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**Annual Report 2011-12**

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# PREFACE

The agriculture scenario in the north-eastern India has become a blend of commercial and traditional agriculture and slowly moving towards large scale modernization. To support this transformation, generation of new technologies has become a major challenge. Constantly changing climate necessitates introduction of new crops and cropping sequences, modernization of animal health care with intensified surveillance and control measures and a relook at the water use strategies. ICAR Research Complex for NEH Region, taking note of these and their future ramifications, worked on the futuristic technologies while maintaining a balanced focus on improving the present scenario.

As detailed in the report, during the last year the institute paid major attention in delivering technologies to the farmers in the region. With the special support from the Govt. of India under Tribal Sub Plan, technological inputs like seeds of improved varieties of crops, livestock, poultry and fish, agronomical packages, animal health care, implements construction materials for water harvesting structures etc. were delivered to thousands of farmers across the hill states. Under NAIP, support to the poorest farmers in the most backward districts in the region was continued for the fifth year. In addition, new varieties of field and horticultural crops for the poor farmers living in the unfavorable environment, cost effective technologies for crop management like INM, IPM, weed control, biological pest control, soil health management etc. were developed. A disease survey programme with special focus of transboundary diseases of livestock to assess current and emerging threats was initiated.

Conservation tillage and zero tillage are two viable options for reducing water and soil loss from agricultural operations. Based on multiple year data our scientists have developed technologies for its application in hill agriculture. A new poultry species, 'Emu', was introduced and studied. In our quest for developing climate ready agricultural technologies, stress tolerant crop genotypes were identified; stress tolerant attributes of local livestock were studied. In the animal science research significant progresses were made in the area of bore semen cryopreservation, superovulation and molecular disease diagnostics. New improved fish breed was introduced for farming in hills. Animal health care was given a new dimension by organizing regular health camps at the door step of the farmers. In the HRD sector, apart from giving regular training, the institute provided teaching and research support to Central Agricultural University in conducting PG courses. The institute also organized several meetings, including the Regional Committee Meeting with the stakeholders to mould its programmes for increased effectiveness.

All these were possible due to the constant support and able guidance received from our Director General, ICAR and Secretary, DARE, Govt. of India, Dr. S. Ayappan and Dy. Director General (NRM), Dr. A.K. Singh and the support received from all my colleagues at the HQ and regional centres.

I complement the editorial board for the pain they took in compiling the report and sincerely believe that the document will be of immense value to the agriculture fraternity of the country as a whole and the region in particular.

**(S. V. Ngachan)**
**Director**

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# कार्यकारी सारांश

वर्ष 2011-12 के दौरान किये गये कार्यो के मुख्य निष्कर्श संक्षेप में निम्नलिखित है:

एक साधारण कम लागत वाला खरपतवर काटने वाला यंत्र बनाया गया जो ज्यादा तेज और परंपरागत उपकरणों की तुलना में कम उर्जा खपत करता है। वर्षा, जलसमेट क्षेत्र और भूमि उपयोग ढॉचा पर लागत लगाकर एक रिग्रेशन समीकरण सूक्ष्म जल समेट के कुल बहाव का अनुमान लगाने के लिए बनाया गया। तामिलनाडू कृषि विश्वविद्यालय द्वारा बने सुपारी छीलने का यंत्र ने 76.06 प्रतिशत छीलने की क्षमता और 23 प्रतिशत टूटे हुई सुपारी प्रदर्शित की, जिसकी छीलन क्षमता 75 किलोग्राम / घंटे थी, कृषि परीक्षण क्षेत्रों पर 6 से ज्यादा और सभी उन्नत कृषि / मशीनों का प्रदर्शन अलग अलग स्थानों पर किया गया। उन्नत उपकरणों के प्रोटोटाइप जिनका मूल्य रूपये 7,22,765 था, का निर्माण किया तथा स्टैक धारकों को आपूर्ति किया गया। मधुछत्ता चारकोल ब्रिकेट की सामान्य ज्वलन दर घनत्व के अनुसार बदलती है। कुल ज्वलन समय घनत्व बढ़ाने के अनुसार बढ़ा। यह गणना की गयी कि एक उद्यमी 6000 ब्रिकेट के औसत उत्पादन द्वारा लगभग 21000 रुपये प्रति माह अर्जित कर सकता है। एक पावर टिलर द्वारा संचालित एक प्लान्टर का डिजाइन, निर्माण और परीक्षण सोयाबीन बीजों के साथ प्रयोगशाला में किया गया और यह पाया गया कि इसका अधिकतम चूषण दाब ६ किलो पास्कल, मिस इंडेक्स 8.25 प्रतिशत और मल्टीपल इंडेक्स 3.3 प्रतिशत था।

उपराउ भूमि धान उत्पादन में आर सी पी एल लाइन 1-3912 और 1-414 (3.7 टन / हेक्टेयर) सबसे अच्छी पायी गयी जबकि 1-473 (4.04 टन / हेक्टेयर) निचली भूमि परिस्थिति में सबसे अच्छी पायी गयी। अम्लीय मृदा की स्थिति में झूम धान खेती में जड़ो की लम्बाई, तने का भार और पौधों की ऊंचाई में तुलनात्मक विभेद उपज से अत्याधिक रूप से संबन्धित पाया गया। धान में विभेदक जीन अभिव्यक्ति के अध्ययन के अन्तर्गत एल्युमिनियम के विषैपालन ने यह प्रदर्शित किया कि विषाक्तता की दशा में अधिकांश सम्बन्धित जीन 72 घंटे में बंद हो गये यहां तक की प्रतिरोधक प्रजाति, में भी सिर्फ सी एक्स 2 को छोड़कर जिसने जीन प्रदर्शन में कमी दिखायी। एक अत्यधिक एल्युमिनियम विषाक्तता प्रतिरोधक धान प्रजाति से एक सप्रेशन सबस्ट्रक्टेड हाईब्रिडाईजेशन लाईब्रेरी बनाया गयी। ताप सहिष्णु धान प्रजातियां यथा आर सी पी एल 1-136, 1-74, 1-188, 1-185, 1-132, 1-460, 1-409, 1-106 और आर सी एम 17 जिनका रिलेटिव वाटर कन्टेट अच्छा था, पहचानी गयीं।

धान की आर सी एम 4 और भालूम 1 प्रजातियॉ पीला तना छेदक तथा धान के गन्धी बग के प्रति सहिश्णु पायी गयीं। धान के ब्लास्ट रोग कवक की प्रचण्डता पिछले वर्ष की प्रतिक्रिया से भिन्न थी। कुल 863 प्रविष्टियॉ, जो कि धान के ब्लास्ट रोग के लिये परीक्षण की गयीं उनमें से 43 प्रविष्टियां प्रतिरोधक पायी गयी, धान की शीथ ब्लाइट रोग की स्क्रीनिंग में धान की प्रजाति मेंड्री (0.41) ने तुलनात्मक रूप में धब्बों की लम्बाई में कमी प्रदर्शित की।

धान तथा मक्का के पृथ्कत्व ए जी 1-1 ए से सम्बन्धित पाये गये। मक्का की 10 स्थानीय प्रजातियों ने अंकुरण अवस्था पर $50^0$ सेंटीग्रेड पर सहिष्णुता प्रदर्शित की। मक्का की कुल 539 बी सी 2 - एफ 1 सी एम एल 173 X वी 398 प्रोजेनी को पीढी के लिये चिन्हक सहायी चयन के द्वारा परीक्षित किया गया और 11 को चुना गया। इन के बीज ने 25 प्रतिशत से कम अपारदर्शिता दिखायी। मक्का की 132 प्रजातियों का टर्सिकम लीफ ब्लाइट हेतु परीक्षण किया गया जिनमें 32 प्रतिरोधक पायी गयीं। मक्के का घुन सीनोफिलस जियामेज संग्रहित मक्के के बीज पर 36 से 47 दिनो में अपना जीवन चक्र पूरा करता हुआ पाया गया। समवई परीक्षणों में सोयाबीन का जीनोटाईप डी एस बी 16 और एम ए सी एस 1140 आशाजनक पाये गये। दो प्रजातियां ई सी 241780 और ई सी 241778 ने रस्ट रोग के प्रति मध्यम प्रतिरोधिता दिखाई। प्रजाति एम ए सी एस 1140 (2.12 टन / हेक्टेयर) से सबसे अधिक उपज मिली जीनोटाईप एम ए सी एस 1118 (1.95 टन / हेक्टेयर) और एम ए सी एस 1184(1.85 टन / हेक्टेयर) रस्ट प्रतिरोधक रहे। इमीडालक्लोप्रिड (कानफिडोर) 2 मि.ली. प्रति किलोग्राम बीज की दर से सोयाबीन बीज के साथ उपचारित करना स्टेम फलाई (मिलैनोआग्रोमाइजा सोजी) के प्रति प्रभावी था। सरसों के तेल से उपचारित मूंग दाल के बीजों में बीटल द्वारा अण्डे पैदा करना सबसे कम (9.20 / बीज) प्रदर्शित किया।

पपीता रिंग स्पॉट वायरस – की पहचान आण्विक विधि द्वारा की गयी। संग्रहित नमूनों में से 90 प्रतिशत नमूनों में पॉट बायरस संक्रमण पाया गया। उपराउ भूमि में वर्षा के मौसम में संरक्षण जुताई (3.12 टन / हेक्टेयर) और पारम्परिक जुताई (2.98 टन / हेक्टेयर) में धान की उपज समान थी। परंतु बाद में उगाई जाने वाली तोरिया की उपज में अवशेष पोषक तत्व प्रबंधन का सार्थक प्रभाव देखा गया।

धान की नीचली भूमि में शून्य, न्युनतम तथा पारम्परिक जुताई में धान की उपज पर कोई सार्थक प्रभाव नहीं मिला। पोषक तत्व प्रबंधन क्रियाओं में उर्वरक मात्रा का 50% प्रतिशत तथा यूपैटोरियम का ताजा जैव भार ने सबसे ज्यादा बीज उपज (6.0 टन / हे.) दर्ज की गयी, शून्य, न्यूनतम तथा पारम्परिक जुताई के अन्तर्गत हरी मटर की उपज क्रमश: 6.20, 6.75 और 5.25 टन प्रति हेक्टेयर थी।

जैविक खेती में एफ वाई एम के द्वारा नत्रजन की आवश्यक 50 प्रतिशत मात्रा, आर डी एम और वर्मीकम्पोस्ट के द्वारा 50 प्रतिशत आर डी एम को पंचगव्या के साथ छिड़काव करने पर मक्का तोरिया और फ्रेंचबीन में अधिकतम उपज दर्ज की गयी।

टेफरोसिया 20 टन प्रति हेक्टेयर की दर से पलवाल करने पर अदरक के प्रकन्द की अच्छी उपज (16.95 टन / हेक्टेयर) हुयी। एम्ब्रोसिया और यूपेटोरियम के साथ पलवाल करने पर हल्दी में ज्यादा अच्छी उपज हुयी जो कि क्रमश: 14.42 और 14.99 टन / हे. थी। कृषि वानिकी में, 25 से भी अधिक पुराने तंत्र का, मृदा स्वास्थ्य पर दीर्घकालीक प्रभाव के लिये मूल्यांकन किया गया।

स्थिरता तथा परिस्थितीकी तंत्र के कार्य करने के लिये एक अतिरिक्त माडल स्वायल क्वालिटी इंडेक्स परीक्षण किया गया जो कि एल्डर आधारित भूमि उपयोग तंत्र 0.755 से 0.858 मतें अधिक था तथा अन्य कृषिवानिकी तंत्र जैसे झूम और शुद्ध पाईन की तुलना में मृदा स्वास्थ्य पर ज्यादा अच्छा प्रभाव डालता हुआ पाया गया।

एलनस नेपालेन्सिस के वृक्षों की कैनोपी के अन्तर्गत धान की दो प्रजातियां भालुम 1 तथा भालुम 2 का फसल पशुधन समन्वयन के द्वारा एकीकृत कृषि तंत्र में क्रमश: 1 टन / हेक्टेयर तथा 1.04 टन / हेक्टेयर उपज दर्ज किया गया। गेमेलिना आरबोरिया के साथ मूँगफली की उपज 1.56 टन / हे. थी, म्यूक्यूना प्रुरियेन्स की 26 प्रजातियों में सबसे अधिक बीजों की उपज प्रजाति यू पी एम पी (1.634 टन / हेक्टेयर) पायी गयी इसके बाद यू पी एम पी – 11 (1.294 टन / हेक्टेयर) डब्लू बी एन एम पी 03 (1.180 टन / हेक्टेयर) और डब्लू बी एन एम पी –06 टन हेक्टेयर से उपज पायी गयी।

अलग अलग पोषक तत्व प्रबंधन के अन्तर्गत मक्के की उपज तथा मृदा जैविक कार्बन के अध्ययन में यह पाया गया कि 100 प्रतिशत एन पी के को चूना 0.5 टन / हेक्टेयर के साथ देने पर अन्य पोषक तत्व प्रबंधन की तुलना में अधिकतम उपज प्राप्त हुई।

यह देखा गया कि 50 प्रतिशत नत्रजन वर्मीकम्पोस्ट (5 टन हेक्टेयर) के साथ मृदा जैविक कार्बन पर सार्थक प्रभाव डालता है। धान (नगोवा) स्वाभाविक उपजाउपन के अन्तर्गत अधिकतम बीज की उपज 3.82 टन / हेक्टेयर देता है। जबकि उपजाउ बनायी हुयी परिस्थिती में प्रजाति साहसरंग और आर सी पी एल 1-960 ने सार्थक बीज उपज प्रदर्शित को इसी अध्ययन में कुल प्राप्त वर्षा (1251-9265 मि.मी.) का टपकन तथा बन्धों के रिसाव के कारण होने वाली हानि 66-63 प्रतिशत तक मिली, जबकि फसल से 26-34 प्रतिशत ई. टी. से हानि हुयी। चूने का 12.5 प्रतिशत एल. आर लाइम, पोल्ट्री मैन्योर, और एफ वाई एम के साथ दो साल में एक बार प्रयोग अधिकतम मक्का की उपज प्राप्त करने हेतु पर्याप्त पाया गया। मेघालय की सात जिलों की प्रतिनिधी मृदाओं के परीक्षण से यह पता कि नमूने में पी एच, प्राप्त नाईट्रोजन, फास्फोरस, कैल्शियम, मॅग्नीशियम, जिंक तथा बोरान क्रमश: 88, 44, 61, 83, 66 और 69 प्रतिशत है।

कृषि की विभिन्न पद्धतियों में सिल्वी – पास्चोरल पद्धति तथा पॉल्ट्री समन्वयन से सर्वाधिक आय (84,320 रुपये प्रतिवर्ष) मिली। एन ए. आई पी. के तृतीय अवयव में मछली तथा बत्तख पर आधारित कृषि पद्धति ने मछली की उत्पादकता को 4.2 टन / हे. तक बढ़ाया एवं किसानों की आय में 10,000 रुपये प्रति जलाशय (25 मी X 15 मी) की दर से वृद्धि हुई। स्थानीय नस्ल (110-120) की तुलना में सोनाली नस्ल की बत्तख ने 150 अंडे प्रतिवर्ष का उत्पादन दिया जिसे 6-7 रुपये प्रति अंडे की दर से बेचा जा सका।

ऊतक सवंर्धित 8 साल पुराने साइट्रस के पौधों की ऊंचाई कलमी पौधों की तुलना में अधिक रही जबकि की फलों का भार कलमी पौधों में अधिक प्राप्त हुआ सर्वाधिक सम्पूर्ण घुलनशील शुगर (9.53 प्रतिशत) प्रतिफल बीजों की संख्या (20.7) एवं सबसे कम छिलके की मोटाई (2.74 मि.मी.)

सी. रेशनी के मूल कांड से प्राप्त हुआ खासी संतरे में पौधों की सर्वाधिक ऊँचाई (2.9 मी.) एवं चंदवा प्रसार (1.35 X 1.20 मी.) (क्रोटोलेरिया टेट्रागोना) द्वारा पलवार करने से एवं सबसे कम खरपतवार का घनत्व काले पॉलीथीन द्वारा पलवार करने से प्राप्त हुआ। बोर्डो मिश्रण का 2 ग्राम कार्बारिल के साथ लेप करने से संतरे में तना छिद्रक कीड़े के अंडों की संख्या को कम किया जा सका (0.67 अंडा प्रति पौध) इन कीड़ो के डिंम्ब के सुरंग मार्ग को इमीडाक्लोरपिड मिश्रित कीचड़ द्वारा अवरोधित कर देने से डिम्बकों की संख्या कम (0.33 प्रति पौध) हो गई। निर्सगा फंफूद नाशी का उपयोग (5 ग्राम प्रति ली.) करने से संतरे में स्कैब रोग को प्रभावी रूप से नियंत्रित किया जा सका।

आडू के पौधों में फूलों के घनत्व को कम करने से फलों के भार (53 ग्राम) लुगदी का भार (48.7 ग्राम) एवं फलों के आकार 49.33 X 48.72 मि.मी) में वृद्धि हुई। टमाटर के मेघा 3 प्रजाति का अचल जीवन के एमएन ओ 4 के प्रयोग के उपरांत 14 दिन देखा गया।

फ्रेंच बीन की प्रजाति अर्का सुविधा (11.4 टन / हे.) बैंगन प्रजाति आर सी एम एल – 3 (38.6 टन / हे.) एवं पत्तागोभी की संकर प्रजाति सी ए बी एच वाई बी 4 (79.5 टन / हे.) आशाजनक रही। कम लागत वाली पॉली गृहों के अन्तर्गत, ककड़ी की प्रजाति आर सी सी 2 (25.7 टन / हे.) एवं जापानी लौंग ग्रीन प्रजाति काफी उत्पादकता पूर्ण साबित हुई। शीत कालीन ऑयस्टर मशरूम की प्रजाति पी एल 11-03 एवं पी एल 11-02 की उत्पादकता क्रमश: 74 एवं 73 कि.ग्रा. प्रति 100 कि.ग्रा. धान की पुआल से प्राप्त हुयी। शिताके मशरूम का उत्पादन साल की लकड़ी के बुरादे पर (45 प्रतिशत बी.ई) प्राप्त हुआ। हल्दी की प्रजाति रोमा (10.67 टन / हे.), एवं अदरक की प्रजाति महिमा ने सर्वाधिक उत्पादन दिया जबकि खासी स्थानीय प्रजाति में सर्वाधिक कच्चा रेशा (7.80 प्रतिशत) एवं औलियों रेज़िन (10.51 प्रतिशत) की मात्रा पायी गई। अरबी की प्रजाति पंचमुखी से सर्वाधिक उत्पादकता (30 टन / हे.) प्राप्त हुई।

पशु उत्पादन विभाग में, शुकर वीर्य जमाने का प्रोटोकॉल को अप्टिमाइज किया गया, जिसके परिणाम से पता चला कि पिघलने के बाद शुक्राणुं गतिशीलता और व्यवाहार्यता की दर, 40 डिग्री सेल्सियस / मिनट की दर जमाने में 20 डिग्री सेल्सियस / मिनट और 60 डिग्री सेल्सियस / मिनट की जमाने दर की तुलनामें अधिक (पी < 0.5) पायी गयी। तीन नस्ल के संकर शुकर का वृद्धि प्रदर्शन संकर सुकर (खासी स्थानीय X हैम्पशायर) का वृद्धि प्रदर्शन 30, 60, 90, 120, 160, और 240 दिनों में अधिक (पी<0.5) पाया गया। बकरी में मद तुल्यकालन के लिए अंतर – योनि प्रोजेस्टेरोन स्पंज और PGF 2 का उपयोग किया गया। इस्ट्र तुल्यकालन और कृत्रिम गर्भाधान के बाद पिचहतर प्रतिशत (75%) गर्भाधान हुआ।

एक नई पक्षी प्रजाति एमु पर अध्ययन किया गया। 3 महीने की उम्र में इसके बच्चों का औसत शरीर का भार 4.5 किलो था. इसकी अनुकूलनशीलता और विकास का अध्ययन किया जा रहा है। जापानी बटेर के प्रजनन और अंडे की गुणवत्ता का अध्ययन किया गया। टर्की और जापानी बटेर के लौथ विशेषताओं को भी अध्ययन किया गया और ड्रेस्ड उपज प्रतिशत 75.4 और 71.3 क्रमश: बाजारी साल की उम्र में पायी गयी। आंवला और नीम के हर्बल चूर्ण को भोजन में मिश्रित कर के उपयोग करने से 0.5-1% ब्रॉइलेर प्रदर्शन के स्तर में वृद्धि हुई। प्याज, आंवला और नीम के अतिरिक्त मिश्रण से 0.5% के स्तर से ब्रॉइलेर मुर्गी में रक्त कोलेस्ट्रॉल के स्तर को कम कर दिया। पी.पी.वी. और पी.सी.वी. दुर्लभ शुकर वायरस हैं, जिनको सफलता पूर्वक शुकर के ऊतकों में प्रदर्शित किया गया। टर्की चेचक में आर.ई.वी (रेट्रोवायरल जीन) का होना पाया। बवेसिया की तीन प्रजातियां बी. बीगमीना इन बोवाइन, बी, केनीस और बी. जीबसोनी कुत्ते के रक्त के नमूनों में पता लगाने के लिए पीसीआर को मानकीकृत किया गया।

ई कोलाई के इ.एस.बी.एल, एम.डी.आर, इन्टेग्रोन्स के आण्विक विश्लेषण से पता चलता है कि पूर्वोत्तर भारत में शुकर से पृथल्लित एम.डी.आर ई। कोलाई का जाहिर तौर पर स्वस्थ शुकरों के मल में मिलने से खतरनाक प्रसार का पता चला। एंटीबायोटिक प्रतिरोध इन्ट्रोग्रोस, $intl_1$ (72.2%) और $intl_1$ (26.2%) पाए गए। पी.सी.आर, आर ऍफ. एल. पी. और आर. ए. पी. डी. के परिणाम पृथक्कितों में विविधता दर्शाते है। मल से प्रथाकरित प्रोबायोटिक्स लैक्टोबैसिलस के प्रयोग में शुकर, मुर्गी और बकरी के प्रदर्शन में सुधार हुआ। चूने (LR 10%) या FYM (5 टन / हेक्टोयर) या संयोजन में उपयोग करने से बाजरा चारा की उपज और गुणवत्ता में वृद्धि आयी। वरदान, बरसीम की चेतक किस्में और लुसर्न को क्रमश: उपयुक्त पाया गया। बरगद और कटहल की पत्तियों को मैश के रूप में शवादिष्ट और पूर्ण फीड ब्लॉक के तरह इस्तेमाल करने से बकरीयों में खाने की छमता बढ़ी।

