वार्षिक प्रतिवेदन
Annual Report
2023

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उत्तर पूर्वी पर्वतीय कृषि अनुसंधान परिसर
उमियम, मेघालय

Indian Council of Agricultural Research
ICAR Research Complex for N.E.H. Region
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PREFACE

ICAR Research Complex for NEH Region, Umiam, Meghalaya, is a leading Institute for agricultural research in the north-eastern region of India. Prime focus of this Institute is on optimizing the utilization of natural resources for the benefit of the farming community of this region. Moreover, the Institute also endeavours in the direction of developing new technologies to foster sustainable and climate-resilient growth in hill agriculture. The developed technologies are also being disseminated through its robust network of KVKs (Krishi Vigyan Kendra's) spread in all the NEH states. Furthermore, this Institute is also actively engaged in skill development, capacity-building and entrepreneurship development initiatives.

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

During the reporting period, the Institute developed several technologies having potential to significantly contribute to agricultural development in the region. Three new crop varieties were released and more than 25 novel technologies were developed. Additionally, committed team of the Scientists of our Institute's published 190 research articles in reputed International and national journals. Along with this, 75 popular articles and 22 bulletins were also published. Skill development has also been an important aspect of rural development and our Institute has conducted/organised 1099 training programmes, 785 demonstrations and 140 awareness/health camps. The Institute, together with its KVK network, provided support to more than 2,80,000 beneficiaries under various schemes. On December 4, 2023 a new beginning was made when the UG Program, B.Sc. (Hons) Agriculture of ICAR-IARI Umiam Hub started at our Institute.

The Institute effectively managed 113 in-house projects, 84 externally funded projects, and 25 AICRPs (All India Coordinated Research Projects) including network projects. Budget utilization efficiency in 2023 was 99.4%. Under Scheduled Tribe Component, the Institute successfully demonstrated and distributed more than 1042 physical assets, including Jalkund, low cost mushroom unit, low cost poly house, low cost vermicompost unit, low cost piggery unit, poultry sheds, vermi-beds, duckery units, processing units, and hatchery units among various stakeholders. During the reporting period, 24,345 tribal farmers benefited under various programmes in STC component.

I take this opportunity to express my gratitude to everyone in ICAR NEH team, including the Heads of the Regional Centres, Heads of the Divisions, Scientists, Technical staff, Administration, Finance and Supporting personnel, for their dedication towards the Institute's growth despite facing many challenges. I also acknowledge the support and guidance provided by the senior officials of ICAR, New Delhi.

(Vinay Kumar Mishra)
Director

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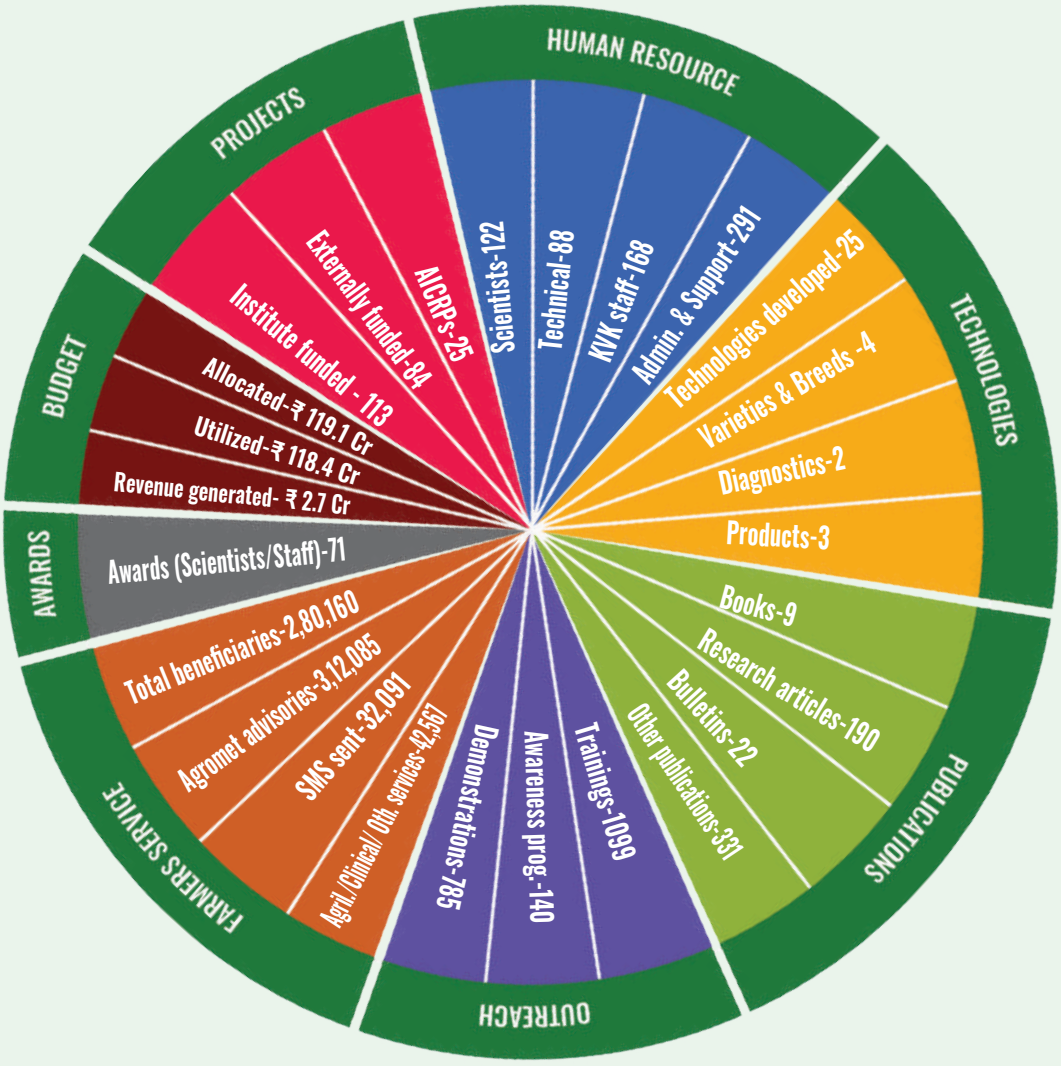
ICAR NEH
in Numbers



कार्यकारी सारांश

भारतीय कृषि अनुसंधान परिषद के उत्तर पूर्वी पर्वतीय क्षेत्र के लिए अनुसंधान परिसर, उमियम, मेघालय में वर्ष 2023 के दौरान 110 बरसात के दिनों में 2069.7 मिमी वर्षा हुई और मानसून के मौसम में, 72 बरसात के दिनों में 1401.1 मिमी वर्षा हुई। वार्षिक और मानसून वर्षा, दीर्घ अवधि के औसत की तुलना में क्रमशः 15% और 10% कम थी। दिसंबर से फरवरी को छोड़कर सभी महीनों के लिए औसत मासिक अधिकतम तापमान 29.3 डिग्री सेल्सियस से 25.2 डिग्री सेल्सियस के बीच रहा। औसत मासिक न्यूनतम तापमान अगस्त (20.5 डिग्री सेल्सियस) में सबसे अधिक और जनवरी (6.6 डिग्री सेल्सियस) में सबसे कम था। हालांकि, सुबह की सापेक्ष आर्द्रता में बदलाव शाम की तुलना में बहुत कम था।

सिस्टम रिसर्च एंड इंजीनियरिंग डिवीजन के तहत कई उल्लेखनीय पहल की गई, जैसे एकीकृत जैविक खेती प्रणाली और एकीकृत खेती प्रणाली मॉडल का मानकीकरण और प्रसार। प्राकृतिक खेती पर दो शोध परियोजनाएं भी शुरू की गई हैं। इसके अलावा, दो पंक्ति मक्का बोने की मशीन, स्वचालित परिशुद्धता बाग स्प्रेयर, ऑयस्टर मशरूम बैग की तैयारी के लिए हाथ कॉम्पैक्टर, धान के लिए ब्रश कटर और मैनुअल अनानास हारवेस्टर सहित उन्नत उपकरणों और कृषि उपकरणों का प्रोटोटाइप, विकास और परीक्षण किया गया है। टमाटर और फूलगोभी के लिए जस्ता, बोरान और मोलिब्डेनम के साथ सूक्ष्म पोषक तत्व प्रबंधन को उच्च उत्पादकता के लिए मानकीकृत किया गया है। मक्का उत्पादकता को श्रेष्ठ करने के लिए एनपीके, चूना, वर्मीकम्पोस्ट और जैव-उर्वरकों के साथ एकीकृत पोषक तत्व प्रबंधन पर काम किया गया है। साथ ही, मेघालय के लिए सर्वोत्तम मक्का-फलीदार अंतरफसल और पोषक तत्व प्रबंधन प्रणाली की पहचान की जा रही है। उल्लेखनीय है कि अम्लीय मिट्टी पर उगाई जाने वाली फूलगोभी के लिए सूक्ष्म पोषक तत्व पैकेज भी विकसित किया गया है। मक्का-फलीदार अंतरफसल में मल्चिंग के माध्यम से जल उपयोग दक्षता बढ़ाने और मक्का, सोयाबीन और फ्रेंच बीन की पैदावार को अनुकूलित करने के लिए जल संरक्षण किया गया है। पत्थर, पोम फलों के लिए बेहतर रूट स्टॉक यानी आरसी पीच 1 और नींबू जीनोटाइप यानी RC-LM-EL--3 की पहचान की गई है। एनईएच क्षेत्र के लिए राजा मिर्च के लिए एकीकृत पोषक तत्व प्रबंधन को मानकीकृत किया जा रहा है। पोम फलों की ट्रेनिंग के लिए वाई-आकार की ट्रेलिस विकसित की गई। मेघालय में खासी मंदारिन के 60 बागों का सर्वेक्षण किया गया। खासी मंदारिन के लिए DRIS सूचकांक सटीक पोषक तत्व प्रबंधन के लिए पत्ती पोषक तत्व विश्लेषण की सही व्याख्या को सक्षम करने के लिए विकसित किए गए हैं। लुप्तप्राय साइट्रस इंडिका के प्रसार के लिए वेज ग्राफ्टिंग की पहचान की गई। सब्जियों के बेहतर जीनोटाइप जैसे फ्रेंच बीन (145), काऊ पी (28), इंडियन बीन (125), राजा मिर्च (29) और कम उपयोग की जाने वाली कुकुरबिट्स (60) का मूल्यांकन किया गया और आशाजनक जीनोटाइप की पहचान की गई। इसके अतिरिक्त, अदरक की दो नई किस्में यानी RCVBG-1 और RCMLG-1 को बहु-स्थानीय परीक्षणों के लिए प्रस्तुत किया गया है। एंथुरियम और किंग चिली के लिए मृदा रहित माध्यम का मानकीकरण किया गया है।

फसल विज्ञान प्रभाग के अंतर्गत उल्लेखनीय अनुसंधान उपलब्धियां- उन्नत धान प्रजनन लाइनें (RCPL 1-440, RCPL 1-441, RCPL 1-442, RCPL 1-443, RCPL 1-444, RCPL 1-446 और RCPL 1-448) स्टेशन परीक्षणों में प्रदर्शन के आधार पर राज्य अनुकूली परीक्षणों के अधीन हैं। इसी तरह, NEH मेघा चावल-1/VL-32546 और भालुम-1/खोनोरुल्लू क्रॉस के F2 बीजों का उपयोग करके ठंड सहिष्णु जीनों की मैपिंग चल रही है। इसके अलावा, धान में कई नए क्रॉस बनाए गए हैं और उन्नत पीढ़ियों को राज्य अनुकूली परीक्षणों और प्रारंभिक वैरिएटल परीक्षणों (IVTs) में नामांकन के लिए आगे बढ़ाया गया है। धान में कम P सहिष्णु जीनोटाइप (भालुम-3, भालुम-5, वरदान, सीएयूएस-107, सीएयूएस-124) की पहचान करने के लिए हाइड्रोपोनिक्स परख और मार्कर एसोसिएशन का उपयोग किया गया, धान में कम प्रकाश सहनशीलता के लिए कई जीन आधारित मार्करों की पहचान की गई है जो जैविक उपज, प्रति पैनिकल अनाज की संख्या और स्पाइकलेट उर्वरता जैसे प्रमुख लक्षणों

से जुड़े हैं। 8 नवंबर, 2023 को संभावित फसलों पर AICRN की VIC बैठक में उत्तरी पहाड़ी क्षेत्र और उत्तर पूर्वी पहाड़ी क्षेत्र के लिए रिलीज और अधिसूचना के लिए दो पेरिला किस्मों (पूर्वोत्तर पेरिला-1 और पूर्वोत्तर पेरिला-2) की पहचान की गई है। जैव रासायनिक लक्षण वर्णन के माध्यम से राइसबीन की उखरुल-15 (22.09%) में सबसे अधिक कच्चा प्रोटीन, IC341987 (0.501 ग्राम/100 ग्राम) में सबसे कम फाइटिक एसिड और उखरुल-1 (5.93 मिलीग्राम क्यूई/जी एफडब्ल्यू) में सबसे कम कुल फ्लेवोनोइड्स दर्ज किया गया। अल्युमीनियम सहिष्णुता के लिए मेटा क्यूटीएल विश्लेषण ने सहनशील जीनोटाइप में ओएसएमटी1, ओएसएनटीआर2.3 और एएलएमटी4 जीन का अपरेगुलेशन पाया गया है।

एनआईआरएस (नियर इन्फ्रारेड स्पेक्ट्रोस्कोपी) का उपयोग करके पेरिला के पोषण घटकों के तेजी से मात्रात्मक मूल्यांकन के लिए पूर्वानुमान मॉडल विकसित किए गए। मक्का में 2 ग्राम/ली की दर से बीटी बायोपेस्टीसाइड्स और 0.4 ग्राम/ली की दर से इमामेक्टिन बेंजोएट 5एसजी का उपयोग करके फ़ॉल आर्मी वर्म और गोभी तितली का प्रभावी ढंग से प्रबंधन किया गया, जिससे तिल में लीफ़ वेबर की सबसे कम लार्वा आबादी दर्ज की गई। लीची में, एपिस सेराना ने परागण दक्षता सूचकांक (पीईआई) द्वारा इंगित परागणकर्ता के रूप में उच्चतम दक्षता का प्रदर्शन किया। क्यूपीएम (क्वालिटी प्रोटीन मक्का) की उन्नीस प्रविष्टियाँ टर्सिकम लीफ़ ब्लाइट (एक्ससेरोहिलम टर्सिकम) के लिए प्रतिरोधी पाई गईं। खासी मंदारिन में गैर-उपचारित पौधों की तुलना में एनपीके उर्वरकों और सूक्ष्म पोषक तत्वों (जस्ता और बोरान) की अनुशंसित खुराक के उपयोग के बाद प्रति पेड़ फलों की संख्या में 25% की वृद्धि हुई। सूक्ष्मजीव समुदाय संरचना विश्लेषण के माध्यम से पीएम-25 के अकार्बनिक उपचार के राइजोस्फेरिक मिट्टी के नमूने में प्रोटियोबैक्टीरिया सबसे प्रचुर मात्रा में (28.6%) पाए गए, जबकि पीएम-25 नमूने के 20 किग्रा/हेक्टेयर रॉक फॉस्फेट उपचार में सबसे कम प्रचुरता (14.6%) देखी गई।

पशु और मत्स्य विज्ञान प्रभाग में पशुधन और एक्वाकल्चर प्रबंधन की विभिन्न चुनौतियों से निपटने के लिए कई उज्ज्वल पहल की गई, जिसमें पूर्वोत्तर क्षेत्र में आदिवासी किसानों की जरूरतों पर विशेष ध्यान दिया गया। पशु प्रजनन में, प्रजनन प्रौद्योगिकियों को बेहतर बनाने पर ध्यान केंद्रित किया गया, जिसमें साँड़ के वीर्य के लिए डीप-फ्रीजिंग भंडारण विधियों की खोज और सूअर के वीर्य की गुणवत्ता और प्रजनन क्षमता पर सेलेनियम नैनोकणों का प्रभाव शामिल है। इसके अलावा, बकरियों के स्वदेशी जर्मप्लाज्म को संरक्षित करने और पहाड़ी किसानों की आजीविका बढ़ाने के लिए ग्रामीण जैव संसाधन परिसरों की स्थापना करने के उद्देश्य से संरक्षण पहल की गई। पशु स्वास्थ्य में, रोग पहचान तकनीकों में प्रगति हुई, जिसमें क्लिनिकल नमूनों में अफ्रीकी स्वाइन फीवर वायरस और दूध में स्टैफिलोकोकस ऑरियस का पता लगाने के लिए नए न्यूक्लिक एसिड परख का विकास शामिल है। राष्ट्रीय पशु रोग महामारी विज्ञान नेटवर्क ने निगरानी क्षमताओं को बढ़ाया गया, पशु स्वास्थ्य में उभरते खतरों का पता लगाने और प्रतिक्रिया में सुधार किया।

इसके अलावा, माइक्रोबायोम मॉड्यूलेशन जैसी नवीन तकनीकों का उपयोग प्रोबायोटिक पूरकता के माध्यम से प्री-वीन किए गए पिगलेट में आंत के स्वास्थ्य को मजबूत करने के लिए किया गया, जिससे स्वस्थ पशुधन के उत्पादन में वृद्धि हुई । आदिवासी पहाड़ी क्षेत्रों में पारंपरिक रूप से किण्वित खाद्य पदार्थों से लैक्टिक एसिड बैक्टीरिया और रोगजनकों के लक्षण वर्णन ने खाद्य प्रसंस्करण विधियों और माइक्रोबियल सुरक्षा के बीच संबंधों में मूल्यवान अंतर्दृष्टि प्रदान की। इसके अतिरिक्त, कोर-रेसिस्टोम विश्लेषण तकनीकों को विकसित किया गया और खाद्य जनित जूनोटिक रोगजनकों के बीच रोगाणुरोधी प्रतिरोध (एएमआर) में अस्थायी रुझानों की निगरानी के लिए लागू किया गया, जिससे एएमआर को प्रबंधित करने के लिए लक्षित रणनीतियों की जानकारी मिली। मेघालय में भैंसों को संक्रमित करने वाली ईमेरिया की चार प्रजातियों की पहचान मोलेकुलर तकनीक का उपयोग करके की गई। पशुधन और मुर्गीपालन में जठरांत्र परजीवी संक्रमण के वित्तीय प्रभाव का आकलन करने के लिए आर्थिक अध्ययन भी किए गए। मत्स्य पालन में, हल्दी और कैरम्बोला अर्क जैसे प्राकृतिक योजकों के मूल्यांकन के माध्यम से मछली के स्वास्थ्य और उत्पादकता को बढ़ाने की दिशा में प्रयास किए गए। इसके अलावा, क्षेत्र में एक्वाकल्चर के आर्थिक महत्व को पहचानते हुए, मछली बीज उत्पादन में सुधार, आपूर्ति श्रृंखला प्रबंधन और राजस्व सृजन को बढ़ावा देने के लिए पहल शुरू की गई।

प्रौद्योगिकी मूल्यांकन और क्षमता निर्माण प्रभाग ने भी रिपोर्टिंग अवधि के दौरान महत्वपूर्ण योगदान दिया। अदरक और हल्दी जैसी महत्वपूर्ण वस्तुओं के लिए पांच महीने की कीमतों के पूर्वानुमान के लिए ARIMA, ARIMAX, ARCH और GARCH जैसे मॉडलों का मूल्यांकन किया गया। विभिन्न वस्तुओं के लिए सर्वश्रेष्ठ फिट मॉडल की पहचान विभिन्न फिट सांख्यिकी का उपयोग करके की गई। सामाजिक विज्ञान में किए गए अध्ययनों से पता चला है कि उच्च उपज देने वाली धान की किस्म और अर्ध-गहन मछली पालन के लिए कृषि विज्ञान केंद्र और मत्स्य अधिकारियों जैसे औपचारिक संचार स्रोतों का प्रभुत्व है, जबकि प्रगतिशील किसानों ने कम निवेश

बैकयार्ड पोल्ट्री फार्मिंग के बारे में जानकारी प्रदान करने में महत्वपूर्ण भूमिका निभाई है। साथ ही, किसानों द्वारा जलकुंड तकनीक को अपनाने के प्रभाव से पता चला कि वे 450 वर्ग मीटर के क्षेत्र में अतिरिक्त उच्च मूल्य वाली सब्जी की फसल लेने में सक्षम थे और साथ ही 27,000 रुपये प्रति वर्ष की अतिरिक्त आय भी अर्जित की। मणिपुर और मिजोरम को छोड़कर, 2008-09 से 2015-16 की अवधि में पूर्वोत्तर में अस्थायी खेती के तहत क्षेत्र में 15% की गिरावट आई है। चार ब्लॉकों में से, पश्चिमी खासी हिल्स का मावसिन्रुट ब्लॉक जलवायु परिवर्तन के प्रति अत्यधिक संवेदनशील पाया गया। फार्मर्स फर्स्ट परियोजना के अंतर्गत एकीकृत कृषि प्रणाली (आईएफएस) को बहुत लाभदायक और आशाजनक बताया गया और इस परियोजना के अंतर्गत प्रौद्योगिकियों के प्रसार के लिए विभिन्न विस्तार गतिविधियां शुरू की गई।

अरुणाचल प्रदेश के बसर में स्थित हमारे संस्थान के क्षेत्रीय केंद्र ने भी क्षेत्र के किसानों के विकास के लिए ठोस प्रयास किए हैं। मौसम रिपोर्ट के अनुसार, कुल वर्षा 2180 मिमी थी जो कि 13.1% कम थी। बारिश के दिनों की कुल संख्या 136 दिन थी जबकि सामान्य दिनों की संख्या 143 दिन होती है। विभिन्न मृदा संरक्षण उपायों के तहत फ्रेंच बीन और बकव्हीट के प्रदर्शन से पता चला कि डबल मल्चिंग ने दोनों फसलों के लिए पौधे की ऊंचाई, सापेक्ष जल सामग्री (%), आर्थिक उपज आदि के लिए सर्वोत्तम परिणाम दिए। तिल के विभिन्न प्रकार के परीक्षण में, पासीघाट स्थानीय ने प्रति पौधे सबसे अधिक फली और बीज उपज (किलोग्राम/हेक्टेयर) दर्ज की। कम लागत वाली वर्षा आश्रय के तहत अध्ययन किए गए विभिन्न सब्जी फसल क्रमों में, फसल क्रम अर्थात शिमला मिर्च – लौकी – पालक ने अधिकतम उपज और आय प्रदर्शित की। असम नींबू के पौधे में लगाए गए सभी जैविक उपचारों में, मल्चिंग के साथ जैविक उपचार अर्थात- एफ.वाई.एम. (7 किग्रा प्रति पौधा) + वर्मीकम्पोस्ट (4 किग्रा प्रति पौधा) + स्थानीय खरपतवार बायोमास (टी5) के साथ मल्चिंग और एफ.वाई.एम. (7 किग्रा प्रति पौधा) + वर्मीकम्पोस्ट (4 किग्रा प्रति पौधा) + नीम केक (0.5 किग्रा प्रति पौधा) + स्थानीय खरपतवार बायोमास के साथ मल्चिंग से असम नींबू की वनस्पति वृद्धि, उपज और फल की गुणवत्ता में बेहतर परिणाम दर्ज किए गए। टमाटर के लेट ब्लाइट के खिलाफ स्क्रीनिंग परीक्षणों के दौरान, टमाटर हाइब्रिड, अर्का अभेद ने लेट ब्लाइट रोग के लिए प्रतिरोधक क्षमता दर्ज की और मिर्च के केसी-4 देशी जर्मप्लाज्म में व्हाइटफ्लाई और वायरल कॉम्प्लेक्स में कमी दर्ज की गई। विभिन्न कृषि-वानिकी प्रणालियों की कार्बन अवशोषण क्षमता का मूल्यांकन करते समय, कास्टानोप्सिस इंडिका में सबसे अधिक तने का बायोमास (203.64 ± 15.07 टन/हेक्टेयर), शाखा बायोमास (171.09 ± 9.41 टन/हेक्टेयर), पर्ण बायोमास (42.06 ± 2.94 टन/हेक्टेयर), जड़ बायोमास (54.50 ± 4.78 टन/हेक्टेयर) और कुल बायोमास (471.34 ± 32.82 टन/हेक्टेयर) दर्ज किया गया। पशुधन और मुर्गीपालकों में स्व-रिपोर्ट किए गए व्यावसायिक खतरों का आकलन करते समय, यह पाया गया कि विभिन्न पशुधन प्रबंधन कार्यों के दौरान किसानों द्वारा बताई गई सबसे आम शारीरिक परेशानी पीठ के निचले हिस्से में तेज दर्द थी। देशी मवेशियों और बकरियों के संरक्षण और सुधार के संबंध में, रूपात्मक और शारीरिक लक्षणों का अध्ययन किया गया है। लेपरदा और पश्चिम सियांग जिलों से मिथुन के 171 नमूनों की मल जांच से 27.48% जठरांत्र परजीवी की व्यापकता का पता चला। मल लार्वा संस्कृति के आधार पर, पाई गई प्रमुख प्रजातियाँ ओसोफेगोस्टोमम एसपीपी, हेमोनचस और ट्राइकोस्ट्रॉन्गाइल एसपीपी थीं। जिले के परिदृश्य का अध्ययन करने के लिए डिजिटल टेरेन एनालिसिस (डीटीए) का उपयोग किया गया, जिसमें शटल रडार टोपोग्राफी मिशन (एसआरटीएम) से एसएजीए जीआईएस और 30-मीटर रिज़ॉल्यूशन डिजिटल एलिवेशन मॉडल (डीईएम) डेटा का उपयोग किया गया।

मणिपुर केंद्र ने रिपोर्टिंग अवधि के दौरान उल्लेखनीय उपलब्धियाँ दर्ज कीं। 11 जीन-आधारित कार्यात्मक मार्करों का उपयोग करके PSTOL1 जीन के लिए 96 चावल जर्मप्लाज्म का एक सेट जांचा गया। दो कार्यात्मक मार्करों, Pup1_K46 और Pup1_K20 के आधार पर PSTOL1 जीन के सकारात्मक एलील के साथ पंद्रह चावल जर्मप्लाज्म की पहचान की गई। अर्ध-बौने काले चावल के जीनोटाइप, आरसीएमबीआर 3 ने बहु-स्थानीय परीक्षण में मूल और स्थानीय जांच से बेहतर प्रदर्शन किया, जिसमें वर्षा आधारित स्थानों में 70% और सिंचित क्षेत्र में 32% की उपज श्रेष्ठता थी। फॉक्सटेल के पांच स्थानीय चयनों का मूल्यांकन किया गया, आरबीडी के बाद एसआईए 3085 और एसआईए 3088 नाम की दो जांचों के साथ इसके प्रदर्शन की जांच की गई और इसे डीयूएस लक्षण भी दिया गया। चंदेल चयन, उखरूल चयन और तामेंगलोंग चयन ने प्रति पौधे 12.9 ग्राम, 11 ग्राम और 6.8 ग्राम उपज के साथ काफी बेहतर प्रदर्शन किया। रबी 2023-24 के दौरान अनुसंधान फार्म और किसानों के खेत में कुल 372.12 क्विंटल और 230.55 क्विंटल गुणवत्ता वाले फसलों के बीज तैयार किए गए जबकि खरीफ/वसंत/ग्रीष्म 2023 के दौरान 55.6 क्विंटल और 2295.3 क्विंटल गुणवत्ता वाले बीज तैयार किए गए। रबी 2022-23 के दौरान मक्का पूसा कम्पोजिट-3 प्रजनक बीजों का 0.60 क्विंटल जबकि मटर-अमन के फाउंडेशन बीजों का

2.70 क्विंटल उत्पादन किया गया। तिलहनों में सरसों के पीएम-27 के 15.20 क्विंटल आधार बीज भी उत्पादित किए गए। कुल 220 एंडोफाइट्स सस्पेंशन एकत्रित किए गए तथा नाइट्रोजन फिक्सिंग क्षमता वाले एंडोफाइट्स की उपस्थिति देखने के लिए स्क्रीनिंग की गई। कुल 48 एंडोफाइट्स की पहचान नाइट्रोजन फिक्सिंग एंडोफाइटिक बैक्टीरिया के रूप में की गई। मीतेई-हेई केले के अंकुरण के लिए पादप हार्मोन की इष्टतम सांद्रता की पहचान के लिए उपचार के रूप में साइटोकाइनिन की छह विभिन्न सांद्रता में एक्सप्लांट के रूप में कुल 38 स्वोर्ड सकर का उपयोग किया गया। इनमें से केवल 12 एक्सप्लांट ही सफलतापूर्वक नए अंकुरों में विकसित हुए हैं। खीरे के जर्मप्लाज्म संग्रह में अधिकतम मेसोकार्प मोटाई चिंगजारोई बेल आकार (2.55 मिमी) में दर्ज की गई, उसके बाद फुंग्योकारा (2.25 मिमी) और एंजल खीरे (2.08 मिमी) का स्थान रहा। आने वाले वर्ष में AICRP (VC) के तहत बहुस्थानीय परीक्षण के लिए दो आशाजनक नमी तनाव सहिष्णु टमाटर लाइनें अर्थात् RCM-N-T-1 और RCM-N-T-2 प्रस्तावित की जाएंगी। आरसी कामेनसेनबा-1 (सेल-9ए) और आरसी मनिथोइबी (सेल-3) के साथ इन दो लाइनों की डीएनए फिंगरप्रिंटिंग टमाटर के 34 एसएसआर मार्करों का उपयोग करके की गई है। सफेद चावल और काले चावल के बीजों में आर्टेमिसिया और एशोल्ट्ज़िया के पिसे हुए पौधों के पाउडर (1%) का उपयोग करके बीज उपचार किया गया। उन्होंने उपचारित चावल के बीजों को चावल के घुन से पूर्ण सुरक्षा दी और परीक्षण की गई सांद्रता पर छह महीने तक भंडारण कीटों का कोई उदय नहीं हुआ। खीरे और फ्रेंच बीन्स पर लीफ रोलर, पत्ती खाने वाले कैटरपिलर और फली बोरर को नियंत्रित करने के लिए, फल लगने के दौरान खीरे पर क्लोरेंट्रानिलिप्रोएल 18.5% w/w एससी @ 25 ग्राम ए.आई./हेक्टेयर का दो बार छिड़काव किया गया। मिट्टी में, खीरे पर अवशेष 5वें दिन तक (0.08 मिलीग्राम/किग्रा) और फ्रेंच बीन्स पर 0.03 मिलीग्राम/किग्रा तक बने रहे। आंतरिक प्रतिलेखित स्पेसर (आईटीएस), ट्रांसलेशनल इलॉन्गेशन फैक्टर 1α (टीईएफ1α), मिनी क्रोमोसोम मेंटेनेंस प्रोटीन (एमसीएम7) और बड़े सबयूनिट राइबोसोमल आरएनए जीन (एलएसयू) क्षेत्रों के आधार पर बारकोड क्षेत्रों के रूप में पहचान के लिए कुल इकतालीस (41) शिताके मशरूम उपभेदों पर डीएनए बारकोडिंग की गई। पेरिला और अलसी के आहार को शामिल करके मुर्गी के सीरम लिपिड प्रोफाइल (कुल सीरम ट्राइग्लिसराइड, कुल सीरम कोलेस्ट्रॉल, एलडीएल कोलेस्ट्रॉल और वीएलडीएल कोलेस्ट्रॉल) में महत्वपूर्ण कमी आई जबकि एचडीएल कोलेस्ट्रॉल में काफी सुधार हुआ। प्रयोग 6 सप्ताह की अवधि के लिए मुर्गी (30 सप्ताह की उम्र) पर किया गया था।

मिजोरम केंद्र ने भी रिपोर्टिंग अवधि के दौरान बहुमूल्य जानकारी दी। भूमि उपयोग के कारण P के विभिन्न पूलों में महत्वपूर्ण अंतर देखे गए। अकार्बनिक NaHCO3-P निचले इलाकों की चावल की मिट्टी में काफी अधिक और सागौन की मिट्टी में सबसे कम था, जबकि कार्बनिक NaHCO3-P सागौन की मिट्टी में अधिक और निचले इलाकों की चावल की मिट्टी में सबसे कम था। चौबीस अलग-अलग निचले इलाकों की चावल किस्मों का मूल्यांकन किया गया और सबसे अधिक अनाज की उपज RC-M-16 से दर्ज की गई, जिसने 6239.47 किलोग्राम प्रति हेक्टेयर पैदावार दी। फ्रेंच बीन के लेपिडोप्टेरान कीटों जैसे स्पोडोप्टेरा लिटुरा, हेलिकोवर्पा आर्मिजेरा और मारुका विट्राटा को जैविक तरीकों से प्रबंधित करने के लिए, एज़ाडिरेक्टा इंडिका 1% EC सबसे प्रभावी जैविक कीटनाशक साबित हुआ। इसने स्पोडोप्टेरा लिटुरा की आबादी को 71.52%, हेलिकोवर्पा आर्मिजेरा की आबादी को 62.66% और मारुका विट्राटा की आबादी को 79.75% तक कम कर दिया। रिपोर्टिंग अवधि के दौरान कुल वर्षा औसत से लगभग 25.51% कम थी, जबकि मानसून की बारिश औसत से 22% कम थी। पशु मूल के खाद्य पदार्थों से प्राप्त ई. कोली आइसोलेट्स (10/459) के 2.17% में प्लास्मिड-मध्यस्थ कोलिस्टिन प्रतिरोध (एमसीआर-1, एमसीआर-3, एमसीआर-4 और एमसीआर-5) जीन का पता चला। मवेशियों और सूअरों से अलग किए गए स्टैफिलोकोकस एसपीपी में, एस. ऑरियस प्रमुख बैक्टीरिया था, जिसके बाद एस. हाइकस, एस. हेमोलिटिकस, एस. क्रोमोजेन्स, एस. ऑरिक्युलरिस और एस. स्किुयुरी थे। सूअरों में एस. ऑरियस के 16 आइसोलेट्स में से, 3 आइसोलेट्स mecC जीन (एंटीमाइक्रोबियल प्रतिरोध जीन) के लिए सकारात्मक पाए गए। कुल 29 स्थानीय स्वदेशी गैर-वर्णित बकरियों (ज़ोकेल) को बकरी पालन इकाई में आनुवंशिक स्टॉक के रूप में रखा जा रहा है ताकि आकारिकी, प्रदर्शन और शव विशेषताओं को रिकॉर्ड किया जा सके। स्थानीय स्वदेशी मवेशियों (ज़ोबांग) के दूध और गोबर की संरचना का मूल्यांकन किया गया और नस्ल पंजीकरण प्रगति पर है। मुर्गियों की उन्नत किस्मों जैसे वनराजा, रेनबो रूस्टर (आरआर), और ब्रॉयलर नेटिव देसी (बीएनडी) के लिए अंडे के बाहरी और आंतरिक गुणों का मूल्यांकन 12 महीने के अंडे देने पर किया गया। मोटाई को दर्शाने वाला एल्बुमिन इंडेक्स, रेनबो रूस्टर और वनराजा की तुलना में बीएनडी में काफी अधिक था। भारतीय मेजर कार्प्स, कैटला, रोहू और मृगल के साथ बैरिलियस टाइलियो के विकास प्रदर्शन से पता चला कि इसने कैटला और मृगल के उत्तरजीविता को कम कर दिया है, इसलिए बी. टाइलियो को शामिल करने के लिए विचार नहीं किया जा सकता है।

नागालैंड केंद्र ने भी रिपोर्टिंग अवधि के दौरान महत्वपूर्ण योगदान दिया। छोटे और सीमांत किसानों की आजीविका में सुधार के लिए, नागालैंड में चार एकीकृत कृषि प्रणाली (आईएफएस) मॉडल विकसित और मूल्यांकन किए गए थे। सबसे अधिक कृषि लाभप्रदता (बी:सी अनुपात) मॉडल 1 (2.05) में पाई गई, उसके बाद मॉडल 2 (1.85), मॉडल 4 (1.80) और मॉडल 3 (1.64) का स्थान रहा। तीन ऊंचाई क्षेत्रों में स्थित 54 गृह उद्यानों के सर्वेक्षण से पता चला कि ऊंचाई ढाल के साथ गृह उद्यानों के आकार में महत्वपूर्ण भिन्नता है। मिट्टी के कार्बनिक कार्बन स्टॉक में ऊंचाई क्षेत्रों के साथ-साथ विभिन्न मिट्टी की गहराई में भी काफी भिन्नता थी। विभिन्न कटाई आवृत्तियों के तहत चारा उत्पादन क्षमता का आकलन करने के लिए तीन फलीदार वृक्ष प्रजातियों, ग्लिरिसिडिया सेपियम, ल्यूकेना ल्यूकोसेफाला और सेसबानिया ग्रैंडिफ्लोरा को उगाया गया। 8 महीने की वृद्धि के बाद, एल. ल्यूकोसेफाला ने 100% जीवित रहने की दर प्रदर्शित की। नागालैंड के मध्य-पहाड़ी क्षेत्र के लिए एक कृषि वानिकी मॉडल विकसित किया गया था जिसमें चार प्रमुख प्रजातियां शामिल थीं, जिनमें तीन बारहमासी लकड़ी के घटक (ऐरेका कैटेचू, पार्किया रोक्सबर्गी और ग्लिरिसिडिया सेपियम) और एक शाकाहारी बारहमासी फसल (अनानास कोमोसस) शामिल थी। अधिकांश चावल जीनोटाइप चावल ब्लास्ट रोग के प्रति संवेदनशील पाए गए। वीर्य प्लाज्मा प्रोटीन को हटाने और मेलाटोनिन के साथ पूरकता के बाद तरल संग्रहीत सूअर के वीर्य की गुणवत्ता का आकलन किया गया और परिणामों से पता चला कि एक μM मेलाटोनिन को सूअर के वीर्य विस्तारक में इसकी प्रजनन क्षमता और एंटीऑक्सीडेंट क्षमता में सुधार करने के लिए जोड़ा जा सकता है। पूर्वोत्तर के पांच स्वदेशी मवेशियों के प्रजनन प्रदर्शन और दूध के मापदंडों का मूल्यांकन किया गया। सूअरों में फरोइंग इंडक्शन पर प्रोस्टाग्लैंडीन F2alpha (PGF2α) प्रशासन की प्रभावशीलता के मूल्यांकन से पता चला कि गर्भावस्था के 113वें दिन PGF2α प्रशासन सूअरों में बिना किसी प्रतिकूल प्रभाव के नियंत्रित फरोइंग के लिए एक विकल्प हो सकता है। कृत्रिम गर्भाधान के माध्यम से किसान के माध्यम से कुल 9195 उन्नत सूअर पैदा किए गए।

सिक्किम में भी उल्लेखनीय उपलब्धियां दर्ज की गई हैं। सिक्किम में रिलीज के लिए मक्का की दो कम्पोजिट किस्में, एसकेएमसी- 3 (केडीएम-34) और एसकेएमसी- 4 (केडीएम-35) की पहचान की गई। इसके अतिरिक्त, चावल की एक उच्च उपज देने वाली किस्म , चिराके सिलेक्शन-1 (आईईटी 30517) की राज्य स्तर पर रिलीज के लिए पहचान की गई है। अधिकतम वर्षा अगस्त (495.9 मिमी) के महीने में दर्ज की गई, जबकि न्यूनतम वर्षा दिसंबर (7.7 मिमी) के महीने में दर्ज की गई। विभिन्न फसल प्रणालियों में, मक्का-फ्रेंच बीन फसल प्रणाली की तुलना में मक्का-सब्जी मटर फसल प्रणाली के तहत काफी अधिक मक्का समतुल्य उपज (11.7t/ha), प्रणाली उत्पादकता (12.9 t/ha), प्रणाली कुल उत्पादन (16.1 t/ha) और प्रणाली B:C अनुपात (2.92) दर्ज की गई। बांस के बागानों से मिट्टी की समग्र स्थिरता सिक्किम हिमालय में ऊंचाई में भिन्नता के बावजूद प्राकृतिक प्राथमिक वन मिट्टी के लगभग बराबर पाई गई। मासिक आधार पर समुद्री शैवाल के रस के उपचार से सिक्किम मैंडरिन की रूपात्मक, शारीरिक और जैव रासायनिक गुणवत्ता में वृद्धि हुई और साथ ही उनके बाजार मूल्य में भी वृद्धि हुई। जब समुद्री शैवाल का रस डाला गया तो सिक्किम मैंडरिन में विच्छेदन-प्रेरक जीन CitSAUR06, CitSAUR08, CitSAUR44, CitSAUR61 और CitSAUR64 नीचे की ओर विनियमित हो गए। टुपिस्ट्रा क्लार्कई के सूखे फूलों का जैव रासायनिक विश्लेषण किया गया और बिना ब्लांच किए छाया में सुखाने के उपचार में सबसे अधिक फिनोल (2.68 ग्राम GAE/100g), कुल फ्लेवोनोइड्स (1.71 ग्राम QE/100g) और एंटीऑक्सीडेंट गतिविधि दर्ज की गई। विभिन्न मृदा गहराई वाली फसल प्रणालियों में कार्बन पूल सूचकांक (CPI) में कोई महत्वपूर्ण अंतर नहीं पाया गया। इसके विपरीत, मक्का-सरसों की फसल प्रणाली के लिए सबसे कम कार्बन प्रबंधन सूचकांक (सीएमआई) मूल्य दर्ज किया गया। दीर्घकालिक स्थान-विशिष्ट दैनिक वर्षा समय श्रृंखला ने वर्षा सांद्रता सूचकांक में महत्वपूर्ण लगातार बढ़ती प्रवृत्ति का खुलासा किया, जो मानसून के बाद के महीनों के दौरान स्पष्ट था।

त्रिपुरा केंद्र ने भी कई उल्लेखनीय उपलब्धियों की सूचना दी। सीवीआरसी द्वारा एरोबिक स्थिति के लिए एक धान किस्म, निक्रा एरोबिक धान 2 जारी की गई। स्टेशन परीक्षणों में बेहतर प्रदर्शन के आधार पर एआईसीआरआईपी आईवीटी परीक्षणों के लिए पंद्रह प्रविष्टियों को नामित किया गया था और आईआरआरआई-एनएआरईएस प्रजनन नेटवर्क परियोजना में एक को एआईसीआरआईपी परीक्षणों के लिए नामित किया गया। एक कम लागत वाली पोर्टेबल बैकयार्ड अनुकूलित रीसर्कुलेटरी छोटी हैचरी असेंबली विकसित की गई जो महिलाओं के लिए बहुत अनुकूल है। कुल मिलाकर, एआईसीआरपी बीज और दलहन बीज हब के तहत क्रमशः जारी चावल किस्मों के 59.5 क्विंटल प्रजनक बीज और 206 क्विंटल टीएल बीज और दालों के 607 क्विंटल टीएल बीज का उत्पादन किया गया। लंबी अवधि के औसत (एलपीए) की तुलना में, रिपोर्टिंग अवधि के दौरान कुल

बारिश कम रही (एलपीए का 77.4%)। वार्षिक औसत अधिकतम तापमान सामान्य से 3.2% अधिक (31.7 डिग्री सेल्सियस) दर्ज किया गया जबकि वार्षिक औसत न्यूनतम तापमान सामान्य से 18.4 डिग्री सेल्सियस (5.7%) कम था। चार जिलों के नौ गांवों को प्रौद्योगिकी अपनाने के अंतर्गत शामिल किया गया है ताकि किसान अतिरिक्त आय अर्जित कर सकें। त्रिपुरा की स्थिति के तहत कंद फसल आधारित बहुमंजिला वार्षिक सब्जी फसल प्रणाली का मानकीकरण किया गया। एनबीपीजीआर से नौ प्रमुख और लघु कंद फसलों को एकत्र किया गया, उनकी विशेषताएं बताई गईं और आईसी नंबर प्राप्त किए गए। बैंगन के इक्कीस जर्मप्लाज्म एकत्र किए गए और उनका मूल्यांकन किया गया, जिनमें से चार लाइनें (टीबीएल-04, टीबीएल-13, टीबीएल-12, टीबीएल-10) फल उपज और अन्य विशेषताओं के मामले में आशाजनक पाई गईं। विभिन्न महत्वपूर्ण मापदंडों के लिए सात विभिन्न बहु-स्तरीय आधारित कृषि वानिकी प्रणालियों (एएफएस) का मूल्यांकन किया गया। छह बायोफोर्टिफाइड मक्का संकरों में से, NEH-BIOFORT-03 ने सबसे अधिक कर्नेल उपज (7.1 t/ha) प्रदर्शित की। चिकन जर्मप्लाज्म में सबसे अधिक उर्वरता रंगीन ब्रॉयलर (84.79%) में पाई गई और सबसे कम कड़कनाथ (77.12%) में। 10% वुल्फिया वाले बेसल आहार ने कड़कनाथ के मामले में उच्च ड्रेसिंग और विसरित उपज दी। 50% और 20% मवेशी अपशिष्ट जल में कैटला कैटला का विकास प्रदर्शन लैबियो रोहिता से बेहतर था। EDTA और एकोर्निया ने पानी में Fe की मात्रा को 95% तक कम कर दिया। रुद्रसागर झील की जल गुणवत्ता पूरे वर्ष बदलती रही, जिसमें विभिन्न मौसमों के दौरान जल गुणवत्ता सूचकांक 33.36 से 56.31 तक रहा।

NICRA के तहत, NICRA एरोबिक धान 2 को 4.11 टन/हेक्टेयर की उपज क्षमता के साथ एरोबिक स्थितियों में खेती के लिए अधिसूचित किया गया है। इसके अलावा, 30.0 टन/हेक्टेयर और 32.0 टन/हेक्टेयर की उपज क्षमता वाली दो सूखा सहिष्णु टमाटर लाइनें (आरसीएम-एन-टी-1 और डीवीआरटी-2) विकसित की गई हैं। दो डिजिटल प्रौद्योगिकियां अर्थात, NES+ (नॉर्थ ईस्ट सॉइल प्लस), मिट्टी के स्वास्थ्य की स्थिति का आकलन करने के लिए एंड्रॉइड एप्लिकेशन और हाइपर ग्रीन इंडेक्सर (एचएसजीआई), आसानी से आवश्यक हाइपरस्पेक्ट्रल वनस्पति सूचकांक उत्पन्न करने के लिए भी विकसित की गई हैं।

4 दिसंबर, 2023 को एक नई शुरुआत की गई है जब आईसीएआर-आईएआरआई उमियम हब के यूजी प्रोग्राम, बीएससी (ऑनर्स) कृषि की शुरुआत आईसीएआर आरसी एनईएचआर में हुई। इस संस्थान को 2023-24 के वर्तमान शैक्षणिक सत्र से ICAR-IARI शैक्षणिक कार्यक्रम के लिए नोडल संस्थानों में से एक का दर्जा दिया गया है।

संस्थान द्वारा कार्यान्वित अनुसूचित जनजाति घटक के अंतर्गत जनजातीय उपयोजना से 24,345 से अधिक जनजातीय किसानों को लाभ मिला है। साथ ही, कृषि व्यवसाय इनक्यूबेशन केंद्र ने नए उत्पाद अवधारणा, लाइसेंसिंग, विपणन और लिंकेज सहित विभिन्न पहलुओं में क्षेत्र के पंजीकृत और अन्य संभावित उद्यमियों को लगातार सहायता प्रदान की है। इसके अलावा, संस्थान के प्रशासनिक नियंत्रण के अंतर्गत आने वाले बीस केवीके ने कृषि और संबद्ध गतिविधियों के विभिन्न क्षेत्रों में 653 प्रशिक्षण कार्यक्रम आयोजित किए हैं, जिसमें पूरे क्षेत्र में 17,815 लाभार्थी शामिल हैं।

EXECUTIVE SUMMARY

During the year 2023, the ICAR Research Complex for NEH Region, Umiam, Meghalaya recorded 2069.7 mm rainfall in 110 rainy days and the monsoon season contributed 1401.1 mm in 72 rainy days. The annual and monsoon rainfall was 15% and 10% lower compared to the long period average, respectively. The mean monthly maximum temperature varied between 29.3°C to 25.2°C for all the months except December to February. The mean monthly minimum temperature was highest for August (20.5°C) and lowest for January (6.6°C). However, the variation in the morning relative humidity was much less as compared to the evening relative humidity.

Under Division of System Research and Engineering several remarkable initiatives have been undertaken viz. standardisation and dissemination of Integrated Organic Farming System and Integrated Farming Systems models. Two research projects on natural farming have also been initiated. Moreover, prototyping, developing and testing of improved tools and farm equipments has been done including two row maize planter, automatic precision orchard sprayer, rapid hand compactor for oyster mushroom bag preparation, weeding attachment of brush cutter for paddy and manual pineapple harvester. Micro-nutrient management with zinc, boron and molybdenum for tomato and cauliflower have been standardized for higher productivity. Integrated nutrient management with NPK, lime, vermicompost and bio-fertilizers for optimizing the maize productivity has been worked out. Also, identification of best maize-legume intercropping and nutrient management system for Meghalaya is being done. Notably, micronutrient package for cauliflower grown on acidic soils was also developed. Water conservation for increasing water use efficiency and optimizing the yields of maize, soybean and French bean through mulching in maize-legume intercropping has been done.

Improved root stock i.e. RC Peach 1 for stone, pome fruits and a lemon genotype i.e. RC-LM-EL-3 have been identified. Integrated nutrient management for king chilli for the NEH region is being standardized. Y-shape trellis for training of stone and pome fruits was developed. Survey of 60 orchards of Khasi Mandarin in Meghalaya was done. The DRIS indices for Khasi mandarin have been developed to enable correct interpretation of leaf nutrient analysis for precision nutrient management. Wedge grafting was identified for propagation of endangered *Citrus indica*. Improved genotypes of vegetables viz. French bean (145), cow pea (28), Indian bean (125), king chilli (29) and underutilized cucurbits (60) were evaluated and promising genotypes have been identified. Additionally, two new accessions of ginger i.e. RCVBG-1 and RCMLG-1 have been submitted for multi-location trials. Standardization of soilless media for anthurium and king chilli has been done.

Noteworthy research achievements under Division of Crop Sciences- Advanced rice breeding lines (RCPL 1-440, RCPL 1-441, RCPL 1-442, RCPL 1-443, RCPL 1-444, RCPL 1-446 and RCPL 1-448) have been subjected to state adaptive trials based on the performance in station trials. Likewise, mapping for cold tolerant genes is underway using F_2 seeds of crosses- NEH Megha rice-1/VL-32546 and Bhalum-1/ Khonorullu. Furthermore, several fresh crosses in rice have been made and advance generations were carried forward for nomination in state adaptive trials and initial varietal trials (IVTs). Hydroponics assay and marker association was used to identify low P tolerant genotypes (Bhalum-3, Bhalum-5, Varadhan, CAUS-107, CAUS-124) in rice. Several gene based markers for low light tolerance in rice associated with key traits such as biological yield, grain number per panicle, and spikelet fertility have been identified. Two perilla varieties (Poorvottar Perilla-1 and Poorvottar Perilla-2) have been identified for release and notification for

Northern Hill Zone and North Eastern Hill Zone in VIC meeting of AICRN on Potential crops on 8th November, 2023. Several ricebean lines were explored through biochemical characterisation and highest crude protein was reported in Ukhrul-15 (22.09%), lowest phytic acid in IC341987 (0.501 g/100g) and lowest total flavonoids in Ukhrul-1 (5.93 mg QE/g fw). Meta QTL analysis for Al tolerance showed upregulation of OsMT1, OsNTR2.3, and ALMT4 genes in tolerant genotypes.

Robust prediction models for the rapid quantitative assessment of Perilla's nutritional components were developed using NIRS (Near Infrared Spectroscopy). Fall army worm and cabbage butterfly were effectively managed by using biopesticides *Bt* @ 2g/l in maize and emamectin benzoate 5SG @0.4 g/l recorded the lowest larval population of the leaf webber in sesame. In litchi, *Apis cerana* demonstrated the highest efficiency as a pollinator as indicated by the Pollination Efficiency Index (PEI). Nineteen entries of QPM (Quality Protein Maize) were found to be resistant to Turcicum leaf blight (*Exserohilum turcicum*). The number of fruits per tree increased by 25% after the application of the recommended doses of NPK fertilizers and micronutrients (Zinc and boron) as compared to the nontreated plants in Khasi mandarin. Proteobacteria were found to be the most abundant (28.6%) in the rhizospheric soil sample of the inorganic treatment of PM-25, whereas the lowest abundance (14.6%) was observed in the 20 kg/ha rock phosphate treatment of PM-25 sample, through microbial community structure analysis.

A series of bright initiatives to tackle the various challenges of livestock and aquaculture management, with a special focus on the needs of tribal farmers in the NEH region were undertaken in the Division of Animal and Fisheries Sciences. In animal production, efforts were focused on improving reproductive technologies, including the exploration of deep-freezing storage methods for bull semen and the impact of selenium nanoparticles on the quality and fertility of boar and buck semen. Moreover, conservation initiatives aimed at preserving indigenous germplasms of goats and establishing Rural Bioresource Complexes to enhance the livelihood of hill farmers. In animal health, advancements were made in disease detection technologies, including the development of novel nucleic acid assays for detecting the African swine fever virus in clinical samples and *Staphylococcus aureus* in milk. The National Animal Disease Epidemiology Network enhanced surveillance capabilities, improving detection and response to emerging threats in animal health.

Moreover, innovative techniques, such as microbiome modulation, were employed to bolster gut health in pre-weaned piglets through probiotic supplementation, contributing to the production of healthier livestock. The characterization of lactic acid bacteria and pathogens from traditionally fermented foods in tribal hill areas provided valuable insights into the relationship between food processing methods and microbial safety. Additionally, core-resistome analysis techniques were developed and applied to monitor temporal trends in antimicrobial resistance (AMR) among foodborne zoonotic pathogens, informing targeted strategies to manage AMR. Four species of Eimeria infecting Buffaloes (*Bubalus bubalis*) in Meghalaya were identified using molecular tools. Economic studies were also conducted to assess the financial impact of gastrointestinal parasitic infections in livestock and poultry. In fisheries, the efforts were focussed towards enhancing fish health and productivity through the assessment of natural additives like turmeric and carambola extract. Moreover, recognizing the economic significance of aquaculture in the region, initiatives were launched to improve fish seed production, optimize supply chain management, and boost revenue generation.

The Division of Technology Assessment and Capacity Building's had also contributed significantly during the reporting period. The models viz. ARIMA, ARIMAX, ARCH and GARCH were evaluated for forecasting five months prices for important commodities such as ginger and turmeric. Best fit models for different commodities were identified using various fit statistic. Studies conducted in the social sciences indicated the dominance of formal communication sources such as Krishi Vigya Kendra and Fishery Officers for high yielding variety of rice and semi-intensive fish farming, while progressive farmers played a crucial role in providing information about low input backyard poultry farming. Also, Impact of adoption of *Jalkund* technology by the farmers revealed that they were able to take up additional high value vegetable crops in an area of 450m^2 and also earned an additional income of Rs. 27,000/annum. Except in Manipur and Mizoram, area under shifting cultivation in NER has declined by 15%

over the period of 2008-09 to 2015-16. Out of four blocks, Mawsynrut block of West Khasi Hills was found to be highly exposed to climate change. Integrated farming system (IFS) under Farmers FIRST project was reported to be very profitable and promising and under this project various extension activities were undertaken for dissemination of technologies.

Regional centre of our Institute located at Basar, Arunachal Pradesh had also put in concerted efforts for the development of the farmers of the region. As per the weather report, the total rainfall was 2180 mm which was a deficit of 13.1%. Total number of rainy days was 136 days compared to normal of 143 days. Performance of French bean and buckwheat under different soil conservation measures showed that double mulching yielded best results for plant height, relative water content (%), economic yield, etc. for both the crops. In varietal trial of sesame, Pasighat local recorded the highest number of pods per plant and seed yield (kg/ha). Among the different vegetable cropping sequence studied under low cost rain shelter, the cropping sequence viz. Capsicum – Bottle gourd – Spinach exhibited maximum yield and income. Among all the organic treatments imposed in Assam lemon plant, the organic treatments together with mulching viz. FYM (7 kg per plant) + vermicompost (4 kg per plant) + mulching with local weed biomass (T5) and FYM (7 kg per plant) + vermicompost (4 kg per plant) + neem cake (0.5 kg per plant) + mulching with local weed biomass recorded better results in vegetative growth, yield and fruit quality of Assam lemon. During the screening trials against late blight of tomato, the tomato hybrid, Arka Abhed recorded resistant to late blight disease and KC-4 native germplasm of chilli recorded low incidence of whitefly and viral complex. While evaluating the carbon sequestration potential of different agro-forestry systems, the highest bole biomass (203.64 ± 15.07 t/ha), branch biomass (171.09 ± 9.41 t/ha), foliage biomass (42.06 ± 2.94 t/ha), root biomass (54.50 ± 4.78 t/ha) and total biomass (471.34 ± 32.82 t/ha) was recorded in *Castanopsis indica*. While assessing the self-reported occupational hazards in livestock and poultry farmers, it was found that most common physical discomfort reported by farmers during different livestock managemental operation was severe pain in lower back. With regard to the conservation and improvement of indigenous cattle and goat, morpho-metric and physical traits have been studied. Faecal examination of 171 samples of Mithun from Leparada and West Siang districts revealed gastrointestinal parasites prevalence of 27.48 %. Based on faecal larval culture, the dominant species found were *Oesophagostomum* spp., *Haemonchus* and *Trichostrongyle* spp. Digital Terrain Analysis (DTA) was use to study the landscape of the district, utilizing SAGA GIS and 30-meter resolution Digital Elevation Model (DEM) data from the Shuttle Radar Topography Mission (SRTM).

Manipur centre also recorded noteworthy achievements during the reporting period. A set of 96 rice germplasm was screened for *PSTOL1* gene using 11 gene-based functional markers. Fifteen rice germplasm were identified with positive alleles of *PSTOL1* gene based on two functional markers, Pup1_K46 and Pup1_K20. The semi-dwarf black rice genotype, RCMBR 3 had outperformed the parent and local check in a multilocation trial, with a yield superiority of 70% in rainfed locations and 32% in irrigated field. Five local selections of foxtail millets were evaluated for their performance with two checks viz. SIA 3085 and SIA 3088 following RBD and were also DUS characterized. The selections: Chandel Selection, Ukhrul Selection and Tamenglong Selection II performed significantly superior with yield per plant of 12.9 g, 11 g and 6.8g. During the rabi season of 2023-24, a total of 372.12 q and 230.55 q of quality seeds of field crops were produced at research farm and at farmers field whereas 55.6 qtls and 2295.3 qtls of quality seeds were produced during Kharif / Spring/Summer 2023. During rabi 2022-23, 0.60 q of Maize Pusa Composite-3 breeder seeds were produced while 2.70 q of foundation seeds of field Pea Aman were produced. Among oilseeds 15.20 q of foundation seeds of mustard PM-27 was also produced. A total of 220 endophytes suspensions were collected and screening was done to see the presence of endophytes with nitrogen fixing ability. A total of 48 endophytes were identified as nitrogen fixing endophytic bacteria. A total of 38 sword suckers as explants in six different concentrations of cytokinin as treatments were used for identification of optimum concentration of plant hormones for shoot initiation of Meitei-Hei banana. Out of this only 12 explants have successfully multiplied into new shoots. The maximum mesocarp thickness in cucumber germplasm collection was recorded in Chingjaroi bell shape (2.55 mm) followed by Phungyokara (2.25 mm) and Angel cucumber (2.08 mm). Two promising moisture stress tolerant tomato lines namely, RCM-N-T-1 and RCM-N-T-2 will be proposed for multilocational trial under AICRP(VC)

in the coming year. DNA fingerprinting of these two lines along with RC Kamenasenba-1 (Sel-9A) and RC Manithoibi (Sel-3) has been carried out using 34 SSR markers of Tomato. Seed treatment was done using grounded plant powders (1%) of *Artemisia* and *Esholtzia* in white rice and black rice seeds. They gave complete protection to treated rice seeds against rice weevil and there was no emergence of storage insects for six months at the tested concentration. To control leaf roller, leaf-eating caterpillars and pod borers on Cucumber and French beans, foliar applications of chlorantraniliprole 18.5% w/w SC @ 25 g a.i./ha twice were sprayed on cucumber during fruiting. The residue on the cucumber persisted upto 9th day with a concentration of 0.04 mg/kg in cucumber and 0.06 mg/kg on French beans. In soil, the residue persisted upto the 5th day (0.08 mg/kg) on cucumber and 0.03 mg/kg on French beans. DNA barcoding was conducted on a total of forty-one (41) shiitake mushroom strains for identification based on the internal transcribed spacer (ITS), translational elongation factor 1α (TEF1α), mini chromosome maintenance protein (MCM7) and large subunit ribosomal RNA gene (LSU) regions as the barcode regions. Experiment was conducted for 6 weeks duration in laying hens (30 weeks old). Significant reduction in serum lipid profile (Total serum triglyceride, total serum cholesterol, LDL cholesterol and VLDL cholesterol) while HDL Cholesterol was significantly improved in laying hen by dietary inclusion of *Perilla* and flaxseed.

Mizoram centre also reported valuable information during the reporting period. Significant differences were observed among the different pools of P due to land use. The inorganic $NaHCO_3$-P was significantly higher in Lowland Rice soil and lowest in Teak soil while the organic $NaHCO_3$-P was higher in Teak and lowest in Lowland Rice soil. Twenty-four different lowland rice varieties were evaluated and the highest grain yield was recorded from RC-M-16 which produced 6239.47 kg ha^{-1}. For managing lepidopteran pests of French bean such as *Spodoptera litura, Helicoverpa armigera* and *Maruca vitrata* through organic means, *Azadirachta indica* 1% EC proved to be the most effective organic insecticide. It reduced the population of *Spodoptera litura* by 71.52%, *Helicoverpa armigera* by 62.66% and *Maruca vitrata* by 79.75%. Overall rainfall during the reporting period was almost 25.51% less than average, while the monsoon rains were 22% less than average. Plasmid-mediated colistin resistance (*mcr-1, mcr-3, mcr-4 and mcr-5*) genes were detected in 2.17% of *E. coli* isolates (10/459) obtained from foods of animal origin. Among the *Staphylococcus* spp. isolated from cattle and pigs, *S. aureus* was the predominant bacteria isolated followed by *S. hyicus*, *S. haemolyticus, S. chromogenes, S. auricularis* and *S. sciuri*. Out of 16 isolates of *S. aureus* in pigs, 3 isolates were found to be positive to *mecC* gene (antimicrobial resistance gene). A total of 29 local indigenous non-descript goat (Zokel) are being maintained as a genetic stock in the Goatery unit for recording morphometric, performance and carcass characteristics. The milk and dung composition of local indigenous cattle (Zobawng) was evaluated and the breed registration is in progress. External and internal qualities of eggs were evaluated for improved varieties of chickens such as Vanaraja, Rainbow rooster (RR), and Broiler Native Desi (BND) at 12 months of laying. The albumen index, representing thickness, was significantly higher in BND as compared to Rainbow Rooster and Vanaraja. The growth performance of *Barilius tileo* along with Indian Major Carps, Catla, Rohu and Mrigal revealed that it reduced the survival of Catla and Mrigal hence, *B. tileo* may not be suitable for incorporation.

Nagaland centre had also contributed significantly during the reporting period. For improving the livelihood of small and marginal farmers, four integrated farming system (IFS) models were developed and evaluated in Nagaland. The highest farm profitability (B:C Ratio) was found in model 1 (2.05) followed by model 2 (1.85), model 4 (1.80) and model 3 (1.64). A survey of 54 homegardens located across three elevation zones revealed significant variation in the size of homegardens along the elevation gradient. The soil organic carbon stock varied significantly along the elevation zones as well as among the different soil depths. Three leguminous tree species, *Gliricidia sepium*, *Leucaena leucocephala* and *Sesbania grandiflora* were grown to assess fodder production potential under different cutting frequencies. After 8 months of growth, *L. leucocephala* exhibited 100% survival rate. An agroforestry model was developed for the mid- hill region of Nagaland comprising of four major species, including three perennial woody components (*Areca catechu*, *Parkia roxburghii*, and *Gliricidia sepium*) and one herbaceous perennial crop (*Ananas comosus*). Most of the rice genotypes were found to be susceptible to rice blast disease. Assessment of liquid stored boar semen quality after removing seminal plasma proteins

and supplementation with melatonin was done and results revealed that one µM melatonin can be added to boar semen extender to improve its fertility and antioxidant potential. Reproductive performance and milk parameters were evaluated for five indigenous cattle of NE. Environmental assessment of broiler chicken production from a cradle-to farm gate perspective using Life Cycle Assessment (LCA) approach was done. The broiler production system was found to have moderate environmental impacts compared to other published LCA studies of chicken production. Evaluation of the effectiveness of prostaglandin F2alpha (PGF2α) administration on farrowing induction in swine revealed that PGF2α administration on 113th day of pregnancy could be an option for controlled farrowing in swine without any adverse effects. A total of 9195 numbers of improved piglets were produced in the farmer's field through artificial insemination.

In Sikkim also, notable achievements have been recorded. Two maize composite varieties namely, SKMC- 3 (KDM-34) and SKMC- 4 (KDM-35) had been identified for release in Sikkim. Additionally, a HYV of rice, Chirakey Selection-1 (IET 30517) has been identified for state release. Maximum rainfall was recorded in the month of August (495.9 mm), whereas minimum rainfall was recorded in the month of December (7.7 mm). Among the different cropping systems, significantly higher maize equivalent yield (11.7t/ha), system productivity (12.9 t/ha), system total production (16.1 t/ha) and system B:C ratio (2.92) was recorded under Maize-Vegetable pea cropping system as compared to Maize-French bean cropping system. Land use specific soil sample analysis confirmed that under long term rice mono-cropping, the soils are least stable. Aggregate stability of soils from bamboo plantation were found to be almost equivalent to natural primary forest soils, irrespective of altitudinal variation in Sikkim Himalaya. Seaweed sap treatment on a monthly basis enhanced the morphological, physiological, and biochemical qualities of Sikkim mandarin while also raising their market value. Abscission-inducing gene *CitSAUR06*, *CitSAUR08*, *CitSAUR44*, *CitSAUR61* and *CitSAUR64* were down-regulated in Sikkim mandarin when seaweed sap was applied. Biochemical analysis of the dried flowers of *Tupistra clarkei* was carried out and the highest phenol (2.68 g GAE/100g), total flavonoids (1.71g QE/100g), and antioxidant activity were recorded in the treatment shade drying without blanching. The Carbon pool index (CPI) did not differ significantly among the cropping system across the soil depth. In contrast, the lowest Carbon management index (CMI) value was recorded for Maize-Mustard cropping system. Long term location specific daily rainfall time series revealed significant persistent rising trend in rainfall concentration index which was evident during post monsoon months.

Tripura centre had also reported several remarkable achievements. One rice variety, NICRA Aerobic Dhan 2 was released by CVRC for aerobic condition. Fifteen entries were nominated to AICRIP IVT trials on the basis of superior performance in station trials and one in IRRI-NARES Breeding Network Project had been nominated to AICRIP trials. A low-cost portable Backyard adapted recirculatory small hatchery assembly had been developed which is very women friendly. In total, 59.5 q breeder seed and 206 q TL seed of released rice varieties and 607q TL seed of pulses were produced under AICRP seed and Pulses seed hub, respectively. In comparison to long period average (LPA), the total rain during the reporting period was deficit (77.4% of LPA). Yearly mean maximum temperature was recorded 3.2% above normal (31.7 °C) while yearly mean minimum temperature was 18.4 °C (5.7%) below normal. Nine villages belonging to four districts have been covered under technology adoption so that farmers can earn extra income. Tuber crop based multistorey annual sequence of vegetable cropping system was standardized under Tripura condition. Nine major and minor tuber crops have been collected, characterised and IC numbers have been obtained from NBPGR. Twenty-one numbers of germplasm of brinjal have been collected and evaluated, out of which four lines (TBL-04, TBL-13, TBL-12, TBL-10) were found to be promising in terms of fruit yield and other characters. Seven different multi-tier based agroforestry systems (AFS) were evaluated for various important parameters. Among the early maturing varieties of groundnut, GPBD-5 exhibited maturity in 90 days, followed by KDG-123 and KDG-182. Among six biofortified maize hybrids, NEH-BIOFORT-03 demonstrated the highest kernel yield (7.1 t/ha). The highest fertility among the chicken germplasm was found in Coloured broiler (84.79%) and lowest in Kadaknath (77.12%). Basal diet having 10% *Wolffia* yielded high dressing and eviscerated yield in case of Kadaknath. The growth performance of *Catla catla* was better than *Labeo rohita* in 50% and

20% diluted cattle wastewater. EDTA and *Eichhornia* reduced the Fe content in water by 95%. Rudrasagar lake's water quality varied throughout the year, with the Water quality index ranging from 33.36 to 56.31 during different seasons.

Under NICRA, NICRA Aerobic Dhan 2 has been notified for cultivation in aerobic conditions with yield potential of 4.11 t/ha. Furthermore, two drought stress tolerant tomato lines (RCM-N-T-1 and DVRT-2) with yield potential of 30.0 t/ha and 32.0 t/ha have been developed. Two digital technologies viz., NES+ (North East Soil Plus), android application to assess the status of soil health and Hyper Green Indexer (HsGI), to effortlessly generate essential hyperspectral vegetation indices were also developed.

A new beginning has been made on December 4, 2023 when the UG Program, B.Sc. (Hons) Agriculture of ICAR-IARI Umiam Hub started at ICAR RC NEHR. This Institute has been considered as one of the nodal Institutes for the IARI –MERU academic programme from the current academic session of 2023-24.

The Tribal Sub Plan under Scheduled Tribe Component, implemented by the Institute had benefitted more than 24,345 tribal famers. Also, Agri Business Incubation Centre has continuously supported the registered and other potential entrepreneurs of the region in various aspects including new product conceptualization, licensing, marketing and linkages. Furthermore, twenty KVKs under the administrative control of the Institute have conducted 653 nos. of training programmes in different areas of agriculture and allied activities covering 17,815 nos. of beneficiaries across the region.

INTRODUCTION

The ICAR Research Complex for NEH Region is a leading agricultural research Institute in the Northeastern Hill Region. Its headquarter is situated in Umiam, Meghalaya, and it has six regional centers across six states (Arunachal Pradesh, Manipur, Mizoram, Nagaland, Sikkim, and Tripura). Development of innovative and location specific technologies for the benefit of the farmers of this region has been a motto of this Institute and it has been working in this direction since its establishment in 1975. This Institute is dedicated towards the development of technologies which promote sustainability, climate resilience and which are also in line with the established traditions of the inhabitants in this region. The complex, diverse and risk prone (CDR) nature of the agriculture in this region makes the task even more challenging. Moreover, Institute has been continuously focusing on net income maximization, food security, women empowerment, drudgery reduction and minimization of loss of natural resources. This is being accomplished by the dedicated and motivated workforce of this Institute which is continuously striving for the advancement of hill agriculture. A strong network of 20 Krishi Vigyan Kendras, strategically located in all the states of the hilly northeastern region supports in dissemination of these developed technologies. Custom-made livelihood options in agriculture and related fields are being provided by the Institute through various capacity building programmes. These options are certainly helping in enhancing tribal livelihood in this region. The Institute has also been at the forefront in enhancing livelihood and nutritional security by providing truthfully labelled seeds, quality planting material, improved animal breeds, poultry and fish seeds, tools and implements for hill agriculture, soil testing kits, diagnostic kits for animal diseases and other critical inputs. This Institute has also played an active role in human resource development, including teaching and research for post-graduate and doctoral students in agricultural and allied sciences from various universities across the country. Furthermore, a new beginning has been made on December 4, 2023 when the UG Program, B.Sc. (Hons) Agriculture of ICAR-IARI Umiam Hub started at this Institute. Being a premier Institute in the northeastern hill region, it also operates many competitive national and international projects funded by agencies such as DBT, DST, SERB, NICRA, NHB, NASF, NMSHE, FFP and TSP, targeting the frontier areas of agricultural research. Additionally, the Institute also pursues several interdisciplinary in-house research projects of strategic and adaptive significance.

Linkages with international organisations like IRRI and other ICAR Institutes has been a priority for this Institute for furthering the cause of improvement of hill agriculture. Many other reputed organisations like MANAGE, NABARD, TISS are part of the Institutional linkage program. Furthermore, the Institute also collaborates with NGOs, farmers' organizations, and cooperative societies to strengthen its outreach activities in the region.

The Institute is primarily focusing on the following mandate and thrust areas-

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

A number of well-equipped laboratories are supporting the scientists of this Institute for doing cutting edge research. Apart from the laboratories in the four divisions of headquarter and six regional centers, there is also a Central Laboratory at Umiam. This is equipped with advanced facilities, 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 facilities are supporting scientists in fulfilling the mandate of this Institute. Available advanced facilities such as FATE, CTGC, biochar, and TOC analyser are the backbone of research focussed on climate resilient agriculture. For value addition and for enhancing farmers income a post-harvest processing unit is also available. The Institute also maintains bio-containment facilities together with state-of-the-art laboratories for addressing the research issues associated with animal pathogens. Agricultural Engineering section runs an advanced workshop that is involved in the prototyping, development and fabrication of novel tools and implements.

HUMAN RESOURCES

Backbone of the Institute are its dedicated and dynamic staff who are constantly working for the progress of the Institute. The workforce comprises scientific, technical, administrative, and support staff (staff strength is 669 as of Dec 2023). Details are in Table 1.

Table 1. Staff details of the Institute

	Category	Sanctioned Post	Filled Post	Vacant Post
Institute	Scientific	155	122	33
	Technical	252	88	164
	Administrative	116	55	61
	Supporting	115	89	26
	Regularized SSS	184	147	--
	Total	**822**	**501**	**284**
Krishi Vigyan Kendra	Sr. Scientist & Head	20	19	1
	T-6(SMS)	120	75	45
	T-4 (Programme Assistant)	40	21	19
	T-4 (Farm Manager)	20	10	10
	T-1 (Driver cum Mechanic)	40	20	20
	Assistant	20	0	20
	Jr. Steno cum Computer Operator	20	1	19
	Skilled Support Staff	40	22	18
	Total	**320**	**168**	**152**
Grand Total		**1202**	**669**	**436**

LIBRARY

The library in the Institute, houses a vast collection of scientific journals and books, providing access to the latest developments in various areas of research. The current collection of books, reports and back volumes of journals exceeds 44,000. Current list of the resources in the library are enlisted in Table 2.

Table 2. Books and Journals in the library of the Institute

Nature of Publication	No. of copies available
Books & Reports	31921
Back Volumes of Journals	12715
Foreign Journals	-
Indian Journals	7
News Papers	9
Hindi Books	4478

BUDGET

During the financial year 2023-24, the Institute had a budget outlay of ₹ 119.1 crore, expenditure incurred was ₹ 118.4 crore with an impressive utilisation of 99.4% of the allocation. During 2023-24 a substantial amount of revenue (₹ 2,70,99,997.00) was also generated. Details of the expenditure are enlisted in Table 3.

Table 3. Annual budget of the Institute for 2023-24 (₹ Crores)

Head	Revised Estimate	Expenditure
A. Recurring		
Establishment charges	59.6771674	59.6771674
Wages	0.0521326	0.0521326
Travelling allowance	1.0237503	1.0237503
Recurring contingences	21.1416145	21.1416145
Other items (HRD)	0.0903782	0.0903782
Repair/ maintenance	11.374257	11.374257
Pension	10.454	10.454
Total A	103.8133	103.8133
B. Non- recurring		
Works	3.034781	3.034781
Equipments	3.2928173	3.2928173
Information technology	0.5267631	0.5267631
Furniture and Fixture	1.1682189	1.1682189
Books	-	-
Livestock	0.2021	0.2021
Other (Vehicle & Vessels)	1.9653197	1.9653197
Total B	10.19	10.19

C. Loans and advances	1.50	0.798404
D. TSP	3.60	3.60
E. SCSP	-	-
Grand total (A+B+C+D+E)	119.1033	118.401704

INFORMATION TECHNOLOGY FACILITIES

To be at the cutting edge of the fast-changing information technology world, our Institute maintains many latest IT facilities with regular updates to the existing repertoire as and when required. Notable among them is a computer lab equipped with various statistical software tools such as SAS, SPSS, and STATISTICA. Furthermore, several GIS software options like Arc GIS and QGIS (Open Source) are also available. Trained manpower for efficiently utilizing these resources/software's is available. This Institute being a centre of various online examinations conducted by Agricultural Scientists Recruitment Board (ASRB), the Institute operates a computerized examination hall equipped with servers, desktops, and backup power systems catering to the needs of this region. During the reporting period eHRMS 2.0 has been implemented at this Institute for proper management of Human resources. Also, Agricultural Research Management System (ARMS 2.0) has been fully implemented for proper monitoring of the research achievements. A functional Computational Biology Unit (CBU), having a dedicated server and terminals is being efficiently utilized for genomics and bioinformatics related research. Additionally, Agro advisory services to the farmers of this region are also being provided through GKMS (Gramin Krishi Mausam Seva) in collaboration with Indian Meteorological Department. Not only headquarters at Umiam but all the six regional centres are also well equipped with computers and accessories connected to the internet enabling the Institute's managerial and research activities.

