonas fluoroscense* 5gms/L, T2-spray of *Trichoderma* viridae 5 gms/l and *Pseudomonas fluorscense* 5gms/L on both the leaf surfaces,T3-spray with Chlorothalonil 0.2% and Propiconazole 0.1% on upper surface only,T4- Chlorothalonil 0.2% and Propiconazole 0.1% on both leaf surfaces and T5 –No sprays were given (control). All the sprays were taken alternatively at 10 ten days interval in each treatment.

Observations were taken weekly from the first month after planting till harvest. The disease Severity Index was calculated using Gauhl's modification of Stover's Sigatoka severity scoring system (0 - 6 scale). The analysis of variance of the disease Severity Index showed statistically significant difference between the treatments Table 11. The lowest mean Severity Index of 17.4 % was recorded in T-4 Chlorothalonil 0.2% and Propiconazole 0.1% (alternating every 10 days interval and sprayed taken on both the leaf surfaces) followed by PDI of 38.0 % with treatment T-3 Chlorothalonil 0.2% and Propiconazole 0.1% (alternating every 10 days interval only on upper surface). The treatment T-4 with the lowest disease Severity Index correspond to the highest value of 7 for youngest leaf spotted which shows the disease could not infect the younger leaves beyond leaf 7. The yield difference of 4.0 kgs per bunch weight was observed in the treatment T-4, which was significantly higher than other treatments.

ALL INDIA CO-ORDINATED RESEARCH PROJECT (AICRP) ON MUSHROOM

Evaluation of *Pleurotus species* of mushroom in winter season (2016)

Under All India Coordinated Research Project (AICRP) on Mushroom, a total of four entries namely PL-16-01 to PL-16-04 of *Pleurotus* sp. were evaluated in the mushroom house of ICAR, Tripura centre with four replications for each entry. All the entries started fruiting from 4th week after the spawning. The highest yield was obtained from PL-16-04 followed by PL-16-01 during the 4th week (Table 12). The yield from all entries decreased in subsequent weeks. However PL-16-01 gave maximum combined yield followed by PL-16-04. Thus, PL-16-01 is suitable for Tripura conditions

Table 11. Effect of the fungicides and biocontrol agents on Sigatoka diseases of banana

Treatment no	SI	YL S (F)	YL S (H)	FUNC LEAF (F)	FUNC LEAF (H)	Bunch Weight (kg)
T1	55.09^{d}	6	2	4	3	11.4^{b}
T2	50.71^{c}	6	2	5	3	11.13^{bc}
T3	38.04^{b}	5	2	5	3	12.56^{c}
T4	17.43^{a}	7	3	8	6	13.56^{a}
T5	65.38^{d}	4	5	2	2	9.53^{d}

SI =Severity Index: YLS (F) =Youngest Leaf Spotted at Flowering: YLS (H) = Youngest Leaf Spotted at Harvesting: FUNC (F)= Number of Functional leaf at flowering FUNC (H)= Number of Functional leaf at harvesting

Table 12. Perfomance of 4 entries of mushroom at weekly interval

Entries	Yield of fresh mushroom (g) at weekly interval					
	4th week	5th week	6th week	7th week	8th week	Total (g)
PL-16-01	5720	2080	590	580	2820	11790
PL-16-02	4060	820	160	890	670	6600
PL-16-03	3130	930	2660	1310	470	8030
PL-16-04	7450	1450	800	470	460	10630

AGRICULTURAL MICROBIOLOGY

Screening of phosphate solubilizing microorganisms to develop temperature resilient biofertilizer

Soils of Tripura is generally low in available phosphorous (P) and mostly acidic in reaction with high amount of exchangeable iron and aluminum contents. Any soluble phosphate fertilizer applied to such soil gets fixed to non available forms resulting in poor phosphorus-use-efficiency. An attempt has been made to screen out effective phosphate solubilising bacteria from 12 isolates of *Bacillus* and *Psedomonas* (PSM1, PSM2, PSM3, PSM4, PSM5, PSM6, PSM7, PSM8, PSM9, PSM10, PSM11, and PSM12) under variable temperatures with an aim to develop a temperature resilient biofertilizer. Different temperatures (20, 25, 30, 35 and 40^{o} C) influenced the P solubilization variably among the isolates at constant pH r 5^{o} 0 (Table 13). Optimum P solubilization was recorded 30^{o} C for *Pseudomonas* strains while 35^{o} C for *Bacillus*. Higher temperature above 35^{o} C proved deleterious for *Pseudomonas* and a sharp decline in P solubilization has been noticed concurrently on increases temperature from 30^{o} C to 35^{o} C. The plausible cause for this effect is temperature influence the P solubilization by i) affecting the physiological growth of the microorganism ii) regulating the production of metabolites (such as organic acids and siderophores). Maximum P was solubilized (upto 27 µ/ml of Pikovskaya broth) by the isolates - PSM 8 and PSM10; and PSM12 of *Bacillus* and *Pseudomonas* respectively at temperature range of 20 - 40^{o} C. Maximum phosphate solubilisation (19-28 µ/ml of Pikovskaya broth) occurred at pH 5, which decreased with increment of pH (Table 14) for all the isolates (*Bacillus* and *Psedomonas*). In general, *Psedomonas* strains were better P solubilizers than *Bacillus* at µ/ml of Pikovskaya broth (at pH 5 and 28^{o} C). These aspects provide a scope to develop a temperature resilient P solubilizing consortia biofertilizer (comprising of PSM 8, PSM10 and PSM12) relevant to acid soils.

Table 13. Phosphate solubilization (µ/ml) in Pikovskaya broth by P solubilizing bacterial isolates at variable temperatures at pH5

Sl. No.	Temp. (°C)	Psm1 B**	Psm2 B	Psm3 P	Psm4 B	Psm5 B	Psm6 P	Psm7 P	Psm8 B	Psm9 P	Psm10 B	Psm 11 P	Psm12 P
1	20	9.8* (12.4)	9.0 (12.0)	11.3 (12.1)	13.0 (12.0)	12.7 (12.8)	12.0 (12.1)	17.0 (11.4)	16.7 (11.5)	18.6 (12.1)	18.8 (12.1)	19.4 (12.3)	27.0 (12.1)
2	25	18.8 (12.1)	18.3 (12.1)	19.5 (12.2)	19.8 (12.0)	20.5 (12.1)	21.0 (12.3)	21.0 (12.3)	22.0 (12.3)	25.1 (12.2)	24.0 (12.2)	24.8 (12.3)	27.2 (12.2)
3	30	19.2 (12.3)	19.3 (12.2)	21.8 (12.4)	22.4 (12.6)	22.8 (12.2)	25.3 (12.6)	25.2 (12.4)	25.0 (12.5)	27.0 (12.8)	26.0 (12.2)	27.8 (12.9)	29.0 (12.3)
4	35	20.3 (12.3)	21.5 (12.2)	8.8 (11.2)	23.6 (12.6)	25.7 (12.3)	8.5 (12.0)	8.2 (12.0)	27.2 (12.6)	10.3 (12.2)	27.8 (12.3)	10.3 (12.1)	11.4 (12.2)
5	40	20.1 (12.3)	20.2 (12.2)	0.0 (0.0)	22.4 (12.6)	25.0 (12.3)	0.0 (0.0)	0.0 (0.0)	27.0 (12.6)	0.0 (0.0)	27.6 (12.2)	0.0 (0.0)	0.0 (0.0)

*Mean of triplicate values, **B= *Bacillus*, P=*Pseudomonas*
Values in the parenthesis indicate population (log cfu/ ml) in Pikovskaya broth by P solubilizing bacterial isolates

Effect of organic manures on performance of native arbuscular mycorrhizal fungi

An effort was made to maximize arbuscular mycorrhizal (AM) fungi on-farm through cropping sequences - maize followed by tomato, maize and pea repeatedly for the third consecutive year under the regime of different organic manures (FYM, poultry manure and vermicompost). It was observed that AM fungi performed better with organic manures compared to control. In general, the trend of AM fungi on P uptake, root colonization and dry weight of shoot was: FYM > poultry manure > vermicompost > control. However statistically ($p \leq 0.05$) no significant differences among the treatments were observed. Concurrently, maximum percent P in plant was recorded with FYM (1.6%) followed by poultry manure (1.4%), vermicompost (1.4%) and control (1.0%). Predictably, percent root colonization had no correlation with the spore count. Highest spore count (249/100 gm soil) was observed in the control plot while least with FYM (181/100 gm soil). From this experiment, it is concluded that FYM is better organic manure for mass production of crude culture (colonized root pieces, spores, broken hyphae) of AM fungi in on-farm production system.

Effect of various carrier media on shelf life of biofertilizer

With an aim to develop liquid biofertilizer, the shelf life of microbial cells in powder based carrier viz., peat, clay ball, Ca-alginate beads, Ca-alginate beads in distilled water, Ca-alginate beads in broth were studied. The experiment was set at a temperature range of 22-28° C with rhizobia as model microorganism whose initial population count during mixing with different carriers was $88x10^9$ cfu/g. Microbial plate counts were recorded at 0, 60 and 90 days of storage. Maximum population count of the rhizobia was obtained from Ca-alginate beads (39×10^9) followed by Ca- alginate beads in distilled water (32.5×10^9), Ca-alginate beads in broth (31×10^9), clay balls (19.5×10^9) and peat (16.3×10^9),

Table 14. Phosphate solubilization (µ/ml) in Pikovskaya broth by P solubilizing bacterial isolates at variable pH at 28°C.

pH	Psm1 B**	Psm2 B	Psm3 P	Psm4 B	Psm5 B	Psm6 P	Psm7 P	Psm8 B	Psm9 P	Psm10 B	Psm 11 P	Psm12 P
5	19.2* (12.3)	19.3 (12.2)	21.0 (12.3)	22.4 (12.5)	22.8 (12.2)	24.2 (12.4)	24.8 (12.3)	25.0 (12.5)	25.4 (12.4)	26.0 (12.2)	26.8 (12.9)	28.0 (12.2)
6	9.8 (12.2)	11.3 (12.1)	15.5 (12.3)	16.0 (12.5)	17.5 (11.5)	19.0 (12.3)	16.2 (12.3)	22.0 (12.3)	22.3 (12.3)	20.1 (12.1)	19.8 (12.3)	20.6 (12.1)
7	8.8 (12.0)	9.0 (12.1)	9.8 (11.3)	10.0 (11.5)	10.5 (11.5)	12.0 (12.1)	19.0 (12.0)	15.3 (12.2)	16.1 (12.3)	17.1 (11.3)	16.3 (11.5)	17.4 (11.3)

**Mean of triplicate values, **B= Bacillus, P=Pseudomonas*

Values in the parenthesis indicate population (log cfu/ ml) in Pikovskaya broth by P solubilizing bacterial strains

respectively during storage period of 90 days. This finding confirms respectively that cell-entrapped biofertilizer either in the form of Ca-alginate beads or clay balls can act as protective covering to temperature sensitive microbial cells during storage. Alginate beads in distilled water holds potential to be developed as a liquid biofertilizer as revealed from the study.