अरुणाचल प्रदेश केन्द्र

झूम चावल की 14 किस्मों का डि यू एस परिक्षण दिशा निर्देश के अनुसार चरित्र किया गया स्थानीय चावल की किस्म मिपुन से अधिकतम उपज (3.90 टन / हैक्टेयर) 50 प्रतिशत खरपतवार और 50 प्रतिशत फसल अवशेषों के साथ प्राप्त हुई। मटर की उच्चतम हरी फली उपज आजाद मटर (3.3 टन / हैक्टेयर), मे दर्ज की गई। तोरिया किस्म / टी. एस. 36 में 57.9 प्रतिशत अधिक उपज दर्ज की गई। एम 27 सफेद रतुआ रोग के लिए सहिष्णु पाई गई। विभिन्न पलवार परीक्षणों तन्युम में कम खरपतवार सूत्रो वनज इम्पेरेटा सिलिन्ड्रिका (10.6 ग्रा./ वर्ग मी.) और वोल्कामरियाना रुटस्टाक तना छिद्रक को घटाता है। संतरे मे मिथाइल यूजीनीयोल फेरोमोन से फल मकखी से कम नुकसान हुआ। अदरक और हल्दी की उपज पारम्परिक विधि की तुलना में रिज और फरो विधि में 18.4 तथा 33.0 प्रतिशत क्रमश: अधिक देखी गयी तथा पैदावार 22.2 और 27.4 टन/हे. दर्ज की गयी। क्रोटोलैरिया की पत्तियों के पलवार से अदरक और हल्दी के प्रकन्दों की पैदावार क्रमश: 22.7 और 26.9 टन / हे. दर्ज की गयी।

लोबिया की एकल फसल में खरपतवार के घनत्व एवंम शुष्क वनज सर्व निम्न पाया गया। विभिन्न उपचारों में खरपतवार रहित खेतों में (9.38 टन / हेक्टेयर) अनाज एवंम (3.44 टन / हेक्टेयर) चारा प्राप्त हुआ। अरबी की 18 प्रजातियों का संग्रह एवम परिक्षण किया गया जिनमें ए पी टी सी (18.5 टन / हेक्टेयर) एवं मुक्त केशी (17.4 टन / हेक्टेयर) अच्छी प्रजातियां रही। टपीयोंका की 8 प्रजातियों का संग्रह एवम विश्लेशण किया गया जिसमें श्री रेखा प्रजाति की उत्पादकता (37.6 टन / हेक्टेयर) अधिकतम पायी गयी। डाइस्कोरिया प्रजाति ए.पी.टी.डी 1 की उत्पादकता 23.0 टन / हेक्टेयर पायी गयी।

जिमिकन्द की गजेन्द्र प्रजाति की 52.6 टन / हेक्टेयर पैदावार हुई। समतल भूमि की तुलना में चौड़ी शैय्या एवम नाली भूमि में मक्के की प्रजाति आर.सी.एम. 1-3 का उत्पादन 29.8 प्रतिशत अधिक था। बिना पलवार की तुलना में धान के पुआल के पलवार से मक्के का 11.8 प्रतिशत अधिक उत्पादन मिला। मक्के के बाद फ्रेंचबिन का बीज छिद्र रोपण किया गया एवम मक्के का चारा का पलवार किया गया। हरी फलियों की उत्पादकता चौड़ी शैय्या एवम नाली विधि में सर्वाधिक (3.32 टन / हेक्टेयर) प्राप्त हुयी। फ्रेंच बीन के बाद सरसों की प्रजाति टी एस 38 का छिद्र रोपण किया गया एवम फ्रेंचबीन का चारा का पलवार किया गया। सर्वाधिक उपज (11.12 टन / हेक्टेयर) चौड़ी शैय्या एवम नाली विधि में दर्ज की गयी। खासी सन्तरा पौधों में 1.0 ई पैन की मात्रा 1 के निकट डिप सिंचाई एवम काला पॉलीथीन पलवार प्रयोग करने से प्रति पेड़ 78 किलो फल प्राप्त हुये।

कोलटेक्स प्रयोग के साथ सूती कपड़े से हाथ से साफ करने से सन्तरे के पेड़ों में लाईकेन का विस्तार कम किया जा सका। स्ट्रॉबेरी को दो पत्तियों तक कटाई छटाई करके कारबेंडाज़िम में भिगा के रोपण करने से बेहतर जीवित रहने की दर एवम जल्दी स्थापना की संभावना देखी गयी। अमरूद में वर्मीकम्पोस्ट 1/2 एनपीके की निर्धारित मात्रा में उच्चतम उपज (68 किलो / पौधा) प्राप्त हुयी। पत्तागोभी की अधिकतम उपज (1063 ग्रा./ पौधा) नत्रजन (150 किग्रा./ हे.) एजोस्पीरिलम (2.5 किग्रा/ हेक्टेयर) व मिट्टी में ट्राइकोडरमा (5 ग्रा. / किग्रा.) प्रयोग करने से प्राप्त हुयी। फ्रेंचबीन में उच्चतम हरी फली उपज 4.6 टन / हेक्टेयर) 2.5 टन / हेक्टेयर वर्मीकम्पोस्ट के प्रयोग से दर्ज की गयी। एक अध्ययन से पता चला की पश्चिम सियांग जिले में शुकर पालन सम्बन्धी तकनीकी का अधिग्रहण 57.5 प्रतिशत चारा सम्बंधी तथा 12.5 प्रतिशत स्वास्थ्य सम्बंधी था। अध्ययन क्षेत्र में प्रमुख बाधाएं दवा और टीका की अनुपलब्धता (89.17%) और अधिक दाम (87.6%) थी।

मणिपुर केन्द्र

एक कम अवधि (95-105 दिन) धान की प्रजाति आरसीएम 13 विकसित की गयी जिसमें एमाइलोज की मात्रा (11.60%) अत्यंत कम थी। धान की 6 प्रजातियों का चयन मध्यम अवधि एवम अधिक उत्पादकता (7.94-8.26 टन / हेक्टेयर) के लिये किया गया। धान एवम मत्स्य के सह उत्पादन के लिये धान की प्रजातियों की पहचान की गई जिनकी उत्पादकता 7 से 7.7 टन / हेक्टेयर पाई गयी। एक स्थानीय प्रजाति अखानफाउ में कम मात्रा में फास्फोरस पोषक तत्व को सहन करने की शक्ति व पर्ण ब्लास्ट प्रतिरोधिता के चार मुख्य ब्लास्ट रोग प्रतिरोधी गुणसूत्र मिले। पर्ण ब्लास्ट, बैक्टीरियल एंवम भूरा धब्बा रोगों की प्रतिरोधी किस्मों की पहचान करने के लिए धान की 439 प्रजातियों का मूल्यांकन किया गया। विभिन्न प्रकार के टमाटरों में से एम.सी.टी.आर. 5 की उपज अधिक (38.3 टन / हेक्टेयर) पायी गयी। चयनित बैगन आर.सी.एम.बी. 10 को जिसकी उत्पादन क्षमता 30.4 टन / हेक्टेयर है। उसे ए आई सी आर पी (वी) में मूल्यांकन के लिए प्रस्तावित किया गया।

यह प्रजाति झुलसा रोग के प्रति मध्यम प्रतिरोधक है। अरबी में तीन क्लोन्स आर.सी.एम.सी. 1,4,व 5 आशाजनक रहे इनकी उपज 31.4, 29.4 व 28.3 टन / है. थी। ये पर्ण ध्वंस रोग के प्रति साधारण प्रतिरोधी हैं। हल्दी के क्लोन आर.सी.एम.टी. 7 का विकास किया गया जिसकी उत्पादन क्षमता 31.9 टन / हेक्टेयर है।

मणिपुर के विभिन्न भागों से संग्रहित विभिन्न प्रकार के फ्रेंच बीन की 30, डॉलिकस बीन की 15, लोबिया की 29 एवम ट्री बीन की 7, प्रजातियों को प्रोटीन रूप रेखा द्वारा चिन्हित किया गया। 38एस एस आर प्राईमर द्वारा राजा मिर्च की 22 लैण्ड रेसज़ का अनुवांशिक विभिन्नता का अध्ययन किया गया। राजा मिर्च में पोटी वायरस की उपस्थिति भी पायी गयी। पैशन फल आधारित फसल प्रणाली की जैविक खेती एवम उत्पादन विधि को विकसित किया गया। फसल संयोजन में सम्मिलित पैशन फल शिमला मिर्च तथा पैशन फल व अदरक, वर्मीकम्पोस्ट 6.5 टन / हेक्टेयर) + अजोस्पीरिलीयम (20 किग्रा. / हेक्टेयर) + ए एम (65 किग्रा. / हेक्टेयर) पी एस बी (२० किग्रा / हेक्टेयर) सबसे लाभदायक रहा। धान के परती में ककड़ी के पैदावार के लिए एस्पेलियर (निफिन) प्रणाली सबसे उपयुक्त पायी गयी। संरक्षित खेती के तहत तरबूजे की अधिकतम उपज (35.5 टन / हेक्टेयर) दर्ज की गई। खुला खेत में उपज 15 टन प्रति हेक्टेयर दर्ज हुयी। कम लागत के पॉलीटनेल उपयोग करने से गेस्टेशन अवधि एक महीने तक कम हो गयी। कचाई नीबू, पेशन फल, करामबोला, सोहीआंग और जापानी करौंदा से मूल्यवर्धित उत्पाद विकसित किये गये।

अनानास कोमोसस, प्रुनस नेपालेंसिस और पैस्सीफ्लोरा ईडुलिस को सुखाने के लिए फुहार विधि को मानकीकृत किया गया। जटरोफा की पॉच प्रजातियां अर्थात MNJ 001, 002, 006, TFR 01 और J1P13 आशाजनक थी। पहाड़ी ढलानों के लिए 2X3 मी. की दूरी सबसे उपयुक्त पायी गयी। मूंगफली के हल्म और प्लास्टिक की पलवार से सरसो, मटर और लैथाइरस की उपज में उल्लेखनीय वृद्धि दर्ज की गयी। मोटे बीज वाली मूंगफली की किस्मों जैसे, ICGS76 (3.41 टन / हे.) के 134 (3.32 टन / हे.) टीजी 37 ए (3.39 टन / हे.) और NRCG-CS268 (2.84 टन / हे.) आशाजनक पायी गयी। बीज प्रौद्योगिकी में बोआई समय को अलग करना बाह्य परागित फसलों में दूरी से अधिक व्यवहारिक है। मक्का की खुले परागण वाली किस्मों में, रबी रोपण (अक्टूबर – जनवरी) द्वारा समय अलगाव को परागण और फसल की कटाई के बाद के कार्य संचालन के लिए उपयुक्त पाया गया। रेपसीड एम 27 में अगेती रोपण (अगस्त–अक्टूबर) उपयुक्त था।

भण्डारण के दौरान में बीज मायकोफ्लोरा घटाने प्लेक्ट्रेन्थस टरनिफोलियस सबसे प्रभावी पाया गया। NICRA के तरत किए गए अध्ययन में शीत सहिश्णु चावल प्रजातियों की पहचान की गयी। अगेती रोपण की अवस्था में आर.सी. मनीफाउ 10 व 7 में बेहतर बीज सेट प्रतिशत (55.55%) पाया गया। जलमग्नता सहनशीलता, अध्ययन में उच्चतम अनाज प्रति पौध आर सी मनीफाउ 7 (914.34 भरे दाने) से 5 दिनों की आधी जलमग्नता में प्राप्त हुये। गोभी कुल की सब्जियों में एफिड 25-31 दिसम्बर के दौरान दिखाई दिये और इनकी औसत संख्या पत्तागोभी (1.34), फूलगोभी (0.65), और ब्रोकोली (0.6), थी। एफिड का चरम स्तर 11 से 17 मार्च के दौरान पाया गया। बुनियाद और अकिंत किया हुआ भूमि चावल, मक्का, रेपसीड, मूगफली और सोयाबिन कुल मिलाकर 2.72 टन कि का उत्पादन किया गया। मेगा पोल्ट्री बीज परियोजना के अर्न्तगत कुल 15, 184, डी.ओ.सी. और 643 बडे चूजों (4 से 5 सप्ताह उम्र) को मणिपुर के नौ जिलों के 633 किसानों में प्रति परिवार 25 पक्षी की दर से प्रदान किया गया। कृषि विस्तार के तहत, कृषि प्रौद्योगिकी के प्रसार में मास मीडिया की भूमिका का मूल्यांकन किया गया। कृषि कार्यक्रमों में बागवानी (39.5%) क्षेत्र फसल (29.5%) पशु–पालन (13%) पौध संरक्षण (6%) रिपोर्ट और दर्शकों के पत्र (6.5%) पाये गये।

### मिजोरम केन्द्र

निचली भूमि में धान की प्रजाति आर.सी.पी.एल. 304 ने 5.37 टन / हे. तथा उपरी भूमि में आर सी.पी.एल 114 ने 2.81 टन / हे. सार्थक रूप से उच्चतम उपज दर्ज की। झूम खेती के अन्तर्गत भालूम 3 ने सबसे अच्छा प्रदर्शन किया। धान की लैण्ड रसेस प्रजातियों में से एम.जेड.आर. 19 ने उच्चतम (4.97 टन / हे.) बीज उपज दर्ज की। उड़द दाल की प्रजाति आर.सी.बी.जी. (1.26 टन / हे.) और मूॅग दाल की प्रजाति आर.सी.जी.जी. 15 (598 किग्रा / हे.) आशाजनक थी।

गेहूं की प्रजाति वी.एल.892 की बीज उपज (2.69 टन / हे.) दर्ज की गयी। मक्का / सोयाबीन फसल तंत्र में 50 प्रतिशत सिफारिश की गयी खुराक – 2.5 टन वर्मीकम्पोस्ट ने ज्यादा अच्छा प्रदर्शन किया। मिजोरम की 10 फ्रेंचबीन प्रजातियों में ज्यादा अच्छी फलियों की उपज (13.5 - 18.4 टन / हे.)

हुई। एम.जेड.एफ.बी. 44, एम. जेड. एफ. बी. 45, एम. जेड. एफ. बी. 46 और एन. जेड. एफ. बी. 48 की बैगनी फलियॉ में 14 से 18 गुना ज्यादा एन्थोसायनिन था। अलग-अलग वासस्थान से 20 जंगली खुम्ब इकट्ठा किये गये। हल्दी की प्रजाति राजेन्द्र, सोनिया, आर. सी. टी. 1, सुरंजना तथा स्थानीय सात प्रजातियां लीफ ब्लॉच और कोलेटोट्राइकम लीफ स्पॉट के प्रति प्रतिरोधक पाये गये। सीढीनुमा खेत पर झूम खेती की तुलना में अदरक का सॉफ्ट रॉट अधिक पाया गया। साफ्ट रॉट के आने का क्रम अगस्त की तुलना में सितम्बर में बहुत ज्यादा पाया गया। हल्दी की सबसे ज्यादा उपज आर. सी. टी 1 में जबकि अदरक की सबसे ज्यादा उपज हिमगिरि में पायी गयी। पशुविज्ञान के सर्वेक्षण में 10.14 प्रतिशत जानवर मैस्टीटीस (स्तन की सूजन) के प्रति सकारात्मक पाये गये।

नागालैंड केन्द्र

वर्षा पर आधारित भारतीय सरसों, बौना मटर तथा तीसी का उर्वरता परिक्षण रबी मौसम में किया गया चावल मसूर चक्र प्रणाली में उर्वरक के प्रयोग में सिफारिश की मात्रा 100% और फसल के अवशेष से एस. आर. आई. पद्धति में धान की उपज में वृद्धि हुई। अप्रैल के पहले सप्ताह में 35 किग्रा / हे. बीज की दर से मूंग की बोआई करने से अधिक उपज दर्ज की गई। चूने का प्रयोग गोबर की खाद के साथ तथा पलवार के प्रयोग से रबी मकई की उपज में वृद्धि दर्ज की गई। पारम्परिक तकनीकी ज्ञान (आई. टी. के) का पुष्टीकरण खरपतवार नियंत्रण के लिये साधारण नमक का व्यवहार, सतत उत्पादन के लिये शुरू किया गया। जनजाति उपयोजना के अर्न्तगत मक्का (आर. सी. एम. 75 और आर. सी. एम. 76), रेपसीड (टी. एस. 36), तीसी (पार्वती) और तोरीया (टी.एस. 36 और टी. एस. 46) का बीज उत्पादन किया गया। छ लिलियम किस्मों का मूल्यांकन किया गया तथा किस्म ब्रुनेलो का परिणाम अच्छा मिला। लिलियम फूल का उपचार 3% सुक्रोज +2 पी. पी. एम. 8 HQ से करने पर उसका अधिकतम आधार जीवन (vaselife 14. 27) दिन पाया गया उष्णकटिबंधी आर्किड अर्थात मोकरा, एरेन्थेरा, वन्डा, आइनसिडियम तथा डेन्ड्रोबियम को मूल्यांकन करने के लिए स्थापित किया गया। पच्चीस अरबी की प्रजातियां नागालैंड के विभिन्न जिलों तथा आसाम से जुड़े इलाकों से प्राप्त करके उनका मूल्यांकन किया गया। उनकी उपज 108. 24 ग्राम से 1.329 किलोग्राम / पौधा पायी गयी। एकीकृत एग्रो कृषि सम्बन्धी मौसम परामर्शी सैवायें, सप्ताह में दो बार (शुक्र, मंगल) मौसम का पूर्वामान, ई मेल, फैक्स, समाचार पत्र तथा रेडियो द्वारा दी गयी। मोबाईल पर 1191 एस.एम.एस., 1191 प्रगतिशील किसानों को दिये गये। मौसम सबंधी आंकड़ो से अवगत कराया गया। कृषि वानिकी आधारित मॉडल के विकास से 478 हे. गैर वन भूमि का विकास किया गया। ई टी का आंकलन, एएस सीई - एफए ओ-56 पेनमन मोनटेश्थ मॉडल के द्वारा विकसित किया गया जो कि एक बेंचमार्क मॉडल है। देखा गया कि ई टी फरवरी से जुलाई तथा अक्टूबर तक बढ़ते क्रम में तथा आगस्त से जनवरी तक घटते क्रम में रहा सिर्फ अक्टूबर को छोड़कर। वार्षिक ईटों घटने की प्रवृति 0.42 मि.मि. / वर्ष थी।

नागालैंड के विभिन्न जिलों से मिट्टी के 224 नमूने लिए गये तथा उसे विश्लेषित कर औसतम N, P, K तथा pH क्रमश: 62: 72 - 2025.26 किग्रा / हे., 3.42 - 24.73 किग्रा. / हे. 20.27 - 519.57 किग्रा. / हे. 0.07 - 6.62 प्रतिशत तथा 4.72 - 5.80 पाया गया। मेगा बीज योजना के अर्न्तगत, 623 शूकर के बच्चों ने जन्म लिया। उसमें से 434 शूकर के बच्चे किसानों, एन. जी. ओ. तथा अन्य लाभ उठाने वाले व्यक्तियों में बाटे गये। मुर्गी बीज योजना के तहत, 38401 चूजे पैदा किये गये तथा 26177 चूजों को नागालैंड, आसाम तथा अरूणाचल प्रदेश के किसानों, एन.जी.ओ. तथा अन्य लाभ उठाने वाले व्यक्तियों को बांटा गया। इसके अलावा टी. एस. पी.के अन्तर्गत 400 पक्षीयों की क्षमता वाली 10 प्रर्दशन इकाइयां स्थापित की गयीं।

विभिन्न पशु स्वास्थ शिविर एडमास पी.डी. के अन्तर्गत लगाये गये। इस सेवा में 300 परिवार, जिसमें में 317 गायों, 761 सुअरों, 316 कुत्तों तथा 4697 मुर्गीयों को सम्मिलित किया गया। स्वास्थ सेवा के अलावा 1200 मुर्गियां 90 लाभ उठाने वाले व्यक्तियों को बांटी गयीं। एक दो दिवसीय पूर्वोत्तर बागवानी किसान मिलन तथा 3 दिन का एक प्रशिक्षण का आयोजन किया गया और चार एफ एल डी कार्यक्रम किये गये।

धान की अधिकतम उपज भालुम 3 (29.26 ग्रा./ पौधा) व आर. सी. पी. एल. 421 (28.46 ग्रा. / पौधा) में दर्ज की गयी। नीचली भूमि में प्रविष्टि आर. सी. पी. एल 1-473 (76.80 ग्रा./पौधा) ने अधिक उपज दिखाई। भालुम 2 और भालुम 1 जल्दी परिपक्व (127 व 129 दिन क्रमश:) हुयीं।

सिक्किम केन्द्र

सोयाबीन प्रविष्टि आर. सी. एस. 1-10 की उच्चतम उपज (3.59 टन / हे.) और शीघ्र परिपक्वता (105 दिन) दर्ज की गई। उर्द दाल की किस्म पहलों दाल 3 (पी डी 3), राजमा प्रविष्टि आई. पी. आर. 9-6-4 (12.10 ग्राम / पौधा), नवगांव राजमा (11.23 ग्राम / पौधा) और एच. यु. आर. 07-48 (10.32 ग्राम / पौधा) आशाजनक पायी गयी। चिलाउनी – युटिस के पत्तों की पलवार 5 टन / हे. तथा वर्मीखाद 1.5 टन / हे. के प्रयोग से तोरिया की अधिकतम उपज (1.29 टन / हे.) दर्ज की गई। तिथे प्रजाति ने लगभग 20 प्रतिशत अधिक उपज दिया मिथे के तुलना में जब एक जैसा वर्मीखाद दोनों में दिया गया। स्थानीय किस्म कोक्सीनेला सेप्टेमपंकटाटा में नोचिलस सेक्समेकुलाटा तथा सेरफिड मक्खी ने एफिड जनसंख्या की कमी के लिए प्राकृतिक शत्रु के रूप में कुछ प्रभाव दिखाया। विभिन्न ट्राइकोडरमा सिक्किम के विभिन्न स्थानों से एकत्र करके उनका कोलेटोट्रिकम ग्लियोस्पोराइडिस के प्रति विपरीत प्रभाव का इन विट्रो अध्ययन किया गया। अधिकतम नियत्रंण (74.35%) ट्राइकोडरमा टी 37 से पाया गया।

सरसों में सफेद रतुआ, ट्राइकोडरमा द्वारा नियंत्रित किया गया जो कि मैटालेक्सिल के समान था। ट्राइकोडरमा – गर्म जल उपचार, अदरक में गलन – सड़न को नियंत्रित करने के लिए प्रभावी था। ऊँीले फलों में कीवी की किस्में जैसे एलिसन, ब्रुनों तथा मोनटी को 4-6° सेलसियस के तहत लगभग 5 महीने के लिए भंडारित किया जा सका। चेरी मिर्च की कमरे के तापमान पर 25 दिन तथा 10 दिन की अधिकतम सेल्फ लाइफ 4° सेलसियस पर दर्ज की गयी। कुल 6824 पशुओं के स्वास्थ की जांच की गई। जिनमें 40.84% संक्रमण हेलमिन्थ का पाया गया। जी आई हेलमिन्थ का संक्रमण बकरियों में अत्याधिक (63.08%), मवेशियों में (30.50%) और याक में (17.72%) था। ट्रिमेटोड, सिस्टोड, निमेटोड व कौक्सीडियन ऊसिस्ट के मिश्रित संक्रमण, अन्य जानवरों की तुलना में बकरियों में अधिक पाये गये। औसतन ई पी. जी मान बकरी में गाय तथा याक की तुलना में ज्यादा था। जी आई हेलमिन्थ का प्रसार सबसे ज्यादा समशीतोष्ण तथा उच्च आद्र क्षेत्र में (46.63%) और उसके बाद शीतोष्ण और ऑद्र क्षेत्र में (41.21%) अल्पाइन कम, नम क्षेत्र (32.23) और अल्पाइन शुष्क क्षेत्र (16.56%) की तुलना में अधिक था। कुल 250 नमूनों में से चिकन (85), चेवान (75) पोर्क (50) और बीफ (40, 25) के नमूनें साल्मोनेला स्पेसिज की उपस्थिति के लिए साकारात्मक थे।