IMPORTANT VISITORS, EVENTS & MEETINGS

Hon'ble Union Minister of Agriculture and Farmers Welfare, GoI inaugurated the largest Agri fair "North East Krishi Kumbh 2023"

The largest Agri Fair in the North East was organized by the ICAR Research Complex for NEH Region, Umiam, Meghalaya, during January 4-6, 2023, along with the Foundation Day celebration. The theme of the Agri fair was "Emerging opportunities in agriculture and allied sectors for income and employment generation". It was inaugurated by the Hon'ble Union Minister of Agriculture and Farmers Welfare, Shri Narendra Singh Tomar. He urged farmers and agriculturists to conserve the rich biodiversity and resources of the region. The Deputy Director General (NRM) of ICAR, New Delhi, Dr. S. K. Chaudhari, in the foundation day lecture, highlighted the significant contribution of ICAR Research Complex for North Eastern Hill Region in uplifting the rural communities and helping the farmers of this region. More than 10,000 farmers from all the eight states of the region and different stakeholders participated in the event. Live demonstrations and exhibitions of recent technologies were conducted through 102 stalls, organized by the host institute and its regional centres, along with all the ICAR institutes in the region. Local products were showcased in more than 50 stalls exhibited by different Self Help Groups, ABI entrepreneurs, FPO/FPCS, and private firms (Fig. 1). Dr. V. K. Mishra, Director of the Institute in his welcome address, expressed gratefulness to the Ministry of Agriculture and Farmers Welfare and the Directorate of Extension for sponsoring and supporting the grand event. Dr. Anupam Mishra, VC, CAU, Imphal, Dr. B. C. Deka, VC, AAU, Jorhat, and Dr. K. M. Bujarbaruah, former DDG & former VC, AAU, also graced the occasion. The vote of thanks was offered by the Organizing Secretary, Dr. G. Kadirvel.

Fig. 1. Hon'ble Union Minister of Agriculture and Farmers Welfare, Shri Narendra Singh Tomar, at the "North East Krishi Kumbh 2023"

National Conference of Indian Association of Hill Farming was inaugurated by the Hon'ble Governor of Meghalaya

Shri Phagu Chauhan, Hon'ble Governor of Meghalaya visited the Institute on 8th June, 2023 to inaugurate the National conference entitled "Rebooting the hill farming for future sustainability and livelihood (RHFFSL)" held during 8-9 June, 2023 at Meghalaya (Fig. 2). Dr. KM Bujarbaruah, Former Vice Chancellor, AAU, Jorhat, Former DDG, Animal Sciences, ICAR, Dr. Anupam Mishra, Vice Chancellor, CAU, Imphal and Dr. Uttam C. Sharma, Vice President, International Commission on Water Resources Systems graced the occasion as special guests during the event. The Hon'ble Governor of Meghalaya stressed the importance of conserving land and water resources for the benefit of farmers in Meghalaya. The valedictory session was chaired by Prof. Prabha Shankar Shukla, Vice Chancellor, NEHU, Shillong. Convener of the conference, Dr. V.K. Mishra, emphasized on the steps to be taken for making the farming sustainable in this region.


Fig. 2. Shri. Phagu Chauhan, Hon'ble Governor of Meghalaya during the inaugural programme

Secretary, DARE & Director General, ICAR visited ICAR Research Complex for NEH Region, Umiam, Meghalaya

Dr Himanshu Pathak, Secretary, DARE & Director General, ICAR, New Delhi visited to ICAR Research Complex for NEH Region, Umiam, Meghalaya on 24th June 2023. While taking stock of the Institute research activities, Dr. Pathak visited Integrated Farming System research fields, Agricultural Engineering Workshop, Livestock and Fisheries Farms, Organic Farming fields and NICRA Research facilities. To celebrate the much sought after visit by Secretary, DARE & Director General, ICAR, a plantation programme was also organized in the premise of the Institute for posterity. (Fig. 3).

Fig. 3. Dr. Himanshu Pathak, Hon'ble Secretary, DARE & DG, ICAR

Visit of Hon'ble Member of Parliament, Lok Sabha, Shillong

Shri Vincent H. Pala, Hon'ble Member of Parliament, Lok Sabha, Shillong, Meghalaya visited ICAR RC for NEH Region, Umiam, on the occasion of the Annual Review cum Action Plan Workshop of NICRA program for Krishi Vigyan Kendras (Zone-VII) on 28th April, 2023, where he was the Chief Guest. He lauded ICAR for implementation of NICRA program in the Northeast region through KVKs to combat climatic vulnerabilities in agriculture. The review programme was presided over by Dr. S.K. Chaudhari, Deputy Director General (Natural Resource Management) with other eminent dignitaries, Dr. V. K. Mishra, Director, ICAR Research Complex for NEH, Umiam, Dr. A.K. Mohanty, Director, ATARI-VI, Umiam, Dr. V. K. Singh, Director, ICAR-CRIDA, Hyderabad and Dr. B Venkateswarlu, NICRA Review Committee Chairman and Former VC, VNMKV, Parbani. (Fig. 4).

Fig. 4. Shri Vincent H. Pala, Hon'ble Member of Parliament, Shillong, Meghalaya during his visit to the Institute

Minister of Fisheries, Meghalaya, Shri Alexander Laloo Hek, graced the inaugural function of one-day workshop on "Boosting coldwater aquaculture and fisheries in Meghalaya" in collaboration with ICAR- DCFR

The ICAR-DCFR in Bhimtal organized a one-day workshop on 'Boosting Coldwater Aquaculture and Fisheries in Meghalaya' on 18th August, 2023, in collaboration with the ICAR Research Complex for NEH Region and the Department of Fisheries, Meghalaya. The Honorable Minister of Fisheries, Meghalaya, Shri Alexander Laloo Hek, graced the inaugural session as the Chief Guest. Other distinguished attendees included Shri Sibhi Chakravarthy Sadhu, Secretary of the Department of Fisheries, Meghalaya; Dr. Pramod Kumar Pandey, Director of DCFR; Dr. V.K. Mishra, Director of ICAR NEH; Dr. A.K. Mohanty, Director of ATARI Zone VII; Dr. S.V. Ngachan, Former Director of ICAR NEH; Smti A.L. Mawlong, Director of the Department of Fisheries, Meghalaya; as well as scientists and technical staff from DCFR, ICAR NEH, and KVK, and officers including the Superintendent of Fisheries and Assistant Directors from the State Fisheries Department. The workshop was attended by nearly 100 farmers, entrepreneurs, and stakeholders discussing the challenges and potential of coldwater fisheries in Meghalaya (Fig. 5).

Fig. 5. Workshop on Boosting coldwater aquaculture and fisheries in Meghalaya

Hon'ble Agriculture Minister of Tripura visited the model village Satdubia, Mohanpur Block, West Tripura

Hon'ble Agriculture Minister of Tripura, Shri Rattan Lal Nath, visited the model village Satdubia, Mohanpur Block, West Tripura on 6th June, 2023 where demonstration of resource conservation technology with mulching for vegetable cultivation was demonstrated and field day was organized (Fig. 6.).

Fig. 6. Hon'ble Agriculture Minister of Tripura at the model village Satdubia, Mohanpur Block, West Tripura

Hon'ble Chief Minister & Agriculture Minister, Govt. of Tripura graced the National conference cum Buyer seller meet on Agri - Horti crops

Hon'ble Chief Minister of Tripura, Shri Manik Saha and Hon'ble Agriculture Minister, Shri Rattan Lal Nath, visited the stall of ICAR Tripura Centre during the National conference cum Buyer Seller Meet on Agri - Horti crops of Tripura jointly organized by Directorate of Horticulture & Soil Conservation, Govt of Tripura in collaboration with APEDA, Govt of India at Pragna Bhawan, Agartala on 3rd July, 2023 (Fig. 7).

Fig. 7. Hon'ble Chief Minister of Tripura Shri Manik Saha and Hon'ble Agriculture Minister Shri Rattan Lal Nath visited the stall of ICAR Tripura Centre

Visit of DDG (NRM) at ICAR Manipur Centre for foundation stone laying ceremony of Administrative building of ICAR- KVK Imphal West

Foundation Stone of Administrative Building of ICAR- KVK Imphal West was laid at the campus of ICAR Research Complex for NEH Region, Manipur Centre, Lamphelpat on the 18th March 2023. The function was graced by Dr. Suresh Kumar Chaudhari, Deputy Director General (Natural Resource Management), Indian Council of Agricultural Research, New Delhi, as the Chief Guest; Dr. Anupam Mishra, Hon'ble Vice Chancellor, CAU, Imphal; Shri Nabakumar, Hon'ble member of ICAR Governing Body and Dr. R. Bordoloi, Principal Scientist, ATARI, Umiam as Guests of Honour and Dr. Vinay Kumar Mishra, Director, ICAR NEH Region, Umiam as the president (Fig. 8). DDG (NRM) expressed his happiness that the Foundation Stone laying ceremony of ICAR KVK Imphal West was realized after a span of 44 years and acknowledged the support from Ministry of Agriculture and Farmers Welfare, GOI, Ministry of Development of North Eastern Region and North Eastern Council. A Farmer–Scientists interaction was also organized as part of the function.

Fig. 8. DDG (NRM) at ICAR Manipur Centre

DDG (NRM), ICAR, New Delhi laid the foundation stone of Administrative Building of ICAR-KVK West Tripura

The foundation stone of administrative building of KVK West Tripura, Belbari under ICAR Research Complex for NEH Region, Meghalaya was laid by Dr. Suresh Kumar Chaudhari, DDG (NRM), ICAR, New Delhi in presence of Dr. Vinay Kumar Mishra, Director, ICAR RC NEH Region on 30th April 2023. Farmers-Scientists interaction meet-cum-input distribution programme was also organized where around 150 farmers from different parts of West Tripura district were present. DDG (NRM), visited the KVK farm and gave valuable suggestions for further improvements of demonstration units and area expansion by developing the available land. An exhibition was also organized where various technologies developed at ICAR Tripura Centre, technologies which are being disseminated by KVK West Tripura and produce and products of local FPO and farmers were displayed (Fig. 9 & 10).

Fig. 9. Dr. S. K. Chaudhari, DDG (NRM), with Director and staff at ICAR Tripura Centre

Fig. 10. Distribution of different inputs to the farmers of Tripura

Shri. Mhathung Yanthan, State Advisor to Agriculture, Government of Nagaland visited ICAR Research Complex for NEH Region, Nagaland Centre

Shri. Mhathung Yanthan, State Advisor to Agriculture, Government of Nagaland, paid a visit to the ICAR Research Complex for NEH Region, Nagaland Centre, accompanied by state officials from the agriculture department on 18th October 2023. During the visit, he engaged with the scientific staff of the centre and shared insights into the current activities and projects being implemented by the state department (Fig. 11).

Fig. 11. Shri. Mhathung Yanthan, Hon'ble Agriculture Advisor, Govt. of Nagaland with state officials from the agriculture department at ICAR Nagaland Centre

Visit of QRT Team of AICRPs

QRT Meeting was conducted during May 18-20, 2023 at ICAR-Research Complex for NEH Region Umiam, Meghalaya to review the work done by various centres of AICRP on Farm Implements & Machinery, Ergonomic & Safety in Agriculture (ESA), Increased Utilization of Animal Energy with Enhanced System Efficiency (UAE) and Consortia Research Platform (CRP) on Engineering Intervention in Precision Farming (PF) and Micro Irrigation Systems (MIS) located in Northeast India. The QRT Team was chaired by Dr. M.M. Pandey along with Dr. Y.C. Bhatt (Member, QRT), Dr. B. Sridhar (Member, QRT), Dr.T.K. Bhattacharya (Member, QRT), Dr. K.V. Ramana Rao (Member QRT) and Dr. K.N. Agrawal (PC, AICRP on ESA) (Fig. 12).

Fig. 12. QRT Team of AICRP on FIM, ESA, UAE and CRP on PF (MIS)

Research Advisory Committee Meeting (RAC) 2023

The Research Advisory Committee (RAC) meeting of the Institute was organized during 19-20 June, 2023. The two day event was chaired by Dr. V.N. Sharda, former Member, Agricultural Scientists Recruitment Board (ASRB), Dr. Ashok Halepyati, former Dean, University of Agricultural Sciences, Raichur, Dr. H.K. Senapati, former Dean(PG), Odisha University of Agriculture and Technology, Bhubaneswar, Dr. S. Rajan, former Director, ICAR-Central Institute of Sub-tropical Horticulture, Lucknow, Dr. K. K. Baruah, former Director, ICAR-National Research Centre on Yak, Dirang and Dr. A. K. Tripathi, former Director, ATARI-Guwahati as members (Fig. 13 & 14).

Fig. 13. Honourable Chairman of RAC with the members

Fig. 14. RAC Team interacting with the scientists of Agril. Engg. Section, DSRE, ICAR-RC NEH Region Umiam

Institute Research Committee (IRC) Meeting, 2023

The Institute Research Committee Meeting 2023 was held during 3-7 July 2023 chaired by Dr V. K. Mishra Director, ICAR Research Complex for NEH Region, Umiam and attended by all the Scientists of the Institute including those from the regional centres. Three invited experts also attended the meeting who presented their expert views viz., Dr Girish Patil, Director ICAR, NRC, Mithun, Nagaland, Dr. Dilip Kumar Verma, PS, ICAR-IARI, Regional Station, Indore, Dr. Om Prakash Chaturvedi, Former Director, ICAR-CARI, Jhansi, UP (Fig. 15).

Fig. 15. Institute Research Committee Meeting, 3-7 July 2023

ICAR- Agripreneurs Meet cum National Symposium organized at ICAR RC for NEH Region, Umiam

A National Symposium on "Strategies for promotion of incubates in Agriculture and Allied Sectors in the Northeastern Region of India" was organized by the Agri-Business Incubation Centre during 4-5 October, 2023. The programme was inaugurated by Dr. Ch. Srinivasa Rao, Director, ICAR- National Academy of Agricultural Research Management, Hyderabad. The two day programme consisted of technical deliberations in 7 different themes and exhibition of products made by agripreneurs in the region. The event was attended by 50 entrepreneurs and 150 delegates (Fig. 16).

Fig. 16. Dr. Ch. Srinivasa Rao, Director, ICAR- National Academy of Agricultural Research Management, Hyderabad

A two-day workshop on Regional Fisheries in collaboration with ICAR-CIFT

A comprehensive two-day regional workshop focusing on "Technologies for sustainable and resilient fishery-based livelihood in the North East Region" was organized during 19-20 January, 2023, in collaboration with the Central Institute of Fisheries Technology (CIFT), Cochin, at Umiam. The inaugural session witnessed the esteemed presence of Mrs. A.L. Mawlong, Director of Fisheries, Meghalaya, as the Chief Guest, Dr. George Ninan, Director ICAR-CIFT, and Dr. P. Putra, Former Asst. Director (Marine Fisheries.), ICAR, New Delhi. Dr. V.K. Mishra, Director ICAR (RC) for NEH Region, Umiam, graced the occasion as the Guest of Honor. The event drew participation from various experts and stakeholders in the fisheries domain, SMSs from all KVKs across the NE states, representatives from the NFDB, officials from state fisheries departments in NE, and other relevant developmental agencies, totaling 50 participants (Fig. 17).

Fig. 17. Workshop on technologies for sustainable and resilient fishery-based livelihood in North East Region

A one day workshop on the onset of International Year of Millet

The program, organized on 25th January, 2023, was graced by several dignitaries: Shri P. Vaiphei, IAS, Additional Chief Secretary, Department of Horticulture and Soil Conservation, Government of Manipur Shri R.K. Dinesh, IAS, Commissioner Agriculture, Government of Manipur, Dr. S. B. Singh, Director of Instruction, CAU, Imphal, Smt. N. Guite, General Manager, NABARD, Manipur Regional Office, Lamphelpat, Manipur and Dr V. K. Mishra, Director, ICAR-RC for NEH Region, Umiam, Meghalaya. Several lectures were delivered by Experts/Scientists from Indian Institute of Millets Research, Hyderabad on aspects of cultivation and management of pests and diseases (Fig. 18).

Fig. 18. Celebrating International Year of Millet at ICAR Manipur Centre

Celebration of World Soil Day

The Soil Science section, DSRE, ICAR RC for NEH Region, Umiam, Meghalaya organized an Awareness program on "*Soil and Water: A Source of Life*" on the occasion of World Soil Day on 5th December, 2023. The main aim of the programme was to create awareness among the tribal students and farmers and sensitize them about the importance of healthy soil and quality water in household food security and instil a sense of responsibility towards stewardship and conservation of their own soil and water for a sustainable future. The programme was organized under the aegis of Tribal Sub-Plan (TSP), ICAR RC for NEH Region, Umiam, Meghalaya (Fig. 19)

Fig. 19. Celebration of World Soil Day 5th Dec 2023

Interface meet with the District level Agriculture and Horticulture officers of Government of Meghalaya

An Interface meet was organised with the district level Agriculture and Horticulture officers of government of Meghalaya on 8th of December at the IATC conference hall MAMETI building Upper Shillong. The programme was graced by the Director, Department of Agriculture and Farmers Welfare, Smti. J. C Lyngdoh and Shri. W Syiemlieh, Joint Director, Research and Training, Government of Meghalaya. The Interface meet was attended by 45 District Agricultural/Horticultural Officers from all districts of the State and the scientists from ICAR RC for NEH Region, Umiam (Fig. 20).

Fig. 20. ICAR Interface meet with state agricultural functionaries at Upper Shillong

Valedictory programme of 30 days Skill cum vocational training programme for rejuvenating livelihoods of inmates in relief camps under Imphal West district of Manipur

A 30 days training programme entitled "30 days Skill cum Vocational Training Programmes for Rejuvenating Livelihoods of Inmates in Relief Camps under Imphal West District of Manipur State" to impart training on various aspects like Mushroom cultivation, Food processing, Vermicomposting, Bee Keeping, Floriculture, Seed production, Vegetable gardening, Poultry, Piggery, Ornamental fishery, including Farmers' Schemes and Credit linkages to the displaced persons on 27th Sept., 2023. A total of 435 inmates from 13 numbers of relief camps were covered during the 30 day skill cum vocational training. (Fig. 21).

Fig. 21. Valedictory programme of thirty days skill cum vocational training programme

Hindi Diwas and Hindi Ullas Pakhwada Celebration

ICAR Research Complex for NEH Region, Umiam including all its six regional centre celebrated the Hindi Diwas and Hindi Ullas Pakhwada during 14-29 September, 2023. The celebration was part of the Central Government exercise to make Hindi language popular and to increase usage of Hindi language in Central Government offices. In Meghalaya, the event was inaugurated by Dr. Brahmadev Ram Tiwari, IAS, Commissioner and Secretary to the Governor of Meghalaya. The event featured a variety of competitions including Hindi poetry recitation, Hindi typing in Unicode, debates, note writing, scientific article presentations, and Antakshari. These competitions saw enthusiastic participation from both Hindi and non-Hindi speaking officers and employees (Fig. 22).

Fig. 22. Hindi Diwas and Hindi Ullas Pakhwada Celebration

Celebration of Kisan Diwas cum National Mushroom Day 2023

The celebration was held on 23rd December 2023 at ICAR Manipur Centre and the program was graced by Shri. N Gojendro Singh Director, Department of Agriculture and Shri. K Debadutta Sharma, Project Director, MOMA and Additional Director, Horticulture & Soil Conservation; as Chief Guest and Guest of Honour respectively, participated 209 farmers and displayed 19 stalls of different mushrooms and other agri products (Fig. 23.).

Fig. 23. Celebration of Kishan Divas Cum National Mushroom Day 2023

International Women's Day Celebration

International Women's Day was celebrated on 8th March, 2023 on the theme "Digit All : Innovations & technology for gender equality" at ICAR RC for NEH Region, Mizoram Centre where all the female staff members participated the programme (Fig. 24).

Fig. 24. Observation of International Women's Day at ICAR Mizoram Centre

MEGHALAYA

SUMMARY

In 2023, Meghalaya experienced deficit rainfall (15%) and marginal increase in maximum temperature. Integrated farming system Agro-pastoral system has shown higher net income and benefit to cost ratio. Natural farming and application of lime in finger millet and natural farming with application of lime and Farm Yard Manure (FYM) in cowpea resulted in higher yield. Integrated Nutrient Management (INM) with 50% NPK + 50% FYM + Lime + Biofertilizer increased the maize grain yield by 15-64%. Development of two row maize planter for hilly terrain and automatic precision orchard sprayer are in progress. Different IOFS models have been standardized and disseminated to the farmers. The DRIS indices for Khasi mandarin were developed. Genotypes of vegetables viz. French bean (145), cow pea (28), Indian bean (125), king chili (29) and underutilized cucurbits (60) were evaluated and promising genotypes have been identified. Under Crop Sciences, two perilla varieties (Poorvottar perilla 1 and Poorvottar perilla 2) were identified for release and notification in VIC meeting of AICRN on Potential crops. Aluminium tolerance study in rice through MetaQTL analysis showed upregulation of OsMT1, OsNTR2.3, and ALMT4 genes in tolerant genotypes. NIRS (Near Infrared Spectroscopy) a powerful and non-destructive tool was used to develop robust prediction models for the rapid quantitative assessment of Perilla's nutritional components. Biopesticides, *Bt* @ 2g/l was a highly effective treatment against fall army worm and cabbage butterfly. *Apis cerana* demonstrated the highest efficiency as a pollinator of litchi, as indicated by the Pollination Efficiency Index (PEI). Microbial community structure analysis revealed the abundance of Proteobacteria, Bacteroida, etc. in the test soil. In the Animal & Fisheries Sciences, potential of deep-freezing storage of frozen semen in bulls, and the impact of selenium nanoparticles on the quality and fertility of boar and buck semen was investigated. Also, efforts were directed towards the conservation of indigenous germplasms of goats and native fish species and the establishment of Rural Bioresource Complexes for improving the livelihoods of hill farmers. Development of novel nucleic acid assays for detecting the African swine fever virus in clinical samples, and *Staphylococcus aureus* in milk. Emerging metabolic technique, microbiome modulation, was employed on pre-weaned piglets to bolster gut health through probiotic supplementation, thereby contributing to the production of healthier livestock. Similarly, the development and application of core-resistome analysis techniques to decipher temporal trends of antimicrobial resistance in foodborne zoonotic pathogens proved helpful in informing targeted intervention strategies to manage AMR. Studies were undertaken to assess the economic impact of gastrointestinal parasitic infections in livestock and poultry. Under fisheries assessment of natural additives such as turmeric and carambola extract on fish health and productivity was done. Under Social Sciences, study on Social Network Structures vis-à-vis Information on Agricultural Technology among the farmers of Meghalaya indicated the dominance of formal communication sources. Five months prices for commodities such as ginger and turmeric were forecasted using ARIMA, ARIMAX, ARCH and GARCH models. Area under shifting cultivation in NER declined by 15% over the period of 2008-09 to 2015-16, however the area under shifting cultivation during the same period increased by 70% and 15% in Manipur and Mizoram , respectively. Integrated farming system under Farmers FIRST project was found to be very profitable and promising.

Division of System Research and Engineering

Weather Report

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

Umiam received 2069.7 mm of annual rainfall (110 events). About 68% of the annual rainfall i.e. 1404.1 mm was received in monsoon season in 72 rainy days. The May and October months have contributed 24 rain events. The rainfall received in January, February, April, May, July, September, October and November was considerably lower than the Long Period Average (LPA), however March, June and December months received higher rainfall than normal monthly rain. The total rainfall for the year was 15% lower compared to normal and for the monsoon season the deficit was 10%. The monthly and annual pattern in rainfall is depicted in Fig 1. The highest single day rainfall of 109.6 mm occurred on 10th June, 2023. The total annual pan evaporation was 1023.6 mm. The rainfall was more than the pan evaporation from April to October, but the reverse is true for the rest of the months.

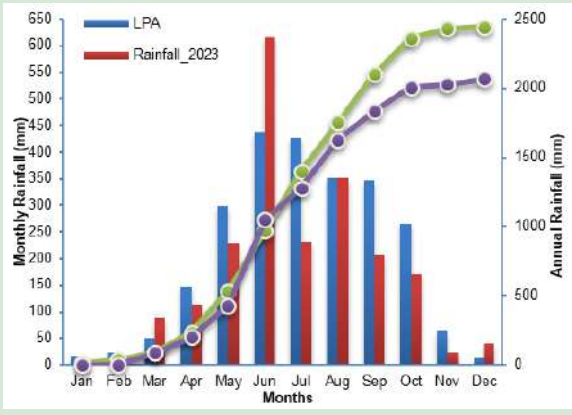
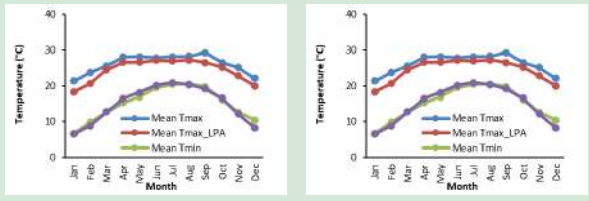


Fig. 1. Monthly & annual rainfall pattern

The mean monthly maximum temperature (Mean T_{max}) and mean monthly minimum temperature (Mean T_{min}) showed a similar trend throughout the year (Fig 2 a). The mean T_{max} varied between 29.3°C to 25.2°C for all the months except December to February when it varied from between 23.7°C to 21.3°C. It is clear from the data that for almost all the months, the T_{max} was either similar or more than its LPA. 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} in Umiam. The mean monthly T_{max} of September was 29.3°C which was highest for the year. Further, the rainfall for July and September was much lower than normal and this can be attributed to prevalence of high temperature during the period. The Mean T_{min} was highest in August (20.5°C) and lowest in January (6.6°C). It is seen that the mean monthly minimum temperature increased after January and reached maximum in August and thereafter decreased until it reached minimum in the month of January. The mean monthly T_{min} value was closer to LPA.



(a) **(b)**

Fig. 2. Monthly values of (a) mean maximum & minimum temperature and (b) mean relative humidity during 2023

The variation in morning relative humidity ($RH\text{-}_{morning}$) is much lesser compared to the relative humidity ($RH\text{-}_{evening}$) in the evening (Fig 2 b). The $RH_{(morning)}$ varied between 93.7 % to 78.4% in August and April respectively and $RH_{(evening)}$ varied between 85.2% and 60.5% in July and January respectively. Due to heavy rainfall in June the relative humidity also reached to higher denomination. The $RH_{(evening)}$ was much higher than LPA throughout many months in the year. The average wind speed was lower than normal for almost all the months except from March to June (19% to 56%) which was higher than LPA. It was observed that the wind speed over the years in Umiam decreased persistently.

RESEARCH ACHIEVEMENTS

Agricultural Engineering

Automatic Precise Orchard Sprayer for Hilly Region

(*H. J. Singh and N. Singh*)

Looking into the various challenges while developing orchard sprayers especially the precise segmentation of regions of interest, a study was conducted to deploy a Convolutional Neural Network (CNN) for the segmentation of citrus plants. The CNN training involves capturing of RGB images using an image acquisition system which is followed by pixel-wise annotation to the images to serve as the ground

truth during network training. It was revealed that the CNN model proficiently segments citrus plants thereby provides accurate results alongside labelled images. To increase the accuracy in estimating the surface area of plant, a depth camera was deployed to measure the surface area of plant and based this, it would be easy to carried out spraying operation. A prototype was fabricated using CAD software i.e. Solid Works (Fig. 3). A small single-board computers (SBCs) and Raspberry Pi is incorporated and the work with regard to standardization of electronics components like DC pump, solenoid valve, DC batteries etc. is in progress.

Fig. 3. Prototype of orchard sprayer

Hand compactor for oyster mushroom cultivation

(H. J. Singh and N. Singh)

A prototype of hand compactor for oyster mushroom bed was fabricated and evaluated in Agricultural Engineering Section, ICAR-RC NEH Region Umiam, Meghalaya (Fig. 4). The hand compactor consisted of main-frame, split cylinder, split cylinder hopper, ram, wheel, assembly for ram adjustment, ram holder, pedal and cable & pulley. The newly devised straw-spawn filling cum compaction machine is manually operated. The straw-spawn mixture is filled manually into the mushroom bags (placed inside the cylinder) layer by layer with spawning at the rate of 10% per kg of dry straw weight. After completion of filling, the straw-spawn mixture is compacted with the ram and rope-pully arrangement. The compacted straw-spawn mixture in bag is being tightly closed and kept in cropping room under rack system for mushroom production. This machine facilitates preparation of about 17 number of bags per hour by one operator compared to 4-6 bags in manual method. The machine simple, easy to use and maintain, cost effective and highly portable. The farmers can operate the machine in standing position that results in maintaining proper posture while working thereby enhance occupational wellness from ergonomic perspective.

Fig. 4. Evaluation of developed hand compactor

Weeding attachment of brush cutter for paddy, manual pineapple and other improved farm tools and equipment

(*H. J. Singh and N. Singh*)

FLD of weeding attachment of brush cutter for intercultural operation of paddy was performed under lowland conditions in two locations at Pynthor, Ri-Bhoi District, Meghalaya (Fig. 5). A total of 20 rice farmers participated in demonstration. The performance of the weeding attachment was found satisfactory in lowlands under Meghalaya condition. Even though human labour is more effective in weeding, however the mechanized weeding saves labour and reduced drudgery. The machine has good scope for small scale mechanization in paddy cultivation in Meghalaya.

Fig. 5. Frontline demonstration of weeding attachment

Three demonstrations on manual pineapple harvester were conducted in select pineapple growing villages in Ri Bhoi, Meghalaya. About 62 pineapple farmers participated in demonstrations. The pineapple

harvester could harvest 75 to 110 fruits per hour depending on fruit density. Traditionally, harvesting of pineapple is being done by using a locally made knife and a bamboo basket that is being kept behind the back. This tool with proper PPEs and improved basket for collecting fruits would help in reducing the drudgery while harvesting the pineapple fruits.

Gramin Krishi Mausam Sewa (GKMS)

(*D. Chakraborty and P. S. Rolling Anal*)

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 under the Impact Based Forecast (IBF) for Meghalaya. Three Farmers' Awareness Programmes (FAP) were organized in Ri-Bhoi District and East Khasi Hills District, 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, J. Layek, M. Chakraborty and P.S. Rolling Anal*)

Field experiments on rainfed rice (cv. Bhalum 1) and Mustard (cv. Bhavani) were conducted under FASAL project. Rice was sown in the 1st week of July, while Mustard was sown in 3rd week of November. 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 3235 and 628 kg/ha, respectively.

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

(*D. Chakraborty and J. Layek*)

This study envisaged developing a suitable model for the yield estimation of turmeric 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). Further, the system was also integrated with different feature selection methods viz. PCA, RF, CORR, BAKEL, FOREL, STPSL etc. Results showed that different models varied in terms of performance even though many 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 RFR, LASSO, ENET and SVM with very high accuracy (<5% nRMSE). The results also suggest that using weather variables, the yield of turmeric in Meghalaya can be estimated with considerable accuracy and can be used for policy consideration and planning.

Performance of maize-legume intercropping and mulching under organic nutrient management in rainfed flat land configuration

(*D. Chakraborty and B.U. Choudhury*)

Field experiment under rainfed conditions was conducted during the monsoon season (kharif) to evaluate the integrated effects of legumes (e.g. French bean and Soybean) as intercrop and mulching (rice straw and green rice bean) on the performance of maize-based cropping systems at mid-altitude Meghalaya. The results revealed that there is a significant effect of mulching and legume intercropping on sole crop yield (Maize/Soybean/ French bean) and as well as intercropping systems yields. Sole maize produced a Maize Equivalent Yield (MEY) of 4350 kg ha^{-1}. Growing soybean reduced MEY by 29% while sole French bean increased MEY by 35% over sole maize. Incorporation of straw from the previous season's rice crop (@ 5.0 t ha-1) in all the crops i.e. maize, soybean and French bean significantly increased the yield with highest response i.e. 32.0% noted in sole French bean. Replacing soybean with French bean in the maize-based intercropping system resulted in significant improvement in MEY i.e. 20.0% higher compared to sole maize. Like in the sole crops, mulching in intercropping also significantly increased the productivity with highest response in Maize-French Bean system under mulching (17%) compared to Maize-French Bean without mulching.

Agro-forestry

Temporal variation of soil moisture content and leaf litter fall in different Alder (*Alnus nepalensis*) based agroforestry systems in mid hill of Meghalaya

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

Monthly variation of soil moisture (%) up to 1 m depth in three different alder based (Alder + seasonal crops-AFS 1; Alder + pineapple-AFS 2; and Alder + Tea-AFS 3) Agro-forestry Systems (AFS) revealed that alders with seasonal crops had higher moisture content in the profile during monsoon season (July to September) compared to the other AFSs and there was no trend in the soil moisture content during the months of October to December. In the alders cum seasonal crop system, the soil moisture fluctuates across depths and months with values ranging from 26.18% (December) to 35.87% (September). In case of alders and pineapple based system, significant variations in soil moisture was noticed particularly in the 15-30 cm depth range (e.g., August: 46.74%, September: 40.16 % compared to alders and seasonal crops (33.56 % and 34.09 %). Whereas, in Alders and tea, the uppermost soil layer (0-15cm) consistently recorded the higher soil moisture content in July (38.94 %), August: (50.38 %), September (47.17 %), October (41.04 %), November (46.04 %) and December (34.64 %) compared to sub-surface soil layers (Table 1).

Table 1. Soil moisture content (%) under different Alder based agroforestry systems (AFSs)

Soil Depth						
Alder + Agril. Crops (AFS 1)	July	August	September	October	November	December
0-15	28.82	32.67	37.86	30.76	30.21	26.18
15-30	28.37	33.56	34.32	32.63	30.00	27.07
30-45	29.41	33.56	34.09	31.28	29.87	28.12
45-60	30.25	32.19	32.81	30.86	30.00	28.54
60-80	30.63	35.50	35.41	32.54	32.63	27.53
80-100	29.80	35.87	34.50	34.23	32.80	28.91
Alder + Pineapple (AFS-2)						
0-15	28.25	46.95	39.72	41.25	41.04	38.75
15-30	34.59	46.74	40.16	36.99	37.08	34.73
30-45	35.04	38.41	39.57	37.27	36.85	33.47
45-60	34.91	39.86	40.16	37.98	37.70	30.90
60-80	38.77	38.94	41.83	41.59	36.66	35.59
80-100	36.24	39.42	44.28	42.20	37.22	38.36
Alder + Tea (AFS-3)						
0-15	38.94	50.38	47.17	41.04	46.04	34.64
15-30	31.28	30.07	38.51	33.47	35.18	29.83
30-45	26.42	32.98	35.14	30.89	31.97	28.82
45-60	32.28	44.50	34.05	29.91	31.49	29.87
60-80	34.45	35.59	37.98	33.03	35.14	31.10
80-100	33.25	26.30	36.29	33.56	33.73	31.36

The monthly leaf litter collected from three alder based AFS showed that alders with pineapple recorded higher litter (0.96±0.03 t ha^{-1}) followed by alders and tea (0.82±0.01 t ha^{-1}) during January (Fig. 6). However, alders with seasonal crops recorded higer litter fall (0.78±0.01 t ha^{-1}) in December month. The leaf litter accumulation across the different AFS was lesser during the pre-monsoon months i.e. February-June. The accumulation of leaf litter on the tree floor gradually increased from August and reached highest during the winter months i.e. December-January.

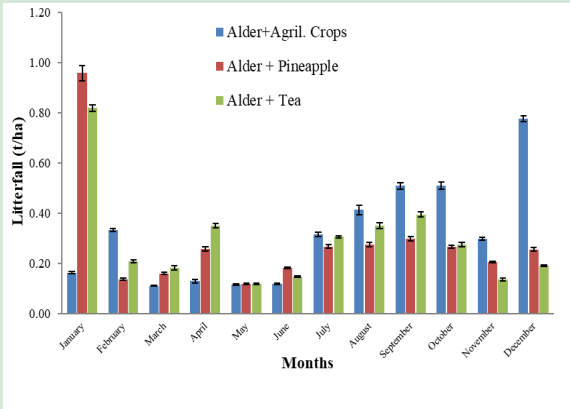


Fig. 6. Monthly leaf litter fall (t ha-1) in different Alder based AFS

Agronomy

Farming system research project (FSRP)

(B. Makdoh, N. Biswakarma, S. Hazarika, S. Das, K.M. Reddy and 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 evaluated on long term basis (Fig. 7). The data revealed that the Agro-Pastoral System (FSW-4) found to be better in terms of net return (Rs.1,69,166/year). The results showed that Agro-Pastoral System (FSW-4) found to be better in terms of net return i.e. ₹ 1,29,166/- followed by FSW-1 (₹ 1,06,796/-).

Fig. 7. Farming system research model

Integrated Farming System (IFS)

(B. Makdoh, N. Biswakarma and J. Layek)

An IFS model viz. agri-horti-livestock-fish based farming system was developed and tested on long term basis. The two systems evaluated include rice-toria-french bean system and maize-soybean-blackgram-greengram. The results revealed that IFS model with crop, vegetable, livestock and fish generated a net return of ₹2,57,112ha^{-1} $annum^{-1}$. The data showed that highest B:C ratio was noted with fisheries (2.85) followed by crop component (2.54) and livestock(2.17).

Integrated organic farming system (IOFS) model

(N. Biswakarma, B. Makdoh, R. Krishnappa, S. Patra, P. Baiswar and T. Ramesh)

In view of the fact that the farming in North East Hilly Region (NEHR) is by and large is less dependent on external inputs and the agri-based commodities produced here are considered as default organic in nature, there is a huge potential to develop organic farming to augment the demand for organic products elsewhere in the country from this region. Hence, an Integrated Organic Farming System (IOFS) model (0.43 ha area) was developed in ICAR RC for NEH Region, Umiam that comprise of cereals, pulses, oilseeds, vegetables, fruits, dairy (2 milch cows + 1 calf), fodders, farm pond, duckery (20 ducks), farmyard manure pits and vermicomposting unit. 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 data revealed that 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 98.0% of the total nitrogen, 83.8% of the total phosphorous, 99.4% of the total potassium and the majority of the micronutrient requirement could be met within the model itself.

Evaluation of vegetable-based cropping system

(N. Biswakarma, B. Makdoh and J. Layek)

In the Eastern Himalayan Region, the vegetables play an pivotal role in house hold nutritional security. Growing of vegetables viz. carrot, potato, tomato and French bean after *kharif* crops increases the cropping intensity, utilizes the land efficiently, generate employment and increase the profitability of small and marginal farmers. Thus, the field experiment was initiated in 2005 to evaluate the impact of different vegetable-based system and organic nutrient management. The result showed that, the highest maize yield of 2000 kg ha^{-1} was obtained in the maize + soybean-french bean system followed by maize + soybean–tomato (1900 kg ha^{-1}) and maize + soybean–potato (1800 kg ha^{-1}).

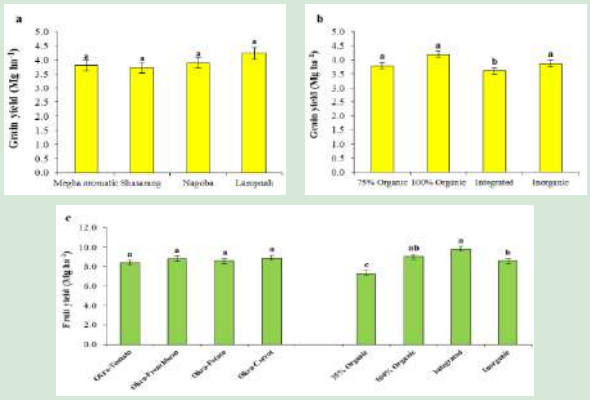


Fig. 8. Yield (Mg ha^{-1}) of Rice (a-main plot & b-sub-plot and c- Bhindi) on raised & sunken beds as influenced by various cropping systems, and management practices.

Studies on comparative efficiency of organic, chemical and integrated management practices on soil health and crop productivity under various cropping systems

(N. Biswakarma, B. Makdoh, J. Layek and S. Hazarika)

In an experiment, comparative efficiencies organic, chemical and Integrated Nutrient Management (INM) practices on soil health and crop productivity under various cropping systems was evaluated that include four rice varieties viz. Megha Aromatic 2, Shahsarang-1, Ngoba, and Lampnah in sunken bed and four cropping system i.e. okra-carrot, okra-potato, okra-French bean and okra-tomato in raised bed with varied fertility treatments. The result revealed that the supply of 100% nutrient requirement through organic sources resulted in the highest rice yield of 4200 kg ha^{-1}, followed by 75% supplementing through organic sources and 100% supplementation through inorganic sources and INM (Fig. 8). Unlike in rice, the yield of okra in raised beds with INM was found to be higher (9800 kg ha^{-1}) followed by 100% organic (9000 kg ha^{-1}), inorganic (8600 kg ha^{-1}) and 75% organic (7300 kg ha^{-1}). Further, highest yield of tomato (18000 kg ha^{-1}) and potato (19000 kg ha^{-1}) and French bean (4800 kg ha^{-1}) and carrot (16000 kg ha^{-1}) was noted under integrated and 100% organic, respectively (Fig. 9).

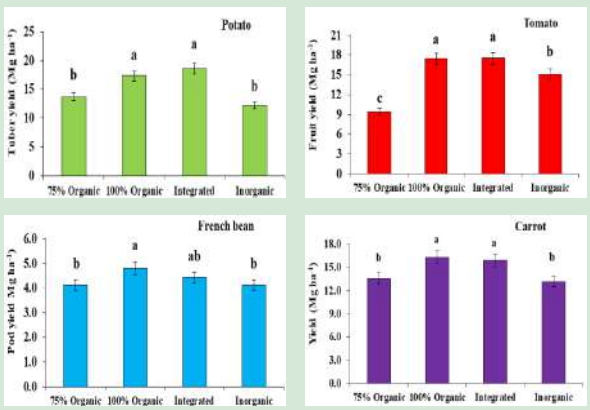


Fig. 9. Yield (Mg ha^{-1}) of vegetables on raised beds as influenced by various nutrient management practices

Evaluation of different varieties of major crops under organic farming

(N. Biswakarma, B. Makdoh and J. Layek)

In an experiment twelve varieties of groundnut (TPG 41, TG37A, ICGS76, ICGV00350, JL501, GIRNAR, GJG31, GG7, ICGV91114, KADIRI 9, GPVD 5 and GJG18) and twelve varieties of rapeseed (PM-25, NRCNB, PT-303, BHAWARI, DRMR, Ragini, Binoy, PM-28, PM-26, YSH, TL-15 and Topeshwari) were evaluated to identify a suitable variety for mid hills region of Meghalaya under organic management practices. Among the 12 varieties of groundnut, highest pod yield of groundnut was recorded in GG7 (1800 kg ha^{-1}) followed by GJG-18 (1200 kg ha^{-1}). In case of rapeseed, cv. DRMR 15 recorded highest yield i.e. 450 kg ha^{-1}

followed by PM 25 (430 kg ha^{-1}) recorded significantly higher seed yield than the other varieties. Based on the findings GG7 and GJG-18 in groundnut and DRMR 15 and PM 25 in rapeseed are found suitable to the region under organic farming (Fig. 10.).

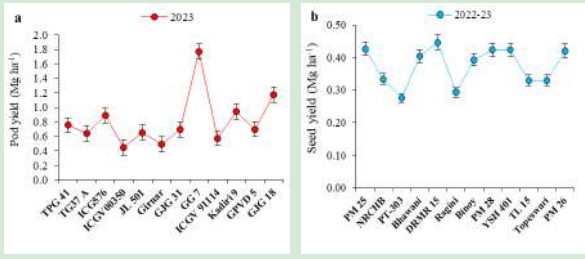


Fig. 10. Yield of groundnut (a) and rapeseed mustard (b) in organic farming

Evaluation and Validation of Natural Farming Practices

(N. Biswakarma, B. Makdoh and J. Layek)

An experiment was undertaken in the upland situation to study the comparative efficiency of Natural Farming (NF), Organic Farming (OF), and Integrated Crop Management (ICM) in turmeric + cowpea intercropping (Fig. 11). Results showed that OF package recorded highest yield (56.1%) followed by ICM, whereas the lowest yield was observed under control followed by natural farming.

Fig. 11. Performance of turmeric under natural farming and organic farming

Horticulture

Germplasm Evaluation

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

French bean: A total of 124 pole type accessions of French bean were evaluated for the growth and yield attributes. Among the accessions, MNFB-9 identified as earliest genotype with regard to days to first flowering (32.3) and harvesting (47.0) followed by NFBC-16 and Collection-1 both for days to first flowering (32.33)and harvesting (50.0). The maximum pod length was observed in HFBC-11 (20.33 cm) followed by MZFBC-3 (19.56 cm), and RCFBS-5 (19.23 cm). However, the maximum average pod weight was observed in NWFBC-5 (16.33g), RCFB-78 (15.83g), and MZFBC-13 (15.66g). The cultivars RCFB-61(657.33g), RCFB-18(486.67g) and MNFB-9 (580.0g) were identified as high yielding types.

Cowpea: Thirty genotypes of cowpea were evaluated for the growth, yield and nutritional values in the edible pods. Results shows that there was variability with regard to all major traits viz. days to first flowering (29.66 days to 75.0 days), days to first harvesting (47.66-98.0 days), pod length (18.4 cm – 50.93 cm), pod weight (4.5g - 22.16g), number of seeds per pod (10.0-20.0), seed weight (7.20 g -19.06), protein content (20.92-28.17%), zinc content (11.58-59.64 ppm) and iron content (36.29-182.79 ppm). Among the genotypes the highest yield per plant was recorded with RCCPS-1 (785.3g) followed by RCCPS-3 (750.5g) and RCCPS-16 (663.6g).

Studies on pollen viability and germination in teasel gourd induced hermaphrodite flowers

(*V. K. Verma, H. Rymbai and P. Baiswar*)

A comparative study of pollen viability and germination in male and Ag NO_3 (500ppm) induced hermaphrodite flowers of teasel gourd was carried out in July, 2023 (Fig. 12). The pollen viability of male and induced hermaphrodite flower ranges from 88.0-96.0% in male and 82.5-93.66 % induced hermaphrodite flowers. The pollen germination under controlled conditions was 15.0 -18.33% in male and 12.24-15.57% in induced hermaphrodite flowers 48 hrs after the incubation. The pollen germination increased significantly to 79.02% and 68.63% in male and induced hermaphrodite flowers by the using of nutrient solution comprised of sucrose (15%) + boric acid (25 ppm) + calcium nitrate (25 ppm), respectively.

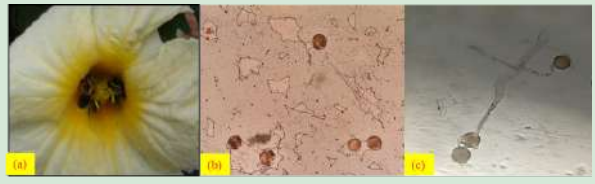


Fig. 12. Induced hermaphrodite flower, pollen viability and germination in teasel gourd

Comparative performance of the brinjal landraces against biotic stresses:

(*V.K .Verma and S. Patra*)

Twelve local landraces of brinjal tolerant to bacterial wilt were evaluated against shoot and fruit borer. Among the accessions, Local White and Local Green were found to be moderately resistant to shoot infestation (12.88 % and 12.30 %) and highly resistant to fruit infestation (5.77 and 8.66%) respectively (Fig. 13). However, Arka Harshitha was found to be highly susceptible to shoot and fruit borer with 47.45% fruits infested with fruit and shoot borers. Similarly, the marketable fruit yield per plant was also maximum 1.08 and 0.87 kg in Local White and Local Green, respectively.

Fig. 13. Infestation of shoot and fruit borer in brinjal

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

(*V. K. Verma, M. Bilashini Devi, P. Baiswar and S. Patra*)

One hundred sixteen accessions were evaluated during 2023 for growth, yield and quality traits. The plant height ranges from 48.87 to 91.0 cm, number of tillers (2.0 – 12.0) and stem diameter (0.56 - 0.89 cm). Among the accessions, RCGC-20 (503.87 g) was identified as high yielding type followed by Nadia (439.11 g), RCGC-2 (419.9 g), ACC-39 (402.9 g) and IC-584325 (387.86 g). Of the total six new accessions collected, two entries viz. RCVBG-1: CVT Ginger Bold and RCMLG-1: CVT Essential oil have been submitted for Multi-Location Testing (MLT) under AICRP on Spices.

Standardization of soil-less media for protray nursery raising in King Chilli (*Capsicum chinens*e Jacq.)

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

A field experiment was conducted to evaluate the effect of different soil-less media on rooting and growth of King chilli nursery (Fig. 14). Results showed that that the soil-less mixture comprising of cocopeat + perlite + vermiculite (60:20:20) recorded higher growth parameters and better performance in the main field. Growing media cocopeat + vermicompost + perlite (60:20:20) recorded higher seedling emergence (99.40%), stem diameter (3.56 mm), root length (11.87 cm), lesser number days required to transplant (33.87 days), minimum number of days to establish (5.32 days), number of days to flowering (51.33 days), number of days to harvest (119.5 days), number of fruits per plant (178), plant height (120.53cm), average fruit weight (9.06g) and yield per plant (941.34g).

Fig. 14. Performance king chilli seedlings on cocopeat + perlite + vermiculite (60:20:20) root media

Evaluation and development of elite cultivars of Turmeric (*Cucurma longa* L.) rich in curcumin content

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

A total of 150 genotypes of turmeric were evaluated. Results showed that there is wider variability with regard to plant height (99.43 to 121.63 cm), leaf length (53.20 to 62.53 cm), leaf breadth (12.50 to 15.73 cm), number of leaves (17.67 to 28.67) yield (13.33 to 25 t ha^{-1}), curcumin content (4.85 to 7.51 %) and dry matter percentage (18.7 to 21.8%).

Germplasm collection, characterization and conservation of local stone, pome and indigenous fruits

(*H. Rymbai*)

Several genotypes i.e. eight in peach (Flordaprint, Pratap, Flordasun, Shan-e-Punjab, Alton, RC-Peach-1, RC-Peach-2, Flordaguard), three in pear (Lagoon, Naspati, Fertility), eight in plum (Sutlej Purple, Doris, Kala Amritsar, Japanese plum, RC Plum-1, RC Plum-2, Santa Rosa, Meriposa), ten in guava (Allahabad safeda, Megha Seedless, Megha Magenta, Megha Supreme, Megha Wonder, Lalit, L-49, RCGH-10, Sangam, Mizo Purple), two in avocado (Perkington, Fuerto), four in kiwifruit (Bruno, Hayward, Allison, Monty), one in dragon fruit, five in sohiong, one in soh snam and five in sohshang were collected and conserved in the gene bank, Horticulture Farm, ICAR RC for NEHR, Umiam.

Evaluation and identification of promising local rootstocks for stone and pome fruits germplasm

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

Eight local rootstocks of stone and pome fruits (RC Plum-1, RC Plum-2, RC Peach-1, RC Peach-2, RC Peach-3, RC Sohjhur-1, RC Sohjhur-3 and Florda guard) were collected, evaluated, and conserved in the Horticulture Farm, ICAR RC for NEHR, Umiam. The results showed that the root stocks performance was significant with regards to vegetative and yield characteristics (Table 2). RC Peach-1 had the highest plant spread (E-W 3.4±0.2a m & N-S 3.9±0.1a m), TCSA (24.3±2.1a cm^2), canopy volume (18.3±9.2a m^3) and fruit yield (257.3±25.2 number per tree).

Table 2. Growth and yield attributes of selected local rootstocks for stone and pome fruits

Genotypes	Plant height (m)	Plant spread		Trunk cross section area (cm^2)	Canopy volume (m^3)	Yield (number of fruits per tree)
		E-W (m)	N-S (m)			
RC Plum 1	1.8±0.3b	1.5.6±0.8d	1.5±0.8d	11.3±2.3ab	1.9±0.8b	282.7±36.7a
RC Plum 2	2.3±0.5a	2.3±0.2 c	2.1±0.4c	12.3±3.6ab	6.8±5.3ab	147.3±84.2bc
RC Peach 1	2.4±0.1a	3.4±0.2a	3.9±0.1a	24.3±2.1a	18.3±9.2a	257.3±25.2a
RC Peach 2	2.3±0.1a	2.7.3±0.1b	2.7±0.1b	23.2±1a	8.9±0.4ab	232.5±15.1ab
RC Peach - 3	2.6±0.6a	2.4±0.1bc	2.2±1.3c	15.4±3.5ab	8.4±6.1ab	247.1±21.7ab
RC Sohjhur 1	2.2±0.1a	2.5±0.8 bc	2.4±0.5bc	5.6±0.6b	8.1±0.8ab	51.7±13.1cd
RC Sohjhur 2	2.4±0.1a	2.5±0.6 bc	2.5±0.6bc	8.1±0.9b	7.5±1.2ab	18.3±3.6d
Florda gourd	1.6±0.3b	2.3.6±1c	2.4±0.2bc	5.3±1.7b	4.1±2.6b	194.7±31.3ab

Rootstock-scion compatibility of peach, plum and *Pyrus pashia* in promising local rootstocks

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

A study on compatibility of commercial cultivars of plum (Kala Amritsari and Satluj Purple), peach (Shan-e-Punjab, Flordaprince, and Partap) and *Pyrus pashia* (Sohjhur RC-2) on different local rootstocks was done. The result indicated that increased plant height (183.6±24.5 cm) and plant spread (193.3±13.6 cm) were recorded in Satluj Purple on RC Peach-1. Kala Amritsari recorded maximum number of fruits (136.6±18.6) on RC Peach-1. Further, the compatibility performance of *Pyrus pashia* (Sohjhur RC-2) was higher on RC Sohjhur -1.

Evaluation of suitable training systems for improved cultivars of stone and pome fruits

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

Performance of improved cultivars of peach (Partap and Flordaprince) and plum (Kala Amritsari and Satluj Purple) were studied under different training systems, viz., Y-shape trellis (YSS), Espallier trellis (ETS), Open Centre (OCS), and Leader System (LS). The results showed that fruit weight was highest in Partap in YSS system (76.51±1.13^a g) and higher yield in Satluj Purple under YSS (10±0.01^a kg/tree) system. Highest ascorbic acid content was noted in Flordaprince in YSS system (42.11±0.19^a mg/100 g). Further, higher reducing sugar (3.11±0.07^a%) and

total sugar (10.05±0.09[a]%) were recorded in Satluj Purple in YSS system. Fruit firmness was highest in Flordaprince in ETS (63.84±6.29[a] N/mm/secs), while higher a* and b* value were recorded with Satluj Purple in YSS system (23.44±0.6[a]) and Partap in YSS system (42.00±3.14[a]) respectively.

Performance of *Khasi* mandarin (*Citrus reticulata* Blanco) with respect to slope, aspects and ages of orchards

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

A survey was conducted in 144 orchards of Khasi Mandarin (*Citrus reticulate* Blanco) in various locations in Meghalaya. It was revealed that canopy volume (15.5 m^3) was maximum in the gentle slope gradient (<20%) which was 104% and 167% higher than mid (20–40%) and steep slope (>40%) respectively. The fruit yield was highest at a gentle slope gradient (516.7 nos. of fruits per tree) compared to mid- and steep slopes. The fruit weight was maximum in the gentle slope gradient (165.8 g) which was higher than mid-slope by 9% and steep slope by 19%. With regard to quality parameters i.e. TSS, reducing sugar and total sugar, higher values was noted with steep slopes. In so far as other parameters are concerned, 15–30 year old orchards have the maximum canopy spread (14.9 m^3), fruit weight (169.5 g) and fruit yield (515.2 numbers of fruits per tree). With regard to soil physical and chemical parameters, bulk density was highest at higher slopes while water-stable aggregates, soil pH, and SOC were highest on gentle slopes, while soil nutrients were higher at gentle slopes except Fe. However, Mn and Cu showed no patterns with slope.

DRIS Standards for identifying yield limiting nutrients in *Khasi* Mandarin (*Citrus reticulata* Blanco)

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

A study was conducted to identify nutrient constraints, establish norms for leaf-based diagnostic recommended and integrated system (DRIS) and determine nutrients' relationship with fruit yields in 144 orchards in various locations in Meghalaya. Result showed that the DRIS indices predicted a nutritional optimum value for Khasi mandarin i.e. 2.26–2.83% N, 0.11–0.16% P, 1.86–2.07% K, 1.85–2.12% Ca, 0.33–0.48% Mg, 170.10–225.10 mg kg^{-1} Fe, 74.03–83.43 mg kg^{-1} Mn, 1.24–2.45 mg kg^{-1} Cu, and 19.84–21.28 mg kg^{-1} Zn. The DRIS norms identified the nutrients Zn, P, Ca, K, N, and Mg as deficient to low levels (14.15→2.14), while Fe, Mn, and Cu were at higher to excessive levels (5.50→18.25) (Fig. 15). The nutritional balance index had a significant negative relationship with the fruit yield (Fig. 16). Leaf nutrient concentrations of N (0.909**), P (0.827**), K (0.867**), Zn (0.833**), Ca (0.827**), and Mg (0.592**) had a significant positive correlation with fruit yield. The finding will facilitate the correct interpretation of leaf nutrient analysis and the norms would facilitate a precise intervention through nutrient management for higher yields in mandarin citrus.

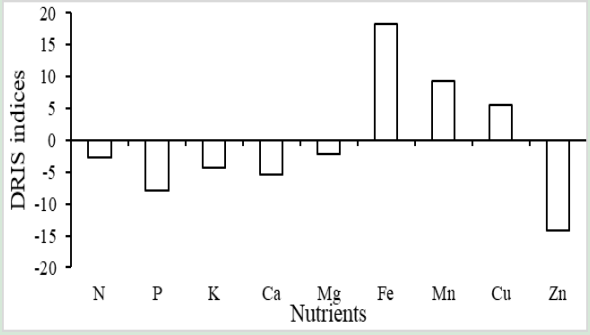


Fig. 15. Identifying nutrient constraints in *Khasi* mandarin trees using DRIS based leaf analysis

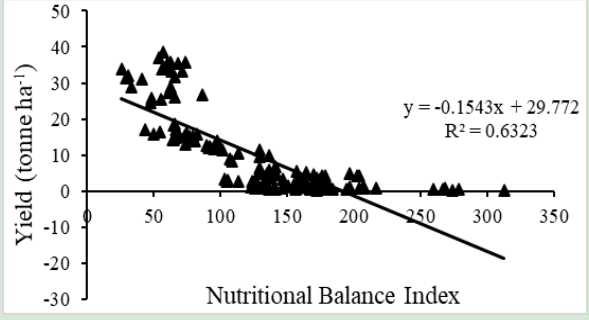


Fig. 16. Relationship between the Nutritional Balance Index (NBI) and yield (tonne ha^{-1}) of *Khasi* mandarin trees

Germplasm collection, evaluation and conservation of fruit crops

(*H. Rymbai and H.D. Talang*)

Various genotypes of citrus (67), *C. limon* (24), *C. jambhiri* (one), *C. reticulata* (one), *C. latipes* (two), *C. indica* (three), *C. aurantifolia* (12), *C. medica* (one), *C. sinensis* (2), *C. grandis* (10), *C. macroptera* (one), *C. trifoliata* (one), Rangpur Lime (one), Soh tlong (one), NRC-Rootstock-4 (one), NRC-3 (one), NRC-2 (one), NRC-1 (one), Tancy Tanjello (one), Cleopatra (one), *C. taiwanica* (one) were collected, characterized, and conserved in the gene bank at Horticulture Farm, ICAR RC NEHR, Umiam.

Collection, characterization and conservation of an endangered *Citrus indica*

(*H. Rymbai*)

About 33 genotypes of an endangered *C. indica* were collected, characterized, and conserved in the gene bank at Horticulture farm, ICAR RC for NEHR, Umiam. Genotypes, viz., Chandigre CI-003, Chandigre CI-004, and Sakalgre CI-026 performed better for vegetative parameters. Wedge grafting was found to be suitable for rapid multiplication in an endangered *C. indica*.

Collection, characterization and conservation of lemon (*Citrus limon* (*L*) Burm)

(*H. Rymbai*)

Collection, characterization and conservation of twenty-five varieties/genotypes of lemon (*Citrus limon* (*L*) Burm) was carried out. Result showed that highest fruit weight (274.3±21.1 g), pulp weight (179.7±36.2 g) and TSS (8.8±0.2 ^{0}Brix) was found in RC-LM-EL-3, while the maximum titratable acidity (6.03±0.6%) and ascorbic acid content (88.4±3.2 g /100 ml) were noted in RC-LM-Dhemaji AL-1. The antioxidant activity i.e. TPC (51.2±6.7 mg GAE/ 100 ml) and FRAP assay (236.5±13.4 mM FeSO4 eq./100 ml) were recorded higher in RC-LM-JL-1.

Technologies Developed - RC Peach 1 as potential local rootstocks for stone fruits

(*H. Rymbai, V.K. Verma, R. Krishnappa, S. Patra and T. Ramesh*)

Among the different rootstocks evaluated, performance of plum i.e. Kala Amritsari and Satluj Purple and peach i.e. Shan-e-Punjab, Flordaprince and Partap was found to be the highest in RC Peach-1 rootstock for growth and yield attributes.

RC-LM-EL-3 as potential lemon (Citrus limon (*L*) Burm) genotype

(*H. Rymbai*)

Lemon genotype RC-LM-EL-3 was identified as the potential genotypes for higher yield and quality i.e. fruit weight (274.3±21.1 g), oil gland density (101±4.3 cm^{2}), peel thickness (11.6±0.8 mm), pulp (57.3±5.2%), juice content (66.3±6.3%), fruit firmness (88.6±14.7 N/mm/sec) and seed number (41.3±10.2 per fruit). Similarly, it also recorded higher TSS (8.3±0.2 °B), titratable acidity (6.7±0.3%), ascorbic acid content (70.2±5.5 /100 ml juice), TPC (43.6±2.4 mg GAE / 100 ml juice), TFC (12.6±1.3 mg QE / 100 ml juice), DPPH (IC_{50} 32.7±0.8 µg/ml), FRAP (136.3±12.8 mM FeSO4E /100 ml juice), total carbohydrates (16.3±1.0 mg glucose / ml juice) and reducing sugar (5.1±0.6 mg glucose / ml juice).

Evaluation of different rootstocks of *Khasi* mandarin in different altitudes

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

Performance of *Khasi* mandarin plants grafted on *C. karna* , *P. trifoliate*, *C. jambhiri*, *C. limonia*, *C. latipes*, *C. taiwanica*, *C. volkameriana* and *Khasi* mandarin seedlings as control was evaluated with respect to growth, yield and quality parameters. Result indicated that there is wider variability with regard to plant height (154.00-348.00 cm), plant girth (37.52-63.60 mm) in all locations, plant height ranged, 154.00-348.00 cm and plant girth 37.52-63.60 mm, canopy spread (96.33-152.00 cm in east-west and 93.33-148.33 cm in north-south). Fruit weight and number of fruit per plant ranged between 78.12-146.49 gm and 1.33-57.00 respectively with highest values for the both parameters recorded with *C. limonia + Khasi mandarin.* Maximum TSS with minimum acidity was recorded in Khasi mandarin seedlings followed by *C. volkameriana + Khasi* mandarin that was however at par with *C. limonia + Khasi mandarin*.

All India Coordinated Research Project on Tuber Crops

(*H. D. Talang and V.K. Verma*)

- Eleven Cassava entries were evaluated for the yield parameters. TCA 21-2 recorded the highest tuber yield (35.42 t ha^{-1}) and local entry recorded highest starch content (31.05%) and a CMD score of 0 was observed in all the entries.
- Among eleven sweet potato entries that were evaluated TSp 21-3 recorded the highest total yield (22.34 t ha^{-1}) and marketable yield (15.64 t ha^{-1}).
- In another study, eleven orange flesh sweet potato entries were evaluated and local entry i.e. RCSP 45 recorded highest total yield (32.02 t ha^{-1}) and marketable tuber yield (25.52 t ha^{-1}), whereas Bhu Sona recorded highest beta carotene content (12.05 mg 100 g^{-1} FW) followed by Local (RCSP 45) with (11.93 mg 100 g^{-1} FW).
- Among fourteen Colocasia entries that were evaluated, TTr 22-5 recorded highest number of cormels/plant (28.25), highest cormel weight/plant (847 g), highest weight of corm/plant (303.25 g), total cormel yield (23.34 t ha^{-1}) and total yield (33.82 t ha^{-1}).
- Under genetic resources conservation and evaluation, 32 collections of Colocasia are being evaluated and the results showed that RC Taro 30 recorded highest total cormel yield (24.82 t ha^{-1}) and total yield (33.05 t ha^{-1}).
- In another study, among six colocasia entries were evaluated, TTr 17-12 recorded highest cormel yield and total yield. TTr 17-12 was recommended to be release in the states of Meghalaya, Bihar, Jharkhand, Maharastra, Tamil Nadu, Kerala, Tripura by the 23rd Annual Group Meeting of AICRP on Tuber Crops held at Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, West Bengal during 10th - 12th May, 2023. Megha Taro 3 is yet another promising variety of colocasia developed through clonal selection from the local race. Megha Taro 3 is found to be rich in dry matter (18-20%), starch (20-22%), low in calcium oxalate (18-20 mg/100g), intermediate in maturity (150-180 days) and high keeping quality (>30 days). Further, the leaves, petioles, corm and cormels of the same are suitable for consumption by human beings. Megha Taro 3 is also a high yielder with average yield of 25-28 t ha^{-1}.

All India Coordinated Research Project on Cashew

(*H. D. Talang*)

- Seven varieties of Cashew were planted and their performance was studied in the experimental farm of ICAR-KVK, West Garo hills, Tura, Meghalaya (Fig. 17). Result indicated highest plant height was recorded in BPP-8 (5.57 m) followed by VRI (CW) H-1 (5.30 m) and Vengurla-9 (5.20 m). Higher plant spread (EW X NS) was recorded in Dhana (5.26 m x 5.84 m), while the lowest spread was found with VRI-3 (4.61 m X 5.01 m). Highest nut weight (8.1 g) and shelling percent (32.06%) was recorded with BPP-8m while highest apple weight i.e. 77.67 g was recorded in Dhana. Results also indicated that the nut yield per tree was found to be highest in BPP-8 (7.84 kg) followed VRI-3 (6.98 kg).

Fig. 17. Performance of cashew varieties

- In another study ten varieties of cashew were collected from OUAT, Bhubaneswar, Odisha and are being evaluated in KVK Farms of Tura and Peren for suitability in NEH region.

Enhancing the storability of *Prunus nepaliensis* and *Docynia indica* with edible coating

(*S.R. Assumi and H. Rymbai*)

Experiments were undertaken to study the influence of polysaccharide based edible coatings *viz.* carboxy methyl cellulose (1%), sodium alginate (2%), chitosan (1, 2%) and guar gum (1, 2%) on the storability of *Prunus nepaliensis* and *Docynia indica* in ambient room temperature and relative humidity (18-24°C, 80-90% RH respectively) at 2 and 3 days interval. Maximum shelf life of eight days was recorded in *Prunus nepaliensis* with guar gum (1%) and 15 days with chitosan (2%) in *Docynia indica* compared with other coatings and uncoated fruits. Increase in shelf life was attributable to delaying weight loss (6.3, 6.5%) and lowering the activity of cell wall degrading enzymes (1.2, 42.8 Newton).

Standardisation of soilless media composition for cultivation of Anthurium

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

A soilless media composition was standardized for cultivation of Anthurium (*Anthurium andreanum* L.) cv. Tropical Red under 75% shade net condition. cocopeat + charcoal + river sand + vermiculite + perlite (1:1:1:1:1) recorded maximum spathe length (15.5±0.10 cm), maximum spadix length (5.0±0.58 cm), minimum spadix (candle) angle (30±1.65^{0}C), maximum petiole length (26.0±0.58 cm), minimum days to full spathe unfurling (54±0.18 days), maximum flowering duration (46±0.50 days) and maximum tissue nutrient content (NPK). Cocopeat + perlite + leca (hydroton) (2:1:1) media enhanced photosynthetic pigments (58.0±0.33 SPAD), vase life (11.0±0.53days) and highest antioxidant activity under Ferric reducing antioxidant power assay (315±12.42 µmol TE/g dry weight), highest antioxidant activity with DPPH method (0.55±0.58 µmol TE/g dry weight), total phenolic content (12.30±1.14 mg GAE/g FW) and flavanol content (0.67 ±0.01 mg QE/g DW).

Evaluation of phytochemicals composition and antioxidant potential of *Anthurium andreanum* leave extracts under soilless substrate

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

A comprehensive antioxidant potent and phytochemicals composition on pink spathe anthurium (*Anthurium andreanum* L.) cv. Zavi was ascertained on soilless substrate under 75% shade net condition. Results showed that higher extraction yield was noted with methanol solvent (21.24%), while lower yield was observed with ethyl acetate solvent (19.00%). The TFC varied between 30.00±1.14 - 32.95±1.14 mg/g and total phenol content by Folin-Ciocalteu assay was between 10.00±0.60 - 13.30±1.14 mg/g GAE. Antioxidant activity was calculated based on diphenyl picryl hydrazyl (DPPH) radical scavenging ability that showed the scavenging activity ranging between 0.33±0.06 - 0.67±1.11 µmol TE/g DW.

Evaluation and maintenance of Orchid germplasms

(Vanlalruati, H. Rymbai and S.R. Assumi)

A total of 50 orchid species including five new species/genotypes were evaluated under AICRP on Floriculture Crops (Fig. 18). The five new orchid collections include *Cattleya schroederae (E)*, *Cattleya* spp. *(E)*., *Bulbophyllum odoratissimum (E)*, *Habenaria medusa (T)* and *Macropadanthus alatus (E)*. Leaf number (13.0), inflorescence diameter (6.0 cm), flower size (7.3 cm), lip length (3.3 cm) and diameter (3.0 cm) was maximum in *Cattleya schroederae*. Maximum inflorescence length (7.5 cm) and stalk length (11.5 cm) was recorded in *Habenaria medusa* while leaf length (18.5 cm) maximum flowers/ spike (13.0) and maximum vase life (33.0 days) was recorded in *Macropadanthus alatus.*

Fig. 18. Terrestrial and epiphytic orchids (E: Epiphytic, T: Terrestrial)

Performance evaluation of gerbera germplasms for flowering and yield attributes

(Vanlalruati, H. Rymbai and S.R. Assumi)

Five gerbera cultivars (Glorious Purple, Olympic, Intense, Fundy and Stanza) were tested against a popular cultivar Alsmera both under Low Cost Polyhouse (LCP) and Open Field Condition (OPC) at Horticulture Research Farm, ICAR RC NEHR, Umiam during 2023-2024. The gerbera cultivars performed better under polyhouse compared to open field condition for all the parameters. Cultivar Glorious Purple recorded maximum number of leaves (12.7 and 11.0), leaf length (22.8 and 21.7 cm), leaf width (11.5 and 10.5 cm) and vase life (11.0 and 10.0 days). With regard to flowering attribute, cv. Intense recorded maximum stalk length (39.5 cm and 34.3 cm) and flower stalk diameter ((0.67 and 0.65cm) and cv. Fundy exhibit largest flower diameter (12.5 cm and 11.8 cm) under LCP and OFC respectively. With regard to yield and quality traits, cv. Olympic recorded minimum days to bud formation (73.4 and 77.2 days), minimum days to bud burst (83.2 and 87.3 days) and minimum days to first flower flowering opening (88.2 and 93.8 days), maximum flowers per plant (12.6 and 11.0) and maximum number of suckers/plant (14.5 and 13.3)) under LCP and OFC respectively. Cultivar Glorious Purple and Olympic were found promising for potted purpose while cvs. Intense and Fundy were found suitable for cut flower purpose.

Soil Science

Standardization and development of native phosphorus solubilizing microorganisms (PSMs) based bio-formulation for increasing phosphorus (P) dissolution in acidic soils of North Eastern Hill Region

(*B.K. Christy Sangma, A. Ratan Singh, S. Hazarika and B.U. Choudhury*)

The native Phosphorus Solubilizing Microorganisms (PSM) strains (PPS 01 to PPS 018) were isolated from acidic soils in different regions in North Eastern Hill region. The strains were subjected to DNA extraction and amplification and sequencing (Fig. 19). Further the PSM strains were subjected to pH compatibility test in Pikovskaya's broth of different pH level. The Performance of PPS 07 is high in almost all the pH condition followed by PPS 05, PPS 01 and PPS 08. The PPS 015 didn't grow in pH 3 and pH 5 conditions. Most of the strains perform better in pH 3 to pH 5. The bio-formulation prepared from these strains was isolated and tested in the pot culture experiment both in the form of seed treatment and soil application. The results are presented in Table 3.

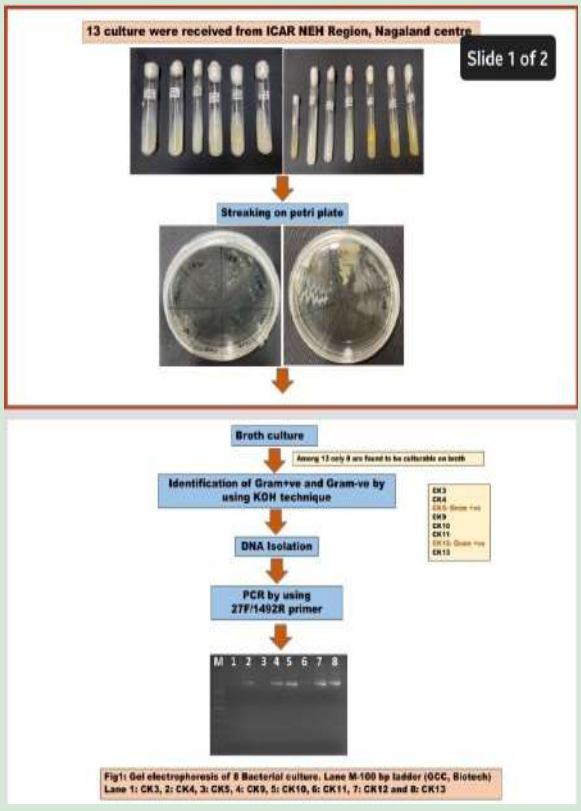


Fig. 19. DNA extraction and amplification of phosphorus solubilizing microorganism strains

Table 3. Effect of PSM strains bio-formulation in maize plant for seed treatment and soil application in pot experiment

Sl. No.	Parameters		NA media	PDA media	Pikov. media
			Viable population count (cfu ml^{-1}) in pot experiment		
1.	Seed treatment	Initial	1.28×10^{6}	0.9×10^{6}	0
		Final	3.0×10^{4} -4.4×10^{6}	1.0×10^{3} -2.7×10^{6}	1.2×10^{5} -1.7×10^{6}
2.	Soil application	Initial	1.28×10^{6}	0.9×10^{6}	0
		Final	2.0×10^{4} -4.5×10^{6}	1.0×10^{4} -2.7×10^{6}	2.0×10^{4} -4.9×10^{6}
			Result of the soil parameters for pot experiment		
Sl. No.	**Parameters**		**pH**	**SOC (%)**	**Avail P (kg ha^{-1})**	**Total P (%)**
1.	Seed treatment	Initial	4.95	0.42	7.02	0.38
		Final	4.0- 5.2	0.26- 1.58	3.71 - 14.33	0.20-1.60
2.	Soil application	Initial	5.05	0.45	7.32	0.39
		Final	4.1- 5.3	0.35-1.71	4.76-16.42	0.21-1.61

Effect of Natural vis-a-vis Organic nutrient management practices on soil and crop health in acid soils of NE Region

(*H.K. Christy Sangma, B.U. Choudhury, R. Katiyar, B. Makdoh, H. Ch. Rukmi Sangma and S. Hazarika*)

An experiment was conducted to study the comparative performance of natural farming and organic farming management practices on soil health and crop growth in finger millet and cowpea intercropping system. The results showed that the yield of finger millet was higher in natural farming and application of lime followed by natural farming alone. In case of cowpea the yield was highest in i.e. natural farming with application of lime and FYM and mulching with crop residue followed by natural farming and lime application.

Effect of nutrient management on stress physiological and quality attributes of king chilli in acid soils of Meghalaya

(*L. Joymati Chanu, S. Hazarika, R. Krishnappa, T. Ramesh, A. Balusamy and M. Bilashini Devi*)

A controlled pot experiment was conducted under a rain shelter to investigate the effects of various doses of nutrient combination on the stress physiology and quality attributes of king chilli (cultivar ML-5) during spring and summer. Application of moderate and higher doses of nitrogen increased leaf chlorophyll content and photosynthetic rate by 12%, 28% and 17%, 33% respectively compared to application of lower doses of nitrogen (@ 50% flowering stage). Further, higher leaf chlorophyll (4.5 mg g^{-1}) and carotenoid (118.5 µg g^{-1}) content were observed with application of N:P_2O_5:K_2O 150:65:65 ha^{-1} at 50% flowering stage. The photosynthetic rate and leaf capsaicin levels in king chilli showed positive correlation (Fig. 20). Application of N:P_2O_5:K_2O @150:65:65 kg ha^{-1} resulted in the highest capsaicin concentration i.e. 4.2% which was 121% higher compared to control. Results also showed that application of N:P_2O_5:K_2O @ 150:65:65 kg ha^{-1} resulted in higher yield, better quality, market price and overall profitability of king chilli in the north eastern region of India.

