वार्षिक प्रतिवेदन
ANNUAL REPORT
2022

भारतीय कृषि अनुसंधान परिषद्
उत्तर पूर्वी पर्वतीय कृषि अनुसंधान परिसर
उमियम-793 103, मेघालय

Indian Council of Agricultural Research
ICAR Research Complex for N.E.H. Region
Umiam-793103, Meghalaya

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Annual Report 2022

ICAR Research Complex for NEH Region

ISBN : 978-93-5967-409-4

Published by
Director
ICAR Research Complex for NEH Region
Umiam – 793103, Meghalaya, India

Correct citation
Annual Report 2022, ICAR Research Complex for NEH Region, Umiam, Meghalaya-793103 INDIA

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Cover design :
Cover images were generated using Deep Learning framework (Stable Diffusion XL) using text-to-image models (SD15NewVAEpruned checkpoint and sd_xl_refiner_1.0), run on a Windows computer with Intel Xeon CPU (32 GB RAM), nVIDIA GPU (4 GB vRAM)

Designed & Printed at :

Rumi Jumi Enterprise
6th Mile, Guwahati
Ph.No. 9864075734

PREFACE

ICAR Research Complex for NEH Region, located in Umiam, Meghalaya, is a premier institute for agricultural research in the north-eastern region of India. The institute's primary focus is on optimizing the utilization of natural resources to benefit the farming community of the region in a holistic manner. Additionally, the institute aims to develop new technologies to foster sustainable and climate-resilient growth in hill agriculture, which it then disseminates through its robust network of KVKs (Krishi Vigyan Kendras). Beyond its technological endeavours, the institute is actively engaged in skill development, capacity-building programs, and entrepreneurship development initiatives.

The institute boasts six regional centers, each situated in one of the hill states of north-eastern India, thereby establishing a presence across the entire northeast hill region. Alongside its 20 KVKs, these regional centers provide technical support to state governments in matters pertaining to both Central and State sector schemes related to farming, livelihood security, natural resource management, skill enhancement, and rural development.

During the reporting period, the institute developed numerous agro-technologies with the potential to significantly contribute to agricultural development in the region. In total, 26 novel technologies were developed, alongside the notification of 3 new crop varieties and the registration of 2 breeds. Furthermore, the dedicated efforts of the institute's scientists resulted in the publication of 21 books, 216 research papers in journals, 32 bulletins, and 129 popular articles. In pursuit of skill development for tribal farmers and enterprising youths in the region, the institute conducted 517 training sessions, as well as 134 on-farm trials and 168 front-line demonstrations. The institute, together with its KVK network, provided support to over 211,000 beneficiaries under various schemes, fostering the creation of a substantial amount of social capital and physical assets.

Within the framework of the Scheduled Tribe Component, the institute successfully demonstrated and distributed more than 1300 physical assets, including low-cost poly-houses, poultry sheds, pig sheds, mushroom units, *Jalkunds*, vermi-beds, duckery units, processing units, and hatchery units among various stakeholders. On the research front, the institute effectively managed 95 in-house projects, 84 externally funded projects, and 12 AICRPs (All India Coordinated Research Projects). Remarkably, a budget utilization efficiency of 100% was achieved.

I would like to take this opportunity to express my appreciation to everyone within the ICAR NEH team, including the Heads of the Regional Centers, Heads of the Divisions, Scientists, Technical staff, Administration, Finance personnel, and Supporting personnel, for their dedicated contributions to the institute's growth despite the many challenges. I also extend my acknowledgment to the senior officials of ICAR, New Delhi, for their invaluable support and guidance.

(Vinay Kumar Mishra)
Director

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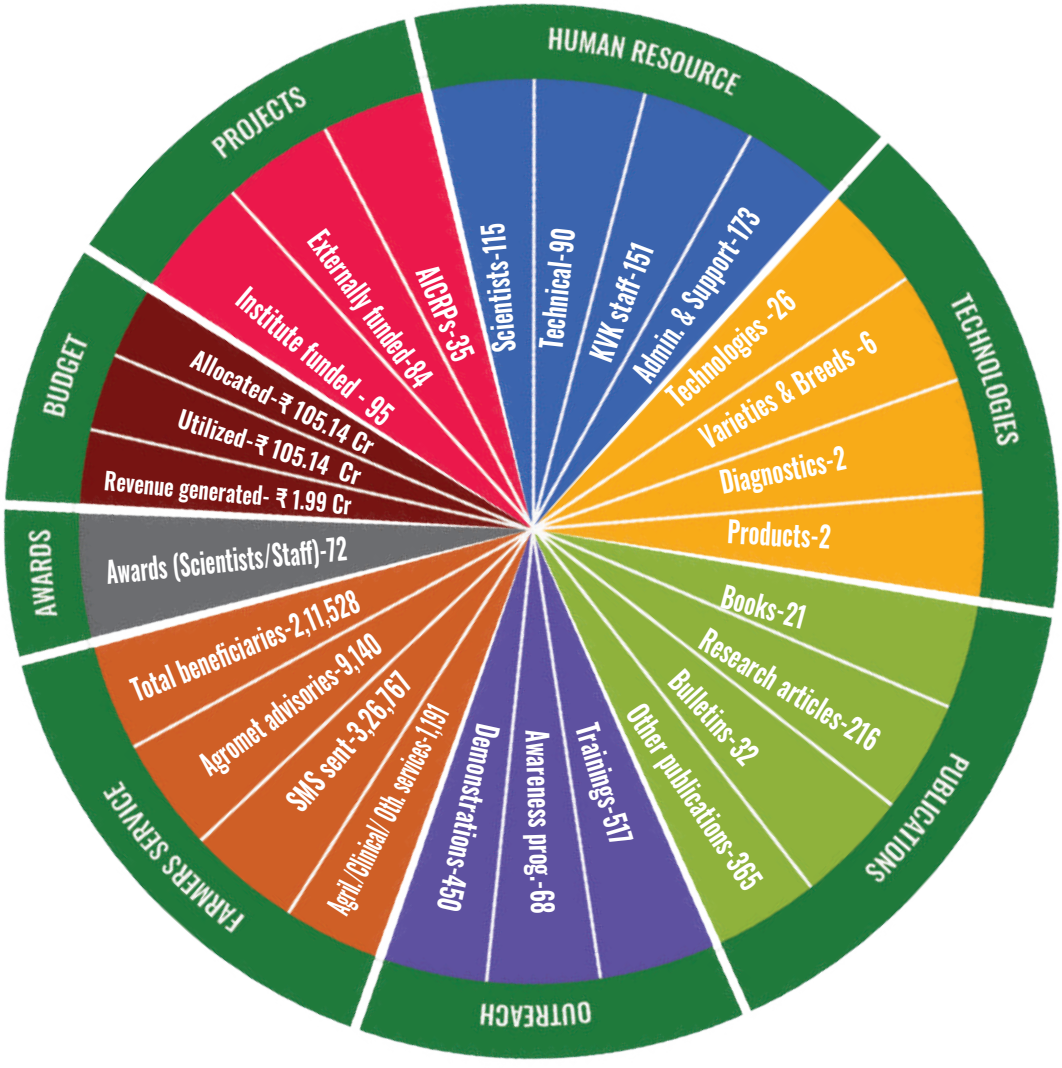
ICAR NEH

in Numbers



कार्यकारी सारांश

भारतीय कृषि अनुसंधान परिषद के उत्तर पूर्वी पर्वतीय अनुसंधान परिसर, उमियम, मेघालय में वर्ष 2022 के दौरान कुल 137 वर्षा दिवसों में कुल 2260.8 मिमी वार्षिक वर्षा दर्ज की गई। इसमें से 80 वर्षा दिवसों 1219 मिमी वर्षा मानसून के दौरान हुई जो में होने वाली कुल वार्षिक वर्षा का 54% है। विशेष रूप से, मार्च, अप्रैल, जुलाई, अगस्त, सितंबर, नवंबर और दिसंबर माह में दीर्घावधि के औसत (एलपीए) की तुलना में काफी कम वर्षा प्राप्त हुई। पूरे वर्ष के दौरान कुल वर्षा सामान्य से लगभग 8% कम हुई, जबकि मानसूनी वर्षा लगभग 22% कम हुई। दिसंबर से फरवरी को छोड़कर अधिकांश महीनों में अधिकतम औसत तापमान (T_{max}) 28.9 ^{0}सें0 से 25.2 ^{0}सें0 के बीच था जबकि दिसंबर से फरवरी में यह 22.1 ^{0}सें0 से 19.0 ^{0}सें0 के बीच था। दूसरी ओर, औसत न्यूनतम तापमान (T_{min}) जुलाई और अगस्त में 20.8 ^{0}सें0 के शिखर पर पहुंच गया, जबकि फरवरी में यह अपने सबसे निचले बिंदु पर पहुंच गया तथा तापमान गिरकर 7.1 ^{0}सें0 पर आ गया। सुबह और शाम के समय, सापेक्षिक आर्द्रता (आरएच) की तुलना करने पर सुबह के समय आरएच में परिवर्तन सायंकाल की अपेक्षा उल्लेखनीय तौर पर कम स्पष्ट था। प्रात:कालीन सापेक्षिक आर्द्रता (आरएच) जून में 91.7% से मार्च में 74.8% के बीच थी, जबकि सायंकालीन सापेक्षिक आर्द्रता मार्च में 42.6% से लेकर जून में 90.1% के बीच पाई गई। सभी महीनों में हवा की औसत गति लगातार सामान्य से नीचे बनी रही जो 6% से लेकर 74% तक कम थी। पिछले कुछ वर्षों में इस क्षेत्र में हवा की गति में लगातार कमी होने की प्रवृत्ति देखी गई है।

बदलते जलवायु पैटर्न के बावजूद इस संस्थान ने पूर्वोत्तर पर्वतीय क्षेत्र में कृषि एवं इससे संबद्ध क्षेत्रों के समग्र विकास को बढ़ाने के महत्वपूर्ण प्रयास किए हैं। मेघालय के उमियाम स्थित संस्थान मुख्यालय में प्रणाली अनुसंधान एवं अभियांत्रिकी प्रभाग (सिस्टम रिसर्च एंड इंजीनियरिंग डिवीजन) के तहत कई उपलब्धियाँ हासिल की गईं। इनमें कम लागत वाली हाइब्रिड हल्दी ड्रायर (30 किग्रा) और पैर-चालित राइज़ोम वॉशर (79 किग्रा/घंटा) का विकास शामिल है। इसके अलावा, संस्थान ने किसानों के बीच 1352 मौसम-आधारित कृषि-परामर्शों का सफलतापूर्वक प्रसारण किया। अलग-अलग आईएफएस मॉडलों का उपयोग करके मृदा क्षरण एवं अपवाह (रनऑफ) का अनुमान लगाया गया, जिससे पता चला कि अन्य प्रणालियों की तुलना में कृषि प्रणाली में कम अपवाह और गाद (सेडीमेंट) की मात्रा पाई गई। इसके साथ ही अनेक प्रकार के आईओएफएस मॉडलों का मानकीकरण करके किसानों के साथ उन्हें साझा किया गया। मेघालय में कदन्न (मोटे अनाजों) उत्पादन की तकनीक संस्थापित की गई जिसे प्राकृतिक खेती पर आधारित एक अनुसंधान परियोजना के साथ प्रारंभ किया गया। गुठली युक्त और पोम फलों के लिए स्थानीय प्रकंद (आरसी पीच 1) की पहचान तथा आरसी-एलएम-ईएल-3 के रूप में चिह्नित नींबू जीनोटाइप की पहचान का कार्य पूरा किया गया। गुठली युक्त एवं पोम फलों की सधाई (ट्रेनिंग) के लिए वाई-आकार की जाली जैसे नवोन्मेषों को तैयार किया गया। मेघालय में खासी मंडारिन के 60 बागों को शामिल करते हुए एक व्यापक सर्वेक्षण किया गया। इसके अतिरिक्त, नींबू की एक संकटग्रस्त प्रजाति साइट्रस इंडिका के प्रवर्धन (प्रोपेगेशन) के लिए वेज ग्राफ्टिंग विधि का निर्धारण किया गया। फ्रेंच बीन (145), लोबिया (28), इंडियन बीन (125), किंग चिली (29), और कम उपयोग में लाए गए कद्दूवर्गीय (60) सब्जियों सहित अनेक सब्जियों के जीनरूपों (जीनोटाइप) के मूल्यांकन के फलस्वरूप आशाजनक स्ट्रेनों (उपभेदों) की पहचान संभव हुई। विशेष रूप से अदरक की दो प्राप्तियों (आरसीवीबीजी-1 एवं आरसीएमएलजी-1) को एमएलटी (बहुस्थानीय परीक्षण) के लिए भेजा गया। एंथ्यूरियम के लिए प्रमाणिक मिट्टी रहित माध्यम का विकास एक और उपलब्धि है। इसके साथ ही मेघालय के लिए मक्का - फलीदार फसलों की अंत:फसल की सबसे प्रभावी विधियों और पोषक तत्व प्रबंधन रणनीतियों की पहचान की गई। अम्लीय मृदा में फूलगोभी की खेती के लिए एक विशेष सूक्ष्म-पोषक युक्त पैकेज तैयार किया गया। इसके अलावा, मक्का-फलीदार फसलों की खेती में मल्चिंग (पलवार बिछाने) करने पर जल उपयोग दक्षता में वृद्धि देखी गई, जिससे उसके बाद बोई गई मक्का, सोयाबीन और फ्रेंच बीन की पैदावार को ईष्टतम करने में सफलता मिली। इसके अलावा,सूक्ष्म-पोषक गोबर की खाद (एफवाईएम) के उपयोग से बारानी (वर्षाश्रित) हल्दी की उत्पादकता में 92% की उल्लेखनीय वृद्धि हुई।

फसल विज्ञान प्रभाग के तहत संचालित अनुसंधान गतिविधियों में चावल की कई उन्नत किस्मों की पहचान की गई जिनसे विशेष रूप से आरसीपीएल 1-448 (3.5 टन/हेक्टेयर), आरसीपीएल-1-440 (3.5 टन/हेक्टेयर), आरसीपीएल 1-443 (3.7

टन/हेक्टेयर), आरसीपीएल-1-441 (3.4 टन/हेक्टेयर), आरसीपीएल 1-446 (3.8 टन/हेक्टेयर), आरसीपीएल-1-444 (3.7 टन/हेक्टेयर), आरसीपीएल 1-442 (3.4 टन/हेक्टेयर) हेक्टेयर) और आरसीपीएल 1-450 (3.3 टन/हेक्टेयर) किस्मों से प्रति पौधा बढ़ी हुई उपज प्राप्त हुई जिन्हें बाद में हैदराबाद में अखिल भारतीय समन्वित अनुसंधान परियोजना (एआईसीआरआईपी) के प्रारंभिक किस्म परीक्षणों (आईवीटी) के लिए नामित किया गया। एसएसआर मार्करों, अर्थात् एपी 4007, एपी 56595, सी 1454 और आरएम 208 की चावल प्रध्वंश प्रतिरोधी गुणों के साथ सम्बद्धता को भी स्थापित किया गया। चावल की भालुम-3, भालुम-5, और वरधान किस्मों ने फॉस्फोरस के न्यून स्तरो के प्रति उल्लेखनीय सहनशीलता प्रदर्शित की। एल्यूमिनियम सहिष्णुता के प्रति स्क्रीनिंग की सुविधा के लिए विशेष तौर पर मैग्नावाका सॉल्यूशन (घोल) पर आधारित एक संशोधित अमोनियम नाइट्रेट-मुक्त फॉर्मूला विकसित किया गया। मसूर की जल्दी पकने वाली जीनरूपों की पहचान में डीपीएल-15 (डीएएस), डीपीएल-62 (डीएएस) और आईपीएल-81 (95 डीएएस) शामिल हैं। जलवायु-स्मार्ट चावल की किस्मों को विकसित करने की पहल में सीआर धान 801 के साथ शासारंग की क्रॉसब्रीडिंग सम्पन्न की गई। मेघालय के भिंडी के नमूनों के आण्विक विश्लेषण में लेपिडोप्टेरा ऑर्डर के भीतर नोक्टुइडे कुल से संबंधित हिबिस्कस कैटरपिलर, ज़ैंथोड्स ट्रांसवर्सा की नई भौगोलिक वितरण की स्थिति पाई गई। विभिन्न कुलों (फेमिलीज) एवं कीट क्रमों (आर्डर) का प्रतिनिधित्व करने वाले अनेक प्रकार के कीट आगंतुकों को देखा गया। इस समूहन में हाइमनोप्टेरा ऑर्डर की 4 कीट प्रजातियाँ, डिप्टेरा की 13 प्रजातियाँ, लेपिडोप्टेरा की 4 प्रजातियाँ, हेमिप्टेरा की 2 प्रजातियाँ और कोलोप्टेरा की 2 प्रजातियाँ शामिल थीं, जिन्हें मुक्त परागण स्थितियों के तहत दिन के उजाले के दौरान लीची के पुष्पों पर मंडराते और उनसे पराग ग्रहण करते पाया गया। उन्नत जैविक दक्षता वाले ऑयस्टर मशरूम(प्लुरोटस पल्मोनारियस) के उपभेदों की सटीक पहचान की गई। प्रयोगशाला (इन विट्रो) में जांची गई 20 ट्राइकोडर्मा प्रजातियों में से दो ने मृदा-जनित कवक रोगाणु स्क्लेरोशिनिया स्क्लेरोशियोरम के विरुद्ध उल्लेखनीय विरोधी क्षमता प्रदर्शित की। नींबू प्रजाति के पौधों ने एनपीके उर्वरकों और सूक्ष्म पोषकों (जिंक और बोरॉन) की अनुशंसित खुराक के अनुप्रयोग के प्रति स्पष्ट प्रतिक्रिया दिखाई जिससे प्रति वृक्ष फलों की संख्या में 26% की उल्लेखनीय वृद्धि पाई गई।

वर्ष 2022 में पशु एवं मत्स्य विज्ञान अनुसंधान में उल्लेखनीय प्रगति दर्ज की गई। अनुसंधान के तहत स्वदेशी पशुओं एवं मत्स्य के संरक्षण और संवर्द्धन पर विशेष ध्यान केंद्रित किया गया जिसके परिणामस्वरूप प्रतिवेदित अवधि के दौरान मेघालय में पाई जाने वाली स्वदेशी नस्लों के रूप में गोपशु की "मैसिलम" और सुअर की "वाक चम्बिल" नस्ल का पंजीकरण कराया गया। मत्स्य संरक्षण के प्रयासों में दो स्थानिक मत्स्य प्रजातियों, चॉकलेट महसीर (नियोलिसोचिलस हेक्सागोनोलेपिस) और रेबा कार्प (सरहिनस रेबा) का संग्रह किया गया। प्रजनन क्षमता में वृद्धि को ध्यान में रखते हुए पशुधन और मत्स्य के वीर्य की गुणवत्ता एवं क्रायोस्टोरेज (हिमपरिरक्षण) दशाओं में सुधार लाने के उद्देश्य से तकनीकों को और अधिक परिष्कृत करने के प्रयास किए गए। रोग निदान के लिए विश्व स्वास्थ्य संगठन के "एश्योर्ड" मानदंडों के अनुरूप ब्रुसेलोसिस और अफ्रीकी स्वाइन फीवर की पहचान के लिए नैदानिक किट विकसित किए गए। पूर्वोत्तर के सभी राज्यों में ब्रुसेलोसिस, एलएसडी, जेई, एएसएफ, पीआरआरएस, क्रिप्टोस्पोरिडिओसिस, क्यू फीवर, टीबी, स्वाइन इन्फ्लुएंजा और सिस्टिसरकोसिस जैसे रोगों को शामिल करते हुए पशुजनित और सार्वजनिक स्वास्थ्य की दृष्टि से महत्वपूर्ण पशु रोगों की व्यापक सीरो-निगरानी की गई। इसके अलावा, महत्वपूर्ण पशु रोगों, पशु एवं कुक्कुट (पोल्ट्री) परजीवियों के निदान के लिए नैदानिकी प्रयोगशाला को क्रियान्वित किया गया। विषैले एवं बहुऔषध-प्रतिरोधी स्टैफिलोकोकस ऑरियस जीवों के संभावित संचरण को समझने के प्रयास में कृंतक और छछूंदर जैसे पशुजन्य रोगाणुओं के भंडार की जांच की गई। वैक्सीजेनिक प्रोटीन, प्रोबायोटिक्स और हर्बल संपूरकों द्वारा लक्षित दृष्टिकोणों के माध्यम से पशुओं एवं मत्स्य का प्रतिरक्षा मॉड्यूलेशन जानने का प्रयास किया गया। पहाड़ी किसानों की आजीविका में वृद्धि लाने के लिए पशुधन आधारित सतत एकीकृत सामूहिक (क्लस्टर) खेती को नियोजित किया गया। इस पहल में हस्तक्षेप, आदानों (इनपुट) के वितरण, व्यावहारिक प्रशिक्षण और जागरूकता कार्यक्रमों के माध्यम से पूर्वोत्तर राज्यों के सात महत्वाकांक्षी जिलों में सुअर पालन उद्यमिता को बढ़ावा देना शामिल रहा है। मछली उत्पादन को इष्टतम स्तर पर लाने के लिए पूर्वोत्तर क्षेत्र में विभिन्न मत्स्य पालन प्रणालियों और पिंजड़ा पालन सहित कई प्रकार की विधियां अपनाई गईं और उनकी उपयुक्तता का मूल्यांकन किया गया। उन्नत पशुधन और कुक्कुट नस्लों को लोकप्रिय बनाने के लिए कई प्रकार के कार्यक्रमों का संचालन किया गया ताकि मांस, दूध, अंडा और मछली उत्पादन में वृद्धि प्राप्त की जा सके। लाभार्थियों को काफी संख्या में उन्नत चूजे (22,000 से अधिक) और 548 संकर सुअरशावकों (क्रॉसब्रेड पिगलेट) का वितरण किया गया और इसके साथ ही कॉमन कार्प, कटला, रोहू, गोनियस, जावा पुथी, ग्रास कार्प और अन्य प्रजातियों के 150,000 मछली के जीरों (फिश सीड) का वितरण विभिन्न परियोजनाओं के तहत किया गया।

प्रौद्योगिकी मूल्यांकन एवं क्षमता निर्माण प्रभाग के अनुसंधान प्रयासों से भी इस अवधि के दौरान सकारात्मक परिणाम प्राप्त हुए। मेघालय के री-भोई जिले में किफायती मुर्गी पालन (बैकयार्ड) और उच्च उपजशील चावल की किस्मों पर जानकारी प्राप्त करने के लिए किसानों के सामाजिक दायरे की जांच में औपचारिक संचार स्रोतों, विशेष रूप से कृषि विज्ञान केंद्र (केवीके) कर्मियों की सार्थकता को रेखांकित किया। आलू के मूल्य के पूर्वानुमान के संदर्भ में, AR(2)-GARCH(1,1)-NOINT मॉडल को माविओंग विनियमित बाजार, मेघालय के लिए सबसे उपयुक्त मॉडल के रूप में पहचाना गया। प्रौद्योगिकी प्रसार के तरीकों पर गहन चर्चा के दौरान एक अध्ययन से यह स्पष्ट होता है कि वैज्ञानिकों द्वारा सबसे अधिक नियोजित तरीकों के रूप में प्रशिक्षण और प्रदर्शन को पाया गया है। स्व-स्थाने सूक्ष्म वर्षा जल संचयन संरचनाओं (जलकुंड) के लाभों और प्रभावों की जांच से संबंधित अध्ययनों में इस बात का संकेत मिलता है कि किसान जलकुंड सिंचाई का उपयोग करके लगभग 450 वर्ग मीटर क्षेत्र की सिंचाई करने में सक्षम पाए गए। कम लागत वाली जलकुंड प्रौद्योगिकी को अपनाने से किसानों की घरेलू आय में रु. 1,45,000/- से रु. 1,91,125/- तक की समग्र वृद्धि पाई गई। डीएसटी-वित्त पोषित परियोजना के तहत ब्लॉक-स्तरीय संवेदनशीलता विश्लेषण में पश्चिम खासी हिल्स जिले के नोंगस्टोइन ब्लॉक को चार ब्लॉकों में सबसे संवेदनशील (वल्नेरेबल) पाया गया। फार्मर फर्स्ट (किसान प्रथम) परियोजना में 08 स्पष्ट मॉड्यूलों के आधार पर इंटरवेंशन (हस्तक्षेप) किया गया जिससे 300 से अधिक किसानों को लाभ हुआ। उल्लेखनीय हस्तक्षेपों में चावल की परती भूमि में सलाद पत्ता, पत्तागोभी, ब्रोकोली, मटर और धनिया जैसी रबी सब्जियों को उगाना, सुअर प्रजनन इकाइयों की स्थापना, मशरूम स्पॉन का उत्पादन तथा कस्टम हायरिंग केंद्र में कुक्कुट पालन इकाई (पोल्ट्री हैचरी यूनिट) की स्थापना शामिल है। प्रतिवेदित अवधि में 16 से अधिक क्षमता-निर्माण कार्यक्रमों को बेहतर तरीके से संचालित किया गया और इस संपूर्ण अवधि के दौरान लगभग 29 प्रकाशन निकाले गए।

उत्तर पूर्वी पर्वतीय कृषि अनुसंधान परिसर के क्षेत्रीय केंद्रों में सबसे दूर स्थित होने के बावजूद अरुणाचल प्रदेश केंद्र के वैज्ञानिकों द्वारा किए गए अनुसंधान प्रयासों के सफल परिणाम प्राप्त हुए हैं। इस मौसम के दौरान कुल 3136.9 मिमी वार्षिक वर्षा प्राप्त हुई जो सामान्य से 27 प्रतिशत अधिक थी। इस पूरी अवधि में कुल 128 वर्षा दिवस गिने गए जो सामान्य 143 वर्षा दिनों की अपेक्षा 16 दिन कम थे। इस अवधि के दौरान औसत सापेक्षिक आर्द्रता (आरएच) लगातार 70% से ऊपर बनी रही। फॉस्फोरस (P) की दो अलग-अलग मात्राओं (0 और 40 किग्रा पी2ओ5 एच-1) को प्रयुक्त करने पर चावल के कई जीनरूपों (जीनोटाइप) जिनमें अमहाम (35.3 क्विं/हे0), चंची (32.5 क्विं/हे0), पांगिन (31.3 क्विं/हे0), आरे लाई (30.5 क्विं/हे0), अमलुम (30.5 क्विं/हे0), पुमदे (29.2 क्विं/हे0), रियू एम्मो (28.5 क्विं/हे0), और एम्टम (26.0 क्विं/हे0) शामिल हैं, ने आशा के अनुरूप प्रदर्शन किया। लेपराडा क्षेत्र के तिरबिन सर्कल में कई झूम भूमियों से लिए गए मृदा के नमूनों और जीपीएस आंकड़ों के विश्लेषण से पता चलता है कि झूम चक्र, ऊंचाई की स्थिति और अंतर्निहित स्थान का उल्लेखनीय प्रभाव होता है। कम लागत वाले वर्षा आश्रय (रैन शैल्टर) के संदर्भ में शिमला मिर्च - लौकी - पालक से जुड़े फसल क्रम में उच्चतम उपज और आय प्रदर्शित हुई। टमाटर की फसल में जैविक विधियों द्वारा लेट ब्लाइट रोग का प्रबंधन प्रभावी ढंग से किया गया जिसमें 6 दिन के अंतराल पर 2.5 ग्राम/लीटर कॉपर ऑक्सीक्लोराइड के छिड़काव पौधे के छत्र (कैनोपी) पर करने तथा मृदा में काली पॉलिथीन (30 माइक्रोन) की पलवार (मल्चिंग) बिछाकर किया गया। अदरक की सर्वाधिक उपज सिन्नामोमम कैम्फोरा (14.2 टन/हे0) के पौधों में दर्ज की गई और तत्पश्चात इसे बहु उद्देश्यीय वृक्षों (एमपीटी) के अंतर्गत एक अंत:फसलीय अध्ययन में टर्मिनेलिया मायरियोकार्पा (12.3 टन/हे0) में पाया गया। पशुधन एवं मुर्गीपालन में होने वाले व्यावसायिक जोखिमों पर किए गए एक अध्ययन से पता चला है कि पशुधन प्रबंधन की विभिन्न प्रक्रियाओं के दौरान अंगू गांव के किसानों द्वारा महसूस की गई सबसे सामान्य शारीरिक परेशानियों में पीठ के निचले हिस्से में बहुत गंभीर दर्द (37.13%), आई, लोगम (34.28%), पाकम (31.42%) और (28.52%) को सूचित किया गया। लगभग 13.17% (27/205) गोपशुओं, 73.33% (11/15) मिथुन पशुओं, 84.31% (43/51) बकरियों और 83.56% (61/83) सूअरों में जठरआंत्रीय (गैस्ट्रोइंटेस्टाइनल) परजीवियों की पहचान की गई। गोपशुओं, मिथुन और बकरियों में पाए जाने वाली प्रमुख परजीवी प्रजातियाँ में स्ट्रॉन्गाइल, एइमेरिया, मोनीज़िया और एम्फ़िस्टोम को पाया गया। अन्य उल्लेखनीय उपलब्धियों में फ्री जियोस्पेसियल डेस्कटॉप एप्लिकेशन गूगल अर्थ प्रो के उपयोग से आईसीएआर अनुसंधान फार्म, गोरी हेतु एक जीआईएस मानचित्र को तैयार करना शामिल है। इस जीआईएस मानचित्र में 8192*4643 पिक्सल का अधिकतम रिज़ॉल्यूशन था और जो हवाई चित्र (एरियल इमेज) में मौजूद विशेषताओं के साथ-साथ उनके संबंधित क्षेत्रों का सटीक प्रतिनिधित्व करता था।

संस्थान के मणिपुर केंद्र ने भी प्रतिवेदित अवधि के दौरान अपनी अनुसंधान गतिविधियों में उल्लेखनीय प्रगति की। विशेष रूप से काले चावल की 02 अर्ध-बौनी मध्यम परिपक्व वंशावलियों

जिनमें आरसीएमबीआर 3 और आरसीएमबीआर 5 शामिल है, ने स्थानीय चेक किस्म चखाओ एमुबी एवं चखाओ पोरीटोन को पीछे छोड़ कर 59.8% की बेहतर उपज / लाभ दिखाया। चखाओ पोरिटोन तथा चखाओ एमुबी के बीच अंतर करने के लिए 06 एसएसआर मार्कर्रों (आरएम 12293, आरएम 19303, आरएम 20948, आरएम 7311, आरएम 24071, और आरएम 18239) के एक सेट की पहचान की गई। चखाओ और सीआर धान 801 के बीच संकरण (क्रॉस) से Pi54 और OsSPL14 जीनों को शामिल करते हुए 16 वंशावलियों (लाइंस) के विकास ने अलग-अलग ब्लैक ग्रेन एंथोसायनिन अंश को प्रदर्शित किया जिसका रेंज 240.31 से 1.35 मिग्रा/100 ग्राम नमूने तक था। इसके अलावा, चखाओ की 15 स्थानीय किस्मों (लैंडरेसेज) की पहचान की गई, जिनमें से प्रत्येक में Sub1A और Sub1C जीनों के पॉजिटिव एलील (सकारात्मक युग्मविकल्पी) पाए गए। मणिपुर में ब्लैक राइस की जैविक खेती के लिए 6 टन/हे0 की दर से एफवाईएम + वर्मी कम्पोस्ट 1 टन/हे0 की दर से + सेसबानिया सहित हरी खाद को 25 किग्रा/हे0 की दर से प्रयुक्त करने की सिफारिश की जाती है। विशेष रूप से टिलरिंग और दाना भरने की अवस्था में 20 किग्रा/हे0 की दर से जिंक सल्फेट का आधारीय (बेसल) प्रयोग तथा दो पर्णीय छिड़काव के फलस्वरूप सभी परीक्षणाधीन ब्लैक राइस की किस्मों में दानों की उपज में सर्वाधिक वृद्धि हुई। एस. अंडरेटम, आईसी 394877, आईसी 090084, आईसी 420656 और आईसी 090869 सहित बैंगन के कुछ जननद्रव्यों (जर्मप्लाज्म) ने बैक्टीरियल विल्ट (जीवाणु मुरझान) के प्रति मध्यम सहिष्णुता प्रदर्शित की। मटर, ब्रॉडबीन, पत्तागोभी, फूलगोभी और ब्रोकोली पर प्रयुक्त कीटनाशक अवशेषों (लैम्ब्डा-साइहलोथ्रिन, क्लोरेंट्रानिलिप्रोल और फिप्रोनिल) पर लिए गए प्रेक्षणों में इनके 7वें दिन तक बने रहने का संकेत मिलता है। फिप्रोनिल को छोड़कर अन्य अवशेषों को 2% NaCl के घोल से संक्रमणरहित (35-40%) किया जा सकता है। उपचार के 48 घंटे बाद तक 40,000 पीपीएम पर इसेंसिशल तेल, एल्शोल्ट्ज़िया ग्रिफ़िथी के साथ उपचारित करने पर चावल के घुन, सिटोफिलस ओराइजी पर किसी प्रकार की संपर्क विषाक्तता नहीं देखी गई। अदरक के सॉफ्ट रॉट (मृदु गलन) के प्रबंधन हेतु पांच ट्राइकोडर्मा प्रजातियां (टी. एस्पेरेलम, टी. एट्रोविरिडे, टी. हार्ज़ियानम, टी. लॉन्गिब्राचियाटम और टी. एरिनेसम) अत्यधिक प्रभावी पाई गईं और जीसी-एमएस विश्लेषण ने 1-पेंटाडेसीन और 13-16-ऑक्टाडिकेडिओनिक अम्ल की उपस्थिति को प्रकट किया। एम्ब्रोसिया की 07 भृंग (बीटल) प्रजातियों की उनके फ्युजेरियम प्रजाति के सहजीवियों (सिंबॉयोएंट) के साथ पहचान ट्री बीन के क्षय में उनकी भूमिका पर प्रकाश डाला। मीलवर्म (टेनेब्रियो मोलिटर) से बने आहार से पोषित कार्प स्पॉन ने गैरउपचारित (कंट्रोल) वर्ग की तुलना में स्पष्ट वृद्धि को प्रदर्शित किया। विशेष रूप से सूअर के मांस से अलग किए गए एक ई. कोलाई आइसोलेट जो 19 एंटीबायोटिक दवाओं के प्रति प्रतिरोधक है का परीक्षण किया गया जिसे blaNDM-1 (एक्सेसन नंबर OP006128) के प्रति सकारात्मक पाया गया। इसके अतिरिक्त, आहार में 10% एइकचोर्निया क्रैसिप्स शामिल करने से अंडों में सीरम कुल प्रोटीन (4.04 ग्राम/डीएल) और सीरम एल्ब्यूमिन (1.67 ग्राम/डीएल) का स्तर काफी बढ़ गया। एक महत्वपूर्ण जानकारी से स्पष्ट होता है कि झुमिया किसान अपने खर्च का लगभग 85% भूमि की तैयारी, बुआई, अंतरकृषि प्रक्रियाओं के संचालन, फसल की कटाई एवं मंड़ाई के लिए खेतिहर मजदूरों को काम पर रखने में खर्च करते हैं।

मिजोरम के तराई क्षेत्र में किए गए चावल परीक्षणों से उल्लेखनीय निष्कर्ष प्राप्त हुए। चावल की गोमती किस्म में सर्वाधिक दानों की उपज की प्राप्ति हुई और तत्पश्चात इसे आरसीएम 10 किस्म का स्थान था। उपराऊं (अपलैंड) भूमि में मक्का या चावल की फसल को राइसबीन के साथ अंत:फसल के रूप में लगाने और बुआई के 20 दिन बाद (डीएएस) हाथ से निराई करने पर खरपतवार का प्रभावी प्रबंधन प्राप्त हुआ। संग्रह और संरक्षण अभियान के अंतर्गत जंगली मशरूम की 85 प्रजातियाँ, विंग्ड बीन की 36 किस्में, 9 प्रकार के पेरिला, 3 प्रकार के जॉब्स टियर, 8 प्रकार के अदरक, 2 प्रकार की काली हल्दी और जंगली हल्दी, काला अदरक और मैंगो जिंजर की एक-एक किस्म का संकलन किया गया। इनमें MZWB-L2 किस्म विशेष रूप से उल्लेखनीय है जिसकी फली की लंबाई 53.12 सेमी तक होती है। अदरक को प्रभावित करने वाले लीफ ब्लाइट (एक्सेरोहिलम रोस्ट्रेटम) जैसी नई बीमारियाँ साथ ही जॉब्स टीयर को प्रभावित करने वाले सामान्य सेरुलियन तितली (जेमाइड्स सेलेनो) और फॉल आर्मीवर्म (एफएडब्ल्यू) की उपस्थिति भी चिंता का विषय है। विभिन्न प्रकार के भू-उपयोगों में किए गए मृदा विश्लेषण में उपलब्ध फॉस्फोरस (पी) के न्यून अंश (1.5 से 9.5 मिग्रा/किग्रा) का संकेत मिलता है, जबकि कुल फॉस्फोरस (पी) की मात्रा 409.5 मिग्रा/किग्रा से 468.09 मिग्रा/किग्रा के बीच पाई गई। मृदा की अम्लीय पीएच के अधिक होने से Fe2O3 और चिकनी मिट्टी (क्ले) के कारण P की उपलब्धता कम हो गई। फॉस्फोरस के अवशोषण को टीक (सागौन) में उच्चतम (86.63%) और चावल में न्यूनतम (70.39%) देखा गया। विशेष रूप से Lmax ने मृदा की पीएच के साथ महत्वपूर्ण नकारात्मक सहसंबंध तथा मृदा सामग्री, Fe2O3 और Al2O3 के साथ सकारात्मक एवं उल्लेखनीय सहसंबंध प्रदर्शित किया। जहां तक जीवाणु प्रतिरोधिता का संबंध है, सूअरों से पृथक किए गए

स्टैफाइलोकोकस ऑरियस ने जेंटामाइसिन (61.3%), ऑक्सेसिलिन और पेनिसिलिन (58.99%) के प्रति सबसे अधिक प्रतिरोधिता प्रदर्शित की जबकि गोपशुओं में सेफिक्साइम (72.23%), पेनिसिलिन (66.67%) और ऑक्सासिलिन (62.77%) में सबसे अधिक प्रतिरोधिता देखी गई। स्थानीय स्वदेशी गैर-वर्णित बकरी की नस्ल जिसे ज़ोकेल के नाम से जाना जाता है को उल्लेखनीय प्रजनन क्षमता के साथ मांस के लिए बेहतर पाया गया। स्थानीय स्वदेशी गैर-वर्णित गोपशु (ज़ोबांग) के संदर्भ में नर पशुओं का औसत जन्म भार 14.5 किग्रा और मादा पशुओं के संबंध में 12.2 किग्रा दर्ज किया गया। इंडियन मेजर कार्प (आईएमसी) के साथ पाली गई एमूर कार्प और ओ. बेलांगिरी की वृद्धि पर किए गए एक व्यापक अध्ययन से संकेत मिलता है कि आईएमसी के साथ एमूर कार्प (10%) और पेंगबा (10%) के संयुक्त पालन से मछली पालन को समग्र रूप से बढ़ाया जा सकता है।

वर्ष 2022 के दौरान नागालैंड स्थित क्षेत्रीय केंद्र में कुल वार्षिक वर्षा 1563.1 मिमी दर्ज की गई जो 1515.4 मिमी की सामान्य वर्षा से 3% अधिक थी। हालाँकि, मानसूनी वर्षा को अपेक्षित औसत से 5% कम दर्ज किया गया। चावल-तोरिया- उड़द तथा मक्का- फ्रेंच बीन- उड़द को सम्मिलित करते हुए इन दोनों फसल प्रणालियों पर संसाधन संरक्षण प्रौद्योगिकी के प्रभाव का आकलन करने के लिए दीर्घकालिक खेत परीक्षण शुरू किए गए। इन चारों एकीकृत कृषि प्रणाली (आईएफएस) मॉडलों के मूल्यांकन का उद्देश्य उनकी लाभकारी क्षमता और मृदा स्वास्थ्य के संबंध में उनकी आत्मनिर्भरता का निर्धारण करना था। चुमौकेदिमा जिले में तीन अलग-अलग ऊंचाई वाले क्षेत्रों : EZ1(<250 मीटर), EZ2 (251-500 मीटर), और EZ3 (>500 मीटर) में स्थित कुल 54 गृहवाटिकाओं (होमगार्डन) का विविधता विश्लेषण किया गया। भाकृअनुप के नागालैंड केंद्र के फार्म में तीन फलीदार वृक्ष प्रजातियों जिनमें ग्लिरिसिडिया सेपियम, ल्यूकेना ल्यूकोसेफला और सेसबानिया ग्रैंडिफ्लोरा शामिल हैं की चारा उत्पादन क्षमता का आकलन करने के लिए एक खेत परीक्षण किया गया। भाकृअनुप के नागालैंड केंद्र में मटर की 10 किस्मों के मूल्यांकन में आईपीएफडी-18-2 को उपज (4.14 क्विं0/हे0) के मामले में सबसे अच्छी किस्म पाया गया और इसके बाद आईपीएफडी-17-2 (3.36 क्विं0/हे0) को पाया गया। फसलोपरांत (फसल की कटाई के बाद) होने वाले नुकसान को कम करने के लिए किंग चिली प्यूरी और सॉस तैयार करने की प्रक्रिया का विकास एवं मानकीकरण किया गया। धनसिरी नदी के दो स्थानों दोमुखिया और मंगलामुख में मत्स्य प्रजातियों की विविधता की जानकारी के लिए एक व्यापक अध्ययन किया गया। मेलाटोनिन संपूरक से सूअर के वीर्य में कृत्रिम दशाओं और पशुओं (इन-विट्रो एवं इन-विवो) में वीर्य की गुणवत्ता में उल्लेखनीय सुधार हुआ। कृत्रिम गर्भाधान (एआई) से प्रति ब्यॉत शुद्ध लाभ (यूएस $ 464.8 बनाम यूएस $ 248.11) में काफी वृद्धि देखी जिसके परिणामस्वरूप सामान्य प्रजनन की तुलना में प्रति ब्यॉत शुद्ध लाभ में 87.3% की वृद्धि हुई। नागालैंड के तीन अलग-अलग कृषि-पारिस्थितिक क्षेत्रों (उष्णकटिबंधीय, उपोष्णकटिबंधीय एवं उप-समशीतोष्ण) में स्वदेशी मुर्गी उत्पादन प्रणाली (आईसीपीएस) का लक्षणवर्णन किया गया। पशु प्रक्षेत्रों में 844 जानवरों का गर्भाधान कराया गया जिससे प्राप्त प्रजनन दर 85.3% और प्रति प्रसव 9.44 सुअरशावकों (2 से 17 सुअरशावक तक) की औसत संख्या प्राप्त हुई। प्रभावशाली ढंग से कृत्रिम गर्भाधान के कारण किसानों को कुल 6796 उन्नत सूअर शावकों की प्राप्ति हुई।

सिक्किम में किए गए अनुसंधान में मक्का - फ्रेंचबीन की तुलना में मक्का - हरी मटर को बोने पर प्रणालीगत कुल उत्पादन (8.75 टन/हे0), मक्का समकक्ष उपज (14.4 टन/हे0), प्रणाली की उत्पादकता (17.4 टन/हे0), प्रणाली से प्राप्त सकल लाभ (288.1 x 103 ₹/हे0), प्रणाली से प्राप्त शुद्ध लाभ (208.80 x 103 ₹/हे0) और प्रणाली का बी: सी अनुपात (2.63) दर्ज किया गया जो उल्लेखनीय रूप से अधिक था। विभिन्न बागानों में से किवी के बगीचे में कुल मृदा जैविक कार्बन की मात्रा, कार्बन पूल सूचकांक, लेबिलिटी सूचकांक और उच्च कार्बन प्रबंधन सूचकांक अधिक था अत: सिक्किम हिमालय में कार्बन जब्ती या उसे पृथक करने के लिए किवी को सबसे बेहतर बाग उत्पादन प्रणाली माना जाता है। सिक्किम मंदारिन में 15-20 किग्रा गोबर की खाद/पेड़ या 2.5 किग्रा वरेम कम्पोस्ट/पेड़ के प्रयोग से युवा पौधों की परिपक्वता प्रति वर्ष एक एवं फल देने वाले पौधों की परिपाकवता साल में दो बार सुनिश्चित की गई। बायोचार के प्रयोग से मक्का और उड़द में दानों की गुणवत्ता पर प्रतिकूल प्रभाव पड़ सकता है और अनाज में पोषणीय असंतुलन हो सकता है। सबसे अधिक उपज सिक्किम रागी- 3033 (23 क्विं0/हे0) में पाई गई और तत्पश्चात इसे सिक्किम रागी- 3029 (21 क्विं0/हे0) और सिक्किम रागी- 3014 (19 क्विं0/हे0) में पाया गया। सिक्किम रागी-3033 एवं सिक्किम रागी-3029 को इसके उच्च पोषणिक गुणों (न्यूट्रास्युटिकल वैल्यू) के कारण आशाजनक वंशावलियों के रूप में पहचाना जा सकता है। टैरेस पर धान बुवाई की तुलना में बांस रोपण का फैलाव अनुपात 26.3% अधिक था। सबसे अधिक सूक्ष्मजीवी बायोमास कार्बन, चीड़ के वृक्षों (639 पीपीएम) में दर्ज किया गया और उसके बाद इसे देशी बांस (563 पीपीएम) में पाया गया। विस्तारित टी-बार और परगोला सिस्टम पर साधे गए

किवी फल के पौधे, प्रजनन चरण में आने एवं फल देने वाले पौधों में प्रथम पाए गए। जी सैप 10%, के सैप 10% , एएन 10% , ईएम 10% , एचए 10% से उपचारित किवी फल की किस्म 'हेवर्ड' की पत्तियों और जड़ों ने गैरउपचार (कंट्रोल) की अपेक्षा सभी चार मूल संवर्धन केंडीडेट जीनों (GH3-3, LBD16, LBD29 और LRP1) की उच्च अभिव्यक्ति प्रदर्शित की। 28 वंशावलियों के सभी फलों के आधार सिरे (बेसल एंड) पर फलों की गर्दन (फ्रुट नैक) को नहीं पाई गई/। विरंजन किए बिना विवर्ण (ब्लांचिंग) किए सौर ऊर्जा से सुखाने पर नमी प्रतिशत के साथ-साथ रंग को बनाए रखने में बेहतर पाया गया।

भाकृअनुप - उत्तर पूर्वी पर्वतीय कृषि अनुसंधान परिसर के त्रिपुरा केंद्र में किए गए अनुसंधान के फलस्वरूप कई उल्लेखनीय उपलब्धियां हासिल हुई हैं। इन उपलब्धियों में निकरा एरोबिक धान 2 (टीआरसी 2020-14/आईईटी 29409) की पहचान शामिल है, जिसे केंद्रीय स्तर पर विमोचन हेतु सीवीआरसी-वीआईसी द्वारा बिहार और हरियाणा राज्यों में वायवीय (एरोबिक) दशाओं के तहत बुवाई के लिए अनुशंसित किया गया था। इसके अतिरिक्त, चावल की 04 प्रविष्टियों को एडवांस वेराइटल ट्रॉयल (एवीटी) चरण में आगे ले जाया गया है।

एक महत्वपूर्ण अध्ययन में चावल के 100 जीनरूपों (जीनोटाइप) के विभिन्न ऊतकों (दानों, तना, पत्तियां और जड़ें) में Fe और P सामग्री के ऊतक वर्गीकरण का विश्लेषण किया गया। भाकृअनुप बीज परियोजना के अंतर्गत जारी किस्मों के प्रजनक बीज (27.89 क्विं.) और टीएल बीज (117.6 क्विं.) का सफलतापूर्वक उत्पादन किया गया और दलहन बीज हब के सहभागी प्रयासों के माध्यम से 607 क्विं. दलहन बीज का उत्पादन किया गया। पोषक तत्व प्रबंधन की विभिन्न प्रक्रियाओं के अधीन मूंगफली की 20 किस्मों के मूल्यांकन से पता चला कि मूंगफली को FYM+PM+AL+RP से उपचारित मिट्टी में बोने पर सर्वाधिक औसत फली उपज (2.25 टन/हे0) प्राप्त हुई और तत्पश्चात इसे 1.98 टन/हे0 FYM + PM को प्रयुक्त करने पर पाया गया। जैवप्रबलित (बायोफोर्टिफाइड) मक्का के मूल्यांकन में NEH-BIOFORT-02 से सर्वाधिक दाना (कर्नेल) उपज (6.8 टन/हे0) प्राप्त हुई और तत्पश्चात इसे NEH-BIOFORT-03 (5.5 टन/हे0) और NEH-BIOFORT-01 (5.1 टन/हे0) का स्थान था। रेजिलिएंट (लचीली) खेती प्रणाली के अध्ययनों में आईएसएफएस और आईआईएफएस प्रणाली से क्रमश: 3.6 और 3.1 के संगत लाभ-लागत (बी:सी) अनुपात के साथ रु. 1,76,881 और रु. 1,76,980 का शुद्ध लाभ प्राप्त हुआ। खुली सिंचाई (फ्लड प्लेन) खेती प्रणाली से 13 टन/हे0/वर्ष चावल की तुल्यांक उपज सहित रु. 2,60,000/हे0/वर्ष की सकल आय उत्पन्न हुई। त्रिपुरा की उपराऊं भूमि में 3.4 के लागत लाभ (बी:सी) अनुपात के साथ सब्जी फसल प्रणाली हेतु एक मल्टीस्टोरी वार्षिक अनुक्रम का मानकीकरण किया गया। दलदली भूमि में अरबी (तारो) की खेती हेतु मानकीकृत खेती तकनीक में 15 टन/हे0 की दर से एफवाईएम + एन-पी2ओ5-के2ओ (120-60-90 किग्रा/हे0) की उर्वरक खुराक शामिल करने पर उच्च स्टोलॉन उपज (54.7 टन/हे0) और स्यूडोस्टेम (34.6 टन/हे0) की उपज प्राप्त हुई। त्रिपुरा की जलवायु दशाओं में छोटे-दिनों वाली रबी प्याज की किस्मों में भीमा शक्ति, भीमा सुभ्रा, अर्का प्रगति, अर्का कीर्तिमान और अर्का कल्याण ने अच्छा प्रदर्शन किया है जिनसे प्राप्त उपज 27 से 30 टन/हे0 के बीच पाई गई है। स्वदेशी त्रिपुरी गोपशु अपनी हृष्टपुष्टता, रोग प्रतिरोधक क्षमता और दूध उत्पादन के लिए जाने जाते हैं जिसकी विशेषता इसमें उच्च वसा (6%) का पाया जाना है। बीएनडी क्रॉस के ई-6 मूल्यांकन में 72 सप्ताह में फार्म में अंडों का उत्पादन 159.32 अंडे और फील्ड दशाओं में 138.76 अंडे था। इसके अलावा, एयरोमोनास फ़ेज GomatiRiver_11, एक नया T4- लाइक बैक्टीरियोफेज, जो एरोमोनस हाइड्रोफिला को संक्रमित करता है, के संपूर्ण जीनोम अनुक्रम को सफलतापूर्वक हासिल किया गया।

इसके अलावा, शोध से पता चला कि लेबियो बाटा में 96 घंटे तक फेरिक नमक की मारक सांद्रता 14 पीपीएम थी। इचोर्निया और ईडीटीए ने 3 दिनों के भीतर पानी से लौह (Fe) को 97% तक दूर करने की क्षमता प्रदर्शित की। स्ट्रैस के प्रति फीनोटाइपिंग माइनिंग में लेबियो रोहिता की सामान्य संख्या की तुलना में कम पीएच (5-6) और हाइपोक्सिया के क्रोनिक संयोजन में अजैविक तनाव के प्रति सहिष्णु व्यष्टियों में रूपात्मक और शारीरिक लक्षणसमूहों (फीनोटाइपों) में स्पष्ट और मात्रात्मक अंतर देखा गया। अंत में, बार्बोनिमस गोनियोनेटस को बांस-आधारित सब्सट्रेट प्रणाली में पालने पर उसने सिराहिनस मृगाल की तुलना में उत्कृष्ट प्रदर्शन किया।

EXECUTIVE SUMMARY

In the year 2022, the ICAR Research Complex for NEH Region in Umiam, Meghalaya, recorded a total annual rainfall of 2260.8 mm across 137 events. Of this, the monsoon rainfall accounted for 1219 mm, representing 54% of the total annual rainfall, occurring over 80 rainy days. Notably, the months of March, April, July, August, September, November, and December experienced significantly lower rainfall compared to the Long Period Average (LPA). Throughout the year, the total rainfall fell approximately 8% below the normal levels, with the monsoon rainfall lagging by around 22%. The mean maximum temperature (T_{max}) exhibited a range of 28.9°C to 25.2°C for most months, excluding December to February, during which it ranged from 22.1°C to 19.0°C. On the other hand, the mean minimum temperature (T_{min}) peaked in July and August at 20.8°C, whereas it hit its lowest point in February, plummeting to 7.1°C. Comparing the relative humidity (RH) between morning and evening, the variation in RH during the morning was notably less pronounced than in the evening. RH in the morning spanned from 91.7% in June to 74.8% in March, while RH in the evening ranged between 42.6% in March and 90.1% in June. Across all months, the average wind speed remained consistently below normal, ranging from 6% to 74% lower. A persistent trend of decreasing wind speed has been observed in the region over the years.

In spite of shifting climatic patterns, the institute dedicated significant efforts to foster the comprehensive development of agriculture and allied sectors in the northeastern hill region. Situated at the institute headquarters in Umiam, Meghalaya, under the Division of System Research and Engineering, various accomplishments emerged. These included the development of a low-cost hybrid turmeric dryer (30 kg) and a pedal-operated rhizome washer (79 kg/hr). Moreover, the institute successfully disseminated 1352 weather-based agro-advisories to farmers. Estimations of soil erosion and runoff were conducted utilizing different IFS models, revealing that the agriculture system exhibited lower runoff and sediment compared to other systems. Furthermore, diverse IOFS models were standardized and shared with farmers. For Meghalaya, millet production technology was established, complemented by the initiation of a research project focused on natural farming. The identification of local rootstocks (RC Peach 1) for stone and pome fruits, as well as a lemon genotype denoted as RC-LM-EL-3, was accomplished. Innovations like the Y-shape trellis for the training of stone and pome fruits were devised. A comprehensive survey involving 60 orchards of Khasi Mandarin in Meghalaya was meticulously carried out. Additionally, the propagation method of wedge grafting for the endangered Citrus indica was determined. The evaluation of various vegetable genotypes, encompassing French bean (145), cowpea (28), Indian bean (125), king chili (29), and underutilized cucurbits (60), resulted in the identification of promising strains. Notably, two ginger accessions (RCVBG-1 and RCMLG-1) were submitted for MLT (Multi-Locational Trial). Another achievement was the development of a standardized soilless medium for anthurium. This was accompanied by the identification of the most effective maize-legume intercropping methods and nutrient management strategies for Meghalaya. On the front of cauliflower cultivation in acidic soils, a specialized micronutrient package was formulated. Additionally, the implementation of mulching in maize-legume cultivation displayed amplified water use efficiency, subsequently optimizing the yields of maize, soybean, and French bean. Moreover, the application of FYM (Farmyard Manure) led to a remarkable 92% increase in the productivity of rainfed turmeric.

Research activities under Division of Crop Science led to identification of several advanced lines of rice exhibiting enhanced yield per plant, specifically RCPL 1-448 (3.5 t/ha), RCPL-1-440 (3.5 t/ha), RCPL 1-443 (3.7 t/ha), RCPL-1-441 (3.4 t/ha), RCPL 1-446 (3.8 t/ha), RCPL-1-444 (3.7 t/ha), RCPL 1-442 (3.4 t/ha), and RCPL 1-450 (3.3 t/ha), which were subsequently nominated for the initial varietal trials of AICRIP in Hyderabad. The association of SSR markers, namely AP4007, AP56595, C1454, and RM208, with the rice blast resistance trait was

established. Rice varieties Bhalum-3, Bhalum-5, and Varadhan displayed commendable tolerance to low phosphorous levels. Notably, a modified ammonium nitrate-free formula based on the Magnavaca solution was developed to facilitate Al tolerance screening. The identification of early-maturing lentil genotypes included DPL-15 (DAS), DPL-62 (DAS), and IPL-81 (95 DAS). Initiatives to create climate-smart rice varieties encompassed the crossbreeding of Shasarang with CR Dhan 801. Molecular analysis unveiled a new geographical distribution of the hibiscus caterpillar, Xanthodes transversa, belonging to the *Noctuidae* family within the Lepidoptera order, in okra specimens from Meghalaya. Diverse insect visitors representing various families and insect orders were observed. The assemblage included 4 insect species from the Hymenoptera order, 13 species of *Diptera*, 4 species of *Lepidoptera*, 2 species of *Hemiptera*, and 2 species of *Coleoptera*, all engaging in flower visitation and foraging on litchi flowers during different daylight periods under open pollination conditions. Strains of the oyster mushroom (*Pleurotus pulmonarius*) characterized by elevated biological efficiency were accurately identified. Among the twenty *Trichoderma* species screened in vitro, two exhibited notable antagonistic potential against the soil-borne fungal pathogen *Sclerotinia sclerotiorum*. Citrus plants demonstrated a discernible response to the application of recommended doses of NPK fertilizers and micronutrients (Zinc and boron) fertilizer, leading to a significant 26% increase in the number of fruits per tree.

The year 2022 marked substantial progress in Animal and Fisheries Sciences research. Research focused on the conservation and enhancement of indigenous livestock and fish, resulting in the registration of the cattle breed "Masilum" and pig breed "Wak Chambil" as indigenous breeds originating from Meghalaya during the reporting period. The conservation efforts extended to two endemic fish species, the Chocolate Mahseer (*Neolissochilus hexagonolepis*) and Reba carp (*Cirrhinus reba*), which were collected. Efforts were dedicated to refining techniques aimed at improving the quality and cryostorage conditions of livestock and fish semen, with the objective of enhancing fertility. In alignment with WHO's "ASSURED" criteria for disease diagnosis, diagnostic kits were developed for the identification of Brucellosis and African Swine Fever. Extensive sero-surveillance was conducted on animal diseases of zoonotic and public health significance, including Brucellosis, LSD, JE, ASF, PRRS, Cryptosporidiosis, Q Fever, TB, Swine Influenza, and Cysticercosis, across the northeastern states. Moreover, laboratory diagnostics were employed to diagnose crucial animal diseases and livestock and poultry parasites. In an endeavor to comprehend the potential transmission of virulent and multidrug-resistant Staphylococcus aureus organisms, reservoirs for zoonotic pathogens like rodents and shrews were investigated. Immune modulation of animals and fish was achieved through targeted approaches involving vaccigenic proteins, probiotics, and herbal supplements. Sustainable integrated cluster farming based on livestock was employed to enhance the livelihoods of hill farmers. This initiative encompassed interventions, promotion of piggery entrepreneurship across seven aspirational districts in the northeastern states through the distribution of inputs, hands-on training, and awareness programs. To optimize fish production, diverse approaches including species culture systems and cage culture were implemented and assessed for suitability in the NE region. A variety of programs were executed to popularize improved livestock and poultry breeds, thereby augmenting meat, milk, egg, and fish production. A significant number of improved chicks (more than 22,000) and 548 crossbred piglets were distributed to beneficiaries, along with 150,000 fish seeds of species such as Common Carp, Catla, Rohu, Gonius, Java Puthi, Grass Carp, and others, supplied under various projects.

The Division of Technology Assessment and Capacity Building's research efforts during the period also yielded substantial outcomes. The investigation into farmers' social networks concerning information acquisition on low-input backyard poultry farming and high-yielding variety rice underscored the prevalence of formal communication sources, particularly KVK personnel, in Ri Bhoi District, Meghalaya. In the context of price forecasting for potatoes, the AR(2)-GARCH(1,1)-NOINT models were identified as the most suitable fit for Mawiong regulated market, Meghalaya. Another study delving into technology dissemination modes established that training and demonstrations

emerged as the most employed methods by scientists. Studies examining the benefits and impacts of in-situ micro-rainwater harvesting structures (Jalkund) indicated that farmers were able to irrigate an approximate area of 450 sq. m using jalkund irrigation. Implementation of the low-cost jalkund technology led to an overall increase in farm household income from Rs. 1,45,000/- to Rs. 1,91,125/-. Within the scope of the DST-funded project, block-level vulnerability analysis pinpointed Nongstoin block in the West Khasi Hills district as the most vulnerable among the four blocks. In alignment with the Farmers' FIRST Project, interventions were executed based on eight defined modules, benefiting over 300 farmers. Noteworthy interventions encompassed the introduction of Rabi vegetables such as lettuce, cabbage, broccoli, garden pea, and coriander in rice fallow, establishment of pig breeding units, mushroom spawn production, and the installation of a poultry hatchery unit in the custom hiring center. Throughout the reporting period, more than 16 capacity-building programs were meticulously organized, and approximately 29 publications were authored.

Despite being one of the most remote regional centers, the research endeavors of scientists at the Arunachal Pradesh center have yielded rewarding outcomes. The total annual rainfall during the season reached 3136.9 mm, which was 27 percent above the normal levels. Throughout this period, the count of rainy days amounted to 128 days, which was 16 days fewer than the normal count of 143 days. The average relative humidity during this period consistently remained above 70 %. Several rice genotypes, including Amham (35.3 q/ha), Chanchi (32.5 q/ha), Pangin (31.3 q/ha), Are lai (30.5 q/ha), Amlum (30.5 q/ha), Pumde (29.2 q/ha), Riew Ammo (28.5 q/ha), and Amtum (26.0 q/ha), demonstrated promising performance under two different phosphorus (P) environments (0 and 40 kg P2O5 h-1). Analysis of soil samples and GPS data from various *Jhum* lands in the Tirbin circles, Leparada region, revealed significant variation attributed to *Jhum* cycle, altitudinal position, and inherent location. In the context of a low-cost rain shelter, the cropping sequence involving Capsicum – Bottle gourd – Spinach exhibited the highest yield components and income. The management of late blight disease in tomatoes was effectively achieved through organic means, employing six canopy sprays of copper oxychloride @ 2.5g/L at 6-day intervals, coupled with soil mulching using black polythene (30 micron). The highest ginger yield was recorded in plantations of *Cinnamomum camphora* (14.2 t/ha), followed by *Terminalia myriocarpa* (12.3 t/ha) in an intercropping study within MPTs. A study on occupational hazards in livestock and poultry revealed that the most common physical discomfort reported by farmers during various livestock management operations was severe pain in the lower back in 28-37% of the farmers studied. Gastrointestinal parasites were identified in 13.17% (27/205) cattle, 73.33% (11/15) Mithun, 84.31% (43/51) goats, and 83.56% (61/83) pigs. Among cattle, mithun, and goats, the predominant parasite species were *Strongyle*, *Eimeria*, *Moniezia*, and *Amphistome*. A noteworthy accomplishment involved the creation of a GIS map for the ICAR research farm Gori, utilizing the free geospatial desktop application Google Earth Pro. The GIS map featured a maximum resolution of 8192*4643 pixels and accurately represented the features present within the aerial image, along with an estimation of their respective areas.

The Manipur center of the institute too, achieved remarkable progress in research activities during the reporting period. Notably, two black rice semi-dwarf medium maturing lines, RCMBR 3 and RCMBR 5, surpassed the local checks, Chakhao amubi and Chakhao poreiton, displaying a yield superiority/advantage of 59.8%. A set of six SSR markers (RM12293, RM19303, RM20948, RM7311, RM24071, and RM18239) were identified for distinguishing between Chakhao poreiton and Chakhao amubi. The development of sixteen lines incorporating Pi54 and OsSPL14 genes from the cross between Chakhao and CR Dhan 801 showcased varying black grain anthocyanin content, ranging from 240.31 to 1.35 mg/100 gm sample. Moreover, fifteen Chakhao landraces were identified, each carrying positive alleles of *Sub1A* and *Sub1C* genes. For organic black rice cultivation in Manipur, it is recommended to apply FYM @ 6 t/ha + VC @ 1 t/ha + Green Manuring with Sesbania @ 25 kg/ha. Notably, the application of zinc sulphate @ 20 kg/ha as basal and two foliar sprays during tillering and grain filling stages resulted in the highest grain yield increase across all tested black

rice varieties. Certain brinjal germplasm, including *S. underatum,* IC 394877, IC 090084, IC 420656, and IC 090869, exhibited moderate tolerance to bacterial wilt. Observations on insecticide residues (Lambda-cyhalothrin, chlorantraniliprole, and Fipronil) applied on pea, broadbeans, cabbage, cauliflower, and broccoli indicated persistence up to the 7th day. Residues could be decontaminated (35-40%) with a 2% NaCl solution, except for Fipronil. No contact toxicity on rice weevil, *Sitophilus oryzae*, was noted when treated with essential oil, Elsholtzia griffithi, at 40,000 ppm up to 48 hours post-treatment. For combatting ginger soft rot, five *Trichoderma* species (*T. asperellum, T. atroviride, T. harzianum, T. longibrachiatum,* and *T. erinaceum*) were highly effective, and GC-MS analysis unveiled the presence of 1-Pentadecene and 13-16-Octadecadienoic acid. The identification of seven ambrosia beetle species with symbionts *Fusarium* spp highlighted their role in causing tree bean decline. Carp spawn fed with mealworm (*Tenebrio molitor*)-based diets exhibited observable growth effects in comparison to the control group. Notably, one E. coli isolate from pork meat, resistant to 19 antibiotics, tested positive for blaNDM-1 (Accession no. OP006128). Additionally, the dietary addition of 10% *Eichchornia crassipes* significantly elevated serum total protein (4.04 g/dl) and serum albumin (1.67 g/dl) levels in eggs. A noteworthy insight revealed that *Jhumias* incurred approximately 85% of their expenses in hiring farm labor for land preparation, sowing, intercultural operations, harvesting, and threshing.

In Mizoram, lowland rice trials have revealed notable findings. The Gomati variety demonstrated the highest grain yield, followed by RCM 10. Effective weed management was achieved by intercropping maize or upland rice with rice bean, combined with hand weeding at 20 days after sowing (DAS). A collection and conservation effort encompassed 85 wild mushroom species, 36 varieties of winged bean, 9 types of perilla, 3 types of job's tear, 8 types of ginger, 2 types of black turmeric, and one each of wild turmeric, black ginger, and mango ginger. Particularly noteworthy is the MZWB-L2 variety, which boasts the longest pod at 53.12 cm. Emerging concerns include new diseases such as leaf blight (*Exerohilum rostratum*) affecting ginger, along with the presence of the common cerulean butterfly (*Jamides celeno*) and fall armyworm (FAW) affecting Coix. Soil analysis indicated low available phosphorus (P) content (ranging from 1.5 to 9.5 mg kg-1) across various land uses, while the total P ranged from 409.5 mg kg-1 to 468.09 mg kg-1. More acidic soil pH led to reduced P availability due to Fe2O3 and clay content. P sorption exhibited the highest rate for Teak (86.63%) and the lowest for rice (70.39%). Notably, Lmax displayed a significant negative correlation with soil pH and a positive significant correlation with clay content, Fe_2O_3, and Al_2O_3. Concerning bacterial resistance, *Staphylococcus aureus* isolated from pigs showed the highest resistance to gentamicin (61.3%), oxacillin, and penicillin (58.99%), whereas in cattle, the highest resistance was observed in cefixime (72.23%), penicillin (66.67%), and oxacillin (62.77%). The local indigenous non-descript goat breed known as Zokel stands out as a meat type goat with notable prolificacy. In terms of local indigenous non-descript cattle (Zobawng), the average birth weight for males was recorded as 14.5 kg and for females as 12.2 kg. A comprehensive study on the growth performance of Amur carp and *O. belangiri*, cultured alongside Indian Major Carps (IMC), indicated that composite fish farming is enhanced by cultivating Amur carp (10%) and Pengba (10%) alongside IMC.

In the year 2022, the Nagaland regional center experienced a total annual rainfall of 1563.1 mm, marking a 3% increase from the normal value of 1515.4 mm. However, monsoon rainfall was observed to be 5% below the expected average. Long-term field experiments were initiated to assess the impact of resource conservation technology on both Rice-Toria-Green gram and Maize-French bean-Green gram cropping systems. The evaluation of four Integrated Farming System (IFS) models aimed to determine their remunerative potential and self-sustainability in relation to soil health. Diversity analysis was conducted on a total of 54 homegardens situated across three elevation zones: EZ1 (<250 m), EZ2 (251-500 m), and EZ3 (>500 m) in the Chümoukedima district. At the ICAR Nagaland Centre farm, a field trial was conducted to gauge the fodder production potential of three leguminous tree species: *Gliricidia sepium, Leucaena leucocephala,* and *Sesbania grandiflora*. The evaluation of 10 varieties of field pea

at ICAR Nagaland Centre highlighted IPFD-18-2 as the top performer in terms of yield (4.14 q/ha), closely followed by IPFD-17-2 (3.36 q/ha). To mitigate post-harvest losses, the standardization and development of King Chilli Puree and Sauce were achieved. A comprehensive study of fish species diversity was conducted in River Dhansiri at two sites, Domukhia and Manglamukh. Melatonin supplementation significantly improved both in-vitro and in-vivo semen quality in boar semen. Artificial insemination (AI) demonstrated a substantial increase in net return per sow (US$464.8 vs. US$248.11), resulting in an 87.3% rise in net returns per farrowing compared to natural breeding. The Indigenous Chicken Production System (ICPS) was characterized across three distinct agro-ecological zones (tropical, sub-tropical, and sub-temperate) in Nagaland. In the field, 844 animals underwent insemination, achieving a farrowing rate of 85.3% and an average litter size of 9.44 piglets per litter (ranging from 2 to 17 piglets). Impressively, artificial insemination led to the production of 6796 improved piglets on farmers' fields.

Research effort in Sikkim led to significantly higher system total production (8.75 t/ha), maize equivalent yield (14.4 t/ha), system productivity (17.4 t/ha), system gross returns (288.1 x 10^3 ₹/ha), system net return (208.80 x 10^3 ₹/ha) and system B: C ratio (2.63) was recorded under Maize-Vegetable pea cropping system than Maize-French bean. Among the orchards, kiwi orchard had greater amount of total soil organic carbon, carbon pool index, lability index and higher carbon management index and hence, considered the best orchard production system to sequester carbon in the Sikkim Himalaya. For Sikkim mandarin, young plants manured once/year, bearing plants twice/year (June-July and after harvesting in December-January) at 15-20 kg FYM/tree or 2.5-3 kg vermicompost/ tree. Biochar application may affect the grain quality in maize and black gram adversely and nutritional imbalance in grains might occur. Highest yield was found in Sikkim Ragi- 3033 (23 q ha^{-1}), followed by Sikkim Ragi- 3029 (21 q ha^{-1}) and Sikkim Ragi- 3014 (19 q ha^{-1}). Sikkim Ragi- 3033 and Sikkim Ragi- 3029 can be identified as potential lines due to its high nutraceutical values. Result on dispersion ratio was 26.3% higher for bamboo plantation than terrace paddy. Highest Microbial biomass carbon was recorded for Pine plantation (639 ppm) followed by native bamboo (563 ppm). Kiwifruit plants trained on Extended T-Bar and Pergola systems were the first one to turn out in to reproductive phase and yielded fruits. Leaves and roots of kiwifruit cultivar 'Hayward' by treatment with G Sap at 10%, K Sap at 10%, AN at 10%, EM at 10%, HA at 10% exhibited higher expression of all the four root promoting candidate genes (*GH3-3, LBD16, LBD29* and *LRP1*) as compared to control. Fruit neck at basal end of all the fruits of 28 lines was absent. Solar drying without blanching was found to be superior in terms of moisture percentage as well as for retention of colour.

The research conducted by the Tripura Centre of the institute have resulted in several noteworthy achievements. One of these achievements includes the identification of NICRA Aerobic Dhan 2 (TRC 2020-14/ IET 29409), which was endorsed by the CVRC-VIC for central release under aerobic conditions in the states of Bihar and Haryana. Moreover, four rice entries have advanced to the AVT stage. An important study involved the tissue compartmentalization analysis of Fe and P contents in various tissues (grain, stem, leaves, and roots) of 100 rice genotypes. Breeder seeds (27.89 q) and TL seeds (117.6 q) of released varieties were successfully produced within the ICAR Seed Project, and 607 q of pulses seeds were produced through participatory efforts via the Pulses Seed Hub. An evaluation involving 20 groundnut varieties subjected to different nutrient management practices revealed that the highest average pod yield (2.25 t/ha) was achieved when groundnut was cultivated in soil treated with FYM+PM+AL+RP, followed by 1.98 t/ha when using FYM+PM. In the assessment of biofortified maize, NEH-BIOFORT-02 displayed the highest kernel yield (6.8 t/ha), followed by NEH-BIOFORT-03 (5.5 t/ha) and NEH-BIOFORT-01 (5.1 t/ha). Resilient Farming System studies yielded a net return of Rs. 1,76,881 and Rs. 1,76,980, with corresponding B:C ratios of 3.6 and 3.1, under ISFS and IIFS, respectively. The Flood Plain Farming System generated a gross income of Rs. 2,60,000/ha/annum, along with a rice equivalent yield of 13 t/ha/annum. A multi-storey annual sequence of vegetable cropping system with a BC ratio of 3.4 was standardized for upland conditions of Tripura. A standardized cultivation technology for swamp taro involved a fertilizer dose of FYM @ 15 t/

ha + N-P2O5-K2O (120-60-90 kg/ha), yielding higher stolon (54.7 t/ha) and pseudostem (34.6 t/ha) yields. Several short-day rabi onion varieties demonstrated promise under Tripura conditions, including Bhima Shakti, Bhima Subhra, Arka Pragati, Arka Kirtiman, and Arka Kalyan, with a yield range of 27-30 T/ha. Indigenous Tripuri Cattle were noted for their hardiness, disease resistance, and potential for milk production, characterized by a higher fat percentage (6%). In E-6 evaluation of BND cross, egg production over 72 weeks amounted to 159.32 eggs under farm conditions and 138.76 under field conditions. Additionally, the complete genome sequence of Aeromonas phage GomatiRiver_11, a novel T4-like bacteriophage that infects *Aeromonas hydrophila*, was successfully achieved. Furthermore, research demonstrated that the 96-hour lethal concentration of Ferric salt was 14 ppm in *Labeo bata*. *Eichhornia* and EDTA exhibited the ability to remove Fe from water by 97% within 3 days. In phenotyping mining to stress, clear and quantifiable differences in morphological and physiological phenotypes were observed in individuals tolerant to chronic combination abiotic stress of low pH (5-6) and hypoxia compared to the general population in *Labeo rohita*. Lastly, *Barbonymus gonionatus* demonstrated superior performance in a Bamboo-based substrate system of culture compared to *Cirrhinus mrigal*.

INTRODUCTION

The ICAR Research Complex for NEH Region continues to hold its position as the premier agricultural research institute in the Northeastern Hill Region since its establishment in 1975. With its headquarters situated in Umiam, Meghalaya, and regional centers spanning six states (Arunachal Pradesh, Manipur, Mizoram, Nagaland, Sikkim, and Tripura), it stands as one of the largest institutes under the Indian Council of Agricultural Research across the entire country. Empowered by a diverse yet specialized workforce, the institute has been steadfastly dedicated to devising solutions for hill agriculture through the development of location-specific technologies that demonstrate sustainability, climate resilience, and cultural alignment with the tribal traditions of the region. The dissemination of these developed technologies is facilitated by a robust network of 20 Krishi Vigyan Kendras, strategically located in all states of the hilly northeastern region.

The institute also plays a significant role in enhancing tribal livelihoods through various schemes. It provides tailored livelihood options in agriculture and related fields by focusing on capacity building and the creation of rural social capital. Human resource development is another active sphere for the institute, encompassing teaching and research for post-graduate and doctoral students in agricultural and allied sciences from various universities across the country.

Serving as the epicenter of agricultural research in the northeastern hill region, the institute oversees numerous competitive national and international projects funded by agencies such as DBT, DST, SERB, NICRA, NHB, NASF, NMSHE, FFP, and TSP, targeting the forefront of agricultural innovation. In addition to externally funded projects, the institute pursues several interdisciplinary in-house research projects of strategic and adaptive significance. These endeavors aim to address the unique requirements of hill agriculture in the northeast region.

The Institute has been disseminating modern technologies to enhance livelihood and nutritional security in the region. These technologies encompass truthfully labeled seeds, high-quality planting materials, improved livestock and poultry breeds, and fish seeds, as well as prototype implements and tools tailored for hill agriculture. The Institute also provides soil health testing kits, diagnostic kits for animal diseases, and other crucial inputs.

To foster its goals, the Institute has been actively establishing and nurturing connections with various other ICAR institutes and international organizations such as IRRI and CIMMYT. It has also developed linkages with non-ICAR national institutes like TISS, NABARD, MANAGE, NERCOMP, MRDS, among others. Besides developing academic linkages, the institute also collaborates with NGOs, farmers' organizations, and cooperative societies to strengthen its outreach activities in the region.

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.

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, agro-forestry, 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 transboundary diseases.

LABORATORIES AND WORKSHOP

The institute's headquarters in Umiam is equipped with comprehensive laboratory facilities across all divisions. In addition to the laboratories in the various divisions and regional centers, there is a Central Laboratory at the Umiam headquarters. This Central Laboratory is outfitted with advanced equipment, such as an atomic absorption spectrophotometer (AAS), high-performance liquid chromatography (HPLC), gas chromatograph, flow cytometer, 24-capillary Sanger sequencer, and a computational biology unit with servers and terminals. These resources support a wide range of research activities aligned with the institute's mandates. For research in climate-resilient agriculture, the institute has access to advanced facilities such as FATE, CTGC, biochar, and TOC equipment. A post-harvest processing unit is also available to enhance value addition and increase farmers' income. The Division of Agricultural Engineering operates an advanced workshop that is engaged in the research and development of novel tools and implements, as well as the fabrication and design of prototypes. To address research in animal pathogens, the institute maintains bio-containment facilities alongside state-of-the-art laboratories. The institute's regional centers are similarly equipped with advanced laboratories that serve as hubs for basic, applied, and strategic research in the realm of hill agriculture and related subjects.

HUMAN RESOURCES

The institute's success is built on the shoulders of a diverse and energetic workforce of 728 people (as of 2022). The workforce comprises scientific, technical, administrative, and support staff. Table 1 below provides details about the staffing structure.

Table 1. Human resources of ICAR Research Complex for NEH Region in 2022

	Category	Sanctioned post	Filled post	Vacant post
Institute	Scientific	155	115	40
	Technical	252	90	162
	Administrative	116	60	56
	Supporting	115	90	25
	Total	**638**	**355**	**283**
Krishi Vigyan Kendra	Sr. Scientist & Head	20	2	18
	Subject Matter Specialist (T-6)	120	75	45
	Programme Assistant (T-4)	40	21	19
	Farm Manager (T-4)	20	10	10
	Diver-cum-Mechanic (T-1)	40	20	20
	Assistant	20	0	20
	Jr. Steno-cum-Computer Operator	20	1	19
	Skilled Supporting Staff	40	22	18
	Total	**320**	**151**	**169**
Grand total		**958**	**506**	**452**

LIBRARY

The institute's library is a valuable resource for scientists and other researchers. It subscribes to a variety of scientific journals and magazines, providing access to the latest research in a variety of fields. The library also has an impressive collection of over 30,000 books and reports, which can be consulted for in-depth information on specific topics. Current inventory of the library are as below (Table 2).