त्रिपुरा केन्द्र

फसलों, सब्जियों, फलों, पशु, मुर्गी पालन और मत्स्य घटकों में अनुसंधान किया गया। चावल सुधार कार्यक्रम के अन्तर्गत विभिन्न परीक्षण यथा आई. वी. टी – आइएम, आई वी. टी. ई. एम. ई. आई. वी. ओ. – एल. ए. वी. टी. एम. – आई. एम. ई किये गये। चावल के किस्म टी आर सी 2008-4 (आई. ई. टी. 22112) आई. वी. टी. – आई. एम. के अन्तर्गत 5.5 टन / हे. उपज दर्ज की गई। बिल तथा मेलिंडागेटस फाउंडेशन प्रोजेक्ट के अन्तर्गत विविध प्रयोग करके सुखार में सहन करने वाली चावल की किस्म की प्राप्त की गई। कुल 347 एफ. एल. डी किए गये जिसमें 8 रो चावल प्लास्टिक ड्रम सीडर का प्रदर्शन किया गया। वर्षा के बाद के मौसम में मक्का का त्रिपुरा में फसल विविधिकरण के लिए एक नई पहल की गई। नई विकसित की गई मूंगफली की किस्म जी. जी. 11 से अधिक उपज दर्ज की गई। पोल्ट्री से प्राप्त खाद (10 टन / हे.) के प्रयोग से 1.19 टन / हे. तोरिया की उपज दर्ज की गई। जैव जीवनाशक के प्रयोग से लीफ कर्ल रोग का बचाव किया गया। जैट्रोफा पर शोध कार्य किए गए 3 फसल की प्रणाली मक्का–उर्द–मक्का तथा बंद गोभी से अधिकतम लाभ / लागत के अनुपात को दर्ज किया गया। दुग्ध उत्पादन के तहत हरा चारा मिश्रित घास के उपयोग से दुग्ध उत्पादन के लिए तरीकों में सुधार किए गये। काली बंगाल बकरी पर अनुसंधान कार्य किए गए। शूकर की घुंघरू किस्म – स्वदेशी शूकर और हेम्पशायर पर नस्ल सुधार का प्रर्दशन किया गया। एआई सी आर पी के तहत विभिन्न किस्मों की मुर्गी के 1871 चूजों की किसानों को आपूर्ति की गई। त्रिपुरा काला देशी – डेलहेम लाल का प्रर्दशन उत्साह वर्धक था। ओमपाक बाइमैकुलेटस कैटफिश का कम्पोजित सम्बर्धन में अध्ययन किया गया। लेबियो की वृद्धि, एफ.सी.आर. का अध्ययन किया गया। मछली के चारे में जैटरोफा के बीज मिलाकर सीरम प्रोटीन, एल्बूमिन, ग्लूकोज़ व कोलेस्ट्रॉल का अध्ययन किया गया। एन ए. आई पी., एन आई सी आर ए तथा टी एफ के अन्तर्गत कार्य किये गये।

# EXECUTIVE SUMMARY

The salient findings of the research work done during 2011-12 are summarized below:

**Meghalaya Headquarter**

A simple low-cost reciprocating weed cutter was designed which was faster and less energy intensive compared to traditional tools. A regression equation i.e., $Y = 0.0038\ X_1 + 4.9\ X_2 - 0.36\ X_3 - 0.45X_4 + 12.24$ ($R^2 = 0.9938$) was developed for predicting the total flow of a micro-watershed by giving input data on rainfall, watershed area and land use pattern. Testing of a TNAU make arecanut sheller revealed 79.09% shelling efficiency and 23% broken nut, with shelling capacity of 75 kg/h. More than six on farm trials and demonstration of all improved farm implements and machinery were carried out at different locations. The prototypes of improved tools and implement worth of ₹ 7, 22,765 were fabricated and supplied to different stake holders. Normalised Burn Rate (NBR) of beehive charcoal briquette varied exponentially with density ($NBR = 26.17e^{-0.002*DEN}$). Total burning time increased exponentially with increasing density ($TBT = 34.44e^{0.002*DEN}$). It was calculated that an entrepreneur can earn approximately ₹ 21,000 per month with an average production of 6000 briquettes. A power tiller operated pneumatic planter was designed, fabricated and tested in laboratory with soybean seeds and found that at maximum suction pressure of 6 kPa, miss index was 8.25 % and multiple index was 3.3%.

In rice, RCPL lines 1-412 and 1-413 (3.7 t/ha) were the best under upland, while 1-473 (4.04 t/ha) was the best for lowland ecology. A set of *jhum* paddy indicated that relative difference in root length, shoot weight and plant height were highly correlated with yield under acid soil condition. Differential gene expression study in rice under $Al^{+++}$ toxicity condition showed that most of the related genes were shut off by 72 hours even in the tolerant genotypes except *CAX2* which showed reduction in expression. A forward suppression subtracted hybridisation library was constructed from a highly $Al^{+++}$ tolerant rice genotype. Heat tolerant rice genotypes identified were RCPL lines *viz*., 1-136, 1-74, 1-188, 1-185, 1-132, 1- 460, 1- 409, 1-186 and RCM17 with good relative water content (RWC). RCM 4 and Bhalum 2 varieties of rice were tolerant to yellow stem borer and rice gundhi bug. Out of 863 entries tested against rice blast disease, 43 entries were resistant. Screening against sheath blight disease of rice showed less relative lesion length in rice genotype Mendri (0.41). Isolates from rice and maize were found to be belonging to AG 1 -IA. Ten local genotypes of maize showed tolerance to 50°C temperature at germination stage. A total of 539 $BC_2F_1$ (CML 173 X V 398) progenies of maize were tested through marker aided selection for generation advancement and 11 lines were selected. These lines also showed less than 25% opaqueness in grain. Out of 132 maize genotypes screened against Turcicum leaf blight, 32 were resistant. Maize weevil (*Sitophilus zeamais*) was found to complete its life cycle in 36-47 days on maize seed in storage. Soybean genotypes DSB16 and MACS 1140 were found promising in the coordinated trials. Two genotypes (EC 241780 and EC241778) showed moderate resistance against rust disease. Genotypes MACS 1140 (2.12 t/ha) was identified as high yielding resistant genotype. Genotypes MACS1188 (1.95 t/ha) and MACS1184 (1.85 t/ha) were rust tolerant genotypes. Soybean seed treatment with imidacloprid (Confidor 17.8 SL) @ 2 ml/kg of seeds was effective against stem flies (*Melanoagromyza sojae*). Mustard oil treated green gram seeds showed the lowest (9.20 nos/seed) egg laying by pulse beetle.

Molecular detection of *Papaya ring spot virus*-P (PRSV-P) was done. Potvirus infection in 90% of the collected samples was detected. In upland, the rice (Bhalum1) yield was similar under conservation tillage (3.12 t/ha) and conventional tillage (2.98 t/ha) during rainy season but significant effect of residue (nutrient) management practices was observed on succeeding *toria* yield. Single release of predator, *Coccinella septumpunctata* @ 200/acre + parasitoid, *Diaeretiella rapae* @ 500 mummified aphids/acre + single spray of 2% sugar solution + improvised yellow sticky traps @ 1trap/100m$^2$ against mustard aphid (*Liphaphis erysimi*) increased 83% yield over control. In lowland rice, zero, minimum and conventional tillage did not have any significantly different effect on yield of rice. Among the nutrient management practices, 50 % recommended dose of fertilizer + fresh biomass of *Eupatorium* recorded the highest yield (6.08 t/ha of rice). The average productivity of green pea was 6.20,

6.75 and 5.25 t/ha under zero, minimum and conventional tillage (CT), respectively.

In organic farming, combination of 50 % recommended dose of nitrogen (RDN) through FYM and 50 % RDN through vermicompost along with spraying of Panchagavya recorded maximum grain yield of maize, *toria* and French bean. Mulching with *Tephrosia* @ 20 t/ha produced significantly higher rhizome yield in ginger (16.15 t/ha). Mulching with *Ambrossia* and *Eupatorium* produced higher yield of turmeric *viz*., 14.42 and 14.11 t/ha, respectively.

In agroforestry, more than 25 year old agroforestry systems were evaluated for their long term effect on soil health. For the sustainability and ecosystem function, an additive model soil quality index highest SQI was estimated which was higher for Alder based landuse systems (0.755 to 0.858) as compared to had better impact on soil health as compared to other agroforestry systems, *Jhum* and pure pine stand.

Integrated farming system through crop livestock integration with two paddy varieties *viz*., Bhalum 1 and Bhalum 2 under the tree canopy of *Alnus nepalensis* recorded yields of 1.8 t/ha and 1.04 t/ha, respectively. The groundnut yield under *Gmelina arborea* was 1.57 t/ha.

Among the 26 genotypes of *Mucuna pruriens*, highest seed yield was obtained from the genotypes UPMP-06 (1.634 t/ha) followed by UPMP-11 (1.214 t/ha), WBNMP-03 (1.180 t/ha) and WBNMP-06 (0.835 t/ha).

Studies on different nutrient management practices on maize yield and soil organic carbon (SOC) revealed that 100% NPK along with lime (0.5 t/ha) gave maximum yield compared to other nutrient management practices. It was observed that 50% N along with vermicompost @ 5 t/ha had significant effects on SOC. Rice (Ngoba) produced the highest grain yield (3.82 t/ha) under natural fertility. However, under fertilized condition, genotypes Shahsarang and RCPL 1-160 showed significant increase in grain yield. In the same study, out of the total rainfall (1251-1275 mm) received, percolation and under-bund seepage loss accounted for 66-73% while crop used consumptively only 27-34% as actual ET losses. Liming @ 12.5% LR once in two years with poultry manure and with FYM, was sufficient to achieve optimum maize productivity. Analysis of representative soil samples from seven districts of Meghalaya revealed that percentage of samples low in pH (< 5.5), available N, P, Ca and Mg, Zn and B were 89, 44, 61, 83, 66 and 61%, respectively.

Among the various farming systems, silvi-pastoral system with poultry component produced highest net income of ₹ 84,320 per annum.

In NAIP (Component III), fish + duck based farming system in South Garo Hills, Meghalaya resulted fish productivity of 4.2 t/ha and individual farmers earned a net income of about ₹18000/- from pond (25 m x 25 m). Duck (Sonali) gave 150 eggs /annum as compared to local breed (110-120). The villagers could sell eggs @ ₹ 6-7/egg.

Eight year old tissue cultured citrus recorded higher plant height (3.33 m) compared to grafted on *C. reshni* (3m) rootstock. The fruit weight (123.47 g) was maximum in plants grafted on *C. taiwanica* rootstock. The highest TSS (9.53%), no. of seeds/fruit (20.7) and lowest peel thickness (2.74 mm) were noticed on *C. reshni* rootstock. In mulching trial with *khasi* mandarin, the highest plant height (2.9 m) and canopy spread (1.35 x 1.20 m) was recorded in *Crotolaria tetragona* mulch while, the weed density was lowest in black polythene mulch (0.60 kg/$m^2$). Pasting of tree trunk with Bordeaux mixture with 2 g of carbaryl, recorded the lowest egg laying (0.67 nos./plant) of citrus trunk borer. Blocking larval tunnels of citrus trunk borer with imidacloprid impregnated mud recorded the lowest (0.33 nos./plant) number of adult emergence holes/ plant. Nisarga (*Trichoderma viride*) @ 5 g/l was found effective against scab disease in citrus.

The flower thinning in peach cv Flordasun during full bloom at 70% intensity showed maximum fruit weight (53 g), pulp weight (48.7 g) and fruit size (49.33 x 48.72 mm). Shelf life of Megha Tomato3 by using $KMnO_4$ was 14 days at room temperature storage.

French bean (bush type) Arka Subidha (11.4 t/ha), brinjal genotype BRLVAR-2 (38.6 t/ha), cabbage hybrid CABHYB 4 (79.5 t/ha) were promising. Under low cost polyhouse, high yielding cucumber varieties found were RCC 2 (25.7 t/ha) and Japanese Long Green (25.5 t/ha). Oyster mushroom strains *viz*., PL11-03 and PL11-02 recorded 74 kg and 73 kg fresh mushroom yield, respectively per 100 kg dry paddy straw. Shitake mushroom recorded 45% BE on *Sal* saw dust.

In turmeric, cv. Roma recorded the highest yield (10.67 t/ha). Ginger genotype Mahima recorded the highest yield (5.22 t/ha), whereas, *khasi* Local recorded highest crude fiber (7.80 %) and oleoresin (10.51 %) contents. In colocasia, the highest total yield was recorded in var. Panchmukhi (30 t/ha).

In Animal Production, boar semen freezing protocol was optimized. Results revealed that the post-thaw

sperm motility and viability was significantly ($P$<0.05) higher in the freezing rate of 40ºC/min when compared to freezing rate of 20ºC/min and 60ºC/min. The growth performance of three breed cross piglets was significantly ($P$<0.05) higher as compared to cross breed pig (*khasi* local X Hampshire) at 30, 60, 90, 120, 160 and 240 days. Estrus synchronization in goat was done using intra-vaginal progesterone sponge and PGF2. Seventy five percent (75%) conception rate was reported following estrus synchronization and AI.

A new poultry species 'Emu' was introduced and studied. The average body weight of chicks at 3 months of age was 4.5 kg. The adaptability and growth performance is being studied. The studies were conducted on reproductive and egg quality traits of Japanese quail under deep litter system of rearing. The carcass characteristics of Turkey and Japanese quail were also studied and the dressed yield percentage was found to be 75.4 and 71.3, respectively at market age. Herbal powders as feed additives *viz*., *Emblica officinalis* and *Azadirachta indica* enhanced the performance of broiler at 0.5 - 1% levels. *Allium sativum*, *E. officinalis* and *A. indica* at 0.5% level of supplementation reduced the blood cholesterol level in broiler chicken. PPV and PCV are rare porcine viruses that were successfully detected from porcine tissue samples. REV (retroviral gene) insert in turkey pox virus was reported. PCR based detection for three species of Babesia *viz.*, *B. bigemina* in bovine, *B. canis* and *B. gibsoni* in canine blood samples were standardized. Molecular characterization of ESBL, MDR, integrons of *E. coli* isolates from swine in Northeast India revealed alarming prevalence of MDR *E.coli* isolates in faeces of apparently healthy pigs. Antibiotic resistance integrons detected were *intI1* (76.2%) and *intI2* (26.2%). RFLP and RAPD results gave a very diverse and heterogeneous nature of the isolates. Supplementation of probiotics prepared from faecal isolate of Lactobacillus strain, improved the performance of pigs, poultry and goats. Application of lime (10% of LR) or FYM (5 t/ha) individually or in combination improved yield and quality of bajra fodder.

**Arunachal Pradesh Centre**

Fourteen *jhum* rice varieties were characterized as per DUS testing guidelines. The local rice cv. Mipun recorded the highest yield (3.90 t/ha) and growth with 50% weed biomass and 50% crop residues. In field pea, the highest green pod yield was recorded in var. Azad Pea 1 (3.3 t/ha). *Toria* var. TS36 registered 57.9% higher seed yield over M27. Mustard var. M27 was tolerant to white rust disease. Among the various mulches tested, lowest weed dry weight was recorded with *Imperata cylendrica* (10.6 g/m$^2$). *Tanyum* and Volkamariana root stocks reduced the incidence of stem borer in mandarin. Methyl euginol pheromone trap reduced the damage by fruit fly. Ginger and turmeric grown under ridge and furrow (R&F) and flat method showed that R&F method recorded 18.4 and 33.0% higher yields (22.2 and 27.4 t/ha, respectively) than traditional flat bed method (18.7 and 20.6 t/ha, respectively). Among the mulches, higher rhizome yields of ginger and turmeric were recorded with *Crotalaria* leaf mulch *viz*., 22.7 and 26.9 t/ha, respectively. Studies on weed dynamics of various intercrop with maize showed the lowest weed density and weed dry weight on sole cowpea. Among the various treatments, weed free recorded 1.38 and 3.44 t/ha of grain and stover yields, respectively. Eighteen cultivars of colocasia were collected and screened; APTC (18.5 t/ha) and Muktakeshi (17.4 t/ha) were promising. Eight varieties of tapioca were collected and evaluated and var. Sree Rekha showed higher yield (37.6 t/ha). Discorea genotype APTD 1 recorded yield of 23.4 t/ha. Among elephant foot yams, var. Gajendra produced maximum yield of 52.6 t/ha. Maize var. RCM 1-3 under broad bed and furrow recorded 29.8% higher grain yield over flat bed. Under paddy straw mulch, maize recorded 11.8% higher yield over no mulch. After taking maize crop, French bean seeds were dibbled and maize stubbles were used as mulch. Green pod yield was highest with broad bed and furrow (3.32 t/ha). After harvesting of French bean, mustard var.TS38 was dibbled and French bean stover was used as mulch. The maximum yield was recorded with broad bed and furrow (1.12 t/ha).When *khasi* mandarin plants were supplied drip irrigation at 1.0 Epan along with black polythene mulch gave fruit yield of 78 kg/plant. Application of Coltex (2 ml/l) along with manual cleaning with cotton cloth reduced the lichen growth on mandarin trees. In strawberry, pruning up to two leaves along with carbendazim dip treatment showed better survival rate and early establishment. In guava, vermicompost + half NPK dose recorded the highest yield (68 kg/plant). In cabbage, maximum head weight (1.07 kg/plant) was recorded with N 150 kg/ha + *Azospirillum* 2.5 kg/ha + *Trichoderma harzianum* soil application (5 g/kg of FYM). In French bean, the highest green pod yield was recorded at the spacing of

15 cm (4.6 t/ha). In organic ginger production, the highest rhizome yield (25.5 t/ha) was recorded from vermicompost application @ 2.5 t/ha.

Study on pig farming practices and adoption level of pig farmers in West Siang district revealed highest level of adoption (57.50%) in feeding and the least adoption (12.50%) in health practices. The major constraints in the study area were non-availability of medicine and vaccine (89.17%) and high cost of feeds (87.6%).

Under NICRA, the experimental findings showed that minimum tillage gave the seed yield of 0.98 t/ha which were statistically at par with conventional tillage (0.95 t/ha). The lowest yield was recorded with no tillage (0.78 t/ha).

**Manipur Centre**

A short duration (95-105 days) rice cultivar RCM 13, having low amylose content (11.70%) was developed. Six promising rice lines were selected for high yields (7.94-8.26 t/ha) and medium duration. Rice genotypes suitable for paddy cum fish culture were identified that recorded 7-7.7 t/ha yields. A local cultivar '*Akhanphou*' was found completely resistant for leaf blast and positive for four major blast resistant genes and tolerant to low phosphorus conditions. Total 431 rice lines were evaluated against leaf blast, bacterial blight and brown spot diseases and resistant lines were identified.

Among tomato lines, MCTR 5 recorded the highest yield (38.3 t/ha). Brinjal selection RCMB 10 (30.4 t/ha) was proposed in AICRP (V). The line was moderately resistant to bacterial wilt. In colocasia, three high yielding clones *viz*., RCMC 1 (31.4 t/ha), RCMC 4 (29.4 t/ha) and RCMC 5 (28.3 t/ha) were promising. RCMC 5 was moderately resistant to leaf blight. Turmeric clone i.e., RCMT 7 with a yield potential of 31.9 t/ha was developed. Genotypes of local French bean (30), Dolichos bean (15), cow pea (21) and tree bean (7) were collected from different parts of Manipur and characterized based on SDS-PAGE protein profiling. Genetic diversity in 22 King chilli landraces using 38 SSR primers was studied. In King chilli, the presence of *Potyvirus* was observed. Organic production package for passion fruit based cropping system was worked out. Crop combination involving passion fruit + capsicum and passion fruit + ginger grown with vermicompost (6.5 t/ha) + *Azospirillum* (20 kg/ha) + PSB (20 kg/ha) + AM (65 kg/ha) was the most profitable. Espalier (Kniffin) system of trellis was found to be the most suitable for cucumber grown in paddy fallow. Under protected cultivation of watermelon, maximum yield (35.5 t/ha) was recorded with poly tunnel and soil application of fertilizers as compared to open field condition (15 t/ha). The gestation period was reduced to 1 month by using low cost poly tunnel. Different value added products were developed from *kachai* lemon, passion fruit, carambola, *sohiong* and Japanese gooseberry. Spray drying technique for *Ananas comosus*, *Prunus nepalensis* and *Passiflora edulis w*as standardized. In jatropha, five genotypes *viz*., MNJ 001, 002, 006, TFR 01 and JIP 13 were promising. A spacing of 2 m x 3 m was found best for hill slopes.

The significantly higher grain yields of mustard, lathyrus and pea were recorded with plastic mulching + groundnut haulms. Bold seeded groundnut varieties *viz*., ICGS 76 (3.41 t/ha), K 134 (3.32 t/ha), TG 37A (3.31 t/ha) and NRCG-CS 268 (2.84 t/ha) were promising.

In seed technology, time isolation was found to be more practicable than the distance isolation for out crossed crops. For maize (open pollinated varieties), time isolation by *rabi* planting (Oct-Jan) was suitable both for pollination and post harvest operations. Early planting (Aug to Oct) was suitable for rapeseed var. M27 in the uplands. *Plectranthus ternifolius* was most effective in reducing the seed mycoflora during storage.

Under NICRA, studies were undertaken on identification of cold tolerant rice genotypes. In early sown condition, RC Maniphou10 gave better seed set percentage (55.55 %). In the study on submergence tolerance, the highest grains/plant was found in the var. RC Maniphou7 with 914.34 filled grains in 5 days half submergence.

In cole crops, aphid appeared during 25$^{th}$ -31$^{st}$ December with an average population of 1.34, 0.68 and 0.8 on cabbage, cauliflower and broccoli, respectively. The peak level of aphid infestation was attained during 11-17$^{th}$ March.

Altogether, 2.72 tonnes basic and labelled seeds of rice, maize, rapeseed, groundnut and soybean were produced. Under the Mega Poultry Seed Project, a total of 15,184 DOC and 643 grown up chicks (4 -5 wks old) were provided to 633 farmers (@ 25 birds per family) in nine districts of Manipur.

Under agricultural extension, the role of mass media in farm technology dissemination was assessed. In the DDK, the agriculture programme covered horticulture (39.5%), field crops (29.5%), animal husbandry (13%), plant protection (6%), reports and viewers' letter (7.5%).

**Mizoram Centre**

The rice var. RCPL1-304 recorded significantly higher yield (5.37 t/ha) under low land and RCPL1-114 (2.81 t/ha) in upland trials. Bhalum3 performed better under *jhum* condition. Among the landraces of rice, MZR 19 recorded significantly higher grain yield (4.97 t/ha). The black gram var. RCBG 06 (1.26 t/ha) and green gram var. RCGG 15 (598 kg/ha) were promising. The wheat var. VL 892 recorded 2.69 t/ha grain yield. In maize/soybean cropping system, 50% recommended dose + 2.5 t vermicompost performed better. Ten French bean genotypes from Mizoram showed better pod yields (13.5-18.4 t/ha). MZFB 44, MZFB 45, MZFB 46 and MZFB 48 with purple-pods showed 14-18 fold higher anthocyanin. Twenty wild fleshy fungi were collected from different habitats. Turmeric vars. Rajendra, Sonia, RCT 1, Suranjana and Local 7 were found to be resistant against leaf blotch and colletotrichum leaf spot. The terrace cultivation favoured soft rot of ginger than *jhum* cultivation. The incidence of soft rot was high in September than in August. The maximum yield of turmeric was recorded for RCT1 while Himgiri recorded the highest yield in ginger. In animal science survey, 10.14% animals were found positive for clinical mastitis.