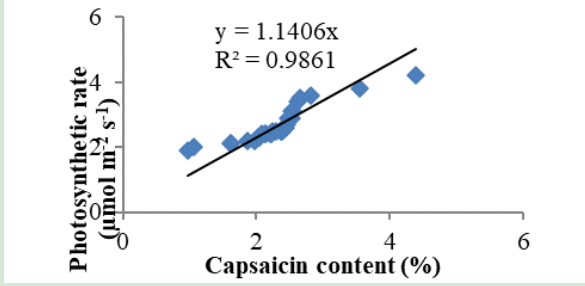


Fig. 20. Correlation between Photosynthetic rate and capsaicin content of King Chilli grown under various nutrient combinations (N, P & K)

Effect of micronutrient applications on tomato growth and yield

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

A field experiment was carried out to investigate the influence of graded micronutrient doses viz. Zinc Sulphate (ZS), Borax (BX) and Ammonium Molybdate (AM) on the yield and quality of tomato (Variety: Arka-Abhed) under Meghalaya conditions (Fig. 21). The experiment consists of 15 treatment combinations including Soil Application (SA) of graded doses of ZS and BX each @ 5-20 kg ha^{-1} and AM @ 0.5-3.0 kg ha^{-1}, soil application of ZS and BX each @ 5-20 kg ha^{-1} & AM @ 0.5-3.0 kg ha^{-1}) + Foliar Application (FA) of ZS @ 0.25-0.50 %; BX @ 0.25-0.50% and AM @ 0.10-0.20% and FA alone.

Micronutrients application significantly and positively increased the yield (kg ha^{-1}) of tomatoes. The soil application of ZS and BX @ 5 Kg ha^{-1} + AM @ 0.5 Kg ha^{-1} along with 3 times foliar application of micronutrients (ZS and BX each @ 0.25% and AM @ 0.10%) at 15 days interval starting from 30 days after transplanting (DAT) positively increased per plant tomato yield (from 1.97 kg in control to 2.70 kg and overall yield up to 36.8 %). The individual fruit weight ranged from 107 g to 135 g and overall the influence of micronutrient application on fruit weight of tomato is in the order of Soil + Foliar-1 (129.8 g/fruit) > Soil alone (125.9 g/fruit) > Foliar alone (120.4g/fruit) > Soil + Foliar-2 (116.7g/fruit).

Fig. 21. a. Effect of micronutrients on curd yield of tomato; b. overview of experimental setup

Effect of micronutrient applications on ascorbic acid and scavenging activity of tomatoes

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

The FA of micronutrients significantly increased the ascorbic acid content, whereas soil alone or soil + FA reduced the same (Fig. 22). With regard to scavenging activity, it varied form 31-69 %, with the highest in soil application of ZS and BX @ 5 Kg ha^{-1} + AM @ 0.5 Kg ha^{-1} along with three times foliar application of micronutrients (ZS and BX each @ 0.25%, AM @ 0.10%) at 15 days interval starting from 30 days after transplanting (DAT). Soil application (ZS and BXeach @5 Kg ha^{-1} + AM @ 0.5 Kg ha^{-1}), along with three times foliar application of micronutrients (ZS and BX each @ 0.25% and AM @ 0.10%) found effective in increasing tomato productivity in the NEH region.

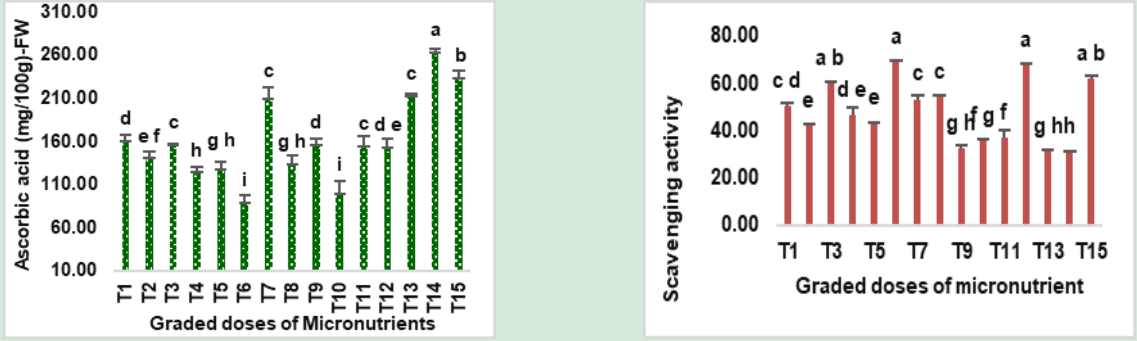


Fig. 22. a.Effect of micronutrients on ascorbic acid content of tomato; b. Micronutrients on scavenging activity of tomato

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

(*M. Chakraborty, S. Hazarika, B.U. Choudhury, A. Balusamy, B.K. Christy Sangma, Lungmuana, S.K. Das and A. Tasung*)

Geo-referenced soil samples from rice-growing areas of northeastern hill states viz., Meghalaya, Nagaland, Mizoram, Tripura, Manipur, Arunachal Pradesh and Sikkim were collected for analysing plant-available zinc (Zn). In Nagaland, soil samples were collected from rice growing fields under lowland, terrace and jhum ecosystems covering the districts of Dimapur, Peren, Kohima, Phek, Zunheboto and about 40 percent of samples collected in rice-growing soils in Nagaland (n=50) were found to have DTPA- extractable Zn in the range of 1.0 to 2.0 mg kg^{-1}. Analysis of soils of Mizoram showed that, about 55 percent of total soil samples collected (n=52) from rice growing fields under both lowland and upland ecosystems were found to have DTPA- extractable Zn in the range of 1.0 to 2.0 mg kg^{-1}. In Meghalaya, an extensive survey was carried out to cover both lowland and upland rice ecosystems in RiBhoi, East Khasi Hills and Jaintia Hills districts. Wide variation in DTPA- extractable Zn in these soils was observed, notably in upland rice soils with 40 percent soils found to have DTPA- extractable Zn below 1.0 mg kg^{-1}. A pilot study (pot experiment) was also taken up to assess the response of Zn fertilization on the rice crop (cv. *Shahsarang- 1*) under a Zn deficient soils in Meghalaya and it was found that soil application of zinc sulphate ($ZnSO_4$) could significantly increase the grain yield (19-26%) as compared to control and the increase was more with increasing doses of Zn application from 2.5 to 5 kg. Results showed that soil application ($ZnSO_4$ @ 5 kg Zn ha^{-1}) + foliar application (@ 0.5% at flowering) was found to be more effective in increasing the rice grain yield (34%) followed by soil application (19-26%). However, there is no significant effect of foliar application Zn alone on rice grain yield.

Impact of long-term nutrient management (LTNM) on soil quality and crop productivity

(T. Ramesh, S. Hazarika, R. Krishnappa, L. Joymati Chanu, M. Chakraborty, A. Balusamy, J. Layek, S. Patra and Tasvina R. Borah)

A first year field experiment was conducted with Maize (Megha maize-1) - French bean based cropping system to study the impact of Long Term Nutrient Management (LTNM) during 2023. A total of six treatments were adopted namely, T1-Control, T2-100% NPK, T3-100% NPK +Lime, T4-Farmyard Manure, T5-Farmyard Manure + Lime and T6-Integrated Nutrient Management (INM) (50% NPK + 50% FYM + Lime + Biofertilizer). A total 12 maize plant parameters such as plant height, root biomass, shoot biomass, cob length, cob diameter, number of rows, test weight, grain yield, etc. were recorded. Results showed that the plant height was highest i.e. 235.9 cm INM with 50% NPK + 50% FYM + Lime + Biofertilizer and lowest i.e. 190.3 cm in control. Cob weight was highest i.e. 180.9 g with 100% NPK followed by INM with 50% NPK + 50% FYM + Lime + Biofertilizer. Among the treatments, INM with 50% NPK + 50% FYM + Lime + Biofertilizer recorded 13% higher shoot biomass while root biomass showed 97.8% increase compared to control (Fig.23). Adoption of INM i.e. 50% NPK + 50% FYM + Lime + Biofertilizer practices increased the maize grain yield by 15-64% compared to other nutrient management practices. Further, the soil pH varied from 5.04 to 5.40 and INM i.e. 50% NPK + 50% FYM + Lime + Biofertilizer recorded 3-7% increase in soil pH compared to other nutrient management practices. Available N, P and K varied between 260-280, 40-60 and 101-183 kg/ha respectively and INM with 50% NPK + 50% FYM + Lime + Biofertilizer recorded highest available N (8%) and K (88%) compared to control, while application of NPK with lime in furrows increased the available P in soil by 50% compared to control.

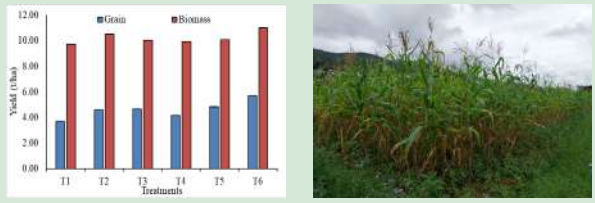


Fig. 23. Performance maize under various nutrient management practices

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

(T. Ramesh and A. Balusamy)

An experiment was conducted to assess the effect of steel slag on the productivity and economics of cereal based (Rice and maize) and vegetable based (French bean and pea) cropping systems in acid soils

of north-east India. In the second year French bean (Selection 9) and Pea (Arkel) in *rabi* and rice (IURON 554) and maize (Megha maize-1) were grown during the *kharif* season in 2022-2023. A total of five Tata steel Slag-based Products (TSP) viz. TSP 24, TSP 25, TSP 26, TSP 27 and TSP 28 were tested and compared with control i.e. RDF (80%). Among the treatments, TSP 25 performed best in French bean, maize and rice followed by TSP 26, while in pea TSP 28 performed best followed by TSP 25 with regard to growth yield and soil parameters (Fig. 24).

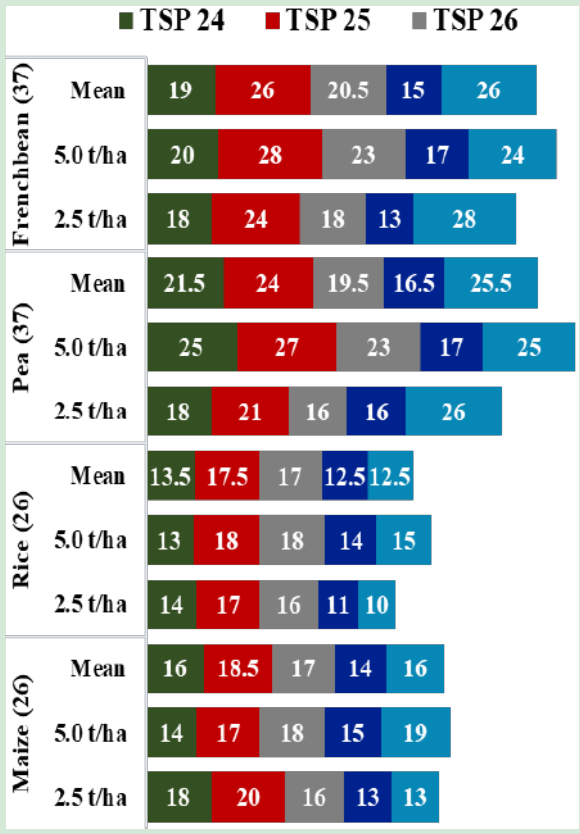


Fig. 24. Response of crops to TSP products (number in the parentheses is the number of estimated growth, yield and soil parameters)

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

(T. Ramesh)

Apple, walnut, and kiwi orchards in Arunachal Pradesh were sampled at four depths (0-20, 20-40, 40-60 and 60-80 cm) on three elevations (lower <1600 m, mid -1600-2000 m, and higher >2000 m). All soil samples had medium to high soil organic carbon. The highest SOC was recorded in walnut (2.60 to 2.81%) followed by apple (Fig. 25). Top soil has more organic matter than deeper soil depth in all the three orchards. At higher altitudes i.e. >2000 m the organic carbon content of apple and walnut were higher (2.73% and 2.81 respectively) while in in mid altitudes the organic carbon content was 2.49% in all the three crops. Walnut orchard recorded 1.74 % labile organic carbon followed by Apple (1.38%). Walnut at higher altitude (>2000 m) and apple and kiwi in lower altitude (<1600 m) had more Labile organic carbon. Further, walnut orchard recorded higher labile organic carbon (1.65%) followed by Kiwi (1.56%). The extremely labile fraction of organic carbon was higher in walnut (1.66%) at higher altitudes i.e. >2000 while the same is true with apple and kiwi in lower altitude i.e. <1600 m. Kiwi (2.04%) and walnut (1.83%) orchards recorded higher low labile organic carbon. Kiwi and apple at mid altitude (1600-200 m) and walnut at higher altitude (>2000 m) recorded higher low labile organic carbon. Walnut (2.89%) and apple (2.73%) orchards had higher non-labile-non-TOC. Apple, walnut, and kiwi orchards at higher altitude (>2000m) and low altitudes (<1600 m) had higher non-labile organic carbon. The iron, manganese, copper, and zinc contents were abundant in all the cropping systems across all the altitudes. Walnut orchards had 38.00 mg/kg soil iron followed by Kiwi (33.6 m/kg). Walnut in >2000 m altitude and apple and kiwi orchard in <1600 m altitudes recorded higher soil iron content. Walnut (9.46 mg/kg) shown higher copper than kiwi (6.67 mg/kg). Copper was higher in walnut at mid altitude (1600-2000 m), kiwi in lower altitudes (<1600 m) and apple in higher altitude (>2000 m). Walnut orchard has high zinc (5.78 mg/kg) and followed copper. Manganese was abundant in all soil samples. Apple (15.13 mg/kg) and walnut (14.59 mg/kg) orchards have more manganese. Lower altitude (<1600 m) in apple and mid altitude (1600-2000m) in walnut and kiwi recorded higher soil manganese.

Fig. 25. Soil sample collection in kiwi and apple orchards in Arunachal Pradesh

Effect of vermicomposts prepared from various locally available biomasses on soil and crop productivity

(*M. Prabha Devi and R. Krishnappa)*

A field experiment was conducted to study the effect of vermicompost (prepared out off locally available biomasses) on soil attributes, plant growth and productivity in Maize (RCM 1- 76) - French bean (Naga local) cropping system. Irrespective of the vermicompost sources, application of vermicompost @ 2t/ha recorded increase in soil available nitrogen (N), phosphorus (P) and Potassium (K), pH and soil organic carbon (SOC) from the second year onwards. Available N, P and K ranged between 242 – 248 kg/ha, 296.76 – 346.5 kg/ha and 17.34 – 27.32 kg/ha respectively while in control the N, P and K content were 235.4 kg/ha, 276.6 kg/ha and 16.07 kg/ha respectively. All the vermicompost-amended soil recorded significantly higher organic carbon (1.90 – 2.16 %) and pH (5.47 – 5.55) compared to control. Results showed that application of vermicompost prepared from either alligator weed or lantana significantly increased the cob weight (181.1 g/cob) with alligator weed while it was 195.9 g/cob with lantana as against 181.9 g/cob in case of control. Further, the kernel yield of maize also increased significantly by applying vermicompost prepared from either alligator weed or beggars' tick species (3.2 t/ha to 3.5 t/ha) compared to control (2.9 t/ha). In case of French bean also vermicompost prepared from eastern hay scented fern bio-mass recorded highest seed yield i.e. 2.5 t/ha compared to control (Fig. 26). It can concluded from the study that the plant based biomasses which is abundantly available in northeastern states can be easily converted into nutrient rich vermicompost that can be effectively be utilized to improve soil fertility and crop yields.

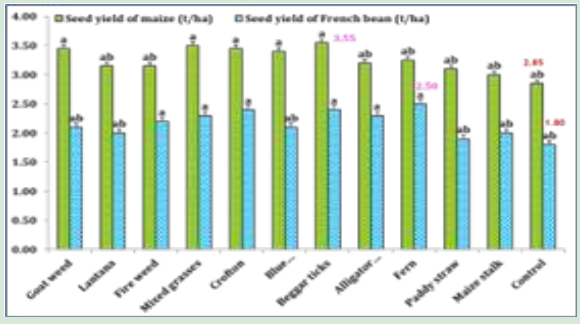


Fig. 26. Effect of vermicompost on seed yield of maize and French bean

DIVISION OF CROP SCIENCE
RESEARCH ACHIEVEMENTS

Development of acid-tolerant rice genotypes suited to medium ecology

(A. Kumar, L. Touthang and P.W. Shimray)

Yield evaluation trials

A set of 450 upland and lowland rice germplasm was evaluated. Significant differences ($p < 0.05$ and $p < 0.01$) were observed among the genotypes for all the traits. Yield per plant showed a significant positive correlation with the number of effective tillers per plant (0.29), panicle length (0.26), number of filled grains per panicle (0.65), spikelet fertility (0.63), test weight (0.31), and harvest index (0.72). Advanced breeding lines, evaluated in the station trial, were subjected to a state adaptive trial (Shillong, Tura, and Jowai) with the assistance of state officials for yield and its component traits (Table 1, Fig. 1).

Table 1. List of advanced breeding lines of rice grown in state adaptive trial

Breeding lines	Cross
RCPL 1-440	IURON-44 X Bhalum-3
RCPL 1-441	Nanglaijok X Bhalum-1
RCPL 1-442	RCPL 1-114 X Nania
RCPL 1-443	Bhalum-1 X Bhalum-3
RCPL 1-444	IVT-M (2805) X SakurA
RCPL 1-445	Kubon-3 X Megha-SA-2
RCPL 1-448	IR-64 X Shahsarang
Check-1: Shahsarang	
Check-2: Megha SA-2	

Fig. 1. Adaptive trial of rice at Jowai

Several advanced lines with higher yield per plant resulting from cross combinations, namely RCPL 1-93/Bhalum-1, RCPL 1-93/Tzutsang Tsuk, Kba Lieh/Bhalum-3, Kuki/Bhalum-6, IR 64/N-39, Japo/N-110, IR-64/N-10, and Pusa-44/N-60, were identified through the station trial. These high-yielding lines will be nominated for the initial varietal trial-2024 of AICRIP, Hyderabad.

Development of cold-tolerant rice genotypes suited to high ecology

(A. Kumar, L. Touthang and P.W. Shimray)

A set of 150 early maturing germplasm and 45 advanced breeding lines were evaluated to assess their suitability under high-altitude lowland conditions in Meghalaya. Several germplasm and breeding lines were identified as tolerant to the cold conditions prevalent at higher altitudes (Table 2). The identified lines now need to undergo evaluation in state adaptive trials for varietal release and notification. To map the gene/s responsible for cold tolerance, F2 seeds of cross combinations NEH Megha rice-1/VL-32546 (200 plants) and Bhalum-1/Khonorullu (157 plants) were evaluated for agro-morphological traits. The screening of parental polymorphism using SSR markers distributed over all the chromosomes of rice is currently in progress.

Generation and evaluation of segregating generations

Individual plant progenies from a set of 14 crosses in the F7 generation, 15 crosses in the F6 generation, 18 crosses in the F5 generation, 34 crosses in the F4 generation, 58 crosses in the F3 generation, and 75 crosses in the F2 generation were grown. Superior progenies were identified and further advanced to the next generation. In total, 95 crosses were attempted in 2023, and F1 seeds were harvested for sowing in the *kharif* season of 2024.

Table 2. List of cold-tolerant germplasm and breeding lines of rice

Breeding lines	Germplasm
RCPL 1-431	Bordubi 2
RCPL 1-438	Bordungsh 1
RCPL 1-439	Vak
RCPL 1-442	Satabdi
RCPL 1-443	Gomini
RCPL 1-446	Tudong
RCPL 1-447	UD-93
RCPL 1-449	
RCPL 1-450	

Fig. 2. Adaptive trial of rice suited to high altitudes

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

(A. Kumar)

A set of 150 BC2F4 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 both yield and resistance to blast (fig. 3). The lines demonstrated resistance to moderately resistant levels against blast disease. The range of yield varied from 10.24 g/plant to 39.65 g/plant.

Fig. 3. Improved version of Shahsarang and Bhalum-5 after marker assisted gene pyramiding

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

(A. Kumar and R. Krishnappa)

A set of 33 selected rice genotypes, selected for low P tolerance and nitrogen use efficiency, were procured from ICAR-IIRR, Hyderabad, ICAR-NRRI, Cuttack, ICAR-IIAB, Ranchi, and CPGS-AS,

CAU, Umiam. These genotypes were evaluated for agro-morphological traits through hydroponics with varying treatments of Nitrogen and Phosphorus (N+P+, N+P-, N-P+, N-P-) to assess their superiority. Genotypes such as Bhalum-3, Bhalum-5, Varadhan, CAUS-107, CAUS-124 were found to be tolerant. The 33 genotypes were further subjected to a physiological study, including parameters like SPAD, IR, root dry weight estimation, and anthocyanin estimation. Root dry weight, total chlorophyll content, and anthocyanin content were consistently found to be higher in N+P+ and N+P- treatments, especially in genotypes like Bhalum-5 and Varadhan. Moreover, F2 seeds of 14 cross combinations derived from selected parents were grown in the field for evaluating important agro-morphological traits. A total of 29 gene-based/linked markers were employed to explore natural variation for phosphorus use efficiency (PUE) and nitrogen use efficiency (NUE). It was observed that gene-based markers RM169, RM12558, RM12557, and RM13201 exhibited high gene diversity and PIC values (Table 3).

Table 3. Genotypic variability in rice genotypes grown at different nutrient treatments in mid-hill altitudes of Meghalaya

	IR(oC) (Infrared thermometer reading)				SCMR(SPAD chlorophyll meter reading)			
	N+P+	N+P-	N-P+	N-P-	**N+P+**	N+P-	N-P+	N-P-
Mean	**29.19**	**28.44**	**28.60**	**29.30**	**33.99**	**29.64**	**30.16**	**31.08**
Range	26.67-35.07	26.10-33.03	24.13-32.60	25.33-32.40	26.23-41.97	22.0-37.13	24.37-41.83	22.5-41.17
CD@0.05	G=0.919±0.649				G=3.594±1.290			
	T=0.320±0.226				T=1.251±0.449			
	G*T=1.837±1.299				G*T=7.188±2.580			

Study of rice yield under low light intensity using genomic approaches

(A. Kumar, C. Aochen, S. Jaiswal, R. Krishnappa, N. Umakanta and P.W. Shimray)

Light intensity is a crucial environmental factor that significantly impacts photosynthesis and, consequently, grain yield in rice. Several markers, namely HvSSR01-66, HvSSR02-44, HvSSR02-52, HvSSR02-54, HvSSR02-56, HvSSR06-69, HvSSR09-45, CAU-CG-ILA1-3, and CAU-CG-RK-3, associated with key traits such as biological yield, grain number per panicle, and spikelet fertility, have been identified. Based on the published information, differentially expressed genes related to biochemical traits between low-light-tolerant and susceptible rice plants were collected (Table 4). To identify InDel markers within genic regions, an *in-silico* analysis was conducted using the RiceVarMap 2.0 online database (http://ricevarmap2.ncpgr.cn/v2/vars_in_gene/). In this analysis, only indelregions with a minimum of 10-base insertion/deletion were considered.

Table 4. Differentially expressed genes related to biochemical traits between the low light tolerant and susceptible rice plants

Gene ID	Name
OS07G0558400	chlorophyll a-b binding protein CP29.1, chloroplastic
OS07G0141400	oxygen-evolving enhancer protein 2, chloroplastic
OS03G0333400	photosystem II repair protein PSB27-H1, chloroplastic
OS07G0577600	chlorophyll a-b binding protein 7, chloroplastic
OS02G0764500	chlorophyll a-b binding protein 4, chloroplastic
OS11G0242800	chlorophyll a-b binding protein CP26, chloroplastic
OS01G0501800	oxygen-evolving enhancer protein 1, chloroplastic
OS08G0200300	photosystem II 10 kDa polypeptide, chloroplastic
S06G0320500	chlorophyll a-b binding protein 1B-21, chloroplastic
Os04g0234600	sedoheptulose-1, 7-bisphosphatase
OS01G0102900	light-regulated protein
Os01g0971800	transcription factor PCL1
Os05g0202800	Plant metallothionein, family 15 protein
OS01G0600900	chlorophyll a-b binding protein 2

To map the gene/s responsible for low light tolerance, two F2 populations derived from parents, namely Dhanteswari/MTU 1121 with a total of 654 progenies, and IRCTN 91-84 x ISM with a total of 413 progenies, were evaluated under treatment (30% shade net) and control conditions (Fig 4). The survey for parental polymorphism with SSR markers present over all the chromosomes is currently in progress.

Fig. 4. F2 population of Dhanteswari / MTU 1121 and IRCTN 91-84 x ISM under treatment (30 per cent shading) and control conditions

Evaluation of soybean breeding lines

(A.Kumar, L. Touthang and P.W. Shimray)

Fifty-two crosses involving 61 parents underwent the F7 and F8 generations in a generation advancement program. Morphological variation among these selected lines was assessed based on higher yield from all the lines in F7 and F8 generations in the station trial. Selected advanced breeding lines of soybean were grown in a state adaptive trial (Shillong, Tura, and Jowai) with the assistance of state officials for yield and its component traits (Table 5, 6). Additionally, several cross combinations were evaluated at the station and will be targeted for the state adaptive trial in 2024

Table 5. Advanced breeding lines of soybean under state adaptive trial 2023

SN	Breeding lines	Germplasm
1	RCS 1-12	JS335 X P1416937
2	RCS 1-13	995 X 20-34 X EC
3	RCS 1-14	JS 335 XAGS 25
4	RCS 1-15	JS 97-52 X PP6
5	RCS 1-16	JS 335 X P1416937
6	RCS 1-17	20 X 34 X AK887
7	Umiam Soybean-1 (CK)	
8	Sikkim Pahalo Bhatmas-1 (CK)	

Table 6. Advanced breeding lines of soybean proposed for state adaptive trial 2024

1	MAUS 2/SL 688
2	CAT3293/JS 90-41
3	SL 958/AGS 25
4	RVS2001-18/EC 572154
5	EC 383165/DS 6-10
6	AGS 25/AS 2911
7	SL 96/AGS 25
8	JS 97-52/AGS 25
9	JS 20-98/JS 20-34
10	MACS 1188/EC 251396

Varietal development in potential crops

(A. Kumar)

Perilla is an important underutilized oilseed crop cultivated by tribal and marginal farmers in hilly areas of north-eastern region of India. The crop has good oil quality and plays an important role in providing nutritional security to the tribal farmers. After three years of AICRN coordinated trials two perilla varieties (Poorvottar perilla 1 and Poorvottar perilla 2) were found to be superior and identified for release and notification for Northern Hill Zone and North Eastern Hill Zone in VIC meeting of AICRN on Potential crops on 8th November, 2023 (Fig 5). Several entries of perilla namely, RCPS-400, RCPS-407, RCPS-410, RCPS-417, RCPS-421 (AVT 2), RCPS 402, RCPS 15, RCPS 46 (AVT 1) and IC-0645860, IC-0644430, IC-0644431, IC-0644434 (IVT) are in the process of multi-locational evaluation under AICRN on Potential crops.

Fig. 5. Poorvottar Perilla 1

Similarly, Job's tear is another potential crop often referred to as "Green Food" and is utilized in various preparations, including powder, biscuits, tea, beverages, alcohol, and vinegar. Several entries of Job's tear, namely IC334314, IC419466 (AVT 2), and IC540173, along with IC416868, IC416831, IC540222, IC089383 (AVT 1), are currently undergoing multi-locational evaluation under the AICRN on Potential Crops. Additionally, a set of 34 Job's tear accessions from the northeastern Hilly Himalayan region were characterized using morphological and molecular markers. Based on the Multi-Trait Stability Index, five accessions, namely IC 600638, IC 89392, IC 540181, IC 604098, and IC 540256, were found to be suitable (Fig 6).

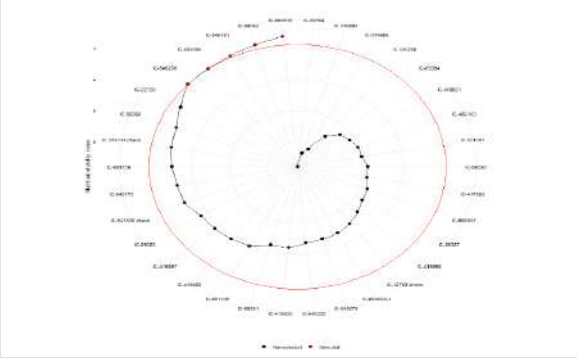


Fig. 6. Selected Job's tear lines (red colour) based on Multi Trait Stability Index

(*Vicia faba* L.), also referred to as broad bean, fava bean, horse bean, or field bean, is an ideal protein source (24-35%) for humans and can fix up to 200 kg of atmospheric nitrogen per hectare. Several entries of fababean, namely RCBB-1, RCBB-2, RCMBC-1, RCMBC-2 (AVT 2), and RCMBC-3 (AVT 1), are currently undergoing multi-locational evaluation under the AICRN on Potential Crops (Fig.7).

Fig. 7. RCBB-2 grown at Plant Breeding farm

Seed production program

Under the breeder seed production program, the Institute produced quality seeds of varieties developed by the Institute. Rice varieties, namely Shahsarang (1.5 q), Megha SA 2 (1.0 q), Bhalum 3 (0.5 q), and Bhalum 5 (0.2 q), were multiplied using the panicle to row method. At the Upper Shillong farm, seeds of cold-tolerant rice varieties, namely NEH Megha Rice 1 (0.5 q) and NEH Megha Rice 2 (0.5 q), were produced. In terms of maize varieties, quality seeds of Megha Maize 1 (7.0 q), Megha Maize 2 (8.0 q), RC Manichujak 1 (1.0 q), and RC Manichujak 2 (1.5 q) were produced. Breeder seeds of soybean varieties, namely Umiam Soybean 1 (0.5 q) and Sikkim Pahelo Bhatmas 1 (0.5 q), were also produced at the Upland farm of Plant Breeding.

Identification and characterization of promising maize lines for the NEH Region

(L. Touthang, A. Kumar, P.W. Shimray and B.K. Singh)

We evaluated 30 maize landraces collected from Arunachal Pradesh and 50 inbred lines from ICAR-IARI, New Delhi, at ICAR RC NEHR Umiam during kharif-2023 to identify promising genotypes for future breeding programs (Fig. 8). We maintained the landraces and inbreds through controlled pollination. The experiment was conducted in an augmented design with two checks, Megha Maize-2 and Hemant. Yield traits varied widely among the genotypes (Table 7). Principal component analysis extracted two Principal Components (PCs), accounting for 64.27% of the total variation, indicating substantial diversity among the genotypes. The desirable staygreen trait was exhibited by 11 inbreds, namely PML-29, PML-48, PML-58, CML-364, CML-465, CML-303, CML-578, CML-599, CML-601, CML-340, and CML-579. Based on yield per plant, the following genotypes were identified as promising: AR-Maize01 (100.3 g/Pl), PML-29 (95.6 g/Pl), CML-578 (85.6 g/Pl), CML-589 (93.3 g/Pl), PML-71 (92.3 g/Pl), PML-48 (92.3 g/Pl), AR-Maize-7 (90.15 g/Pl), AR-Maize-38 (90.08 g/Pl), and AR-Maize-22 (89.2 g/Pl), respectively.

Table 7. Descriptive statistics of maize yield traits

Descriptive Statistics						
Traits	**Min.**	**Max.**	**Mean**	**Std. Error**	**Std. Deviation**	**CV%**
Plant height (cm)	103.33	253.67	171.8	4.08	31.83	18.53
Days to 50% flowering	59	78	72	0.86	4.63	6.43
No. of cob/Pl	1	2	1.12	0.03	0.25	22.36
Cob length (cm)	9.67	26	14.24	0.36	2.84	19.91
Cob diameter (cm)	4.695	13.835	13.13	0.32	2.53	19.24
Rows/cob	9.5	14.34	11.68	0.21	1.12	9.59
Seed/row	8.67	49	22.56	1.51	11.81	52.32
TW (100) g	11.13	31.9	21.13	0.44	3.47	16.4
Seed yield/Pl (g)	14.17	102.3	58.64	3.36	26.22	44.71

Fig. 8. Illustration of the performance of 80 maize genotypes

Molecular Characterization of Rice bean Genotypes

(P.W. Shimray, B.K. Singh, A. Kumar and L. Touthang)

Ninety-four rice bean genotypes, along with four checks, were evaluated using 43 simple sequence repeats (SSR). The Polymorphic Information Content (PIC) values exhibited a range from 0.01 (for cG29169c0) to 0.44 (for cG18775c0), with an average value of 0.27 (Table 8). Notably, cG18775c0 (0.44) displayed the highest PIC value, closely followed by cG21640c0 with a PIC value of 0.37. The Analysis of Molecular Variance (AMOVA) indicated that a significant proportion of the existing variation, specifically 98%, originated within populations. In contrast, only 1.79% of the variation was attributed to differences among populations. The FST matrix analysis revealed significant variation among various population pairs. Notably, the Manipur-Mizoram (FST > 0.08), Mizoram-Meghalaya (FST > 0.08), and NBPGR-Mizoram (FST 0.06-0.08) pairs exhibited the highest levels of significant variation. Additionally, moderate significant variation (FST 0.02-0.05) was observed in the Manipur-Meghalaya and Manipur-NBPGR Shimla population pairs.

Table 8. Summary statistics of characterization of fourteen SSR markers on a set of ninety four accessions

Marker	Major Allele Frequency	na*	ne*	Gene Diversity	Heterozygosity	PIC	I*
Cg18775c0	0.48	3.00	1.69	0.54	0.15	0.44	0.60
cG29169c0	0.57	2.00	1.96	0.49	0.53	0.37	0.68
cG9589c1	0.87	2.00	1.60	0.23	0.18	0.20	0.56
cG25883c0	0.59	2.00	1.85	0.48	0.82	0.37	0.65
cG21640c0	0.55	2.00	1.99	0.49	0.81	0.37	0.69
cG25619c0	0.99	2.00	1.00	0.01	0.01	0.01	0.00
cG26585c1	0.79	2.00	1.95	0.35	0.13	0.32	0.68
cG22836c1	0.63	2.00	1.42	0.47	0.49	0.36	0.47
cG11123c0	0.90	2.00	1.32	0.17	0.13	0.16	0.41
cG11226c0	0.99	2.00	1.15	0.02	0.02	0.02	0.26

cG23872c0	0.83	2.00	1.07	0.28	0.28	0.24	0.15
cG28852c0	0.81	2.00	1.42	0.30	0.20	0.26	0.47
cG18775c0	0.50	2.00	2.00	0.50	1.00	0.38	0.69
cG9711c0	0.63	3.00	1.77	0.47	0.74	0.36	0.63
Mean	**0.72**	**2.14**	**1.59**	**0.34**	**0.39**	**0.27**	**0.50**

Biochemical Characterization of Rice bean Genotypes

Ten rice bean genotypes collected from different north-eastern states, were assessed for various biochemical parameters (Table 9). Within the examined genotypes, the lowest total flavonoids were observed in Ukhrul-1, a Manipur landrace (5.93 mg QE/g fw), while the lowest phytic acid was observed in ICAR-NBPGR collection IC341987 (0.501 g/100g). The highest crude protein was exhibited by Bete 14, a Mizoram landrace (26%), and Ukhrul-15, a Manipur landrace (22.09%).

Table 9. Details of different biochemical parameters evaluated among ten rice bean accessions

Genotype	Moisture content (%)	Crude Protein (%)	Crude Fiber (%)	Total Flavonoids (mg QE/g fw)	Phytic acid (g/100g)	ENERGYIN Kj/100g
IC341987	8.52^{bc}	20.91^{c}	2.87^{a}	9.97^{a}	0.501^{i}	1483.04^{bc}
IC521087	7.11^{d}	20.34^{d}	2.36^{ab}	7.94^{d}	0.694^{g}	1518.28^{a}
IC563980	7.36^{d}	21.35^{c}	2.20^{ab}	6.68^{e}	1.08^{c}	1488.61^{b}
Thoubal-3	9.00^{b}	21.22^{c}	1.27^{c}	8.38^{bc}	1.04^{d}	1471.68^{d}
Ukhrul-1	8.59^{bc}	19.64^{e}	2.44^{ab}	5.93^{f}	0.540^{h}	1452.99^{f}
Ukhrul-14	8.13^{c}	19.34^{e}	1.38^{c}	7.99^{d}	0.733^{f}	1521.80^{a}
Ukhrul-15	8.56^{bc}	22.09^{b}	2.32^{ab}	8.60^{b}	1.119^{b}	1473.44^{d}
Bete-14	10.44^{a}	26.03^{a}	1.43^{c}	6.41^{e}	0.849^{e}	1463.92^{e}
LRGP-8	8.15^{c}	22.23^{b}	2.84^{a}	7.76^{d}	1.312^{a}	1477.81^{cd}
LRGP-17	8.66^{bc}	20.91^{c}	1.73^{bc}	8.08^{cd}	0.849^{e}	1472.25^{d}
Mean	8.45	21.41	2.08	7.77	0.872	1482.00
Std. Dev.	0.91	1.87	0.59	1.18	0.263	22.12
CV	10.694	8.540	29.745	14.857	29.439	1.462
Std. Error	0.202	0.409	0.139	0.258	57.425	4.845
t Value	41.820	52.370	15.030	30.100	15.190	305.970

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

(P.W. Shimray, A. Kumar, L. Touthang and B.K. Singh)

A total of 100 lines of lentil procured from IIPR-Kanpur and 25 lines from ICARDA, Bhopal were evaluated for their yield performance and its corresponding traits during rabi season of 2023-24 under rice and maize based cropping system at Upper Plant Breeding farm ICAR-RC-NEH Region, Umiam. Variability analysis was performed for the genotypes under study (Table 10).

Table 10. Variability parameters of 125 lentil genotypes

Trait	Mean	GCV	GCV category	PCV	PCV category	ECV	hBS	hBS category	GAM	GAM category
DTF	80.9	7.3	Low	7.6	Low	1.97	93.3	High	14.7	Medium
DTM	121.4	2.23	Low	2.7	Low	1.6	65.8	low	3.7	Low
PH	32.5	12.8	Medium	13.3	Medium	3.6	92.7	High	25.5	High
PPP	34.2	30.0	High	30.3	High	4.1	98.1	High	61.3	High
SPP	1.94	0.1	low	6.6	Low	22.0	63.1	low	3.2	low
100SW	2.37	12.0	Medium	12.9	Medium	4.8	85.8	High	22.9	High
SYPP	1.07	31.90	High	33.1	High	9.1	92.4	High	63.2	High
SYP Plot	268.9	48.1	High	48.2	High	2.3	99.7	High	99.2	High

Evaluation of advanced lentil and pea lines under hilly conditions of Meghalaya

(P.W. Shimray, A. Kumar, L. Touthang and B.K. Singh)

Fifteen advanced lines, germplasm selections, and entries of lentil, namely IPL-239, IPL-240, IPL-541, IPL-237, IPL-234, IPL-345, IPL-603, IPL-233, IPL-238, IPL-336, IPL-339, IPL-537, IPL-538, IPL-220(CH), and IPL-316(CH), were evaluated during the rabi season of 2023-24 at Upper Plant Breeding Farm, ICAR-RC-NEH Region, Umiam (Fig 9, Table 11). The field layout followed a randomized block design (RBD) with three replications, 25 cm row-to-row spacing, 5 cm plant-to-plant spacing, and a plot size of 4.5 sq. m. The highest yield was recorded in IPL-603 (1.23 tonnes/ha) and IPL-240 (1.05 tonnes/ha), which were higher than both the checks.

Fig. 9. Lentil trial at Upper Plant breeding farm

Table 11. Observations recorded on lentil genotypes at ICAR-RC-NEH Region, Umiam

S. No	Entry	Days to 50% Flowering	Days to Maturity	Plant Height	Pods per Plant	Seeds per Pod	Hundred Seed Weight	Seed Yield per Plant	Seed Yield per Plot	Yield per ha (tonne)
1	IPL-239	107	124	32.1	33	2	2.5	1.76	491.3	1.01
2	IPL-240	95	131	31.5	35	2	2.7	1.21	443.4	1.09
3	IPL-541	101	125	32	35	2	2.2	1.12	433	0.9
4	IPL-237	104	133	38	35	2	2.4	1.15	543.5	1.2
5	IPL-234	102	131	36.11	35	2	2.1	1.30	328.4	0.7
6	IPL-345	95	129	39.13	32	2	2.1	1.13	251	0.5

7	IPL-603	102	131	39.66	32	2	2.4	1.49	546.5	1.23
8	IPL-233	103	133	38.12	25	2	2.2	1.21	150.5	0.3
9	IPL-238	97	130	32.77	28	2	2.4	1.14	335.3	0.7
10	IPL-336	104	130	33	35	2	2.7	2.12	400	0.9
11	IPL-339	90	133	41.11	37	2	2.6	1.63	454.2	1.02
12	IPL-537	93	130	32.33	35	2	2.2	1.32	213.3	0.7
13	IPL-538	98	125	39.43	38	2	2.4	1.46	459.1	1.02
14	IPL-220 (Check)	87	130	32.13	38	2	2.4	1.43	541.2	1.03
15	IPL-316 (Check)	93	131	29.75	33	2	2.5	1.42	243.5	0.7

Field trial and screening of Pea germplasm

Ten advanced lines, germplasm selections, and entries of pea, namely IPFD 17-2, IPFD 18-2, IPFD 16-4, IPFD 12-8, IPFD 14-2, IPF 16-18, IPF 17-19, IPF 18-14, IPF 16-13, and TRCP-8 (Ch), (Fig 10, Table 12) were evaluated during the rabi season of 2023-24 at Upper Plant Breeding Farm, ICAR-RC-NEH Region, Umiam, in a randomized block design (RBD) with three replications, 30 cm row-to-row spacing, 10 cm plant-to-plant spacing, and a plot size of 5.4 sq. m. IPFD-16-18 (2.71 tonnes/ha) and IPFD-18-2 (2.38 tonnes/ha) recorded the highest yield, surpassing the check.

Fig. 10. Pea trial at Upper Plant breeding farm

Table 12. Observations recorded on pea genotypes at ICAR-RC-NEH Region, Umiam

S. No	Entry	Days to 50% Flowering	Days to Maturity	Plant Height	Pods per Plant	Seeds per Pod	Hundred Seed Weight	Seed Yield per Plant	Seed Yield per Plot	Yield per ha (tonne)
1	IPFD-17-2	74	115	132.5	7	6	20.5	5.7	755.5	1.25
2	IPFD-18-2	73	115	106.5	6	6	22.5	12.1	1250.7	2.38
3	IPFD-16-4	81	116	104.1	7.	5	19.9	6.7	363.4	0.57
4	IPFD-12-8	75	117	87.2	6	6	21.5	6.5	722.1	1.55
5	IPFD-14-2	69	116	105.1	6	6	21.7	7.4	1184	2.17
6	IPFD-16-18	75	119	141.5	8	6	22.8	8.5	1451.5	2.71
7	IPFD-17-19	82	114	100.4	7	5	20.3	10.1	595.3	1.10
8	IPFD-18-14	74	114	120.2	8	5	21.4	6.7	443	0.79
9	IPFD-16-13	65	120	157.4	7	5	20.4	7.8	322	0.43
10	TRCP-8 (Check)	100	122	107.2	7	6	21.4	9.2	1231	2.22

MetaQTL analysis to identify genetic factors associated with Al toxicity response in Rice

(*S. Jaiswal, B. K. Singh, A. Kumar and S. Kaur*)

Rice is known for its tolerance to high aluminium (Al) concentrations in soil. Although this trait is crucial for the growth of rice in acidic conditions, the precise genetic and physiological mechanisms are yet to be fully understood. Recent research has identified several candidate genes and quantitative trait loci (QTLs) associated with Al tolerance in rice. Nevertheless, many more genes/QTLs are yet to be precisely mapped. We employed Meta-QTL (MQTL) analysis, integrating 11 independent mapping studies and six genome-wide association studies (GWAS). Meta-analysis, using the Veyrieras algorithm, identified 54 MQTLs from 153 projected QTLs. Overlapping QTLs on a consensus map narrowed down these QTLs to 28 MQTLs (Fig 11). Gene identification through batch retrieval from the RAP database yielded 2674 non-redundant genes within the 28 MQTL regions. Overlapping MQTL candidate genes (CGs) with five expression datasets associated with Al toxicity tolerance in rice resulted in the identification of 198 candidate genes with significant differential expression. Twenty-five common genes (CGs) were identified across at least two studies, including OsMT1, OsNTR2.3, and ALMT4, which showed up-regulation in response to Al stress in tolerant genotypes (Fig 12). Understanding these meta-regions holds potential for developing improved rice varieties capable of withstanding Al toxicity in acidic soils. Additionally, the study enhances our knowledge of the genetic basis of Al tolerance in rice, providing valuable insights for crop breeding programs.

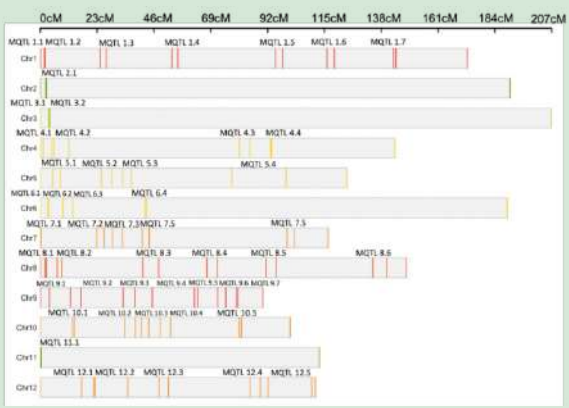


Fig. 11. Distribution of Al toxicity related meta-QTLs on rice chromosomes

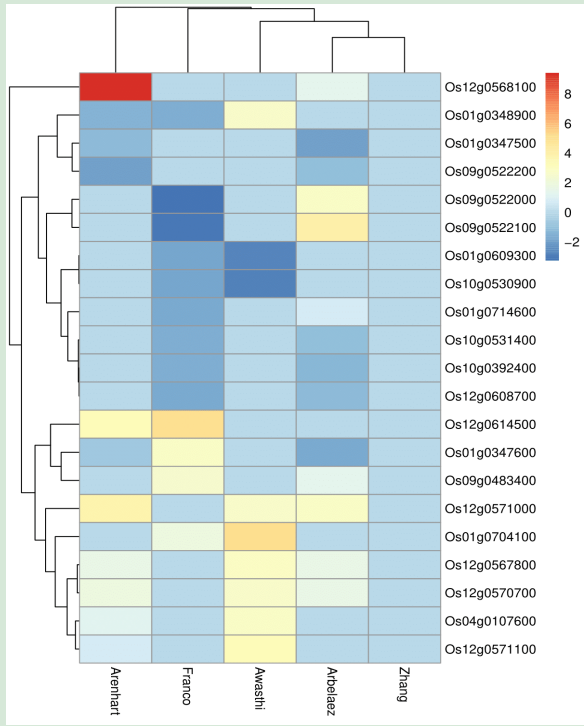


Fig. 12. Heatmap highlighting the fold change expression pattern of 25 candidate genes as reported in different expression studies

Assessing Habitat Suitability for *Perilla frutescens* L. in the North Eastern Hill (NEH) Region of India Using MaxEnt: An Ecological Modelling Approach

(*S. Kaur, N. Singh, A. Kumar, S. Jaiswal, B. K. Singh and S. Hazarika*)

Perilla frutescens L., a crucial annual oilseed crop in the Lamiaceae family, possesses significant medical, industrial, and nutritional value, particularly as a source rich in omega-3. To address the urgent need for its conservation amidst environmental threats and land use changes in the North Eastern Hill (NEH) Region of India, we utilized MaxEnt software to model the potential habitat distribution of Perilla (Fig 13). By analyzing bioclimatic variables, elevation, slope, aspect, and utilizing 177 occurrence points, the study identified elevation, precipitation patterns, and diurnal range as crucial determinants. The MaxEnt model demonstrated high accuracy (with AUC values of 0.92 and 0.87 for training and testing datasets, respectively), emphasizing its reliability. These findings establish a robust foundation for Perilla restoration, conservation planning, and management strategies in the face of ecological challenges.

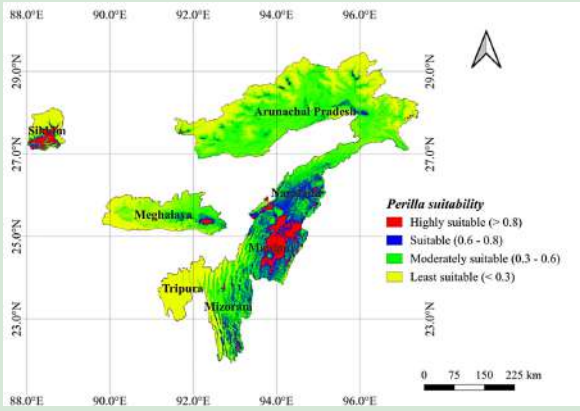


Fig. 13. Habitat Suitability for *Perilla frutescens* across North Eastern Hill region using MaxEnt Model

Development of a Convolutional Neural Networks-based Model to Classify the Rice Varieties

(*S. Kaur, N. Singh, A. Kumar and B. K. Singh*)

Rice (*Oryza sativa* L.) plays a pivotal role as a staple in India, especially in the North Eastern Hill (NEH) region. Meeting the increasing demand and recognizing the significance of international trade require precise identification of rice varieties. We compiled a dataset featuring four key varieties.

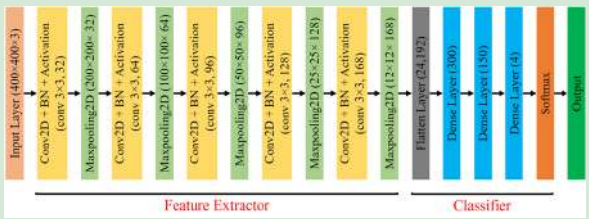


Fig. 14. The architecture of the proposed CNN-model for the identification of rice varieties

Bhalum-5, Shahsarang, Nagina-22, and IR-64—consisting of high-quality seed images captured using smartphones with varying seed counts.

By implementing a Convolutional Neural Network (CNN) with a 5-layer architecture, our innovative classifier achieved a notable 91.0% accuracy, demonstrating exceptional performance, particularly with the prominent Shahsarang variety (Fig 14). This success highlights the classifier's potential for accurate rice variety identification, addressing a critical need in the field.

Development and validation of NIRS-based prediction models for selected nutritional traits of Perilla

This work pioneers the application of Near-Infrared Spectroscopy (NIRS) and chemometrics to develop robust prediction models for key nutritional components in Perilla seeds (Fig 15). The scatter plots illustrate a strong correlation between reference and predicted values, highlighting the efficacy of NIRS modeling for moisture, ash, total phenols, and grain protein. Notably, seed meal protein prediction stands out with an exceptional RSQ value of 0.9593, emphasizing the model's precision in estimating this vital nutritional trait. Consistently high RSQ and Ratio of Performance to Deviation (RPD) values across various parameters, except for total soluble sugars, underscore the reliability and accuracy of the NIRS models. These results validate NIRS as a powerful and non-destructive tool for the rapid quantitative assessment of Perilla's nutritional components. Beyond scientific understanding, the study contributes to streamlined methodologies for nutritional assessment, advancing breeding strategies, and supporting efficient screening of germplasm collections in Perilla. The developed models offer an eco-friendly, less labor-intensive, and cost-effective alternative to conventional methods, positioning NIRS as a valuable tool for plant breeding, food industries, and inspection agencies in evaluating the intrinsic nutritional quality of Perilla seeds.

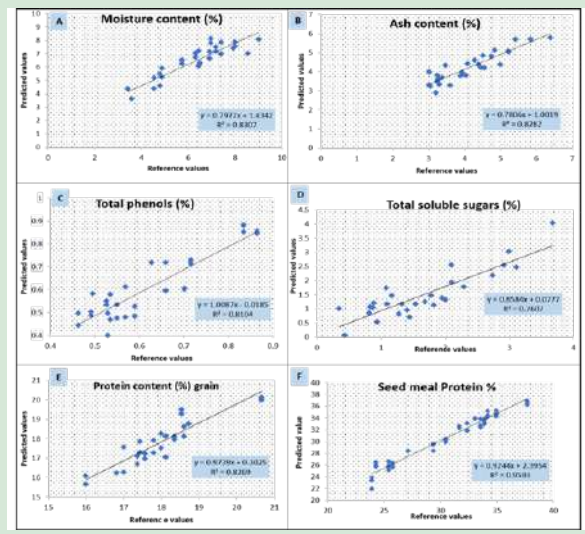


Fig. 15. Scatter plot between the reference versus predicted values for (A) Moisture, (B) Ash, (C) Total phenols, (D) Total soluble sugars, (E) Protein (grain), and (F) Seed meal protein.

Ecofriendly management fall armyworm in maize with different dates of sowing

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

Maize was sown on five different dates along with whorl application with soil and spraying of *Bacillus thuringiensis* var *kurstaki* for eco-friendly management of fall armyworm under Meghalaya conditions. Sowing of maize began during the first fortnight of April, with three replications for each sowing. The results revealed that among the different dates of sowing, maize sown during the second fortnight of April, with two soil applications at 20 & 40 DAS, and two sprays with *Bt* @2g/l, recorded the minimum infestation of fall armyworm with the highest grain yield.

Ecofriendly management practices against fruit borers in tomato in Meghalaya

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

To develop eco-friendly management practices against fruit borers of tomato, five different sowing dates along with other management practices were evaluated. Tomato seedlings were transplanted at 15-day intervals starting from the first week of January. It was found that transplanting tomatoes during the third week of January, along with the application of pheromone traps for *Tuta absoluta* and two sprays with *Bt* @2 g/l, recorded the maximum yield of tomatoes with less fruit borer infestation (<10% each) of *Helicoverpa armigera* and *Tuta absoluta*.

Studies on insect diversity in radish ecosystem in Meghalaya

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

Insect diversity analysis conducted during 2022-23 in the radish ecosystem identified a total of 16 insect species in the radish ecosystem from seedling to maturity. Out of these, 12 species were insect pests, and 4 species were natural enemies. The insect species belonged to 4 orders and 7 families, namely, Coleoptera (*Monolepta quadriguttata* M., *Luperomorpha* sp., *Phyllotreta striolata* F., *Phyllotreta cruciferae* G., *Aulacophora foveicollis* L, *Coccinella septempunctata* L., *Cryptogonus quadriguttatus* W., *Coccinella transversalis* F., and *Micraspis* sp.), 3 Lepidoptera (*Pieris brassicae* L., *Pieris rapae* L., and *Agrotis* sp.), 2 Hemiptera (*Lipaphis erysimi* K. and *Murgantia histrionica* B., *Bothrogonia tibetana* M.), and 1 Hymenoptera (*Athalia lugens proxima* G.). Among them, Coleoptera (73.90%) was more abundant, followed by Hemiptera (21.46%), Lepidoptera (3.89%), and Hymenoptera (0.75%) during 2022-23.

Studies on impact of weather parameters on population dynamics of major insect pests of radish with different dates of sowing

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

To understand the impact of weather parameters on major insect pests of radish, the population dynamics of the striped flea beetle and crucifer flea beetle were studied during 2022-23. The results showed that the population of both beetles started in the early seedling stage of radish. The striped flea beetle population ranged from 0.85 beetles/plant (November) to 12.6 beetles/plant (March), whereas the crucifer flea beetle population ranged from 0.67 to 5.82 beetles/plant. The peak population was found in March when the Tmax and Tmin were the highest during the crop growing seasons. Results of the correlation study revealed that Tmax and Tmin had a positive influence on both beetles.

Organic management of major insect pests of radish in Meghalaya

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

Six biopesticides, along with chemical and control checks, were evaluated against major insect pests of radish in Meghalaya during 2022-23. The treatments, namely *Beauveria bassiana* 1× 108 CFU/ml (5ml/l), neem oil 0.03% (3ml/l), *Lecanicillium lecanii* 1× 109 CFU/ml (5ml/l), *Bacillus thuringiensis* var. *kurstaki* (2g/l), *Metarhizium robertsii* 1× 108 CFU/ml (5ml/l), vermiwash 10% (100ml/l), cypermethrin 10 EC (1ml/l), and control, were applied at 25 and 45 days after sowing. Results revealed that among the biopesticides, *B. bassiana*, neem oil, and *M. robertsii* were effective treatments against the striped flea beetle with 32.45%, 34.26%, and 33.09% reduction over control, respectively, and against the crucifer flea beetle with 38.03%, 45.86%, and 45.41% reduction

over control, respectively. All biopesticides were relatively safe for coccinellid beetles in the radish ecosystem.

Studies on insect pests complex in sesame and their management in Meghalaya

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

The results revealed that more than fifteen insect species and a few natural enemies (predatory bugs, coccinellids, and spiders) were found on sesame. Among these, the sesame leaf webber (*Antigustra catalaunalis* Duponchel) and mirid bug (*Nesidiocoris tenuis* Reuter) were identified as major pests on sesame under Meghalaya conditions. Eight treatments, namely neem oil 0.03% (3ml/l), *Beauveria bassiana* (3ml/l), *Bacillus thuringiensis* var *kurustaki* (2ml/l), spinosad 45% SC (0.5ml/l), *Bacillus thuringiensis* var *kurustaki* + *Saccharopolyspora spinosa* 15% (2 ml/l), emamectin benzoate 5% SG (0.4ml/l), imidacloprid 17.8SL (0.3ml/l), and control (water), were applied at 45, 60, and 75 days after sowing. Among the treatments, emamectin benzoate 5SG @0.4 g/l recorded the lowest larval population of the leaf webber and the highest reduction over control, followed by spinosad, spinosad + *Bacillus thuringiensis*.

Biointensive pest management in cole crops in Meghalaya

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

Six biopesticides, namely *Beauveria bassiana* (5ml/l), neem oil 0.03% (3ml/l), *Lecanicillium lecanii* (5ml/l), *Bacillus thuringiensis* var. *kurstaki* (2g/l), *Metarhizium robertsii* (5ml/l), and vermiwash 10% (100ml/l), along with a chemical and control check, were evaluated against the cabbage butterfly in cole crops in Meghalaya during 2022-23. Results showed that among the biopesticides, *Bt* @ 2g/l was a highly effective treatment against the cabbage butterfly, exhibiting the minimum number of larvae per plant in all cole crops and resulting in higher yields. Additionally, all biopesticides were found to be relatively safe for the natural enemies present in all cole crops.

Documentation of diversity of insect visitors and pollinators in Litchi

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

The insect visitors and pollinators visiting the flowers of litchi were documented during the months of March and April 2023. A variety of insect visitors belonging to different families and insect orders were observed. Approximately 5 species of insects belonging to the order Hymenoptera, 14 species of Diptera, 4 species of Lepidoptera, 3 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 visitors and 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.

Impact of applied pollination with Indian Honey bee on the fruit quality and yield of litchi

A study was conducted on the impact of the Indian honey bee, *Apis cerana* Himalaya, on the pollination and yield of the Litchi variety, Bombay. The research was conducted from February to May 2023 at the Entomology farm, ICAR-Research Complex for NEH Region. The evaluated treatments included pollination with Indian honey bee, *Apis cerana* Himalaya under caged conditions, open pollination, and a control group with pollinator exclusion. *Apis cerana* demonstrated the highest efficiency as a pollinator of litchi, as indicated by the Pollination Efficiency Index (PEI). The applied pollination conditions resulted in a higher yield of approximately 87.67 kg/tree, whereas open pollination conditions yielded 81.33 kg/tree. Aril weight, juice content, TSS content, Vitamin C content, total sugar, and acidity under applied pollination conditions were 9.87g, 27.47%, 15.40% Brix, 52% mg/100ml, 5.28 g/100g, and 0.94% fresh weight, respectively. These values were comparable to those obtained under open pollination conditions (10.67g, 36.41%, 15.73% Brix, 40 mg/100ml, 5.40 g/100g fresh weight, and 0.84%).

Evaluation of QPM, Sweet corn, speciality corn and OPV Maize lines against Turcicum leaf blight

(P. Baiswar)

Four trials were conducted, namely QPM, Early Medium OPV, and Sweet Corn; Medium Maturity; Specialty Corn and OPV. In the case of QPM, there were a total of 27 entries, and out of these, 19 entries were found to be resistant. For Early Medium OPV and Sweet Corn, there were a total of 25 entries, with 17 entries identified as resistant. In the Medium Maturity trial, which had a total of 39 entries (with nine exceptions), all entries, except nine, were found to be resistant. In the Specialty Corn and OPV trial, there were 45 lines, and 24 of them were found to be resistant. All entries were evaluated at Umiam against *Turcicum* leaf blight (*Exserohilum turcicum*). These lines were provided by DMR, Ludhiana, under the AICRP on Maize. The evaluation involved using two rows of 2m length, and artificial inoculation was carried out to increase the disease intensity.

Evaluation of rice entries against rice blast

(P. Baiswar)

Seventy-two rice entries under the National Screening Nursery-Hills (NSN-Hills) trial were screened against rice blast using a uniform blast nursery pattern. Fourteen entries were identified as highly resistant. The experiment was conducted under natural epiphytotic conditions, and an SES (0-9) scale was followed for evaluation. The average maximum temperature during the period was 28ºC, the minimum temperature was 18.9ºC, and the relative humidity was 89.7% in the morning and 80.3% in the evening.

Evaluation of bioagents and bioinputs for management of Sclerotinia sclerotiorum

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

Antagonistic potential of native *Trichoderma* spp. and bioinputs was evaluated against *Sclerotinia sclerotiorum* causing white mold of cabbage. *Trichoderma* isolates were identified based on morphology, microscopic and molecular characterization (Fig.16) as *T. viride* (MT1;MT11), *T. asperellum* (MT2;MT5;MT6;MT8;MT9;MT10), *T. harzianum* (MT7), *T. afroharzianum* (MT3) and *T. hamatum* (MT4). The isolates showed maximum growth rate of 44.48 mm/day (MT7) and 44.40 mm/day (MT11), with correlated biomass production of 8.40 g/100ml (MT7) and 7.87g/100ml (MT11). Similarly, screening for functional and plant growth-promoting attributes revealed high iron chelation efficiency by MT7 (89.23%) and MT11 (88.24%), IAA production by MT7 (4.25µg/ml) and MT11 (4.07µg/ml), Zn solubilizing ability MT7 (74.33%) and MT11 (73.21%) and PO_4 solubilizing ability MT7 (49.07%) and MT5 (38.47%). All eleven (11) isolates exhibited more than 50 percent inhibition of the fungi *S. sclerotiorum*. Maximum inhibition of 88.81% was shown by MT-7, followed by 85.15% inhibition by MT-11.The combined efficacy of best potential *Trichoderma* isolates [MT-7 (*T. harzianum*) and MT-11 (*T. viride*)] and bioinputs (panchgavya 2% and neem oil 0.1%) were further tested in pot experiment with 12 treatments. The results showed the treatment combination of MT-7 (*T. harzianum)* + panchgavya 2%+neem oil 0.1% (T4) could reduce the white mold disease severity of cabbage to 4.15% which was at par with the treatment (T11) with fungicide (AmistarTop) of 4.11 % over control. Accordingly, the average maximum yield was for the treatments T4 and T8 which were 3.75 kg and 3.74 kg respectively and at par statistically. The best treatments from pot experiment were further evaluated with field experiment. Field experiment results showed the lowest percent disease incidence of 5.55 for the treatment T3 [MT-7 (*T. harzianum*) +panchgvaya 2%+neem oil 0.1%], followed by 6.88 percent for T8 (AmistarTop) and 8.74 percent for T4 [MT-11 (*T. viride*) +panchgavya 2%+neem oil 0.1%)]. The maximum yield was recorded in the treatment T3 of 17.58q/ha, followed by treatment T4 of 15.85 q/ha.

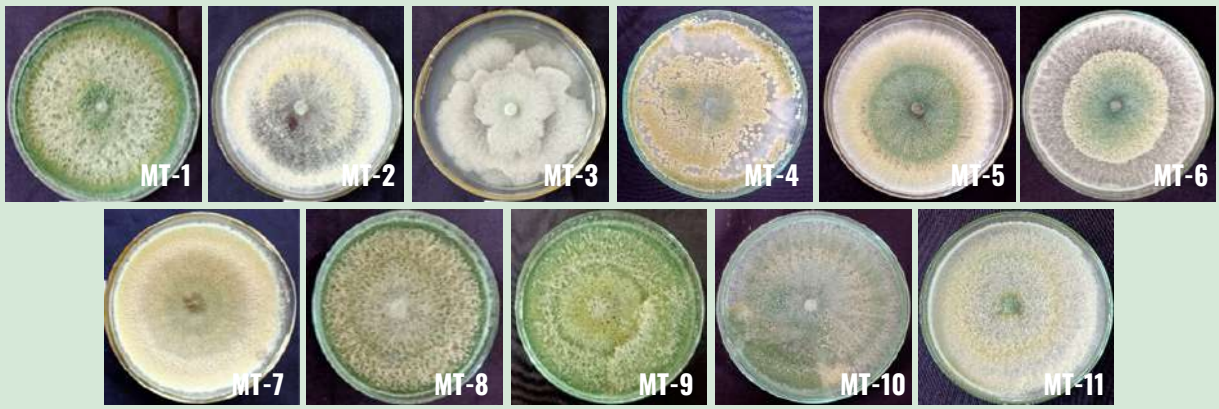


Fig. 16. Morphology of the *Trichoderma* isolates

Observations on incidence of biotic stresses in Khasi mandarin

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

Observations of disease and insect pest incidence in citrus orchards on the horticultural farm, as well as in selected orchards in farmers' fields, were conducted periodically. Notably, powdery mildew was mostly observed during the dry winter months (November–February), while citrus scab appeared during March-April. The combination of warm temperatures and high rainfall during July-August favored the build-up of citrus gummosis pathogens in poorly drained orchard soils on terraces. The warm, humid summer season also promoted the infestation of sooty mold in shaded orchards. The increase in temperature and humid conditions from March-April to July-August marked the incidence of citrus trunk borers. In addition, common pests of citrus such as leaf miners, black flies, hoppers, and scale insects were noted from February-March to September-October. These periodic observations were recorded to formulate eco-friendly management approaches tailored to the specific needs of farmers, as most orchards were of seedling origin, and intercropping with crops like ginger and pineapple was practiced. Unfortunately, a proper schedule for weeding, pruning, and the application of Bordeaux paint was not consistently followed. To address these issues, growers were informed and demonstrated the application of biocontrol agents, as well as the preparation and application of Bordeaux mixture during a field day.

Demonstration of rejuvenation technologies for *Khasi* mandarin

(T. R. Borah and A. Balusamy)

The field trial on rejuvenation technologies of citrus orchards was conducted in Nongtrylaw village of Sohkhowai, Nongpoh, Ri Bhoi by selecting 75 bearing plants in the near-decline stage orchard. In the orchard, 50 Khasi mandarin plants were selected and applied with the recommended doses of FYM and fertilizers. In the same citrus orchards, another 25 plants were marked/tagged as controls, following prevailing farmers' practices (no FYM, fertilizers, or plant protection materials). Plant height, collar diameter, fruit weight, the number of seeds per fruit, total soluble solids, rind thickness, and juice content showed non-significant differences between the treatments. However, the application of the recommended dose of NPK fertilizers and micronutrients (Zinc and boron) significantly increased the number of fruits per tree by 25% compared to the untreated plants. Thus, by applying the recommended practices, farmers can potentially increase their income.

DIVISION OF ANIMAL AND FISHERIES SCIENCES

RESEARCH ACHIEVEMENTS

Livestock Production

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

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

A total of 8 ejaculates were collected from three HF crossbred bulls, and the ejaculates with initial progressive motility≥ 70% were pooled. Each ejaculate was divided into 3 aliquots. The first aliquot was diluted with a standard dilutor (T1), whereas, rest two aliquots were diluted with an extender containing 25% egg yolk (T2) and standard diluent supplemented with 2 mg CLC/120 million spermatozoa (T3). Following freezing, the semen straws were plunged into LN_2 and after 24 h, straws from T2 and T3 were transferred to an ultra-deep freezer (-80 °C). The semen samples were thawed at 37 °C for 30 seconds as the thawing conditions were standardized during the previous year and the highest progressive motility was observed during the aforementioned thawing conditions. The post-thaw progressive motility and viability were found to be similar (p≥0.05) between the LN_2 and −80 °C groups, which included the standard diluent and standard diluent with CLC groups. This comparison was conducted on day 1 and day 7 of storage using 6 ejaculates. The progressive motility and viability were significantly lower in the 25% egg yolk group as compared to the LN_2 and CLC group. A fertility trial was also conducted at 2 dairy units. Two cross bred cows were inseminated with frozen-thawed semen from the CLC group stored at -80 °C. Pregnancy diagnosis was performed by ultrasonography (USG) on the 43rd day of gestation (Fig. 1) and both animals were found to be pregnant.

Fig. 1. Bovine embryo on 43rd day of gestation examined by USG examination

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

(S. Deori and R. Katiyar)

The research work involved investigating the effect of different concentrations of selenium nanoparticles (Se-NPs) supplementation in semen extenders during liquid semen preservation in boar semen and cryopreservation in goat semen. For boar semen, Se-NPs were supplemented in Beltsville Thawing Solution extender @1 µg/ ml and 2 µg/ ml and compared with the control samples which were without the supplementation of Se-NPs. The samples were preserved at 15°C in a BOD incubator. Extended semen was evaluated at 0 (immediately after dilution), 24, 48, 72, and 96 h of storage for sperm motility, live sperm, plasma membrane integrity, acrosome integrity, DNA integrity, and mitochondrial membrane potential (MMP). The mean percentage of sperm motility, live sperm, and sperm with intact plasma membrane and acrosome, and MMPs were significantly ($p < 0.01$) higher in both the treated groups compared to the control at 24, 48, 72, and 96 h of storage. Sperm with intact DNA in treated groups increased significantly at 48 ($p < 0.05$), and 72 and 96 ($p < 0.01$) h of storage compared to the control group. For goats, semen was collected from four Assam Hill Goat bucks (10 ejaculates per buck) to investigate the effect of supplementing selenium nanopraticles (Se NPs) at different concentrations in TRIS extender on seminal attributes after freeze-thawing. Ejaculates were divided into three aliquots and then diluted in TRIS extender containing Se NP supplementation at different concentrations (T0: control; T1: 0.5 µg/ mL Se NPs and T2: 1 µg/mL Se NPs). After dilution, semen samples were filled in straws, equilibrated and then cryopreserved in LN2. The post-thaw attributes, including motility, viability (CFDA+/PI-), morphology (eosin-nigrosine), plasma membrane integrity (HOS+), DNA integrity (AO+) and mitochondrial membrane potential (JC1agg) (Fig. 2) were evaluated as per standard protocol. The lipid peroxidation (LPO) profile was assessed by the malondialdehyde (MDA) assay. Results showed that Se NPs @ 1 µg/mL (T2) had significantly ($p<0.001$) higher post-thaw sperm quality attributes compared to T0 and T1. The activities of SOD, CAT and GST were significantly ($p<0.001$) higher in T2 compared to the other groups. The MDA levels were significantly ($p<0.001$) lower in T2 compared to T0 and T1. 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, thereby lowering the oxidative stress associated with freeze-thawing.

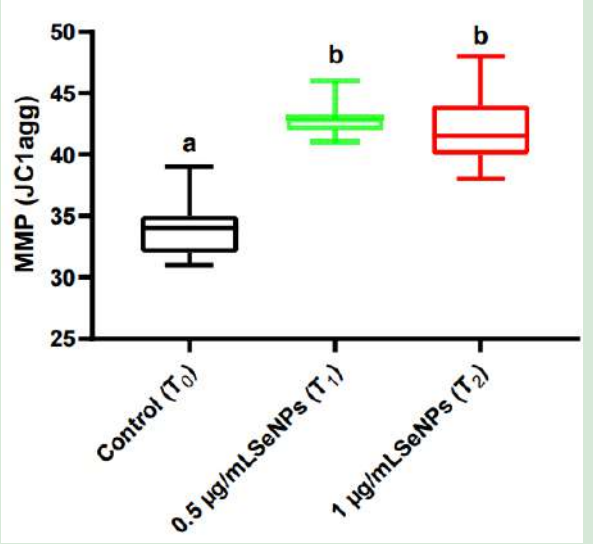


Fig. 2. Evaluation of mitochondrial membrane potential (JC1agg)

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 and M. Bhatt)

The objectives of the project are to characterize and conserve the native goats of northeastern region of India, to evaluate the important economic traits in respect to growth, reproduction, health and carcass characteristics and to undertake improvement of the native goats through selective breeding. The project is operational in all the regional centres of the institute namely, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Sikkim and Tripura with identical objectives focused on indigenous goats of their respective states. In the Meghalaya centre, a nucleus herd of Assam Hill goat was established with a herd strength of 88 during the reported year. Various productive and reproductive traits were recorded during the year. Semen is collected from Assam Hill goats and processed for preservation using Tris-Egg Yolk-Glycerol Extender in Liquid Nitrogen. The fresh semen characteristics of Assam hill goats are detailed in Table 1.

Table 1. Fresh semen characteristics of Assam hill Goat

Semen parameters	
Ejaculate volume (ml)	0.45 ± 0.13
Initial motility (%)	83.03 ±2.03
Sperm concentration (x10^6)/ml	3179.95 ± 190.77
Live sperm (%)	83.90 ± 2.70
Sperm abnormality (%)	8.55 ± 2.18
HOST-reacted sperm (%)	68.71 ± 3.10
Intact Acrosome (%)	91.87 ± 3.77

Development of a novel sensitive single-tube nested PCR for the detection of African swine fever virus

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

African swine fever (ASF) is a highly fatal and contagious viral disease caused by African swine fever virus (ASFV), leading to significant economic losses for the swine industry and posing a serious threat to food security worldwide. Diagnostic tests with high sensitivity are essential for effective ASF management. While polymerase chain reaction (PCR) is commonly used for ASFV detection, its limited sensitivity can result in false-negative results. A single-tube nested PCR (STN-PCR) assay was developed for the detection of ASFV, involving two consecutive amplification steps within a single tube. Two pairs of novel primers (outer and inner) were designed to target the *p72* gene of ASFV. Primer concentrations, annealing temperatures and number of amplification cycles were optimized to ensure the consecutive utilization of outer and inner primer pairs during amplification while minimizing the likelihood of amplicon contamination. Compared to the conventional PCR assay, the newly developed STN-PCR assay demonstrated a 100-fold increase in analytical sensitivity, detecting 100 copies of ASFV genomic DNA while the endpoint PCR assay could only detect 10,000 copies. The clinical performance of the STN-PCR assay was validated using 95 ASFV-suspected tissue samples. The STN-PCR displayed 100% specificity by detecting 73 out of 95 samples tested. Among them, three PCR-negative samples were detected by the STN-PCR assay and the Cohen's kappa value of 0.91 indicates a perfect agreement between the two assays. The developed novel STN-PCR will be a valuable tool, greatly benefiting the successful control of ASF in India. Figure 3 depicts the specificity analysis of the developed assay. An Indian patent (TEMP/E-1/52617/2023-DEL) has been filed for the application of STN-PCR for the detection of ASFV.

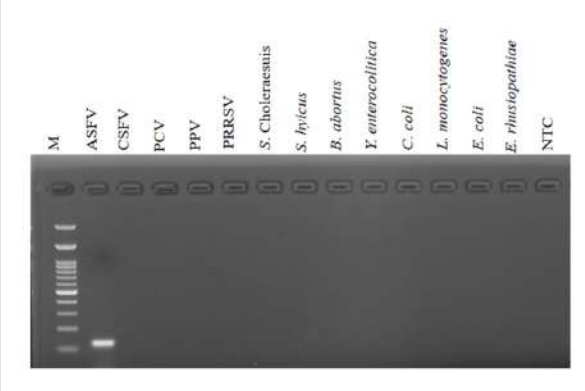


Fig. 3. Specificity analysis of STN-PCR for the detection of ASFV

First seroepidemiological investigation of Hepatitis E virus infection in backyard pigs from Northeastern India: Prevalence and associated risk factors

(A.A.P. Milton, S. Das, S. Ghatak, B. Sailo, Lalhruaipuii, M. Singh and A. Sen)

Hepatitis E virus (HEV) is the leading cause of acute viral hepatitis globally, with zoonotic potential, and pigs are considered the major reservoir. To determine the seroprevalence of HEV infection in pigs reared in backyard conditions in the northeastern region of India, blood samples were collected from 400 pigs from five northeastern states (80 samples from each state) and tested for IgG antibodies against HEV using an ELISA assay. Questionnaires on farm characteristics and management practices were completed, and risk factors associated with HEV were studied using univariate and multivariate analysis. The apparent seroprevalence of HEV infection was 51% (46.1–55.9, 95% CI), with a true prevalence of 52.98% (47.22–58.75, 95% CI). The risk factors significantly associated with higher HEV seropositivity were as follows: lack of disinfection (OR 4.65), feeding swill (restaurant and bakery waste) (OR 2.55), failure to follow the all-in-all-out production system (OR 3.47), and medium holding size (OR 9.83), which refers to mixed rearing of younger and older age groups. This study demonstrates that HEV is widespread among pigs reared in northeastern India. The risk factor analysis conducted in this study provides valuable insights into the prevalence of HEV in the region.