Table 2. Books, journals and other documents available at library

Nature of Publication	No. of copies available
Books & Reports	31614
Back Volumes of Journals	12715
Foreign Journals	-
Indian Journals	45
News Papers	14
Hindi Books	4478
Magazines	06

Table 3. Actual budget expenditure for 2022 (₹ Lakhs)

Budget head	Allocation	Expenditure
Building	635.9	635.9
Equipment	100.59	100.59
IT	27.95	27.95
Library Books	-	-
Vehicle Vessels	56.41	56.41
Livestock	6.35	6.35
Furniture & fixtures	37.76	37.76
Others	-	-
Salary	5768.41	5768.41
Wages	117.63	117.63
Pension	1268.08	1268.08
Travelling allowance	57.13	57.13
Research & operational	1294.74	1294.74
Administrative expenses	1000.89	1000.89
Miscellaneous expenses	142.06	142.06
Total	**10513.90**	**10513.90**

BUDGET

During the year 2022, the institute had a budget outlay of ₹ 105.14 crore for meeting its various expenses. The institute was able spend 100% of its budget while earning a revenue of ₹ 1.99 crore. The largest expenditure in 2022 was on salary, which accounted for ₹5,768.41 lakhs (54.9%). The second largest expenditure was on research and operational activities, which accounted for ₹1,294.74 lakhs (12.3%). Other major expenditures included pension (12.1%), administrative expenses (9.5%), and building (6%). Details of the expenditure are in Table 3.

INFORMATION TECHNOLOGY FACILITIES

To facilitate the integration of information technology into agriculture and allied sciences for the betterment of farming communities in the northeast hill region, the institute maintains an array of IT facilities. These encompass a computer lab equipped with various statistical software tools such as SAS, SPSS, and STATISTICA. Additionally, several GIS software options like Arc GIS and QGIS (Open Source) are at hand. Skilled scientists are available proficient in utilizing these software applications.

Serving as a hub for multiple online examinations organized by the Agricultural Scientists Recruitment Board (ASRB), the institute operates a computerized examination hall. This hall is outfitted with servers, desktops, and backup power systems, effectively addressing the human resource development needs of the northeast region. Alongside the ASRB infrastructure, a fully functional Computational Biology Unit (CBU), complete with a dedicated server and terminals, supports research initiatives in genomics and bioinformatics.

Furthermore, the institute collaborates with the Indian Meteorological Department to extend agro-advisory services such as Gramin Krishi Mausam Seva (GKMS) to farmers in the region. In terms of connectivity, the institute benefits from a dedicated internet feeder line from the National Knowledge Network. This line services over 200 computers for staff at the Umiam headquarters. Moreover, each regional center is equipped with an ample number of computers and accessories connected to the internet facilitating the institute's administrative and research activities.

IMPORTANT VISITORS

Visit of Shri Narendra Singh Tomar, Hon'ble Union Minister of Agriculture and Farmers' Welfare to ICAR Research Complex for NEH Region, Nagaland Centre

On June 26, 2022, Shri Narendra Singh Tomar, Hon'ble Union Minister of Agriculture and Farmers' Welfare, Government of India visited the ICAR Nagaland Centre. He laid the foundation stone of the Administrative Building of the Krishi Vigyan Kendra, Dimapur, and released three publications, including one edited book and two technical bulletins. He also unveiled the mushroom soup formulation developed by the Centre. The Hon'ble Minister engaged in an interactive session with farmers, scientists, and staff of the ICAR Nagaland Centre and the National Research Centre on Mithun, faculty members and students of the College of Veterinary and Allied Sciences, Jalukie, and officials from various line departments of the Government of Nagaland. The program was also attended by Shri Kaito Aye, Hon'ble Minister of Agriculture, Government of Nagaland; Shri Y. Kikheto Sema, Agricultural Production Commissioner, Government of Nagaland; Dr. Anupam Mishra, Vice Chancellor, Central Agricultural University, Imphal, Manipur; Dr. V.K. Mishra, Director, ICAR Research Complex for North Eastern Region; Dr. Prabhat Kumar, Horticulture Commissioner; and Shri Mhathung Yanthan, Advisor, Horticulture and Border Affairs, Government of Nagaland. Power tillers, fish fingerlings, fish feed, chicks, and various agricultural tools and implements were also distributed to the farmers (Fig. 1).

Visit of Shri Giriraj Singh, Hon'ble Union Minister of Rural Development and Panchayati Raj to ICAR Research Complex for North Eastern Region, Umiam, Meghalaya

On his visit to the ICAR-Research Complex for North Eastern Region, Umiam, Meghalaya on May 18, 2022, Shri Giriraj Singh, Hon'ble Union Minister of Rural Development and Panchayati Raj, Govt. of India, visited the piggery, poultry, and dairy farms of the institute and witnessed the pig breed Lumsniang developed by the institute. He was accompanied by Shri Arpit Upadhyay, Deputy Commissioner, and Shri Giri Prasad M, Superintendent of Police, Ri Bhoi

Fig. 1. Shri Narendra Singh Tomar, Hon'ble Union Minister of Agriculture and Farmers' Welfare, Government of India being felicitated by Dr V.K. Mishra, Director, ICAR Research Complex for North Eastern Region

District, Meghalaya. In the inaugural session, Dr. S. K. Das, Director In charge, welcomed the gathering and gave a brief overview of the institute's achievements and its mandates. Shri Giriraj Singh, the Chief Guest, highlighted the inevitable challenge of food security in the coming years due to the country's growing population pressure. He reminded the gathering of the Green Revolution's contribution to the country, but he stressed that we still need to produce more food grains with better yields. He stated that a holistic, integrated approach is essential for bringing about any development in an aspirational district like Ri Bhoi. He called for the ICAR and CAU-College of Post Graduate Studies to collaborate, keeping the farmers' needs first. The focus should be on taking research findings from the lab to the field. He also stressed the need to promote Moringa (drumstick) cultivation, as it has the potential to absorb carbon if we are to develop carbon neutral villages in the country. The Hon'ble Chief Guest concluded his address by saying that the country and its villages will only prosper when the farmers prosper, and that this will only happen if they can get more economic returns from their harvest and use that income to support more agricultural activities. The institute's scientists also had an in-depth discussion with the Hon'ble Minister on May 17 evening at CAU-CPGS, along with staff from the relevant institutes, on various issues related to agriculture and allied sectors, particularly livestock and fishery (Fig. 2).

Fig. 2. Shri Giriraj Singh, Hon'ble Union Minister of Rural Development and Panchayati Raj during his visit to ICAR Research Complex for North Eastern Region

Visit of His Excellency Shri. Dr. Hari Babu Kambhampati, Hon'ble Governor of Mizoram to ICAR Research Complex for NEH Region in Kolasib

On June 10th, 2022, the Hon'ble Governor of Mizoram, Shri. Dr. Hari Babu Kambhampati, inaugurated a two-day training under the Tribal Sub Plan at the ICAR Research Complex for NEH Region in Kolasib, Mizoram. The training was attended by the tribal farmers from various parts of the state of Mizoram. In his address, the Governor highlighted the importance of training for tribal farmers in order to improve their agricultural productivity and urged the farmers to take advantage of the training and to adopt modern agricultural practices developed and demostrated by ICAR Research Complex for NEH Region, Kolasib, Mizoram (Fig. 3). During the inauguration ceremony, the Hon'ble Governor also released folders published by the Centre.

Fig. 3. Hon'ble Governor of Mizoram, Shri. Dr. Hari Babu Kambhampati during his visit at ICAR Research Complex for NEH Region in Kolasib, Mizoram

Shri Kailash Choudhary, Hon'ble Union Minister of State, Department of Agriculture & Farmers' Welfare, Government of India visits the ICAR Research Complex for NEH Region, Tripura Centre

Shri Kailash Choudhary, the Hon'ble Union Minister of State for Agriculture & Farmers' Welfare, Government of India, visited the ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra, West Tripura on 28th June, 2022. The visit was part of the "Agri-Interaction with Stakeholders: FPOs/FPCs, FPO implementing agencies and CBBOs". More than 100 participants, including those from FPOs/FPCs, FPO implementing agencies and CBBOs, officials from line departments, and KVKs, attended the programme. The Hon'ble Minister was welcomed by Dr. Biswajit Das, Joint Director, ICAR Research Complex for NEH Region, Tripura Centre. In his address, the Hon'ble Minister highlighted the importance of FPOs in the development of agriculture and rural economy. He said that FPOs are playing a key role in connecting farmers to markets, providing them with access to credit and inputs, and improving their incomes. He also stressed the need for strengthening the FPO ecosystem and providing more support to FPOs (Fig. 4).

Fig. 4. Shri Kailash Choudhary, Hon'ble Union Minister of State, Department of Agriculture & Farmers' Welfare, Government of India during his visit at the ICAR Research Complex for NEH Region, Tripura Centre

Dr. Rajkumar Ranjan Singh, the Hon'ble Minister of State for Education and External Affairs, Government of India visits ICAR Research Complex for NEH Region, Manipur Centre

On 31st May, 2022, the ICAR Research Complex for NEH Region, Manipur Centre, had the privilege of hosting Dr. Rajkumar Ranjan Singh, the Hon'ble Minister of State for Education and External Affairs, Government of India. During his visit, Dr. Singh's graced the Garib Kalyan Sammelan event as Chief Guest. This gathering held immense significance, attracting around 400 farmers hailing from diverse corners of Manipur. Other notable attendees included Shri Sapam Kunjakeswor Singh, Hon'ble Member of the Legislative Assembly, Government of Manipur, Laishram Boby Devi, Up-Adhyaksha of Imphal West, and Dr. N. Johnson Meetei, Additional District Magistrate of Imphal West (Fig. 5).

Fig. 5. Dr. Rajkumar Ranjan Singh, the Hon'ble Minister of State for Education and External Affairs, Government of India along with other dignitaries at the ICAR Research Complex for NEH Region, Manipur Centre

Study Visit of Parliamentary Standing Committee on Agriculture, Animal Husbandry and Food Processing on 24th and 25th May, 2022

The study visit of the Parliamentary Standing Committee on Agriculture, Animal Husbandry and Food Processing, GoI was held during 24th & 25th May, 2022 at Hotel Radisson Blu, Guwahati, Assam under the Chairpersonship of Shri. P. C. Gaddigoudar, Chairperson, Hon'ble MP, Lok Sabha. ICAR officials present during the meeting were Dr. S. Bhaskar, Chief Nodal Officer & ADG (AFF&CC), Dr. B. K. Pandey, ADG (HS-II), Dr. V. K. Mishra, Director, ICAR RC-NEH, Umiam, Dr. V. K. Gupta, Director, NRC on Pig, Guwahati and Dr. Rajesh Kumar, Director, ICAR-ATARI, Guwahati

On 25.05.2022 an informal discussion was held between the Representatives of Govt. of Assam and Ministry of Agriculture and Farmers Welfare (Department of Agricultural Research and Education) on the subject "Contribution of ICAR in Agricultural Research for Tribal and Hilly Region". Welcome address was delivered by Dr. S. Bhaskar, Chief Nodal Officer & ADG (AAF & CC), ICAR. It was followed by the presentations made by Dr. V. K. Mishra , Director, ICAR RC NEHR highlighting the work and achievements of the Institute over the years in the region. Dr. Rajesh Kumar, Director, ICAR-ATARI, Guwahati also highlighted the activities and achievements. In the interactive session, the queries of the Hon'ble Members PSCA were replied satisfactorily. Hon'ble Chairperson PSCA in his remarks appreciated the efforts of ICAR for the development of Agriculture and Animal Husbandry in the region. (Fig. 6).

Fig. 6. Members of Parliamentary Standing Committee on Agriculture, Animal Husbandry And Food Processing at ICAR RC NEH Region, Sikkim Centre

Visit of Shri Thongam Biswajit, Hon'ble Minister of Agriculture, Power, Forest, Environment and Climate Change, Science and Technology, Government of Manipur to ICAR Research Complex for NEH Region, Manipur Center

On April 26, 2022, Shri Thongam Biswajit, Hon'ble Minister of Agriculture, Power, forest, Environment and Climate Change, Science and technology, Government of Manipur, and Shri Kh Nabakumar Singh, Member ICAR Society, New Delhi visited the ICAR Research Complex for NEH Region, Manipur Center. The visit was aimed at understanding the work being done by the institute to promote the welfare of farmers in the state. During the visit, Hon'ble Ministers took part in the Farmers' Fair under Kisan Bhagidhari Prathamikta Hamari organized by the Centre. They interacted with the farmers and listened to their concerns. They were impressed with the work being done by the institute to develop high-yielding varieties of crops and fruits that are suitable for the agro-climatic conditions of Manipur. They also appreciated the center's work on developing climate-resilient crops, promoting organic farming, and improving livestock productivity. In his address, Shri Biswajit emphasized the need for a coordinated approach to farmers' welfare that is suitable for the state and is complemented by modern techno-scientific advances. He said that the focus should be on increasing the productivity of the land, improving the quality of life of the farmers, and creating sustainable employment opportunities. He also emphasized the need for the government to provide financial assistance and technical support to the farmers (Fig. 7).

Fig. 7. Shri Thongam Biswajit, Hon'ble Minister of Agriculture, Power, forest, Environment and Climate Change, Science and technology, Government of Manipur addressing the gathering at the ICAR Research Complex for NEH Region, Manipur Centre

Visit of Dr Subbanna Ayyappan, Hon'ble Chancellor, CAU, Imphal and Former Secretary, DARE, New Delhi to the ICAR Research Complex for NEH Region, Manipur Center

Dr Subbanna Ayyappan, Hon'ble Chancellor, Central Agricultural University, Imphal, Manipur and Former Secretary, Department of Agricultural Research and Education, M/o Agriculture and Farmers' Welfare, New Delhi visited the ICAR Research Complex for NEH Region, Manipur Center on July 14, 2022. The visit was aimed at understanding the work being done by the institute to promote sustainable livelihood development for the tribal farmers of the state. During his visit, Dr Ayyappan interacted with the scientists of the center and discussed various ways to furthering the livelihood development of the tribal farmers of the state in a sustainable manner. He was impressed with the work being done by the scientists to develop high-yielding varieties of crops and fruits that are suitable for the agro-climatic conditions of Manipur. He also appreciated the center's work on developing climate-resilient crops, promoting organic farming, and improving livestock productivity. Dr Ayyappan stressed the need for a holistic approach to livelihood development for the tribal farmers of Manipur. He said that the focus should be on increasing the productivity of the land, improving the quality of life of the farmers, and creating sustainable employment opportunities. He also emphasized the need for the government to provide financial assistance and technical support to the farmers (Fig. 8).

Fig. 8. Dr Subbanna Ayyappan, Hon'ble Chancellor, CAU, Imphal and Former Secretary, DARE, New Delhi alongwith the scientists of the ICAR Research Complex for NEH Region, Manipur Center

Visit of Shri Naresh Kumar, Chief Secretary, Government of Arunachal Pradesh, to the ICAR Research Complex for NEH Region, Arunachal Pradesh Center

Shri Naresh Kumar, Chief Secretary, Government of Arunachal Pradesh, visited the ICAR Research Complex for NEH Region, Arunachal Pradesh Center on 6th April 2022. The visit was aimed at understanding the work being done by the institute to promote sustainable livelihood development for the tribal farmers of the state. During his visit, Shri Kumar inspected the institute's research farms and orchards. He was impressed with the work being done by the scientists to develop high-yielding varieties of crops and fruits that are suitable for the agro-climatic conditions of Arunachal Pradesh. He also interacted with the scientists to get a better understanding of their research work. Dr H. Kalita, Joint Director, ICAR Research Complex for NEH Region, Arunachal Pradesh Center, explained in detail the various technical collaborations the center is taking up with the state government. He highlighted the center's work on developing climate-resilient crops, promoting organic farming, and improving livestock productivity. He also spoke about the center's efforts to train farmers on modern agricultural practices. Shri Kumar was satisfied with the work being done by the institute. He praised the scientists for their dedication and commitment to improving the lives of the tribal farmers of Arunachal Pradesh. He also assured the scientists of the state government's support for their work (Fig. 9).

Fig. 9. Shri Naresh Kumar, Chief Secretary, Government of Arunachal Pradesh interacting with Dr H. Kalita, Joint Director, ICAR Research Complex for NEH Region, Arunachal Pradesh Center

Visit of Dr. S. K. Chaudhari, Deputy Director General (NRM), ICAR, New Delhi to the ICAR Research Complex for NEH Region, Umiam

Dr. S. K. Chaudhari, Deputy Director General (NRM), ICAR, New Delhi and Smti. Rajeshree Sunil, Deputy Secretary (NRM) ICAR, New Delhi visited the ICAR Research Complex for NEH Region, Umiam on 17- 18th July 2022. The visit was aimed at reviewing the research and other activities of the institute. Dr. Chaudhari was impressed with the work being done by the institute, but he also felt that the institute could do more to focus its activities on the new programmes launched by the Government of India from time to time. He recommended that the institute develop a strategic plan that aligns its research and other activities with the Government's priorities. He also suggested that the institute set up a dedicated unit to monitor and evaluate its progress in implementing the plan. Dr. Chaudhari was also happy to inaugurate the renovated Agri-Business Incubation Centre of the institute. He felt that the centre would play a valuable role in promoting entrepreneurship and innovation in the agricultural sector in the North East region. He urged the institute to make full use of the centre to help young entrepreneurs start and grow their businesses. The visit of Dr. Chaudhari was a positive step for the ICAR Research Complex for NEH -RCNEH, Umiam. His recommendations will help the institute to further improve its research and other activities, and the inauguration of the Agri-Business Incubation Centre is a major boost for entrepreneurship in the region (Fig. 10).

Fig. 10. Dr. S. K. Chaudhari, Deputy Director General (NRM), ICAR, New Delhi inaugurating the renovated ABI building in presence of Dr V.K. Mishra, Director, ICAR Research Complex

IMPORTANT EVENTS AND MEETINGS

ICAR-Research Complex for North Eastern Hill Region Celebrate 48th Foundation Day

The 48th foundation day of the institute was commemorated on the 11th January 2022 along with a series of events abiding with the COVID 19 protocols. In his welcome address Dr. V.K Mishra, Director; ICAR Research Complex for NEH Region said that the existence of the research institute and with its six regional centers has made a deep impact in the field of agriculture of the region, however there is immense scope of improvisation in the agricultural sector in the coming years with the implementation of modern technologies. The foundation Day lecture was given by Dr. K. M. Bujarbaruah, former VC, AAU, Jorhat, former DDG, animal Sciences, ICAR and former Director, ICAR Research Complex for NEH Region. He emphasized on the fact that it is the only institute in the entire region which focuses on all the disciplines. He further added that pandemic has proven the fact that there is no alternative to agriculture as rightly said by Pandit Nehru that "everything else can wait, but not agriculture". The institute needs to focus on the sustainable developmental goals and aim for a hunger free world. 48th institute foundation day also witnessed the felicitation of the staffs of the institute for their commendable contributions towards the institute. Innovative farmers Shri. Vanlalghaka Pachau from Mizoram, Smti Dilli Maya Bhattarai from Sikkim and Smti. Plenty Makri of Meghalaya were also awarded for their contributions in the field of agriculture (Fig. 1).

Fig. 1. Dr. V.K. Mishra, Director, ICAR RC NEH and Dr K.M. Bujarbaruah, Former Vice Chancellor, AAU conferring award to a progressive farmer in presence of Dr Sunil Doley, Organizing Secretary

Outreach programme for tribal farmers at Shella Bholagang in collaboration with Ramakrishna Mission, Sohra

The institute in collaboration with Ramakrishna Mission, Sohra organized a day long agriculture technology outreach and capacity building programme under Tribal Sub Plan on the 26th of March, 2022 for livelihood improvement of tribal farmers of Shella Bholaganj, East Khasi Hills, Meghalaya. On the occasion, various important agricultural inputs worth Rs. 5 lakhs were distributed to the farmers selected by the Mission. More than 80 beneficiaries were covered in the distribution programme which included 40 back mounted sprayers, 20 water pumps of 1.5 HP, 20 water tank of 1000 liters capacity, 20 vermi-bed silpaulin sheets, 5 jalkund silpaulin sheets, 38 insect light traps, farm hand tools of Rs 50,000 and animal medicines of Rs 50,000 along with animal feeds. Welcoming the delegates Swami Anuragananda, Secretary Ramakrishna Mission, Sohra thanked the ICAR NEH for taking this noble initiative and expressed his keen interest to extent the activities of the Mission in agriculture sector also. Dr. V. K. Mishra, Director of the institute expressed that this humble approach would help the organization and the farmers of the area to come closer. Dr Mishra also shared his vision on establishment of a model village which will be sound in agriculture and allied sectors where the farmers and the villagers can attract tourist with their farm products to this historic place which is already a popular tourist destination (Fig. 2).

Fig. 2. Swami Anuragananda, Secretary Ramakrishna Mission, Sohra distributing farm implements to tribal farmers in presence of Dr. V.K. Mshra, Director, ICAR RC NEH and other dignitaries

Inauguration of KVK Tura Farmers Training Hostel and farmers input distribution at Tura

Dr. S. K. Chaudhari, Deputy Director General, NRM, ICAR, New Delhi, Smti. Rajeshree Sunil, Deputy Secretary (NRM) along with Dr V. K. Mishra, Director ICAR Research complex for NEH Region Umiam and Heads of Divisions of the institute visited the Krishi Vigyan Kendra, Tura, West Garo Hills, on the 19th July 2022. The KVK was established way back in 1970. Dr. S. K. Chaudhari inaugurated the Farmers' Training Hostel of the KVK and laid the foundation stone for the administrative building in presence of the other dignitaries. On this occasion an input distribution programme under the Tribal Sub Plan was also organized where more than 100 farmers of Tura and neighboring villages attended. The other dignitaries who attended the programme were, Director ATARI-VII, Dean College of Home Science, Nodal Officer TSP & Nodal Officer KVK. The DDG NRM while addressing the gathering urged upon the farming community to

provide feedback on improvement and modification on the interventions made by ICAR. He also released several publications on the occasion. The dignitaries also distributed inputs worth 15 lakhs to about 105 farmers who received Knapsack Sprayer, silpaulin sheets, sewing machine, drip irrigation kits, improved seed materials, poultry birds, medicines, feed, feeders, water pump etc. (Fig. 3.).

Fig. 3. Dr. S. K. Chaudhari, Deputy Director General, NRM, ICAR, New Delhi unveiling the inauguration plaque of the Farmers Training Hostel at Krishi Vigyan Kendra, Tura, Meghalaya

ICAR Research Complex for NEH Region, Umiam organized International Symposium on "Zoonotic and Transboundary Diseases: Breaking the Chain through Multidisciplinary Approach"

To combat recurrent threats of livestock and zoonotic diseases in the region, ICAR Research Complex, Umiam brought together national and international experts to discuss the roads ahead at the International Symposium on Zoonotic and Transboundary Diseases during 1st and 2nd December, 2022. The two day event, with participants from all over the country, including those from Veterinary Department of Meghalaya and International Livestock Research Institute, touched upon crucial aspects for control of transboundary and zoonotic diseases recommending a One Health approach which was also underscored by Prime Minister, Shri Narendra Modi in his address to G20 nations with India in presiding role. In the inaugural session, Padmashree Dr K.K. Sarma emphasized the need of One Health for managing diseases of wildlife that affect domestic livestock, while Col. Professor A.M. Paturkar, Vice Chancellor, MAFSU endorsed the multidisciplinary approach in handling complex biological challenges. The international narrative from ILRI also underpinned the same, giving examples from their efforts to contain African Swine Fever in the south Asian countries. Dr Ashok Kumar Assistant Director General, Animal Health, ICAR, New Delhi pointed out that One Health is a focal theme of the ICAR at the national level also. The organizing team was led by the Chairman, Dr V.K. Mishra, Director, ICAR NEH alongwith Dr Sandeep Ghatak, Organizing Secretary, Dr Arnab Sen, Convenor, Dr Samir Das, Co-Organizing Secretary and Dr A.A.P. Milton, Co-Organizing Secretary. The institute committed to working in multidisciplinary mode to address the challenges faced by the state and the region, especially in the livestock sector (Fig. 4).

Fig. 4. Dignitaries lighting the lamp during the inaugural ceremony of the International Symposium on 'Zoonotic and Transboundary Diseases: Breaking the Chain through Multidisciplinary Approach'

World Soil Day observed at ICAR-Research Complex for NEH Region

ICAR Research Complex for NEH Region, Umiam, Meghalaya celebrated a One-day Workshop on the occasion of World Soil Day, 2022 on 5th December, 2022 (Theme - Soils: where food begins) with the aim to sensitize and empower the tribal school children pertaining to the importance of a healthy soil in achieving food security and to instill a sense of responsibility towards stewardship and conservation of their own soil for a sustainable future. The programme was sponsored by the Tribal Sub-Plan (TSP), ICAR Research Complex for NEH Region, Umiam, Meghalaya. A total of one hundred five (105) numbers of students and four (4) numbers of teachers from 5 different schools viz. Christ Senior Secondary School (International), Nongsder; St. Francis D'assisi School, Umbir; Kendriya Vidyalaya, Umroi Cantt.; Umroi Presbyterian Higher Secondary School and Umsawkhwan Presbyterian Secondary School, participated in the event. Scientists of the institute also attended the program. The program was chaired by Dr. S.K. Das, Head & Principal Scientist (Division of Animal Sciences & Fisheries, DASF) and then Director In-Charge of the institute. The program started with display and reading out of the messages from Shri Narendra Singh Tomar, Honorable Agriculture Minister, GoI and Dr. Himanshu Pathak, Honorable Secretary (DARE) & Director General (ICAR). This was followed by a welcoming remark from Dr. Samarendra Hazarika (Head & Principal Scientist, DSRE and Nodal Officer, TSP) and he also highlighted the importance of World Soil Day celebration and significance of soil in our lives. Dr. B.U. Choudhury (Principal Scientist & PI, NICRA Project) enlightened the audience with his thoughtful insights on the degrading soil health with specific regard to climate change prevailing in the region. Dr. S.K Das elaborately emphasized on the significance of good soil quality in aquaculture. He appreciated and encouraged the young minds to involve in sustaining soil health. Mrs. M. Prabha Devi and Dr. Mahasweta Chakraborty delivered lectures

on "Understanding Soil Ecology: A step towards sustainable development" & "Soils for food security", respectively to make the students aware about soil as a treasured asset. An exposure visit to the Soil Science Laboratory of the institute accompanied by a hands- on exercise on Rapid Soil Health Testing kit was undertaken. This was followed by an Extempore Speech Competition amongst the school students. The programme concluded with a formal vote of thanks by Dr. T. Ramesh, Senior Scientist (Fig. 5).

Fig. 5. School students learning basics of soil analysis in the Soil Science laboratory at ICAR Research Complex for NEH Region, Umiam

Celebration of 22nd National Fish Farmers Day

On the 21st of November, 2022, Division of Animal Fisheries Sciences, ICAR Research Comples for NEH Region, Umiam, Meghalaya organized the World Fisheries Day 2022 along with the "Ranching of Indigenous Fish in Umiam Lake and Fish Seed Distribution Program" at Umniuh Village under Tribal Sub-Plan. A total of 52 farmers from various parts of Ri-Bhoi District, Meghalaya, participated in the program. During the event, ranching activities were carried out in Umiam Lake, where 10,000 indigenous fish fingerlings of *Labeo rohita* and *Labeo gonius* species were released. Dr. V. K. Mishra, Director of ICAR RC NEH Region was present during the ranching process, alongside the fish farmers and the Ri-Bhoi Farmers Association. Subsequently, the distribution of fish fingerlings took place, benefiting 50 local farmers from Ri-Bhoi District. A total of 10,000 fish fingerlings of Labeo rohita and Labeo gonius were distributed, providing 200 fingerlings per farmer (Fig. 6).

Fig. 6. Celebration of 22nd National Fish Farmers Day at ICAR Research Comples for NEH Region, Umiam, Meghalaya

Valedictory Programme of the Winter School on Organic Farming at ICAR Research Complex for NEH Region, Sikkim Centre

ICAR Research Complex for NEH Region, Sikkim Centre, Tadong, Gangtok organized the valedictory programme of the Winter School on "Advances in the Organic Production System in Sikkim Hamalayas" on 10th December, 2022. The function was graced by Dr. Vinay Kumar Mishra, Director, ICAR Research Complex for NEH Region as Chief Guest. In his address, Dr Mishra emphasized that soils are over exploited and soil carbon levels shrunken to threshold levels, and thereby caused vulnerable soil health conditions for cultivation of food crops. He highlighted the need for introducing need based organic farming through natural farming practices due to its immense export potential and sustainability for ecosystem. Dr Mishra presented winter school training certificates to the all the 15 participants. On this occasion the technical bulletin "Livelihood improvement of Tribal Farmer in Ri-Bhoi District of Maghalaya" under Biotech-KISAN was released by Chief Guest. Earlier, Dr. S. Hazarika, Head, DSRE, ICAR RC NEH, Umiam emphasized that the quality aspects and the marketing opportunities for organic produce need to be explored keeping in view the food security goals of the nation. The programme was also attended by Dr. Ramgopal Laha, Joint Director and Course Director of the Winter School, Dr. Sudip Kumar Dutta, Senior Scientist of the Centre, in addition to all scientists, administrative staff, and other staff of ICAR Sikkim Centre.

Fig. 7. Valedictory Programme of the Winter School on Organic Farming at ICAR Research Complex for NEH Region, Sikkim Centre

Kisan Mela at ICAR Research Complex for North Eastern Hill Region, Mizoram Centre, Kolasib

The ICAR Research Complex for North Eastern Hill Region, Mizoram Centre, Kolasib organized a two-day Kisan Mela-2022 on 14th and 15th November, 2022. The event was inaugurated by the Honorable Chief Minister of Mizoram, Shri Zoramthanga, along with Shri K. Lalrinliana, the Honorable Minister for Civil Supplies and Consumer Affairs, and Fisheries. The Kisan Mela featured a variety of stalls from different government organizations, self-help groups, and farmers' groups. The stalls showcased a wide range of products and technologies, including agricultural produce, livestock, processed food, handicrafts, and machinery. There were also live demonstrations of various farming techniques, as well as seminars and workshops on topics of interest to farmers. The Mela was attended by over 400 farmers from different parts of Kolasib district. The farmers were able to learn about the latest agricultural technologies and practices, and they also had the opportunity to interact with experts and other farmers. The Mela was a valuable opportunity for farmers to improve their agricultural knowledge and skills, and it also helped to promote the use of modern agricultural technologies in the state (Fig. 8).

Fig. 8. Inauguration of Kisan Mela by Hon'ble Chief Minister of Mizoram Shri. Zoramthanga at ICAR Research Complex for North Eastern Hill Region, Mizoram Centre, Kolasib

Celebration of World Egg Day at the ICAR Research Complex for NEH Region, Mizoram Centre, Kolasib

World Egg Day was celebrated at the the ICAR Research Complex for NEH Region, Mizoram Centre, Kolasib . Honorable Chief Minister of Mizoram, Shri Zoramthanga, on 14th October, 2022 greeted the organizing team which included Dr Sunil Dole, Head of the Regional Centre, Dr L. Pui, Sr. Scientist and others. The event was attended by a number of poultry farmers and stakeholders. The Chief Minister highlighted the importance of eggs as a nutritious food and encouraged the farmers to adopt modern poultry farming practices. He also appreciated the efforts of ICAR Research Complex for NEH Region, Mizoram Centre, Kolasib in promoting poultry farming as a source of livelihood and affordable nutrition for tribal farmers of the state (Fig. 9).

Fig. 9. Honorable Chief Minister of Mizoram, Shri Zoramthanga with organizing team of World Egg Day celebration at ICAR Research Complex for NEH Region, Mizoram Centre, Kolasib

Observation of World Water Day 2022 at ICAR Research Complex for North Eastern Hill Region, Nagaland Centre, Jharnapani

The ICAR Research Complex for North Eastern Hill Region, Nagaland Centre, Jharnapani organized World Water Day on 22nd March 2022 under the theme 'Making the invisible visible' to create awareness about judicious use of water and importance of freshwater. The programme was inaugurated by Dr. Anupam Mishra, the Vice-Chancellor of Central Agricultural University, Imphal. Dr. S.V. Ngachan, the former Director of ICAR NEH Region, and Dr. Arun K. Sangwan, the Dean of the College of Veterinary Science and Animal Husbandry, CAU Jalukie, were the guests of honor. Around 70 farmers attended the programme and participated in various activities. They also received various inputs on water conservation. The programme was a success and it helped to raise awareness about the importance of water conservation among the farmers. It also highlighted the need for judicious use of water and the importance of protecting our water resources (Fig. 10).

Fig. 10. Inaugural programme of World Water Day 2022 at ICAR Research Complex for North Eastern Hill Region, Nagaland Centre, Jharnapani

Tripura Krishi Unnati Parv, 2022 celebrated by ICAR Research Complex for North Eastern Hill Region, Tripura Centre

The ICAR Research Complex for North Eastern Hill Region, Tripura Centre celebrated Tripura Krishi Unnati Parv - 2022 from December 5 to 7, 2022. The event included the celebration of World Soil Day on December 5 at the ICAR RC NEH Region, Tripura Centre, followed by Tripura Krishi Unnati Diwas on December 6 at Pragya Bhawan, Agartala, and a training-cum-field day on rice at Mirza, Gomati District on December 7, 2022. The event was attended by about 600 participants, including farmers, officials from line departments, KVKs, and ICAR. The Hon'ble Minister of Agriculture & Farmers Welfare, Government of Tripura, Shri Pranajit Singha Roy, was the chief guest at the Tripura Krishi Unnati Diwas. Shri. Apurva Roy, Secretary, Agriculture and Farmers welfare, Govt of Tripura and Dr. Arunava Pattanayak, Vice Chancellor cum Director, ICAR-IIAB, Ranchi were present as Guest of Honour and Special Guest, respectively. Shri Roy expressed his appreciation to the ICAR Research Complex for North Eastern Hill Region, Tripura Centre for joining hands with line departments to boost crop productivity and farmers' income. He emphasized on innovative technologies such as maize, millets, blackgram, orange, dragon fruits, high-value products, and their processing to further enhance farmers' income. He also urged scientists and extension personnel to work together to find solutions to address the problem of citrus decline, especially for Jampui orange in Tripura. On this occasion, about 300 bottles of nano-urea, improved vegetable and rice seeds (300 packets), about 2000 save grain bags, 50 power-operated sprayers, 5 electric motor pumps (1 HP), 10 cycle weeders, 20 vermibeds, 2 low-cost incubators, 8 millet threshers, and 10 fishing nets were distributed among farmers (Fig. 11).

Fig. 11. Inaugural programme of the Tripura Krishi Unnati Diwas at Pragya Bhawan, Agartala

MEGHALAYA

SUMMARY

In 2022, Meghalaya received 8% deficit rainfall with a slight increase in maximum temperatures. Noteworthy developments included the creation of a low-cost hybrid turmeric dryer, a pedal-operated rhizome washer, and a rapid hand compactor for mushroom bed preparation. Soil erosion and runoff measurements for various IFS models, revealed that runoff and sediment from the agricultural system were lower compared to other systems. Various IOFS models were standardized and shared with farmers. Two promising plant types (stone and pome fruits: RC Peach 1; lemon: RC-LM-EL-3) were identified and a Y-shape trellis was developed for training of stone and pome fruits. Wedge grafting was optimized for the propagation of the endangered *Citrus indica*. Various vegetable genotypes, including French bean (145), cowpea (28), Indian bean (125), king chili (29), and underutilized cucurbits (60), were evaluated, leading to the identification of promising candidates. Two ginger accessions, RCVBG-1 and RCMLG-1, were submitted for multi-location trials. Soilless media for *Anthurium* cultivation was standardized. Optimal maize-legume intercropping and nutrient management for Meghalaya were determined. A micronutrient package for cauliflower grown in acidic soils was developed. Under Crop Sciences, numerous advanced lines of rice with increased yield per plant, namely RCPL 1-448 (3.5 t/ha), RCPL-1-440 (3.5 t/ha), RCPL 1-443 (3.7 t/ha), RCPL-1-441 (3.4 t/ha), RCPL 1-446 (3.8 t/ha), RCPL-1-444 (3.7 t/ha), RCPL 1-442 (3.4 t/ha), and RCPL 1-450 (3.3 t/ha), were identified and selected for initial varietal trials. Additionally, SSR markers AP4007, AP56595, C1454, and RM208 were found to be associated with the rice blast resistance trait. Ammonium nitrate-free formula based on Magnavaca solution was developed for aluminium tolerance screening. Early maturity lentil genotypes (DPL-15, DPL-62, IPL-81) were identified. Molecular analysis unveiled new geographical distribution of the hibiscus caterpillar, *Xanthodes transversa* in okra. Numerous insect visitors (*Hymenoptera*-4, *Diptera*-13, *Lepidoptera*-4, *Hemiptera*-2, *Coleoptera*-2) were observed visiting and foraging on litchi flowers during daytime under open pollination conditions. Strains of oyster mushrooms (*Pleurotus pulmonarius*) with high biological efficiency were identified. Further, two *Trichoderma* species with anti- *Sclerotinia sclerotiorum* potential were identified. Nutrient management of citrus plants with recommended doses of NPK, zinc and boron significantly increased (26%) the fruit yield. Research in Animal and Fisheries Sciences led to registration of the cattle breed "Masilum" and the pig breed "Wak Chambil". Additionally, two endemic fish species, Chocolate Mahseer and Reba carp were collected for conservation. Techniques to improve the quality and cryo-storage of livestock and fish semen for enhanced fertility were developed. Diagnostic kits for detecting Brucellosis and African Swine Fever were developed for rapid disease detection. Besides undertaking sero-surveillance in the entire NEH region for animal diseases with zoonotic potential, laboratory diagnoses of important livestock and poultry diseases were performed. Immune system modulation in animals and fish was achieved through targeting vaccigenic proteins, probiotics, and herbal supplements. Piggery entrepreneurship was promoted in seven selected aspirational districts through input distribution, hands-on training, and awareness programs. To augment fish production, diverse species culture systems and cage culture were implemented. Under social science research initiatives, investigation into social networks among farmers revealed the predominance of KVK personnel as formal communication source for information on agricultural technologies. Moreover, 'AR(2)-GARCH (1,1)-NOINT' emerged as best-fitting models for forecasting of potato price in regulated market. Impact analysis of *in situ* micro-rainwater harvesting structures (*Jalkund*) revealed that the farm household income increased by 32.8% after adoption of *Jalkund* technology.

Division of System Research and Engineering

Weather Report - 2022

(*D. Chakraborty, P. S. Rolling, and S. Das*)

Umiam received a total annual rainfall of 2260.8 mm in 137 events with monsoon rainfall of 1219 mm (54% of annual rainfall) in 80 rainy days (58% of annual). The May and October months have 34 rainy days. The rainfall received in March, April, July, August September, November, and December was considerably lower than the Long Period Average (LPA), but the months of January, February, May, June, and October received higher than normal rainfall. During the year, the total rainfall was about 8% lower than normal and monsoon rain was also lower by about 22%.The monthly and annual pattern in rainfall is depicted in Fig. 1. The highest rainfall in a single day was 169.4 mm which occurred on October 25th, 2022. The total annual pan evaporation was 898.4 mm. The rainfall was more than the pan evaporation from May to October, but the reverse happened during the rest of the months.

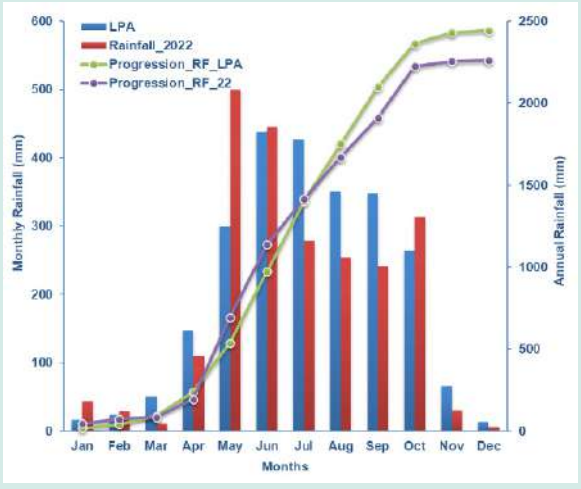


Fig. 1: Monthly & annual rainfall pattern

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 2a). The mean T_{max} varied between 28.9°C to 25.2°C for all the months except December to February when it varied between 22.1°C to 19.0°C. It is clear from the figure that for almost all the months the T_{max} was either similar or more than its LPA value except February and May. This phenomenon of higher-than-normal T_{max} was also seen in the last few years, indicating a slow but persistent increase in T_{max} over the place. The mean monthly T_{max} of July and August was 28.9°C which was the highest for this year. As the rainfall for the month of July and August was much lower than normal, this may have caused high temperatures during the period. The Mean T_{min} was highest for the month of July and August with a value of 20.8°C and lowest for the month of February with a value of 7.1°C (Fig. 2b). It is clearly seen that the mean monthly minimum temperature increased after February to reach the maximum in August and therefore decreased to the minimum in February. The mean monthly T_{min} value was either similar to or lower than its LPA for all the months except during the month of January and March, indicating the decrease in the T_{min} over the years.

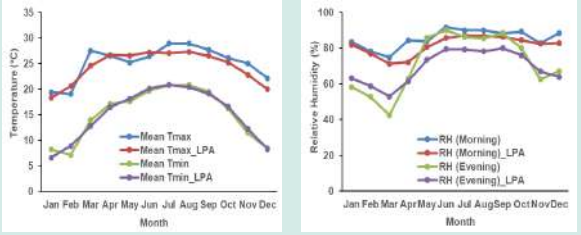


Fig 2: Monthly values of (a) mean maximum & minimum temperature and (b) mean relative humidity during 2022

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 91.7 % to 74.8% in June and March, respectively and $RH_{evening}$ varied between 42.6% and 90.1% in March and June respectively. Due to heavy rainfall in the month of June the relative humidity also became high. The $RH_{evening}$ was much higher than its LPA value throughout many months of the year. The average wind speed was lower than normal by 6% to 74% for all the months. It has been observed that the wind speed over the years in the place has decreased persistently.

RESEARCH ACHIEVEMENTS

Agricultural Engineering

Two Row Maize Planter for Hilly Region

(N. Singh)

The designing and development of two row maize planter for hilly region is in progress. The CAD model for the proposed planter is shown in Fig. 3.

Seed metering techniques were created and tested. For the system control, electronic circuit was designed that was simulated and tested in the laboratory. Fabrication of the machine is completed. The use of sensor and image processing required for plating at uniform distance was standardized in Python programming environment.

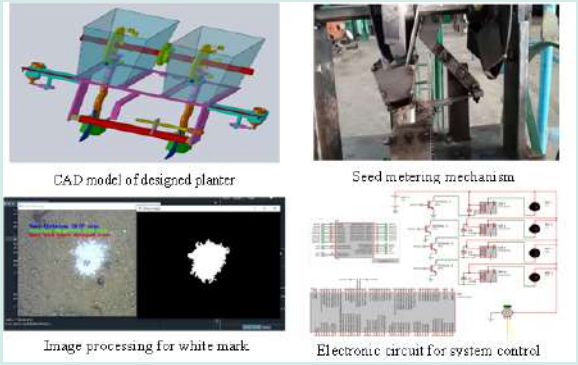


Fig. 3. Design and details of two row maize planter

Biomass based hybrid dryer

(N. Singh)

A hybrid low-cost device of 30 kg capacity that runs on two sources of energies i.e. solar power and heat generated form biomass was developed for drying turmeric (Fig. 4). It can dry the turmeric within 6-7 days when tested during 3 days of continued rains.

Fig. 4. Biomass based hybrid dryer

Pedal operated turmeric washer

(N. Singh)

The washing of rhizomes of turmeric and other crops is not only labor and time intensive but also consumes considerable amount of water. Therefore, a pedal operated rhizome washer with a capacity to wash about 79.0 kg of rhizomes was developed for use in various crops to facilitate quick washing with lesser quantity of water (Fig. 5).

Rhizome washer | Turmeric rhizome before and after washing

Fig. 5. Pedal operated rhizome washer

Evaluation of Runoff and Sediment Yield Potential of Major IFS Models in Meghalaya

(K. Ajaykumar, N. Singh, D. Chakraborty, J. Layek, M. Chakraborty and S. Hazarika)

The soil erosion and runoff were estimated eight different integrated farming system (IFS) models viz. Dairy based Farming System (FSW-1), Mixed Forest (FSW-2), Silvi-Pastoral System (FSW-3), Agro-Pastoral System (FSW-4), Agri-Horti-Silvi-Pastoral System (FSW-5), Silvi-Horticulture System (FSW-6), Natural Forest Block (FSW-7) and Timber Based Farming System (FSW-8). Total rainfall received during the season was 1415 mm. The maximum intensity of rainfall was 75 mm/hr that was observed during September whereas for other months the average intensity of rainfall was 45.6 mm/hr. Maximum runoff (675 mm) was generated in mixed forest micro watershed, while the minimum runoff (402 mm) was recorded in natural forest block (Fig. 6). Highest sediment yield i.e. 35.9 t/ha was noted in mixed forest compared to other systems (Fig. 6). Highest peak flow of 20.48 mm/hr was observed in agro-pastoral system where as the lowest flow (3.62 mm/hr) was recorded in timber based system. The runoff generated in dairy based system, agriculture, agri-horti-silvia-pasture and horticulture systems were 479 mm, 458 mm, 504 mm and 531 mm, respectively. Similarly the sediment yield obtained from these systems was 18.16 t/ha, 14.9 t/ha, 18.4 t/ha and 23.49 t/ha, respectively.

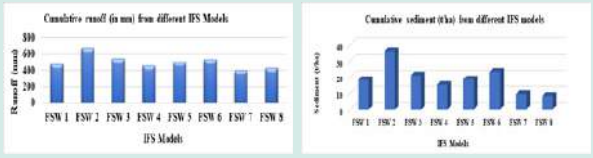


Fig. 6. Runoff and sediment yield in different IFS models

Ridging attachment for raised bed vegetable cultivation in Meghalaya

(H. Jiten Singh, N. Singh and M. Bilashini Devi)

Mono cropping of rice is common practice in lowland valley ecosystems in Meghalaya. There is scope for crop intensification by growing vegetable in rice fallow. The prevalent land configuration system in rice fallows is to grow vegetables on raised beds using traditional tools that are not only time and labour intensive but also involve considerable human drudgery. Hence, a low cost ridging attachment that could be attached to power tiller could make the optimal use of available resources. Hence, a study was initiated during 2022-23 for mechanization of vegetable cultivation on ridged/raised bed system. Ergonomic risk factors using REBA tool were studied to assess the key working postures while preparing raised beds. The study highlighted a high-risk factor score of 8-10 (action level 3) for more than 80 % of farmers. Design of CAD model for development of the prototype of ridging attachment is completed.

***Gramin Krishi Mausam Sewa* (GKMS)**

(D. Chakraborty and P. S. Rolling)

A total of 1352 Agro-Advisory Service (AAS) bulletins were prepared and disseminated to various stakeholders. Special Agricultural Contingency Bulletin was also prepared and disseminated in connection with Impact Based Forecast (IBF) for the state of Meghalaya. Four farmers' awareness campaigns and two field visits were conducted in Ri-Bhoi and East Jaintia Hills, Meghalaya on the importance of weather-based Agro-advisory and popularization of Meghdoot app.

Forecasting agricultural output through space agro-meteorology and land based observations (FASAL)

(D. Chakraborty, M. Dkhar, J. Layek, M. Chakraborty and P. S. Rolling)

Field experiments for rainfed rice (cv. Bhalum 1) and Mustard (cv. Bhavani) were conducted under the FASAL project. Rice was sown in the 1stweek of July, while Mustard was sown in 3rdweek of November. The rainfall received and rainy days occurred during the rice growing season (July-November) were 1116.9 mm and 67 rainy days, whereas during mustard growing season (November-February), 36.4 mm of rainfall was received in three rainy days. Statistical, machine learning and crop simulation models were used for yield estimation. Artificial Neural Network (ANN) was used for yield prediction. The calibration and validation accuracy for the ANN model was found to be satisfactory. ANN model was used to simulate crop yield and other parameters and correlated with field experimental data. The forecasted yields in Ri-Bhoi district of Meghalaya for rice and mustard were 3353 and 645 kg/ha, respectively.

Understanding the rainfall anomalies and its impacts on agriculture of northeastern India

(D. Chakraborty, S. Saha, N. Uttam Singh, S. K. Das, Christy B. K. Sangma, I. M. Singh, B. Das, and H. Kalita)

A study was conducted to understand the anomalies of rainfall using long-term regional and point climate datasets. The analysis showed inter-regional and intra-regional variation in rainfall and the trends suggest variability did not follow any similar patterns. The significant observations include a) the rainfall anomalies for all India summer monsoon are quite different from that of the north-eastern region (NER), b) the NER has shown statistically significant decrease in summer monsoon during the last three decades, c) within the NER, Sub-Himalayan West Bengal and Sikkim showed significant decrease in summer monsoon rainfall followed by Assam, Meghalaya, Nagaland, Manipur, Mizoram and Tripura, d) huge spatial variability in the climatic parameters was observed within the NER e) steady increase in maximum temperature with values varying from place to place f) no fixed trend w.r.t. minimum temperature and rainfall and h) change point analysis showed variations among the places and climatic parameters between years1990 and 2000. This clearly indicates further studies to identify the effect of climate change on the performance of ecosystem in general and on agriculture in particular in the region.

Growth and yield modeling of major crops using weather and remote sensing inputs

(D. Chakraborty, M. Ray, and J. Layek)

In this study, it is envisaged to develop a suitable model for the yield estimation of pineapple using different weather variables using various models viz. Multiple Linear Regression (MLR), Least Absolute Shrinkage and Selection Operator (LASSO), Elastic Net (ENET), ridge regression and machine learning techniques i.e. Classification And Regression Tree (CART), Random Forest Regression (RFR), Artificial Neural Network (ANN) and Support Vector Machine (SVM). Results showed that different models had different performance accuracies even though various models were able to capture the variation in yield (having high R^2 values > 0.90), the error indicated by root mean square error (RMSE) and normalized RMSE (nRMSE) was comparable with ridge regression, LASSO, ENET, RFR, and SVM, all having very good accuracy (<5% nRMSE). The results suggest that using weather variables, the yield of pineapple in Meghalaya can be estimated with considerable accuracy and can be used for policy consideration and planning.

Agroforestry

Soil organic carbon fractions in different Alder (*Alnus nepalensis*) based agroforestry systems of mid hill of Meghalaya

(N. Raju Singh, A. Balusamy, T. Ramesh, B.U. Choudhury and S. Hazarika)

A study on soil organic carbon fractions in three different Alder (*Alnus nepalensis*) based Agro-Forestry Systems (AFS) viz. alder + pineapple + black pepper (AFS 1); alder + tea + black pepper (AFS 2) and alder + seasonal crops (AFS 3) was conducted (Fig. 7). The results revealed that soil under AFS 1 recorded maximum total organic carbon (TOC) content (1.88%) followed by AFS 3 and AFS 2 (Table 1). The very labile carbon was found to be the highest in AFS 2 which contributed 40.1% of the TOC followed by AFS 3 (39%) and AFS 1 (38.5%). The labile carbon was highest in AFS 3 (20.7% of TOC) followed by AFS 2 (20.2%) and AFS 1 (19.4%). The less labile carbon was found to be the highest in AFS 2 which contributed to 7.9% of the TOC followed by AFS 1(7.8%) and AFS 3 (5.6%). Contrarily, the non-labile carbon was the highest in the AFS 3 (34.7% of TOC) followed by AFS 1 (34.3%) and AFS 2 (33.3%). Active and passive carbon pools varied widely. The contribution of active pool (AP) ranged between 58.0 and 60.3% of the TOC, while the passive pool (PP) contributed 40.3 to 42% of the TOC.

Fig. 7. A view of alder based agro-forestry systems

Table 1. Details of soil carbon fractions in alder based agro-forestry systems

AFS	TOC	SOC	F1	F2	F3	F4	AP	PP
	%							
AFS 1	1.88±0.80	1.23±0.50	0.72±0.23	0.36±0.28	0.15±0.08	0.64±0.34	1.09±0.47	0.79±0.35
AFS 2	1.72±0.76	1.15±0.44	0.69±0.22	0.35±0.19	0.14±0.08	0.57±0.36	1.04±0.35	0.71±0.41
AFS 3	1.78±0.75	1.17±0.47	0.70±0.23	0.37±0.28	0.10±0.04	0.62±0.33	1.07±0.47	0.72±0.32

Agronomy

Integrated Organic Farming System (IOFS) Model for Livelihood and Nutritional Security of small and marginal farmers

(*J. Layek, K. R, P. Baiswar, S. Patra and R. T*)

The IOFS model (0.43 ha area) developed in the institute is comprised of cereals, pulses, oilseeds, vegetables, fruits, dairy (2 milch cows + 1 calf), fodders, central farm pond, duckery (20 ducks), farmyard manure pits and vermicomposting unit (Fig. 8). A farm pond of 460 m^2 area with an average depth of 1.5 m forms part of the IOFS that provides life-

saving irrigation, rearing ducks and aquaculture. The washings from the dairy/duckery are diverted to fish pond for promoting growth of planktons. Harvested rainwater was used for lives saving irrigation in the winter months. The net return from the IOFS model was Rs. 88,820/- per year which is much higher than the traditional farmer practices i.e. rice fallow or rice-vegetable system. It was estimated that 95.4% of the total nitrogen, 83% of the total phosphorous, 98.2% of the total potassium and the majority of the micronutrient requirement could be met within the model itself.

Fig. 8. IOFS model in lowland farm

Evaluation of different millets under organic management practices

(*J. Layek, K. R, S. Patra and A. Kumar*)

An experiment was undertaken with improved (VL Mandua 352) and local land races of finger millet (Nagaland-2) to standardize organic nutrient management and cropping systems. Application of RDN through 75% FYM + 25% VC in VL Mandua 352 recorded highest yield followed by application of 75% RDN through FYM and 25% through green leaf manure from Tephrosia sp. (Fig. 9). Sowing of millets during 1-15 July gave highest yield as compared to sowing in the month of June. Maize (green cob)-millet sequence showed highest millet equivalent yield (MEY) followed by millet-pea and millet-mustard cropping sequence.

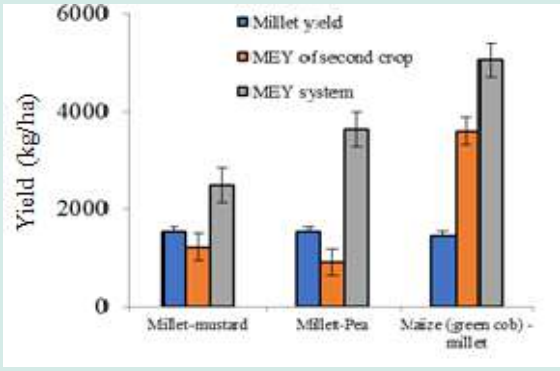


Fig. 9. Performance of millet-based cropping systems

Natural Farming in Rice

(*J. Layek*)

Field experiment was undertaken in valley wetland at Umiam, Meghalaya to evaluate production potential of rice (Shahsarang-1) under standard natural farming protocol i.e. in-situ recycling of crop and weed residues and application of Jeevamrit and Panchagavya. The production of rice straw was estimated to be about 5-6 t/ha. The yield of rice across the plots varied between 2.5and 3.3 t/ha. The soil biological properties such as population of phosphorus-solubilizing bacteria and earthworm were found to be higher in natural farming condition compared to crop managed inorganically.

Natural Farming in Turmeric based system

(*J. Layek, S. Patra*)

A field experiment was undertaken in upland farm to study the comparative efficiency of Natural Farming (NF), Organic Farming (OF) and Integrated Nutrient Management (INM) options in turmeric + cowpea intercropping (Fig. 9). The NF treatment resulted in comparatively lower turmeric equivalent yield as compared to OF and INM in the 1st year of experimentation.

Fig. 9. Natural Farming experiment in turmeric

Natural Farming formulations

(C. B. K. Sangma, J. Layek, B.U. Choudhury, R. Katyar)

Different types of bio-formulations required for the natural farming were prepared and showcased during the Krishimela held during January, 2023 for the farmers (Fig. 10). Hands-on demonstrations on

the use of these formulations were conducted during the mela.

Fig. 10. Formulations for Natural farming

Farming System Research

(*J. Layek, S. Hazarika, S. Das, R. Katiyar*)

Eight micro watershed-based farming system models viz., Dairy-based Farming System (FSW-1), Mixed Forest Block (FSW-2), Silvi- Pastoral System (FSW-3), Agro- Pastoral System (FSW-4), Agri- Horti-Silvi- Pastoral System (FSW-5), Silvi- Horticultural System (FSW-6), Natural Forest Block (FSW-7) and Timber Based Farming System (FSW-8) that were developed during 1983 and are being maintained on long term basis (Fig. 11). The data revealed that the Agro-Pastoral System (FSW-4) found to be better in terms of net return (Rs.1,69,166/year).

Fig. 11. A view of farming system research farm

Horticulture

RC-LM-EL-3 as promising lemon genotypes

(H. Rymbai, V.K. Verma, H.D. Talang)

RC-LM-EL-3 was found to be a promising lemon genotype in terms of fruit weight (313.83±38.71 g), fruit diameter (94.05±27.46 mm), oil glands density (107±6.24 cm^2), peel thickness (10.22±1.01 mm), pulp (59.28±4.49%), juice content (74.67±2.31%), fruit firmness (83.33±16.32 N /mm/ secs) and seed number (39.00±12.53 per fruit) (Fig. 12). Similarly with regard to quality attributes, RC-LM-EL-3 recorded higher total soluble solids (8.67±0.07°Brix), total acidity (6.21±0.06 %), vitamin C (73.78±3.02 /100 ml juice), total phenolics (40.69±3.68 mg GAE / 100 ml juice), flavonoids(14.27±0.93 mg QE/100ml juice), DPPH IC_{50} (27.49±0.32 µg /ml), standard ascorbic acid (12.08±0.99 µg/ml), FRAP (151.45±18.25 mM FeSO4E /100 ml juice), total carbohydrates (13.59±0.78 mg glucose/ ml juice) and reducing sugar (4.74±0.03 mg Glucose / ml juice).

Fig. 12. Fruit of RC-LM-EL-3

Improvement of stone and pome fruits quality by using local fruits species and canopy modification

(H. Rymbai, R. Krishnappa, S. Patra and T. Ramesh)

Eight rootstocks of stone and pome fruits, *viz*., RC Plum-1, RC Plum-2, RC Peach-1, RC Peach-2, RC Peach-3, RC Sohjhur-1, RC Sohjhur-3 and Florda guard (control) were evaluated for growth and seed attributes. It was found that RC-Peach-1 had the highest germination (88.37%) and survival rate (85.67%) followed by RC Sohjhur-1. Similarly, RC Peach -1 recorded highest plant spread, stem girth, canopy volume (16.83 m^3) and yield (262.86 fruits/ tree). Further, a compatibility study of commercial cultivars of plum (Kala Amritsari and Satluj Purple), peach (Shan-e-Punjab, Florda prince and Partap) on RC Peach 1 and *Pyruspashia* (Sohjhur RC- 2) on RC Sohjhur -1 were conducted. Result showed that Satluj Purple had the highest plant height (164.20±32.85 cm), number of leaves (246.33±36.42), plant spread (157.35±8.46 cm), while Kala Amritsari recorded maximum number of secondary branches and number of fruits (13.33±2.02) on RC Peach 1. In another study i.e. evaluation of suitable training systems in stone

and pome fruits cultivars, results showed that growth in terms of trunk cross section (62.4±0.67cm^2) and canopy volume (11.2±0.53m^2) were higher in open central system. However, the yield attributes i.e. fruit weight (38.10±16.34^a g), fruit length (3.85±0.82^a m), fruit breath (113±24.55cm), fruit number (113±24.55 per tree) and fruit yield (3.96±1.32 kg per tree) were highest in Y-shape trellis. Y-shaped trellis also recorded highest TSS (10.22±0.81 ^{0}Brix), Ascorbic acid (26.38±14.21mg/ 100 g pulp) and Total sugar (7.83±1.34%).

Rejuvenation of Khasi mandarin orchards through horticultural management practices for improving yield and quality

(*H. Rymbai, H.D. Talang, V.K. Verma, M. Chakraborty, T. Ramesh, D. Chakraborty and S. Hazarika)*

A survey that was conducted in 60 orchards of Khasi Mandarin (*Citrus reticulate* Blanco) in various parts of Meghalaya revealed that majority of the orchards were located at a 10-20% slope (35.2%), 112.5°-157.5° aspect (30.0% orchards) and most of the orchards are of 20-30 years old (43.3%). The canopy volume was highest with <5% slope (21.1 m^3) and 25-30 years old orchards(16.03 m^3). The yield of Khasi mandarin was recorded highest at <5% slope (603.29 fruits per tree) and orchards of 25-30-year-old (519.57 fruits per tree). Total soluble solids were found to be the higher in 900-1200 m altitude (10.9%), 35-40% slope (11.3%) and 25-30 years old gardens (11.1%). The ascorbic acid content was found to be maximum at 900-1200 m altitude (38.4 mg/100 ml), 30-35% slope (39.5 mg/100 ml) and 35-40 years old tree (42.4 mg/ 100 ml). Thirty-three genotypes of an endangered *C. indica* were collected and conserved in the field gene bank at Horticulture farm. The genotypes CI-02, CI-03, CI-04, and CI-09 were found to be promising. Among four methods of propagation, wedge grafting resulted in highest graft success (76.53%), number of leaves, number of branches and seedling survival (72.67%).

With regard to collection, characterization and conservation of lemon (*Citrus limon* (*L*) Burm), 24 varieties/genotypes of lemon were collected, conserved and characterized for physico-biochemical and antioxidant properties. RC-LM-EL-3 had the highest fruit weight (313.83±38.71 g), pulp weight (181.58±63 g) and TSS (8.67±0.07 ^{0}Brix). RC-LM-Dhemaji AL-1 showed the highest acidity (6.84±0.73%) and Vitamin C (87.72±4.11 g /100 ml), RC-LM-ALCRS-2 and RC-LM-JL-1 recorded higher total phenolic contents (46.72±8.26 mg GAE/ 100 ml) and FRAP assay (243.62±3.2 mM FeSO4 eq./100 ml) respectively.

Evaluation of different rootstocks of Khasi mandarin in different altitudes

(H. D. Talang, H. Rymbai, H. Kalita and P. Baiswar)

The performance in terms of growth, yield and fruit quality of *Khasi* mandarin plants grafted on *C. karna* ,*C. trifoliate*, *C. jambhiri*, *C. limonia*, *C. latipes*, *C. taiwanica* and *C. volkameriana* were evaluated at different altitudes (653 to 1350 m). The fruit weight, fruit length, fruit diameter and number of segments were higher in *C. taiwanica*+ khasi mandarin at Altitude II and III (1350 m above MSL) conditions while *C. volkameriana*+ khasi mandarin performed better at Altitude I (653 m above MSL) condition. The fruit set i.e. number of fruits after 3 years of planting was higher in case of *C. jambhiri*+ khasi mandarin (9) in Altitude II, while it was higher in *C. limonia*+ khasi mandarin at altitude I and III

Biochemical and nutraceutical properties of underutilized fruits

(S. R. Assumi and H. Rymbai)

A comprehensive proximate and biochemical profile and bioactive potential of three underutilized fruits (*Myrica nagi*, *Myrica esculenta* and *Eleagnus latifolia)* was ascertained. The presence of anti-proliferative activity was observed in *Myrica esculenta*, *Myrica nagi* and *Eleagnus latifolia.* The higher inhibition was observed in *Myricanagi* (23.45%) and the lowest was noted in *Eleagnus latifolia* (12.03%). Maximum anti-hyperglycemic activity was recorded in *Myricanagi*(0.34 IC_{50}, mg/ml) followed by *Myrica esculenta* (0.65 IC_{50}, mg/ml).

Collection, Evaluation and Conservation of Genetic Resources in Vegetable Crops

(*V. K. Verma and M. B. Devi*)

French bean: A total of 145 accessions of french bean evaluated for growth and yield attributes

i.e. days to first flowering, first harvesting, pod length, number of pods and yield attributes were recorded. Among all the accessions RCMNFB-4, MZFB-32 and MZFB-384 were found to be promising. In case of cowpea, a total of 28 genotypes were evaluated for yield and quality traits viz. days to flowering, days to harvesting, pod length, number of pods, no. seeds per pods, 100 seed weight, yield, crude protein etc. Four genotypes viz. RCCPS-1, RCCPS-3 and RCCPS-16 were identified as high yield genotypes.

With regard to Indian bean, Among 125 genotypes that were evaluated, four genotypes i.e. ASDBC-17, TRDBC-6, TRDBC-34 under pole type and Sel-1 under bush type have been found to be promising in terms of yield. In case of underutilized cucurbits, 60 genotypes of chow-chow and 50 genotypes of teasel gourd were evaluated and among them Mizoram collection-1 (chow-chow) and RCTG-15 (teasel gourd) were identified as promising genotypes.

In so far as biochemical characterizations in chili**,** four GI tag chilies viz. birds eye chili, dalle chili, king-chili and sirarakhong chili were characterized for quality traits i.e. capsaicin and oleoresin. The highest capsaicin content was found in king chili (4.0 - 4.63 %) followed by birds eye chili (3.67 - 3.97), dale chili(3.33 - 3.51%) and sirarakhong chili (2.28-3.10%). Similarly highest oleoresin content was observed in king-chili (27.0 -32.0 %) followed by dalle chili (21.5 – 23.6 %), sirarakhong chili (20.10 -21.16 %) and birds eye chili (20.0-20.55).

Evaluation of King Chili (*Capsicum chinense* Jacq.) for yield and quality traits

(M. B. Devi and V. K. Verma)

A total of 29 genotypes were collected from different regions of North East India and evaluated for yield and quality traits. There was wide variation for morphological and horticultural traits (Fig. 13). The fruit shape was categorized into four major groups viz., elongated, triangular, blocky and campanulate and the fruit surface was grouped into smooth and wrinkled. Four major colours viz., dark red, light red, orange and brown at mature fruit stage; light green, light green with purple tings at neck and dark green at immature fruit stage were observed. Out of the genotypes, the line ML-5 recorded the highest yield per plant (1.5 kg) The line ML-3 exhibited a unique shiny brown color fruit with highest antioxidant capacity (82.32±0.02 µg AAE/g); total flavonoids (4.80±0.005 mg QE/g); total carotenoids (1.40±0.04 mg/g). The total anthocyanin and total phenol content were found to be 2.05±0.072 mg/land 2.12±0.018 mg GAE/g), respectively.

Fig. 13. Genetic variability of fruits in king chili

Development of oleoresin rich and rhizome-rot tolerant cultivar of ginger (*Zingiber officinale* Rosc.)

(V. K. Verma, M. B. Devi, P. Baiswar & S. Patra)

A total 112 accessions of ginger were evaluated for growth, yield and quality traits (Fig. 14). The high yielding accessions were identified as IC-584363 (450 g/plant) followed by ACC-391(416.7g), Vighinharta (400.0g) and RCGC-8 (383.3g). The highest oleoresin content was recorded in RCGC-17 (6.74%) followed by RCGC-20 and Acc-22(6.72% each). Further, 36 new accessions were collected during last 2 years from different parts of the region and two entries (RCVBG-1: CVT Ginger Bold and RCMLG-1: CVT Essential oil) has been submitted for Multi Location Testing (MLT) under AICRP on Spices.

Fig. 14. Ginger accession IC-584363

Organic Nutrient Management in Seed Spices

(V. K. Verma, M. Bilashini Devi, H. D. Talang, Tasvina R Bora, &Sandip Patra)

The field experiment on organic nutrient management in seed spices viz. fennel, coriander and fenugreek was conducted under mid-hill conditions of Meghalaya (Fig. 15). Treatments include combinations viz. T1: FYM (5 t/ha) + lime (2.5 q/ha) T2: FYM (10 t/ha) + lime (2.5 q/ha) T3: Vermicompost (2.5 t/ha) + lime (2.5 q/ha) T4: Vermicompost (5 t/ha) + lime (2.5 q/ha) and T5: N: P: K @ 90:10:10. In fennel and coriander higher yield (11.22 q/ha) was recorded in T4, while in case of fenugreek the highest seed yield of 23.21 q/ha was recorded in T2.

Fig.15. Coriander crop in full bloom

Performance of minor seed spices under mid-hills of Meghalaya: Three minor seed spices viz. Ajwain, Dill and Nigella were evaluated in the mid-hill conditions of Meghalaya in collaboration with ICAR-NRCSS, Ajmer, Rajasthan. Among the three spices, the highest yield was recorded in Nigella (10.23 q/ha) followed by Ajwain (8.23 q/ha) and dill (7.45 q/ha).

Standardization of soilless media composition for cultivation of anthurium

(*Vanlalruati, H. Rymbai, S. R. Assumi and J. L. Chanu)*

Seven soilless growing media viz. coco peat, vermiculite, perlite, saw dust, charcoal, river sand, leca (hydroton) were used in 6 different combinations and soil was kept as control (Fig. 16). Different growth parameters and flowering attributes were recorded. Growing media comprising Coco peat + charcoal + river sand + vermiculite + perlite in 1:1:1:1:1 ratio was found to be the best soilless media for growing Anthurium in mid hill of Meghalaya.

Fig.16. Performance of Anthurium (cv. Tropical Red) in different media in shade net

Lettuce production under open and hydroponic system

(V. K. Verma, M. Bilashini Devi & S. Hazarika)

A demonstration unit of hydroponics was established under the aegis of Centre for Development of Advanced Computing (C-DAC), Mohali in 2022. Three varieties of lettuce viz. Iceberg, Great Lakes and Romain were evaluated for growth and yield related traits (Fig. 17). The seedlings were raised in plug trays using soilless media. The crops were grown in coco peat and liquid nutrients were supplied as ready to use Hoagland solution and pH (6.8) was maintained by using of the phosphoric acid. The highest yield (3.06 kg m^{-2} area) per unit area was recorded in case of variety Iceberg (Table 2). The average yield under the hydroponic facility was 89.20% higher over the open condition.

Fig. 17. Lettuce var. Iceberg under hydroponics

Table 2. Performance of lettuce under hydroponic and open conditions

Variety	Leaf length (cm)	Leaf width (cm)	Number of outer leaves / plant	Marketable yield (g/plant)	Yield (kg m^{-2} area)
A.Under hydroponic					
Iceberg	19.90	18.00	9.80	191.00	3.06
Great Lakes	25.90	11.68	6.60	180.00	2.88
Romain	20.86	15.98	8.40	120.50	1.93
Mean	22.22	15.22	8.27	163.83	2.62
CD (%)	1.45	1.22	1.67	17.68	0.17
B. Under open conditions					
Iceberg	22.60	16.50	8.30	210.00	1.68
Great Lakes	24.00	12.00	6.00	188.00	1.50
Romain	22.67	15.50	8.80	125.00	1.00
Mean	23.09	14.67	7.70	174.33	1.39
(CD %)	1.86	1.75	1.41	21.45	0.22

Front Line Demonstration on Garden pea

(V. K. Verma, H. Rymbai & M. Bilashini Devi)

A field demonstration on garden pea (cv. Kasha Shakti and Kashi Samuridhi) was conducted in 25 farmer's fields in Ri-Bhoi, Meghalaya in 1.2 ha under the aegis of ICAR-Indian Institute of Vegetable Research, Varanasi. The highest green pod yield was recorded in Kashi Samuridhi (74.0 q/ha) followed by Kashi Shakti (58.0 q/ha).

cv. Kashi Samuridhi in Ms. Pynsuklin Kharumnuid field

Incidence of powdery mildew in cv. Kashi Shakti in farmers field

Fig. 18. Performance of garden pea varieties under front line demonstrations

Soil Science

Effect of maize-legume intercropping on soil acidity and carbon sequestration potential in northeast India

(Ramesh T, S. Hazarika, J. Layek, R. Krishnappa, A. Balusamy and J. L. Chanu)

The maize equivalent yield (MEY) under maize (M) + French bean (FB) intercropping was higher by 26.6 to 62.2% compared to maize + rice bean (RB), maize +groundnut (GN) +maize + soybean (SB) systems (Fig.19). Enzyme activity viz. dehydrogenase, urease, nitrate reductase and microbial biomass and total organic carbon were found to be higher M+RB intercropping, while the TOC and the very labile and less labile carbon to TOC were higher under M+FB. Inclusion of legumes as intercrops in maize resulted in 2-11% increase in SOC stocks and inclusion of French bean improved the soil quality with highest Carbon Management Index (CMI) i.e. 136. Application of FYM and lime along with recommended dose of fertilizers increased CMI value to 147.7. Maize and legumes reduced total potential acidity by 2.7-10.4%, exchangeable acidity by 2.9-11.1%, exchangeable $Al^{3+}$by 3.7-9.6%and exchangeable H^{+} by 23.4-120%.

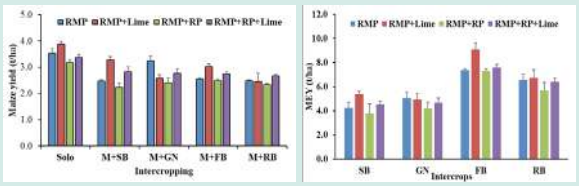


Fig. 19. Effect of maize-legume intercropping and nutrient management practices on maize yield and MEY in acid soils

Development of steel slag-based cost-effective eco-friendly fertilizers for sustainable agriculture and inclusive growth

(Ramesh T and A. Balusamy)

Five Tata steel Slag-based Products (TSP) viz. TSP 24, TSP 25, TSP 26, TSP 27 and TSP 28 were tested on French bean (cv. Selection 9), pea (cv. Arkel), rice (cv. IURON 554) and maize (cv. Megha maize-1) with RDF (80%) as control (Fig. 20). It was observed that TSP 24, TSP 25 and TSP 26 performed better compared to RDF (80%).

Fig. 20. An overview of the experimental site

Carbon footprints and energy budgeting of micro-watershed-based farming system models

(Ramesh T, J. Layek, and A. Kumar)

Results showed that agro-pastoral system (W4) with maize recorded highest Carbon Use Efficiency (CUE) and Carbon Sustainability Index (CSI). Pulses have lower C footprint and global warming intensity under maize based agro-pastoral system. Carbon dynamics showed that under W5 with french bean based production system recorded highest CUE and CSI followed by capsicum and tomato. French bean production reduced C footprint and global warming while livestock rearing caused maximum global warming (1.81). Agro-pastoral model had the lowest greenhouse gas intensity (GHGI), maximum energy use efficiency and lowest specific energy (Table 3). Results also showed that small-scale milk production is unprofitable without integration of other enterprises.

Table 3. Carbon footprint of different land use system farming systems

Farming system	GHGI (CO_2 e kg/kg)	Energy use efficiency (kg/MJ)	Specific energy (MJ/kg)
W1 (Dairy based)	0.45	0.34	0.78
W4 (Agro-pastoral)	0.31	0.39	0.52
W5 (Agri-horti-silvi)	0.42	0.37	0.68

Assessment of soil carbon dynamics and carbon sequestration potential of temperature fruit crops of Arunachal Pradesh

(Ramesh T)

Apple, Walnut, and Kiwi orchards of Arunachal Pradesh were sampled at four depths (0-20, 20-40, 40-60 and 60-80 cm) covering three elevations (lower-<1600m, mid- 1600-2000m and higher - >2000m). Soil pH, available K and very labile C were maximum under Walnut, while SOC, DHA, SMBC and Ca and Mg were higher under Apple orchard (Table 4). Walnut based system was better than other systems w.r.t. soil acidity parameter. With regard to altitudes, soil pH, SOC, Ca and Mg, available S, SMBC, DHA and SOC were higher in the lower altitudes while the soil acidity and available P and K were found to be higher under the mid altitude.

Table 4. Soil physico-chemical and enzyme activity in different fruit orchards in Arunachal Pradesh

Orchards	pH (1:2.5)	SOC (g/100g)	N	P	K	DHA (ug/g/hr)	Urease (mg/g/hr)
			(kg/ha)				
Apple	5.90	2.46	205.9	18.1	287.7	0.10	14.05
Walnut	6.12	2.31	208.0	20.7	291.4	0.09	12.27
Kiwi	6.04	2.17	236.9	21.2	229.9	0.09	18.29

Standardization of appropriate nutrient combinations (N, P, K & B) for improving yield and quality of King Chili in acid soils of Meghalaya

(L. J. Chanu, S. Hazarika, Ramesh T., A. Balusamy and M. B. Devi)

Field and pot culture experiments were conducted to study the response of N, P, K and B on yield and quality of king chili (cv. ML-5). During first and second years pot culture studies were conducted under controlled conditions to find the response on yield and capsaicin content of king chili. In third year, a field trial was conducted to validate the results of pot culture study. It was revealed that N:P_2O_5:K_2O @ 120:50:65 ha^{-1} + 0.25% B (foliar application) recorded the higher number of fruits per plant and fruit yield (Fig. 21). Further the same treatment also recorded highest N, P and K uptake compared to control. Application N:P_2O_5:K_2O @150:65:65 kg ha^{-1} recorded 4.0-4.2% higher Capsaicin under pot as well as field experiments which is 101-110 % higher control. Highest total chlorophyll and carotenoid content at the 50% flowering stage were recorded under 150:65:65: N: P_2O_5:K_2O kg ha^{-1}.

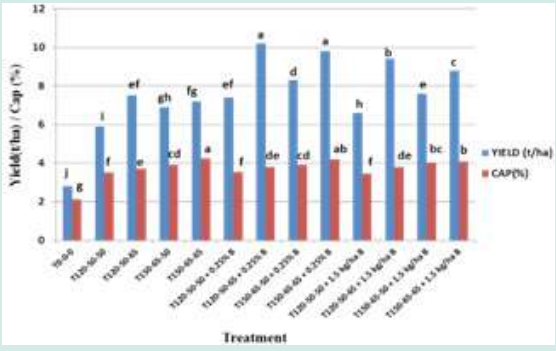


Fig. 21. Effect of nutrient combinations on fruit yield and capsaicin content

Reclamation of Coal Mine Affected Soils of Jaintia Hills District of Meghalaya for Improving Crop Production

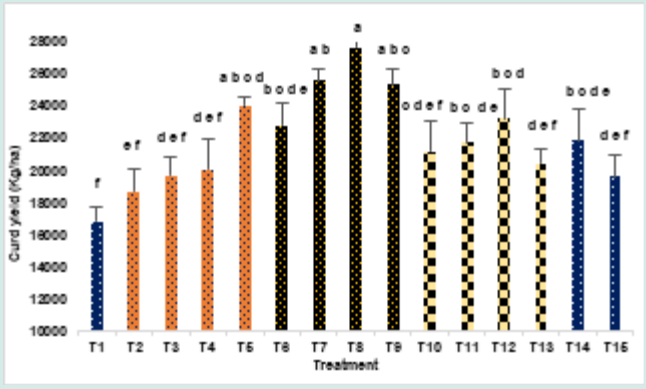
(M. P. Devi, S. Hazarika, B. U. Choudhury, Krishnappa R., A. Balusamy and L. Joymati Chanu)

Geo-referenced soil samples were collected from undisturbed forest and active coal mining sites (*Wapung, Sutnga and Khliehriat*) in East Jaintia Hills, Meghalaya to determine the efficiency of natural zeolites, fly ash, agricultural lime and poultry manure as soil amendment. The pH and organic carbon of mine spoil soil (n = 30) varied from 3.52 to 4.81 and 0.56% to 2.1% respectively. In mine spoil soils, the pH, water holding capacity (WHC) and microbial biomass carbon (MBC) decreased by 27–32 %, 20-23% and 44 - 68%, respectively over the reference site. The mean values of soil dehydrogenase, urease and catalase enzyme activities in the coal mine soils reduced by 91.82%, 99.03% and 91.92%. Surface elemental characterization of composite mine spoil soil revealed the presence of major elements in the order of O > K> Si >Al > Mg > Fe >Ti. Natural zeolite powder has a pH of 8.79 and X-ray fluorescence (XRF) analysis revealed higher values of silica and alkalis indicating the presence of quartz, feldspar and K-rich phyllosilicates in addition to alumina.