Effect of arbuscular mycorrhizal root and crude inoculum on maize root colonization

A comparative study on root colonization efficacy of AM fungi root and crude (comprising of spores, infected root pieces and broken hypae) inoculums isolated from the shifting cultivation sites were tested. A permutation combination of root and crude inoculums from two different plants (*Chloris gayana* and *Leucaena leucocephala*) of two different sites (Assam and Nagaland) revuted rise to eight treatments altogether in this study. In general, crude inoculum achieved better AM fungi root colonization than root inoculum. Co-inoculation of morphotypes (ABC) obtained better percent colonization than solo inoculation. Maximum colonization was noted by consortia crude inoculum viz., NLLCI (71.7%), followed by ACGCI (66.7%). Hence, it can be concluded that the best inoculum for development of AM fungi biofertilizer is crude inoculum in consortia with AM morphotypes. Various forms of AM propagules (spore, infected root pieces, broken hyphae) increased the probability of root colonization than a root inoculum (infected root pieces) alone. Moreover, the consortia of AM fungi (morphotype A, B, and C) are synergistic in expediting the root colonization activity.

Table 15: Effect of organic manures on P uptake, percent root colonization and spore number of AM fungi.

	P conc. of ear leaf (%)	Root colonization (%)	No. of spore /100gm of soil	Dry weight of shoot (gm)
Farmyard manure	1.6a	60.0a	181.8b	167.3a
Poultry manure	1.4a	53.3ab	208.8ab	110.1b
Vermicompost	1.4ab	40.0bc	239.7ab	92.5bc
Control	1.0b	37.5c	249.3a	51.8c

** Means of three replications within each column followed by the same letter are not significantly different ($p \leq 0.05$) according to DMRT*

Table 16. Effect of AM fungi root and crude inoculums on root colonization of maize

Treatment	% Root Colonization[b]			
	ABC[a]	A	B	C
Assam				
Leucaena leucocephala root inoculum	48.9	48.8	53.3	32.2
Leucaena leucocephala crude inoculum	58.9	51.1	57.7	36.7
Chloris gayana root inoculum	56.7	51.1	32.7	33.3
Chloris gayana crude inoculum	66.7	56.6	53.3	38.3
Nagaland				
Leucaena leucocephala root inoculum	45.8	53.3	36.1	41.7
Leucaena leucocephala crude inoculum	71.7	63.3	48.9	53.3
Chloris gayana root inoculum	56.7	51.1	50.0	53.3
Chloris gayana crude inoculum	55.6	53.3	31.1	55.0
CD at 5%	3.3	3.6	2.7	2.5
CD at 1%	4.5	5.0	3.8	3.5

[a] A, B, C represents AM fungi morphotypes with spore diameter >250 µm, 106-250 µm and 53-106 µm respectively
[b] Mean of three replicate values

Development of captive breeding and larval rearing protocols for *Mystus cavasius*

Small Bagrid catfishes of the genus *Mystus* hold regional aquaculture importance in the State of Tripura. Spontaneous spawning was elicited in captivity for the Bagrid catfish *Mystus cavasius* (Fig 8) using a simple set up involving a 30L glass aquarium with floating *Eichhornia crassipes* weeds covering 2/3rd of water surface. The brooders at sex ratio of 2:2 were intramuscularly injected with Ovatide ® at the rate of 06.ml/kg body weight in the late evening and left undisturbed. Eggs were attached to submerged parts of the weeds in the early morning hours, 6-7 hours post induction (Fig 9). Parental care was not exhibited. First hatching occurs at 14 hours post fertilization, with a hatching percentage of ~ 60% in naturally spawned eggs. The larvae exhibited obligatory air breathing behavior immediately after yolk sac absorption was completed (48 hr post hatching) and was phototactic, unlike adults. The fries were fed initially on Infusoria and thereafter, on plankton. Debris was siphoned out daily and 40% water exchange was performed thrice a week. The fry exhibit adult-like behavior after 20 days (1cm size). Larval rearing till 20 days was completed successfully with 63% survival by reducing water column to 8 cm after hatching and thinning of the larval stock to 50-60 ns/L. Grow out technology for the species need to be standardized for ensuring maximum returns for the farmers.

Fig 8. A pair of Mystus cavasius brooders female (above) and male (below)

Evaluation of zooplankton composition and abundance in two different aquaculture systems

Zooplankton samples were collected from two fish ponds, *viz*., a farming system research pond receiving continuous supply of pig excreta and a fertilized pond of the farm facility of ICAR RC for NEH Region, Tripura Centre, Lembucherra. The samples collected were identified and enumerated with the help of Drop Count method. The zooplankton population comprised of two main groups *viz.,* Cladocera and Copepoda. Three genera viz, *Daphnia, Moina* and *Cyclops* (Fig 10) along with zooplankton nauplii represented the zooplankton communities. The two ponds showed significantly different distribution of zooplankton genera (Table 17). In the pig cum fish pond which received pig manure, the total zooplankton abundance was 226000 nos/L. *Cyclops* showed maximum abundance (94%) followed by *Daphnia* (4%) and *Moina* (2%) communities. On the other hand, in the fertilized pond with an abundance of 227000 nos/L, the Cladoceran population of *Daphnia* (49%) and *Moina* (35%) dominated followed by *Cyclops* (12%) and zooplankton nauplii (2%).

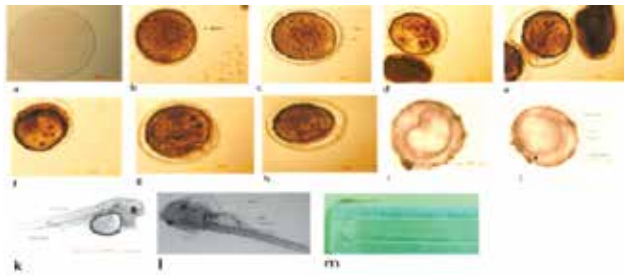


Fig 9. Embryonic and larval development in Mystus cavasius

A: Unfertilized oocyte; b: fertilized zygote; c: Perivitelline space formation: d: Blastodisc formation; e: Single cell stage; f: Morula (mulberry stage); g: Blastula formation begins; h: Advanced blastula; i: Advanced gastrula; j: Early somite block formation; k: Hatchling immediately post hatching; l: 48 hours post hatching; m: 20 day old fry.

Table17. Representation of abundance of different zooplankton genera (nos/L) in the ponds

Zooplankton		Abundance (nos/L)	
		Pig cum fish pond	Fish pond at Coccotilla
Cladocera	Daphnia	9000	110000
	Moina	4000	80000
Cyclopoda	Cyclops	213000	28000
Zooplankton	nauplii	-	9000
Total		226000	227000

Cyclops ***Daphnia*** ***Moina***

Fig 10. Zooplankton genera identified from the ponds

Normal range and seasonal variation of haematological and innate immune system in *Labeo bata*

A study was conducted for a period of two years to establish the normal range and understand the seasonal variation of haematological and immunological response in *Labeo bata*, a minor carp having great consumer demand in NE India. The water quality parameters of the ponds like temperature, dissolved oxygen, pH and total alkalinity were recorded for the ponds. Blood samples were collected randomly from the fishes reared in the pond in three different seasons: summer (March-June), rainy (July-September), and observed winter (October-January). It was that TEC and TLC were significantly higher in summer season. Total protein was significantly lower in winter, and albumin was significantly higher in rainy season (Table 18) and glucose was significantly higher in summer season. The increase in plasma glucose levels is correlated with the production of catecholamine during stress. There was no significant difference in lysozyme in all the three season. Myeloperoxidase activity was significantly higher in summer season while significantly lower respiratory burst activity was observed in winter seasons. This implies that oxygen dependent killing mechanism including phagocytosis and MPO was higher in summer and lower in winter seasons. Moreover, a strong positive correlation in MPO activity and superoxide anion production with respect to temperature was noticed (Table 19). This suggests a direct association between temperature and peroxidase & respiratory burst activities. The present study has established base line information regarding the innate immune function during a particular season in *L. bata*. Any wide variation in the normal range data will help to aid in revealing major environmental fluctuation that might affect the health status of fish. A marked variation among all the parameters was observed and most of the parameters showed either low or equal in level or activity during rainy as compared to the winter season, thus indicating a clear influence of temperature in modulating the immune status of fish. Lysozyme was exceptional as this was insensitive to temperature fluctuation (Table 20).

Table 18. Reference and mean values of various immune parameters of *Labeo bata* irrespective of season

Parameters	Mean	Range	25th-75th per-centile (Q1-Q3)
TEC (10^6)cells/ cumm	1.63±0.12	0.52-4.20	1.31-2.20
TLC (10^3)cells/ cumm	38.20±3.10	6.29-62.46	19.20-33.41
Protein (g/dl)	11.0±0.48	7.100-16.12	7.33-10.06
Albumin (g/dl)	3.8±0.65	1.09-5.61	1.12-2.76
Glucose (mg/ dl)	64.0±4.51	16.0-129.67	52.06-88.70
Lysozyme (ug/ ml)	3.0±0.20	2.0-6.55	2.99-4.51
Myeloper-oxidase (OD 450nm)	0.76±0.01	0.16-1.29	0.47-1.13
NBT (OD 540nm)	0.24±0.02	0.04-0.51	0.22-0.36

Table 19. Seasonal variation in the innate immune parameters of *Labeo bata*

Parameter (Units)	Summer	Rainy	Winter
TEC (10^6) cells/cumm	2.01±0.29[b]	1.77±0.19[a]	1.49±0.22[a]
TLC (10^3) cells/cumm	54.30±3.66[b]	44.13±4.25[a]	30.15±4.15[a]
Protein (g/dl)	13.72±1.12[a]	12.26±0.96[a]	9.03±2.41[b]
Albumin (g/dl)	3.87±0.44[a]	4.40±0.36[b]	3.35±0.78[a]
Glucose (mg/dl)	114±8.26[a]	65.24±6.99[b]	88.21±4.36[a]
Lysozyme (ug/ml)	4.01 ±0.29[a]	3.89 ±0.48[a]	3.39 ±0.12[a]
Myeloperox-idase (OD at 450nm)	0.89 ±0.07[a]	0.75 ±0.046[b]	0.65 ±0.05[b]
NBT (OD 540nm)	0.28± 0.03[a]	0.25± 0.01[a]	0.15 ±0.002[b]

Data are presented as mean ± S.E. Means with different alphabetical superscripts in a coloumn are significantly (P<0.05) different.