Novel helix loop-mediated isothermal amplification (HAMP) assay for colorimetric detection of *Staphylococcus aureus* in milk

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

Staphylococcus aureus is an important and leading cause of foodborne diseases worldwide. Prompt detection and recall of contaminated foods are crucial to prevent untoward health consequences caused by *S. aureus*. Helix loop-mediated isothermal amplification (HAMP) is an exciting recent addition to the array of available isothermal-based nucleic acid amplification techniques. This study aimed to develop and evaluate a HAMP assay for detecting *S. aureus* in milk and milk products. The assay is completed in 75 minutes isothermal temperature incubation (64˚C) and dye-based visual interpretation of results based on colour change (Fig. 4). The specificity of the developed assay was ascertained using 27 *S. aureus* and 17 non-*S. aureus* bacterial strains. The analytical sensitivity of the developed HAMP assay was 9.7 fg/µL pure *S. aureus* DNA. The detection limit of the HAMP assay in milk (86 CFU/mL) was 1000X more than the routinely used endpoint PCR (86 x 10^3 CFU/mL). The practicality of applying the HAMP assay was also assessed by analysing milk and milk product samples (n=95) obtained from different dairy farms and retail outlets. The developed test is a more rapid, sensitive, and user-friendly method for the high-throughput screening of *S. aureus* in food samples and may therefore be suitable for field laboratories.

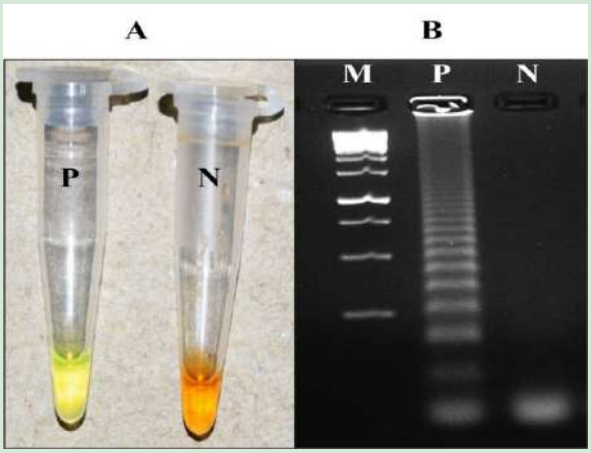


Fig. 4. Visualization of HAMP amplicons (A) SYBR Green I dye (B) Gel electrophoresis (P: Positive; N: Negative; M: 100 bp DNA Ladder)

National Animal Disease Epidemiology Network (NADEN)

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

The major livestock disease reported in Meghalaya during 2023 was African swine fever (ASF) in pigs. ASF spread throughout the state and killed an enormous number of pigs reared by tribal farmers of the state. Additionally, there was incursion of lumpy skin disease (LSD) into the state followed by number of outbreaks. Animal health laboratory of ICAR NEH confirmed LSD and ASF through molecular and serological techniques.

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

(S. Das, A.A.P. Milton, S. Ghatak, S. Deori and G. Khargharia)

A potential probiotic bacterium was isolated from a healthy pig and identified as *Limosilactobacillus reuteri*, confirmed through culture, PCR, and sequencing. The isolate, *L. reuteri* strain number 8, was then used successfully in an animal experimentation trial involving rabbits and is now prepared for experimentation on pigs.

Molecular screening panel and bio-inventorization of cryptic xeno- zoonotic bacteria of porcine origin

(S. Das, A.A.P. Milton, S. Ghatak, S. Deori and G. Khargharia)

In this ICMR funded project, a total of 80 tissues samples has been collected including heart, liver, spleen, kidney, urinary bladder and skin from 14 different animals (porcine). Out of the collected 80 samples, four *Staphylococcus aureus*, one *Enterococcus gallinarium* and one *Salmonella enterica* have been isolated. Whole genome sequencing has been completed for *E. gallinarium* and *S. enterica* and further analysis is ongoing.

Traceable value chain for safe pork in the North Eastern Region of India

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

Thirty-six butchers from four districts in Meghalaya (Ri Bhoi, East Khasi Hills, Eastern West Khasi Hills, and West Jaintia Hills) were interviewed to gather personal and professional details. Contact information was collected to establish them as stakeholders in the pig value chain. Demographic analysis revealed that the majority of pig butchers were under 30 years old (38.8%). Despite Meghalaya being a matrilineal state, men dominate this occupation (77.8%). Most butchers have education up to high school level, with some graduates also involved. Additionally, three key middlemen managing pig traffic along the Guwahati-Shillong Road were interviewed to collect data on weekly pig traffic. Pigs entering Meghalaya come from various Indian regions like Karnataka, Haryana, Rajasthan, and Punjab, primarily consisting of Yorkshire and Hampshire breeds. Trailer frequency ranges from none to three per week on average, with a threefold surge in supply during festive periods like Christmas. Administrative measures halt supply during disease outbreaks. In Ri Bhoi district, 28 pig farmers were interviewed for socio-demographic details, and their contact information was recorded for future integration.

Characterization of lactic acid bacteria and pathogens isolated from traditionally fermented foods in tribal hill areas of Northeast India

(S. Ghatak, R. Sanjukta, A.A.P. Milton, S. Das and A. Sen)

Traditional fermented foods are an important part of daily diets of people. While fermented foods offer potential health benefits, they also carry risks associated with the proliferation of detrimental microorganisms and contaminants due to inadequate hygiene practices. This study aimed to identify lactic acid bacteria (LAB) in fermented food samples sourced from Northeast India, evaluate their advantageous characteristics, and underscore the threat posed by foodborne pathogens with antimicrobial resistance. A comprehensive sampling effort involved the collection of 113 distinct fermented food specimens from local markets across five states in Northeast India (Nagaland, Manipur, Meghalaya, Arunachal Pradesh, and Sikkim). Conventional laboratory methods were employed to isolate LAB strains, assess their probiotic potential, enumerate coliform bacteria, isolate presumptive staphylococci from the fermented food matrix and determine their antimicrobial resistance profiles. The investigation yielded 30 LAB strains with probiotic attributes. The aerobic colony counts in the sampled fermented foods ranged from 4.4 to 7.7 log-cfu/g and coliform bacteria were detected in 43% of the samples,

indicating suboptimal hygiene conditions. Notably, certain food specimens harbored staphylococcal strains displaying phenotypic markers of antibiotic resistance, including methicillin resistance. These findings highlight the coexistence of probiotic LAB strains alongside potential contaminants with antibiotic resistance traits in traditional fermented foods from Northeast India, posing potential health risks for consumers.

Development and application of core-resistome analysis technique to decipher temporal trends of antimicrobial resistance in foodborne zoonotic pathogens: Evidence from Indian isolates of *Salmonella enterica*

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

Antimicrobial resistance (AMR) in *Salmonella* spp. is a growing crisis. The present study was undertaken to develop and apply core-resistome analysis technique to delineate the temporal trends in the emergence of antimicrobial resistance (AMR) and apply it to the same for *Salmonella enterica* strains from India. Initially, a workflow involving parallel analysis of genomes with the Resistance Gene Identifier tool was optimized in conjunction with application IntegronDB, TransposonDB, Roary and IQ-TREE. The optimized methodology was then applied to *S. enterica* genome sequences and antibiotics approval data from NCBI and Central Drug Control Standards Organisation, respectively. The results revealed the occurrence of AMR genes against 23 antibiotic classes with cephalosporins and fluoroquinolones being the most prevalent (17 genes each). For many antibiotics (monobactams, glycylcyclines, fosfomycins, elfamycins, edeine), occurrences of AMR genes preceded the approval of the antibiotic for use. Statistically significant differences ($P<0.05$) were observed for resistance mechanisms, gene families and SNP patterns, although no difference was noted for AMR gene carriage among salmonellae at decadal intervals. Our results provide a robust methodology for deciphering the trends of AMR in foodborne zoonotic bacteria. Further, the application of the technique to Indian isolates of *S. enterica* revealed occurrences of AMR genes and mechanisms prior to antibiotic approval, highlighting the usefulness of the developed core-resistome (Fig. 5) analysis technique for guiding future stewardship policies for AMR.

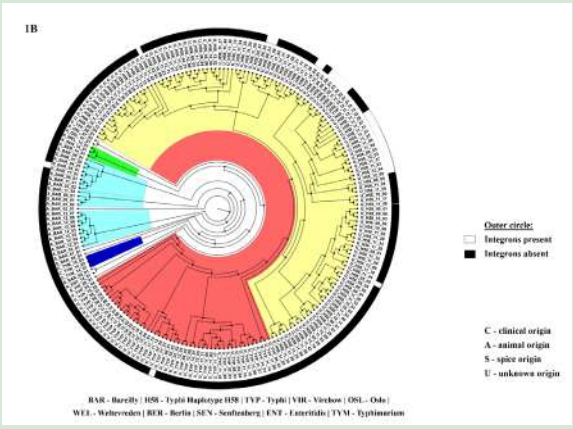


Fig. 5. Core-resistome phylogeny of *Salmonella enterica* of Indian origin

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

(M. Das, R. Katiyar, D. Chakraborty, R. Kumar and H.R. Gowda)

The economic impact of gastrointestinal (G.I.) parasitic infections in livestock and poultry is significant, leading to lowered fertility, reduced work capacity, decreased food efficiency, lower weight gain, reduced milk production, increased treatment costs and mortality in heavily parasitized animals. Subclinical infections are common and cause high morbidity and mortality in young animals resulting in substantial production losses in adults. The effect of anthelmintic treatments on egg per gram of feces (EPG) and milk production was recorded (Table 2) along with the monthly pasture larval burden (PLB L_3/Kg DM) in different types of pasture, which was estimated and correlated with temperature, rainfall and humidity. Third stage G.I. nematode larvae (L_3) including *Haemonchus* sp., *Trichostrongylus* sp., *Oesophagostomum* sp., *Cooperia* sp. and *Mecistocirrus* sp. were observed in Bermuda grass (*Cynodon dactylon*), Guinea grass (*Panicum maximum*), Napier grass (*Pennisetum purpureum*), and Paragrass (*Brachiaria mutica*).

Table 2. Effect of anthelmintic treatment on Mean EPG of cattle (Means with different superscripts differ significantly; P<0.05)

Group	No. of animals	Anthelmintic treatment	Pre-treatment EPG ± SE	Post-treatment EPG (Mean±SE)			
				1st week	2nd week	3rd week	4th week
I	6	Neozide plus	840 [a] ± 27.69	0.00 [b]	0.00 [b]	0.00 [b]	0.00 [b]
II	6	Albomar	810 [a] ± 43.97	0.00 [b]	0.00 [b]	0.00 [b]	0.00 [b]
III	6	Control	860 [a] ± 34.80	865 [a] ± 35.78	850 [a] ± 19.72	870 [a] ± 23.80	875 [a] ± 27.13

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

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

Livestock significantly contributes to the rural economy by offering year-round employment, especially to small and marginal farmers. Farmers in the state rely on raising livestock and crops for a living, typically using low-cost agro-byproducts as animal feed. A questionnaire-based survey was carried out in the aspirational district, Ri Bhoi (Umsning, Umling Block), Meghalaya to determine the socioeconomic profile of livestock farmers. One hundred respondents were randomly selected in proportion to the overall population. The data were then translated into a standard score for tabulation. It was observed that males constituted the majority of respondents in Umsning Block (56%) and that 52% are in the middle age range (39-50) with a medium level of education (44%). The majority (68%) belonged to scheduled tribes and had medium-sized households (4-6 members). Sixty percent of the farmers owned land of less than one acre, while 60% of the respondents rented land of less than one acre. About 40% of the respondents used surface irrigation techniques such as canals, minor tanks and traditional water harvesting structures. About 58% of respondents reported a medium yearly income (20000-50000), and the majority (70%) were not part of any farmer's groups or cooperative societies. Approximately 44% of people use media at a medium level and 44% use information sources moderately. The majority of responders (98%) were engaged in agriculture, horticulture, and animal husbandry on a daily basis. The main occupations of the respondents were farming (94%) and livestock rearing (90%). In Umling Block, the majority of the respondents (60%) were male, with 48% falling in the 39-50 age range and 40% having a medium level of education. About 52% of respondents used surface irrigation techniques such as canals, minor tanks and traditional water harvesting structures. Sixty percent reported a medium yearly income (20000–50000), and 74% were not part of any farmer's groups or cooperative societies. Approximately 46% of people use media at a medium level, and 50% use their information sources moderately. Ninety percent of respondents were engaged in agriculture-related work, followed by horticulture (80%) and animal husbandry (78%). The respondent's main occupation were farming (96%) and animal rearing (80%).

Phylogenetic analysis of *Eimeria tenella* isolates from chickens in Meghalaya's subtropical hilly areas

(M. Das)

Fecal samples (n=337) and dead chicks (n=298) were collected from poultry farms in and around Umiam, Ri-Bhoi, Meghalaya from January to July 2023. The chicks were categorized into different age groups*:* < 3 weeks, 3-6 weeks and >6 weeks. Samples were examined by flotation and modified McMaster techniques. Oocyst sporulation was performed in 2.5% potassium dichromate solution. *Eimeria tenella*'s 18S rRNA gene genomic DNA was extracted, amplified, and sequenced. Fecal sample and post-mortem examinations revealed 24.04% and 33.22% infections of *Eimeria* sp., respectively (Table 2). Amplification of the 18S rRNA small subunit gene (SSU) by Polymerase Chain Reaction (PCR) revealed a 1790 bp band size. The amplicon was sequenced and deposited in the NCBI database. BLAST analyses of the SSU rRNA gene of *E. tenella*, Umiam, Meghalaya isolate (OR458392.1) revealed sequence similarities of more than 99% with SSU rRNA gene sequences available in the database. Pair wise alignment exhibited nucleotide homology ranging from 71.59% to 100.0% with the maximum sequence homology

(100.0%) shared with the *E. tenella* isolate from Turkey (HQ680474.1). Phylogenetic analysis with cognate sequences worldwide revealed that SSU rRNA sequences of *E. tenella* from Umiam, Meghalaya isolate is distinct but also share a close phylogenetic relationship with Indian isolates from Bangalore and Andhra Pradesh. However, a distant relationship was identified between the *E. tenella* isolates from Umiam, Meghalaya and three isolates from Kerala, with more than 2% divergence based on the distance matrix.

Molecular diagnosis and phylogenetic insights of *Eimeria* species infecting buffaloes (*Bubalus bubalis*) in Meghalaya's subtropical hilly region

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

Coccidiosis, caused by various species of *Eimeria* is a pathogenic intestinal disease that results in economic losses due to mortality and morbidity in young buffalo calves. Faecal samples from buffaloes (n=218) were collected and screened using flotation and modified McMaster techniques. Morphological characterization revealed *Eimeria bareillyi* (18.18%), *E. zuernii* (9.09%), *E. bovis* (18.18%), *E. ellipsoidalis* (9.09%) and mixed infections (45.45%). Polymerase Chain Reaction (PCR) was employed for molecular characterization of *Eimeria* species. Genus and species-specific primers were used to amplify the ITS-1 region of the 18S rRNA gene, confirming *Eimeria* sp. (410 bp), *E. bovis* (238 bp) and *E. zuernii* (344 bp) infection in buffaloes. Sequencing and Basic Local Alignment Search Tool (BLAST) analysis revealed a similarity of 95.65% to 97.2% of *Eimeria* sp. Umiam isolates (Accession No. OR399550.1) with other isolates of *E. auburnensis*, *E. cylindrica*, *E. ellipsoidalis*, *E. alabamensis*, *E. bovis*, *E. zuernii*, *E. lancasterensis* and *E. maxima* from Japan, Egypt and Italy, respectively. In addition, *E. bovis* (Accession No. OR473385.1) and *E. zuernii* (Accession No. OR498904.1) Umiam isolates revealed 96.88 to 94.12% and 78.2 to 75.3% nucleotide similarity, respectively with the cognate gene sequences available in the database. Phylogenetic analysis of the *E. bovis* Umiam isolate indicated close relationships with isolates from South Korea, Wyoming, USA and Japan. However, the *E. zuernii* isolate from Umiam, Meghalaya, India appeared phylogenetically distant from the Japan isolate with close to 10% divergence in the distance matrix.

FISHERIES

Assessing the effectiveness of turmeric extract as a feed additive for fish

(C. Debnath and S.K. Das)

The effects of turmeric extract as feed additive on the growth and immunity of *Labeo gonius* were evaluated under Meghalaya conditions employing cemented cisterns (each 1 m^3). Fish (average size: 6.38±0.35 g/6.2±0.32 cm) were stocked @ 30 fish/tank and fed feeds containing varying levels of turmeric extract (var. Megha turmeric 1) at 0%, 2%, and 4% representing 3% of their biomass (Fig. 6). Each feed type was evaluated in replicates. Water quality parameters were monitored fortnightly, and monthly assessments measured fish growth. Fish samples (n=10) from each tank were taken on the 15th, 30th, and 60th day post feeding for analysis of growth parameters and blood parameters. Results showed a significant increase in specific growth rate, with a remarkable 48.1% boost in the group fed with feed containing turmeric extract. Survival rates ranged from 88.4% to 90% for fish fed with feed containing turmeric extract compared to 78.4% for the control group. Fish fed with 2% turmeric extract demonstrated better condition. Blood analysis revealed elevated RBC and WBC counts, increased hemoglobin and total protein levels, reduced glucose and cholesterol content and GOT and GPT activity within normal ranges. Optimal outcomes were observed 2% turmeric extract. From this study, it can be concluded that the inclusion of turmeric extract in the feed enhances fish growth, condition, and immunity under the hill settings of Meghalaya.

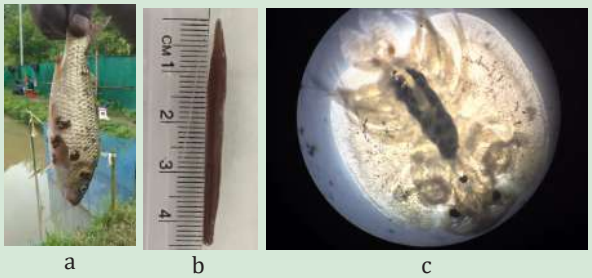


Fig. 7. Fish parasites encountered at ICAR Research Farm (a. Leech infestation; b. *Piscicola* sp. *c. Argulus* sp.)

Fish seed production and supply, and revenue generation

(S.K. Das, C. Debnath, T. Tayung, P. Mahanta and P.J. Ryntathiang)

Meghalaya experiences substantial demand for quality fish seeds every year, relying on diverse sources to meet this growing need. The ICAR Meghalaya Fisheries Research Farm plays a pivotal role in supplying fish seeds to farmers, contributing significantly to the sustainable development of aquaculture in the state. During the reporting period, we produced approximately 100,000 fish seeds of assorted varieties, including common carp (var. normal and amur carp), catla, rohu, gonius, java puthi, and grass carp. We supplied 71,671 fish seeds through various collaborative efforts, partnering with entities such as Krishi Vigyan Kendras (KVKs), the State Fisheries Department, and colleges of CAU. Furthermore, we generated revenue of Rs. 529,525 through the sale of fish seeds and Rs. 24,800/- through the sale of table fish. Additionally, we earned Rs. 23,540/- through the sale of fruits and turmeric produced by utilizing pond dikes, and Rs. 27,430/- through the sale of eggs produced from poultry birds integrated with the fish pond. In total, we generated revenue of Rs. 605,295/- from the fisheries research farm during the specified period.

Native fish germplasm collection for propagation and conservation

(*T. Tayung and S.K. Das*)

In November, we introduced 1000 seeds of *Cirrhinus reba*, commonly known as Reba carp, to our fisheries research farm in Meghalaya (Fig. 8). These seeds were sourced from the College of Fisheries (AAU), Raha, Assam. The primary objective of this introduction is to enhance aquaculture production in the state by diversifying species within regional aquaculture, focusing on locally available and potentially valuable fish species. The Reba carp is currently undergoing domestication in open pond conditions, being fed a farm-made diet comprising rice polish and mustard oil cake in a 1:1 ratio at 5% of their body weight daily. Upon stocking, the fish were estimated to be approximately 1g in size, and we observed lower mortality rates under Meghalaya conditions. As these fish mature, we plan to induce breeding through hormonal manipulations, aiming to further contribute to the sustainable development of aquaculture in the region. This strategic introduction aligns with our commitment to exploring and integrating diverse species that thrive in local conditions, fostering a resilient and thriving aquaculture sector in Meghalaya.

Fig. 8. Introduction of Reba carp into ICAR Research Farm, Umiam

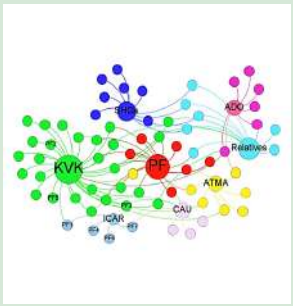
DIVISION OF TECHNOLOGY ASSESSMENT AND CAPACITY BUILDING

RESEARCH ACHIEVEMENTS

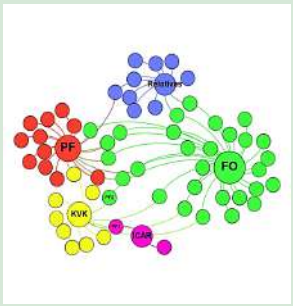
A study on the social network structures vis-à-vis information on agricultural technology among the farmers of Meghalaya

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

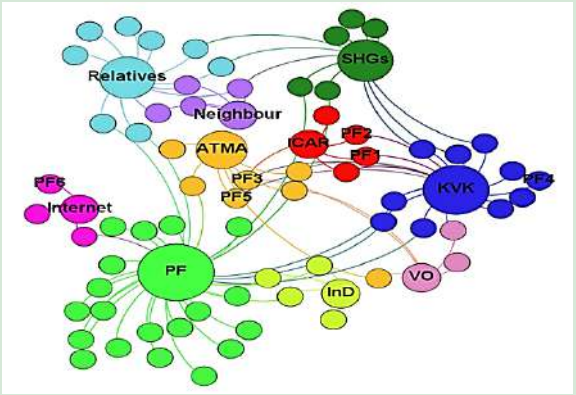
This research seeks to explore and assess the social networks of farmers in relation to obtaining information about low input backyard poultry farming, high yielding variety of rice, and semi-intensive fish farming. Three-stage sampling technique was used to interview 60 technology-adopter farmers in the West Jaintia Hills districts of Meghalaya. Social Network Analysis (SNA) was employed to map the networks, key sources and information access patterns. Findings indicated the dominance of formal communication sources viz. Krishi Vigya Kendra (KVK) and Fishery Officers (FO) for high yielding variety of rice and semi-intensive fish farming, while Progressive Farmers (PF) played a crucial role in providing information about low input backyard poultry farming.



High yielding variety rice



Semi-intensive fish farming



Low input backyard poultry farming

Fig. 1. Information network for agricultural technologies

Note: KVK: Krishi Vigyan Kendra Personnel, SHGs: Self Help Group Members, VO: Veterinary officer of state, FO: Fishery officer of state, InD: Input Dealers, PF: Progressive Farmer, AMTA: Agricultural Technology Management Agency

Farmers' Amenity Centre for Tribal (FACT): A community based approach for livelihood improvement

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

The Farmers' Amenity Centre for Tribal (FACT) is a sustainable participatory extension service mechanism that acts as a single window entity located at the village for facilitating, coordinating, supervising, and monitoring the input distribution activities and implementation of livelihood improvement programmes under the different flagship projects/ schemes of the ICAR-RC NEH, Umiam. The FACT serves as a bridge for providing formal management mechanism between the scientists and technology users. Its main functions are beneficiaries selection, support and assistance in organizing need-based training programme for farmers, providing farm advisories and services, identifying researchable issue through need based participatory approach, farm mechanization and maintenance of farm registry to record various incoming (inputs/technologies received) and outgoing activities (inputs/technologies dissemination) of the FACT. The FACT receives free inputs and technology from the ICAR, but it may sell the inputs at subsidized rates in order to raise revenue for the operation and sustenance of the FACT in the long run. The concept aims to instill in the farmers a sense of ownership and responsibility for the inputs they have purchased at the time of use. The FACT was established on the 26th October 2023 covering four villages viz. Umphrew, Umrynjah, Madan Mawkhar and Umjathang with its headquarters located at Umrynjah village. The FACT provides services to almost 400 households.

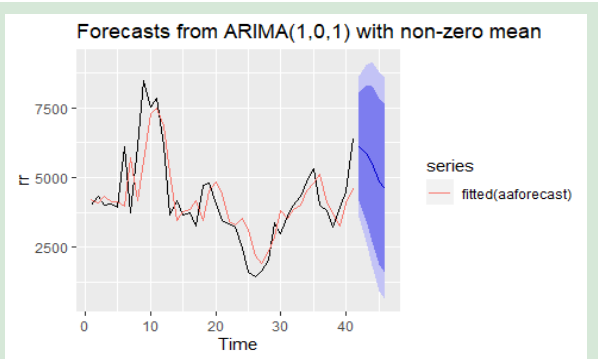
Fig. 2. IARYNTIHLANG Farmers' Amenity Centre for Tribal

Price forecasting for selected agricultural commodities of Meghalaya

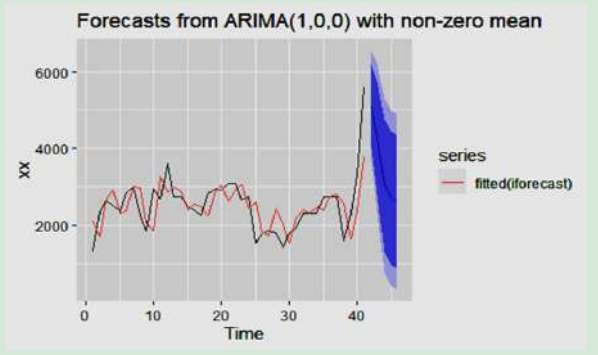
(N. U. Singh, P. Paul, C. Gowda H. R., D. Chakraborty, R. M. Reddy and B.P. Singh)

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, in consultation with stakeholders, for Meghalaya 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. ARIMA (1,0,1) (2,0,2) was identified as the best fit model for Ginger. 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. The price trend was also estimated for Ginger and it was found that for the years 2020

and 2022, there was an increasing trend, but for the year 2021, a decreasing trend was observed. Similarly, ARIMA (1,0,0) (0,0,2) was shown to be the best model fit for turmeric, and we have observed an increasing trend for the years 2020, 2021, and 2022.



Ginger



Turmeric

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

Socio economic impact assessment of Jalkund (micro rainwater harvesting structure) in hill ecosystem of Meghalaya

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

The study assessed the impacts of jalkund on water productivity, farm income and employment in tribal dominant villages of East Khasi Hills and Ri-bhoi districts of Meghalaya. Crop diversification, Cost-Benefit analyses of various farm activities, and water productivity for each activity was estimated. The results revealed that, due to adoption of jalkund, farmers were able to take up additional high value vegetable crops in an area of 450 m^2, earning additional income of Rs. 27,000. The cultivation of vegetables produced 22.21 kg per 1000 litres of stored water. Similarly, for poultry and piggery operations, water productivity was about 16.67 kg/1000L and 26.67 kg/1000 L, respectively. The benefit-cost ratio for the vegetable cultivation, piggery, poultry and fish growing were 2.32, 2.70, 2.04 and 5.00, respectively. The total income of farm households increased from Rs 1,45,000 to Rs 1,91,125 following the implementation of low-cost jalkund technology on the farm. All farm components made a significant contribution to farm income from the use of stored water. The total increase in the gross income from the livestock components (poultry and piggery) was Rs. 58,125. From livestock rearing, farmers spawned additional 20-man days of employment. By raising fish, farmers obtained 4 extra days of employment and an income of Rs. 3,125. The piggery experienced the largest increase in income (36.21%), followed by crop (vegetables) production (26.73%) and poultry (24.17%). Overall, jalkund adoption has increased farm household income by 31.81 percent compared to formerly jalkund adoption. In addition, the adopted farmers were able to generate on average another 46 days of employment. Jalkund technology played a vital role in improving the sustainable livelihoods of hill agricultural households by providing water, especially in the post-monsoon dry months.

Adoption and behavioural intention of tribal farmers towards improved agricultural technologies in Meghalaya

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

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 this, Artificial Insemination (AI) in pig is one of the most popularized technologies in few pockets of the state. Technology dissemination mechanism used also has important role to play in adoption of the same at the farmer's field. This study has found that in case of Megha Turmeric, training (mean score 21.25) was the most effective method for technology dissemination followed by demonstration (mean score 18.67) and 66 percent farmers followed no trial, no adoption behavior and 42 percent defined lack of interest as the reason for not following trial of the same. In case of AI in pig, training with score of 26.31 was highest and found effective method of dissemination. Other than training, scientists has developed few models

of AI delivery at the farmers door like through direct linkage to tribal farmers, through trained educated youth, oestrus synchronisation and fixed-time and mobile van-based AI delivery system through which Ri-bhoi and East Khasi hills districts were covered. 72 percent farmers followed trial before adoption of AI in pig, to understand the observability and utility of the technology and 54 percent of the adopted farmers are continuing the technology for more than a year and few has expressed that lack of observability and understanding is the reason for non-adoption of AI in pig in some areas of Meghalaya.

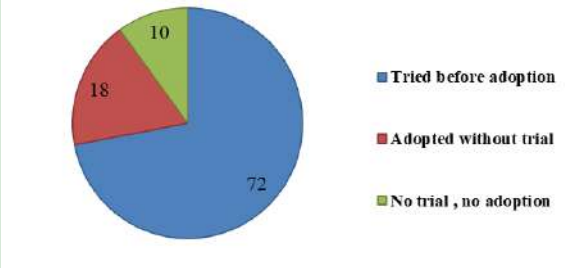


Fig. 4. Trial pattern followed for A.I. in Pig

Livelihood sustainability assessment of shifting cultivation in the Eastern Himalayan Zone

(A. Yumnam, N. U. Singh, A. Roy, D. Jini, H. Verma, S.B. Singh and B.P. Singh)

Shifting cultivation in the North East Region (NER), which falls under the Eastern Himalayan Zone, covers about 0.3 million hectares area and provide livelihood to over 7 lakhs household. The objective of the project is to assess the livelihood sustainability of shifting cultivation in the present context. As a preliminary study for the project, the status of Jhum cultivation vis-a-vis area was studied for all the states of NER at district level. The purpose of the study was to identify the districts most affected by shifting cultivation. There has been a decline in area under shifting cultivation in NER by 15% over the period 2008-09 to 2015-16. The maximum decline was observed in Nagaland followed by Arunachal Pradesh and Meghalaya. Manipur and Mizoram reported an increase in area under shifting cultivation during the same period by 70% and 15% respectively. Among the states of NER, Nagaland has the highest area under shifting cultivation followed by Mizoram, Arunachal Pradesh and Manipur. The percent share of Jhum area in the Net Sown Area (NSA) was however found highest in Mizoram, with almost half of the NSA being allocated to Jhum.

Task force on Himalayan agriculture - National Mission for Sustainable Himalayan Agriculture (II Phase)

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

Climate change in West Khasi Hills was examined through wet and dry period. West Khasi Hills (WKH) comprise of four blocks viz., Mairang, Mawsynrut, Mawthadraishan and Nongstoin. The wet period and dry period was analysed for all these four blocks using Standardized Precipitation Index (SPI). The wet and dry period was classified into moderate, severe and extreme wet and dry period.

Mawsynrut has the highest percentage of total wet period (15.05%) among all the four blocks, showing that the block was highly exposed to heavy rainfall. During the study period (1960-2021) there was occurrence of moderate, severe and extreme wet period in all the four blocks. Mairang block received the highest (7.66%) moderate wet while Mawsynrut received the highest severe (4.30%) and extreme (3.63) wet period. The lowest percentage of total wet period (12.76%) was observed in Mawthadraishan block. The block also experienced the lowest moderate (6.31%) and severe (3.09%) wet indicating that the block was least exposed to heavy rainfall (Fig.5). The total dry period (16.13%) was highest in Mawsynrut block. The block also experienced highest percentage of severe dry (12.36%) indicating that the block was highly exposed to climate change among all other blocks. On the other hand Mawthadraishan block received the lowest percentage of total dry period (12.09%). Moreover, the block experienced the lowest percentage of moderate (8.06%) and extreme dry (0.94%) period. This indicate that Mawthadraishan block was least exposed to climate change among all other blocks (Fig. 5).

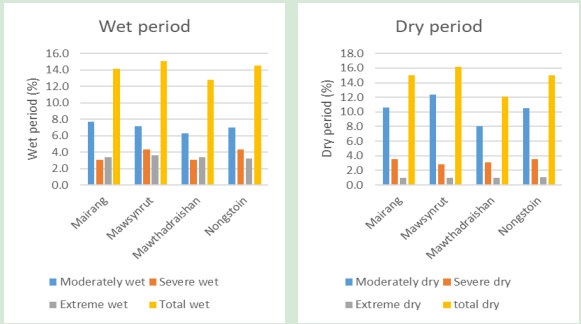


Fig. 5. Wet and dry period in West Khasi Hills District

Livelihood improvement of hill farmers through sustainable farming systems in North Eastern Hill region (Farmers FIRST)

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

Integrated farming system (IFS) which provides an opportunity to increase economic yield per unit area per unit time by virtue of intensification of crop and allied enterprises, has been recommended to be established in the Marngar village clusters. The IFS model consisting of Fish, Pig, Rabbit, Poultry, Goat, Duck and vegetables (Bitter gourd, Bottlegourd, Brinjal) established at beneficiary's farm of 1.6 ha which includes two ponds (1000 sq.m each), has proved to be a profitable farm land use model (Table 3). Among the components, duckery, vegetables, rabbittery and fishery recorded the highest profitability. With the success of this intervention, another site has been chosen for establishment of IFS in Mawphrew village.

Table 1. Income generated from different components of IFS unit, Nalapara village, 2022-23

Component	Description	Total Income (Rs.)	Expenditure (Rs.)	Net profit (Rs.)	B:C ratio
Fishery	2 ponds	1,50,000.00	75,000.00	75,000.00	2.00
Vegetables	0.1 Acre	2,400.00	1,100.00	1,300.00	2.18
Piggery	12 piglets	1,45,000.00	75,000.00	70,000.00	1.93
Rabbitery	10 offspring	4500.00	2,100.00	2,400.00	2.14
Poultry	27 birds, 756 eggs	35,748.00	18,000.00	17,748.00	1.98
Goatery	2 kids	14,000.00	7,500.00	6,500.00	1.86
Duckery	15 birds	7500.00	3000.00	4500.00	2.50
Total		3,51,648.00	1,81,700.00	1,77,448.00	1.93

Azolla, which is rich in protein and contains essential minerals like Iron, Calcium, Magnesium, Phosphorus, Copper, Manganese etc. apart from appreciable quantities of vitamin A and vitamin B12 and almost all the essential amino acids, many probiotics, bio-polymers and beta carotene, was recommended as fish feed substitute. The intervention was made in beneficiary's farm in Purangang village, Marngar, as possible measure to reduce expenses for large scale fish rearing.

Jalkund which provides life-saving irrigation at critical stages of crop growth, for washing crop produces of ginger, turmeric, carrot, radish, fish rearing, for animal husbandry and livestock rearing and domestic activities have been recommended for construction in the villages of Marngar cluster. Upon site survey, five numbers of Jalkund (5m x 4m x 1.5m) have been constructed in Mawphrew, Umthan, Borgang and Borkhatsari villages.

For efficient utilization of rice-fallow, demonstration on cultivation of cole crops was organized and improved seeds were distributed to 67 nos. of farmers. In order to enhance efficiency and reduce drudgery in farming operations, demonstration on paddy threshers fabricated at ICAR RC for NEH Region, Umiam was conducted and two threshers have been provided for a three-week period in Borgang village for trial.

Fig. 6. Various interventions in FFP village clusters at Marngar, Ri Bhoi

Technology Dissemination Monitoring System (TDMS)

(N. U. Singh, K.P. Biam, A. Yumnam, P. Paul, C. Gowda H. R., A. Roy, K. M. Reddy, B.P. Singh and V.K. Mishra)

A systematic user interface and real time web based spreadsheet was developed to serve as data repository for the agricultural technologies disseminated under different programmes/schemes/projects of the institute. The primary objective of the project was to provide transparency and accountability in utilization of public funds of the institute. The spatio-temporal dynamics in terms of beneficiaries, expenses, technologies disseminated was analysed. In the year 2023, the total reported expenditure on agricultural inputs of the institute under various programmes was Rs.238.60 lakhs. Maximum expenditure was reported in Meghalaya (Rs. 58.6 lakhs), followed by Sikkim (Rs. 57.1 lakhs), Nagaland (Rs.41.7 lakhs), Arunachal Pradesh (Rs. 37.8 lakhs), Manipur (Rs. 20.4 lakhs), Tripura (Rs. 16.1 lakhs) and Mizoram (Rs. 6.81 lakhs). The total number of beneficiaries covered under various programmes in different states was highest in Meghalaya, followed by Tripura and Arunachal Pradesh. The item wise expenditure on agricultural inputs is presented in Fig.8. Maximum expenditure was made on distribution of piglets, followed by seeds and irrigation kits. Minimum expenditure was made in insecticides and pesticides. Project-wise, the maximum expenditure was made under TSP followed by NICRA and AICRP. Large amount of expenditures were also made under undescribed head, others. Similarly, the total number of beneficiaries covered was highest under TSP, followed by AICRP and NICRA.

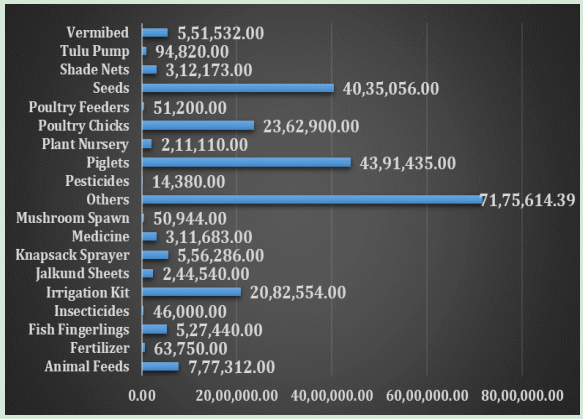


Fig. 7. Item – wise expenditure on agricultural inputs distributed for the year 2023

ARUNACHAL PRADESH

SUMMARY

During the period, the total rainfall was 2180 mm against the normal of 2466 mm, a deficit of 13.1%. Notably, the rain in December was 64% deficit from normal. Total number of rainy days was 136 days compared to normal of 143 days. The maximum temperature was generally above normal throughout the year. The month of September was the hottest with rise of 15.5%. In post monsoon experiment conducted after the harvest of Jhum paddy, among all the soil conservation structures, double mulching yielded the best results for plant height, relative water content (%), economic yield, etc. for both frenchbean and buckwheat. And the vegetative duration was shortened for both the crops under the same treatment. Out of three sesame varieties, the highest number of pods/plant and seed yield (kg/ha) was observed in Pasighat local. Under low cost rain shelter, the cropping sequence *i.e*. Capsicum – Bottle gourd – Spinach exhibited maximum with respect to yield components and income. In screening trials, tomato hybrid (F_1) Arka Abhed recorded resistant to late blight disease and KC-4 native germplasm of chilli recorded low incidence of whitefly and viral complex disease. In evaluation of carbon sequestration potential of different agroforestry systems, the highest bole biomass (203.64 ± 15.07 t/ha), branch biomass (171.09 ± 9.41 t/ha), foliage biomass (42.06 ± 2.94 t/ha), root biomass (54.50 ± 4.78 t/ha) and total biomass (471.34 ± 32.82 t/ha) was recorded in *Castanopsis indica.* Faecal examination of Mithun 171 samples from Leparada and West Siang districts of Arunachal Pradesh revealed gastrointestinal parasites prevalence of 27.48 % (47/171). Based on faecal larval culture, the dominant species found were *Oesophagostomum* spp., *Haemonchus* and *Trichostrongyle* spp. Leparada district's digital terrain analysis offers comprehensive data on elevation, slopes, aspects and the Topographic Wetness Index (TWI) which shows that the district's north-eastern and west-south region have moderate to steep slopes and are associated with low TWI values.

Weather report

In terms of temperature and rainfall, the climate of the location may be defined as Thermic Per-humid. The location comes under Eastern Himalayan Ecozone-II and under Alpine and Temperate Sub-Alpine zone. During the period, the total rainfall was 2180 mm against the normal of 2466 mm, a deficit of 13.1%. Notably, the rain in the month of December was 64% deficit from normal. Total number of rainy days was 136 days compared to normal of 143 days (Fig. 1)

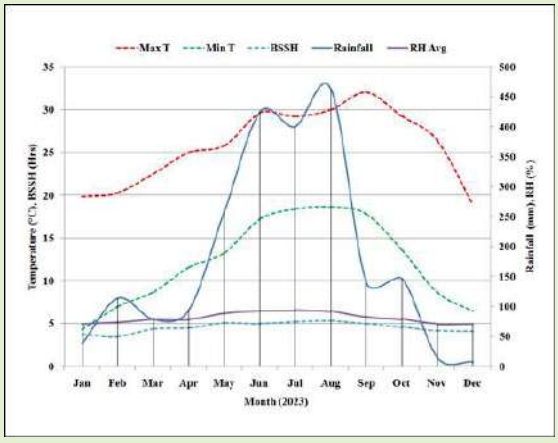


Fig. 1. Monthly total rainfall compared to normal

The maximum temperature was generally above normal throughout the year. The month of September was the hottest with rise of 15.5% compared to normal. Following the 15 years trend, this year also the average minimum remained below normal throughout the year. The average relative humidity during the reporting period remained above the 30 years normal.

Gramin Krishi Mausam Sewa (GKMS)

The *Gramin Krishi Mausam Sewa*, since its inception in the year 2008, has been playing a vital role in agricultural development and livelihood improvement of farming community of Arunachal Pradesh. Regularly it is providing customized weather based advisories to farmers and other stake holders of the state on every Tuesday and Friday. Till now, there are over 3,40,000 beneficiaries across the state. During the period around 1854 location specific weather-based district level agro-advisories were prepared for 18 districts of Arunachal Pradesh and disseminated to the farmers through different media and agencies. Also around 824 block level agro-advisories were prepared and disseminated for 8 blocks of West Siang district of Arunachal Pradesh. In addition, during adverse weather prediction, advisories were prepared and disseminated based on emergency impact based forecast and warning issued by the met department. For popularization of the service, three farmers' awareness programmes were organized under the project at different location. During the period, six Youtube videos were uploaded on subject related to management of crop and livestock/poultry for different weather conditions.

RESEARCH ACHIEVEMENTS

Soil Science

Study on performance of French bean and buckwheat under soil conservation structures grown after *Jhum* rice in mid hills of Arunachal Pradesh

(A. Tasung, B. Makdoh and L. Wangchu)

A field experiment was conducted after the harvest of Jhum paddy at the research farm Gori of ICAR RC AP centre, Basar, under NICRA-NRM, in which performance of Frenchbean (Fig. 2) and Buckwheat (Fig. 3) were studied under various soil moisture conservation structures i.e. Mulching, Double mulching, Conservation furrows and Contour trenches. Among all the treatments, double mulched plots produced the best results in terms of plant height, relative water content and economic yield of respective crops. The crops flowered earlier when the mulching materials were doubled (Table 2).

Table 2. Performance of crops under soil conservation structures

Treatments	Frenchbean				Buckwheat			
	Plant height (cm)	Days to 50% flowering	Relative Water Content (%)	Green Pod Yield (q/ha)	Plant height (cm)	Days to 50% flowering	Relative Water Content (%)	Grain Yield (q/ha)
Control	31.04	47	79.46	33.77	56.38	41	86.32	2.81
Mulching	41.36	44	87.98	42.73	64.16	39	92.58	4.29
Double Mulching	52.52	44	88.84	46.78	64.28	39	93.52	4.37
Conservation Furrows	37.84	46	84.52	41.87	62.38	34	88.72	3.83
Contour Trenches	35.24	47	80.68	39.98	59.54	41	87.66	3.76

Fig. 2. French bean

Fig. 3. Buckwheat

Evaluation of some promising sesame varieties for seed production for mid hills region of Arunachal Pradesh

(A. Tasung and L. Wangchu)

Under AICRP-IIOR Project 3 varieties of sesame (Namsai, Pasighat and Amrit) were evaluated taking two local varieties as check (Namsai and Pasighat) in 2023 (Fig.4). The final plant stand was observed to be highest in Pasighat local cultivar which was at par with Namsai Local. Sowing of Pasighat Local variety was done in the first week of August i.e., on 03/08/23. Whereas Namsai Local were also sown in the same date as Pasighat Local. Amrit variety was sown in two different date i.e., on 11/10/23 and re-sowing was done in 18/10/23. Among the varieties, Pasighat Local reached to 50% flowering at (46 days) after sowing, followed by Namsai local (49 days). Amrit took longer time to reach to 50% flowering (52.3 days). The number of days to maturity was highest with Namsai Local (162 days) which was at par with Pasighat Local (159 days), while Amrit took only (88 days) to come to maturity. Pasighat local variety recorded significantly highest plant height (83 cm) followed by Namsai Local (73 cm) and Amrit (55 cm). The highest number of pods/plants was observed in Pasighat local (93) followed by Namsai (41) and Amrit (22). Seed yield (kg/ha) was found to be highest in Pasighat Local (230 kg/ha) followed by Namsai local (186 kg/ha) and Amrit (178 kg/ha). The variation in seed yield of Amrit and Local variety is due to the variation of date of sowing, Pasighat local is best suited under mid hills condition of Arunachal Pradesh. A field day on sesame seed production was

also conducted in Research Farm, Gori, ICAR RC NEH, Arunachal Pradesh Centre on the 10th of October, 2023 where a group of 20 dedicated farmer trainees from Leparada district of Arunachal Pradesh participated in the program (Fig. 5)

Fig. 4. Evaluation of Sesame varieties

Fig. 5. Field Day on Sesame seed produciton

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 2023, under low cost rain shelter (Fig. 6a), the cropping sequence (CS-3) i.e. Capsicum – Bottle gourd – Spinach exhibited maximum with respect to total annual production (211.8 kg/40 sq. m), production efficiency (0.74 kg/40 sq. m/day) and BC ratio (2.96). Meanwhile under low cost poly tunnel (Fig. 6b), the cropping sequence (CS-2) i.e. Broccoli – Lettuce – Amaranthus – French bean exhibited maximum with respect to total annual production (36.66 kg/5 sq. m), production efficiency (0.12 kg/ 5 sq. m) and BC ratio (2.99).

Vegetable cropping sequence under low cost rain shelter

Fig. 6(a). Vegetable cropping sequence under low cost rain shelter

Vegetable cropping sequence under low cost polytunnel

Fig. 6(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 2023 (Fig. 7), 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 (15.63 cm, 10.15 %) and stem girth (0.56 cm, 15.92 %) was observed in treatment T_5 closely followed by treatment T_{10}. With respect to yield attributing parameters, maximum fruit set (39.76 %), number of fruits per plant (67.2) and yield per plant (10.25 kg) was recorded in the treatment T_5 followed by treatment T_{10} with fruit set (38.9 %), number of fruits per plant (60.27) and yield per plant (8.11 kg). In case of fruit quality, the treatment T_5 exhibited maximum juice content per fruit (45.72 ml), reducing sugar (3.88 %), total sugar (5.84 %) meanwhile the treatment T_{10} divulged maximum TSS (6.01 °Brix) and ascorbic acid content (40.15 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. 7. Imposition of organic treatments and harvesting in Assam lemon

Plant Pathology

Field evaluation of tomato germplasm for their resistance to late blight disease

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

Eight germplasms were evaluated against late blight disease under natural epiphytotic conditions (Table 3). Out of them, Arka Abhed was resistant to the late blight disease (Fig. 8).

Fig. 8. Late blight disease resistant tomato ($T_{3;}$ Arka Abhed) & highly susceptible (T_8; local)

Table 3. Late blight disease severity and disease reaction of tomato germplasm under natural epiphytotic conditions

Germplasm	Disease severity (PDI)	Disease reaction	Germplasm	Disease severity (PDI)	Disease reaction
T_1 (Arka Samarat)	66.67	HS	T_5 (Arka Aditya)	80.00	HS
T_2 (Arka Rakshak)	73.33	HS	T_6 (Arka Vishesh)	75.00	HS
T_3 (Arka Abhed)	18.33	R	T_7 (Kashi Adarsh)	93.33	HS
T_4 (Arka Apeksha)	71.67	HS	T_8 (Local)	100.00	HS

*Whereas, R: Resistant and HS: Highly susceptible

Screening of chilli germplasm against key insect-pest and disease

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

Eighteen native germplasms were screened against key insect-pest and disease under rain-shelter (Table. 4 & Fig. 9). Out of them, KC-4 was recorded low incidence of whitefly and viral complex disease. These germplasm were further deposited in seed bank of NBPGR for preservation.

Table 4. Incidence of key insect-pest and disease of chilli

Genotype	Source of collection	Incidence* of key insect-pest & disease		Genotype	Source of collection	Incidence of key insect-pest & disease	
		Whitefly	Viral disease			Whitefly	Viral disease
KC-1	Gori-III	+++	+++	KC-10	Mengujuma	++++	++++
KC-2	Sago	+++	+++	KC-11	Deopani	++++	++++
KC-3	Sago	+++	+++	KC-12	Deopani	++++	++++
KC-4	Piri	+	+	KC-13	Piphema	++++	++++
KC-5	Piri	++	++	KC-14	Piphema	++++	++++
KC-6	Peducha	++++	++++	KC-15	Medziphema	++++	++++
KC-7	Peducha	++++	++++	KC-16	Medziphema	++++	++++
KC-8	Peducha	++++	++++	KC-17	Seiyhama	++++	++++
KC-9	Mengujuma	++++	++++	KC-18	Kodompokpi	+++	+++

*Whereas, + = low; ++= medium; +++ = high and ++++ = severe incidence.

Fig. 9. View of experimental trial & severity of white fly infestation on king chilli

Fig. 10. Typical symptom of root knot nematode in tomato and king chilli

Root-knot nematode (*Meloidogyne incognita*) of tomato and king chilli:

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

During the experimental trial, it was observed for the first time that the king chilli and tomato were infested by root knot nematode. Showing the general symptom of patchiness, yellowing of leaves and wilting of infested plants as well as the typical symptom of root knots/galls formation (Fig. 10) with the presence of egg masses attached to it. Morphological studies in laboratory reveal that, the heavily infested king chilli and tomato plant samples were by the root-knot nematode, *M. incognita*.

Development of oyster mushroom pickles

(R. Singh, T. Angami, A. Tasung and L. Wangchu)

Oyster mushroom is highly perishable and starts deteriorating after few hours depending upon the storage conditions. Hence, it is necessary to develop suitable post-harvest techniques for its prolonged usage. According to the formulations three mushroom pickles were developed (Table 5 & Fig. 11).

Table 5. Composition of oyster mushroom pickles

Ingredients	Quantity of ingredients (g/kg)		
	Oyster mushroom & king chilli pickle	Oyster mushroom, bamboo shoot & king chilli pickle	Dried oyster mushroom & king chilli pickle
Oyster mushroom	600 g (fresh)	400 g (fresh)	600 g (dry)
King Chilli	80 g	70 g	60 g
Chopped bamboo shoots	-	270 g	
Turmeric powder	10 g	10 g	10 g
Coriander powder	20 g	10 g	20 g
Fenugreek powder	10 g	10 g	20 g
Fennel powder	10 g	-	20 g
Yellow mustard powder	10 g	-	10 g
Perilla seeds powder	10 g	-	10 g
Cumin powder	20 g	10 g	20 g
Mustard oil	200 ml	200 ml	200 ml
Vinegar	20 ml	10 ml	20 ml
Salt	10 g	10 g	10 g

Fig. 11. View of oyster mushroom & king chilli pickle (A), oyster mushroom, bamboo shoot & king chilli pickle (B), dried oyster mushroom & king chilli pickle (C) & final products (D)

Agro-forestry

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

(R. A. Alone and A. Tasung)

Under this project, the allometric equations were developed for total 9 Multipurpose Trees (MPTs) relating Girth at Breast Height (GBH) with dry weight of tree components.

$\log Y = a + b \log (X)$ Where

Y = dry weight (kg) of the component (Bole, branch, foliage, root)

X = Girth at Breast Height (GBH) in cm

a and b are allometric constants

The component wise biomass was estimated for all 9 MPTs. The highest bole biomass (203.64 ± 15.07 t/ha), branch biomass (171.09 ± 9.41 t/ha), foliage biomass (42.06 ± 2.94 t/ha), root biomass (54.50 ± 4.78 t/ha) and total biomass (471.34 ± 32.82 t/ha) was recorded in *Castanopsis indica* followed by *Altingia excelsa* where bole biomass (244.79 ± 18.57 t/ha), branch Biomass (63.35 ± 3.97 t/ha), foliage biomass 37.77 ± 2.97 t/ha), root biomass (76.55 ± 5.43 t/ha)

and total biomass was recorded 422.47 ± 27.54 t/ha. The composite samples of bole, branch, foliage and course roots were analyzed for total carbon content. The total carbon concentrations were recorded 43.5 %, 45.67 %, 46.67 % and 35.73 % in bole, branch, foliage and course roots, respectively. The component wise carbon stock was estimated by multiplying biomass of tree component by carbon concentration of the respective tree component. The highest bole carbon stock (88.58 ± 4.12 t/ha), branch carbon stock (78.13 ± 4.23t/ha), foliage carbon stock (19.64 ± 2.34t/ha), root carbon stock (19.48 ± 1.64t/ha) and total carbon stock (205.85 ± 13.56 t/ha) was recorded in *Castanopsis indica* followed by *Altingia excels* where bole carbon stock (106.48 ± 6.32t/ha), branch carbon stock (28.93 ± 1.97t/ha), foliage carbon stock (17.62 ± 1.08 t/ha), root carbon stock (27.36 ± 1.56 t/ha) and total carbon stock was recorded 180.41 ± 7.34 t/ha (Fig. 12).

Fig. 12. *Castanopsis indica* & *Altingia excelsa*

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)

The study on occupational hazard was conducted in two district of Arunachal Pradesh over the last three years using a semi-structured questionnaire developed by Neitzel *et al*. (2014) to identify various discomfort faced by the livestock owners during handling of livestock BPD (Body part discomfort) score was used. In total 350 farmers were interviewed covering different villages under Leparada district (Sago, Gori-I, Gori-II, Nyigam, old daring, Tirbin) and West Siang district (Logum, Eyi, Angu and Pakam villages) purposively selected consisting of 35 farmers per village. The study revealed that in overall 41 % of respondents reported severe lower back pain with BPD score of 16 out of 25 as most common physical discomfort during different livestock managemental operation (Fig. 13). Injury due to close proximity with animals, 14.76 % due to kicking in dairy cattle, 50.47 % due to biting in pigs and 32.38 % due to picking in poultry (Fig. 14). Awareness about zoonotic disease 54.4 % of respondent knew about Bird flu, 52.8 % of swine flu, 11.4 % of Bovine tuberculosis. None knew about Brucellosis. In terms of chemical hazards (Fig. 15) due to contacts (79.52 %) of the respondents reported skin allergies from pigs and (62.85 %) from poultry. Around 41.42 % ringworm infection during cleaning and feeding of pigs. In terms of Psychological hazards overall (31.09 %) of the respondents reported boredom, (20.48 %) reported aggression and 16.19% physical tiredness during management activities in pigs.

Thus it can be concluded from the overall study the most common physical discomfort reported by farmers during different livestock managemental operation was severe pain in lower back. Physical injury due to close proximity and chemical hazards during management was found more in pigs and cattle (bull). Proper understanding about behavior of animals, surrounding environment and knowledge about livestock management practices along with precautionary measures for self protection is necessary for safety of livestock handler as well as animals. Based on it a low cost pig restrain crate was developed in centre with a dimension: Length x Breadth x Height = 4 feet x 1.8 feet x 4.5 feet weighing approximately 60 kg low cost made from available materials trail is undergoing (Fig. 16).

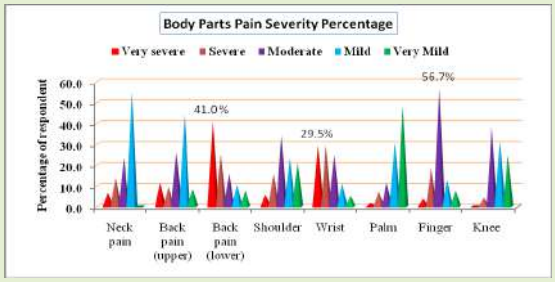


Fig. 13. Physical discomfort reported by farmers during livestock mangemental operation

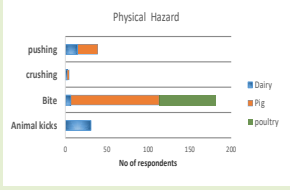


Fig. 14. Physical injury due to close proximity of animal

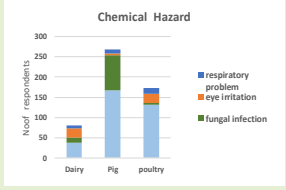


Fig. 15. Chemical hazard due to contacts

Fig. 16. Low cost Pig restraining crate

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. During the period survey was conducted in West Kameng district of Arunachal Pradesh. 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 India

(D. Jini)

As per the earlier objective documentation and survey of Indigenous Gallang cattle (Fig. 17) were further done in West Kameng district in the month of August which was reared by the Brokapa community for breeding purpose particular for cross breeding with yak to produce female Dzomo (F1 female hybrid) for meat and milk purpose. About 20 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 white and brown (60 %), and mix of black and white (25 %) and Black (25 %). The horn orientation curved upward forward (80 %) and curved upward (20 %). Horn color is majority mix of white and black colour (85 %) and remaining black. Cent per cent ear orientation was horizontal. Muzzle were black in colour (75 %) followed by brown colour. Head is straight and convex in majority animals. Hump and dewlap were small with small penis sheath. The udder was bowl in shape and small size. Around 65 % of the teats were cylindrical shaped with rounded tip. Milk vein was non-prominent. Hoof color varied from black (60 %), brown (25 %) and black & white (15 %). Tail was up to the hock with typical spiral switch (marking feature or unique feature).

Fig. 17. Herd of Galang cattle and Galang (Female)

Conservation and improvement of indigenous goat in northeast India

(D. Jini)

In continuation of the overall reproductive performance was found in three different group. Age at first kidding was found to be 253 ± 4.16 days T3 followed by T2 254.33 ± 6.6 and T3 254 ± 4 days. Weight at first kidding was found highest in T3 group 10.7 ± 0.50 ,followed by 9.98 ± 0.32 and 9.63 ± 0.30 kg respectively in T2 and T3 group. Similarly, age at first kidding was 406 ± 9.64, 412 ± 14.64 and 435 ± 15.17 days for T3, T2 and T1 group. Birth weight at birth was non significant in all three groups with overall weight of 0.922 ± 0.21 kg. Twining was more common in all the group (Fig. 18).

Fig. 18. Goat shed with goat and twin kids just after birth

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)

Faecal examination of Mithun 171 samples from Leparada and West Siang districts of Arunachal Pradesh (Fig. 19) revealed gastrointestinal parasites prevalence of 27.48 % (47/171). Based on faecal larval culture, the dominant species found were *Oesophagostomum* spp., *Haemonchus* and *Trichostrongyle* spp. Faecal samples were also collected for examination from

cattle, yak-cattle hybrids, Mithun-cattle hybrids, goats and sheep from Tawang and West Kameng districts. Presence of gastrointestinal parasites were detected in 10.12 % (17/168) in cattle, 23.26 % (10/43) in yak-cattle hybrid, 26.36 % (5/9) in mithun-cattle hybrid, 21.05 % (8/38) goat and 63.75 % (51/80) in sheep, respectively. Species recorded were Strongyle, *Trichuris, Dicrocoelium*, *Eimeria, Moniezia* and Amphistome. For *in-vitro* anthelmintic activity of Persimmon, leaves and fruit samples from astringent variety of Persimmon were collected from Dirang, West Kameng. The plant materials were dried, ground, extracted in solvent and stored for further evaluation (Fig. 20).

Fig. 19. Collection of faecal samples from mithun during Mithun mela at Sago, Leparada district

Fig. 20. Solvent extract of Persimmon fruit

Land and Water Management Engineering

Digital Terrain Analysis: An approach using remote sensing & GIS techniques, in Leparada district, Arunachal Pradesh

(A. Suryawanshi and A. Tasung)

Digital Terrain Analysis (DTA) was used in Leparada district to study its landscape, utilizing SAGA GIS and 30-meter resolution Digital Elevation Model (DEM) data from the Shuttle Radar Topography Mission (SRTM). This data provides detailed elevation information for Earth's land surfaces, ensuring high spatial detail and precision in terrain analysis applications, especially in regions with humid subtropical climates and elevations ranging from 172 to 1886 meters (Fig. 21). List of Digital Terrain Parameters, their purpose and applications are given in Table 6.

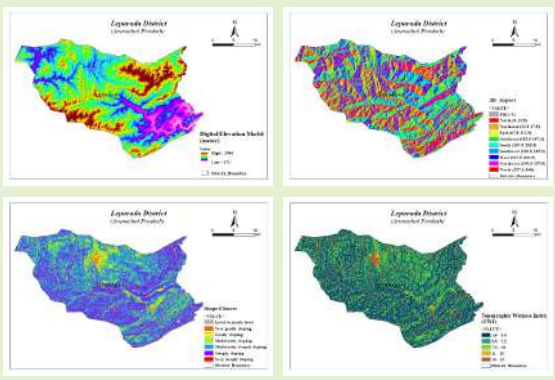


Fig. 21. DEM, 3D Aspect, Slope Classes and Topographic Wetness Index (TWI) map of Leparada District, Arunachal Pradesh

Table 6. List of Digital Terrain Parameters, their purpose and applications

Parameter	Purpose	Application
DEM (Digital Elevation Model)	Represents the elevation values of the Earth's surface in a raster grid format.	Used as a foundational dataset for various spatial analyses, such as terrain visualization, landform classification, and hydrological modelling.
Aspect Analysis	Determine the direction in which a slope faces	Understanding solar exposure is crucial for agriculture, forestry, and site planning, as it impacts vegetation growth on south-facing slopes.
Slope Analysis	Quantifies the steepness of the terrain	Crucial for assessing slope stability, planning infrastructure projects, and identifying suitable locations for activities like agriculture or urban development.
TWI (Topographic Wetness Index)	Evaluates the potential for water accumulation and flow based on slope and upstream contributing area.	Useful in hydrological modelling to identify areas prone to water accumulation and saturation. High TWI values indicate areas with increased potential for wetness or waterlogging.

MANIPUR

SUMMARY

Multi-location trials were conducted using improved semi-dwarf black rice entries RCMBR 3, RCMBR 4 and RCMBR 5. RCMBR 3 had outperformed to an extent of 70% in rainfed locations and 32% in irrigated field over the parent *Chakhao amubi* and 83% and 44% over the check *Chakhao poireiton*. Based on the amplification of *nifH* genomic region, 18 endophytes were validated for Nitrogen-fixing endophytic bacteria isolated from rice. Black rice treated with 50% RDN through FYM + 25% RDN through vermicompost + 25% RDN through green manure sesbania resulted higher content of available nitrogen and extractable NH_4-N with a significant reduction in NO_3-N in the soil. A total of 21 cucumber germplasms were evaluated and the highest fruit diameter was recorded in Senapati cucumber. Plant height of intercrops like taro, ginger and turmeric was significantly higher than the sole crop at 135 days after sowing under *Gmelina arborea*-based agroforestry system. Essential oil of *Artemisia* sp. was performed GC-MS and detected 104 constituent components in different proportions, which was highly effective against rice storage pests. Persistence of imidacloprid 70%WG and Spiromesifen 22.9% w/w SC was recorded up to the 9th and 7th day whereas Imidacloprid 70%WG and chlorantraniliprole 18.5 %SC sprayed on cucumber dissipated till the 7th day and 9th day. *Trichoderma atroviride* and *T. erinaceum* recorded reduced incidences of soft rot (77.39%) in polyhouse and 49.64% in field conditions as compared to control with rhizome yield up to 4.21kg/ m^2 as compared to control (1.06kg/m^2). Vanaraja birds fed with corn soya-based layer diet with flaxseed @ 100g/kg gave significantly higher body weight gain, number of eggs, egg size, egg shape index, york index and egg yolk cholesterol reduction. The growth and survival rate of *Wallago attu* were significantly higher in weight gain, specific growth rate and percentage weight gain compared with unsegregated fish. Different physio-chemical parameters of *Sanapat* of Manipur were recorded and vulnerable indigenous fishes were documented. Survey study reported that 80 percent of the improved rice variety adopters obtained seed from ICAR and the most preferred trait in improved rice is the taste.

Weather report

During the period from January to December 2023, total of 1080.5 mm annual rainfall was recorded against normal rainfall of 1454.2 mm. Highest rainfall day (132.7 mm) was observed on 24th July 2023. July month recorded the highest rainfall of 256.2 mm against highest monthly normal rain of 262.6 mm in June. The highest temperature of 36.8 °C was recorded on 30th May 2023 and coldest (1.3° C) was recorded on 20th January 2023. The monthly average maximum temperature ranged from 23.0°C in December to 30.7°C in September 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 23.0 °C in July 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 71.2 % in May to 92.5 % in January against the normal range of 71.5% in March to 86.5% in July. The monthly average minimum RH ranged from 33.4 % in February to 72.9 % in August against the normal range of 51.4% in March to 77.9% in August (fig. 1). During 2023 July, November and December months rain was above normal whereas in remaining months rain was deficit.

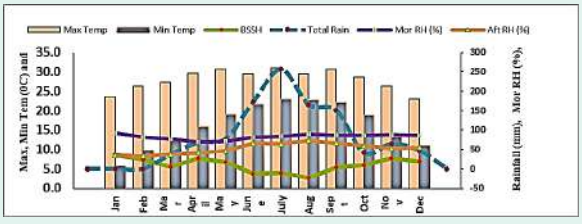


Fig. 1. Monthly average maximum and minimum temperatures (°C), relative humidity (%)

as compared to 2632 kg/ha yield with a significant yield advantage of 109% over the local varieties such as Dharam, Tomba phou, Ayangleima, Kundo Lairembi, RC Manipou 6, RC Maniphou 9 and RC Maniphou 16. Harvest during the previous 4 years in some part of the same field was nil due to drought like situation in Imphal East or Manipur as a whole. In irrigated field, the yield potential of RC Maniphou was 7267 kg/ha as compared to 5870 kg/ha in local varieties with a yield advantage of 24%. A field day was conducted on 27th October 2023. The short duration (115 days to maturity) and drought tolerance of the variety offers it as a contingency crop in rainfed/drought areas, which are expected to increase in years to come. Decrease in total annual rainfall (mm) is alarming as shown in the figure; from 2439 mm in 2017 to 1080 mm in 2022 (Fig 3).

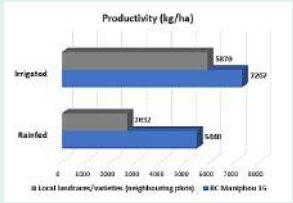


Fig. 2. Significance yield advantage of RC Maniphou 15

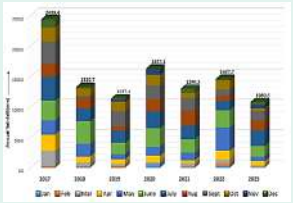


Fig. 3. Alarming decrease in total annual rainfall

Fig. 4. Performance of RC Maniphou 15 as compared to adjoining field with Khamba phou landraces in rainfed condition

RICE

Performance of newly released variety, RC Maniphou 15

(K. Sarika)

RC Maniphou 15 was released as high yielding variety and notified in August, 2022. The frontline demonstration of the variety was conducted in Sawombung, Imphal East district of Manipur both in rainfed and well irrigated condition (Fig. 2 & 4). In the rainfed condition, the yield of RC Maniphou 15 ranged from 3600 kg/ha to 6600 kg/ha, on an average of 5440

Multi-location second year trials of three semi-dwarf black rice varieties

(K. Sarika and I.M. Singh)

During *kharif* 2023, a second-year multi-location trial was conducted across three locations *viz*. Imphal West, Imphal East, Thoubal districts 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 5b). The genotypes, RCMBR 3 has outperformed the parent

and local check, *Chakhao amubi* and C*hakhao poreiton*, for the consecutive two years' multi-location trials with a yield superiority/advantage to an extent of 70% in rainfed locations and 32% in irrigated field over the parent *Chakhao Amubi* and 83% and 44% over the check *Chakhao Poireiton*, respectively (Fig 5a). 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.

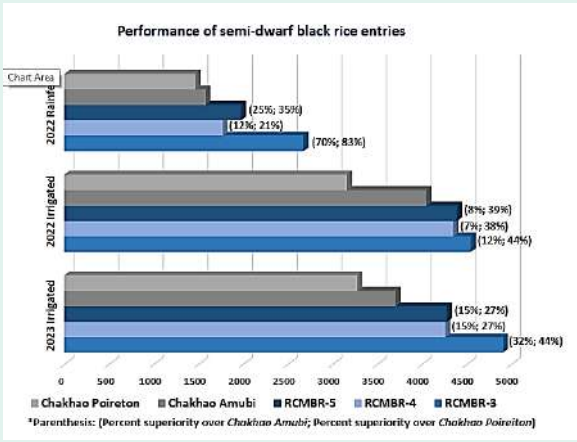


Fig. 5 a. Performance superiority (%) of the three entries RCMBR-3, RCMBR-4 and RCMBR-5 over parent and check, *Chakhao amubi* and *Chakhao Poireiton,* respectively

Fig. 5b. Monitoring visit at multi-location trial site in Farmers' field (Lousangkhong village, Imphal East) along with district District Agriculture Officers

DUS Testing and Grow Out Test of farmers Varieties in North Eastern Hill Region, Manipur Centre

(K. Sarika)

During *kharif* 2023, first year DUS characterization was carried out for 26 farmer varieties of rice along with 28 reference varieties including 11 maintenance lines from Manipur Centre and 6 farmer varieties from the last year 2022. The experiment was carried out in randomized complete block design with three replications under rainfed lowland transplanted condition. Observations were recorded for 48 morphological characters and 14 post-harvest characters/traits for both the farmer varieties from last year and newly received this year. In comparison to reference varieties, for the new farmer's variety entry CAU-R4 (Eenotphou), CAU-R2 (Tomthinphou), CAU-R3 (Mangal phou), Dehangi (AAUDR 9313-14-3) and Him palam lal dhan-1 (HPR2795) found distinct for few character/traits namely 50% flowering, anthocyanin colour of collar, anthocyanin colouration of apex, colour of stigma, anthocyanin colouration of nodes and presence of awn & distribution of awn *etc*.

All India Co-ordinated Rice Improvement Project (AICRIP)

(*K. Sarika*)

Two trials were conducted, namely IVT M(H) and AVT 1-M(H). Under the IVT M(H), 22 entries were tested. Nine entries, 2507, 2508, 2509, 2510, 2515, 2516, 2517, 2519 and 2522 were found to outperformed the local check, RC Maniphou 13. Under AVT 1-M (H), two entries 2404, 2410 outperformed the check RC Maniphou 15 among the 11 entries (Fig 6).

Fig. 6. Field view of AICRIP trial being taken up in Lamphelpat Farm, ICAR RC NEHR Manipur Centre

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

(K. Sarika and N. Umakanta)

For foreground selection of the crosses, Chakhao-22 × CR Dhan 801 and Kalikhasa × CR Dhan 801, the listed primer in the table were used for drought tolerant genes (*qDTY1.1 + qDTY2.1 + qDTY3.1*) and submergence tolerant *Sub1* gene (table 1). The BC1F2 population of Chakhao-22 × CR Dhan 801 were screened for the targeted genes, five, six and 11 plants were found to be homozygous for all 4, 3 and 2 of the targeted genes/loci, respectively (Fig 7). Among the five plants, two plants with good agronomic performance having maximum tillers of 11 were selected for further backcrossing to recurrent parent, Chakhao22. And for the cross, Kali kasha × CR Dhan 801, true F1(s) were selected and backcrossed to its recurrent parent, Kali kasha during the *kharif* 2023.

Table 1. List of Polymorphic Markers used for foreground selection

Genes/QTLs	*qDTY1.1 (SSR marker)*	*qDTY2.1 (SSR marker)*	*qDTY3.1 (SSR marker)*	*Sub1 (*linked / functional markers)
Polymorphism between Chakhao 22/ CR Dhan 801	RM431	RM 324	RM 16030	Sub1BC2, AEX
Polymorphism between Kali Kasha/ CR Dhan 801	RM431	RM 424	RM 16030	Sub1BC2, AEX, RM8300

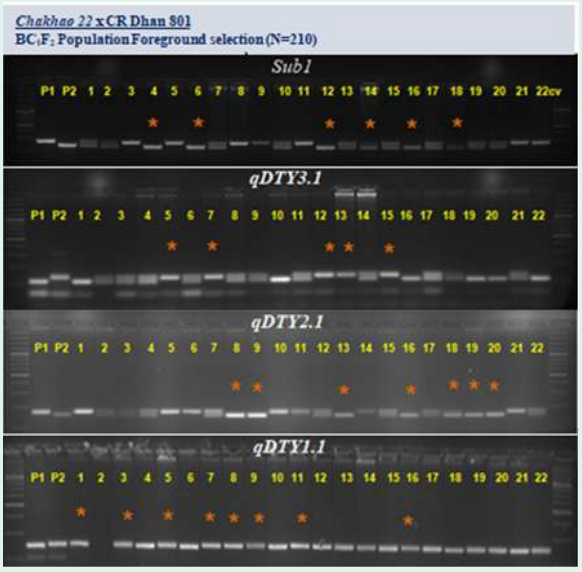


Fig. 7. Foreground selection targeting drought and submergence genes/QTL in Backcross population

Performance evaluation of local selections in foxtail millets

(K. Sarika and I.M. Singh)

Five local selections of foxtail millets were evaluated for their performance with two checks viz. SIA 3085 and SIA 3088 following RBD with three replications and were also DUS characterized during *kharif* 2023. The selections: Chandel Selection, Ukhrul Selection and Tamenglong Selection II performed significantly superior with yield per plant of 12.9 g, 11 g and 6.8g, respectively as against the check SIA 3085 (2.7 g) and SIA 3088 (3.5 g). However, the seed sizes were smaller than the check variety with 1000 seed weight of the selections ranging from 1.4 to 1.9 g with checks from 2.4 to 3.3 g (fig 8). They were DUS characterize with 19 descriptors and found to be highly variables in all the descriptors e.g. stem basal colour, inflorescence compactness, type of bristles, etc. to mention few. Therefore, the local selection has a huge potential for increasing the productivity and utilizing it for further breeding program.

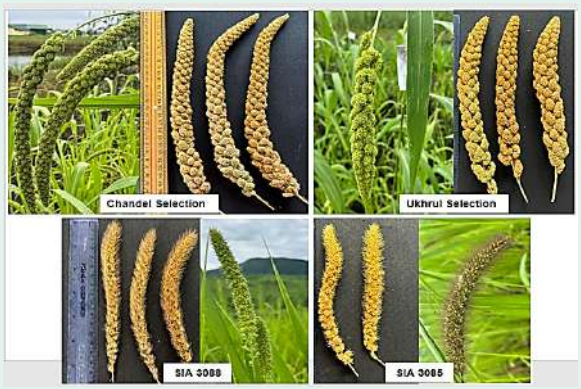


Fig. 8. Panicle architecture of local germplasm selections as compared to improved checks SIA 3088 and SIA 3085

SEED SCIENCE AND TECHNOLOGY

Molecular characterization of Manipur black rice (Chak-Hao) maintained in Manipur Centre

(I. M. Singh and N. Umakanta)

Among the ten Manipur black rice (Chak-hao) collected from different parts of the state for maintenance along with two reference rice genotypes, it was revealed that the CHK-70 is more closed to *Japonica* reference genome. The pH differential method was followed for the determination of total anthocyanin in Chak-Hao grains. The matured grains were dehusked using palm-dehusker. The brown grains were grinded using a grinder or mortar-pestle to make a fine powder. Around 100 g of the grain powder were mixed in a 100 ml of ethanolic HCl followed by addition of 50 ml of ethanolic HCl and stored at 4°C for overnight. The mixture was filtered through a Whatman No. 1 filter paper and collected around 450 ml of extract. A small aliquot of the filtrate with ethanol HCl was taken after storing in dark for 2 hours and measurement was taken at the absorption maximum at 533 nm in a spectrophotometer. The total anthocyanin content of CHK-70 was found 180.80±14.15 mg/100g sample.