Management of zinc, boron and molybdenum for vegetable and citrus cultivation in acid soil of NEH Region

(A. Balusamy, S. Hazarika, B.U. Choudhury, A. Yanthan, B. Das, M Chakraborty, B. Devi, H. D. Talang, Lungmuana, B. Singh, P. Devi, S K Das and S. K. Datta)

A field experiment was conducted to investigate the influence of graded micronutrient doses viz. zinc sulphate (ZS), borax (BX) and ammonium molybdate (AM) on the yield and quality of cauliflower (cv. Seminis Megha) under Meghalaya conditions (Fig. 22). There were15 treatment combinations that consisted of soil application (SA), soil + foliar application (FA) and foliar application alone. Micronutrient treatments significantly and positively increased the plant height (cm), curd diameter (cm), individual curd weight (g) and curd yield (kg ha^{-1}) of cauliflower. It was revealed that the cauliflower productivity increased substantially with the application of ZS (@ 15 kg ha^{-1}), BX (@ 15 kg ha^{-1}), and AM (@ 2.0 kg ha^{-1}) and two foliar applications of micronutrients viz. (FA-1) ZS @ 0.25%, BX @ 0.10%, and AM @ 0.10% at 15-day intervals beginning at 30 DAT. The methods and dose of micronutrient application significantly affected the ascorbic acid concentration and antioxidant activity in cauliflower (Fig. 23). Except for the treatment i.e. soil application of ZS, BX and AM (@10 kg/ha, (@10 kg/ha and @ 1.0 kg/ha) + foliar spray (2 times @ 15 days interval starting from 30 DAT) of ZS, BX and AM (@ 0.50 %, @0.5% and @0.20 %), the ascorbic acid concentration was reduced in cauliflower. The soil application of higher dose of micronutrients (ZS, BX @ 15-20 kg/ha and AM @ 2-3 kg/ha) reduced antioxidant activity, but foliar application alone maintained it.

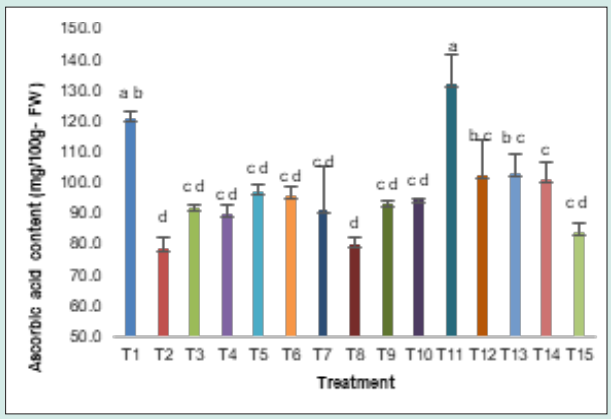


a. Micronutrients on curd yield of cauliflower

b. Overview of experimental setup

T1: Control(FYM @ 20 t/ha and NPK 100:75:50 kg/ha)
T2: SA of ZS, Bx @5 Kg ha^{-1} + AM @ 0.5 Kg ha^{-1}
T3: SA of ZS, Bx @10 Kg ha^{-1} + AM @ 1.0 Kg ha^{-1}
T4: SA of ZS, Bx @15 Kg ha^{-1} + AM @ 2.0 Kg ha^{-1}
T5: SA of ZS, Bx @20 Kg ha^{-1} + AM @ 3.0 Kg ha^{-1}
T6: SA of ZS, Bx @5 Kg ha^{-1} + AM @ 0.5 Kg ha^{-1} +FA1
T7: SA of ZS, Bx @10 Kg ha^{-1} + AM @ 1.0 Kg ha^{-1} +FA1
T8: SA of ZS, Bx @15 Kg ha^{-1} + AM @ 2.0 Kg ha^{-1} +FA1
T9: SA of ZS, Bx @20 Kg ha^{-1} + AM @ 3.0 Kg ha^{-1} + FA1
T10: SA of ZS, Bx @5 Kg ha^{-1} + AM @ 0.5 Kg ha^{-1} + FA2
T11: SA of ZS, Bx @10 Kg ha^{-1} + AM @ 1.0 Kg ha^{-1} + FA1
T12: SA of ZS, Bx @15 Kg ha^{-1} + AM @ 2.0 Kg ha^{-1} + FA1
T13: SA of ZS, Bx @20 Kg ha^{-1} + AM @ 3.0 Kg ha^{-1} + FA1
T14: FA1- ZS, Bx@0.25% & AM 0.1 %
T15: FA2- ZS, Bx@0.5% & AM 0.2 %

Fig. 22. Effect of micronutrients on the yield of cauliflower



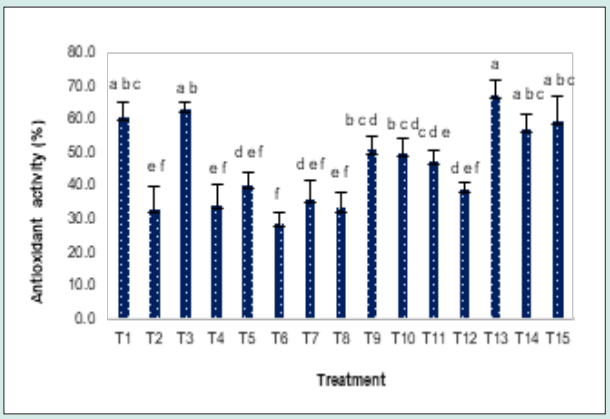


Fig. 23. Effect of micronutrient on ascorbic acid content and antioxidant activity in cauliflower

Assessment of critical limit of available zinc in rice growing ecosystems of Northeast India

(M. Chakraborty, S. Hazarika, B. U. Choudhury, A. Balusamy, C. BK Sangma, Lungmuana, S. K. Das, A. Tasung)

Geo-referenced soil samples from rice-growing soils of Meghalaya, Nagaland, Tripura, Mizoram, Manipur, Arunachal Pradesh and Sikkim were collected for analyzing plant available Zn. An extensive survey was done in Meghalaya to cover both lowland and upland rice ecosystems. The study revealed that lowland rice is cultivated in the valleys with poor to moderately well-drained soils on slope varying from almost levelled surface to gently sloping and upland rice is grown mainly on the shifting cultivation areas or by making terraces on the hillside slopes. Comparative assessment of soil Zn in both the rice ecosystems showed wider variability of DTPA- extractable Zn in upland rice soils as compared to lowland soils. Although wide variation in DTPA-extractable Zn in these soils was observed, about 40 percent of samples in Meghalaya (n=100) were found to have DTPA- extractable Zn below 1.0 mg kg^{-1}.

Division of Crop Science

Development of acid and cold tolerant rice genotypes suited to medium to high hill regions of Meghalaya

(A. Kumar, P. Baiswar and Philanim WS)

Yield evaluation trials

A set of 450 Upland and lowland rice germplasm was maintained. A set of advanced breeding lines were evaluated for yield and its component traits. Several advanced lines with higher yield per plant namely, RCPL 1-448 (3.5 t/ha), RCPL-1-440 (3.5 t/ha), RCPL 1-443 (3.7 t/ha), RCPL-1-441 (3.4 t/ha), RCPL 1-446 (3.8 t/ha), RCPL-1-444 (3.7 t/ha), RCPL 1-442 (3.4 t/ha) and RCPL 1-450 (3.3 t/ha) were identified and nominated to initial varietal trials of AICRIP, Hyderabad .

Generation and evaluation of segregating generations

Individual plant progenies from a set of 14 crosses in F_6 generation, 15 crosses in F_5 generation, 18 crosses in F_4 generation, 34 crosses in F_3 generation and 58 crosses in F_2 generation were grown, superior progenies were identified and further advanced to the next generation. A total of 83 crosses were attempted during 2022 and F_1 seeds were harvested for sowing in *kharif* 2023.

Evaluation of rice genotypes for aluminium toxicity and low Phosphorus tolerance

Hydroponic experiment specific to aluminium toxicity (540µM of $AlCl_3.6H_2O$) and low Phosphorus (0.16mM P) tolerance were carried out. It was found that in aluminium toxicity condition, primary root length was inhibited whereas in case of low phosphorus condition, primary root length was increased significantly among genotypes. It was also noticed that more number of secondary roots were observed in aluminium toxicity condition but the deviation among genotypes was found to be in narrow range. As per overall evaluation, genotypes namely, Manipur Special, GR-12, Yemshea Ngha, Welhinyi Kezurd, Chini Dhan and Dalbao showed superior performance in both field and hydroponic conditions.

Molecular analysis of test genotypes for aluminium toxicity and low phosphorus tolerance

In the current study, marker reported by previous researchers showing high R square value were taken for finding polymorphism among genotypes. Marker K20, K46-2 and Ba76H14_7154 were specific to low phosphorus tolerance and were associated with the *Pup1* gene. Markers namely RM252, RM559, RM258 and ART-1, related to Aluminium toxicity were used in the study. Through association studies using MLM technique, the marker K46-2 was found to be associated with root length, difference in root length and shoot dry weight in treatment and explained about 29.68, 19.71 and 23.95 percent of variation respectively for the traits. Marker RM258 was found to be associated with three traits namely, shoot length, difference in shoot length and root to shoot length ratio under aluminium toxicity conditions and explained 19.15, 17.58 and 21.76 percent of variation respectively as per GLM, whereas through MLM study, the marker RM258 was found to be associated with only root to shoot length ratio in treatment and explained the phenotypic variation of about 14.5%. MLM study also revealed that the marker ART-1 were found to be associated with difference in root length in treatment and explained the phenotypic variation of about 35.3%.

Fig. 1. Morphology of susceptible and tolerant rice genotypes under Aluminium toxicity

Marker-Trait association as analyzed by general and mixed linear methods

Sl.No.	Marker	Trait	GLM P	R square (%)	MLM P	R square (%)
1	K46-2	Root length treatment final	0.01	13.33	<0.001	29.68
		Difference in root length treatment	0.28	-	<0.001	19.71
		Shoot dry weight in treatment	0.57	-	<0.001	23.95
2	RM258	Shoot length treatment final	0.02	19.15	0.332	-
		Difference in shoot length treatment	0.04	17.58	0.961	-
		Root to shoot length ratio treatment	0.01	21.76	0.02	14.5
3	ART-1	Difference in root length treatment	0.87	-	0	35.3

Marker assisted pyramiding of three major genes (*Pi54, Pi1, Pita*) for blast resistance into elite rice varieties, Bhalum 5 and Shahsarang

(A. Kumar and B. Bhattacharjee)

A set of 200 BC_2F_3 plants derived from the crosses (Shahsarang/Pusa Sambha 1850, Shahsarang/Pusa 1853-12-288, Bhalum 5/Pusa Sambha 1850 and Shahsarang/Pusa 1853-12-288) were evaluated for yield and resistance to blast. The lines have shown resistance to moderately resistance to blast disease. The range of yield was from 5.23 g/plant to 41.62 g/plant.

Phenotypic Screening and Molecular Characterization of Blast Resistant Genes in Rice germplasm

The association between blast genes was computed with blast score using GLM and MLM, revealing that the markers AP4007, AP56595, C1454, and RM208 were found to be associated with the trait. The gene profiling of landraces revealed that *Pib* gene was found in all the landraces studied followed by *Pita2* gene in 72 (72%) landraces while, the *Pi54* gene is present in the least number of genotypes, *i.e.,* 28 (28%) landraces followed by *Pi1* gene in 29 (29%) landraces. It was observed that the genotypes with 4 R-genes showed a low blast score and percent disease index as compared to the genotypes with 3 R-genes. The genotypes such as Naga phou, Ching phou khong nembi, Nungshung phou, and Ratkhara were found to be more frequent in the 4 R-genes combinations.

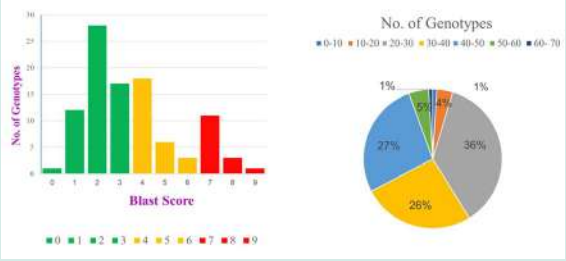


Figure 2. Distribution of genotypes based on blast score and disease index

Out of the total screened genotypes and checks, 6 genotypes namely MN-36, Ratkhara, Ching Phou Khong Nembi, MN-68, RCPL 1-110, and RCPL 1-44 showed amplification for the maximum number of gene-based markers i.e., 7 out of 10 gene-based markers followed by 13 genotypes namely MN-56, Makhara, Naga Phou, Sijali, Nungshang Phou, Anandhi, RCPL 1-103, MN-31, Chamra Phou, Rona Yang, RCPL 1-127, KMP-34, and RCPL-128 showed amplification for 6 gene-based markers.

Efficiency of various combinations of 4 R genes for blast score and disease index

Resistance Genes	Genotypes	Blast score	PDI
Pib + Pi2 + Pita2 + Pi5	MN-36, Priya, Noin, Naga Phou, Tara bali, Ratkhara, Land rice maring, RCPL 1-44	2	26.47
Pib + Pi9 + Pita2 + Pi2	MN-56, MN-36, MN-68, RCPL 1-127, RCPL 1-104, RCPL 1-110, RCPL 1-44	2.3	25.74
Pi2 + Pi5+ Pi54 + Pib	Sijali, Nungshang Phou, Manabe, Ching phou khong nembi, RCPL-128	2.5	24.33
Pi2 + Pi5+ Pi54 + Pib	Nungshang Phou, RCPL 1-82	2.7	25.14
Pi2 + Pi5+ Pi54 + Pita2	Sijali, Ching phou khong nembi, RCPL-128	2.4	24.82
Pi5+ Pi54 + Pib + Pi9	Naga Phou, Nungshang Phou, Ratkhara	2.5	26.07
Pi5+ Pi54 + Pib + Pita2	Chakhao Amubi, Makhara, Naga Phou, Sijali, MN-47, Ratkhara, RCPL-128, Ching phou khong nembi	2.2	25.21

Deciphering and deploying low P tolerance and nitrogen use efficiency in rice using targeted genomics approach

(A. Kumar and A. Balusamy)

A set of 33 rice genotypes were evaluated at varying N and P concentrations (N+P+, N+P-, N-P+ and N-P-), where each of these genotype were subjected to four kinds of Nitrogen (N) and Phosphorus (P) treatments and the response were seen for each of these genotypes. The effect of varying treatments on yield and its component traits were observed. Under N+P- conditions, more vegetative growth is being observed whereas, under N-P+ conditions grain filling was better. Several lines performing better in low N and P conditions, based on plant yield were observed. On the basis of the above observed traits, Bhalum-3, Bhalum-5 and Varadhan were identified as tolerant varieties.

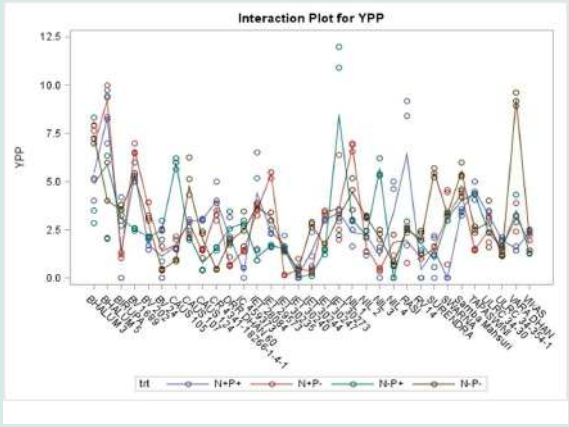


Fig 3. Interaction plot of yield per plant for all the 33 genotypes

Development of Ammonium Nitrate-Free Modified Magnavaca's Solution and Evaluation of Rice Germplasm from Northeast India

(S. Jaiswal, A. Kumar, B. U. Choudhury, R. Thangam, H. Verma, B. Bhattacharjee)

An experiment was conducted to assess rice genotypes' tolerance to aluminum (Al) toxicity, a major constraint in acidic soils. To overcome the lack of suitable nutrient media for Al tolerance screening, we devised a modified ammonium nitrate-free formula based on Magnavaca solution. Ammonium nitrate was substituted with $NH_4H_2PO_4$, NH_4Cl, and $Ca(NO_3)_2.4H_2O$, maintaining the elemental composition suggested by Famoso et al. (2010). By adding 550 µM of aluminum chloride hexahydrate ($AlCl_3.6H_2O$) at pH 4.1, we achieved an active Al^{3+} concentration of 160.9 µM. Notably, during the plant growth screening, diverse rice genotypes exhibited significant root growth variations under different Al toxicity levels. This facilitated their categorization as tolerant (Nagina22, Swarna, Naveen) or sensitive (Motodhan, Aaha, Sundari) genotypes. Furthermore, based on the Relative Tolerance Index, we classified the 105 rice lines into highly tolerant, moderately tolerant, and sensitive categories. The experiment yielded a valuable nutrient formulation for Al toxicity screening of rice genotypes. The identified tolerant and sensitive genotypes warrant further investigation into the molecular mechanisms of Al toxicity response in rice. Additionally, these genotypes hold promise for future breeding programs aimed at developing Al-tolerant rice varieties.

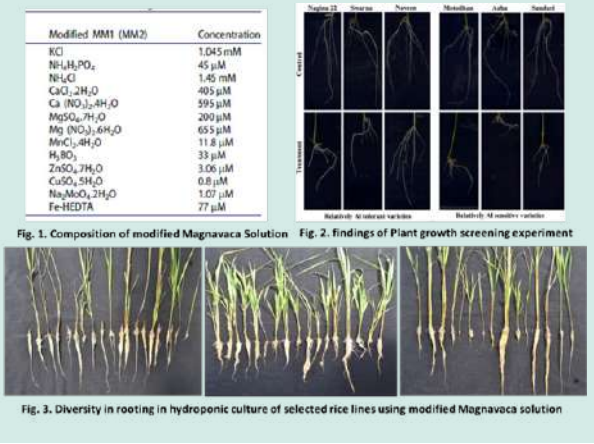


Fig. 1. Composition of modified Magnavaca Solution

Fig. 2. findings of Plant growth screening experiment

Fig. 3. Diversity in rooting in hydroponic culture of selected rice lines using modified Magnavaca solution

Association mapping for yield and yield related traits in a diverse core set of rice bean

(Philanim W.S.)

Ninety rice bean genotypes representing a core set from collection of germplasm across different North eastern states were evaluated for yield and yield corresponding traits. The germplasm were assessed for genetic diversity and stability. Total of 14 polymorphic markers amplified for a total of 30 alleles with an average of 2.14 alleles per each polymorphic marker. Markers Cg18775c0 and cG29169c0 recorded highest Polymorphic Information Content (PIC) of 0.76 and 0.73 respectively. Major allele frequency ranged (MAF) ranged from 0.48 to 0.99 with an average of 0.72 where cG25619c0 (0.99) andcG11226c0 (0.99) had highest MAF. AMOVA showed that 98% of existing variation was from within population and 1.79% variation came from among populations. The high percentage showed how genotypes are greatly diversified within a population. FST index which

helps to differentiate and decipher the probability by descendance obtained value of 0.01789 indicating a high FST to differentiate the groups. The matrix showed that the population pairs Manipur-Mizoram (FST > 0.08), Mizoram- Meghalaya (FST &GT:0.08) and NBPGR- Mizoram (FST 0.06-0.08) showed highest significant variation. STRUCTURE based analysis of the multi locus genotype data estimated the true value of ΔK at 2 indicating two sub populations. Based on the analysis the rice bean accessions were grouped into 4 clusters.

Fig 4. Gel electrophoretic pictures of polymorphic SSR markers in ricebean germplasm

Table 1. Summary of genetic variation of 14 polymorphic SSR markers

Marker	Major Allele Frequency	na*	ne*	Gene Diversity	Heterozygosity	PIC	I*
Cg18775c0	0.48	3	1.69	0.54	0.15	0.44	0.6
cG29169c0	0.57	2	1.96	0.49	0.53	0.37	0.68
cG9589c1	0.87	2	1.6	0.23	0.18	0.2	0.56
cG25883c0	0.59	2	1.85	0.48	0.82	0.37	0.65
cG21640c0	0.55	2	1.99	0.49	0.81	0.37	0.69
cG25619c0	0.99	2	1	0.01	0.01	0.01	0
cG26585c1	0.79	2	1.95	0.35	0.13	0.32	0.68
cG22836c1	0.63	2	1.42	0.47	0.49	0.36	0.47
cG11123c0	0.9	2	1.32	0.17	0.13	0.16	0.41
cG11226c0	0.99	2	1.15	0.02	0.02	0.02	0.26
cG23872c0	0.83	2	1.07	0.28	0.28	0.24	0.15
cG28852c0	0.81	2	1.42	0.3	0.2	0.26	0.47
cG18775c0	0.5	2	2	0.5	1	0.38	0.69
cG9711c0	0.63	3	1.77	0.47	0.74	0.36	0.63
Mean	**0.72**	**2.14**	**1.59**	**0.34**	**0.39**	**0.27**	**0.5**

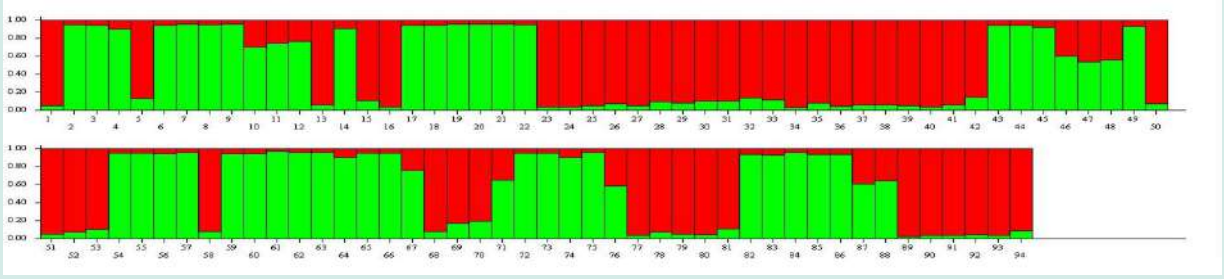


Fig 5. Population structure diagram of 94 Rice bean genotypes based on estimate of Delta K=2

Identification of Short Duration High yielding lentil genotypes suitable for Rice-Lentil cropping system

(Philanim W.S. and Amit Kumar)

A total of 100 lines of lentil procured from IIPR-Kanpur were evaluated for their yield performance and its corresponding traits during rabi season of 2022 under rice and maize based cropping system at Upper Plant Breeding farm. Earliest crop maturity was recorded in DPL-15 (DAS), DPL-62 (DAS) and IPL-81 (95 DAS). Highest seed yield per plot were recorded in) Bari-5 (450g), IC5060291 (440 g) and IPL-220 (400g) and were found promising among all the lines.


Upland field, Plant Breeding


Lowland field, Plant Breeding

Fig 6. Evaluation of lentil genotypes under rice and maize based cropping system

Crossing programme

A hybridization programme was initiated in lentil during the Rabi season 2022. A number of crosses were made between parents of contrasting characters viz., DPL-15 x PSL-9, IPL-220 x PSL-9, ILL-7663 x PSL-9, L-112-7 x PL8, 3113 x PL-8, 4322 x PL-8, 2576 x PL-8, 3330 xPL-8, 3278 x PL-8, IC-559610 x PL-8 and IC-208336 x PL-8. Successful crosses were obtained in hybridisation between DPL-15 x PSL-9, ILL-7663 x PSL-9 and L-112-7 x PL-8.

Fig. 7 Crossing programme in lentil

Development of maize inbreds to develop heterotic hybrids for Meghalaya

(Philanim W.S. and Amit Kumar)

A set of 29 genotypes were selected from original population of 740 based on their field performance and sown in Kharif 2022. Observations were recorded in the selected genotypes to identify superior genotypes to initiate population improvement programme through recurrent selection. Highest yield was recorded in 414 that performed better over all the checks and genotypes 524, 582, 518, 435 and 418 that performed better over two checks.

Study of rice yield under low light intensity using genomic approaches (ICAR - Incentivizing Research in Agriculture Scheme)

(C. Aochen, Amit Kumar, R. Krishnappa, N. Umakanta and Philanim W.S)

Field trial of 15 screened genotypes was undertaken under Normal Light (NL) and Low Light (LL, 30% shade) during Kharif 2022 with tolerant checks Swarna Prabha (SP) and Susceptible check IR-8. Five genotypes were selected for physiological and biochemical evaluation (Fig 1).

Fig 1. Low light experimental plot during *kharif* 2022

Under LL, tolerant genotypes Shasarang, Danteswari and Red Tribeni exhibited 28% mean increase in Normalized Difference Vegetation Index (NDVI), indicating a denser green canopy. Increased Mean leaf angle at the base canopy also observed in Red Triveni (103.3%) and Danteswari (102.7%). Higher percent increase in Transmission coefficient of canopy observed in tolerant genotypes under LL with lesser reduction in transmitted Photosynthetic Active Radiation (TPAR). While LL decreases Eff. panicle No., SF%, SW, the increased biomass increases stem reserves potential. Non-structural Carbohydrates (NSC) (water soluble carbohydrates) and Nitrogen (as proteins and amino acids) are components of pre-anthesis stem reserves potentially available for grain filling. NSCs contribute up to 40% to rice yield. The penultimate internode of main tillers at 5 DAA and 30 DAA, respectively, sampled for the study. Stem NSC and Stem Nitrogen was evaluated to understand the capacity of rice genotypes to accumulate stem reserves and their remobilization efficiency under LL. Higher stem NSC observed in tolerant genotypes (Red Triveni, Danteswari) under LL with higher content Remobilized, and thereby increased or least decrease in Remobilization efficiency(%) (Table 1). For QTL mapping, Biparental cross of GAR-2 x Danteswari advanced to F3. For developing climate smart varieties, cross of Shasarang X CR Dhan 801 initiated.

Table 1. Stem Carbohydrates Remobilization pattern under Low Light

Genotype	Stem NSC content (mg g^{-1} dw)				Stem NSC Remobilization (mg g^{-1} dw)		Remobilization Efficiency (%)		
	5 DAA		30 DAA						
	NL	LL	NL	LL	NL	LL	NL	LL	Efficiency Dcr%
Red Triveni	313.9	299.1	108.4	94.3	205.4	204.8	65.5	68.5	-4.60
Danteswari	294.0	311.0	125.4	119.2	168.6	191.8	57.4	61.7	-7.51
Swarna Prabha	235.2	246.8	83.9	103.5	151.3	143.4	64.3	58.1	9.72
Shasarang	288.0	261.8	114.8	120.8	173.3	141.0	60.2	53.9	10.46
IR-8	302.9	265.5	88.3	102.5	214.5	163.0	70.8	61.4	13.31
Narendra-1	292.6	301.1	99.9	128.1	192.7	173.0	65.9	57.5	12.75

Evaluation of Perilla (*Perilla frutescens* L.) for nutritional and medicinal benefits under different storage conditions

(C. Aochen, A. Kumar, K. Puro, B. Bhattacharjee and S. Jaiswal)

Five selected perilla genotypes, *viz.* RCPS-400, RCPS-407, RCPS-410, RCPS-412, RCPS-417, RCPS-421 are under station trials under AICRN Potential Crops. Peroxide Value, indicating fat oxidation and rancidity, trend for Cold and Vacuum storage (<6 meq/kg) indicates capacity for longer storage without compromising on oil quality, and can be considered viable storage conditions (Fig. 2). Leaf Antidiabetic activities i.e. Inhibition of α-amylase activity and Inhibition of α-glucosidase activity was up to 40.3% @ 100 µg/ml (IC50 83.03 µg/ml) and up to 79.4% @ 1 mg/ml (IC50 0.73 mg/ml). Perilla seeds can provide reliable sources of cereal-limiting quality proteins (Lysine 4.63% ± 0.08;Tryptophan 2.65% ± 0.03).

Conservation, taxonomy, diversity, cytology, molecular characterization and nutritional analysis of *Momordica subangulata* Blume subsp. subangulata and other edible species of *Momordica* L. from Northeast India

(C. Aochen and S. Ruth Assumi)

Among the 8 accessions evaluated, the highest β-carotene and Vitamin A (RAE) content is observed in leaves of *M. charantia* var. *muricata* (HJ/mis-19-107) at 78.5 ± 0.38 mg/100g and 39.38 ± 0.18 µg/100g, respectively. The methanolic extracts of shade-dried leaf clippings and fruits of different *Momordica* spp. exhibited antidiabetic effects. Increase in inhibition of α-glucosidase activity for antidiabetic study at concentrations 1.6-3.4 mg/ml was observed with higher inhibition% observed in leaves (81-95%) compared to fruits (57-70%). IC50 highlights the higher capacity of leaves to inhibit α-glucosidase activities at lower concentrations as compared to fruits (Fig 3).

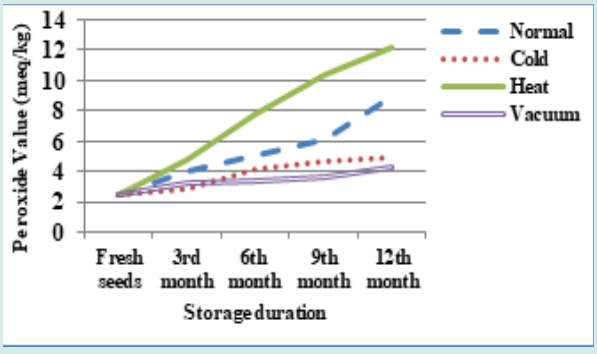


Fig 2. Peroxide value under different durations of storage

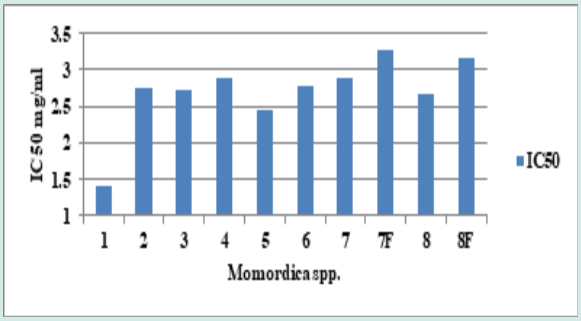


Fig. 3 IC50 for α-glucosidase Inhibitory activity

Harnessing Root traits and Rhizosphere efficiency for maximised P uptake under acid soils of Meghalaya.

(Krishnappa R, A. Kumar, J. Layak, Prabha M, Gangarani A, Bijoya B, Claribel C Iawim, and V. K Mishra)

A Field experiment was carried out by sowing the buckwheat crop throughout the year at 15days interval in upland farm of agronomy (Fig.1A). Days taken for first flowering were lowest and highest for 18th June and 2nd January sowing. Whereas Days taken for 100% flowering was highest for 15th and 3rd March sowing. Highest crop duration of 133 days was observed for 30th April sowing whereas lowest was recorded for 1st February (Fig.1B). Significantly higher leaf chlorophyll and carotenoids to the tune of 68% and 93.2% were recorded for 15th December sowing .respectively. In similar line substantially higher number of leaves (63.8%), plant height (29.5%) and crop yield (10-12 times) was noticed for sowing of crop between 1st October to 15th November. and plant height (53.5cm). In another field evaluation experiment comprised of 194 genotypes of buckwheat conducted in collaboration with plant breeding have revealed significant genetic variability for various physio-morphological and yield traits . Frequency distribution of growth traits showed that around65.8% of genotypes have leaf number in the range of 12-24 whereas around 57.9% of genotypes have plant height in between 35.0 to 55.0cm. Higher levels of leaf chlorophyll expressed in terms of SPAD chlorophyll meter reading(SCMR) was noticed in IC26592(40.7) and IC10796(40.0) and cooler canopies were observed in IC13413 (21.1 IR reading) and IC49678(21.3IR)Plant height was noticed highest in IC13143(60.3cm) and IC26592(63.3cm) whereas number of leaves were Found highest in IC13413 (42.7) and IC17368(41). Buckwheat genotypes like IC26592 and IC26589 have yielded 58% and 44.7% higher yield than local check Himapriya. Interestingly, seed yield was positively linked to number of leaves and TDM with r2 value of 0.186 and 0.296 whereas significantly positive correlation was also recorded between plant height and TDM with r2 value of 0.145.

Fig 1A. Field experiment of year growth potential of Buckwheat at mid-altitudes of Meghalaya

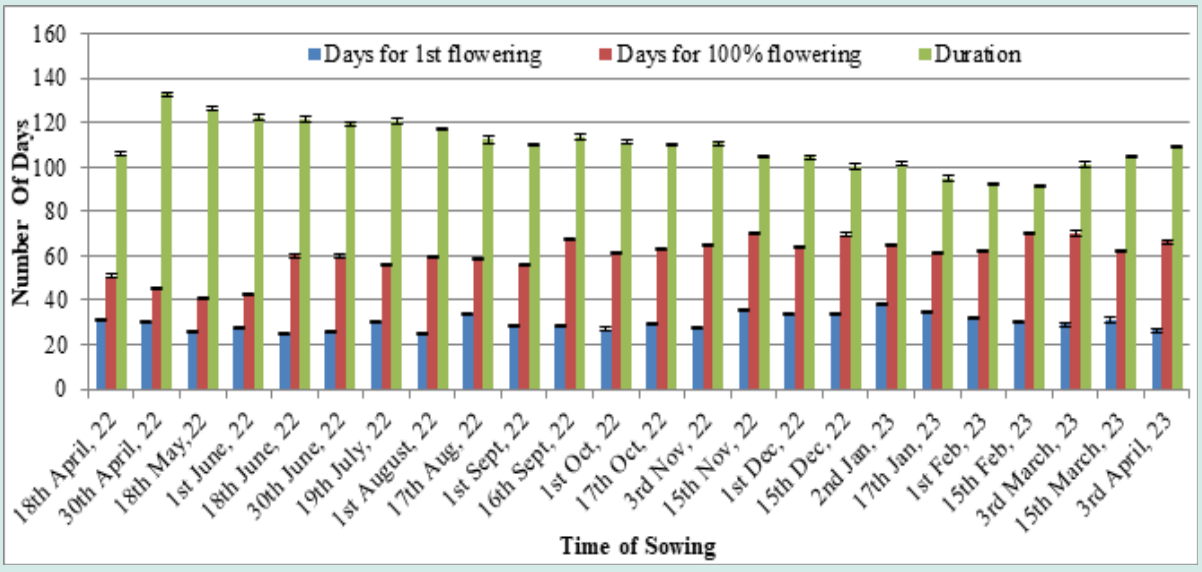


Fig 1B. Effect of sowing time on flowering time and crop duration in Buckwheat at Meghalaya

Understanding the impact of variation in plant defenses with edaphic factors on tritrophic interaction using Brassica Plants from NER as study system

(Krishnappa R, K. Chanu, B. Kharkhongor, K. Syiem, J. Buragohain, P. M, Jayanta L, Bijoya B and V. K. Mishra)

Field experiment comprising brassica cultivars viz., two mustard cultivars (PM-25 and M-27) and two local cabbage cultivars (Fast trac and KSP) with six P treatments was conducted at lowland agronomy revealed that most of stress physiological traits were influenced by P stress gradients(Fig.2). The mean anthocyanin content was found to be highest 2.85 µg/g FW in mustard variety PM-25 compared to M-27 irrespective of P gradients whereas Mustard variety PM-25 showed higher carotenoid content of 40.74 µg/g FW under inorganic treatment compared to mustard cultivar M-27 which shown higher values 20kg/ha phosphate application. Cabbage cultivar fast trac showed decreased significantly carotenoids with higher dose of 60 kg/ha and 80 Kg/ha phosphate. Total chlorophyll was higher (1.317 mg/g) under inorganic treatment of PM-25mustard variety. Mustard cultivars have showed increased anthocyanin content compared to cabbage cultivars whereas cabbage cultivars have showed higher carotenoids compared to mustard cultivars. Total chlorophyll content decreased with higher concentration of rock phosphate in cabbage cultivar fast trac compared to control. In similar line increased chl a/b ratio was observed by mustard cultivars compared to cabbage cultivars. Lower chl a/b ratio of 2.74 and 2.95 was showed by cabbage cultivar fast trac and KSP @80kg/ha. Higher cell membrane stability (CMS) of 96.1% and 95.3% was shown by Mustard cultivar PM-25 @ 40 and 60kg/ha phosphate supply. In addition lower values of MDA(Malondialdehyde) like 27.1 and 24.1µM/g FW were noticed by cabbage cultivars under control whereas higher MDA values of 91.2 and 79.4µM/g FW by PM-25 and M-27 respectively. Moderately higher TRL by mustard cultivars was noticed under no phosphate application whereas Cabbage cultivar fast trac has shown highest TRL under no phosphate application. In similar line higher values of RSA of 64.0 and 39.3 cm2 were shown by Mustard cultivars like PM-25 and M-27 under lower P dose of 20kg/ha P whereas cabbage cultivars have shown higher RSA of 87.2 and 81.88 cm2 by fast trac and KSP respectively. Highest values of RV with 10.1 and 9.38cm3 were observed in cabbage cultivars viz., fast trac and KSP under control with no phosphate application respectively. Highest yield of 7.57 qt/ha and 6.0qt/ha was noticed by PM-25 and M-27under inorganic treatment whereas lowest yield by both cultivars recorded under control. In cabbage highest yield of 33.6t/ha was noticed by KSP under 60kg/ha P application whereas highest yield of 34.99 t/ha was recorded by PM-25 under inorganic P supply. Harvest index (HI) of cabbage cultivars were recorded higher than mustard cultivars. Highest HI of 47% was shown by M-27 under 60kg/ha P application whereas higher HI of 25.1 was recorded by PM-25 under 80kg/ha P application. Even though improved mustard cultivar, PM-25 yielded better than local cultivar, M-2, it has shown better adaptation to low P supply of acid soil with favorable physiological traits like lower lipid peroxidation and higher anthocyanin and higher chla/b ratio. Application of 60kg/ha P application is highly essential for higher yield in cabbage cultivars.

Fig 2. Overview of brassica cultivars trial at Agronomy field

Monitoring, diagnosis and management of invasive alien insect pest species in North East India

Developed eco-friendly management practices against fall armyworm in maize

(S. Patra and R. H. Ch. Sangma)

Five dates of sowing of maize were evaluated to manage the fall armyworm under Meghalaya condition. Sowing of maize started during first fortnight of April with three replications for each sowing. It was found that among the different date of sowing, maize sown during second fortnight of April with combination of two soil application at 20 &40 DAS and two spray with *Bt*@2g/l recorded minimum dead heart (4.12%) with highest grain yield (3.38q/ha) of maize.

Developed eco-friendly management practices against fruit borers in tomato

(S. Patra and R. H. Ch. Sangma)

Tomato was transplanted with five different dates at 15 days interval starting from first week of January to manage the major fruit borers. The results revealed that tomato transplanting during 3rdweek of January along with application of pheromone trap of *T absoluta* and two spraying with *Bt* @2 g/l recorded maximum yield of tomato (120.52q/ha) with less fruit borer infestation (8.82% *H. armigera* & 12.86% *T. absulata*).

Monitoring and identification of insect pests in different crops in NEH Region

(S. Patra and Rumki H. Ch. Sangma)

Insect pests were monitored and collected from different agricultural and horticultural crops in Meghalaya. All collected insect species preserved with standard protocol for identification with traditional taxonomic keys and at molecular level. DNA barcode has been developed for many insect pests of different crops. Molecular analysis revealed new geographical distribution of hibiscus caterpillar, *Xanthodes transversa*, Noctuidae, Lepidoptera in okra from Meghalaya. Results also revealed that two insects namely slender burnished brass moth, *Thysanoplusia orichalcea* Fab.,Noctuidae, Lepidoptera and semilooper, *Lassaba parvalbidaria*, Geometridae: Lepidoptera were reported from fennel and ajwain and these two crops (fennel and ajwain) may be considered as new hosts.

Biological control of Indian Fritillary butterfly, *Argynnis hyperbius* by a tachinid fly

The caterpillars (1.4.a) of Indian fritillary butterfly, *Argynnis hyperbius* (Leidoptera; Nymphalidae) (1.4.b.) were found to infest the pansy plants, defoliating the plants at entomology field, ICAR-Research Complex for NEH region, Umiam, Meghalaya during January-April, 2022. The larvae were collected and reared under laboratory conditions for adult emergence. However, all the larvae were found to be parasitized by a larval-pupal parasitoid of a tachinid fly, *Sturmia bella* (Diptera: Tachinidae). The eggs were laid by the adults of the fly (1.4.e.) on 3rd-4th larval instar and the fully developed maggots (1.4.c.) emerge out from the host pupae and pupate(1.4.d.) in the ground. The larvae became sluggished as a result of parasitization. 1-2 maggots of the fly were found inside a single host pupa. About 90% parasitization of the caterpillars occurred under field conditions.

a. Caterpillar (Larva) | b. Adult butterfly *Argynnis hyperbius* | c. Host pupa with maggots | d. Pupae *(Sturmia bella)* | *e.* Adult fly, *Sturmia bella*

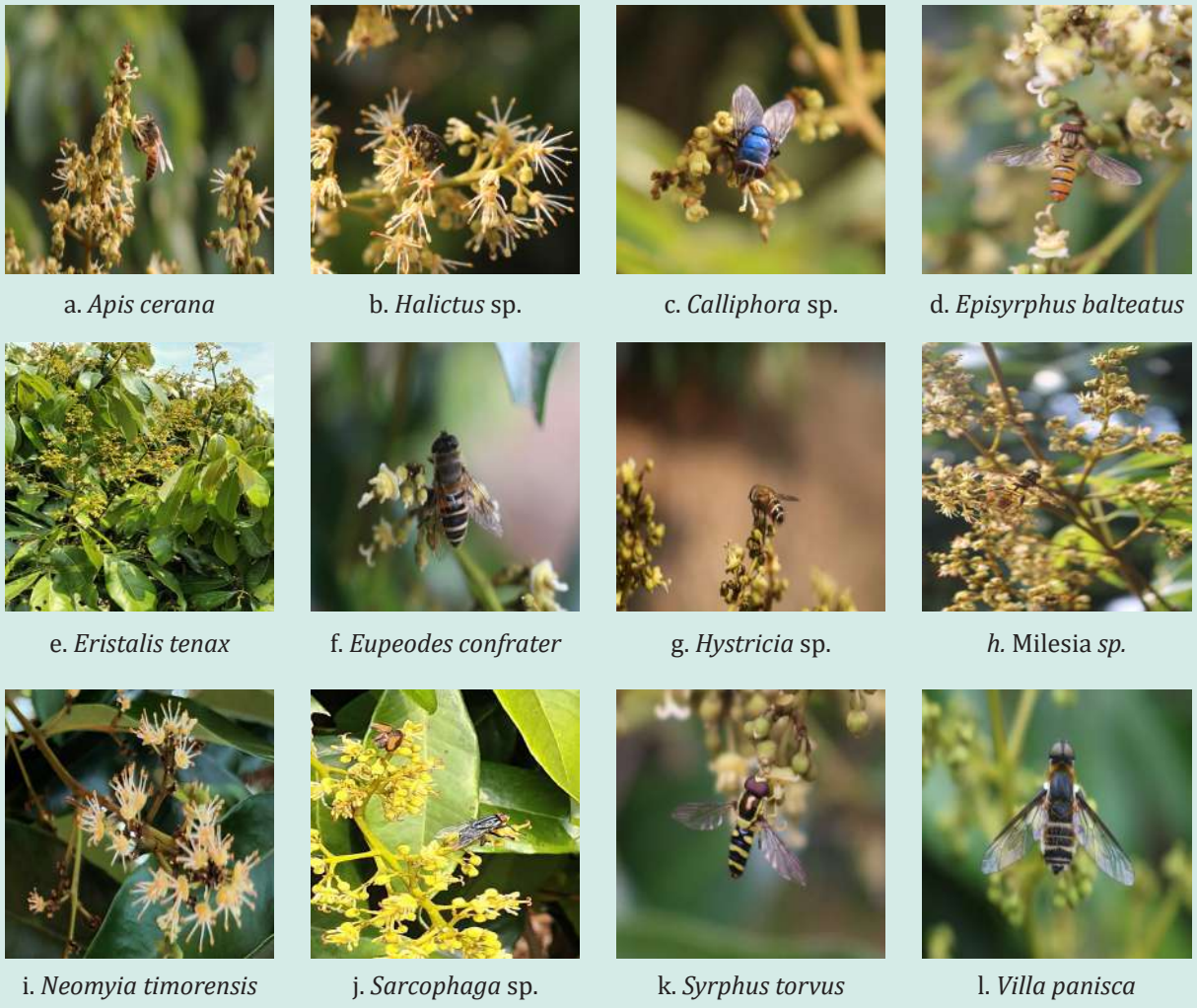
Fig 1. Different life stages of Indian Fritillary butterfly, Argynnis hyperbius and its Tachinid parasitoid, *Sturmia bella*

Biodiversity of pollinators in mid altitude hills of Meghalaya

Documentation of diversity of insect visitors and pollinators in Litchi

(R. H. Ch. Sangma, S. Patra, K. Kuotsu, H. Talang and B. Bhattacharjee)

The insect visitors and pollinators visiting the flowers of litchi were documented during the months of March and April 2022. A number of insect visitors belonging to different families and insect orders were found. About 4 species of insects belonging to order Hymenoptera, 13 species of Diptera, 4 species of Lepidoptera, 2 species of Hemiptera and 2 species of Coleoptera were found visiting and foraging on litchi flowers at different times of the day under open pollination conditions. The main insect pollinators identified through integrative taxonomy were *Apis dorasata*, *Apis cerana* (2.1.a), *Halictus* sp. (2.1.b.), *Calliphora* sp.(2.1.c.), *Episyrphus balteatus* (2.1.d.), *Eristalis tenax* (2.1.e), *Eupeodes confrater* (2.1.f.), *Hystricia* sp.(2.1.g), *Milesia* sp. (2.1.h.), *Neomyia timorensis* (2.1.i.), *Sarcophaga* sp.(2.1.j) , *Syrphus torvus* (2.1.k.), *Villa panisca* (2.1.l.), and Villa sp..



a. *Apis cerana* b. *Halictus* sp. c. *Calliphora* sp. d. *Episyrphus balteatus*

e. *Eristalis tenax* f. *Eupeodes confrater* g. *Hystricia* sp. *h.* Milesia *sp.*

i. *Neomyia timorensis* j. *Sarcophaga* sp. k. *Syrphus torvus* l. *Villa panisca*

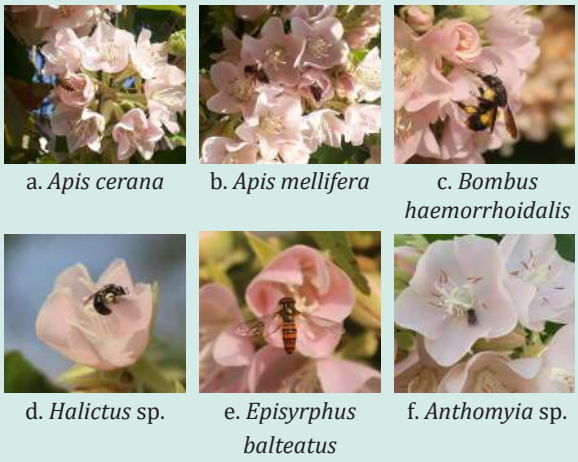
Fig 2. Diversity of insect pollinators in Litchi, *Litchi chinensis*

Impact of applied pollination with Indian honey bee, *Apis cerana* on the yield of mustard mustard

The study on the impact of Indian honey bee, *Apis cerana himalaya* in pollination and yield of mustard crop variety, T-S-67 was carried out from November 2022-February 2023 at Entomology farm, ICAR- Research Complex for NEH Region. The treatments that were evaluated include pollination with Indian honey bee, *Apis cerana Himalaya* under caged conditions, open pollination and control (pollinator exclusion). The main insect pollinators in decreasing order of per cent relative abundance were *Apis cerana*, *Halictus* sp., *Apis florea* and *Eristalis tenax*. Pollination Efficiency Index (PEI) was worked out based on the foraging activity, relative abundance and loose pollen grains adhering to the body of the insect pollinators. Results revealed *Apis cerana* and *Apis florea* as the most efficient pollinator of mustard based on PEI, respectively.

Studies on diversity of insect pollinators in pink ball tree, *Dombeya spectabilis*

The insects visiting the flowers of *Dombeya spectabilis* were documented during February-April, 2022. The most common insects in descending order of abundance were *Apis cerana* (2.3.a.), *Apis mellifera* (2.3.b.), *Bombus haemorrhoidalis* (2.3.c.), *Halictus* sp. (2.3.d.), *Episyrphus balteatus* (2.3.e.), and *Anthomyia* sp. (2.3.f.). The percent mean abundance was highest for *Apis cerana* with a mean abundance of 17.66 bees/m2/5mins followed by *Apis mellifera* and *Bombus haemorrhoidalis with a mean abundance of* 11.66 and 9.66 bees/m2/5mins.



a. *Apis cerana* b. *Apis mellifera* c. *Bombus haemorrhoidalis*

d. *Halictus* sp. e. *Episyrphus balteatus* f. *Anthomyia* sp.

Fig 3. Diversity of insect pollinators in Litchi, *Litchi chinensis*

Organic management of soil borne fungal pathogens of vegetables in Meghalaya

Occurrence of soil borne fungal diseases

(T. R. Borah, P. Baiswar, A. R. Singh, S. Patra, D. Chakraborty, M.Chakraborty and V. K. Verma)

Vegetable production, be it in homestead gardens or commercial cultivation is one of the major activities of all farmers in the state. Soil-borne fungal pathogens take a toll on vegetable production by causing diseases and total loss of production at times under favorable weather conditions and their management becomes an arduous task due to their characteristic attributes such as wide host range, scarce resistant source, and long period of survival in the soil through various resting structures. In recent times the soil-borne fungal pathogen *Sclerotinia sclerotiorum* has been seen to cause infections and heavy losses in cabbage. *In vitro* evaluation of twenty *Trichoderma* spp. obtained from different rhizospheric soil samples against mycelial growth of *Sclerotinia scletiorum* using dual culture method with three replication found the best two *Trichoderma* spp. with the mycelial growth inhibition of MT7(83.29%) and MT11 (81.55%). *In vitro* evaluation of the potent *Trichoderma* spp. showed correlated growth rate of MT7 (1.91mm/hr) and MT11 (1.87mm/hr), biomass production of MT7 (7.87g/100ml) and MT11 (6.49g/100ml). Similarly, their functional attributes were evaluated for production of siderophore MT7 (88.16%) and MT11 (86.01%), IAA MT7 (0.425µg/ml) and MT11 (0.242µg/ml), Zn solubilising ability MT7 (74.33%) and MT11 (73.20%) and PO_4 solubilising ability MT7 (68.48%) and MT11 (60.94%) and HCN production (positive). Under organic and natural farming systems the bioagents along with other bioinputs can provide holistic management of the soil borne fungus *Sclerotinia sclerotiorum*.

Cataloguing the diversity of biotic stresses and development of eco-friendly management practices in Khasi mandarin

Survey on incidence of biotic stresses in Khasi mandarin

(T. R. Borah, S. Patra, B. Bhattacharjee, H. Rymbai, D. Chakraborty and A. Balusamy)

Periodical observations of disease and insect pests on citrus orchard in horticultural farm as well as some selected orchards in farmer's field of Meghalaya was done. Seasonal occurrence of diseases was observed; citrus scab was seen during March-April. In July-August when the temperature was warm (20.1°C-29.8°C) and rainfall maximum of 114.2mm, infestation by citrus gummosis pathogen was observed. The warm humid summer season also favoured infestation by sooty mold (Fig.1). Powdery mildew (Fig.2) was seen mostly during the dry winter months (November – February). Incidence of citrus trunk borer was noticed from March-April to July-August whereas incidence of other pests *viz*. leaf miner, black flies, hoppers, scale insect were noticed from February-March to September-October. The farmer's orchards were of seedling origin and intercropping is practiced with exhaustive crops like ginger and pineapple. Proper schedule of weeding, pruning and application of Bordeaux paint was not practiced.

Fig 1. Sooty mold

Fig 2. Powdery mildew

Collaborative Research and Development Activities for Promotion of Seed Spices Varieties/ technologies in NEH Region

(T. R. Borah and V. K. Verma)

Incidence of disease on seed spices (fenugreek and fennel) was observed and recorded. Fenugreek crop was affected by *Fusarium oxysporum* at all stages of growth from seedling to maturity causing wilt, reduced plant stand and yield. During mid-December when the ambient temperature ranged 22.4°-9.5°C, the dill and fennel (Fig.3 & 4) crop at vegetative stage showed water soaked lesions. Gradually the lesions enlarged and blight symptoms appeared with discolouration and necrosis of the affected tissues. The blight affected plant parts turned dark brown to black in colour and the symptoms spread to the other parts of the plant finally killing the whole plant. The symptoms developed and were more prominent on the head and nodes. Isolation and identification of the causal organism was established as *Sclerotinia sclerotiorum*.

Fig 3. Blight symptoms in Dill

Fig 4. Blight symptoms in fennel

Demonstration of rejuvenation technologies for *Khasi* mandarin

(T. R. Borah and A. Balusamy)

The rejuvenation technologies of citrus orchards was demonstrated in Nongtrylaw village of Sohkhowai, Nongpoh, Ri Bhoi by selecting 75 number of bearing plants in the near decline stage orchard. In the orchard 50 numbers of Khasi mandarin plants were selected which were applied with the recommended doses of FYM and fertilizers. In the same citrus orchards, another 25 plants were marked/tagged as control with prevailing farmers practice (no FYM or fertilizers or plant protection materials). The average plant height of citrus in the demonstration site is 4.64 m in the treated plants and 4.35 m in the control site. Plant height, collar diameter, fruit weight, number of seeds per fruit, total soluble solids, rind thickness and juice content were non-significant between the treatments. Application of recommended dose of NPK fertilizers and micronutrients (Zinc and boron) fertilizer significantly influenced the number of fruits per trees to a tune of 26 per cent. Following the recommended practices farmer can able to earn an additional income of ₹ 1200/- (@8.0 per fruit for 150 fruits on an average). The result of the study disseminated to the other citrus grower in the nearby area in the form of field day on Khasi Mandarin.

Advance varietal trial-1 of high yielding varieties/strains of Oyster Mushroom (*Pleurotus pulmonarius*) on paddy straw

(P. Baiswar)

Six strains *viz*. PP-22-01 to 06 were evaluated in Mushroom house at ICAR, Umiam in the year 2023. The strains were supplied by DMR, Solan under AICRP on Mushroom. Substrate used was chopped paddy straw. Hot water treatment was done for 20 minutes by boiling the soaked paddy straw (soaking for 20 minutes). Spawning was done @ 100 g/3 kg substrate. Total 5 bags per replication and 5 replications per treatment were used in Randomised block design. Strain PP-22-06, 02, 04 and 01 gave highest yield and were statistically at par (Fig. 1 & 2; Table 1). Lowest yield was recorded in case of PP-22-05 (34.6% BE).

Table 1. Evaluation of high yielding strains/ varieties of Oyster Mushroom (Pleurotus pulmonarius)

Strains	Yield kg/100kg dry straw/saw dust
PP-22-01	62.4
PP-22-02	74.0
PP-22-03	54.0
PP-22-04	59.2
PP-22-05	34.6
PP-22-06	75.8
CD (0.05)	18.1

Fig 1. Fruiting stage (PP-22 series)

Fig 2. Fruiting in strain PP-22-02

Evaluation of QPM and OPV Maize lines against Turcicum leaf blight

(P. Baiswar)

Two trials were conducted *viz*. consisting of QPM (27 entries), and OPV and others (39 entries). All entries were evaluated at Umiam against Turcicum leaf blight (*Exserohilum turcicum*). These lines were provided by DMR, Ludhiana under AICRP on Maize. Two rows of 2 m length were used for evaluation. Artificial inoculation was done to increase the disease intensity. In case of OPV except 3 entries all were found to be susceptible and in case of QPM ten entries showed resistant reaction against Turcicum leaf blight.

Division of Animal and Fisheries Sciences

Research Achievement

Livestock Production

Exploring the prospects of deep-freezing storage of frozen semen in bulls: An alternative to cryostorage

(R. Katiyar, S. Deori, M. Singh, M Das)

The deep freezing storage technique was explored for semen ejaculates of Holstein Friesian crossbred bulls with 3 different diluents and compared with LN_2 storage. The first aliquot was diluted with standard dilutor (T1), whereas, other two aliquots were diluted with extender containing 25% egg yolk (T2) and standard diluent supplemented with 2 mg CLC/120 million spermatozoa (T3). The dose @ 2 mg CLC/120 million spermatozoa yielded best results for deep freezing storage. The thawing conditions were standardized and it was observed that the post-thaw motility was significantly higher when semen was thawed at 37 °C for 30 seconds as compared to 30 °C for 45 seconds and 45 °C for 15 seconds. It was also observed that the post-thaw progressive motility and viability were comparable ($p \geq 0.05$) in the LN_2 and −80 °C group (standard diluent and standard diluent with CLC groups) on day 1 and 7 of storage. Supplementation of egg yolk @25% did not yield any beneficial effect on post-thaw motility and viability.

Conservation and improvement of Indigenous cattle in North East of India

(*R. Katiyar, D. Jini, S. Deori, M. Singh, Lalhruaipuii, S. Doley*)

The Balang cattle of Arunachal Pradesh was evaluated and recorded the breed as small to medium sized, having small hump with tuft of hairs on forehead and ears. white patches present on the forehead of some animals. The coat colour varied between brown (23.8%), light brown (14.2%) and black (62%). The average body length, heart girth, height at wither, horn length, ear length, face length and tail length, neck length of male was 101.06±0.38 cm, 135.29±0.44 cm, 104.01±0.46 cm, 12.11±0.20 cm, 18.90±0.11, 38.34±0.17 and 90.39±0.32 cm respectively. The corresponding values for female were 97.67±0.96 cm, 128.64±0.68 cm, 99.73±0.32, 9.96±0.17 cm, 18.46±0.17 cm, 37.99±0.15 cm and 86.69±0.18 cm respectively. The average daily milk yield, peak yield, lactation length was 1.10±0.67 L, 1.31±0.51 L and 170.24± 9.32 days respectively. Milk fat % and SNF % were 4.52±0.48 and 8.27±0.54 respectively. During the reported year, "Masilum" is registered as new cattle breed from Meghalaya with Accession No.: INDIA_CATTLE_1300_MASILUM_03053

Impact of selenium nano-particles in semen extender on quality and fertility of boar and buck semen

(S Deori, R. Katiyar)

The effect of supplementing different concentrations of selenium nanoparticles (Se NPs) in TRIS extender on seminal attributes after freeze-thawing was investigated in semen of Assam Hill Goat bucks. Qualified semen samples (>70% progressive motility) were divided into three (3) aliquots and then diluted in TRIS extender containing Se NP supplementation at different concentrations (T_0: control; T_1: 0.5 µg/mL Se NPs and T_2: 1 µg/mL Se NPs). After dilution, semen samples were filled in straws, equilibrated and then cryopreserved in LN_2. The post-thaw attributes *viz*., motility, viability ($CFDA^+/PI^-$), morphology (eosin-nigrosine), plasma membrane integrity (HOS+), DNA integrity (AO^+) and mitochondrial membrane potential ($JC1_{agg}$) were evaluated. The LPO profile was assessed by malondialdehyde (MDA) assay. The enzymatic activities of SOD, CAT and GST as per standard methods. Results (**Fig: 1**) showed that Se NPs @ 1 µg/mL (T_2) had significantly ($p<0.001$) higher post-thaw sperm quality attributes in comparison to T_0 and T_1. The activities of SOD, CAT and GST were significantly ($p<0.001$) higher in T_2 in comparison to the other groups. The MDA levels were significantly ($p<0.001$)

lower in T_2 in comparison to T_0 and T_1. In conclusion, extender supplemented with 1 µg/mL Se NPs improved post-thaw semen quality of cryopreserved buck spermatozoa by lowering the formation of lipid peroxides and subsequently enhancing the antioxidant defenses, in turn lowering the oxidative stress associated with freeze-thawing.

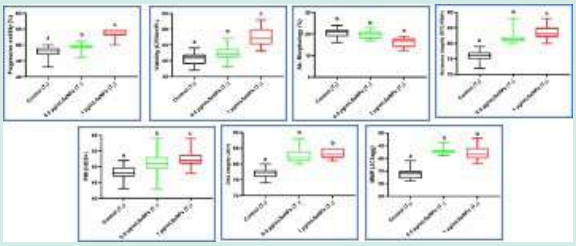


Fig.1: Post-thaw seminal attributes of Assam Hill Goat semen with different concentration of nanoparticle supplementation

Conservation of indigenous goat germplasms of North Eastern Hill region of India

(S. Deori, S. Das, D. Jini, B. Sailo, Lalhruaipuii, M. Singh, A. Chakrabarti, M. Bhatt)

The objective is to characterize and conserve the native goats of six north-eastern states of India, to evaluate the important economic traits like growth, reproduction, health and carcass characteristics and to undertake improvement of the native goats through selective breeding. The project is implemented in all the regional centres *viz*. Arunachal Pradesh, Nagaland, Manipur, Mizoram, Sikkim and Tripura with the same objectives with respect to indigenous goat of the respective states. In Meghalaya centre, a nucleus herd of Assam Hill goat (AHG) was established and different productive and reproductive traits were recorded during the reported period. Carcass characteristics and proximate composition were also recorded (**Table:1**).

Table. 1: Carcass Characteristics and Proximate Composition of Assam Hill Goat Meat

Parameters	Mean ± SE
Live Body Weight (kg)	15.65 ± 1.35
Carcass weight (kg)	7.15 ± 0.58
Dressing percentage	45.68 ± 1.55
Moisture (%)	73.64 ± 1.60
Fat (%)	3.00 ± 0.24
Protein (%)	21.20 ± 1.12
Ash (%)	1.1± 0.03
Shear Force (Kg/cm2)	3.56± 1.46

All India Co-ordinated Project on Pig

(S. Deori, S. Das)

Total herd strength maintained in the reported year was 269 pigs, which included 142 Lumsniang, 38 crossbred (F1- 50% H × 50% NM), 11 Hampshire, 33 Niang Megha and 45 Wak Chambil. The Lumsniang variety recorded litter size at birth of 9.34±0.67, litter size at weaning of 8.24±0.73 and body weight of 87.54±0.59 at 300 days. The mortality percentage for pre-weaning and post-weaning were 8.78 and 5.41. The breed characterization for Wak Chambil (**Fig: 2**) was done and successfully registered by Breed Registration Committee of Indian Council of Agricultural Research on August 31, 2022 with the Accession number INDIA_PIG_1300_WAKCHAMBIL_09013.

Fig: 2. Wak Chambil Sow

Poultry Seed Project

(S. Deori, K. Puro, R. Katiyar)

Under this project, improved variety parent stock (Vanaraja: 1473 and Srinidhi: 1070) was procured during the reporting year for production and supply to farmers. A total of 16,246 chicks were supplied to 767 beneficiaries in Meghalaya. Under the Tribal Sub plan component of the Poultry Seed Project, 03 numbers of farmer's training and field day cum demonstrations were organized. A total of 6020 Vanaraja chicks along with feeding and watering troughs, feed, medicines etc., were provided to 266 tribal farmers from different districts of Meghalaya during the period. Three exposure visits of local farmers to the institute poultry farm were also arranged to impart them with scientific poultry housing, feeding and health management systems.

Animal Health

Characterization of *Campylobacter coli* Field Isolates for Development of a Vaccine Prototype for Pigs

(S. Ghatak, A.A.P. Milton, S. Das, S. Deori, A. Sen, K. Puro)

The present study was conducted to identify the putative antigenic components of *Campylobacter coli* bacterium which is a major pathogen causing zoonotic infections in humans and production loss to swine husbandry as well. *C. coli* field strain was isolated previously from pig faecal sample following standard microbiological method (ISO 10272-1:2017). After molecular and genomic confirmation of the strain identity, whole genome sequencing (WGS) was undertaken on Illumina Nextseq platform. Moreover, whole proteome of the bacterium was also resolved by SDS-PAGE. Proteome and WGS data were analysed with a variety of tools and methods to identify potential peptides with vaccigenic potential. Our results from proteome study revealed two potential peptides of 45kDa and 29kDa that could be targets for vaccine development. Analysis of WGS data, on the other hand, identified 51 cell wall and capsule associated genes and 49 genes associated with virulence, defense and disease causation. Of these, there were 21 highly antigenic fractions and 9 very highly antigenic fractions with mean antigenicity score of 0.9389 ± 0.0309. To understand the chromosomal organization, these promising peptides were also mapped to the whole genome of *C. coli*. The mapping results showed that these peptides were encoded by genes located in the regions between 100 - 600 kbp and 2300 - 2500 kbp indicating future possibility of recombinant peptide synthesis. In order to assess the exposure of the peptide to host immune system to evoke a protective response, we estimated the trans-membrane domains of each peptides (**Fig: 3**). Our initial results revealed that of the 30 peptides, 3 peptides were most promising with 3 - 5 trans-membrane domains implying that these segments would be exposed to host immune system eliciting an immune response. Taken together, our results identified 3 putative peptides with vaccine potential from the field isolate if *C. coli* through a combination of microbiological, proteomic, genomic and immuno-informatics approach.

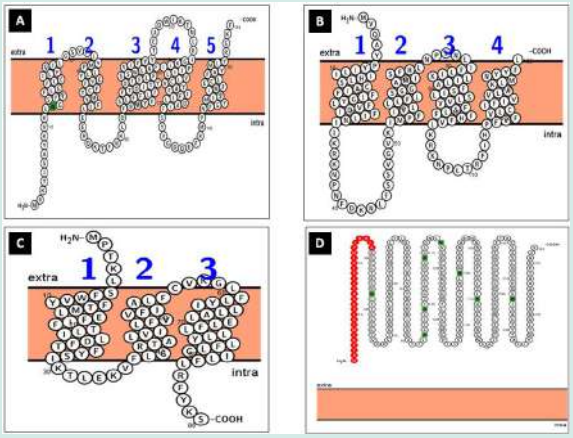


Fig:3.Trans-membrane (TM) domains of important protective antigens of Campylobacter coli field strain. Antigens with 5 TM domains (A); 4 TM domains (B); 3 TM domains (C); TM domain with signal peptide (red) (D).

Establishment of a Consortium for One Health to address Zoonotic and Transboundary Diseases in India, including the North-East Region

(S. Ghatak, A.A.P. Milton, S. Das, K. Puro, A. Sen)

Based on their zoonotic and public health importance, samples from three states, namely Meghalaya, Nagaland, and Tripura, underwent screening for several diseases, including Brucellosis, Lumpy Skin Disease (LSD), Japanese Encephalitis (JE), African Swine Fever (ASF), Porcine Reproductive and Respiratory Syndrome (PRRS), Cryptosporidiosis, Q Fever, tuberculosis, and Cysticercosis. Sera samples were collected from both porcine and bovine categories and tested for the mentioned diseases. Upon analyzing the samples from Meghalaya, a notable prevalence of several diseases was observed. The percentage positivity for Brucellosis was 15%, with three out of 20 samples testing positive. Similarly, a positivity rate of 21.6% was noticed for LSD. However, the JE positivity rate was much higher at 56%, whereas only 2.9% of samples were positive for ASF, indicating successful control efforts for the latter disease. PRRS showed a positivity rate of 3%. In the state of Nagaland, different degrees of positivity were observed following sero-surveillance. For Brucellosis, the percentage positivity was 15%, and for LSD, it was 5%. However, a relatively high positivity rate of 46% was noticed for JE, and

swine influenza showed a positivity rate of 49%. On the other hand, the occurrence of PRRS was relatively low, with a positivity rate of 1.5%. In the state of Tripura, Brucellosis and JE were major contributors to the disease burden, with 45% and 40% of samples testing sero-positive, respectively. On the contrary, LSD and PRRS were less prevalent, with sero-positivity rates of 4.8% and 1.6% among the collected samples.

This comprehensive sero-surveillance provides crucial insights into the prevalence of various diseases in the mentioned states, assisting in the formulation of effective control and prevention strategies for the well-being of both human and animal populations.

Detecting molecular signatures of avian respiratory viruses

(K. Puro, A. Sen, A.A.P. Milton, S. Ghatak, S. Das, S. Doley)

A total of 232 blood samples were randomly collected from farm birds (Vanaraja, Kadaknath, Srinidhi, Duck and Turkey) during the reported period and screened for molecular signatures of avian respiratory viruses: New Castle disease virus (NDV), Avian Influenza virus (AIV) and Infectious Bronchitis virus (IBV) by RT-PCR. The samples were screened for detection of specific virus species genes viz., NDV *HN*, AIV *Uni A* and IBV *S* genes. Representative samples of all the species were screened for presence of antibodies by ELISA method. Investigations of poultry mortality suspected of respiratory diseases detected five cases positive for AIV and one IBV.

National Animal Disease Epidemiology Network (NADEN)

(*S. Das, A.A.P. Milton, S Ghatak, A Sen, K Puro, R Sanjukta*)

The five year (2018-22) animal disease trend for the state of Meghalaya included FMD of bovine, caprine and swine, Black Quarter (BQ), Haemorrhagic Septicaemia (HS) and Classical Swine Fever (CSF) were graphically presented (**Fig: 4**). The Major livestock diseases reported during 2022 was African Swine Fever (ASF) in pig and it has been spreading over the state with frequent outbreaks. Molecular and serological detection of Lumpy Skin Disease virus (LSDV) in Cattle showed that the disease is present and spreading in the state of Meghalaya.

Fig:4. Five year Animal Disease data of Meghalaya

Modulation of gut microbiome of pre-weaned piglet by supplementation of probiotics for growing healthy pigs

(S. Das, A.A.P. Milton, S. Ghatak, S. Deori)

The probiotic (a combination of *Bacillus clausii, Saccharomyces boulardii, Lactobacillus acidophilus* and *Bifidobacterium*) fed to pre-weaned piglets for modulating gut microbiome were assessed by meta-genomics analysis of faecal samples. The pre-weaned piglets were fed in two groups with probiotic treatment on day 5, day 10, day 15 and non-treated control group. The faecal material in triplicates of day 5 (control) and day 30 (both control and probiotic fed group) were analysed for gut microbiome diversity. The probiotic fed group (day 30) had increased diversity of bacteria than control group. Also, a probiotic potential bacteria has been isolated from healthy pigs and identified as *Limosilactobacillus reuteri*. The isolate *L. reuteri no* 8 was taken for on-going animal experimentation.

Novel sensitive isothermal-based diagnostic technique for the detection of African swine fever virus

(A.A.P. Milton, S. Das, S. Ghatak, A Sen)

A rapid, simple and sensitive diagnostic technique for the detection of African Swine Fever virus (ASFV) nucleic acid was developed for testing clinical samples in the field or resource-constrained settings. The saltatory rolling-circle amplification (SRCA) technique was developed using World Organization for Animal Health (WOAH) approved primers targeting the p72 gene of the ASFV genome. The lower limits of detection of SRCA, endpoint PCR, and real-time PCR assays were 48.4 copies/µL, 4.84 ×

10^3 copies/µL, and 4.84 × 10^3 copies/µL, respectively. Thus, the newly developed SRCA assay was found to be 100 times more sensitive than endpoint and real-time PCR assays. Clinical tissue samples obtained from ASFV-infected domestic pigs and other clinical samples collected during 2020-22 from animals with suspected ASFV infection were tested using the SRCA assay, and a 100% accuracy rate, negative predictive value, and positive predictive value were demonstrated. This novel diagnostic kit (**Fig: 5**) is in compliant with the WHO "ASSURED" criteria advocated for disease diagnosis, as it is affordable, specific, sensitive, user-friendly, rapid and robust, equipment-free, and deliverable. Therefore, this SRCA assay may be preferable to other complex molecular techniques for diagnosing African swine fever.

Fig: 5. Diagnostic kit for detection of ASFV

Development of a novel visual isothermal amplification assay for rapid detection of *Brucella* spp.

(A.A.P. Milton, S. Ghatak, S. Das, I Shakuntala, A Sen, KK Baruah)

Brucellosis is an economically important livestock disease worldwide besides having a noteworthy impact on human health. A rapid, simple, and ultra-sensitive nuclei-acid diagnostic technique was developed for the detection of brucellosis harnessing saltatory rolling circle amplification (SRCA). The diagnostic method was developed using World Organization for Animal Health (WOAH) approved primers targeting the *bcsp31* gene of the *Brucella* genome. The assay can be accomplished within 90 min at a temperature of 65 ◦C without the requirement of sophisticated instrumentation. The result interpretation can be done with the naked eye with the aid of SYBR green dye (**Fig: 6**). The developed technique displayed 100% specificity by amplifying only 10 reference and field strains of *Brucella* spp. and there was no cross-reactivity with the other tested pathogens. The lower limit of detections of SRCA and end-point PCR assays were 9.7 fg/µL (2.7 genome copies of *Brucella*) and 970 fg/µL, respectively. Thus, the developed SRCA assay was found to be 100× more sensitive than the end-point PCR assay. To the best of our knowledge, our study is the first one to develop an SRCA-based assay for the detection of brucellosis and it can be a diagnostic tool for resource-constrained laboratories and veterinary hospitals.

Fig: 6. SRCA based kit for detection of *Brucella* spp. (M- Marker; PC: Positive Control; NTC: No Template Control)

Development of a multiplex PCR assay for simultaneous detection of African swine fever virus and classical swine fever virus

(A.A.P Milton, S. Das, K. Puro, S. Ghatak, A. Sen)

African swine fever (ASF) and classical swine fever (CSF) are two devastating viral diseases that poses significant threats to the global swine industry. Rapid and accurate diagnosis is crucial for effective disease control and prevention. We developed a multiplex polymerase chain reaction (PCR) assay capable of simultaneously detecting ASF virus (ASFV) and CSF virus (CSFV) in swine samples (**Fig: 7**). The assay utilized specific primers targeting the *p72* gene of African swine fever virus (ASFV) and the 5'-UTR gene of classical swine fever virus (CSFV), respectively, allowing for the simultaneous amplification and identification of both viruses. The multiplex PCR assay demonstrated excellent sensitivity and specificity, with no cross-reactivity observed with other common swine pathogens. Validation of the assay using clinical samples confirmed its reliability and feasibility for routine diagnostics. The development of this multiplex PCR assay provides a valuable tool for the early and accurate detection of ASFV and CSFV, facilitating prompt implementation of control measures to mitigate the spread of these highly contagious diseases in swine populations.

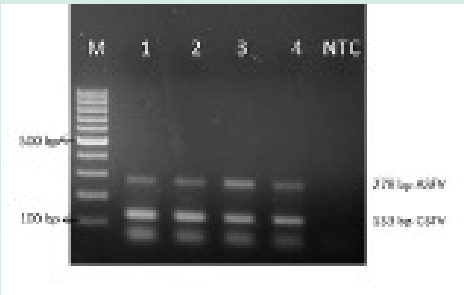


Fig: 7. Amplification of 5'-UTR gene CSFV (133 bp) and p72 gene (278 bp) of the ASFV

Synanthropic rodents and shrews as reservoirs of virulent and multidrug resistant *Staphylococcus aureus* in Meghalaya

(A.A.P. Milton, S. Ghatak, S. Das, A. Sen)

Staphylococcus aureus (*S. aureus*) is a Gram-positive bacterium that greatly impacts animal and human health by causing various diseases. Public health issues arise by the frequent zoonotic transmission of *S. aureus*, including methicillin-resistant *S. aureus* (MRSA), from pet and synanthropic animals including rodents and shrews. In the present study, oropharyngeal swabs from 150 animals comprising six species of rodents i.e., *Mus musculus* (n = 15), *Mus booduga* (n = 7), *Rattus rattus* (n = 9), *Rattus norvegicus* (n = 3), *Bandicota indica* (n = 30), *Bandicota bengalensis* (n = 62) and one species of shrew, *Suncus murinus* (n = 24) were processed for the isolation of *S. aureus. S. aureus* was isolated from 71 oropharyngeal swabs (47.3%) collected from six species of rodents and shrews. The occurrence rate of *S. aureus* was as follows, *Bandicota bengalensis* (60.5%), *Bandicota indica* (28%), *Rattus norvegicus* (1.4%), *Mus musculus* (1.4%), *Mus booduga* (1.4%) and *Suncus murinus* (7%). Antimicrobial susceptibility testing by Kirby Bauer disc diffusion method revealed that resistance rates were highest against β-lactams (methicillin, cefoxitin, and penicillin with 32.3%, 29.5%, and 28%, respectively). All the isolates were susceptible to tetracycline, chloramphenicol, teicoplanin, and vancomycin. Twenty-three isolates (32.39%) turned out to be multi-drug resistant (MDR). Based on the phenotypic resistance to methicillin and cefoxitin, sixteen (22.5%) MRSA was identified. Virulence genes such as *sec* (14%), *seb* (8.4%), *etb* (5.6%), *sea* (4.2%) and *see* (4.2%) were detected by PCR based analysis. Two isolates (2.8%) were found to harbor *mecA* gene. Evaluation of biofilm forming ability by crystal violet assay revealed that 85.9%isolates (61/71) were biofilm producers. The presence of virulence genes and biofilm forming ability were found to be strongly correlated. Using pulsed-field gel electrophoresis (PFGE) fingerprinting, twenty-five *S. aureus* isolates, representative of each rodent species were genotyped. Twenty pulsotypes were generated, and based on 89% similarity, they were grouped into three clusters. To the best of our knowledge, this is the first study in India to investigate the occurence, virulence profilng and genotyping of *S. aureus* isolated from free-living rodents and shrews. Prevalence of MDR and virulent *S. aureus* from synanthropic rodents and shrews is alarming as they can potentially contaminate food, environment and can infect humans and animals.

Economic impact of gastrointestinal parasitic infections in livestock and poultry and its integrated management in hill farming system.

(M. Das, R. Kumar, R. Katiyar, C. Gowda HR)

The economic losses caused by gastrointestinal (G.I.) parasites are lowered fertility, reduced work capacity, reduction in food efficiency and lower weight gain, lower milk production, increased treatment cost and mortality in heavily parasitized animals. Subclinical infection is common and causes high morbidity and mortality in young animals and enormous production losses in adults. Anthelmintics treatment increased milk production in dairy cattle and buffalo upto 17.50% and 12.83%, respectively. Identified G.I. parasites in cattle *viz*. Strongyle sp. (65.96%), *Strongyloides* sp. (22.17%), *Eimeria* sp. (22.24%), *Trichuris* sp. (12.15%), *Moniezia* sp. (8.90%), *Nematodirus helvetianus* (2.61%). *Eimeria* in cattle *viz. E. bovis* (42.19%), *E. zuernii* (30.23%) and *E. auburnensis* (27.58%) recorded. In pigs, *E. debliecki* (42.99%), *E. suis* (27.10%), *E. porci* (15.89%), *E. perminuta* (10.28%), *E. spinosa* (2.80%), *E. cerdonis* (0.93%) causing piglets mortality. Month wise pasture larval burden (L_3/Kg DM) estimated (**Fig: 8**). Third stage G.I. nematode larvae (L_3) *viz. Haemonchus* sp., *Trichostrongylus* sp., *Oesophagostomum* sp., *Cooperia* sp. and *Mecistocirrus* sp. observed in Bermuda grass (*Cynodon dactylon*), Guinea grass (*Panicum maximum*), Napier grass (*Pennisetum purpureum*), Paragrass (*Brachiaria mutica*). Isolated and identified nematophagous fungi (*Duddingtonia flagrans*) from cattle faeces.

Haemonchus sp., *Trichostrongylus* sp. | *Oesophagostomum* sp. | *Cooperia* sp.

Fig: 8. Third stage larvae (L3) of G.I. nematode larvae in pasture (400x)

Parasitic Infections in Buffaloes in North East region and its managements.