Lipopolysaccharide (LPS) enhances immunity *Labeo bata*

This study investigates the effects of dietary lipopolysaccharide (LPS) as an immunostimulant on hematology, innate immunity, immune gene expression and protection against *Edwardsiella tarda* on *Labeo bata* (Fig 11). A basal diet supplemented with 0, 50, 100 and 150 mg LPS kg/diet was fed to the four different groups for 30 days. The haematological (total erythrocyte count, total leukocyte count, total serum protein, albumin and globulin), innate immune parameters (respiratory burst, serum lysozyme, myeloperoxidase and serum bactericidal activity),

Table 20. Correlation of the immune parameters with temperature

Parameters	Correlation with temperature
TEC (10^6)cells/cumm	0.93
TLC (10^3)cells/cumm	0.88
Protein (g/dl)	0.94
Albumin (g/dl)	0.41
Glucose (mg/dl)	0.44
Lysozyme (ug/ml)	-0.50
Myeloperoxidase (OD 450nm)	1.00
NBT (OD 540nm)	0.97

immune gene expression (C3, β-2 microglobulin, lysozyme g, transferrin, IFN-1, IFN-γ) were monitored at 7th, 15th, 22nd and 30th days. All the studied haematological, innate immune parameters and expression of immune gene increased significantly ($p \leq 0.05$) in LPS fed group compared to control. However the group fed to 100 mg/kg LPS in feed showed highest activity on 7th day and 1DPC. The group fed to 100 mg/kg LPS also recorded the highest relative percent survivability after challenge with *E. tarda*. In conclusion, our results demonstrate the usefulness of LPS as a dietary immunostimulant. LPS stimulates both innate and adaptive immune parameters and also increases the RBC, WBC, protein, albumin and globulin in *L. bata*. The present results suggest that LPS at 100 mg/kg feed could be considered as a good supplement to improve the immune status of *L. bata*. It was observed that most of the immune parameters and expression of the immune genes had higher values on 7th day and 1 DPC. Hence, short term pulse feeding strategy can be recommended for a week period before the onset of cold weather when risk the of disease is more.

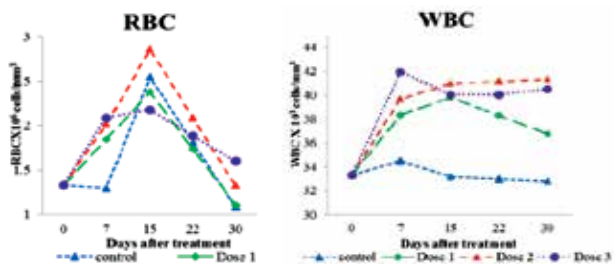


Fig 11. Effect of dietary supplemented graded levels of LPS on (A) total erythrocyte count, (B) total leukocyte count of L. bata (Mean ± SE)

POULTRY SCIENCE

AICRP on Poultry Breeding (Rural Poultry Production)

Evaluation of performance of dual type chicken

Dual variety chicken was developed during 2014-15 at the Division of Poultry Science, ICAR, Tripura Centre by crossing of Tripura Black, Coloured Broiler and Dahlem Red. The evaluation of mean performance of dual variety chicken is evaluated at institute farm as well as at the farmer's fields(Table 21).

Table 21. Evaluation of mean performance of dual type chicken at institute farm and famer's fields:

Traits	Institute	Famer's fields
Day old BW (g)	41.4	-
4 Wk BW (g)	243.7	-
8 Wk BW (g)	547	503
12 Wk BW (g)	1007	840
20 Wk BW (g)	1806	1595
40 Wk BW (g)	2653	2275
Age of first egg (Days)	165	178
Egg wt 40 WK (g)	56	52
Egg Production upto 72 WK	122	99

Evaluation of mean performance of different poultry germplasms at institute farm

The evaluation of mean performance of Tripura black, dahlem Red, Coloured Broiler (dam line), ND Cross (50%) and Dual type chicken was done at institute farm which are given below (Fig 12).

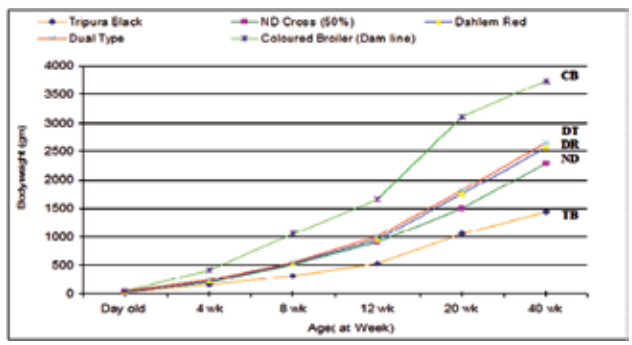


Fig 12. Graph showing the body weight of different poultry breeds

Evaluation of Fertility and Hatchability of Different Chicken Germplasms

Hatching eggs were collected from different breeder stocks of poultry farm of ICAR - Research complex, Tripura Centre, Lembucherra and brought to the hatchery unit. After proper cleaning and fumigation, the hatching eggs were stored in the egg holding room at 65°F (18° C) and relative humidity 75-80% to stop embryonic development completely. A total of 15688 eggs of Dahlem Red,

Coloured Broiler, Tripura Black, ND Cross (50%), BN Cross (50%) and dual type chicken were set for hatching in the hatchery unit. Hatching eggs was kept in incubator for first 18 days and then transferred to the hatcher for last 3 days during incubation period. Proper temperature, relative humidity and ventilation were maintained in incubator as well as in hatcher during the period. Optimum temperature (99.5^0 C) was maintained inside the incubator for the first 18 days and 99^O C was maintained inside the hatcher during the last 3 days of incubation. Eggs were turned at 3 hours intervals, at least 7- 8 times daily and candled at 18th day to remove the infertile ones and dead embryos (dead in germs), respectively. A total of 8672 chicks of different breeds / varieties / lines were hatched out at 21st day. Estimation of fertility, hatchability on fertile eggs and hatchability on set eggs were calculated.

A total of 8672 chicks of different varieties / lines of chicken were produced. The overall average percent fertility was 76.5% in different breeds / varieties / lines of chicken. The highest percent fertility was found in Tripura Black (82.1%) and lowest percent fertility was found in BN Cross (60.6%). The overall average percent hatchability on total egg sets (TES) and fertile egg sets (FES) were 55.3 % and 72.2 %, respectively. The highest hatchability TES and on FES was found in Dual type (60.0 %) and BN Cross (86.8%) respectively. The lowest hatchability on TES and on fertile egg sets FES was found in Dahlem red (47.9%) and ND Cross (59.5%) respectively (Table 22)

LIVESTOCK PRODUCTION

Performance of Murrah buffaloes in Tripura condition

Aiming at exploring the prospects of buffalo in Tripura, the world famous indigenous Murrah buffalo has been brought from Rohtak of Haryana to ICAR Research Complex, Tripura Centre, Lembucherra, in the month of April 2013. At present, there are 15 buffaloes including calves in the Livestock Farm. The animals are housed in well ventilated shed with space and feeding manger for individual animal. The highest lactational yield for 305 days was 1830 litres with peak milk production of 11.5 litres per day during 2016-17. At farm conditions, buffaloes showed estrus throughout the year, but in many places, a seasonal pattern of ovarian activity has been reported. One female buffalo calf and one male buffalo calf have born during the period at livestock farm. The performance of Murrah buffaloes are given in Table 23.

Table 23. Performances of Murrah buffalo in Tripura conditions

Animal No.	Total yield (Litre) (Lactation period 305 days)	Avg. yield (Litre)	Peak yield (Litre)	Gestation Period (days)
MU-5	1830	6	11.5	303
MU-7	1534	5.07	11	299
Avg.	1682	5.5	11.25	301

Performances of Cattle in Tripura condition

The Livestock farm of ICAR Research Complex, Tripura Centre maintaining successfully three varieties of cattle i.e Holtein Friesian cross, Jersey cross and Sahiwal, till date. At present, there are 9 Sahiwal, 6 Jersey and 9 Holstein Friesian cows, bulls and calves in the Livestock Farm. Two male and one female Holstein Friesian cross calves were born in the year 2016-2017 at ICAR livestock farm. The highest lactational yield for 305 days was 1891 liter with milk production of 8 liters per day during 2016-17 (Table 24)

Table 22. Fertility and Hatchability of Different Chicken Germplasms

Breed/ Variety/Strain	Total no of eggs set	No of fertile eggs	Fertility (%)	Total no of Chicks hatched	Hatchability (%)	
					Total Eggs Set (TES)	Fertile Eggs Set (FES)
Dahlem Red (Male line)	1005	720	71.5	481	47.9	66.6
Coloured Broiler	1751	1376	78.6	983	56.1	71.4
Tripura Black	784	644	82.1	453	57.8	70.3
ND Cross (50%)	3198	2546	79.6	1515	47.4	59.5
BN Cross (50%)	1743	1056	60.6	917	52.6	86.8
Tripura Black X Coloured Broiler X Dahlem Red [Dual type]	7207	5663	78.6	4323	60.0	76.3
TOTAL	15688	12005	76.5	8672	55.3	72.2

Table 24. Performances of Cattle in Tripura conditions

Animal No.	Total yield (Liter) (Lactation period 305 days)	Avg. yield (Liter)	Peak yield (Liter)	Gestation Period (days)
HF-2003	1891	6.2	8	291
HF-2004	1575.8	5.16	7	278
Avg.	1733.4	5.68	7.5	284.5

All India Coordinated Research Project on Pig Evaluation of performance of Mali and Hampshire Pig

With an aim to establish Tripura local Mali pig breeding stock, with special reference to production, reproduction, nutrition and health status, All India Coordinated Research Project on Pig has been started since 12th Jan, 2015 at ICAR Research Complex (RC), Tripura Centre, Lembucherra, India. The performance of Mali pig and Hampshire evaluated up to weaning at the farm of the Centre. The pigs were fed with commercially available pig ration as per recommendations. Body weight of each piglet was recorded at weekly interval at the morning before offering any feed. Mali pigs were maintained under standard farm management practices. Performance of Mali and Hampshire cross are given in table 25.