Experiments under STR component (AICRP on Seed)

(I.M. Singh, K. Sarika and N. Umakanta)

Development of seed enhancement techniques for low temperature stress during seedling establishment in Rice

The experiment was carried out 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,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 (fig 9). Among the treatments, germination rate of RC Maniphou-7 with treatment T_4 (Primed with GA (@100ppm) followed by DAB+ Biophos) was found the highest germination index, 6.11(1.86) as compared to the other two rice varieties. Significance differences in numbers of tiller 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_3- Seed coating on Hydroprimed (30h@250C) seeds with *Trichoderma harzianum* was found to be tallest (125.60cm) in plant height. Moreover, RC Maniphou 7 with treatment T2- Control (seed treatment as per package of practices), was found to be highest tiller numbers (16.00) and effective tiller number (13.67) respectively. RC Maniphou-7 was found to be highest grain yield (0.453kg) and 1000 seed weight (29.14gm) with treatment T_2- Control (seed treatment as per package of practices).

Fig. 9. Experimental field Rice of experiment: Development of seed enhancement techniques for low temperature stress during seedling establishment in Rice

Optimization of Organic Seed Production System for Maize and Black Rice

With the objectives to evaluate crop varieties for 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, three different rice genotypes *viz*. V1-Chakhao Porieton (tall), V2-Chakhao Porieton (black), and V3-Chakhao (white) was grown at experimental field, Lamphelpat farm for three nutrient management treatments: N_1-Control (no fertilizer and Manure), N_2- State recommended Dose of NPK fertilizer and N_3- RDN through Vermicompost with combination of 10 kg PSB/ha + 10 kg KSB/ha and three replications for each treatment (fig 10). Seed treatment with biocontrol agent *viz*., *Trichoderma harzianum* @10g/kg of seed was done at the time of sowing (Fig a & b). Similar experiment in maize with varieties, Pusa composite, RCManichujak-2 and local chandel was carried out at ICAR Langol farm

with three varieties and three nutrient management treatments N_1-Control (no fertilizer and Manure), N_2- State recommended Dose of NPK fertilizer and N_3-RDN through Vermicompost with combination of 10 kg PSB/ha + 10 kg KSB/ha (Fig 11). Seed treatment with biocontrol agent viz., *Trichoderma harzianum* @10g/kg of seed was done at the time of sowing. In rice, variety V1-ChakhaoPorieton (tall) gave the highest seed yield under RDN through Vermicompost with combination of 10 kg PSB/ha + 10 kg KSB/ha followed by V1 under state recommended dose of NPK fertilizer. In maize, V1 gave the best seed yield under the treatment N3.

Fig. 10. Experimental field Rice of experiment: optimization of Organic Seed Production System for Black Rice at Lamphelpat Farm

Fig. 11. Experimental field Rice of experiment: optimization of Organic Seed Production System for Maize at Langol Farm

Development of controlled & target specific release coating technologies for management of biotic and abiotic stresses and for quality seed production.

To study the effect of seed coating with PGPR formulations on seed yield and quality, experiments 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 .Among all the treatments T5- Thiram + Bavistin was found the highest in plant stand establishment rate/m2 (5.30m2) and field emergence % (81.20%).T6-AnLaxa was found to be highest grain yield (396.71gm/plant) and tallest plant height (253.27) (Fig 12).

Fig. 12. Field Experimental view on study of effect of PGPR seed coating on Maize (HQPM 5)

Production of Quality Seeds

During the rabi season of 2023-24, a total of 372.12 q and 230.55 q of quality seeds of field crops were produced at research farm and at farmers field whereas 55.6 qtls and 2295.3 qtls of quality seeds were produced at research farm and farmers field during Kharif / Spring/Summer 2023 (Table 2) (Fig 13&14). During rabi 2022-23, 0.60 q of Maize Pusa Composite-3 breeder seeds were produced while 2.70 q of foundation seeds of field Pea Aman were produced. Among oilseeds 15.20 q of foundation seeds of mustard PM-27 was also produced (Table 3). The list of training and programmes taken under AICRP on Seed's TSP and NEH component are given in table 4 & 5.

Activities taken up at Relief Camps

The activities taken up in Relief Camps and affected areas under NEH component of AICRP on seed and input distribution were given in table 6 and fig 15. The various extension activities organized during 2023 under AICRP in Seed (Crops) is presented in table 7.

Table 2. Production of quality seed during 2023-24 (in quintals)

Particular	*Rabi 2022-23*				*Kharif / Spring/Summer 2023*			
	In Research Farm		In farmers' field		In Research Farm		In farmers' field	
Field Crops	**Indent**	**Ach.**	**Target**	**Ach.**	**Target**	**Ach.**	**Target**	**Ach.**
Breeder seed	180.00	350.00	0.00	0.00	42.5	55.6	0.00	0.00
Foundation seed	6.75	7.20	22.00	32.00	0.00	0.00	29.5	39.3
Certified seed	5.50	9.50	35.50	61.00	0.00	0.00	1995	2256
Truthfully labelled seed	3.00	5.42	71.00	137.55	0.00	0.00	0.00	0.00
Total	**195.25**	**372.12**	**128.50**	**230.55**	**42.5**	**55.6**	**2024.5**	**2295.3**

Table 3. *Rabi* 2022-23 Seed Production undertaken at Institute (in quintals)

Crop	Variety	Duration of variety	Ideal planting window (from/to)	Breeder seed		Foundation seed	
				Target	Production	Target	Production
Cereals							
Maize	Pusacomposite-3	130-125	Dec-Jan	0.40	0.60	0.00	0.00
Pulses							
Field pea	Aman	125-130	Oct- Nov	0.00	0.00	2.50	2.70
Oil seeds							
Mustard	PM-27	115-120	Oct-Nov	0.00	0.00	14.50	15.50

RC Maniphou-13 at Louren, Kakching | RC Maniphou-13 at Keibi Lousangkhong, Imphal East | RC Maniphou-16 at Heingang Awang Leikai, Imphal | RC Maniphou-10 at Lamdong, Kakching

Fig. 13. Quality Seed production in farmers' field under participatory seed production program, Manipur Centre

RC Maniphou-13 at Keibung Oinam Leikai, Imphal West | RC Maniphou-14at Maidangpok, Imphal West | RC Maniphou-16 at Keibi Lousangkhong, Imphal East

Fig. 14. Monitoring team visit for quality Seed production under participatory seed production program

Table 4. List of training taken under AICRP on Seed's TSP and NEH component

Training Topic	No. of Training	No. of Participants	Centre
TSP			
Seed Production of Cereals	1	50	Chandel District
Seed Production of Oilseeds	1	25	Tamenglong District
NEH			
Quality seed production of early *kharif* rice	1	20	Imphal West
Seed production for rice for higher income Importance of rogueing in quality seed production	2	50	Imphal West, Imphal East, Kakching, Thoubal & Bishnupur

Table 5. List of programme taken up under TSP and NEH component of AICRP on Seed

Name of Programme	Particulars/ crops	No. of Programme	Centre
TSP			
Input distribution to Tribal farmer	Field pea, Lentil, Mustard, Rajma, Broad bean	3	Chandel, Tamenglong, Ukhrul
NEH			
Critical input distribution	HYV Rice Seeds	1	Imphal West, Imphal East, Kakching, Thoubal & Bishnupur
Critical input distribution	Fertilizer (Urea, SSP, MOP)	2	Imphal West, Imphal East, Kakching, Thoubal & Bishnupur

Table 6. List of activities currently taken up in Relief Camps and affected areas under NEH component of AICRP on Seed

Activity	Crop	District
Nursery Production at Relief Camp and affected area	Fruits: Papaya, Watermelon Vegetables: Brinjal, Tomato, Green chilli, Capsicum, Cucumber, Zucchini, Drumstick	Konthoujam Relief Camp, Sagoltongba Relief Camp, Lamboi khongnangkhong Relief Camp, Khumbong affected area, Phayeng affected area

Fig. 15. Quality seed usage & raising of nursery cum input distribution in Relief Camps and affected area

Table 7. Extension activities organized during 2023 under AICRP in Seed (Crops)

Programme	Date	No. of participant	Venue
Seed Production and Quality Control (Trainer training)	21st April 2023 to 30th April 2023	50	ICAR RC NEH Region, Manipur Centre
Training on Participatory Seed Production for Field crops Under AICRP on Seed (Crops)	19th to 20th October, 2023	66	ICAR RC NEH Region, Manipur Centre
Quality Seed Production of Rabi crop Under AICRP (QSP)	14th November, 2023	30	Chandel, Manipur
Farmers awareness programme cum seed distribution Rabi Vegetables and Field Crops.	29th November, 2023	25	Phayeng affected areas, Imphal West, Manipur
Quality Seed Usage and Input Distribution Under AICRP on Seed (Crops)- NEH programme	25th December, 2023	22	Oinam, Bishnupur district, Manipur
Quality Seed Usage and raising of nursery cum Input Distribution Under AICRP on Seed (Crops)- NEH programme	27th December, 2023	39	Konthoujam Relief Camp, Imphal West, Manipur

Identification of rice genotype(s) with Low-Phosphorous tolerant, Pup1 gene cum low phytate content grain for high Iron and Zinc bioavailability and sustainable agriculture

(N. Umakanta, K. Sarika, T. Basanta Singh, I. M. Singh and R. Laha)

An important gene, *PSTOL1* was identified in rice to enhance the P-uptake by root with 70% phenotypic variance by increasing the plant's tillering ability and root growth. However, about 60-85% of the absorbed phosphorus by the plants are stored in the grains in the forms of phytic acids which is considered as anti-nutrition factors. Moreover, high phytic acid content in rice grains act as a chelating agent that binds minerals like zinc (Zn) and iron (Fe) making them unavailable to human and monogastric animals and resulting eutrophication. A set of 96 rice germplasm collected from different parts of the Manipur state were screened for *PSTOL1* gene using 11 gen-based function markers. Fifteen rice germplasm were identified with positive alleles of *PSTOL1* gene based on two functional markers, Pup1_K46 and Pup1_K20 (fig 16). Intriguingly, a strong positive correlation between the presence of *PSTOL1* gene and P content of grains (r = 0.6343 at *P value* = 0.05) was observed. These 15 germplasms would be useful for finding novel alleles of *PSTOL1* gene and as donor for rice breeding programme. The minimum and maximum of Phosphorus, Iron and Zinc content were found to be 0.27 mg g^{-1} (Insatang Makokching) – 3.78 mg g^{-1} (Allechisho), 1.28 ppm (Arunachal-1) – 17.12 ppm (Thekrulha), and 8.2 ppm (Insatang Makokching) – 23.21 ppm (Thekrulha), respectively. The Pearson correlation coefficients (r) for pairwise analysis among the P, Fe and Zn contents showed non-significant corelations. The present finding would be a useful for development of low-phosphorus tolerance rice breeding lines and for minimizing the long-term negative impacts and consequences of environment-related challenges.

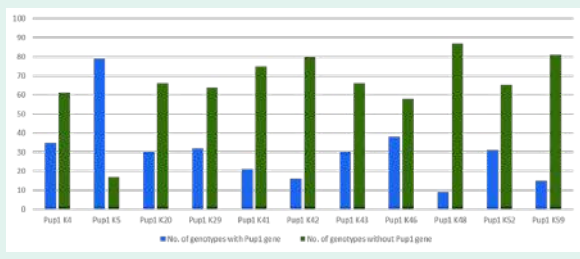


Fig. 16. Graphical representation showing number of germplasms possessing Pup1 gene

Biological Nitrogen fixing endophytic bacteria for Organic Manipuri Black Rice (*Chakhao*)

(N. Umakanta, T. Basanta Singh, Kh. Rishikanta Singh and R. Laha)

A total of 14 rice germplasm including wild rice 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. A total of 48 endophytes were identified as nitrogen fixing endophytic bacteria. Based on nifH primers (Forward 5' GTTTTACGGCAAGGGCGGTATCGGCA 3' and Reverse 5' TCCTCCAGCTCTCCATGGTGATCsG 3'), 18 endophytes were validated for Nitrogen fixing endophytic bacteria (Fig 17).

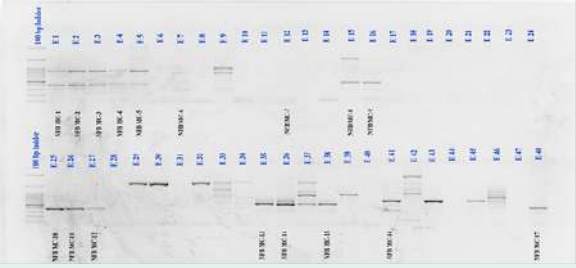


Fig. 17. PCR amplification for biological nitrogen fixing endophytic bacteria using nifH primer

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, K. Sarika, T. Basanta Singh and R. Laha)

The RC Maniphou 7 was crossed with CR Dhan 801 (*qDTY1.1* + *qDTY2.1* + *qDTY3.1* and *Sub1*) genes and generated F1 seeds which was furthered back-crossed with RC Maniphou 7 to develop BC_1F_1. Around 5 BC1F1s lines was selected based on the foreground selection using polymorphic markers of Waxy, Sub1 and drought tolerant QTL between the parental lines, recipient parent (RC Maniphou-7) and donor, CR Dhan 801 and developed 15 BC2F1 seeds (fig 18). Three BC1F1s plants were selected for testing the hybridity using polymorphic markers for targeted genes related to drought. Three SSR markers RM5791, RM521 and RM6374 linked to qDTY2.1 were used for hybridity testing among the BC1F1s along with parental lines, CR Dhan-801 into RC Maniphou 7. All the three BC1F1s (MCR-4, -7 & -9) were found true to hybridity which are further used for development of BC2F1 seeds. Around 2-3 BC2F1 plants/lines showing maximum phenotypic appearance to recipient parent along with glutinous/stickiness grain quality and carrying more than 80% genome recovery of recurrent parent were further selected for selfing to develop 1300-1500 BC2F2 population.

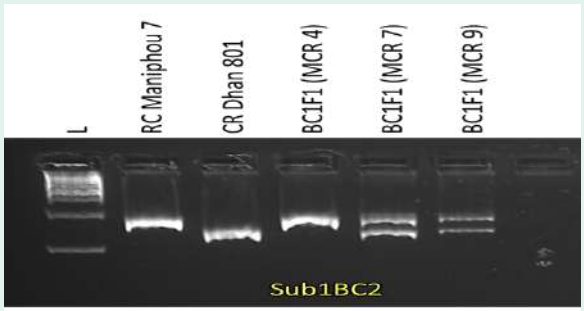


Fig. 18. PCR amplification for hybridity testing using BC1F1 plants along with the parental lines, RC Maniphou 7 and CR Dhan 801 using polymorphic markers for Sub1 gene

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

(*T. Basanta Singh, L. C. Langlentombi and R. Akoijam*)

The study was conducted at the experimental farm of ICAR, Manipur Centre to standardize the organic nutrient management package for black rice (*Chakhao Poireiton*) and to evaluate the impact of organic nutrient management on growth, yield, quality, nutrient uptake and impact on soil health. The experiment comprised of 11 treatment and tested in Randomized Block Design with three (3) replications (fig 19). The organic nutrient management has impact on soil nitrogen pools. The rage of available nitrogen, NH_4-N and NO_3-N in soil were respectively 241.0-397.0 kg/ha, 42.0-88.7 mg/kg and 28.0-60.0 mg/kg. The treatment comprising 50% RDN through FYM + 25% RDN through vermicompost + 25% RDN through green manure sesbania resulted in the higher content of available nitrogen and extractable NH_4-N with the significant reduction in NO_3-N in soil which may be a strategic approach to control the nitrogen leaching and increasing the nitrogen use efficiency (Fig 20).

Fig. 19. Experimental field of black rice

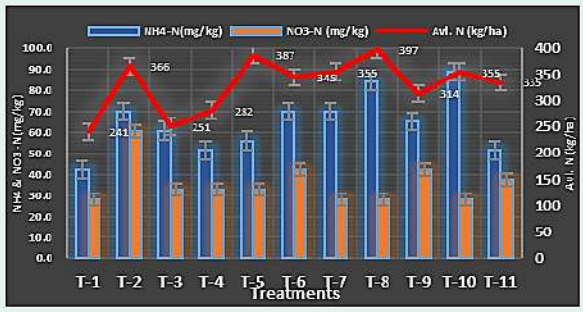


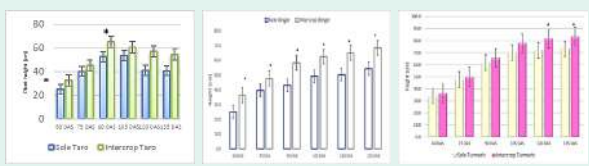
Fig. 20. Nitrogen dynamics of black rice soil

AGROFORESTRY

Evaluation of *Gmelina arborea* based agroforestry system for hill agroecosystem of Manipur.

(L. Chanu Langlentombi and T. Basanta Singh)

The experiment with seven treatments was designed in RBD to study the growth performance of three crops (taro, ginger, and turmeric) under *Gmelina arborea* based agroforestry system located at ICAR, Langol Farm during 2023. The results revealed that the plant height of intercrop taro was higher than sole taro where the significant value was observed at 60 and 90 DAS (days after sowing) (Fig. 21 a). Plant height of intercrop ginger was observed to be significantly higher than sole ginger during the entire study period (Fig. 21 b). Intercrop turmeric was also observed higher plant height than the sole turmeric with significant value at 120 and 135 DAS (Fig. 21 c).



(a) (b) (c)

Fig. 21. Effect of cropping system on growth of (a) ginger (b) turmeric and (c) Taro

HORTICULTURE

Banana

Standardization and Optimization of *In-vitro* Mass Multiplication of Promising Local Cultivars of Meitei-Hei Banana for Promotion of Virus Free Quality Planting Material

(N. Umakanta, S.S. Roy, S.K. Sharma, Ch. Tania, Ch. Premabati Devi, T. Basanta Singh, Kh. Rishikanta Singh and R. Laha)

A total of 38 sword suckers as explants in six different concentrations of cytokinin as treatments were used for identification of optimum concentration of plant hormones for shoot initiation of Meitei-Hei banana. The optimum condition of MS medium was identified by considering the phenotypic data such as Increase in plant height (cm) at 4 days interval, increase in pseudostem diameter (cm) at 4 days interval, no. of days taken for greening of shoot, no. of days taken for first new shoot generation and no. of shoots per explant. Out of 38 explants, 24 explants have successfully established. In terms of faster establishment of explant in culture medium, optimum concentration of plant hormones was identified to establish within short duration (30 days) which may be considered optimum condition for shoot initiation of Meitei-Hei banana. In order to investigate the optimum conditions for shoot multiplication in Banana multiplication (BM) media with different concentrations of Cytokinin hormone were used to successfully shoot initiated Meitei-Hei cultures (Fig 22). Out of the 24 well-established explants, only 12 explants were found to be successfully multiplied into new shoots. After the shoot initiation and shoot multiplication steps, the *in-vitro* rooting and hardening of *in-vitro* raised banana plantlets was carried out.

Fig. 22. Depiction of different shoot multiplication rate of Meitei-Hei banana in MS medium with different concentrations of cytokinin.

Cucumber

Morphological diversity of cucumber germplasms in North East India

(Ch. Premabati Devi, Tania, A. Ratankumar Singh, N. Umakanta, K. Sarika and R. Akoijam)

Different germplasm of cucumber was collected from ICAR RC NEHR, Sikkim Centre (2 lines) and 19 lines from Manipur and their morphological traits were studied. The germplasms were found significant morphological variation in shape, size, colour of the fruit (fig 23). Selfing was performed to develop first generation (F1) and fruits from selfed- (F1) were harvested after the fruit turn to brown colour. We recorded different morphological traits including fruit weight(cm), fruit length(cm), fruit diameter (cm), and mesocarp thickness (mm). The maximum fruit weight (1784.38 g) from C-S-6 followed by Senapati cucumber (1723.33 g) and Phungyokara (1576.81 g). The maximum fruit length was recorded from the germplasm line CCpur 1 (36.05 cm) followed by C-S-6 (35.71 cm) and Phungyokara (29.84 cm). The highest fruit diameter was recorded in Senapati cucumber (97.33 cm) followed by (96.09 cm) and Angel cucumber (91.3 cm). The maximum mesocarp thickness was recorded in Chingjaroi bell shape (2.55 mm) followed by Phungyokara (2.25 mm) and Angel cucumber (2.08 mm).

Fig. 23. Morphological diversity in shape, size and color of cucumber

Screening cucucumber germplasm against powdery mildew under polyhouse conditions

(Ch. Premabati Devi, Ch. Tania, A Ratankumar Singh, Umakanta N, K. Sarika and R. Akoijam)

Twenty-one (21) germplasms of cucumber, 2 lines from ICAR Sikkim Centre and 19 lines from Manipur region were screened naturally under shade net polyhouse conditions. Maximum germplasm lines were found susceptible to powdery mildew whereas Kalen Thabi germplasm was recorded the most tolerant.

Pea

Initiation of mass multiplication of F7 lines of field pea

(I.M Singh and Ch. Premabati Devi)

Initiation of mass multiplication of field pea has been started by planting F7 generation of 12 lines (Makhyatmubi, Popular local cultivar cross with HUDP-16, a Powdery mildew and rust resistant donor line). The 12 lines were sowed at ICAR Experimental Farm, Lamphelpat maintaining spacing of 25 x 10 cm in randomized block design with three replications.

Onion

Evaluation of onion varieties under Manipur conditions

(Ch. Tania and Ch. Premabati Devi)

Five onion varieties obtained from ICAR-DOGR and a local check was evaluated for their growth, yield and quality attributes under Manipur conditions during 2023-2024. The varieties were Bhima Subhra, Bhima Super, Bhima Dark Red, Bhima Shakti, Bhima Red and Local as a control (fig 24 a&b). The highest in plant height (64.40 cm), number of leaves per plant (7), leaf length (49.44 cm) at 90 days after transplanting was recorded Bhima Dark Red and lowest plant height (52.20 cm), number of leaves per plant (5.2), leaf length (43.17 cm) recorded in control (local).

Fig. 24 a. Onion Crop at 60 DAT

Fig. 24 b. Onion crop at 90DAS

NICRA Tomato-Sub project: Development of drought tolerant tomato for NEH region

(*N. Umakanta, S.S. Roy and Ch. Premabati Devi)*

The seed multiplication for two promising moisture stress tolerant tomato lines namely, RCM-N-T-1 and RCM-N-T-2 has been successfully undertaken. The lines will be proposed for multilocational trial under AICRP(VC) in 2024. DNA fingerprinting of RCM-

N-T-1 and RCM-N-T-2 along with RC Kamenasenba-1 (Sel-9A) and RC Manithoibi (Sel-3) has been carried out using 34 SSR markers of Tomato. Out of 34 SSR markers, only 30 markers (88.23%) were successfully amplified in all four tomato genotypes. Based on amplicon size of TGS-522, RCM-N-T-1 and RCM-N-T-2 could be differentiated from Sel-3 whereas, RCM-N-T-1 and RCM-N-T-2 could be differentiated from Sel-3 through TGS 192 marker. Genomic DNA of three moisture stress tolerant Bacterial Strains (RCMN-24, US-3 and UN-14) isolated from tomato have been isolated, purified and quantified for whole genome sequencing.

Medicinal and Aromatic Plants

Extraction of essential oil from indigenous plant traditionally used in pest management, identification of major compounds and evaluation against storage pest, *Sitophilus oryzae*

(*A. Ningombam and R. Akoijam*)

Artemisia sp is an indigenous aromatic plant from Manipur (*Laibakngou*) belonging to the Asteraceae family. It is used as an ITK for pest management by different communities in Manipur. Plants of *Artemisia* L. genus have a long history of use in folk and modern medicine also in cosmetic and pharmaceutical industries. In Manipur, tender stems and leaves are also eaten in traditional cuisine. Essential oil was extracted from the vegetative young stage of this plant using steam hydrodistillation (Fig 25). Essential oil could not be extracted from older plant stages. The average yield of essential oil was approx. 1.0 %. Gas chromatograph-mass spectrometry (GC-MS) analysis of the extracted oil showed that it contained a variety of volatile molecules such as terpenes, phenolic-derived aromatic, and aliphatic compounds (Fig 26). GCMS detected the presence of 104 constituent components of different proportions, and most were in traces. The important compounds present in major proportions are given in the table 8.

Table 8. Major compounds detected from artemisia essential oil through GCMS

Apex RT	Start RT	End RT	Area	%Area	Compound
9.3	9.27	9.52	884105.4	11.04	Artemisyl ketone
13.02	12.87	13.25	405481.6	5.06	Bergamotol
13.68	13.59	13.9	1610171	20.11	Artemisia alcohol
13.99	13.95	14.1	127977.3	1.6	Docosahexanoic acid, methyl ester
14.44	14.41	14.63	190106	2.37	Ocimene
16.33	16.29	16.63	836176.4	10.44	Trans carenol
20.46	20.42	20.58	252631.8	3.15	Himachalene
23.03	22.97	23.12	141995.1	1.77	Guaiene
24.43	24.37	24.48	131171.2	1.64	Bufa-20,22 dienolide
24.53	24.48	24.63	195441.9	2.44	Camphor
25.8	25.75	25.9	99943.95	1.25	Pregnan-20-one
26.13	26.08	26.23	276767.7	3.46	Naphthalene
26.28	26.23	26.37	181054.6	2.26	Cholestan-3,7,12,25-tetrol, tetraacetate
26.54	26.5	26.64	102610.6	1.28	Androst-5,7-dien-3-ol-17-one, acetate

Seed treatment was done using grounded plant powders (1%) of *Artemisia* and *Esholtzia* in white rice and black rice seeds. They gave complete protection to treated rice seeds against rice weevil and there was no emergence of storage insects for six months at the tested concentration.

Fig. 25. Essential oil extraction from Artemisia leaves

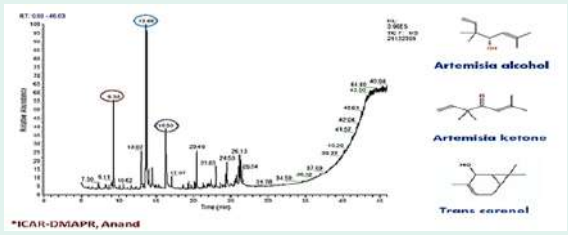


Fig. 26. Major compounds identified from essential oil of Artemisia through Gas Chromatograph Mass Spectrometry

VEGETABLES

Dissipation of Imidacloprid 70% WG @ 35 g a.i./ha on Brinjal and 24.5 g a.i./ha on cucumber and its on-farm decontamination methods

(R. Akoijam, A. Ningombam and Ch. Premabati Devi)

In the fruit development stage of brinjal, imidacloprid 70% WG @ 35 g a.i./ha was sprayed twice through foliar application due to infestation of whiteflies and thrips. The samples were extracted and analysed to quantify at HPLC. The initial deposits of imidacloprid were found to be 1.15 mg/kg at 1 hour after the last application. It was dissipated gradually to 0.90 mg/kg on the first day of sampling and found to be the lowest concentration of 0.03 mg/kg on the 9th day while the residue was found till the 7th day (0.02 mg/kg) in soil. With the on-farm decontamination methods of treating the freshly collected samples with 2% NaCl solution, 0.1% Sodium bicarbonate solution and washing with running water for 5 mins, the samples treated with 2% NaCl solution, was found to be the most effective thereby reducing the concentration of imidacloprid to 0.59 mg/kg at 1 hour after the last application. The residue was found to be detected till the 7th day (0.05 mg/kg) as compared to decontamination with 0.1 % $NaHCO_3$ solution and washing with normal water. The half-life values according to Hoskins (1961) worked out as 4.04 days for imidacloprid 70% WG sprayed with 35 g a.i./ha in brinjal.

However, in cucumbers, the residue was found to be 1.89 mg/kg at 1 hour after the second application of Imidacloprid @ 24.5 g a.i./ha (fig 27). The residues were not detected on the 9th day and its half-life was worked out as 2.51 days. The residue was detected till the 5th day (0.02 mg/kg) in soil. Here also, the decontamination of using 2% NaCl solution was found to be the most effective (0.04 mg/kg till 5th day).

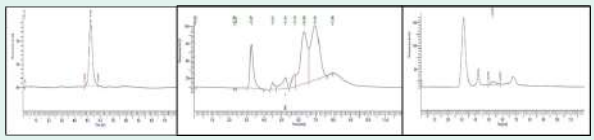


Fig. 27. Chromatograms of Imidacloprid Standard (left), Imidacloprid detection at Brinjal sample (middle) and Imidacloprid detection at Cucumber sample (right)

Fate of Spiromesifen 22.9% w/w SC@ 96 g a.i./ha on brinjal and french beans and its on-farm decontamination methods

(R. Akoijam, A. Ningombam and Ch. Premabati Devi)

There was a heavy infestation of Red Spider Mite on brinjal and French beans during the fruit/pod initiation stage on leaves (fig 28). Foliar applications of Spiromesifen 22.9% w/w SC@ 96 g a.i./ha were sprayed twice to manage them. The residue of Spiromesifen was found to be 0.64 mg/kg at 0 day after the last application. It steadily degraded to 0.04 mg/kg on the 7th day and there was a below detection limit (BDL) on the 9th day of sampling and its residues in soil were observed as 0.02 mg/kg on the 5th day. The half-life of Spiromesifen was found to be 4.08 days. Among the decontamination methods of washing the samples with 2% NaCl solution, 0.1% Sodium bicarbonate solution and washing with running water for 5 mins, treatment with 2% NaCl solution has decontaminated the residues at the maximum (0.02 mg/kg on 5th day). The half-life of this treatment was found to be 3.06 days. The residues of Spiromesifen at initial deposits was 0.98 mg/kg at 0 days, and it decreased to 0.06 mg/kg on the 5th day and found BDL on the 7th day in French beans. The half-life value was 2.86 days. However, in soil, the residues were found to be drastically degraded (0.01 mg/kg on the 5th day). The decontamination utilizing 2% NaCl solution degraded to 0.44 mg/kg at 0 day and its residues were found till the 3rd day of sampling.

Fig. 28. Red Spider Mite, *Tetranychus urticae* Koch on brinjal leaf surface (left and middle) and French beans plot (right)

Persistence of chlorantraniliprole 18.5% w/w SC @ 25 g a.i./ha on Cucumber and French beans and on-farm decontamination methods

(R. Akoijam, A. Ningombam and Ch. Premabati Devi)

To control leaf roller, leaf-eating caterpillars and pod borers, foliar applications of chlorantraniliprole 18.5% w/w SC @ 25 g a.i./ha twice were sprayed on cucumber during fruiting (fig 29). The residue on the cucumber persisted upto 9th day with a concentration of 0.04 mg/kg in cucumber and 0.06 mg/kg on French beans. In soil, the residue persisted upto the 5th day (0.08 mg/kg) on cucumber and 0.03 mg/kg on French beans. However, the residue was found to persist upto to only 0.01 mg/kg (on the 9th day) when treated with 2 % NaCl solution and 0.1% $NaHCO_3$ solution separately on cucumber. With the use of 2 % NaCl solution, the residue in French beans was persisted upto 7th day (0.05 mg/kg) on French beans.

Fig. 29. Cucumber plot and leaf-eating caterpillars infesting French bean leaves

Dissipation study of Cypermethrin 25% EC @ 40 g a.i./ha on French beans through foliar application

(R. Akoijam, A. Ningombam and Ch. Premabati Devi)

Cypermethrin was tested on French beans by foliar sprayed during the pod formation stage. The initial deposits of 1.58 mg/kg on 0 day dissipated to 0.08 mg/kg on the 9th day while in soil, the initial deposits were only 0.79 mg/kg on the same day and dissipated to 0.01 mg/kg on the 7th day (fig 30). There were no residues detected on the 9th day. the half-life values were 5.05 days in French beans and 2.78 days in soil. The decontamination methods of using 2% NaCl solution were found to decontaminate the residues at the maximum followed by using 0.1% NaHCO3 solution and washing with normal water.

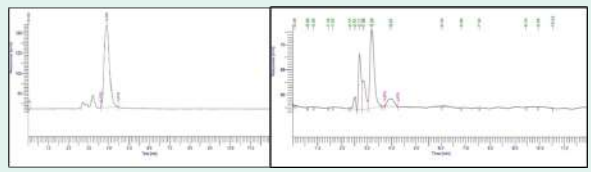


Fig. 30. Chromatograms of Cypermethrin Standard (left), and Cypermethrin detection at French beans sample (right)

Pesticide Residues Analysis on Vegetables from Local Markets of Manipur and Nagaland

(R. Akoijam and A. Ningombam)

Out of total 58 numbers of vegetable samples collected from major local markets of Manipur and 20 samples from Nagaland, 11 samples were found to detect the residues of imidacloprid (2.52, 0.38, 0.58, 0.90, 1.04, 1.85 mg/kg), carbofuran (0.17, 0.72 mg/kg), chlorantraniliprole (0.62 mg/kg) and fipronil (0.14, 0.56 mg/kg) on cabbage, cauliflower and pea collected from Manipur above Maximum Residue Limit fixed by Food Safety and Standards Authority of India (Fig 31). However, there were no detection of residues on the samples collected from Medziphema.

Fig. 31. Vegetable sample collection from Manipur and Nagaland markets

Management of Fall armyworm, *Spodoptera frugiperda* through Biopesticides and Chemical insecticides in maize at ICAR RC for NEH Region, Nagaland Centre, Jharnapani

(R. Akoijam, H. Kalita, L. J Bordoloi, A. Ningombam and A. Sen)

Plant product insecticide like Azadirachtin 1% @1ml/litre water and Biopesticides such as *Bacillus thuringensis* @5ml/litre water, *Beauveria bassiana* @ 5ml/litre water and *Metarrhizium anisoplae* @5ml/litre water) were evaluated for

comparing the efficiencies of the insecticides against FAW, *S. frugiperda* under field conditions. Chemical insecticides such as Emamectin benzoate 5%SC @0.4g/litre water and Chlorantraniliprole 18.5%SC @ 0.4ml/litre water) were also included for comparing the efficiencies of the insecticides. The pheromone traps were also installed on maize plots (Fig 32). The chemical sprayed is comparatively lesser infestation as compared to Azadirachtin and other biopesticides. There were 222 numbers of *S. frugiperda* adults collected from 10 pheromone traps installed at maize crops.

Fig. 32. Management techniques of FAW on maize at Nagaland Centre, Jharnapani

Management of Weevil on Assam Lemon (Citrus Limon L. Burmf) at Jharnapani, Nagaland

(R. Akoijam, H. Kalita, L.J Bordoloi, A. Ningombam and A. Sen)

Hypomeces squamosus (Fabricius) belong to Curculionidae family was identified and found to occur occasionally in Assam lemon orchard at ICAR Research Complex for NEH Region, Nagaland Centre, Jharnapani. The insect has a polyphagous type of feeding in nature where it feeds on Assam lemon, mango, gliricidia, other fruit trees, *etc*. The weevil usually emerges and starts infesting Assam lemon during April. Increasing temperatures with dry weather intensified the infestation. The larvae live underground, feeding on the roots of a wide range of plants. The adult *H. squamosus* feeds by chewing leaves mostly the growing tip, flowers and young leaves are preferentially chosen and eaten from the edge inwards. When older, more mature leaves are consumed, the softer parts between the veins are eaten and the veins are left. A foliar spray of *Metarrhizium anisopleae* @5ml/litre water was done to manage biologically and to establish disease inoculum of the Entomopathogenic fungus for sustainable management. The infestation is comparatively low in the sprayed plot as observed.

Pathology

Suppression of soft rot of ginger caused by *Fusarium oxysporum* f.sp. *zingiberi* by native *Trichoderma* spp. under field and pot conditions

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

Trichoderma spp. (*Trichoderma asperellum, T. atroviride, T. harzianum, T. longibrachiatum* and *T. erinaceum*) that were antagonistic against *Fusarium oxysporum* f. sp. *zingiberi* causing soft rot disease of ginger was identified (Fig 33). *In vitro* assays identified positive interactions for plant growth and disease suppression.

During 2022-2023, evaluated the different *Trichoderma* species with rhizome treatment and soil drenching in both field and pot conditions, exhibited significant in plant growth and suppressed soft rot as compared to control. In comparison with all treatments, *T. atroviride* (T_3) and *T. erinaceum*, (T_6) recorded the maximum rhizome production of 0.37g/ pot efficiency with less incidences of soft rot and (77.39%) reduction compared to control (100%), in a polyhouse condition with a challenge inoculation with the pathogens. In field experiments, *T. erinaceum* reduced soft rot to 49.64% over the untreated control. The treatment (T_6) recorded rhizome yield up to 4.21kg/m^2 and produced an increased rhizome yield with an average increase of 74.82% relative to the control (1.06kg/m^2). The treatment (T_7) NEH Extract @ (8%) applied with rhizome treatment and soil drenching, recorded significant in sprouting (86.51%), rhizome yield (3.35kg/m2) and reduced the soft rot incidence up to 30.36%.

Fig. 33. Field and pot experiment, Ginger plants with rhizhome treated with (C) and control plot and (T6) *T. erinaceum*

Isolation, identification and characterization of pathogens causing stem rot of the red-fleshed dragon fruit, *Hylocereus polyrhizus*

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

Dragon fruit (*Hylocereus polyrhizus*) is an emerging cactus fruit crop in the region due to its attractive color, taste, sweet, juicy pleasant and nutritional richness with medicinal properties and high adaptability. Two *Fusarium* species were isolated from different sites of ICAR NEH Region Umiam, Meghalaya and identified by morphological, microscopic and molecular characteristics as *Fusarium oxysporum* and *Fusarium longifundum* (Fig 34). These *Fusarium* species showed significant variation in colony colour, growth rate, margin, pigmentation.

The conidial size was maximum in *F. oxysporum* (10.11-18.41 x 2.00- 3.65µm) and minimum in *F. longifundum* (2.3-6.7 x 1.6-2.03 µm). *F. oxysporum* was found highly virulent and produced a larger area of the lesion (32.16 cm^2) in the pathogenicity test. Evaluated *Trichoderma* species, plant extracts (NEH plant extract) in 10 treatments, among treatments T_8: (combination of *T. harzianum, T. longibrachiatum* and *T. erinaceum*) was found superior in plant height (55.60 cm), number of branches (2), branch length (50.08 cm), cladode width (4.47 cm), arch height (0.48 cm), distance between areoles (4.82 cm), number of spines (50.45), minimum stem rot severity (0.00%) as compared to control (80.00%).

Fig. 34. Pure culture of Fusarium species, *Fusarium oxysporum* and *F. longifundum*) and pathogenicity test on stem of Dragon fruit

Mushrooms

DNA barcoding of different Shitake mushrooms strains for Identification, conservation and improvement

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

Shiitake mushrooms (*Lentinula edodes*) is a highly valued edible fungi with significant economic and nutritional importance. DNA barcoding was conducted on a total of forty-one (41) shiitake mushrooms strains for identification based on the internal transcribed spacer (ITS), translational elongation factor 1α (TEF1α), mini chromosome maintenance protein (MCM7) and large subunit ribosomal RNA gene (LSU) regions as the barcode regions (Fig 35 a &b). We emphasized the importance of establishing and maintaining a comprehensive reference library of shitake mushroom barcode sequences to facilitate accurate identification and quality control in the industry.

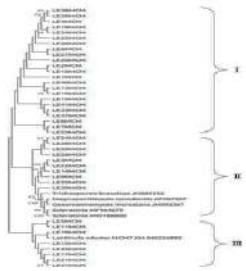


Fig. 35 a. Phylogenetic tree of 41 Shiitake mushroom strains based on the MCM7 gene three distinct clusters: Cluster 1 (23 strains), Cluster 2 (10 strains) and Cluster 3 (8 strains).

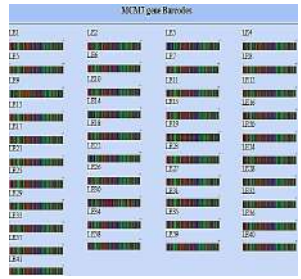


Fig. 35 b. Barcode images depicting the MCM7 gene sequences of 41 Shiitake mushroom strains barcode images generated using the Bio-Rad Barcode Generator

Animal Science

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

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

The experiment was conducted done for 6 weeks duration in laying hens of 30 weeks old and there were 20 birds in each treatment. There were five number of different treatments, T1 – Control (Corn soya based layer diet), T2- Corn soya based layer diet with *Perilla* @ 50 g/kg in diet, T3- T3- Corn soya based layer diet with *Perilla* @100 g/kg in diet and T4- Corn soya based layer diet with flaxseed @ 50g/kg in diet and T5- Corn soya based layer diet with flaxseed @ 100g/kg in diet. The results revealed that birds in T5

group have shown significantly better body weight gain (2422 g) when compared with control group during 1st week of feeding. Better intake of feed was observed in layer birds fed with *Perilla* and flaxseed at 5% and 10 % inclusion level in 1st, 5th and 6th week feeding trial. No significant effect on feed conversion ratio was observed. T3 group have shown highest egg production percentage however the change was non-significant. Birds in T3 and T5 group receiving 10% Perilla and 10 % of Flaxseed had given significantly better egg weight at III, V and VI week feeding period when compared with other groups in laying hen. The highest egg weight of 58g in T5 group (with 10% flaxseed). Higher values of egg shape index (76) was found in T3 and T5 group while there was no effect on specific gravity of the egg. No significant difference was found on shell weight % and shell thickness of the egg of laying hen in any of the treatment group though there is slight improvement in both the parameters in T3 group. Yolk index of T3 (with 10% *Perilla*) and T5 (with 10% *Flaxseed*) groups at III and VI week feeding had higher values of 46.2 to 46.96. Significantly better albumen index was observed in T3 and T5 group at III week and VI week feeding period. No change in the Haugh unit at III week feeding value while better Haugh unit was observed in T3 and T5 group at III and VI week feeding. No significant differences in the yolk weight while yolk cholesterol content was effectively reduced when compared with control group. Egg yolk cholesterol reduction of 9.37% and 14% in T3 (with 10% *Perilla*) and T5 (with 10% flaxseed) group at III and VI week. Significant reduction serum lipid profile (Total serum triglyceride, total serum cholesterol, LDL cholesterol and VLDL cholesterol) while HDL Cholesterol was significantly improved in laying hen by dietary inclusion of *Perilla* and flaxseed.

ICAR-Poultry Seed Project

(C. Sonia, R. Laha, and B. Sailo)

The total number of parent stock of, Vanaraja and Srinidhi poultry birds maintained as a genetic stock in the poultry farm was 729 birds (346 Vanaraja and 383 Srinidhi). The total germplasm supplied during the calendar year from January 2023 to December, 2023 was 21,998 under PSP, ICAR Manipur Centre. A total farmer benefited under this project was 208 numbers from different districts of Manipur during January 2023 to December 2023. Revenue generated during the reporting period was Rs. 10,41,940.00. 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 gained 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.

Dairy and Goatery Unit

(C. Sonia, R. Laha, B. Sailo and S. Deori)

At present, 12 numbers of Local x Jersey and Local x HF cross-bred cattle (Milch cow=4, Dry cow=2, Calf male=1, Calf female=5, and 11 local indigenous Meitei San cattle (Cow=3, Heifer-1, Bull=1, Calf female=2, and Calf male=4) are maintained as a genetic stock in the Dairy Unit. A total of 21 local indigenous goats (Local Name: *Hameng*) are maintained as a genetic stock (Buck: Doe: 9, Male kids: 9 and Female kids: 2) in the Goatery unit.

Fishery

Production of *Wallago attu* in pond condition by manipulating feeds and stocking density.

(Ch. Basudha Devi, Wakambam A. Meetei and N. Peetambari Devi)

Experiments on rearing of *Wallago attu* (Bloch & Schneider, 1801) by feeding with different feed and stocking densities for 13 months duration in ponds (fig 36 a & b). The performance of fishes fed on different feeds in different stocking densities were analysed with respect to survival. Fish were fed with silver carp fries and tilapia. Fish were consistently kept at the same size and separated every two months. The growth and survival rate of fish of similar size were significantly higher ($P<0.05$) in weight gain, specific growth rate, and percentage weight gain compared with unsegregated fish (table 9).

Fig. 36 a. Initial size of *Wallago attu*

Fig. 36 b. 1year and 3 months old *Wallagu attu*

Table 9. Growth performance of *Wallago attu* culture for thirteen months in ponds

Parameters	Non-segregated	Segregated
Initial weight (g)	45±1.2	45±1.2
Final weight (g)	2280±1.1	2850±1.2
Weight gain per day	5.68 ±0.2	7.32±0.1
Specific growth rate (SGR)	0.43±0.2	0.45±0.2
Survival Rate (%)	35.0	58.0

Studies on Silurid distribution in Manipur

Survey and investigation on distribution were carried out in various water areas of Manipur. 15 samples of silurid fishes were collected comprising 5 number of *Ompok pabo* (Hamilton, 1822) from the Lokchao river, Tengnoupal district, 3 numbers of *Ompok bimaculatus* (Bloch, 1794) from the Khordrak rivulet, Bishnupur district, Manipur and *Wallago attu* from culture ponds (Fig 37 a, b & c). Checklist of Silurid fishes of Manipur.

Fig. 37a. Ompok pabda

Fig. 37b. Ompok bimaculatus

Fig. 37c. Wallago attu

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

(Wakambam A. Meetei, Ch. Basudha Devi, Kh. Rishikanta Singh, B. Sailo, T. Basanta Singh and N. Peetambari Devi)

Study location: Sanapat wetland, Bishnupur district, Manipur. A co-operative functioning in the Sanapat namely '*The Khunpham Fishing-Cum-Pisciculture Co-Operative Society Ltd.*', Regd. No. 18 of 1981-82, P.S. Nambol, Bishnupur district, Manipur-795134 was identified for executing the project through community participation. Along with members of the cooperative, sample collection was undertaken in the proposed site for installation of pen enclosures for fish seed production (fig 38 a, b & c). In the wetlands, a large number of fish farms has

been developed inside the lake. 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 indicating a 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 vulnerable indigenous fishes in the pats were *Anabas testudineus, Pangio pangia, Channa gachua, Mystus bleekeri, Pethia manipurensis, P. ater, P. chola, etc*.

Fig. 38 a. A part of Sanapat Wetland for fish biodiversity assessment

Fig. 38 b. Soil Sample collection

Fig. 38 c. Community participation in site selection for Pen installation

Temporal variation of water quality and plankton diversity in Amkahoh river, Meghalaya

(N. Peetambari Devi)

Assessment of temporal variation for limnological parameters (water quality) and plankton diversity in a sub-tropical Amkahoh river, India were carried out during the selected months the winter (November to February), pre-monsoon (March to April), monsoon (May to September) and post-monsoon (October to November) seasons. Results revealed that there is significant variation in different water quality across the seasons. Dissolved oxygen (DO) ranged 8.2 to 11.2 mg/L where the highest DO (11.2 mg/L) was recorded during the monsoon period. Comparatively, the water quality improved during the dry season than the wet season. The study on the planktonic diversity revealed that altogether 19 nos. of plankton species were observed during the study period. During the winter, pre-monsoon, and monsoon seasons, phytoplankton belonging to the group Chlorophyceae was the most abundant, while the phytoplankton belonging to the group Bacillariophyceae dominated during the post monsoon. (fig.39a). In terms of phytoplankton diversity index, highest values of Simpson's Index (1.22), Shannon Index (0.67) and Evenness Index (0.85) were recorded during the monsoon season indicating more plankton diversity during this period. On the account of the zooplankton diversity analysis, zooplankton of the group Rotifer were found to be the most abundant type of zooplankton during the winter, monsoon, and post-monsoon seasons, while the Cladocera group of zooplankton were dominated during the post monsoon (fig. 39b). Unlike phytoplankton, the zooplankton diversity indices i.e. Simpson's Index (0.63), Shannon Index (1.05), and Evenness Index (0.95) were recorded highest during the pre-monsoon season, where the values of phytoplankton diversity indices were more in monsoon season.

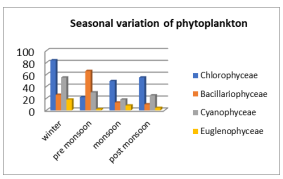


Fig. 39a. Seasonal variation of phytoplankton

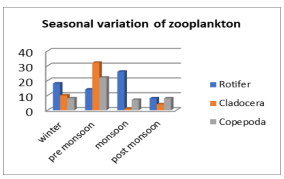


Fig. 39b. Seasonal variation of zooplankton

Assessment of temporal limno-ecological parameters of Simsang river, Meghalaya

(N. Peetambari Devi)

The present study was conducted to study whether there is any significant variation in different water quality across the different seasons in Simsang river, India. Water and plankton sample were collected during the pre-monsoon, monsoon and post-monsoon seasons. The results revealed that there is significant variation in different water quality across the seasons. The study showed that monsoon season with highest temperature (27.6° C ± 0.39), DO (7.4 ± 0.25), hardness, TDS and alkanity as compared to other seasons. The study on the planktonic diversity revealed that altogether 19 nos. of plankton species were observed during the study period. The study showed there is seasonal variation on plankton diversity across the seasons. Chlorophyceae and Euglenophyceae were dominant group during monsoon season while

bacillariophyceae was the dominant group during post monsoon season (Fig.40a). In terms of phytoplankton diversity index, highest values of Shannon Index (1.2), Simpson's Index (0.78), and Evenness Index (0.98) were recorded during the monsoon season indicating more plankton diversity during this period. On the account of zooplankton diversity analysis, Rotifer zooplankton dominated during the monsoon and post-monsoon seasons, while the Cladocera zooplankton dominated during the pre-monsoon and monsoon (Fig.40b). The zooplankton diversity indices i.e. Simpson's Index (0.83), Shannon Index (1.02), and Evenness Index (0.97) were recorded highest during the pre-monsoon season.

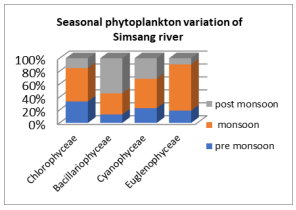


Fig. 40 a. Seasonal variation of phytoplankton

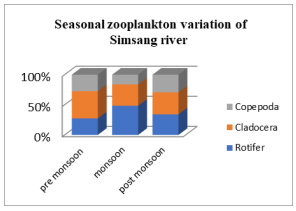


Fig. 40 b. Seasonal variation of zooplankton

SOCIAL SCIENCE

Comparison of adopters and non-adopters of improved rice varieties in Imphal West district of Manipur

(Kh. Rishikanta Singh, N. Umakanta, I. M. Singh, N. Uttam Singh, A. Roy, D. Jini, A. Gangarani Devi, L. Singson, E. Lamalakshmi Devi and H. Verma)

During the last 10 years *ie*. 2011-12 to 2020-21, the percentage area under high yielding and improved varieties have increased from 54.71 per cent to 58.63 per cent in the state (Economic Survey Manipur). A survey of 25 rice growers from Imphal West District of Manipur was conducted in the year 2023, comprising of 15 adopters and 10 non adopters. The study found that 80 per cent of the adopters obtained improved rice seeds from ICAR while the remaining 20 per cent was from own saved seeds and those obtained from friends. In case of non-adopters, 50 per cent of the seeds sown was own saved seeds while the remaining were from friends and neighbours. The study of traits preferred by the adopter farmers in selecting rice varieties comprised of taste (33.33 % farmer response), followed by yield (26.66%), pest and disease resistance (20%), early maturing (13.33%) and new release as the last traits/ characteristics with 6 per cent respondent giving preference. In case of non-adopter category, taste and yield were the only two preferred traits with 50 per cent farmers preference respectively. The average production of rice was 4720.54 kg per hectare for adopter group with gross return of Rs. 1,29,815 per hectare compared to production of only 4095.62 kg per hectare with gross return of Rs. 1,12,630 per hectare for non-adopters. The five major constraints faced by the adopters in rice cultivation are lack of irrigation facilities with Garrett score of 71.06, followed by pest and disease incidence (64.13 score), fertilizer not available as and when required (64.06 score), high cost of fertilizer (63.80 score) and high cost of agro chemicals (56.46 score). Uneven rainfall and scarcity of rainfall are problem faced by the farmers which is related to climate change and it is affecting the rice cultivation as majority of the rice cultivated areas in the state are rainfed. For the North Eastern Hill Region, the important improved rice varieties grown comprises of RC Maniphou 7, RC Maniphou 10, RC Maniphou 12, RC Maniphou 13, RC Maniphou 15, RC Maniphou 16, CAU R1, Sanaphou, Megha SA 1, Megha SA 2, Sasarang, NEH Megha Rice 1, NEH Megha Rice 2, Bhulum -3, Bhulum -5, Ranjit, Bahadur, Badgoti, IR-8, IR-64, DRRH2, Raja Dhan, Jaya, Arai, Gomati, Tripura Hakuchuk 1, Tripura Hakuchuk 2, Tripura Aus, Tripura Chikan, Naveen, Khowai, Abhishek, Sikkim Dhan 1, Pusa Basmati 1, IR-8, Jaya, Ranjit and Gomati.

Agri-Business Incubation (ABI) Manipur Centre

(Kh. Rishikanta Singh)

Agribusiness Incubation (ABI) Centre, ICAR Research Complex for NEH Region, Manipur Centre envisage facilitating incubation of new startups/ entrepreneurs for innovative/commercial/potential technologies by providing the need based physical, technical, business and networking support. Till now, 85 number of entrepreneurs are enrolled, of which 8 ABI entrepreneurs are enrolled during the year 2023. During North East Krishi Kumbha-2023 held during 4 to 6 January 2023, organized by ICAR-NEH, Umiam, eight entrepreneurs from Manipur participated and showcase their products (fig 41 a). One of our entrepreneur Mrs. Khayiwon Shangh participated in one day workshop on Millet on the onset of International Year of Millets, 2023 organized at ICAR, Manipur Center and received consolation prize for best value-added products of millet. Three ABI entrepreneurs participated and exhibits their

products in NE Regional Agri Fair, organized by CAU at Dimapur. Coordinated in organizing 5 days EDP on Meat Processing organized at ICAR, Umiam, where 11 participants from Manipur take part in the training. ABI-ICAR Manipur Centre also sponsored in organizing National Mushroom Day cum Kishan Diwas held on 23 December 2023, where our entrepreneurs showcasing their Mushrooms and its value-added products (Fig 41 b). ABI-ICAR Manipur Centre support our entrepreneur in applying for funding from different source. Mr. Rakesh Khumanthem has been selected for funding of Rs. 10 Lakh grand in aid from RKVY-RAAFTAR and it will be releasing this year.

Fig. 41 a. Participation in North East Krishi Kumbha, ICAR Umiam during 4-6 January, 2023

Fig. 41 b. National Mushroom Day, 2023 at ICAR Manipur Centre on 23rd December, 2023

TSP Activities taken up by ICAR Manipur Centre

Promotion of village based Farming System for Improving Productivity Profitability Sustainability of Agricultural and Allied Sector

A TSP programme was implemented at three villages *viz*. Noarem Kubui, Leimapokpam Kabui and Chingphu village of Bishnupur district of Manipur with the title *"Promotion of village based Farming System for Improving Productivity Profitability Sustainability of Agricultural and Allied Sector*" during 2022-2023. The socio-economic status of these villages before the interventions are very poor. Local non-descriptive chicks were reared and growth and productivity were very low. Fish-based integrated Farming system is predominant but rearing was traditionally done by the villagers. Pond making, feeding management, and maintenance of pond water quality were not done scientifically. Vegetable cultivation was done in small patches of land around fish ponds but in a very limited way. The practice of pig rearing was not hygenic and scientific and there was the mortality of livestock *viz*. pigs, ducks, and poultry which caused great economic losses. The plantation of agroforestry tree species like tree beans and papaya was not practiced in villages. The expert contact and linkages with line departments were very poor. Farmers depend on local friends and shopkeepers for the selection of crop varieties and medicine for livestock. Secondary agriculture like mushroom cultivation, beekeeping and pig and poultry rearing has been introduced. Mr Raja Gangmei of Chingphu Kabui village is a landless successful beekeeper earned an income Rs 33900/- quarterly from 6 bee boxes. Fishery-based farming system taken up by Mr. Thoiba Kabui of Chingpu village Bishnupur district, Manipur. Thoiba Kabui has diversified the fish rearing with a total water area measuring 1.50 ha along with a vegetable farm at the pond sides and bunds. The fish harvested consists of Carps *viz*. *Ctenopharyngodon idella* (Grass carp), *Cyprinus carpio* (Common carp), *Hypophthalmicthys molitrix* (Silver carp), *Labeo rohita* (Rohu) and Chichlids, *Oreochromis niloticus* (Nile tilapia) and recorded huge net return. An improved breed of poultry Vanaraja was introduced in adopted villages and 1500 birds were distributed to six progressive farmers to initiate a poultry venture. Four training programmes and a Fish Field Day was organized at the adopted villages. Photos of various activities taken up are presented in Fig 42.

Fig. 42. Harvesting of fish, input distribution of poultry, tree bean at bund of fishpond, poultry rearing and honey bee production during Kisan Mela

MIZORAM

SUMMARY

Production potential of low land rice varieties revealed that Ranjit recorded the longest duration (165 days), and least duration was recorded from RC-M-12 (115 days). The highest harvest index (1000 seeds weight) was observed in RC-M-12 (30.95 g). Among the 24 lowland rice varieties tested, RC-M-16 has the highest grain yields (6239.47 kg ha^{-1}. Significant difference in P was observed in different land use systems which were highly influenced by the soil pH. Different land use systems conserving more soil organic matter maintained higher organic P pools to act as a reserve for P cycling for a long term which reflects the importance of soil organic management in different land use systems. The detection of plasmid-mediated colistin resistance determinants mcr-1, mcr-2, mcr-4 and mcr-5 from foods of animal origin poses a serious public health concerns. Among the *Staphylococcus* spp,. isolated from cattle and pigs, *S. aureus* was the predominant bacteria isolated followed by *S. hyicus*, *S. haemolyticus, S. chromogenes, S. auricularis* and *S. sciuri*. Three isolates of *S. aureus* from pigs (18.75%) were found to be positive for *mecC* gene. The morphometric characteristics of different age groups of local indigenous goat (Zokel) and their carcass characteristics were evaluated. The milk and dung composition of local indigenous cattle (Zobawng) was evaluated and the breed registration is in progress. The growth performance of *Barilius tileo* was evaluated along with Indian Major Carps, Catla, Rohu and Mrigal.

Weather report

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

Daily weather observations were recorded at the agro-meteorological observatory of ICAR Research Complex for NEH region, Mizoram Centre. Total 2098.5 mm rainfall was received in Kolasib in 103 rainfall events, with monsoon rains accounting for 1413 mm (67.33 percent of the annual rainfall) and occurring on 66 rainy days (64 percent of the total annual rainfall). There were 80 rainy days and 1636.5 mm of rainfall between May and October. Compared to the Long Period Average (LPA), the amount of rainfall that was received in January, February, March, April, May, June, July, August, September, and October was much lower. On the other hand, the amount of rainfall that was received in November and December were significantly more than the average. The year's overall rainfall was almost 25.51% less than average, while the monsoon rains were 22% less than average. Fig. 1 shows the rainfall pattern on a monthly and yearly basis. On the 18th of November in 2023, the highest single day rainfall was received (97.4 mm).

The mean monthly maximum temperature (Mean T_{max}) and the mean monthly minimum temperature (Mean T_{min}) exhibited a consistent pattern of change throughout the year, as illustrated in Figure 2. The Mean T_{max} ranged from 25.5°C to 30.4°C for most months, except from December to January, when it was cooler, ranging from 22.9°C to 23.2°C. The figure reveals that for almost all months, T_{max} was either close to or higher than its LPA, except March, June, August, October, November, and December. April's mean monthly T_{max} peaked at 30.4°C, the highest of the year. Meanwhile, the mean T_{min} reached its peak in July and August at 23.0°C and dropped to its lowest in January at 12.9°C, as shown in Figure 2. After February, the mean monthly minimum temperature progressively increased, peaking in July, before decreasing again to its lowest point in January. The Mean T_{min} was comparable to or greater than its LPA for most months, except February and March, indicating a long-term increase in T_{min}. Highest Maximum temperature was observed on 08th and 11th May, 2023 (34.1°C) and lowest minimum temperature was observed on 19th January, 2023 (9.4°C).

The variability in morning relative humidity ($RH_{maximum}$) was considerably less pronounced compared to evening relative humidity ($RH_{minimum}$), as depicted in Figure 3. The RH maximum fluctuated between 95.0% in October and 64.9% in April, while the $RH_{minimum}$ ranged from 84.3% in August to 54.6% in February. The relative humidity increased notably from July to September, corresponding with higher rainfall during these months. Throughout many months, the RH minimum consistently exceeded its LPA.

The average bright sunlight hours decreased across all months by 1.6% to 47.6% below the average, highlighting a consistent decline in this location over the years. Wind speed exhibited an increase, being higher all the months in the year except August. This trend of increasing wind speed has been a persistent observation over the years in the area (Fig. 4).

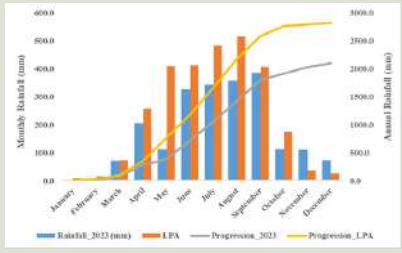


Fig. 1. Monthly & annual rainfall pattern

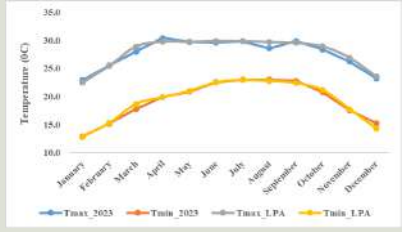


Fig. 2. Monthly values of mean maximum & minimum temperature during 2023

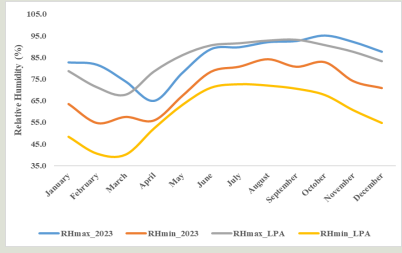


Fig. 3. Monthly values of mean maximum & minimum relative humidity during 2023

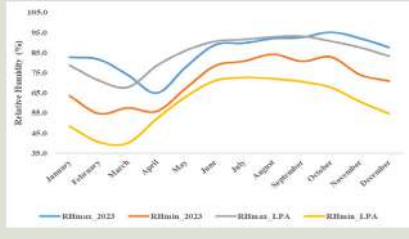


Fig. 4. Monthly values of mean bright sunshine hour & wind speed during 2023

RESEARCH ACHIEVEMENTS

Effect of land use on phosphorus pools and sorption characteristics in acidic soil of Mizoram

(Lungmuana)

Significant difference was observed among the different pools of P due to land use. The inorganic $NaHCO_3$-P was significantly higher in LR soil and lowest in T while the organic $NaHCO_3$-P was higher in T and lowest in LR. Similarly, the inorganic NaOH-P was highest in LR soil and lowest in OP while the organic NaOH-P was highest in F and lowest in LR. The HCL-P was higher in LR and lowest in F and the Res-P was highest in A respectively. The inorganic P pools were highly influenced by the soil pH thereby supplying short-term available P nutrition while the organic P pools were associated with SOC and clay content. The higher proportion of NaOH-PO (2 to 5) time in A, T, R, OP and F land uses suggested the moderately PO involvement in long term P transformation and cycling. The NaOH-P pools contributed 16–44% and dominated the P pools while $NaHCO_3$-P and HCL-P contributed 11–15% and 2–13% respectively (Fig 5). The dominance of NaOH-P in acidic soils was due to the presence of Fe and Al oxide and hydroxides with large specific surface area for P adsorption by virtue and degree of weathering associated with reduction in soil pH. This study has also revealed that land use conserving more soil organic matter maintained higher organic P pools to act as a reserved for P cycling for a long term reflecting the importance of maintaining soil organic matter in plantations and agroforestry systems under humid sub-tropical regions.

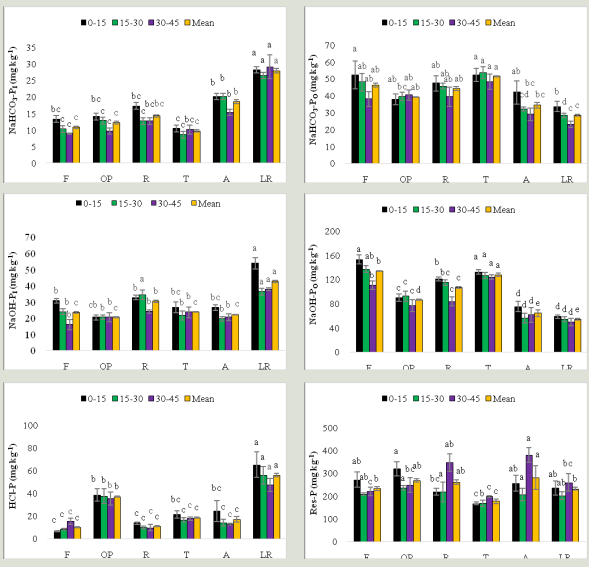


Fig. 5. Effect of different land uses on different P pools

Note: F: Forest; OP: Oil palm; R: Rubber; T: Teak; A: Arecanut and LR: Lowland rice; Numbers (±) represents standard error of means (n = 3). Different lowercase letters are significantly different ($p<0.05$) between land use of the same soil depth according to DMRT post hoc test

Evaluation of different varieties of rice under lowland conditions of Mizoram

(Lungmuana)

A field experiment was conducted during the *kharif* season of 2023 to evaluate the production potential of 24 rice varieties under lowland conditions in Mizoram (Fig 6). Among the varieties longest duration was recorded from Ranjit (165 days) and however, the least duration of 115 days was recorded from RC-M-12 (Table 1). The tallest plant was observed under PNR-546 (170.67 cm) while the least height of 115.27 cm was recorded from RC-M-15. More numbers of tillers and panicles were observed from Aizawng (27 and 28) whereas the least was recorded from Taposil (11.67) and PS-5 (12.67). The number of grains per panicle was highest for Aizawng (317) and lowest was recorded from RC-M-14 (119.8). The highest harvest index (1000 seeds weight) was observed from RC-M-12 (32.95 g). Out of the twenty-four different lowland rice varieties, the highest grain yield was recorded from RC-M-16 which produced 6239.47 kg ha^{-1}, under lowland condition of Mizoram.

Fig. 6. Field view of different lowland rice

Table 1. Yield attributes of different rice varieties under lowland condition of Mizoram

Variety	Duration (Days)	PH (Cm)	No of tillers	No of panicles	No of grains per panicle	1000 seeds (g)	Grain yield (kg ha^{-1})
RC-M-13	128.33	117.00	26.03	22.27	170.40	21.53	3987.79
T. Hakuchuk	128.33	140.33	15.44	12.81	183.00	25.07	3273.00
PNR-546	128.67	170.67	15.55	12.87	176.32	29.32	3601.00
RC-M-10	124.67	143.67	16.11	15.67	187.67	29.35	3984.69
RC-M-14	130.00	120.53	17.00	16.33	119.82	30.56	5545.29
PS-5	130.00	130.57	13.78	12.67	139.08	26.87	2758.24
RC-M-11	129.00	119.33	14.55	15.00	143.67	25.39	5543.12
B. Bhog	129.33	133.80	13.93	13.83	142.67	28.57	3434.74
NLR-1	130.33	139.07	21.33	22.33	214.33	26.35	4295.03
ICGV	130.00	158.87	20.00	19.00	202.33	24.91	4187.21
M. Aromatic	130.00	145.20	16.33	16.00	207.33	31.33	4743.03
RC-M-15	131.33	115.27	21.37	20.67	241.12	30.09	5439.47
RC-M-12	115.33	125.67	13.13	13.67	254.45	32.95	5606.14
Taposil	131.00	107.37	11.67	13.00	259.69	21.57	4439.47
RC-M-7	130.00	138.47	20.00	21.43	266.56	25.24	3706.14
Lampnah	156.00	147.27	14.00	13.39	169.36	25.31	4239.47
RC-M-16	150.33	135.13	12.13	12.77	251.79	30.03	6239.47
NLR-9	156.00	126.30	20.80	20.33	231.12	26.62	4569.47
Shahsarang	157.00	158.13	21.33	21.33	182.69	24.00	3372.80
Ranjit	165.00	141.23	20.30	21.67	211.55	18.67	4039.47
TRC-2015-7	157.00	161.43	26.10	27.00	198.03	28.33	5106.14
Aizawng	150.00	124.13	27.00	28.00	317.03	18.00	2506.14
IR-64	157.00	125.73	18.00	17.67	307.03	25.12	2769.47
Gomati	135.00	118.63	24.00	24.00	237.36	19.12	3606.14
CV (%)	9.98	12.04	24.91	26.23	24.66	15.6	23.66
SD	13.77	16.27	4.57	4.74	51.52	4.06	995.68

Note: PH: Plant height.

Organic Management of Pest Complex in Popular Maize Cultivars in North-East India

(A. Ningombam, S. Chowdhury, A. Romila and S. Doley)

The importance of organic management of pest complexes in popular maize cultivars in North-East India cannot be overstated, particularly given the region's unique ecological and agricultural landscape. Maize, a staple crop in North-East India, is prone to various pests that can significantly impact yield and quality. Conventional chemical-based pest control methods, while effective, often lead to environmental degradation, soil fertility loss, and potential health risks due to pesticide residues. In contrast, organic pest

management aligns with the sustainable agricultural practices that are crucial for this ecologically sensitive region. In this context, an experiment has been conducted at ICAR Research Complex for NEH Region, Mizoram centre in collaboration with ICAR Research Complex for NEH Region, Manipur centre to evaluate the efficacy of different organic insecticide in different popular varieties of maize during *kharif* season (Fig 7). Under this experiment, five eco-friendly organic treatments *viz. Azadirachta indica* 1% EC , *Metarhizium anisopliae, Beauveria brassiana, Bacillus thuringiensis* and control with seven popular maize varieties, like RCM 1-61, RCM 1-76, Vijay, Hemant, RCM 1-2, MZM 8 and MZM 2 were selected. Organic insecticides were applied at different stages like establishment, vegetative, active growth, pollination/ kernel development and grain filling stage. The design of the experiment was Factorial Randomized Block Design (FRBD). Fall armyworm (FAW) was found most devastating pest during the crop growth. The table 2 presents a comprehensive analysis of the effectiveness of various treatments on FAW control in maize at different growth stages. *Azadirachta indica* 1% EC shows significant effectiveness, with the mean population per plant being substantially lower than the control across all stages (1.32, 2.66, 2.59, 1.27 and 0.85 per plant) followed by *Bacillus thuringiensis* (1.82, 2.33, 2.84, 1.43 and 0.98 per plant) and *Metarhizium anisopliae* (3.18, 4.64, 3.13, 1.54 and 1.28 per plant), notably achieving a 70.18% decrease in the Grain Filling stage. This indicates a high level of pest control efficacy (More than 50% in all stages) of *Azadirachta indica*. *Bacillus thuringiensis*, a well-known biopesticide, also shows considerable effectiveness in all the stages, where it closely rivals the performance of *Azadirachta indica*. *Metarhizium anisopliae* and *Beauveria brassiana*, both fungal biocontrol agents, also demonstrate notable decreases in pest populations compared to the control, with *Metarhizium anisopliae* showing a consistent performance across all stages. *Beauveria brassiana* appears slightly less effective than *Metarhizium anisopliae* but still presents a significant reduction in FAW populations, especially in the initial stages of growth. The table 2 also compares the performance of different maize varieties against FAW populations, indicating that certain cultivars like RCM 1-61 (1.88, 2.55, 3.45, 1.32 and 0.85 per plant), RCM 1-76 (1.94, 2.34, 4.57, 1.62 and 1.02 per plant), and Vijay (2.56, 3.85, 5.01, 1.98, 1.64 per plant) are more resistant to FAW compared to others like Hemant, RCM 1-2, MZM 8, and MZM 2. The variability in resistance across these varieties suggests that genetic factors play a crucial role in pest management in maize cultivation. In conclusion, the data indicates that biopesticides can be highly effective in managing pest populations in maize, with certain treatments showing exceptional results at various growth stages. Additionally, the choice of maize variety is crucial, as inherent resistance to pests varies significantly across different cultivars.

Azadirachta indica 1% EC shows the highest effectiveness, yielding 5439 kg/ha of maize and 8875 kg/ha of biomass, resulting in a gross income of Rs. 135,974. After accounting for the cultivation costs of Rs 58,500, the net income stands at Rs. 77,474, leading to a CBR of 1.32. This indicates a strong return on investment, making it the most economically viable option among the tested treatments. *Bacillus thuringiensis* also shows promising results with a yield of 5270 kg/ha and a net income of Rs. 73,262, yielding a CBR of 1.25. This places it as a highly effective treatment, second only to *Azadirachta indica*. *Metarhizium anisopliae*, while effective, results in a slightly lower yield and net income, with a CBR of 1.07. Similarly, *Beauveria brassiana* leads to a yield of 4980 kg/ha and a net income of Rs. 66,008, resulting in a CBR of 1.13, which is commendable but not as high as *Azadirachta indica*. In conclusion, the table highlights the economic viability of using organic pesticides in maize cultivation to control the fall armyworm. *Azadirachta indica* 1% EC emerges as the most cost-effective option, providing the highest return on investment, followed by *Bacillus thuringiensis*, *Beauveria brassiana*, and *Metarhizium anisopliae* (Table 3). This data is crucial for farmers in making informed decisions about pest management strategies that are not only effective in controlling pests but also in maximizing economic returns.

Table 2. Effect of organic insecticides application on the population of fall armyworm (*Spodoptera frugiperda*) on maize at different growth stage

Treatment	Establishment stage		Vegetative stage		Active growth		Pollination/ Kernel development		Grain filling stage	
	Mean population / plant	Percentage decrease over control	Mean population / plant	Percentage decrease over control	Mean population / plant	Percentage decrease over control	Mean population / plant	Percentage decrease over control	Mean population / plant	Percentage decrease over control
Azadirachta indica 1% EC	1.32^{a}	67.47	2.66^{c}	65.30	2.59^{a}	55.73	1.27^{b}	64.14	0.85^{b}	70.18
Metarhizium anisopliae	3.18^{b}	23.79	4.64^{d}	28.85	3.13^{b}	41.50	1.54^{c}	46.65	1.28^{c}	35.44
Beauveria brassiana	3.52^{c}	31.15	4.79^{ab}	30.62	3.33^{a}	38.08	1.91^{d}	56.20	1.84^{a}	55.09
Bacillus thuringiensis	1.82^{d}	60.61	2.33^{a}	60.25	2.84^{c}	51.45	1.43^{a}	60.60	0.98^{d}	65.61
Control	4.62^{e}		6.71^{e}		5.85^{d}		3.58^{e}		2.85^{e}	
SED	0.01		0.02		0.03		0.02		0.02	
CD (P = 0.05)	0.02		0.03		0.06		0.05		0.04	

Maize variety	Establishment stage	Vegetative stage	Active growth	Pollination/ Kernel development	Grain filling stage
	Mean population / plant	Mean population / plant	Mean population / plant	Mean population / plant	Mean population / plant
RCM 1-61	1.88^{a}	2.55^{ab}	3.45^{a}	1.32^{a}	0.85^{a}
RCM 1-76	1.94^{b}	2.34^{c}	4.57^{b}	1.62^{c}	1.02^{g}
Vijay	2.56^{c}	3.85^{a}	5.01^{ab}	1.98^{ab}	1.64^{b}
Hemant	3.35^{bc}	4.28^{b}	5.94^{c}	2.84^{b}	1.98^{c}
RCM 1-2	4.25^{e}	6.85^{f}	7.08^{d}	3.05^{c}	2.39^{d}
MZM 8	6.34^{d}	8.17^{c}	7.85^{e}	3.38^{d}	2.81^{c}
MZM 2	6.88^{f}	8.82^{e}	8.34^{f}	3.54^{e}	3.10^{e}
SED	0.01	0.02	0.01	0.02	0.03
CD (P = 0.05)	0.02	0.04	0.04	0.05	0.06

*Data are mean values of main crop three replications and four replication for border crop
Mean value ± Standard Error
In a columns means followed by same letter(s) are not significantly different (P=0.05) by DMRT

Table 3. Cost benefit ratio (CBR) of different organic pesticide to control fall armyworm (*Spodoptera frugiperda*) on maize

Treatments	Yield of maize (kg/ha)	Biomass yield of maize (kg/ha)	Gross income (₹)	Cost of cultivation + cost of seeds (₹)	Net income (₹)	CBR*
Azadirachta indica 1% EC	5439	8875	135974	58500	77474	1.32
Metarhizium anisopliae	4837	7895	120921	58500	62421	1.07
Beauveria brassiana	4980	8016	124508	58500	66008	1.13
Bacillus thuringiensis	5270	8592	131762	58500	73262	1.25
Control	4514	7492	117859	58500	59359	1.01

Fig. 7. Organic Management of Pest Complex in Popular Maize Cultivars in North-East India

Organic management of pest complex in popular pole type frenchbean local landraces in North-East India

(A. Ningombam, S. Chowdhury, A. Romila and S. Doley)

French beans boost productivity and production in North-East India. French beans, which fit several soil types and climates, thrive in North-East India's varied environment. French bean farming in this region is crucial to the local economy and supports small and marginal farmers. The crop's nutritional qualities and commercial potential give farmers a steady income. However, insect complexes can severely impair production and quality while growing these native landraces. Organic pest management is crucial here. It follows local sustainable agriculture techniques and meets worldwide demand for organic food. In contrast, organic pest management aligns with the sustainable agricultural practices that are crucial for this ecologically sensitive region. In this context, a collaborative experiment by ICAR RC for NEH Region, Mizoram Centre, in collaboration with ICAR RC for NEH Region, Manipur Centre, was conducted at the ICAR Research Complex for the NEH Region, Mizoram Centre, to assess the effectiveness of various organic insecticides on different pole-type French bean local landraces during the post-Kharif season. The study involved five treatments, namely *Azadirachta indica* 1% EC, *Metarhizium anisopliae*, *Beauveria brassiana*, *Bacillus thuringiensis*, and a control group. Seven local landraces of pole type French beans were chosen for this experiment, including MZ Frenchbean 1, MZ Frenchbean 2, MZ Frenchbean 9, MZ Frenchbean 14, MZ Frenchbean 16, MZ Frenchbean 8, and MZ Frenchbean 6. The organic insecticides were applied at various growth stages, including establishment, vegetative, flower initiation, pod development, physiological development, and seed development stages. The experimental design followed was the Factorial Randomized Block Design (FRBD). The data indicates that *Beauveria brassiana* was the most effective in controlling the *Thrips sp.* population, achieving a 62.91% reduction compared to the control, closely followed by *Azadirachta indica* 1% EC with a 55.20% decrease. For managing Lepidopteran pests such as *Spodoptera litura, Helicoverpa armigera* and *Maruca vitrata*, Azadirachta indica 1% EC proved to be the most effective organic insecticide. It reduced the population of *Spodoptera litura* by 71.52%, *Helicoverpa armigera* by 62.66% and *Maruca vitrata* by 79.75%. *Bacillus thuringiensis* ranked as the second most effective, showing similar percentages of reduction for *Spodoptera litura*, *Helicoverpa armigera* and *Maruca vitrata* as *Azadirachta indica*. *Metarhizium anisopliae* demonstrated moderate effectiveness across all species, with its highest impact being a 40.45% decrease in *Spodoptera litura* populations, as shown in Table 4.