(M. Das, R. Kumar, R. Katiyar)

Coccidiosis is one of the most pathogenic intestinal diseases caused by *Eimeria* species responsible for economic losses in terms of morbidity and mortality in young calves. Clinical signs indicative of Coccidiosis were observed in the Murrah buffalo calves at Umiam, Meghalaya. Morphological characterization of *Eimeria* sp. revealed presence of *E. bareillyi* (18.18%), *E. zuernii* (9.09%), *E. bovis* (18.18%), *E. ellipsoidalis* (9.09%) and mixed infection (45.45%) in buffalo calves. Molecular characterization confirmed genus *Eimeria* sp. (440bp), *E. bovis* (238 bp) and *E. zuernii* (344bp) (**Fig: 9**).

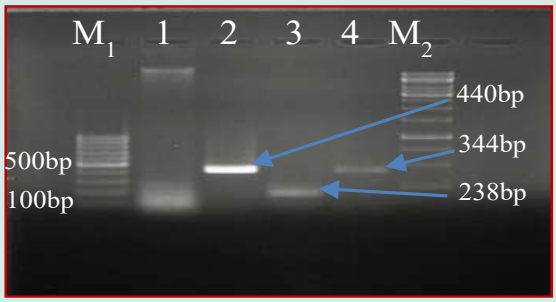


Fig: 9. Amplification of *Eimeria* sp. M1&2- Marker, 1- genomic DNA, 2- *Eimeria* sp. (440bp), 3- E. *bovis* (238bp), 4- E. *zeurnii* (344bp)

Establishment of Rural Bioresource Complex in the aspirational district of Meghalaya for improving livelihood of hill farmers through sustainable livestock based integrated cluster farming.

(M Das, R Kumar, N Singh, P Paul)

To demonstrate and popularize livestock based integrated farming system among tribal farmers of Ri Bhoi, Meghalaya, nine villages *viz.* Sarikuchi, Lalumpam, Borkhatsari, Nalapara, Borgang, Purangang, Nongagang, Umsawkhwan and Umbir were selected. Low cost water harvesting structures, jalkund (3nos.) and drip irrigation system (1no.) were established at Umsawkhwan village for growing vegetables and livestock farming throughout the year. Inputs such as pig and poultry feed, veterinary medicines and vaccines against Classical Swine Fever and Ranikhet disease were given. Faecal samples and blood samples were examined regularly to monitor parasitic infections. In backyard poultry**,** 30.16% (108/358) gastrointestinal parasitic infections were recorded while in pigs, 28.10% (154/548) gastrointestinal parasitic infections recorded. A total of 284 beneficiaries from eight villages were covered. Training and demonstrations (1nos.) and awareness programmes (7nos.) organized. Assisted in generating 54 nos of Self-employment and a pig breeding unit established in Umsawkhwan village.

Expansion of activities of Biotech KISAN Hub in selected seven aspirational districts of North East states.

(0M Das, R Laha, Lalhruaipuii, M Bhatt, G Kadirvel, S Deori, K Puro)

To promote entrepreneurship in piggery in seven selected aspirational districts of NEH region following cluster approach including health coverage 28nos. of villages adopted in the seven aspirational districts *viz.* Kiphire (Nagaland), Dhalai (Tripura), Hailakandi (Assam), Mamit (Mizoram), Namsai (Arunachal Pradesh), West Sikkim (Sikkim) and Chandel (Manipur). A total of 1412 nos. of beneficiaries from Kiphire (143), Dhalai (120), Hailakandi (60), Mamit (60), Namsai (890), West Sikkim (79) and Chandel (60) were benefited from the project. Training (40nos.) and awareness (19nos.) programmes organized. Piglets (548nos.) and pig feed (15950Kg) distributed among beneficiaries. Rural entrepreneurships (63nos.) developed. Pig breeding units established in Mamit, Mizoram and Namsai and Arunachal Pradesh. Hands-on training on meat processing and value addition of pork and pork products (**Fig:10**) organized by Main Hub, Umiam, Meghalaya. Beneficiaries from Namsai, Dhalai and Mamit had initiated enterprises for value added pork products.

Fig: 10. Pork products prepared by trainees from seven aspirational districts

Fisheries

Immunomodulation of fish using herbal resources: effect of feeding mango kernel as feed additive on fish immunity and disease resistance capacity

(C Debnath, S.K. Das)

To investigate the impact of Mango kernel (MK) as feed additive on the immunity, and disease resistance of *Labeo gonius* against *Aeromonas hydrophila*, a 90-day-experiment was conducted in concrete tanks (each 1.22 m^3 =1.7m x 1.2m x 0.6m). Four types of feeds (**Fig: 11a**) were prepared, incorporating MK: 0% (Control), 0.1%, 0.5%, and 1%. The fish (12.5±1.7cm/17.6±5.6g) (**Fig: 11b**), were fed these diets at 3% of their biomass for 60 days. Fish blood samples were collected on 20th, 40th, and 60th days and various parameters (glucose, protein, WBC, RBC, hemoglobin, etc) were analyzed. On day 60, the fish were artificially infected with a lethal dose of *A. hydrophila* ($1x10^5$ cfu/fish) (ATCC 35654TM; HiMedia) and mortalities were recorded over the subsequent 30 days. Additional blood samples were collected on 15th and 30th day post-infection and analyzed for various parameters. The results revealed that fish receiving MK exhibited enhanced immunity and disease resistance ($p \leq 0.05$) compared to the fish without MK supplementation. The survival of the fish in the control group, without MK, was 48.8%, while it ranged from 74.4% to 81.1% in the MK-fed groups. Notably, the dosage of 0.5% MK was found to be the most effective in improving fish immunity and disease resistance.

Fig: 11a. Fish pellet feed with mango kernel

Fig: 11b. *Labeo gonius*

Fish sperm cryopreservation

(T. Tayung, S. K. Das, R. Katiyar)

For work on cryopreservation of sperm from Chocolate Mahseer (*Neolissochilus hexagonolepis*), a high-value endemic fish currently endangered. Live fish were collected from Syntu Ksiar Mahseer Fish Sanctuary on Myntdu River near Jowai, West Jaintia Hills, Meghalaya (**Fig: 12**). The collected Mahseer fishes were stocked and managed in the Fisheries Farm of ICAR, Umiam for sperm/milt samples and their cryopreservation. Attempts have also been made to collect Pengba (*Osteobrama belangeri*) for similar work.

Fig: 12 a. Collection of Chocolate Mahseer Fish

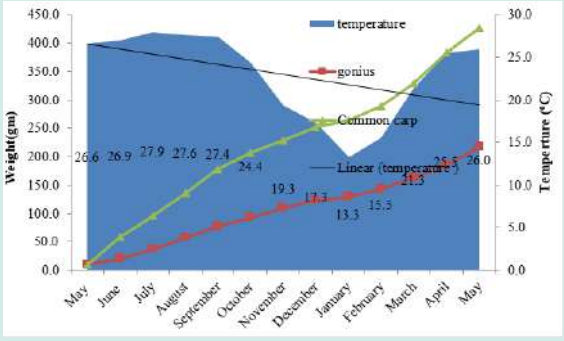
Fig: 12 b. Chocolate Mahseer Fish

Two species Fish culture under Mid-hill climate

(*S. K. Das*)

One of the major challenges in promoting aquaculture in mid-altitude regions is the scarcity of suitable fish species to enhance fish production. The cold climatic conditions prevailing in the

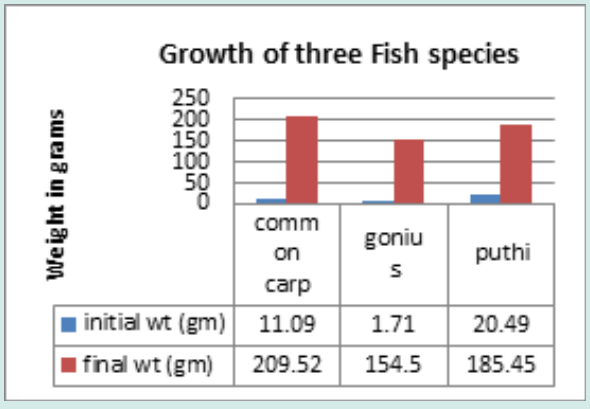
state of Meghalaya limit the fish growing period to approximately 7-8 months per year. The conventional practice of employing a composite fish culture system with six species, commonly successful in lower altitude warmer regions, does not always yield satisfactory results in mid-altitude areas. Hence, a study was conducted to assess the efficacy of a two-species fish culture system using *Labeo gonius* (Hamilton, 1822) and *Cyprinus carpio* Linnaeus, 1758, to augment fish production in the mid-hill region. This technology focuses on the performance of these two species in small ponds over a one-year period. The specific growth rate (SGR) varied between 0.248 and 1.038 g day^{-1} for *L. gonius* and between 0.520 and 1.831 g day^{-1} for *C. carpio*, respectively. The combination of these species resulted in an average fish production of 2550 kg/ha/year.



Three species fish culture under mid hill condition during winter months

(S.K. Das)

To enhance fish production through species diversification in mid-hill aquaculture during the winter months. An experiment was conducted with the following parameters: stocking density of 8,000 fish per hectare with Common Carp: Gonius: Puthi @ 50:30:20, and feeding with a combination of rice polish and MOC (1:1) at 2% of their body weight daily. The experiment took place in a pond measuring 200m^2. The estimated fish productivity during the winter months was 1350 kg per hectare.



Farmer Participatory Cage Culture in Umiam Lake

(S. K. Das, T. Tayung, C. Debnath)

To implement species diversification in cage culture and utilize reservoirs (large water bodies) for fish production, ICAR-CIFRI cages and pellet feed were used for Common carp: 35%, Gonius: 35%, Silver barb: 15%, and Amur common carp: 15%. The stocking density ranged from 4 to 6 fish per cubic meter. A total of approximately 500 kg of fish was successfully produced from a battery of four cages, each measuring 6m x 4m x 2m. Silver barb *(Barbonymus gonionotus)* was identified as a potential species for diversifying cage aquaculture in Meghalaya.

Cage culture of Fish

Fish seed production and supply

(S. K. Das, C. Debnath, T. Tayung)

Meghalaya experiences a substantial demand for fish seeds, and the state relies on diverse sources to meet this burgeoning need. In this regard, the ICAR NEH Fish Farm complex plays a pivotal role in fulfilling the fish seed requirements of local farmers. The complex contributes significantly to the sustainable development of aquaculture in Meghalaya. During this period, the ICAR NEH Fish Farm complex successfully generated approximately 150,000 fish seeds of

common carp, catla, rohu, gonius, java puthi, grass carp, and others supplied under various projects. The collaborative efforts with key partners played an instrumental role in the successful implementation of these projects. The collaborating partners comprised the Krishi Vigyan Kendras (KVKs), the Department of Fisheries, Meghalaya, and the Meghalaya State Fisheries Research and Training Centre, Mawpun.

Native fish germplasm collection for propagation and conservation

(S. K. Das, C. Debnath, T. Tayung)

During the period two endemic fish species Chocolate Mahseer (*Neolissochilus hexagonolepis*) and Reba Carp (*Cirrhinus reba*), were collected. The Chocolate Mahseer is recognized as the 'state fish' of Meghalaya and is listed as an endangered species. 467 live specimens of Chocolate Mahseer were collected from Umngot River in Meghalaya and transported them to ICAR fish farm at Umiam. Currently, conducting the domestication process for the Chocolate Mahseer in both pond and polyhouse conditions. To meet their nutritional requirements, we developed a locally formulated feed consisting of mustard oil cake (30%), rice polish (40%), and dry fish (20%), which provides a protein content of 32.5% (CP). At the beginning of the rearing process, the fish had an initial weight of 2.03±0.32g. After six months, their weight increased to 44.1±5.7g in the pond condition and 42.1±4.5g in the polyhouse condition. These results indicate that the pond ecosystem yields better domestication outcomes compared to the polyhouse ecosystem. Furthermore, 55 Reba seeds (10.03±0.48 cm/8.12±1.24 g) were procured from the Fisheries College, Assam, and introduced them to ICAR fish farm at Umiam. The Reba carp are currently being raised on a pellet feed with a protein content of 28% CP and 5% CL, provided twice a day. After 12 months of rearing, the average weight of the fish reached 58.82g (range: 44.92-76.29g) with a survival rate of 75%. The fishes are yet to reached maturity; this has been confirmed through analysis of reproductive parameters.

Chocolate Mahseer

Reba carp

Division of Technology Assessment and Capacity Building

Project: A study on the Social Network Structures vis-à-vis Information on Agricultural Technology among the Farmers of Meghalaya, Code: IXX17261

(K. P. Biam, N. U. Singh, P. Paul, C. Gowda H. R.)

This study aims to delineate and analyze the configuration of social networks of farmers with respect to the acquisition of information on low input backyard poultry farming and high yielding variety rice. Three stage sampling was carried out by interviewing 60 technology-adopter farmers from Ri-Bhoi districts of Meghalaya. For mapping the network, social network analysis (SNA) was used, which revealed the important sources as well as patterns of information accessed by farmers. Results established the predominance of a formal communication source (KVK personnel) in the study locales followed by small and marginal farmers for crucial information support on technology use. The trend is observed irrespective of their gender in various study areas. Significantly the study thus, underscored the role of homogenous peer groups of farmers in facilitating meaningful interactions as well as information sharing on the technology.

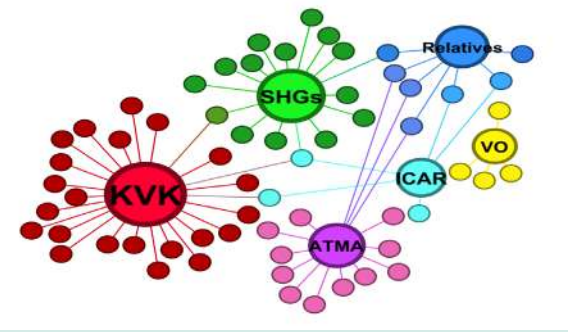


Fig. 1. Low input backyard farming and high yielding variety of rice information network
Note: KVK: Krishi Vigyan Kendra Personnel, SHGs: Self Help Group Members, VO: Veterinary Officer of state , ATMA: Agricultural Technology Management Agency

Project: Price Forecasting for Selected Agricultural Commodities of Meghalaya, Code: IXX16931

(N. U. Singh, P. Paul, C. Gowda H. R. D. Chakraborty, R. M. Reddy)

Since Horticulture crops are frequently impacted by supply side price volatility from year to year and season to season based on various market

forces, therefore 360-degree price forecasting techniques using statistical modelling, consultation with stakeholders, as a pilot for the State was undertaken, in order to help the farmers and the Government in better risk management and price policy strategy. For the purpose, historical price data were used to forecast short term price for selected commodities of Meghalaya viz., ginger, turmeric, potato, tomato, pineapple and broomstick. ARIMA, ARIMAX, ARCH and GARCH models were run and best fit model was determined using fit statistic viz., Variance, Standard Error, AIC and SBC of the identified models. AR (2)-GARCH (1,1)-NOINT was identified as the best fit model for potato. Other models were also identified using forecast accuracy measures like MSE, RMSE, MAPE, etc. and were used to forecast prices of the commodities for next five months.

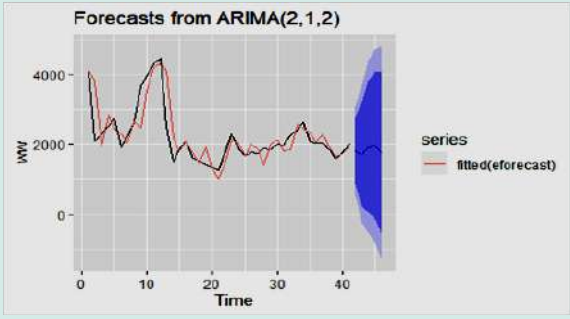


Fig. 2. Forecast values vis-à-vis actual values of prices for potato

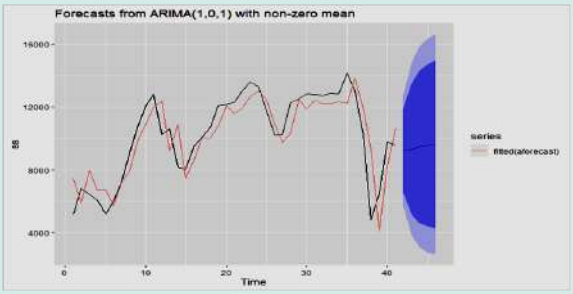


Fig. 3. Forecast values vis-à-vis actual values of prices for broomstick

Project: Adoption and behavioural intention of tribal farmers towards improved agricultural technologies in Meghalaya, Code: IXX17001

(P. Paul, N. U. Singh, C. Gowda, J. Layek, V. K. Verma, G. Kadrivel)

The different technology dissemination methods used by the scientists were critically analyzed. ICAR Research complex for NEH Region, Umiam has developed and modified certain agricultural technologies over the time, such as hybrid maize variety Megha Maize-1, Megha Turmeric (Turmeric variety), Jalkund, a micro water harvesting structure. Apart from aforementioned technologies, Artificial Insemination (AI) in pig is one of the most popularized technologies in few pockets of the state. This study has found that training and demonstrations were the most used dissemination method adopted by the scientists. In case of Megha Maize 1 on an average, every year since 2017-18, 4 nos. of demonstrations and 2 nos. of trainings were conducted. Apart from this with active involvement of the farmers participatory seed production model were operating in 5 districts, where total 210 qt. seeds were produced with coverage of 924 farmers from 22 villages.

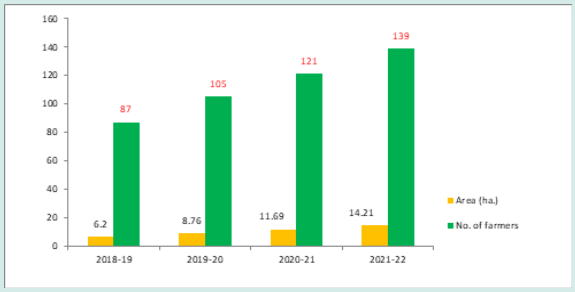


Fig. 4. Demonstration of Megha Maize 1 at the farmer's field

Project: Spatio-Seasonal Relationship in Food Diversity Among the Indigenous Communities of North-East Region, Code: IXX16934

(P. Paul, C. Gowda H.R., N. U. Singh, H. Rymbai, A. Tasung, Kh. R. Singh, Azeze S. and Lungmuana)

The study found that the people of the region are dependent on animal protein as mostly they are non-vegetarian by food habit. The findings of the study revealed that roots and tuber crops have noteworthy occupancy in their food basket. On the other side, even though per capita milk availability is 26.64 Kg/year, the consumption rate is 15.35 Kg/year while that of ICMR dietary recommends is109 kg/year. Consumption of pulses and oil among the Khasi people are very less as they prefer boiled form of food or food cooked with less oil. The Simpson index of Dietary diversity (SIDD) and Individual dietary diversity score (IDDS) for the sampled households revealed that there is ample scope to improve SIDD as well as IDDS value as SIDD

ranges from 0.67 to 0.74 and IDDS ranges in between 6.5 to 7.7, as the value of SIDD ranges from 0-1 and IDDS from 1-10, respectively. Apart from this, reported SIDD value is 0.71 among the Tripuri households from Tripura, where 65.72 percent of vegetables used in food basket are from home produces. Adi households from East Siang district of Arunachal Pradesh were spending 23.37 percent of total expenditure of food on purchasing meat from the market as the demand cannot get fulfilled by home produces. At the next level, this study is intended to analyze the availability and accessibility factors which has direct or indirect control over the food habit and moreover specifically the food diversity among the people.

Project: Socio economic impact assessment of Jalkund (micro rainwater harvesting structure) in hill ecosystem of Meghalaya, Code: IXX17002

(C. Gowda H. R, N. U. Singh, Pampi Paul and V. K. Mishra)

To assess the benefits and impact of *in-situ* micro-rainwater harvesting structure (Jalkund), the data were collected from the beneficiaries under TSP and farmers' FIRST project. The results revealed that the farmers were able to cultivate around 450 sq. m area under the jalkund irrigation. The overall farm household income has increased from Rs. 1,45,000/- to Rs. 1,91,125/- after implementation of low cost jalkund technology in the farm. Increase in the income from all the activities after having jalkund was about 31.81 percent. Piggery showed the greater increase in the income (36.21%) followed by cultivation of crops (26.73%) and poultry (24.17%). In total, from the implementation of jalkund technology, beneficiaries were able to generate on an average of 46 days additional employment. Overall, the jalkund technology plays a vital role in the livelihood improvement of the hill farm households by providing water especially during the post-rainy season.

Project: Task Force on Himalayan Agriculture-National Mission for Sustainable Himalayan Agriculture (II Phase), Code: OXX5387

(N. U. Singh, P. Paul, A. Roy, A. Yumnam, C Gowda H. R, K. P. Biam, D. Chakraborty)

Block level vulnerability analysis was carried out on a trial basis based on the available indicators in West Khasi Hills district of Meghalaya. The district was selected purposively as it was identified as the most vulnerable district in Meghalaya (IIT and IISB, 2018). There are four blocks in West Khasi Hills district namely, Mairang, Mawshynrut, Mawthadraishan and Nongstoin.

Among the sub- indicators of vulnerability, percentage of extreme wet years (exposure), and percentage of village having livestock extension service (adaptive capacity) has the highest weight followed by village with 20% kutcha house (adaptive capacity). The climate of Meghalaya was analyzed and it was observed that although the state is known for receiving high amount of rainfall, there were occurrence of meteorological drought during monsoon season. During the period (1990-2021), seven years that constitutes 21.88% of the total study period experienced meteorological drought during June, July and October. During August months, 6 years of the said period (18.75%) experienced meteorological drought. Similarly, during September months, 5 years i.e., 15.63% of the study period occurred meteorological drought. Furthermore, there were evidence of extreme drought in the month of July 2000 (-2.07) and October 2011 (-2.36) as per Standardized Precipitation Index.

Table 1. Block level vulnerability index for testing of the method using available indicators.

Block	Exposure	Sensitivity	Adaptive capacity	Vulnerability
Mairang	0.510	0.583	0.639	0.455
Mawshynrut	0.586	0.306	1.398	-0.506
Mawthadraishan	0.220	0.566	0.705	0.080
Nongstoin	0.683	0.470	0.421	0.732

Project: Livelihood Improvement of Hill farmers through sustainable farming systems in North eastern Hill region (Farmers FIRST), Code: OXX04696

(N. U. Singh, P. Paul, C. Gowda, A. Roy, A. Yumnam, K. P. Biam, T. R. Borah, H. Rymbai, N. N. Singh, A. Yumnam, R. Katiyar)

For proper utilization of rice fallow land after Kharif rice harvest, seeds of vegetable crops such as broccoli, French bean, tomato, etc. were distributed to 121 beneficiaries from the adopted villages in the month of June and November, 2022. Out of 121 numbers of beneficiaries a total of 42 nos. of farmers from the adopted villages have cultivated vegetables such as broccoli, cabbage and garden pea.

Table 2. The economics of the vegetable's cultivation

Crop	Variety	Yield (kg)	Rate/kg (Rs.)	Net income (Rs.)	Expenditure (Rs.)	Profit (Rs.)	B:C ratio
Broccoli	F_1 Hybrid destiny	1,705	40	68,200	35,500	32,700	1.9
Cabbage	Swara	1050	20-25	26,250	14,500	11,750	1.8
Garden pea	Bioseed Pea 10	1,100	40-50	51,000	29,500	21,500	1.7
Lettuce	Grand rapid	200	40	8,000	4,350	3,650	1.8
Coriander	Ruchi	320	40	12,800	6,800	6,000	1.8


Lettuce cultivation


Broccoli cultivation


Garden pea cultivation


Cabbage cultivation


Coriander cultivation

Fig. 5. Vegetables distributed and grown after Kharif rice

Improved breeds (Vanaraja/Kruoiler) of backyard poultry chicks (1290 nos.) were distributed to 32 nos. of beneficiaries on the 20th April 2022 and 29th September 2022. Live bird (2.5-3.5 kg) were sold @ Rs. 250-380 per kg live body weight and earn about Rs. 625-Rs.1330 from each bird after rearing for about 8-10 months. Improved breeds of pigs (Hampshire cross bred) were distributed among the farmers (33 nos.) on 22nd March 2022. The overall economics of pig farming earned a profit of Rs. 65000 with benefit cost ratio of 1.7. Three farmers were trained to start pig breeding unit under the enterprise module. Farmers earned a total income of Rs. 544000 (B:C ratio:1.65) by selling 75 nos. of piglets and 6 nos. of adult pigs. The following table shows the economic from pig breeding unit.

Table 3. Successful pig breeding cluster in adopted villages

Name & village	Pigs/Piglets (nos.)	Total Income (Rs.)	Cost of Production (Rs.)	Net profit (Rs.)	B:C ratio
Mrinal Sohkhwai	Piglets: 47 Sown & Boar: 3	3,19,000.00	2,10,000.00	1,18,000.00	1.5
Jiten Sohkhwai	Piglets: 12 Sown & Boar: 3	1,45,000.00	42,500.00	37,500.00	1.8
Nebha Syiem	Piglets: 16	80,000.00	85,000.00	60,000.00	1.7
		5,44,000.00	3,28,500.00	2,15,500.00	1.65

The 1000 eggs capacity incubator was set up in the Marngar custom hiring centre. It allows for precise temperature setting and easy LED display for temperature, hatching day, egg rotation time and humidity features unique and user-friendly designs which ensure efficient egg setting and hatching operations.

Fig. 6. Installation of 1000 eggs capacity Poultry Hatchery unit cum trial at CHC, Purangang village

ARUNACHAL PRADESH

SUMMARY

The total annual rainfall during the season was 3136.9 mm which was 27 per cent above normal. During the period the number of rainy days was 128 days which was 16 days below normal (143 days). The average relative humidity during the period was mostly above 70%. Rice genotypes *viz.* Amham (35.3 q/ha), Chanchi (32.5q/ha), Pangin (31.3q/ha), Are lai (30.5q/ha), Amlum (30.5 q/ ha), Pumde (29.2 q/ ha), Riew Ammo (28.5 q/ ha) and Amtum (26.0 q/ ha) exhibited promising performance under two environment of Phosphorus (P) (0 and 40 kg P_2O_5 h^{-1}). The soil samples and GPS data of different *Jhum* lands in Tirbin circles, Leparada revealed lots of variation in different Jhum area owing to their jhum cycle, altitudinal position as well as their inherent location. Under low cost rain shelter, the cropping sequence *i.e*. Capsicum – Bottle gourd – Spinach exhibited maximum with respect to yield components and income. Late blight disease in tomato can be successfully managed organically with adoption of six canopy sprays of copper oxychloride @ 2.5g/L at 6 days intervals with soil mulching of black polythene (30 micron). Highest yield of Ginger was recorded in the plantations of *Cinnamomum camphora* (14.2 t/ha) followed by *Terminalia myriocarpa* (12.3 t/ha) under intercropping study in MPTs. The study on occupational hazards in livestock and poultry revealed that most common physical discomfort reported by farmers during different livestock managemental operation was very severe pain in lower back (37.13 %) Eyi, logum (34.28 %), Pakam (31.42 %) and (28.52 %) by Angu village farmers. Presence of gastrointestinal parasites were detected in 13.17% (27/205) cattle, 73.33% (11/15) mithun, 84.31% (43/51) goat and 83.56 % (61/83) pigs. The predominant parasite species in cattle, mithun and goat were Strongyle, *Eimeria, Moniezia* and Amphistome. For the first time, GIS map of the ICAR research farm Gori was created using a free geospatial desktop application (Google Earth Pro) with a maximum resolution of 8192*4643 pixels. The Google Earth Pro application has been used to digitize every feature that is included in the aerial image and estimate its approximate area.

Weather report

The total annual rainfall received during the period was 3136.9 mm which was 27 per cent above normal. The distribution of rainfall was very erractic with very unusual high rainfall during the months of June (720.8 mm, 64% above normal) and September (738.0 mm, 130% above normal) and comparatively low rain during the month of August (178.8 mm, 46% below normal). During the period the number of rainy days was 128 days which was 16 days below normal (143 days), consequently there were increase in incidences of extreme rainfall events. The distribution of rainfall is depicted in Fig. 1. The monthly distribution of average maximum and minimum is shown in Fig. 1. During the entire year, there was no significant departure from normal. However, the monthly average minimum temperature during the entire year remained below normal. The average relative humidity during the period was mostly above 70%. The distribution of Bright Sunshine Hours is shown in Fig. 1.

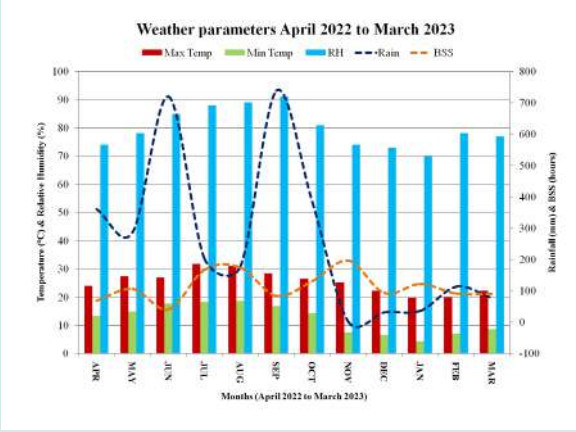


Fig. 1. Weather parameters during April 2022 to March 2023.

Gramin Krishi Mausam Sewa (GKMS)

AMFU Basar is regularly providing weather based agromet advisories to 18 districts of Arunachal Pradesh and 8 blocks of West Siang District on every Tuesday and Friday. Till date there are above 3 lakhs beneficiaries across the state getting advisory mainly through mobile SMS, whatsapp and bulletins. Till date 19212 farmers were getting SMS advisories twice a week. Moreover it is providing customized district level advisory bulletins to 14 Krishi Vigyan Kendras (KVK) of the state and also to other state line departments. During the reporting period, 1800 district level and 800 block level agromet advisory bulletins were prepared, published and uploaded. To reach the farmers of remote villages having no network, hard copy of bulletins were sent through village men to be displayed in the notice board of community halls of 7 such nearby villages. In the period around 623 new farmers and other stake holders get registered in the system. The meteorological unit as Basar is providing weather information and data on request to various department including Disaster Management, National Highway Authority, PHE, PWD, Universities etc. AMFU Basar has launched a new youtube channel to increase the reach and to provide practical advisory to the farmers in real-time basis. During the period, 2 Farmers' Awareness Programmes were organized at Soi and Sago village of Leparada districts to increase the outreach of the service (Fig. 2).

Fig 2. Farmers' Awareness Programmes organized at Soi and Sago village of Leparada district under GKMS

RESEARCH ACHIEVEMENT

Agronomy

Integrated Farming System Approach

(B. Makdoh, A. Tasung, T. Angami, L.Touthang, R. Singh, L.K Baishya, R. Alone, D .Jini and J. Bam)

The Integrated Farming System (IFS) model was established for the past five (5) years at the ICAR (RC), Arunachal Pradesh Centre, Basar (Fig. 5). The module was kept at 0.32 ha representing a land holding size of small and marginal farmers in hilly ecosystems of Arunachal Pradesh. The main motive of the model is showcasing the possibility of integrating different enterprises and intensification of land use especially in small farm producers' system. The IFS model consists of different components that comprises of 1) Vegetable-based cropping system (0.062 ha), 2) Maize-based cropping systems (0.018 ha), 3) Spice-based cropping system (0.021 ha), 4) Horticultural fruit crop-based system (0.069 ha) and 5) Fish Pond (0.15 ha).The vegetable-based cropping systems covering an area of 620 m^2 was systematically rotated with different vegetable crops enhancing cropping intensity as high as 300 %. Crops like cucurbits, french

bean, cowpea, cole crops, carrot, radish, coriander, tomato, pea etc. were included in the cropping sequences in different seasons. In maize-based cropping system various crops viz. soybean, green gram, french bean and garden pea were included and assigned an area of 180 m^2. The spice based cropping system consists of an area of 210 m^2, various crops like ginger and turmeric were grown which was followed by growing of short duration french bean immediately after the harvest of spices. Horticultural fruit-based system composed of pineapple, orange, Assam lemon, papaya and peach. Fisheries component of IFS model includes a fish pond consisting of 1500 m^2 area which is being used as the main source of irrigation water for different crops in the IFS model. The results during the year 2022-23, revealed that the component vegetable- based registered the highest gross return i.e., Rs.41,597/- followed by the fishery component of Rs. 37,500/- (Table 1**)**. With respect to maize equivalent yield (MEY) the vegetable-based cropping systems recorded the highest value of 1.66 tons followed by fishery unit at 1.50 tons. The vegetable based cropping systems recorded the income potential of Rs. 74.42/ m^2.Through this IFS model we could achieve considerably a huge MEY value of 285.13 t/ha which otherwise barely 3.90 t/ha is achievable from conventional solo maize cropping under farmers' condition. The system's net return was calculated Rs. 89,554 with an average B:C ratio of 4.25 was achieved and relative economic efficiency of 344.22 %.

Table 1. Economics and maize equivalent yield from different components in the IFS model

IFS Component	Area (ha)	MEY (tons)	MEY (t/ha)	Cost of production per enterprise (Rs.)	Gross return (Rs.)	net return (Rs.)	Net return (%)	B:C Ratio
Vegetable based cropping	0.062	1.664	189.89	9381.2	41597.0	32215.8	35.97	4.55
Maize-based cropping system	0.018	0.390	21.64	2898	9738.0	6840.0	7.64	3.23
Spice based	0.021	0.675	35.40	2190	16875.0	14685.0	16.40	7.25
Horticultural fruits (pine apple, orange, banana, peach)	0.069	0.629	28.20	5409	15722.5	10313.5	11.52	3.10
Fishery	0.150	1.5	10.00	12000	37500.0	25500.0	28.47	3.13
Total	0.320	4.86	285.13	31878.20	121432.5	89554.3	100.00	4.25

Fig. 5. Different components under IFS approach

Evaluation of released sesame varieties at mid-hill rainfed situation of Arunachal Pradesh (IIOR-NEH)

(B. Makdoh, A.Tasung, L. Touthang and R. Singh)

Thirteen (13) varieties of sesame were tested as varietal screening at the research farm Gori of ICAR RC AP centre, Basar. The sesame varieties tested were VRI-3, TMV-7, VRI (SV)-1, VRI (SV)-2, Prachi, Amrit, Swetha, DS-5, DS-9, GT-10 and CUMS-17 along with two local checks (Table 2). The crop was sown on 7thJuly 2022 with a spacing of 30 cm x 10 cm under normal crop management practices (Fig. 6). The results revealed that plant height of Local-2 which is a jhum variety significantly higher (149.31cm) than other varieties. It is followed by DS-9 (131.28 cm) which was statistically at par with Swetha (124.55 cm) and DS-5 (122.03 cm).Among the varieties, GT-10 (94.07 cm), Amrit (95.23 cm) and TMV-7 **(**96.23 cm) were the short statured varieties which were at par with each other. With respect to days to 50% flowering CUMS-17 (53.67 days), Amrit (54.00 days), Prachi (54.33 days) which were statistically at par with each other took the least time to achieve 50% days to flowering. Amrit (109.33 days), Prachi (110.33 days) and CUMS-17 (111.67 days) recorded the least time to achieve maturity during 2022. Prachi significantly recorded the highest value of number of capsules/ plant (42.47). While Namsai local (35.20), TMV-7 (34.47), Amrit (34.33), GT-10 (31.27) were statistically at par with each other. Number of seeds/ capsule found to significantly higher in Prachi (61.60) which was statistically at par with Namsai local (56.13) and CUMS-17 (53.6). Seed yield was recorded highest in Prachi (951.50 kg/ha) followed by Local 1 (731.98 kg/ha). Among varieties, DS-5 (84.43kg/ha), DS-9 (123.97 kg/ha) and Swetha (98.17 kg/ha) were found non-performing varieties.

Table 2. Performance of released sesame varieties in Arunachal Pradesh condition

Variety	Plant height at harvest (cm)	Days to 50% flowering	Days to maturity	No.of capsules/ plant	No. of seeds/ capsules	Seed yield (kg/ ha)	Stover yield (kg/ha)	Harvest index
GT-10	94.07	56.33	122.00	31.27	53.73	285.53	928.00	23.65
VRI 3	97.53	59.33	135.33	26.20	45.93	377.37	1120.77	25.23
TMV-7	96.23	66.67	129.67	34.47	48.53	321.93	996.37	24.65
Prachi	99.88	54.33	110.33	42.47	61.60	951.50	1909.90	33.32
VRI (SV 1)	102.74	66.67	132.00	27.60	50.60	218.08	992.70	18.30
VRI (SV 2)	102.33	68.00	133.33	20.93	51.07	245.23	965.70	20.38
Swetha	124.55	77.00	156.00	15.93	45.20	98.17	831.60	10.64
DS-9	131.28	81.67	154.00	18.93	49.93	123.97	817.50	13.20
Amrit	95.23	54.00	109.33	34.33	42.60	575.50	1348.90	30.15
CUMS-17	99.95	53.67	111.67	21.80	53.60	373.43	1230.53	23.44
DS-5	122.03	81.00	155.67	24.13	51.20	84.43	914.20	8.52
Local 1	103.67	54.33	117.33	35.20	56.13	731.98	1597.90	31.51
Local 2	149.31	100.00	147.67	31.47	51.93	580.87	1929.10	23.14
Sem±	5.07	1.51	1.52	2.24	2.95	31.74	99.52	1.89
CD at 5%	14.80	4.41	4.44	6.53	8.60	92.64	290.49	5.51

Fig. 6. Field view of different varieties of sesame at Basar

Evaluation of linseed varieties for suitability in Arunachal Pradesh (IIOR-NEH)

(B. Makdoh, A. Tasung, L. Touthang and R. Singh)

The varietal trial of linseed was carried out at the research farm Gori, Agronomy section, ICAR RC for NEH AP centre. Total of 6 varieties *viz.* JLS-95; RLC-153; LSL-93;T-395 (NC); Shekhar; Priyam (ZC) laid out in RBD and maintained a spacing of 30 cm x 10 cm under recommended package of practices (Fig. 7). The crop was sown on 8th November, 2021 and harvested in April 1st week onwards.Out of the six (6) varieties of linseed evaluated, three varieties *viz*. Priyam (13.77 q ha^{-1}), T-397 (13.15 q ha^{-1}) and RLC-153 (13.0 q ha^{-1}) found promising under mid-hill situation of Arunachal Pradesh. Among varieties RLC-153 was the tallest (79.01 cm) and the shortest was LSL-93 (49.08cm). T-395 matured the earliest (144.2 days) which was significant among varieties and JLS-95 took the longest time to reach maturity (157.7 days) (Table 3).

Table 3. Performance of different linseed varieties at ICAR Research farm, Gori Basar, Arunachal Pradesh (2022-23)

Varieties	Plant height (cm)	Number of plants/ha	Days to 50 %flowering	Days to maturity	Stover yield (q/ha)	Seed Yield (q/ha)
LSL-93	49.08	6,42,500	77.2	151.5	18.37	9.66
RLC-153	79.01	8,02,500	101.5	152.0	41.55	13.05
T-395	57.92	7,22,500	88.0	144.2	21.97	13.15
Priyam	69.83	11,57,500	103.7	147.0	39.90	13.76
JLS-95	68.28	7,90,000	95.2	157.7	35.37	12.42
Shekhar	67.06	5,47,500	98.0	149.5	25.72	12.73
SE(m)	***3.04***	***48,424***	***3.48***	***0.47***	***3.42***	***0.30***
C.D.	***9.25***	***1,47,298***	***10.57***	***1.44***	***10.40***	***0.92***

Fig.7. Field view of linseed varieties at Basar, Arunachal Pradesh

Identification of suitable rainfed maize-based intensified cropping systems for upland conditions of Arunachal Pradesh

(B. Makdoh, T. Angami, A. Tasung, L. Touthang and H. Kalita)

During the first year of study, out of the 7 cropping systems that were imposed it was revealed that Maize-Okra-Frenchbean under integrated nutrient management found most promising intensified rainfed maize-based cropping system under mid-hills of Arunachal Pradesh in terms of yield and economics (Fig. 8) The MEY in this treatment combination was found 80% more compared to maize-fallow (control).

Fig.8. Field view of different maize-based cropping systems at Basar, Arunachal Pradesh

Plant Breeding and Genetics

Acidic soil tolerance in rice genotypes for mid altitude of Arunachal

(L. Touthang, B. Makdoh, A. Tasung)

Collected and characterized 35 local rice landraces from different parts of Arunachal Pradesh. Field characterization was carried out under two environment of Phosphorus (P) (0 and 40 kg P_2O_5 h^{-1}) for various agro-morpho and physiological traits. Following genotypes exhibited promising performance *viz.* Amham (35.3 q/ha), Chanchi (32.5q/ha), Pangin (31.3q/ha), Are lai (30.5q/ha), Amlum (30.5 q/ ha), Pumde (29.2 q/ ha), Riew Ammo (28.5 q/ ha) and Amtum (26.0 q/ ha) respectively (Fig. 9).

Amham Chanchi

Fig. 9. Performance of Amham and Chanchi

Local land races for improving yield potential of maize in Arunachal Pradesh

(L. Touthang, B. Makdoh and R. Singh)

Collected and characterized 30 local maize landraces of Arunachal using two standard checks. Significant trait variation was observed among the genotypes. Based on 15 agro-morphological traits, the genotypes were grouped into 3-clusters Fig. 10. Principal component analysis extracted 5 PCs accounting for 56.54% of the total variation. Components of genetic variation revealed moderated to high PCV, GCV, heritability and genetic advance as percent of mean. Based on the yield per plant, the following 11 genotypes were identified as promising viz. AR-Maize-1, AR-Maize-16, AR-Maize-21, AR-Maize-9, AR-Maize-24, AR-Maize-23, AR-Maize-22, AR-Maize-2, AR-Maize-28, AR-Maize-27 and AR-Maize-7 respectively.

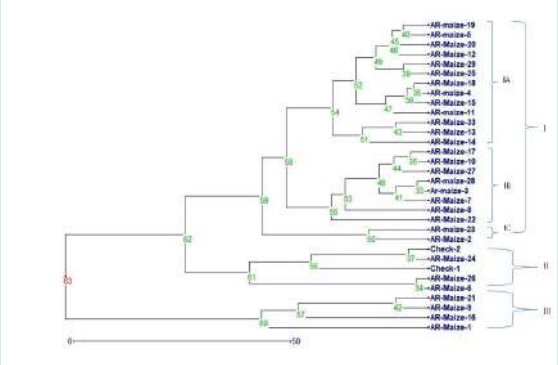


Fig.10. Grouping of 32 maize genotypes based quantitative traits

Evaluation of Jobs tears entries (AICRN on Potential Crops)

(L. Touthang, B. Makdoh, A. Tasung and T. Angami)

Evaluated 38 entries of Jobs tears comprising of 8 IVT, 5 AVT-I and 25 AVT-II during kharif 2022 in mid hill of Basar. Among 8 entries of IVT, highest yield of 31.58 q/ha was recorded in IC-416868 followed by IC-540222 (30.5q/ha) and IC-416831 (29.3q/ha) respectively. Among 5 entries of AVT-I the highest yield potential of 28.57 q/ha was recorded in IC-334314 followed by IC-12703 (25.q/ha) and IC-419466 (16.3 q/ha) respectively. Whereas in AVT-II entries the promising genotypes identified were RJGTP 52 (29.3 q/ha) followed by RJGTP 58 (29.13 q/ha), RJGTP 48 (28.9q/ha) and RJGTP 57 (26.4 q/ha) respectively.

Soil Science

Assessment of spatial variability of soil properties in Tirbin Circle, Leparada District, Arunachal Pradesh using Geospatial tool Analysis.

(A. Tasung, A. Suryawanshi, B. Makdoh, T. Angami and L. Touthang)

The soil samples and GPS data of different *Jhum* lands in Tirbin circles, Leparada (Fig. 11 a) were collected and analysed to assess the spatial variability of soil properties for development of soil fertility map (pH, SOC, soil available N, soil available P and soil available K). The data revealed lots of variation in different Jhum area as shown in (Fig. 11 b) owing to their jhum cycle, altitudinal position as well as their inherent location (Table 4).

Table 4. Soil properties of ground collection point (GCP) from Jhum Fields in Tirbin Circle, Leparada District, Arunachal Pradesh

GPS (Latitude, Longitude)	Altitude (m asl)	Jhum Cycle	Soil Properties									
			Soil pH		Soil Organic Carbon		Soil Available N		Soil Available P		Soil Available K	
			Soil Depth (cm)		Soil Depth (cm)		Soil Depth (cm)		Soil Depth (cm)		Soil Depth (cm)	
			0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
27.990207,94.590977	772	2	4.53	4.53	0.96	0.88	161	147	24.4	20.9	277	237
27.990492,94.591265	787	6	4.55	4.55	1.38	1.26	211	193	31.9	27.5	363	311
27.991153,94.59265	794	4	4.58	4.58	0.96	0.88	217	199	32.9	28.2	374	320
28.011,94.578758	641	8	4.54	4.54	2.06	1.89	292	267	44.2	38.0	502	430
28.010265,94.577762	672	8	4.56	4.56	2.04	1.86	302	276	45.7	39.3	519	444
28.009605,94.577903	667	6	4.60	4.60	1.07	0.98	257	235	38.8	33.4	441	378
Mean			4.56	4.56	1.41	1.29	240	220	36.3	31.2	413	353
Standard deviation			0.023	0.024	0.47	0.43	49.0	44.8	7.42	6.38	84.3	72.1

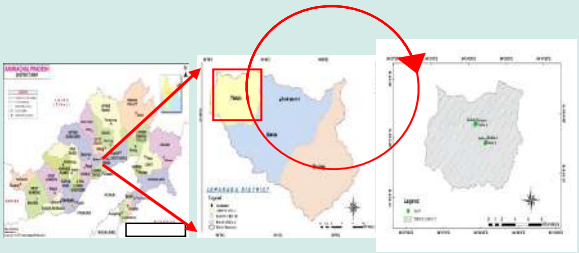


Fig. 11 (a). Location map of study area (Tirbin circle, Leparada District)

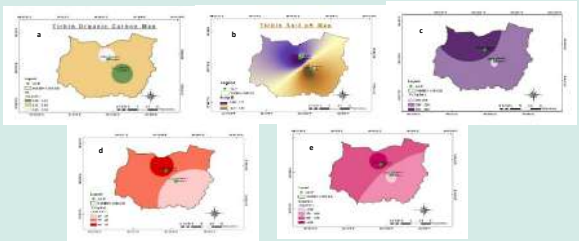


Fig. 11 (b). Spatial distribution map of soil properties in Tirbin circle, Leparada District; a. Soil Organic Carbon, b. soil pH, c. Soil Available N, d. Soil Available P and e. Soil available K.

Horticulture

Standardization of vegetable based cropping sequence under protected structures

(T. Angami, H. Kalita, R. Singh and B. Makdoh)

The experiment was conducted under low cost structures viz. Low cost rain shelter of size 40 sq. m and low cost poly tunnel of 5 sq. m to determine the best cropping sequence to ensure round the year production and profitability of vegetables. During 2022-23, under low cost rain shelter (Fig.12 a), the cropping sequence (CS-3) i.e. Capsicum – Bottle gourd – Spinach exhibited maximum with respect to total annual production (196.75 kg/40 sq. m), production efficiency (0.54 kg/40 sq. m/day) and BC ratio (2.73). Meanwhile under low cost poly tunnel (Fig.12 b), the cropping sequence (CS-2) i.e. Broccoli – Lettuce – Amaranthus – French bean exhibited maximum with respect to total annual production (31.49 kg/5 sq. m), production efficiency (0.09 kg/ 5 sq. m) and BC ratio (2.91).

Vegetable cropping sequence under low cost rain shelter

(Jan/Feb - May) (June - Sept) (Oct - Nov)

Capsicum Bottle gourd Spinach

Fig.12 (a) Vegetable cropping sequence under low cost rain shelter

Vegetable cropping sequence under low cost polytunnel

(Oct-Jan) (Feb-Apr) (May-June) (July-Sep)

Broccoli Lettuce Amaranthus French bean

Fig.12 (b) Vegetable cropping sequence under low cost polytunnel

Standardization of organic nutrient management in Assam lemon under mid hill conditions of Arunachal Pradesh

(T. Angami, H. Kalita, R. Singh and A. Tasung)

Among all the organic treatments imposed during the year 2022 (Fig.13), the organic treatments together with mulching *viz*. FYM (7 kg per plant) + vermicompost (4 kg per plant) + mulching with local weed biomass (T_5) and FYM (7 kg per plant) + vermicompost (4 kg per plant) + neem cake (0.5 kg per plant) + mulching with local weed biomass (T_{10}) recorded better results in vegetative growth, yield and fruit quality of Assam lemon. Maximum mean increment in plant height (18.33 cm, 10.70 %) and stem girth (0.51 cm, 15.88 %) was observed in treatment T_5 closely followed by treatment T_{10}. With respect to yield attributing parameters, maximum fruit set (36.84 %), number of fruits per plant (44.22) and yield per plant (7.16 kg) was recorded in the treatment T_5 followed by treatment T_{10} with fruit set (36.38 %), number of fruits per plant (41.17) and yield per plant (6.70 kg). In case of fruit quality, the treatment T_5 exhibited maximum juice content per fruit (46.61 ml), reducing sugar (3.96 %), total sugar (6.04 %) meanwhile the treatment T_{10} divulged maximum TSS (6.07 °Brix) and ascorbic acid content (43.65 mg per 100 g). Dynamics of physico-biochemical changes in Assam lemon after harvest of fruits was studied at weekly interval *viz*. 7th, 14th and 21st day which was kept in open condition at room temperature (27 ± 2 °C and 80 ± 5 % RH). The physiological loss in weight (PLW) indicated that there was gradual weight loss in all the treatments. Similarly, the juice percent and ascorbic acid content declined in all the treatments. However, there was slight increment in TSS values and gradual fall in acidity across the week.

Fig. 13. Imposition of organic treatments in Assam lemon and fruiting stage

Plant Pathology

Organic management of late blight disease in tomato

(R. Singh, H. Kalita, T. Angami and L. Touthang)

During September 2022 to January 2023, a field experiment was conducted on field efficacy of copper oxychloride 50% WP against late blight disease of tomato. It was found that maximum disease control over control treatment in T-6 (92.04%) followed by T-5 (89.77%) and T-4 (81.82%). Under open field conditions, tomatoes growers can successfully manage late blight disease in organically with adoption of six canopy sprays of copper oxychloride @ 2.5g/L at 6 days intervals with soil mulching of black polythene (30 micron) (Table 5)

Table 5. Field efficacy of copper oxychloride 50% WP against late blight of tomato under open field conditions

Treatment	Disease severity (PDI)	% decrease over control treatment
T-1 (Single canopy spray of copper oxychloride 50% WP @ 2.5g/L at initial symptoms & soil mulching of black polythene, 30 micron)	51.11	47.73
T-2 (Two canopy sprays of copper oxychloride 50% WP @ 2.5g/L at 6 days intervals & soil mulching of black polythene, 30 micron)	32.22	67.05
T-3 (Three canopy sprays of copper oxychloride 50% WP @ 2.5g/L at 6 days intervals & soil mulching of black polythene, 30 micron)	21.11	78.41
T-4 (Four canopy sprays of copper oxychloride 50% WP @ 2.5g/L at 6 days intervals & soil mulching of black polythene, 30 micron)	17.78	81.82
T-5 (Five canopy sprays of copper oxychloride 50% WP @ 2.5g/L at 6 days intervals & soil mulching of black polythene, 30 micron)	10.00	89.77

T-6 (Six canopy sprays of copper oxychloride 50% WP @ 2.5g/L at 6 days intervals & soil mulching of black polythene, 30 micron)	07.78	92.04
T-7 (Control with soil mulching of black polythene, 30 micron)	61.11	37.50
T-8 (Control without soil mulching of black polythene)	97.78	00.00
CV (%)	**14.77**	**-**
CD (0.05)	**09.28**	**-**

Evaluation of different agro-waste substrates for yield and yield attributes of oyster mushroom (*Pleurotus florida*)

(R. Singh, H. Kalita, T. Angami and L. Touthang)

In this study concluded that the eight different agro-wastes used as substrates for *Pleurotus florida* production. In which, comparatively the higher biological efficiency (BE) was obtained in paddy straw (98.33%) followed by sugarcane trash (96.83%) and maize stover (94.67%). However, total crop duration and spawn run were earlier completed in mustard and linseed straw (Table 6).

Table 6. Effect of different agro-waste substrates on spawn run, crop duration and yield of *Pleurotus florida*

Treatment	Spawn run completed (Days)	Total crop duration (Days)	Yield (g/ bag)	Biological efficiency (%)
T-1; Paddy straw	16.67	46.00	983.33	98.33
T-2; Wheat straw	17.00	51.67	860.00	86.00
T-3; Maize stover	18.67	51.00	946.67	94.67
T-4; Linseed straw	12.00	45.67	906.33	90.63
T-5; Mustard straw	12.00	44.67	900.00	90.00
T-6; Job's tear straw	19.33	49.67	836.67	83.67
T-7; Sugarcane trash	19.00	49.33	968.33	96.83
T-8; Banana dried leaves	19.67	48.67	930.00	93.00
CV (%)	**02.29**	**01.83**	**02.21**	-
CD (0.05)	**0.68**	**01.55**	**35.47**	-

Agro-forestry

1. Evaluation of carbon sequestration potential of different Agroforestry systems of mid-hills of Arunachal Pradesh

(Rajesh A. Alone and A. Tasung)

Under this project, intercropping of Ginger, Turmeric, Guinea grass and Broom grass was carried out in the plantations of 10 Multipurpose trees (MPTs) (Fig.14). The highest yield of Ginger was recorded in the plantations of *Cinnamomum camphora* (14.2 t/ha) followed by *Terminalia myriocarpa* (12.3 t/ha). The lowest yield was recorded in *Symmingtonia populnea* (8.4 t/ha).The highest yield of Turmeric was recorded in plantations of *Symmingtonia populnea* (15.8 t/ha) followed by *Terminalia myriocarpa* (13.7 t/ha). The lowest yield of turmeric was recorded in *Manglitia insignis* (9.3 t/ha).The highest yield of Guinea grass was recorded in plantations of *Terminalia myriocarpa* (32.0 t/ha) followed by *Castanopsis indica* (28.8 t/ha). The lowest yield of Guinea grass was recorded in *Altingia excelsa* (21.0 t/ha).The highest yield of Broom grass was recorded in plantations of *Michelia obtusifolia* (21.6 t/ha) followed by *Cinnamomum camphora* (16.6 t/ha). The lowest yield of Guinea grass was recorded in *Altingia excelsa* (9.6 t/ha) (Table 7)

Table 7. Studies on intercropping of ginger, turmeric, guinea grass and broom grass in MPTs

Plantations	Ginger (T/ha)	Turmeric (T/ha)	Guinea grass (T/ha)	Broom grass (T/ha)
Cinnamomum camphora	14.2	10.6	22.8	16.6
Terminalia myriocarpa	12.3	13.7	32.0	12.6
Michelia obtusifolia	11.6	11.3	27.3	21.6
Castanopsis indica	10.3	13.5	28.8	16.2
Symmingtonia populnea	8.4	15.8	22.5	10.5
Manglitia insignis	10.8	9.3	24.3	11.8
Aleurites montana	9.6	10.8	25.2	10.4
Altingia excelsa	11.7	12.1	21.0	9.6
Gmelina arborea	12.1	11.1	21.6	10.9
Ixonanthus khasiana	10.8	11.7	24.9	14.8

Symmingtonia populnea + Turmeric | *Terminalia myriocarpa* + Guinea grass | *Michelia obtusifolia*+ Broom grass

Fig.14. View of intercroppings in multi purpose trees (MPTs)

Veterinary Extension

Assessment of self-reported occupational hazards in livestock and poultry farmers in eastern parts of Arunachal Pradesh

(D. Jini, S. Ghatak and S. Das)

To study the occupational hazards a semi-structured questionnaire developed by Neitzel *et al*. (2014) was used for collection of data. Similarly, to identify various discomfort faced by the livestock owners during handling of livestock BPD (Body part discomfort) score was used. Four villages *viz*., Logum, Eyi, Angu and Pakam of West Siang district were purposively selected consisting of 35 farmers/ villages. The survey was conducted from the month of Sept to January covering only four villages.

- The study revealed that, most common physical discomfort reported by farmers during different livestock managemental operation (Fig.15 a) was very severe pain in lower back (37.13 %) Eyi, logum (34.28 %), Pakam (31.42 %) and (28.52 %) by Angu village farmers. Overall (30.0 %) farmers reported severe pain in the wrist, moderate pain in the finger (47.86 %), knee pain (37.14 %), shoulder (34.29 %) and minimum in palm (39.29 %) was reported.
- Injury due to close proximity with animals, (12.85 %) reported due to pushing in dairy, (50.71 %) biting in pigs and (36 .42 %) picking in poultry (Fig.15 b)
- In terms of chemical hazards due to contacts (98.56 %) of the respondents reported skin allergies in poultry and (81.42 %) from pigs (Fig. 15 c). Fungal infection particular ringworm (45.71.85 %) was reported during cleaning and feeding of pigs.
- But No seropositive cases for brucellosis were found in the animals 10 cattle and 16 pigs (4 boars + 12 sow + when screened using RBPT test during the investigation.

Fig. 15 a) Physical discomfort reported by farmers during livestock managemental operation, b) Physical injury due to close proximity of animal,
c) Chemical hazard due to contacts

Mobile based android application for cattle farmers of Arunachal Pradesh

(D. Jini, J. Bam and U. Singh)

As per the objective survey had to be done in various district of Arunachal Pradesh for gathering information need based on cattle population and cattle farmers. Initial survey was done in Leparada district having 3002 cattle population. Three circle *viz*. Basar, Daring Tirbin circle were purposively selected from each circle 10 farmers were interview using open ended questionnaire covering different aspects of cattle production. Similarly, relevance rating of some variable was sent to experts like DVO, VO and SMS Animal science. Secondary data is being collected from Journals, internet for content development.

Conservation and improvement of indigenous cattle in northeast of India:

(D. Jini)

This is an institute project specifically implemented for the state of Arunachal Pradesh and three eastern districts *viz.* Si Yomi, Anjaw and Tawang were selected. In commensurate with one of the objectives under this project, a documentation survey was conducted using pretested survey instrument in Tawang district. About 30 animals of different age and sex were selected and data on some morpho-metric and physical traits was collected.

Physical traits: The indigenous cattle (*gallang)* were of medium in size and stout in structure. The body colour varied mostly black (76.6 %), and mix of black and white (23.4 %). The horn orientation curved upward forward (63.3 %) and curved upward (36.7 %). Horn color is majority mix of white and black colour (67.6 %) and remaining black. Cent per cent ear orientation was horizontal. Muzzle were black in colour (63.32 %) followed by brown colour. Head is straight and convex in majority animals (60.0 %). Hump and dewlap were small with small penis sheath. The udder was bowl in shape and small size. Around 53.3 per cent of the teats were cylindrical shaped with rounded tip. Milk vein was non-prominent. Hoof color varied from black (53.3 %), brown (26.6 %) and black & white (20.1 %). Tail was up to the hock with switch colour was predominantly black (56.7 %) followed by brown (23.3 %) and white (20.0 %) (Fig. 16 a & b)

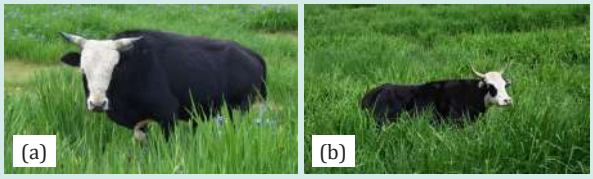


Fig. 16 (a) Galang (male), (b) Galangmu (female)

Conservation and improvement of indigenous goat in northeast of India

(D. Jini)

Twelve numbers of local goats were procured from lika, liru villages Lower Siang district. A low-cost goat shed has been built in the Research farm Gori with 04 numbers of shed with spacing (4X4 sqft)/shed. Before start of experiment animal were quarantine, in isolation room then deworming was done on 23rd day. Four groups were made each group consist of (1 buck + 3 doe). Bodyweight of animals were measured before the experiment study. All animal was kept in tethering method for grazing from morning 7:30 A.M to 3:30 P.M. In Control group no concentrate was provided and remaining treatment group T1(100 g), T2(150 g) and T3(200 g) concentrate ration comprising (Rice grain (40 %), (Maize (30 %), wheat bran (20 %), GNC (9 %) Mineral mixture (1%) and salt (0.5 %) at evening time.

Average mean body weight at 3,6, 9 and 12 months was found highest in T3 group 5.18 ± 0.43, 8.037 ± 0.23, 10.7 ± 0.50 and 13.65 ± 0.55 Kg, T2 group 4.22 ± 0.39, 6.83 ± 0.23, 9.98 ± 0.32 and 12.78 ± 0.14 Kg and T1 group 3.75 ± 0.53, 6.50 ± 0.25, 9.63 ± 0.35 and 12.72 ± 0.47. There whereas not significant difference was found in T1 and T2 group in terms of body weight compared with T3 group.

Veterinary Parasitology

Gastrointestinal parasitism in livestock population of Arunachal Pradesh and the status of Anthelmintic efficacy against nematodes in ruminants

(J. Bam, D. Jini and M. Das)

To study the prevalence of gastrointestinal parasites in the livestock population of Arunachal Pradesh faecal quantitative examination was employed of 205 cattle, 15 mithun, 51 goat and 73 pig

samples from different districts of Arunachal Pradesh. Presence of gastrointestinal parasites were detected in 13.17% (27/205) cattle, 73.33% (11/15) mithun, 84.31% (43/51) goat and 83.56 % (61/83) pigs. The predominant parasite species in cattle, mithun and goat were Strongyle, *Eimeria, Moniezia* and Amphistome. *Fasciola* eggs were detected in 63.63 % (7/11) positive mithun samples. Out of the 205 cattle samples, 83 were collected from Balang (indigenous hill cattle) from Shi Yomi district of Arunachal Pradesh. The overall endoparasitism in Balang was 44.57 % (37/83) with level of infection ranging from 0 to 300 eggs per gram of faeces. The predominant species were Strongyle (34.93 %), followed by *Eimeria* spp. (12.04 %), *Moniezia* spp. (6.02 %) and *Strongyloides* (6.02 %). In 2.41 % animals *Capillaria* spp. (2/83) was detected. The Baerman technique on the pooled Balang faecal sample presence of Lungworm larvae, *Dictyocaulus viviparous*. In pigs, *Ascaris*, Strongyle, *Strongyloides* and *Eimeria* were recorded.

Land and Water Management Engineering

GIS Map of ICAR Research Farm, Gori

(A. Suryawanshi, A. Tasung and L. K. Baishya)

The GIS map of the ICAR research farm Gori at Basar was created using a free geospatial desktop application (Google Earth Pro) with a maximum resolution of 8192*4643 pixels. The Google Earth Pro application has been used to digitize every feature that is included in the aerial image and estimate its approximate area. The total area of the farm is about 42.5 ha, with 26 blocks shown in Table 8. Each location point on Fig.17 characterizes a block or unit present in the map of research farm.

Table 8. List of different units/blocks present in research farm and its approximate area

Name	Approximate Area (m^2)	Name	Approximate Area (m^2)
Agroforestry Block	52675	Horticulture Block	33581
Agronomy Block	8846	Indigenous Fruit Block	3930
Animal Science Block	4340	Khasi Mandarin Plantation	8144
Apple Plantation	2400	Lemon Block	1137
Assam Lemon Plantation	3411	Natural Farming Block	1065
Bamboo Plantation	14133	Nursery Shed House	912
Bamboosetum	11137	Plant Breeding Block	2205
Citrus Germplasm Block	6072	Plant Pathology Unit	1124
Crop Cafeteria	3807	Polyhouse	1302
Entomology Unit	996	Soil Science Block	2290
Forest Area	137674	Terrace Area	1075
FSRP Block	3714	Wet Land Rice cultivation	11757
Ghamari Plantation	21643	Others	85630
		Total	425000

Fig. 17. GIS Map of ICAR Research farm, Gori

MANIPUR

SUMMARY

Research activities at the ICAR RC NEH, Manipur centre made significant achievements, two black rice semi-dwarf medium maturing lines RCMBR 3 and RCMBR 5 outperformed the local check, *Chakhao amubi* and *Chakhao poreiton*, with a yield superiority/advantage to an extent of 59.8%. Six SSR markers (RM12293, RM19303, RM20948, RM7311, RM24071 and RM18239) were identified which can differentiate the *Chakhao poreiton* from *Chakhao amubi*. Sixteen lines pyramided with Pi54 and OsSPL14 genes derived from Chakhao x CR Dhan 801 were developed with black grain anthocyanin content ranging from 240.31 to 1.35 mg/100 gm sample. Fifteen Chakhao landraces carrying both positive alleles of *Sub1A* and *Sub1C* genes were identified. Application of FYM @ 6 t/ha + VC @ 1 t/ha + Green Manuring with Sesbania @ 25 kg/ha can be recommended to the organic black rice growers of Manipur. The soil application of zinc sulphate @ 20 kg/ha as basal and two foliar sprays at tillering and grain filling stages resulted in the maximum increase in grain yield in all the rice varieties tested. Brinjal germplasm, *S. underatum*, IC 394877, IC 090084, IC 420656, IC 090869 were found moderately tolerant against bacterial wilt. The insecticide residues of Lambda-cyhalothrin, chlorantraniliprole and Fipronil applied on pea, broadbeans, cabbage, cauliflower and broccoli persisted upto 7th day and the residues can be decontaminated (%40-35) with %2 NaCl solution except for Fipronil. No contact toxicity on rice weevil, *Sitophilus oryzae* observed treated with essential oil, *Elsholtzia griffithi* at 40,000 ppm up to 48 hrs after treatment. Five different of *Trichoderma* species (*T. asperellum; T. atroviride; T. harzianum; T. longibrachiatum* and *T. erinaceum*) were highly effective against ginger soft rot, and GC-MS analysis revealed the presence of 1-Pentadecene and 13-16-Octadecadienoic acid. Seven species of the ambrosia beetles with symbionts *Fusarium* spp were identified as causing tree bean decline. Carp spawn fed with mealworm (*Tenebrio molitor*)-based diets observed the effect on growth compared to control. One *E. coli* isolates from pork meat resistant to 19 antibiotics tested positive for blaNDM-1 (acc. no. OP006128$_{)}$. The dietary addition of 10% *Eichchornia crassipes* resulted in a significant increase in serum total protein (4.04g/dl) and serum albumin (1.67g/dl) of eggs. *Jhumias* 85% incurred on the hiring of farm labour for land preparation, sowing, intercultural operations, harvesting and threshing.

Weather summary during 2022 at ICAR Manipur Centre, Lamphelpat

During the period from January to December 2022, total of 1457.7 mm annual rainfall was recorded against normal rainfall of 1454.2 mm. Highest rainfall day (78.0 mm) was observed on 27th October 2022. May month recorded the highest rainfall of 382.9 mm against highest monthly normal rain of 262.6 mm in June. The highest temperature of 33.3 °C was recorded on 7th and 17th July 2022 and coldest (3.8° C) was 29th January 2022. The monthly average maximum temperature ranged from 22.5oC in December to 30.4oC in April against the normal range of 21.8oC in March to 29.4oC in September. The monthly average minimum temperature ranged from 23.6 °C in January to 31.0 °C in July against the normal range of 21.8 °C in March to 29.4 °C in September. The monthly average minimum temperature ranged from 5.5 °C in January to 23.9 °C in September against the normal range of 4.4 °C in January to 21.8 °C in July. The monthly average maximum relative humidity (RH) ranged from 79.7 % in March to 95.3 % in December against the normal range of 71.5% in March to 86.5% in July. The monthly average minimum RH ranged from 37.2 % in February to 69.6 % in June against the normal range of 51.4% in March to 77.9% in August (Fig. 1)

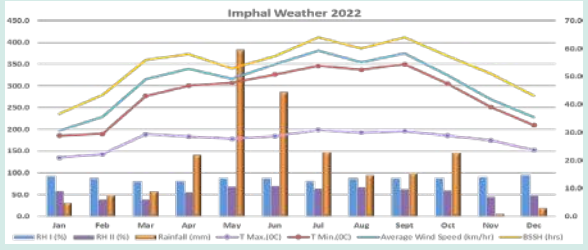


Fig. 1. Monthly average maximum and minimum temperatures (°C), relative humidity (%) for morning & afternoon, rainfall (mm) and bright sunshine hours during 2022 in Imphal

RESEARCH ACHIEVEMENTS

Field Crop Rice

Multi-location trials of three semi-dwarf black rice varietal entries for state release

(K. Sarika, I. M. Singh, S. Gunamani, U. Ngangkham)

During *kharif* 2022, a multi-location trial was conducted across five locations/district viz. Imphal West, Imphal East, Bishnupur, Thoubal and Chande of Manipur at farmers' field to evaluate the performance of promising semi-dwarf black rice entries namely, RCMBR 3, RCMBR 4 and RCMBR 5 (Fig. 2). Among them were the two genotypes, RCMBR 3 and RCMBR 5, that outperformed the parent and local check, *Chakhao amubi* and C*hakhao poreiton,* with a yield superiority/ advantage to an extent of 59.8% during the trial. These lines were derived from the cross *Chakhao amubi* × RC Maniphou 7. The lines were selected after evaluating their performance and stability across four years viz. two years' preliminary yield trials during *kharif* 2019 and 2020 and one-year advanced station yield trial in *kharif* 2021. They are semi-dwarf lines with a height of ~100 cm, effective tiller/hill of 11 with improved cooking quality of ASV value 5. They are medium maturing varieties of 130 days.

Fig. 2 (a) Multi-location trial field at Farmer's field, Irilbung, Imphal East, Manipur (b) Visit of Vice-Chancellor, CAU and Director, ICAR RC NEHR, Umiam at Lamphelpat Black Rice Research plot, Imphal (c) The semi-dwarf rice entry, RCMBR 5 performance in field

Notification of high yielding semi-dwarf rice varieties of State, Manipur

(I. M. Singh, K. Sarika, U. Ngangkham)

Three high yielding varieties, RC Maniphou 14, RC Maniphou 15 and RC Maniphou 16, released officially on 24th June 2021 for Manipur state were notified on 31st August 2022. They are having a potential yield of 7 to 8 tonnes/ha. They have been assigned the National Identity number of IC639305, IC639306 and IC639307, respectively.

Station trials for advanced breeding lines derived from 10 crosses

(K. Sarika)

An advanced line of 59 breeding lines derived from 10 crosses were evaluated for its yield and yield related performance along with 3 checks (RC Maniphou 13, RC Maniphou 15 and KD-2-6-3). Among them, 32 genotypes would be further evaluated for another year. Two of them viz. MC-59-1-1-1 (RCMR 46) and MC-59-1-3-7 (RCMR 47) have been nominated for AICRIP trials during *kharif* 2023 for medium hill region.

Farmers' participatory varietal selection of semi-dwarf black-rice

(K. Sarika, S. Gunamani)

During *kharif* 2022, a total of 12 semi-dwarf genotypes in pipeline were evaluated for its plant and grain types as per farmers' preference. A total of 47 interested farmers participated in the varietal selection assigning each line with their score. A preferential index was calculated based on their ranking or marking. Four lines including the three lines RCMBR 3, RCMBR 4 and 5 under the multi-location trial were identified with high preferential index score.

DUS testing and grow out test (GOT) of farmers' varieties of rice

(K. Sarika)

First year DUS characterization was carried out for 30 farmer varieties of rice along with 28 reference varieties including 8 maintenance lines from Manipur centre and 24 farmer varieties from the last year 2021. Forty-eight morphological characters and 14 post-harvest characters were recorded. In comparison to reference varieties, for the new farmer's variety entry 22 ref 1, 22 ref 2 & 22 ref 6 found distinct for few character/traits namely, presence of highest leaf pubescence of blade surface, strong secondary branching, etc. And among last year entries, 2886/2203 was distinct in seven traits. Nine released variety of the Centre were DUS characterized and RCMANIPHOU-6 and RCMANIPHOU-11 was found to be distinct in some character in comparisons with reference variety.

All India Co-ordinated Rice Improvement Project (AICRIP)

(K. Sarika)

Three trials were conducted, namely IVT M (H), AVT 1-M (H) and AVT 2-M (H). Under the AVT 2-M (H), eight entries were tested (4 entries and 4 checks). Only one entry, 2601 (IET 28907) is found promising only for the state of Manipur and other rejected. Under AVT 1-M (H), 2711 (NIL IET 30503) got promoted to 2nd year of testing. In IVT M (H), out of 15 entries, IET 2811 and IET 2802 expressed significant yield superiority over best check.

NICRA: Development of high yielding climate resilient versions Chakao and kali khasa rice under moisture stress

(U. Ngangkham and K. Sarika)

For the cross, Chakhao-22 × CR Dhan 801, parental polymorphism studies for foreground selection of drought tolerant genes (*qDTY1.1 + qDTY2.1 + qDTY3.1*) and submergence tolerant *Sub1* gene were carried out. For *qDTY1.1*, six SSR markers (RM315, RM11943, RM431, RM12023, RM12091 & RM12233) were used and observed no polymorphism. For *qDTY2.1*, out of seven SSR markers, three markers (RM324, RM6374 and RM424) were found polymorphic. For *qDTY3.1*, two markers (RM16030 & RM520) out of four SSR markers were found polymorphic (Fig. 3). For submergence tolerant gene (*Sub1*), eight linked/functional markers such as ART5, SC3, Sub1BC2, AEX, RM8300, Sub1A203, Sub1C173 and GnS2 were used and three markers, Sub1C173, ART5, Sub1BC2 were found to be polymorphic.

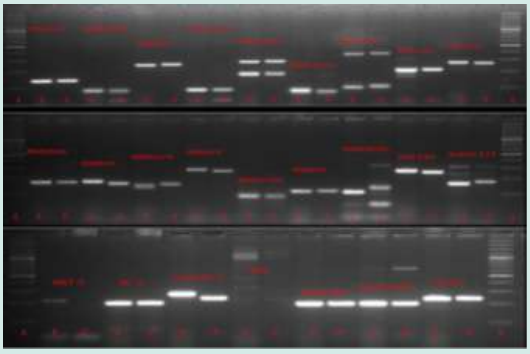


Fig. 3. Foreground polymorphism survey between the parental lines Chakhao-22 and CR Dhan 801

For background polymorphic studies, out of 169 SSR marker screened, 38 and 32 are found to be polymorphic marker between Chakhao-22 and CR Dhan 801 & Kalikhasa and CR Dhan 801, respectively for background selection. The BC1F1 generation of Chakhao-22 × CR Dhan 801 would be backcrossed with Chakhao-22 and the successfully derived F1 from cross, CR Dhan 801 × Kali kasha to be backcrossed with kali kasha during *kharif* 2023

Marker-assisted introgression of high-yield and durable blast resistance genes (OsSPL14 and Pi-54) for genetic improvement in Manipur black rice (Chakhao)

(N. Umakanta, S. Konsam, T. Basanta Singh, A. Sen, I. Meghachandra Singh)

To improve the yield of the low yielder Manipur black rice landrace (Chakhao), Chakhao (CHK-13) harbouring positive allele of *Pi54* gene was made cross with high yielding indica rice variety, CR Dhan 307 carrying favourable allele of *OsSPL14* gene. The resulting F_1s were selfed to produce F_2, F_3 and F_4 advanced populations. Among the 147 F_3 lines, 32 were found to be positive both for OsSPL14 and Pi54 genes which was confirmed through gene-based or functional markers. Out of 32, 16 were of black grain color with anthocyanin content ranged from 240.31 to 1.35 mg/100 gm sample. For genome contribution analysis among the 16 selected F_4 lines, 78 SSR markers covering all the twelve chromosomes of rice were used genotyping all the 16 F_4 black grain lines along with the parental lines, CHK-13 and CR Dhan 307. The genomic contribution of CHK-13 among the selected 16 F_4 lines were ranged from 62.74% (ChM125) to 80.39% (ChM142) with an average of 69.48%. These indicated that the selected F_4 lines would be more similar phenotypically to the recurrent parental line, CHK-13. On the other hand, the genomic contribution of CR Dhan 307 among the selected 16 F_4 lines were ranged from 17.64% (ChM80) to 35.29% (ChM63) with an average of 28.06% (Fig. 4). The presence of heterozygotic allele among the F_4 lines were comparatively less with an average of 0.73% and maximum of 1.96%. The results revealed that the selected F_4 lines were almost fixed and would be suitable for agronomic traits trails like yield, and grain quality.

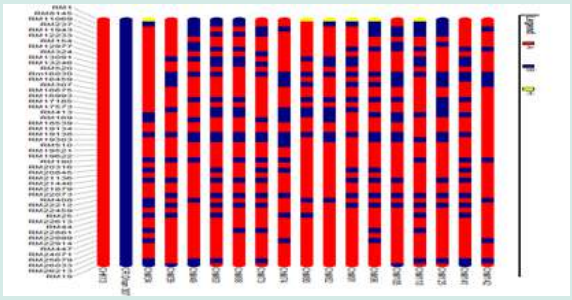


Fig. 4. Graphical representation of genomic contribution of parental lines among the F4 lines. Red and purple colour indicates genome of Chakhao and CR Dhan 307, respectively.

Characterization and genetic improvement of Chakhao landraces (Manipur black rice) for yield, abiotic and biotic stresses through biotechnological strategies

(N. Umakanta, S. Konsam, T. B. Singh, A. R. K. Singh, A. Sen)

A total of 74 Chakhao landraces were collected from different part of the Manipur. Among these, most popular 10 Chakhao were phenotyped for five grain related traits and showed substantial variation revealing the availability of genetic variability among the Chakhao landraces. The analyses of Pearson correlation coefficients (r) between the grain length and grain thickness, grain thickness and grain width showed a weak negative correlation. However, the analyses of correlation between the grain thickness and Ggrain length-width ratio showed a weak positive correlation with r = 0.032 at P value <0.001. The genetic diversity of this ten Chakhao landraces was conducted using 47 SSR markers covering the whole 12 chromosome of rice. Total 65 alleles were produced and the number of alleles per markers (K) ranged from 1 to 4 with an average of 2.03 alleles per locus (Fig. 5). The maximum and minimum PIC was recorded in RM26033(0.594) and RM14981 (0.159) respectively with an average PIC value of 0.26. The robust dendrogram based on Unweighted–NJ tree clustered the divided the 12 rice genotypes into three major subclusters I, II and III. In subcluster I, there were only two genotypes viz. Nipponbare and CHK-70 which revealed that the CHK-70 is more closed to Japonica reference genome. Six SSR markers (RM12293, RM19303, RM20948, RM7311, RM24071 and RM18239) were identified as polymorphic between the Chakhao poreiton and Chakhao amubi.

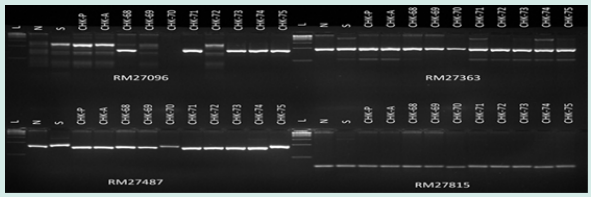


Fig. 5. Pictorial representation of genotyping using SSR markers in selected Chakhao genotypes.

Screening of *Sub1* gene in Chakhao landraces and RC Maniphou varieties through gene-based molecular markers

(N. Umakanta, S. Konsam, T. B. Singh, Kh. R. Singh, A. Sen)

Identification of potential donors for Sub1 gene in rice genotype was carried out for rice breeding programme. A total of 8 linked/functional molecular markers such as Sub1BC2, AEX, RM8300, Sub1A203, Sub1C173, GnS2, Sc3 and ART 5 for Sub1A, Sub1B and Sub1C genes were used for genotyping in 48 rice genotypes including Chakhao and RC Maniphou varieties. Out of 28 Chakhao landraces, 15 of them carry both positive allele of Sub1A and Sub1C genes. Out of 11 RC Maniphou varieties, four varieties such as RC Maniphou-4, -5, -7 and -10 carry both the positive alleles of Sub1A and Sub1C genes (Fig. 6). All the four RC Maniphou varieties such as (RC Maniphou-4, -5, -7 and -10) were evaluated for 14 days submergence and found tolerance which would be useful for development of submergence tolerant rice variety.