It was found that the litter size at birth in Mali piglets were more than Hampshire cross piglets but the litter weight at birth were less than Hampshire cross piglets. Age of sexual maturity was comparable same in both breeds. Gestation periods were somewhat more in Mali piglets than Hampshire cross. The body weight of Hampshire cross piglets were more than the body weight of Mali piglets from at birth to weaning at livestock farm. The growth rate in Hampshire cross piglets were more than Mali piglets fill weaning.

Front Line Demonstration on Rice under NFSM

During 2016-17, FLDs on rice under NFSM were conducted at 6 clusters in Khowai district of Tripura. In total, 125 farmers taken up the FLDs in 57.14 ha area. The technologies showed 18.5 -28.8 per cent yield advantage over the farmers practice (Table 26), (Fig 13 a & b)

Fig. 13 a. Bumper crop of Gomati at Batapura FLD cluster

Fig. 13 b. Farmers with rich harvest after crop cut

Table 25. Performance of Mali and Hampshire pigs at farm

Traits/Characters	Mali Breed			Hampshire Breed		
	Overall	Male	Female	Overall	Male	Female
Average Litter size at birth (no.)	5.9	2.5	3.4	4.7	2.5	2.2
Average Litter weight at birth (kg)	4.2	1.9	2.3	8.9	4.7	4.2
Avg. Individual weight at birth (gm)	850	928	820	2000	2200	1900
Avg. Individual weight at weaning (kg)	4.9	5.6	4.8	13.6	13.7	13.6
Average Age at sexual maturity (Months)	7	-	7	7	-	7
Average Gestation period (days)	119	-	119	114	-	114

Table 26. Performance of different rice genotypes in Front line Demonstration and NFSM

Sl No.	Name of the village conducting FLD	Total number of farmers	Total area under FLD (ha)	FLD Technology	Check plots technology	Avg FLD Plot yield	Check plot yield	Yield advantage
1	Cluster 1: Batapura , Khowai	31	14.54	Gomati + ICM	Swarna + FP	5.94	4.62	28.6%
2	Cluster 2: Batapura , Khowai	23	10.22	Tripura Chikan Dhan	Naveen + FP	5.64	4.76	18.5%
3	Cluster 3: Beltoli, Khowai	21	8.64	Gomati + ICM	Swarna + FP	5.88	4.63	27.0%
4	Cluster 4: Madan cher), Khowai	20	9.76	Gomati + ICM	Swarna + FP	6.12	4.75	28.9%
5	Cluster 5: Lamapara, Khowai	21	9.34	HYV: Gomati + ICM	Swarna + FP	5.85	4.62	26.6%
6	Cluster 6:Batapura , Khowai	9	4.64	HYV: Gomati + ICM	Swarna + FP	6.24	5.15	21.2%

Boro Rice Day & Participatory Varietal Selection, on 3rd June, 2016 at the College of Agriculture, Lembucherra

A Boro Rice Day and PVS on boro rice varieties was organized in collaboration with College of Agriculture, Tripura and Dept. of Agriculture, Govt, of Tripura at Lembucherra on 3rd June. Objective of the programme was to display the promising boro rice varieties and lines developed by the ICAR, Tripura Centre to the farmers and know the preferences. A total of 206 farmers, faculty of College of Agriculture, students of Agriculture College, scientists of ICAR also participated. Tripura Khara dhan 1 came out to be the most preferred variety among the 33 boro varieties and promising lines.

Training cum Seed Distribution Programme under TSP, on 11th June at Hrishyamukh, South Tripura

A training cum seed distribution programme was organized at Hrishyamukh, South Tripura on 11 June, 2016. More than 634 farmers' from 11 villages, including 7 tribal ADC villages attended the occassion. Hon'ble Sabhadhipati, Dakshin Zilla, Shri Himanshu Roy graced the occassion as Chief Gust. Chairman, Agri Standing Committee, Chairman, Hrishyamukh Panchayat Samiti and Head Master of Hrishyamukh H. S. School were present participation. Dr. S. V. Ngachan, Director, also joined the programme and discussed with the representative of the Panchayat Raj bodies regarding ICAR's initiatives in this area. Farmers involvement in the demonstration was highly encouraging.

Input Distribution Programme under TSP on 12th June, 2016 at ICAR Complex, Lembucherra.

An input distribution programme was organized to distribute different inputs to tribal farmers under TSP. Shri Aghore Debbarma, Hon'ble Minister for Agriculture, Tripura, graced the programme as Chief Guest. A total of 106 tribal

farmers attended the programme and received different inputs. Three tribal farmer Clubs were given 12 HP power tillers. Each farmers Club receiving the power tillers will extend the facility to 300-400 farming families in their respective area.

Hon'ble Minister for Agriculture, Tripura, Shri Aghore Debbarma, distributed the Power Tillers to the Tribal Farmers Clubs.

Training & Seed Distribution Programme under TSP on 16th June, Sarashima, South Tripura

A training cum seed distribution programme under TSP was organized at Sarashima, South Tripura. Chairman, Agri. Standing Committee and Chairman, Hrishyamukh Panchayat Samiti were the distinguished guests. A total of 463 farmers from the nearby villages attended the demonstrations programme. A half day training improved package of practices and improved varieties of rice and pulses were given to the farmers. Seed and fertilizers were also distributed among the farmers.

Field Day on FLD Paddy

A Field day was organized on FLD of Paddy on 26th October, 2016 to mark the success of the FLDs conducted. The Field day at East Ramchandra Ghat was attended by 217 farmers from the village and adjoining villages. Dr. B. K. Kandpal, Joint Director, Tripura Centre, Dr. Suneeta Kota, Scientist (PB), IIRR, Dr. A. K. Pal, Plant Breeder, SARS and Dr. Asim Das, Agronomist, SARS, Dept. of Agriculture, Govt. of Tripura, Programme Coordinator, KVK, West Tripura, Subject Matter Specialists of KVK, West Tripura and Scientists of ICAR, Tripura Centre attended the Field Day.

Training cum Seed Distribution Programme

A training cum seed distribution programme was organized on 18.6.2016 in the Ramchandraghat Community Hall. The programme was attended by 147 farmers. Superintendent of Agriculture, Khowai, representatives of local bodies, Programme Coordinator, KVK, West Tripura, Subject Matter Specialists of KVK, West Tripura and Scientists of ICAR, Tripura Centre attended the programme and trained the farmers on improved rice cultivation practices.

Participatory Varietal Selection (PVS) programme on drought tolerant lines

A PVS on promising drought tolerant lines from the Drought Breeding Network under STRASA was organized at KVK, Chebri on 24 November, 2016. In total, 136 farmers participated in the PVS and voted for the varieties. On the basis of their voting, the preference index of the varieties were ranked. Farmers also discussed about their liking and disliking for the varieties. SA, Khowai, PC, KVK, Chebri, all SMS of KVK, Chebri and scientists of ICAR, Tripura Centre took part in the PVS.

Awareness programme on lentil cultivation

An awareness programme was held at pilot village, Jumpuijalla on 16th December 2016 for giving information to the farmers regarding importance of lentil, its production technology and its nutritional quality. A total of 31 farmers were present on the awareness programme. Lentil seeds (HUL 57) were distributed among the farmers at the end of the programme.

NATIONAL INNOVATION IN CLIMATE RESILIENT AGRICULTURE (NICRA)

Change in monsoon and annual rainfall in North East India

Long period monsoon (1971-2015) and annual rainfall trends of North Eastern states of India were analyzed using India Meteorological Department (IMD) data. Average rainfall received during 1991-2010 (20 years) was compared with that of 1971-1990 (20 years) and average rainfall of

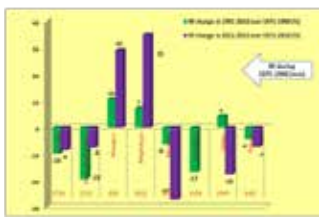


Fig 1(a). Change in monsoon rainfall in NE States during 2011-15

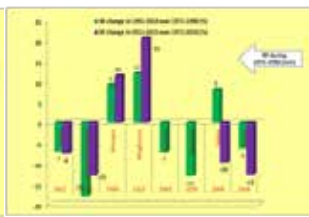


Fig 1(b). Change in annual rainfall in NE States during 2011-15

last five years (2011-2015) was compared with that of 1971-1990. During 1991-2010, average monsoon rainfall increased in Manipur (10%), Meghalaya (7%) and Sikkim (4%) over the period 1971-1990. In all other states, average monsoon rainfall decreased at varying magnitudes: 4% (in Tripura) to 19% (in Arunachal Pradesh). In the last five years (2011-2015), the occurrence of monsoon rainfall was further increased in Manipur (29%) and Meghalaya (35%) over average of 1971-2010 (40 years) while other NE states experienced a decreasing trend from 27 % (in Mizoram) to 8% (in Tripura) over the same period. The pattern of annual rainfall also followed similar trend with monsoon rainfall across these states. Gain of annual rainfall at Manipur and Meghalaya were 11% and 21%, respectively, during 2011-2015 over 1971-2010. There was a sign of improvement in Arunachal Pradesh but Sikkim (-10%) and Tripura (-13%) registered a decreasing trend.

Identification of stress tolerant rice, maize and tomato varieties for NEH ecosystem

Drought tolerance in rice

Identification of major QTLs for grain yield under drought stress in rice varieties for use in marker-assisted breeding to improve yield was carried out in Tripura centre. Drought scoring (following IRRI protocol) was completed for 2178 rice entries (Fig 2). Six mapping populations for QTL studies on drought tolerance in rice: RCPL 1128 x Naveen, Bhalum 3 x Naveen, Fulbadam x Swarna, Kataktara x Naveen, Fulbadam x Naveen and Kataktara x Swarna were created and advanced to F5 (Fig 3). Mapping population CT 99935101M/2*SAMBHA MAHSURI advanced to F7. Parental polymorphism was carried out with 600 SSR primers for the Mapping population CT 99935101M/2*SAMBHA MAHSURI. In total, 286 SSR primers were found to be polymorphic. Parental polymorphism survey of the Bhalum 3 x Naveen mapping population was completed. Drought phenotyping for the Mapping

Fig 2. Phenotyping of a drought QTL Mapping Population CT 99935101M/2 x Sambha Mahasuri

Fig 3. New Mapping population Bhalum 3 x Naveen for QTL studies on drought tolerance in rice

population CT 99935101M/2*SAMBHA MAHSURI was completed for 3 seasons. Whole population genotyping of 311 RILs of the Mapping population CT 99935101M/2*SAMBHA MAHSURI was completed with 286 SSR markers.