**Nagaland Centre**

Fertility trials under rainfed condition were conducted on Indian mustard, dwarf pea and linseed during the *rabi* season. Application of 100 per cent recommended dose of fertilizers and crop residues in SRI method of paddy cultivation increased the yield and yield attributing characters in rice under rice – lentil cropping system. Sowing of mung bean on April first week with seed rate of 35 kg/ha recorded the highest yield and yield attributing characters. Lime application with FYM followed by mulching increased the yield in *rabi* maize var. DA 61-A under rainfed condition. Validation of ITK for weed management for sustainable production of *jhum* rice using common salt was initiated. Under Tribal sub plan, maize (RCM 75 and RCM 76), rapeseed (TS 36), Linseed (Parvati) and *toria* (TS 36 and TS 38) seeds were produced.

Six Lilium varieties were evaluated and var. Brunello was the best. The Lilium flowers treated with 3 % sucrose + 2 ppm 8HQ recorded the maximum vase life upto 14.27 days at room temperature. The tropical orchids *viz*., Mokara, Arenthera, Vanda, Oincidium and Dendrobium were introduced for evaluation. Twenty five colocasia germplasm lines were collected from different districts of Nagaland and adjoining Assam and evaluated in the farm whose yield ranged from 108.24 g to 1.329 kg/plant.

Under the Integrated Agro-met Advisory Services (IAAS), bi-weekly (Tue & Fri) medium range forecast of weather was provided through e-mail, FAX, newspapers and radio. Mobile SMS on daily weather data were provided to 1191 progressive farmers across the state. Development of non-forest wastelands through agroforestry models was implemented in 478 ha of degraded wastelands in Mokokchung, Phek, Wokha, Kohima, Dimapur, Peren, and Mon districts. The estimation of evapo-transpiration (ET) was standardized using the ASCE-FAO-56 Penman-Monteith model as the benchmark model. A total of 16 various ET estimation methods were evaluated using both the continuous daily time series and average time series weather data recorded. There was an increasing trend of ETo during February to July and October, followed by a decreasing trend during August to January except October with an annual decreasing trend of 0.42 mm/year. Analysis of 2244 soil samples from different districts of Nagaland indicated that ranges of average N, P, K, OC and pH of were 62.72-2025.86 kg/ha, 3.42-24.73 kg/ha, 20.27-519.57 kg/ha, 0.07-6.62%, and 4.72-5.80, respectively.

In Mega Seed Project on Pig, 623 piglets were born, of which 434 were distributed to the farmers, NGOs, and other beneficiaries. Six pig breeding units were established at the farmers' field in participatory mode in Dimapur, Kohima, Wokha and Mokokchung districts. In Poultry Seed Project, 38,401 chicks were produced of which 26,177 were distributed to the farmers, NGOs and other beneficiaries of Nagaland, Assam and Arunachal Pradesh. Further, 10 demonstration units with a capacity of 400 birds each were established under TSP. A number of animal health camps were organized under Tribal Sub Plan of PDADMAS and the services were extended to 300 households covering of 317 cattle, 761 pigs, 235 goats, 316 dogs and 4697 poultry birds were covered. Apart from complete health coverage, about 1200 chicken were distributed to 90 beneficiaries. Six 1-day training cum demonstration, one 2- day North East Horti Farmers meet and one 3-day training on floriculture and landscaping for entrepreneurship development were organized and four FLD programmes were also carried out.

**Sikkim Centre**

Soybean entry RCS 1-10 recorded the highest yield (3.59 t/ha) and early maturity (105 days). Pahelo Dal

3 (PD 3), Rajmash entry IPR 9-6-4 (12.10 g/plant), Naogaon Rajmash 3(11.23 g/plant) and HUR 07-48 (10.32 g/plant) were promising during *rabi* trial-2011.The combination of tree leaf (*Chilawney+Utis*) mulch @ 5 t/ha and vermicompost @ 1.5 t/ha recorded the maximum grain yield (1.29 t/ha) of *toria*. Tithe cultivar gave approximately 20% higher grain yield as compared to 'Mithe' at same level of vermicompost.

The population of aphid was significantly and negatively, and saw fly was significantly and positively influenced by the maximum and minimum temperatures. *Coccinella septempunctata*, *Menochilus sexmaculata* and Syrphid fly showed some potential as natural enemies for reduction of aphid population.

The *in vitro* antagonistic effect of various *Trichoderma* isolates collected from various places in Sikkim was studied against *Collectotrichum gloeosporioides*. The maximum inhibition (74.35%) was noticed for the *Trichoderma* isolate T37. The sheath blight pathogen of rice was inhibited by the isolate T2 collected from Panthang by 78.88 per cent. White rust in mustard was controlled by *Trichoderma* which was on par with Metalaxyl. *Trichoderma* + hot water treatment was effective for controlling soft rot incidence in ginger. The fruits of varieties *viz*., Alison, Bruno and Monty could be stored for about 5 months under 4-6°C. Maximum shelf life of 10 days was recorded for cherry pepper at room temperature and 25 days at 4ºC.

In the animal health, 6824 animals were examined. An overall prevalence of 40.84% helminthic infestation was observed. The occurrence of GI helminthic infestation was higher in goats (63.08 %) than that of cattle (30.58 %) and yaks (17.72 %). The mixed infestation of trematode, cestode and nematodes with coccidian oocysts were found higher in goats than in other animals. The mean epg value was also higher in goats as compared to cattle and yaks. The prevalence of GI-helminthes was higher in subtropical and high humid zone (46.63 %) followed by temperate and humid area (41.21 %) as compared to sub-alpine low humid zone (32.23 %) and alpine dry area ( 16.55 %,). Of the 250 samples comprising Chicken (85), Chevon (75), Pork (50), and Beef (40), 25 samples were positive for the presence of *Salmonella* spp.

**Tripura Centre**

The centre conducted research in field crops, vegetables, fruit crops, animal, poultry and fishery components. Under rice improvement programme, trials on IVT- IM, IVT-IME, AVTI-L, AVT1-IME were conducted. The rice var. TRC 2008-4 (IET 22112) under IVT-IM recorded 5.5 t/ha yield. Under Bill & Mellinda Gates Foundation Project, various trials were conducted to find out drought tolerant rice varieties. Total 347 FLDs were organized which included demonstration of 8-row self propelled paddy transplanter and plastic drum seeder. Integrated management of sheath blight in rice was investigated. Varietal improvement programme in pulses was taken. Effect of mulching on the productivity was studied. Post-rainy season maize, a new initiative for crop diversification in Tripura was taken. Among the recently released cultivars of groundnut, GG 11 could produce the highest pod yield. The application of 10 t poultry manure/ha could produce 1.19 t/ha *toria*. The efficacy of bio pesticide in controlling the leaf curl disease in tomato was also tested. Different strains of paddy straw and oyster mushroom were tested. Total no. of CPTs collection in jatropha was 50. The result indicated that three crop rotation of maize + urd - maize and cabbage gave the highest benefit /cost ratio.

Under livestock production, improved feeding practices for milk production with green fodder /mixed grass /concentrate mixture were undertaken. Female black Bengal goats for different kidding size were studied. Black Bengal goats were not always multiple ovular and flushing could bring more goats in estrus with increased ovulation rate in Black Bengal goat. Ghungroo – an indigenous pig and Hamshire cross bred pig performed well. Under AICRP, 1871 chicks of different varieties/lines of poultry were supplied to the farmers. The performance of Tripura black native x Delham red (ND 50 %) was encouraging.

# 1. INTRODUCTION

ICAR Research Complex for NEH Region was established in the year 1975 to cater the needs of research in the agriculture and allied sectors, especially for the north-eastern hill region. The complex headquarters, situated at Umiam in Meghalaya with its six centres in the other hill states of the region, represents a true multi-environment research infrastructure. The institute is serving the north-eastern hill region for the last 36 years through its action oriented and location specific research.

The institute encompasses all major disciplines of agriculture and allied sciences like crop, agroforestry, horticulture, agricultural engineering, animal husbandry, fishery, agricultural economics, extension etc. The entire work is distributed among the eight divisions at the headquarters and the regional centres. At the headquarters, scientists of four divisions are also engaged in teaching and guiding PG students. The institute has a very strong extension network programme for the all north eastern states. Through its programme under NAIP, the institute is disseminating modern technologies and seeds for livelihood security to the most backward districts in the NEH region. Under the Tribal Sub Plan also, the institute has made available the modern technologies and inputs directly to thousands of farmers. These technologies include certified seeds and planting materials of agricultural and horticultural crops, improved breeds of livestock and poultry, fish fingerlings of new breeds, farm implements and other critical inputs.

With the support from the Council headquarters, the strength of scientists in the complex has reached to 120. Several inhouse projects, mostly of interdisciplinary nature, are being pursued. In addition, under NICRA, new research programmes on developing climate ready technologies and identifying climate ready traits were initiated. There are sponsored projects from DBT, DST and other non- ICAR sources, 12 AICRPs, 5 network and 15 collaborative projects in operation. The strategic research on climate change adaptation and mitigation under NICRA is a major research thrust area of the institute. The institute also collaborates with government sponsored agencies like NERCOMP, MRDS, and IFAD Loan Project; several NGOs and farmers bodies for technology extension.

## Thrust areas

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

## Mandate

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

## Human resources

| Category | Sanctioned post | Filled post | Vacant post |
|---|---|---|---|
| **Institute** | | | |
| RMP | 1 | 1 | - |
| Scientific | 181 | 120 | 61 |
| Technical | 253 | 241 | 12 |
| Administrative | 129 | 119 | 10 |
| Skilled Support | 114 | 114 | - |
| **Total** | **678** | **595** | **83** |
| **Krishi Vigyan Kendra** | | | |
| Scientific | 14 | 5 | 9 |
| Technical | 162 | 148 | 14 |
| Administrative | 28 | 15 | 13 |
| Supporting | 30 | 28 | 2 |
| **Total** | **234** | **196** | **38** |

## Library

| Nature of publication | No. of copies available |
|---|---|
| Books and reports | 27434 |
| Back volumes of journals | 11063 |
| Foreign journals | 15 |
| Indian journals | 160 |
| Popular journals | 45 |
| News paper | 17 |
| Hindi books | 3142 |
| Magazine | 8 |
| CD ROM-Soil | - |
| CD ROM-Hort | - |
| CD ROM-Crop | - |
| CD ROM-Vet (1973-2001) | - |

## IT facilities

IT facility has been developed at the Division of Social Sciences. It included an AC Lab of SAS installed 10 computers with projector and internet facility along with UPS power backup of 2.30 h. The lab has seating

## Budget

**Actual expenditure for 2011-2012( ₹ in lakh)**

| | Non - plan | | Plan | |
|---|---|---|---|---|
| | **Allocation** | **Expenditure** | **Allocation** | **Expenditure** |
| **A. Recurring** | | | | |
| Establishment charges | 4113.49 | 4112.39 | | |
| TA | 27.00 | 26.85 | 30.08 | 29.88 |
| HRD | | | 20.02 | 19.52 |
| Contingency | 739.00 | 736.64 | 286.11 | 285.55 |
| Total (A) | 4879.49 | 4875.88 | 336.21 | 334.95 |
| **B.Non-Recurring** | | | | |
| Equipments | 118.07 | 112.98 | 220.99 | 214.83 |
| Information Technology | | | 18.11 | 18.11 |
| Works | 280.00 | 279.01 | 943.5 | 942.61 |
| Library books | | | 50.10 | 50.10 |
| Livestock | | | 0 | 30.00 |
| Other items | 5.00 | 3.85 | 30.09 | |
| Total of (B) | 403.07 | 395.84 | 1262.79 | 1255.65 |
| Total of (A+B) | 5282.56 | 5271.72 | 1599.00 | 1590.61 |
| TSP ( C) | | | 335 | 328.86 |
| TOTAL A+B+C | 5282.56 | 5271.72 | 1934.00 | 1919.47 |

capacity for 20 people. The lab is also having 3 licenses of SPSS and 2 licenses of STATISTICA. All the three software *viz.*, SAS, SPSS and STATISTICA have perpetual license. The SAS software available in the division can be installed on any number of official machines. Besides software and hardware, complete manuals of SAS, both in soft and hard copies, are also available and any NARS personnel can get it along with the SAS software free of cost.

## Important Meetings

### 20th Meeting of Regional Committee

The 20th meeting of the ICAR Regional Committee zone-III was held at ICAR Research Complex NEH Region, Umiam, Meghalaya from May 5 to 7, 2011. His Excellency, the Governor of Meghalaya, Shri R.S. Mooshahary was the chief guest in the inaugural ceremony of this meeting. He launched the website *i.e.,* KIRAN (Knowledge-Innovation Repository in Agriculture for North-East).


**Inugral session of the 20th Regional Committee Meeting –III held on 5th to 7th May 2011**


**His Excellency, the Governor of Meghalaya, Shri Ranjit Shekhar Mooshahary launching 'KIRAN' (Knowledge-Innovation Repository in Agriculture For North-East) at ICAR Research Complex for NEH Region Umiam on 05/05/2011**


**Secretary DARE and D.G. ICAR delivering the inaugural address at the 20th Regional Committee Meeting –III held on 5th to 7th May 2011**

Dr S.V. Ngachan, Director, ICAR Research Complex for NEH Region,Umiam welcomed and expressed his gratefulness to His Excellency, for gracing the occasion.He also welcomed Hon'ble Deputy Chief Minister of Meghalaya, Dr B.M.Lannong; Hon'ble Minister of Agriculture, Horticulture and Soil conservation, Govt. of Mizoram, Shri. H. Lianosailova; Hon'ble Minister for Agriculture and KADA, Govt. of Manipur, Shri. Parijat Singh and Hon'ble Minister for Vety.and A.H., Govt. of Nagaland, Shri. T.R.Zeliang, Dr S. Ayyappan, Secretary DARE and DG, ICAR, New Delhi. He also welcomed the Vice-Chancellors, DDGs, ADGs, Directors and Joint Directors and Heads of Institutes, senior officials of state Department of Agriculture, Govt. of India, Universities, scientists and others.

## Research Advisory Committee (RAC) Meeting 2011

The RAC meeting was held on 20th and 21st July, 2011 at ICAR Research Complex for NEH Region, Umiam. At the beginning, the Hon'ble members of RAC, Prof A. N. Mukhopadhayay, Chairman Dr O. P. Dubey, member, Prof. A.N. Maurya, member, were felicitated by the Director and other senior officials of the Institute.

Dr S.V. Ngachan, Director, ICAR Research Complex for NEH Region, Umiam in his welcome address expressed his gratitude to the RAC members for sparing their time for the meeting. He informed the house that the institute had made good progress in the areas of technology development, extension and commercialization. The projects and technologies developed received appreciation at various levels, and two scientists received ICAR award.


**RAC Meeting held on 20th& 21st July, 2011**

Prof A.N. Mukhopadhaya in his remarks, congratulated the scientists who received ICAR awards. He was of the opinion that the institute should be able to give low-cost technologies and need to work on marketing and linkage development so that there is no distress sale. He also advised the new scientists to utilize the excellent facilities available in the institute. He appreciated the compilation of the annual report.

## Institute Research Council (IRC) Meeting 2011

At the outset, the member secretary of IRC, Dr N. S. Azad Thakur, gave welcome address. Dr S. V. Ngachan, Chairman IRC and Director of the institute, stressed upon the scientists to submit projects in new areas and to avoid proposing projects in areas where research has already been done. All research results, whether from in-house or externally funded projects, should be reported in the Annual Report.

Dr N. S. Azad Thakur, requested the scientists to update the information about their research projects at the ICAR website. However, very significant achievements or some major findings, which could not be discussed in detail in the RAC, may be presented for discussion in the house.

After the initial discussions, project proposals from regional centres were considered which was followed by presentations from the divisions at the headquarters.

## Distinguished Visitors

### A glimpse of DG visit at ICAR RC for NEHR, Meghalaya

Dr S. Ayyappan, Hon'ble Secretary, DARE and Director General, ICAR, New Delhi visited ICAR Research Complex for NEH Region, Umiam, Meghalaya on 4th May, 2011.

**D G inspecting the labs at ICAR RC NEH, Umiam**

**D G ICAR inaugurating the Agro Processing Centre at ICAR RC NEH, Umiam**

**D G ICAR inaugurating the Post Harvest Management Centre at the ICAR RC NEH, Umiam**

## Important Events

### Open ranching

Dr S. Ayyappan, Hon'ble Secretary, DARE & Director General, ICAR, New Delhi in his visit to the institute (04th May, 2011), released more than 10,000 numbers of fingerlings of the Amur common carp produced by the institute in the Umiam lake, Barapani, Meghalaya in the presence of large numbers of farmers, scientists, and officials as a measure to enhance the fish availability in the lake.


**D.G., ICAR speaking at the *Um* Resilience ceremony 4th May 2011**


**Pig and poultry distribution under Tribal Sub Plan on 29th August 2011**

### Distribution of tissue cultured banana at Tripura Centre

Shri Joy Govinda Deb Roy, Hon'ble Minister, Science, Technology and Environment, Govt. of Tripura. Shri P. Biswas, Director, DBT and Shri M. Debnath, Member Dy. Secretary, TBC, Govt. of Tripura distributed 10,000 tissue culture planting material of banana (var. Saberi) to the farmers at a distribution programme organized by Tripura Centre, Lembucherra on 11th May, 2011. In the distribution programme, the importance of banana in fruit based cropping systems possessing a potentiality of high economic return was illustrated by Dr M. Datta, Joint Director, ICAR RC NEH, Tripura Centre.


**Shri Joy Govinda DebRoy, Hon'ble Minister, Science, Technology and Environment, Govt. of Tripura distributing tissue cultured banana**

### National workshop on Disease Forecasting and Prevention through Biotech Intervention

A national workshop on "Disease Forecasting and Prevention through Biotech Intervention" was organised by Integrated Agromet Advisory Services, ICAR Research Complex for NEH Region, Tripura Centre in collaboration with Department of Biotechnology and Department of Agriculture, Govt of Tripura and in association with National Initiatives on Climate Resilient Agriculture, ICAR Research Complex for NEH Region, Umiam, Meghalaya on June 8-9, 2011 at Agartala, Tripura. Workshop was inaugurated by Sri Aghore Debbarma, Hon'ble Minister for Agriculture, Govt. of Tripura. Sri K. V. Satyanarayan, IAS, Principal Secretary, Govt of Tripura, Dr M. Moni, Dy. Director General, National Informatics Centre, Govt of India, New Delhi, Sri Sriram Taranikanti, IAS, Commissioner & Secretary, Govt. of Tripura and Dr S. V. Ngachan, Director, ICAR Research Complex for NEH Region, Meghalaya were also present in the workshop.

On the 8th June, 2011, the workshop had two technical sessions in the area of Weather and Agromet Advisory Services and Pest and Diseases in Crops. On the 9th June, 2011, the workshop had three technical sessions in the area of Climatic Responses on Agriculture and Horticultural Production, Climatic

**Inaugural session of National Workshop on Disease Forecasting & Prevention through Biotech Intervention held on 8th-9thJune, 2011**

Responses on Animal Resources and Fisheries and ICT Application in Agriculture.

**Launching of National Initiative on Climate Resilient Agriculture (NICRA) project in Dimapur district, Nagaland**

Two days programme on "Launching Workshop cum Animal Health Camp" was organised on 7th to 8th September, 2011 at Dhansiripar village under Dhansiripar sub-division of Dimapur district for launching of NICRA project under KVK Dimapur.

Dr Bidyut C. Deka, Chairman of the programme and Joint Director ICAR Research Complex for NEH Region, Nagaland Centre in his welcome address stressed upon the importance of climate change and suggested the farmers for conservation of natural resources like water harvesting through creation of *Jalkund* for homestead gardens.

One hundred fifteen farmers and representatives from DAO, DHO, Sericulture and Land Resources Department, Govt. of Nagaland, Dimapur, World Vision, Mon ADP, Prodigals Home and Scientists from ICAR Research Complex for NEH Region, Nagaland Centre also participated in the workshop.

**Participants at the Launching workshop**

**Best exhibition stall award in the Northeast Agri fare –10-12th Feb., 2012**

The ICAR Research Complex for NEH Region participated in the Northeast Agri fair, 2012 held at Guwahati from 10 – 12th February. The institute displayed various technologies and received best exhibition stall award.

**Farmers' Innovation Day**

The ICAR Research Complex for NEH Region along with its regional centres and the KVKs spread across the north eastern region has observed "Farmers' Innovation Day" on 5 – 6 March, 2012. During the event, showcasing of institutes' improved technologies and innovative technologies developed by farmers were displayed. On this occasion, 17 farmers received the innovative farmers' awards while six received outstanding innovation award. During the occasion critical inputs like seeds of crop varieties, spices, livestock, poultry, fishes etc. were distributed to the farmers under TSP.

**Technology Park**


**38th Foundation day of the institute on 9th Jan, 2012**

### Training for administrative staffs

Two days training programme was organized by the institute for imparting training to the administrative staff regarding pension and related matters from 2nd to 3rd December, 2011.


**A 2 day national workshop on "Strategies for Climate Resilient Agriculture in NEH Region" on 28th -29th February, 2012**

### Tribal sub plan

**Distribution of improved seed, planting material and livestock under Tribal sub plan**

# 2. RESEARCH ACHIEVEMENTS

## MEGHALAYA

### WEATHER REPORT

Various weather parameters *viz*., air temperature, soil temperature, relative humidity, wind speed, evaporation, rainfall, bright sunshine hrs etc. were recorded daily at 06:22, 08:30 and 13:22 hrs from Apr, 2011 to Mar, 2012 and the details are given below.

### Air temperature

The mean monthly maximum temperature varied from 18.5 to 29.4°C. Aug was the hottest month and temperature remained in between 25.6 to 31.7° C. Maximum temperature recorded for a single day was highest (32.1°C ) on 13th Jul and lowest (10.5°C) on 16th Jan. The temperature gradually increased from Apr to Sep then started declining till Jan then again it increased (Fig 1). Mean monthly minimum temperature varied from 5.4°C in Jan to 19.7°C in Jul.

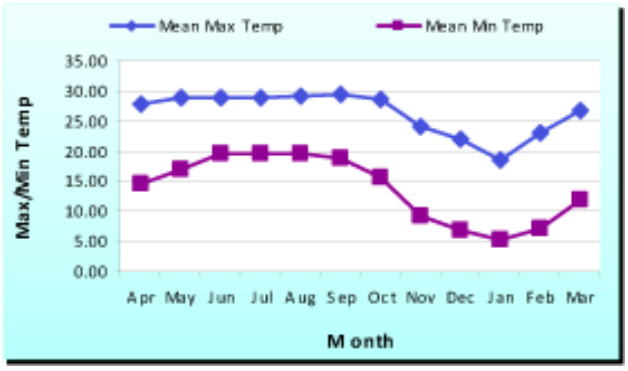



**Fig 1 Mean monthly variation of temperature**

### Soil temperature

Soil temperature in the morning increased with increase in soil depth from 5 to 30 cm whereas, it decreased with increase in soil depth in the evening hours. During morning hours (Fig 2), mean monthly temperature of surface soil was highest in the month of Jul (24.8° C) and lowest in Jan (11.9°C). Soil temperature was always less than the air temperature.