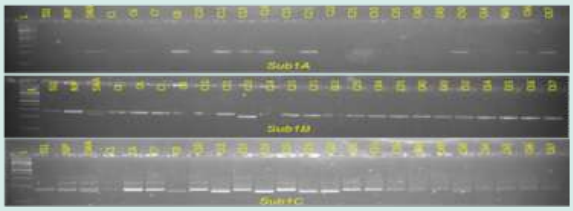


Fig. 6. Genotyping of 48 rice genotypes for Sub1 genes using functional molecular markers.

Endophyte-Mediated Resistance for Organic Manipuri Black Rice (Chakhao) against Blast (*Magnaporthe oryzae*) and Sheath Blight (*Rhizoctonia solani*) pathogens of Rice

(N. Umakanta, T. B. Singh, A. R. Kumar Singh, A. Sen)

Whole plant samples of eleven RC Maniphou varieties such as RC Maniphou 4, RC Maniphou 5, RC Maniphou 6, RC Maniphou 7, RC Maniphou 10, RC Maniphou 11, RC Maniphou 12, RC Maniphou 13, RC Maniphou 14, RC Maniphou 15 and RC Maniphou 16, four Chakhao landraces, 5 Kambong (*Zizania latifolia*) were collected from the rice fields of ICAR Manipur Centre, Lamphelpat during the kharif season, 2022. The leaves, stems and roots of the plants were used to isolate the endophytes following standard protocols. A total of 220 endophytes suspensions were collected. Jensen's media was used as the selective medium for screening the presence of endophytes with nitrogen fixing ability. Jensen's media was prepared using the following composition: 20 g Sucrose, 1 g di-Potassium hydrogen sulfate, 0.5 g Magnesium sulfate, 0.5 g Sodium chloride, 1 g Ferrous sulfate, 0.005 Sodium molybdate, 2 g Calcium carbonate, 15 g Agar. A total of 55 endophytes with nitrogen fixing ability were identified which would be further validated using molecular markers.

Introgression of drought (qDTY1.1 + qDTY2.1 + qDTY3.1) and submergence (Sub1) tolerant genes/QTL into high yielding glutinous RC Maniphou-7 rice variety

(N. Umakanta, S. Konsam, T. B. Singh, A. Sen)

The RC Maniphou 7 was crossed with CR Dhan 801 (*qDTY1.1* + *qDTY2.1* + *qDTY3.1* and *Sub1*) genes and generated 119 F1 seeds which was furthered back-crossed with RC Maniphou 7 to develop BC_1F_1 seeds. A total of 15 BC_1F_1 seeds were developed during kharif season of 2022. For background selection, polymorphism survey was carried out between the two parental lines, RC Maniphou 7 and CR Dhan 801 using 301 SSR markers collected from 12 rice chromosomes covering the whole rice genome (Fig. 7). Out of 301 SSR markers, 83 (27.57%) were found polymorphic between the RC Maniphou 7 and CR Dhan 801 which would be useful for background selection in the advanced backcrossed lines.

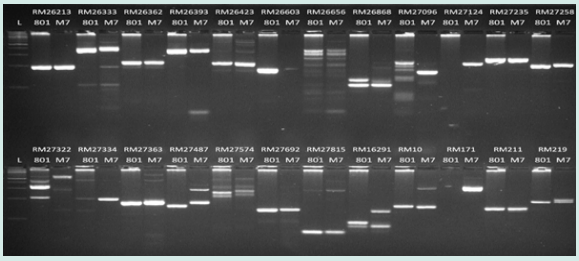


Fig 7: Gel image of polymorphism survey between the RC Maniphou 7 and CR Dhan 801 using SSR markers.

Seed Science and Technology

DNA fingerprinting and barcoding of rice varieties released by ICAR Manipur Centre for varietal identification

(I. M. Singh and N. Umakanta)

In an effort to document and protect the released varieties and select rice germplasm this effort on DNA fingerprinting was taken up. The polymorphism survey among the 11 RC Maniphou rice varieties released by the ICAR Manipur Centre was carried out using 47 SSR markers from 12 rice chromosomes. The 11 RC Maniphou rice varieties are RC Maniphou 4, RC Maniphou 5, RC Maniphou 6, RC Maniphou 7, RC Maniphou 10, RC Maniphou 11, RC Maniphou 12, RC Maniphou 13, RC Maniphou 14, RC Maniphou 15 and RC Maniphou 16. Out of 47 SSR markers used for genotyping in 11 rice varieties, 11 SSR markers were found to be polymorphic among the 11 RC Maniphou rice varieties. Using these 11 SSR markers, three set of multiplex-PCR (SET-1, 2 & 3) were developed that can differentiate the whole 11 RC Maniphou rice varieties from each others (Fig. 8).

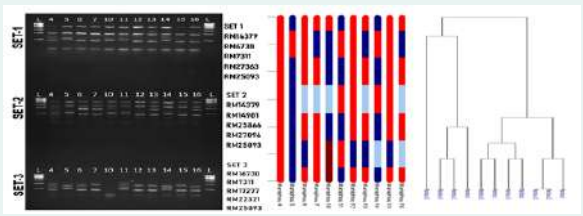


Fig. 8. Graphical representation of InDel markers genotyping of 11(eleven) RC Maniphou rice varieties series by separating the PCR amplicon in 3.5% Metaphor agarose for DNA fingerprinting

Genome-wide association mapping of agronomically important traits in Manipur rice germplasm

(I. Meghachandra Singh and Ngangkham Umakanta)

A set of 85 rice germplasms Manipur of were genotyped using 47 SSR markers from 12 rice chromosomes. Eleven phenotypic data of 85 Manipur rice germplasm viz. plant height, number of effective tillers, panicle length, yield per 5 plants, days to 50% flowering, days to maturity, grain length, grain breadth, grain length: breadth ratio, grain weight were data collected (genotypic and phenotypic) were used for association analysis with GLM algorithm in TASSEL 5.2.27 version software. A total of 31 markers were identified as associated with nine yield related traits. Out of them, six markers viz., RM27815 for tiller number, RM16341 for grain breadth, RM12160, RM16341 and RM25675 for grain length: breadth ratio, and RM15539 for grain weight were identified as major QTLs which would be useful for further fine mapping/molecular characterization.

Seed Technology Research Projects under AICRP Seed (Crops): Seed production and Certification;

Optimization of Organic Seed production System for Black Rice (Varieties: Chakhao Porieton (Black), Chakhao Porieton (ICAR) and Chakhao (white) and Maize (Varieties: Pusa Composite, RC Manichujak 2 and Local Chandel).

With the objectives Evaluation of crop Varieties for their suitability under organic seed production systems and to study the influence of organic nutrient sources on seed yield and quality attributes under organic production systems, Organic seed production experiment with different rice genotypes viz.: V1- Chakhao Poreiton (black), V2- Chakhao Poreiton (I), V3- Chakhao (white) was carried out at Lamphelpat farm for three Nutrient management treatments; N1–Control (no Fertilizer and Manure), N2-State Recommended Dose of Fertilizer and N3- RDN through Vermicompost with combination of 10 kg PSB/ha + 10 kg KSB/ha and three replication for each treatment. Seed treatment with biocontrol agent viz., Trichoderma harzianum @10g/kg of seed was done at the time of sowing (Fig. .9 a &b).

Fig. 9 (a) Experimental Field Black Rice

Fig. 9 (b) Experimental Field Maize

Similar experiment in maize with varieties, Pusa Composite, RC Manichujak 2 and Local Chandel was carried out at Langol hill ICAR farm with three varieties and three (3) Nutrient management treatments, viz: N1–Control (no Fertilizer and Manure), N2-State Recommended Dose of Fertilizer and N3- RDN through

Vermicompost with combination of 10 kg PSB/ha + 10 kg KSB/ha. Seed treatment with biocontrol agent viz., Trichoderma harzianum @10g/kg of seed was done at the time of sowing. In rice, variety Chakhao Poreiton(V2) gave the highest seed yield under RDN through Vermicompost with combination of 10 kg PSB/ha + 10 kg KSB/ha followed by V3, Chakhao (white). In maize too, the respective treatments gave best seed yield in V1 followed by V2.

Development of controlled & target specific release coating technologies for management of biotic and abiotic stresses and for quality seed production: crop - Maize (HQPM 5)

To study the effect of seed coating with PGPR formulations on seed yield and quality, experiment was conducted at ICAR Langol farm in maize (Variety: HQPM) with eight treatments viz: T1-Control, T2-Thiram + Bavistin (2:1)@3g/kg of seed,T3- Thiram + Bavistin in combition with Rhizobium and T4-AnRh,T5- Thiram + Bavistin in combition with AnRh ,T6-AnLaxa ,T7-AnTR and T8-AnRh + AnLaxa +AnTR were given to all the crops . Of theses treatments the best result in terms of seed yield was obtained with T6 (28.62qtl/ha) followed by T2 (23.49 Qtl/ha) (Fig. 10).

Fig. 10. Effect of PGPR seed coating on plant growth and seed yield attributes in Maize at ICAR Langol farm

Seed physiology storage and testing:

STR on Development of seed enhancement techniques for low temperature Stress during seedling establishment in Rice

The experiment was carried out at ICAR RC NEH Region, Manipur Centre, Lamphelpat during rabi season to attenuate low-temperature stress at seedling stage with seed enhancement techniques in paddy, to improve the tillering and synchronous flowering under low- temperature stress in paddy and to study the effect of different seed enhancement techniques on field and yield attributing traits in paddy raised under low temperature conditions. The study was to investigate the effects of different priming methods on growth and yield parameters on three rice varieties such as Arize Gold 6444, RC Maniphou-10 and RC Maniphou-7 with 14 different priming treatments *viz*.T_1-Control (no treatment), T_2-Control (seed treatment as per package of practices), T_3-Seed coating on Hydroprimed (30h@25^{0}C) seeds with Trichoderma harzianum, T_4-Primed with GA (@100ppm) followed by DAB+ Biophos, T_5-Seed coating with cold adoptive PGPB, T_6-Seed treatment with organic Trichojal@5ml/kg seed/lit., T_7- Seed treatment with organic Metajal@5ml/kg seed/lit, T_8- Seed treatment with organic Beauverijal@5ml/kg seed/lit,. Among the treatments, germination rate of RC Maniphou-10 with treatment T_4 was found to be have highest germination index, 6.11(1.86) as compared to the other two rice varieties (Fig. 11). Significant differences in no. of tillers per plant and Number of effective tillers among the treatments in all three varieties were also observed. Among the three varieties, RC Maniphou-10 with treatment T_4 was found to be tallest (135.52cm). RC Maniphou 7 with treatment T_7 was found to give highest tiller numbers (16.58) and effective tiller number (13.93) respectively. RC Maniphou-7 gave highest seeds per panicle (194.33gm), highest seed set percentage (73.99%) and highest grain yield (0.468kg/plot) with treatment T_2- Control (seed treatment as per package of practices).

Fig. 11: Experimental Field Development of seed enhancement techniques for low temperature Stress during seedling establishment in Rice

Table 1: Production of quality seed during 2022-23 (in quintals)

Particular	*Rabi 2021-22*				*Kharif / Spring/Summer 2022*				*Rabi 2022-23*			
	In Institute/ University farm/ lease land*		In farmers' field		In Institute/ University farm		In farmers' field		In Institute/ University farm		In farmers' field	
Field Crops	Indent	Ach.	Target	Ach.	Target	Ach.	Target	Ach.	Target	Ach.	Target	Ach.
Breeder seed	0.25	0.3	0.0	0.0	48.6	83.14	0.0	0.0	180.0	350.0	0.0	0.0
Foundation seed	4.8	6.0	10.0	11.0	21.7	26.75	40.3	80.5	6.75	7.20	22.0	32.0
Certified seed	2.0	3.0	380.0	498.0	10.3	19.5	6273.0	6623.5	5.5	9.5	35.5	61.0
Truthfully labelled seed	0.0	0.0	28.0	38.83	2.0	4.95	341.5	513.7	3.0	5.42	71.0	137.55
Total	7.05	9.3	418.0	547.83	82.62	134.34	6654.8	7217.7	195.25	372.12	128.5	230.55

RC Maniphou-5 RC Maniphou-6 RC Maniphou-7 RC Maniphou-10 RC Maniphou-11 RC Maniphou-13

Fig. 12. Experimental Field for seed production

Table 2. Rabi Seed Production undertaken at Institute (in quintals)

Crop	Variety	Duration of variety	Ideal planting window (from/to)	Breeder seed		Foundation seed		Certified seed		Truthfully labelled seed	
				Target	Production	Target	Production	Target	Production	Target	Production
Cereals											
Manipur Centre											
Maize	Pusa composite-3	125-130	Dec-Jan	0.40	0.60	0.00	0.00	0.00	0.00	0.00	0.00
Manipur Centre											
Field pea	Aman	125-130	Oct- Nov	0.00	0.00	0.50	0.70	0.00	0.00	0.00	0.00
Oil seeds											
Manipur Centre											
Mustard	NRCHB-101	130-150	Oct-Nov	0.00	0.00	0.20	0.30	0.00	0.00	0.00	0.00
	CLM-27	125	Oct-Nov	0.00	0.00	0.25	0.50	0.00	0.00	0.00	0.00

Table 3: Capacity building / technology dissemination on Seed (Crops) during 2022-23

S. No.	Particular	No.	Title	Date	Target group	No. of Beneficiaries
			Manipur Centre			
1	Training	1	Quality Seed production on Kharif crops under AICRP-QSP	6th August,2022	Seed Growers	30
2	Training	1	Quality Seed production on Kharif crops under AICRP-QSP	12th August,2022	Seed Growers	30
3	Training	1	Quality Seed production of rice and its certification	24th Aug. 2022	Seed Growers	60
4	Training	1	One day awareness cum training programme on Quality Seed Production	30th August,2022	Seed Growers	31
5	Training	1	Seed production of rabi field crops	25th Sept 2022	Seed Growers	41

Standardization of organic nutrient management package for black rice and its impact on soil health

The experiment comprised of 11 treatments i.e. Control; Farmers practice with no fertilizer - (T1), 100% of Recommended Dose of Nitrogen for rice (RDN) through FYM @ 12 tonnes/ha- (T2), 100% RDN through Vermicompost (VC) @ 4 tonnes/ha (T3), 75% RDN through FYM + Azolla- (T4), 75% RDN through FYM + 25% RDN through Green Manure Sesbania (GMS) @ 25 kg/ha in pre kharif - (T5), 75% RDN through FYM + 25% RDN through VC (Vermicompost) -(T6), 50% RDN through FYM + 50% RDN through VC - (T7), 50% RDN through FYM + 25% RDN through VC + 25% RDN through GMS (T8), 50% RDN through FYM + 25% RDN through VC + Azolla - (T9), 50% RDN through FYM + 25% RDN through GMS + Azolla - (T10), 50% RDN through VC + 25% RDN through GM + Azolla - (T11). Fresh Azolla was broadcasted on the 7th day after transplanting @ 500 kg/ha). The experiment was tested in Randomized Block Design with three (3) replications. Plant height was highest (1901.9± cm) for T7 and T8 and lowest for T1 (138±4.0 cm), the number of effective tillers was highest for T8 (11.2±0.4) and lowest for T1 (8.9±0.4). The grain yield was highest for T8 (2,217±54 kg/ha) and lowest for T1, straw yield was highest for T8 (4,743±7 kg/ha) and lowest for T2 (4,300±50 kg/ha). The Ca, Mg, Fe, Mn, Zn, Cu content in grain was highest for treatments T4, T10, T6, T9, T11 and T5 witt corresponding values of 21.3±1.2, 166±7.3, 9.43±1.1, 3.7±0.24, 12.5±1.4, 2.44±0.26 mg/kg, respectively and lowest for T1, with their corresponding values of 12.8±0.1, 141±16.7, 3.39±1.2, 0.9±0.05, 10.4±0.5, 1.28±0.09 mg/kg, respectively (Fig. 14). The Anthocyanin content (186±30 mg/kg), Antioxidant activity (16.6±1.2 µmol trolox E/g), Amylose Content (11.2 %), Ash content (1.63±0.63 %) were highest for T8. Therefore, application of FYM @ 6 t/ha + VC @ 1 t/ha + Green Manuring with Sesbania @ 25 kg/ha can be recommended to the organic black rice growers of Manipur. The organic nutrient management has positive impact on soil microbial biomass carbon and soil enzymes.

Fig. 13. Experimental field at ICAR, Lamphel Farm

Study on Zinc bio-fortification in the rice varieties of Manipur

(T. B. Singh and M. A. Ansari)

The experiment was conducted to identify the rice variety which is suitable for Zinc biofortification and to standardise the zinc application technique for zinc biofortification. It was tested in four varieties

RC-Maniphou 7, RC-Maniphou 10, RC-Maniphou 11 and RC-Maniphou 13. The treatments comprised of 3 levels of Zinc applications with a control viz. No Zinc application, Soil application of Zinc @ 25 kg/ha as basal, Three foliar sprays (tilletring stage, pre-flowering and at grain forming stage @ 0.5%) and Soil application of Zinc @ 20 kg/ha as basal + 2 foliar sprays (pre-flowering and at grain forming stage @ 0.5%) (Fig. 14). With the application Zinc the increase in yield of rice grain ranged 6.2 to 35.3 (Maniphou 11) followed by RC Maniphou 10 (24.5%), RC Maniphou 13 (24.1%), and RC Maniphou 10 (10.3%) over control (no Zinc) with the soil application of Zinc Sulphate @ 20 kg/ha as basal and two foliar sprays at tillering and grain filling stages. The zinc reponse value for RC-Maniphou 11 is higher (1.37) than the other 3 varieties but the zinc efficiency is higher for RC- Maniphou 7. The effect of Zinc application method on the zinc transfer co efficient is higher for RC- Maniphou 11 i.e. 1.038 (table 4). The soil application of Zinc Sulphate @ 20 kg/ha as basal and two foliar sprays at tillering and grain filling stages caused maximum increase in grain yield in all the varieties tested.

Table 4: Effect of Zinc application method on the zinc transfer co efficient (root to grain)

	No Zinc	Zinc @ 25 kg/ha as basal	Three foliar sprays (@ 0.5%)	Zinc @ 20 kg ha as basal + 2 foliar sprays	Mean A
RC-Maniphou-7	0.65	0.79	0.773	0.813	0.757
RC-Maniphou-10	0.673	0.673	0.907	0.997	0.813
RC-Maniphou-11	1.05	0.867	1.073	1.163	1.038
RC-Maniphou-13	0.917	0.97	1.05	0.94	0.969
Mean B	0.823	0.825	0.951	0.978	
Factors	C.D.	SE(d)	SE(m)		
Factor(A)	0.037	0.018	0.013		
Factor(B)	0.037	0.018	0.013		
Factor(A X B)	0.074	0.036	0.025		

Fig. 14. Experimental field at ICAR Lamphel Farm

HORTICULTURE CROP

Identification of stress-tolerant brinjal germplasm

(Ch. P. Devi, Ch. Tania, S. K. Sharma, A. Ningombam)

Twenty-one brinjal germplasm lines were screened against bacterial wilt using plug tray and micro centrifuge tube and *S. underatum*, IC 394877, IC 090084, IC 420656, IC 090869 were found moderate tolerants under both methods. Fifty-six (56) brinjal and its wild relative germplasm were screened for two years consecutively against fruit and shoot borer and found M8, Chwangte, Wabagai Khamen Aashangbi Macha and Marpara were found to be tolerant to shoot and fruit borer. Further germplasm was carried out the biochemical analysis and recorded the maximum anthocyanin content, IC 090026 (3.60 mg/100g) followed by Wabagai Khamen Aashangbi Macha (3.49 mg/100g). The vitamin C (12.75 mg/100g) content was recorded in Marpara and the maximum antioxidant was observed in IC 136176(11.36 µmol trolox/g). Total phenol content was observed in line, IC 090151(1814.20 mg/kg)

Development of organic cultivation packages of indigenous vegetables of Manipur

(Ch. Tania, Ch. P. Devi, and T. B. Singh)

Alocasia **(***Alocasia indica)* with application of 100% N through Vermicompost + *Azospirillum* + PSB + AM recorded the most efficient plant growth and yield parameters viz. plant height of (92.05 cm), number of petiole (5.72), length of petiole (69.45 cm), length of girth (23.43 cm), number of leaves per plant (5.72), leaf length (33.38 cm), weight of corm (125.82 g), yield per plot (2.73 kg) and projected yield per ha (12.12 t/ha), highest soil pH of 6.38, organic carbon (1.68%), available nitrogen (452.66 kg/ha), available phosphorous (26.59 kg/ha) and available potassium 473.68 kg/ha.

Chinese chive *(Allium odorum):* Among the organic treatment under study T7: 100% N through Vermicompost + Azospirillum+ PSB + AM recorded maximum plant height of 27.08 cm, number of leaves/plants 21.83, yield/plot 3.12 kg and projected yield 13.86 t/ha. The soil analysis after harvest also reveal highest soil pH of 6.38, organic carbon (1.68%), available nitrogen (432.66 kg/ha), available phosphorous (26.59 kg/ha) and available potassium (473.68 kg/ha) with T7: 100% N through Vermicompost + Azospirillum+ PSB + AM.

INM of spices

(Ch. Tania, Ch. P. Devi, and T. B. Singh)

Application of vermicompost (5t/ha) + lime (2.5q/ha) recorded the maximum plant height (35.22, 30.22 and 34.00 cm), number of umbellets/plant (23.11,19.62 and 6.83), number of umbels/plant (7.00, 3.00) and number of seeds per plant (43.78) were recorded in coriander, dill and fennel whereas, Fenugreek crop, application of Vermicompost 2.5 t/ha + lime 2.5 q/ha was recorded the maximum plant height (31.78 cm), number of pods/plant (2.56) and number of seeds/pod (5.99).

Optimization of spacing and sowing/planting time for coriander and fenugreek

(Ch. Tania, Ch. P. Devi and T. B. Singh)

Coriander sown in mid-October with spacing 30 x 15cm recorded highest plant height (77.17 cm), no. of primary branches (7.83), no. of umbellets/umbel (35.17), no. of umbels/ plant (78.83), and seed yield/plot (83.15 gm) in case of fenugreek crop sown with spacing 20 x 15cm recorded the highest number of branch/plant (5.64), no. of pods/plant (12.83) and seed yield/plot (33.2 g).

Persistence of Lambda-cyhalothrin 5%EC (Karate) @ 25 g a.i./ha on Pea and on-farm decontamination methods

(R. Akoijam, A. Ningombam)

In pod formation stage of pea, lambda-cyhalotrin 5% EC was sprayed through foliar application @ 25g a.i./ha for controlling pod borer. The samples were analysed to quantify at reverse phase High Performance Liquid Chromatography (RP-HPLC). The initial deposit was found to be 0.31 mg/kg on 1st day of sampling. The residue was persisted upto 7 days (0.01 mg/kg). The same sample was treated with 2% NaCl, 0.1% Sodium bicarbonate and washed with running water for 5 mins. The lowest persistence was observed in samples treated with 2% NaCl (0.01 mg/kg followed by samples treated with 0.1% Sodium bicarbonate (0.02 mg/kg) and that of washed with running water (0.03 mg/kg) though they all are persisted upto 5th day. The half-life values of samples treated with insecticides was found to be 1.72 days. The half-life values of the samples treated with on-farm decontamination methods were worked out as 1.17 days for samples treated with 2% NaCl, 1.43 days for decontamination with 0.1% Sodium Bicarbonate and 1.59 days for samples washing with running water.

Persistence of Lambda-cyhalothrin 5%EC (Karate) @ 25 g a.i./ha on Broadbeans and on-farm decontamination methods

(R. Akoijam, A. Ningombam)

In broadbeans, foliar application was done with lambda-cyhalothrin 5%EC @25g a.i./ha to control aphids, leaf miner and pod borer. After quantifying at RP-HPLC, the initial deposit of 0.40 mg/kg was found after 1 hour of application. The residue was persisted upto 7th day with the concentration of 0.03 mg/kg. However, the residue was decreased to persist upto 5th days with 0.05 mg/kg when the samples washed with running water. The samples decontaminated with 0.1% Sodium bicarbonate was also persisted upto 5th day with the lower residual value of 0.03 mg/kg. The lowest residue was found at samples decontaminated

with 2% NaCl with the residue of 0.01 mg/kg (5th day). The half-life values of samples treated with insecticides was found to be 1.72 days. However, the half-life reduced when decontamination methods practiced such as 1.07 days for decontamination with 2% NaCl, 1.45 days for samples decontaminated with 0.1% Sodium Bicarbonate and 1.69 days for samples decontaminated with running water.

Persistence of chlorantraniliprole 18.5% w/w SC (Coragen) @ 30 g a.i./ha and Fipronil 5% SC (Fax) @ 50 g a.i./ha on Broccoli, Cauliflower and Cabbage and on-farm decontamination methods

(R. Akoijam, A. Ningombam)

To control cabbage butterfly, diamond back moth, cabbage head borer and aphids, insecticides like chlorantraniliprole and fipronil were sprayed to control them on cabbage, cauliflower and broccoli. When chlorantraniliprole 18.5% w/w SC (Coragen) @ 30 g a.i./ha was sprayed on cabbage, cauliflower and broccoli, the residues of chlorantraniliprole was persisted upto 5th day (0.11 mg/kg) and 7th day on both cauliflower (0.05 mg/kg) and broccoli samples (0.04 mg/kg). However, the decontamination method of using 2% NaCl was found to be the most effective (0.02 mg/kg) at 5th day on cabbage and found 96.36% dissipation on 5th day of samples, 0.06 mg/kg at 5th day on cauliflower and 0.07 mg/kg at 5th day on broccoli) followed by 0.1% Sodium bicarbonate and washed with running water.

Fipronil 5% SC (Fax) @ 50 g a.i./ha was also applied as foliar spray on cabbage, cauliflower and broccoli. The residues of fipronil were detected upto 7th days on both cabbage (0.10 mg/kg) and cauliflower (0.02 mg/kg) but found to persist up to 9th day on broccoli (0.02 mg/kg). Among the decontamination methods, 0.1% Sodium bicarbonate was found to be the most effective (0.03 mg/kg at 7th day on cabbage, 0.08 mg/kg at 5th day on cauliflower and 0.02 mg/kg at 7th day on broccoli) followed by 2% NaCl and washed with running water. Decontamination method with 0.1% Sodium bicarbonate showed 96.87% dissipation on 7th day of sample.

The half-life values of cabbage samples treated with chlorantraniliprole and fipronil was found to be 1.99 days and 2.61 days, respectively whereas in cauliflower, the half-life values of samples treated with chlorantraniliprole was found to be reduced to 1.74 days and that of fipronil was 1.40 days. It was again reduced to 1.61 days for broccoli samples treated with chlorantraniliprole and 1.68 days for fipronil treated samples.

Medicinal and Aromatic Plants

Extraction of essential oil from aromatic indigenous plant, identification of major compounds and evaluation against storage pest, *Sitophilus oryzae*

(A. Ningombam and R. Akoijam)

Elsholtzia griffithi syn. *E. communis* is an indigenous aromatic plant from Manipur (*Lomba*) belonging to the Lamiaceae family. Throughout Asia, the plants of this genus have a long history of use in folk medicine and traditional cuisine. Essential oil was extracted from the inflorescence of this plant using steam hydrodistillation. The average yield of essential oil was approx. 1.1%. Gas chromatograph-mass spectrometry (GC-MS) analysis of the extracted oil showed that citral A and citral B are the main constituents of the oil followed by geranyl acetate (Fig. 15). Bioassay contact toxicity on rice weevil, *Sitophilus oryzae*, was done. No contact toxicity on rice weevil was observed up to 40,000 ppm concentration at 24 hrs and 48 hrs after treatment (Fig.16). Test concentrations (ppm)- 100, 300, 500, 700, 1000, 1500, 2000, 15000, 20000, 25000, 30000, 35000 and 40000 were tested. In Progeny Production bioassay test, the essential oil gave complete protection to treated rice seeds against rice weevil and there was no emergence of insects for six months at the tested concentrations.

Fig. 15. Essential oil was extracted from the indigenous aromatic plants using steam hydrodistillation.

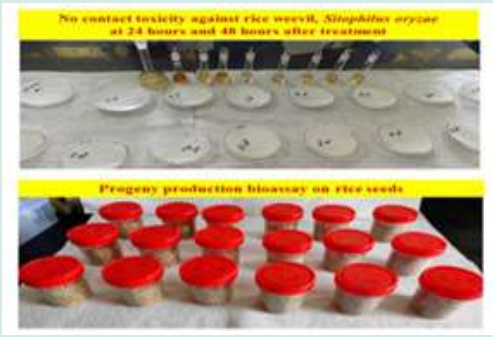


Fig. 16. Progeny Production bioassay test

Native isolates of *Trichoderma* spp. showed multifaceted biocontrol strategies to inhibit soft rot ginger causal agent *Fusarium oxysporum* both *in vitro* and *in planta*

(A. R. Singh, T. R. Borah, P. Baiswar, V. K. Verma and M. Chakraborty)

Five different of *Trichoderma* species (*Trichoderma asperellum; T. atroviride; T. harzianum; T. longibrachiatum* and *T. erinaceum*) which has recorded substantial inhibitory effect on *Foz in vitro*, was isolated from the Zingerberaceae plants and found effective against the rhizome rot, *Fusarium oxysporum* f. sp. *zingiberi* (*Foz*) of ginger (Fig. 17). In both field and pot experiments, all *Trichoderma* species effectively reduced the rhizome rot incidence, stimulated plant growth, and compared to the control. *Trichoderma*-treated plants significantly increased rhizome yield up to 9.52% and decreased the *Foz* up to 32.23% compared to control plants. GC-MS analysis revealed the presence of 1-Pentadecene, 13-16-Octadecadienoic Acid, 3-Eicosene and 3-Hexadecene are major compounds in different *Trichoderma* species. This study highlights the application prospect of novel native bioagents in ginger production for both disease suppression and growth promotion.

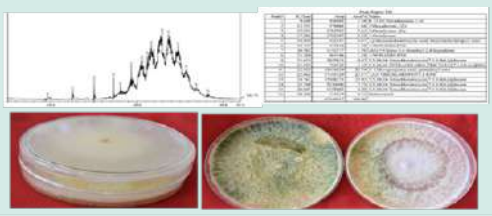


Fig. 17: Different compound of Trichoderma isolates (GC-MS analysis) and Antifungal activity of volatile organic compound (VOC) emitted by Trichoderma spp.

Identification and characterization of Ambrosia beetles and their fungal symbionts causing Tree bean decline in North East India

(*A. R. Singh, S. K. Sharma, R. Akoijam, D. M. Firake, T. R. Borah, P. Baiswar)*

In the last two decades, *Parkia timoriana* popularly known as tree bean grown in the Northeastern region of India has declined and recorded widespread incidences of 47.62 to 64.69%. The in-depth studies revealed that the novel symbioses between ambrosial insects and fungi is one of the major responsible for the decline. Several species of the ambrosia beetles were molecularly identified viz; *Euwallacea similis, Euwallacea interjectus, Euwallacea fornicates, Euplatypus parallellus, Xylosandrus crassiusculus* and *Xyleborinus* sp along with their fungal symbionts *Fusarium* spp (*F. euwallaceae, F. ambrosium, F. solani, F. oxysporum,)* (Fig. . 18). These fungus-farming ambrosia beetles carry their nutritional mutualistic fungi in specialized structures called mycangia. Virulence of these ambrosial fungi *Fusarium euwallaceae, F. ambrosium*, *F. solani* and *Lasiodiplodia theobromae* (non-ambrosial) were tested and established the Koch postulate.

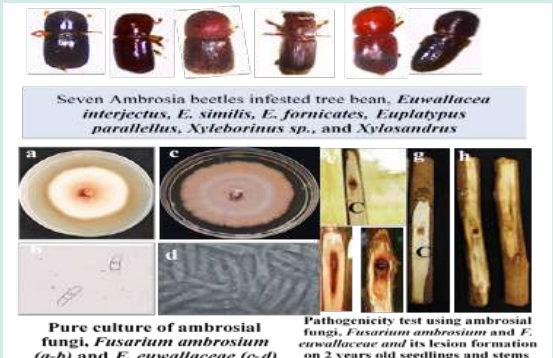


Fig. 18. Ambrosia beetles, ambrosial fungi anf pathoginecity test

Genetic and quasispecies diversity of viruses in chilli, passion fruit

(A. R. Singh, S. K Sharma, A. Ningombam, S.S. Roy, R. Akoijam and R. Singh)

Distribution of sequencing quality reads in different chilli pool-A and chilli pool-B carried out and indicated that 39% of sequenced reads belonged to cucumber mosaic virus, 21% to bell pepper endornavirus, 14% to chilli veinal mottle virus, 11% to hot pepper endornavirus, 7% to *Phaseolus vulgaris*

endornavirus-2. The first report of chilli virome and virus profiling from Indian chilli groves and global virome indicated the presence of potyvirus, cucumovirus and endornavirus-like sequences in the infected passion fruit samples collected from Northeastern India. A simplified RT-recombinase polymerase amplification (RT-RPA) assay for detection of large cardamom chirke virus (LCCV) in crude plant extract was developed (Fig. 19).

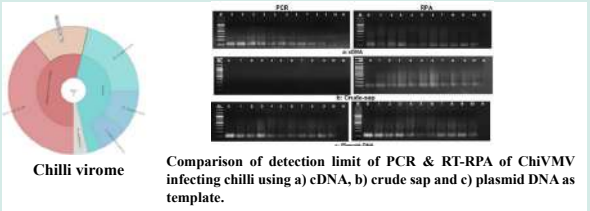


Fig. 19. A simplified RT-recombinase polymerase amplification (RT-RPA) assay for detection of large cardamom chirke virus (LCCV) in crude plant extract.

Secondary Agriculture: Mushroom

Collection, identification and cultivation of native oyster mushroom

(A. R. Singh, S. K. Sharma, A. Ningombam and Ch. P. Devi)

The oyster mushroom, *Pleurotus* species (IMP-19-01, accession nos. DMRX-1779) was collected from Manipur in 2019. The strain was cultured, morphologically and molecularly identified (ITS &L SU, *P. pulmonarius*) and further evaluated for yield and biological efficiency for three consecutive years. Yield recorded an average of 850-900 grams/1kg of dry straw and biological efficiency (BE%) of 85.00-90.00%. This strain is submitted to the Directorate of Agriculture, Government of Manipur for release as a variety for the Manipur state.

Evaluation of Shitake Mushroom, *Lentinula edodes* strains and DNA barcoding for Manipur Condition

(A. R. Singh, S. K. Sharma, S.S. Roy, A. Ningombam and R. Singh)

Forty-six (46) strains of shitake mushroom, *Lentinula edodes* collected from all over India, conducted trial in the centre, and found nine strains DMRO-1179, DMRO-1180, DMRO-1181, DMRO-51, DMRO-356, DMRO-327, DMRO-34, DMRO-328, DMRO-412) gave a consistent performance in yield, biological efficiency on enriched paddy straw-based substrate under Manipur conditions (Fig. 20). A strain, DMRO-356 gave the maximum biological efficiency of 90.5% followed by DMRO-412 and DMRO-327 which gave a biological efficiency of 88.6% and 87.5% respectively. An average yield of 700-800gm based on two harvests and the first harvest generally ranges from 65-75 days. DNA barcodes of forty-one strains has generated for germplasm conservation.

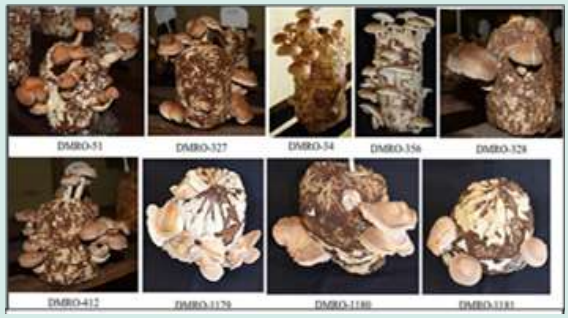


Fig. 20. Performance of different shiitake strains under Manipur condition

Animal Science And Poultry

Molecular characterization of *Helicobacter pullorum* and *Escherichia coli* from Poultry Samples

(*B. Sailo, C. Sonia, Lalmuankimi and M. Laishram)*

A total of six *Helicobacter pullorum* (Chicken meat=2 and Caecal contents=4), and 559 *Escherichia coli* (Pork meat=157, Chicken meat=219, Chevon=74, and Beef=109) were isolated and characterized. The six *H. pullorum* isolates were tested for bla_{ESBL} and other resistant genes, and revealed that $bla_{CTX\text{-}M\text{-}1}$ (n=1), bla_{TEM} (n=2), *aac(6')-Ib* (n=1), and *tet*A (n=2) were positive. Out of the 559 *E. coli* isolates, one hundred and sixty four isolates were found to be bla_{ESBL} positive isolates, whereby bla_{TEM} (n=110), $bla_{CTX\text{-}M\text{-}1}$ (n=35), $bla_{CTX\text{-}M\text{-}2}$ (n=6), $bla_{CTX\text{-}M\text{-}3}$ (n=3), $bla_{CTX\text{-}M\text{-}9}$ (n=2), $bla_{CTX\text{-}M\text{-}1+}bla_{TEM}$ (n=7) bla_{SHV} (n=1), *tet*A (n=5), *tet*B (n=11), *aac(3')IIa* (n=22), and *aac(6')Ib* (n=3) were the antibiotic drug resistant genes detected. One *E. coli* isolates from pork meat which was resistant to 19 antibiotics tested was positive for $bla_{NDM\text{-}1}$, and the gene sequence submitted to GenBank (Accession No. OP006128). Reported findings constitute a Knowledge Product.

Utilization of *Trapa bispinosa* roxb, *Eichchornia crassipes* and perilla for improving the performance and quality of chicken egg.

(C. Sonia, B. Sailo, S. Doley and M. Laishram)

For first experiment, Lay out of experimental design was made and there were four treatments, T1 – Control (Corn soya based layer diet), T2- Corn soya based layer diet with water hyacinth @ 30 g/kg in diet , T3- Corn soya based layer diet with water hyacinth @60 g/kg in diet and T4- Corn soya based layer diet with water hyacinth @100g/kg in diet. Feeding trial was done for 6 weeks duration to laying hens of 30 week old. There were 20 birds in each treatment. The results revealed that highest body weight of 2540.1 g at 6th week feeding in T4 group fed with 10% *Eichchornia crassipes* but change in the body weight was not significant and also no significant change in the feed conversion ratio was observed. Birds fed with 3,6 and 10 % *Eichchornia crassipes* have shown significantly better feed intake at 5th week of feeding when compared with control group. No significant differences were observed in Egg production percentage, shape index, egg specific gravity, shell weight and shell thickness by dietary addition of *Eichchornia crassipes* in laying hen. Birds in T3 and T4 group receiving 6 and 10 % of *Eichchornia crassipes* had given highest egg weight at I, III, IV, V and VI week feeding period when compared with others groups in laying hen. Yolk index of T3 (with 6% *Eichchornia crassipes*) and T4 (with 10% *Eichchornia crassipes*) group at VI week feeding had higher values of 44.7 and 45.02. Significantly better albumen index was observed in T4 group at V week (9.51) and VI week (9.64) feeding period. No changes in the shell thickness and Haugh unit value of the egg. Birds in T4 group fed *Eichchornia crassipes* at 10 % level had significantly improved Total erythrocyte count (3.07 x $10^{6/}$ mm^{3}**)** and total leucocyte count (33 x $10^{3/}$ mm^{3}**)** while no changes were observed in the values of Hb, PCV, MCV, MCH and MCHC values in laying hen. No significant effect was also found in lymphocyte, heterophil, eosinophil and monocyte of differential count in laying hen. Dietary addition of of 10% *Eichchornia crassipes* had a significant influenced on serum total protein (4.04g/dl) and serum albumin (1.67g/dl) in T4 group. No influenced on Serum globulin, total cholesterol and triglyceride were found in any of the test diets in laying hen. Reported findings constitute knowledge product.

ICAR-Poultry Seed Project

(C. Sonia, B. Sailo and M. Laishram)

The total number of parent stock of, Vanaraja and Srinidhi poultry birds maintained as a genetic stock in the poultry farm was 695 birds **(**291 Vanaraja and 322 Srinidhi**).** The total germplasm supplied during the calendar year from Jan 2022 to December, 2022 was 12,469 under PSP, ICAR Manipur centre. A total farmer benefited under this project was 92 numbers from different districts of Manipur during Jan 2022 to Dec 2022. Revenue generated during the reporting period was Rs 11,42,095. New batch of germplasm of Vanaraja and rinidhi were received during the first week of August 2022. One no of 3 days training on Poultry Biosecurity and Disease Prevention was held on 14-16th December, 2022. A total of 30 trainees participated in the training programme coming from nook and corner of Manipur. The training gave basic insights on how to prevent diseases and how to maintain a biosecure area in the local context of Manipur. Poultry Seed Project (PSP) has got very much popularity in the state and there is enormous demand of chicks from different districts of Manipur. It has gain tremendous popularity in both hill and valley districts of Manipur as Vanaraja, Srinidhi and gramapriya can reared as a backyard poultry moreover the quality of the meat and eggs is almost similar with desi poultry birds. Reported findings constitute knowledge product.

Dairy and Goatery Unit

(B. Sailo, S. Deori, C. Sonia, B. K. Sharma and M. Laishram)

At present, 14 numbers of Local x Jersey and Local x HF cross-bred cattle (Milch cow=4, Dry cow=1, Calf male=3, Calf female=4, Bull=1 and Heifer=1), and 8 local indigenous Meitei San cattle (Cow=4, Bull=1, Calf female=2, and Calf male=1) are maintained as a genetic stock in the Dairy Unit. A total of 23 local indigenous goats (Local Name: Hameng) are maintained as a genetic stock (Buck: 3, Doe: 9, Male kids: 9, and Female kids: 2) in the Goatery unit. Reported findings constitute knowledge product.

Fishery

Growth performance of *Wallago attu* in pond condition in Manipur

(Ch. Basudha Devi)

Wild collection of *Wallago attu* (Bloch & Schneider, 1801) seeds were obtained from rivers of Silchar district, Assam and stocked in a pond in at Laphupat Tera, Imphal West district. (Fig. 21)

Fig. 21 (a). Yearling of *Wallago attu*

Fig. 21 (b). Performance of *Wallago attu* in fermers field

Fig. 21 (c). Matured *Wallago attu*

A study was conducted to find the effect of stocking density on growth, specific growth percentage weight gain and survival rate in pond condition of three different locations of Manipur (Fig. 22).

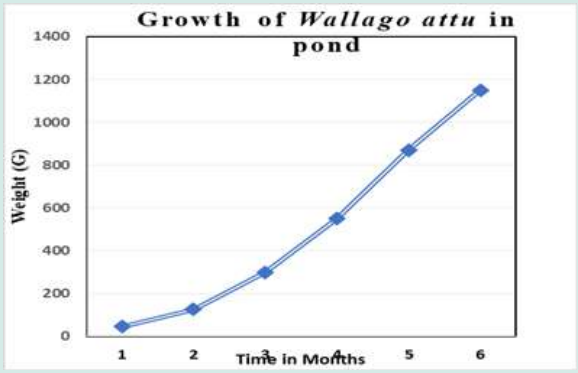


Fig. 22. Growth performance of *Wallago attu.*

Detection of saprolegnia species infection in *Pangio pangia* by using molecular approaches

(Ch. B. Devi)

Pangio pangia (Hamilton 1822) is an economically important fish for both food and ornamental fish in Manipur. It is a species of ray-finned fish in the genus *Pangio.* Earlier it was known as *Acanthopyhalmus pangia.* It is found in India, Myanmar and Bangladesh. During winter, cotton-like outgrowths on the skin, gills, depigmented skin and sunken eyes (50-80% incidence) were observed when the water temperature dipped below 15°C in winter. Infected fishes will begin to die slowly over time. Fish samples were collected from Imphal Valley from different locations since 2018 during winter The Oomycetes, typically *Saprolegnia* species, cotton wool fungus, commonly seen attached to the skin of affected fish and also found in gills, rapidly lead to mortality. The present method described the application of molecular markers for the identification of *Saprolegnia* spp. in *Pangio pangia.* Infected *Pangio pangia* with visible symptoms of Saprolegnia were selected from the collections (Fig. 23 a,b &c). The skin portion of the fish exhibiting visible symptoms was dissected using a sterile scalpel into small pieces 0.5g-1.0g and sterilized as per Wolf and Quimby (1969) and then placed onto YPS media. The resultant mycelial growths were sub cultured multiple times to obtain the pure culture of the isolate. A conventional phenol-chloroform-based DNA is olation method was used for standard DNA isolation from oomycete cultures.

Fig. 23.(a) Infected *Pangio pangia*

Fig. 23(b)Infected *P. pangia*

Fig. 23 (c) Collection site

Fig. 24(a) Primer:SAPRO-18s amplification with 10ng/ul

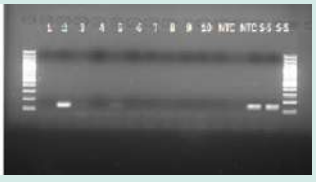


Fig. 24 (b) Primer: SAPRO-ITS amplification with 10ng/ul

Amplification is achieved using oligonucleotide primers ITS and 18s i.e., that are specific for the portion of the DNA to be amplified (Fig. 24 a & b).

The PCR product was visualized on 0.8% agarose gel and was purified, sequenced, and analyzed by BLAST. The sequence has been deposited to NCBI GenBank database with accession number ON585855. Saprolegniasis is an important fish disease caused by oomycete pathogens in the genus Saprolegnia. This method would be helpful for the early detection of *Saprolegnia* spp. Pathogens found in Manipur can significantly reduce losses and allow informed decisions for fungal disease treatments.

Evaluation of yellow Mealworm *Tenebrio molitor* as protein source in formulated feed on the growth of carp spawn.

(Ch. Basudha Devi)

A feeding experiments was conducted in plastic-lined ponds (4 x 6 x 0.75m^3) to examine the effects of *Tenebrio molitor* worm meal to developed non-fish meal and non fish oil based diet for carp nurseries. The study intended to determine the effect of mealworm (*T. molitor) baseddiet* on the growth performance and feed utilization efficiency of *L. rohita*. Three diet treatments, viz., mealworm-based diet (MWD), commercial diet (CMD), and without feed treatment (WF) which serves as a control, were used in this experiment. Diet MWD, having 36% crude protein based on mealworm meal, was formulated with 10% mustard oil cake, 3% vegetable oil, 2% mineral, 1% vitamin mixture and made up to 100% with rice bran. A series of ponds with 0.00125 ha were taken for these experiments, stocked with 15,000 nos. *L. rohita* spawns with 0.002 g body weight. Fishes were fed @ 5% body weight per day

Good growth, food conversion ratio (1.13) and protein efficiency ratio (2.46) were observed in fish fed with mealworm-based diets and found to be significantly higher than other commercial and control treatments. Better apparent protein digestibility coefficient values (APD was also obtained in fishes fed with mealworm-based diets i.e., 86.08%. The results concluded that *L. rohita* could utilize *T. molitor* worm meal-based protein diet to improve the growth of fish. This is the first report of using *T. molitor* as the protein source in carp spawn feed and proves to be an excellent alternative animal protein source for sustainable aquaculture.

Study on upscaling of fish seed production in pen enclosures under Manipur conditions

(W. A. Meetei, Ch. B. Devi, Kh. R. Singh, B. Sailo and T. B. Singh)

Survey in the Sanapat wetland shows that the peripheral area of the lake is heavily encroached for agricultural purposes. A large number of fish farms by a number of fishing cooperative societies was also developed inside the lake (Fig. 25). Some of the economic aquatic plants were *Trapa natans*, *Nymphoides*, *Nymphaea* and *Nelumbo* species. The water quality assessed were pH: 4.5-6.4, Free CO_2: 6.3-8.9 mg/l, D.O: 3.2-4.3 mg/l and indicated deteriorating water quality. Soil texture in the pat were predominantly sandy (88-93%) in nature. Soil was acidic in nature, organic carbon (%) ranges between 1.43- 1.58 %, PO_4 between 1.3 to 1.61 mg/kg, pH ranged between 6.5 to 7.3. The fishes in the wetland comprises of Common carp, Grass carp, Bighead carp, tilapia, IMCs and other small indigenous fishes. Some of the endangered indigenous fishes in the pats were *Anabas testudineus, Anguilla bengalensis, Acanthophthalamus punctuates, Channa orientalis, Botia bagarius, Barilius dogarsinghi, Garra graveli, Ompok bimaculatus.*

Fig. 25. Site for Pen Culture at Sanapat Wetland, Bishnupur District, Manipur

Social Science

Socio-economic perspectives of *Jhumias* to farming and climate change: A study in Manipur

(Kh. R. Singh, N. U. Singh, L. S. Singh, R.K. Roshan, K. S. Singh and I. M. Singh)

The present study is an attempt to fill the information gap and to explore the socio-economic aspects of shifting cultivation in the state. The study was based on primary data collected during the year 2021-22 from 100 numbers of *Jhumias* covering three hill districts of Manipur viz. Noney, Churachandpur and Chandel. The study found that maximum of the *jhumias* (33 per cent) were in the age group of 51 to 60 years and have an average family size of 6 persons. Rice, maize, colocasia, pea and cabbage are

found to be the major crop grown. Due to difference in altitude and topography, crops were sown or planted much earlier compared to valley areas. As advance equipment's, machineries and farm tools cannot be used in *jhum*, there is huge dependence on farm labour. Maximum of the expenses *ie*. 85 per cent is incurred on hiring of farm labour for soil preparation, sowing/ planting, interculture operations, harvesting and threshing. The cost of cultivation per hectare for paddy, colocasia, maize, pea and cabbage were work out to be Rs. 34837, Rs, 25757, Rs. 27111, Rs. 30940 and Rs. 25915 respectively (table 5). The average yield obtained per hectare was 1765.11 kg for rice, 1258.49 kg for colocasia, 1231.04 for maize, 960.56 kg for pea and 2380 kg for cabbage respectively. Considering the average market price, among the major crop grown, the highest net return *ie*. Rs. 41505 was obtained in pea, followed by cabbage *ie*. Rs. 18163, colocasia *ie*. Rs. 12312, rice *ie*. Rs. 11638 and the lowest net return (Rs. 5955) was obtained in maize. Similarly, the benefit cost ratio of pea was the highest *ie*. 2.34 and it was the least for maize *ie*. 1.22 respectively.

Table 5: Cost of cultivation, yield and net return in crop production (Rs./ha)

Crop	Cost of cultivation (Rs. Ha)	Yield (kg/ ha)	Rate (Rs./kg)	Value (Rs/ Ha)	Net return (Rs./ Ha)	B:C Ratio
Rice	34837.0	1765.11	26.33	46475	11638	1.33
Colocasia	25757	1258.49	30.25	38069	12312	1.48
Maize	27111	1231.04	26.86	33066	5955	1.22
Pea	30940	960.56	75.42	72445	41505	2.34
Cabbage	25915	2380.0	18.52	44078	18163	1.7

None of the *jhumias* obtained institutional loans or credit from banks and governments agencies. It was found that out of the total 100 respondents, only 12 household borrowed money informally from local money lenders, relatives and from friends. The *jhumias* face a number of problems and constraints in crop production. The list of five major constraints along with the Garrett score are given in table 6.

Table 6: Constraints faced in shifting cultivation

Sl No	Constraints	Garrett Score	Rank
1	Difficulty in access to agri inputs (fertilizers, insecticide, pesticides)	68.80	1
2	Pest and disease infestation	67.98	2
3	High cost of hired labour	56.95	3
4	Lack of irrigation facilities	54.98	4
5	Poor soil fertility	54.73	5

MIZORAM

SUMMARY

Lowland rice trials revealed that Gomati variety had the highest grain yield, followed by RCM 10. Intercropping maize or upland rice with rice bean, along with hand weeding at 20 DAS, effectively smother weeds. Eight five wild mushroom, 36 winged bean, 9 perilla, 3 job's tear, 8 ginger, 2 black turmeric, and one each of wild turmeric, black ginger and mango ginger have been collected and conserved. Notably, MZWB-L2 exhibits the longest pod among (53.12 cm) among winged bean genotypes. New diseases such as leaf blight (*Exerohilum rostratum*) and the presence of the common cerulean butterfly (*Jamides celeno*) affecting ginger, and FAW impacting Coix, have been reported. The available P content of soil was low (1.5 to 9.5 mg kg^{-1}) across different land uses while the total P ranged from 409.5 mg kg^{-1} to 468.09 mg kg^{-1}. More acidic soil pH decreases the availability of P due to Fe_2O_3 and clay content. The P sorption was highest for Teak (86.63%) and lowest for rice (70.39 %) land uses. The Lmax had a negative significant relationship with soil pH and positive significant relationship with clay content, Fe_2O_3 and Al_2O_3. The *Staphylococcus aureus* isolated showed highest resistance to gentamicin (61.3%) followed by oxacillin and penicillin (58.99%) in pigs and the highest resistance was observed in cefixime (72.23%) followed by penicillin (66.67%) and oxacillin (62.77%) in cattle. Local indigenous non-descript goat (Zokel) is a meat type goat with high prolificacy. The average birth weight of local indigenous non-descript cattle (Zobawng) male and female was observed as 14.516 kg and 12.250 kg respectively. Study on the growth performance of Amur carp and *O. belangiri* cultured along with Indian Major Carps showed that culture of Amur carp (10%) and Pengba (10%) with IMC is suitable for composite fish farming.

Weather report

(S. Chowdhury, Vanthawmliana, Lungmuana and S. Doley)

Daily weather observations were recorded at the agro-meteorological observatory of ICAR Research Complex for NEH region, Mizoram Centre during January, 2022 to December, 2022 (Fig. 1). The total amount of rainfall received during the period was 2712.4 mm with 116 rainy days (more than 2. 5mm rain per day) and one extreme rainy days (more than 100 mm rain per day) was observed on 8th July, 2022 (103.2 mm) and 6th August, 2022 (107.03 mm). Maximum rainfall received in monsoon (1893.70 mm) followed by pre monsoon (629.00 mm), post monsoon (159.90 mm) and winter (37.40 mm). Maximum monthly rainfall was observed in July (744.2 mm) and lowest monthly rainfall was observed in month of lowest in November (3.4 mm). *Jhum* farmer extended their farming from last week of March to second week of April due to less rain during March (10.1 mm) upto second week of April. Seasonal deficit was observed only in post monsoon season (43.15%). The considerable variation in mean monthly maximum temperature (Mean T_{max}) and mean monthly minimum temperature (Mean T_{min}) was evident (Fig.1). The mean T_{Max} varied from 28.3^{0}C to 30.2^{0}C in March and October respectively while mean T_{Min} varied between 12.4^{0}C to 12.5^{0}C in January and February respectively. Highest Maximum temperature was observed on 23rd April, 2022 (33.0°C) and lowest minimum temperature was observed on 13th February, 2022 (8°C). The variation in the morning relative humidity (RH morning) was much less as compared to the evening relative humidity (RH-evening). The variation RH-morning was much less than the RH-evening and varied from 87.0% (during April) to 94.6% (during October) while the RH-evening varied between 61.0% (during March) to 86.4% (during September) respectively. Southerly to South-Easterly was most prevalent wind direction throughout the year with wind velocity. The Average Bright Sunshine Hours varied from 1.44 to 6.57 hrs and wind velocity 1.09 to 3.55 km/hr.

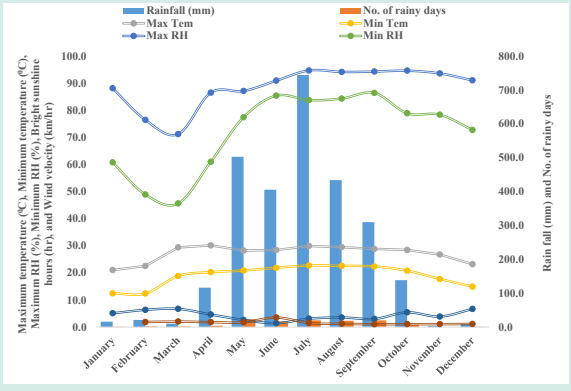


Fig. 1. Graph depicting the mean monthly weather condition recorded at ICAR Research Complex for NEH region, Mizoram, centre during January, 2022-December, 2022

Research achievements

Regional Complex Research Trials for lowland rice varieties

(J. K. Soni and S. Doley)

A field experiment was conducted during the *Kharif*, 2022 in ICAR Kolasib to assess the production potential of 23 rice varieties / cultivars, including a local cultivar as a check. The experiment aimed to evaluate their performance under lowland conditions. The results are presented in Table 1 and Fig. 2. Among the varieties tested, the local cultivar exhibited the longest crop duration after transplanting, with 124 days, which was significantly higher than all other varieties. On the other hand, the shortest crop duration was observed in the PNR 546 variety. The local cultivar also showed the tallest plant height, reaching 142.5 cm, which was significantly greater than the height of all other varieties. The PS-5 variety exhibited the shortest plant height. The Gomati variety had the highest number of productive tillers per hill, with an average of 17.8, while the local cultivar had the lowest number of productive tillers per hill, with an average of 5.1. In terms of grain yield, the Gomati variety recorded the highest yield at 3954 kg/ha, followed by the RCM 10 variety at 3652 kg/ha. The PS-5 variety had the lowest grain yield at 1598 kg/ha. When considering the weight of 1000 grains, the RCM-13 variety exhibited a significantly higher value of 31.0 g compared to all other tested varieties. The PS-5 variety had the lowest 1000 grain weight.

Table 1. Performance of different low land rice varieties / cultivars at ICAR Mizoram centre

Variety / cultivar	Days to maturity (DAT)	Plant height at maturity (cm)	No. of productive tiller per hill	Grain yield (kg/ha)	1000 grain wt. (g)
Badshah Bhog	111	119.2	12.9	2242	24.0
Gomati	117	126.8	17.8	3954	27.6
NLR-1	113	124.1	14.0	3160	27.1
NLR-2	118	116.2	12.0	2489	27.3
NLR-3	119	110.3	14.6	2210	29.0
NLR-4	118	114.2	8.4	2545	28.1
NLR-5	118	118.2	11.4	2598	29.0
NLR-9	113	111.2	15.6	2431	30.0
PNR-546	103	124.1	9.4	2321	24.1
PS-5	108	106.2	12.2	1598	21.0
Ranjit	117	118.8	11.4	3120	21.3
RCM-7	119	111.9	11.2	2465	26.0
RCM-10	113	119.0	13.2	3652	27.1
RCM-11	119	123.5	14.6	3215	28.0
RCM-13	120	118.8	14.9	3425	31.0
RCM-9	120	118.3	10.2	2540	26.5
TRC-2013-11	105	121.4	12.2	2515	24.0
TRC-2015-7	106	132.1	11.0	3077	26.8
Tripura chikan	119	110.2	12.6	3042	28.3
Tripura hakuchuk	104	118.7	10.2	3128	25.0
Tripura nirogi	104	113.9	9.4	2841	27.0
Tripura saarat	118	122.8	11.6	2987	27.6
Local	124	142.5	5.1	1821	27.5
LSD (p=0.05)	*9.2*	*10.3*	*2.2*	*201*	*1.1*

Fig. 2. Field view of RCRT trial for lowland rice varieties

Effect of legume crops on weed smothering, soil biological and crop growth variability on cereal based intercropping in Mizoram

(J. K. Soni and Lungmuana)

An experiments was undertaken during *Kharif* 2022 at ICAR Kolasib to study the weed smothering effect of legume crops on cereals (maize & upland rice)-based intercropping system and system productivity (Table 2, Figure 3). The maize with legume intercropping was followed with 2:2 paired rows cropping of 45/75 while upland rice (UR) was with 2:1 paired row cropping of 20/30. Findings indicated that under the maize and upland rice-based legume intercropping, legumes caused smothering effect on weeds (WSE) significantly. Among all the treatments, at 60 DAS, simultaneously sown maize + rice bean (2:2 paired row cropping 45/75) with hand weeding at 20 DAS resulted in 75.4% WSE. Whereas, at 90 DAS, simultaneously sown maize + groundnut (2:2 paired row cropping 45/75) with hand weeding at 20 DAS resulted in 94.6 % WSE. Similarly, simultaneously sown upland rice + rice bean (2:1 paired row cropping 20/30) with hand weeding at 20 DAS resulted in significantly WSE of 76.1 and 71.1% at 60 and 90 DAS, respectively.

System productivity in terms of total maize equivalent yield was significantly highest in simultaneously sown maize + groundnut (2:2 paired row cropping 45/75) with hand weeding at 20 DAS with 7421 kg/ha whereas, maize without weeding was recorded only 1254 kg/ha. System productivity in terms of total rice equivalent yield was significantly highest in simultaneously sown upland rice + groundnut (2:1 paired row cropping 20/30) with hand weeding at 20 DAS with 4982 kg/ha whereas, sole upland rice without weeding was recorded with 1102 kg/ha system productivity. The finding also showed that under legume intercropping with maize and upland rice; soil biological activities were enhanced as compared to sole cereals-based intercropping. It indicated better soil health under the cereal + legume intercropping system. The result showed that maize + rice bean (2:2 paired row cropping 45/75) with hand weeding at 20 DAS resulted significantly higher urease (42.24 µg NH4–N g^{-1} h^{-1}), dehydrogenase (6.21 µg g^{-1} h^{-1}) and microbial biomass carbon (421.01 µg g^{-1}) than sole maize cropping. A similar pattern was found with upland rice and legume intercropping systems. Therefore, intercropping of cereals with legumes constitutes a new promising approach to weed management for low-input Jhum agriculture under Mizoram conditions with higher system productivity and cost savings of two-hand weeding.

Table 2. Effect of legumes on weed smothering efficiency and system productivity on cereal based on intercropping

Treatments	Maize + legume			UR + legume		
	WSE (%)		Maize equivalent yield (kg/ha)	WSE (%)		UR equivalent yield (kg/ha)
	60 DAS	90 DAS		60 DAS	90 DAS	
Sole maize or UR without weeding	-	-	1254	-	-	1102
Sole maize with HW at 20, 40 and 75 DAS or sole UR with HW at 20, 40 and 90 DAS	-	-	4167	-	-	2112
*Maize or UR + cowpea with HW at 20 DAS	50.4	59.3	5139	71.2	65.5	2928
*Maize or UR + groundnut with HW at 20 DAS	57.7	94.6	7421	64.8	71.0	4982
*Maize or UR + french bean with HW at 20 DAS	40.4	69.3	6159	70.3	60.9	2968
*Maize or UR + rice bean with HW at 20 DAS	75.4	93.6	3298	76.1	71.1	2942
#Maize or UR + cowpea with HW at 20 DAS	39.8	83.4	4384	66.1	71.1	3462
#Maize or UR + groundnut with HW at 20 DAS	45.8	80.4	3534	74.5	54.0	4051
#Maize or UR + french bean with HW at 20 DAS	42.3	63.2	3809	69.5	52.1	2516
#Maize or UR + rice bean with HW at 20 DAS	57.8	50.0	4369	66.0	64.2	1516
LSD (p=0.05)	-	-	*615*	-	-	*659*

* Treatment 3 to 6, simultaneous sowing of both component crops
#Treatment 7 to 10, intercrop was sown 20 DAS of maize or UR *i.e* after first weeding

Fig. 3. Field view of cereal-based intercropping with legumes, (a) unweeded check, (b) cereal + groundnut, (c) cereal + rice bean

Collection, conservation and identification of wild edible and medicinal mushrooms

(J. K. Soni and L. Sailo)

Eighty-five species of different types of wild edible, non-edible and medicinal mushrooms were collected from different parts of Mizoram from January 2022 to December 2022. These wild mushroom species were collected from various habitats such as soil, jhum field, forest, decaying wood, rotting plant parts, markets, road side etc. (Fig. 4). Among them, 21 species were identified as wild edible *viz*., *Auricularia auricula judae, A. delicate*, *Calocybe gambosa, Dacryopinax spathularia, Favolus brasilensis, Ganoderma lucidum, Lactifluus corrugis, L. volemus, L. cladopus, Lentinus sajor-caju, L. squarrosulus, L. tigrinus, Phallus indusiatus, Pleurotus giganteus, Russula subfragliformis, Schizophyllum commune, Termitomyces clypeatus, T. heimii, T. microcarpus, Volvariella bombycina* and *V. volvaceae*. From the above collection, in-house cultivation of *S. commune* has been standardized for Mizoram region. All the collected mushrooms have been conserved and documented.

Fig. 4. Photos of some of wild edible mushroom spices of Mizoram, (a) *A. auricula judae,* (b) *L. corrugis,* (c) *L. cladopus,* (d) *P. giganteus* (e) *S. commune,* (f) *T. microcarpus*

Collection, characterization and selection of extra-long podded winged bean genotype (MZWB-L2)

(J. K. Soni, Lungmuana, A. Kumar, B. Lalramhlimi and S. Doley)

Forty-one genotypes of winged bean including thirty-eight local genotypes and three popular varieties collected from different places were evaluated at ICAR Mizoram Centre. Significant variation ($P<0.05$) was observed across genotypes for all the studied traits, suggesting the potential for crop improvement through the selection of superior genotypes. Pod length ranged from 12.12 to 53.12 cm, and pod width ranged from 2.02 to 4.21 cm. The pod weight varied from 13.4 to 120.1 g, while the number of pods per plant ranged from 7.5 to 41.1. Among the genotypes, MZWB-L2 exhibited the highest pod length (53.12 cm; Fig. 5), which was comparable to MZWB-L3, while the popular varieties RMDWB-1, IWB-1, and AKWB-1 had pod lengths of 16.9, 16.4, and 15.4 cm, respectively. MZWB-L2 also had the highest pod weight (116.1 g), followed by MZWB-L3, while RMDWB-1, IWB-1, and AKWB-1 had pod weights of 24.1, 21.1, and 16.9 g, respectively. The highest pod yield (t/ha) was recorded in MZWB-L2 (68.1 t/ha), followed by MZWB-L3.

Fig. 5. Field photo of extra-long podded winged bean genotype (MZWB-L2)

Identification of new pests and diseases in ginger and job's tear

(J. K. Soni, B. Lalramhlimi and S. Doley)

Leaf blight caused by *Exerohilum rostratum* was recorded as a new disease of ginger at the ICAR Mizoram Centre. The disease typically occurs between the months of July to September in crops planted in May. The distal end and leaf margin of the ginger plants were primarily affected, exhibiting initial symptoms such as reddish-brown spots with a yellow halo. These spots were oval-shaped, distinct,

and appeared water-soaked. Over time, these spots merged to form brownish blighted areas, eventually leading to complete leaf blight. The symptoms initially manifested on the lower leaves of the crop and gradually spread upwards, affecting the blighting leaves in the middle region of the plants. The severely blighted leaves appeared similar to burnt foliage (Fig. 6a). Infection symptoms, characterized by brown, oval-shaped spots with dark borders and a yellow halo, were also observed on the leaf sheaths of ginger.

The common cerulean butterfly, *Jamides celeno* (Lepidoptera: Lycaenidae), is a prevalent butterfly species in India. This report likely represents the first instance of *J. celeno* infestation on ginger inflorescence in Mizoram. The butterflies lay their eggs on young leaves or inflorescences. Upon hatching, the caterpillars feed on the lamina of the young leaves or inflorescences, creating bore holes as they consume the plant material. Infested inflorescences exhibit a yellowish-brown discoloration, which eventually leads to rotting and subsequent detachment (Fig. 6b). The presence of this insect pest is observed primarily from September to October. While it is believed to have minor significance as it does not attack the rhizome, severe infestation could result in economic losses as ginger flowers are consumed as a vegetable by the Mizos.

Job's tears (*Coix lacryma-jobi*; Family: Poaceae) is an underutilized crop with significant potential. However, the infestation of Fall Armyworm (FAW) on Job's tears was observed at the Research farm of ICAR, Kolasib, drawing significant attention due to the destructive nature of this invasive insect. The range of infestation among Job's tears genotypes was found to be 4.0-19.05% in early crop growth stages of the first week of July sown crop starting from second fortnight of August which peaked in September. This infestation peaked in September, while no further infestations were observed in the subsequent months. The larvae of FAW were primarily found feeding on the leaves and leaf whorl of Job's tears (**Fig. 6c**). To the best of our knowledge, this is the first documented report of FAW infestation on Job's tears crop.

Fig. 6. Incidence of new disease and pest (a) ginger Leaf blight, [b(i)] infected ginger inflorescence by Common cerulean butterfly, [b(ii)] adult cerulean butterfly; [c(i)] infested Coix plant by FAW, [c(ii)] FAW larva feeding on the crop, [c(iii)] FAW larva

Diversity exploration of ginger and turmeric germplasms of Mizoram

(J. K. Soni, B. Lalramhlimi and S. Doley)

Mizoram is blessed with varied diversity of ginger and turmeric. Local genotypes of ginger (Thingpui, Thinglaidum, Thingria, Sawhthing), black ginger, mango ginger and black turmeric (Ailaidum) were collected from different parts of Mizoram. National Bureau of Plant Genetic Resources, New Delhi has given accession numbers to all thirteen collections. Among the gingers, Thingpui and Thinglaidum acquired GI Tag already and are collectively called 'Mizo Ginger'. They have high gingerol content to the range of 1.23-1.25%, higher oil (1.6-2.5%) and higher oleoresin (5.9-8.5%). Locally they are eaten and sold in the market in fresh forms. Thingpui is bold in size, yellow to creamish flesh while Thinglaidum is medium in size with blackish ring in flesh. Thingria is slightly smaller in size, and has a well-defined blackish ring in flesh and really pungent (Fig. 7). The three collections 'Sawhthing' are location specific gingers which differ in sizes and colour of flesh. All these gingers are used locally for treatment of nausea, migraines, rheumatic disorders, muscular pain, and digestive ailments. The black turmeric, locally called Ailaidum showed a bluish ring in a white to creamish flesh colour. It is locally used for medicinal purposes in Mizoram for treatment of cough, cold, fever, asthma, vomiting, anthelmintics, rheumatic arthritis, and as a good source of antioxidant. Other medicinal rhizomatous plants like black ginger (*Kaempferia parviflora*) and mango ginger (*Curcuma amada*) were also collected from different parts of Mizoram which are conserved in research farm, ICAR, Kolasib Centre for further multiplication and research.

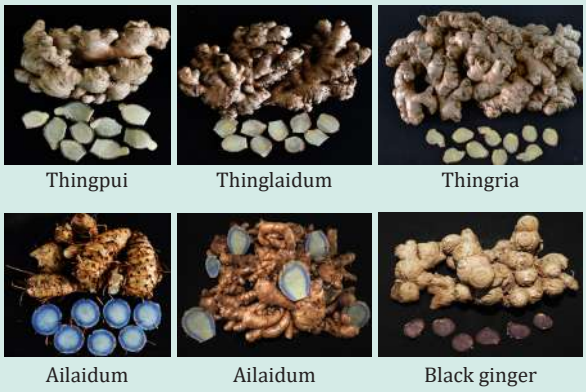


Fig. 7. Photos of different genotypes of ginger and turmeric

Effect of land use on the availability of P and related soil properties

(Lungmuana)

The available P content (Fig. 8) in the studied soil was low ranging between 1.5 to 9.5 mg kg^{-1} where it was highest in lowland rice land use (8.83 mg kg^{-1}) and least in oil palm (3.81 mg kg^{-1}) and deceased with increasing soil depth. Similarly, the M-P was highest in LR (6.55 mg kg^{-1}) and least in T (2.71 mg kg^{-1}). The O-P ranged from F and A (0.01 %) to LR (0.026 %) and the ACP activity ranged from LR (316.03 µg pNP $g^{-1}h^{-1}$) to F (753.89 µg pNP $g^{-1}h^{-1}$). While the total P ranged from OP (409.5 mg kg^{-1}) to R (468.09 mg kg^{-1}), the Fe_2O_3 % ranged from LR (0.99 %) to T (1.92 %) respectively. Total P has no correlation to any of the P forms and have significant relationship with SOC implying that T-P was influenced by the organic matter and the SOC in turn increased the ACP activity. The available P was negatively related to Fe_2O_3 suggesting that the availability of P was negatively affected by the Fe_2O_3, and the negative relationship between soil pH and Fe_2O_3 further imply that less soil pH decrease the availability of P due to Fe_2O_3 which affects the different forms of P (M-P and O-P).

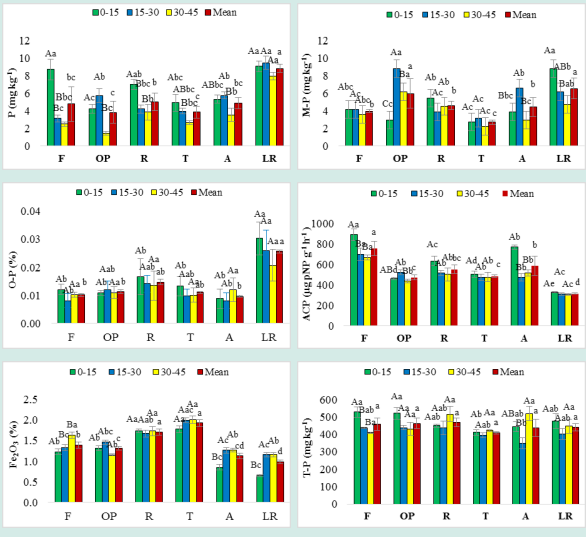


Fig. 8. Effect of different land uses on different forms of P and and Fe_2O_3.

Note: F: Forest; OP: Oil palm; R: Rubber; T: Teak; A: Arecanut and LR: Lowland rice; P: Available P; M-P: Melich 1 P; P-P: Oxalate P; ACP: Acid phosphatase enzyme, Fe_2O_3: Dithionite iron oxide and T-P: Total P; Bars represent SEM. Different lowercase letters are significantly different between land use of the same soil depth and different uppercase letters are significantly different soil depths of the same land use.

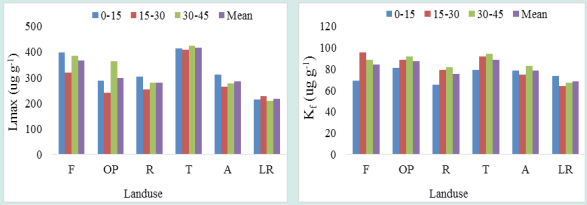


Fig. 9. Effect of land use on Langmuir an Freundlich adsorption parameters.

Effect of land use on P adsorption kinetics

(Lungmuana)

The extend of added solution P adsorbed by the soil decrease with the increase in added P and the adsorption was highest for Teak (86.63%) and lowest for rice (70.39 %). The adsorption maxima through the Langmuir isotherm (Lmax) was highest for T (415.7 ug g-1) to LR (217.3 µg g-1) and constant related to the bonding energy (K) varies between 0.17 to 0.49 mL µg-1 and Lmax was inversely proportional to the P bonding energy (K) (Fig. 9). Similarly, the Lmax had a negative significant relationship with soil pH and positive significant relationship with clay content, Di-Fe2O3 and O-Al2O3 implying that more acidic soils and clayey soil increased the adsorption of P in the region. The Freundlich constant (Kf), an index of P adsorbed taken as a measure of relative P sorption capacity ranged between 64 to 95 µg g-1 irrespective of the land use and soil depth and again highest for Teak (88.29 µg g-1) and lowest for LR (68.32 µg g-1) irrespective of the soil depth. The Freundlich constant (n; related to the energy of adsorbed P) ranged between 1.8 to 3.18 and is significantly and positively elated to the boning energy of Langmuir bonding energy. Thus, the Fe2O3 present in the soil depending on the soil pH may play an important role in the fixation of P in the region.

Surveillance and analysis of antimicrobial resistance pattern of *Staphylococcus aureus* in pig and cattle in Mizoram

(Lalhruaipuii and S. Doley)

A total of 40 milk samples and 185 numbers of skin scrapings/nasal swab were collected from clinical samples of cattle and pig irrespective of their age, sex and breeds from organized and unorganized farms of Champhai, Kolasib and Mamit district of Mizoram. Ninety three (93) isolates from pig and 35 isolates from cattle were found positive to *Staphylococcus* by biochemical test and PCR (Fig. 10). Twenty one (21) and five (5) isolates from pig and cattle were found positive to *Staphylococcus aureus.*

Based on the Antimicrobial Susceptibility test by Disc diffusion test the highest resistency was observed in gentamicin (61.3%) followed by oxacillin and penicillin (58.99%) in pigs. The highest resistency was observed in cefixime (72.23%) followed by penicillin (66.67%) and oxacillin (62.77%) in cattle. Out of 21 isolates of *Staphylococcus aureus* in pigs 2 isolates (10%; 2/21) were found positive to *mecA* gene.

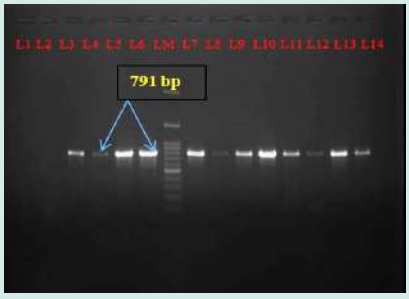


Fig. 10. Agarose gel electrophoresis showing the PCR amplicons of 16S rRNA (791 bp) obtained from *Staphylococcus* isolated from pig samples.

LM: 1200bp DNA Ladder; L1 : Negative control; L6 : Positive control

L2 to L5 & L7 to L14: Representative samples showing 16S rRNA gene amplicon.

Conservation and propagation of indigenous goat germplasms of North Eastern hill region of India

(Lalhruaipuii, S. Deori and S. Doley)

Local indigenous non-descript goat (Zokel) is a meat type goat with high prolificacy. The reproductive and productive traits of local indigenous non-descript goat was studied in an organized herd maintained at ICAR-RC-NEH, Mizoram Centre, Kolasib during 2022-23. In total, fourteen nos. of kidding was achieved which yielded 24 nos. of kids. Out of fourteen kidding, the percentage of single, twin and triplets were 57.14, 14.29 and 28.57 respectively. The percentage of pre-weaning mortality, post weaning mortality (3-8 months) and adult mortality (above 8 months) were 20, 0 and 9. The average birth weight (kg) was 1.67±0.13 and 1.53±0.09 in male and female respectively (Table 3). The overall performance of local indigenous non-descript goat of Mizoram are found to be better than Assam Hill goat.

Table 3. Productive and reproductive traits of Zokel

Parameters	Zokel
Birth weight (kg)	Male – 1.67±0.13; Female – 1.53±0.09
3-month weight (kg)	7.21±0.63
6-month weight (kg)	10.01±0.83
12- month weight (kg)	17.23±1.01
Adult weight (kg)	Male – 22.45±1.09; Female – 21.81±1.25
Weaning age (days)	85.75±0.85 (84-89 days)
Age at first mating (days)	225.25±8.04
Weight at first mating (kg)	12.12±0.94
Age at first kidding (days)	391.25±9.41
Weight at first kidding (kg)	17.93±0.68
First kidding interval (days)	232.5±8.09
Service period (days)	86.61±6.93
Gestation period (days)	146±1.87

Conservation and improvement of indigenous cattle in North East of India

(Lalhruaipuii, G. Kadirvel and S. Doley)

The reproductive and productive performance of local indigenous non-descript cattle (Zobawng) was studied in an organized herd maintained at ICAR-RC-NEH, Mizoram Centre, Kolasib during 2022-23. The average birth weight of male and female was observed as 14.516 kg and 12.250 kg respectively. The average gestation period and inter-calving period was found to be 287 days and 423 days. The average body weight gain per week of solely fed with fodder and fed with fodder plus concentrate was 2.74 kg and 3.4 kg respectively. The milk production is around 800 to 1200 ml/day.