Genotyping of 74 Tripura's local landraces, improved varieties, cultivars and breeding lines and other rice varieties were completed using 30 SSR marker linked to different QTLs for grain yield under drought stress. A total of 88 alleles were detected. The number of alleles ranged from 2-5 with an average 2.93 alleles per locus. Cluster analysis based on 30 SSR marker revealed five clusters and also indicated the presence of variability within the Tripura rice varieties. The presence of seven droughts tolerant QTLs, qDTY1.1, qDTY12.1, qDTY2.1, qDTY2.2, qDTY3.1, qDTY4.1 and qDTY9.1 were also surveyed in 74 Tripura rice germplasms. The QTLs distribution among 74 genotypes were grouped into clusters, which showed that cluster III as the largest with all the seven QTLs having 34 genotypes, cluster I having 24 genotypes. Cluster analysis was used to group the varieties and to construct a dendogram. A total of 4 distinct groups or clusters resulted in from the analysis of pooled SSR marker data. This dendogram revealed that the genotypes that are

derivatives of genetically similar type cluster were more together (Fig 4, 5).

A total of 255 rice germplasm/entries were evaluated in Sikkim under direct-seeded rainfed upland condition for moisture stress tolerance. Out of 255 rice entries, 47 lines attained maturity within 120 days. Days to maturity of 47 lines is presented graphically in Fig 6. Days required for attaining maturity was found to be the lowest in case of Dular (111 days). Among the local rice germplasm of Sikkim, days to attain maturity was the lowest in

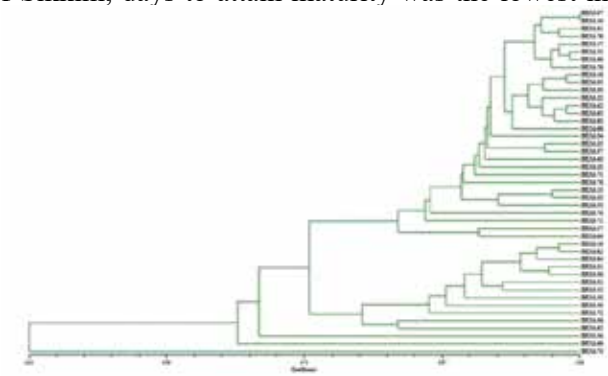


Fig 4. Clustering of 45 JHUM rice samples based on pooled SSR markers

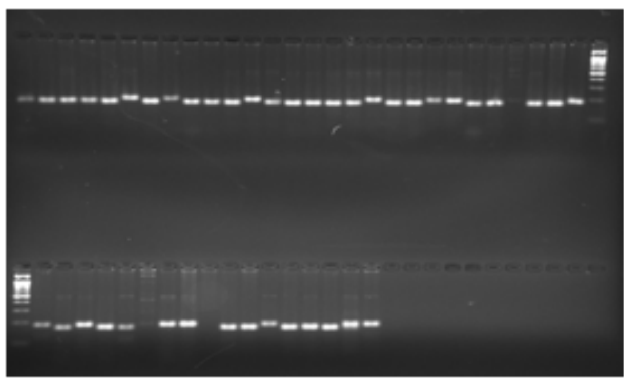


Fig 5. Sample Gel picture of diversity analysis of 45 jhum rice lines with 50 SSR markers; PRIMER RM161

Takmaru (Lama Dhan, 119 days). Days required to attain 50% heading was the lowest in IRCTN9184 (52 days).

Fifty local rice cultivars were tested for drought tolerance under controlled conditions (pot experiment, Fig 7). Grain filling under severe drought conditions was observed only in 17 entries. Total number of grains and filled grains per panicle was found to be the highest in Tabrey cultivar (Fig 8).

Drought tolerance in maize

A total of 17 maize germplasms i.e. Onglakemii, Com Pong Oglak, Nyakmakonglak, Cheloonglak,

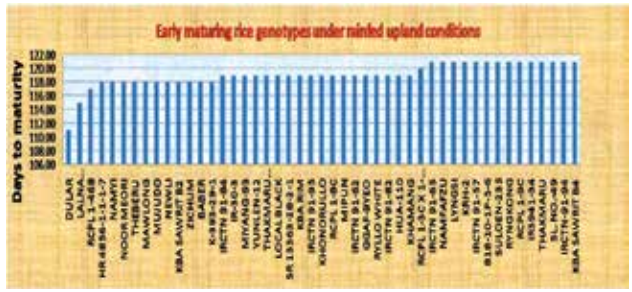


Fig 6. Early maturing rice genotypes under rainfed upland condition

Cheloonglak, Hupkenglocal, Jharnapanilocal, Wokhalocal, Wokhalocal, Theruyire, Razuphemavillage, DA-61-A, VQPM-9, RCM-1-2, Vijayacomposite, RCM176, RCM175 and RCM11 were grown in moisture stress condition to identify suitable lines tolerant to drought stress condition. Soil moisture content during the period of experimentation ranged between 5.80 to 26.3% (wt./wt.). Maximum grain yield was recorded with maize cv. VQPM9 (3800 kg/ha), followed by cv. RCM175 (3233 kg/ha) and Vijaya composite (2733kg/ha). Minimum grain

Fig 7. Screening of severe drought tolerant rice cultivars under pot experiment

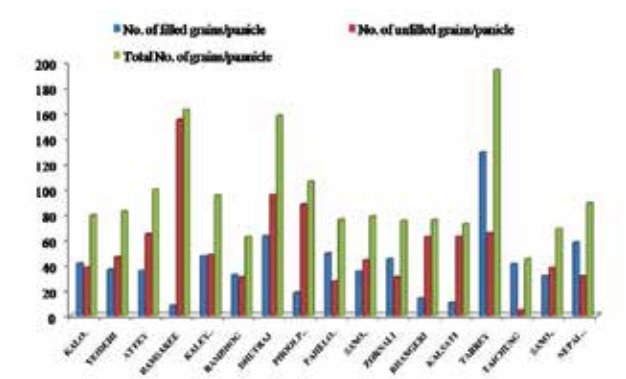


Fig 8. Grain filling in rice under severe drought conditions (pot experiment)

yield was recorded with cv. Nyakmakonglak (300kg/ha). Maize cultivars VQPM9, RCM175 and Vijaya composite performed well under moisture stress condition.

Heat tolerance in maize

Seedling growth response of six maize genotypes (RCMGP40, RCMGP47, RCMGP63 and RCMGP 105, RCMGP121 and RCMGP124) to different duration of heat treatments i.e. 5 sec, 7 sec, 10 sec, and 15 sec, respectively in boiling water bath (100° C) was studied Treated seeds were raised in sand media in plastic cups (dimension of 7.5 x 4.5 x 8.5 in cm) under ambient condition with nutrient media. Different growth parameters namely shoot and lengths, fresh weight of shoot and roots of 10 days old seedlings were recorded. Seeds exposed to heat exhibited better seedling growth compared to seedlings raised under ambient condition. In relatively tolerant genotypes namely RCMGP47, RCMGP63, RCMGP105, distinct variation in the distribution of photosynthates between shoot and root was observed. The increase in root length in RCMGP63 was accompanied by a sharp decrease in shoot length, and vice-versa (Fig 9a,b). Either way, establishment of seedling growth is a significant trait in more tolerant genotypes. This trend was not observed in untreated control or less tolerant genotypes like RCMGP40 and RCMGP121. More tolerant genotypes acclimatized better to heat treatments. Higher shoot and root weights were also recorded in RCMGP47 and RCMGP105 (Fig 9c,d).

Physiological response of maize to elevated temperature under CTGC facility

Physiological parameters of maize responsive to temperature stress were assessed using CTGC facility available in the institute. Maize crop was grown at an elevated temperature of 5^0 C (±0.8^0 C) over the ambient condition (18-29^0 C during day and 9-16^0 C during night time). Result revealed that, the total chlorophyll content of maize grown inside the CTGC chambers was increased whereas chl.a/b ratio was decreased as compared to that under ambient conditions. Other stress indicators *viz*., carotenoid content of leaves has increased under temperature stress inside the chambers whereas leaf thickness, leaf area and Cell Membrane Stability (CMS) of maize were reduced markedly (Table 1).

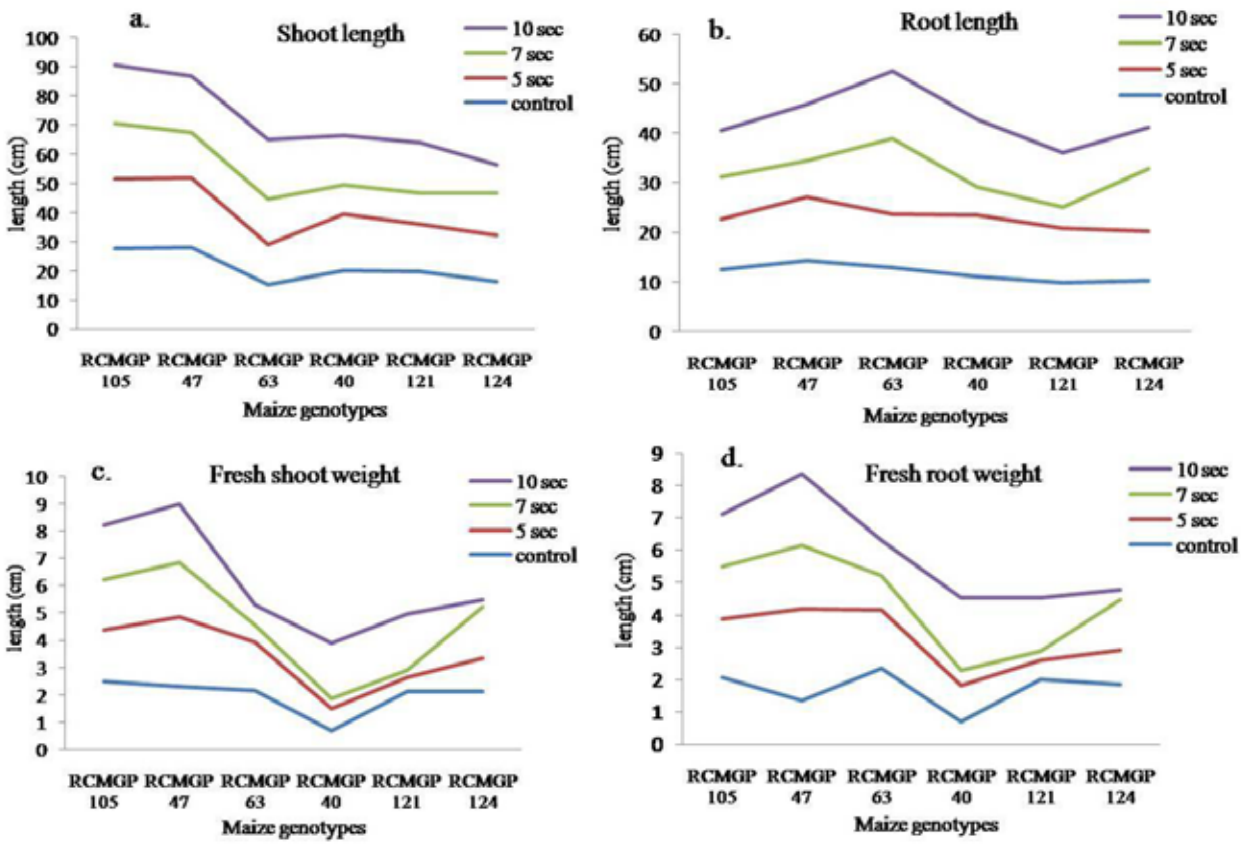


Fig 9 (a-d). Seedling growth studies among selected maize genotypes under different heat treatment in seeds