During evening hours (Fig 3), mean monthly temperature of surface soil was highest in Jun (29.6° C) and lowest in Jan (19.9°C).

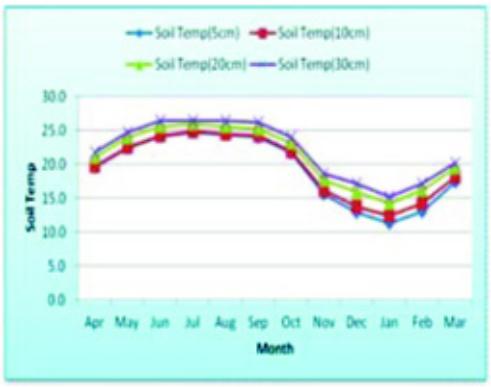



**Fig 2 Soil temperature variation in the morning hours**


**Fig 3 Soil temperature variation in the evening hours**

### Rainfall and rainy days

Total rainfall received during Apr, 2011 to Mar, 2012 at Umiam was 2596.9 mm which was distributed over 193 days (considering rainfall of any amount) and 143 days (considering rainfall more than 2.5 mm). Yearly rainfall was about 28 mm more than last year (2568.5 mm) and about 196 mm more than yearly normal rainfall. Total number of rainy days was 143 days which was more than the normal year. Rain occurred almost every month of the year ranging from 1.8 mm in Mar to 635.1 mm in Jun. More than 80% of rainfall was received during Jun to Oct. There were about 172 days without any rain. Highest amount of rainfall for a single day was recorded on 30th Jun (110.7 mm). The analysis showed that the monthly rainfall in 2012 was in downward trend from Jan - Mar whereas normal rain was in upward trend (Fig 4). Fig 5 depicts deviation of weekly rain during Apr, 2011 to Mar, 2012 from the normal rain.

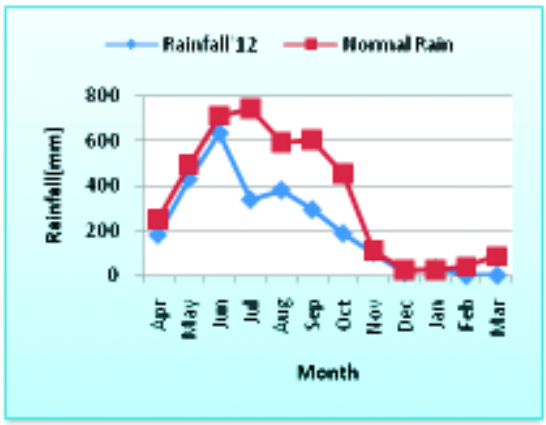



**Fig 4 Deviation of monthly rainfall, 2012 from normal rainfall**

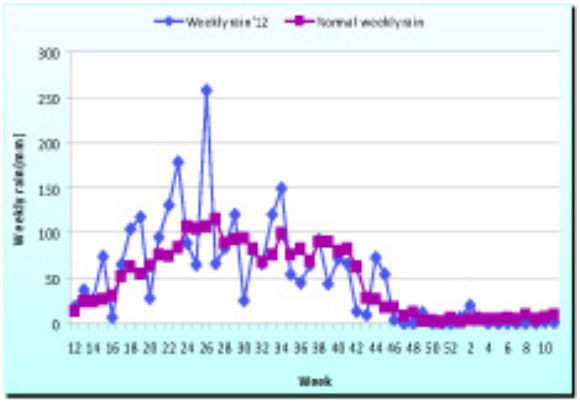



**Fig 5 Deviation of weekly rainfall, 2012 from normal weekly rainfall**

## Evaporation

Total monthly evaporation was highest in Mar (100.7 mm) and lowest (46.0 mm) in Jan. Evaporation recorded in a single day was highest (7.3 mm) on 30th Mar and lowest (0.6 mm) on 30th Jun and 10th Jan. From Dec to Mar evaporation was higher than the rainfall but from Apr to Nov rainfall was higher than the evaporation (Fig 6). This indicates the water stress in the soil from Dec to Mar. The total evaporation for this year was 840.7 mm.

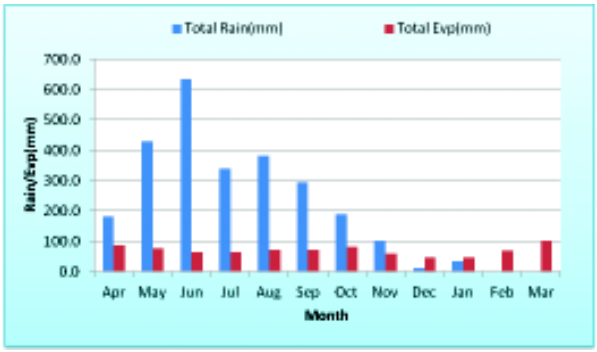



**Fig 6 Distribution of total rainfall and evaporation**

## Relative humidity

Mean monthly relative humidity in morning hours at Umiam was highest in Sep (89.9%) and the lowest in Apr (75%). Relative humidity remained low during Feb, Mar and Apr. Relative humidity in the evening varied from 46.9% in Feb to 78.8% in Sep (Fig 7). Relative humidity was above 95 per cent in 12 days, whereas, in 67 days relative humidity was below 55 per cent.

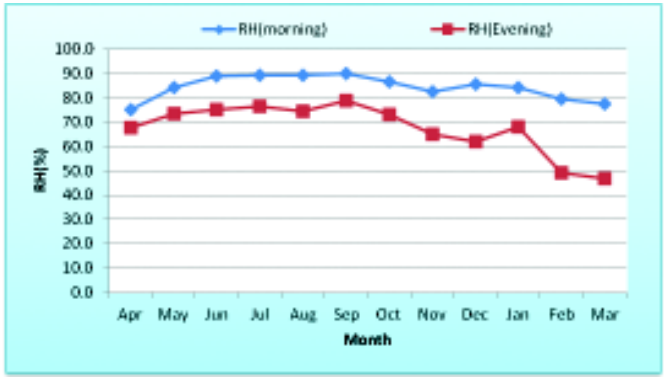



**Fig 7 Variation of humidity during morning and evening hours**

## Sunshine hours and cloud cover

The sunshine hour at Umiam ranged from 2.57 hrs/day in Jul to 7.63 hrs/day in Feb. From Jun to Oct, sunshine hour ranged from 2.5 to 6.6 hrs/day. But from Nov onwards, sunshine was available for more than 6 hrs/day except in Jan. There were about 12 days where sunshine was available for more than 9 hrs/day and in 33 days sky was overcast throughout the day.

## Wind speed

Mean monthly wind speed ranged from 1.5 km/hr in Sep to 3.7 km/hr in Mar and Apr. During the rainy season, wind was blowing at 2 to 5 km/hr. Wind speed was highest (14.7 km/hr) on 21st Apr.

## CROP SCIENCES

### RICE

#### Yield evaluation trials

#### Upland

Under upland conditions, five yield trials (two RCRT, three AICRP trials and one Consortium for Unfavorable Rice Environments,CURE-PVS, trial) were conducted. In RCRT- 1 (medium duration) trial, RCPL 1-413 (3.7 t/ha), RCPL 1-412 (3.7 t/ha) and RCPL 1-128 (3.5 t/ha) performed significantly better than the check Bhalum 1 (2.4 t/ha). In RCRT-2 (early to medium duration) trial, higher performing genotypes were RCPL 1-93 (2.3 t/ha) and IR-46 (2.2 t/ha). In AVT-2-UH, Sl.No. 3402 (3.7 t/ha); in AVT-1-UH, Sl.No. 3505 (2.8 t/ha); and in IVT-UH, Sl.No. 3603 (2.7 t/ha) were the top yielding genotypes. Significant differences were observed in days to 50% flowering. A set of 32 test entries were evaluated (CURE-PVS trial) with superior performance shown by test entries IR 08L 216 (2.9 t/ha) and IR 08L 269 (2.8 t/ha).

#### Evaluation of introgression lines

Fifty true breeding introgression lines derived from elite x wild advanced backcross (Swarna - *O. nivara* $BC_2F_7$ and KMR3 - *O. rufipogon* $BC_3F_7$) population were tested for the second year with respect to yield, flowering duration and resistance to blast. The lines were not agronomically superior.

#### Evaluation of segregating and advanced generations

Under upland condition, 250 individual plants from 8 crosses were selected based on panicle weight (14.35 - 36.26 g) and fertility percentage (70.25 - 89.31%) for further advancement.

#### Yield trials in lowland ecosystem

Under lowland condition, 3 RCRTs and 3 station trials were conducted during *kharif* 2011 (Table 1). Based on various agronomic characters, 16 genotypes were selected in RCRT-1, 12 lines from RCRT-2 and 11 lines were selected in RCRT-3. From station trials, 22 lines were selected from station trial-1, 16 lines from station trial-2 and 19 lines were selected from station trial-3. All the selected lines will be further evaluated.

#### Evaluation of segregating generations/advanced generations

Under lowland condition, two segregating populations, $F_4$ and $F_6$ were screened, and the best performing lines were advanced for future generations. Fifty $F_6$ lines along with six checks were evaluated for yield in Augmented Randomized Block Design (RCBD). Two genotypes Lab PG520 x Shasarang 4-24-1 (1.78 kg/plot,120 DF), Lab PG520 x Shasarang 4-24-2 (1.74 kg/plot, 122 DF) were found promising and yielded significantly better than all the checks. Based on various agronomic characters, 29 lines from $F_4$ were advanced to the next generation.

#### Research Complex Regional Trial (RCRT)

Three lowland RCRT in rice were conducted at five regional centres of the institute and one state research centre of Meghalaya. Complete data for all the trials were received from Meghalaya and Sikkim. In lowland trial 1, RCPL 1-307 (2.27 t/ha), RCPL 1-417 (2.14 t/ha), RCPL 1-167 (2.11 t/ha) were the best genotype for Meghalaya while, RCPL 1-417 (4.68 t/ha), RCPL

**Table 1 Summary of yield data from various trials in lowland rice ecosystem**

| Rank/ Check | RCRT-1 (Y, DF)* | RCRT-2 (Y, DF)* | RCRT-3 (Y, DF)* | Station-1 (Y, DF)* | Station-2 (Y, DF)* | Station-3 (Y, DF)* |
|---|---|---|---|---|---|---|
| 1 | RCPL1-407 (2.43, 126) | RCPL1-144 (2.48, 117) | RCPL1-467 (1.61, 110) | B-9856-D-MR-93-23-KY-1 (2.46, 118) | RCPL1-449 (1.97, 127) | IR 64X3C 12-23-2 (1.54, 125) |
| 2 | RCPL1-300 (2.28, 130) | RCPL1-145 (2.18, 129) | RCPL1-473 (1.49, 109) | BM 9855 (2.42, 124) | RCPL1-430 (1.95, 122) | IR 64X3C 13-22-4 (1.53, 122) |
| 3 | RCPL1-167 (2.17, 128) | RCPL1-131 (1.99, 111) | RCPL1-472 (1.41, 108) | IR 83376-B-B-8-2 (2.18, 111) | RCPL1-73 (1.86, 122) | IR 64X3C 7-25-2 (1.40, 125) |
| Check-1 | RCM-21 (1.79, 119) | RCPL1-76 (1.77, 122) | - | RCM-21 (1.59, 115) | RCPL1-160 (1.67, 117) | RCPL1-160 (1.57, 122) |
| Check-2 | Shahsarang (1.98, 116) | RCPL1-160 (2.13, 119) | - | - | Shahsarang (1.51, 118) | Shahsarang (1.98, 116) |

*Y=Yield (kg/plot), DF=Days to 50% flowering

1-167 (3.54 t/ha) and RCPL 1-410 (2.91 t/ha) were best for Sikkim. The genotype RCPL 1-417 was the best among all the 16 genotypes for both the locations (Meghalaya and Sikkim).

In lowland trial 2, RCPL 1-144 (2.29 t/ha) and RCPL 1-145 (2.27 t/ha) were the best genotypes for Meghalaya while RCPL1-144 (3.76 t/ha), RCPL 1-123 (3.05 t/ha), RCPL 1-145 (2.34 t/ha), RCPL 1-126 (2.20 t/ha) and RCPL 1-131 (2.07 t/ha) were the best for Sikkim. Among 12 genotypes tested across the locations, the genotype RCPL 1-144 was the best for both the locations (Meghalaya and Sikkim). In trial 3 of lowland, RCPL1-467 (1.88 t/ha) and RCPL 1-473 (1.64 t/ha) were the best genotypes for Meghalaya while, RCPL1-473 (4.04 t/ha), RCPL1-132 (3.44 t/ha), RCPL1-466 (3.39 t/ha) and RCPL1-469 (3.15 t/ha) were the best genotypes for Sikkim.

**Construction of SSH library for Al tolerance**

Differential expression of 6 genes under aluminium toxicity was studied through semi-quantitative PCR (Fig 1). The selected genes were bHLH transcription factor PTF1, Phosphorus-dependent inducible gene and promoter thereof, Phosphate transporter, Induced phosphate starvation 1, Phosphoenolpyruvate carboxylase (PEPC), CAX2 and 18S rRNA gene (as loading control). A tolerant genotype N861 was selected for this experiment. Root samples were collected from Al (300 µM available $Al^{+++}$) and used for RT-PCR. Gene specific forward and reverse primers were used for the amplification of target sequence. As seen in Fig 1, the phosphorus-dependent inducible gene and promoter thereof, phosphate transporter and phosphoenolpyruvate carboxylase (PEPC) showed complete shut off after 72 hours of exposure. bHLH

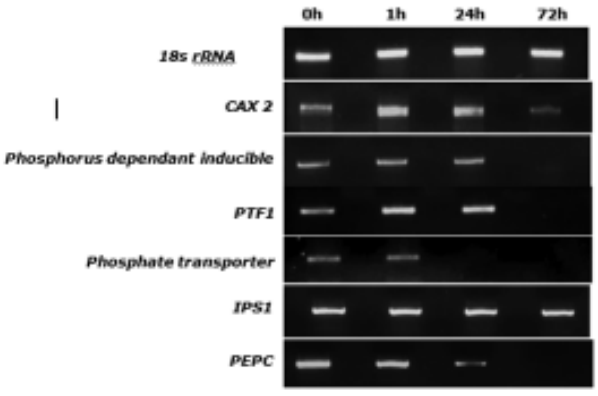



**Fig 1 Expression pattern of different genes under aluminium stress in cv. N861.**

transcription factor PTF1 was shut off by 72 hour. There was a gradual down regulation of CAX2 while IPS1 was unaffected.

For the identification and analysis of genes and gene profiles under Al toxicity, a forward suppression subtracted hybridization (SSH) library was constructed from roots of an Al toxicity tolerant genotype. RNA was isolated from roots (2 cm from tips) of both Al treated (pH 4.5) and normal seedlings (pH 7) grown in hydroponic culture. The cDNAs of Al treated seedlings was used as 'tester'. The cDNAs of control seedlings were used as 'driver' and hybridised with the 'tester' cDNAs ligated with both the adaptors. The differentially expressed cDNAs were subtracted, enriched and cloned in *pGEMTEasy* vector. A colony PCR was performed for the verification of inserts using M13 forward primer and resolved the product in 1.5% agarose gel. The library contains wide variety of differentially expressed genes. These would be sequenced and matched with rice genome and known genes.

**Screening of rice germplasm for heat tolerance**

Germination percentage of 600 germplasm lines from both lowland and upland ecology (altitude range of 200 -1900 m msl) of the north-eastern hills were screened at 40°C, 45°C and 50°C over a period of 15 days. Genotypes that showed germination at higher temperature were further screened for post germination tolerance. Seventy eight genotypes showed more than 80% germination at 40°C and at 45°C, 27 genotypes showed a minimum of 80% germination. No seed germination was observed at 50°C. After heat treatment of the latter 27 genotypes at 40°C and 45°C at seedling stage, 18 successfully recovered at 40°C and 9 recovered at 45°C. All these tolerant types were lowland genotypes. Nine genotypes that survived at 45°C at the seedling stage were found to contain 30-60% relative water content (RWC) under drought (no watering for 27 days). The genotypes that were found to tolerate heat at early growth stage with good RWC are RCPL 1-136, RCM17, RCPL 1-74, RCPL 1-188, RCPL 1-185, RCPL 1-132, RCPL 1-460, RCPL 1-409, RCPL 1-186. Fig 2 shows various effects of heat stress and water stress on the test genotypes.

## DISEASES

Screening trial for identifying resistant lines against blast disease (pathogen- *Pyricularia oryzae*) was conducted following uniform blast nursery pattern. Out

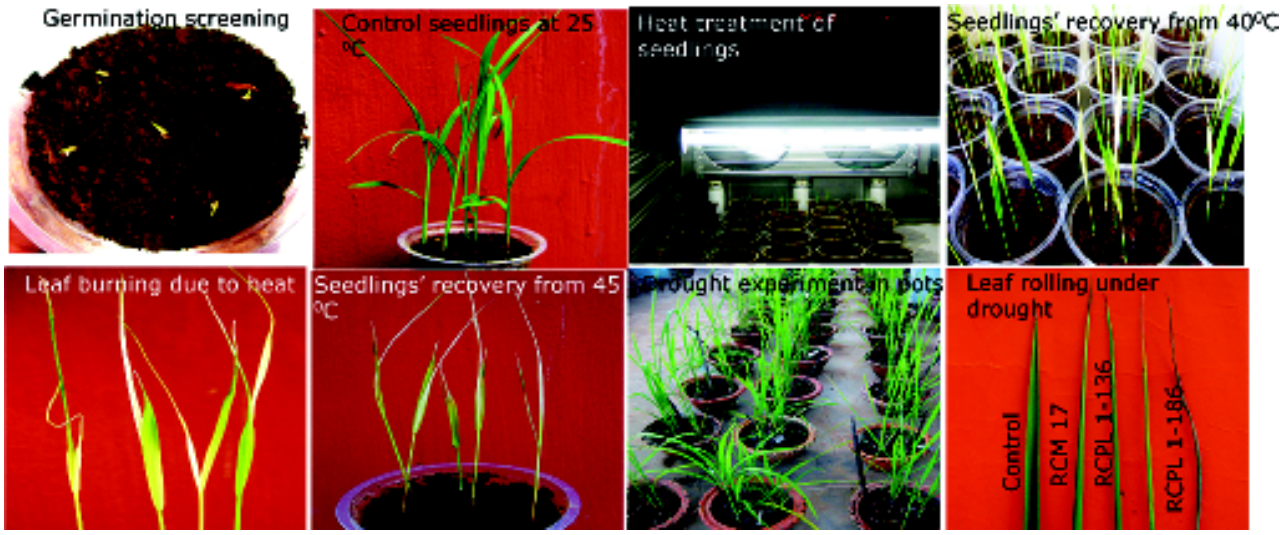



**Fig 2 Effects of heat stress and water stress on the test genotypes**

of 863 entries tested against rice blast disease, 43 entries were resistant (Table 1). In Donor screening nursery, few entries *viz*., CB 05-754, RP Patho-4 and 11, HPR 2745, 2720, 2723 and 2739 were found to be resistant.

**Table 1 Screening for rice blast disease**

| Name of the nursery | Total entries | Resistant entries |
|---|---|---|
| National Hybrid screening nursery | 107 | 7 |
| National screening nursery -1 | 163 | 8 |
| National screening nursery -2 | 540 | 18 |
| Donor screening nursery | 53 | 10 |

**Field monitoring of virulence of *Pyricularia oryzae***

The nursery included sixty one lines consisting of differentials, donors and commercial cultivars. Tetep, BL 122 and 142 were resistant against blast disease. Virulence pattern was different from the previous year reaction. Detached tillers were used for screening against sheath blight (*Rhizoctonia solani*) of rice. Relative lesion height was computed. It was less in case of Mendri (0.41) and very high in case of CH 45 (0.94), IR 64 (0.85), Lumpnah (0.82), Manipuri (0.85), Krishna Hamsa (0.89) and Shahsarang (0.76). Isolates from rice and maize have also been collected and characterized and found to be belonging to AG 1 -IA. Universal ITS primers as well as AG subgroup specific primers were used for confirmation of AG subgroups.

Thirteen varieties *viz*., IR64, Bhalum2, Shahsarang, Mendri, Lumpnah, Manipuri, Krishna Hamsa, Bhalum 1, Ngoba, Bhalum 3, Bhalum 4, RCPL 1-160 and RCPL 76 were screened against blast disease. Bhalum 1 to 4 were found to be resistant. RCPL 1-160 and RCPL 76 were highly susceptible with scoring >7 in SES. Shahsarang, Mendri, Lumpnah, Manipuri and Krishna Hamsa were susceptible.

## INSECT PESTS

### RICE

**Varietal screening against major insect pests**

Out of 17 rice varieties screened against major insect pests of rice, RCM- 4 recorded the lowest yellow stem borer (*Scirpophaga incertulas*) infestation (0.50%) and Lumpnah recorded the highest (20.80%). Whorl maggot (*Hydrellia philippina*) damage was recorded highest in DR-92 (20.00%) and lowest in Local Mandri (5.17%). Rice leaf folder (*Cnaphalocrosis medinalis*) and root aphid (*Tetraneura nigriabdominalis*) (Fig 3) damage was maximum in variety Bhalum 2 and minimum in Bhalum 4 under

**Fig 3 Rice root aphid (*Tetraneura nigriabdominalis*)**

upland conditions. Rice gundhi bug (*Leptocorisa oratorious*) damage was the highest in Bhalum 3 and lowest in Bhalum 2.

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

Application of Sevin dust @ 20 kg/ha during flowering stage recorded the highest (84.62%) reduction of rice gundhi bug (*Leptocorisa oratorious*) at 7 DAT. Amongst botanicals, karanjin @ 2 ml/l recorded the lowest (1.25) number of gundhi bugs/hill at 7 DAT, but NSKE @ 2 ml/l recorded highest (1.50) number of gundhi bugs/hill.

## MAIZE

**Genetic improvement for yield in maize**

A total of 93 germplasm lines were evaluated in augmented design. Kernel yield per plant ranged from 20 to 150 g. Based on similarity in plant height, kernel color and maturity, two gene pools, yellow and white were created for its genetic improvement.

The Nagaland yellow and Nagaland white pools were evaluated for yield performance along RCM 1-1, RCM 1-3, Vijay Composite and Hemant. The yield performances of both the pools were very low and the duration was longer than RCM 1-1 and RCM 1-3. The plants remained fresh and green in the two pools for longer period; therefore the two pools can be best suited for green fodder and for silage preparation.

**AICMIP Trials**

Twelve co-ordinated trials received from All India Co-ordinated Maize Improvement Project (AICMIP) were evaluated for the yield performances. Four IET, five AVT-1, three AVT-2 and one Zonal trial were conducted during *kharif* -2011. The best performing lines in each trial is presented in the table 1.

**Screening of maize genotypes for heat tolerance**

The effect of heat stress on germination of 134 genotypes of maize under different heat treatments was tested by two methods *viz*., germination paper method and sand method. In germination paper method, genotypes collected were allowed to grow in germination paper for 10 days in the incubator at different temperatures *viz*., 35°C, 40°C, 45°C and 50°C and germination was recorded after 10 days. In sand method, same genotypes were allowed to grow in the sand at the above mentioned temperatures and data on total fresh shoot wt., total dry wt., plant height, root length and crude protein were recorded.