Studies on the prevalence of Gastro-intestinal parasitic infections in Pigs of Mizoram, N.E India under DBT Biotech-KISAN Expansion project.

(Lalhruaipuii, S. Doley, M. Das and R. Laha)

A total of 383 numbers of pig faecal samples were randomly collected from organized and unorganized farms of Kolasib and Mamit districts of Mizoram during 2022-23. The parasitological examinations of these faecal samples were done by direct smear and flotation methods as per standard techniques. The examination of faecal samples of pigs revealed overall 45.69% pigs were infected with gastrointestinal parasitism. Among the helminths, *Ascaris suum* infections (33.94%) were predominant followed by *Strongyle* spp. (19.32%) and *Trichuris* spp. (6.01%). Amongst protozoa only *Eimeria* spp. (34.73%) was recorded. The present study indicates *Eimeria* spp. as the most prevalent gastrointestinal parasites followed by *Ascaris suum* (Fig. 11).

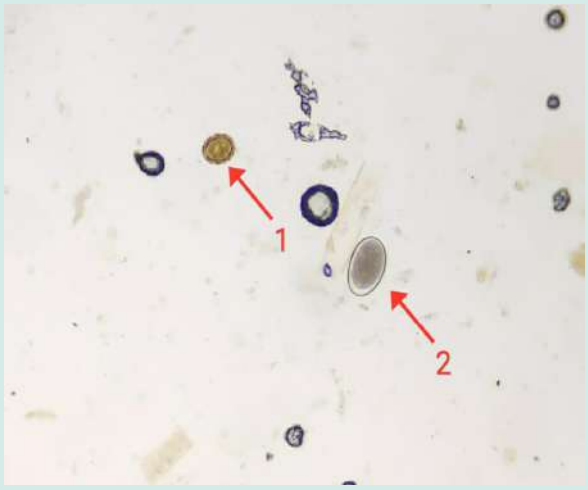


Fig. 11. *Ascaris suum* (1); *Strongyle* spp. (2)

A Comparative study on the laying performance of Vanaraja, Rainbow Rooster and BND in Mizoram.

(Lalhruaipuii, S. Doley and Tamilarasan K.)

The study was conducted to evaluate the laying performance of Vanaraja, Rainbow rooster (RR), and BND at Poultry Unit of ICAR, RC for NEH region Mizoram centre. All the birds were reared under uniform and standard managemental practices. The data for age at first egg, body weight at first egg, Hen day egg production, egg weight at first egg and at 52 weeks were recorded. Age at first egg was lowest in Rainbow Rooster (127days) followed by BND (134 days) andVanaraja birds (169 days). Average annual egg production was highest in BND (191.33 eggs) followed by Vanaraja (142.46 eggs) and Rainbow Rooster (115.33 eggs). The average Hen Day Egg Production (HDEP) for BND, Vanraja and rainbow Rooster were found to be 53.15%, 39.57% and 32.04% respectively. The weight at first egg was observed as 32.05g, 38.68g, and 45.52g for BND, Rainbow Rooster and Vanaraja respectively.The average egg weight at 52 weeks was highest in Vanaraja (54.51g), followed by rainbow rooster (50.88g) and lowest in BND (41.14 g). The body weight at first egg was found to be 1.16 kgs, 2.30 kgs, and 2.50 kgs for BND, Rainbow Rooster and Vanaraja respectively. It was observed that even though the BND is higher in egg production but Dual purpose Vanaraja bird performed better in terms of growth rate and egg weight in Mizoram condition.

Growth performance evaluation of *Osteobrama belangiri* along with Indian Major Carps

(P. L. Lalrinsanga and S. Doley)

An experiment was conducted to study the growth performance of Pengba (*Osteobrama belangiri*) cultured along with Indian Major Carps (IMC), Catla, Rohu and Mrigal. Three different treatments viz. Control (Catla, Rohu and Mrigal at the same ratio); Treatment I (Catla, Rohu and Mrigal at the same ratio + 20% Pengba) and Treatment II (Catla, Rohu and Mrigal at the same ratio + 30% Pengba) were evaluated and compared with three replicate for each treatment. The experiment was carried out in Concrete nursery tanks for a period of 60 days culture duration. A total of 90 nos. of fish was stocked in each tank and sampling was done every 15 days interval and water exchange was carried out every 7 days interval. Important water quality parameters were recorded by taking water sample before water exchange. The study showed that the final weight gain of *O. belangiri* was significantly lower than the IMCs in all the treatments including control (Table 4) with no significant variation of the final body weight among the treatments. No significant variation was observed in the survival of IMC between Control (87.33±0.67%) and Treatment I (86.67±1.76%). However, the survival of IMC reduced at an incorporation of 30% Pengba i.e. 82.00±1.15%. Further, the SGR was found to be highest for IMC in Control (1.23%) followed by Pengba in T-II (1.04%). However, there was no significant variation in the SGR of all the treatments.

Table 4. Growth performance of *O. belangiri* cultured along with Indian Major Carps.

Sl. No	Growth Parameters	Control	Treatment I		Treatment II	
		IMC	IMC	Pengba (20%)	IMC	Pengba (30%)
1	Initial weight (g)	5.64±0.17	5.84±0.13	3.86±0.45	5.72±0.18	4.06±0.48
2	Final weight (g)	13.27±0.81	11.09±0.42	7.32±0.73	11.72±0.44	8.36±0.62
3	Initial length (cm)	8.72±0.07	8.82±0.08	7.19±0.22	8.64±0.15	7.34±0.22
4	Final length (cm)	10.9±0.24	10.6±0.18	9.89±0.36	10.68±0.17	9.97±0.23
5	Survival (%)	87.33±0.67	86.67±1.76	73.34±3.34	82.00±1.15	77.67±2.34
6	Specific Growth Rate (SGR)	1.23	0.92	0.92	1.03	1.04

Growth performance evaluation of Amur carp with Indian major carps in Mizoram

(P. L. Lalrinsanga and S. Doley)

Growth performance evaluation study of Amur carp with Indian Major Carps at different level of incorporation was conducted in concrete cement tanks. Three different treatments viz. Control (Catla, Rohu and Mrigal at the same ratio); Treatment I (Catla, Rohu and Mrigal at the same ratio + 20% Amur Carp) and Treatment II (Catla, Rohu and Mrigal at the same ratio + 30% Amur carp) were compared with three replicate for each treatment. The experiment was carried out in Concrete nursery tanks for a period of 60 days culture duration. A total of 90 nos. of fish (IMC) was stocked in each tank while 20% Amur carp in T-I and 30% Amur carp were stocked along with IMC in T-II. Sampling was done every 15 days interval and water exchange was carried out every 7 days interval. Important water quality parameters were recorded by taking water sample before water exchange. The study revealed no significant difference in the final weight gain between fishes from different treatments (Table 5). The survival percentage of Amur carp was highest (86.67±3.33%) in T-I (20% Amur incorporation) which was significantly higher than T-II (79.89±3.95%). Further, the survival of IMC was found lower in T-1 and T-II compared to control. Additionally, no significant difference was observed in SGR of fishes in control and both the treatments. However, the SGR of Amur carp in T-II was found lower than control as well as T-I (Table 5). The present study revealed that incorporation of Amur carp at 20% resulted in reduced survival and SGR of IMC as well as Amur carp.

Table 5. Growth performance of Amur carp cultured along with Indian Major Carps in Mizoram.

Sl. No	Growth Parameters	Control	Treatment I		Treatment II	
		IMC	IMC	Amur (20%)	IMC	Amur (30%)
1	Initial weight (g)	6.25±0.03	6.32±0.01	5.52±0.10	6.58±0.10	6.41±0.15
2	Final weight (g)	12.51±0.05	13.06±0.02	11.90±0.28	13.07±0.04	12.09±0.06
3	Initial length (cm)	8.99±0.05	8.98±0.07	7.62±0.08	8.99±0.03	7.90±0.10
4	Final length (cm)	10.69±0.05	10.82±0.09	10.22±0.01	10.78±0.07	10.33±0.05
5	Survival (%)	85.33±1.33	83.33±0.67	86.67±3.33	82.00±1.15	79.89±3.95
6	Specific Growth Rate (SGR)	1.00	1.05	1.11	0.99	0.91

Growth performance evaluation of Amur carp and pengba with Indian major carps

(P. L. Lalrinsanga and S. Doley)

Experiment was conducted to study the growth performance of Amur carp and Pengba (*Osteobrama belangiri*) cultured along with Indian Major Carps, Catla, Rohu and Mrigal at different level of incorporation. Three different treatments viz. Control (Catla, Rohu and Mrigal at the same ratio); Treatment I (Catla, Rohu and Mrigal at the same ratio + 20% Amur Carp) and Treatment II (Catla, Rohu and Mrigal at the same ratio + 10% Amur Carp + 10% Pengba) were compared with three replicate for each treatment. The experiment was carried out in concrete nursery tanks for a period of 60 days culture duration. A total of 90 nos. of fish (IMC) was stocked in each tank while 20% Amur carp in T-I and 10% Amur carp + 10% Pengba were stocked along with IMC in T-II. Sampling was done every 15 days interval and water exchange was carried out every 7 days interval. Important water quality parameters were recorded by taking water sample before water exchange. No significant difference was observed between the control and treatment in respect of the final weight gain of IMC, Amur carp and Pengba (Table 6). However, final weight gain of both Amur carp and Pengba was found lower than IMC in control and both the treatments. Although the survival of Amur and Pengba was found lower in T-II, no significant difference was observed. Similarly no significance was observed in the SGR among the control and treatments, however, the SGR of Pengba in T-II was found highest in T-II compared to control and T-I (Table 6).

Table 6. Growth performance of Amur carp and Pengba along with Indian Major Carps in Mizoram.

Sl. No	Growth Parameters	Control	Treatment I		Treatment II		
		IMC	IMC	Amur (20%)	IMC	Amur (10%)	Pengba (10%)
1	Initial weight (g)	13.41±0.28	13.03±0.19	11.67±0.34	12.90±0.24	12.04±0.40	9.72±0.53
2	Final weight (g)	27.12±0.61	27.35±0.71	22.05±0.89	25.55±0.91	21.98±0.79	20.77±0.44
3	Initial length (cm)	11.12±0.29	10.95±0.29	10.35±0.16	11.07±0.18	10.67±0.12	9.58±0.35
4	Final length (cm)	13.26±0.04	13.54±0.26	12.97±0.34	12.98±0.24	12.92±0.24	12.13±0.22
5	Survival (%)	87.78±2.94	91.11±1.11	88.89±3.21	86.67±3.84	85.19±3.70	85.19±3.70
6	Specific Growth Rate	1.17	1.24	1.06	1.14	1.00	1.25

Carcass evaluation of Chocolate Mahseer, *Neolissocheilus hexagonolepis* from Mizoram

(P. L. Lalrinsanga and S. Doley)

A study was conducted to evaluate the carcass characteristics of Chocolate Mahseer, *Neolissocheilus hexagonolepis* (McClelland, 1839) from Mizoram. Specimens of *N. hexagonolepis* ranging from 360 to 1500 g were collected from the wild and the carcass yield, offal yield and carcass cutability were assessed following standard carcass evaluation technique (Fig.12). The percentage gutted yield amounted to 74.93±1.60% (Table 7) while the final headless dressed yield was found to be 62.10±1.63% (Table 7), which is higher than Indian major carps. Further, the study revealed that in the filleting process the two posterior round cuts produced a combination of 26.46% and 24.25% while the fore cut produced the lowest yield of 22.05% of the total weight yield.

Table 7. Carcass yield characteristics of Chocolate Mahseer, *Neolissocheilus hexagonolepis* from Mizoram

Traits	Mean±SE	Yield %
Live weight (Kg)	0.78±0.25	
Dressed body weight (gm)	585.76±191.41	74.93±1.60
Headless dressed body weight (g)	483.02±156.15	62.10±1.53

Fig. 12 a & b. *Neolissocheilus hexagonolepis* and different processing cuts for carcass evaluation

NAGALAND

SUMMARY

Total annual rainfall received during the year 2022 was 1563.1 mm, 3% above normal (1515.4 mm) while monsoon rainfall was 5% below normal. Long term field experiments were established to compare the effect of resource conservation technology in Rice-*Toria*-Green gram and Maize-French bean-Green gram. Four numbers of Integrated farming system models were evaluated for their remunerative and self-sustainability in respect to soil health. A total of 54 homegardens located across 3 elevation zones EZ_1 (<250 m), EZ_2 (251-500 m), and EZ_3 (>500) in Chümoukedima district were surveyed for diversity analysis. A field trial was conducted at ICAR Nagaland Centre farm to assess the fodder production potential of three leguminous tree species, *viz. Gliricidia sepium, Leucaena leucocephala* and *Sesbania grandiflora*. A total of 10 varieties of field pea were evaluated for their yield performance at ICAR, Nagaland Centre. Among these varieties, IPFD-18-2 recorded the highest yield (4.14 q/ha) followed by IPFD-17-2 (3.36 q/ha). To reduce post-harvest losses, King Chilli Puree and Sauce were standardized and developed. Species diversity of River Dhansiri in two sites Domukhia and Manglamukh was studied to assess the occurrence of different fish species. Melatonin supplementation to boar semen improved in-vitro and in-vivo semen quality. The net return per sow was significantly higher ($P<0.001$) in artificially inseminated sows (US$464.8 vs. US$248.11). AI resulted in an 87.3% increase in net returns per farrowing as compared to natural breeding. Indigenous chicken production system (ICPS) was characterized in three different agro-ecologies (tropical, sub-tropical, and sub-temperate) in Nagaland. In the field, 844 animals were inseminated with the farrowing rate of 85.3% and average litter size of 9.44 (2-17) piglets per litter. A total of 6796 numbers of improved piglets were produced in the farmer's field through artificial insemination.

Weather Report

Total annual rainfall received during the year 2022 was 1563.1 mm, 3% above normal (1515.4 mm) while monsoon rainfall was 5% below normal. The most deficit rainfall (i.e. nil) was observed during the month of Nov. Total monthly distribution of rainfall is depicted in **Fig 1**. The highest rainfall in a single day was 94.0 mm (22nd July, 2022) followed by 62.2 mm (23rd July, 2022). The number of rainy days was 1% below normal (92 days). The highest average max. temperature of 33.6°C was observed in July (Fig 2). Highest max. temperature and the lowest max. temperature recorded for a single day was 37.6°C (16th July, 2022) and 17.9°C (4th Feb, 2022), respectively. Highest max and min. temperature for a single day was 26.0°C and 6.3°C, respectively. Max. temperature during the period showed increasing trend while min. temperature was in decreasing trend. Total pan evaporation loss was 1012.5 mm (2.8 mm/day) against the total rainfall received i.e., 1563.1mm.

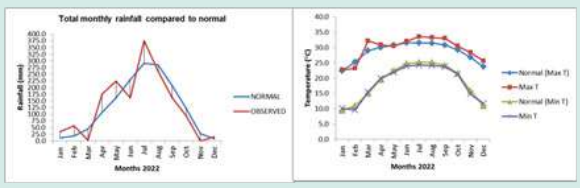


Fig 1. Total Monthly rainfall pattern and Average temperature

RESEARCH ACHIEVEMENTS

Effect of Resource conservation technology in Cereal-based cropping System in foot hills of Nagaland.

(L. K. Baishya, Co-PI: Christy B. K. Sangma, J. Layak and D. J. Rajkhowa)

Long term field experiments were established to compare the effect of Resource Conservation Technology in Rice-*Toria*-Green gram and Maize-French bean-Green gram at Research farm, Nagaland Centre during 2021-2022 **(F2)**.

Effect of Conservation tillage and Nitrogen Management on growth and yield of Rice and Maize

Rice (RCM-9) and Maize (RCM-76) were grown during *kharif* season in different tillage practices i.e., conventional tillage and conservation tillage with green gram stubble incorporation and different Nitrogen management practices. The highest yield of rice (5.44 t/ha) was observed receiving LCC (4-5) based Nitrogen management practices, followed by SPAD (36) based N management practices (5.08 t/ha). The farmers practices (150 kg urea/ha) of Nitrogen management recorded the lowest rice yield (3.13 t/ha. The highest yield of maize grain (3.70 t/ha) was observed in the crop receiving LCC (4-5) based Nitrogen management practices, followed by SPAD (45) based N management practices (3.55 t/ha). However, the farmers practices (150 kg urea/ha) of Nitrogen management recorded the lowest rice yield (2.40 t/ha). The different tillage practices did not fail to show any significant differences in both rice and maize.

Effect of Conservation tillage and Irrigation Management on growth and yield of Toria and French bean

Toria (Var. TS-67) and French bean (Anupam) were grown during *rabi* season after rice and maize, respectively, under different tillage practices, i.e. conventional tillage and conservation tillage practices, with rice stubble and maize stubble incorporation with different irrigation management practices. Crop receiving irrigation regimes IW/CPE=1 recorded highest yield of *toria* (1529 kg/ha) followed by IW/CPE=0.8 (1261.03 kg/ha). The lowest yield was recorded in non-irrigated control treatment (737.3 kg/ha). The different tillage practice revealed that conservation tillage practices with mulching recorded significantly higher yield (1543.7 kg/ha) as compared to conventional tillage practices (808.04 kg/ha). French bean receiving irrigation regimes IW/CPE=1.0 recorded highest yield (2349.7 kg/ha) under conservation tillage practices followed by IW/CPE=0.8 (2042.3 kg/ha). The lowest yield was recorded in farmers practice/control (1.562.6 kg/ha). The different tillage practice revealed that conservation tillage practices with mulching recorded significantly higher yield (2429.8 kg/ha) as compared to conventional tillage practices (1539.9 kg/ha).

F2. Rice-toria–Green gram (as Catch crop) based cropping system

Studies on Resource use efficiency, Energy budgeting and Sustainability of IFS models for small and marginal farmers of Nagaland.

(L. K. Baishya, D. J. Rajkhowa, J. Barman, A. Seyie, A. W. Yanthan, C. B.K. Sangma, M. Singh, L .J. Bordoloi)

Four numbers of Integrated farming system models (IFS: 5 years old) were evaluated for their remunerative and self-sustainability in respect to soil health **(F3).**

Model No.1. (Horticulture + Agriculture + Fishery + Piggery + Vermicompost). The Model covering an area of 0.55 ha altogether recorded a net return of ₹158520/unit (= ₹283984/ ha/year) during the year 2020-2021 with B:C ratio 2.30, and employment generation of 319 mandays/year/unit (571 mandays/ ha). This model was remunerative and self-sustaining for small and marginal farmers of Nagaland with the highest value of SVI (0.39). Organic carbon increased from 0.80% to 1.05% after 5 years.

Model No. 2. (Horticulture + Agriculture + fishery + Goatery + Vermicompost). The Model totalling an area of 0.42 ha recorded net income of ₹119962.31/unit (= ₹281403/ ha/year) during the year 2020-2021 with B:C ratio 2.20, and employment generation of 284 mandays/year/unit (666 mandays/ha). This model was remunerative and self-sustaining for small and marginal farmers of Nagaland with SVI value of 0.35. Organic carbon increased from 0.85% to 1.04% after 5 years.

Model No. 3. (Horticulture + Agriculture + Fishery + Duckery + Vermicompost). The Model covering an area of 0.40 ha recorded net income of ₹ 85535/ unit (= ₹212985.55/ha/year) during the year 2020- 21 with B:C ratio 2.09 and employment generation of employment generation of 210 mandays/year/unit (523 man-days/ha). This model was remunerative and self-sustaining for small and marginal farmers of Nagaland with SVI value of 0.28. Org. carbon increased from 0.86% to 1.05% after 5 years.

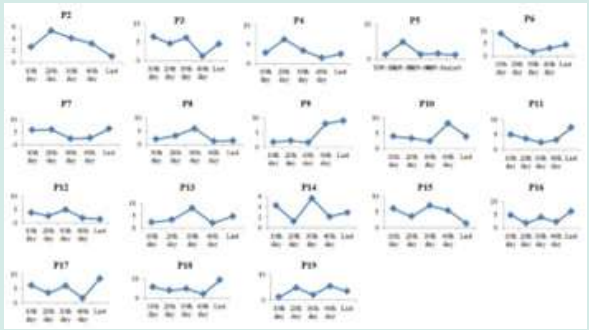
Model No. 4. (Horticulture + Agriculture + Fishery + Poultry + Vermicompost + Mushroom). The model covering an area of 0.63 ha recorded highest net income of ₹152290/unit (= ₹238250.93/ha/year) during the year 2020-2021with B:C ratio 2.23 and employment generation of 320 mandays /year/unit (501 mandays/ha). This model was remunerative and self-sustaining for small and marginal farmers of Nagaland with SVI value of 0.37. Organic carbon increased from 0.87% to 1.15% after 5 years.

F3. IFS Model No. 1 and 4

Standardization and development of native phosphorus solubilizing microorganisms (PSMs) based bioformulation for increase phosphorus (P) dissolution in acidic soils of North Eastern Hill Region

(C. B.K. Sangma, S. Hazarika, R. K. Singh, L. J. Bordoloi, B.U. Choudhury, T. Ramesh)

18 no. of strains (PPS-01, PPS-02, PPS-03, PPS-018) of native type phosphorus (P) solubilizing microorganisms (PSM) isolated from rhizosphere soil of different crops were tested for their rhizosphere colonization ability in sterile soils. The different treatments allotted are *viz*. P1-control (Zero PSM), P2-PPS01 strain...P19-PPS018 strain) under control condition with maize (HQPM 76) as the host crop. The population counts were carried out in Pikovskaya's media and the growth curve of various strains of P solubilizers at 10^6cfu ml^{-1} are shown in **F4**. The different strains exhibited different growth pattern and the treatment P7 (with PPS-06 strain) and P11 (with PPS-08) showed consistency in the colonization ability.



F4. Growth curve of different strains of P solubilizers at 10^6cfu ml^{-1}

Assessment of species composition and carbon stock of existing agro-forestry systems under mid tropical zone of Nagaland

(P. L. Bhutia, C. B. K. Sangma, A. Seyie, L. K. Baishya)

54 homegardens located across 3 elevation zones EZ_1 (<250 m), EZ_2 (251-500 m), and EZ_3 (>500) in Chümoukedima district were surveyed (**F5**). These homegardens comprised of 4-5 vertical strata, and a total of 130 plant species were recorded, excluding weed species. Among these, trees constituted the majority of the total plant species (47.69%), followed by herbs (43.85%) and shrubs (8.46 %). Importance Value Index (IVI) of the woody/non woody perennials revealed the dominant species in each elevation zone:

EZ_1 (<250 m) (**IVI**: 15.93 – 39.8): *Areca catechu- Bambusa tulda- Cocos nucifera- Parkia roxburghii- Mangifera indica- Musa paradisiaca*

EZ_2 (251-500 m) (**IVI**: 12.41-33.06): *Bambusa tulda- Areca catechu- Musa paradisiaca-Mangifera indica- Cocos nucifera- Parkia roxburghii.*

EZ_3 (>500) (**IVI**: 15.1-38.85): *Areca catechu- Musa paradisiaca- Parkia roxburghii- Mangifera indica- Artocarpus heterophyllus- Schima wallichi*

F5. Typical homegarden at 180 amsl

Evaluation of tree legumes for fodder production potentiality in NEH region.

(P. L. Bhutia, A. W. Yanthan, A. Seyie, C. Aochen, M. Singh, H. Kalita)

A field trial was conducted at ICAR Nagaland Centre farm to assess the fodder production potential of three leguminous tree species, *viz. Gliricidia sepium, Leucaena leucocephala* and *Sesbania grandiflora*, under different cutting frequencies (C_1: Once a year, C_2: twice a year, C_3: four times a year and C_4: six times a year) (**F6**). Tree seedlings were planted with a spacing of 1 m between rows and 0.5 m between plants. After 8 months of growth, *L. leucocephala* exhibited 100% survival rate, followed by *G. sepium* (98.4%) and *S. grandiflora* (91.1%). Average height of *S. grandiflora, L. leucocephala* and *G. sepium* was 197.1 cm, 188.6 cm and 168.8 cm, respectively. Similarly, the average diameter was 2.49, 1.72 and 2.28 cm, respectively.

F6: Tree legumes Protein bank

DUS testing and grow out test (GOT) of farmers' rice varieties under PPV & FRA

(H. Verma)

ICAR, Nagaland Centre received a total of 40 entries for DUS testing from PPV & FRA, New Delhi in the reporting year, out of which 37 entries germinated and were evaluated along with 7 checks, RCM-9, Pusa Sughand, Ranjit, Sikkim Dhan 1, Sikkim Dhan 2, Sikkim Dhan 3 and Sikkim Dhan 4, during *kharif* season in lowland ecology **(F7)**. A total of 7 landraces were also collected from Kohima district. Observations were recorded for the 62 DUS characters. All the entries were found to be distinct from the check varieties.

F7. DUS testing of candidate and farmers' varieties

vii) Evaluation of bio-fortified maize hybrids for yield and yield attributes

(H. Verma)

A total of six maize hybrids were evaluated under organic (100%) and inorganic (100% RDF) conditions using split plot design at ICAR, Nagaland Centre. Overall performance of the crop was recorded significantly higher in 100% inorganic condition compared to 100% organic manure condition. The performance of NEH-BIOFORT-22-02 hybrid was significantly higher in all the traits as compared to other maize hybrids evaluated in the present study. However, in terms of yield the NEH-BIOFORT-22-05 performance was observed significantly at par with NEH-BIOFORT-22-02.

Evaluation of field pea for agronomic performances and adaptability

(H. Verma)

A total of 10 varieties of field pea were evaluated for their yield performance at ICAR, Nagaland Centre. Among these varieties, IPFD-18-2 recorded the highest yield (4.14 q/ha) followed by IPFD-17-2 (3.36 q/ha) **(Table 1)**.

Table 1. Agronomic performances of field pea

Genotypes	Days to 50 % flowering (days)	Days to 80 % maturity (days)	No. of pods/ plt	No. of seeds/pod	100 seed weight (g)	Net plot seed yield (kg)
TRCP-8	71.00	150.7	10.00	7.33	18.50	0.14
IPFD-18-2	72.00	145.3	12.67	6.67	17.62	0.60
IPFD-16-13	74.67	126.7	9.67	8.00	16.36	0.28
IPF-17-19	72.67	130.7	8.33	8.00	17.41	0.28
IPFD-14-2	70.00	142.3	11.00	11.00	16.74	0.36
IPFD-18-14	72.00	126.0	8.00	8.00	17.48	0.23
IPF-16-4	70.67	139.7	13.33	6.33	16.68	0.29
IPF-16-18	73.33	125.3	6.67	7.67	15.47	0.26
IPFD-17-2	62.67	126.3	15.33	6.00	17.70	0.49
IPFD-12-8	75.00	137.3	12.67	7.00	17.48	0.34
Mean	71.40	135.03	10.77	7.60	17.15	0.33
C.V.	2.62	1.20	19.11	15.96	1.40	18.61
C.D. 5%	3.21	2.79	3.53	2.08	0.41	0.10

Evaluation of French bean for agronomic performances and adaptability

(H. Verma)

A total of seven varieties of French bean were evaluated for their yield performance at ICAR Nagaland Centre. Among these varieties, IPR 41 recorded the highest yield (10.13 q/ha) followed by IPR 52 (8.55 q/ha) **(Table 2)**.

Table 2. Agronomic performances of French bean

Genotypes	Days to 50 % flowering (Days)	Days to 80 % maturity (Days)	No. of pods per plant	No. of seeds per pod	1000 SW (g)	Net plot seed yield (kg)
ARUN	50.44	75.26	5.41	6.34	38.09	6.16
HUR 137	50.85	75.27	6.26	3.95	34.43	4.61
UTKARSH	48.40	72.37	7.82	5.93	39.61	8.18

HUR 15	50.63	76.18	10.4	5.52	30.44	3.77
IPR 252	50.69	79.21	11.76	6.2	55.42	5.68
IPR 41	48.13	75.04	14.3	5.37	22.16	10.13
IPR 52	46.00	71.93	10.26	4.44	37.42	8.55
Mean	49.31	75.04	9.46	5.39	36.8	6.73
C.V.	0.88	1.34	6.92	13.68	2.27	16.94
C.D. 5%	0.77	1.79	1.16	1.31	1.48	2.03

Seed production

Farmers' participatory seed production

The centre conducts trainings and field days to enhance the quality seed production through farmers' participatory seed production approach to have timely access to quality seed at an affordable price for improving crops productivity and farm profitability. Besides this, the centre is promoting location-specific improved varieties of rice, maize, sesame, toria, green gram, linseed, green pea and field pea, to minimize yield gap in Nagaland **(Table 3)**.

Table 3. Truthfully labeled (TFL) seed produced at ICAR research farm and at farmers' fields in participatory mode

Crop	Variety	TFL Seed produced (q)	Foundation seed production (q)
Rice	RCM-9 & RCM-13	300	6
Maize	RCM-76	10	
Toria	TS-67 & TS-36	100	4
Sesame	Amrit, Prachi	20	3
Field Pea	Azad	2	
Green Pea	Arkel	2	
Linseed	Parvati, Sharda, Ruchi	5	
Sesame	Amrit & Prachi	6	
Greengram	Pratap	10	
Assam lemon	-	4000	-
Black pepper	-	2000	-

Development of protocols for value addition in Naga mircha (*Capsicum chinense* Jacq.)

(A. W. Yanthan, V. Hesuh, C. Aochen, A. Seyie and D. J Rajkhowa)

Development of Naga King Chilli Puree and Sauce Considered one of the hottest chillies in the world, Naga King Chilli is a GI-tagged crop with immense export potential. Due to high moisture content and active metabolism, the Naga King chilli has a short shelf life of 2-3 days under normal condition. To reduce post-harvest losses, King Chilli Puree and Sauce were standardized and developed. Puree was prepared from a pulp concentrate of 21°B. King Chilli Sauce was developed from 10% of the Puree; puree was blended with mango pulp, tapioca powder as filler and different spices and condiments in different compositions **(F8)**. Acidity of the sauce was maintained at 1.25% with 25°B TSS, respectively. Given its adequate polyphenolic and antioxidant potential, these products can be a good source of value-addition for commercial production **(Table 4).**

Table 4. Biochemical content of King Chilli products

Parameter	Puree	Sauce
Total Phenols (mg GAE g^{-1})	1.94	0.302
Total Flavonoids (mg QE g^{-1})	2.37	0.109
Total Antioxidant Capacity (mg AAE g^{-1})	6.31	6.98

F8. King Chilli Sauce

Development of *Carallia brachiata* RTS drink

(A. W. Yanthan, V. Hesuh, C. Aochen, A. Seyie and D. J Rajkhowa)

Carralia brachiata is a minor underutilized fruit crop found under wild condition in North East, India. Scanty information is available on its commercial importance and usage. Therefore, attempt was made to develop a value added product (Ready to Serve drink) in order to promote and popularize the fruit. Pulp of ripe fruits was extracted followed by juice extraction and homogenization with syrup solution containing sugar+water+citric acid. RTS drink was standardized with 15% juice at TSS 15˚B and 0.3% acidity, and was pasteurized at about 90˚C for 25 min after bottling **(F9)**. Total phenolic content was 6.44 mg GAE/100 ml, total flavonoids was 4.68 mg QE/100 ml, and total antioxidant capacity of 198.7 mg AAE/100 ml. Owing to its colorful appearance and rich biochemical content, the fruit has potential for commercialization in future.

F9. RTS Drink of C. *brachiata*

Effect of various packaging systems on Shelf- life of Naga Mircha

(A. W. Yanthan, Azeze Seyie, S. Ruth Assumi, C. Aochen)

Fresh Naga Mircha packed in low density polyethylene (LDPE), polyethylene terephthalate (PET) and paper bag revealed PET material suitability with significantly lesser physiological loss in weight (11.01±1.34%) compared to control (51.93±2.24%) and paper bag (36.05±1.82%). Texture analyses indicated that PET packaging (0.94±0.23 N) retained significantly better texture compared to control (0.09±0.02 N). PET achieved an effective shelf life of more than 8 days as compared to control (< 3 days) under ambient condition.

Evaluation of Naga King Chilly under low cost protected cultivation and different nutrient management practices

(A. Seyie, A. W. Yanthan)

Study on growth and yield attributes of Naga king chilli under variable growing condition and nutrient management revelaed that polymulch condition were statistically higher (1-1.2 kg per plant) compared to polyhouse (0.7-0.8 kg per plant) and open condition (September sowing). Capsaicin was higher (5.87) under polyhouse condition followed by polymulch (5.46 %) and 4.64 % in open condition. Also, Poultry manure 2.5 t/ha + 30:12:12 NPK kg/ha yielded 9.8 t/ha against the control (3.5 t/ha)

Evaluation and promotion of different varieties of seed spices

(A. Seyie, A. W. Yanthan)

Coriander varieties ACr-1 (8.7 q/ha) and ACr-2 (9.75 q/ha) were superior in terms of its productivity. Vermicompost (5t/ha) + lime (2.5 q/ha) along with the recommended dose of fertilizer was better as compared to control. Acr-2 variety of coriander was promoted and demonstrated in farmers field in Dimapur.

AICRP on Mushroom

(A. W. Yanthan)

Collection and identification of wild edible mushrooms of Nagaland

Collections of wild edible mushrooms were carried out in kohima and Phek district of Nagaland. A total of 35 wild edible mushrooms were collected out of which 16 cultures were submitted to DMR solan, and obtained 3 accession numbers, viz. DMRX 2146 (*Crepitodus sp*), DMRX 2147 (*Auricularia sp.*) and DMRX 2148 (*Pleurotus sp.*).

Ichtyo-diversity study of River Dhansiri near Domukhia and Manglamukh village, Dimapur, Nagaland

(J. Barman, D. J. Rajkhowa)

Species diversity of River Dhansiri in two sites Domukhia and Manglamukh was studied to assess the occurrence of different fish species. In Domukhia, a total of 41 fish species under 8 orders, 13 families and 31 genus was recorded. Cypriniformes with 27 species was the dominant followed order by Silurifomes with 5 species and Anabantiformes with 4 species. The order Gobiiformes, Cyprinodontiformes, Synbranchiformes and Osteoglossiformes were represented by single species. Variation in occurrence of species in number was observed in different month and season. Number of species recorded varied from 31 during post monsoon to 33 during pre-monsoon and 36 during monsoon. Manglumukh site has recorded 45 fish species under 9 orders, 14 families and 31 genus. The order Cypriniformes was dominant with 30 species followed by Siluriformes (6), Anabantiformes (3), Gobiformes (1), Cypinodontiformes (1), Synbranchiformes (1), Osteoglossiformes (1), Beloniformes (1) and Perciformes (1). Number of species recorded varied from 34 (pre-monsoon and post-monsoon) and 41 during monsoon.

Assessment of liquid stored boar semen quality after removing seminal plasma proteins and supplementation with melatonin

(Mahak Singh, Rahul Katiyar, G. Kadirvel)

Excessive production of reactive oxygen species during liquid storage of boar semen leads to poor fertility. Therefore, an experiment was conducted to improve the quality of stored boar semen by supplementation with melatonin. In the experiment, 60 ejaculates from 10 boars were collected by glove hand technique. The ejaculates were diluted in 3:1 ratio with Beltsville Thawing Solution (BTS) extender. The ejaculates were analysed and then divided into 4 groups namely, Group I (control), Group II (1 µM melatonin), Group III (2 µM melatonin), Group IV (4 µM melatonin). Semen quality parameters (Table 1) were done at Day 1 and after 72 hrs of liquid storage at 17°C (Day 3). The in-vivo fertility of the best group was also evaluated. The Day 3 semen quality parameters (motility%, live-dead%, acrosomal integrity% and HOST reactive) of Group-II were significantly (P<0.05) higher than other three groups **(Table 5)**. In-vivo fertility was significantly higher of Group-II as compared to control Group-I. In summary, 1 µM melatonin can be added to boar semen extender to improve its fertility.

Table 5. Supplementation of melatonin on semen quality parameters of boar during liquid storage (Mean ± SEm)

Semen Parameters	Day 1				Day 3			
	Group I	Group II	Group III	Group IV	Group I	Group II	Group III	Group IV
Motility %	87.8±1.02^{a}	87.8±1.02^{a}	87.8±1.02^{a}	87.8±1.02^{a}	70.25±2.24^{b}	79.2±2.07^{a}	74.2±2.82^{a}	65.1±2.24^{b}
Live-Dead %	91.3±1.25^{a}	91.3±1.25^{a}	91.3±1.25^{a}	91.3±1.25^{a}	78.1±2.05^{b}	83.8±2.48^{a}	80.2±2.61^{a}	68.9±2.04^{b}
Acrosomal Integrity %	95.7±1.18^{a}	95.7±1.18^{a}	95.7±1.18^{a}	95.7±1.18^{a}	80.20±2.14^{b}	85.0±2.01^{a}	82.3±2.07^{a}	74.3±2.18^{b}
HOST %	87.25±1.89^{a}	87.25±1.89^{a}	87.25±1.89^{a}	87.25±1.89^{a}	76.3±2.08^{b}	82.4±2.12^{a}	80.2±2.21^{a}	70.2±2.52^{b}
In-vivo fertility								
	Animal inseminated (n)		Animal farrowed		Farrowing %		Litter size at birth	Litter size at weaning
Group-I	112		79		70.05^{b}		8.25±0.57^{b}	7.98±0.50^{b}
Group-II	112		91		81.25^{a}		10.75±0.89^{a}	10.05±0.78^{a}

Different superscripts among the groups differ significantly (P<0.05) in semen quality parameters. In in-vivo fertility, different superscripts between the groups differ significantly (P<0.05).

Conservation and improvement of indigenous cattle in North East of India

(Makak Singh)

Five indigenous female cows and one indigenous male bull was reared for the first time. Three cows were in lactation at the time of induction and produced 342, 424 and 151 litres of milk during the reporting year. The milk analysis revealed that fat and solid not fat (SNF) ranges from 3.2 to 4.6 and 9.6 to 9.9%, respectively.

Conservation and propagation of indigenous goat germplasm of north eastern hill region of India

(Makak Singh)

The goat research unit has 14 female and 3 male adult animals. There were 14 kidding during the reporting year and produced 16 kids (11 males and 5 females) with three twinings. All the animals were dewormed and vaccinated against PPR and Enterotoximia.

ICAR-Poultry Seed Project, Nagaland Centre

(Makak Singh)

Indigenous chicken production system (ICPS) was characterized in three different agro-ecologies (tropical, sub-tropical, and sub-temperate) in Nagaland with respect to its role in food and economic security of traditional communities. ICPS here is semi-extensive, providing homegrown feed and temporary night shelter. In sub-temperate agro-ecology, females owned non-significantly (P=0.170) more indigenous chicken flocks than males. Households in sub-temperate agro-ecologies had significantly (P=0.000) larger flock sizes and tropical livestock units (chicken-TLU). However, the livestock diversity index (LDI) was significantly higher (P=0.000) in tropical and subtropical agro-ecology. The households in the sub-temperate region highly (P=0.000) valued indigenous chicken because of its survivability and adaptability. The mortality rate of adult birds in sub-temperate agro-ecology was 9%, and it was 14% and 15% in tropical and sub-tropical agro-ecologies, respectively. In sub-temperate agro-ecology, larger flock size translated into significantly higher (P=0.000) egg production and subsequently a significant (P=0.000) higher egg consumption per household per month. Besides, households dietary diversity score was significantly (P=0.000) higher. Moreover, the average annual income from ICPS was significantly higher (P=0.000) and accounted for 18% of household income. ICPS' marketing chain was relatively short in the sub-temperate region. In all agro-ecologies, indigenous chicken and egg demand was significantly higher (P=0.000) in the winter. ICPS litter is used as farmyard manure, enhancing ecological resilience. In all agro-ecologies, the three most frequently cited obstacles to extending the indigenous chicken production system are illness, predators, and availability of chicks. Besides, the parent stock of Vanaraja and Srinidhi variety (one batch of each variety) of chicken were reared during 2022. A total of 61,368 numbers of germplasm of Vanaraja and Srinidhi was disseminated to 847 stakeholders in 150 villages.

ICAR-Mega Seed Project on Pig, Nagaland Centre

(Makak Singh)

A study was conducted to compare the efficacy of two different protocols for estrus induction and synchronization in multiparous sows. In group-I, sows (n=40) were injected with P.G. 600 (equine chorionic gonadotropin (eCG) 400 I.U. and human chorionic gonadotropin (hCG) 200 I.U.) and in group-II, P.G. 450 (eCG 300 I.U.and hCG 150 I.U.) intramuscularly. Estrus induction and farrowing rate were numerically higher in group-2 but statistically non-significant (p>0.05). Treatment to estrus induction interval was 55.59 h and 55.57 h in group-I and group-2, respectively. Similarly, total litter size at birth and litter size at weaning were non-statistically higher in group-2 (p>0.05) as compared to group-1. In overall, the reproductive performances of the sows in group-2 (P.G. 450) were similar to group-1 (P.G. 600). In conclusion, the present study demonstrated that estrus induction and synchronization can be successfully achieved in multiparous sows with P.G. 450 and this will reduce the cost of hormonal treatment.

Another study was conducted with the objective to study the pig herd size and to evaluate the impact of artificial insemination (AI) on profitability and sustainability in the small-holder pig production system. The mean pig population varied from 4.75 to 6.42 in the study region. The farrowing rate, total born piglets (TBPs), and live born piglets (LBPs) were significantly higher (P<0.001) in artificially inseminated sows compared to naturally bred sows

(9.37 vs. 6.28; 8.93 vs. 5.45). The farrowing rate was significantly (P<0.001) less in sows that were located more than 30 km away from the semen center (66.66 vs. 82.90%). The net return per sow was significantly higher (P<0.001) in artificially inseminated sows (US$464.8 vs. US$248.11). AI resulted in an 87.3% increase in net returns per farrowing as compared to natural breeding.

The reporting year began with 73 breedable sows and 9 breeding boars of Rani breed and closed with a standing herd of 57 sows and 13 breeding boars. Altogether 759 piglets were farrowed with a farrowing rate of 67.21%. The improved pig germplasm 558 piglets were disseminated to 45 stakeholders of 29 villages including KVKs, NRC Mithun, state government agencies and other states. In addition, 1675 numbers of AI kit in pig was disseminated to 723 farmers in 70 villages. In the field, 844 animals were inseminated with the farrowing rate of 85.3% and average litter size of 9.44 (2-17) piglets per litter. A total of 6796 numbers of improved piglets were produced in the farmer's field through artificial insemination. Technologies of Rani pig and artificial insemination in pig was adopted by 99 villages in Nagaland.

NASF Project: Pork marketing chains in North East India for Sustainable Livelihood of Tribal Women (Assam, Meghalaya and Nagaland)

(Makak Singh)

Livestock population dynamics, demand and supply of livestock products and their consumption pattern in Nagaland was analyzed over last 20 years. The state is deficient to the tune of 50% in all livestock products. Mean pig population was significantly (p<0.05) higher in urban districts with significant pig trade of live pigs and pork products. The majority of the respondent purchased (91%) or sold (60%) the pigs during past 12 months. Swill feeding was common in entire study area. Majority of the respondent (80%) in rural districts were unaware of African Swine Fever. In case of on-farm biosecurity measures, only 6.9% of respondents had fencing of pig farm, 99.3% did not have provision of footpath and only 17.2% of the respondents restricted the visitors' access to pig farm. The log-odds of death among pigs was positively associated with illiteracy and primary education (OR=1.11, p<0.05). Pig mortality was significantly higher when sick pigs were treated by respondents themselves (OR=2.02, p<0.05) or pharmacist (OR=1.94, p<0.05) as compared to treatment given by Veterinarian (OR=0.35, p<0.05). Likewise, the log-odds of occurring death among pigs decreased with concrete pig pens, daily manure collection, use of disinfectant for cleaning, CSF vaccination, deworming and improved biosecurity practices at the farm. The primary cost contributing factors for backyard farmers are the stock purchase of pigs and feed cost. The marketing efficiency came out to be 2.13 for Nagaland. It was also found that the untreated waste is utilized in field and only 2% of farmers use the manure in pisciculture.

SIKKIM

SUMMARY

Sikkim experienced normal rainfall and moderate annual temperature regime during 2022, without any severe fluctuation in daily weather conditions. Under variable organic nutrient management practices, the system productivity of different Maize and Rice based cropping systems were the highest for Maize Vegetable Pea (18.8 t/ha; B:C ratio 2.57) and Rice-Fenugreek-Maize (25.8 t/ha; B:C ratio 2.54) espectively. Studies on the carbon sequestration potential of different established orchards, revealed Kiwi orchards (186.96) had the highest C sequestration potential expressed in Carbon management Index, followed by Peach (180.55) and Citrus (179.82). However, Microbial biomass carbon and soil dehydrogenase activity followed the sequence as pine>bamboo>broom grass>Mandarin+large cardamom>terrace paddy. Under crop improvement, the three potential maize inbred lines GP(H)-6-1-5, Mizo-16(B)-3-4-1 and GP-21 (A) II) for higher crop yield (82.3-89.7 g/ plant); four inbred lines for stay green characteristics (GP(H)-6-1-5, Mani-3-3-3-4, GP(H)-20-2-2-1 & Mizo-16(B)-2-3-1) and three lines for multi-cob characteristics (Mizo-16(B)-2-3-1, Mizo-41(A)-4-3-1 and GP(H)-20-3-2-2) were identified. Chirakey Selection-1 (IET 30517) were identified for having moderate resistance to neck blast, rice tungro disease, glume discoloration and resistant to sheath rot disease. Some potential lines of Finger millet (Sikkim Ragi-3033 & Sikkim Ragi-3029), Rajmah (IPR- 277 & KR22-6) and Buckwheat (Sikkim buckwheat 7) were identified securing higher crop yield with high nutraceutical content under organic crop management options. Kiwifruit plants trained on Extended T-Bar and Pergola systems were the first one to turn out into reproductive phase and yielded fruits. Application of 10% solution of *Gracilaria edulis* (G Sap), *Kappaphycus alvarezii* (K Sap), *Ascophyllum nodosum*, *Ecklonia maxima* and Humic acid ensured higher expression of all the four root promoting candidate genes (*GH3-3, LBD16, LBD29* and *LRP1*) resulted in 'Hayward' Kiwifruit cultivar against control. Phenotypic variation of local red cherry pepper (*dale*) and *Tupistra clarkei* (nakima) were also documented.

Weather report

The total rainfall received during January-2022 to December-2022 was 3232 mm; maximum rainfall was recorded in the month of June (783 mm) whereas minimum rainfall was (0.2 mm) recorded in the month of December. The maximum temperature (33°C) was observed in August and the minimum (2°C) in February. The maximum relative humidity of 99 % was observed during July and August month and the minimum was observed in March (19%). The maximum bright sunshine hours 5.0hr was observed during October and the minimum was observed in December 1 hr (**Fig. 1**).

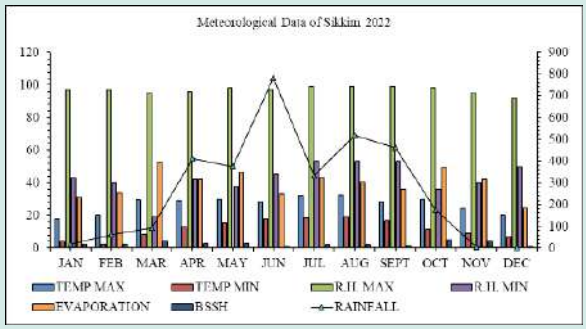


Fig 1. Meteorological data of ICAR Sikkim Centre in 2022

RESEARCH ACHIEVEMENT

Development of organic nutrient management packages for intensified rice and maize based cropping sequences

(*A. Kumar, S. Saha, T. L. Bhutia*)

Organic nutrient management for intensified maize based cropping sequences

The experiment comprised of two cropping systems like CS1: Maize-Vegetable pea; CS2: Maize-French bean and five organic nutrient management practices *viz*., N1:100% recommended dose from organic sources of nutrients to each crop; N2-100% recommended dose of nutrient for first crop+75% recommended dose of nutrient for second crop; N3-100% recommended dose of nutrient for first crop + 50% recommended dose of nutrient for second crop; N4-75% recommended dose of nutrient for firstcrop+75% recommended dose of nutrient for second crop; N5-FP were laid out in Factorial Randomized Complete Block Design (FRCBD) with three replications (**Fig. 2**). Results showed that among the different cropping systems significantly higher system total production (8.75 t/ha), maize equivalent yield (14.4 t/ha), system productivity (17.4 t/ha), system gross returns (288.1x 10^3 ₹/ha), system net return (208.80x 10^3 ₹/ha) and system B:C ratio (2.63) was recorded under Maize-Vegetablepeacroppingsystem as compared to Maize-French bean cropping system. In case of organic nutrient management practices, the system total production (9.29 t/ha), maize equivalent yield (14.1 t/ha) and system productivity (18.8 t/ha) was also found to be significant highest in N1 followed by N2 where all the treatments remained non-significant. The significantly maximum system gross returns (314.6x 10^3 ₹/ha), system net returns (226.7x 10^3 ₹/ha) and system B: C ratio (2.57) was observed under N1 as compared to other treatments.

Fig 2. Organic nutrient management for Maize based cropping sequence

Organic nutrient management for intensified rice based cropping sequences

The experiment comprised of three cropping systems like CS1: Rice-vegetable pea-maize; CS2: Rice-vegetable pea-maize; CS3: Rice-fenugreek-maize and four organic nutrient management packages *viz*., N1- 100% recommended dose from organic sources of nutrients for each crop; N2- 100% first crop, 100% second crop, 75% third crop; N3- 100% first crop, 75% second crop, 75% third crop; N4-FP (Control) were laid out in Factorial Randomized Complete Block Design (FRCBD) with three replications (**Fig. 3**). Results showed that, among the different cropping systems significantly higher rice equivalent yield (22.8 t/ha), system productivity (25.8 t/ha), system gross returns (489x 10^3 ₹/ha), system net return (358x 10^3 ₹/ha) and system B:C ratio (2.54) was recorded under CS3 as compared to other cropping systems. While, system total production (16.9 t/ha), was recorded under CS1 it was statistically at par with CS3 and significantly higher than CS2. In case of organic

nutrient management practices highest system total production (17.7 t/ha), rice equivalent yield (22.8 t/ha), system productivity (26.9 t/ha), system gross returns (509x 10^3 ₹/ha), system net return (373.4x 10^3 ₹/ha) and system B:C ratio (2.74) was noticed under N1 which was statistically at par with N2 and significantly higher than other treatments, respectively.

Fig 3. Organic nutrient management for Rice based cropping sequence

Soil organic carbon stocks and fractions in different orchards of north eastern hill region of India

(*S.K. Das, S.K. Dutta, E.L. Devi*)

Experiment was conducted during the year 2018-2022 to estimate soil organic carbon stocks and fractions in different orchards at ICAR-Sikkim Centre (**Fig. 4**). Various soil properties like pH, available nitrogen, available phosphorus, available potassium and micronutrients of all the orchards were estimated and presented here. The oxidizable organic carbon (Mg C ha^{-1}) in soils (0-15 cm soil depth) of the selected fruit orchard was highest in peach (20.91), followed by kiwi (20.58), citrus (20.16), guava (20.10), pear (19.71), plum (19.66) and lowest in mandarin (19.61). The similar trend was observed in the entire soil layer (15-30, 30-45, and 45-60 cm). Active carbon pools (Mg ha^{-1}) in soils in 0-15 cm layers of different fruit orchard was significantly higher in citrus (15.48) followed by kiwi (15.45), peach (15.08), guava (14.42), mandarin (13.56), pear (13.40) and lowest in plum (12.57). Here also similar trends in active carbon pool were observed in all the below ground different soil profile. The very labile fraction of carbon (C $frac_1$) contributed the largest percentage of total soil organic carbon, leading to the more active carbon pool in the surface soil can reasonably be used as good indicator for assessing soil for its crop productivity. Passive carbon pools in soils (Mg ha^{-1}) in 0-15 cm soil layer of different fruit orchard was highest in peach (9.98) followed by guava (9.80), kiwi (9.75), pear (9.42), mandarin (8.56), citrus (8.46) and lowest in plum (8.26). After four years of the experiment the carbon pool index, lability index and carbon management index were calculated for recognition of best fruit orchard production system to sequester more carbon in the mid hill of Sikkim. The lability index was highest (0-15 cm) in kiwi orchard (1.64) followed by peach (1.57), guava (1.56) and lowest in plum (1.32). As mentioned above the similar trend for lability index was also observed in other soil depth. The carbon pool index was also higher in kiwi (1.15) followed by peach (1.14), guava and citrus (1.11) and lowest in mandarin and plum (1.08). Finally, the carbon management index was higher in kiwi orchard (186.96) followed by peach (180.55), citrus (179.82), guava (173.16), pear (161.32), mandarin (154.44) and lowest in plum (142.56). Among the orchards, kiwi orchard had greater amount of total soil organic carbon, carbon pool index, lability index and higher carbon management index and hence, considered the best orchard production system to sequester carbon in the Sikkim Himalaya. The second and third position was achieved by peach (180.55) and citrus (179.82) with respect to carbon management index.

Fig 4. Soil sample collections from orchard systems

Development of productive and genetically broad-based inbred lines from local maize germplasm of North Eastern India for evolving superior hybrids (IXX14715)

(*E. L. Devi, A. Kumar, S. K. Das, R. Devadas*)

Diverse inbred lines developed

Third generation selfing of 52 selected maize lines were completed during summer, 2022 (**Fig. 5**). Moreover, 6th generation of selfing of 435 maize lines derived from local landraces were completed during summer 2022 and S_6 seeds were obtained. Many diverse/ unique traits were identified among the lines were submitted for IC registration (**Table 1**). Some of the potential advance lines identified are GP(H)-6-1-5 (grain yield/ plant: 89.7 g; stay green trait), Mizo-16(B)-3-4-1 (grain yield/ plant: 82.3 g), GP-21 (A) II (grain yield/ plant: 84 g), Mani-3-3-3-4 (grain yield/ plant: 74.3 g; stay green trait), GP(H)-20-2-2-1 (grain yield/ plant: 66.7 g; stay green trait), Mizo-16(B)-2-3-1 (grain yield/ plant: 25 g; multicob; stay green trait), Mizo-41(A)-4-3-1 (grain yield/ plant: 24.3 g; multicob), GP(H)-20-3-2-2 (grain yield/ plant: 23.3 g; multicob), Mizo-46(B)-3-1 (mucous in brace roots) *etc*.

Fig 5. Field view of maize at ICAR, Sikkim Centre

Table 1. Composite varieties developed/ evaluated

S. No	Name of variety	Grain/ fodder purpose	Status of the variety
1.	SKMC- 3 (KDM- 34)	Grain purpose	Multilocation trial ongoing
2.	SKMC- 4 (KDM- 35)	Grain purpose	Multilocation trial ongoing
3.	SKFMC- 1 (KDFM- 8)	Fodder purpose	Multilocation trial ongoing
4.	SKMC- 5	Grain purpose	Two years station trial completed

Development of high yielding rice (*Oryza sativa* L.) varieties with biotic and abiotic stress resistance for organic conditions of Sikkim (IXX14716)

(*E. L. Devi, A. Kumar, S.K. Das, R. Devadas*)

Under this project, a total of 4 high yielding rice varieties have been released and notified for the state of Sikkim for organic conditions. Few native local germplasm evaluated were registered for IC numbers (**Table 2**). A total of 12 crosses between promising entries/ varieties and local cultivars with promising entries/ varieties were attempted during *kharif* 2021 and F_1 seeds were obtained. The F_1 seeds were sown during *kharif*, 2022 at ICAR Sikkim centre research farm. CS-1 (IET 30517), a pureline selection from local *Chirakey* was nominated in IVT Medium (hills) trial under AICRIP (Paddy) during 2022. For Medium altitude Northern hills (951-1500 MSL) trial, among the entries, CS-1 recorded the highest yield of 5296 Kg/ha (IET 30517) with shortest days to 50% flowering of 81days. This variety was found to have moderate resistance to Neck blast, Rice Tungro disease, Glume discoloration and resistant to Sheath rot disease.

Table 2. IC numbers of rice germplasm collections

S. No	Name of the germplasm	IC number
1	Kala Nunia	IC-0647704
2	Jhapakey	IC-0647705
3	Attey	IC-0647706
4	Champasari	IC-0647707

Enhancing Productivity of the Finger Millet in North-Eastern States of India (ICRISAT Collaborative project)

(*E. L. Devi, R. Devadas*)

A trial was conducted at research farm, ICAR Sikkim centre to identify promising breeding lines (shared by ICRISAT, Hyderabad) for organic conditions of Sikkim. A total of 40 lines including local check were evaluated for yield and its attributes for 2 consecutive years (2021-22) in two replications. Proximate analysis was also performed to estimate total N, P, K (%) along with micronutrients like Fe, Mn, Cu and Zn contents (mg/kg). Highest yield was found in Sikkim Ragi-3033 (23 q ha^{-1}), followed by Sikkim Ragi-3029 (21 q ha^{-1}) and Sikkim Ragi- 3014 (19 q

ha^{-1}). Despite highest yielding, Sikkim Ragi-3033 and Sikkim Ragi- 3029 can be identified as potential lines due to its high nutraceutical values.

Evaluation of Rajmash entries for agronomic performance and adaptability in the NEH regions (Under IIPR- NEH pulse program)

(*E. L. Devi, R. Devadas*)

Total of 8 entries *viz*. Arun, Utkarsh, IPR- 277, IPR- 205, Uday, IPR- 236 and IPR- 242 (shared by ICAR- IIPR, Kanpur) including local check (Tripura Selection- 1) was evaluated for its yield performance and adaptability during August, 2022 under organic conditions. Parameters like days to 50% flowering, days to 80% maturity, plant height (cm), no. of pods/ plant, pod length (cm), no. of seeds/ pod, 100 seed weight (g) and grain yield (t/ha) were recorded. The highest yield was recorded in IPR- 277 (13 q ha^{-1}), followed by Uday (11 q ha^{-1}) and IPR- 242 (10 q ha^{-1}). The yields of other lines were at par with the local check. The promising lines can be released for cultivation in Sikkim following multi-location trials.

Assigned Activity: Development and evaluation of buckwheat breeding lines for yield performance in Sikkim

(*E. L. Devi, R. Devadas*)

A total of 23 breeding lines of buckwheat were developed and were further evaluated for yield and other attributes (**Fig. 6**). High level of phenotypic variations was seen between the lines. The highest grain yield/ plant was recorded in Sikkim buckwheat 7 (42.1 g), followed by Sikkim buckwheat 2 (34.3 g) and Sikkim buckwheat 5 (31.1 g).

Fig 6. Buckwheat trial at ICAR Sikkim centre

Assessing the impact of land use systems on soil bio-physical properties influencing soil erosion process under contrasting agro-climatic regions in Sikkim Himalaya

(S. Saha, Lungmuana, A. Kumar, M. Chakraborty, D. Chakraborty)

Soil samples of identified land use systems were analyzed for physical and biological properties *viz.*, Bamboo plantation, Terrace paddy (36 years), Mandarin+large cardamom agroforestry system, pine and broom grass (52 years) from Timberbong, West Sikkim. First year result on dispersion ratio was 26.3% higher for bamboo plantation than terrace paddy (**Fig. 7**). However, the highest Microbial biomass carbon was recorded for Pine plantation (639 ppm) followed by native bamboo (563 ppm). The soil dehydrogenase activity were almost equivalent for both the first year experimentation as our observations followed the sequence Pine> Bamboo > broom grass> Mandarin +large cardamom > Terrace paddy (36 years).

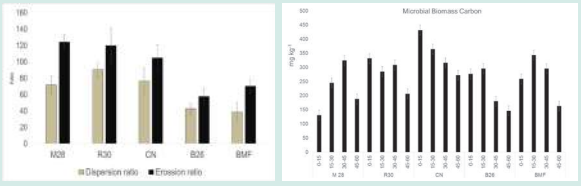


Fig 7. Variation of (a) dispersion ratio and erosion ratio, (b) Microbial biomass carbon in different land use systems of Sikkim Himalaya

Flower and fruit drop studies in Sikkim mandarin under organic management practices

(*S. K. Dutta, S. K. Das, T. L. Bhutia, E. L. Devi*)

For controlling flower and fruit drop in Sikkim mandarin, ten treatment combinations were designed as T1: control, T2: 5% KA sap, T3: 10% KA sap, T4: 5% GE sap, T5: 10% GE sap, T6: 5% AN sap, T7: 10% AN sap, T8: 10% KA sap +75% DON, T9: 10% GE sap +75% RDON and T10: 10% AN sap +75% RDON, Among the treatments T7: 10% AN sap recorded the maximum post bloom fruit set of 74.93%. TSS was found to be highest with treatment T8: 10% KA sap +75% DON and acidity was lowest in T8: 10% KA sap +75% DON. Fruit weight was highest with treatment T7: 10% AN sap. While pre harvest set was highest in T9: 10% GE sap +75% RDON with a fruit set of 14.93 % (**Table 3**).

Table 3. Flowering and fruit attributes of Sikkim Mandarin as influenced by foliar application of different sea weed saps (pooled mean of year 2019–22)

Treatments	Post bloom fruit set (%)	TSS (°Brix)	Acidity (%)	Fruit wt. (g)	Pre harvest fruit set (%)
T1: control	55.33^{c}	13.17^{b}	1.13^{a}	72.33^{b}	7.70^{b}
T2: 5% KA sap	54.00^{c}	14.07^{ab}	1.00^{ab}	80.00^{ab}	14.83^{a}
T3: 10% KA sap	69.26^{ab}	14.23^{ab}	0.90^{ab}	80.33^{ab}	13.97^{a}
T4: 5% GE sap	63.66^{b}	14.23^{ab}	1.00^{ab}	79.67^{ab}	10.10^{b}
T5: 10% GE sap	74.43^{a}	14.17^{ab}	0.86^{ab}	82.00^{a}	13.10^{a}
T6: 5% AN sap	63.00^{b}	14.10^{ab}	0.87^{ab}	83.67^{a}	13.83^{a}
T7: 10% AN sap	74.93^{a}	14.20^{ab}	0.83^{b}	85.00^{a}	14.83^{a}
T8: 10% KA sap +75% DON	67.66^{ab}	14.70^{a}	0.80^{b}	84.67^{a}	14.73^{a}
T9: 10% GE sap +75% RDON	66.00^{b}	14.03^{ab}	0.90^{ab}	84.33^{a}	14.93^{a}
T10: 10% AN sap +75% RDON	69.33^{ab}	14.40^{ab}	0.83^{b}	82.00^{a}	14.80^{a}

GE Sap (*Gracilaria edulis*), KA Sap (*Kappaphycus alvarezii*), AN sap (*Ascophyllum nodosum*), DON dose of organic nutrient, RDON recommended dose of organic nutrient.

Study the effect of canopy architecture and source sink competition in organic kiwifruit production system

(*S. K. Dutta, S. K. Das, T. L. Bhutia, E. L. Devi*)

Two kiwifruit varieties *viz.,* Hayward and Allison along with respective pollinator's *viz.,*Tomuri and Allison male has been collected from Solan and planted in four training systems *viz.,* Extended T-Bar, Pergola, Tatura Trellis and Traditional system with densities as suggested in technical program. Further, two more training systems *viz.*, Double Square Trellis and Double Circle Trellis were also added in the experiments (**Fig. 8**). The kiwifruit orchard is maintained under organic management system. All the plants are growing well and training and pruning of kiwifruit vines on different training systems has been done. Kiwifruit plants trained on Extended T-Bar and Pergola systems were the first one to turn out in to reproductive phase and yielded fruits (**Table 4**). Hand pollination has been initiated to ensure fruit set. Plants have been covered with 50% agro-shade net to protect the flowers from heavy rain and hails. There is no pest and disease incidence observed so far in the planted orchard.

Fig 8. Different canopy architecture of kiwifruit cultivar Allison on (a) T-Bar, (b) Extended T-Bar, (c) Pergola, (d) Tatura Trellis, (e) Double Circle, (f) Double Square systems

Table 4. Reproductive growth of kiwifruit varieties planted under different training structures

Training structures	Varieties	No. of Flowers	No. of Fruit Set	Fruit Set (%)	Yield (kg/ tree)	TSS (°Brix)
Tatura Trellis system	Allison	145.7	94	64.52	8.46	19.7
	Hayward	151.3	105	69.40	9.45	18.6
Extended T-Bar system	Allison	164.8	129	78.28	11.61	18.2
	Hayward	139.9	132	94.35	11.88	19.6

Pergola system	Allison	143.66	136	94.67	12.24	19.1
	Hayward	129.0	116	89.92	10.44	18.1
Traditional system	Allison	135.5	127	93.73	11.43	18.2
	Hayward	145.5	128	87.97	11.52	18.9
Double Circle system	Allison	123.1	78	63.36	7.02	18.8
	Hayward	154.5	89	57.61	8.01	17.8
Double Square system	Allison	156.5	96	61.34	8.64	18.2
	Hayward	107.7	99	91.92	8.91	19.6

Improvement of rooting and growth in kiwifruit cuttings with organic biostimulants

In this study, the cuttings were treated with 1, 5, 10 and 50 % solutions of G Sap (*Gracilaria edulis*), K Sap (*Kappaphycus alvarezii*), AN (*Ascophyllum nodosum*), EM (*Ecklonia maxima*), HA (Humic acid) and control (water) for 6 hours as base dipping and then the treatments of G Sap, K Sap, AN, EM, HA and control were repeated after every 15 days for a period of six months as application of 50 ml solutions in the potted cuttings. All the treatment exhibited significant effect on the rooting percent in all the kiwifruit cultivars *viz*. 'Monty', 'Abott', 'Hayward', 'Allison' and 'Bruno' ($P \leq 0.01$) as compared to control (**Fig. 9**). Shoot and root growth parameters like leaf number per cutting, number of roots per cutting, number of branches, plant height, shoot diameter, root length, root diameter and root weight were all positively increased with the application of seaweed extracts ($P \leq 0.05$). Seaweed extract treated cuttings gave significant ($P \leq 0.05$) higher pigments (chlorophyll a, chlorophyll b and total carotenoids), metabolites (total carbohydrates and soluble phenols) and less electrolyte leakage as compared to the control cuttings. Significant positive and negative correlations were observed between biochemical parameters combined with plant nutrient concentration. Principal component analysis (PCA) analysis revealed that PC1 and PC2 (first two principal components) accounted for 75% of the entire variation. While, the PC1 accounted for 63% of the total variation, the PC2 accounted for 11% of total variation. Leaves and roots of kiwifruit cultivar 'Hayward' by treatment with G Sap at 10%, K Sap at 10%, AN at 10%, EM at 10%, HA at 10% exhibited higher expression of all the four root promoting candidate genes (*GH3-3, LBD16, LBD29* and *LRP1*) as compared to control. Therefore, it can be concluded that, seaweed extract and humic acid can be used as a suitable alternative of synthetic hormones for promoting the rooting and growth in kiwifruit cuttings.

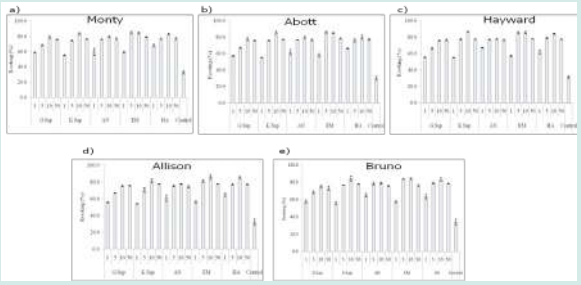


Fig 9. Effect of various treatments (1, 5, 10 and 50 % solutions of G Sap, K Sap, AN, EM, HA and control) on rooting of kiwifruit cultivars 'Monty', 'Abott', 'Hayward', 'Allison' and 'Bruno'. The treatment effect exhibited the following F values and level of significance: a) Monty, F- value= 63.09 b) Abott, F- value= 85.63** c) Hayward, F- value= 151.48** d) Allison, F- value= 58.88** e) Bruno, F- value= 48.18** (** indicates statistically significant differences at $P \leq 0.01$)**

Collection and characterization of under- utilized vegetables of North East India and Darjeeling Himalayas

(T. L. Bhutia, S. K. Dutta)

Capsicum annumm (Dalle/Red cherry pepper)

A total of 28 collected lines have been sown and selfing was carried out in protected condition for further seed multiplication and evaluation. During the initial morphological evaluation, it was found that out of 28 lines, 5 lines had almost round fruit, 12 lines recorded triangular fruit shape, 10 recorded blocky and 1 recorded blocky fruit shape. Fruit neck at basal end of all the fruits of 28 lines was absent. Almost all the lines observed had yellowish green corolla expect line WS-3 which recorded white corolla and WS-6 which recorded light yellow corolla. WS-3 also recorded a corolla spot which was purplish at the edges while other lines did not show any spot on its corolla. Calyx pigmentation was absent in all the lines

except WS-6 which recorded yellow greenish spot in the calyx. With respect to stigma, all the lines showed exerted stigma which means it has more possibility of cross pollination. Some of the lines were found to be resistant of virus. These lines will be further evaluated for its confirmation. The variation in leaf and fruit shape was also observed and recorded (**Fig. 10**).

Fig 10. Morphological variation in fruit & fruit type in dalle chilli

Tupistraclarkei (nakima): Four lines have been collected from four districts of Sikkim and have been planted. Since it is a perennial plant it takes around three years to come to give its potential yield. However, other morphological characteristics data was being collected. These wild vegetables flowers for very short duration and is very costly during its availability. It is available for very short time only *i.e.,* Sept 2nd week to Nov 1st week. It is considered to be anti diabetic in Sikkim and its preferential demand is very high. Therefore, to make its availability throughout a year an experiment on its drying method was undertaken. Different drying method was adopted namely, sun drying without blanching, sun drying with blanching, shade drying without blanching, shade drying without blanching, oven drying without blanching, oven drying with blanching, solar drying without blanching, solar drying with blanching and control. Out of these treatments, Solar drying without blanching was found to be superior in terms of moisture percentage as well as for retention of colour.

Mustard leaf: A total of 12 lines have been collected from various villages of Sikkim. The collected materials have been planted and selfed for seed multiplication.

AICRP (Paddy) IVT/AVT Mid (Hills)

(*R. Devadas, E. L. Devi*)

Filed preparation for Paddy evaluation trials and received AICRP Trial (Paddy) was done in May, 2022 and nursery sowings were completed by first week, June. Paddy transplanting was done for IVT lines (19 no.), AVT-I (15 entries) and AVT-II (8 entries) during second week of July 2022 (**Fig. 11**). Paddy transplanting was done for IRRI lines and RC lines part from seed multiplication for institute released varieties during 2nd week, July 2022. The nominated pure line of Paddy, Chirakey Selection-1 (IET 30517) from ICAR, Sikkim Centre was tested in trial. Progress of trial was presented online for progress review meeting date: 17.09.2022 and final review meeting online on 28.02.2023.

Fig 11 (a). AVT Medium (Hills)-Irrigated (AICRP/Paddy)

Fig 11 (b). IVT Medium (Hills)-Irrigated (AICRP/Paddy)

IVT (Rajmah) Kharif Trial

(*R. Devadas, E. L. Devi*)

Ten entries received for Kharif Rajmah IVT trial under AICRP (MULLaRP) were evaluated, with delayed sowing owing to high rainfall. Entry no KR22-6 performed well with good yield (**Fig. 12**).

Fig 12. IVT *Kharif* Rajmah Trial, 2022

TRIPURA

SUMMARY

Research activities of Tripura Centre of the Institute led to a number of significant achievements. NICRA Aerobic Dhan 2 (TRC 2020-14/ IET 29409) was identified by the CVRC-VIC for central release for aerobic condition in the states of Bihar and Haryana. Four rice entries have been promoted to AVT stage. Tissue compartmentalization studies of Fe and P contents in grain, stem, leaves and root tissues were accomplished in 100 rice genotypes. Breeder seeds (27.89 q) and TL seeds (117.6 q) of released varieties were produced under ICAR Seed Project and 607q pulses seed were produced under Pulses Seed Hub through participatory mode. Evaluation with 20 varieties of groundnut under different nutrient management practices showed highest average pod yield as 2.25 t/ha in groundnut grown in soil treated with FYM+PM+AL+RP followed by 1.98 t/ha in case of FYM+PM. Among the 6 evaluated biofortified maize, highest kernel yield was recorded from NEH-BIOFORT-02 (6.8 t/ha) followed by NEH-BIOFORT-03 (5.5 t/ha) and NEH-BIOFORT-01 (5.1 t/ha). In Resilient Farming system studies, the net return received was Rs. 1,76,881 and Rs, 1,76,980 and B:C ratio was 3.6 and 3.1, under ISFS and IIFS , respectively. Flood Plain Farming System generated a gross income of Rs.2,60,000/ha/annum with a rice equivalent yield of 13t/ha/annum. Multi-storey annual sequence of vegetable cropping system with a BC ratio of 3.4 was standardized for upland conditions of Tripura. Swamp taro cultivation technology was standardized with fertilizer dose of FYM @ 15 t/ha + N-P_2O_5-K_2O (120-60-90 kg/ha) gave higher yield of stolon (54.7 t/ha) and pseudostem (34.6 t/ha). Short day rabi onion varieties viz., Bhima Shakti, Bhima Subhra, Arka Pragati, Arka Kirtiman, and Arka Kalyan and late Kharif var. Bhima Super were found to be promising under Tripura condition with yield range of 27-30 T/ha. Indigenous Tripuri Cattle were hardy and disease resistant and had good potential for milk production with higher fat percentage (6%). In E-6 evaluation of BND cross, the 72 week egg production was 159.32 eggs under farm and 138.76 under field conditions. Complete genome sequence of *Aeromonas* phage GomatiRiver_11, a novel T4like bacteriophage that infects *Aeromonas hydrophila was* achieved. 96 hour lethal concentration of Ferric salt was found 14 ppm in *Labeo bata*. Eichhornia and EDTA could remove Fe from water by 97% in 3 days. In Phenotyping mining to stress, the presence of clear and quantifiable differences in morphological as well as physiological phenotypes in individuals tolerant to chronic combination abiotic stress of low pH (5-6) and hypoxia as compared to the general population in *Labeo rohita* could be established*. Barbonymus gonionatus* performed better than *Cirrhinus mrigal* in Bamboo based substrate system of culture.

Weather Report

(D. Daschaudhuri & B. Das)

A total of 2014.1 mm rainfall in 86 rainy days was received against total pan evaporation losses of 838.6 mm (2.3 mm/day) during the year 2022-23. There were 6 events of rainfall of more than 50 mm and 2 events of more than 100 mm in 24 hours, The total rain from April, 2022 to March, 2023 was 89 percent of LPA (long period average). During Monsoon (Jun to Sep) and winter (Jan to Mar), rain was 25 and 26 percent deficit over LPA. During summer and post monsoon rain was 4 and 18 percent excess over LPA.

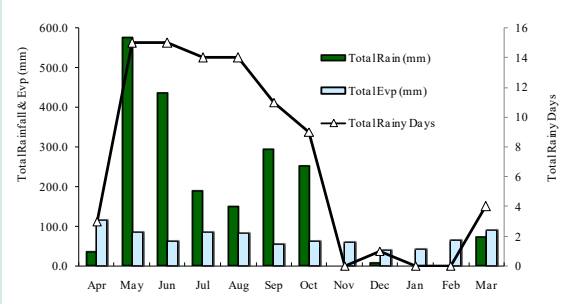


Fig. 1: Monthly variation in Evaporation, Rain and Rainy Days during 2022-23

Rain was more than LPA during May (42%) and October (48%). On October 24th & 25th, more than 75 mm rain was recorded that affected the aman rice, vegetables and early sown potatoes.

The deficit rains in July and August, which was more than 53 percent, had a significant impact on the crop particularly in the rice field where the crop was in tillering stage. After October 25, there was a long dry spell of 137 days that affected the boro cultivation, seasonal vegetables.

Mean monthly maximum air temperature varied from 25.1^{0}C during January (1% above normal) to 34^{0}C during April (5% above normal) while mean monthly minimum temperature varied from 9.1^{0}C during January (10% below normal) to 23.1^{0}C during July (5% below normal). Yearly mean maximum temperature recorded 2.2% above normal (31.4^{0}C) while yearly mean minimum temperature recorded was 18^{0}C which is 8% below normal.

The anomaly of seasonal mean maximum temperature recorded lowest during summer followed by monsoon and post monsoon (2% above normal) and highest during winter (4% above normal). Similarly seasonal mean minimum temperature recorded lowest during summer (2% below normal) followed by 5 percent and 6 percent below normal during monsoon and winter. The highest anomaly recorded during post monsoon (17% below normal). In brief maximum temperature during the period is showing increasing trend (2% above normal) while minimum temperature is in decreasing trend (about 8 percent below normal).

Available bright sunshine hour during entire year was about 10% less than normal. During summer months (Apr & May) sunshine was more than 25 percent below the normal. The average monthly sunshine hour was beyond the normal range (±19%) during the month of April to June and March. But improvement of bright sunshine during July to November promoted better translocation of photosynthates to sink.

Mean monthly maximum relative humidity in the morning throughout the year remained above 90 percent while in the evening, humidity ranged from 51 percent in the month of March to 82 percent during June. Relative humidity in the evening during winter remained below 60 percent. During the entire period, 46 times the morning humidity recorded 100 percent while during afternoon 11 times. On April 20, June 18 and October 24, the humidity both in morning and afternoon was 100 percent. This may be due to unprecedented rainfall on June 18, when a rainfall of 187.8 mm was recorded.

Analysis of 24 hours average wind speed reveals that 81 percent wind was within the range of 2km per hour followed by 11 percent 2 to 4 km per hour. Only about 1 percent wind found within the range of 1 percent. Direction of wind during morning was mostly southerly (49.6%) while during evening 26.85 percent wind was from same direction. South and south easterly wind together contributes about 70 percent of total observation in the morning while about 35 percent in the evening. North, north easterly and north westerly wind in the morning observed 16 percent and 37 percent in the evening.

Rice Improvement / All India Coordinated Rice Improvement Project:

(One Variety identified by VIC-CVRC for central release)

(S.P. Das and Ayam G. Devi)

On the basis of excellent performance in All India Coordinated Rice Improvement Project trials over the last 3 years, one entry developed at Tripura Centre qualified for VIC-CVRC proposal TRC 2020-14/ IET 29409 (developed from a cross Hakuchuk-1 X Naveen) was tested in AICRIP-AVT2 Aerobic trial.VIC proposal was submitted for one variety. This variety was identified by the CVRC-VIC for central release for aerobic condition in the states of Bihar and Haryana

Fig. 2. TRC 2020-14/ IET 29409 was identified by the CVRC-VIC for central release for aerobic condition in the states of Bihar and Haryana

Performance of the CVRC-VIC identified varieties:

Performance of TRC 2020-14/ IET 29409

Entry TRC 2020-14 / IET 29409 is medium early duration, tall erect, highly vigorous, non-lodging, non-shattering and dark green in colour. The plant comes to maturity within 117 days, plants are 101 cm tall and it produce good biomass, long panicle, and have short bold grain with white kernel. In the state of Bihar, the entry TRC 2020-14 / IET 29409 produced 17.47% higher yield over national check (NC), 8.01% over regional check (RC) and 5.30% over local check (LC). Yield superiority of the proposed variety over the other qualified variety is 10.04% on the basis of weighted mean of 3 years (2020-22). In the state of Haryana, the entry out yielded the NC, RC and LC by 18.64 %, 36.14% and 30.58%, respectively. In addition, the entry TRC 2020-14/ IET 29409 possess very good grain quality attributes of Hulling % (76.40%), Milling (68.75%) and Head Rice Recovery (64.6%), VOC, amylase content of 21.82% and GC of 24.