Table 1. Physiological parameters of maize as affected by the temperature stress inside CTGC chambers with temperature elevation

Growth condition		Chl. a (mg/g)	Chl. b (mg/g)	Chl. a/b	Total chl. (mg/g)	Carote-noids (µg/g)	Leaf thick-ness (µM)	Leaf area/ plant (cm^2)	CMS (%)
Normal	Ambient	1.18	0.69	1.71	1.89	37.1	190	867.8	23.7
Elevated (ambient+ 5^0C)	CTGC-1	1.08	1.00	1.08	2.11	48.2	175	706.9	13.9
	CTGC-2	0.93	0.89	1.04	1.91	70.8	160	736.1	15.7
	CTGC-3	1.02	1.04	0.98	2.07	68.6	170	728.0	11.1
	CTGC-4	1.10	0.94	1.17	2.08	39.9	180	747.2	16.2

Assessment of mitigation potential through soil and water management practices for enhancing climatic resilience

Development of climate resilient cropping system

Maize (Green cob)-Pahelo dal (Urd bean)-Buckwheat cropping system was identified as climate resilient cropping system under Sikkim condition, which gave maximum system productivity (8.83 t/ha), profitability (B:C ratio of 2.55) and employment generation (282 man days) compared to Maize -Fallow, Maize-Rajmash, Maize-Mustard, Maize-Buckwheat cropping system.

GHG emission fluxes of CH_4, CO_2 and N_2O were measured under different establishment and nutrient management practices

An emission study was conducted in rainfed low land rice (*var*. Shahsarang) to determine efflux patterns of GHGs (CO_2, CH_4 and N_2O) associated with different nutrient sources under conventional and conservational tillage practices. Treatments include 50% NPK (40:30:20 N : P_2O_5: K_2O kg/ha), 100% NPK (80: 60: 40 N : P_2O_5: K_2O kg/ha), 50% NPK+ISRR (*In situ* residue retention @ 5 t/ha of rice straw), 50% NPK+WB (*Ambrosia artemisiifolia* @ 10 t/ha fresh weight basis), 50% NPK+ GLM (Green Leaf Manure-*Tephrosia purpurea* 10 t/ha fresh weight basis) and FYM (5 t/ha) +WB (Weed Biomass-*Ambrosia artemisiifolia* @ 5 t/ha fresh weight basis) + RP (Rock Phosphate-60 kg/ha). GHG determination was done by collecting the gas samples periodically between 10 am to 12 noon at different time intervals (0, 20, 40, 60 minutes) using closed chambers, and analyzed by Gas Chromatograph (ThermoFisher Scientific Trace GC 800). Soil temperature was recorded for each chamber during the gas collection. Highest CO_2-C flux was observed in treatment with FYM+WB+RP in both conventional and conservational tillage. Maximum flux was observed during 75-100 DAT. Lowest flux was observed in 50% NPK in both ZT and CT. However CO_2-C Flux was high throughout the season with small fluctuations which may be governed by soil temperature and other soil physical attributes. Highest CH_4 flux was observed in treatments with 50% NPK + GLM in both ZT and CT. Maximum flux was observed during initial vegetative growth phase and after 75 DAT. Lowest flux was observed in 50% NPK in both ZT and CT. Highest N_2O-N flux was observed in treatment with 100% NPK in both ZT and CT. Lowest was observed in 50% NPK in both ZT and CT. Maximum flux was observed during 60-75 DAT. A decreasing trend in emission was observed at maturity stage. Seasonal variation in N_2O emission was observed with maximum flux during later growth stage of the crop.

Fig 10. Experimental setup in GHG's emission studies in rice field

Agro-forestry intervention in relation to carbon sequestration

The effect of spacing (2x3m, 3x3m, 4x3m, 5x3m, 6x3m, 2x4m, 3x4m, 4x4m, 5x4m and 6x4m) on biomass, carbon stock and carbon sequestration potential of *Ghamari* (*Gmelina arborea*) plantation was evaluated. The tree component wise biomass was estimated by using the allometric equations relating to the tree Girth at Breast Height (GBH). The planting design of spacing 2 by 3m of Ghamari recorded the highest bole biomass (95.97 t/ha), branch biomass (112.25 t/ha), foliage biomass (10.32 t/ha), root biomass (124.76 t/ha) and

total biomass (343.31 t/ha). Next to 2x3 m spacing, 3 x 4m spacing of Ghamari also registered significant improvement in biomass production The 2 x 3m spacing also recorded the highest carbon stock in bole (41.75 t/ha), branch biomass (51.26 t/ha), foliage (4.82 t/ha), root (44.58 t/ha) and total carbon stock (142.41 t/ha) followed by 3 x 4m spacing plantation of Ghamari. Thus, closer spacing is more effective in maximizing carbon sequestration along with wood production.

Potential of fallow chronosequence in shifting cultivation to conserve SOC

Study was undertaken to evaluate the impact of secondary forest on SOC stock and its allocation into pools of different oxidizable [very labile (CVL), labile (CL), less labile (CLL) and non-labile C (CNL)] C along the soil depth using three fallow chronosequences (Hengkot, Chandanpokpi, Monsangpantha) of shifting cultivation located in the subtropical mid-hills of north east India (Mizoram). Each chronosequence included a young (F1; 5–9 years), mid-aged (F2; 18–20 years) and old (F3; 28–33 years) fallow stand as well as adjacent recently cultivated land (F0). Result revealed that, SOC in 0–0.45m depth varied from 67.5 to 110.3 Mg/ha and showed significant (p = 0.05) variation among the fallow stands. There was net build-up of SOC with age of the fallow stand after slashing and burning of forest followed by consecutive 2–3 years of cultivation. Across the chronosequences, the values of SOC stock in 0–0.45 m depth were 75.9, 78.4, 91.5 and 102.8 mg/ha in F0, F1, F2 and F3, respectively (Fig 11). Increase in SOC stock was higher in the surface (29.6%) than that in the lower layers (11.8 and 11.0% for 0.15–0.30 and 0.30–0.45 m, respectively). Quality of soil organic matter as assessed by C: N ratio was significantly (p = 0.05) different among the fallow stands, the highest values were observed under old fallows across soil depths.

Oxidizable organic C in soil, which constituted 71.9% of the SOC, increased with fallow age after forest clearing and successive cropping for 2–3 years. The increase was considerably higher compared to SOC as was reflected from the average values across the chronosequences: 5.8, 31.6 and 50.6% in F1, F2 and F3, respectively, over F0. Active pools (CVL + CL) constituted 65.7%, whereas passive pools accounted the remaining 34.3% of the SOC. Among the different fallow stands, older fallow maintained higher amount of all the pools compared to younger fallows. Their accumulation was higher in surface as compared to lower layers. Results thus indicate that soil in shifting fallow conserves increasing amount of organic C during regeneration of forest vegetation and majority of the SOC is in active or labile pools of shorter residence time.

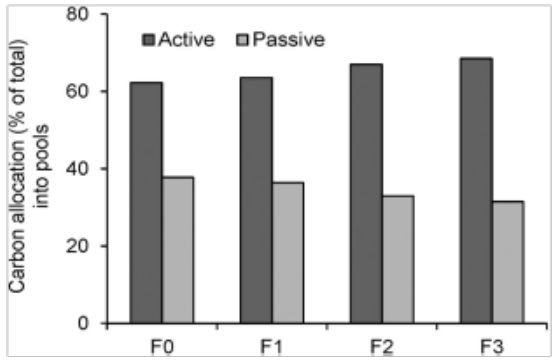


Fig 11. Allocation of soil organic C into active and passive pools. F0-Land cleared and cropped consecutive 2/3 years; F1 - young fallow; F2 - mid-aged fallow; and F3 - old fallow

Effect of bedding materials on performance of pig under climate resilient deep litter pig pan model

The performance of pigs reared in sheds with different flooring materials [concrete floor as control group (C), saw dust (T1), rice husk (T2), pine leaves (T3) and indigenous tree leaves available in the region (T4)] was evaluated in Basar, Arunachal Pradesh. Standard ratio was provided as per BIS standard. Monthly body weight was recorded. Higher body weight was found in concrete floor (control group), which was at par with that in saw dust (Fig 12). Saw dust was found relatively better substrate. Microbial activity in deep litter pig housing is shown in Fig 13.

Fig 12. Body weight gain under different substrate in deep litter pig housing

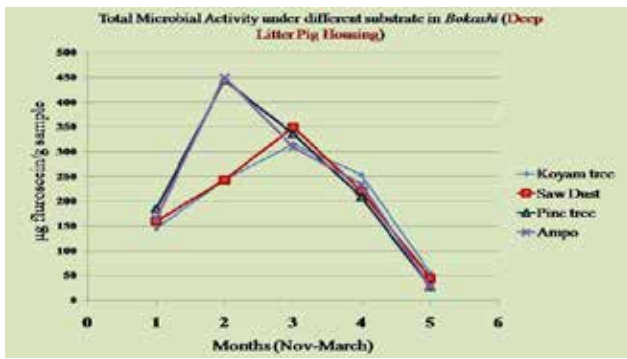


Fig 13. Microbial activity under different substrate in deep litter pig housing

Evaluation of physiological adaptation and performance of poultry germplasms in different agro-climatic conditions of NEH region

Performance of different poultry germplasms available in the NEH region were evaluated across the seasons under different housing systems. Irrespective of seasons, Vanaraja performed better followed by Gramapriya and Indigenous. In terms of growth rate and feed conversion ratio (FCR), chicks performed better in pre-monsoon compared to monsoon and post-monsoon seasons. Maximum chicks mortality took place during pre-monsoon and post-monsoon seasons, mostly due to relatively less average temperature and humidity compared to the monsoon season. Irrespective of types of bird, performance under raised floor housing system was found better compared to deep litter system (Fig 14).