In the second section, the table no 1 shows the impact of these organic insecticides on different local land race varieties of frenchbeans, labelled as MZ Frenchbean 1, 2, 9, 14, 16, 8, and 6. The evaluation is based on the number of infested leaves per plant and the average insect population per plant or per hill for each variety. Notably, MZ Frenchbean 9 displays notably lower levels of infestation for all tested insect types (with counts of 3.95, 2.24, 2.08 per plant), except for *Maruca vitrata*, suggesting it has superior natural resistance. Varieties MZ Frenchbean 1 and 2 show a moderate amount of leaf infestation, with MZ Frenchbean 2 having a slight advantage in controlling *Spodoptera litura* (2.88 per plant). Varieties MZ Frenchbean 8 and 6 present varied responses; MZ Frenchbean 8 is more effective against *Helicoverpa armigera* (1.81 per plant) but struggles with a higher *Thrips sp.* infestation (5.57 per plant). In contrast, MZ Frenchbean 14 and 16 are more susceptible, especially to *Spodoptera litura*, *Helicoverpa armigera* and *Maruca vitrata*.

Table 4. Effect of organic insecticides application on the population control of different insects on pole-type frenchbean

Treatment	*Thrips* sp.		*Spodoptera litura*		*Helicoverpa armigera*		*Maruca vitrata*	
	Average of leaf infested / plant	Percentage decrease over control	Mean population / plant	Mean population / plant	Mean population / plant	Percentage decrease over control	Mean population / plant	Percentage decrease over control
Azadirachta indica 1% EC	5.64[a]	55.20	1.17[a]	71.52	2.05[b]	62.66	1.15[a]	79.75
Metarhizium anisopliae	8.47[b]	32.72	3.93[b]	40.45	3.40[c]	38.07	3.73[ab]	34.33
Beauveria brassiana	4.67[c]	62.91	4.53[ab]	31.36	4.08[a]	25.68	2.73[c]	51.94
Bacillus thuringiensis	9.24[d]	26.61	2.07[c]	68.64	2.18[e]	60.29	1.82[d]	67.96
Control	12.59[e]		6.60[e]		5.49[d]		5.68[e]	
SED	*0.02*		*0.03*		*0.02*		*0.02*	
CD (P = 0.05)	*0.09*		*0.04*		*0.05*		*0.05*	

Frenchbean Pole type (Local land races)	*Thrips* sp.	*Spodoptera litura*	*Helicoverpa armigera*	*Maruca vitrata*
	Average of leaf infested / plant	Mean population / plant	Mean population / plant	Mean population / hill
MZ Frenchbean 1	6.25[b]	2.88[a]	3.15[a]	0.58[a]
MZ Frenchbean 2	4.15[a]	3.64[b]	2.27[c]	0.85[b]
MZ Frenchbean 9	3.95[c]	2.24[c]	2.08[d]	1.28[c]
MZ Frenchbean 14	7.85[e]	5.47[e]	3.95[ab]	2.95[d]
MZ Frenchbean 16	9.92[d]	5.87[g]	4.28[d]	3.52[e]
MZ Frenchbean 8	5.57[f]	3.57[bc]	1.81[e]	1.38[e]
MZ Frenchbean 6	6.93[g]	2.93[d]	2.61[f]	1.67[f]
SED	*0.02*	*0.02*	*0.01*	*0.01*
CD (P = 0.05)	*0.03*	*0.05*	*0.02*	*0.03*

*Data are mean values of main crop three replications and four replication for border crop
Mean value ± standard Error
In a columns means followed by same letter(s) are not significantly different (P=0.05) by DMRT

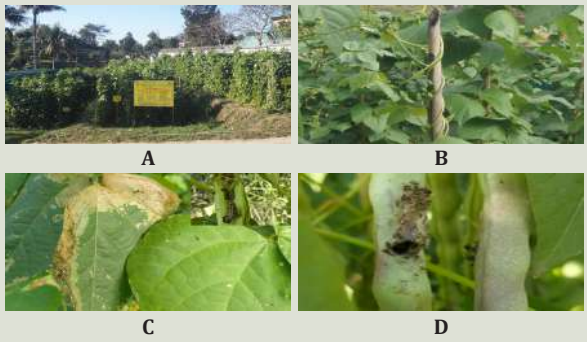


Fig. 8. Organic management of pest complex in popular pole type frenchbean local landraces. A- Organic management of pest complex in popular pole type frenchbean local landraces in North-East India, B- Leaf infestation by *Thrips sp.*, C- Leaf and pod infestation by *Spodoptera litura, and* D- Pod infestation by *Helicoverpa armigera*

Yield evaluation of various local landraces of pole-type frenchbeans (*Phaseolus vulgaris* L.) in Mizoram

(S. Saha, S. Chowdhury, R. Kumar, B. Sailo, Lungmuana, I. Shakuntala and S. Doley)

French bean landraces, particularly in Mizoram, hold significant importance due to their extensive genetic diversity, shaped by years of evolution. This diversity is a valuable resource in breeding programs for disease resistance, drought tolerance, and unique flavours. Moreover, these landraces embody traditional agricultural practices and local culinary preferences, reflecting the rich cultural and historical heritage of their cultivators.

Recognizing this, the ICAR Research Complex for NEH Region, Mizoram Centre, initiated a seed collection project for pole-type French beans during 2019-20 and 2020-21. From various locations in Mizoram, seventeen local landraces were collected. Notably, seven of these landraces demonstrated superior performance in the subtropical agro-climatic region and were subsequently assigned accession numbers by the ICAR-National Bureau of Plant Genetic Resources (NBPGR). These seven landraces, named MZ FB 1 (IC-0646258), MZ FB 2 (IC-0646259), MZ FB 9 (IC-0646229), MZ FB 14 (IC-0646231), MZ FB 16 (IC-0646232), MZ FB 6 (IC-0646227), and MZ FB 8 (IC-0646261), along with an improved variety, Zorin bean, were selected for an experiment using a Randomized Block Design (RBD).

The study highlighted notable variations in growth characteristics. Plant height ranged from 85.7 cm in MZ FB 6 to 174.9 cm in MZ FB 2. Pod production per plant varied significantly, with MZ FB 1 yielding the highest number of pods (94.80) and MZ FB 9 producing the heaviest pods (19.68g). The number of seeds per pod was relatively consistent across the varieties, averaging between 6 and 8. In terms of pod yield, MZ FB 9 led with 11.00 tons per hectare, while MZ FB 8 had the lowest yield at 4.89 tons per hectare. Similar trends were observed in grain yield and biomass yield, with MZ FB 9 achieving the highest (5.20 and 13.02 tons per hectare, respectively) and MZ FB 16 followed by MZ FB 6 the lowest in their respective categories (2.02 and 8.87 tons per hectare; 2.10 and 8.87 tons per hectare). Seed weight was another varied parameter, with the highest weight recorded in MZ FB 14 (301.50 g) and the lowest in MZ FB 1 (203.42 g). The growth cycle's duration also varied, with MZ FB 9 having the shortest period of 84.62 days and MZ FB 16 the longest at 126.48 days (Table 5).

Table 5. Growth and yield of local landraces of pole-type frenchbeans (*Phaseolus vulgaris* L.) in Mizoram

	Plant height (cm)	No of pod/ plant	Pod weight (g)	No of seed / pod	Pod yield (t/ha)	Grain yield (t/ha)	Biomass yield (t/ ha)	Seed weight (g)	Duration (Days)
MZ FB 1	162.2	94.80	10.26	7.95	9.74	4.33	11.92	203.42	98.42
MZ FB 2	174.9	86.36	12.97	6.25	10.22	4.93	12.43	235.71	112.89
MZ FB 9	147.3	65.86	19.68	6.83	11.00	5.20	13.02	283.20	84.62
MZ FB 14	168.0	74.76	12.76	7.12	9.62	4.05	11.83	301.50	125.94
MZ FB 16	149.5	53.21	10.66	6.05	5.55	2.02	10.61	225.46	119.31
MZ FB 6	85.7	49.62	9.84	5.32	4.89	2.10	8.87	208.48	126.48
MZ FB 8	91.0	45.98	10.32	5.93	4.70	2.19	9.06	223.88	115.75
Zorin bean	142.6	72.37	10.48	6.15	7.63	3.87	9.84	215.42	107.03
SEm±	*2.1*	*0.78*	*0.10*	*0.08*	*0.13*	*0.05*	*0.11*	*1.42*	*1.17*
CD (P=0.05)	*6.4*	*2.36*	*0.31*	*0.24*	*0.40*	*0.15*	*0.34*	*4.31*	*3.55*

Fig. 9. Pod and seed coat colour of Frenchbean in Mizoram

A- MZ FB 1 (IC-0646258) pod colour and seed coat colour, B- MZ FB 9 (IC-0646229) pod colour and seed coat colour, C- MZ FB 2 (IC-0646259) pod colour and seed coat colour, D- MZ FB 14 (IC-0646231) pod colour and seed coat colour, E- MZ FB 8 (IC-0646261) pod colour and seed coat colour, and F- MZ FB 6 (IC-0646227) pod colour and seed coat colour

Detection of plasmid-mediated colistin resistance determinants *mcr-1*, *mcr-3*, *mcr-4* and *mcr-5* from foods of animal origin

(B. Sailo, C. Sonia, Lalhruaipuii and S. Doley)

A total of 459 *Escherichia coli* isolated from foods of animal origin (Pork meat=157, Chicken meat=119, Beef=109, and Chevon meat=74) were screened for detection of plasmid-mediated colistin resistance determinants *mcr-1*, *mcr-3*, *mcr-4* and *mcr-5*. Plasmid-mediated colistin resistance (*mcr*) genes was detected in 2.17% of *E. coli* isolates (10/459), out of which plasmid-mediated colistin resistance determinants *mcr-1* was detected in four *E. coli* isolates (Chicken meat=2/119, 1.68 %; Beef=1/109, 0.91 %; and Pork meat=1/157, 0.63 %), *mcr-3* was detected only in one beef isolates (1/109, 0.91 %), *mcr-4* was detected in four chicken meat isolates (4/119, 3.36 %), and *mcr-5* was detected only in one beef isolates (1/109, 0.91 %) (Fig. 10). The study findings demonstrated that the *mcr* genes is prevalent in foods of animal origin in this part of the region highlighting the importance of continuous monitoring and control of colistin-resistant Enterobacteriaceae to prevent them from being transmitted to humans.

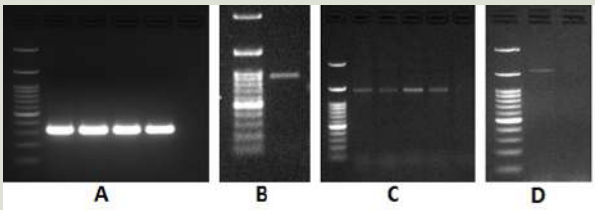


Fig. 10. Gel photos showing Plasmid-mediated mobile colistin resistance (*mcr*) genes A: *mcr-1*, B: *mcr-3*, C: *mcr-4* and D: *mcr-5*

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

(Lalhruaipuii, S. Doley and B. Sailo)

A total of 182 milk samples and 399 numbers of skin scrapings/nasal swabs were collected from clinical samples of cattle and pig irrespective of their age, sex and breeds from organized and unorganized farms of Aizawl, Kolasib and Lunglei district of Mizoram. One hundred and one (101) isolates from pig and 27 isolates from cattle were shown positive to *Staphylococcus* by biochemical test and PCR. A total of 16, 7, 4, 3 isolates were shown positive to *Staphylococcus aureus, Staphylococcus hyicus, Staphylococcus haemolyticus* and *Staphylococcus chromogenes* whereas two isolates

were shown positive to *Staphylococcus auricularis and Staphylococcus sciuri* from pig isolates. A total of two each *Staphylococcus aureus* and *Staphylococcus sciuri* and one *Staphylococcus haemolyticus* were found positive in cattle isolates. Out of 16 isolates of *Staphylococcus aureus* in pigs, 3 isolates (18.75%; 3/16) has shown positive to *mecC* gene.

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

(Lalhruaipuii, S. Deori, S. Doley and B. Sailo)

A total of 29 (Does=8, Buck=1, Doeling=3, Buckling=4, goat kids=13) local indigenous non-descript goat (Zokel) are maintained as a genetic stock in the Goatery unit during the reporting year. The milk content of Fat % and SNF % was found to be 5.7% and 9.5%.The morphometric, performance and carcass characteristics of Zo Kel were studied. The chest girth, body length, height at wither, ear length, ear width, tail length and horn length at 0 to 3 months were 38.36.75±1.53, 34.60±1.22, 36.25±0.93, 9.07±0.28, 4.19.22±0.23, 6.10±0.47 and 3.86±0.98 centimetres, respectively. The chest girth, body length, height at wither, ear length, ear width, tail length and horn length at 3 to 6 months were 42.71±1.63, 39.63±1.52, 39.39±1.81, 10.31±0.21, 5.17±0.04, 6.93±0.36 and 2.91±0.35 centimetres respectively. The chest girth, body length, height at wither, ear length, ear width, tail length and horn length at 6 to 9 months were 50.50±1.07, 45.23±1.02, 43.81±0.80, 11.13±0.35, 5.31±0.13, 8.10±0.59 and 7.49±1.01 centimetres respectively. The chest girth, body length, height at wither, ear length, ear width, tail length and horn length above 9 months were 61.25±1.23, 56.40±1.07, 49.67±2.55, 11.90±0.52, 6.45±0.36, 9.38±0.46 and 9.30±0.60 centimetres respectively. The carcass characteristics and fleece traits are highlighted in Table 6.

Table 6. Performance characteristics of Zokel

Parameters	Male Zokel	Female
Age at slaughter (days)	1052	1023
Weight at slaughter (kg)	37.80	23.15
Dressing % (Hot)	39.96	33.63
Dressing % (Cold)	46.42	27.69
Greasy Fleece Weight (g)	933.306	41
Clean Fleece Weight (g)	750	28

Conservation and improvement of indigenous cattle in North East of India

(Lalhruaipuii, R. Katiyar, S. Doley and B. Sailo)

A total of 12 (Cows=4, Bull=1, Heifer=1 and calves=6) local indigenous cattle (Zobawng) and 6 nos. of cross-bred cattle has been maintained as a genetic stock in the Dairy Unit during the reporting year. The average Fat % and SNF % of local indigenous cattle (Zobawng) was found to be 5.7% and 9.5%, and Fat % of 2.9 and SNF 8.6 % for cross-bred cattle. A total of 4992.5 litres of milk was produced during the reporting year. The effect of feeding on the dung composition of local indigenous cattle and crossbred cattle is highlighted in Table 7.

Table 7. Dung composition of cattle

Particulars	Nitrogen	Phosphorus	Potassium
Local indigenous cattle (Zobawng) fed with only fodder	1.12	0.304	0.281
Local indigenous cattle (Zobawng) fed with fodder and concentrate feed	1.19	0.545	0.634
Crossbred cattle fed with fodder and concentrate feed	0.84	0.355	0.439

A Comparative study on the external and internal quality of Vanaraja, Rainbow Rooster and BND eggs in Mizoram

(Lalhruaipuii, S. Doley, Tamilarasan K and B. Sailo)

The study was conducted to evaluate the external and internal qualities of eggs for improved varieties of chickens such as Vanaraja, Rainbow rooster (RR), and Broiler Native Desi (BND) at 12 months of laying at Poultry Unit of ICAR, RC for NEH region Mizoram centre. All the birds were reared under uniform and standard managemental practices.

Table 8. External and Internal egg quality analysis (Mean±SE)

Parameters	Vanaraja (n=43)	Rainbow Rooster (n=43)	BND (n=43)
External egg quality			
Egg weight (g)	60.09±0.46^{b}	62.93±0.59^{a}	55.94±0.83^{c}
Egg length (mm)	58.42±0.20^{a}	58.50±0.54^{a}	55.53±0.58^{b}
Egg width (mm)	42.91±0.27^{b}	45.25±0.56^{a}	42.73±0.24^{b}
Shell weight (g)	5.14±0.08^{a}	5.06±0.07^{a}	4.76±0.08^{b}
Shell thickness (mm)	0.39±0.01^{b}	0.41±0.002^{a}	0.40±0.003^{ab}
Shape index (%)	73.48±0.51^{b}	77.71±1.38^{a}	77.27±0.88^{a}
Shell ratio (%)	8.56±0.12	8.50±0.13	8.53±0.10
Internal egg quality			
Albumen length (mm)	90.46±0.90^{a}	82.77±1.38^{b}	83.77±1.43^{b}
Albumen width (mm)	78.85±0.97^{a}	73.16±1.13^{b}	71.99±1.24^{b}
Albumen height (mm)	6.67±0.14^{b}	6.97±0.14^{b}	7.59±0.18^{a}
Albumen weight (g)	31.40±0.64^{b}	33.93±0.52^{a}	29.17±0.69^{c}
Albumen volume (ml)	36.63±0.81	36.60±0.73	35.02±0.71
Albumen index (%)	8.52±0.22^{c}	9.71±0.29^{b}	10.75±0.37^{a}
Yolk length (mm)	45.05±0.45^{a}	44.08±0.46^{a}	42.47±0.47^{b}
Yolk width (mm)	43.39±0.53^{a}	42.80±0.33^{a}	41.29±0.38^{b}
Yolk height (mm)	16.18±0.19^{b}	18.09±0.31^{a}	16.65±0.15^{b}
Yolk weight (g)	20.57±0.36^{a}	20.93±0.44^{a}	17.32±0.24^{b}
Yolk volume (ml)	20.77±0.22^{a}	20.33±0.14^{ab}	19.72±0.23^{b}
Yolk index (%)	37.51±0.63^{b}	42.41±0.83^{a}	40.48±0.56^{a}
Haugh unit	80.97±0.85^{b}	82.21±0.90^{b}	87.66±1.12^{a}

Note $^{a-c}$ Means with different superscripts in the same row were differ significantly.

Table 8 highlights significant variations in external egg quality among Vanaraja, Rainbow Rooster and BND chicken. Rainbow Rooster leads in egg weight (62.93g), surpassing Vanaraja (60.09g) and BND (55.94g) eggs ($p<0.001$). Egg length differs significantly, with BND (55.53mm) shorter than Vanaraja (58.42mm) and Rainbow Rooster (58.50mm) ($p<0.001$). Egg width is similar for Vanaraja and BND but significantly less than Rainbow Rooster (45.25mm) ($p<0.001$). Shell characteristics vary, with Vanaraja having the heaviest shells (5.14g), followed by Rainbow Rooster (5.06g) and significantly low for

BND (4.76g). Rainbow Rooster eggs show the thickest shells (0.41mm), while Vanaraja (0.39mm) and BND (0.40mm) have slightly thinner shells. Rainbow Rooster leads in shape uniformity (77.71%), followed by BND (77.27%), while Vanaraja has the lowest shape index (73.48%). Shell ratios are consistent, with Vanaraja, Rainbow Rooster, and BND showing similar values of 8.56%, 8.50%, and 8.53%, respectively. Table 4 presents the internal egg quality analysis for three chicken varieties—Vanaraja, Rainbow Rooster, and BND—indicating mean values along with standard errors (Mean±SE). In terms of albumen characteristics, Rainbow Rooster eggs exhibited significantly higher values for length (82.77±1.38b) compared to Vanaraja (90.46±0.90a) and BND (83.77±1.43b), while BND eggs showed a significantly greater albumen height (7.59±0.18a) compared to both Vanaraja (6.67±0.14b) and Rainbow Rooster (6.97±0.14b). Albumen weight was highest in Rainbow Rooster eggs (33.93±0.52a), significantly different from Vanaraja (31.40±0.64b) and BND (29.17±0.69c). The albumen index, representing thickness, was significantly higher in BND (10.75±0.37a) compared to Rainbow Rooster (9.71±0.29b) and Vanaraja (8.52±0.22c).

For yolk characteristics, Rainbow Rooster eggs displayed a significantly greater length (44.08±0.46a) compared to Vanaraja (45.05±0.45a) and BND (42.47±0.47b), while Rainbow Rooster (18.09±0.31a) had a higher yolk height compared to Vanaraja (16.18±0.19b) and BND (16.65±0.15b). Yolk weight was significantly higher in Rainbow Rooster (20.93±0.44a) compared to Vanaraja (20.57±0.36a) and BND (17.32±0.24b). The yolk index, indicating yolk roundness, was significantly higher in Rainbow Rooster (42.41±0.83a) compared to BND (40.48±0.56a) and Vanaraja (37.51±0.63b).

Growth performance study of *Barilius tileo* with Indian Major Carps

(*P.L. Lalrinsanga and S. Doley*)

Experiment was conducted to study the effect of incorporation of *Barilius tileo* (Fig 11) along with Indian Major Carps, Catla, Rohu and Mrigal on the growth performance. Two different treatments viz. Control (Catla, Rohu and Mrigal at the same ratio); Treatment I (Catla, Rohu and Mrigal at the same ratio + 20% B. tileo) 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% *B. tileo* in T-I along with IMC in T-II. Sampling was done every 15 days interval and water exchange was carried out every 7 days interval. The study revealed that the final body weight gain in catla (7.43±0.03g) was higher in Control than Treatment group (7.03±0.03g), while the growth of Rohu & mrigal showed no difference (Table 9). The survival of Catla and Mrigal (68.88% & 64.45%) was significantly lower in Treatment compared to Control (71.11% & 73.33%) while no significant difference in survival of Rohu. The final body weight and specific growth rate of *B. tileo* (4.65±0.07g & 0.91±0.01 respectively) was significantly lower than IMCs. The result revealed that incorporation of *B. tileo* affected and reduced the survival of Catla and Mrigal thus suggesting that the species may not be suitable for incorporation.

Table 9. Growth performance of *B. tileo* with Indian Major Carps

Parameters	Control			Treatment			
	Catla	Rohu	Mrigal	Catla	Rohu	Mrigal	B. tileo
Initial body weight (g)	2.45±0.02	1.08±0.04	2.22±0.02	2.32±0.04	2.43±0.02	2.51±0.02	1.81±0.04
Final body weight (g)	7.43±0.03	7.11±0.05	7.09±0.03	7.03±0.03	7.08±0.02	6.88±0.11	4.66±0.07
SGR (%)	1.07	1.33	1.12	1.07	1.03	0.97	0.91
Survival (%)	71.11±2.22	68.89±4.45	73.33±3.85	68.88±4.44	68.89±2.22	64.45±2.23	66.67±3.33

Fig. 11. Indigenous fish of Mizoram, B*arilius tileo*

Studies on the Morphometry and biology of important indigenous fishes of Mizoram

(P.L. Lalrinsanga and S. Doley)

Morphometric and biology studies were conducted for important indigenous fishes including *Cirrhinus reba, Labeo dyocheilus, Garra natusa and Barilius tileo* (Fig 12a & 12b). The morphometric study showed that the fishes could attain large size of 50.61 g in *L. dyocheilus* to 101.51g in *C. reba* indicating the potential for culture of these species. The gut content study revealed that *C. reba, L. dyocheilus* and *B. tileo* are primarily omnivorous in feeding habit while *G. natusa* is more of detritivous feeder and indicated by the maximum contribution by sand and debris along with phytoplanktons. The relative gut length (RGL) was found highest at 10.87 in *G. natusa* whereas it is lowest in *B. tileo* (Table 10).

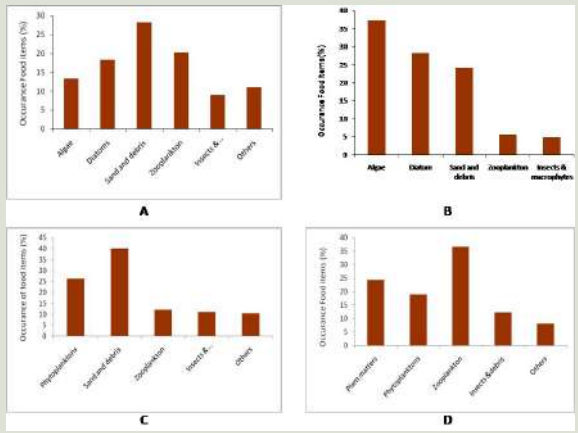


Fig. 12. Gut content of important indigenous fishes

A- Gut content of *Cirrhinus reba*, B- Gut content of *Labeo dyocheilus,* C- Gut content of *Garra natusa*, D- Gut content of *Barilius tileo*

Table 10. Relative gut length of important indigenous fishes from Mizoram

Fish species	Relative Gut Length (RGL)
Cirrhinus reba	2.42±0.56
Labeo dyocheilus	2.35±0.37
Garra natusa	10.87±0.52
Barilius tileo	1.34±0.21

NAGALAND

SUMMARY

Total annual rainfall received during the year 2023 was 1299.7mm, 14% below normal (1515.4mm). Four numbers of Integrated farming system models were evaluated for their remunerative and self-sustainability in respect to soil health. For promotion of intensive vegetable cultivation through efficient utilization of land, labour, water and other resources, various crops are being evaluated to find the best suitability for growing under poly-tunnel cum rain shelter. A survey of 54 homegardens located across three elevation zones in Chümoukedima district revealed significant variation in the size of homegardens along the elevation gradient with the maximum average area (291.46±35.70 m^2)observed in elevation zone 3 (>500), while the minimum area (98.17±181.63 m^2)was recorded in elevation zone 1 (<250 m). In a comprehensive survey of vegetation analysis spanning 54 homegardens distributed across three elevation zones in the Chümoukedima district, species dominance based on the Importance Value Index (IVI) was analysed to identify ecologically suitable and economically viable species for the establishment of an agroforestry model suitable for mid hill subtropical region of Nagaland. Three leguminous tree species, *viz. Gliricidia sepium, Leucaena leucocephala* and *Sesbania grandiflora* were grown to assess fodder production potential 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). 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. The natural screening of 83 rice genotypes for blast disease during 2023 kharif season at the Centre revealed that most of the rice genotypes were found susceptible to blast disease. The disease incidence varied from 20-100% among the genotypes. The mean disease incidence was 71.49% indicating high blast disease incidence. The parent stock of Vanaraja and Srinidhi variety of chicken were reared during the reporting year and a total of 156584 eggs were produced from Vanaraja and Srinidhi birds. From these eggs, 95489 chicks were produced and 92336 chicks were supplied to 1296 farmers. The reporting year began with 57 breedable sows and 13 breeding boars of Rani breed. Altogether 682 piglets were farrowed with a farrowing rate of 71.01%. The improved pig germplasm 558 piglets were disseminated to 87 stakeholders. In addition, 2418 numbers of AI kit in pig were disseminated to 1012 farmers in 97 villages. In the field, 1373 animals were inseminated with the farrowing rate of 73.99% and average litter size of 9.05 (2-17) piglets per litter.

Weather report

Total annual rainfall received during the year 2023 was 1299.7mm, 14%below normal (1515.4mm). Monsoon rainfall was 4% below normal. The distribution of rainfall for the period (except March, June, November and December) was below normal. The most deficit rainfall (which was nil) was observed during the month of January and February only. Total monthly distribution of rainfall compared to normal is depicted in Fig 1. The highest rainfall in a single day was 109.6mm (23rd July, 2023) followed by 57.6mm (8th June, 2023); there were two events of rainfall of more than 50.0mm. During the year the number of rainy days (considering precipitation of more than 2.5mm) was 80 days which was 13% below normal (92 days). The monthly average maximum temperature showed significant departure from normal. Maximum temperature during the period showed increasing trend The highest being 33.7^{0}C observed in September. Highest maximum temperature recorded for a single day was 39.1^{0}C (6th June, 2023) which was the highest maximum temperature ever recorded for a single day since 1998 and the lowest maximum temperature for a single day was 19.3^{0}C (9th December, 2023). However, the monthly average minimum temperature for all the months except February, September, October, November& December was below normal (Fig 2). Highest minimum temperature for a single day was 26.5^{0}C (30th July 2023) whereas the lowest minimum temperature for a single day was 4.0^{0}C (21st January 2023). The variation in the morning relative humidity was much less as compared to the evening relative humidity. Total pan evaporation loss was 1070.6 mm (2.9mm/day) against the total rainfall.

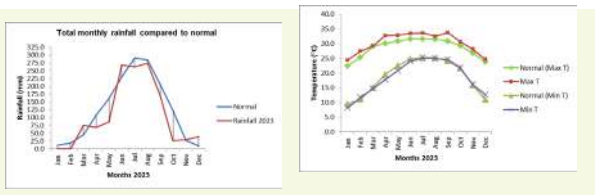


Fig 1. Total monthly rainfall pattern and average temperature

RESEARCH ACHIEVEMENTS

Integrated Farming System (IFS) models for small and marginal farmers of Nagaland

(*A. W. Yanthan, J. Barman, A. Seyie, P. L. Bhutia, C. Aochen, M. Singh, H. Verma and H. Kalita*)

Envisaging income and employment generation round the year, suitable nutrient and biomass management strategy at farm levels and sustainable crop production for improving the livelihood of small and marginal farmers, four (4) integrated farming system (IFS) models were developed and evaluated in Nagaland (Table 1). The highest farm profitability (B:C Ratio) was found in model 1 (2.05) followed by model 2 (1.85), model 4 (1.80) and model 3 (1.64). Highest sustainable value index (SVI) was found in model 1 (0.39) followed by model 4 (0.37). Soil health status also recorded to be improved after 5 years by increasing in organic carbon, available nitrogen, phosphorus and potassium. The models have been successfully replicated and demonstrated in major districts of Nagaland.

Table 1. Comparative studies on four IFS models

IFS Models	Gross Return(₹)	Cost of Cultivation(₹)	Net Return ₹/unit	Benefit: Cost ratio	Sustainable value index (SVI)
Model 1	193162.80	93090.60	100072.20	2.05	0.39
Model 2	177443.50	95618.75	81824.78	1.85	0.35
Model 3	160091.00	98732.60	61358.40	1.64	0.28
Model 4	205209.70	112850.40	62501.30	1.80	0.37

Model 1. Horti + Agri+ fishery + piggery + Vermicompost

Model 2. Horti + Agri+ Fishery + Goatery + Vermicompost

Model 3. Horti + Agri+ Fishery + Duckery + Vermicompost

Model 4. Horti + Agri+ Fishery + Poultry + Vermicompost + Mushroom

Year round cultivation of vegetables under low cost poly-tunnel cum rain shelter

(*A. W. Yanthan, A. Seyie and H. Kalita*)

For promotion of intensive vegetable cultivation through efficient utilization of land, labour, water and other resources, various crops are being evaluated to find the best suitability for growing under poly-tunnel cum rain shelter. Bamboos were utilized for making the structures having dimension of 45 ft. length, 7 feet breadth and 6 ft. height. Transparent UV stabilized plastic sheet of 45 GSM was utilized for roofing and side wall cladding. Development of various cropping sequence for maximum profitability are under progress.

Fig. 2. Tomato under low cost polytunnel cum rain shelter

Table 2. Crops grown round the year under low cost polytunnel cum rain shelter

Crops	Spacing	Planting time	Harvesting time
Coriander	15 cm x 5 cm	March	April
Leafy Radish	15 cm x 5 cm	April	May
Sweet pepper	50 cm x 40 cm	May	August
Palak	15 cm x 5 cm	June	July
Naga mircha	50 cm x 40 cm	July	October
Tomato	60 cm x 45 cm	August	November

An Assessment of Species Diversity and Carbon Stock in homegardens of the Mid Subtropical Zone of Nagaland

(P L. Bhutia, A.Seyie, A. W. Yanthan, N.R. Singh and H. Kalita)

A survey of 54 homegardens located across three elevation zones in Chümoukedima district revealed significant variation in the size of homegardens along the elevation gradient. The maximum average area (291.46±35.70 m^2)was observed in elevation zone 3 (>500), while the minimum area (98.17±181.63 m^2)was recorded in elevation zone 1 (<250 m). The number of species per square meter did not vary significantly, ranging from 0.18±0.025 in EZ 1 to0.31±0.07 in EZ2. Diversity analysis of the woody/ non woody perennials indicated that the Shannon Weiner Index did not vary significantly among different elevation zones. However, species evenness showed significant variations, with the highest value of 0.83±0.02 in EZ 3 and the lowest value of 0.68±0.03 in EZ 1. Species richness also differed significantly, with maximum value of 1.65±0.13in EZ 3 and minimum value of 1.25±0.09 in EZ 1 and value (1.34±0.13) in EZ 2 was at par with EZ 1 and EZ 3. The correlation analysis of homegarden size with species number / m^2 &vegetation indices revealed that homegarden size has negative significant correlation with species number/m^2, species richness and evenness index. A 162 composite soil sample from four depths (0-15 cm, 15-30 cm, 30-45 cm and 45-60 cm) were collected from 54 homegardens along elevation zones to compute the soil organic carbon (SOC) stock. The result revealed that SOC stock varied significantly along the elevation zones as well as among different soil depths (Fig. 3). The maximum average value of SOC (0-60 cm) was found to be 93.64 MgC/ha at elevation zone 3 and minimum average value (0-60 cm depth) of 58.93 at elevation zone 1.

Evaluation of tree legumes for fodder production potentiality in NEH region

(P. L. Bhutia, A. Seyie, M. Singh, P. Sarkar, C. Aochen and 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) (Fig 4). 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.

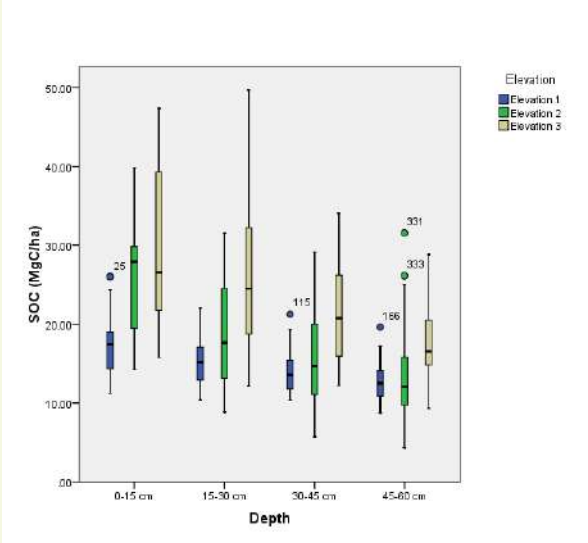


Fig. 3. SOC stock (MgC/ha) distribution at different soil depths along the elevation gradient

(a)

(b)

Fig. 4. Tree legumes Protein bank experimental unit (a) Before basal cut (b) After basal cut

Table 3. Fodder and firewood yield (green weight) of tree legumes after 9 months of planting

Tree species	Green fodder yield per plant (kg)	Green Firewood yield per plant (kg)	Green fodder yield per ha (tons)	Green firewood yield per ha (tons)
Gliricidia sepium	2.54±0.24 a	0.88±0.15 a	50.75±4.81 a	17.55±7.17 a
Leucaena leucocephala	0.89±0.10 b	0.44±0.07 ab	17.71±1.96 b	8.81±3.60 ab
Sesbania grandiflora	1.04±0.10 b	0.39±0.13 b	20.86±1.93 b	7.76±3.17 b

Development of Agroforestry model suitable for the mid-hill subtropical region of Nagaland

(*P.L. Bhutia, A. W. Yanthan, A. Seyie, N.R. Singh and H. Kalita*)

In a comprehensive survey of vegetation analysis spanning 54 homegardens distributed across three elevation zones in the Chümoukedima district, we analysed species dominance based on the Importance Value Index (IVI). Our aim was to identify ecologically suitable and economically viable species for the establishment of an agroforestry model suitable for mid hill subtropical region of Nagaland. This model was established on sloping land in the ICAR Research Complex for NEH Region farm.After analyzing the vegetation of agroforestry systems in the region, the most preferred perennial woody components were identified as *Areca catechu* and *Parkia roxburghii*. However, farmers reported a dieback problem with *Parkia*after harvesting pods for 2-3 years, typically occurring when the tree reaches 10 years of age (although it starts bearing/economical production after 7 years).Farmers tend to grow arecanut due to its easy sale, good price and favorable environmental conditions. Pineapple appears to be a promising option for the understory component.The finalized agroforestry model comprises four major species, including three perennial woody components (*Areca catechu, Parkiaroxburghii,* and *Gliricidiasepium*) and one herbaceous perennial crop (*Ananascomosus*). To address the sloping terrain, miniature terraces were constructed along the arecanut rows (across the slope) for ease of operation and slope management. The plantation of different species were done between mid July to end of August, 2023. The experimental layout in details are given in the schematic diagram below.

Fig. 5. Experimental site: ICAR Res. Complex for NEH Region, Nagaland Centre. Area: approx. 2600 m2, Slope: 63.33%

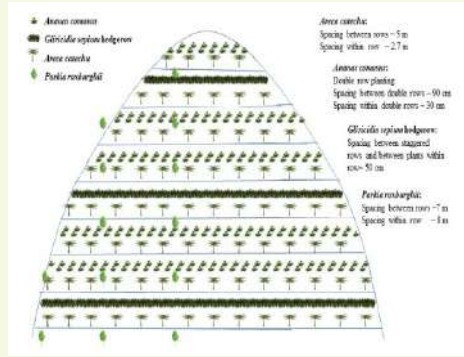


Fig. 6. Schematic diagram of Agroforestry Model

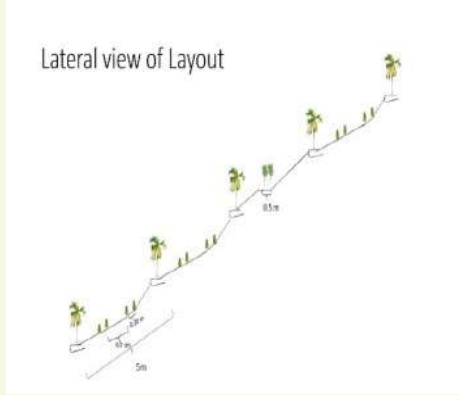


Fig. 7. Lateral view of the Agroforestry Model

Screening and selfing of promising Naga king chilli breeding lines

(A. Seyie and H. Verma)

Promising lines and disease free plants from 5 different types of Naga mircha were selected (around 30-50 plants) and selfed. Various parameters on the growth and yield were recorded for further improvement work.

Fig. 8. Selfing in desirable Naga King chilli plants

Development of HYVs for Nagaland

(H. Verma and C. Aochen)

A total of 7 parents were identified to be used in hybridization programme for the development of rice varieties and crosses were made among these parents in diallel mating design.

Fig. 9. Development of HYVs for Nagaland

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

(H. Verma)

ICAR, Nagaland Centre received a total of 26 entries from the PPV & FRA, New Delhi in the year 2023-24. These 26 entries were evaluated along with 15 reference varieties RCM-9, Pusa Sughand, Ranjit, Sikkim Dhan 1 and Sikkim Dhan 2 during *kharif* season in lowland ecology (Fig.10). Observations were recorded for the 62 DUS characters on 10 randomly selected plants. All the entries were found to be distinct from the check varieties . A total of 10 landraces were collected from Wokha district.

Fig. 10. DUS testing of rice entries under PPV & FRA project

DMT Maize

(H. Verma)

The centre has identified LQMH-1 maize hybrid suitable for the state and has been popularizing this maize hybrid in the state.

Fig. 11. Evaluation of LQMH-1 bio-fortified maize hybrid at the centre

IIOR NEH Component

(H. Verma and H Kalita)

The centre has done quality seed production ofAmritvariety of sesame; LSL-93, Priyam and Parvati varieties of linseedand KBSV-1103 sunflower variety at the Research Farm of the Nagaland Centre during 2023 year (Fig. 12,13,15) and has conducted a field day on quality seed production of sesame (Fig.14).

Fig. 12. Seed production of Amrit variety of sesame

Fig. 13. Seed production of LSL-93 variety of linseed

Fig. 14. Field day on "Seed production of Amrit variety of sesame"

Fig. 15. Seed production of Priyam variety of linseed

Physiological qualities and biochemical properties database of local rice germplasm/varieties of NER

(C. Aochen, H. Verma, A. Kumar, B. Bhattacharjee, G. Ayam Devi, K. Sarika, L. Touthang, L. Singson and L. Devi)

In the reporting year popular varieties and cultivars from Meghalaya were analysed for some of the physicochemical composition as presented in Table 4. Field evaluation of pigmented rice was also taken up during kharif 2023. Collections from Sikkim and Nagaland were processed for further analyses.

Table 4. Physicochemical composition of released varieties and cultivar from Meghalaya

Varieties/ Cultivars	Fat %	Fibre %	Protein %	Amylose %	Resistant Starch%	Tryptophan %
Shasarang	2.47	2.15	9.61	15.6	1.29	1.34
Megha SA2	1.78	3.80	10.01	19.24	1.14	1.113
Bhalum 3	1.62	0.750	8.75	19.2	1.09	0.882
Bhalum 5	2.42	0.833	10.12	18.38	1.29	1.27
Jwain	3.42	0.567	10.59	16.83	0.9	0.809
Mean	2.34	1.62	9.82	17.85	1.14	1.08

Screening of rice genotypes against blast resistance in field conditions

(M. S. Baite, C. Aochen, H. Verma and H. Kalita)

The natural screening of 83 rice genotypes for blast disease during 2023 kharif season at ICAR Nagaland Centre revealed that most of the rice genotypes were found susceptible to blast disease (Fig. 16). The disease incidence varied from 20-100% among the genotypes. The mean disease incidence was 71.49% indicating high blast disease incidence.

Fig. 16. Natural screening of rice genotypes for blast resistance

Collection, isolation, identification of Rice blast disease specimens from different locations in northeast India

(M.S. Baite, P. Sarkar and L. Singson)

Rice blast samples were collected from different was locations in Nagaland, Manipur, Meghalaya, Mizoram, Tripura and Assam (Fig. 17). Isolation of the causal pathogen, *Pyriculariaoryzae* was made using Potato dextrose agar medium and incubated at 26°C. During the survey it was found that rice blast is the major disease causing heavy infection and affecting rice cultivation.

Fig. 17. Rice Blast

Assessment of liquid stored boar semen quality after removing seminal plasma proteins and supplementation with melatonin

(M. Singh, R. Katiyar and G.Kadirvel)

Free radical in the form of reactive oxygen is a double edge sword for boar spermatozoa. In the limited quantity, they regulate the normal physiological functions of spermatozoa including maturation and capacitation. However, excessive production during storage of semen leads decrease in functional competence and poor fertility. To ameliorate the oxidative stress during storage, melatonin was added to boar semen in different concentration. 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 ejaculateswere analysed and then divided into 4 groups namely, Group I (control), Group II (one µM melatonin), Group III (two µM melatonin), Group IV (four µM melatonin). The results revealed that at day 3 semen quality parameters (motility%, live-daed%, acrosomal integrity% and HOST reactive), antioxidant status of semen and spermatozoa and *in-vivo* fertility of group-II were significantly (P<0.05) higher than other three groups. In conclusion, one µM melatonin can be added to boar semen extender to improve its fertility and antioxidant potential.

Conservation and improvement of indigenous cattle in North East of India

(M. Singh)

Under the project, five indigenous female cows and one indigenous male bull was reared under intensive management. In total 1402.5 litre of milk was produced during the reporting year. Reproductive performance and milk parameters are mentioned in Table 5.

Table 5. Reproductive performance and milk quality parameters of indigenous cow

Reproductive performance	
Conception rate (90 days)	100%
Calving rate	100%
Service period (days)	74.4±3.58
Gestation length (days)	283.6±1.69
Calving interval (days)	358±4.04
Milk parameters	
Fat %	4.16±0.22
SNF%	9.64±0.09

Conservation and propagation of indigenous goat germplasm of north eastern hill region of India

(M. Singh)

The goat research unit has 16 female and 3 male adult animals. There were 15 kidding during the reporting year and produced 22 kids (14 males and 8 females). There were three twinning. All the animals were de-wormed and vaccinated against PPR and enterotoxaemia. Growth rate of male and female goats are mentioned in Table 6.

Table 6. Growth rate of male and female goat in Nagaland

Age in months	Male	Female	P-value
Birth	1.32±0.07^{a}	1.13±0.08^{a}	0.12
1	3.24±0.06^{a}	2.23±0.11^{b}	<0.001
2	5.25±0.23^{a}	3.27±0.14^{b}	<0.001
3	6.47±0.22^{a}	4.50±0.18^{b}	<0.001
4	7.90±0.10^{a}	5.97±0.08^{b}	<0.001
5	8.71±0.14^{a}	7.82±0.20^{b}	0.002
6	10.47±0.14^{a}	8.87±0.22^{b}	<0.001
7	12.25±0.17^{a}	9.68±0.15^{b}	<0.001
8	14.02±0.27^{a}	11.53±0.19^{b}	<0.001

Different superscripts in a row represents significant (P<0.05) difference.

Evaluation on production performance through different species combination for enhancing aquaculture production under Nagaland condition

(J. Barman)

Under the project, performance of three species combination for mid-altitude (400-1200 m above msl) and high-altitude (>1200 m above msl) is being studied for their compatibility and suitability for adoption. A combination of *Labeogonius, Puntuisgonionotus* (silver barb) and Amur common carp was followed for mid-altitude. For high altitude, grass carp, Amur common carp and common carp was followed as three species combination. Three treatment involving three stocking densities (T 1-10000; T 2-8000; and T 3-6500 nos. per hectare) with three replications for each treatment was followed for both altitudes. A combination of rohu *(Labeo rohita),*catla *(Catla catla)* and mrigal *(Cirrhinus mrigala)* was used as control for both altitudes. The result obtained so far is being presented in Table 7.

Fig. 18. Performance of species combination in mid altitude and high altitude

Table 7. Performance of three species combination for mid-altitude and high altitude

SN	Species	Mid-Altitude							
		Control		T-1		T-2		T-3	
		SGR* (g/day)	Avg K-factor	SGR* (g/day)	Avg K-factor	SGR* (g/day)	Avg K-factor	SGR* (g/day)	Avg K-factor
1	Catla	1.50 – 1.63	2.09						
2	Rohu	0.58-1.48	1.63						
3	Mrigal	1.34-1.77	1.21						
4	Gonius			0.56-1.47	1.21	0.66-2.05	1.88	1.55-2.08	1.24
5	Silver barb			1.59-2.39	1.62	1.52-2.11	1.83	1.73-2.12	1.59
6	Amur carp			1.65-2.17	2.93	0.85-2.11	2.84	1.73-2.27	2.17
		High-Altitude							
SN	Species	Control		T-1		T-2		T-3	
		SGR* (g/day)	Avg K-factor	SGR* (g/day)	Avg K-factor	SGR* (g/day)	Avg K-factor	SGR* (g/day)	Avg K-factor
1	Catla	2.31-2.67	2.00						
2	Rohu	0.55-1.35	1.52						
3	Mrigal	1.08-2.01	1.60						
4	Grass carp			0.15-1.22	1.46	1.13-1.39	1.34	0.45-1.80	1.52
5	Common carp			1.27-1.52	1.48	1.11-1.29	2.11	1.37-1.78	3.01
6	Amur carp			1.06-1.71	2.80	1.09-2.04	2.14	1.84-2.01	2.78

*data in range for three replications for 171 days

All India Coordinated Research Project on Poultry, Nagaland Centre

(M. Singh)

A comprehensive study on environmental assessment of broiler chicken production in India from a cradle-to farm gate perspective using Life Cycle Assessment (LCA) approach was done. The objective of the study was to identifying environmental *hotspots* in the broiler production system. Inventory data for the broiler chicken farms were collected from six different farms but typical of Indian broiler production system, and background data was sourced from Ecoinvent 3.0 database. For the LCA study, Sima Pro (v 9.3.0.3) was used with ReCiPe 2016 Midpoint impact assessment methodology. For this study, functional unit of the"1-

kg live weight chicken produced was taken into consideration". Results showed that broiler chicken feed was primarily responsible for environmental impacts, followed by transportation and electricity. Broiler chicken production had a total GWP of 3.77 kg CO2-eq per kilogram of live weight. Specifically, the energy component of feed viz. production of maize was the main source of environmental impact. The process of transporting feed and chicks to the broiler farm also had a significant impact on the environment. The broiler production system was found to have moderate environmental impacts compared to other published LCA studies of chicken production. Besides, the parent stock of Vanaraja and Srinidhi variety of chicken were reared during the reporting year. A total of 156584 eggs were produced from Vanaraja and Srinidhi birds. From these eggs, 95489 chicks were produced and 92336 chicks were supplied to 1296 farmers.

All India Coordinated Research Project on Pig, Nagaland Centre

(M. Singh)

The variation of gestation length in sows leads to difficulties performing farrowing supervision in commercial farms. An experiment was done to evaluate the effectiveness of prostaglandin F_2alpha ($PGF_2\alpha$) administration on farrowing induction in swine. The sows (n=50) were randomly divided into two groups. In group-1, sows (n=25) were injected with placebo intramuscularly (one mL sterile water) on 113thday of gestation at 8.00 am in the morning. In group-2 (n=25), cloprostenol sodium (250 mcg) was injected intramuscularly on 113thday of gestation at 8.00 am in the morning. Gestation length was significantly ($p<0.05$) shorter in Group-2 compared to Group-1. Similarly, the interval from PGF2α administration to onset of farrowing was significantly ($p<0.05$) shorter as compared to natural farrowed sows. Farrowing duration was not differ significantly ($p>0.05$) between two groups. There was no effect of PGF2α administration on NTB, NBA, stillbirths, mummified fetuses. The numbers of alive piglets at day 3 of lactation were also similar between two groups ($p>0.05$). In conclusion, PGF2α administration on 113thday of pregnancy could be an option for controlled farrowing in swine without any adverse effects.

Another study was conducted with the objective to describing the pig production system, farm management, pig movement, and existing biosecurity level of smallholders' pig production in Nagaland. A cross-sectional survey of 1,000 pig producers in four districts (two urban and two rural) in core pig-producing regions of India, where ASF occurrence had been reported, was conducted. The mean pig population was significantly ($p < 0.05$) higher in urban districts. The majority of the respondent purchased (91%) or sold (60%) the pigs during the past 12 months. Swill feeding was common in the entire study area. The majority of the respondents (80%) in rural districts were unaware of ASF. Significant pig trade of live pigs and pork products was observed in the urban district. In the case of on-farm biosecurity measures, only 6.9% of respondents had fencing for the pig farm, 99.3% did not have provision for a footbath, and only 17.2% of the respondents restricted visitors' access to the pig farm. The study revealed that the pig production system is dominated by smallholding units with a frequent introduction or exit of pigs along with poor on-farm biosecurity measures. With the current level of farm management and biosecurity practices, smallholder pig farmers are at an increased risk of ASF and other contagious diseases. The reporting year began with 57 breedable sows and 13 breeding boars of Rani breed. Altogether 682 piglets were farrowed with a farrwoing rate of 71.01%. The improved pig germplasm 558 piglets were disseminated to 87 stakeholders. In addition, 2418 numbers of AI kit in pig was disseminated to 1012 farmers in 97 villages. In the field, 1373 animals were inseminated with the farrowing rate of 73.99% and average litter size of 9.05 (2-17) piglets per litter. A total of 9195 numbers of improved piglets were produced in the farmer's field through artificial insemination.

AICRP on Mushroom

Collection, characterization and spawn production of Mushrooms

(M.S. Baite, A.W. Yanthan, A. Seyie, P. L. Bhutia, C. Aochen, H. Verma, S. R. Assumi and H. Kalita)

Three wild mushroom species (*NL 23-01, NL 23-02 and NL 23-03*) were collected, isolated, identified based on morphology and cultures were sent to DMR, Solan for grant of accession numbers (Fig.19). Apart from conducting the AICRP mushroom experiments, Mushroom spawns are also produced on demand basis and supplied to the farmers at ICAR Nagaland Centre, Medziphema. Evaluation of six different

strains of oyster mushrooms under AICRP Mushrooms are undergoing for yield performance and other morphological characteristics (Fig. 20).

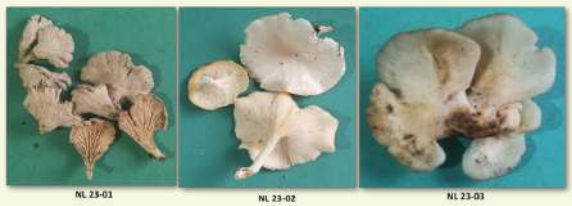


Fig. 19. The three wild mushrooms identified and sent to ICAR-DMR, Solan

Fig. 20. Evaluation of oyster mushroom under AICRP Mushrooms at ICAR Nagaland Centre

Farmers' participatory seed production

(H.Verma and H. Kalita)

The centre is conducting training and field days to enhance the quality seed production through farmers' participatory seed production approach under Seed Project, 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 8. Truthfully labeled (TFL) seed produced at ICAR research farm and at farmers' fields in farmer's participatory mode

Crop/variety	Variety	TFL Seed produced(q) (2021-22)	Foundation seed production (q) (2021-22)
Rice	RCM-9 & RCM-13	300	6
Maize	RCM-76	10	
Toria	TS-67 and TS-36	100	4
Sesame	Amrit, Prachi	20	3
Field Pea	Azad	2	
Green Pea	Arkel	2	
Linseed	Parvati, Sharda and Ruchi	5	
Sesame	Amrit and Prachi	6	
Greengram	Pratap	10	

Frontline demonstration on scientific potato cultivation in Nagaland

(A. W. Yanthan, A.Seyie, P. L. Bhutia, R. S. Assumi, M S. Baite and H. Kalita)

Scientific cultivation of potato in Nagaland was promoted in collaboration of ICAR- CPRI, Shillong center. 3 tonnes of potato Cv. Kufri Pukhraj was distributed covering an area of 1.5 Ha in Dimapur and Chumoukedima districts benefitting 10 farmers.

Fig. 21. Hands on training and demonstration on scientific potato cultivation

SIKKIM

SUMMARY

Significantly higher maize equivalent yield (12.7 t/ha), system total production (16.8 t/ha), system gross returns (312.1 x 10^3 ₹/ha), system net returns (226.9 x 10^3 ₹/ha) were noticed under 100% recommended dose from organic sources of nutrients to each crop as compared to other treatments but remained at par with 100% recommended dose of nutrient for first crop + 75% recommended dose of nutrient for second crop. Two maize composite varieties namely, SKMC- 3 (KDM-34) and SKMC- 4 (KDM-35) has been identified for release under organic conditions of Sikkim. A total of 23 breeding lines of buckwheat were developed and these lines were evaluated for yield and other attributes. *Fusarium oxysporum* has been identified as the causal agent of wilt in Dalley Khursani (Gene bank accession number: OR467445). Biochemical analysis of the dried product of Nakima was also carried out and the highest phenol (2.68g GAE/100g), total flavonoids (1.71g QE/100g), and antioxidant activity were recorded by the treatment shade drying without blanching. *CitSAUR06, CitSAUR08, CitSAUR44, CitSAUR61*, and *CitSAUR64* are abscission-inducing genes that are down-regulated in Sikkim mandarin when seaweed sap is applied. Aggregate stability of soils collected from bamboo plantation was almost equivalent to natural primary forest soils, irrespective of altitudinal variation in Sikkim Himalaya. The growth performance of large cardamom was in accordance with NPOF packages + *Trichoderma viride* > NPOF packages + biochar > NPOF packages > Natural Farming > Mixed compost > VC @ 5.0 kg + FYM 5.0 kg/clump + biochar > control.

Weather report

Total rainfall received during January, 2023 to December, 2023 was 2661.2 mm; maximum rainfall was recorded in the month of August (495.90 mm), whereas minimum rainfall was recorded in the month of December (7.70 mm). The maximum temperature (29.6 °C) was observed in September and the minimum (7.49 °C) in January. The maximum relative humidity of 90.29 % was observed during July month and the minimum was observed in January (44.32 %). The maximum bright sunshine hours 3.91 hr was recorded during October, and the minimum during January 0.53 hr (Fig. 1).

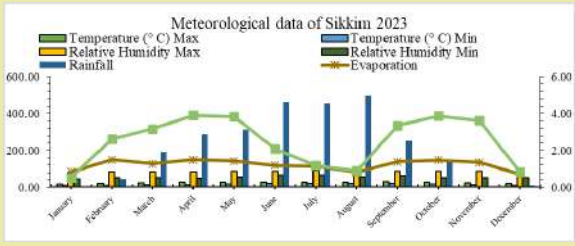


Fig. 1. Meteorological data of ICAR Sikkim Centre

RESEARCH ACHIEVEMENTS

Development of organic nutrient management packages for intensified maize based cropping sequences

(A. Kumar, S. Saha and T. L. Bhutia)

The experiment was conducted at Research Farm of ICAR Sikkim Centre, Tadong, Gangtok, Sikkim. The experiment comprised of two cropping systems like CS_1:Maize-Vegetablepea; CS_2: Maize-French bean and five organic nutrient management practices *viz*., N_1:100% recommended dose from organic sources of nutrients to each crop; N_2-100% recommended dose of nutrient for firstcrop+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 first crop + 75% recommended dose of nutrient for second crop; N5-FP were laid out in Factorial Randomized Complete Block Design (FRCBD) with three replications. Results showed that among the different cropping systems significantly highest maize equivalent yield (11.7t/ha), system productivity (12.9 t/ha), system total production (16.1 t/ha), system gross returns (296.3 x10^3 ₹/ha), system net returns (220.7 x 10^3 ₹/ha) and system B:C ratio (2.92) were recorded under Maize-Vegetable pea cropping system as compared to Maize-French bean cropping system. In case of organic nutrient management practices highest system productivity (11.2 t/ha) was recorded under N_1, which was statistically at par with N_2 and N_4; and significantly higher than other treatments. However, significantly higher maize equivalent yield (12.7 t/ha), system total production (16.8t/ha), system gross returns (312.1x10^3 ₹/ha), system net returns (226.9 x 10^3 ₹/ha) were noticed under N_1 as compared to other treatments, but remained at par with N_2. Whenever, maximum system B:C ratio (2.83) was recorded under N_4 which was significantly higher than remaining treatments, respectively.

Development of organic nutrient management packages for intensified rice-based cropping sequences

(A. Kumar, S. Saha and T. L. Bhutia)

The experiment was conducted at Research Farm of ICAR Sikkim Centre, Tadong, Gangtok, Sikkim. The experiment comprised of three cropping systems like CS_1: Rice-Vegetable pea-Maize; CS_2: Rice-Vegetable pea-Maize; CS_3: Rice-Fenugreek-Maize and 04 organic nutrient management packages *viz*., N_1: 100% recommended dose from organic sources of nutrients for each crop; N_2: 100% first crop, 100% second crop, 75% third crop; N_3: 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. Results showed that among the different cropping systems significantly highest maize equivalent yield (16.2 t/ha) was noticed under Rice-Vegetable pea-Maize followed by Rice-Fenugreek-Maize. Significantly maximum system productivity (21.3 t/ha), system total production (25.1 t/ha), system gross returns (485 x10^3 ₹/ha), system net returns (352 x 10^3 ₹/ha) and system B:C ratio (2.65) were recorded under Rice-Fenugreek-Maize cropping system as compared to other cropping systems. In case of organic nutrient management practices highest rice equivalent yield (17.2 t/ha), system productivity (22.8 t/ha), system total production (26.3 t/ha), system gross returns (509x10^3 ₹/ha), system net returns (367x10^3 ₹/ha), maximum system B:C ratio (2.63) was recorded under 100% recommended dose from organic sources of

nutrients for each crop which was statistically at par with 100% first crop, 100% second crop, 75% third crop and significantly higher than other treatments.

Development of productive and genetically broad based inbred lines from local maize germplasm of North Eastern India for evolving superior hybrids

(*E. L. Devi, R. Devadas and S. K. Das*)

Diverse inbred lines developed: A total of 452 inbred lines has been developed under this project and 52 lines have completed 4th generations of selfing. Three of our lines *viz*. MZ 46 (B), MN 13 and MN 3 have secreted mucous in the roots and these lines are under process of registration (Fig. 2). Two maize composite varieties namely, SKMC- 3 (KDM-34) and SKMC- 4 (KDM-35) has been identified for release under organic conditions of Sikkim. Sikkim Maize Composite-3 (SKMC-3) was developed from pool C4, syn-1 and yellow maize pool of Sikkim with the objective to evolve high yielding medium duration maize composite for organic conditions of Sikkim with inherent disease tolerance. The entry was tested in State Trials during 2022 & 2023 and recorded yield superiority of 19.1% and 33.4%, respectively over best check. The entry was tested at two locations during 2022 and at five locations during 2023 and recorded an average yield of 38.70 q/ha and 42.30 q/ha, respectively during both the years with a mean of 40.50 q/ha.

Fig. 2. Cobs and grains of SKMC-3

The maize composite variety, Sikkim Maize Composite-4 (SKMC-4) was developed from pool 42, C-6 and hill early yellow pool with the objective to evolve high yielding medium duration maize composite for organic conditions of Sikkim. The entry was tested in State Trials during 2022 and 2023 and recorded yield superiority of 11.3 % and 27.4 %, respectively over best check. The entry was tested at two locations during 2022 and at five locations during 2023 and recorded an average yield of 35.60 q/ha and 40.40 q/ha, respectively during both the years with a mean of 38.0 q/ha (Fig. 3).

Fig. 3. Cobs and grains of SKMC-4

Development of high yielding rice (*Oryza sativa* L.) varieties with biotic and abiotic stress resistance for organic conditions of Sikkim

(*E. L. Devi, R. Devadas and S. K. Das*)

During *Kharif,* 2023, 100 F_2 plants from the cross IET 26596 x IR-144 were selected based on yield attributing traits and disease reaction. Total number of effective tillers in the selected lines ranged from 6 to 21 (Fig. 4). A HYV, Chirakey Selection-1 (IET 30517) has been identified for state release under organic conditions of Sikkim (Fig. 5). It was developed at ICAR Research Complex for NEH Region, Sikkim centre, Tadong through pure line selection from local *Chirakey*. It has yield superiority of 10.4 % over the best check. It is found to have moderately resistant to neck blast and Rice Tungro disease and resistant to Sheath rot disease (Table 1).

Fig. 4. Promising F2 plants selected from cross (IET 26596 x IR-144)

Table 1. Quality parameters of paddy variety (IET 30517)

Parameter	Value
Grain type	Short medium
Hulling percentage	75.42 %
Milling percentage	68.0 %
Head rice recovery	60.37 %
Chalkiness percentage	20.0 %
Alkali spreading value	5.0
Amylose content	8.65 %
Amylopectin content	91.35 %
Grain length	5.1 mm
Grain Breadth	2.0 mm
L/B ratio	2.6

Fig. 5. Chirakey Selection- 1

Development of nutri-rich and high yielding buckwheat varieties

(R. Devadas, E. L. Devi and S. K. Das)

A total of 23 breeding lines of buckwheat were developed and these lines were evaluated for yield and other attributes (Fig. 6). A high level of phenotypic variations was seen between the lines in terms of plant height, stem (Fig. 7) and leaf margin coloration, leaf shape, number of branches, cyme length, days to maturity *etc*. 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. Maintenance & seed multiplication of promising Buckwheat lines

Fig. 7. Sikkim Buckwheat 7

Assessing the impact of land use systems on soil physical properties influencing soil erosion process under contrasting agro-climatic regions in Sikkim Himalaya

(*S. Saha and A. Kumar*)

Land use specific soil sample analysis confirmed the least stability for soils under long term rice mono-cropping. However, aggregate stability of soils collected from bamboo plantation were almost equivalent to natural primary forest soils, irrespective of altitudinal variation in Sikkim Himalaya (Fig. 8). The exponential relationship of SOC% (R = 0.89; Fig. 11a) was in sharp contrast with the linear proportion of clay % (R = 0.48; Fig. 9) when plotted against aggregate stability index. Higher values of aggregate stability index indicate better soil health and less proneness to soil erosion under similar slope gradient and other topographical conditions.

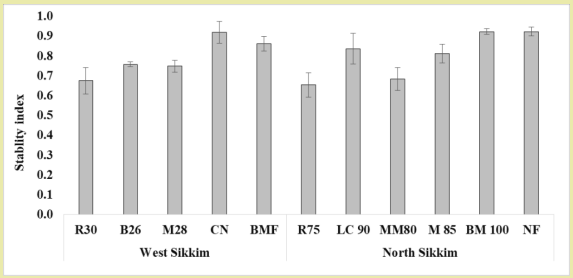
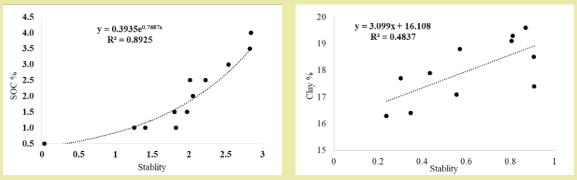


Fig. 8. Soil aggregate stability index for different land use systems in Sikkim Himalaya



(a) (b)

Fig. 9. Dependence of soil aggregate stability on (a) soil organic carbon content % (b) clay content %

Note: *Different land use system includes rice fallow systems 30 years (R30), broom grass 26 years (B26), orchards mandarin 28 years (M28), conifers forest (CN), bamboo dominated mixed forest (BMF) type of land use systems in West Sikkim(subtropical-mesic); Lowland rice mono-cropping 75 years (R75), Large cardamom 90 years (LC90), Mandarin orchard 85 years (M85), Maize + millet 80 years (MM80), Bamboo orchards >100 years (BM100), Primary forest (PF) type of land use systems in North Sikkim(Subtropical – thermic)*

Nutrient synchronization with crop demand, agro-energetics and quality analysis in Large Cardamom under organic system

(*S.K. Das, S.K. Dutta, T.L. Bhutia, A. Kumar and R. Krishnappa*)

Sikkim is the largest producer of large cardamom and contributes lion's share to the Indian and world market. An experiment entitled nutrient synchronization with crop demand, agro-energetics and quality analysis in Large Cardamom under organic system was started during the year 2023 (July) as per approved IRC-2023 (Fig. 10). New suckers of large cardamom have been planted as per the plan of experiment. Observations recording has been started for organic nutrient sources, lime and micronutrient (B & Mo) application for higher large cardamom yield; energy budgeting and emergy synthesis; quality and bioactive compound variability; profiling root exudates, N and P dynamics/fractionations etc. Data analysis is also going on for further evaluation and conclusion.

Fig. 10. Planting of and manuring in large cardamom

Flower and fruit drop studies in Sikkim mandarin under organic management practices

(*S. K. Dutta, S. K. Das and T. L. Bhutia*)

Flower and fruit drop in mandarin (*Citrus reticulata*) is a major problem worldwide and their organic management is a major challenge. Sikkim is a completely organic state in India and mandarin grown in the state is locally known as 'Sikkim mandarin'. In this study, we have characterised the flower and fruit drop in Sikkim mandarin (*Citrus reticulata*) and attempted their organic management under mid-altitude Himalayan conditions (Fig. 11). The study's data showed that Sikkim mandarin plants older than fifteen years had greater rates of flower and fruit drop. Furthermore, compared to retained fruits, dropped fruits had smaller fruit diameters and lower fruit carbohydrate concentrations. Boron was found to be a constraining element in the soil and plant, which results in the Sikkim mandarin flower and fruit drop (Fig. 12). The study's findings indicated that using seaweed sap treatments on a monthly basis would enhance the morphological, physiological, and biochemical qualities of Sikkim mandarin while also raising their market value. *CitSAUR06, CitSAUR08, CitSAUR44, CitSAUR61*, and *CitSAUR64* are abscission-inducing genes that are down-regulated in Sikkim mandarin when seaweed sap is applied. In all four study locations (Lingey Payong, South Sikkim; Thingling-3, West Sikkim; and Dzongu, North Sikkim), the foliar spraying of various seaweed sap treatments significantly affected net return, production, and economic efficiency. To find out how seaweed sap affects mandarin's overall performance over the long run, more research may be conducted in various locations and over longer durations (Fig. 13).

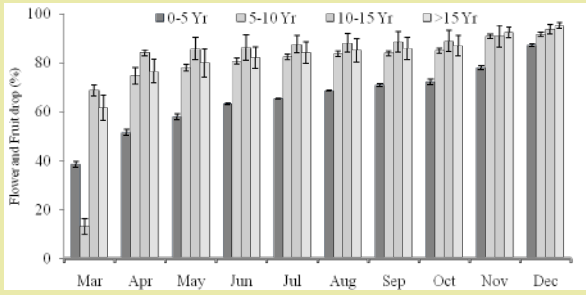


Fig. 11. Flower and fruit drop in Sikkim Mandarin of different age groups (0-5 years, 5-10 years, 10-15 years and > 15 years old) at different interval of times

The vertical bar represents the standard error of mean. For age: F value=615.17**, for month: F value=164.89** and for age X month: F value=15.85**. ** means significant at *P*< 0.001

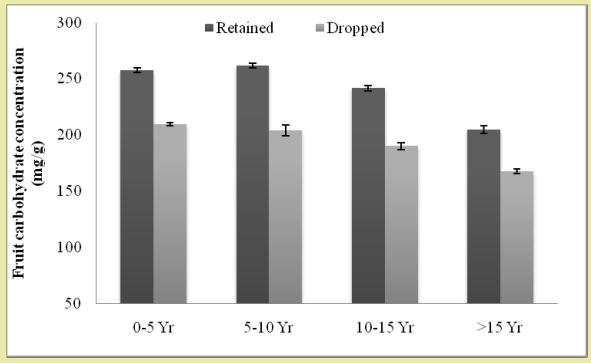


Fig. 12. Fruit carbohydrate concentration in different age groups (0-5 years, 5-10 years, 10-15 years and > 15 years old) of Sikkim mandarin plantations

The vertical bar represents the standard error of mean. For retained/dropped: F value=282.18**, for age: F value=236.84** and for retained/dropped X age: F value=23.78**. ** means significant at *P*< 0.001

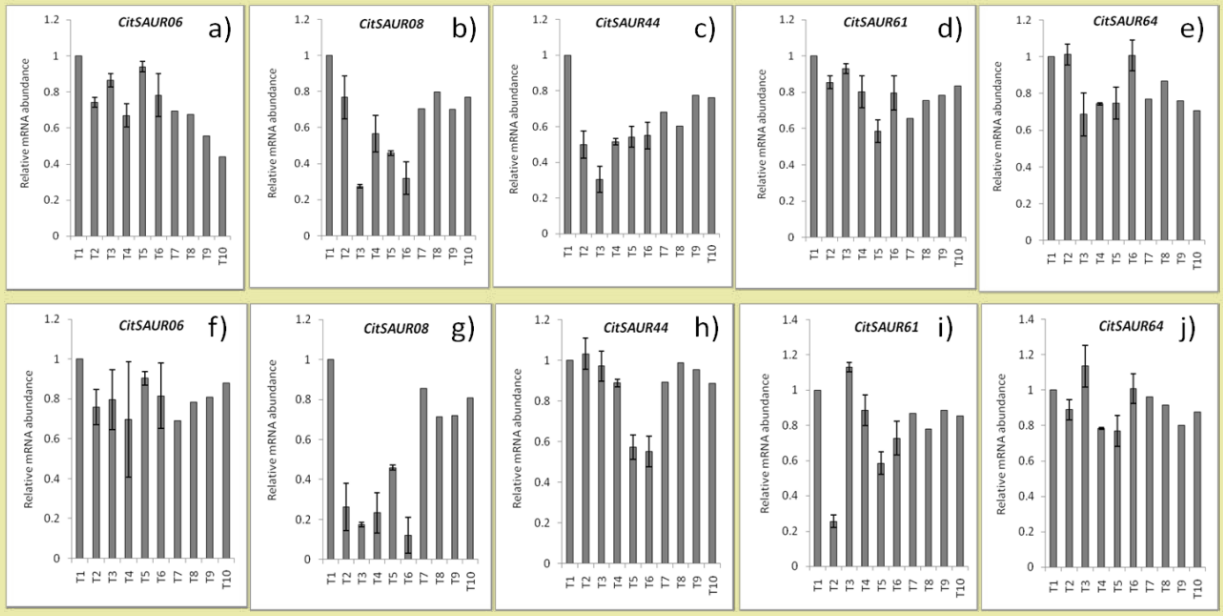


Fig. 13. Relative expressions of abscission genes (*CitSAUR06, CitSAUR08, CitSAUR44, CitSAUR61* and *CitSAUR64*) in a-e) leaves and f-j) pedicels of *Citrus reticulata* by qRT-PCR after foliar application of different sea weed saps

T_1: Water spray (control), T_2: 5% KA sap, T_3: 10% KA sap, T_4: 5% GE sap, T_5: 10% GE sap, T_6: 5% AN sap, T_7: 10% AN sap, T_8: 10% KA sap +75% DON, T_9: 10% GE sap +75% RDON and T_{10}: 10% AN sap +75% RDON. Data are means ± SeM of n = 3 biological replicates.

Collection and characterization of under- utilized vegetables of North East India and Darjeeling Himalayas

(*T. L. Bhutia and S. K. Dutta*)

Table 2. Morphological characteristics of *Dalley Khursani*

Characteristics	Character	Type	No of Genotypes
Flower characteristics	Corolla color	White	01
		Light Yellow	01
		Yellowish green	26
	Corolla shape	Rotate	28
	Corolla spots colour	Absent	27
		Present	01 (yellow greenish spot)
	Calyx margin	Dentate	25
		Intermediate	03
	Anther colour	Purple	27
		Yellow	01
	Stigma exertion	Exerted	27
		Same level	01
	Flower position	Drooping	10
		Semi drooping	15
		Erect	03

Characteristics	Character	Type	No of Genotypes
Fruit characteristics	Fruit shape	Almost round	05
		Triangular	10
		Moderately triangular	01
		Blocky	09
		Cordate	02
		Circular	01
	Fruit curvature	Absent	28
	Fruit neck at basal end	Absent	28
	Fruit surface	Smooth	24
		Slightly rough	04
	Fruit colour at ripe stage	Dark red	01
		Red	24
		Orange	03
	Fruit shape at apex	Blunt	23
		Pointed	03
		Acute	01
		Depressed	01

Morphological characterization of 28 lines of *Dalley Khursani* was characterized. The minimum days taken for first flowering were recorded by WS-3 (39 days), followed by ES-5 (42 days). The highest fruit length (3.72 cm), fruit diameter (2.63 cm) and average fruit weight (5.03g) was recorded by WS-6 while the maximum plant height at final harvest was recorded by WS-2 (105cm). Dalley Khorsani is being affected by a wilt disease which is becoming a major concern in all Dalley growing areas of Sikkim (Table 2). A crop loss up to 80% was observed in the village Thanka, East Sikkim. Hence, to identify the casual organism of this disease infected sample as well as soil was collected and cultured. Based on morphological and molecular characterization, *Fusarium oxysporum* has been identified as the casual agent of this wilt, and the sequence has been deposited in GenBank under accession number OR467445 (Fig. 14).