State	Year of testing	Name of the trial	TRC 2020-14/ IET 29409	NC*	RC*	LC*
Bihar	2020	IVT-Aerobic	2250	1972	2158	2918
	2021	AVT-1 Aerobic	5310	4960	4874	4612
	2022	AVT-2 Aerobic	4855	3802	4473	4377
	Weighted mean % increase of over		4240.71	3610.00	3926.14	4027.29
			2020	+14.10	+4.26	-22.89
			2021	+7.06	+8.95	+15.13
			2022	+27.70	+8.54	+10.92
	% increase of over Weighted mean		+17.47	+8.01	+5.30	
Haryana	2020	IVT-Aerobic	5361	4515	4550	4387
	2021	AVT-1 Aerobic	5046	4255	2482	3301
	2022	AVT-2 Aerobic	5256.00	4428.33	3860.67	4025.00
	Weighted mean		5256.00	4428.33	3860.67	4025.00
	% increase of over		2020			
			2021	+18.74	+17.82	+22.20
			2022	+18.59	+103.30	+52.86
			+18.69	+36.14	+30.58	

* NC- National Check, RC-Regional Check & LC-Local Check

Promoted rice entries in AICRIP during 2021-22

Out of the nominated entries 4 entries are promoted to AICRIP AVT1 (2nd year of testing) and AVT2 (3rd year of testing) on the basis of their superior performances in the trials. Two entries are promoted to AVT2, rest of the two entries are promoted to AVT1.

Sl. No.	Entry Designation	IET No.	Cross	Trial name	Yield (Kg/Ha)	Promotion
1	TRC GTS 739-B-B-4-1	30772	Gomati/ Tripura Sarat	IVT-IM	7012	Promoted to AVT 1-IM
2	TRC GN 116-B-B-14-2	30895	Gomati/ Tripura Nirog	IVT-AEROB	4773	Promoted to AVT 1-AEROB
3	TRC 185-B-B-82-2-11	30034	Tripura Nirog / TRC 87-251	AVT 1-AEROB	4962	Promoted to AVT 2-AEROB
4	TRC 184-B-B-76-1-1	30023	Tripura Nirog / TRC 87-251	AVT-1 AEROB	4323	Promoted to AVT 2-AEROB

AICRIP Trials–Varietal Improvement 2022: 19 coordinated trials (IVT & AVTs) were also conducted during the period and 627 IETs of rice were evaluated for different segments in replicated trials and data reported to AICRIP Rice. Promising entries were identified for Tripura.

Sl. No.	Location	Trial name	No. of Entries	DOS	DOT	Local check	Promising entries
1	Mirza	IVT- ETP	64	12/07/2022	2/18/2022	Hakuchuk 2	3612, 3627, 3648, 3646, 3655, 3660, 3661
2	Mirza	IVT-IM	64	13/07/2022	1/8/2022	Gomati	4216, 4242, 4201, 4263, 4228, 4264, 4245
3	Mirza	IVT-IME	64	15/07/2022	3/08/2022	Tripura Nirog	3935, 3907, 3906, 3903, 3949, 3942, 3959, 3920, 3902
4	Mirza	IVT-MS	64	13/07/2022	03/08/2022	Tripura Chikan	5058, 5051, 5053, 5011, 5024, 5014, 5062
5	Mirza	IVT-AEROB	64	10/07/2022	01/08/2022	TRC 2015-5	4702, 4760, 4758, 4747, 4751, 4761, 4753
6	Mirza	IVT-RSL	55	08/07/2022	29/07/2022	Khowai	408, 410, 446, 404, 414, 420, 409, 442, 452, 450
7	Mirza	AVT-AEROB	31	12/07/2022	03/08/2022	TRC-2015-5	Nil
8	Mirza	AVT 1-RSL	13	10/07/2022	01/08/2022	Khowai	306, 312, 310
9	Mirza	AVT 2-L	9	16/07/2022	08/08/2022	Jala Dhan	4301, 4303, 4305, 4308
10	Mirza	AVT 2-ETP	13	09/07/2022	30/07/2022	Hakuchuk-2	3413, 3412, 3403
11	Mirza	AVT 1-ETP	25	12/07/2022	03/08/2022	Hakuchuk-2	3504, 3503, 3510, 3506
12	Mirza	AVT-1 (IME)	27	10/7/2022	1/8/2022	Tripura Nirog	3801, 3813, 3809, 3812, 3819
13	Mirza	AVT1-IM	36	12/07/2022	01/08/2022	Gomati	4105, 4109, 4135
14	Mirza	AVT 2- IM	19	11/07/2022	1/8/2022	Gomati	4018, 4015, 4017, 4008, 4003
15	Mirza	AVT 1-MS	13	10/7/2022	01/8/2022	Tripura Chikan Dhan	4922, 4918, 4904, 4921, 4912, 4902, 4919, 4908
16	Mirza	AVT 2-IME	17	12/7/2022	01/8/2022	Tripura Nirog	3711
17	Mirza	AVT 2-AEROB	20	10/7/2022	3/08/2022	TRC 2015-5	4508
18	Mirza	ESA-RSL	19	09/7/2022	01/8/2022	-	96, 87, 91, 98, 95
19	Mirza	AVT-2 MS	10	13/7/2022	3/8/2022	Tripura Chikan	4805, 4806, 4802

Pulses improvement & AICRP MULLaRP:

- In mung bean on the basis of multiyear station trial data, 72 promising entries from different cross combinations are at seed bulking stage for nomination to AICRP MULLaRP, RCRT and State trial. In mungbean selected lines from 39 cross combinations are advanced and are in F4 to F8
- In urd bean, 15 most promising entries on the basis of station trial are taken up for seed bulking for nomination to AICRP MULLaRP, RCRT and State trial. Selected lines from 20 cross combinations are advanced and are in F4 to F8
- In AICRP MULLaRP, 11 coordinated trials (IVT & AVTs) were conducted during the period under report and 185 entries of mungbean, urdbean, lentil field pea and chickpea were evaluated in replicated trials and data reported to AICRP MULLaRP. Promising entries were identified for Tripura.

Candidate gene association mapping for tolerance to iron toxicity and low phosphorus stress in rice

Plant samples (root, shoot and grains in triplicates) of 100 rice germplasm from North East grown in iron toxic field (778-1500 ppm ferrous iron) were estimated for tissue compartmentalization for iron and phosphorus content in ICP coupled OES. Leaf Fe content was highest in Kemelou-U (5424.33 ppm) and lowest in Birion Black (901.24 ppm) (Fig. 1).While in stem tissue, Fe content was highest in RCPL-1-190 (17629.37 ppm) and lowest was noted in RCPL-1-426 (669.76 ppm) . Maximum accumulation of Fe was observed in root tissues with the value ranging from 4,1340.41 to 199004.2 ppm in Kaifera and Nokrak, respectively. In grain, highest Fe content was noted

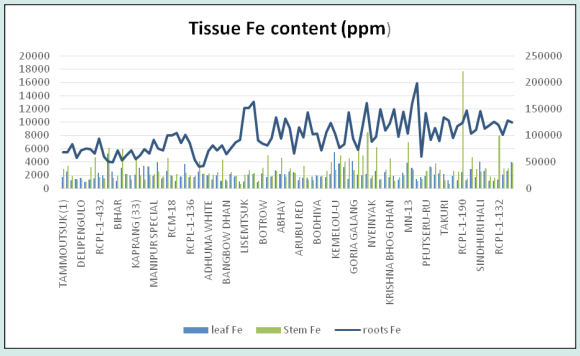


Fig 3. Tissue iron (Fe) content in leaf, stem and root tissues of 100 rice genotypes grown in iron toxic field

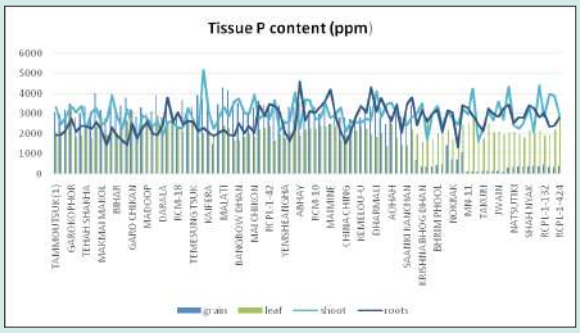


Fig 4. Tissue phosphorus (P) content in leaf, stem, grain and root tissues of 100 rice genotypes grown in iron toxic field

in Maitung (51.31 ppm) and lowest in Dubosi Bao (10.93 ppm) (Fig. 8). Highest leaf P content was noted in Garokophor (3217 ppm) and lowest in Meupr-23 (1378.66 ppm). In stem tissue the P content ranged from 1578.86 to 5160.62 ppm in Kaprang and Beti, respectively. Grain P content was highest in Malati (4310.17 ppm) and lowest in MN-11 (104.5 ppm). In root tissue P accumulation was highest in Abhay (4590.68 ppm) and lowest in Kaifera (1334.205 ppm).

Seed production

In total 27.89q breeder seed and 117.6 q TL seed of released varieties are produced under ICAR Seed Project and 607q pulses seed were produced under Pulses Seed Hub during the year 2022-23 in participatory mode

Table 1. Details of quality seed produced during 2022-23 under ICAR Seed Project (figures in quintals)

Sl No.	Crop/ Variety	Breeder Seed	TL Seed
1	Rice: TRC PSM-1720-B-B-5	0.6	-
2	Rice: Gomati Dhan	3.5	15
3	Rice: Tripura Jala 1	0.36	5
4	Rice:Tripura Chikan	5	20
5	Rice:Tripura Sarat	3	5
6	Rice:Tripura Nirog	0.46	10
7	Rice: Tripura Hakuchuk 1	0.43	-
8	Rice: Tripura Hakuchuk 2	5	30
9	Rice: Tripura Aush	0.35	10
10	Rice: Khowai	0.72	15
11	Rice: TRC 2014-8	0.45	3

12	Rice: TRC 2016-14	0.25	-
13	Blackgram: Tripura Maskolai 1	-	434
14	Greengram: Tripura Mung 1	-	143
15	Sesame Tripua Siping	1.5	1
16	Fieldpea TRCP-8	1	2
17	Fieldpea TRCP-9	0.22	1
18	Toria: Tripura Toria	0.05	0.60
	Total	**22.89**	**694.6**

AICRN on Potential Crop

Varietal trial (IVT and AVT-II) comprising of ten entries (5 entries in IVT and 5 entries in AVT-II) including three checks was conducted. Significant differences were observed among the entries for seed yield. In IVT trial, seed yield was the highest in PWB-18-2 (18.8 q/ha) and PWB-18-3 (18.3 q/ha). The entry RWB-37 (15.07 cm) and RWB-38 (15.01 cm) showed the highest pod length. Days to 50% flowering ranged from 67.33 to 83.3 days. The entry RWB-38 was the earliest flowering line. Green pod yield was highest in the entries RWB-37 (117 q/ha) followed by PWB 18-3 (115 q/ha). 100 seed weight was found to be highest in RWB-37 (42 g). In AVT-II trial, the entry RMDWB 20-3 (21.29 q/ha) recorded the highest seed yield. The pod length was highest in the entry RWDWB 20-1 (15.1 cm) and RWBWD 20-3 (15.09 cm). The entry RWDWB 20-1 showed the highest green pod yield (171.61 q/ha) followed by RWDWB 20-3 (125 q/ha) and IC 026946 (125 q/ha). The Days to 50% flowering ranged from 76.6-86.3 days and entry RWDWB 20-1 was found to be the earliest. 100 seed weight was highest in entry EC-178318 (40g).

Integrated resource conservation technologies for improving soil health under sub-tropical Hill ecosystem

(A. Das and A. G. Devi)

A conservation agriculture-based experiment was initiated at ICAR Tripura centre with four (4) tillage practices viz. no-till (NT), minimum Tillage (MT), conventional tillage (CT) and permanent broad bed and furrow system (PBBF) and four cropping systems viz. rice-fallow (Cs-1),vegetable cowpea-rice-maize (Cs-2), vegetable cowpea–rice-mustard (Cs-3) and vegetable cowpea-rice-lentil (Cs-4). Under NT, about 50% residues from all the crops were retained on soil surface, while the residues were incorporated into the soil for MT and removed completely for CT. The highest rice equivalent yield was obtained with cowpea-rice-maize(Cs-2) based cropping system (9.21 ton/ha) followed by cowpea-rice-mustard (Cs-3) based cropping system (8.78 ton/ha) and cowpea-rice-lentil (Cs-4) based cropping system (7.58 ton/ha). The Rice equivalent yield of Cs2 under NT (9.92 ton/ha) and MT (9.68 ton/ha) were significantly higher than most of other combinations. Organic carbon (%) was found to be highest in NT over other treatments at 0-10cm (0.83%) and 10-20 cm (0.73%), respectively. Among the cropping system cowpea-rice-maize had higher organic carbon content over others. At 0-10 cm depth, except for MT (1.27Mg/m^3) bulk density (BD) under CT, NT and PBBF (1.31 Mg/m^3) was found to be same. Whereas, at 10-20 cm depth BD under CT (1.35Mg/m^3) was highest over others. Soil moisture at 0-10 cm was found to be highest in PBBF (0.52%) and cowpea-rice-lentil had resulted into highest soil moisture. At 10-20 cm depth, soil moisture was highest under CT (12.02%) and cowpea–rice-mustard had highest soil moisture. At 20-30 cm depth, soil moisture was highest under MT (13.33%) and cowpea–rice-mustard had highest soil moisture.

Table 2: Depth-wise distribution of soil organic carbon, soil moisture and bulk density under four tillage practices and four cropping system

Treatments	SOC (%)			Soil moisture (%)			BD (Mg/m^3)		
	0-10 cm	10-20 cm	20-30 cm	0-10 cm	10-20 cm	20-30 cm	0-10 cm	10-20 cm	20-30 cm
NT	0.83	0.73	0.54	0.50	9.98	11.49	1.31	1.32	1.45
MT	0.79	0.67	0.54	0.44	11.98	13.22	1.27	1.33	1.47
CT	0.72	0.62	0.52	0.50	12.02	13.18	1.31	1.35	1.47

PBBF	0.74	0.64	0.53	0.52	10.97	12.52	1.31	1.30	1.47
Sem	0.01	(NS)0.03	(NS)0.02	0.00	0.06	0.05	0.01	0.00	(NS)0.01
LSD (p=0.05)	0.05	(NS)0.11	(NS)0.06	0.01	0.19	0.19	0.02	0.01	(NS)0.03
CS1	0.72	0.61	0.49	0.49	11.28	12.62	1.32	1.34	1.47
CS2	0.80	0.69	0.55	0.48	11.09	12.43	1.31	1.34	1.47
CS3	0.77	0.66	0.53	0.49	11.56	12.73	1.31	1.32	1.46
CS4	0.79	0.69	0.54	0.50	11.01	12.63	1.28	1.31	1.47
Sem	0.02	(NS)0.03	(NS)0.02	0.00	0.07	(NS)0.07	0.00	0.01	(NS)0.01
LSD (p=0.05)	0.05	(NS)0.09	(NS)0.06	0.01	0.21	(NS)0.22	0.01	0.02	(NS)0.02

Development of multi-tier based sustainable agroforestry system in Tripura

(P. K. Sarkar, B. Das, A. Das, L. Devi, A. G. Devi and B. Das)

Models of seven different multi-tier based agroforestry systems were developed in the year 2022 at Cocotilla farm of ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra based on different factors including, local needs, canopy structure, plant physiological characteristics, multipurpose uses, soil characteristics, *etc*. In these models, different combinations of multipurpose tree species (MPTs) like Jackfruit (*Artocarpus heterophyllus*), Bael (*Aegle marmelos*), Arjun (*Terminalia arjuna*), Tree bean (*Parkia roxburghii*), Drumstick (*Moringa oleifera*), Tejpatta (*Cinnamomum tamala*), Pigeon pea (*Cajanus cajan*), Lemon (*Citrus sp.*) and other important plants like Banana (*Musa paradisiaca*), Pineapple (*Ananas comosus*) and Black pepper (*Piper nigrum*) were introduced based on canopy structure. Moreover, Rubber (*Hevea brasiliensis*) plantation based agroforestry systems following three different spacing *viz.,* 3 m X 4 m, 3 m X 5 m and 4 m X 6 m were also developed. Among the alley crops, seasonal crops like French bean, Cow pea, Chilli, Maize, Finger millets, Foxtail millets, Elephant Foot Yam, *etc*. are growing as per the experimental/ project needs. The species like *Areca catechu* (Areca nut) and *Tephrosia candida* (Bhoomi Sudha/ Tephrosia) were also planted at the boundary of the agroforestry systems primarily for the additional income and for soil amelioration, respectively. Till date, the plants like Jackfruit, Arjun, Tree bean, Tejpatta, Lemon, Banana and Rubber plants are performing well in respect of their growth with cent per cent survivability.

Fig. 5: Multi-tier based agroforestry system + intercrops

Participatory seed production and capacity building programme in oil seeds (Under ICAR-IIOR, NEH Component, Hyderabad)

(A. Das, P. K. Sarkar, R. Podder and A. Sarkar)

A field experiment was conducted during summer season 2022, at ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra under ICAR-IIOR, Hyderabad, NEH component project. In this trial, two sesame varieties (Tripura sipping and local variety - White sesame) at five different Sulphur levels (0; 10; 20; 30; 40 kg/ha) were tested for higher seeds yields and income. Among the treatments, plant height, number of branches, plant stand and test weight were recorded significantly higher in Tripura Sipping (at Sulphur level 30 kg/ha) when compared to White sesame (at Sulphur level 30 kg/ha). Average plant height noted in Tripura sipping was 95.8 cm (at Sulphur level 30 kg/ha) and white sesame was 81.8

cm (Sulphur level 30 kg/ha). The maximum seed yield of 1.25 t/ha (at Sulphur level 30 kg/ha) was recorded in case of Tripura Sipping. While testing the Performance of sesame variety (Tripura Sipping) in different locations of Tripura, demonstrations (with 300 kg Sesame seeds) were conducted in 180 farmer's field located at Khowai, South Tripura and Dhalai, aspiration District in Tripura. The average seed yield recorded from the farmer's field were in the range of 1.12 to 1.26 t/ha. Through participatory cum training programme, four training programme were conducted at South Tripura, Khowai and West Tripura district. Total 393 farmers were benefitted with different technologies of ICAR and received 150 kg Sesame seeds under ICAR-IIOR project.

Fig. 6: On farm testing (OFT) sesame varieties under Tripura condition

Screening of groundnut varieties for cultivation under Tripura conditions

(A. Das, P. K. Sarkar and R. Podder)

A varietal evaluation trial with 20 varieties *viz.,* GJG-22, GJG-HPS-1, KDG-123, GJG-HPS-2, JL-776, Rajmungfuli-2, GJG-32, Girmar-3, HNG-123, DH-256, KDG-182, HNG-69, TAG-24, JL-1085, TCGS-1157, Mallika, GJG-19, GPBD-5, Rajmungfuli-3 and JL-501 were conducted following uniform nutrient doses of Vermicompost (VC 2.5 t/ha), Farm yard manure (FYM 5 t/ha), Agricultural lime (AL 500 kg/ha) and Rock phosphate (150 kg/ha). The highest pod yield was recorded in case of HNG-69 (2.67 t/ha) followed by KDG-123 (2.12 t/ha) and TCGS-1157 (2.06 t/ha). In another trial, groundnut varieties were grown under 14 different organic nutrient combination *viz.,* Farm Yard Manure (5t/ha), Vermicompost (2.5 t/ha), Poultry manure (PM 2.5 t/ha), Goat manure (GM 2.5 t/ha), Rock phosphate (RP 150 kg/ha) and Agricultural Lime (AL 500 kg/ha) to standardize organic nutrient management for groundnut production in Tripura. In this, the highest average pod yield was recorded as 2.25 t/ha in case of the groundnut grown under the soil condition having treated with FYM+PM+AL+RP and followed by 1.98 t/ha in case of FYM+PM.

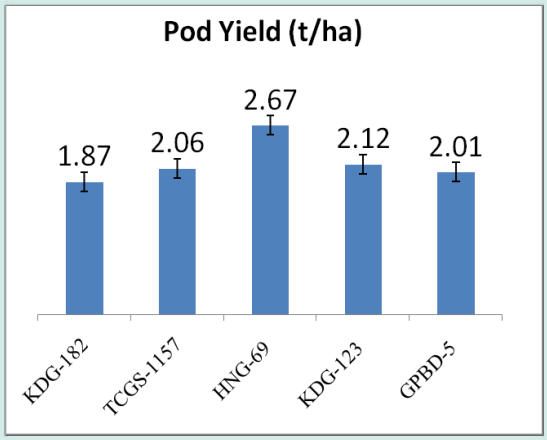


Fig. 7: Productivity of some potential groundnut varieties under Tripura condition

Fig. 8: Overview of nutrient trial in groundnut

Performance of biofortified maize hybrids in Tripura Conditions

(A. Das, P. K. Sarkar, V. Singh and A. Sarkar)

During the year 2022-23 kharif season trial was conducted at ICAR Tripura centre with 6 biofortified hybrid maize hybrids (NEH-BIOFORT-01, NEH-BIOFORT-02, NEH-BIOFORT-03, NEH-BIOFORT-04, NEH-BIOFORT-05, NEH-BIOFORT-06) with 100% RDF and 100% organic conditions. Among the six bio fortified hybrids, highest kernel yield was recorded from NEH-BIOFORT-02 (6.8 t/ha) followed by NEH-BIOFORT-03 (5.5 t/ha) and NEH-BIOFORT-01 (5.1 t/ha). The plant height was comparatively maximum

in case of NEH-BIOFORT-02 (220.46 cm) followed by NEH-BIOFORT-05 (205.18 cm). In case of 100 seed weight, the highest seed weight was recorded in NEH-BIOFORT-01 (43.3 g) followed by NEH-BIOFORT-03 (27.15 g). Among the biofortified varieties Pusa VQPM-9 (80 days) matured early followed by LQMH1 and HQPM-5. During the year, around 650 kg of biofortified hybrid maize were distributed among 429 beneficiaries (125 women and 217 tribal farmers) of Tripura.

Table 3: Performance of Biofortified Maize hybrids in Tripura

Parameters	Yield Performance	
	Highest	Lowest
Grain Yield (t/ha)	NEH-BIOFORT-02 (6.8 t/ha)	NEH-BIOFORT-05 (3.8 t/ha)
Plant height (in cm)	NEH-BIOFORT-02 (220.46 cm)	NEH-BIOFORT-04 (147.8 cm)
100 Seed Weight (g)	NEH-BIOFORT-01 (43.3 g)	NEH-BIOFORT-05 (17.15 g)

Fig. 9: Field day on Biofortified Maize under KVK Unakoti

Standardization of vegetable based intercropping system for upland conditions of Tripura

(B. Das and H. L. Devi)

Multi-storey annual sequence of vegetable cropping system was standardized for upland conditions of Tripura. In winter season two vine type climbing vegetable crops namely Hyacinth bean and Bottle gourd were grown in separate blocks using bower support system. Under these two vine crops, ground vegetable crops namely, vegetable peas (7.4 t/ha), French bean (12.4 t/ha), coriandergreen leaf (9.9 t/ha) and spinach (8.4 t/ha), brinjal (24.6 t/ha) and cowpea (10.3 t/ha) performed better in terms of Land Equivalent Ratio (LER) which ranged from (0.74-0.96) and BC ratio range of (2.6-4.0). In Summer season vine type vegetable crops namely teasel gourd and ridge gourd was grown and under these two crops, Swamp taro (33.5 t/ha), Amaranthus-Leaves (15.5 t/ha), Amaranthus shoot type (28.2 t/ha), okra (10.9 t/ha) and cowpea (10.5 t/ha) were better performer in terms of LER range of 0.92-0.97 with BC ratio in the range of 2.6-3.5. Nutrient combination of FYM (5t/ha) + NPK (50%RFD) gave better performance along with application of lime, PSB and *Rhizobium* in terms of yield of peas (8.1 t/ha), French beans (16.2 t/ha), coriander (6.7 t/ha), Swamp taro (28.5 t/ha), okra (12.5 t/ha) and Amaranthus (15.2 t/ha).INM with NPK 75% RFD + FYM + Rhizobium + PSB gave better yield response. Demonstration was given at farmers' field and bottle gourd with coriander cropping system gave higher return to the farmers with BC ratio of 3.4.

Fig. 10: Vegetable based intercropping system

Standardization of swamp taro production technology (AICRP Tuber Crops)

(B. Das and H. L. Devi)

Swamp taro cultivation technology was standardized with fertilizer dose of FYM 15 t/ha + N-P_2O_5-K_2O 120-60-90 kg/ha) which gave higher yield of stolon (54.7 t/ha), weight of pseudostem (0.94 kg) and yield of pseudostem (34.6 t/ha). Planting time was mid to last February, peak harvesting of stolon during May-August and peak pseudostem harvesting duration is June-August. Tuber crop based integrated farming system was demonstrated at tribal farmers

field with Horti + piggery + poultry + goat and after intervention net income was increased to Rs. 101600.00 with BC ratio of 2.8in comparison to Rs. 36300.00 with BC ratio of 1.8 before intervention.

Fig. 11: Swamp Taro cultivation

Varietal evaluation and popularization of improved onion varieties (AINRP (Onion and Garlic)

(B. Das and H. L. Devi

To popularize the onion cultivation in the state some new high yielding varieties have been evaluated at the ICAR Research Complex for NEH Region, Tripura Centre. Varieties Bhima Shakti, Bhima Subhra, Arka Pragati, Arka Kirtiman, and Arka Kalyan as short day rabi and var. Bhima Super as Late Kharif were found to be promising along with few more Short-day rabi onion varieties under Tripura condition with yield range of 27-30 T/ha. Garlic variety Bhima Purple with yield range of 32-35 q/ha was better performer under Tripura condition. Days to harvest ranged from 120-135 days and bulb weight ranged from 90 g to 180 g. Some white varieties with higher TSS content were also found promising namely Bhima Shweta (16.6 ^{0}B), DOGR HT-3 (16.6 ^{0}B), DOGR H-1 (16.2 ^{0}B) Agrifound White (15.7 ^{0}B), W-504-M-4 (15.8^{0}B), Palampur White (15.4 ^{0}B) and DOGR HT-4 (15.4^{0}B). Critical time for seedling transplanting was found from 25th October to 15th November, which may be extended to even upto 1st week of December for short day Rabi onion and 15th August-15th September for kharif onions. However, critical time for harvesting of the bulb from the field was found during the time period of 25th February to 10th March for Rabi onions and November-December for late Kharif onions. Popularization of selected varieties namely, Bhima Shakti, Bhima Super, Agrifound Dark Red etc. are being done by training and demonstration to the farmers also in collaboration of other organization such as KVKs.

Augmentation and evaluation of jackfruit and mango germplasm in Tripura (AICRP Fruits)

H.Lembisana Devi, Biswajit Das & Bapi Das

During the period, potential jackfruit and mango growing areas viz., West Tripura district (Kamalghat, Agartala, &Nagicherra), Gomati (Korbook), Dhallai(Gandacherra) and South Tripura (Julai Bari) were surveyed, collected six promising jackfruit genotypes, five mango genotypes and evaluated their physico- chemical parameters as per the minimal descriptors. Jackfruit accession TJS 41/22, TJS recorded the maximum fruit weight (6.63kg), number of flakes per kg fruit (25.24) and TJS – 36/22 recorded the maximum TSS (26.8º B). Mango accessions viz., TM-9/22, TM – 15/22, TM – 17/22 and TM – 20/22 showed attractive light orange – yellow orange colour pulp and tolerant to anthracnose. TM -17/22 recorded the maximum fruit weight 381.2g and TSS (16.1^{0}Brix).

Fig. 12: Non-descript Mango genotypes identified

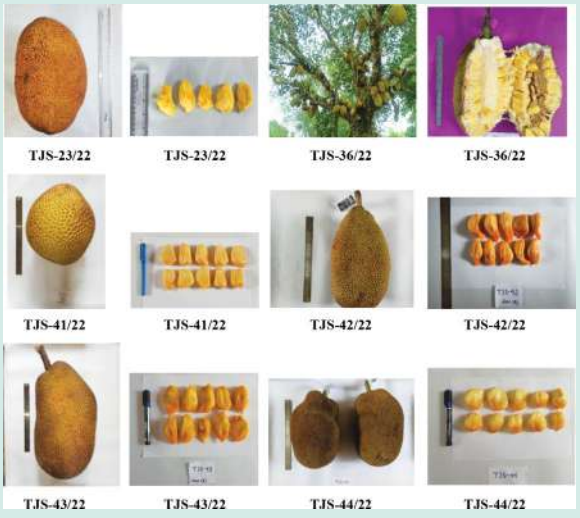


Fig. 13: Non-descript Jackfruit genotypes identified

Assessment of Vegetable based Farming Systems for Tripura

(B. Das, A. Das, L. Sahoo, H L. Devi, B. Das and A. Chakraborti

Vegetable based Farming System was established at ICAR-Tripura Centre, Lembucherra in an area of 0.85 ha during 2022-23 for improving of livelihood and to generate income for the rural farmers of Tripura. This farming system has four terraces, one mushroom producing unit, compost pit, one pond (0.16 ha) for fish farming and fruits crops like mango, banana, litchi, Bael and Jamun, plantation crop like arecanut, coconut and black paper etc. The terraces are used for growing seasonal kharif vegetables (Brinjal, cowpea, Okra, Chilli, Water melon), Rabi vegetables (Cauliflower, Potato, green mustard / laipata), spice crop (Ginger and Turmeric) and the boundary area of terraces are used for growing crop like mango, banana, litchi, Bael and Jamun, arecanut , coconut and black paper etc. The whole system gave a total yield of 500 kg Vegetables, 360 kg Mango, 75 kg Litchi, 650 kg Fish and 108 kg Mushroom, which will give the gross income of Rs. 136000 (One lakh thirty six thousand).

Fig 14: General view of Vegetable based Farming Systems

Collection and Maintenance of plant genetic resource: Collected genotypes viz., 18 Dolichos genotypes (IC-0629403, IC-0629404, IC-0629401, IC-0629402, IC-0629400, IC-0629405, IC-0629407, IC-0629406, IC-0629408, IC-0629409, IC-0629410, IC-0629411, IC-0629412, IC-0629413, IC-0629414, IC-0629415, IC-0629416 and IC-0629417) , one Colocasia genotype TRC Colocasia-3 (IC-0629418), one brinjal genotype TRC Brinjal Laffa-1 (IC-0629419) and three lemon genotype viz., TRC Gandharaj Lebu-1 (IC-0629420), TRC Elaichi Lebu-2 (IC-0629421), TRC Kagazi Lebu-3 (IC-0629422) and one bloodfruit (IC 629038) are being maintained during the period. Also, passport data of 7 mango germplasm, 2 spine gourd, 5 teasel gourd and 9 tuber crops germplasm are submitted to NBPGR, New Delhi for issuance

Resilient farming systems for efficient factor productivity and livelihood security in Tripura

(A. Das, L. Sahoo, V. Singh, H. L. Devi, B. Das)

Two farming systems, *viz.,* Integrated Seed based Farming System (ISFS) and Integrated Intensive farming system (IIFS) were evaluated for improvement of livelihood and enhancing income of farmers. Apart from the crop production, both the systems included fodder grasses on the terrace risers and fences, compost pits, ponds for fish farming and life saving irrigation, plantation crops like arecanut, mango, banana, litchi, papaya, coconuts, etc. The ISFS is divided into 7 terraces used for growing vegetation like lentil, vegetable pea, cowpea, maize, mustard etc. and also included a dairy unit. The IIFS comprised of 4 terraces which are used for cultivation of commercial crops like vegetable pea, okra, brinjal, beans etc. The cropping systems adopted during the year 2022-23 under ISFS included cowpea-Maize-lentil, Blackgram-Maize-Maize, Cowpea- Rice- Vegetable pea, Cowpea-Groundnut-Mustard, etc., and that under IIFS were Vegetable pea-Maize, Mustard-Cowpea and Brinjal-Okra. Under ISFS, Cowpea-Rice-Vegetable pea (14705.8 kg ha^{-1}), cowpea- groundnut- mustard (14493.2 kg ha^{-1}), Cowpea-maize-raddish (9534.9kg/ha), were the best performing systems which gave higher rice equivalent yields. Whereas, in IIFS Cowpea–Okra-Bottlegourd+Chilli (25463 kg ha^{-1}), Maize-cowpea-Maize+ vegetable pea+ cowpea (12577.7 kg/ha), Maize-Blackgram-Maize (7487.4 k ha^{-1}), gave the most promising outcomes in terms of REY. The fodder yield obtained under ISFS and IIFS were about 37.4 t/ha and 32.8t/ha, respectively. There was a reducing trend determined in bulk density (BD) under both the systems. BD of soil under ISFS has decreased from 1.46-1.49 Mg/m^3 in 2017-2018 to 1.31 -1.35 Mg/m^3 in 2022-2023 and from 1.42-1.44 Mg/m^3 in 2017-2018 under IIFS to 1.34-1.40 Mg/m^3 in 2022-2023. The Soil Organic Carbon content of ISFS at 0-10cm, 10-20cm and 20-30cm were 6.81 g/kg, 11.76 g/kg and 14.6 g/kg, respectively and for IIFS it was 6.48 g/kg, 12.29 g/kg and 13.01 g/kg. The available nitrogen content for ISFS at 0-10cm, 10-20cm and 20-30cm were 256.11 k/ha, 248.64 kg/ha and 232.43 kg/ha respectively and for IIFS it was 272.12 kg/ha, 233.81 kg/ha and 216.57 kg/ha. The available potassium content of ISFS at 0-10cm, 10-20 cm and 20-30 cm were 273.66 kg/ha, 232.28 kg/ha and 209.38 kg/ha and for IIFS it was 267.45 kg/ha, 228.19 kg/ha and 156.24 kg/ha. The net return received was Rs. 1,76,881 and Rs, 1,76,980

and B:C ratio was 3.6 and 3.1, under ISFS and IIFS , respectively. The total energy of input used in ISFS is 249522.3 MJ and the energy of the output is 619728.4 MJ and total energy of input used in IIFS is 134322.54 MJ and the energy of the output is 542432.6 MJ, so the energy use efficiency for ISFS was 2.52 and for IIFS was 4.05 respectively. Employment generated for ISFS was 345 days and for IIFS it was 326 days. The Rice Equivalent yield for the whole ISFS was 12725.8 kg/ha and for IIFS it was 13958.8 kg/ha.

Fig. 15: Integrated Seed based Farming System (ISFS) and Integrated Intensive farming system (IIFS)

Organic nutrient management for vegetable based system

(A. Das, B. Das, L. Sahoo, H. L. Devi, B. Das)

Three cropping systems viz, Cowpea-Okra-Tomato, Cowpea-Okra-Carrot and Cowpea-Okra-Cabbage were evaluated under different organic nutrient management practices. The nutrient treatments included: Control, Vermicompost (VC) @ 5t/ha, VC @ 5t/ha + Agricultural lime (AL) @ 500kg/ha, VC @ 5t/ha + AL @ 500kg/ha + Rock Phosphate (RP) @150kg/ha. Among three cropping systems, the highest okra equivalent yield was obtained with Cowpea - Okra-Carrot under VC+AL+RP (19.11 t/ha) followed by Cowpea-Okra-Tomato under VC+AL (16.17 t/ha) and Cowpea-Okra-cabbage under VC (14.23 t/ha). The highest soil organic carbon (SOC) was observed in Cowpea-Okra-Tomato cropping system under VC+AL+RP (8.02 g/kg at 0-10 cm, 7.67 g/kg at 10-20 cm and 6.22 g/kg at 20-30 cm) followed by Cowpea-Okra-cabbage under VC+AL (7.15 g/kg at 0-10 cm, 6.13 g/kg at 10-20 cm and 5.25 g/kg at 20-30 cm) and Cowpea-Okra-Carrot under VC (7.03 g/kg at 0-10 cm, 6.05 g/kg at 10-20 cm and 4.22 g/kg at 20-30 cm).

Mushroom:

(L. Sahoo & B. Das)

Mushroom was promoted in Tripura through dissemination of quality spawns and capacity building programmes. Women and unemployed youths were largely taken up for mushroom cultivation. Three wild mushroom strains were collected and characterized. 7000 kgs of mushroom spawn were produced and distributed among the farmers of the state. 10 women beneficiaries were adopted through NICRA-SCSP Programme who were given help for establishing low cost mushroom house and also provided with quality spawns. They were able to improve their income by 30-60% through adoption of mushroom cultivation. 8 capacity building programmes were organized at various places of Tripura covering almost 700 farmers for promotion of mushroom cultivation for food, nutritional and livelihood security. Under AICRP Mushroom Programme, Six strains of oyster mushroom (PP-22-101 to PP-22-106) were evaluated for AVT-1. PP-22-103 performed best with BE of 56.93% followed by PP-22-104 with BE of 50.67%. 6 strains of *Schizophyllum commune* was evaluated on paddy straw (AVTS-22-101 to AVTS-22-106) on paddy straw. AVTS-22-103 was the highest yielding strain with BE of 11% followed by AVTS-22-102 with BE of 9.53%.

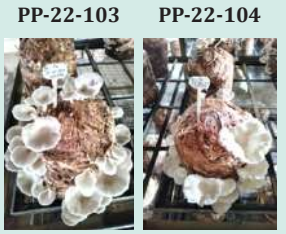


Fig. 16: AVT-1 of Oyster Mushroom *(Pleurotus pulmonarius)* on Paddy straw

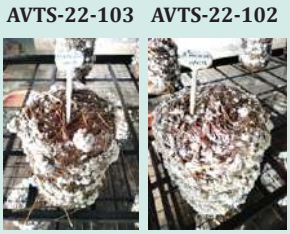


Fig. 17: AVT-1 of *Schizophyllum commune* on paddy straw

Performance evaluation and characterization of Indigenous Tripuri cattle

(A. Chakrabarti, V. Singh, B. Das)

Data were collected from the institute farm and also from the all 8 districts of Tripura state. From each district 20 cattle farmers were randomly selected those who are keeping indigenous Tripuri cattle. The

farmers were interviewed to record information on various management practices followed by them. The survey included 873 animals including 418 male and 455 female animals. Age wise distribution of animals includes calves 0 to 3 months (163), 3 to 6 months (152), 6 to 12 months (144), 1to 3 years (138), bullocks 117 and cows 159. The body measurements data were analyzed by least square maximum likelihood program (Harvey 1990) including age within sex as fixed effects.

1. Physical traits of Tripuri cattle:

Cattle of Tripura are non descriptive indigenous animal. They are of small size animal, well built, stout, very hardy and of cylindrical shape. Bullocks were famous for draught power. The body colour varies from black (23%), brown (45 %), gray (14%), tan (11%), white (5%) and others (2%). Present study indicates that brown colour is predominant in Tripuri cattle. Bullocks had medium hump and dewlap but in cow hump and dewlap were small. It was recorded that the Tripuri cattle have small head, short and concave face, prominent poll, short and thin neck, small ears, small black (82%) or gray (18%) horns with outward, upward or curved orientation towards face, black (81%) and brown (19%) hoofs; black (93%) and brown (7%) muzzles. The udder was small and not well developed and milk vein was not prominent. Small teats 5.5 to12 cm long, mostly of funnel (78%) and cylindrical shape (22%) and the tips of teats were round (90%) or funnel shape (10%). Naval flap was short and tucked up with body penis sheath flap. Tail of the animal was above the hock with black (57%), brown (36%) and gray (7%) switch. Temperament of the adult female animal was docile (97%) but, in some cases male animal was aggressive (21%).

2. Morphometric traits: The morphometric data given in table -4.

Age	Sex	No	Body length	Height at wither	Heart girth	Paunch girth	Ear length	Face length	Tail length without switch	Horn length
0–3	M	84	57.22±1.98	66.43±1.33	70.21±1.59	72.28±2.02	14.01±0.43	22.64±1.23	40.56±2.15	
	F	79	54.10±1.91	67.25±1.54	72.35±1.52	74.57±1.95	13.05±0.53	21.43±0.58	36.97±1.21	
3–6	M	78	61.57±1.47	76.35±1.29	83.53±1.17	84.17±1.55	13.81±0.33	25.21±0.43	41.42±1.19	
	F	74	60.44±1.31	75.33±1.51	81.44±1.25	83.13±1.45	14.25±0.22	24.66±0.57	42.41±1.18	
6–12	M	71	76.31±1.43	89.54±1.78	103.17±1.69	103.10±2.74	16.73±0.43	32.10±1.45	55.09±0.52	
	F	73	73.30±1.91	87.22±1.53	102.32±1.39	107.19±2.57	17.01±0.33	30.33±0.54	54.77±1.90	
12–36	M	68	85.66±1.39	95.59±1.13	116.25±1.38	122.53±1.79	17.68±0.40	33.57±0.41	65.65±1.14	10.61±0.99(49)
	F	70	83.43±1.41	92.13±1.51	114.23±1.43	118.95±1.61	17.53±0.39	33.49±0.32	63.63.55±0.71	6.61±0.85(56)
Bullock>36	M	117	101.52±1.01	105.14±1.11	136.89±1.78	140.53±1.05	19.48±0.19	38.16±0.22	74.33±0.53	11.76±0.34(101)
Cows>36	F	159	99.13±1.67	103.45±1.35	131.56±1.61	137.66±1.93	20.31±0.33	38.10±0.69	74.62±1.29	11.75±1.02(142)

Results showed that all the morphometric traits in different age groups of Tripuri cattle did not differ significantly.

Fig. 18:Tripuri cattle with calf in institute farm

3. Performance of Tripuri cattle:

The birth weight of calf ranged from 8 to 13 kg. The estimated average body weights in cow and bullock were 150 kg and 200 kg, respectively. The average age at first calving, daily milk yield, lactation length, dry period, service period, calving interval, herd life and number of calving during life time were 1,130 days (32 to 48 months), 1.48±0.25 kg (1.0 to 1.8 kg), 190 days (150 to 230 days), 100 days (90 to 100 days), 110 days (95 to 135 days), 430 days (12 to 16 months), 14 to 17 years and 7 to 10 calving, respectively. It was observed that the Tripuri cows were hardy and

disease resistant and had good potential for milk production with higher fat percentage (6%) and need to be developed through a genetic improvement and selection programs to explore the productivity of the indigenous cow.

Pre-weaning growth performance of Black Bengal goatkids in an organized farm in Tripura

(A. Chakrabarti, R. S. Godara and V. Singh)

The data collected from 190 Black Bengal goat kids from 0 to 90 days from birth to 3 month of age for 5 years for the assessment of pre-weaning growth performance of kids and analyzed. Result showed that the performance ofBlack Bengal was found quite satisfactory in regards to prolificacy and twinning percentage. It was observed that well management practices in a organized farm will enhance gains in terms of weaning weight and average daily gain compared to other Indian small goat breeds. It may be recommendedthat Black Bengal goat is most suitable for agro-climatic condition of Tripura state.

Table 5: Effect of sex, type of birth and parity on pre-weaning growth performance of Black Bengal goat kids.

Sl. No.	Particulars	Birth weight (kg)	Weaning weight at 3 months (kg)	Pre-weaning Average daily gain (gm)
1	**Overall mean**	1.11 ± 0.06	4.82 ± 0.20	41.22 ± 3.15
2			**Sex**	
	Male	1.12±0.07	5.25±0.21*	45.89 ±3.21*
	Female	1.07±0.04	4.63±0.24*	39.56±2.38*
3			**Type of Birth**	
	Single	1.14 ± 0.10	5.69 ± 0.44	50.56 ± 4.51
	Twin	1.11 ± 0.05	5.38 ± 0.24	47.44 ± 3.53
	Triplets	1.09 ± 0.12	5.19 ± 0.37	45.55 ± 4.02
	Quadruplets	1.05± 0.11	4.87 ± 0.37	42.44± 5.02
4			**Parity**	
	First	1.17 ± 0.11	5.63 ± 0.53	49.56 ± 4.56
	Second	1.14 ± 0.04	5.35 ± 0.27	46.67 ± 3.82
	Third	1.17 ± 0.07	5.45 ± 0.48	47.79 ± 4.12

AICRP on Poultry Breeding (Rural Poultry Production):

(V. Singh, A. Chakraborty, L. Sahoo, H. L. Devi, & B. Das

Achievement 1: Evaluation of Performance of BND Cross chicken:

'BND' or "Tokbari" is a multicoloured bird developed for rural poultry production under AICRP on Poultry Breeding. BND is a Dual type bird developed by crossing of Coloured Broiler, native i.e. local breed Tripura Black and Dahlem Red. **"BND"** chicken variety has attractive multi-coloured feather pattern with moderate body weight, good escaping ability and scavenging habits and suitable for rural backyard poultry farming in NEH Region. The annual egg production was recorded 150-170 and 130-150 at institute farm and at the farmer's fields respectively. The egg weight at 40 wk of age at Institute farm and farmers fields was 50-55 gm and 45-50 gm respectively. The **BND backyard birds** had **8% lower** age at maturity than native birds. The egg weight is **26% higher** and annual egg production is **133% higher** than the native birds at farmer's fields. The farmers are getting good number of eggs from improved germplasm and satisfied by the performance of the stock. It is comparatively heavier than local desi birds with faster growth potential and possesses good immunity and can thrive well on low plane of nutrition. Till date more than 1 lakhs chicks of BND Cross were distributed among the farmers across Tripura to popularize backyard technology. *The newly developed **BND Cross*** poultry variety is well adapted to local agro climatic condition and is readily accepted by farmers as stock of choice for backyard poultry farming in rural areas.

Sixth evaluation of performance of *BND* Cross chicken has been completed at institute farm as well as the farmer's field's conditions. In E-6 evaluation of BND cross, the 72 week egg production was 159.32 eggs under farm and 138.76 under field conditions. E7 evaluation of BND cross is going on at farm and farmers fields and E-7 evaluation was completed upto the 52 week of age at farm and 40 wks of age at field condition. During E-7 evaluation of BND cross, the 40 week egg production was 64.38 and 54.12 eggs under farm and field conditions, respectively. The body weight recorded in E-7 at 20 and 40 weeks of age showed slightly increased in comparison to previous (E-6) evaluation under farm. The age at sexual maturity was almost similar to previous (E-6) evaluation under farm and field. The egg weight for field was almost similar and farm was slightly decreased compared to previous evaluation.

Fig. 19: Collection of data of BND birds from farmer fields

Comparative evaluation of fertility and hatchability of different chicken germplasms:

(V. Singh, A. Chakraborty, L. Sahoo, H. L. Devi & B. Das)

During the period, a total of 50087 eggs of different breeds/varieties/ lines of chicken were set for hatching at the hatchery unit of Poultry Science Section of ICAR Tripura Centre. A total of 31175 chicks of different varieties / lines of chicken were produced. The overall average percent fertility was estimated 83.73% in different breeds/varieties/ lines of chicken. The highest fertility was found in Tripura Black (87.38%) and lowest fertility was found in Kadaknath (80.33%). The overall average hatchability on fertile egg set (FES) and total egg set (TES) were estimated; 74.33% and 62.24%, respectively. The highest hatchability on fertile egg set (FES) and total eggs set (TES) was found 77.26% and 65.62% in BND Cross and Colour Broiler respectively. The lowest hatchability on fertile egg set (FES) and total egg set (TES) was found 55.20% and 44.34% in Kadaknath.

Feeding value of Duckweed and Tapioca in diets of Kadaknath Chicken:

(V. Singh, A. Chakraborty, L. Sahoo, H. L. Devi, P. Debnath & B. Das

- The fertile eggs of Kadaknath were procured from ICAR- CARI, Izatnagar, Uttar Pradesh and eggs were set in egg incubator for hatching at the hatchery unit. After hatching of eggs, the chicks were grown upto 12 wks of age and kept for feeding trial.
- The nursery ponds were prepared for cultivation of duck weeds. The fresh culture of duck weed (Wolffia) was taken from College of Fisheries, CAU, Lembucherra, West Tripura and culture was used in necessary ponds for cultivation of duck weeds. Duck weeds were harvested at regular interval and fresh weight was taken for estimation of moisture content. Duckweeds were used in formulation of different experimental diets after sun drying and grinding.
- Proximate analysis indicated that Wolffia (Duckweed) powder contains 3.68% moisture, 45.81% CP, 22.11% total ash and 3.18% ether extract.
- A basal diet was prepared based on maize and soybean meal to meet the energy and protein requirement as per (ICAR, 2013) standard for Kadaknath chicken during Grower (12-20 wk) and Layer phase (21-52wk). From this basal diet, a total 5 experimental diets were formulated replacing Soybean meal with duckweed at 0, 5, 10, 15 and 20 % in the basal diet and offered to 3 replicated groups of 10 birds each.
- A feeding trial is going on a total of 150 birds (30 birds/treatment) and birds are reared in litter system under uniform and standard management practices.
- The feeding trial will be continued for 40 weeks (12 to 52 weeks of age). The weighted amount of experimental diets are offering as mash adlibitum to respective groups of birds daily and fresh and wholesome potable water are always made available to the birds throughout the experimental period. Recording of data like body weight, feed intake and other parameters of birds is going on at regular interval.

Fig. 19: Kadaknath birds in experimental sheds

Expansion of Activities of Biotech-KISAN Hub in selected Seven Aspirational Districts of North East States (DBT Biotech-KISAN Hub Sub-project)

(V. Singh, A. Chakraborty, P. Debnath & B. Das)

- A total 9 piglets were distributed among 9 beneficiaries of selected villages of Dhalai district.
- Mineral mixtures, vitamins, dewormer feed supplements and medicines, vaccines distributed among beneficiaries.
- A total 3 nos. of trainings/demonstrations/ awareness programmes on scientific pig farming were carried out for farmers and a total 120 beneficiaries of 4 selected villages of Dhalai district were participated in the different programmes.
- **Technology:** Improved pig breed/ variety (Hampshire cross) were distributed.

Growth performance of piglets:

The regularly surveys/monitoring were done at farmers fields and feedback was taken from farmers. The data regarding growth, production performance and health aspect of the given piglets were collected regularly. It was found that the growth performance of Large white Yorkshire pig was found better than other Mali, Hampshire, and Hampshire Cross pigs.

Table 6: Growth performances of different breeds/variety of piglets at famer's fields

Weight (Kg) Breeds	Body weight at distribution (Average)	3M (Average)	6M (Average)	9M (Average)	12M (Average)
Mali	6.38	10.7	25.86	45.9	48.6
Hampshire Cross	6.93	11.49	19.88	46.27	53.3
Hampshire	8.6	13.00	23.95	31.5	47
Large white Yorkshire	8.5	10.63	33.5	55.4	71.2

Effect of Ferric salt on *L. bata*:

(L. Sahoo, C. Debnath, B. Debnath, H. Bharati, V. Singh)

An experiment was conducted to evaluate the LD50 of Ferric iron on *Labeo bata*. Ferrich chloride salt was used at concentration ranging from 2 to 22 ppm for 96 hours. The 96 hour LD50 concentration was evaluated to be 14ppm for *L. bata*.

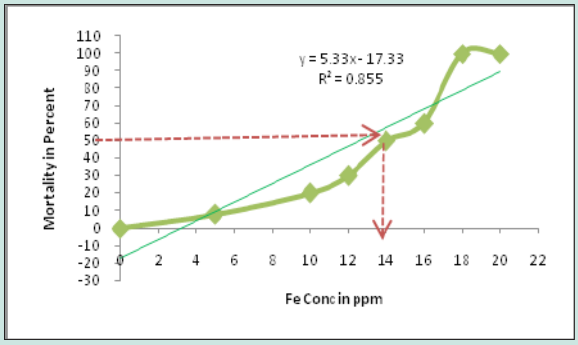


Fig. 21: 96 hours LD50 in *L. bata*

Fe removal by water hyacinth and EDTA: An experiment was conducted to evaluate the efficacy of an aquatic weed Eichhornia on removal of Fe from water. T1 (5 Plants), T2 (8 plants) and T3 (10 plants) were the treatment groups which were evaluated in 100 litres of water with 10 ppm Fe (in the form of Fe3+) for a period of 3 days. A control group was included with no Eichhornia. It was seen that in a span of 3 days Eichhornia could drastically reduce the Fe concentration in water by 98.2% (T1), 98.65% (T2) and 99.2% (T3). A second experiment was conducted with EDTA with T1 (1gm), T2 (2 gm) and T3 (3 gm) for a period of 3 days in 100 litres of water. After 3 days it was seen that a reduction of Fe by 98.9% (T1), 99.1% (T2) and 99.3% (T3) with no significant difference between the treatments.

Effect of bamboo based periphytonic substrate on growth performance of fishes in composite fish culture system:

(L. Sahoo, H. Bharati, V. Singh)

A study was conducted to evaluate the effect of bamboo based substrate on growth and yield of fish in composite fish culture system. A total of 200 bamboos were placed in a slanting manner. Fingerlings were stocked at 10,000/ha in a species combination of Rohu: Catla: *Barbonymus gonionatus*:Mrigal in a ratio of 3:4:2:1 and in the second pond Rohu:Catla: *Barbonymus gonionatus*:Mrigal were stocked in the same ratio ratio without bamboo substrate. The study was conducted for a period of 6 months. Feeding was restricted to once a day @3% of body weight. It could be seen that bamboo substrates enhanced the overall production of the system. This is because bamboo act as substrates for growth of periphytons which are natural fish feed. Among the treatments, *Barbonymus gonionatus* performed better than *Cirrhinus mrigal* in both bamboo based and without bamboo based substrates, suggesting *Barbonymus gonionatus* as a partial replacement for mrigal in composite fish culture system.

Table 7a: Effect of bamboo substrate on growth parameters of CFC species

Species	Initial Weight	Final Weight	Specific growth rate (SGR)	Apparent FCR
Barbonymus gonionatus	10.12±0.54	475±13.60	2.11±0.82	3.41 ± 0.03
Labeo rohita	14.38±0.39	631.4±87.4	2.15±0.68	
Catla catla	22.58±1.94	847.85±207	2.17±0.58	
Cirrhinus mrigala	13.3±0.30	520.4±92	1.83±0.57	

Table 7b: Growth parameters of CFC species without bamboo substrate

Species	Initial Weight	Final Weight	Specific growth rate (SGR)	Apparent FCR
Labeo rohita	14.38±0.39	605.4±75	2.13±0.72	2.29 ± 0.08
Catla catla	22.58±1.94	787.85±159	2.15±0.30	
Cirrhinus mrigal	13.3±0.30	417.4±92	1.78±0.57	
Barbonymus gonionatus	10.12±0.54	388±15.41	2.08±0.37	

Fig. 22: Production of fishes in bamboo based systems

Backyard Farming System:

(L. Sahoo, A. Das, V. Singh, H. L. Devi, H. Bharati)

A backyard farming system was conceptualized and evaluated for ensuring the nutritional security of landless labourers in an area of 300 m^2. Integration of vegetables, pulses, fruits, spices, fishes and ducks were done in the limited available area. Technological interventions with the integration of ducks (Khaki campbell), fish (carps and Self recruiting species), pulses, leafy vegetables, can help in improving the nutrient consumption of the family. A total of 1400 kg of vegetables (including root vegetables and leafy vegetables) could be produced from an area of 150m^2 that can fulfil 30-70% of the vitamins requirement of the family. A net return of INR. 30,000 from 300 m^2 could be obtained with B:C ratio of 2.98. The food produced from the system can contribute to the nutritive requirements throughout the year besides leading to a greater diversity in the food consumption pattern of the family.

Fig. 23: Backyard Farming System

Complete genome sequence of *Aeromonas* phage GomatiRiver_11, a novel T4like bacteriophage that infects *Aeromonas hydrophila*

(L. Sahoo & C. Debnath)

The phage genome is 10,390 bp in length with GC content of 44.1%. A total of 9 ORFs were identified. BLASTn analysis of the complete genome sequence showed the best match with the podovirus *Aeromonas* phage Asfd_1(MK577502.1), with 85.83% identity (ID) and 99% query coverage (QC). There are no tRNAs in this phage genome. Out of the total 3.26 million PE reads, 0.78 million were mapped to the reference genome of *Aeromonas* phages. The PHASTER analysis revealed that the sequenced phage genome is complete i.e. intact (score > 90). The largest gene was found to be tail sheath monomer or tail protein and smallest being pro-head core protein with a length of 1991 and 245 bp, respectively. The phage genome annotation has been shown in Fig 2. The TEM analysis showed that the bacteriophage has a icosahedral head and longer tail of 73.6 ± 14.8 nm long and 47.0 ± 9.5 nm wide and 209.2 ± 12.7 nm long and 17.6 ± 1.8 nm wide, respectively (Fig. 3). This range falls under the characteristic features of family Myoviridae according to ICTV- International Committee on Taxonomy of Viruses. So the identified phage family is Myoviridae. The phylogenetic analysis showed that the phage genome is closely related to T4-like phages of the family Myoviridae and shared same clade with *Aeromonas* phage 44RR2.8t (Fig. 4). This newly identified phage in the present study will help in controlling *A. hydrophila* in aquaculture and further research. The NGS data generated from the present study has been submitted to NCBI SRA with accession SRR15264672 and the genome sequence to GenBank with accession OP967013.

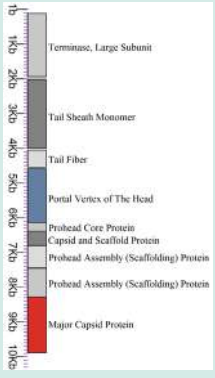


Fig. 24: Phage gene annotation

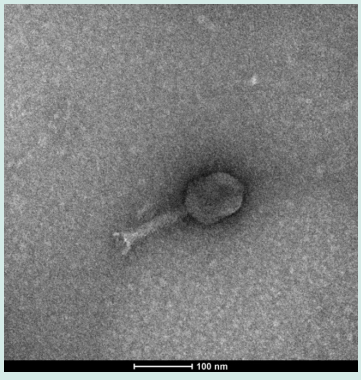


Fig. 25: TEM image

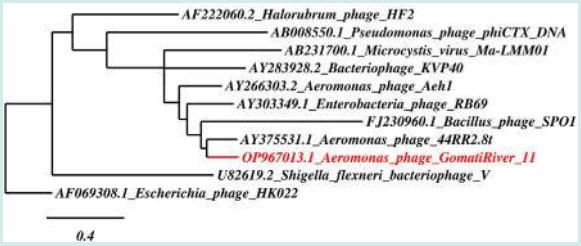


Fig. 26: Phylogenetic analysis

High Density Fingerling Rearing:

(L. Sahoo & H. Bharati)

Spawn was stocked at 2 million/ha. Supplementary feeding in the form of powdered Mustard oil cake and Rice bran @5% of body weight was provided. Pulse aeration for 20 minutes was given thrice daily. Bamboo substrates were placed in the pond for periphyton production. After 4 months fingerling were harvested with 60% survivability.

Fig.27: High Density Fingerling Rearing

Evaluation of growth, survival of *Catla catla* cultured in cattle wastewater

(K. Nath, A. Chakraborti, S. K. Das)

A study on the growth, survival of *Catla catla* was performed for 90 days. The fishes were cultured in cattle wastewater. The wastewater collected in jalkund (5m^3) and treated with quick lime @ 5g/L. After 15 days the wastewater was diluted (50%) and *Lemna minor* was inoculated to remove the excess nutrients and BOD from the cattle wastewater. *C. Catla* was stocked @5000nos/ha in jalkunds after 7 days of *L mimor* inoculation. The fishes were not feed with artificial feed and there was no aeration. The survival was recorded 100%, SGR 1.87, DWG 5.99 and productivity 2955 kg/ha in 8 month.

Fig. 28: Production in cattle waste water

Stock collection of indigenous edible aquatic flora of Tripura

(K. Nath, R. Das, P. K. Sarkar, B. Das and B. Shil)

A live germplasm collection for aquatic plants of local dietary and medicinal significance was started. A shallow, seasonal pond with irreparably damaged dykes was restructured for the purpose. Planting material were sourced from different parts of Tripura. The current standing stock collection includes 12 species of aquatic flora (Table 1).

Table 8: Details of the standing stock of edible aquatic plant germplasm collected

S. No.	Species	Common Name	Vernacular Name	Source
1.	*Marsilea minuta* (F: Marsileaceae)	Water clover/ pepper wort	*Sushni Sak*	Udaipur, Gomoti district
2.	*Hygrophila spinosa* (F: Acanthaceae)	Marsh barbel	*Kulekhara*	West Tripura
3.	*Enhydra fluctuans* (F; Asteracea)	Buffalo spinach	*Helencha*	West Tripura
4.	*Ipomea aquatica* (F: Concolvulaceae)	Water spinach	*Kalmi Sak*	Two varieties -West Tripura
5.	*Neptunia oleracea* (F: Fabaceae)	Water mimosa	*Jal lajak*	Two varieties, collected from West Tripura
6.	*Trapa sp.* (F: Trapaceae)	Water chestnut	*Singara*	West Tripura
7.	*Ludwigia adscendens* (F: Onagraceae)	Water primrose	*Keshardam*	Udaipur, Gomoti district
8.	*Nelumbo* spp. (F: Nelumbonaceae)	Lotus	*Padma*	Three species- collected from Rudrasagar, west Tripura and Manipur

Fig. 29: Germplasm collection of edible aquatic plants of Tripura.

Pond structure stabilization through agroforestry based interventions in Carp Fingerling Production Units

Pradip Kumar Sarkar, Kouberi Nath, Bapi Das, Rekha Das and Bikas Shil

In addition, an agroforestry model for stabilization of dykes of fish ponds was developed using selected economically important plants. The research fish farm facility with woody perennials along the periphery of dykes faced the issue of destabilization

of soil outside the rooting range of the planted trees. Since a deep-rooted intercrop could potentially affect the productivity of the standing trees in the long run, a newer model was explored involving plant species with superficial rooting structures and minimal maintenance demands. The model was employed within the inner slopes of the pond dykes leaving 1m margin from corners to allow movement of personnel for aquaculture operations. The plant species within the model includes herbs, shrubs and medium sized multipurpose trees of medicinal importance.

Fig. 30: Pond stabilization through agro-forestry based interventions

Mining for stress tolerant genotypes of *Labeo rohita* suitable for low maintenance aquaculture ponds of Tripura

(R. Das, S. K. Das, S. P. Das, K. Nath)

The aquaculture systems in Tripura are typically affected with low pH and suboptimal fluctuations in dissolved oxygen, leading to poor productivity and survival. The mortality patterns in advanced fry of *Labeo rohita* (3-5cm) subjected to chronic stress of low pH and hypoxia, either alone or in combination, was studied over a period of 21 days. The treatment groups in triplicate were subjected to a period of 8 hours of reduced pH (5-6) or dissolved oxygen (60% saturation) or both (combined stress) daily during the experimental period in order to simulate the dynamic nature of these parameters encountered in earthen ponds. Each tank contained 30 fish and were maintained in triplicate. Complete Randomised Design was followed for the experimental set up; appropriate controls were maintained. The treatment groups exhibited around 4-9 fold higher Standard Mortality rates than Control group, with the mortality in combined stress, hypoxia and low pH in the descending order. The cumulative mortality rate in the combined stress, hypoxia and low pH groups were 28.8%, 17.7% and 14.4% respectively as against 3.3% in the control group. While the excess mortality estimated with reference to the control group was not significantly different between the treatment groups ($P>0.05$), the combined stress group had a faster rate of mortality ($P<0.05$) among the groups. On the other hand single abiotic stressors appear to act in the longer term, though the ultimate survivability in the long run remains similar. Our results also indicate that hypoxia is a more potent stressor to advanced fry of *L. rohita* than low pH.

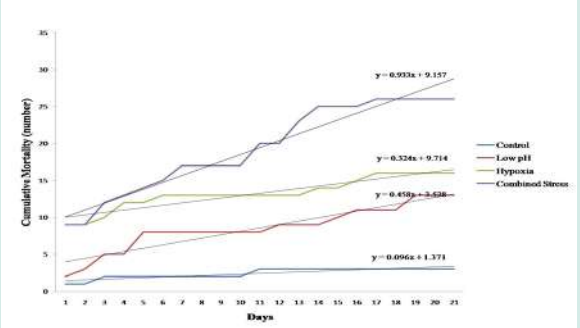


Fig. 31: Mortality pattern of *Labeo rohita* advanced fry exposed to chronic abiotic stress

Production of fingerlings

(K. Nath, R. Das)

Total 300 cc spawn stocked at cocotila. The seed were feed with farm made prepared feed (30% CP). Total 20000 nos fingerlings produced and Rs 50,000/- revenue generated. A 8000 nos fingerlings were distributed under tuber crops projects of ICAR-Tripura centre and some used for institutional research project and some are stocked at cocotilla farm for brood stock generation and for other study.

Fig. 32: Production of fingerlings

Trophic State Assessment of Rudrasagar Lake

(H. Bharati, L. Sahoo, C. Debnath and S. K. Das)

The Carlson's Trophic State Index (TSI) was calculated with the seasonal averages of total phosphorus (TP), secchi disk transparency (SD) and chlorophyll *a* (Chl-*a*) for Rudrasagar lake during the period 2017-2020. The calculated TSI values were then compared with the Carlson's trophic state classification criteria. According to Carlson's TSI, the lake was hyper-eutrophic during pre-monsoon season (73.46 ± 0.404 to 75.11 ± 0.263) while it was eutrophic during monsoon (68.10 ± 0.561 to 70.35 ± 0.557), post-monsoon (69.01±0.524 to 70.88 ±0.361) and winter (68.70 ± 1.459 to 69.96 ± 0.520) seasons. This may be due to precipitation and mixing during monsoon, post-monsoon and winter months. The trophic state index based on TP (TSI-TP) ranged from 69.53 to 86.63 across the selected four sampling stations. According to TSI-TP values, the lake was found to be eutrophic to highly eutrophic in nature in all the seasons. During pre-monsoon season in particular, the TSI-TP values ranged from 80.44 to 86.63 indicating highly eutrophic nature of the lake. The trophic state index based on SD (TSI-SD) ranged between 60.29 to 74.99 across all the sampling stations. The TSI-SD values were lower compared to TSI-TP values and indicated the lake's eutrophic to highly eutrophic nature. The monsoon recorded the lowest TSI-SD values (60.29 to 64.23) which classify the lake to be eutrophic. The TSI-SD values during the post-monsoon season ranged from 67.71 to 71.02, classifying the lake to be eutrophic. However, the values gradually increased in winter (71.07 to 73.48) and pre-monsoon (73.17 to 74.99) seasons, during which the lake was highly eutrophic. The trophic state index based on CHl-*a* (TSI-Chl-a) ranged between 63.35 to 67.85 across the sampling stations, according to which the lake can be classified as eutrophic. Comparing to TSI values based on TP and SD, TSI-Chl-a values were relatively lower. In all the seasons, the lake was eutrophic in nature. The TSI-Chl-a values ranged from 64.62 to 67.61 in monsoon season, 64.16 to 67.85 in post monsoon season, 63.35 to 65.83 in winter season and 63.74 to 65.21 in pre-monsoon season.

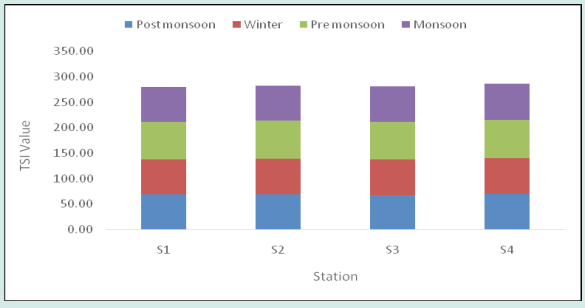


Fig. 33. Overall carlson's TSI values

NATIONAL INNOVATIONS IN CLIMATE RESILIENT AGRICULTURE (NICRA)

Crop Improvement

Development of high yielding drought tolerant varieties of rice

(S. P. Das and A. Ganga Rani)

An ICAR-NEH NICRA Aerobic Dhan 2/29409 / TRC 2020-14 (Fig. 1) entrance was identified by the Varietal Identification Committee (VIC) for the release of CVRC for aerobic conditions in the states of Bihar and Haryana. The entry performed better than the best check in all the years of testing (2020-2022). The entry showed yield superiority of 10.8% over NC (National Check), 14.7% over ZC (Zonal Check), and 5.9% over LC (Local Check) on a weighted mean basis of 3 years. The yield superiority of NICRA Aerobic Dhan 2 in Bihar was 17.5% (NC), 8.0% (RC) and 5.3% (LC), respectively. In Haryana NICRA Aerobic Dhan 2 showed yield superiority over NC, RC and LC by 18.6%, 36.1% and 30.6%, respectively. The entry's grain quality was superior, with 68.8% milling, 64.6% HRR (head rice recovery), and long bold grains (kernel length: 6.02 mm and kernel breadth: 2.37 mm; LB: 2.55). Similarly, the variety had an alkaline diffusion value of 7.0, an amylase concentration of 21.8% and a gel consistency of 24. In terms of disease response, the entrance showed resistance to False Smut.

Fig.1. ICAR-NEH NICRA Aerobic Dhan 2/29409 / TRC 2020-14 notified for Bihar and Haryana

Screening of drought tolerant upland rice germplasm

(S. P. Das, A. Ganga Rani, and R. Krishnappa)

Thirty-six upland rice germplasm were evaluated for superior root traits under reproductive drought stress and control conditions in PVC pipes in Rainout Shelter (Kharif 2022). Drought tolerance was confirmed in previously identified six germplasm from Nagaland centre viz. Neikedo-u lha tsia, Samro yoh, MTU1010, Mekhrilha Kecha, Narichitpi and Teke (Fig. 2). Maximum root length was recorded in Nailong Mapok (98.8 cm), Vepvu Tsuk (99 cm), Goyo Tsuk (99 cm), Shopvu (100 cm), and Chachak hou (110.9 cm). High root volume was recorded in Shopvu (90 ml) and Bordungsha-1 (100 ml), Chachak Hou (80 ml) (Fig.3).

Fig. 2. Experimental set up for evaluation of root traits in PVC pipes under rainout shelter

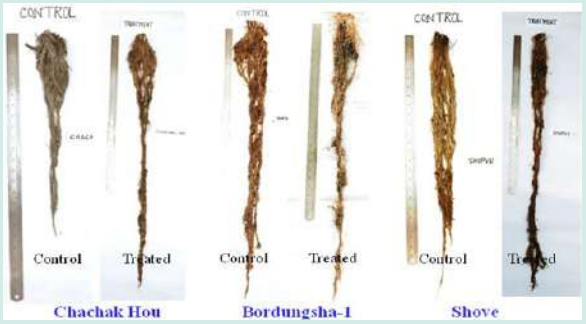


Fig. 3. Rice genotypes expressing promising root traits

Identification and characterization of differentially expressed genes under moisture and high temperature stress conditions in rice (*Oryza sativa* L.)

(B. Bhattacharjee, A. Ali, and R. Krishnappa)

The study dealt with the expression profile of the moisture tress gene in rice in two parts: (i) The impact of polyethylene glycol (PEG – 6000) on antioxidant machinery and gene expression profile of rice lines from NEH India, (ii) The effects of polyethylene glycol (PEG – 6000) on antioxidant and gene expression analysis in rice callus cultures.

Effect of PEG induced drought stress on seed germination percentage revealed significant differences between studied rice lines. While 100% seed germinated in the control (0% PEG treatment), seed germination % decreased with further increase in PEG concentration in the studied rice lines. Amongst the studied rice lines, Sahbhagi Dhan, RCPL 1-82, Bhalum-3, RCPL 1-128, Baglami and Bhutmari showed comparatively higher seed germination (%) (Fig.4), shoot and root lengths.

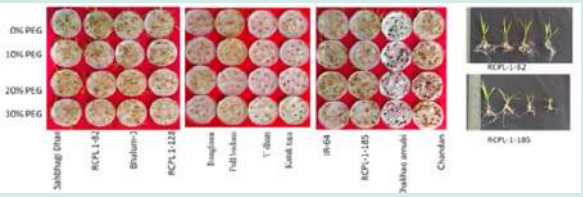


Fig. 4. Seed germination of rice treated with in-situ PEG-6000 stress gradients (e.g. 0 to 30%)

The preliminary genetic relationship among 112 rice lines was evaluated using 57 previously reported drought stress tolerance markers, which were linked to 5 Random Amplified Polymorphic DNA (RAPD) and Simple Sequence Repeat (SSR) markers. A total of 1395 alleles were identified using the RAPD and SSR markers. Among them, 219 (15.7%) were monomorphic and 1176 (84.3%) were polymorphic. A banding pattern representing the study rice lines was shown in Figure 5. In RAPD, OPB-10 had the largest range of allele sizes, while in the SSR marker, RM3 had more polymorphism and the maximum number of alleles compared to other primers and RM11 generated the least number of alleles (Fig. 5). The allele frequency ranged from 0.25 to 0.71 with an average value of 0.46, and the high range of allele size (165-269 bp) was displayed by RM3233. The polymorphism information content (PIC) ranged from 0.48 to 0.93, with an average value of 0.77. Although RM3 showed the highest PIC value, RM204 showed the lowest PIC value, suggesting the potential use of these markers in the genotyping and diversity analysis study.

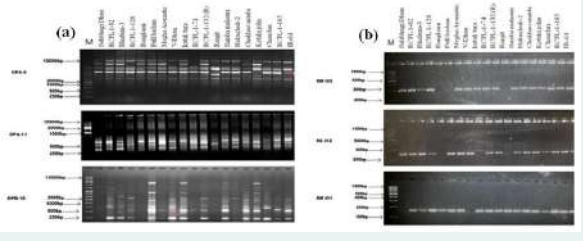


Fig.5. RAPD (a) and SSR (b) profiles of 19 rice cultivars

The Calli model system was utilized in the study to examine how different rice genotypes (Sahbhagi Dhan, RCPL-1-82, RCPL-185 and IR64) responded to PEG-mediated osmotic stress (Fig.6). The results showed that the extent of proliferation of calluses was between 72 and 93%. The highest value of callus proliferation, proline content, and shoot formation was found in Sahbhagi Dhan and RCPL-1-82, compared to the other two lines (RCPL-185 and IR64). Expression of stress response genes SOD and CAT correlated with the accumulation of proline content at different concentrations of PEG in all genotypes. Cat and GPX activity declined with increased PEG stress, while SOD activity increased with increased PEG stress at Calli. Antioxidant activity was found to be higher in Sahbhagi Dhan and RCPL-1-82 compared to RCPL-1-185 and IR64. Sahbhagi Dhan and RCPL-1-82 had a higher expression of DREB1, SOD, p5cs, WRKY97, rbcs and AAO1 compared to RCPL-1-185 and IR64. Expression of WRKY114 decreased with increased fluid stress.

Fig.6. Representative flow pictures of callus induction and plant regeneration in rice

Development of high yielding drought tolerant varieties of rice

(H. Verma)

The present study evaluated 114 genotypes for drought tolerance, root, shoot, yield, and physiological traits in both moisture stress and irrigated conditions (Fig.7). Analysis of variance revealed significant differences among the genotypes for all traits measured in the study, indicating that the differential response of genotypes might have a genetic basis. The wide range of variation in root, shoot traits, drought sensitivity score, drought tolerance index, and physiological traits indicate the scope for selection to improve these traits. Response to droughts varied between genotypes. According to leaf rolling scores,

Meche, Tsuk Nakla, Teke, and Dzuku Nya were drought-tolerant, while Yingching, Rukhatang, Bordungsha, Leimaphou, Shangya and Motiro, showed moderate drought tolerance under stressed conditions.

Fig.7. Experimental field depicting drought tolerant rice trials at Nagaland

A total of 9 genotypes, MTU 1010>Tsuk Nakla> Shangya>Mekhrilha Kecha>Nari Chitpi>Neikedo-ulha Tsia>Rukhatang>Teke>Dzuku Nya, were found to be resistant to drought based on the drought tolerance index (DTI). However, when both DTI and yield under stress condition were considered, six of them, namely Neikedo-u lha tsia, Samro yoh, MTU1010, Mekhrilha Kecha, Narichitpi, Teke, Dzuku Nya were superior genotypes. A hierarchical tree was constructed using the UPGM method to study genetic diversity. The UPGMA-based dendrogram analysis grouped the 114 rice genotypes into 6 clusters using 10 roots, shoots, and drought tolerance index traits. Clusters, namely II, III, IV, V and VI comprised 2, 5, 7, 7, and 92 genotypes, while cluster I was solitary. Epyo Tsuk's hybridisation with Neikedo-u lha Tsia, Samro Yoh, Narichitpi can produce transgressive segregation to improve droughtt tolerance as well as yield. Principal component analysis revealed the genetic diversity among 114 rice germplasm of the present study (Fig. 8). The analysis identified that among 10 morpho-physiological traits, yield, root volume; fresh root weight, dry root weight and fresh shoot weight were the most important traits for classifying the variation. Cluster 4 has 7 genotypes and is characterized by drought-tolerant genotypes, while cluster 3 has 5 genotypes and has a better root system.

The marker trait association analysis revealed a total of 26 associations at P <0.0001 for roots, shoot and drought tolerance traits with R^2 ranging from 4.0% to 11.62% under moisture stress and irrigated conditions and were significantly associated with a total of 3 SSR markers. One association was detected for the drought tolerance index on chromosome 12, explaining 11.62% of the variation. The marker RM3345 located on chromosome 5 showed associations with root length, drought tolerance index, root angle and dry root weight and explained 7.55%, 6.86 %, 5.26% and 4.96% of the variation, respectively.

Fig. 8. Grouping of genotypes based on first two principle components

Assessment of combined stress tolerance of rice lines under drought and elevated temperature conditions at CTGC research facility

(R. Krishnappa, B. U. Choudhury, and T. Ramesh)

To investigate how the combined stress effects of drought stress (DS: 50% FC) and elevated temperature (ET, +3° C) on crop physiology and climate stress resilience of rice cultivars, a field experiment was conducted under CTGC (carbon dioxide temperature gradient chamber) environment (Fig.9). Eleven rice lines (Oryza sativa) of which eight viz., Iuron, Black Rice, V-Dhan, IR 64, Megha Aromatic, Bhalum3, Bhalum5, and CAU-R1 were collected from Meghalaya and three viz., Nirog, Hakuchuk 2, TRC-2016-3 from Tripura. Drought stress (DS) treatment was imposed at 65 days (PI to flowering stage) at two levels, i.e. providing water at 1 time/week and 3 times/week. After 25 days of DS, rice lines like Mega aromatic and Hakuchuk-2 showed a higher Chlorophyll a/b ratio in ET and AT conditions (ambient temperature), while carotenoids levels increased in rice lines such as IURON, Vivekdhan, N-22, and Bhalum-3 under ET (Fig.10).

Fig. 9. The growth of rice genotypes under CTGC

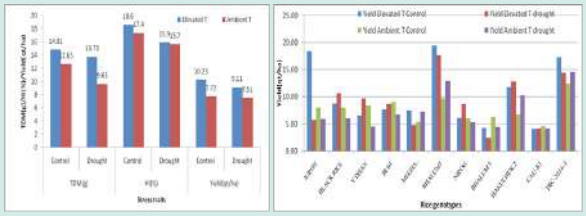


Fig.10. Effect of drought and elevated temperature on TDM and Yield of rice under CTGC

Combined stress (drought and elevated temperature) on physiological analysis of important Rabi crops of North East India at CTGC facilities

(R. Krishnappa, B. U. Choudhury and T. Ramesh)

A field experiment, including 5 Rabi crops: French beans, peas, mustard, lentils and buckwheat were undertaken to study the combined stress of drought and elevated temperature (+3° C) on stress physiology, growth and yield under CTGC (Fig.11). The leaf chlorophyll content decreased by 10.3 to 18.9% in the studied five crops as a result of combined stress compared to the control. The leaf chlorophyll a/b ratio of a pea was higher, followed by buck wheat under combined stress. High temperatures during periods of drought increased the Chla/b ratio by 8.53%, 48.06%, 7.69%, 42.81% and 36.75% in peas, French beans, lentils, mustard and buckwheat, respectively with ambient temperature.