Fig 14. Raised floor housing system

Evaluation of different breeds of poultry under different climatic conditions

A study was conducted in three distinct topographical locations of (i) Manchukha (high hill and altitude range: 2000-4000m msl) with average temperature ranging from -0.5 to 24.0°C, which comes under temperate to alpine zone, (ii) Basar (mid-hills and altitude range: 600-700m msl) with average temperature ranging from 2.0-36.0°C comes under subtropical-hill zone and (iii) Likabali (foothill and altitude range: 200-300m msl) with average temperature ranging from 5.0°C- 39.0°C that comes under tropical agro-climate zone. Bodyweight gain was the lowest in the foothill Likabali area followed by Menchukha. The Basar area showed the best growth compared to other study areas (Fig 15). During the hot season, the disease incidence/mortality rate was most prominent in Likabali followed by Basar and almost absent in Menchuka areas. The most prevailing diseases were Ranikhet and coccidiosis in these three locations. The mortality was highest in Menchukha due to excessive cold, while in Basar and Likabali, mortality rate was marginal.

Three variety of poultry breed *viz*., Vanaraja, Kamarupa and indigenous were evaluated for their performance under cold conditions. The data revealed that the body weight gain was highest in Vanaraja followed by Kamrupa. Also, feed intake and water intake was found to be the highest in Vanaraja, which was at par with Kamarupa. But, the FCR was found to be the highest in Kamarupa. While in Vanaraja, the ratio decline with age and found to be the lowest at maturity. The study revealed that all the birds take more feed with drop in temperature, which was more prominent in Kamarupa and Vanaraja, and almost steady in local. But the body weight gain in Vanaraja was steady and highest as depicted by FCR value. Thus Vanaraja was found to be most preferred variety.

Technology demonstrated in the farmers' field

The following technologies were demonstrated in the NICRA adopted village (Nongthymai)

- Low cost deep litter housing system for rearing pig
- Zero tillage cultivation of pea, lentil and rapeseed in rice furrows
- Rain water harvesting and its efficient utilization
- Resource conservation in Rice based cropping system
- Resource conservation in Maize based intercropping system
- Soil moisture conservation by land configuration (raised and sunken bed)
- Land-use model for hill slopes to enhance water and nutrient use efficiency

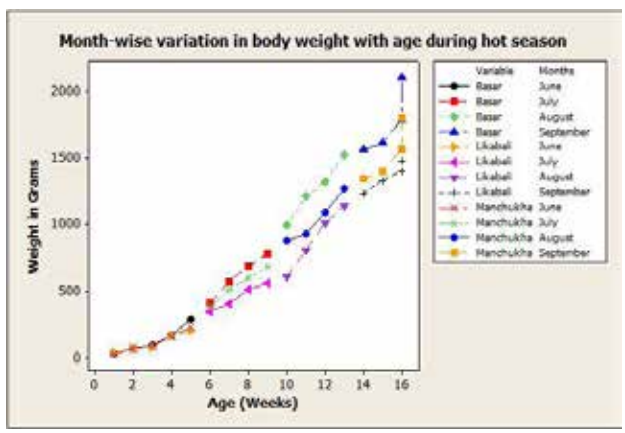


Fig 15. Month wise variation in body weight with age during hot season

TRIBAL SUB PLAN (TSP)

More than 17835 numbers of tribal farmers of North Eastern States were benefitted during 2016-17 by various livelihood improvement programmes conducted under Tribal Sub Plan (TSP). Two hundred seventy eight (278) numbers of different physical assets viz. low cost polyhouse (28), low cost pig shed (13), low cost poultry shed (13), vermi beds (87), *Jalkund* (47), pig breeding unit (20), integrated farming system model (6), mushroom demonstration unit (17), low cost rabbit unit (3), roof top water harvesting structure (7), fruit processing unit (1), concrete pig shelter (1), low cost goat rearing unit (1), deep litter pig shed (13), rain water harvesting structure (8), modern honey bee boxes along with accessories (7), oil expeller (3), turmeric grinder (2), diesel pump 5 HP (1) were developed/ provided in different tribal villages across North Eastern States of India.

Agricultural inputs like seeds, planting materials, fertilizers, bio-fertilizers, manures (Vermicompost, FYM, Compost and Neem cake), nutrient solutions, herbicides, pesticides and bio-pesticides etc. were distributed.

Besides these, seeds of millets (6 kg), job's tears (2 kg), beans (10 kg), lathyrus (3 kg), perilla (4 kg), sesamum (2.5 kg), rabi vegetables (2 kg), chilli (2.254 kg), brinjal (4.87 kg), pumpkin (9.5 kg), ridge gourd (2 kg), bottle gourd (8 kg), sponge gourd (6.6 kg), bitter gourd (14.6 kg), cucumber seeds (6.52 kg), beet root (16 kg), lettuce (3.25 kg), knol khol (1.25 kg) and capsicum (3.09 kg) were also distributed.

Distribution of planting materials

Planting materials of pineapple suckers (2000 nos.), sugarcane sets (105000 nos.), mango seedlings (150 nos.), banana (3450 nos.), guava (675 nos.), orange (8750 nos.), potato tubers (4685 nos.), garlic cloves (4 kg), large cardamom (208000 nos.), kiwifruit seedlings (11000 nos.), kiwifruit grafts (1350 nos.), Khasi mandarin seedlings (500 nos.), mandarin budded plant (1400 nos.), moringa cuttings (2200 nos.), papaya seedlings (600 nos.), bamboo seedlings (10000 nos.), plum seedlings (2400 nos.), lemon seedlings (10268 nos.), litchi seedlings (2990 nos.), coconut sapling (520 nos.), peach seedlings (610 nos.), sohshang seedlings (705 nos.), sohiong seedlings (185 nos.), jack fruit (90 nos.), gerbera seedlings (6000 nos.), broccoli seedling (2510 nos.), arecanut seedlings (1700 nos.), tree bean seedlings (950 nos.), cabbage seedlings (30 nos.), king chilli seedlings (950 nos.), turmeric seed rhizome (80460 kg), ginger seed rhizome (25000 kg), colocasia seed corms (2000 nos.), multipurpose trees (3000 nos.), cardamom suckers (5800 nos.), sweet potato cuttings (450 nos.), Naga king chili seedlings (600 nos.), cole crop seedlings (2000 nos.) and gerbera suckers (2375 nos.) were distributed among the famers.

Fertilizers/bio-fertilizer/manure/soil amendment/nutrient solutions/pesticides

Fertilizers-NPK (106500 kg), manures (37639 kg), bio-fertilizers (3876 kg), vermicompost (1015 kg), microbial compost (150 kg), lime (17195 kg), micronutrients (21 kg), elemental sulphur (40 kg), zinc sulphate (40 kg), borax (50 kg), bioorganic manures (50 kg), bio-fungicides in 100ml (30 nos.), *Streptocycts* 6 g packets (20 nos.), foliar spray (205 kg), neem cake (1600 kg), neem powder (50 kg), biochar (1550 kg), foliar spray (10 L), insecticides like neem oil of 1000ml bottles (20), phytoneem (333 L),

Table1. Seeds of cereal, pulses, oilseeds and vegetables distributed among the tribal farmers

Item	Quantity (kg)	Item	Quantity (kg)	Item	Quantity (kg)	Item	Quantity (kg)
Rice	9478	Soybean	3504	Lentil	11124	Radish, garden pea, cabbage, cauliflower	291
Maize	10915	Rajmah	5392	Field pea	14501	Coriander, onion, broccoli, spinach	336
Rice bean	1850	Pigeon pea	2700	Groundnut	1401	Rapeseed/mustard	350
Black gram	5475	French bean	1833	Broadbean	625	Tomato	402.5
Green gram	4021	Pahelo dal	1300	Black pepper	100	Cowpea, urd bean, carrot, okra, fenugreek	282

blitox (257.5 kg), bio-pesticides (210 kg), herbicides (10 L), stickers in 100 ml (30 nos.), tilt in 100ml pack (20 nos.), formaldehyde (15 L), cypermethrin (700ml), chlorpyriphos (500 ml), multineem (1000 ml), sulfex (12 kg), carbendazim (12), Dithane M 45 (4 kg), biopower (12.4 L), nimbecidine (4 L), biocure (15 L) and bio-pesticides (300 ml) were distributed among the tribal farmers for livelihood improvements. Apart from these inputs, polybags (189 kg) and spawn (700 kg) were distributed among the farmers for popularizing mushroom cultivation as a source of livelihood.

Livestock, fish fingerlings and antibiotics

A total of 425 nos. of improved breed of piglet, 67467 nos. of poultry chicks, 36 nos. of goat, 149700 nos. of fish fingerlings, 3000 nos. of earthworms, 11330 kg of feed supplements, 1020 kg of feed (animal/poultry), 6 kg of mineral mixtures, 90 kg of wheat bran were distributed among the tribal farmers for livelihood improvement. Antibiotic powder (6 packets), coccidiostat powder (6 packets), antibiotic liquid (3 bottles), 236 kg of medicines and mineral supplements for management of various animal diseases. Around 18 nos. of leaflet on pest management in Khasi language and rapid soil health testing kit (7 nos.) were also distributed.

Minor agricultural tools and implements

Minor agricultural tools and equipment's/ implements *viz.* hoe (51 nos.), spades (149 nos.), knapsack sprayers (190 nos.), grass cutter (16 nos.), khurpi (30 nos.), juicer (15 nos.), OTG oven (20 nos.), mixer grinder (20 nos.), fruit Juicers (15 nos.), poultry feeder (136 nos.), poultry drinker (36 nos.), plastic roll (17 nos.), cooking vessel (3 nos.), steel bowl (90 nos.), UV stabilized poly sheet (3 nos.), drill (1 no.), rose can (10 nos.), adjustable row marker (42 nos.), U-blade weeder (5 nos.), zero-till furrow opener (24 nos.), drums (13 nos.), tarpaulin sheets (3 nos.), thermometer (2 nos.), measuring cylinder (3 nos.), kitchen balance (2 nos.), buckets (3 nos.), straw cutter (10 nos.), briquette moulder (6 nos.), Dao (8 nos.), Bee box without bee (5 nos.), watering can (6 nos.), Gas Cylinder (1 no.), squash bottles (500 nos.), utensils (4 nos.), charcoal bag (9 nos.), dibblers (30 nos.), maize shellers (30 nos.), winnower (2 nos.) waterer for birds (100 nos.), plastic pipe (2.5 inch diameter 500 m, 0.5 inch diameter 6 roll), silpaulin sheet (34 nos.) and polyhouse sheet rolls (13 nos.) were also distributed among the tribal farmers.