The study revealed that the tested seeds tolerated the stress conditions up to a certain point. The germination percentage and seedling growth decreased with the rise of temperature. In germination paper method, out of 134 genotypes screened, 14 genotypes showed more than 60% germination at 50°C. However, in the sand method, only 11 genotypes (RCMGP 10, 11, 16, 21, 32, 33, 34, 42, 43, 47 and 60) germinated at 50°C. Some of these genotypes also showed tolerance to this temperature in the germination paper method.

**Development of QPM lines by MAS**

A total of 539 $BC_2F_1$ (CML 173 X V 398) plants were grown for evaluation using foreground and background selection. Foreground selection using *phi*112, *phi*057, *umc*1066 and*o*2-392 identified 113 lines which were homozygous for *opaque 2*. These lines were selfed and used for background analysis using SSR markers spread over all the chromosomes.

Background selection using SSR polymorphic markers identified 11 individuals which shared more

**Table 1 List of superior lines in AICMIP trials**

| Trial No. and Duration | No. of entries | Lines |
|---|---|---|
| IET 61 (Late) | 60 | Orbit, HTMH 5402, Seed Tech 2324, MCH 46, GK 3102, DADA |
| IET 62 (Medium) | 57 | KMH-3696, P-52, HKH-322, CMH10-474, EHL 161708 (Hyb), MM1108 |
| IET 63 (Early) | 20 | CMH10-526, CMH10-525, EH-2170, FH 3534, EH-2184, JH 31485 |
| IET 64 (Extra Early) | 12 | FH 3555, Vivek Hybrid 9, FH 3554, DH-229, DH-230, DH-228 |
| AET 65 (Late ) | 17 | Bisco New 704, X35A176, A 7501, NMH-713, PMH 3, CMH08-287 |
| AET 66 (Medium) | 33 | NMH-1242, P3396, B 63, KDMH 176, S6217, CMH08-350 |
| AET 67 (Early) | 16 | KDMH 755, X8B561, SUN VAAMAN, FH 3513, KNMH 4010141, REH 2009-12 |
| AET 68 (Extra Early) | 09 | BIO 9637, KH-9888, JH 3459, HM 8, FH 3510, FH 3525 |
| AET 69-Z-1 (Late) | 09 | PMH 3, Seed Tech 2324, NMH-920, HM 10, Bio 9681, NMH-958 |
| 71-Z-1 (Early) | 09 | Prakash, REH 2003, REH 2001, KH-9560, BIO 605, JH 3459 |
| 72-Z-1 (Extra early) | 08 | PMH 4, Vivek Hybrid 9, BIO 9637, FH 3478, Vivek QPM 9, JH 3459 |
| ZR 102 (Medium) | 22 | EHL 611, RCM-1-3, Bio 9637, EHL2111, EHL 1811, EHL 1911, RCM 75 |

than 70% of the markers in common with VL398 which was used as recurrent parent. Eleven $BC_2F_1$ individuals showing inheritance of *o2* and recovery of more than 70% recurrent parent have been selected for further evaluation. Light box analysis (Fig 1) also identified that all the selected lines produced seeds with 25% or less opaqueness.

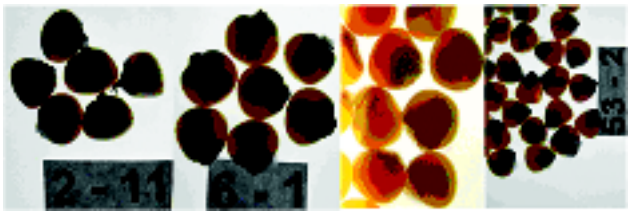


**Fig 1 Light box analysis of the seeds (from $BC_2F_1$) of selected lines**

## DISEASES

### AICMIP: Trap nursery

Ten genotypes were evaluated for naturally occurring diseases in 1-5 (TLB, MLB) and 1-9 (common rust) rating scale under trap nursery trial from AICMIP, DMR, New Delhi. In the trial, 5 genotypes (Madhuri, V351, JCY3-7-1, EC-619491 A, EC-619512 A) received all three diseases *viz*., turcicum leaf blight (TLB), maydis leaf blight (MLB) and common rust, three genotypes (V341, CML 163, CML 117-3) received only TLB and MLB.

### Screening for Turcicum leaf blight resistance

Five (#75, 76, 77, 78 & QPM) screening trials were conducted. Altogether, 132 genotypes were screened for resistance/susceptibility against TLB. Of these genotypes, 32 were resistant, 83 moderately resistant, 11 moderately susceptible and 5 were susceptible to highly susceptible.

### Field screening of maize lines/varieties against major diseases

Disease screening of 125 local maize germplasm lines of North East India and seven maize varieties *viz*., RCM 1-3, Hemant, RCM-76, RCM-75, DS 61, Vijay Composite and Local Yellow were done in the trial plot. To identify tolerant as well as susceptible maize lines/varieties against major diseases *viz*., turcicum leaf blight (TLB) and banded leaf and sheath blight (BLSB). TLB was the most important disease showing per cent disease index (PDI) of 68-100% at the silk dry stage on the basis of 0-5 rating scale (Elliot and Jenkins, 1946). None of the maize lines/varieties showed tolerance to the TLB disease. The incidence of BLSB was found to be more severe during July-August. Among the varieties, RCM-76 showed the highest susceptibility to the disease having 58.33% PDI, while RCM-75 showed the least susceptibility (only 21.67% PDI) to the disease following 1-5 rating scale. Rest of the local varieties exhibited 30-40% disease severity.

## INSECT PEST

### Biology of maize weevil (*Sitophilus zeamais*)

Biology of maize weevil (*Sitophilus zeamais*) (Fig 2) showed that the eggs hatched in 4-6 days and larvae go through four larval instars in 25-31 days. Pupal period varied from 7-10 days. The life cycle of maize weevil completed in 36-47 days on maize seed in storage.

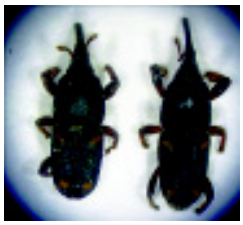


**Fig 2 Maize weevil (*Sitophilus zeamais*)**

## PULSES

## MUNGBEAN

An AVT 2+1/2011 was conducted in upland condition. Among the tested entries, KM 11-504 (345 kg/ha) and KM 11-503 (308 kg/ha) were found to be superior.

## STORAGE PEST OF PULSES

### Evaluation of botanical oils against pulse beetle in storage

Egg laying of pulse beetle (*C. chinensis*) was recorded on green gram seeds treated with different oils at 5 ml/kg seed. Out of different oils tested, mustard oil treated seeds showed the lowest (9.20 eggs/seed) egg laying by pulse beetle whereas, neem oil and soybean oil treated seeds showed the highest egg laying (21.26 and 21.20 eggs/seed, respectively). No adult emergence was observed in neem, sunflower, safflower and mustard oil at 5 ml/kg seed treatments. The treatments *viz*., coconut oil, groundnut oil and soybean oil @ 5 ml/kg seed recorded 19.81, 16.35 and 18.14 per cent adult emergence, respectively.

### Biology of pulse beetle (*Callosobruchus chinensis*) in storage

Biology of pulse beetle (*Callosobruchus chinensis*) on different pulses was studied. Life cycle of *C. chinensis* was recorded shortest in cowpea (28.67 days), followed by pigeon pea (29.33 days) and green

gram (29.67 days). The average developmental period of *C. chinensis* was longest in soybean (38.00 days) and was at par with bengal gram (33.67 days), kabuli chana (32.33 days), rice bean (31.67 days) and pea (31.33 days).

## PEA

The F6 segregating generation of different crosses were sown in lowland ecology and superior plants were selected. High performing genotypes *viz*., TRCP8 and TRCP9 were multiplied.

## DISEASES

### Evaluation of field pea varieties disease reaction at Umiam

Field pea varieties *viz*., TRCP 8 and TRCP 9 were tested under fungicide protected and unprotected conditions. Sowing was done late (12 Dec 2011) and harvesting was done on 3 Apr 2012. Fungicide triadimefon 25% WP was used @ 0.1 % of formulation. Two sprays were given in protected treatments. Rust disease was recorded at maturity in both the varieties. Its severity in TRCP 9 measured as percent disease index (PDI) was 33.95 in unprotected treatment. Fungicide protected treatment recorded 16.22 PDI. TRCP 8 showed only traces of rust disease. Both the varieties were found free from powdery mildew and ascochyta blight diseases. Yield was 640 kg/ha and 529 kg/ha in protected and unprotected condition, respectively in TRCP 9. Due to variation in plot yields there was no statistically significant difference. In TRCP 8, pod filling was very poor and little yield was recorded.

## LATHYRUS

Two genotypes with low BOAA toxin content *viz*., Mahatewara and Nirmal were grown in upland rice fallows to check their suitability for cultivation in Meghalaya. Both these genotype were found suitable for cultivation. Mahatewara was early genotype (135 days) and yielded 0.53 t/ha whereas Nirmal matured in 145 days and yielded 0.93 t/ha.

# OILSEEDS

## SOYBEAN

Three coordinated yield trials (IVT, AVT- I and AVT- II) and one station trial was conducted. Code 11, Code 37 and Code 08 were found superior in IVT trial whereas, entry DSB-18 was found promising from AVT- I - 2011 trial. Both DSB- 16 and MACS 1140 were found promising among AVT-II-2011 trials (Fig 1). Genotype RCS 1-9 along with RCS 1-10 was also found promising in farmers' field. Seeds of RCS 1-1, RCS 1-9 and RCS1-10 along with JL-335 were distributed to farmers.

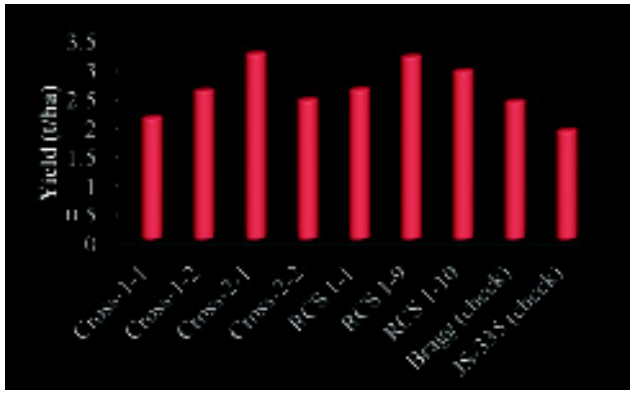



**Fig 1Performance of different soybean genotypes**

## INSECT PESTS

### Eco-friendly management of major insect pests of soybean

Stem fly (*Melanoagromyza sojae*), blister beetle (*Mylabris* spp.) and leaf beetle (*Monolepta signata*) were found to be the major pests of soybean. Interestingly, leaf folder (*Nacloiea* spp.) population was considerably lower throughout the season. Seed treatment with imidacloprid (Confidor 17.8 SL) @ 2 ml/kg of seeds was very effective against stem flies, where only 3-5% infestation was recorded. NSKE 5% crude extract was most effective against leaf beetles where it reduced 78.33% beetle damage in soybean. Furthermore, *Beaveria bassiana* $1x10^9$ cfu/ml @ 6 ml/ l of water was most effective against blister beetles; it prevented 63.33% yield loss of soybean.

## DISEASES

### Survey and surveillance for soybean diseases

Rust (*Phakopsora pachyrhizi*), aerial blight (*Rhizoctonia solani*), frog eye leaf spot (*Cercospora sojina*), collar rot and anthracnose (*Colletotrichum truncatum*) on pods were observed in farm area in various trials. Disease severity observed was high (up to 94.44%) for rust. Other diseases appeared in low severity.

**Evaluation of breeding materials for resistant donor(s)**

Thirty eight test entries of soybean were tested in field for rust disease resistance. The trial included susceptible check-1(JS 335), check-2 (Bragg), additional entries NRC 7, JS 93-05, EC 241780, EC241778. PDI ranged from 18.09 to 94.44 among the genotypes. None of the test entries showed absolute or high resistant reaction against rust disease. Genotypes EC 241780 and EC241778 showed moderate resistance with PDIscore 18.89 and 33.33, respectively. Two lines, code 3 and 18, were moderately susceptible. Thirteen entries were susceptible and twenty seven were highly susceptible. Susceptible check Bragg and JS 335 scored PDI 86.66 and 81.11, respectively.

**Evaluation of soybean genotypes for tolerance against rust**

Twelve genotypes were grown under fungicide protected and unprotected conditions and yield losses were estimated. Yield losses ranged from 9% to 47%. Based on yield potential and loss, genotypes MACS1140 (2.12 t/ha) and NRC80 (1.72 t/ha) were identified as high yielding resistant genotypes. Genotypes MACS1188 (1.95 t/ha) and MACS1184 (1.75 t/ha) were identified as tolerant genotypes.

## GROUNDNUT

**Eco-friendly management of major insect pests of groundnut**

Blister beetles (*Mylabris* spp.), leaf beetles (*Monolepta signata*) and white grubs (*Holotrichia* spp.) were recorded as major pests in groundnut. Seed treatment with imidacloprid (Confidor 17.8 SL) @ 3 ml/kg of seeds was observed to be very effective against white grubs (83.67% reduction in damage) followed by chloropyriphos @ 3 ml/kg of seeds. NSKE. 5% was found to be the most effective against leaf beetles (79.67% reduction in beetle population). Myco-insecticide, *Beaveria bassiana* $1x10^9$ cfu/ml @ 6 ml/l was superior over other insecticides for the control of blister beetles (76.33% reduction in damage over control).

## FLAX

Seven genotypes were multiplied in upland farm of ICAR Research Complex for NEH Region, Umiam, Meghalaya. RCF-3 and JRF-2 were found superior with a yield of 752 kg/ha and 687 kg/ha, respectively.

## MUSTARD/TORIA

## INSECT PEST

**Bio-intensive management of mustard aphid and large white butterfly in mustard**

Different eco-friendly management modules were evaluated against mustard aphid, *Liphaphis erysimi* (Fig 1). Among all, most effective strategy was bio-control module consisting of single release of predator, *Coccinella septumpunctata* @ 200/acre + parasitoid, *Diaeretiella rapae* (Fig 2 A and B) @ 500 mummified aphids/acre + single spray of 2% sugar solution + improvised yellow sticky traps @ 1trap/100 $m^2$; increased 83% yield over control. This was followed by another module consisting of single alternate spray of Neem oil @ 2 ml/litre + Confidor 17.8SL @ 2 ml/ litre of water.

**Fig 1 Aphid infestation on mustard**


**Fig 2 Parasitized/mummified aphid (A) by *Diaeretiella rapae* (B)**

In another experiment only sticky traps were evaluated and results indicated that improvised yellow sticky traps with red colored outer band (Fig 3) was superior (60 % increase in yield) over yellow trap with green outer band, yellow trap with blue outer band and only yellow colored traps. However, yellow sticky traps could not be a sole option for the control of aphids during severe infestation and therefore, it can only be a suitable component in IPM programme.

Different eco-friendly practices were also evaluated against large white butterfly, *P. brassicae*. Among all, mechanical control consisting of regular removal of

**Fig 3 Farmers friendly and cost effective yellow sticky traps in mustard**

egg masses and early instar larvae was the most effective control of butterflies, which provided almost 93% control, followed by biological control consisting release of *Hyposoter ebeninus* @ 200 cocoons/ha + *Cotesia glomerata* @ 500 cocoons/ha and *Bacillus thuriengiensis* (Lipel 8SP) @ 2g/litre of water.

## FRUITS

### CITRUS

**Evaluation of tissue cultured and grafted plants of *Khasi* mandarin**

Tissue cultured and grafted plants of *Khasi* mandarin (rootstocks *viz.,Citrus volkamariana, C. latipes, C taiwanica, C. reshni* and *C. jambhiri*) of eight years old were evaluated for growth, yield and fruit quality traits. Tissue cultured plants recorded the highest plant height (332.5 cm), stem diameter (85.80 mm) and canopy spread (120.62 x 115.62 cm). Among the rootstock, *C. reshni* was found to be vigorous in plant height (300 cm), rootstock diameter (61.77 mm), scion diameter (47.87 mm), plant canopy spread (90 x 85 cm) and fruit yield (185 Nos.). In physico-chemical traits, maximum fruit weight (123.47 g), fruit length (55.16 mm) and fruit diameter (63.20 mm) were observed in *C. taiwanica* rootstock. The highest TSS (9.53%), no. of seed/fruit (20.67 Nos.) and lowest peel thickness (2.74 mm) was observed in *C. reshni* rootstock. The *C. jambhiri* recorded the highest juice content (47.33%) while *C. latipes* recorded lowest juice content (36.02%) and acidity (0.77%).

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

Nucellar and grafted plants of *Khasi* mandarin (rootstocks *viz.,Dancy Tanzelo, C. grandis, C. limon* and *C. reshni)* of five years old were evaluated for growth performance. The highest plant height (335.0 cm), stock diameter (84.12 mm), canopy spread (115 x 125 cm) and fruit yield (48 Nos.) were recorded in *C. reshni* rootstock. Physico-chemical traits of *Khasi* mandarin fruits revealed that *C. grandis* rootstock produced the highest fruit weight (123.64 g), fruit length (54.60 mm) and fruit diameter (61.79 mm) while, least number of seed (12.5 Nos.), acidity (0.55%) and highest TSS (9.75%) was observed in *C. reshni* rootstock. The fruits of nucellar seedling had the highest juice content (57.80%) and lowest peel thickness (3.15 mm).

Performance of nucellar and grafted plants of *Khasi* mandarin (rootstocks *viz.,Citrus volkamariana, C. jambhiri, C. latipes,* Rangpur lime*, Dancy Tanzelo* and *C. grandis*) of four years old were also studied. The highest plant height was recorded in *C. jambhiri* rootstock (250.0 cm) followed by *C grandis* (243.33 cm), *C. latipes (*243.30 cm), *Citrus volkamariana* (234.10 cm) and nucellar seedling (203.33 cm) while, minimum in *Dancy Tanzelo* (195.0 cm) rootstock. However, rootstock diameter, scion diameter and plant canopy spread in E-W and N-S directions found maximum in *C. volkamariana* (78.35 mm, 60.44 mm and 125.0 x 117.5 cm, resp.) and minimum in *Dancy Tanzelo* (45.59 mm, 36.03 mm and 93.30x 80.0 cm, resp.)rootstock.

**Effect of different organic manure on *Khasi* mandarin**

An experiment on effect of different organic manure comprising seven treatments *i.e.,* T1: 20 kg FYM + 600 g N + 200 g P + 400 g K/tree, T2: FYM @ 40 kg/tree, T3: Poultry manure @ 28 kg/tree, T4: FYM @ 30 kg + Poultry manure @ 10 kg/tree, T5: FYM @ 30 kg + Vermicompost @ 10 kg/tree, T6: Poultry manure @ 20 kg + Vermicompost @10 kg/tree, T7: FYM @ 20 kg + poultry manure @ 10 kg + Vermicompost @ 10 kg/tree on growth, yield and fruit quality of *Khasi* mandarin was conducted at farmer's field. The data revealed that the highest plant height (3.92 m), stem diameter (23.45 cm) and plant canopy spread (4.38 x 4.20 m) was observed in T4 (FYM @ 30 kg + Poultry manure @ 10 kg/tree). However, the highest number of fruits/tree (250.0 Nos.) was recorded in T1 (20 kg FYM + 600 g N+ 00 g P+400 g K/tree) followed by T4 (231.4 Nos.) while, least (170.58 Nos.) was obtained in T2 (FYM @ 40 kg/tree).

Physico-chemical traits of *Khasi* mandarin fruits revealed that the highest fruit weight (123.59), fruit length (6.49 cm) and diameter (6.46 cm) was noticed in T5 (FYM @ 30 kg+Vermicompost @ 10 kg/tree)

whereas, the highest specific gravity (1.20), seed/fruit (23.0) and TSS (11.3%) was observed in T6 (Poultry manure @ 20 kg+Vermicompost @ 10 kg/tree). However, highest juice and lowest acidity content was recorded in T2 (FYM @ 40 kg/tree) and T1 (20 kg FYM+600 g N+200 g P+400 g K/tree), resp.

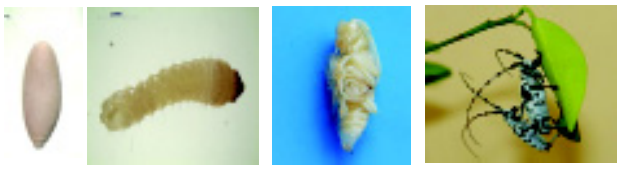
**Intercropping with *Khasi* mandarin**

Six crops *viz.,* French bean, cow pea (Kashi kanchan), groundnut (ICGS-76), soybean (JS-335), rice bean (RCRB1-6) and urdbean (T-9) were grown as intercrops during *kharif* season in six years old *Khasi* mandarin orchard. Cow pea exhibited the highest yield (3245 kg/ha, green pod) followed by ground nut (2480 kg/ha), French bean (1444 kg/ha, green pod), soybean (750 kg/ha), urdbean (472 kg/ha) and rice bean (428 kg/ha).

## INSECT PESTS

**Biology of citrus trunk borer**

The adult female of *Anoplophora versteei* was found to lay 114-258 eggs in 42-68 days of ovipositional period. Eggs hatched in 5-7 days and grubs went through nine larval instars in 240 -310 days on artificial diet. Pupal period lasted for 23-31 days and completed its life cycle in 268-340 (Fig 1).



a b c d

**Fig 1 Citrus trunk borer (*Anoplophora versteegi*), (a) egg, (b) grub, (c) pupa and (d) adults**

**Management of citrus trunk borer (*Anoplophora versteegi*)**

Out of seven chemical treatments, pasting of tree trunk with Bordeaux mixture with 2 g of carbaryl recorded the lowest egg laying of citrus trunk borer (0.67 nos/plant). Blocking the larval tunnels with Imidacloprid impregnated mud recorded the lowest number of adult emergence holes/plant (0.33 nos./plant) and was on par with the treatments with monocrotophos injection (0.67 nos./plant), imidacloprid spray (0.67 nos./plant) and Bordeaux mixture (0.67 nos./plant). Aluminium phosphide and carbofuran 3G recorded 1.67 and 2.33 number of adult emergence holes/plant, respectively.

Biological control of citrus trunk borer revealed that the treatments *viz.*, azadirechtin injection and azadirechtin spray recorded the lowest (0.67 nos./plant) number of adult emergence holes/plant, which were on par with NSKE injection (1.00 nos./plant) and spray (1.33 nos./plant), karanjin injection and spray (1.00 nos./plant). The treatments with *Beauveriabassiana* and *Steinernema carpocapsae* (50 IJS/ml) injection recorded 2.33 and 2.67 number of emergence holes/plant, respectively and were found to be on par with control (3.33 nos./plant).

**Major insect pests of fruit crops**

Survey was conducted for monitoring of different fruit flies species on different fruit crops. *Bactrocera dorsalis* was recorded on plum (*Prunus domestica*), guava (*Psidium guajava*), peach (*Prunus persica*), black berry (*Prunus nepalensis*) and *Soh phie* (*Myrica esculenta*) and *Bactrocera zonata* on peach only. Citrus trunk borer (*Anoplophora versteegi*) and citrus leaf miner (*Phyllocnistis citrella)*were recorded as major pests of citrus.