The maximum carotenoids content was estimated in buckwheat and due to the elevation of temperature under drought conditions; it went up by 43.77% further. Mustard produced the maximum LAI during drought and high temperatures increased by 18.99% from ambient conditions (Fig.12). Leaf temperature increased by 9.26%, 11.03%, 11.75%, 9.66% and 7.54% in pea, French beans, lentil, mustard, and buckwheat under combined stress compared to control. Total dry matter was highest for French beans when temperatures and dryness were high. High temperatures and drought conditions result in a 25.20% and 35.51% decrease in TDS accumulation relative to ambient drought conditions in French beans and buckwheat, respectively. The stress hormone ABA was elevated in leaves by 67.45%, 69.68%, 27.27%, and 51.74% in buckwheat, French bean, mustard, and lentil under elevated temperature and drought stress conditions (Fig. 12). Under ambient drought stress condition, ABA increased by 178.9%, 108.5%, 85.6%, 135.5% and 24.7% in buckwheat, French bean, mustard, lentil, and pea, respectively. Under combined stress, crop yield decreased by 22.6%, 12%, and 7.2% in buckwheat, mustard, and lentil, respectively, compared to control (Fig.12). The yield reduction under ambient drought stress was 18.6%, 15.3%, and 22.7% in buckwheat, mustard, and lentil, respectively, above control. Under combined drought and elevated stress conditions of CTGC, French beans and buckwheat were relatively tolerant.

Fig.11. Overview of growth of five selected crops under drought stress and elevated temperature under CTGC

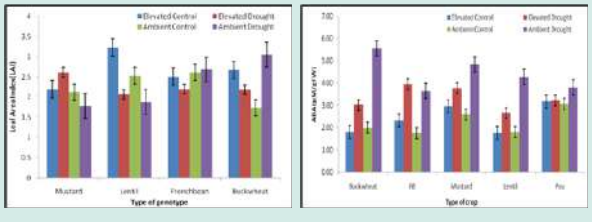


Fig.12. Effect of elevated temperature and drought stress on leaf area index and leaf Abscisic acid content in five selected crops under CTGC

Development of high yielding climate resilient versions Chakhao and kali khasa rice under moisture stress

(N. Umakanta and K. Sarika)

For introgress drought tolerant gene(s) /QTL (qDTY1.1 + qDTY2.1 + qDTY3.1) and submergence tolerant gene (Sub 1) into Manipur black rice/Chakhao and Kali khasa, Chakhao-22 and Kali kasha, the recurrent parental (RP) line, were combined with the donor parental line, CR Dhan 801. A total of 9 and 4 F1 seeds were harvested, respectively. BC1F1 seeds were developed by backcrossing F1 plants with RP and Chakhao-22. A total of 10 BC1F1 seeds were derived in the case of Chakhao-22, and BC1F1 seeds from the case of Kali will be derived during Kharif 2023. Selection with the foreground of drought-tolerant genes (qDTY1.1 + qDTY2.1 + qDTY3.1) by studies of parental polymorphism and submergence-tolerant sub1 gene was conducted. The use of six SSR markers (RM315, RM11943, RM431, RM12023, RM12091 and RM12233) was done. For qDTY1.1, six SSR markers (RM315, RM11943, RM431, RM12023, RM12091 and RM12233) were and no polymorphism was observed. For qDTY2.1, out of seven SSR markers, three markers (RM324, RM6374 and RM424) were found to be polymorphic. Two markers (RM16030 & RM520) out of four SSR markers were found to be polymorphic for qDTY3.1. For the tolerance gene (Sub1), eight related/functional markers such as ART5, SC3, Sub1BC2, AEX, RM8300, Sub1A203, Sub1C173, and GnS2 were used and three markers, Sub1C173, ART5, and Sub1BC2, were identified as having polymorphism (Fig.13). For background polymorphic studies, out of 169 SSR markers screened, 38 and 32 were found to be polymorphic markers between Chakhao-22 and CR Dhan 801 & Kalikhasa and CR Dhan 801, respectively. The BC1F1 generation of Chakhao-22 and CR Dhan 801 would be backcrossed with Chakhao-22 and F1 would be successfully derived from the cross CR Dhan 801 and Kali Kasha, which will be backcrossed with Kali Kasha during Kharif 2023.

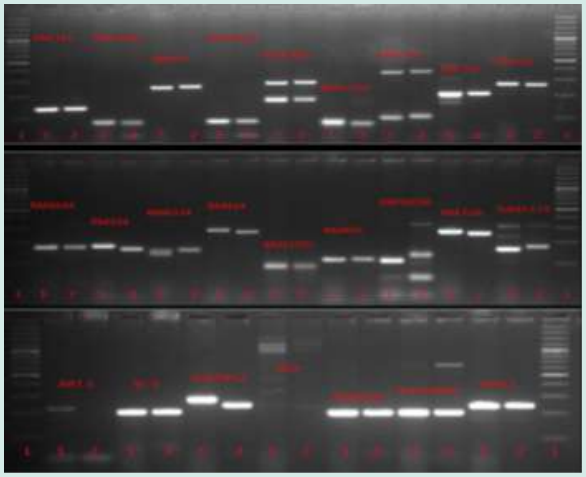


Fig. 13. Foreground polymorphism survey between the parental lines Chakhao-22 and CR Dhan 801

Development of excess moisture stress tolerant maize for NEH region:

(E. L. Devi and team)

At almost all stages of the crop, maize is susceptible to water logging. The North East India typically receives heavy rainfall during the monsoon months, resulting in water logging in lowland areas. Heavy rains in mountainous areas can cause soil saturation, leading to excessive water stress in maize. The NEH region must develop maize lines that are resistant to excessive moisture stress. Keeping in mind the above points, this study identified superior moisture tolerant inbred maize lines that were developed from genetic material in the northeastern regions. The total number of lines used was 37, with 32 from ICAR RC NEHR, Sikkim Centre and 5 from ICAR- IIMR, Ludhiana. In two replications, two experiments were set up to control and treat excess moisture stress (Fig.14). Fifteen days continuous water logging treatment was provided in V5-6 stages to screen lines tolerant to excess moisture stress.

Fig.14. Field view of control and treatment fields

From the 1st year trial at, Sikkim centre, some potential lines were identified *viz*. Mizo-41(A)-2-4, Mizo-21(B)-2-3, UMI-1210 (ICAR- IIMR line), Mizo-13(b)-1-3, Mizo-16(B)-2-3 and Mani-3-2-1 (Fig.15).

Fig.15. Mizo-21(B)-2-3 and Mani-3-2-1 on the 15th day of waterlogged treatment; comparison of roots between control and treatment

The present study revealed an increase in the Anthesis-Silking interval. The seed weight and overall yield of all lines under stress conditions were reduced. In some lines, there was no seed setting at all. The grain yield/plant of certain promising lines was comparable to the control (Fig.16). These were Mani-3-2-1 (45.5 g), Mizo-13(b)-1-3 (23 g), Mizo-21(b)-2-3 (25 g), Mizo-41(a)-2-4 (32.5 g) and UMI-1210 (28.8 g).

Fig. 16. Trends of seed setting after water logged treatment

Development of drought tolerant tomato for NEH region

(S.S.Roy and N. Umakanta)

The replicated yield trial for two promising moisture-stress-tolerant tomato lines, namely, RCM-N-T-1 and RCM-N-T-2, was successfully conducted and seed multiplication of these two lines was completed. Additionally, RCM-N-T-2 was tested under moisture stress conditions. Even after a 25-day moisture stress period, the yield for RCM-N-T-2 in stress was 608.70 g/plant compared to 895.50 g/plant under non-stress conditions; whereas for DVRT-2 (susceptible check), the values are 104.6 and 711.50 g/plant, respectively. The results were validated by analyzing the relative leaf water content and activity of glutathione reductase and ascorbate peroxidase enzymes under stressed and non-stressed conditions. Line RCM-N-T-2 was tested under moisture stress against DVRT-2 moisture stress sensitive genotype. Regular watering was carried out in the control group. The average soil moisture content in stressed and non-stressed plants was found to be 9.26% and 30.52%, respectively. After 25 days of stress, RCM-N-T-2 and DVRT-2 had a survival rate of 97% and 56%, respectively. The ratio of the number of green leaves to brown leaves in RCM-N-T-2 after 25 days of water stress was found in 4.76; whereas, the ratio was 18.13 at well-watered plants. The ratio was only 0.91 in DVRT-2 when there was moisture stress.

Despite a 25-day moisture stress period, RCM-N-T-2 achieved a yield of 608.7 g/plant under stress compared to 895.5 g/plant under non-stress condition; while the values for DVRT-2 were 104.6 and 711.5 g/plant, respectively. The activity of glutathione reductase (GR) and ascorbate peroxidase (APX) enzyme is also higher in stressed plants than in controls. The activity of GR (285.26 U/min/mg protein) and APX (0.617 U/min/mg protein) was higher with RCM-N-T-2 under stress compared to well-watered plants (98.25 and 0.285±0.04 U/min/mg protein, respectively). The GR activity of stress and non-stressed plants in DVRT-2 was comparatively lower at 115.27 and 75.52 U/min/mg protein, respectively, and an APX of 0.235 and 0.246 U/min/mg protein, respectively. The results were validated further by estimating the relative leaf water content (RWC). The RWC in stressed and non-stressed plants of RCM-N-T-2 and DVRT-2 was 67.15% and 55.34%, respectively, as compared to well-watered plants (70.50% and 72.13%, respectively). The reading of the data clearly indicates that RCM-N-T-2 has a systemic tolerance to water stress, as evidenced by higher GR and APX activity as well as increased RWC and fruit yield.

Natural Resource Management Component

Analysis of seasonal drought occurrences across Northeastern Region of India

(S. Saha)

The Standardized Precipitation Index (SPI) time series was used to analyses the pattern of seasonal drought occurrences, calculated over 2, 3, 4 and 12 month intervals for 36 stations in eastern India (1969-2020) (Fig.17). During the pre-monsoon and monsoon months, there was a significant increase (p <0.05) in seasonal drought occurrences in Aizawl (Mizoram) and Kohima (Nagaland). There was no immediate threat of increased seasonal droughts in the rest of northeast India. The majority of the studied stations showed the accumulated impact of reducing annual wetness (12 month SPI) except for Dibrugarh (Assam), Darjeeling / Jalpaiguri (West Bengal), Aizawl (Mizoram) and Kohima (Nagaland). Therefore, we observed no immediate threat of extensive meteorological and agricultural drought; but there was an increasing trend for future hydrological drought events across Eastern India.

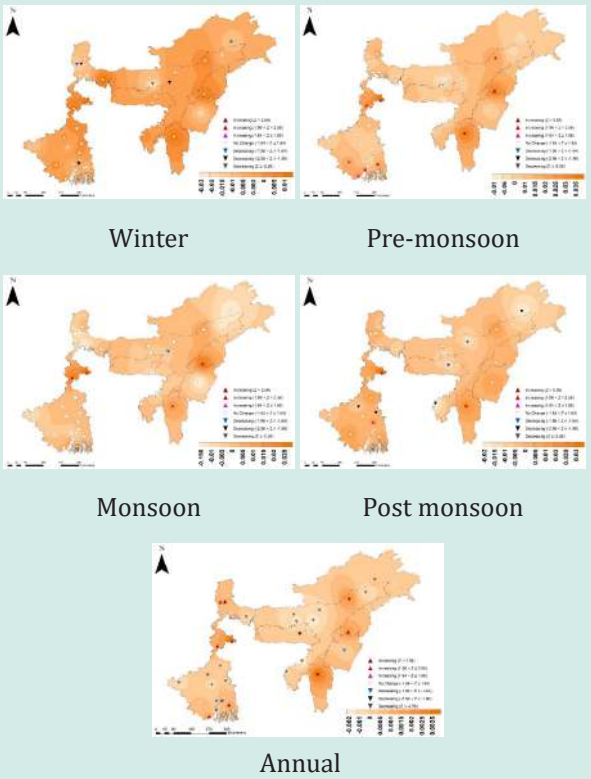


Fig. 17. The trend in the seasonal precipitation index (SPI) based seasonal drought occurrences across eastern India

The effect of elevated CO_2 and temperature on maize, and French bean growth and productivity under Free Air Temperature Enrichment (FATE)

(T. Ramesh, B.U. Choudhury and R. Krishnappa)

The effect of high CO_2 and temperature on the growth performance of maize and French Beans was investigated by conducting an experiment in a Free-air temperature enrichment chamber (FATE) (Fig. 18). Maize (MCR 1-61) and French beans (Selection 9) were the test crops for the kharif and Rabi seasons. The main treatment comprised (i) Ambient CO_2 (ACO_2) and temperature (AT), (ii) Ambient CO_2 and elevated temperature (ET: +3° C), and (iii) Elevated CO_2 (ECO_2: 550 ppm) and ET. The sub-treatments consisted of (i) Control (NPK-nil), (ii) Inorganic fertilizers (NPK), (iii) Integrated Nutrient Management (INM), and (iv) Organic (FYM). The standard procedures were used to record all plant parameters at the end of the crop growth period.

Maize growth and yield parameters

The increase in temperature (ET) resulted in 21.5, 19.2, 11.5, 16.3, 4.4, 2.7, and 9.3% reductions in shoot dry weight, height, number rows, number grains per cob, test grain weight, cob length and diameter, respectively over the ACO_2 and AT (130.5g, 296.6cm, 33.9, 414.7, 35.4g, 15cm, and 14.1cm, respectively) (Figs.19a and 19b). When the temperature was elevated, the RDW went up by 10% compared to AT and ACO_2. The SDW (22.5%) and test grain weight (7%) were significantly increased by the increase in temperature and CO_2 concentration (550 ppm) compared to AT and ACO_2. However, ECO_2+ET significantly increased the SDW (49%), number of grains (18.4%), test weight (11.5%), cob length (4%), and cob diameter (7%) compared to ET alone. The increase in temperature alone significantly reduced the Stover and grain yields by about 16 and 15.5%, respectively compared to ACO_2 and AT (8.7 and 3.7 t/

Fig.18. Experimental site and data observations under Free air temperature enrichment (FATE)

ha, respectively) (Figs.19a and 19b). Stover and grain yield were increased by 3% and 13%, respectively, compared to ACO_2 and AT when elevated environments (ECO_2 and ET) were added. The addition of ECO_2 resulted in a 19 and 29% increase in Stover and grain yield, respectively compared to ET alone.

The INM displayed the highest values (6 parameters) among the estimated plant parameters (10). Regardless of ECO_2 and ET, the FYM application had a 17% increase in straw yield over control, while the INM treatment had the highest grain yield (20%), while the FYM application had a 17% increase in straw yield over control (Figs.19c and 19d). According to the study above, maize growth parameters and grain yield were reduced solely by elevated temperature but the inclusion of ECO_2 with ET resulted in a significant increase in all growth parameters, including grain yield. The negative impact of ET on maize growth attributes can be mitigated by ECO_2 in the changing climate scenario, as suggested. Integrated nutrient management could be an appropriate management option for changing climate conditions, with consideration of elevated CO_2 and temperature.

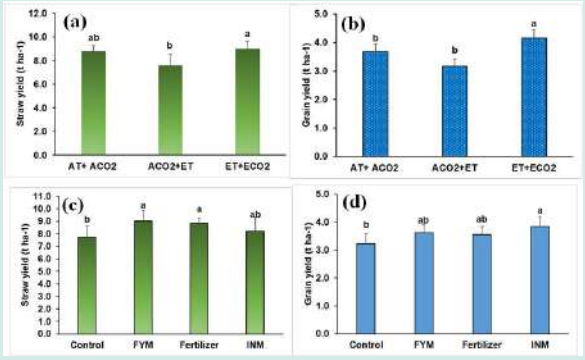


Fig. 19. Effect of elevated environment on biomass (a, c) and grain yield of maize (t/ha) (b, d) under different nutrient management practices

French Beans growth and yield parameters

The experiment examined the effect of high temperatures and CO2 on the growth characteristics and pod production of French beans under FATE. According to the results, the yield for SDW, RDW, and pod varied from 2.82-3.54 g/plant, 0.7-1.24 g/plant, and 6.57-8.16 t/ha, respectively. The increase in temperature (ET) alone caused a decrease in SDW, RDW, and pod yield by 10.8, 58.4, and 19.7% compared to the ambient environment. The yield of SDW, RDW, and pod was increased by 13, 12, and 4%, corresponding to the ambient environment, when CO2 was added with ET. ET+ECO2 had SDW (25%), RDW (77%), and pod yield (24%) that were significantly higher than ET alone (Figs. 20a and 20b). The losses of SDW, RDW, and pod yield were compensated by about 12, 65, and 20% by the addition of ECO_2 to ET, as stated. One of the nutrient management practices, FYM had about 51, 48, and 42% increases in SDW, RDW, and pod yield. Inorganic fertilizers showed about 67, 45, and 55% higher SDW, RDW, and pod yield. The INM experienced the highest increase of 86, 51, and 59% in SDW, RDW, and pod yield, respectively compared to control.

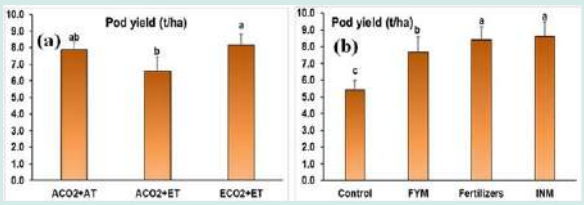


Fig. 20. Effect of ECO_2 and ET on French beans pod yield (a) under different nutrient management (b) practices.

The impact of elevated CO2 and temperature on rice and soybean growth and productivity in the Carbon Dioxide Temperature Gradient Chamber (CTGC)

(T. Ramesh, B.U. Choudhury, and R. Krishnappa)

Second year experiment was conducted in the CTGC to study the effect of ECO_2 and ET on the growth performance of rice and Soybean (Fig.21). The main treatment consisted of (i) ACO_2 and AT, (ii) AT and ECO_2 (550 ppm), (iii) ACO_2 and ET (+3° C), and (iv) ECO_2 (550 ppm) and ET (+3° C). The sub-treatments consisted of (i) Control (no fertilizer/manure), (ii) Inorganic fertilizers (NPK), (iii) Integrated Nutrient Management (INM), and (iv) Organic manure (FYM).

Fig.21. Rice and Soybean performance evaluation under elevated environment in CTGC facilities.

Rice growth and yield attributes

Rice variety IURON 514 was chosen as an experimental crop for this experiment. The results revealed that the average plant height, panicle length, no. of tillers, shoot dry weight, root dry weight, and 1000 seed weight ranged from 124-152cm, 26-31cm, 4.9-8.8, 25-37 g/plant, 3.4-6.4 g/plant, and 23-24 g, respectively. Amongst the four CO_2 and temperature combinations, the ET+ECO_2 combination recorded the highest value of plant height, SDW, and test grain weight which increased by 9-23, 7-46, and 4.3-6.1%, respectively. On the other hand, ECO_2+AT recorded an increase in panicle length, number of tillers, and RDW by 7-18, 22-79, and 5-88%, respectively, over other treatment combinations. The highest above ground biomass yield (=33 to +56%) was observed under ET+ECO_2 (4.7 t/ha) than the other treatment combinations (Fig. 22a). ET+ECO_2 achieved a maximum grain yield of 28 q/ha, which is approximately 44% higher than the ambient conditions (Fig. 22a).

INM observed a significant increase in plant height (3-11%), panicle length (2-6%), number of tillers (3-17%), and SDW (1-16%) in nutrient management practices while RDW was the most effective inorganic fertilizer (18-25%) compared to other nutrient management practices. Application of inorganic fertilizers showed an 11-29% increase in straw yield compared to other practices (Fig. 22b). On the other hand, the FYM application had about a 5-42% increase in grain yield compared to other nutrient management practices (Fig. 22b). From this study, it can be concluded that the plant growth parameters were significantly improved by ECO_2+AT and ET+ECO2, including grain yield, ET alone significantly decreased plant growth parameters over other treatment combinations. However, the inclusion of ECO2 with ET could negate the impact of elevated temperatures irrespective of nutrient management practices. A suitable nutrient management option could be to follow INM practices under elevated climatic conditions, which would result in higher grain and biomass yields.

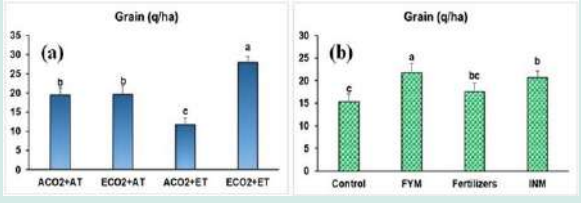


Fig. 22. Effect of elevated CO2 and temperature on rice grain yield (a) under different nutrient management (b) practices

Soybean growth and yield attributes

Elevated temperature (ET) decreased the root height (5.8%), shoot height (7.8%), number of pods (6.4%), and RDW (84%) while increasing the number of branches (4%) in French Beans compared to ambient conditions. ECO_2+ET resulted in an increase in root height, shoot height, number of branches, pods, RDW, and test grain weight in ambient conditions. The highest grain yield was recorded under ECO_2+ET (1.35 t/ha) followed by ECO_2+AT, while ET alone recorded the lowest yield (0.97 t/ha) (Fig. 23). The highest grain yield (24%) was recorded under FYM application, followed by INM and inorganic fertilizers (at par) compared to control among nutrient management practices.

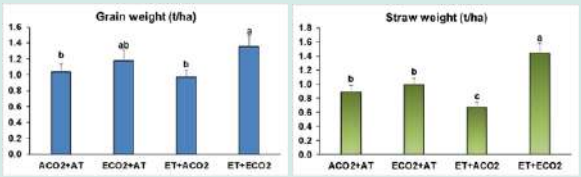


Fig. 23. Effect of elevated CO2 and temperature on French Bean grain and straw yield under different nutrient management practices.

Evaluation of carbon sequestration potential and soil carbon stock of major Agroforestry / other land use systems in the Northeastern Hill ecosystem

A. Mizoram Center *(Contributor: Lungmuana):* For the evaluation of carbon sequestration potential, eight dominant land use systems were selected in the mid hills of Mizoram, ranging in elevation from 500 to 800m MSL (Fig. 24). Soil samples were collected from three locations to be replicated and, at each location, five points were delineated, and composite samples were collected. For analysis, soil samples were collected up to one meter depth (0-100 cm; 0-20, 20-40, 40-60, 60-80, 80-100 cm). The soil pH ranged from 4.5 to 5.3 across the soil depth and land use systems (Table 1).

Fig. 24. Soil collection for C sequestration evaluation of different land use systems of Mizoram

Bamboo and areca nuts had the highest soil pH compared to other land uses. Water holding capacity (WHC %) ranged between 37.5% to 62.5% and decreased with increasing soil depth in all land uses except for agriculture. The available major nutrient content was low in the studied soil where the N ranges between 186.49 kg ha^{-1} to 322.80 kg ha^{-1}, P between 1.03 kg ha^{-1} to 15.19 kg ha^{-1}, and K between 128.25 kg ha^{-1} to 551.60 kg ha^{-1}. The N was the highest for areca nut, P for tree bean, and K for teak in the soil profile, where P and K decreased with the soil depth increasing. Dehydrogenase activity, an indicator of soil health ranged between 0.24 µg TPF $g^{-1}h^{-1}$ to 6.92 µg TPF $g^{-1}h^{-1}$ where the activity was the highest orange (2.83 µg TPF $g^{-1}h^{-1}$). The highest concentration of soil basal respiration was found in forest soil (1.86 µg CO_2-C $g^{-1}h^{-1}$) and it significantly decreased with soil depth. The TC ranged between 6.77 to as high as 24.50 mg kg^{-1} with the highest value observed in the tree bean soil profile (15.81 mg kg^{-1}) and significantly decreased with increasing soil depth.

Table 1. Two-way ANOVA of the studied soil parameters in Mizoram

Sl. No.	Soil Parameters	Landuse (L)	Soil depth (D)	LxD
1	Soil pH	19.39**	ns	ns
2.	WHC	5.33**	11.55**	3.51**
3.	Available N	11.98**	38.27**	ns
4.	Available P	9.01**	58.48**	3.78**
5.	Available K	35.15**	82.98**	4.55**
6.	Dehydrogenase	24.14**	881.85**	3.94**
7.	Basal respiration	32.33**	525.15**	3.80**
8.	Total Carbon	16.83**	881.0**	5.1**

The study suggested that leguminous tree-like tree bean is important in conserving soil C and also improves the biological soil properties compared to other land uses like oil palm to maintain soil health. Plantation trees, such as oranges and areca nuts, conserved soil C and improved biological soil properties compared to other plantations, such as teak, rubber, and oil palm.

B. Sikkim Center

(S. K. Das)

The active carbon (AC) pool is a very labile and labile pool of oxidable organic carbon. The mean AC pool in soils was between 19.1 and 23.3 Mg ha^{-1} across the land use in the 0-90cm depth (Fig. 25). Among the land use/ cropping systems, Black gram + Mandarin + *Alnus nepalensis* and Soybean + *Ficus hookerii* + guava recorded significantly ($P \leq 0.05$) higher AC pool over Buckwheat + Mandarin in 0-15cm depth (19.2 Mg ha^{-1}). Compared with other land uses, Black gram + Mandarin + *Alnus nepalensis* (BMA) recorded the maximum weighted average AC pools (23.3 Mg ha^{-1}) followed by Soybean + *Ficus hookerii* + guava (SFG) (21.8 Mg ha^{-1}) in the top 0.90m depth. A minimum pool of total AC was registered in the land use practices of buckwheat + Mandarin (19.1 Mg ha^{-1}). The results confirmed that there were no significant differences in the total passive carbon (PC) pool in 0-90cm depth among soils of different land use systems. But the statistically same value of passive C pool at 0-15 cm depth was noticed between the Black gram + Mandarin + *Alnus nepalensis* and Buckwheat + Mandarin land use system. The PC pool in soils varied from 22.4 to 25.1 Mg ha^{-1} across land use in the 0-90cm depth.

Fig. 25. Soil collection for C sequestration evaluation of different land use systems of Sikkim

Meghalaya

(B. U. Choudhury, A. Singh, and A. Balusamy):

Land degradation worldwide is posed by abandoned cropland, particularly in the eastern Himalayas. The practice of converting forests into cropland and abandoning it is widespread. Soil degradation and carbon (C) losses can be mitigated by agroforestry systems. Restoration efforts are hindered by limited studies that compare abandoned cropland with agroforestry in soil C. The response of 18-year-old abandoned cropland to changes in soil C inventories in the eastern Himalayas (Meghalaya) was assessed by us (Fig.26). Four 35-year-old tree-based agroforestry were evaluated for soil C reconstruction using a 55-year-old dense mixed forest as a baseline. The contribution of trees and intercrop biomass, including leaf litter carbon, to agroforestry, was assessed as well. The total C concentration in forest soils was higher (p <0.05) (3.10%, weighted mean per 1.0m depth). Cropland abandonment caused a 45.5% decrease in TC, while agroforestry saw a smaller decrease (-25.8 to -28.1%). Total organic and inorganic carbon decreased more in abandoned cropland (-44.4 to -49.0%) than in agro-forestry (-25.5 to -33.3%). Soil microbial biomass C and active C pools declined more in abandoned cropland than in agroforestry. The forest had a total estimated C stock of 358.7 Mg ha-1 for a soil depth of 1.0 m and on conversion to agroforestry, it declined by 16.2-21.1% while in abandoned cropland, it declined more sharply (-35.5%). The amount of total C contributed by total organic C was 83.1-85.7%, while the amount of total inorganic C was 14.2-16.9%. Alder's tree biomass C (above and below ground) was 12.0-26.0% higher than agroforestry based on Som and Grevillea trees. Dead leaf biomass in agroforestry contributed between 1.68 and 1.75 Mg ha^{-1} year^{-1} C to the soil. Alder and pineapple provided a more readily available microbial and very labile C and C storage that is comparable to other agroforestry systems. The Indian Himalayas may benefit from the adoption of alder-pineapple agroforestry to restore carbon loss in degraded abandoned cropland.

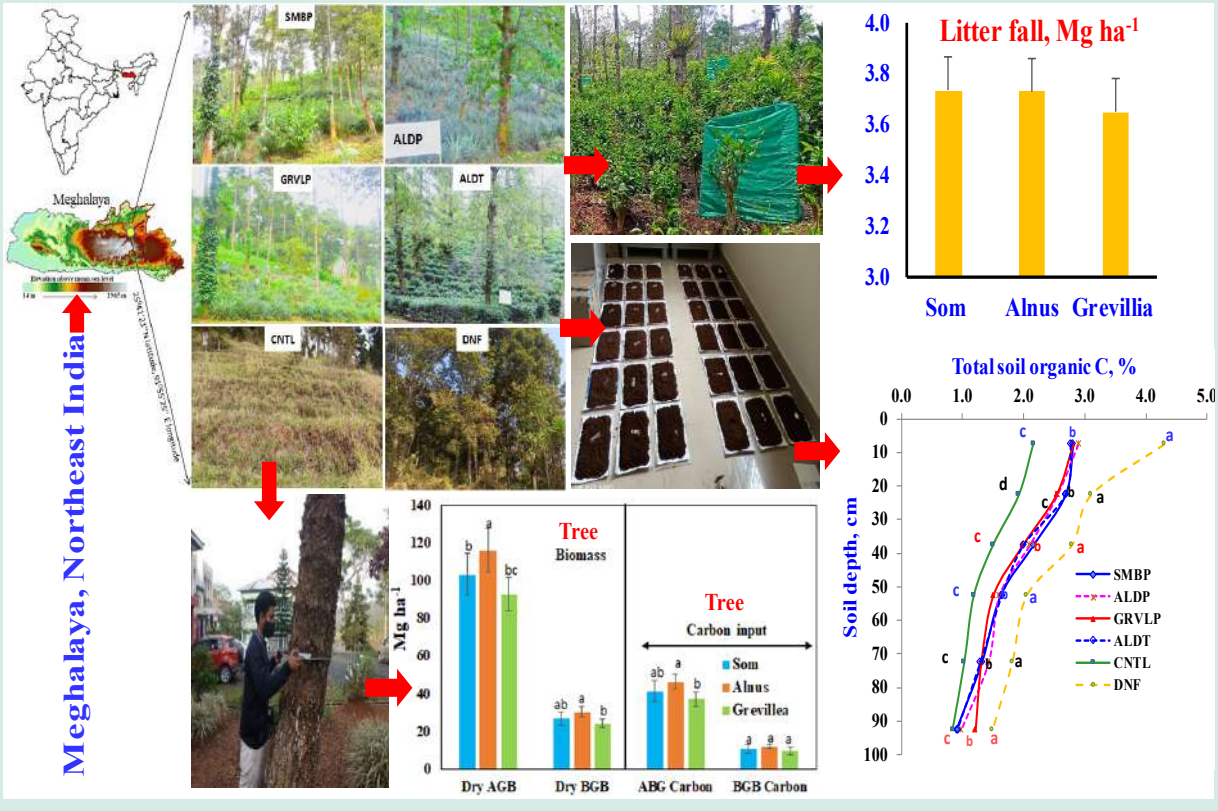


Fig. 26. Location of the study area (Umiam, Meghalaya in the Eastern Himalayan India) representing four Agroforestry systems (SMBP: Som +Broom +Pineapple, ALDP: Alder +Pineapple, GRVLP: Grevillea +Pineapple, ALDT: Alder +Tea), Abandoned cropland (CNTL), and Dense mixed forest (DNF)

Effect of irrigation regimes and N management on winter maize performance.

(L. K. Baishya and P. L. Bhutia)

To evaluate the performance of maize in differential moisture conservation and nitrogen (N) management, a field experiment was conducted in the foothills of Nagaland (Fig. 27). Two cultivars, sweet corn (NSCH-130) and locally grown maize, were used in the experiment. The experiment involved two factors: irrigation regimes (IW/CPE = 0.8; IW/PET = 0.8; mulching; control) and nitrogen (N) management (Recommended Dose of Fertilizer - RDF and Leaf Colour Chart – LCC (4-5)). Sweet corn was found to outperform local maize, with a significantly higher yield of 9.78 t ha^{-1}, length of cob (20.1 cm), and number of rows per cob (15.3). The management of nitrogen through LCC (4-5) resulted in a significantly higher green cob yield of 7.15 t ha^{-1} compared to the RDF treatment, as confirmed. The highest grain yield (8.57 t ha^{-1}) was achieved by the moisture regime at IW/CPE = 0.8 led among the irrigation regimes while the lowest grain yield was recorded in a plot without irrigation (5.38 t ha^{-1}). Analyzing the N content of the soil at a depth of 30 cm during the knee height and tasselling stages of maize revealed that the control group (without irrigation) showed a higher value of N (213.5 kg ha^{-1}) after harvest compared to other treatments.

Fig. 27. Experimental field of winter maize crop having (a) Sweet corn and (b) local maize cobs

Double cropping in the Jhum ecosystem through soil moisture conservation practices in Arunachal Pradesh

(B. Makdoh and A. Tasung)

This field experiment was conducted in Jhum field situated at the Research farm, Gori, ICAR Research Complex, AP center, Basar during 2022-23. Jhum rice was sown in normal conditions in the farmers' Jhum field on April first week and harvested in August last week 2022. Immediately after the harvest of rice, three crops were taken with the imposition of various soil moisture conservation (SMC) measures (Fig. 28). The experiment was laid out in factorial RBD with five (5) SMC measures viz., T1: Control, T2: Paddy straw mulching after harvests @ 2.0 t/ha, T3: Double mulching using weed biomass (fresh @10 t/ha) at growing stage+ S1, T4: Conservation furrows after 2 rows interval+ in-situ paddy straw retention, T5: Contour trenches at 2 m intervals + in-situ paddy straw retention, followed by three (post kharif) crops viz., C1-Frenchbean, C2-Green gram, and C3-Buckwheat. The subsequent crops were sown under the recommended agronomic management practices. During the cropping season of post-rice harvest, the field received an ample amount of rainfall (>800mm). With the imposition of SMC measures, there was a moisture retention of more than 17% compared to the control. The soil moisture profile dynamics depicted in Figure 29 illustrate that at a depth of 0 to 5 cm, higher moisture retention was observed in mulching and double mulching at 30-90 days after sowing (DAS). At soil depths of 5-15 cm and 15-30 cm, conservation furrows produced better results, particularly after 90 DAS. As crop stages progress, the soil at lower depths was observed to retain more moisture in contour trench plots as harvested water seeps down the soil profile. With respect to yield performance, green pods of French beans were 21-45% higher in SMC measures than the control.

Fig.28. Post-Jhum rice winter crops grown under different moisture conservation practices in Arunachal Pradesh

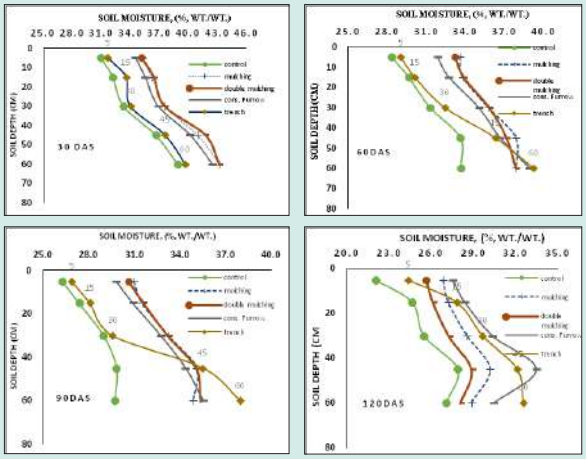


Fig.29. Profile moisture dynamics in the Jhum field post rice harvest

Similarly, the yield of green gram and buckwheat was 7-25% and 6-24% higher than the control treatment, respectively. The highest grain yield of green gram was observed in T4 (4.94 q/ha) and the least in control (3.94 q ha^{-1}). The rice equivalent yield was the highest in T_2 (3630.4 kg ha^{-1}) which was tied with T_3 (3605.2 kg ha^{-1}) and T_4 (3524.0 kg ha^{-1}) and the lowest in T_1 (2762.8 kg/ha). The water use efficiency (WUE) of French beans in T2, T3, and T4 increased by 36.3 to 41.1 % over the control. Leaf area covered by mulching and conservation furrows has increased by 26% and 20% respectively. The highest chlorophyll content was found in mulching, which was 27% more than the control. According to this study, mulching and conservation furrows can be utilized as effective SMC measures for double cropping in Jhum ecosystems in the mid-hills of Arunachal Pradesh.

Spectral library of crops and discrimination of major vegetables grown in the eastern Himalayan ecosystem: a proximal hyperspectral remote sensing approach

(B. U. Choudhury)

It is difficult to identify, characterize and map unique vegetable crops grown on small mixed lands in the eastern Himalayan mountainous ecosystem using traditional methods. The exploration of high-resolution, multispectral optical satellite data to map vegetable areas is hindered by heavy rainfall, clouds, and year-round fog/snow cover. The region bordering several international countries restricts hyperspectral imaging to security concerns. Vegetable crops grown in the Himalayan ecosystem are not covered in the global literature on spectroscopy. Using a portable Field Spec Handheld2 (ASD) spectroradiometer, we characterized 28 important vegetables from 10 different families (Fig.30). Over consecutive seasons (summer and winter) in 2020-2022, they were grown without stress (healthy) in the experimental field (Umiam, Meghalaya, Eastern Himalayas). The ground radiometer had a spectral resolution of 3 nm in the 325 to 1075 nm wavelength range. During critical growth stages, data was obtained at 1100 and 1300, 1 m above the crop at less than 25° FOV during cloud-free days. Crop-specific sensitive wavebands were identified and 12 vegetation indices (VI) relevant to the biophysical and biochemical properties of crop discrimination were estimated. Near infrared region (NIR: 700-1070 nm) was effective for crop discrimination. Of the 10 families, the mean NDVI values varied in the next descending order: Umbelliferae (0.878)> Malvaceae (0.863)>Cucurbitaceae (0.802)>Lamiaceae (0.732)>Solanaceae(0.721)>Leguminosae(0.651)> Cruciferae (0.607)> Amaranthaceae(0.604)> Zingiberaceae (0.595) >Liliaceae (0.531). Fenugreek (0.922) had the highest NDVI among vegetables, while Broccoli had the lowest (0.421). The position of the red edge (700-750nm) varied greatly, and the estimated VI values representing chlorophyll, carotenoids, xanthophyll, and anthocyanin pigments varied between crop families. We defined the scales of these indices as healthy or stressed crops for the region. From the multi-season spectral signature, a Spectral Crop Library (CSL) of all vegetables was developed under clearly defined conditions (growth stage, time and year, soil, cultivar type, and climate). The CSL generated from the study provides a baseline spectral source for spatial mapping and quantitative spectral modeling to evaluate crop conditions and prescribe measurements. Promoting precision agriculture in the eastern Himalayan ecosystem and other similar ecosystems will require this crucial step.

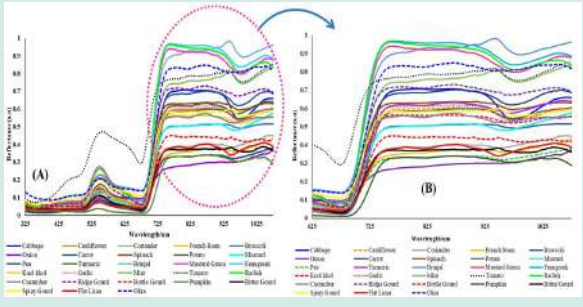


Fig. 30. Spectral library of 28 vegetables (A) full spectrum (325 to 1075 nm), (B) peak reflectance 791 to NIR spectrum (700 to 1075 nm).

Developing an Android Mobile App – Northeast Soil Plus (NES+):

(B.U.Choudhury, Md. Zafar, B.C. Verma, and S. Hazarika)

NES+ (North East Soil Plus) is an Android mobile application that covers 12 important soil parameters (soil acidity, carbon, macro-, and micronutrients) for acid soils in the NE region (Fig.31). The use of this software will be advantageous in assessing the status of soil health based on the field test results. In this application, there is a recommendation guide that covers location-specific soil acidity and plant nutrient management for nine important crops (rice, maize, pulses, and vegetables). Generally speaking, it falls under the Soil Health Card + Recommendation gambit. The Hon'ble Union Minister of Agriculture and Farmer's Welfare Shri Narendra Singh Tomar launched this Android Mobile App on January 5th, 2023 in the inaugural session of North East Krishi Kumbh 2023.

Fig.31. Android mobile application (NES+) for soil fertility recommendation guide

Animal Component

Development of an eco-friendly heating system to manage cold stress during pre-weaning period in piglets reared under hill ecosystem of Meghalaya

(R. Katiyar and S. Deori)

Pre-weaning mortality in piglets is one of the major management problems that affect herd productivity and economics in the swine industry. Cold stress during the winter season is one of the main causes of pre-weaning mortality. Considering this fact, the study aimed to investigate the performance of piglets on exposure to "The Briquette Fuel Animal Heating System (BFAHS)" (Fig.32). It is designed to burn beehive briquettes (charcoal and mud in a 2:1 ratio) and consists of skeletal support, casing, top cover, and wire mesh. One briquette can produce heat for up to 2 hrs. Thirty (n=30) piglets were subjected to three groups viz. Incandescent bulb (T1), Beehive briquettes (T2), and Control (T3) in 3 farrowing pens over a period of two months (January-February). The heating system was placed inside the crate. The body weight and body condition score (BCS) were recorded at 15 days intervals. Mortality was also recorded. The findings of the study revealed that body weight at 30 and 45 days was higher ($p \leq 0.05$) in the Beehive group as compared to other groups. Also, no piglet mortality was observed in the beehive group. Whereas, the number of piglets that died during the course of the study was 3 and 2 in the control and Incandescent bulb groups, respectively. The number of piglets with body condition scores (BCS) BCS-3 was 10 in the T2 group, whereas the number was 5 and 4 in T1 and T3 groups, respectively. The study's findings indicate that BFAHS can be effectively utilized during winter to improve piglet performance and avoid pre-weaning mortality from cold stress.

Fig.32. Briquette fuel heating system

Alligator weed supplementation in chicks' diet improves production performance, immune response and antioxidant function during winter season

(K. Puro, S. Deori and S. Doley)

Alligator weed (AW) can have severe ecological and economic consequences by impacting water quality, flow, and the growth of native flora and fauna. Plants, both edible and inedible, contain phenolics, compounds that can serve as antioxidants. Using this background information, the study aimed to explore the possible anti-oxidative nature of alligator weed (AW) by incorporating it as a supplement on production performance, gene expression, and antioxidant levels during the summer and winter seasons in chicks. A proximate analysis of AW is presented in Table 2. Two hundred forty (n= 240; 35 days old) chicks were subjected to 4 experimental treatments over a period of 35 days during the study seasons (summer

and winter). The experimental diet consisted of the following: Control diet without any supplements (C); basal diet + 1% AW (T1); basal diet + 2% AW (T2) and basal diet + 4% AW (T3). The production performance, cytokine gene expression (IFN-γ, IL-1β, IL-6, IL-12) and iNOS, serum antioxidants viz., catalase (CAT), and superoxide dismutase (SOD) were evaluated. Results indicated that body weight, average body weight gain, and weekly feed intake in the T1 group were significantly (p <0.05) higher as compared to other groups. FCR in group T1 was significantly (p <0.05) lower during winter than in summer. A significant (p <0.001) up-regulation in the expression of IL-6, IL-1β, and IL-12 in T1 as compared to other groups was reported. IFN- γ, IL-1β, IL-6, and iNOS were significantly (p <0.001) up-regulated in winter. SOD and CAT activity was significantly (p <0.001) higher in T1 as against T0, and both were significantly (p <0.05) higher during winters as against summer. Results suggested that AW has the potential to mitigate the consequences of cold stress on growth, immune response, and antioxidant function during winter. We propose adding 1% AW which can possibly function as an antioxidant to the diet of chicks to enhance their production performance and immunity levels.

Table 2. Proximate Analysis of Alligator Weed

Proximate components	Moisture	DM	TA	CP	EE	CF	NFE
	82.57	17.43	8.51	25.48	1.97	17.30	46.74
	0.40±	**0.40±**	**0.26±**	**1.42±**	**0.51±**	**1.34±**	**2.55±**

Black Turmeric: A Feed Supplement for Combating Heat Stress in Laying Hen

(V. Singh)

Birds are very much susceptible to heat stress and it affects their growth, productive performance, reproductive performance, and egg quality traits of poultry birds which causes very huge economic losses to poultry farmers. Therefore, it is very essential to minimize the economic losses due to heat stress in birds by adopting climate-resilient technologies. Black turmeric *(Curcuma caesia)* is an auspicious herb that has anti-oxidant properties and medicinal values. It contains 1-8 cineole, camphor, turmerone, camphene, curcumene, and other flavonoids and alkaloids. Considering this background information, the study aimed to explore the possible anti-oxidative nature of black turmeric by incorporating it as a feed supplement on production performance, egg quality traits, blood-biochemical profile, and stress parameters in laying hens during heat stress conditions (Fig. 33). Five groups of birds (Dahlem Red, Age 30 week) are maintained in stress condition (37^0C) while other one group of birds is kept as a control in a normal environment to compare the effect of heat stress. Induced heat stress (37^0C) is created in a poultry shed for 4 hr daily for 30 days. Birds are fed a basal diet supplemented with black turmeric powder (0.5, 1.0, 1.5 & 2.0%) during the feeding trial. Recording of data like body weight, feed intake, egg production, egg weight, rectal temperature, and other parameters of birds is going on at regular intervals. Proximate analysis indicated that black turmeric powder contains 73.62% moisture, 20.23% CP, 7.95% total ash, and 1.68% ether extract (Table 3).

Table 3. Proximate Analysis of Black turmeric

Proximate components	Moisture (%)	DM (%)	CP (%)	TA (%)	EE (%)
	73.62	26.38	20.23	7.95	1.68

Emerging Viral Infections in Pigs in the Climate Change Scenario: Sero-molecular Epidemiological Investigation (Animal Health Component)

(A. A. P. Milton)

In recent years, pigs have emerged as a key focal point due to their susceptibility to various viral pathogens and their potential role as intermediaries for zoonotic transmission to humans. The alarming rise in these viral infections among pigs can be attributed to multiple factors, including changes in climate patterns resulting from climate change. This project aims to investigate the sero-molecular epidemiology of two prominent viral infections in pigs, namely Japanese encephalitis and African swine fever, within the context of a changing climate. This investigation will employ

a sero-molecular approach, combining serological and molecular techniques, to analyze the prevalence, distribution, and genetic characteristics of these viral infections among pig populations. Ultimately, this study will provide insights into the epidemiological patterns and genetic diversity of these viral pathogens in the context of climate change. Understanding the interplay between climate change, viral infections, and pig populations is crucial for developing effective surveillance, prevention, and control strategies. So far, 300 serum and blood samples were collected from pigs in Meghalaya and 60 tissue samples suspected of ASF were acquired from Dept. of Vety. & A.H., Govt. of Meghalaya. ELISA analysis, DNA/RNA extraction, and molecular screening are in progress.

Technology demonstration under NICRA

Climate Resilient Technology for Active Flood Plain of Tripura

(L. Sahoo)

A flood plain system was developed and evaluated at ICAR RC for NEH Region (Fig.34). This technology is targeted at low-lying flood-prone zones. During unprecedented heavy rainfall, the extent of damage to crops is to the tune of 50-100%. In this system, the area of 0.15 ha was divided into raised and sunken bed systems. All the beds were used for paddy cultivation during the rainy season. In addition, lowlands were used for a fish culture where in high demand small indigenous and self-recruiting species like Puntius, Mola, and Kanla along with carp can be cultured. In addition, the raised beds were used for vegetable cultivation during the winter and summer seasons. Additionally, vegetables like Pumpkin, bottle gourd, bitter gourd, and ash gourd were also cultivated in vertical farming above the fish trenches.

Fig. 34. Climate resilient active flood plain production system

The paddy production in midland and lowland was lesser in 2020-21, probably because of the higher rainfall in September. But the production in the upland was not affected. Thus through this technology, farmers can reduce their economic losses. Vegetable was produced in all three levels, midland recorded more production than upland and lowland. The vegetable production ranged from 1.0 t/ha in the lowland to more than 6.0 t/ha in the midland. To make the system more economical, edible aquatic plants like Water mimosa and Ipomoea were introduced to the system along with fishes (Rohu, Catla, and Mrigal and SRS like Mola and Puti). Production of fish was 700-725 kg/ha with aquatic plants 600-750 kg/ha. Edible aquatic plants Incorporated in the system have very good demand in tribal markets and are sold at around Rs.30 -50/bundle. The system generated a gross income of Rs.2,60,000/ha/annum with a rice equivalent yield of 13 t/ha/annum. Thus the system could enhance productivity by about 3 times compared to conventional mono-cropping of paddy in flood-prone areas. Since field crops, vegetables, and fish are integrated with the system, it also generates year-round income and employment making the system climate resilient.

Rainwater harvesting structure (Jalkund) for use in water stress condition in Meghalaya

(N. Uttam Singh, A. Balusamy, A. Roy and B.U.Choudhury)

The technology was demonstrated at 10 farmers' fields in Kyrdemkulai and Mairung villages of Ri-Bhoi District, Meghalaya in participatory mode (Fig.35). The capacity of the Jalkund was 35,000 liters of water. Rain water from rooftops or direct rainwater was stored in the Jalkund during the rainy season which can be utilized to provide protective irrigation to the crops for successful cultivation. Stored water was utilized for the cleaning purposes of cattle and piggery houses. Fish rearing was also taken in the harvested water. Major crops which were grown through utilizing Jalkund harvested water include vegetable crops such as French beans, mustard leaves, mints, peas, and cabbage.

Fig. 35. Jalkund and its utilization in irrigating crops in Kyrdemkulai-5km and Mairung villages of Meghalaya

Implementation of an integrated farming system for some productive beneficiaries of Jalkund

(A. Roy, T. Ramesh, A. Balusamy and B. U. Choudhury)

The selection of sites for implementing the integrated farming system (IFS) under the NICRA Technology Demonstration Component was completed on 15th November 2022 in two villages Kyrdemkulai and Mairung villages (Fig.36). The site selected was based on the performance of the Jalkund beneficiaries of the two villages on how they maintained and utilized their Jalkund, farming practices and their interest on adopting scientific farming. On the basis of these attributes, out of the 8 sites surveyed, 4 sites were selected 2 from each village.

Fig. 36. Site selection for Integrated farming system

Introduction of an improved variety of pigs (Hampshire cross) and poultry (Rainbow Rooster) with a scientific method of rearing to address changing climatic scenarios.

(N. Uttam Singh, A. Roy, and team)

A total of 600 chicks and 25 piglets were distributed to the farmers of Kyrdemkulai on March 2022 where a total no of 25 farmers benefitted (Fig.37). Inputs in the form of veterinary medicines such as anthelmintics, vitamins and mineral supplements, anticoccidials, antibiotics, etc. were also distributed among farmers. The productive traits with disease incidence were recorded at the farmer's field. When compared to the local indigenous pigs and chickens, the improved livestock varieties gained higher body weight and feed conversion efficiency. The upgraded pig Hampshire cross pig shows a better performance than the local indigenous pig with a B: C ratio of 1.45 while that of the Rainbow rooster is 1.25.

Fig. 37. Improved livestock distributed to farmers in Kyrdemkulai village

The success story of a farmer on multiple stocking and harvesting with stunted fingerlings in ponds of SC farmers for better production and higher income

(L. Sahoo)

Stunted fingerlings are suitable stocking material for carp culture because of their higher survival rate. They can reach marketable size within a less time period i.e. grow up to 700-800 gm within 2.5 to 3 months leading to higher yield and income (Fig.38). These are having good market demand as they utilize seasonal grow-out ponds efficiently and fish can be sold at a higher price too. Multiple stocking and multiple harvesting (MSMH) is a method of composite fish farming, through which fish production can be increased by many folds (6 to 10 tons/hectare/year). This technology is a climate-resilient technology as the majority of farm ponds are seasonal. Regular stocking with stunted fingerling gives better growth and survival of fish in the ponds compared to stocking with spawn. Multiple harvesting releases obnoxious gases and mixing of bottom nutrients which enhances the primary productivity of the system. This also gives remuneration every 4 months to the farmers which he can utilize for his household and other agricultural operations.

Name: Fulkumar Sarkar: Address: Bamutia, Mohonpur, West Tripura

Status before intervention: Mr. Sarkar was practicing Single stocking and single harvesting with Catla, Rohu, and Mrigal spawns. He was earning Rs 35,000/ year from a 0.5-acre pond.

Status after intervention: Mr. Sarkar adopted the technique of MSMH and could earn Rs.62, 500/ from his water area.

Fig. 38. The success story of a farmer on the improvement of income generation from climate resilient fish production technology in Tripura.

A list of capacity-building programs that were conducted in 2022 under NICRA

Twelve numbers of Capacity building and Awareness programs on Climate resilient agricultural technologies, state of the art facility (FATE and CTGC), scientific fish farming Practices, mushroom cultivation, and Integrated Farming Systems were conducted for State Govt. Officials and farmers to help them understand climate change and the means they can adopt to mitigate the effects of climate change (Table 4, Fig. 39).

Table 4. List of capacity building programmes conducted under NICRA HRD/SC-SP at Meghalaya and Tripura

Sl. No.	Programme Heading /class of beneficiaries	No. of beneficiaries
1.0	Seven days Training Programme on "Climatic and Edaphic Stress Management under Changing Climate Scenario in Hill Agriculture: Applications of High Throughput Instruments"/ Meghalaya State Govt. Officials	30
2.0	Seven days training programme on "*Enhancing Climate Stress Resilience of Hill Agriculture under Changing Climate*", 14th – 21st March, 2022/ Meghalaya State Govt. Officials	33
3.0	Seven days residential training programme on "*Soil Health Management under Changing Climatic Scenarios*", 19th - 25th September, 2022/ A. Pradesh State Govt. Officials	30
4.0	Capacity building programme of farmers on Climate Resilient Agriculture through improved seeds, livestock mechanization and skill development at Tripura/ Farmers	45
5.0	National Campaign on "Emerging Aquaculture System and practices" on the occasion of "National Fish Farmers Day" at Tripura/ Farmers	60
6.0	World Fisheries Day at Tripura/ Farmers	35
7.0	Kisan Diwas at Tripura/ Farmers	60
8.0	Swachatta programme at KVK West at Tripura/ Farmers	53
9.0	Climate resilient practice for enhancing aquaculture productivity at Tripura/ Farmers	50
10.0	Climate resilient practice for enhancing aquaculture productivity at Gandacherra at Tripura/ Farmers	200
11.0	Capacity building programme on technological support for farmers livelihood improvement at Brajendra Nagar at Tripura/ Farmers	100
12.0	Capacity building programme on technological support for farmers livelihood improvement at Pratyekray at Tripura/ Farmers	100

Fig. 39. Capacity building programmes on climate resilient fish production at Tripura and Meghalaya

SCHEDULE TRIBE COMPONENT (STC)

More than 28,194 tribal famers from seven North Eastern states were benefited during 2022 under various livelihood improvement programmes conducted under Tribal Sub Plan (TSP). A total of 1364 numbers of different physical assets/ farm tools and implements viz., *Jalkund* (micro rainwater harvesting unit), low cost mushroom unit, low cost poly house, low cost vermicompost unit, low cost piggery unit, low cost poultry unit, low cost duckery unit, honey bee boxes, mini kit seed, knapsack sprayer, sewing machine, cycle weeder, vermi bed, silpaulin sheet, agro-shade net, pump, drip irrigation set, hatchery unit, nursery unit, 29 nos. animal health camp, 214 nos. veterinary health services and 3685 nos. of literature were created/ distributed in different tribal villages of north east India.

Development of climate resilient IFS/IOFS model village

In Sikkim, fifteen location specific Integrated Organic Farming System (IOFS) models were developed, and they exhibited a significant impact on livelihood improvement of hill farmers. Due to IFS interventions, the income of the farmer-benificiaries increased significantly. Depending on the components of IFS models and the area covered under the models, the net return varied between INR 67,000/- and 3,22,000/-. Similarly, 7 location specific IFS models were established in Manipur, reaching out to nine farmers and two farm women at four locations in Naorem Kabui village, five locations in Chingphu (Terapokpi) village, and two locations in Leimapokpam Kabui village. Various enterprises viz. cropping, fishery, poultry, piggery, horticulture, sericulture were selected for integration in these models. Combinations of these enterprises were made based on the farmers' preference and location specificity. Integration of field crops and poultry produced an average benefit-cost ratio of 2.5 to 1.4. At Basar, Arunachal Pradesh, three IFS models were established: two in the village of Sago and one in the village of Gori. The IFS model included elements like livestock (pigs, poultry, and ducks), vegetable crops, fruit crops (Khasi mandarin and Assam lemon), and vermicomposting units. Ten IFS models comprising vegetable crop under low cost poly house, oyster mushroom, vermicompost, *jalkund*, backyard poultry and piggery as components were established and demonstrated by KVK, West Siang, Arunachal Pradesh.

The IFS models with agriculture, horticulture, fisheries, piggeries/poultry, and vermicomposting unit as components were established in the fields of 46 farmer beneficiaries of Maova village by KVK Dimapur, Nagaland. Vermicomposting units helped in recycling of farm waste to meet the nutrient needs of the field/ horticultural crops. KVK Wokha, Nagaland established and demonstrated four IFS models: (i) horticulture-based integrated pig farming system, (ii) integrated poultry cum fish farming system, (iii) integrated duck cum fish farming system, and (iv) integrated pig cum fish farming system models in ten numbers of farmers' fields at Yanthamo village. The models were established on a 3 ha area that included concrete-floored scientific pig barns with pens that were 8x8 feet in size and a channel that led to a fish pond. A 15x30-ft low-cost polyhouse was also established for growing horticultural crops.

Distribution of seeds/ planting materials

Agricultural inputs like seeds, planting materials, mushroom spwan etc. was distributed among the tribal farmers during 2022. Seed (17.2 t) of improved varies of different crops viz., rice, maize, vegetable (cucumber, potato, French bean, chilli, brinjal, bhindi, bottle gourd, tomato, pumpkin, coriander, broccoli, radish, cabbage, cauliflower onion, okra, pea, high value seed spice etc.) was distributed among the hill farmers for increasing the productivity of crops. Besides these, 44,118 nos. of quality planting materials (tree seedling, fruit seedlings, vegetable seedlings) were also distributed among the tribal farmers. About 4893 packets (250 gm/400 gm) of mushroom spawn was distributed for popularizing of mushroom cultivation as an additional source of income.

Distribution of fertilizers /bio-fertilizer/soil amendment/ plant protection chemicals/ Micronutrients/FYM/vermicompost

Plant protection chemicals (131 kg), micronutrient (1317 kg), FYM/Vermicompost (4918 kg) was distributed among the tribal farmers for enhancing crop productivity as well as economic security.

Livestock, fish fingerlings and medicines

A total of 156 nos. of improved breeds of piglet, 4539 nos. of poultry chicks, 350 nos. of duckling and 69600 nos. of fish fingerlings, 33.3 t of animal/poultry/ fish feed, 6592 dose of medicine, 29 kg of mineral mixture, were distributed for income enhancement through scientific production and management of livestock/poultry/fishery/duckery. Further, 1370 nos. of artificial insemination were done during the year 2022.

Capacity building of tribal farmers

Training, demonstration, exposure visit and awareness programme (990 nos.) were organized for capacity building of tribal farmers in various field of agriculture (crop production, animal production and management, mushroom cultivation, production and management of horticultural crops etc.). A total of 11045 numbers of tribal farmers were benefited from these interventions.

AGRI-BUSINESS INCUBATION CENTER

To fulfill the objectives of ABI, the centre has organized seven (7) Sensitization/Awareness Programs/seminar/webinars/workshops during the year 2022 in collaboration with Food Safety and Standards Authority of India (FSSAI), Small Farmers Agribusiness Consortium (SFAC), National Bank for Agriculture and Rural Development (NABARD), Ministry of Micro, Small & Medium Enterprises (MSME) and a-IDEA, NAARM. Five (5) Entrepreneurship Development Programme (EDPs) were organized *viz.,* EDP on Meat Processing and Value Addition (8th- 17th March 2022); EDP on Mushroom Spawn Production (23rd – 25th March 2022), EDP in collaboration with Khyndai Kyntoit Social and Cultural Organization (KKSCO) funded by NABARD (10th-11th October 2022 and 10th February 2023), EDP on Processing and Value Addition (2nd -7th December 2022) in collaboration with ICAR-KVK Chandel, Manipur where more than 150 potential entrepreneurs have been trained in various sectors. One National Conference on Agri-Startups-Prospects, Challenges, technologies and Strategies (AGRiPACTS-2022) was organized during 26th-27th May 2022 in Gangtok, Sikkim in collaboration with Agricultural and Processed Food Products Export Development Authority (APEDA), Sikkim Organic Mission (SOM), Manipur Organic Mission Agency (MOMA) and National Bank for Agriculture and Rural Development (NABARD). More than 700 participants have participated during the conference which includes Technologists, Scientists, Business Experts, Agri-Startups, Students and Other Stakeholder from different Institutions across the country. New Renovated ABI Building which consists of Exhibition hall, Training cum Conference hall, incubates Chambers to provide the promotional facilities to the entrepreneurs associated with ABI centre was inaugurated by Dr. S. K. Chaudhary, DDG (NRM), ICAR, New Delhi on 17th July 2022 (Fig. 1 and 2). In addition, initiation of NARI outlet was facilitated by the ABI centre to provide market linkages/facilities to the entrepreneurs/enterprises. In addition, ABI and a-IDEA jointly organized FPO and Startup Immersion Programme on 5th March 2022, Sponsored by NABARD (Fig. 3).

The centre has supported and facilitated development and launching of five (5) innovative products viz., King chilli sauce of Ngayam Foods, Guava Fruit Tea of Shrin Food and Handmade Organic herbal Soaps (Tulsi & Neem Flavour, Lemon Flavour and Alovera Flavour) of Angela Rai. These products were launched in presence of Manipur state Hon'ble minister of Agriculture during 'Farmers Fair under "Kisan Bhagidari Prathamikta Hamari" on 26th April, 2022 at ICAR Research Complex for NEH Region, Manipur Centre. Mr. Rakesh Kh. Singh (Lemlei Enterprise, Manipur) has been facilitated in launching of the first Indegineous Canned Fish (pengpa & Ngaton) product in Northeastern region on 5th October 2022. Ms. Pipi Keithellakpam, one of the energetic and promising entrepreneurs, has created and inaugurated the first Artificial Insemination (AI) Centre on pig at Manipur under the support and guidance of ABI Centre on 23rd October 2022. She was trained for AI under ABI centre in collaboration with AICRP on Pig, ICAR RC NEH, Umiam. The centre has supported and facilitated launching ceremony of revamped packaging of IMA Chenghi (a heritage traditional shampoo) in presence of Hon'ble Minister (Ministry of Public work Dept., youth Affairs & Sport) Shri. Govindas Konthoujam on 12th November 2022.

The centre has also collaborated and sponsored in organizing Kisan Diwas (Farmers, Day) Cum National Mushroom Day-2022 at ICAR Research Complex for NEH Region, Manipur Centre on 23rd December 2022. During this programme, three (3) of ABI entrepreneurs has been awarded with Best Stall/Exhibition Award and approx 150 participants have been sensitized on the scope and potential of Mushroom production and Processing. Apart from these, ABI centre has worked on various publications including two (2) books, nine (9) book chapters, one (1) souvenir, five (5) training manuals and various numbers of brochures and information leaflets. During 2022, ten (10) entrepreneurs have been admitted for incubation and the centre has facilitated in testing of more than 40 food products for nine (9) entrepreneurs.

Fig. 1. Inauguration of renovated ABI Building by Dr. S. K. Chaudhary, DDG (NRM), ICAR, New Delhi

Fig. 2. Renovated exhibition hall to showcase and promote entrepreneurs' products

Fig. 3. ABI and a-IDEA jointly organized FPO and Startup Immersion Programme on 5th March 2022, Sponsored by NABARD

HUMAN RESOURCES DEVELOPMENT

Employees trained

During the relevant period (**April 2022 to March 2023**), a total of 102 employees participated in various types of training and capacity development programs. Training programs were primarily offered to those candidates for better improvement. Of the 102 employees, 37 scientists, 53 technical officers (including subject matter specialists from KVKs) and 12 administrative staff including finance staff, were trained **(Fig.1).** The host institutes/organizations that delivered training were the Food and Agricultural Organization (FAO), Institutes of Indian Council of Agricultural Research (NBPGR-New Delhi, IIHR-Bangalore, ICAR (RC) for NEH-Manipur, NAAS-New Delhi, NAARM-Hyderabad, NBSS & LUP- Nagpur, IISWC-Dehradun, DMR-Solan, IIVR- Izatnagar, ICAR-RCER-Patna, CTCRI-Bhubaneswar, etc.), State, and Central Agricultural Universities (SKUAST TAJ- Jammu, Mizoram University, N. Deshmukh Veterinary Science-Jabalpur, Kerala Veterinary and Animal Sciences University-Kerala, RPCAU-Bihar, CAU-Imphal, etc.).

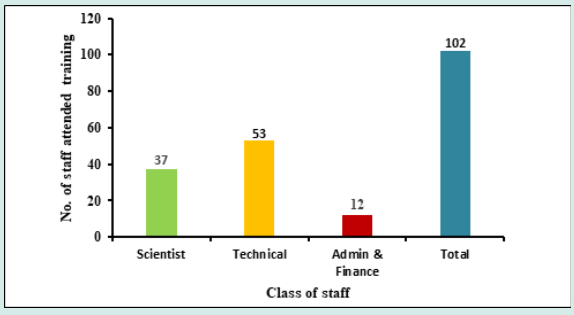


Fig.1. Different categories of employees trained at National Institute/ Universities during 2022-2023

Scientists: The scientists were trained to focus on enhancing skill, knowledge competencies to effectively manage and in order to hold leadership role, supervise team and contribute in various fields like Sustainable Entrepreneurship in Agriculture and allied sectors, Plant Genetic Resources Management and Utilization, Science and Technology for Staying Healthy & Feeding, Hydroponics in vegetable, Flower and control, Management of water surplus - deficit dichotomy in NE India, Recent advances in disease diagnosis and vaccines, Vigilance officers of ICAR Institutes, MDP on PME in agricultural research projects, Remote sensing and GIS in land resource management, Integrated nutrient management and nutrient budgeting, etc.

Technical Officers: Similarly, Training focuses on equipping them with necessary knowledge and skill to effectively handle related task and responsibilities within their technical role, technical officers (including KVK SMS) were trained to develop a business plan and accelerate OP/FPs, oil palm production technology, agricultural weather and climate services. In addition, they were trained in seed testing in accordance with the ISTA standard, Rejuvenation Technologies for Citrus Decline, Fall Armyworm Management on Corn, Creating an effective science document using LaTeX software, Natural Resource Management for Sustainable Horticulture, Livestock Based Integrated Farming System for Doubling Farmers Income, Advances in Weed Management for Sustainable Agriculture, Kisan Sarathi Portal Registration, Sericulture, family stress management: Issues and coping strategies, Statistical tools, research and data analysis, E-office and GeM procurement, Soil analytical methods for determination of Macro- and micronutrients, Seed Certification and Quality Control, Eri and Muga silkworm rearing and diseases and pest management, Handling and preservation of fish with waste utilisation, Adaptation and mitigation strategies for agriculture under climate variability situation, etc.

Administrative staff: Administrative staff, including finance staff, have received training on accrual accounting work, pension and retirement benefits, as well as electronic governance applications within the ICAR system, Administration, and Financial Management for the Assistant, Administrative Due Diligence Discipline, Training Program for Administrative and Financial Officers, Note Taking and Writing, etc. On the basis of the feedback received from trainees from various categories of employees, the impact of the training was deemed satisfactory for scientific staff (scale 4.10/5.0). Similarly, technical staff (including SMS, administration and finance) also provided 3.97 feedbacks on a 5.0 scale to improve their professional performance.

Training programmes organized during the reporting period (April 2022-March 2023)

From April 2022 until March 2023, the Institute organized a total of 22 trainings for various stakeholders, including government officials, extension officials, students of professional courses and unemployed rural youth (**Fig.2**). In addition, a further 460 trainings for farmers in the North-East region were organized (**Fig.3**). Thus, a total of 482 training programmes was organised for various stakeholders during the periods April 2022 to March 2023 (**Fig.3**).

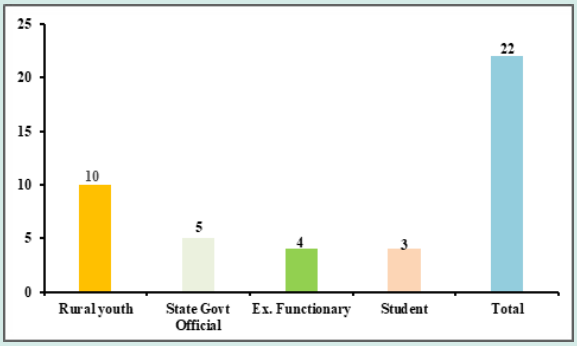


Fig.2. Total numbers of training programmes (excluding farmers) conducted for various stakeholders (2022-2023)

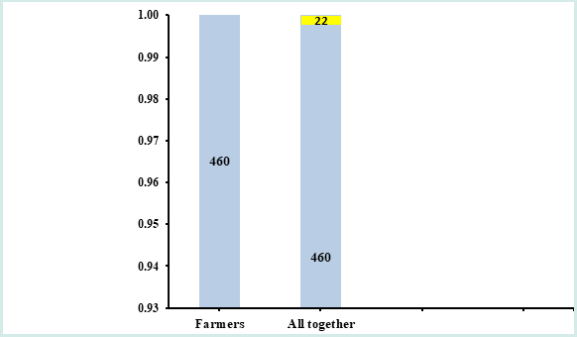


Fig.3. Total numbers of farmers and all together training programmes conducted for various stakeholders (2022-2023)

Beneficiaries covered in the training programmes-

Among the 22 training programs, 152 rural youth were trained in independent agricultural entrepreneurship, agribusiness skills on value addition of agricultural and allied sectors (poultry/ piggery framings, meat processing, milk products, etc.) (**Fig. 4**).

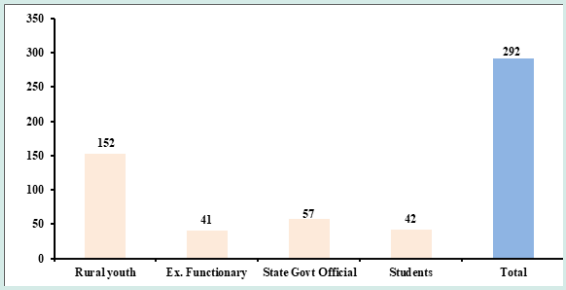


Fig.4. Number of benefiociaries (Excluding farmers) trained during FY (2022-2023) under different sections.

As well, 57 government officials were trained on climate change adaptation and mitigation strategies for agriculture and related sectors, advanced agricultural tools (Remote sensing/GIS, greenhouse gas emission measurements, statistical computing tools, etc.) for the duration of seven days (**Fig. 4**). Other beneficiaries include extension officials and students in vocation training (**Fig. 4**).

Farmers: A total of 460 one-day to seven-day training programs covering 14,943 farmers (**Fig. 5**) were delivered in eight states in northeaster India. The training programs were self-help group formations, soil health management and crop productivity enhancement, value addition in agriculture commodities, rural poultry and pig farming for livelihood improvement, animal health management, disease and pest managements, Mushroom production, Bee-keeping, Jalkhund and water productivity improvement, Apple and citrus production technology, acid soil management, Value addition of vegetables and fruits, etc .

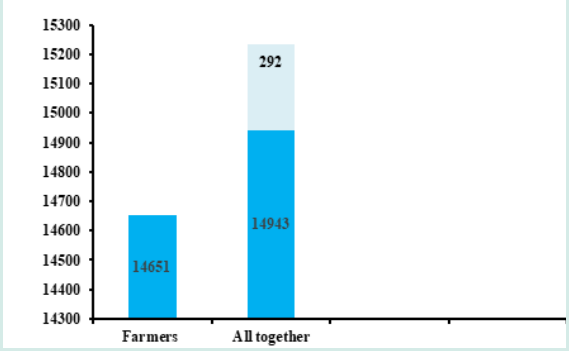


Fig.5. Numbers of farmers as beneficiaries trained during FY 2022-2023 under different section.

KRISHI VIGYAN KENDRA (KVK)

ICAR Research Complex being one of the premier Institutes in the region is relentlessly involved in developing location specific technologies through its various divisions in the headquarters and regional centres which are disseminating to farmers field through KVKs. The twenty (20) KVKs (Hailakandi in Assam; Anjaw, Longding, Namsai, West Siang in Arunachal Pradesh; Chandel, Churachandpur, Imphal West, Tamenglong and Ukhrul in Manipur; Ri-Bhoi and West Garo Hills in Meghalaya; Peren, Longleng, Kiphere, Wokha and Dimapur in Nagaland; East Sikkim in Sikkim; South Tripura and West Tripura in Tripura) are under the administrative control of the Institute. The KVKs in both the Zones i.e Zone VI and Zone VII are performing multi-dimensional roles, starting from core activities such as technology backstopping, resource-conservation methods, introduction of cutting edge technologies and upscaling at one end and envisioning entrepreneurial opportunities in rural areas, providing vocational/skill training to rural youth, women folks.

The mandate of KVK is Technology Assessment and Demonstration for its Application and Capacity Development (TADA-CD). To implement the mandate effectively through creation of awareness about improved agricultural technologies, the following activities have been defined for each KVK.

- On-farm testing to assess the location specificity of agricultural technologies under various farming systems.
- Out scaling of farm innovations through frontline demonstration to showcase the specific benefits/worth of technologies on farmers' fields.
- Capacity development of farmers and extension personnel to update their knowledge and skills in modern agricultural technologies and enterprises.
- Work as Knowledge and Resource Centre for improving overall agricultural economy in the operational area.
- Conduct frontline extension programmes and provide farm advisories using ICT and other media on varied subjects of interest to farmers.
- Data documentation, characterization and strategic planning of farming practices.

These KVKs are working tirelessly at the grass root level for the upliftment of the farming community and the society in general through these technologies by assessment and refinement, demonstrations, capacity building/trainings etc. During the reporting period a total of 781 nos. training programmes were conducted in different areas of agriculture and allied activities covering 24,544 nos. of beneficiaries across the region which includes farmers/farm women, rural youth, extension personnel and other agri-preneurs. The major areas of training were on Crop production, Soil Health and Fertility Management, Integrated Nutrient Management, Integrated Pest Management, Integrated Farming System, Disease Management, Crop Diversification, Processing and value addition, Small tools and implements, Management in farm animals, Mushroom cultivation as income generator, Vermicomposting technique, Bee Keeping, Organic farming, Scientific Honey bee rearing, Protected cultivation of Vegetable crops, Nutrient Use Efficiency, Poultry Management, Fodder production and quality enhancement, empowerment of rural women, plant protection, etc. In order to assess the location specificity of agricultural technologies under various farming systems, 134 nos. of On Farm Trials were conducted on the farmers' field under the thematic areas of varietal evaluation, integrated farming systems, integrated disease management, integrated nutrient management, value addition, storage techniques, farm machineries, etc. To demonstrate the production potential of newly released technologies on the farmers' fields at various locations, more than **168 nos**. of technologies were demonstrated on cereals, pulses, oilseeds, vegetable crops, fruit crops, flower crops, plantation crops, fodder crops, livestock, fisheries, feeding management, vaccination, breed performance, etc. During the reporting period, the KVKs organized **5205 nos**. of other extension programmes / activities reaching over **60,734** farmers and other targeted beneficiaries including farm women, rural youth, school children, etc. The major extension activities include Diagnostic visits, Exposure visits, Scientists visit to farmers' field, Kisan

Mela, Animal Health Camps, Field Days, Exhibitions, Advisory services, Soil Health Testing Campaigns, TV/ Radio Talks, Celebration of important days, Film Show, Self Help Group Convenors Meeting, Method demonstrations, Kisan Goshthis, Mahila Mandal Convenors Meetings, distribution of extension literature like technical bulletins, leaflets, pamphlets, folders, etc.

Apart from the mandated activities, KVKs were also involved in many other projects and programmes like National Innovations in Climate Resilient Agriculture(NICRA), Cluster Frontline Demonstrations of Pulses and Oilseeds under National Food Security Mission(NFSM), Attracting and Retaining of Rural Youth (ARYA), Skill Development Programme under ASCI, Swachhta Action Plan, Tribal Sub-Plan programme, Central Sector Scheme-Formation and Promotion of FPOs Project under NCDC, Scientific Beekeeping under Beekeeping and Honey Mission (NBHM), Boitech-KISAN programme, Poshan Vatika Maha Abhiyan and Tree Plantation, Farmers' Outreach Programme on Natural Farming, Scaling Out Climate Smart Agriculture for Resilient Farming in India, etc

The KVKs also established linkages with other departments/ agencies also like, IIAB, Ranchi, NFDB, IIHR, Benhgaluru, CIFT, Cochin, DCFRI, CRIDA, Hyderabad, SBI, NBHM, NABARD, ATMA, .

KVKs were also engaged in conducting special programmes viz., World Soil Day, World Fisheries Day, World Honey Bee Day, International Women's Day, Poshan Maah, World Environment Day, Swachhta Pakhwada,.

Other than the above activities, construction work for administrative buildings of 10 nos KVKs were initiated viz., Hailakandi, East Sikkim, Anjaw, Kiphere, Peren, Dimapur, Imphal West, South Tripura, West Tripura and West Garo Hills. The vehicles (Bolero) for KVKs were also placed orders for the procurement on replacement basis for nine (9) KVKs viz., Hailakandi, West Siang, East Sikkim, Namsai, Dimapur, Wokha, Churachandpur, Ukhrul and West Garo Hills) under Zone VI and Zone VII, respectively for smooth functioning of KVKs..

Table1. Activities undertaken in KVKs of ICAR Research Complex for NEH Region during 2022

Sl No.	Name of the Place	Training Program	Participants Nos	FLDs	OFTs	Extension Activities	No. of beneficiaries
1)	Wokha	34	1610	06	07	205	4341
2)	Dimapur	61	1605	04	04	148	2976
3)	Tamenglong	79	2090	12	12	336	5428
4)	East Sikkim	23	587	12	08	311	3962
5)	Imphal West	28	917	16	12	180	2143
6)	Peren	47	1185	06	06	108	2174
7)	West Garo Hill	32	1066	05	03	202	3373
8)	Longding	14	832	02	02	74	257
9)	Ri- Bhoi	61	1517	10	10	530	5085
10)	South Tripura	40	911	09	09	517	5344
11)	Anjaw	12	362	02	02	81	224
12)	Longleng	24	1488	04	02	168	3238
13)	Kiphire	19	620	04	03	104	3238
14)	Namsai	34	1580	07	05	412	2204
15)	Hailakandi	36	1026	08	06	502	8936
16)	West Tripura	25	892	11	04	284	2790
17)	West Siang	37	1814	08	08	120	1980
18)	Ukhrul	35	975	08	08	130	1382
19)	Chandel	72	1448	17	12	121	2132
20)	Cepur	68	2040	12	11	521	2765
	Total	**781**	**24544**	**168**	**134**	**5205**	**60734**

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Other publications

Book chapters: **13**
Technical/Extension bulletins: **06**
Abstracts: **76**
Leaflets/Folders/epub/Training manuals: **21**
Popular articles/Success stories: **36**
Total: **152**

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Other publications

Books: **04**
Book chapters: **11**
Technical/Extension bulletins: **02**
Abstracts: **18**
Leaflets/Folders: **05**
Popular articles/Success stories: **05**
Total: **45**

MIZORAM CENTRE

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Other publications

Books: **06**
Book chapters: **06**
Technical/Extension bulletins: **01**
Abstracts: **07**
Leaflets/Folders: **07**
Popular articles/Success stories: **09**
Total: **35**

NAGALAND CENTRE

Research Papers

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Other publications

Book: **01**
Book chapters: **06**
Technical/Extension bulletins: **02**
Popular articles/Extension folders: **19**
Total: **28**

SIKKIM CENTRE

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Other publications

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Abstracts: **14**
Popular articles/Success stories: **24**
Total: **56**

ISBN 978-93-5967-409-4

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