Trainings and capacity building

Training and awareness programmes (232 nos.), front line demonstrations (1238 nos.), demonstration programmes (98 nos.) covering an area of 2219.6 ha were organized for capacity development in various fields of agriculture (crop production, animal production and management, mush room production, production and management of horticultural crops etc.). Training on household level food and nutritional supplement (20 nos.) was conducted. Two numbers of farmers club and four numbers of SHGs formed. A total of four (4) numbers of field days were organized under TSP project for the benefit of tribal farmers in different states of NE India.

HUMAM RESOURCE DEVELOPMENT

During the period under report w.e.f. April to December, 2016 following tasks have been done under Human Resource Management Unit of the Institute -

Participation in trainings (Category-wise)

Category	No. of Employees undergone training during the year 2016-17
Scientist	37
Technical	44
Administrative and Finance	2
Total	83

HRD fund allocation and utilization (Rs. In Lakhs):

BE 2016-17 for HRD			Actual Expenditure up to December, 2016 for HRD		
Plan	Non-Plan	Total	Plan	Non-Plan	Total
30.00	1.44	31.44	13.74	1.44	15.18

PUBLICATIONS

MEGHALAYA (HQ)

Research papers

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Other Publications (HQ)

Books	: 03
Book Chapters/Popular articles/electronic articles/Articles	: 23
Technical Bulletins/Training manuals/Folders/ Extension folders/leaflets/Success stories	: 24
Conference/Symposium presentation/Abstracts/ Papers presented/Conference Seminar proceedings	: 17

ARUNACHAL PRADESH CENTRE

Research papers

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Other Publications

Books	: 02
Book Chapters/Popular articles/electronic articles/Articles	: 16
Technical Bulletins/Training manuals/Folders/ Extension folders/leaflets/Success stories	: 06
Conference/Symposium presentation/Abstracts/ Papers presented/Conference Seminar proceedings	: 23

MIZORAM CENTRE

Research papers

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Other Publications

Book chapters/Proceedings/Abstracts/Popular article	: 03

NAGALAND CENTRE

Research papers

Babu S, Singh R, Avasthe RK, Yadav GS, Chettri TK and Rajkhowa DJ. 2016. Productivity, profitability and energetics of buckwheat cultivars as influenced by varying levels of vermicompost in acidic soils of Sikkim Himalayas, India. *Indian Journal of Agriculture Sciences* **86** (7): 844-848. (NR 2016: 6.17)

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Pandey R, Azad Thakur NS, Ngachan SV and Rajkhowa DJ. 2015. First record of wax beetle, *Platybolium alvearium* Blair (Coleoptera: Tenebrionidae), in Eastern Himalaya: A new threat to Indian honey bee (*Apis cerana fabricius*) colonies. *Journal of Entomological Research* **39** (3): 269-273. (NR 2016: 5.05)

Rajkhowa DJ**,** Sarma AK, Mahanta K, Saikia US and Krishnappa R. 2017. Effect of vermicompost on greengram productivity and soil health under hilly ecosystems of North East India. *Journal of Environmental Biology* **38** (1):15-19. (NR 2016: 6.53)

Sarkar D, Meitei Ch. B, Baishya LK, Das A, Ghosh S, Chongloi KL and Rajkhowa DJ. 2015. Potential of fallow chronosequence in shifting cultivation to conserve soil organic carbon in northeast India. *Catena* **135**:321-327. (NR 2016: 8.61)

Shamim SA, Rajkhowa DJ and Nanher AH. 2015. Influence of vermicompost and weed biomass incorporation on growth, yield and economics of rice. *Trends in Biosciences* **8** (9): 2325-2329. (NR 2016: 3.94)

Shamim SA, Rajkhowa DJ, Nanher AH and Kumar V. 2015. Nitrogen mineralization pattern in acidic soil amended with vermicompost and weed biomass. *Trends in Biosciences* **8** (15): 3761-3764. (NR 2016: 3.94)

Sharma H, Puro K, Kumar A, Mahanta N, Das M, Dewary RK, Rajkhowa DJ and Sen A. 2016. Impact of heat shock protein (HSP) expression in swine: A review. *Journal of Cell and Tissue Research* **16** (2): 5733-5735.

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Singh R, Babu S, Awasthi RK, Yadav GS and Rajkhowa DJ. 2016. Productivity, profitability and energy dynamics of rice under tillage and organic nitrogen management practices in rice-vegetable pea cropping system of Sikkim Himalayas. *Indian Journal of Agricultural Sciences* **86** (3): 326-330. (NR 2016: 6.17)

Other Publications

Books/ Book chapter/ Manual/ Bulletins	: 10
Popular Article	: 06
Success Stories	: 03

SIKKIM CENTRE

Research papers

Ahmed T, Islam R, Lone FA and Malik AA. 2016. Effect of washing on the post-thaw quality of cryopreserved ram epididymal spermatozoa. *Veterinary World* **9** (5): 519-523. (NR 2016: 5.71)

Avasthe RK, Babu S and Singh R. 2016. Organic pulses production in India: Perspectives and opportunities. *Indian Journal of Agronomy*. **61** (4th IAC Special Issue): 144-152. (NR 2016: 5.46)

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Das SK, Mukherjee I and Roy A. 2016. Alachlor and Metribuzin Herbicide on N_2-fixing Bacteria in a Sandy Loam soil. *International Journal of Bioresource and Stress Management* **7** (2): 334-338. (NR 2016: 4.65)

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Gopi R, Avasthe RK, Kalita H, Kapoor C, Yadav A, Babu S and Das SK. 2016. Traditional pest and disease management practices in Sikkim Himalayan Region. *International Journal of Bioresource Management* **7**(3):471-476. (NR 2016: 4.65)

Gopi R, Avasthe RK, Kalita H, Yadav A and Poudyal C. 2016. A new record of *Fusarium oxysporum* causing stem lodging, inflorescence and capsule rot in large cardamom, *Indian Phytopathology* **69** (3): 2-6. (NR 2016: 5.90)

Gopi R, Avasthe RK, Kapoor C and Kalita H. 2016. Organic management of White Rust of Mustard in Sikkim Himalaya. *Indian Journal of Plant Protection* **44** (1): 116-121. (NR 2016: 5.07

Gopi R, Avasthe RK, Yadav A and Kalita H. 2016. Biological soil disinfestation and biofumigation: Alternatives for chemical fumigation in organic farming. *Advances in Plants & Agricultural Research* **4** (2): 00135 doi:10.15406/apar.2016.04.00135.

Gopi R, Kalita H and Avasthe RK. 2016. Organic management of soft rot of ginger (*Zingiber officinale*) in Sikkim Himalayan region. *Indian Journal of Agricultural Sciences* **86** (12): 1586-1590. (NR 2016: 6.17)

Gudade BA, Babu S, Aage AB, Bora SS, Dhanpal K, Bhat S, Bhutia T and Singh R. 2016. Influence of *In-*

situ soil water conservation practices on growth, yield and economics of Large Cardamom under rainfed condition at North East India. *Journal of Experimental Agriculture International* **14** (3): 1-8.

Kalita H, Avasthe RK, Gopi R and Kapoor C. 2016. Seasonal abundance of Mustard aphid, *Lipaphis erysimi* (Kalt.) and Saw fly, *Athalia lugens proxima* (Klug) in relation to abiotic factors and their eco-friendly management. *International Journal of Bioresource and Stress Management* **7**(2): 252-257. (NR 2016: 4.65)

Kalita H, Avasthe RK, Gopi R, Yadav A and Singh M. 2016. Tea mosquito bug (*Helopeltis theivora*) and mealy bug, (*Paraputo theaecola*) – new threats to large cardamom. *Current Science* **110** (8):1390-1391. (NR 2016: 6.97)

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Rather HA, Islam R, Malik AA and Lone FA. 2016. Addition of antioxidants improves quality of ram spermatozoa during preservation at 4 °C. *Small Ruminant Research* **141**:24-28. (NR 2016: 7.08)

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Sharma M, Rana M, Sharma P and Das SK. 2016. Effect of different organic substrates and plant botanicals on growth and flowering of Chincherinchee (*Ornithogalum thyrosides* jacq). *Indian Journal of Hill Farming* **29** (2):72-74. (NR 2016: 4.39)

Singh M, Gupta B, Sarvade S and Avasthe RK. 2015. Biomass and carbon sequestration potential in different agroforestry systems in Giri catchment of North Western Indian Himalaya. *Indian Journal of Agroforestry* **17**(2): 42-48. (NR 2016: 4.53)

Other Publications

Abstract/Extended summary/Book chapters	: 12
Popular articles/Extension folders	: 05
Success Stories	: 05

TRIPURA CENTRE

Research papers

Debnath C, Sahoo L, Haldar A, Datta M, Yadav GS, Singha A and Bhattacharjee J. 2016. Proximate and mineral composition of freshwater snails of Tripura, North-East India. *Fishery Technology* **53**: 307-312. (NR 2016: 5.25)

Devi AG, Yadav GS, Devi HL and Ngachan SV. 2016. Effect of acute iron toxicity on key antioxidative enzymes in contrasting rice (*Oryza sativa* L.) cultivars of Northeast India. *International Journal of Bioresource and Stress Management* **7**(3): 388-392. (NR 2016: 4.65)

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Priyadarshi H, Das R, Kumar S and Kishore P. 2016. Analysis of variance, normal quantile-quantile correlation and effective expression support of pooled expression ratio of reference genes for defining expression stability. *Heliyon* (in press).

Priyadarshi H, Singh AA, Jamoh N, Chakraborty P, Bogi R, Singh SB, Mallik A, Mahendrajit A, Khuman ON, Paul T and Das R. 2016. Identification of key factor to negotiate spontaneous spawning of *Clarias batrachus* in confinement. *Fishery Technology* (in press). (NR 2016: 5.25)

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Other Publications

Abstract/Extended summary/Book chapters	: 03

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