## DISEASES

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

Out of seven treatments tested, commercial formulation Nisarga(*Trichoderma viride*) @ 5 g/l was found effective followed by Bavistin (carbendazim) @ 2 g/l in the first year trial.

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

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

Six *Trichoderma* spp. were tested for their effectiveness on *P. citrophthora* using dual culture technique, effect of volatile compounds and non-volatile compounds.In dual culture, *T. harzianum* and *T. longibrachiatum* were effective among the six species against *P. citrophthora* with inhibition of 65.18 % and 64.58 %, respectively.In volatile compound effect experiments, four ways experiments (inoculation of bio-agent and pathogen on same '0' day, bio-agents 1, 2 and 3 days ahead to pathogen) were conducted. In all experiments, *T. brevicompactum* (52.16%)followed by *T. longibrachiatum* (50.51%) was found superior over other species.In the non-volatile effect experiment with 10, 20 and 30% culture filtrate, *T. brevicompactum* (99.37%)followed by *T. harzianum* (54.07%) were found superior.

## GUAVA

### Performance of guava genotypes under meadow orchard

In the second year, genotype RCGH7 out performed the RCG11 with respect to yield attributes when evaluated under meadow orchard (2 m x 1.5 m). The fruits yield (kg/plant) was higher in RCGH7 (6.26 kg/plant) compared with RCG11 (2.70 kg/plant). Similarly, RCGH7, recorded highest fruit weight (125.25 g), fruit length 5.99 cm and diameter 5.89 cm than RCG11 (92.95 g, 5.33 cm and 5.23 cm respectively). With respect to fruit quality, RCG11 recorded the higher TSS and ascorbic acid (10.18% and 187.13 mg/100 g, respectively.) than RCGH7 (9.92% and 182.10 mg/100 g, respectively). Similarly, minimum acidity was recorded in RCG11 (0.55%) followed by RCGH7 (0.61%)

## PEACH

### Standardization of leaf to fruit ratio (LFR) for yield and quality traits in peach

Heavy bearing habit of peach adversely affects the fruits yield and quality traits resulting poor returns. An experiment to standardize leaf to fruit ratio (LFR) was conducted before pit hardening stage of fruit on nine year old low chilling peach cv. Flordasun. Result (Table 1) revealed that the treatment *viz.*, 35:1 followed by 25:1 leaf to fruit ratio were found superior for the various quality traits assessed.

### Effect of flower thinning on fruit size and quality of peach

Experiment on flower thinning with three intensities were conducted at full bloom stage on nine year old low chilling peach cv. Flordasun to assess its effect on fruit size and quality. The result showed that fruit weight, pulp weight and fruit size L x B (53.00 g, 48.74 g and 49.33 mm x 48.72 mm respectively) were recorded maximum in 70% flower thinning followed by 50% (51.95 g, 47.81 g and 48.43 mm x 47.60 mm respectively) while minimum in control (47.11 g, 43.24 g and 45.02 mm x 44.56 mm respectively). However fruit yield was highest in control (35.07 kg/tree) followed by 30% (27.37 kg/tree). The 70 % (16.13 kg/tree) and 50 % (19.41 kg/tree) flower thinning showed at par values. In quality traits *viz*., TSS and ascorbic acid content (12.01°B and 6.15 mg/100 g) were maximum in 70 % flower thinning followed by 50 % (11.91°B and 5.96 mg/100 g) while minimum in control (10.16°B and 5.09 mg/100 g). The fruits of 70 % flower thinning intensity were less acidic (0.41%) followed by 50% (0.45%) and 30% (0.49%).

## UNDERUTILIZED FRUITS

### Variability in fruit yield and physico-chemical parameters of *Sohshang*

Five genotypes of *Sohshang* (*Elaeagnous latifolia*) were evaluated for their fruit yield and physico-chemical traits. Number of fruits per plant and fruit yield ranged from 793 to 1248 and 4.52 to 8.5 kg, respectively among the genotypes. Fruit weight, fruit length, fruit diameter, seed weight, pulp and dry matter content ranged from 6.07 to 11.42 g, 27.16 to 39.05 mm, 18.66 to 21.55 mm, 1.24 to 2.15 g, 74.13 to 81.17% and 18.2 to 28.22%, respectively. The quality traits *viz.,* TSS, acidity, ascorbic acid, reducing and total sugar varied from 8.2 to 11.5%, 1.66 to 2.82%, 19.76 to 31.92 mg/100 g, 3.08 to 3.64% and 5.88 to 7.69%, respectively among the genotypes.

## PAPAYA

## DISEASES

### Molecular Detection of *Papaya ring spot virus* (PRSV)

*Papaya ring spot virus* is an aphid-transmitted plant virus belonging to the genus *Potyvirus*, family *Potyviridae*, with a positive-sense, single-stranded,

**Table 1 Effect of LFR on yield and quality traits of peach cv. Flordasun**

| Treatment | Fruit yield (kg/tree) | Fruit wt. (g) | Pulp wt. (g) | Fruit color (4-point basis) | TSS (°Brix) | Acidity (%) | Ascorbic acid (mg/100g) | Total sugars (%) |
|---|---|---|---|---|---|---|---|---|
| T1 (15:1) | 16.31 | 47.87 | 43.93 | 2.45 | 11.58 | 0.51 | 5.78 | 6.02 |
| T3 (25:1) | 12.63 | 49.92 | 45.09 | 2.85 | 11.87 | 0.48 | 6.14 | 6.13 |
| T2 (35:1) | 14.37 | 50.84 | 45.82 | 2.96 | 12.05 | 0.46 | 6.61 | 6.21 |
| T4 (45:1) | 11.33 | 49.39 | 44.88 | 2.47 | 11.55 | 0.49 | 5.94 | 6.16 |
| T5 (Control) | 20.37 | 41.28 | 38.10 | 2.33 | 10.75 | 0.69 | 5.09 | 5.31 |
| CD (*P*=0.05) | 1.45 | 1.11 | 1.01 | 0.11 | 0.32 | 0.02 | 0.69 | 0.13 |

mono-partite RNA genome. Plant samples were collected randomly on the basis of visual symptoms including leaf mosaic and chlorosis, distortion of young leaves (Fig 1) forming shoestring from Umiam and Umsning of Meghalaya and maintained in the laboratory condition for detection. Total RNA was extracted from leaf samples followed by cDNA synthesis. The PCR amplifications were carried out using *Potyvirus* genus specific degenerate primers. During gel electrophoresis (Fig 2), the presence of ~1.3 kb amplicon (region covering partial Nib and CP domain of ORFI) confirmed potyvirus infection in the collected samples. The amplified fragment was sequenced and aligned in BLAST programme of NCBI which confirmed the presence of PRSV-P in symptomatic papaya samples.

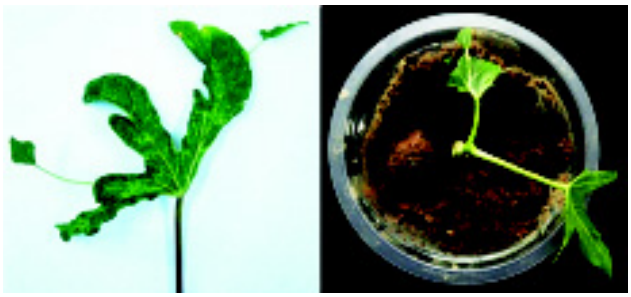


**Fig 1 Symptomatic papaya leaves having leaf distortion, mosaic and shoe string formation**

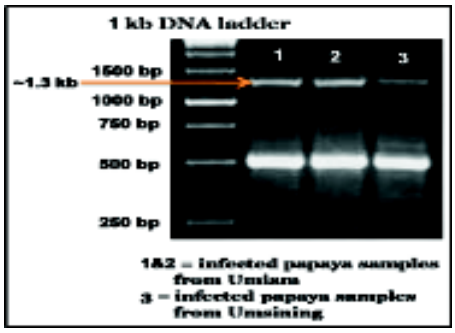



**Fig 2 PCR detection of PRSV using *Potyvirus* genus specific degenerate**

## BANANA

## DISEASES

### Molecular characterization of *Banana bunchy top virus* (BBTV) from Meghalaya showed similarity to "Pacific-Indian Oceans" group

*Banana bunchy top virus* (BBTV) is a multi-component, circular single stranded DNA virus belonging to the genus *Babuvirus* and family *Nanoviridae*. Presence of BBTV has been confirmed in symptomatic samples (Fig 1) collected from Umsning area by PCR-based detection using DNA R specific prime? The amplified fragment has been sequenced and the DNA sequence of 1092bp has been deposited to NCBI Sequence Database under the accession number JQ911667. The nucleotide sequence of Meghalaya-BBTV DNA R (Fig 2) was compared with previously reported sequences (collected from NCBI). The multiple alignment and phylogenetic tree (constructed following CLUSTAL W algorithm and Maximum Likely-hood method of MEGA 5 software, respectively) clustered the Meghalaya isolate within the ''Pacific-Indian Oceans'' group (Fig 3).

**Fig 1 Symptom of banana bunchy top disease**

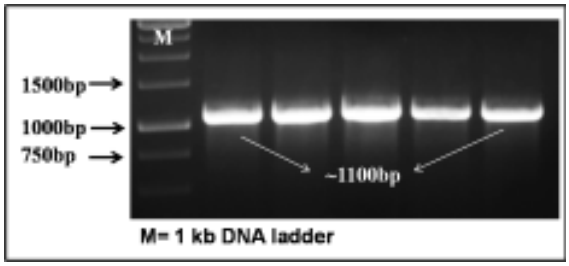



**Fig 2 PCR detection of BBTV using DNA R-specific primer**

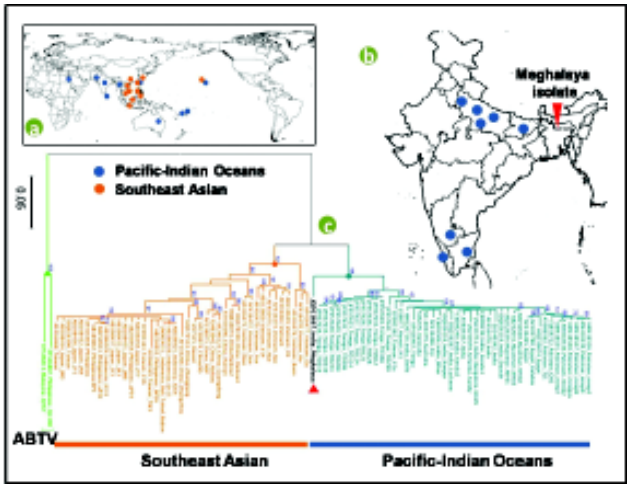



**Fig 3 (a) The world map showing the distribution of "Southeast Asian" and "Pacific-Indian Oceans" group of BBTV. (b) BBTV DNA R reported earlier from India including the new isolate from Meghalaya. (c) The phylogenetic tree of nucleotide sequence of BBTV DNA R rooted with *Abaca bunchy top virus* (ABTV), confirms the Meghalaya isolate (indicated by red arrow) within "Pacific-Indian Oceans" group**

## VEGETABLE CROPS

### TOMATO

**Evaluation of tomato genotypes**

Out of nine genotypes, the maximum average fruit weight and yield was recorded from the genotype TODVR1 (74.91 g, 31.5 t/ha) followed by TODVR5 (59.74g, 28.7 t/ha). The maximum TSS was observed from TODVR7 (5.67) followed by TODVR1 (4.67). However, all the genotypes were susceptible to early and late blight during later stage of the crop.

**Evaluation of genotypes against bacterial wilt**

Among the tomato genotypes the highest yield was recorded from the genotype Megha tomato-2 (34.2 t/ha) followed by LE626 (31.93 t/ha). The yield was lowest in the genotype LE1-2 (24.5 t/ha). The wilting (%) was least in the genotype. Megha Tomato-2 (8.83%) followed by LE626 (11.89%). However, the maximum wilting was recorded from the LE1-2 (29.67%). All the genotypes were susceptible for early and late blight. However, Megha Tomato2 was also tolerant to early and late blight.

**INM under protected condition**

This experiment was conducted under low cost poly house with cultivar Megha Tomato3. Out of nine treatments maximum average fruit weight was recorded from the $T_9$ 50% NPK + 50% vermicompost (84.67g) followed by $T_8$ 50% NPK + 50% poultry manure (84.0g) and they were significantly at par. However, the estimated yield per hectare was highest in $T_8$ 50% NPK + 50% poultry manure (62.4 t/ha) followed by $T_9$ 50% NPK + 50% vermicompost (57.8 t/ha).

### FRENCH BEAN

**Genetic characterization of pole type genotypes**

The set of 34 pole type genotypes were evaluated for sixteen characters. Phenotypic and genotypic coefficients of variation showed varied ranged between low (8.68) to high (50.38). Heritability in broad sense was high for all the characters. Yield was significantly and positively correlated with leaf area, plant height, pod length, number of seeds/pod, number of pods/plants and average pod weight.

**Evaluation of bush type genotypes**

Ten genotypes of French bean (bush type) were evaluated for the yield and related traits. The average plant height was maximum in the genotype Arka Anoop (47.59 cm) followed by Contender (54.28 cm). The highest yield was recorded from the genotype Arka Subidha (11.39 t/ha) followed by Arka Anoop (10.99 t/ha). None of the entries were higher in yield over the checks.

### BRINJAL

**Evaluation of genotypes**

This trial was conducted with the eight genotypes of brinjal including check (BCBII). The maximum plant height was recorded from the genotype BRLVAR4 (70.55 cm). The highest average fruit weight was found in genotype BCB11 (139.83 g) followed by BRLVAR1 (128.17 g) and the highest yield was recorded from the BRLVAR2 (38.60 t/ha) followed by check BCB11 (38.53 t/ha).

### CABBAGE

**Evaluation of hybrids**

Among the cabbage hybrids the earliest maturity was observed for CABHYB5 (67 days) followed by H139(C) (68 days). However, genotype Questo (125 days) took maximum duration to mature. The highest yield was recorded from the genotype CABHYB4 (79.5 t/ha) followed by CABHYB3 (74.8 t/ha). The lowest yield was recorded for genotype CABHYB2 (42.37 t/ha).

## INSECT PESTS

**Bio-intensive management of major insect pests of cole crops**

Cutworm, cabbage butterfly, cabbage aphid and diamond back moth were observed as major pests on cole crops. Among different dates of sowing, crops transplanted during mid October had very less infestation; whereas, crops transplanted in January suffered heavy losses due to *P. brassicae*, *B, brassicae* and *P. xyllostella.* Among all bio-pesticides tested, *B.t.* var *kurstaki* (Lipel 8SP) @ 2 g/l of water was found to be effective (reduced 69% damage) against cabbage butterfly and diamond back moth followed by NSKE 5%; while Anonin @ 2 ml/l of water was the least effective.

**Bio-intensive management of cabbage butterfly (*Pieris brassicae*) on cole crops**

Eco-friendly pesticides were evaluated against cabbage butterfly under field conditions. Spinosad @ 0.01% was most effective followed by Lipel 8 SP @ 2

gm/lit, *B. bassiana* (1x10$^9$cfu/ml) @ 6ml/l and NSKE 5%. The reduction in damage as compared to control by spinosad, Lipel (*B. bassiana*) and NSKE 5% were 60.82%, 50.16%, 41.82%, and 40.38% damage, respectively

**Natural parasitism of large white butterflies in cruciferous ecosystem**

Hymenopteran wasps *viz*., *Hyposoter ebeninus* (Grav.), *Cotesia glomerata* (L.), *C. ruficrus* (H.), *D. rapae*, *P. puparum* (L.), *B. femorata* and dipterans flies *viz*. *E. sorbilans* and *E. bombycis* were recorded as the important parasitoids in cruciferous ecosystem. *H. ebeninus* (Fig 1) was found to be the most dominant larval parasitoid of *P. brassicae* (L.) followed by *C. glomerata* (Fig 2) and *P. puparum* (Fig 3). Natural larval parasitism by *H. ebeninus* was observed to be highest (56.51%) during the end of Feb, while in case of *C. glomerata* and *P. puparum*;it was found to be exceptionally higher (32 and 36.17%, respectively) during Mar. Correlation with climatic factors revealed that, temperature, wind speed and sunshine have shown significant positive correlation with parasitism by *C. glomerata* and *P. puparum* whereas, and similar parameters have negative correlation with parasitism by *H. ebeninus*. Furthermore, relative humidity has negative correlation with parasitism by *H. ebeninus* and *C. glomerata*.

**Fig 1 *Hyposoter ebeninus***

**Fig 2 *Cotesia glomerata* cocoons**

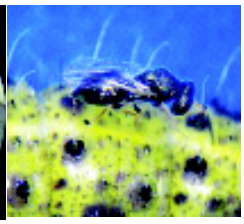


**Fig 3 *Pteromalus puparum***

## CUCUMBER

**Evaluation under low cost polyhouse**

This experiment was conducted under lowcost polyhouse with six collected genotype (RCC1 & 2, RCC3 & 4, Japanese Long Green and Kalyanpur Hara). The maximum numbers of fruits were recorded in the RCC2 (15 fruits/plant) followed by RCC1 (14 fruits/plant). The fruit length was maximum in the genotype Long Green (24.30 cm) followed by Kalyanpur Hara (22.42 cm). However, the highest estimated yield was recorded from RCC2 (25.7 t/ha) followed by Long Green (25.5 t/ha). Genotype RCC1, 2, 3 & 4 were found to be more prone to bottle neck disorder under low cost polyhouse

## SPICES

## TURMERIC

**Varietal evaluation**

Ten different varieties/genotypes of turmeric (*Curcuma longa*) were evaluated. Megha Turmeric1 recorded the maximum plant height (143.83 cm) closely followed by BSR2 (141.17) whereas minimum in Rajendra Sonia (97.50 cm). Roma produced highest yield 10.67 t/ha followed by Megha Turmeric1 (10.0 t/ha) whereas, lowest yield was noted in Kedaram (8.5 t/ha). Dried samples were analysed for curcumin content, results revealed that highest curcumin in Allepey supreme (8.46 %) with a dry recovery of 22.81 % followed by Kedaram (7.34 % and 21.81 %, respectively).

## GINGER

**Varietal evaluation**

Plant height was found maximum in Nadia (67.40 cm) followed by Mahima (64.16 cm) whereas, lowest in *Khasi* Local (47.73 cm). Mahima recorded the highest yield (5.22 t/ha) followed by Nadia (4.44 t/ha). Crude fibre content was found highest in *Khasi* Local (7.80 %) followed by Mahima (7.28 %) whereas, Rejatha recorded highest dry matter content (22.90 %) followed by Himgiri (22.63%). The highest oleoresin content was observed in *Khasi* Local (10.51 %) and lowest in Suprabha (3.70 %).

## DISEASES

**Identification and molecular characterization of bacterial witt disease in solanaceous crop and ginger**

Survey was conducted to 6 states covering 120 villages and 14 districts. The pathogen (*R. solanacearum*) causing wilt disease of solanaceous crops and ginger was isolated. Bio-control agents, *Bacillus subtilis* and *Pseudomonas fluorescens* were also isolated from collected soil samples. *R. solanacearum* was identified using specific 759/760 primers. The amplification of *R. solanacearum* was noted at 280bp.

Genomic studies on *R. solanacearum* isolates using PCR based molecular tools were conducted following universal scheme of "multi-locus sequence typing" (MLST) of house-keeping genes of *R. solanacearum*. So far, we have amplified and sequenced the *fliC* (*Flagellin* encoding protein gene) of *R. solanacearum*

isolates from ginger, capsicum, brinjal, tomato. The amplified products of *fliC* gene of four *R. solanacearum* isolates (RC_18 to RC_21) were sequenced and sequence of *R. solanacearum* strain RC_18 was submitted to NCBI gene bank (**Accession No. JQ770164**).

**Test of bio-efficacy of bio-agents against *R. solanacearum***

The *in-vitro* bio-efficacy of bio-agents was tested. *P. fluorescens* isolate 404 and *Bacillus subtilis* isolate 507, were found producing clear zone of inhibition against *R. solanacearum*. Culture suspensions of above isolates were also tested under field condition. Both the isolates i.e. 404 and 507 were found effective, reducing 41.94% and 56.45% disease incidence over control.

**Soft rot of ginger (Pathogen: *Pythium* spp.)**

a) **Survey and surveillance:** The survey was conducted for *Pythium myriotylum* and 61 isolates (23 isolates from Meghalaya, 19 Mizoram, 11 Sikkim and 8 from Arunachal Pradesh)were preserved.

b) ***In-vitro* efficacy of botanicals against *P.myriotylum*:** The botanicals *viz.,* onion, colocasia, neem, marigold, maize, lantana, wild turmeric and garlic @ 5% and 10% were tested *in-vitro* against virulent isolate of *P.myriotylum*.Garlic followed by Lantana and Colocasia inhibited 81.11, 32.59 and 31.48 per cent mycelial growth at 5% concentration, respectively. At 10% concentration, garlic inhibited 100% mycelial growth followed by onion (49.26%) and Lantana (47.78%).

c) **Management trial**: A trial with five replications was conducted, where HWT (54$^0$C) for 5 min + *Trichoderma* (2.5 kg/ha) mixing in soil at planting time + Copper oxychloride (0.3%) as soil application, recorded maximum yield (34.60 t/ha), minimum (13.66%) yield loss.

## TUBER CROPS

### COLOCASIA

**Varietal evaluation**

Six varieties of colocasia were evaluated for their growth and yield attributes. The plants were harvested at six months maturity. Maximum plant height was recorded in the line ML2 (94.43 cm) with maximum number of side shoots (10.0). The variety ML9 recorded the highest number of cormels (9.00) per plant and the highest cormel yield (14.00 t/ha), whereas, ML1 recorded the highest yield (25.50 t/ha). Leaf blight incidence was found to be the lowest in the variety ML 2 (18.00%).

In another trialforty genotypes of colocasia were evaluated in which plant height was maximum in the variety Nadia Local (122.38 cm). The maximum number of side shoots per plant (8.33) was found in ARCol-8. The variety Nainital recorded the highest number of cormels/plant (20.67) followed by BCC2 (17.33), while, the variety KCA 1 exhibited the lowest number of cormels/plant (4.33). Highest cormel yield (21.00 t/ha) recorded from the variety Kadina Local and total yield (30.00 t/ha) from the variety Panchmukhi. Varieties ML1 (16.00%) and White Gauriya (17.00%) were found tolerant to leaf blight of colocassia followed by ML9 (18.00 %) and Meghalaya Collection-1 (20.00%).

Moisture content was highest in Meghalaya Collection 2 (88.83 %) with a lowest dry matter of 11.17 % whereas lowest moisture content was observed in AR Col2 (58.03 %) with highest dry matter of 41.97 %. Nainital showed the highest total sugar (5.61 %) whereas, lowest was in Nadia Local (1.81 %). Starch content was found to be highest in BCCI-A (40.43 %) and lowest in Meghalaya Colllection1 (10.29 %). Varieties Megha Collection -2 and Telia had the highest calcium oxalate content (2.52 %) whereas, AR Col-8 showed lowest (0.72 %). Protein content was highest in AR Col 8 (10.28 %) and lowest in TMV239 (2.32 %).