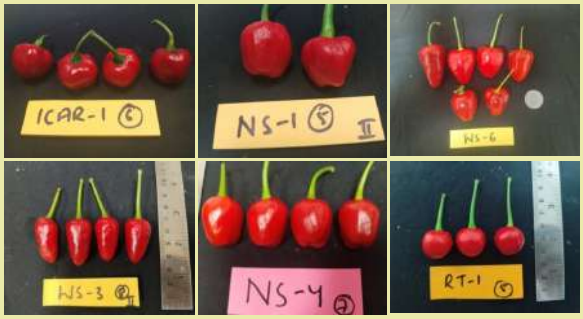


Fig. 14. Different fruit shapes of dalley khorsani

Nakima (*Tupistra clarkei*)

The flower of Nakima is available for very short duration hence to make it available throughout the year; a value-added product like dried flower was developed (Fig. 15). In this experiment, *Tupistra clarkei* flowers were dried with different drying methods *viz.*, sun drying, solar drying, shade drying and oven drying along with blanching and without blanching. Biochemical analysis of the dried product was also carried out and the highest phenol (2.68 g GAE/100g), total flavonoids (1.71g QE/100g), and antioxidant activity were recorded by the treatment shade drying without blanching.

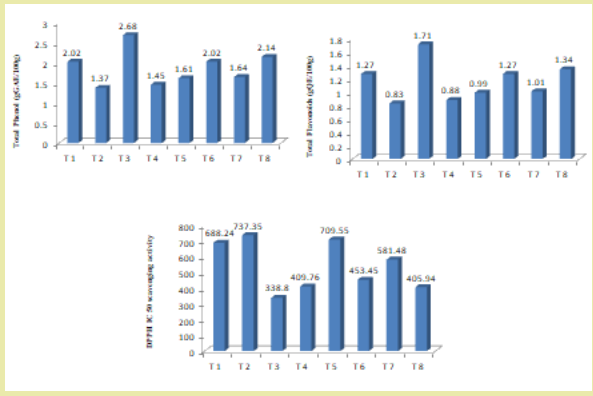


Fig. 15. Biochemical profile of Value added product (Dehydrated flower) of Nakima

AICRP (Paddy) IVT/AVT Mid (Hills) Trials

(*R. Devadas, E. L. Devi and S. K. Das*)

AICRP Trial (Paddy) received evaluation trials was sown in April, 2023 and transplanting was done in June with IVT lines (23 no.), and AVT-I (9 entries). Evaluation and multiplication was done for IRRI lines and RC lines part from seed multiplication for institute released varieties. Four early flowering and 5 late flowering AICRP lines were multiplied for further evaluation (Fig. 16).

IVT (Paddy) **IVT (Paddy)**

Fig. 16. AICRP (Paddy) IVT/AVT Mid (Hills) Trials

TRIPURA

SUMMARY

One rice variety NICRA Aerobic Dhan 2 was released by CVRC for aerobic condition in the states of Bihar and Haryana. Seventeen rice entries developed under NICRA and one entry from IRRI-NARES Breeding Network Project has been nominated to AICRIP trials. Eighteen coordinated trials (IVT & AVTs) were also conducted during the period and promising entries were identified for Tripura. Seventy-two entries of mung bean have been bulked for nomination to AICRP MULLaRP, RCRT and State trial. A low-cost portable backyard small hatchery assembly has been developed. Plant growth response was found to be dependent on the available Fe concentration within plants which is not only influenced by the environmental Fe concentration but also P concentration in case of rice. Total 59.5 q breeder seed and 206 q TL seed of released varieties are produced under ICAR Seed Project. Nine villages covering 4 districts of Tripura have been selected for adoption of technologies developed by ICAR Tripura Centre. Tuber based multistorey cropping system was designed with commercially important vine crops teasel gourd and ridge gourd in summer and Hyacinth bean and Bottle gourd in winter. Promising brinjal germplasm has been identified in terms yield, fruit shape and size. Multi-tier based sustainable agroforestry system for uplands of Tripura has been developed and is being assessed and refined. Promising groundnut varieties (KDG-123, HNG-69 etc.) have been identified for cultivation under Tripura conditions. Six Biofortified maize hybrids were evaluated under organic and conventional system. Comparative evaluation of fertility and hatchability of different chicken germplasms has been done and highest fertility was found in Coloured broiler. Carcass quality traits in case of Kadaknath were evaluated after supplementation of feed with *Wolffia* (10%). The average Fe in the different water bodies of Tripura ranged from 0.3-1.8 mg/L and the highest concentration of Fe was recorded in the winter season. A single plant of *Eichhornia* reduced 30 ppm Fe from 100 litres of water in a span of 8 days. EDTA at 20 ppm improved hatchability and survivability of eggs and spawn for both *Cyprinus carpio* and *Labeo rohita*. Total 24386 poultry germplasms were supplied among 559 farmers.

Weather report

(D. Daschaudhari)

Overall, 1795.9 mm rainfall in 80 rainy days was received against total pan evaporation losses of 811.5 mm (2.2 mm/day) during the year 2023. There were 9 events of rainfall more than 50 mm and 3 events of more than 100 mm in 24 hours. In comparison to long period average (LPA), the total rain during 2023 was deficit (77.4 percent of LPA). During summer (Apr & May) rain was only 25 percent of the LPA followed by winter (Jan to Mar) 73.7 percent, Monsoon (Jun to Sep), 89.4 percent. During winter rain was 136.3 percent of LPA. Out of 12 months, rain was Normal (±19 percent of LPA) during March, June, August, November and December. Unprecedented rain recorded during November and December (> 300 percent of LPA).

Mean monthly maximum air temperature varied from 25.1^{0}C during January to 34^{0}C during August while mean monthly minimum temperature varied from 9.1^{0}C during January (10.7% below normal) to 23.4^{0}C during July& August (4% below normal). Yearly mean maximum temperature recorded 3.2% above normal (31.7^0 C) while yearly mean minimum temperature recorded 18.4^0 C which is 5.7% below normal.

The anomaly of seasonal mean maximum temperature recorded lowest during post monsoon (0.2 percent below normal) followed by monsoon (3.5 percent above normal) and winter (4.3% above normal) and highest during summer (5.8% above normal). Seasonal mean minimum temperature recorded lowest during post monsoon (9% below normal) followed by 6 percent and 5 percent below normal during summer and winter. 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 11% less than normal. During winter months (Jan to Mar) sunshine was 25 percent below the normal. During July the average monthly sunshine hour was 38 percent above normal.

Mean monthly maximum relative humidity in the morning throughout the year remains above 90 percent while in the evening humidity ranges from 48 % in the month of April to 81 % during August. Relative humidity in the evening during winter (Jan to Mar) remains below 50 percent. During the entire period, 62 times the morning humidity recorded 100 % while during afternoon it was seven times.

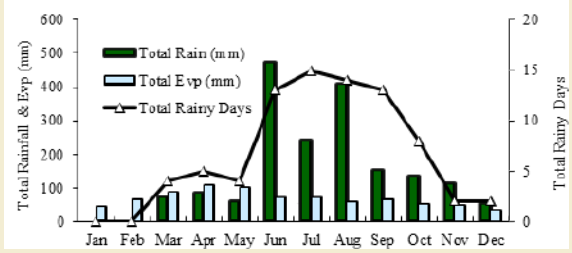


Fig. 1. Monthly variation in Evaporation, Rain and Rainy Days

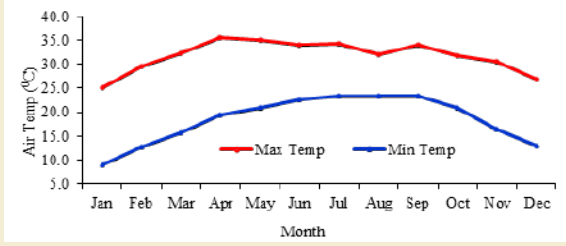


Fig. 2. Monthly variation of Temperature (Max & Min)

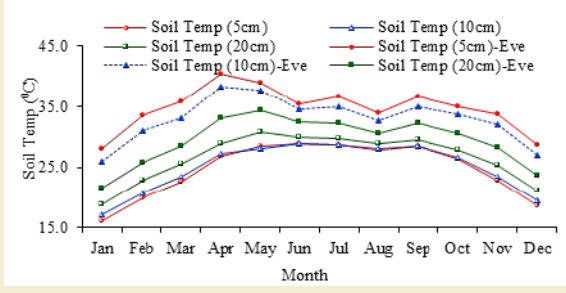


Fig. 3. Monthly variations in Soil Temp at different depths

Rice Improvement / All India Coordinated Rice Improvement Project

(A. G. Devi and R. Kumar)

One Variety released by CVRC

NICRA Aerobic Dhan 2 (TRC 2020-14/ IET 29409) has been released by the CVRC for aerobic condition in the states of Bihar and Haryana. The variety yielded 4.2 t/ha under aerobic condition and showed yield advantage of 17.47% over national check (NC), 8.01% over regional check (RC) and 5.30% over local check (LC).

Fig. 4. NICRA Aerobic Dhan 2 released by CVRC for aerobic condition in the states of Bihar and Haryana

Nominated rice entries in AICRIP during Kharif 2023

Total 15 entris were nominated to AICRIP IVT trials in five different segments viz. irrigated medium maturity (IM), aerobic (Aerob), late maturity (L), medium slender (MS) and rainfed shallow lowland (RSL) on the basis of their superior performances in the two years station trials.

AICRIP Trials–Varietal Improvement 2023

Eighteen coordinated trials (IVT & AVTs) were also conducted during the period and 677 IETs of rice were evaluated for different segments in replicated trials and data reported to AICRIP Rice. Promising entries were identified for Tripura.

One IRRI-NARES Breeding Network Project

Two entries viz. *TRC 202351/IR 126999-B-32-2-1-3* and *TRC 2023-52/ IR18A1042* were nominated to AICRIP IVT trials in irrigated mid early (IME) and irrigated medium maturity (IM)segment based on superior performance in the two years station trial.

Pulses improvement & AICRP MULLaRP

- In mung bean, seeds of 72 promising entries have been bulked for nomination to AICRP MULLaRP, RCRT and State trial. In addition, mungbean lines selected from 39 cross combinations are advanced and are in F5 to F9.
- In urd bean, seeds of 15 promising entries have been bulked for nomination to AICRP MULLaRP, RCRT and State trial. Selected lines from 20 cross combinations are advanced and are in F5 to F9.

AICRP on Rice fallow/Spring/Summer pulses

- Two coordinated trials (IVT & AVT 1) in mungbean were conducted during spring season and total 27 entries were evaluated. In IVT trial 7 entries viz. IPM 1707-1, BCM 20-45, JLPM 818-8, PM 1711, PMS 9, BCM 20-50 and RMG 1196 were found to be promising for Tripura and showed a yield superiority ranging from 13.38% to 37.67% over the check varieties Virat and SML 1115.

AICRP on Kharif Pulses

- One coordinated trial (AVT+IVT) in urdbean were conducted comprising of 18 entries. Four entries viz. KU (23-1), KU (23-8), KU (23-10) and KU (23-30) were found to be promising for Tripura with a yield advantage of 13.3 to 20 % over the best check variety (Tripura Maskolai).
- Two coordinated trials (AVT 1and IVT) in mungbean were conducted during kharif season. In the AVT 1 trial, out of the 8 entries evaluated two entries viz. KM 23-1 and KM 23-4 were found to be promising.In the IVT trial, total 35 entries were evaluated and 4 were found to be promising (KM 23-26, KM 23-44, KM 23-46, KM 23-54, KM 23-61 and KM 23-64).

AICRN on Potential Crop

Varietal trial (IVT) comprising of four entries was conducted. In addition, total 70 germplasm was evaluated for eight quantitative traits.

Understanding the physiological mechanism for P uptake in rice under iron toxic environment

Hydroponic experiment was set up to standardize the iron and phosphorus level for screening the rice genotypes. Results showed maximum toxicity induction at 1800 µM Fe ($Fe_2SO_4.7H_2O$) and optimal plant growth expression at 300 µM Fe and 500 µM P ($NaH_2PO_4.2H_2O$) concentration. Based on these findings, a pot experiment was set up following the methods described by Sikirou et al. (2019) comprising of four treatmentsT1: control (300 µM

+ 500 µM), T2: Fe (1800 µM) + P (500 µM), T3: Fe (1800 µM) + P (2 µM) and T4: without Fe and P. To understand the uptake mechanism of Fe and P, tissue iron and phosphorus distribution was studied under four different treatment combination usingthe rice genotype Yemsheangha. The study revealed highest shoot and root Fe concentration in T3 (Toxic Fe with low P) followed by T2 (Toxic Fe) (Fig.5a). Similarly, soluble Fe concentration in shoot tissue was highest in T3 (Toxic Fe with low P) followed by T2 (Toxic Fe) (Fig.5b). In case of tissue phosphorus distribution, seedlings grown under low P treatment (T3 & T4) showed significantly lower inorganic phosphorus (Pi) and total P concentrations than those seedlings grown under optimal P condition (T1 & T2) (figs. 5c & 5d). Higher Pi and P concentration noted in T3 (Toxic Fe with low P) positively correlates with enhanced acid phosphatase activity which showed 65 % and 17 % increase in acid phosphatase activity in T3 and T2, respectively, as compared to the control. This result indicates that plant growth response is dependent on the available Fe concentration within plants which is not only influenced by the environmental Fe concentration but also P concentration.

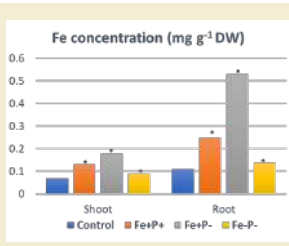


Fig. 5a

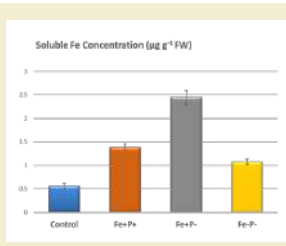


Fig. 5b

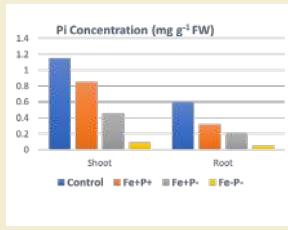


Fig. 5c

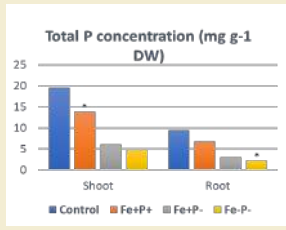


Fig. 5d

Seed production

In total 59.5q breeder seed and 206 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 2023 in participatory mode.

Details of quality seed produced during 2023 under ICAR Seed Project

Crop	Variety	Yield (q)	
		Breeder seed	TL seed
Rice	Tripura Chikan Dhan	6	59
	Khowai	2	10
	Gomati	7	38
	Tripura Jala	2	0
	Tripura Sarat	1	0
	Tripura Nirog	2	10
	Hakuchuk-1	1	0
	Hakuchuk-2	7	10
	Khara Dhan-2	1	0
	TRC 2015-5	1	24
	TRC 2014-8	2	0
	TRC PSM 1720	2	10
	Naveen	0	11
	Tripura Aush	2	0
Green gram	Tripura Mung	0.6	6.4
Blackgram	Tripura Maskoloi	2.2	13.8
Lentil	Tripura lentil selection	0.6	8.4
Sesamum	Tripura Siping	2.2	4.8
Fieldpea	TRCP-8	5.5	12.5
Rajmash	Tripura Rajmash Selection-1	2.2	1.8
Toria	Tripura Toria	0.2	1.3
	Total	59.5	206

Extension

Total nine villages covering 4 districts of Tripura have been covered under adoption of technologies developed by ICAR Tripura Centre. With the adoption of these technologies the farmers will be earning an extra income of Rs 4.8 Lakhs and Rs 6.0 lakhs (20-30% increase in income), respectively, from pulses and oilseeds in addition to the income from rice.

Variety name	Village Name	Area in ha (approx.)	District	No. of Farmers
Pulses (Released varieties)				
Tripura Mung	Satchand	1.5	South Tripura	4
	East Ramchandraghat	1	Khowai	5
Tripura Maskolai	East Ramchandraghat	1	Khowai	5
	Yuvraj Nagar, Kadamtala & Dasde	2	North Tripura	10
	Kaulikora, Gournagar	1	Unakoti	10
Tripura Rajmash Selection-1	Saboom	5	South Tripura	40
	Kaulikora, Gournagar	1	Unakoti	10
Tripura Lentil Selection-1	Risamukh	3	South Tripura	10
Oilseeds (Released varieties)				
Tripura Siping	Kaulikora, Gournagar	3.5	Unakoti	25
	Yuvraj Nagar, Kadamtala & Dasde	4	North Tripura	25

Revenue generation

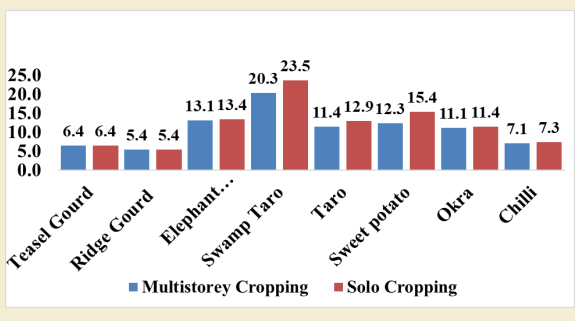
Total revenue amount of ₹ 8,10,879.60/- has been generated through sale of 125.3 q seeds (Rice, Pulses and Sesamum)

Crop	Quantity	Type	Amount	Remarks
Rice (Released varieties)	118 quintals	TL seed	7,24649.6	State departments, KVKs within and outside state
	3.5 quintals	Breeder Seed	25410	KVKs & IRRI
Tripura Maskolai	2.8 quintals	TL Seed	49280	KVKs within and outside state
	1 quintal	Breeder seed	24700	Private Farm
TRCP 8	3 quintals	TL seed	36000	CAU, Imphal
Tripura Lentil Selection 1	0.40 quintals	TL Seed	7040	KVK, Khowai
Tripura Rajmash	0.30 quintals	TL seed	8800	ICAR, Mizoram
Tripura Siping	1.7 quintals	TL seed	35000	KVKs within and outside state
Total			₹ 8,10,879.60/-	

Tuber crop based multistorey annual cropping system

(Biswajit Das)

Tuber crop based multistorey annual sequence of vegetable cropping system was standardized under Tripura condition. Vegetable cultivation was found to be most remunerating agricultural entrepreneurship in Tripura with total production of 892527 MT over an area of 46182 ha and productivity 19.33 MT/ha. Taro, Swamp Taro and elephant foot yam are the major tuber crops grown in the state with production of 21649 MT, 20212 MT and 2070 Mt over an area of 1278 ha, 552 ha and 81 ha, respectively. Productivity of tuber crops is 20.3 MT/ha. The multistorey cropping system was designed with commercially important vine crops teasel gourd and ridge gourd in summer and Hyacinth bean and Bottle gourd in winter. These crops were trained with bower system with bamboo structures and plastic nets. Under the vine crops, tuber crops were planted in the month of March. Various tuber crops namely, Sweet potato (var. Sweet potato Local Selection), Colocasia eddoe type (var. Muktakeshi), Elephant Foot yam (var. Gajendra), Swamp taro stolon producing type were planted. The productivity of these crops was 22 MT/ha, 22.5 Mt/ha, 40.5 MT/ha and 35.6 MT/ha, respectively. BC ratio ranged from, 2.7-2.9. Other crops vegetable crops were also cultivated under for diversification, and to increase the profitability of the annual cropping system by increasing cropping intensity. Under these vine crops, ground vegetable crops namely, vegetable peas (7.4 t/ha), French bean (12.4 t/ha), coriander green 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 winter. In Summer season 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.



All India Coordinated Research Project (Tuber Crops)

(Biswajit Das)

Various major and minor tuber crop germplasm have been collected and characterized. IC numbers from ICAR NBPGR have been allotted for 9 tuber crops. 1) TRC Colocasia 4 (IC-0648807): Petiole reddish, medium to high Leaf Blight tolerant, Consumable, Low in acridity. 2) TRC Bish Kachu-1(TRCBK-1) (IC-0648808): Petioles are fleshy, green, 60-80 cm long. Leaves are 50-75 cm long and 45-75 cm in breadth, bifid and lobbed at base, prominent mid rib and veins. Around 4-6 leaves arises from single rhizome. 3) TRC Swamp Taro-1 (IC-0648809): Petioles are green, Caudex with greenish brown scales. Colour of caudex after cross section is white, thick and greenish stolons. Non acrid type. 4) TRC Swamp Taro-2 (IC-0648810): Petioles are maroon burgundy coloured, Caudex skin colour is maroon burgundy. Colour of caudex after cross section is creamy white, thick maroon burgundy coloured stolons. Non acrid type. 5) TRC Swamp Taro-3 (IC-0648811): Petioles have brown scars and stripes on green base light green, Caudex skin colour is light brown. Colour of caudex after cross section is creamy white, light green-brownish stolons. Non acrid type. 6) TRC Swamp Taro-4 (IC-0648812): Petioles are green with dark brown strip at petiole margin, Produces thick and light green stolons. Non acrid type. 7) TRC Swamp Taro-5 (IC-0648813): Petioles are green, Caudex small in size, Produces thin and light green-brown stolons. Low-medium acidity. 8) TRC Fen Kachu-1(TRCFK-1) (IC-0648814): Leaves are green, broad, 75-90 cm long and 60-80 cm in breadth, bifid and lobbed at base, prominent mid rib and veins. Around 4-6 leaves arises from single rhizome. Petioles

are 70-90 cm long, sheathing at base. Rhizome length 0.90-1.5 m, girth 50-65.0 cm and weight 5.0-9.5 kg. Low -medium in calcium oxalate content. Rhizome is consumed. 9) TRC Wild Batema-1 (IC-0648815): Leaf stalk is fleshy, speckled with light and dark green spots or blotches. 4-5 leaves arises on the stalk, each leaves contains 3-4 leaflets. Leaflets are narrow and tapering. Leaf stalk dia. is 30-35 mm, length 50.0-75 cm. Rachis spread: 0.5 m^2. Under ground tubers sprouts in the month of April-May and plants dries in November. Tubers are 300-600g in weight and 10.0-20.0 cm. Highly acrid.

Collection and morphological characterization of brinjal germplasm of Tripura

(Bapi Das, B. Das, P. K. Sarkar, V. K. Verma, H Lembisana Devi, K. Nath and R. Kumar)

A total of 21 numbers of brinjal germplasm was collected from the all most all the district of Tripura and apart from this 02 numbers of germplasm collected from Mizoram. During the initial study it was observed that out of 23 genotypes, 15 lines have purple colour fruit, 02 lines have white colour fruit and 06 lines have green colour fruits. Regarding fruit shape, 06 lines have round shaped fruit, 10 lines have cylindrical shaped fruit and 07 lines have oblong shaped fruit. In case of flower colour, 16 lines showed light purple colour flower and 07 lines showed deep purple colour flower. Some of the lines like TBL-04, TBL-13, TBL-12, TBL-10 are showing promising in terms of fruit yield, nos. of fruits per plant, fruit size and shape and also showing resistant to bacterial wilt till date.

Fig. 6. Some of the promising lines of Brinjal

Augmentation and evaluation of jackfruit and mango germplasm in Tripura (AICRP Fruits)

(H. Lembisana Devi, Biswajit Das and B. Das)

During the reporting period the centre has conducted survey of different mango and jackfruit growing areas of West Tripura district (Naogaon, Laxmilunga, Kalibazar, Bhatifatikcherra, South Majleshpur, Jirania, Joynagar, Kalabagan) and South Tripura (Hichachara, Birendranagar) in Tripura, evaluated their physico - chemical characteristics and conserved 5 new local mango germplasm at the centre, 7 mango accessions obtained IC number from ICAR – NBPGR, New Delhi and 5 accesions of Jackfruit deposited at NAGS (IIHR Bangalore).

Fig. 7. Non-descript Mango & Jackfruit genotypes identified at Lembucherra centre

Evaluation of Avocado varieties under AICRP Fruits

(H. Lembisana Devi, Biswajit Das and B. Das)

During the period 3 varieties viz., Arka Supreme, Arka Coorg Ravi & TKD-1 were planted at 6m x 6m spacing for evaluation. The percent establishment is 98.4%.

Table 1. Growth parameters of the established plants (First year)

Sl no.	Variety	Plant height (m)	Plant Girth (cm)
1	Arka Supreme	0.46	0.76
2	Arka Coorg Ravi	0.39	0.77
3	TKD-1	0.33	0.91

Mushroom

(L. Sahoo, Biswajit Das and B. U. Choudhury)

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. 8500 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. 6 capacity building programmes were organized at various places of Tripura covering almost 450 farmers for promotion of mushroom cultivation for food, nutritional and livelihood security. Under AICRP Mushroom Programme, 20 different mushroom species were collected and characterized morphologically. Six strains of oyster mushroom (PP-23-101 to PP-23-106) were evaluated for AVT-1. PP-23-104 performed best with BE of 66.17% followed by PP-23-102 with BE of 54.37%.

PP-23-201 PP-23-202 PP-23-203 PP-23-204 PP-23-205 PP-23-206

Evaluation of 6 strains of Oyster Mushroom under AICRP

Calocybe indica *Psathyrella* sp. *Leucocoprinus birubaumii*

Lepista nuda *Lepista nuda* *Leucocoprinus fragillissimus*

Schizophyllum sps *Ganoderma* sps.

Germplasm collection of Mushroom

Development of multi-tier based sustainable agroforestry systems for uplands of Tripura

(P.K. Sarkar, Biswajit Das, Bapi Das, L. Devi and A. Gangarani Devi)

Under this project, models of seven different multi-tier based agroforestry systems (AFS) were developed in the year 2022 at Cocotilla farm of ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra. The models comprised of Jackfruit (*Artocarpus heterophyllus*), Bael (*Aegle marmelos*), Arjun (*Terminalia arjuna*), Treebean (*Parkiarox burghii*), Drumstick (*Moringa oleifera*), Tejpatta (*Cinnamomum tamala*), Pigeon pea (*Cajanus cajan*), Lemon (*Citrus sp.*) and other important plants like Banana (*Musa Paradisiaca*), Pineapple (*Ananas comosus*) andBlack pepper (*Piper nigrum*). 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 multipurpose tree species (MPTs), cent per cent survival was recorded in Rubber plantation, where as maximum mortality was recorded in case of drumstick upto 46.67% during summer. While comparing the percent increment of plant height and trunk diameter, the maximum value with 61.31% and 47.60%, respectively were recorded in case of Treebean which was at par with Rubber with 60.81% and 45.72% incrément in height and trunk diameter, respectively. Among the alley crops,

seasonal crops like French bean with its green pod yield ranged from 6.87±0.07 to 7.91±0.09 t/ha, Cow pea with average yield ranged between 3.5 to 5.9 t/ha, Chilli yield ranged between 1.2 to 1.8 t/ha, Maize yield ranged between 3.1 to 4.5 t/ha, yield of Finger millets ranged between 0.79 to 0.94 t/ha, average yield of Elephant Foot Yam ranged between 17.8 to 24.6 t/ha and average yield of turmeric ranged between 12.3 to 15 t/ha during the year. The low production from the seasonal crops might be due to the growing seeds of local one and also due to low soil fertility gradient. Hence, improved varieties of all the crops will also be grown to check their performance as well as their potentiality under newly developed agroforestry systems. While comparing the soil nutrient status upto 30 cm depth, the bulk density in the developed systems, was recorded in the range of 1.09±0.11to 1.44±0.08g/ cm^3, soil pH ranged from 3.9±0.3 to 5.0±0.3, EC ranged between 0.048±0.001 to 0.0 71±0.004mS/ cm, available organic carbon ranged from 0.52±0.09% to 0.67±0.13%, available Nitrogen (163.5±31.3 to 216.9±23.4 kg/ha), available Phosphorus (8.8±2.6 to 17.1±1.7 kg/ha) and available Potassium (186.3±38.8 to 277.8±27.7kg/ha). The Shannon's diversity Index of 0.89± 0.10 implies high weed diversity. Among the weeds, *Spilanthes paniculata, Alternanthera sessile, Cyperus rotundus* and *Eupatorium odoratum*, were the most common one recorded in the AFS.

Multitier based agroforestry system+intercrops

French bean based system

Cow pea + Maize based system

Finger millet based system

Participatory seed production of Sesame and capacity building programme in oil seeds Under ICAR-IIOR, NEH Component, Hyderabad

(P.K. Sarkar, Anup Das and Bapi Das)

Response of sesame varieties for sulphur application in NEH Region

During the summer season of 2023, a field experiment was carried out at ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra, under the ICAR-IIOR, Hyderabad, NEH component project. The trial involved the testing of two sesame varieties, Tripura Sipping and Local variety-White sesame, along with four different sulphur levels, including a control (0, 10, 20, 30, 40 kg/ha), to assess their impact on seed yields and income enhancement. Manual line sowing was conducted on May 3, 2023, with harvesting completed on July 4, 2023. Thinning/gap filling activities were carried out after 7 and 15 days, respectively, maintaining a spacing of approximately 25 cm x 15 cm. The recommended doses of fertilizers and sulphur were applied according to the designated treatments. Among the treatments, Tripura Sipping (Sulphur level 30 kg/ha) exhibited higher plant height, number of branches, plant stand, and test weight compared to other treatments, including White sesame (sulphur level 30 kg/ha). The average plant height observed in Tripura Sipping was 103.7 cm (Sulphur level 30 kg/ha), followed by 91.6 cm (Sulphur level 40 kg/ha), 84.5 cm (Sulphur level 20 kg/ha), and White sesame at 80.9 cm (sulphur level 30 kg/ha). Maximum seed yield was recorded in Tripura Sipping at 1.27 t/ha (sulphur level 30 kg/ha), followed by White sesame at 1.01 t/ha (sulphur level 30 kg/ha).

On farm testing (OFT) sesame varieties in Tripura condition

Training Cum Participatory Seed Production of Sesame

Six training programs were conducted during the financial year 2023-24 in Unakoti district, Khowai district, and West Tripura district. A Field Day cum Capacity Building program on "Participatory Sesame Seed Production and Crop Diversification through

Vegetable Production" took place in Rangauti village, Unakoti Tripura, on October 12, 2023, organized under the ICAR-IIOR, Hyderabad component. Approximately 60 farmers, both men and women, participated in the program, aimed at improving oilseeds crop productivity, income, and livelihood at farmers' fields. Scientists and experts engaged with farmers on various agricultural aspects, discussed the performance of different activities at farmers' fields, and addressed constraints in agriculture. The experts suggested the application of lime for soil reclamation due to acidic conditions, along with recommending the use of urea, SSP, MOP, vermicompost, DAP, VAM, nano urea, and NPK 19:19:19 for cultivation. Many farmers reported earnings ranging from Rs. 40,000 to Rs. 45,000 per annum from sesame cultivation. A successful farmer, Mr. Amal Sarkar, earned Rs. 90,000 per annum from a 3-kani sesame field, selling at Rs. 250 per kg. In an effort to enhance farmers' income and livelihood, 150 kg of sesame seeds (Variety Tripura Sipping), along with 2 sprayers, summer vegetable seeds, groundnut seeds, and mustard seeds (Variety-NRCHB 101), as well as hybrid maize seeds, were provided to the farmers. As part of a Front Line Demonstration initiative, 80 kg of sesame seeds (Variety -Tripura Sipping) and 200 kg of manure were provided to beneficiary farmers in West Tripura district. Other programs were held on November 7th and 8th, 2023, at KVK Belbari, KVK West Tripura, and ICAR Tripura Centre, with a total of 317 farmers, both men and women, participating. To enhance farmers' livelihoods, 50 kg of sesame seeds (Tripura Sipping), 16 kg of summer vegetable crops, and 6 power-operated sprayers were distributed at the end of the program. Farmers expressed satisfaction with ICAR, acknowledging their improved earnings from oilseeds.

Training cum participatory seed production of Sesame

Screening of groundnut varieties for cultivation under Tripura conditions

(P.K. Sarkar, Anup Das and Bapi Das)

A varietal evaluation trial was conducted as part of the DGR-Groundnut project, utilizing 20 varieties provided by DGR, Junagarh. The tested varieties included 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. Sowing of the crop took place on June 7, 2023, at FSR-3 (strip-4), and harvesting was done on October 11, 2023. Uniform nutrient doses of vermicompost (VC 2.5 t/ha), farmyard manure (FYM 5 t/ha), agricultural lime (AL 500 kg/ha), and rock phosphate (150 kg/ha) were applied. The study revealed a highly variable trend in pod yield, number of pods per plant, pod weight, and plant height for certain varieties, such as KDG-182, HNG-69, TCGS-1157, JL-776, and KDG-123. The highest pod yield was obtained in HNG-69 (2.87 t/ha), followed by KDG-123 (2.52 t/ha) and JL-776 (2.02 t/ha). Conversely, the lowest pod yield was recorded in GJG-19 (1.42 t/ha), followed by GPBD-5 (1.34 t/ha) and Rajmungfuli-2 (1.29 t/ha). The highest pod weight was noted in HNG-69 (2.02 g/pod), followed by KDG-182 (1.78 g/pod) and KDG-123 (1.71 g/pod). On the other hand, the lowest pod weight was obtained in Rajmungfuli-2 (1.23 g/pod), followed by Mallika (1.21 g/pod) and DH-256 (1.17 g/pod). Among the early maturing varieties, GPBD-5 exhibited maturity in 90 days, followed by KDG-123 and KDG-182.

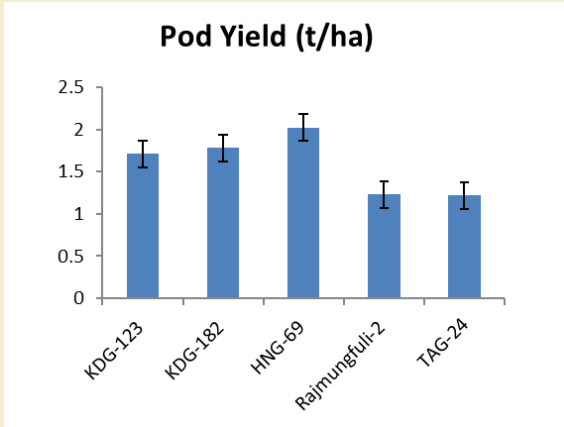


Fig. 8. Productivity of some potential groundnut varieties in Tripura Conditions

Organic nutrient management for groundnut production in Tripura

In a varietal trial, 14 combinations of farmyard manure (FYM 5t/ha), vermicompost (VC 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) were evaluated. Among these nutrient combinations, the highest pod yield of groundnut was observed under FYM + PM + AL + RP (2.68 t/ha), followed by FYM + PM (1.94 t/ha) and FYM + GM + AL (1.89 t/ha).

Furthermore, the combinations FYM + PM + AL exhibited the highest plant height and number of leaves per plant, followed by FYM + GM + AL + RP and FYM + GM. In terms of soil organic carbon (SOC), the combination FYM + VC + AL demonstrated the highest levels (7.41 g/kg at 0-10 cm, 7.39 g/kg at 10-20 cm, and 6.52 g/kg at 20-30 cm), followed by FYM + GM + AL (7.33 g/kg at 0-10 cm, 6.49 g/kg at 10-20 cm, and 5.08 g/kg at 20-30 cm), and FYM + PM (6.11 g/kg at 0-10 cm, 6.07 g/kg at 10-20 cm, and 5.58 g/kg at 20-30 cm).In conclusion, the nutrient combination of FYM + PM + AL + RP proved to be highly effective in achieving the maximum pod yield in groundnut cultivation. Additionally, FYM + PM + AL demonstrated superior performance in terms of plant height and number of leaves per plant. The combinations FYM + VC + AL and FYM + GM + AL exhibited the highest levels of soil organic carbon at different soil depths, emphasizing their positive impact on soil health.

Fig. 9. Overview of nutrient trial in groundnut

Performance of biofortified maize hybrids in Tripura Conditions

(P.K. Sarkar, V. Singh, Anup Das and Bapi Das)

Maize cultivation is particularly popular among tribal communities in the state, but their reliance on a limited number of local cultivars results in low yields. To address this issue and achieve the objectives of enhancing maize productivity and ensuring nutritional security in rural areas, demonstrations were conducted featuring popular biofortified maize hybrids. In the 2023-24 period, a total of four on-farm trials (one in kharif and three in rabi seasons) and 18 farmers' field demonstrations (all in rabi season) were initiated in three districts of Tripura—West Tripura, KVK Khowai, and KVK Unakoti. During the kharif season trial in 2023-24, conducted at ICAR Tripura Centre, six biofortified hybrid maize varieties (NEH-BIOFORT-01, NEH-BIOFORT-02, NEH-BIOFORT-03, NEH-BIOFORT-04, NEH-BIOFORT-05, NEH-BIOFORT-06) were assessed under 100% RDF and 100% organic conditions. Among these hybrids, NEH-BIOFORT-03 demonstrated the highest kernel yield (7.1 t/ha), followed by NEH-BIOFORT-02 (5.07 t/ha) and NEH-BIOFORT-01 (5.01 t/ha), while NEH-BIOFORT-05 recorded the lowest yield (4.1 t/ha). In terms of plant height, NEH-BIOFORT-03 stood out as the tallest (230.01 cm), followed by NEH-BIOFORT-05 (201.56 cm), with NEH-BIOFORT-04 being the shortest (142.87 cm). Regarding 100-seed weight, NEH-BIOFORT-03 had the highest seed weight (52.88 g), trailed by NEH-BIOFORT-02 (37.15 g), and NEH-BIOFORT-05 recorded the lowest weight (19.15 g). Among the biofortified varieties, Pusa VQPM-9 matured early in 80 days, followed by LQMH1.In the same year, approximately 130 kg of hybrid maize and biofortified hybrid maize, along with six sprayers and 24 kg of seasonal vegetable seeds, were distributed to 125 beneficiary farmers, including 68 women farmers, aiming to support sustainable farming practices and improve agricultural outcomes.

Fig. 10. Inputs distribution under Biofortified maize project at KVK Belbari West Tripura

Fig. 11. Training cum field day on Biofortified maize project at Unakoti, Tripura

Tripuri cattle: A unique cattle germplasm of Tripura

(A. Chakrabarti, R. Kumar, V. Singh and D. Daschaudhuri)

Table 2. Comparative evaluation of physical traits of Tripuri cattle at different age group in home tract

Traits	Tripuri Cattle		
	Male	Female	Calves
Size	Small to medium	Comparatively small sized	Small, short
Shape	Well-built, dumpy neck, very hardy with cylindrical shape of body	Well-built, dumpy neck, very hardy with cylindrical shape of body	Well-built and in round shape
Body colour	Comparatively mixed body colors from other breeds, including brown (41-45 %), black (20-25 %), grey (9-13%), tan (10-14%), white (4-5%) and others (2-3 %)	Comparatively mixed body colors from other breeds, including brown (43-46 %), black (18-23 %), grey (12-14 %), tan (8-11 %), white (3-5 %), and others (1-2 %)	Brown (54-63 %), black (35-39 %), grey (7-11 %), tan (4-7 %), white (2-4 %), and others (1-2 %)
Skin	Brownish black	Brownish black	Brownish black
Muzzle	Black-90-93 % Spotted- 5% Brown- 4-7 %	Black-91-95 % Spotted- 5% Brown- 5-9 %	Black-88% Spotted- 7% Brown- 5%
Hump	Bullocks have medium with sparse of hairs over the hump	Without hairs, small hump	Underdeveloped to Rudimentary
Dewlap	Small to moderate	Small to moderate	Small
Horn	The horns are relatively small with black (78-86 %) and grey (16-20 %) colors, oriented upward, outward, or curved towards the face.	The horns are relatively small with black (81-85 %) and grey (9-16 %) colors, oriented upward, outward, or curved towards the face.	NA
Hoove	The predominant hooves colour seen in the majority of cattle black (73-81 %) and brown (11-32 %)	The predominant hooves color seen in the majority of cattle black (73-81 %) and brown (11-32 %)	The hooves colour seen in the majority of calves are black and greyish brown
Neck	Dumpy neck	Dumpy neck	Small
Ears	Small to moderate ear size (Avg. 23.45 cm) and orientation towards horizontal	Small to moderate ear size (Avg. 20.31 cm) and orientation towards horizontal	Small
Eyelids	The majority of cattle's eyelids are brown (64-72 %), followed by black (16-22 %) and mixed (2-3%) color	The majority of cattle's eyelids are brown (71-76 %), followed by black (13-20%), grey (11-16%) and mixed (1-2%) color	The majority of cattle's eyelids are brown & black
Udder and milk vein	NA	Udder is small with bowl & round in shape; milk veins are not easily visible; teats are either funnel (78%) or cylindrical (22%); teat tips are either round (90%) or flap/ funnel (10%)	NA
Naval flap	Small	Under developed	Under developed
Tail	Tail is above the hock with black (48-57 %), brown (32-36 %), and grey (6-13%) switch	Tail is above the hock with black (45-56 %), brown (35-42%), and grey (4-10%) switch	Above hock joint, bunched
Production traits	NA	Tripuri cows produce an average of 435.16 kg of milk per lactation, with an average milk fat content of 6.04% (ranging from 5.89 to 6.26%)	NA
Temperament	Moderate aggressive	Docile	Docile

Tripuri Cattle Farm in ICAR NEH Tripura Centre

Tripuri cattle calves produced in ICAR Tripura Centre

Study on Goat Management Practices in Tripura

(A. Chakrabarti, V. Singh and D. Daschaudhuri)

Goat rearing is one of the most fertile areas to ease out the pressure of population on crop cultivation in Tripura state. Among the livestock based vocations, goat farming occupies a pivotal position due to its enormous potential to bring about rapid economic growth with low input investment. Mostly Black Bengal goats (97.63%) were found in the study area along with Assam Hill goat (2.37%). The females come in puberty at the age of 7 to 8 months. The average time at first conception and kidding is 7.33 and 11.31 months, respectively. The average kid production per goat is 1.92. The cases of retention of placenta (6.56%), anestrus and repeat breeding (14.53%) were found more. Deworming practices were not followed and also vitamin, minerals were not supplied in the diet. Due to deficiency of minerals and trace elements like copper, cobalt, selenium, zinc, iodine etc deficiency in feed and fodder resulting in anemia and reproductive disorders. The average daily gain was recorded 49.97 g/day. Toxemia and diarrhoea were found to be most common diseases at farmers' field. Other diseases like Peste des petits ruminants (PPR), contagious ecthyma, haemorrhagic septicemia also prevalent in the study area. Skin related diseases like hair loss, itching and ectoparasites are very common. Increased incidences of metabolic disease (8.87%), corneal opacity (5.67%) and night blindness (5.28%) were also observed. Kid mortality was (20.43%) higher than the adult mortality (13.11%). The farmers sell their goats at an average of 9 month (7 to 9 kg) body weight. Farmers prefer uncastrated male goats than the castrated males due to extra good market price. Constraints in includes lack of technical knowledge of goat farming, high cost inputs, good quality feed & fodder high incidence of diseases etc. The goat production system in Tripura can be easily boosted up with better meat production. To improve the socio-economic status of the traditional farmers, backyard goat farming is a handy enterprise with low-cost initial investment, but high economic return along with guarantee for improving protein deficiency among the poor.

Black Bengal goat in ICAR NEH Tripura Centre

Black Bengal Goat with village woman in Tripura

Comparative evaluation of fertility and hatchability of different chicken germplasms

(V. Singh, A. Chakrabarti, L. Sahoo, H. Lembisana Devi, H. Bharati, Biswajit Das and B.U. Choudhury)

During the period, a total of 57130 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 34002 chicks of different varieties / lines of chicken were produced. The overall average percent fertility was estimated 83.04% in different breeds/varieties/ lines of chicken. The highest fertility was found in Coloured broiler (84.79%) and lowest fertility was found in Kadaknath (77.12%). The overall average hatchability on fertile egg set (FES) and total egg set (TES) were estimated; 71.66% and 59.51%, respectively. The highest hatchability on fertile egg set (FES) and total eggs set (TES) was found 77.80% and 64.59% respectively in Tripura black The lowest hatchability on fertile egg set (FES) and total egg set (TES) was found 46.10% and 35.55% in Kadaknath.

Carcass quality traits analysis of Kadaknath chicken fed with Wolffia (Duckweed)

(V. Singh, A. Chakrabarti, L. Sahoo, H. Lembisana Devi, H. Bharati, Biswajit Das and B.U. Choudhury)

A feeding trial was carried out with a total of 150 birds (30 birds/treatment) and birds were reared in litter system under uniform and standard management practices. 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 (Wolffia) duckweed at 0, 5, 10, 15 and 20 % in the basal diet and offered to 3 replicated groups of 10 birds each. Nine male birds from each treatment were slaughtered at the age of 5 month and analysis of carcass quality traits was completed.

Result revealed that carcass quality traits such as pre slaughter live weight, blood loss and fat, and various cut-up parts such as breast, drumstick, back, neck and shank did not differ significantly among different dietary treatments. However, other carcass traits like shrinkage loss, feather, dressing yield, eviscerated yield, giblet and intestine, and various cut-up parts such as thigh, wing and head differ significantly (Table - 1, 2 & 3). Results revealed that dressing yield and eviscerated yield was significantly ($P<0.01$) highest in T3 group fed with basal diet having 10% Wolffia in compare to other groups.

Harvesting of Wolffia from nursery ponds

Fresh Wolffia

Different experimental diets

Kadaknath birds in experimental sheds

Analysis of Carcass traits

Table 3. Carcass Quality Traits of Kadaknath

Treatment	Group	Pre-slaughter live wt (gm)	Shrinkage (%)	Blood loss (%)	Feather (%)	Dressing yield (%)	Eviscerated yield (%)	Fat (%)
T1	Basal diet (Control)	1244.44	5.74^{b}	3.52	7.11^{c}	72.74^{a}	67.30^{a}	0.29
T2	Basal diet + Wolffia (5%)	1441.22	3.78^{a}	3.94	4.66^{a}	78.58^{b}	74.61^{b}	0.27
T3	Basal diet + Wolffia (10%)	1559.44	4.99^{ab}	3.17	6.03^{bc}	78.93^{b}	75.09^{b}	0.34
T4	Basal diet + Wolffia (15%)	1484.33	5.48^{b}	3.25	6.56^{bc}	76.66^{b}	72.22^{b}	0.34
T5 Basal diet + Wolffia (20%)		1357.67	5.97^{b}	3.20	5.56^{ab}	77.83^{b}	73.99^{b}	0.37
Pooled SEM		37.37	0.24	0.12	0.22	0.52	0.59	0.013
P value		NS	P<0.05	NS	P<0.01	P<0.01	P<0.01	NS

Table 4. Weight (%) of Visceral Organs of Kadaknath

Treatment	Group	Giblet (%)	Heart (%)	Liver (%)	Gizzard (%)	Intestine (%)
T1	Basal diet (Control)	5.43^{c}	0.51	2.11^{c}	2.82^{c}	4.63^{b}
T2	Basal diet + Wolffia (5%)	3.97^{ab}	0.50	1.50^{ab}	1.96^{ab}	3.50^{a}
T3	Basal diet + Wolffia (10%)	3.84^{a}	0.55	1.57^{ab}	1.72^{a}	3.36^{a}
T4	Basal diet + Wolffia (15%)	4.44^{b}	0.43	1.67^{b}	2.34^{b}	4.50^{b}
T5	Basal diet + Wolffia (20%)	3.85^{a}	0.49	1.38^{a}	1.97^{ab}	3.47^{a}
Pooled SEM		0.12	0.015	0.052	0.081	0.17
P value		P<0.00	NS	P<0.01	P<0.01	P<0.05

Table 5. Cut-up parts (% eviscerated weight) of Kadaknath

Treatment	Group	Breast (%)	Thigh (%)	Drumstick (%)	Back (%)	Neck (%)	Wing (%)	Head (%)	Shank (%)
T1	Basal diet (Control)	15.83	12.25^{a}	11.11	16.34	6.22	10.34^{b}	4.76^{a}	4.18
T2	Basal diet + Wolffia (5%)	15.41	15.05^{b}	11.67	15.73	5.64	9.61^{ab}	5.14^{ab}	3.97
T3	Basal diet + Wolffia (10%)	17.02	12.80^{a}	11.74	16.39	5.90	10.19^{b}	4.75^{a}	3.80
T4	Basal diet + Wolffia (15%)	15.59	12.47^{a}	11.26	15.36	5.42	9.14^{a}	4.72^{a}	3.83
T5	Basal diet + Wolffia (20%)	15.99	12.74^{a}	11.82	15.81	6.06	10.08^{b}	5.44^{b}	4.40
Pooled SEM		0.27	0.34	0.12	0.24	0.12	0.14	0.09	0.079
P value		NS	P<0.05	NS	NS	NS	P<0.05	P<0.05	NS

Effect of High water borne Iron in aquaculture and development of mitigation measures

(L. Sahoo, C. Debnath, H. Bharati, V. Singh, Biswajit Das and B.U. Choudhury)

Estimation of Iron in different water bodies of Tripura:

Water samples were collected from various districts of Tripura in three different seasons. Various water quality parameters like Temperature, DO, pH, Total alkalinity and Fe were estimated (Table 6). It was found out that the average Fe ranged from 0.3-1.8 mg/L in the different water bodies of Tripura and the highest concentration of Fe recorded in the winter season. Iron was also assayed in the different hatcheries of Tripura (Table 7). The total Fe was recorded to be 0.45mg/l.

Table 6. Water quality of Culture Water bodies of Tripura

Parameters	Summer (March-June)	Rainy (July-September)	Winter (October-December)
Temperature ^{0}C	29.27±1.75	26.63±2.05	22.7±1.9
Dissolved oxygen (DO mg/l)	5±1.3	5±3.5	4±1.2
pH	5.92±1.5	5.5±0.5	5±0.8
Total alkalinity (mg/l)	60±6.5	70±7.2	55 ±5
Iron (mg/l) shown in Range	0.3-0.9	0.3-0.9	0.3-1.8

Table 7. Iron estimation in different hatcheries of Tripura

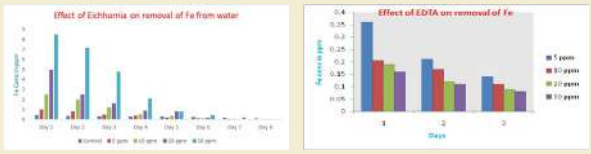
Name of the Hatcheries	Total Iron(ppm)	Fe2+(ppm)	Fe3+(ppm)
Rangamoyee Fish Hatchery	0.7	0.2	0.5
Maa Ganga Hatchery	0.5	0.1	0.4
Ornamental Fish Breeding and Training Centre	0.3	0.1	0.2
Prawn Hatchery Unit (Saline water)	0.3	0.2	0.1
Prawn Hatchery Unit (Fresh Water)	0.3	0.15	0.15
Zakir Fish Farm	0.65	0.2	0.45
Carp Hatchery, CAU	0.4	0.2	0.2
Air Breathing Fish Hatchery, CAU	0.5	0.2	0.3
Carp Hatchery , Govt. of Tripura	0.45	0.3	0.15
Mean ± SE	0.45 ± 0.04	0.18 ± 0.02	0.27 ± 0.04

Effect of Eichhornia and EDTA on removal of Fe from water

An experiment was conducted to evaluate the effects of Eichhornia on Fe levels of water. A single Eichhornia plant was kept in 100 litres of water. The experimental duration was 8 days.

1. Control-1 Eichhornia + No added Fe
2. T1-1 Eichhornia + 5 ppm Fe
3. T2-1Eichhornia + 10 ppm Fe
4. T3- 1Eichhornia + 20 ppm Fe
5. T4- 1 Eichhornia + 30 ppm Fe

A single plant of Eichhornia could reduce 30 ppm Fe from 100 litres of water in a span of 8 days.



Similarly EDTA at 5 PPM could reduce the Fe to below 0.1ppm in 3 days.

Effect of EDTA on eggs and spawn

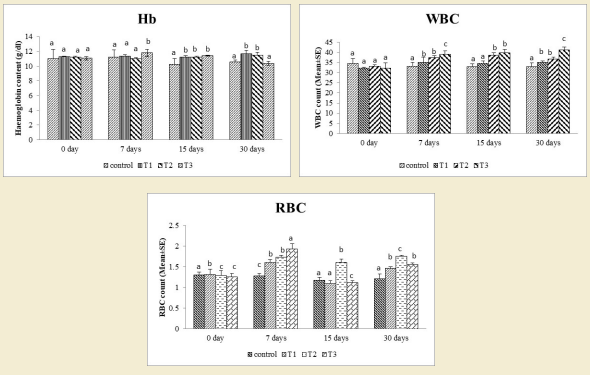
EDTA was used as Fe chelator for eggs of *Cyprinus carpio* and *Labeo rohita*. The treatment groups T1, T2 and T3 receive 10 ppm, 20 ppm and 30 ppm of EDTA respectively while the control group did not receive any EDTA, In *Cyprinus carpio* hatching, Eichhornia was used as substrate. Eggs were stocked at 2000/litre. Water Volume for carpio hatching was 20 litres while for Rohu hatching was 15litres. EDTA was added to carpio tank one time and in rohu tank EDTA was added every 4 hours. Hatching of spawn from eggs and survivability of spawn was recorded. The iron in EDTA treated tanks reduced to 0.01mg/l in EDTA treated tanks while in control tanks, the Fe content was recorded to be 0.45 mg/l. The egg hatching percentage in C. Carpio was 85% and 75% in *L. rohita*, The spawn survivability was 70% in carpio and 80% in Rohu. EDTA improved the hatchability and survivability of eggs and spawn wrt control where no EDTA was added. EDTA at 20 ppm was found to be the best for both *Cyprinus carpio* and *L. rohita* eggs.

Water quality analysis in hatching tanks of *Labeo rohita* and *Cyprinus carpio* (3rd Day)

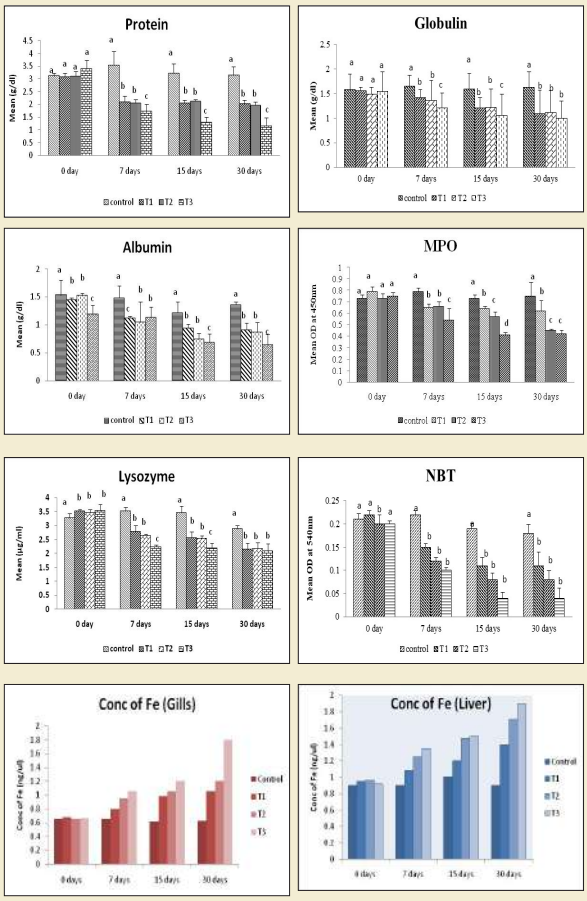
Parameters	*C. Carpio* system	*L. rohita* system	Control Tanks (*C.carpio*)	Control Tanks (*L.rohita*)
Temperature ^{0}C	25.10±1.35	25.25±2.05	24.7±1.3	25.14 ±2.11
Dissolved oxygen (DO mg/l)	5.5±1.6	6.2±1.5	5.5±1.3	6.11 ±1.2
pH	5.92±1.5	6.8 ±1.7	5.8±1.4	6.1±1.0
Soluble Organic Carbon (mg/l)	6.5	6.1 ±1.08	6.3 ±1.8	6.4±2.1
Iron (mg/l) shown in Range	**0.01**	**0.01**	**0.45**	**0.54**

Effect of exposure of sub-lethal Fe on Labeo bata

The 96 hour LC50 with $FeCl_3$ was determined to be 14 ppm. Based on LC dose of 14 ppm, three sub-lethal doses were taken: T1-1/16 of LC=0.87 ppm, T2-1/8 of LC=1.75 ppm, T3-1/4 LC=3.5 ppm. Experimental animal was *Labeo bata*, Experimental duration was 30 days and sampling was done at 0 days, 7 days, 15 days and 30 days. All standard protocols followed and analysis by Excel and SPSS.



Haematological parameters like haemoglobin, Red blood Cell and White Blood Cell counts were evaluated. And it was seen that the blood parameters increased with increased exposure to Fe. Blood biochemical parameters like serum protein, albumin and globulin decreased with increased exposure to Fe. Glucose increased and serum bactericidal activity decreased in treatment tanks over control tanks. Immunological parameters like Myeloperoxidase activity, Lysozyme and NBT were evaluated. All the immunological decreased post treatment with Fe. Level of tissue Fe increased in gills and liver. Concentration of Fe increased with exposure of time and concentration of Fe. Alkaline Phosphatase increased while Catalase and superoxide dismutase decreased after exposure to Fe. CAT and SOD decreased the highest at 7 days indicating oxidative stress.



High density fingerling rearing

(L. Sahoo and 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 fingerlings were harvested with 60% survivability.

Water quality assessment in Rudrasagar lake using Water quality index

(H. Bharati and L. Sahoo)

Water Quality Index (WQI) is considered to be one of the most effective methods of assessing water quality considering the physical, chemical or biological characteristics of a water body as it transforms the complex information into a single value ranging from 0 to 100. The study was carried out to assess the Water Quality Index (WQI) of Rudrasagar Lake, the only Ramsar wetland of Tripura, which has been under serious pressure due to increasing anthropogenic activities. A total of thirteen physico-chemical parameters viz., temperature, pH, depth, secchi disk transparency, dissolved oxygen, biochemical oxygen demand, total alkalinity, total hardness, chloride, nitrate, nitrite, phosphate and chlorophyll *a* were analyzed using standard procedures. The estimated values were compared with the standard values as per the guidelines suggested by the World Health Organization (WHO) and Bureau of Indian Standard (BIS). Most of the parameters were within the standard permissible limits. However, the phosphate values were very high depicting organic pollution in the lake. Out of the analyzed parameters, eight parameters *viz.*, pH, DO, BOD, Secchi disk transparency, nitrate, total alkalinity, total hardness and chloride were selected to calculate WQI using Weighted Arithmetic Water Quality Index (WAWQI). The calculated WQI values were then compared with Table 8 which represents ranges of WQI values and its corresponding water quality categories. Rudrasagar Lake's water quality varied throughout the year, with the WQI ranging from 33.36 to 56.31, signifying good to poor water quality in different seasons. One way ANOVA revealed that the mean WQI values were observed to be varying significantly during the different seasons (p= 0.05). Figure 15. depicts that higher WQI values were observed during June-August (monsoon season) during which the water quality belonged to poor category. Considering the significance of Rudrasagar Lake based on its biodiversity and socio-economic importance, the proper management of the lake is very crucial. WQI and its implementation will be a very helpful tool for the decision makers and public for effective evaluation of the water quality of Rudrasagar Lake and its sustainable management.

The equations used for calculating WQI using WAWQI method are as follows:

Equation 1: $$WQI = \frac{\sum QiWi}{\sum Wi}$$

Equation 2: $$Qi = 100 * [(Vi - Vo)/(Si - Vo)]$$

Equation 3: $$Wi = {}^{k}/_{Si}$$

Equation 4: $$k = {}^{1}/_{\sum(\frac{1}{Si})}$$

Table 8. WQI ranges and corresponding water quality category

WQI Range	Water Quality
0-24	Excellent
25-49	Good
50-74	Poor
75-100	Very poor
>100	Unfit for human consumption

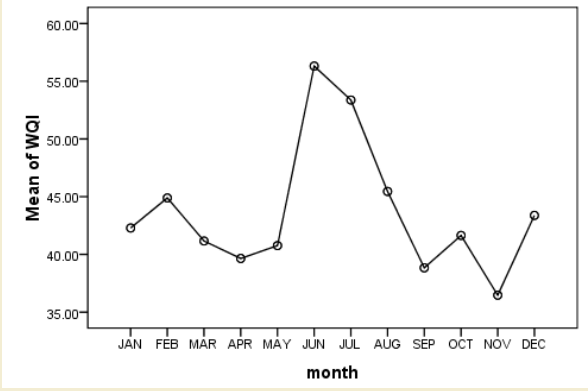


Fig. 15. Monthly variations of Mean WQI values in Rudrasagar Lake

Comparative growth, survival study of *Catla catla* and *Labeo rohita* in different diluted cattle wastewater

(K. Nath, A. Chakraborti and S.K. Das)

A comparative study on growth and survival of *Catla catla* and *Labeo rohita* was investigated after 60 days. The experiment was conducted in 250L cemented circular tank in triplicate. The experiment was design in 3×2 factorial CRD. The cattle wastewater was diluted for preparing 50% and 20% diluted solution for experiment. The two Indian major carps i.e., *C. Catla* and *L. rohita* was stocked @ 10 nos per tank after 15 days acclimatization. The fishes were feed with artificial floating pelleted feed @ 2% body weight twice in a day. There was a significant difference in survival between Calta and Rohu in 50% diluted wastewater. *L. rohita* was not survive in 50% diluted wastewater. The growth performance of *C. catla* was better than *L.rohita* for both 50% and 20% diluted wastewater.

The length-weight study of *Gudusia Chapra* from three lakes namely Amarsagar, Dhani Sagar and Rajdhannagar at Udaipur

(K. Nath)

The length-weight of *Gudusia Chapra* and water parameters like alkalinity and pH were studied for three bigwater bodies for seven month. The details are presented in Fig16. The study indicated that the Rajdhannagar lake stock shows bigger length-weight than Amarsagar, Dhanisagar. The alkalinity of Rajdhannagar lake shows little lower side than other two lakes and pH does not show much difference between the lake.

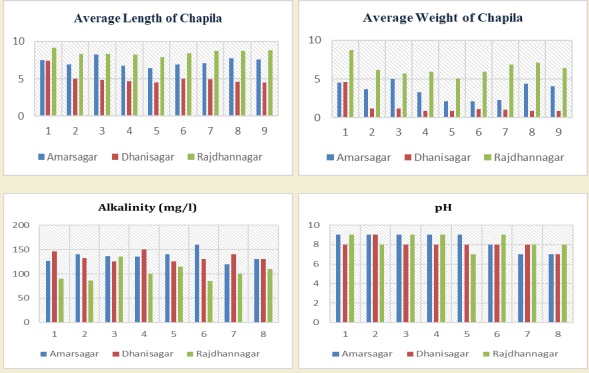


Fig. 16. The length-weight, Alkalinity and pH

Growth study of *S. sarana* under control condition

(K. Nath)

The growth study of *S. sarana* was investigated for 110 days under controlled condition at indoor tarpaulin circular tank (5000L). *S. sarana* mean weight of 12±0.05g was stocked @ 300 nos/5000L and feed with floating pelleted feed @ 5 % body weight. After 110 days the mean weight, survival and DWG was 56.75±0.075g, 50% and 0.41g/day.

Production of fingerlings

(K. Nath and R. Das)

A total of 30000 nos fingerlings produced at cocotilla farm for used in different research activities as well as for dissemination.

Maintaining stock of aquatic plants

(K. Nath, R. Das, P.K. Sarkar and Bapi Das)

A total of seven varieties of aquatic plants having medicinal and economic value namely Kalmi, Helencha, Kulekhara, Water mimosa, Lotus, Trapa, Colocasia (two varieties) are maintained at cocotilla farm.

ICAR-BARSHA: A low- cost, portable, recirculatory carp hatchery model

(R. Das, H. Priyadarshi, S.P. Das, K. Nath, S.K. Das, A. Shuklabaidya and V.K. Mishra)

ICAR- *BARSHA* (Backyard Adapted Recirculatory Small Hatchery Assembly), an automated, small scale carp hatchery prototype was developed at the ICAR RC for NEH Region, Tripura Centre using commonly available materials at an insignificant cost. The complete hatchery assembly includes (1) The re-circulatory egg incubation chamber and (2) a sand filtration unit. The incubation chamber also has an in-built spill control switch to prevent overflow of water in an event of clogging. The hatchery assembly operates with complete recirculation of water for the entire cycle. As such the water loss during operation is virtually zero. While the prototype has been tested to operate placed within tanks (600-700L water), it can also be operated by re-circulating water from an overhead water source through the bio-filtration unit. The entire unit is designed to run at just 1.5 KWhr per cycle of three days. The model was tested within a rectangular *jalkundh* of dimensions 3m x 1.6m x 1m constructed using Polyvinyl chloride sheets (2-3mm thickness) and bamboo containing 25-30cm water (Fig. 17). The entire hatchery unit, including the *jalkundh*, cost less than Rs.10,000.00. Around 1,00,000 fertilized eggs of carp can be efficiently handled by a single unit per cycle, with 80-90% survival. Since the incubation chamber is completely portable and comes as a single assembled unit, brooders can be induced to spawn within a hapa suspended in the same tank used to house the hatchery unit prior to operation. Besides, being a small unit, it can be operated by a single person while the complete automation of the system reduces need for regular monitoring during operation. All these features eliminate the need for the operator to enter water at any stage of the operation, making it extremely woman friendly.

Fig. 17. The complete unit of ICAR-BARSHA with all component parts

A: The recirculatory incubation chamber; B: Sand filtration unit; C: Spawn collection unit; D: Breeding hapa ; E: Jalkundh/ water reservoir for the operation of the re circulatory hatchery assembly.

NATIONAL INNOVATIONS IN CLIMATE RESILIENT AGRICULTURE (NICRA)

Crop Improvement

Development of high yielding climate resilient versions of *Chakao* and *Kali Khasa* rice under moisture stress

(K. Sarika and N. Umakanta)

For foreground selection of the crosses, Chakhao-22 × CR Dhan 801 and Kalikhasa × CR Dhan 801, the listed primer was used for drought tolerant genes (*qDTY1.1 + qDTY2.1 + qDTY3.1*) and submergence tolerant *Sub1* gene (Table 1). The BC1F2 population of Chakhao-22 × CR Dhan 801 were screened for the targeted genes, five, six and 11 plants were found to be homozygous for all 4, 3 and 2 of the targeted genes/loci, respectively (Fig. 1). Among the five plants, two plants with good agronomic performance having maximum tillers of 11 were selected for further backcrossing to recurrent parent, Chakhao22. And for the cross, Kali kasha × CR Dhan 801, true F1(s) were selected and backcrossed to its recurrent parent, Kali kasha during the *kharif* 2023 (Fig. 2).

Table 1. Selected rice genotype primer

Genes/QTLs	*qDTY1.1 (SSR marker)*	*qDTY2.1 (SSR marker)*	*qDTY3.1 (SSR marker)*	*Sub1 (*linked / functional markers)
Polymorphism between Chakhao 22/ CR Dhan 801	RM431	RM 324	RM 16030	Sub1BC2, AEX
Polymorphism between Kali Kasha/ CR Dhan 801	RM431	RM 424	RM 16030	Sub1BC2, AEX, RM8300

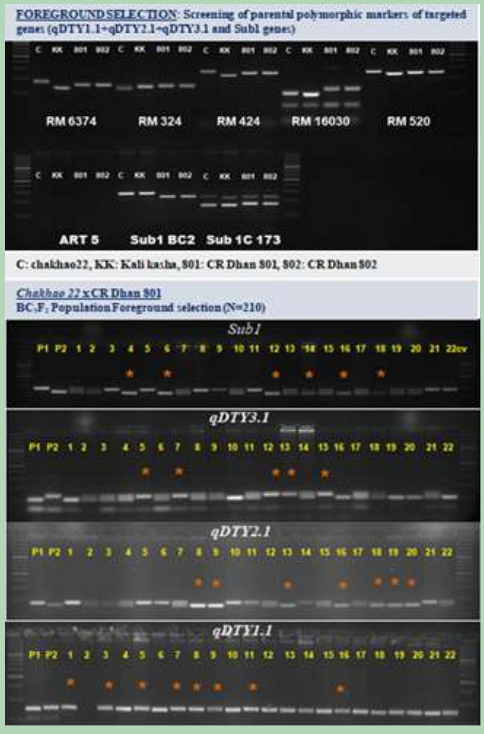


Fig. 1. Foreground parental polymorphism survey and foreground selection in BC1F2 population Chakhao-22 × CR Dhan 801

Fig. 2. Kali Khasa parent and its true F1 hybrid derived from the crossing with CR Dhan 801

Assessment of combined stress tolerance of rice lines under drought and elevated temperature conditions of CTGC research facility of NICRA project

(K. Rangappa, B.U. Choudhury, B. Bhattacharjee, A. Kumar, J. Layek and P. Moirangthem)

Combined stress effects of drought and elevated temperature (T) on physiological and climate stress resilience of rice cultivars was studied with two major stress treatments *viz.*, elevated temperature (T) (+3°C) and drought stress (50% FC) under CTGC (Carbon dioxide temperature gradient chamber) facility (Fig. 3). Drought stress treatment was imposed at 65DAS (PI to flowering stage) at two levels *i.e.*, providing water @ 1 time/week and 3 times/week. After 25 days of drought stress, rice lines like Mega aromatic and Hakuchuk-2 out of 11 rice lines showed higher chl a/b ratio under drought conditions of both elevated and ambient T conditions, whereas rice lines like IURON, Vivek dhan, N-22 and Bhalum-3 had increased carotenoids level under drought conditions of elevated temperature. The R/S ratio has varied significantly across stress treatments and rice lines with range of 0.13 to 0.36 and 0.14 to 0.40 under control and drought stress conditions, respectively. The rice lines like IURON, Vivek dhan and Bhalum-3 has showed increased root biomass under drought of elevated temperature. As mean of 11 rice lines, the extent of reduction in TDM was to the tune of 14.5 %, cell membrane stability (CMS) was to the tune of 11.0% and ;eaf relative water content (LRWC) reduced to the tune of 17.8% under drought of elevated temperature. The rice lines like CAUR1, TRC-2013-3, IR 64 and Bhalum3 have maintained higher leaf water under drought of elevated temperature. In the similar way, the yield traits like harvest index (HI) and seed yield have significantly reduced under drought of both elevated and ambient conditions but the extent of reduction in drought of elevated temperature was observed to be more (14.7% and 10.9%, respectively) than ambient conditions (9.8% and 2.75%), whereas rice lines like TRC2016-3, Nirog and Hakuchuk-2 showed higher HI under drought of elevated temperature with higher seed yield, were promising for further crop improvement as highly stress tolerant to drought and elevated temperature conditions of CTGC (Fig. 4). The physiological traits like Chl a/b ratio, leaf carotenoids, CMS, LRWC and Seed yield were emanated as better sensitive stress indicator for drought and elevated temperature stresses of CTGC.

Fig. 3. The growth of rice genotypes under CTGC

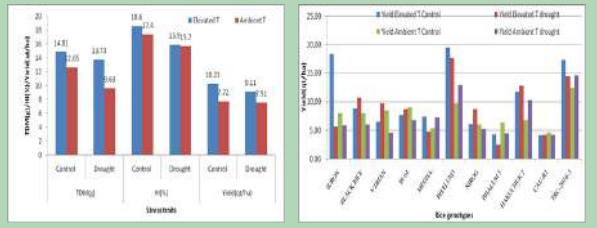


Fig. 4. Effect of drought and elevated temperature on TDM and Yield under CTGC in rice

Combined stress physiological analysis of drought and elevated temperature stress on important rabi crops under of CTGC

(K. Rangappa, B.U. Choudhury, B. Bhattacharjee, A. Kumar, J. Layek and P. Moirangthem)

A field experiment comprising of five rabi crops viz., French bean, Pea, Mustard, Lentil and Buckwheat was undertaken to study the impact of combined stresses *viz.*, drought and elevated temperature(+3°C) on stress physiology, growth and crop yield (Fig. 5). Leaf chla/b ratio was observed higher in Pea followed by buckwheat under drought stress of elevated temperature and drought stress of elevated temperature leads to enhanced Chla/b ratio by 8.53%, 48.06%, 7.69%, 42.81% and 36.75% in pea, french bean, lentil, mustard and buckwheat, respectively as compared to ambient drought condition. Buckwheat registered maximum carotenoid content among all five crops under drought stress of elevated temperature but there was a mean increase of carotenoid content by 43.77% as compared to control.

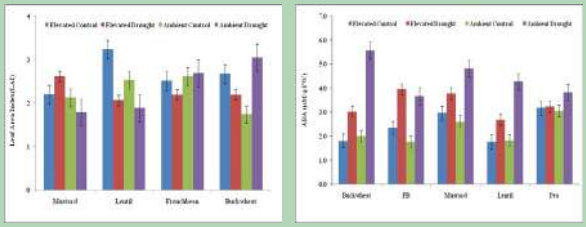


Fig. 5. Effect of elevated temperature and drought stress on Leaf area index (LAI) and leaf ABA (Abscisic acid) content in five selected crops under CTGC

Maximum leaf area index obtained in Mustard crop under drought of elevated temperature stress conditions with an increase of 18.99% compared to control, whereas Buckwheat has recorded maximum LAI under ambient drought condition with an increase of 75.65% in relation to control (Fig. 5).

Elevated temperature and drought condition leads to decrease in accumulation of TDM by 25.20% and 35.51% over ambient drought condition in French bean and buckwheat, respectively. Under drought stress of elevated temperature condition, stress hormone ABA has increased in leaves of buckwheat, French bean, mustard and lentil by 67.45%, 69.68%, 27.27% and 51.74% , respectively (Fig. 5). Crop yield (qt/ha) was decreased under drought stress of elevated temperature by 22.68%, 12% and 7.29% over control in buckwheat, mustard and in lentil, respectively whereas under drought stress of ambient condition yield reduction was to the tune of 18.64%, 15.37% and 22.78 % over control in buckwheat, mustard and in lentil, respectively. As overall, French bean and buckwheat were found relatively tolerant under combined stresses of drought and elevated stress conditions of CTGC.

Evaluation of Rice landraces for drought tolerance and yield

(H. Verma)

A total of 42 rice landraces selected from screening of 250 rice landraces were evaluated for drought tolerance based on various physiological, roots and drought tolerance traits. A total of 4 landraces, viz. SamroYoh, Narichitpi, Teke and Meche were identified as drought tolerant based on yield under stress and stress tolerance index (STI) (Table 2. and Fig. 6). Additionally, a total of 14 rice breeding lines were evaluated at ICAR NEH, Nagaland centre and multi-location trials across the state for yield and yield attributes. The results indicated that a total of 8 breeding lines (TRC-395, TRC-171, TRC-308, TRC-138, TRC-189, TRC-295, TRC-836, TRC-131) out yielded check variety with early duration. TRC-171 showed the highest yield with 58.23 q/ha followed by TRC-131 with a yield of 56.74 q/ha (Fig. 7).

Table 2. Selected Rice landraces based on morpho-physiological and yield traits

Name of Landraces	RWC (%)	Total Chlorophyll	Days to 50% Flowering	Days to Maturity	Plant Height	Grain Yield/ Plant (S) (g)	Grain Yield/ Plant (N) (g)
SamroYoh	65.82	5.391	95	122	131.1	59.23	72.27
Narichitpi	79.57	6.467	112	142	96.1	52.90	56.60
Teke	84.57	2.580	98	129	95.4	46.60	59.23
Meche	79.41	2.316	100	128	117.8	41.60	46.53
Vandana (Check)	67.37	3.632	105	136	103.1	43.33	69.80
Sahabagi Dhan (Check)	68.12	1.655	110	138	102.4	42.03	55.90

Performance of Samroyoh under stress

Field visit to drought experiment by Agriculture advisor, Govt. of Nagaland

Fig. 6. Field view of experimental site

Field visit by scientists of ICAR Nagaland Centre

TRC 308 and TRC 138 breeding line

TRC 171 breeding line

Field visit to breeding line by Agriculture officers

Fig. 7. Field view of the experimental site

Identification of major QTLs for grain yield under drought stress in rice varieties of NE region for use in marker assisted breeding to improve yield under drought under climate change

(A.G. Devi and R. Kumar)

Morpho-physiological traits linked to QTLs under drought stress were mapped using 304 recombinant inbred lines (RILs) derived from Sambha Masuri and CT 999. The recombinant inbred lines and parents were phenotyped for six morpho-physiological traits related to drought and yield under drought stress for two consecutive years starting from 2020. All the morpho-physiological traits estimated from the contrasting parents showed significant variations between the parents and among RIL populations (Table 3). The morpho-physiological parameters estimate viz., seedling vigor and grain yield were observed to be high in tolerant parent CT999, while leaf rolling, tip drying, panicle number and panicle length was observed high in susceptible parent Sambha Masuri. Thus, the selection of contrasting parents for development of mapping population for mapping of these traits was effective.

In the present investigation, 560 SSR primers were used for detection of parental polymorphism. Out of 560 primers, 236 primers were detected to be polymorphic between the parents. These polymorphic markers were used for the genotyping of the RILs population. The analysis using inclusive composite interval mapping (ICIM) method detected nine QTLs linked to 6 morpho-physiological traits in the first year (Table 4 to 6 and Fig. 8). However, in the second year, thirteen QTLs were identified for the drought and yield related traits (Table 3, Fig. 8). Three major QTLs (R^2> 10%) namely *qLR-3-1, qTDR-5-1 and qYLD-5-1*with phenotypic variance 12.06, 10.18 and 10.87 respectively and six minor QTLs (R^2< 10%) were detected in the year I. In II year, 10 minor QTLs and three major QTLs namely *qSVG-12-1, qTDR-2-1* and *qYLD-5-1* were detected on chromosome 12, 2 and 5 respectively. Five consistent QTLs related to seedling vigor, leaf rolling, panicle length and yield per plant were identified (Table 4). These QTLs were identified in both the seasons of the year I and II. These consistent QTLs with major effects viz. *qLR-3-1* and *qYLD-5-2* can be effectively utilized for the marker assisted breeding for development of drought tolerant rice varieties.

Table 3. Descriptive statistics of evaluated morpho-physiological traits in parents, and RIL populations

Trait	Parents		Difference between parents	Year I		Year II	
	Sambha Masuri	CT999		Range	Mean±SD	Range	Mean±SD
SVG	1	5	4	1-9	2.9 ± 1.49	1-9	3.08 ± 1.46
LR	7	2	5	0-9	1.8 ± 2.1	0-9	1.84 ± 2.13
TDR	6	0	6	0-9	2.3 ± 2.61	0-9	1.78 ± 2.43
PN	16	8	8	2-20	9.0 ± 3.71	2-22	8.67 ± 3.17
PL	22.4	20.3	2.1	9-28.5	23.2 ± 3.57	15-28.7	22.28± 2.71
YLD	12.67	16.97	4.3	2-28.5	16.2 ± 4.61	1.5-38.5	14.3 ± 3.85

Seedling Vigour (SVG); Leaf Rolling (LR); Tip Drying (TDR); Panicle number per plant (PN); Panicle Length (PL); Yield per plant (YLD).

Table 4. QTLs identified for morpho-physiological traits in RIL populations in the year I

Trait	QTL	Chr. No.	Marker Interval	Map Pos. (cM)	LOD	PVE (%)	Add
Seedling Vigour	*qSVG-12-2*	12	RM28076-RM28828	7	4.22	6.26	-0.40
Leaf Rolling	*qLR-3-1*	3	RM14824-RM15606	5	6.49	12.06	0.77
	qLR-6-1	6	RM19323-RM20089	18	4.92	6.52	0.57
Tip Drying	*qTDR-1-1*	1	RM8278-RM12293	160	4.67	0.99	-0.75
	qTDR-5-1	5	RM17709-RM18539	217	16.66	10.18	-2.31
Panicle number per plant	*qPN-7-1*	7	RM21189-RM20775	184	3.53	6.28	-0.90
Panicle Length (cm)	*qPL-4-1*	4	RM16251-RM17185	126	2.54	3.56	-0.96
Yield per plant (g)	*qYLD-4-1*	4	RM16782-RM17440	194	3.74	6.83	-2.77
	qYLD-5-1	5	RM17709-RM18539	241	2.95	10.87	-2.31

Table 5. QTLs identified for morpho-physiological traits in RIL populations in the year II

Trait	QTL	Chr. No.	Marker Interval	Map Pos. (cM)	LOD	PVE (%)	Add
Seedling Vigour	*qSVG-10-1*	10	RM5304-RM25335	103	2.90	2.91	-0.30
	qSVG-12-1	12	RM28731-RM28076	4	13.68	15.13	-0.66
	qSVG-12-2	12	RM28076-28828	7	3.12	6.82	-0.43
	qSVG-12-3	12	RM28268-28040	46	4.96	7.14	0.47
Leaf Rolling	*qLR-3-1*	3	RM14824-15606	2	4.62	8.28	0.61
	qLR-8-1	8	RM22378-3215	206	2.66	4.12	0.43
Tip Drying	*qTDR-2-1*	2	RM13205-13091	8	8.62	11.05	1.11
Panicle number per plant	*qPN-5-1*	5	RM18389-17709	181	4.14	6.09	-1.39
Panicle Length (cm)	*qPL-4-1*	4	RM16251-17185	123	9.01	9.71	1.12
	qPL-8-1	8	RM22847-23355	89	3.22	3.97	-0.73
Yield per plant (g)	*qYLD-4-1*	4	RM16782-17440	191	2.64	1.43	-2.35
	qYLD-5-1	5	RM18389-17709	180	6.15	10.06	-3.44
	qYLD-5-2	5	RM17709-18539	219	3.28	8.30	-5.60

Table 6. Consistent QTLs for drought tolerant traits discovered in both the years (I and II)

Trait	QTL	Chr. No.	Marker Interval	Map Pos. (cM)	LOD
Seedling Vigour	*qSVG-12-2*	12	RM28076-28828	7	3.1182
Leaf Rolling	*qLR-3-1*	3	RM14824-15606	2	4.6244
Panicle Length (cm)	*qPL-4-1*	4	RM16251-17185	123	9.0138
Yield per plant (g)	*qYLD-4-1*	4	RM16782-17440	191	2.6422
	qYLD-5-2	5	RM17709-18539	221	3.2823

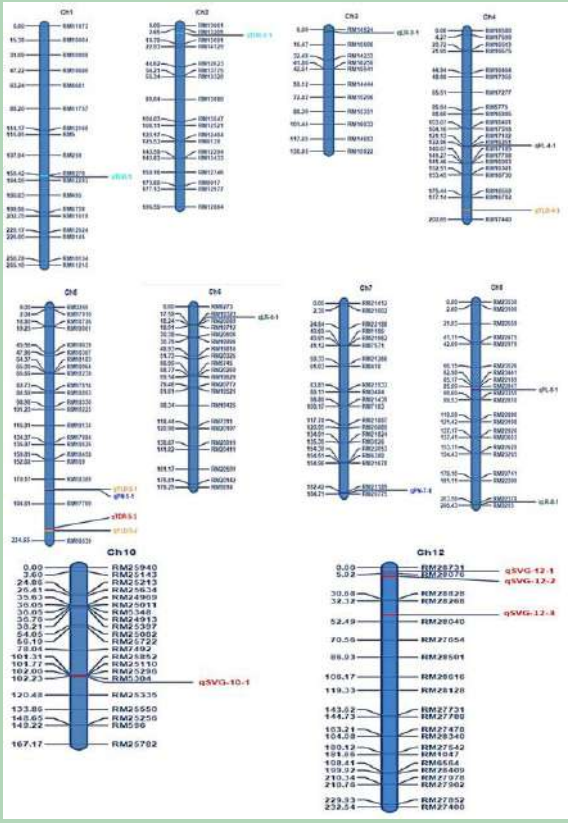


Fig. 8. Mapping positions of various drought and yield related QTLs in this study

Natural Resource Management

Effect of elevated CO_2 and temperature on Maize, French bean, Lentil and Pea growth and productivity under Free Air Temperature Enrichment (FATE)

(R. Thangavel, B.U. Choudhary, R. Krishnappa, P. Moirangthem, J. L. Chanu, A. Balusamy, J. Layek and S. Hazarika)

Effect of high CO_2 and temperature on the growth performance of Maize, French bean, lentil and Pea was investigated for the third year by conducting an experiment in Free-air temperature enrichment (FATE) (Fig. 9). Maize (Megha Maize-1), French bean (Selection-9), Lentil (Hull-77) and pea (Arkel) were the test crops for Kharif and Rabi seasons. The main treatments are (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, (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.

With maize, elevation of temperature reduced the plant height, root weight, cob weight, cob diameter and grain yield by 16.9, 7.99, 4.82, 3.59 and 14% respectively over AT+ACO_2 (201, 25.4, 17.3, 3.59 cm and 4.18 t/ha, respectively). However, addition of CO_2 to ET increased significantly increase the plant biomass (12.4%), no. of grains per cob (10.8%), grain yield (16%) and stover (9.6%) over ET+ACO_2. (Fig. 9a). FYM application increased the plant height (5.76%), root height (1.02%), Cob height (4.15%), plant weight per plant(1.05%), root weight (13.10%), no. of grains per plant (6.53%), grain yield (15.34%), stover yield and (25.98%) respectively over control (235.6 cm, 27.6 cm, 18.1cm, 383.3g, 67.11g, 459.8 respectively). In French bean, ET resulted in 21.93, 27.10, and 3.55 % reduction in pod yield, biomass and plant height respectively over AT+ACO_2 (12.06 t/ha, 0.34 t/ha and 46.84 cm,respectively (Fig. 9b). When temperature and CO_2 were increased, there was an increase in Stover yield per plant (43.1%), RDW (61.8 %), and SDW per plant (13.18%) compared AT+ACO_2 and ET alone. Addition of inorganic fertilizers increased the biomass, plant height, root height, stover yield per plant, SDW per plant by 62.28, 70.72, 56.51, 122.8, 91.9 % (0.43 t/ha, 59.26 cm, 21.73 cm, 12.32 g, and 4.40g) respectively over the control. INM alone increased the pod yield by 96.23% over control (17.6 t/ha).

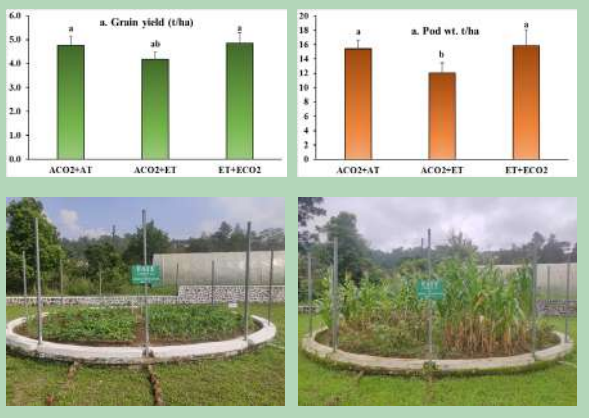


Fig. 9. Effect of elevated environment on maize grain yield (a) and French bean pod yield (b) under different nutrient management practices

In Lentil, ET alone reduced the grain yield more than 90% while combination of ET and ECO_2 significantly increased the pod yield (277%), stover yield (91.8%), SDW (90.1%), pod weight per plant (19.7%), root height (89.5%), root dry weight (21.2%), No. of pods per plant (20.4%) over AT+ACO_2 (0.41t/ha, 0.87 t/ha, 5.22g, 0.69g, 5.52 cm, 0.46 g, 34.81 respectively)(Fig. 10c). INM showed a significant increase in pod yield(71.9%), plant height (48.21%), pod weight per plant (74.9%), RDW (70.64%), No. of pods per plant (66.31 %) and test weight of 1000 seeds (48.21%) as compared to control (by 0.32 t/ha, 39.07 cm, 0.79 g, 0.51 g, 37.54 and 26.76 g, respectively) (Fig. 10). In pea, under elevated temperature condition, there was a negative impact on the pod yield (1.89 t/ha), biomass (0.45 t/ha), straw height (63.3 cm) which were reduced by 23.2, 48.1 and 9.40% in comparison to AT+ACO_2. There was a significant increase in, no. of grains per pod (7.41),root height (13.12 cm), RDW (1.49 g), pod weight per plant (188.8 g), no. of pods per plant (10.6), and plant dry weight (8.45 g), respectively when both temperature and CO_2 concentration were increased over AT+ACO_2 (1.13, 16.69,39.9, 36.71, 36.55 and 48.91% respectively) (Fig. 10d). The application of FYM recorded the highest value in pod weight (2.15 t/ha), no. of grains per pod (7.77), root height(12.18 cm), RDW (1.35g), test weight of 1000 grains (23.8g), no. of pods per plant (9.98), SDW (7.36g) which were increased by 2.15,2.94, 12.77, 0.91, 0.54, 11.59 and 9.39 %, respectively in comparison to control. However, INM had highest yield in biomass (0.64 t/ha) and straw height (66.01 cm) by 17.44 and 2.14 % respectively. On the other hand, inorganic fertilizers application showed the highest pod weight per plant (188.2 g) by compared to the control plot. (Fig. 10)

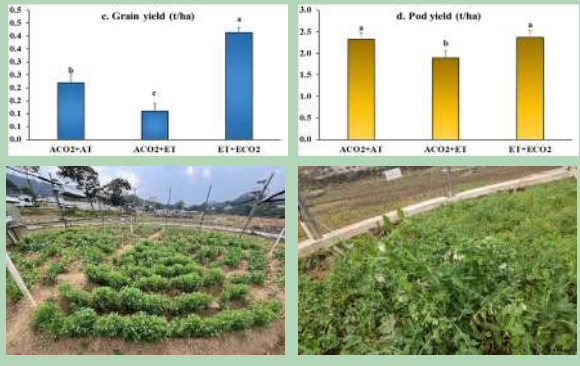


Fig. 10. Effect of elevated environment on lentil grain yield (c) and pea pod yield (d) under different nutrient management practices.

Impact of elevated CO_2 and temperature on French bean and rice growth and productivity in Carbon Dioxide Temperature Chamber (CTGC)

(R. Thangavel, B.U. Choudhary, R. Krishnappa, P. Moirangthem, J.L. Chanu, A. Balusamy, J. Layek and S. Hazarika)

First year experiment was conducted in the CTGC to study the effect of ECO_2 and ET on the growth performance of French bean (Selection 9) and Rice (Bhalum 3) (Fig. 11). 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 were (i) Control (ii) Biochar @ 10t/ha + 100% NPK (iii) Nano fertilizers (iv) Mulching + 100 % NPK (v) Hydropriming + 100% NPK and (vi) Liming @ 500 kg/ha + 100% NPK.

With respect to French bean, results revealed that the pod yield, stover yield, plant height, RDW, SDW per plant and pod length ranged from 6.64-12.53 t/ha, 0.33-0.61 t/ha, 19.9-37.9 cm, 1.43-2.11 cm, 7.05-9.17 g and 11.81-13.69 cm respectively (Fig. 11a). Amongst the four CO_2 and temperature combinations, the ET and CO_2recorded the highest value of fresh pod weight, stover yield, plant height, RDW, straw fresh weight, and SDW per plant, which increased by 13.5%, 10.7 %, 14.6 %, 28.4 %, 27.3%, 31.0 and 17.5 % respectively in comparison to ACO_2 and AT. However, the pod length (11.8 cm) was reduced by 13.7% over ACO_2 and AT. Nano fertilizer +100% NPK observed a significant increase in root height, RDW, straw fresh weight and pod length by 25.8, 23.4, 26.3 and 25.8%, respectively comparing to control. However, the pod yield and straw yield was maximum under mulching with NPK application which is on par with lime application with NPK and biochar application with NPK fertilizers.

In rice, the grain yield, biomass, no. of tillers, panicle height and test weight of 1000 grains ranges from 0.97-1.72 t/ha, 3.20-3.89 t/ha, 2.86-4.41, 18.6-20.31 cm, 24.2-24.6 g respectively. ET decreased the grain yield by 35%, root height by 16.1%, plant height by 5.71%, number tillers and test weight by 27 and 2.5%, respectively as compared to ACO_2 and AT (10.2 cm, 127.9 cm, 3.94 and 24.6g, respectively) (Fig. 11b). However, both elevated temperature and CO_2 also had a positive impact on most of the plant parameters over ET alone. Increased in temperature with CO_2, increased the grain yield and biomass of the crop by 31.1, and 20 % respectively in comparison to ACO_2

and AT. The increased in CO_2 alone also increased the number of tillers per plant and the panicle height by 11.9 and 3.24 % respectively. There was a reduction in number of tillers (3.25) by 27.1 % on application of nano fertilizers application. Application of Biochar @ 10 t/ha +100 % NPK showed a significant increased on grain yield (1.56 t/ha), biomass (3.82 t/ha), plant height (132.2 cm) and panicle length (20.95 cm) by 48.16, 33.2, 19.36 and 15.23 % respectively as compared with control. Hydropriming with NPK application increased the root height by 15.27 % and value ranged from 8.33-10.37 cm whereas, liming @500kg/ha + 100 % NPK increased the test weight of 1000 grains by 5.84 % over control.

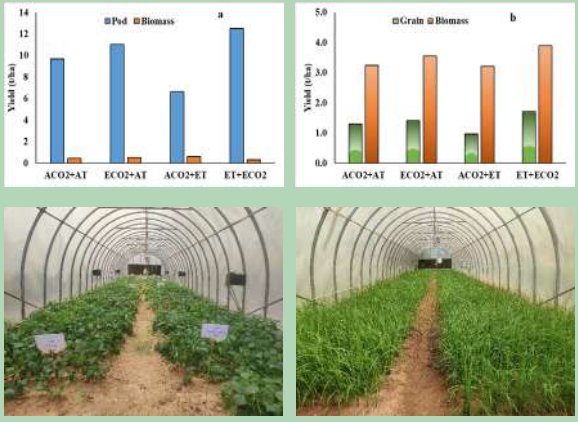


Fig. 11. Effect of elevated CO_2 and temperature on French Bean (a) and rice (b) growth parameters under different nutrient management practices

Effect of soil aggregates size on soil total organic carbon (TOC) and soil oxidizable carbon (SOC) content under prominent agroforestry systems

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

Among the different land uses, the total organic carbon (TOC) content ranged 2.37 to 3.16% in the surface soils (L1) irrespective of aggregate size (Fig. 12). Macro aggregates (>2.0mm) had 2.6 to 21.6% and 6.9 to 12.5% higher TOC than micro (<0.25mm) and meso (0.25-2.0mm) aggregates (14). Among the AFSs, Alder+pineapple (ALDP) had higher (<0.25mm) TOC in the surface soil under macro and micro aggregates while Som+broom+pineapple (SMBP) based AFS had higher TOC content under meso aggregates in the surface soil (L1:0.0-0.15m) (Fig. 12). The AFSs had 8.4 to 39.0%, 24.3 to 33.7%, and 15.8 to 34.9% higher TOC content than abandon cropland (CNTL) in surface soils under micro, meso and macro aggregates respectively (Fig. 12). TOC content declined consistently from immediate subsurface (L2: 0.15-0.30m) to the bottommost soil profile depth (L6: 0.80-1.0m) irrespective of land use but the decline was more intense in abandoned cropland soils (21-66.7% in micro, 11.7-63.5 in meso and 3.3 to 68.5% in macro aggregates) compared to the AFSs (8-65.2% in micro, 8.7-61.6% in meso and 4.9-72.0% in macro aggregates) (Fig. 12). AFSs were comparable in TOC content under different aggregate size. Alder+tea (ALDT) had marginally lesser TOC content in the subsurface (L2:0.15-0.30m) to the middle of soil profile (L3:0.30-0.45m) while Silver oak+pineapple recorded lesser TOC content in the bottommost soil profile depth (L6: 0.80-1.0 m) under different aggregates size (Fig. 12).

Soil oxidizable carbon (SOC) content (Walkley and Black carbon) content was higher in macro aggregates compared to other aggregates (micro and meso) (Fig. 12). SOC content ranged 1.45 to 2.02% in the surface soils (L1) under micro aggregates irrespective of land uses (Fig. 12). Regardless of land uses, SOC content varied widely -6.5% to +9.8% under meso aggregates while macro aggregates had 3.1 to 16.5% higher SOC content compared to the micro aggregates in the surface soils (L1) (Fig. 12). Among the AFSs, ALDP had 10.7 to 16.5% higher SOC content in micro aggregates while Som+broom+pineapple had marginally 2.4 to 3.8% and 0.8 to 7.7% higher SOC content in meso and macro aggregates in the surface soils (L1) (Fig. 15). Cropland abandonment leads a loss of 16.6 to 28.4%, 22.6 to 25.4% and 18.8 to 24.6% in SOC content under micro, meso and macro aggregates respectively in surface soils (L1) compared to the different AFSs (Fig. 12). Similar to TOC, SOC also decreased constantly with depths across the different land uses (Fig. 12). Among the AFSs, SOC reduced 14.2 to 75.9%, 12.5 to 70.4% and 8.7 to 78.5% in micro, meso and macro aggregates respectively compared to the surface soils (Fig. 15). Cropland abandonment soils lesser SOC content and drastic decline in SOC content across the soil profile (L1:0.0-0.15m to L6: 0.80-1.0 m) compared to different AFSs (Fig. 12).

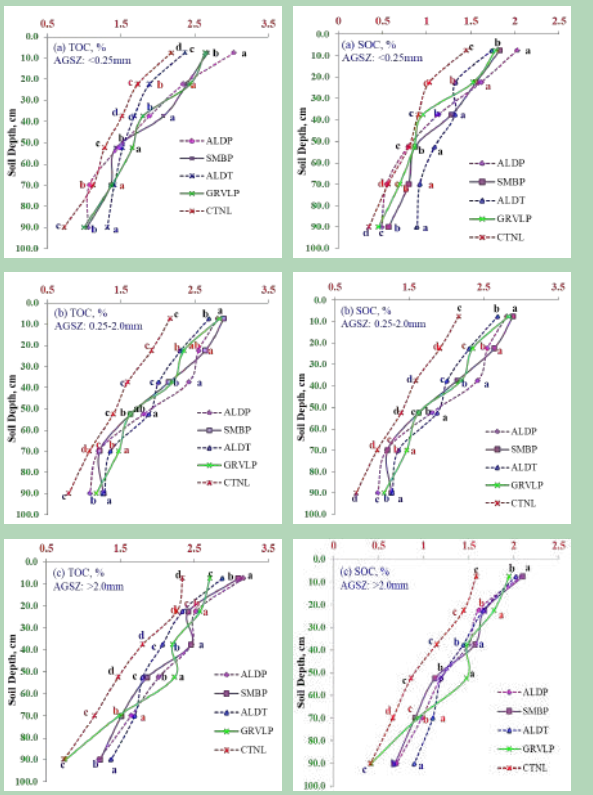


Fig. 12. Vertical distribution of soil total carbon content (%) and soil oxidizable carbon content (%) in different soil aggregates under various agroforestry systems

Non-destructive and rapid estimation of the foliar nitrogen of the tomato plant by proximal hyperspectral remote sensing

(B. U. Choudhury and K. Rangappa)

Soil nitrogen is an essential major plant nutrient that is responsible for optimum plant growth and yielding performances of tomato plants. Enzymes, vitamins, chlorophyll, and other cell constituents all depend on it for crop growth and development. However, too much nitrogen can depress yields, affect the availability of other essential nutrients, pollute the environment, including water resources, and increase the cost of production. If there is a shortage of nitrogen in relation to plant uptake requirements, it also hinders plant vegetative growth and decreases yields. Traditional destructive methods of measuring crop nitrogen status are tedious, error-prone, skill-oriented, require a well-equipped laboratory for measurement, and take time to take corrective measures, such as fertilizing based on laboratory measurements. With advances in hyperspectral proximal remote sensing technology, plant N estimation can be conducted quickly and non-destructively, while being economical and repetitive in monitoring.

In this study, we attempted to develop a non-destructive hyperspectral proximal remote sensing-based estimation method for predicting the leaf N concentration of standing tomato plants. We used an ASD Handheld 2 Spectroradiometer to measure leaf spectral reflectance multiple times and correlated them with destructive laboratory measurements on multiple occasions. For this, Tomato (*cv.* RCM-1-76) was grown as a test crop in stress-free, open field conditions at the ICAR Research Complex for the NEH Region, Umiam, Meghalaya. Periodic spectral reflectance measurements of standing tomato crop were taken in increments from 325 to 1075 nm by a field portable Spectroradiometer and correlated with corresponding laboratory measured plant N concentration (Fig. 13). SG filters were used to process periodic reflectance data and create smoothed spectra, which were then transformed into normalized spectra. To select variables (grouping and predictor), correlation coefficient and step-wise discrimination analysis (SDA) were performed on a large dataset to identify sensitive wavelength regions. The sensitive wavelength regions were identified as visible (401-702 nm) and NIR (702-1020 nm (Fig. 14). Using MLR, Random Forest, Ridge Regression, and SVM Regression, multiple linear regression models are being employed to select a satisfactory predicting model based on R square and RMSE.

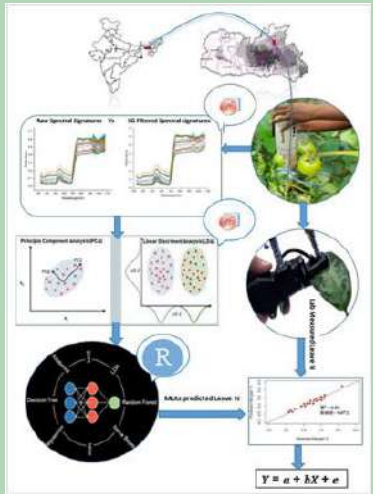


Fig. 13. Steps followed in deriving the spectral predictive models

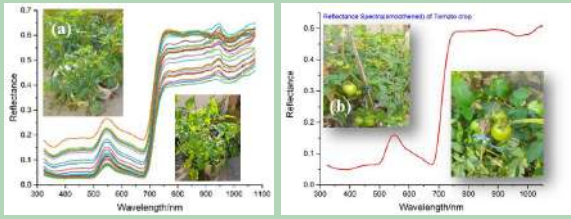


Fig. 14. Smoothened spectra of Tomato crop

Reflectance in the Visible and NIR regions was found to be sensitive to the N of tomato growth. Correlation coefficient analysis was carried out between nitrogen and spectral wave bands, along with Principal Component Analysis (PCA). It was found that the plant N concentration was best predicted using reflectance in the visible (401-702 nm) region, specifically at wave bands 678 nm in the visible region (Table 7). The smoothed spectra were subjected to multiple linear regressions and MLAs like a Support Vector Machine (SVM), Random Forest (RF), and Ridge Regression (RR), which resulted in R2 values between 0.85 and 0.91, and RMSE values between 0.07% and 0.09%. The developed Random Forest model demonstrated robust performance in predicting nitrogen levels in tomato leaf with an R2 of 0.91 and an RMSE of 0.07%. The model was trained on a set of hyperspectral data that contained various spectral features. The Root Mean Square Error (RMSE) and R2 were used to assess the model's performance. The obtained values indicate the accuracy of the model in capturing nitrogen variations.

Table 7. Predictive models for estimating leaf nitrogen using tomato crop spectral reflectance (R = reflectance)

Discriminated	Sensitive Spectral region (nm)	Sensitive bands (nm)	Most Sensitive band(nm)	Model	Predictive Model
Smooth	410 – 1020	550, 678, 853, 972	678	RF	$Y = 0.203+90.24*R_{678}$
Smooth	410 – 1020	550, 678, 853, 972	678	SVM	$Y = 0.696+81.96*R_{678}$
Smooth	410 – 1020	550, 678, 853, 972	678	RR	$Y = 0.653+82.95*R_{678}$
Smooth	410 – 1020	550, 678, 853, 972	678	MLR	$Y = 0.753+81.45*R_{678}$

The Study demonstrated that MLAs based Spectral prediction model can estimate leaf N concentration quickly and non-destructively. Robusting the developed spectral model from multi-location studies can be a potential cost–effective and non-destructive alternative to expensive and time consuming Laboratory based measurement. This can have a potential application in precision agriculture.

Litter decomposition and their nutrient release pattern of different agroforestry tree species in mid-hill condition of Meghalaya

(N. Raju Singh, B.U. Choudhury and A. Balusamy)

Leaf litter decomposition and nutrient release pattern of major prominent agroforestry trees namely *Alnus nepalensis*, *Machilus bombycina*, *Parkia roxburghii*, *Chukrasia tubularis*, *Psidium guajava*, *Schima wallichii*, *Michelia champaca*, Citrus limon *Grivellia robusta* and *Citrus recticulata* were studied by following nylon-bag technique (Fig. 15).

Fig. 15. Schematic diagram showing litter decomposition study

Among the different Agroforesty trees, Citrus species (Lemon and mandarin) had higher decomposition rate (57.7% and 55.3%) in the month of October from the initial weight (30 gram), respectively (Fig. 16). Again the leaf matter of lemon and mandarin decomposed 9.1% to 12.9% respectively in the November month compared to the October (Fig. 16). Among other trees except lemon and mandarin, *M. bombycina* (Som) had shown the slowest decomposition rate (only 11.14% in October and

14.04% in November compared to the initial weight) while *C. tubularis* (Poma) had higher decomposition (29.84% in the October and 36.53% in the November month compared to the initial weight) (Fig. 16).

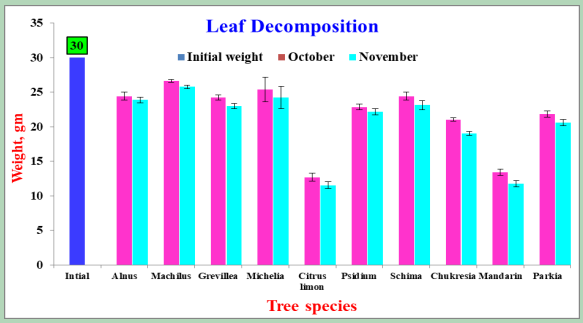


Fig. 16. Leaf decomposition rate of different potential agroforestry tree species

Evaluation of carbon sequestration potential and soil carbon stock of major land use systems in Mizoram

(Lungmuana)

Eight dominant land use systems were selected in the mid hills; elevation (500 to 800 masl) for carbon sequestration potential evaluation. Soil samples were collected from three locations for replication and from each location, five points were demarcated and composite samples were made. Soil sample collection was done upto one meter (0-100 cm; 0-20, 20-40, 40-60, 60-80, 80-100 cm) for analysis (Fig. 17).

Fig. 17. Soil collection for C sequestration evaluation of different land use systems

The soil C pools significantly exerted differences and decreased with soil depth and land uses (Fig. 18). The non-labile C pool (C_{NL}) was higher in F (8.28–3.38 g kg^{-1}) and TB (7.64–4.22 g kg^{-1}) ≥ T > R = B > A = O > OP while the less labile C pool (C_{LL}) was higher in TB (4.19–2.04 g kg^{-1}) and A (4.24–1.14 g kg^{-1}) ≥ O ≥ B = F ≥ OP ≥ R = T. The labile C pool (C_L) was again higher in TB (6.11–3.92 g kg^{-1}) > B = F = T = A = R > O = OP and the very labile C pool (C_{VL}) was higher in O (8.09–2.05 g kg^{-1}) ≥ OP ≥ R ≥ T = A = F = TB ≥ B. The active C pool (C_{AC}) was higher in TB (12.68–5.39 g kg^{-1}) ≥ O = T ≥ F = R = A ≥ B > OP. The passive C pool (C_{PC}) was also higher in TB (11.82–6.27 g kg^{-1}) and F (12.39–4.41 g kg^{-1}) > B ≥ T = A = R ≥ O > OP respectively.

Among the land use, the above ground biomass C (AGBC) was higher in F ≥ B = T ≥ OP > A ≥ R ≥ TB ≥ O. The below ground biomass C (BGBC) was again higher in F ≥ B = T ≥ OP >A ≥ R ≥ B > O. The vegetation C stock (VC) i.e. addition of AGBC and BGBC was subsequently higher in F ≥ B = T ≥ OP > A ≥ R ≥ TB ≥ O. The litter C was higher in B = F = T = R = OP > TB ≥ A > O. The shrub C content was higher in O ≥ F ≥ A ≥ R ≥ TB = T ≥ OP = B. The soil profile C stock (PCS) was higher in TB ≥ F ≥ T ≥ R = B = A > O > OP. The overall ecosystem C stock (ECS) which was the addition of PCS, VC, shrub C and litter C was higher in F = T = B > OP = A = TB = R > O respectively

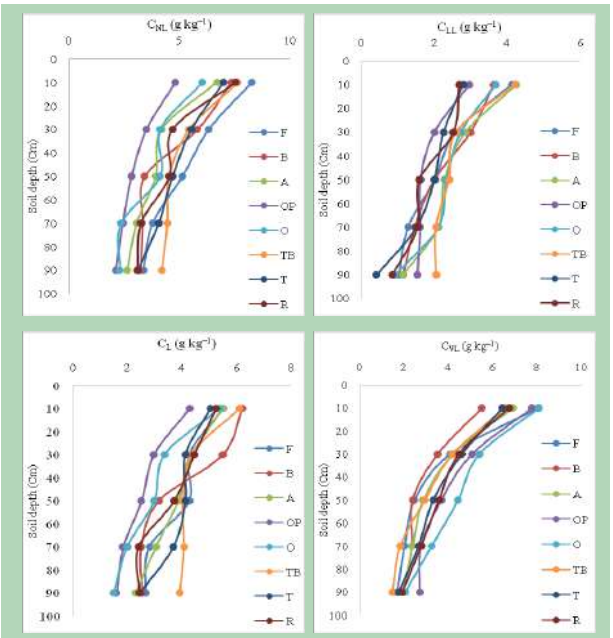


Fig. 18. Effect of different land use and soil depth on different C pools

Note: CNL: Non labile; CLL: Less labile; CL: Labile; CVL: Very labile C pool; F: Forest; B: Bamboo; A: Arecanut; OP: Oil palm; O: Orange; TB: Tree bean; T: Teak; R: Rubber.

Spatiotemporal variability of rainfall concentration index (CI) across Eastern India region

(S. Saha)

Long term location specific daily rainfall time series (1969-2020) were pre-owned to calculate Concentration index (CI; Gini index) expressed as, the relative weightage of days that accounting the highest (lowest) precipitation amounts over any specific study period. The values of constants a and b of exponential

function of Lorenz curve are mentioned in Table 8, along with the percentage of total precipitation amount received over respective 5%, 10%, 25% and 50% of rainiest days in the location specific rainfall time series. In our study, the values of CI range between 0.58 (moderate; Kohima) to 0.69 (high; Cooch Behar). The temporal evolution of seasonal CI was assessed using Mann–Kendall trend analysis (Fig. 19a to d).In particular, the widespread significant persistent rising CI trend was evident during post monsoon months; towards increasing degree of daily rainfall anomaly occurring after south west monsoon withdrawal over eastern India.

Table 8. (i) Percentage of precipitation contributed by the top rainiest days (ii) Values for constants a and b of exponential curves and concentration index (CI) of the rain gauge stations in eastern India

Code	Stations	Annual Rainfall (mm)	(i) Rainiest day thresholds				(ii) Rainfall Concentration		
			5%	10%	25%	50%	a	b	CI
42727	Aizawl	1588.4	24.91	39.91	65.88	89.27	0.04	0.03	0.59
42623	Imphal	1370.6	28.26	44.11	69.13	91.93	0.03	0.03	0.61
42515	Cherrapunjee	11447.3	21.15	39.87	81.71	99.71	0.00	0.10	0.66
42516	Shillong	2142.6	34.80	49.98	75.80	92.69	0.02	0.04	0.65
42220	Pasighat	4220.2	34.78	45.77	69.32	91.88	0.02	0.04	0.64
42299	Gangtok	3339.3	25.78	41.20	70.37	92.12	0.03	0.04	0.61
42527	Kohima	1761.6	25.69	40.21	67.28	89.24	0.05	0.03	0.58
42724	Agartala	2124.0	30.94	46.91	75.56	93.03	0.02	0.04	0.65
42618	Kailashar	2539.6	27.90	42.84	70.50	90.70	0.03	0.03	0.62
42314	Dibrugarh	2556.6	26.58	41.42	69.31	91.52	0.03	0.03	0.61
42414	Chaparmukh	2018.4	33.45	48.00	72.46	90.53	0.03	0.03	0.63
42410	Guwahati	1703.7	28.18	43.99	71.82	91.28	0.03	0.04	0.62
42309	N Lakhimpur	3068.5	25.27	39.85	69.42	91.50	0.03	0.04	0.61
42408	Rangia	1603.6	27.62	40.30	66.49	88.90	0.04	0.03	0.59
42409	Tangla	1821.7	27.62	42.38	70.12	90.89	0.03	0.03	0.61
42415	Tezpur	1732.6	26.99	42.31	70.54	91.13	0.03	0.03	0.61
42403	Coochbehar	2892.8	36.28	53.30	78.81	94.78	0.01	0.04	0.69
42295	Darjeeling	2717.3	26.72	41.60	68.84	89.11	0.04	0.03	0.59
42399	Jalpaiguri	3175.7	30.05	46.50	73.45	92.43	0.02	0.04	0.64
42296	Kalimpong	1185.7	32.72	46.05	72.83	89.51	0.03	0.03	0.62
42503	Malda	1245.8	35.47	51.71	77.55	94.21	0.02	0.04	0.67
42506	Balurghat	1089.1	29.95	46.83	69.44	93.07	0.03	0.03	0.61
42603	Berhampore	1413.0	31.21	46.80	72.72	90.94	0.03	0.03	0.62
42708	Shantiniketan	1466.9	30.58	46.80	73.75	91.76	0.02	0.04	0.64
42711	Krishnanagar	1263.5	29.78	44.50	70.50	91.40	0.04	0.03	0.60
42807	Alipore	1804.8	29.02	46.85	74.82	92.07	0.02	0.04	0.64
42809	Dumdum	1732.1	29.41	44.44	72.04	92.60	0.02	0.04	0.63
42812	Canning	1801.8	30.78	45.45	71.97	91.10	0.03	0.04	0.63

42714	Bagati	1459.4	29.08	43.45	69.62	89.66	0.04	0.03	0.60
42709	Burdwan	1442.5	28.31	42.59	70.51	90.71	0.04	0.03	0.61
42900	Contai	1634.8	32.36	46.78	71.52	92.24	0.03	0.03	0.63
42803	Midnapore	1634.2	17.97	33.89	59.76	86.63	0.05	0.03	0.52
42705	Purulia	1342.6	30.90	47.20	71.25	92.22	0.03	0.04	0.63
42805	Uluberia	1680.6	29.99	44.42	70.73	90.17	0.04	0.03	0.61
42806	Haldia	1808.7	27.56	40.48	66.01	86.96	0.03	0.03	0.62
42811	Diamond Harbour	1685.2	29.98	46.12	72.48	91.26	0.03	0.04	0.63

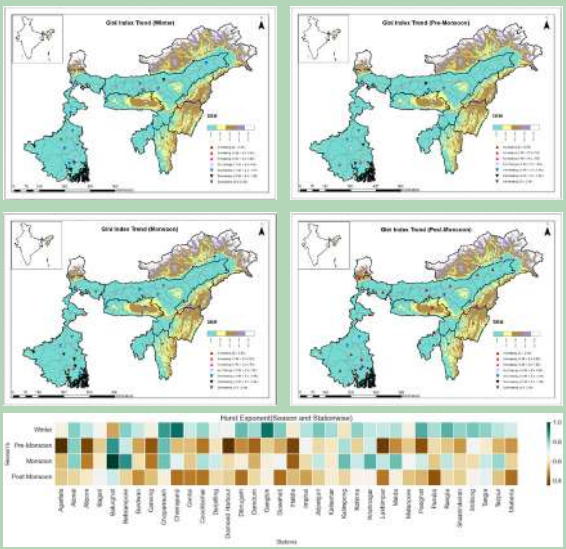


Fig. 19. Monotonic trend persistence of CI values (a) winter (b) pre-monsoon (c) monsoon (d) post monsoon seasons across eastern India

Effect of organic nutrient management practices on carbon sequestration and soil carbon pools in different cropping systems in Sikkim

(S. K. Das)

Effect of cropping system on soil organic carbon fractions (g kg soil^{-1})

The Soil organic carbon fractions differ significantly among different cropping system across the soil depth (Table 9). The mean VLC ranged from 5.05 to 6.20 g kg soil^{-1}, LC ranged from 3.52 to 4.41 g kg soil^{-1}, LLC ranged from 3.15 to 4.04 g kg soil^{-1}and NLC ranged from 4.22 to 4.53 g kg soil^{-1} across the cropping system. It is found that Maize-soybean and Maize-Vegetable pea cropping system recorded the maximum VLC 6.78 and 6.40 g kg soil^{-1}in 0-15cm, 6.12 and 5.58g kg soil^{-1}in 15-30cm and 5.69 and 5.40g kg soil^{-1} in 30-45cm soil depth. Maize-mustard recorded the lowest VLC followed by Maize- rice cropping system in all the soil depth. The LC valued also varied significantly with respect to cropping system. Among the different cropping system Maize-Vegetable pea had found significantly higher LC4.54g kg soil^{-1} in 0-15cm, 4.32g kg soil^{-1}in 15-30cm, 4.12g kg soil^{-1}in 30-45cm soil depth. The least LC was recorded in Maize-mustard3.75 in 0-15cm, 3.55g kg soil^{-1}in 15-30cm and 3.27g kg soil^{-1} in 30-45cm soil depth. The LLC also varied significantly with respect to cropping system in all the soil depths. Maize- black gram cropping system has recorded highest LLC followed by Maize- buckwheat in all the soil depth. Lowest LLC was recorded in Maize-mustard followed by Maize-rice cropping system. The highest NLC was observed in Maize- rice4.85g kg soil^{-1}in 0-15cm, 4.67 g kg soil^{-1}in 15-30cm and 3.35 g kg soil^{-1}in30-45cm followed by Maize-mustard cropping system. The lowest NLC was recorded in Maize- black gram 4.48 g kg soil^{-1}in 0-15cm, Maize- mustard 3.61g kg soil^{-1}in 15-30cm and maize- rice 3.35 g kg soil^{-1}in30-45cm.

Active carbon pool and Passive carbon pool

The active carbon pools of soil differ significantly among the cropping system across the soil depth (Table 9). The active carbon pool corresponds to very labile carbon and labile carbon pool. The mean AC pool in soil ranged from 8.57 to 10.27 Mg ha^{-1}. Among the different cropping system, Maize-soybean, Maize-Vegetable pea, Maize- black gram, Maize- buckwheat and Maize-rice recorded significantly higher active carbon pools over Maize-mustard cropping system in all the soil depth. The maximum AC pool was observed in 0-15 cm soil depth being highest in Maize-soybean 11.08 Mg ha^{-1}followed by Maize- Vegetable pea10.94 Mg ha^{-1}while lowest AC pool was found in Maize-mustard 9.10 Mg ha^{-1}followed by Maize- rice 9.88 Mg ha^{-1}cropping system.

The passive carbon pools of soil also differ significantly among the cropping system and it corresponds to less labile and non-labile carbon pool. The mean PC pool in soil ranged from 7.40 to 8.37 Mg ha^{-1} across the cropping system in 0-45cm soil depth. Maize-soybean and Maize- black gram cropping system recorded the maximum PC pool 8.80 and 8.72 Mg ha^{-1}in 0-15cm, 8.40 and 8.22Mg ha^{-1}in 15-30cm, 7.92 and 7.83Mg ha^{-1}in 30-45cmamong different cropping system. The minimum PC pool was observed inMaize-mustard8.10Mg ha^{-1} in 0-15cm, 6.73 Mg ha^{-1} in 15-30cm, 7.36 Mg ha^{-1}in 30-45cm soil depth.

Table 9. Effect of cropping system on soil organic carbon fractions (g kg soil-1)

Cropping system	Soil depth (cm)			
	0-15	15-30	30-45	Mean
(A) Very labile carbon (VLC)				
Maize- black gram	6.00^{c}	5.39^{c}	5.01^{c}	5.47^{c}
Maize- rice	5.76^{d}	5.12^{d}	4.85^{d}	5.24^{e}
Maize-soybean	6.78^{a}	6.12^{a}	5.69^{a}	6.20^{a}
Maize –mustard	5.35^{e}	5.02^{e}	4.77^{e}	5.05^{f}
Maize- buckwheat	5.90^{c}	5.24^{d}	4.91^{d}	5.35^{d}
Maize- Vegetable pea	6.40^{b}	5.58^{b}	5.40^{b}	5.79^{b}
(B) Labile carbon (LC)				
Maize- black gram	4.38^{b}	3.96^{b}	3.86^{c}	4.07b
Maize- rice	4.12^{b}	3.61^{c}	3.52^{d}	3.75d
Maize-soybean	4.30^{b}	4.08^{b}	4.85^{a}	4.41a
Maize –mustard	3.75^{c}	3.55^{c}	3.27^{e}	3.52e
Maize- buckwheat	4.20^{b}	3.86^{b}	3.78^{c}	3.95c
Maize- Vegetable pea	4.54^{a}	4.32^{a}	4.12^{b}	4.33a
(C) Less Labile carbon (LLC)				
Maize- black gram	4.24^{a}	4.10^{a}	3.77^{a}	4.04^{a}
Maize- rice	3.67^{d}	3.30^{d}	3.18^{c}	3.38^{d}
Maize-soybean	4.05^{b}	3.85^{b}	3.64^{a}	3.85^{b}
Maize –mustard	3.30^{e}	3.12^{d}	3.04^{c}	3.15^{e}
Maize- buckwheat	4.08^{b}	3.92^{a}	3.75^{a}	3.92^{a}
Maize- Vegetable pea	3.86^{c}	3.54^{c}	3.38^{b}	3.59^{c}
(D) Non Labile carbon (NLC)				
Maize- black gram	4.48^{b}	4.12^{b}	4.06^{b}	4.22^{b}
Maize- rice	4.85^{a}	4.67^{a}	3.35^{c}	4.29^{b}
Maize-soybean	4.75^{a}	4.55^{a}	4.28^{a}	4.53^{a}
Maize –mustard	4.80^{a}	3.61^{c}	4.32^{a}	4.24^{b}
Maize- buckwheat	4.52^{b}	4.08^{b}	4.06^{b}	4.22^{b}
Maize- Vegetable pea	4.76^{a}	4.50^{a}	4.25^{a}	4.50^{a}

*Means followed by different letters (a-f) are significantly different with respect to the LSD (least significant difference) values at p = 0.05. Significant differences shown are with regard to cropping system.

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*)

The study aimed to investigate the performance of piglets on exposure to "Briquette Fuel Animal Heating System (BFAHS) (Fig. 20). Thirty (n=30) piglets were subjected to three groups viz, Incandescent bulb (T_1), Beehive briquettes (T_2) and Control (T_3) over a period of two months (January-February). During the study, the average minimum temperature recorded was 6.6 ºC. The body weight and body condition score (BCS) were recorded at 15 days interval. Pre-weaning mortality rate was recorded. Results showed that, at weaning the growth performance of piglets in group T2 was significantly ($p<0.05$) higher than T1 and T3, i.e., 9.45±0.09kg, 7.28±0.65kg and 7.14±0.55kg respectively. At weaning, BCS revealed that all the piglets in group T_2 were healthy, whereas in T_1,out of 8 piglets, 5 were healthy, 2 moderately compromised and 1 very compromised, similarly, in T_3, out of 7 piglets, 3 were healthy, 3 moderately compromised and 1 very compromised. No mortality in T_2, although, T_1 and T_3 had 20% and 30% mortality rates. The study indicated that BFAHS can be effectively utilized during winter to improve piglet's performance and avoid pre-weaning mortality from cold stress.

Fig. 20. Briquette fuel animal heating system

Production performance, egg quality parameters and Blood-biochemical profile of laying hen supplemented with Black Turmeric under heat stress condition

(V. Singh, A. Chakrabarti, L. Sahoo, H. Lembisana Devi, H. Bharati, B. U. Choudhury, S. Deori and B. Das)

Heat Stress in poultry birds has adverse effect on growth, productive and reproductive performance, and poultry health which causes huge economic loss to the poultry industry and farmers. So, herbal supplementation may be beneficial in combating heat stress as well as in maintaining the production performance of poultry birds. Black turmeric (*Curcuma caesia*) is a very important herb which has medicinal values and anti-oxidant property (Fig. 21 and 22). It contains active chemicals like 1-8 cineole, camphor, turmerone, camphene, curcumin and other flavanoids and alkaloids. Considering this background information, a study aimed to explore the possible anti-oxidative nature of black turmeric by incorporating it as a feed supplement in diet of laying hen exposed to heat stress. A feeding trial was conducted to study the effect of dietary supplementation of Black turmeric on production performance, egg quality traits and physiological parameters in laying hens exposed to heat stress (Fig. 23). A total 60 laying hens (Dahlem red, age 30 weeks) were kept in individual cages and birds were divided into six equal groups/treatments-T1, T2, T3, T4, T5 and T6; each group having 10 birds. The five groups (T2, T3, T4, T5 and T6) of birds were maintained in artificially induced heat stress condition (37+1°C), while control group (T1) of birds was reared in normal environment. Induced heat stress (37^0C) was created in experimental poultry shed for 4 hours daily for 30 days. The birds of T1 and T2 group was fed with a basal diet only, whereas the T3, T4, T5 and T6 groups were fed with basal diet supplemented with black turmeric powder (0.5, 1.0, 1.5 & 2.0%) respectively throughout the experiment.

The results revealed that production parameters like egg production, egg mass, daily feed intake and FCR were reduced significantly by 23%, 33.23%, 7.06% and 42.80% respectively in heat stressed group (T2) having basal diet only due to heat stress. However, egg production, egg mass, feed intake and FCR were further improved by 19.67%, 45.21%, 7.19% and 28.88% respectively in heat stressed group (T6) supplemented with 2% black turmeric powder in compare to heat stressed group (T2). Present study

revealed that serum corticosterone level was increased significantly (P<0.01) in all heat stressed birds except control group and it was maximum in (T2) group fed with basal diet only. However, corticosterone level was further declined significantly in (T6) heat stressed group supplemented with 2% black turmeric powder but not up to control level. There were no significant change observed in serum glucose, protein, albumin, and cholesterol among different treatments. However, serum triglyceride level was significantly (P<0.01) increased as increasing graded level of black turmeric powder. Haemoglobin level was significantly (P<0.01) reduced in heat stressed birds as compare to control due to heat stress and it was minimum in (T2) group fed with basal diet only. However, haemoglobin level was further improved significantly up to control level in heat stressed group (T6) supplemented with 2% black turmeric powder. Study also revealed that no significant change in cell mediated immunity and egg quality traits except yolk index. Study also revealed that rectal temperature of birds were increased significantly in all heat stressed groups as compare to control group. But there was no significant difference was observed among different heat stressed birds supplemented with different level of black turmeric powder. Respiration rate of birds significantly increased in all heat stressed groups as compare to control due to heat stress and it was maximum in T2 group fed with only basal diet. However, respiration rate was further reduced and it was minimum in T6 group supplemented with 2% black turmeric powder but not up to control level.

It was concluded that dietary supplementation of 2% black turmeric powder improved production performance and reduced serum corticosterone in laying hen without affecting egg quality traits under heat stress condition.

Fig. 21. Fresh Black Turmeric rhizome

Fig. 22. (A) Fresh Black Turmeric **(B) Dried Black Turmeric powder**

Fig. 23. (A) NICRA Experimental Shed **(B) Egg Quality Analysis**

Alligator weed supplementation in chick's diet improves production performance, immune response and antioxidant function during winter season

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

The perennial plant, Alligator weed (AW; *Alternanthera philoxeroides* (Mart.) Griseb) can be found growing on land or in dense mats on water and can have severe ecological and economic consequences by impacting water quality, flow, and the growth of native flora and fauna (Fig. 24). Despite this, incorporating it into animal feed or using it as a supplement presents a sustainable and environmentally friendly alternative to chemical weed control and provides valuable feed for livestock and poultry. Using this background information, the possible impacts of incorporating AW on the production performance, innate immune markers gene expression, and antioxidant levels in Rainbow rooster chicks raised in a semi-intensive system under normal summer and extreme winter conditions was evaluated. A total of two hundred forty Rainbow rooster chicks, were subjected to 4 experimental treatments over a period of 35 days during both the study seasons (summer and winter). The experimental diet consisted of the following:

C: Control diet without any supplements; T_1: 1% AW + basal diet (BD); T_2: 2% AW + BD; and T_3: 4% AW + BD. The basal diet included maize, rice polish, soya, and groundnut cake (GNC) and AW powder was supplemented at different levels in the diet. The proximate composition of AW (on % dry matter basis) was as follows: Moisture (82.57±0.40), total ash (8.51±0.26), crude protein (25.48±1.42), ether extract (1.97±0.51), crude fiber (17.30±1.34) and nitrogen free extract (46.74±2.55). The body weight, average body weight gain and weekly feed intake in T_1 group (1 % AW) were higher in comparison to other groups. There was a significant up regulation in the expression levels of IL-1β (1.17fold), IL-6 (1.67 fold) and IL-12 (4.95 fold) in group T_1 in comparison to control. Furthermore, when in comparison between seasons, the expression of iNOS (4.37 fold in summer vs 29.81 fold in winter), IFN- γ (2.4 fold in summer vs 9.72 fold in winter), IL-1β (1.1 fold in summer vs 99.4 fold in winter) and IL-6 (1.6 fold in summer vs 2.1 fold in winter) were significantly upregulated by many folds in winter in comparison to summer. Superoxide dismutase activity was higher in T_1 during winter (2.45 U/mL) but Catalase activity was elevated during both summer (2.12 U/mL) and winter (4.8 U/mL) periods in comparison to the control (1.12 U/mL). Thus, AW has the potential to mitigate the negative effects of cold stress on growth performance, immune response, and antioxidant function. Thereby, adding 1% AW to the diet of layer birds to enhance their production performance and immunity levels winter stress.

Alligator Weed | Harvesting | Sun drying

Fig. 24. Collection and preparation of alligator weed as chick's feed

Climate Resilient Technology for active floodplain

(L. Sahoo)

There are around 50,000 ha area in Tripura which are flooded 3-4 years over a span of 10 years. The water level during rainy season varies from 30 cm to 1 m or more depending on extent of rainfall and drainage facilities. The extent of damage to crops is to the tune of 50-100%. Most of these low lying Lunga (locally called) lands are owned by small and marginal farmers of the state. To address this problem, a land shaping model "Climate Resilient Technology for active floodplain" was assessed under low lying flood prone areas.

An area of 0.15ha was developed modified to raised beds and sunken beds by earth cutting and filling approach (Fig. 25). The difference in height of high raised bed and mid raised bed and the sunken bed was kept at 0.5m. Drain outs and spillways were made in the system for stopping the losses due to inundation. All the beds were used for paddy cultivation during rainy season. In addition, sunken beds were also used for fish culture where in high demand small indigenous and self recruiting species like Puntius, Mola and Kanla along with carps were cultured. The raised beds were used for vegetable cultivation during winter and summer season. A lowland water harvesting structure of 10% of the total area of the system is dug at one side of the system as a catchment area for water run –off and also for pisciculture. A deep trench of 50m^2 was developed in the water harvesting structure itself to ensure water availability for the fishes round the year. To make the system more economic, 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). One side of the system was developed for Vertical Farming of different gourds.

Production and productivity of the system

The System Productivity in Flood Plain Farming system (70.3 Kg/ha/day) was higher than that observed in Farmers' Practice (20-25 Kg/ha/day). This was because of the development of three zones (High-bed, Mid-bed and Low-bed) which supported not only paddy but also vegetables in Pre-Kharif and Rabi seasons as well as Fish in the lowland along with edible aquatic plants. Moreover, one side of the system was used for Vertical farming which further enhanced the production efficiency. The Rice equivalent Yield was estimated to be 14.4t/ha(Table.10).

Table 10. Rice equivalent yield, systems productivity of the system

System	Rice Equivalent Yield (t/ha)	System Productivity (Kg/ha/Day)
Flood Plain Farming System	14.4	70.3
Farmers' Practice (FP)	2.2	20

In traditional method of rice monocropping, the systems water use efficiency is 1.5-2.0 Kg/mm rainfall, but in this system the SWUE was recorded to be 6.78 Kg/mm rainfall which is 77% higher than FP. This higher water use efficiency is because of high production potential of vegetables, edible aquatic plants and fishes. The energy efficiency was calculated to be 6.55 as compared to 2.25 in FP. With lower energy input and higher output, Flood plain Farming system can be justified as an energy efficient system (Table.11).

Table 11. Water use efficiency and energy efficiency of the system

System	Water Use Efficiency (Kg/mm Rainfall)	Energy Efficiency
Flood Plain Farming System	6.78	1.5
Farmers' Practice (FP)	6.55	2.25

The Multiple Cropping intensity (MCI) was 300% which was also higher than the FP (100%). The Cultivated Land Utilization Index (CLUI) gives an idea about how the available land area has been put into use. In this system The CLUI was recorded to be 92.5 compared to 42 in FP. The Diversity Index (DI) was recorded to be 6.25 compared to 1 in FP (Table 12).

Table 12. Multiple cropping intensity (MCI), cultivated land utilization index (CLUI) and diversity index (DI) of the system

System	MCI (%)	CLUI	DI
Flood Plain Farming System	300	92.5	6.25
Farmers' Practice (FP)	100	42	1

The system water use efficiency was 6.78 Kg/mm rainfall compared to 2Kg/mm in FP. The system production efficiency in Flood Plain Farming system (70.3 Kg/ha/day) was higher than that observed in Farmers' Practice (20-25 Kg/ha/day). This was because of the development of three zones (High-bed, Mid-bed and Low-bed) which supported not only paddy but also vegetables in Pre-Kharif and Rabi seasons as well as Fish in the lowland along with edible aquatic plants. Moreover, one side of the system was used for Vertical farming which further enhanced the production efficiency.

The Energy efficiency was 6.55 compared to 2.2 in FP. The land use efficiency was 63% compared to 32% in Rice monocropping system. The land use efficiency was almost doubled compared to FP. The system generated an economic efficiency of Rs.71.4/ha/day with B:C ratio of 2.8.

Fig. 25. Raised and sunken bed system for active flood plain

SCHEDULE TRIBE COMPONENT (STC)

More than 24,345 tribal famers from seven North Eastern states were benefited during 2023 under various livelihood improvement programmes conducted under Tribal Sub Plan (TSP). A total of 1042 numbers of different physical assets (viz., *Jalkund*, 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, vermibed, drip irrigation set etc.), farm tools and implements (small and medium tools, knapsack sprayer, sewing machine, cycle weeder, pump etc.), 17 nos. animal health camp, 36 nos. of veterinary services and 4193 nos. of literature were created/provided/ distributed in different tribal villages of north east India.

Distribution of seeds/planting materials

Agricultural inputs like seeds, planting materials, mushroom spawn etc. were distributed mong tribal farmers during 2023. Seeds (13,978 kg) of improved varieties of different crops viz., rice, maize, oilseed, 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.) were distributed. Besides these, 7532 nos. of planting materials (tree seedling, fruit seedlings, vegetable seedlings) and 200 kg of turmeric rhizome were also distributed among the tribal farmers for their livelihood improvement. About 800 packets of mushroom spawn were distributed for popularizing mushroom cultivation as an additional source of income.

Table 1. Distribution of seed and planting materials

Particulars	Quantity
Turmeric rhizome	200 Kg
Seeds	13977.8 Kg
Planting material	7532 nos.
Mushroom spawn	800 pkts

Distribution of fertilizers /bio-fertilizer/soil amendment/ plant protection chemicals/ Micronutrients/FYM/ vermicompost

Plant protection chemicals (249 kg), micronutrient (1131 kg) and FYM/Vermicompost (137 tonne) were distributed among the tribal farmers of North East for enhancing crop productivity as well as livelihood improvement.

Table 2. Distribution of plant protection chemicals, micro-nutrient and manures among the farmers

Particulars	Quantity
Plant protection chemicals	249 Kg
Micronutrients	1131 Kg
FYM/Vermicompost	137 tonnes

Livestock, fish fingerlings and medicines

A total of 229 nos. piglets of improved breed, 31,119 nos. of poultry chicks, 1296 nos. of duckling and 61,534 nos. of fish fingerlings, 62.5 tonnes of feeds and 11,255 doses of medicine were provided for income enhancement through scientific production and management of livestock/poultry/fishery / duckery. Apart from these critical inputs, 252 nos. of artificial insemination was done in the villages.

Table 3. Distribution of critical inputs for livestock, fishery and poultry sector (AI=Artificial insemination)

Particulars	Quantity
Feeds	62479 Kg
Fish fingerlings	61534 Nos.
Duck	1296 Nos.
Poultry	3119 Nos.
Piglets	229 Nos.
AI	252 Doses
Medicine	11255 Doses

Capacity building of tribal farmers

Training, demonstration, exposure visit and awareness programme (654 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 7618 numbers of tribal farmers were benefited from these interventions.

Employment generation for livelihood

About (1407) man months was provided under TSP for employment generation among the ST population during 2023.

Table 4. Capacity building, services and creation of physical assets for livelihood improvement of tribal farmers in the region

Particulars	Quantity (Nos.)
Physical assets created	1042
Veterinary services	36
Animal health camp	17
Literature	4193
Training and awareness	654
Employment	1407 (Man months)
Total beneficiaries	24345

AGRI-BUSINESS INCUBATION CENTRE

To fulfill the objectives of ABI, 5 (Five) Sensitization/ Awareness Programs, two virtual webinars and one National conference were conducted in the current year. To facilitate financial and market assistance, two Virtual Business Meets viz., "Entrepreneurship Development Schemes and Financial Assistance in North East India (28th February 2023)" and "Marketing Linkage for Entrepreneurship development in Northeast India (14th March 2023)" were organized. The centre facilitated in linking of potential entrepreneurs/enterprises to various Financial Institutions/Agencies such as State Bank of India (SBI), National Bank for Agriculture and Rural Development (NABARD), Ministry of Micro, Small & Medium Enterprises (MSME) and North Eastern Development Finance Corporation Limited (NEDFi) and successful Agri-startups such as CAPSBER Global Agro Pvt. Ltd. and Farmitopia for financial and marketing assistance. In addition, ICAR-Agripreneurs Meet cum National Symposium on "Strategies for Promotion of Incubatee in Agriculture and Allied Sectors in NE Region of India" was organized during 4th -5th October 2023 in collaboration with NABARD, ICAR-ATARI Zone VI & VII and Manipur Organic Mission Agency (MOMA). More than 300 participants have participated during the conference which included Technologists, Scientists, Business Experts, Agri-Startups, Students and other Stakeholder from different Institutions across the country. One Entrepreneurship Development Programme (EDP) on Value Addition of Meat Products was organized during 11-15 December 2023 where 17 potential entrepreneurs have been trained. During the year, 7 (Seven) potential Entrepreneurs have been admitted for incubation and 2 (Two) New products viz., Ragi Millet Gulla (Gullab Jamun) and Pennywort Herbal Health drink/Tea have been developed by the incubatees in collaboration with ABI Centre. Further continuing the entrepreneurial support, ABI Centre has facilitated in acquiring 3 (Three) FSSAI Registrations and 3 (Three) Trademark applications. The centre has also participated in 3 National Conferences/Workshops and received Best Oral Presentation Award at National Conference on "Rebooting the hill farming for future sustainability and livelihood (RHFFSL 2023)" during 8-9 June 2023 at ICAR Research Complex for NEH Region, Umiam, Meghalaya. The centre has also published 1 Research Article, 1 Training Manual and 1 Souvenir in the current year.

Fig. 1. ICAR-AgriMNS-2023 during 4-5 Oct

Fig. 2. Virtual Business Meet on Entrepreneurship development schemes and financial assistance in NE India

Fig. 3. Innovative products developed under the guidance of ABI Centre

HUMAN RESOURCES DEVELOPMENT

Employees trained

During the reporting period (January 2023 - December 2024), a total 60 employees underwent various type of training and capacity building programmes, of which scientists, technical officers (including Subject Matter Specialists from KVKs) and administrative staaf including finance were 35, 22 and 3, respectively (Fig. 1). The employees underwent training programs organized solely or jointly by Institutes of Indian Council of Agricultural Research (ICAR) and non-ICAR institutes such as ILRI and Royal Veterinary College, College of Horticulture and Forestry (CAU, Pasighat, Agro Environmental Development Society (AEDS) Rampur, RECAST, Kathmandu and University of Debrecen, Hungary, NAARM-Hyderabad, North Eastern Space Applications Centre (NESAC), Meghalaya, CRIDA, Hyderabad, ASTHA Foundation Meerut, Uttar Pradesh, National Institute of Plant Health Management (NIPHM), Hyderabad, ICAR- CIPHET, Ludhiana, Assam Agricultural University (Jorhat, Assam), ICAR-NBSS&LUP, Nagpur, Maharashtra, ICAR-ATARI, Umiam etc.

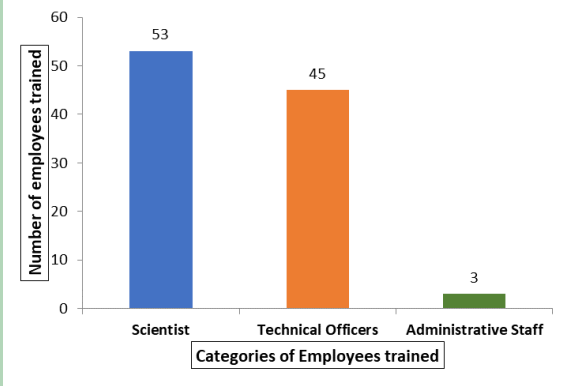


Fig. 1. Different categories of employees trained at National Institutes/Universities during Jan – Dec 2023

Scientists: The scientists were trained in various fields like Risk assessment in food safety, Crime against women and sexual harassment of women at workplace, Technology innovation in agriculture, horticulture, animal husbandry, fisheries, sericulture and allied sectors for sustainable entrepreneurship, Next level approach toward smart farming, innovations and agri-preneurship, Emerging challenges and opportunities in biotic and abiotic stress management, Professional attachment training of the newly recruited scientists, applications of Remote Sensing and GIS in agriculture and allied areas, Remote Sensing and GIS Applications in forestry and ecology, MDP on Leadership Development (a Pre RMP Programme), Recent advances in molecular diagnostics of insect species including invasive and their natural enemies, Laboratory quality management system and internal audit as per ISO/IEC 17025:2017, Enhancing pedagogical competencies for agricultural education, Technology smart agricultural interventions for doubling farmers income and entrepreneurship development in NEH region: Strategies and approaches, etc.

Technical Officers: Similarly, technical officers (including SMS from KVKs) were trained in Agriculture in future & future in agriculture, Technological innovation in assisted reproductive technologies for the improvement of caprine germplasm, Value Chain Management in Natural Fibres, Technology smart agricultural interventions for doubling farmers income and entrepreneurship development in NEH region: strategies and approaches, advanced rice production technologies suitable for Hill ecosystem, Assessment & development of Action Plan on OFT and FLD, natural Farming, food processing, packaging and value addition of agricultural and livestock produce, current trends in treatment and control of parasitic diseases of livestock to promote profitable livestock farming, "application of Remote sensing and Geographical Information System in Agriculture Development (Under CBC)", seed Production and quality control for officials of NEH Region under AICRP on Seed (Crops), etc.

Administrative staff: The administrative and finance staffs were trained in different fields such as efficient administration and accounts management, vigilance perspective for ICAR officers, etc. from various institutes.

Based on the feedback of trainees received from different categories of employees, the impact of training was considerably satisfactory for scientific staff (4.2/5.0 scale). Similarly, the Technical staff

(including SMS, Administrative and finance) also gave a feedback of 4.00 out of 5.0 scales in improving their Job performances.

Training programmes organized during the reporting period (Jan-Dec, 2023)

During the period of Jan – Dec 2023, the Institute conducted a total of 559 numbers of various training and capacity building programs for various stakeholders including farmers, state govt. officers, students from professional courses and rural unemployed educated youth (Fig. 2).

Farmers and unemployed youths: A total 9938 farmers and 150 unemployed youths underwent training and capacity building programmes varying from one-day (01) to seven-days (07) duration across the eight states of Northeast India. They were imparted training on various avenues such as production and management of winter vegetables, soil health management, and crop productivity enhancement, rapid soil heath testing kits, value addition in agriculture commodities, mushroom production, scientific fish rearing, rural poultry and pig farming for livelihood improvement, meat processing, winter aquaculture management and Good Aquaculture Practices (GAP), boosting cold water aquaculture and fisheries in Meghalaya, natural farming, millet production, and value addition for entrepreneurship development etc. (Fig. 2)

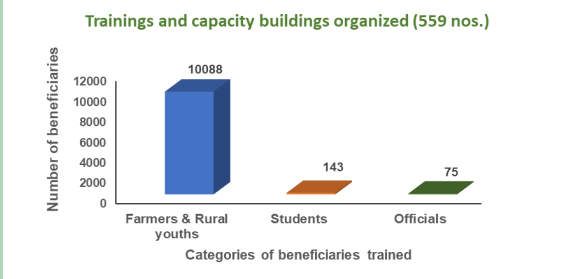


Fig. 2. Number of beneficiaries trained during Jan-Dec, 2023 across 8 states

Various training and capacity building programs conducted during Jan-Dec 2023

Students-professional trainings: Twenty-seven students from Himalayan University, Jollang village, Itanagar, have been trained on Mushroom cultivation and post-harvest technology for five days at ICAR-Krishi Vigyan Kendra, West Siang. Nine (09) B. Sc (Agril.) students underwent 21 days RAWE (Rural Agriculture Work Experience) programme while a final year student of Himalayan University underwent a three months Experimental Learning. Thirty (30) students from Manipur University also underwent exposure visit. In addition, seventy six (76) school students from Ri-Bhoi District, Meghalaya participated in the awareness programme on the occasion of World Soil Day.

State Government officials: Around 75 number of state Government officials from Meghalaya, Manipur and Sikkim were imparted training on various technologies comprising of Climate resilient agricultures, management of acid soils in the hill ecosystem, IFS models, integrated organic farming system models, comprising trees, crops and livestock components for livelihood improvement of marginal and small farmers.

ICAR- IARI UMIAM HUB

Our Institute, ICAR Research Complex for NEH Region embarked on a new journey in 2023 with a teaching programme in Agricultural Sciences at its headquarter, Umiam, Meghalaya. The ICAR-IARI Umiam Hub is now one of the 16 regional Hubs of parent organization ICAR-IARI, New Delhi starting from the session 2023-24 onwards as approved by the Academic Council, ICAR-IARI, New Delhi in its 418th meeting.

The ICAR RC NEHR, Umiam started the UG programme in Agriculture Sciences from the academic session of 2023-24 with the ICAR-Central Potato Research Institute (ICAR-CPRI) Regional station, Shillong, ICAR- National Bureau of plant genetics resources (ICAR-NBPGR) Regional station, Umiam and ICAR- Agricultural Technology Application Research Institutes (ATARI, Zone VII) Umiam, Meghalaya as the cooperating satellite Institutes to assist in the academic programme. Initially, 25 students for the B.Sc. Hon's (Agriculture) degree programme for the academic session 2023-24 were allotted to ICAR NEHR-IARI Umiam Hub. However, during the first academic session, 22 students (13 boys and 9 girls) enrolled for the UG Program at this Hub. Students were admitted through NTA-CUET (UG) - 2024 under ICAR-All India Quota (AIQ). Many facilities such as smart class rooms, laboratories, student's hostels along with required infrastructure and human resources have been provided to the students for smooth conduct of the academic programme. Scholarship has been provided to the admitted students. Eventually, on successful completion of their degree program, the students at the regional hubs will be conferred degrees by The Graduate School, ICAR-IARI, New Delhi.

The academic programme of the hub is functioning according to the guidelines of The Graduate School, ICAR-IARI, New Delhi, as it is one of the constituent Institute of Indian Council of Agricultural Research. The Director of the Institute, Dr. V.K. Mishra is acting as the Hub director of the Nodal Institute, while Dr. S.K. Das - a senior Principal Scientist of the Institute coordinates the programme as the Hub Academic Coordinator. An academic cell has been established for smooth conduct of the academic programme with Dr. A. Roy, Sr. Scientist as the UG Coordinator and Dr. V.K. Verma, Sr. Scientist as the PG Coordinator. The Umiam hub also proposes to start the post graduate programmes leading to Master's and Ph.D degrees in Vegetable science, Fruit science, Plant breeding and in Soil Science soon. The hub has already received financial sanction for establishment of the girl's hostel.

Academic Cell and Lecture Hall at IARI Hub, Umiam, Meghalaya


Hon'ble DG, ICAR and Secretary, DARE, Dr. Himanshu Pathak interacted with the students and laid the foundation stone for Girls Hostel on the foundation day of the Institute on 09.01.2024

KRISHI VIGYAN KENDRA

The Krishi Vigyan Kendras (KVKs) working at the grass root levels have been involved in facilitating adoption of technologies developed by the National Agricultural Research System. At present there are twenty (20) KVKs under the administrative control of ICAR Research Complex for NEH Region, Umiam, Meghalaya located across the North Eastern Region viz., (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). The KVKs in both the Zones i.e ICAR- Agricultural Technology Application Research Institute (ATARI), Zone VI, Guwahati and Zone VII, Umiam 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, school drop outs and extension functionaries of line department of the district and state agriculture and allied sectors.

The mandate of KVK is "*Technology Assessment and Demonstration for wider Application and to enhance 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 (OFT) to assess the location specificity of agricultural technologies under various farming systems.
- Out scaling of farm innovations through Front Line Demonstration (FLD) 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.

During the reporting period a total of 653 nos. training programmes were conducted in different areas of agriculture and allied activities covering 17,815 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, Cropping Systems, Crop intensification and diversification, Soil Health and Fertility Management, Integrated Nutrient Management, Integrated Pest Management, Integrated Farming System, Disease Management, 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, 124 nos of On Farm Testing (OFT) 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, millets varieties etc. To demonstrate the production potential of newly released technologies on the farmers' fields at various locations, more than 142 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 4465 nos. of other extension programmes / activities reaching over 74,321 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, Awareness programmes on Natural

Farming, Rain water harvesting and its efficient use, 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-TDC), Cluster Frontline Demonstrations of Pulses and Oilseeds under National Food Security Mission (NFSM), Attracting and Retaining of Rural Youth (ARYA), 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), Knowledge System and Homestead Agriculture Management in Tribal Area (KSHAMTA), Nutri-Sensitive Agriculture Resource Innovation (NARI), Farmers' Outreach Programme on Natural Farming, Scaling Out Climate Smart Agriculture for Resilient Farming in India.

The KVKs also established linkages with other departments /agencies like, Directorate of Groundnut Research, Junagadh, Indian Institute of Pulse Research, Kanpur, CIH, Nagaland, NBAIM, Mau. IIHR, Bengaluru, IARI, New Delhi, CIFT Cochin, CIFE, Mumbai etc. KVKs were also engaged in conducting special programmes viz., Awareness on Millets Programme, Millet Recipe contest, Mera Mati Mera Desh Programme, Janjatiya Gaurav Divas, Viksit Bharat Sankalp Yatra, World Soil Day, World Fisheries Day, World Honey Bee Day, International Women's Day, Poshan Maah, World Environment Day, Swachhta Pakhwada etc.

Table 1. Activities undertaken in KVKs of ICAR Research Complex for NEH Region during 2023

Sl. No.	Name of the Place	Training Programs	Participants Nos.	FLDs	OFTs	Extension Activities	No. of beneficiaries
A.	**Zone VI**						
1	Anjaw	13	390	02	02	81	244
2	Longding	20	581	02	03	593	4553
3	Namsai	33	1289	08	06	289	17,534
4	West Siang	22	755	06	06	167	1714
5	Hailakandi	26	795	06	05	447	10,842
6	East Sikkim	24	632	06	08	153	985
	Total	138	4442	30	30	1730	35,872
B.	**Zone VII**						
7	Ri-Bhoi	32	572	11	07	445	1,394
8	West Garo Hills	41	939	06	06	235	3189
9	Chandel	87	1797	26	13	144	1100
10	Churachandpur	35	826	05	04	27	507
11	Imphal West	43	1868	07	05	177	1869
12	Tamenglong	37	983	12	12	249	7638

13	Ukhrul	35	942	06	09	206	6482
14	Dimapur	57	1437	06	07	222	3424
15	Longleng	14	436	04	03	189	1204
16	Kiphere	27	822	04	04	38	3876
17	Peren	21	473	06	07	191	1617
18	Wokha	23	718	03	04	94	647
19	South Tripura	42	820	07	06	367	3172
20	West Tripura	21	740	09	07	151	2330
	Total	515	13,373	112	94	2735	38,449
	Grand Total (A+B)	653	17,815	142	124	4465	74,321

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Other publications

Book chapters: **17**
Popular articles: **24**
Technical manuals/ Bulletins: **12**
Abstracts: **29**
Success stories: **03**
Software/mobile applications: **01**
Souvenirs: **02**
E publication: **02**
Total: **90**

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Research Papers

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Other publications
Book: **01**
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Total: **14**

NAGALAND CENTRE

Research Papers

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Other publications
Books: **02**
Bulletins: **02**
Book chapters: **04**
Popular articles/folders: **07**
Total: **15**

SIKKIM CENTRE

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Other publications
Books: **02**
Bulletins: **03**
Popular articles: **11**
Total: **16**

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Other publications

Books: **02**
Book chapters: **11**
Popular articles: **20**
Technical bulletins: **05**
Leaflets: **13**
Training manuals: **04**
Abstracts: **22**
Total: **77**

MIZORAM CENTRE

Research Papers

Chongtham S, Singh MN, Sailo B, Chongtham T, Romila A, Premabati Ch and Laishram M. 2023. Influence of age, sex and rearing systems on serum corticosterone and heterophil to lymphocyte ratio as a stress profile in pearl guinea fowl. *Asian Journal of Microbiology Biotechnology and Environmental Science* **25**(4): 88-94.

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Other publications
Book: **01**
Books chapters: **05**
Bulletins: **01**
Popular articles: **03**
Abstracts: **15**
Folders: **01**
Success stories: **02**
Total: **18**

TRIPURA CENTRE

Research Papers

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Other publications
Book: **01**
Book Chapters: **07**
Popular articles: **10**
Research Monograph: **01**
Abstracts: **25**
Total: **44**

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