### SWEET POTATO

**Varietal evaluation**

Twenty two different sweet potato varieties were evaluated in the varietal trial for yield and other characters. The variety S107 recorded the highest tuber yield (40.0 t/ha). The maximum tuber length (215.33 mm) was recorded for X24, whereas, tuber diameter was highest (78.24 mm) for the variety Sonipat2.

## FLORICULTURE

### GERBERA

**Evaluation of gerbera hybrids under low cost polyhouse**

Twenty-three hybrids/genotypes including 14 exotic of gerbera were evaluated under low cost polyhouse (Fig 1). Maximum flowers/plant/year (7.37 Nos.) was recorded in *P. Intezz*. Alesmera showed the

maximum flower stalk length (52.00 cm) while, maximum flower stalk diameter (7.53 mm) was recorded in Rising Sun. RCGH95 produced the largest flower diameter (12.71 $cm^2$) and Cantida produced the largest flower disc diameter (5.80 $cm^2$). Maximum vase-life (15.50 days) and field-life (22.00 days) were recorded in RCGH117 and Rising Sun, respectively.

**Fig 1 Gerbera under low cost polyhouse**

## POST HARVEST TECHNOLOGY

### Evaluation of quality of Megha Tomato 3 during storage

Megha Tomato 3 fruits were treated with $KMnO_4$ (ethylene absorbents) which plays an important role in increasing the shelf life. Tomatoes were packed in polypropylene (200 gauge) packets with 0.002% perforation and without perforation. Chalks treated with different concentrations of $KMnO_4$ (1500 ppm-2500ppm) were kept inside the polypropylene packets along with the tomatoes. Tomatoes packed in perforated (0.002%) polypropylene (200 gauge) packets with 2500 ppm $KMnO_4$ treated chalks had the shelf life of 28 days in cold storage (04±5?C and 85% RH) and 14 days in room temperature storage (24±5?C and 70% RH). Chemical analysis showed that the gradual change in the TSS, acidity, lycopene, ascorbic acid, etc. related to senescence was slow in the samples packed with 2500 ppm of $KMnO_4$.

### Development and optimization of citrus peel candy

Experiments were conducted with *Khasi* mandarin peels for developing value added product such as peel candy (Fig 1). Orange peels were sliced into three different sizes *viz.,* 30 mm length, 5 mm width (a), 30 mm length, 10 mm width (b) and 30 mm length, 15 mm width (c). The peel was subjected to different

**Fig 1 *Khasi* mandarin peel candy**

temperatures of blanching i.e., 5 min, 10 min, 15 min and 20 min. It was observed that the peel candy which had the most appealing texture and colour was the one that had been blanched for 20 minutes. Hence for preparation of candy from a, b and c type peels, the peels were first blanched for 20 minutes. They were heated in 45°B syrup for 30 minutes, then in 70°B syrup for 2 hours. The syrup was drained out and the candy dried at 50-55°C for 1 hour. The candies were then analyzed and found that C type candy retained highest amount of ascorbic acid (66.4 mg/100 g).

### Standardization of Jack fruits leather and evaluation of qualities during storage

Ripe jack fruits leather (Fig 2) was prepared without adding any external sugar, acid etc. The strained fruit pulps were dried at different temperature (40°C, 45°C, 50°C, 55°C and 60°C) in the tray drier. Among different drying temperatures, the final product prepared at 50°C recorded best products in terms of colour, softness and also taste. These final products were packed in different

**Fig 2 Jack fruit leather**

plastic packaging materials *viz*., PP, LDPE and metalized polyester and kept at room temperature for six months and evaluated at 30 days interval. Among different packaging materials, metalized polyester recorded maximum shelf life of six months with retaining maximum softness, taste, flavour and also colour while the other packaging materials could not retain original flavour, colour and softness.

**Shelf life extension of capsicum through MAP**

Experiments were conducted to increase shelf life of capsicum cv. California wonder. Fruits were harvested at mature green stage. These freshly harvested fruits were washed with clean water and surface water was removed with the help of muslin cloth. Fruits were then packed in different plastic packaging materials *viz*., LDPE (200 gauge, non-perforated), LDPE (200 gauge, perforated), PP (200 gauge, non-perforated), PP (200 gauge, perforated), HDPE (100 gauge, non-perforated) and HDPE (100 gauge, perforated) and control fruits were kept in open condition in the plastic trays. Packaging materials were made four pin holes to become uniform perforation. Each treatment was replicated five times and each replication consisted of 250 grams of uniform size fruits. Treated fruits were kept at laboratory ambient condition (20±2°C, 65% RH) for estimation of shelf life. To estimate the shelf life, different quality parameters *viz*., colour, texture, ascorbic acid content, and chlorophyll content were evaluated at the initial and also recorded at 3 days intervals for a total periods of 15 days. Among the different treatments, perforated poly propylene (200 gauge) recorded the maximum shelf life of 12 days while fruits packed in non perforated HDPE (200 gauge) recorded the minimum shelf life of six days at ambient storage condition (20±2°C, 65%RH).

## CONSERVATION AGRICULTURE

**Upland rice based cropping system**

Upland rice-*toria* system was evaluated under conservation and conventional tillage practices. In conservation tillage, residue of all the crops grown in the system along with weed biomass was incorporated. In conventional tillage, crop residues and weeds were removed.

The rice (Bhalum 1) yield was similar under conservation tillage (3.12 t/ha) and conventional tillage (2.98 t/ha) during rainy season. However, there was significant effect of residue (nutrient) management practices on succeeding *toria* yield. Among the residue management practices, application of 50 % recommended dose of fertilizer (RDF) + fresh biomass of *Eupatorium* (applied 2 months before sowing and incorporated) recorded maximum grain yield (0.68 t/ha) followed by 50 % RDF + rice straw (0.62 t/ha).

**Lowland rice based cropping system**

A field experiment was conducted to study the effect of tillage and residue management practices on productivity of lowland rice (var. Shahsarang 1). The main plot treatments included tillage practices *viz.,* conventional (4 ploughings), minimum tillage (2 ploughings) and zero tillage (application of glyphosate @ 4ml/l, 15 days before transplanting), while the sub-plot treatments were plant biomass management *viz.,* 50 % NPK, 50% NPK + fresh weed biomass @ 10 t/ha (*Ambrossia* + *Eupatorium*), 100 % NPK (80:60:40 kg/ha), 50% NPK + green leaf manure (fresh *Tephrosia* biomass @ 10 t/ha) and 50% NPK + *insitu* residue management (rice straw @ 6 t/ha) and FYM 10 t/ha + weed biomass 10 t/ha + $P_2O_5$ 30 kg/ha through rock phosphate. Tilage practices did not have statistically significant effect on yield of rice. Among the nutrient management practices, 50 % RDF + fresh biomass of *Eupatorium*recorded highest rice grain yield (6.08 t/ha) which was at par 50% NPK + green leaf manuring (5.94 t/ha) at 5% L.S (Table 1).

After rice harvest, pea (Prakash) and lentil (DPL 15) were grown under zero tillage with a nutrient dose of 20:60:40 kg/ha N:P:K to evaluate the residual effect of zero tillage (ZT), minimum tillage (MT) and conventional tillage (CT) in rice on succeeding pea and lentil crops. The average productivities of green pea were 6.20, 6.75 and 5.25 t/ha, under ZT, MT and CT of rice, respectively and the average productivities of lentil seed were 1.17, 1.42 and 0.96 t/ha, respectively.

The SOC values were maximum under ZT followed by MT at 0- 15 cm and 15-30 cm soil depth (Fig 1). The SOC value in FYM + weed biomass + rock phosphatetreatment was highest in 0-15 cm (Fig 2) 15-

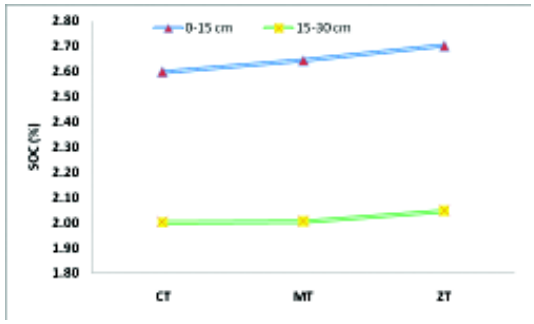



**Fig 1 SOC (%) as influenced by tillage practices**

**Table 1 Effect of tillage and nutrient management practices on yield attributes and productivity of lowland rice**

| Treatments | No. of panicles/m$^2$ | Test wt. (g) | Grain yield (t/ha) | Harvest index |
|---|---|---|---|---|
| **Tillage** | | | | |
| Conventional Tillage | 248.45 | 23.62 | 5.29 | 37.67 |
| Minimum tillage | 258.78 | 24.18 | 5.57 | 41.40 |
| Zero tillage | 283.17 | 24.48 | 5.72 | 43.53 |
| SEm | 6.04 | 0.54 | 0.23 | |
| CD ($P$ = 0.05) | S | NS | NS | |
| **Nutrient management practices** | | | | |
| 50% NPK | 255.05 | 22.78 | 4.72 | 41.92 |
| 100% NPK | 269.83 | 24.35 | 5.87 | 40.06 |
| 50% NPK + Weed biomass | 258.78 | 23.91 | 6.08 | 43.33 |
| 50% NPK+ rice straw | 285.28 | 25.22 | 5.35 | 39.31 |
| 50% NPK + green manure | 267.33 | 23.46 | 5.94 | 42.58 |
| FYM + weed biomass+ RP | 244.50 | 24.83 | 5.19 | 37.99 |
| SE (m) | 5.62 | 1.15 | 0.28 | |
| CD ($P$ = 0.05) | S | S | S | |

30 cm. Due to adaptation of ZT and MT, it was possible to double the cropping intensity and reduce 2 to 3 tillage/ ploughings in rice and at least 2 tillage operations in pulses, resulting in substantial saving of labour, energy and reduction in $CO_2$ emission.

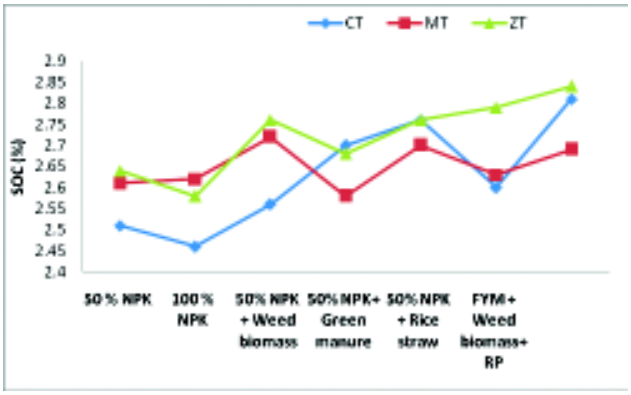



**Fig 2 SOC (%) under different residue management (0-15 cm)**

## ORGANIC FARMING

### Management of soil fertility using organic inputs in important field crop based multiple cropping systems

A field experiment was laid out under Network Project on Organic Farming to evaluate the efficacy of various on and off farm produced organic sources of nutrients/formulations on productivity and soil health. The fertilizer dose applied was 80, 60 and 40 kg/ha of nitrogen (N), phosphorus (P) and potash (K), respectively. Organic manures such as FYM and vermicompost were selected as base manure and applied on N-equivalent basis. Phosphorus (P) requirement was adjusted by applying Mussorie rock phosphate (MRP). All the crop residues were recycled into the field.

Results revealed that combination of 50 % recommended dose of nitrogen (RDN) through FYM and 50 % RDN through vermicompost (VC) along with spraying of Panchagavya recorded maximum grain yield of maize, *toria* and French bean followed by 50 % RDN through FYM + 50 % RDN through VC (Table 1). Improvement in physico-chemical properties of soil was observed due to application of different organic manures. Population of beneficial microorganisms *viz.,Rhizobium, Pseudomonas* and *Actinomycetes* were also found more in 50 % RDN through FYM + 50 % RDN through VC + Panchagavya treatment.

### Management of soil fertility using organic inputs in important vegetable crop based multiple cropping systems

After six cropping cycles, there was significant increase in crop growth and grain yield of maize in all the cropping sequences and nutrient management sources over control (Table 2 & Fig 1). Integrated source (50 % RDN through FYM and 50 % RDN through vermicompost) treatment recorded maximum grain yield of maize and green podyield of French bean.

**Table 1 Yield (t/ha) of crops as influenced by various sources of nutrient**

| Nutrient sources | Maize -*toria* (seed) | | Maize (green cob) -French bean | |
|---|---|---|---|---|
| | Maize | *Toria* | Maize | French bean |
| 50 % RDN through FYM + 50 % RDN through VC | 3.57 | 0.36 | 6.51 | 9.46 |
| 50 % RDN through FYM + 50 % RDN through VC + Panchgavya | 3.68 | 0.46 | 7.13 | 10.17 |
| Panchagavya (3%) spray | 0.81 | 0.09 | 1.67 | 3.28 |
| Biodynamic manure | 0.92 | 0.11 | 0.67 | 3.32 |
| Panchagavya + Biodynamic manure | 1.61 | 0.22 | 3.24 | 3.62 |
| Control | 0.44 | 0.01 | 1.28 | 0.97 |
| CD (*P*=0.05) | 0.59 | 0.007 | 0.90 | 0.94 |

However, 100 % RDN through FYM produced similar yield with that of integrated nutrient source in case of tomato. Maximum yield of potato was recorded with 100 % RDN through vermicompost and was found at par with 100 % RDN through FYM. Soil organic carbon (2.33 %), soil microbial population (223/g) and dehydrogenase enzyme activity (113.36 µg/hr/g soil) were recorded maximum with integrated source of nutrient supply.

**Fig 1 Vegetables based cropping system under organic farming**

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

The experiment is continuing since 2004-05. During 2011-12, upland rice under integrated (50 % RDN through organic + 50 % RDNPK through inorganic) management practice exhibited better yield over 100 % organic and 100 % inorganic management. Rice- French bean cropping systems recorded highest rice yield compared to other cropping systems. All the vegetable crops *viz.*, carrot, potato, French bean and tomato registered highest yield under integrated nutrient management practices and was found significantly superior over all other nutrient sources (Table 3).

Dehydrogenase enzyme activity (µg TPF/hr/g soil) of soil was found significantly higher under organic (114.3 µg/hr/g) treatment compared to other nutrient sources. Maximum value of Soil Microbial Biomass Carbon (SMBC) was also found under organic (173.94 µg/g dry soil) nutrient management practices followed by integrated (142.44 µg/g dry soil) and inorganic (130.98 µg/g dry soil) nutrient management practice (Fig 2).

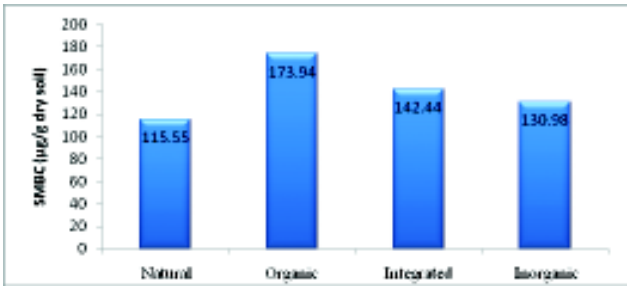



**Fig 2 Soil microbial biomass carbon as influenced by nutrient management practices**

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

| Nutrient sources | Maize + Soybean-Tomato | | | Maize + Soybean- Potato | | | Maize + Soybean-Frenchbean | | |
|---|---|---|---|---|---|---|---|---|---|
| | Maize | Soybean | Tomato | Maize | Soybean | Potato | Maize | Soybean | French bean |
| 100 % RDM FYM | 5.31 | 0.86 | 18.10 | 5.47 | 0.92 | 18.93 | 5.64 | 0.96 | 20.97 |
| 100% RDM VC | 4.84 | 0.78 | 16.84 | 5.29 | 0.86 | 19.59 | 5.48 | 0.90 | 20.56 |
| 50 % FYM+50 % VC | 5.52 | 0.93 | 17.55 | 5.57 | 0.96 | 18.46 | 5.69 | 0.95 | 22.07 |
| Control | 2.14 | 0.41 | 6.26 | 2.26 | 0.44 | 7.84 | 2.37 | 0.47 | 17.15 |
| CD (*P*= 0.05) | 0.66 | 0.38 | 0.64 | 0.50 | 0.19 | 0.65 | 0.79 | 0.23 | 0.45 |

**Table 3 Yield (t/ha) of crops under different cropping systems as influenced by various sources of nutrient management**

| Nutrient sources | Rice- Carrot | | Rice- Potato | | Rice- French bean | | Rice- Tomato | |
|---|---|---|---|---|---|---|---|---|
| | Rice | Carrot | Rice | Potato | Rice | French bean | Rice | Tomato |
| Natural | 1.67 | 1.23 | 1.53 | 5.84 | 2.04 | 1.40 | 1.81 | 0.51 |
| Organic | 3.34 | 11.87 | 3.06 | 15.75 | 3.34 | 8.66 | 3.12 | 21.31 |
| Integrated | 3.30 | 12.45 | 3.29 | 16.30 | 3.50 | 9.54 | 3.40 | 21.63 |
| Inorganic | 3.17 | 7.15 | 3.25 | 14.02 | 3.35 | 7.49 | 3.25 | 14.21 |
| CD *(P=0.05)* | 0.37 | 0.43 | 0.66 | 0.57 | 0.59 | 0.63 | 0.36 | 0.87 |

Quality parameters of tomato such as average fruit weight (g), average fruit length (mm) and average fruit diameter (mm) were 56.80, 49.21, and 50.82, respectively in integratedtreatment which were found superior than other treatments.TSS (%), ascorbic acid (mg/100 g), reducing sugar (%) and lycopene (mg/100 g) content were maximum (4.70, 28.06, 2.53 and 16.49,respectively) in organic treatment where as acidity (0.67 %) and total sugar content (5.35 %) were maximum in inorganic treatment.

In carrot the maximum root diameter (mm), specific gravity (g/ml), total sugar (%) and reducing sugar (%) were 33.64, 1.91, 5.91 and 4.29, respectively in integrated treatment, where as TSS (%), ascorbic acid (mg/100g), acidity, beta carotene (mg/100g) and total carotenoides (mg/g) were 8.28, 39.94, 0.21, 7.97 and 68.93, respectively in organic treatment.

**Weed management in maize-*toria* cropping system**

Experiment on weed management under organic farming in maize-*toria* cropping systems was carried out during *kharif* season. Mulching with fresh *Ambrosia/Eupatorium* @ 10 t/ha after earthing up was found effective in reducing weed growth and produced significantly higher grain yield (3.76 t/ha) of maize as compared to all other treatments. Mulching with fresh *Eupatorium/Ambrosia* has also shown a positive effect on yield of succeeding crop of *toria* and recorded significantly higher seed yield (0.64 t/ha) which may be due to carry over nutrients from the previous crop (Table 4).

**Organic farming of ginger and turmeric on the terraces**

Ginger and turmeric were grown in rain fed terraces under raised bed of 30 cm height and 1 m width using four types of green leaf manure *viz., Tephrosia*, *Ambrossia*, *Eupatorium* and soybean @ 20 t/ha as mulched material (Fig 3). Soybean crop was grown in the inter-row spaces of ginger and turmeric and incorporated during earthing up operation.FYM @ 10 t/ha, vermicompost @ 5 t/ha and rock phosphate @ 150 kg/ha was applied as basal. Mother rhizome of ginger was removed after 65 days of sowing.

**Table 4 Yield of maize – toria (t/ha) and population of weed species at different crop growth stage as affected by various weed management practices**

| Treatment | Maize grain yield | Weed population /m² | | Weed dry wt. /m² | | *Toria* seed yield |
|---|---|---|---|---|---|---|
| | | 40 DAS | 60 DAS | 40 DAS | 60 DAS | |
| Mechanical weeding (20 DAS)+ Hand weeding once (60 DAS) | 3.21 | 720.8 | 180.7 | 71.3 | 29.4 | 0.50 |
| Mulching with fresh *Eupatorium/Ambrosia* @ 10t/ha (after earthing up) | 3.76 | 605.0 | 300.0 | 54.6 | 24.7 | 0.64 |
| Aqueous leaf extract spray of lantana & pine | 3.46 | 840.0 | 162.0 | 60.4 | 36.4 | 0.53 |
| Hand weeding twice | 3.00 | 260.0 | 233.0 | 23.3 | 12.2 | 0.47 |
| Aqueous leaf extract spray of lantana & pine + Hand weeding twice | 3.36 | 387.5 | 267.5 | 40.5 | 18.4 | 0.56 |
| Soybean GM incorporation *in situ* | 3.16 | 495.5 | 269.0 | 32.5 | 21.2 | 0.44 |
| Weed free check | 3.14 | - | - | - | - | 0.46 |
| Weedy check | 2.89 | 963.0 | 412.33 | 146.88 | 36.92 | 0.38 |
| CD (*P*=0.05) | 0.33 | | | | | 0.19 |

**Fig 3 Ginger, turmeric and groundnut cultivation under organic farming**

Experimental results revealed that mulching with *Tephrosia* @ 20 t/ha produced significantly higher rhizome yield in ginger (16.2 t/ha). Mulching with *Ambrossia* and *Eupatorium* also showed significantly higher yield (14.4 and 14.1 t/ha, respectively) over control and these two treatments were at par with each other. Rhizome yield of turmeric (29.6 t/ha) was also found maximum in mulching with *Tephrosia* @ 20 t/ha. Maximum dry matter percentage was recorded 19.60 and 20.40 in ginger and turmeric respectively with *Tephrosia* @ 20 t/ha mulching.

### Groundnut

The performance of groundnut with application of different vermicompost was compared with FYM and control (Table 5). Results indicated that application of VC (Paddy straw) @ 7.5 t/ha along with rock phosphate (150 kg/ha) produced maximum pod yield (3.67 t/ha). Oil content was found highest (41.54 %) in the treatment VC (Banana stem) @ 7.5 t/ha + RP @ 150 kg/ha. Different sources of vermicompost and FYM were found at par with each other. In case of the succeeding crop *toria,* application of VC (Paddy straw) @ 7.5 t/ha + RP @150 kg/ha was resulted in significantly higher yield compared to other treatments.

## BIOORGANICS

### Maize

Maize var. RCM76 was tested with three botanical formulations *viz*., MF129,MF18, and MF 98. Seed was treated @ 10 % conc. with botanicals and one foliar application was undertaken at 30 days after sowing. The formulations MF129,MF18, and MF 98 resulted in yield increase of 26, 19.2, and 17.8 per cent over control (3.45 t/ha).

### Groundnut

Groundnut seed (var. ICGS 76) was treated with three botanical formulations @ 8% conc. for 5 h? and one foliar application @ 2 % conc. was applied at 40 days after planting. The formulations *viz*., GF3, RCHE 490L and RCHE 596L increased pod yield by 18.6 and 15.2 12.8 per cent, respectively over control (2.48 t/ha).

### Wheat

Two formulations were tested. Seed was treated with 8% concentration for 4 hrs before sowing and one foliar spray was applied @ 2% concentration at 30 days after sowing. The treated crop had significantly higher dry weight and overall growth. Higher grain yields (18.2% and 15.8%) were registered in RCHE 572L and RCHE 442L over control (2.21 t/ha).

## CROPPING SYSTEM RESEARCH

### Performance of various rice cultures under *in situ* fertility management in lowland

The experiment was conducted during *kharif* season of 2011 with three spacing (25 x 25, 20 x 20 and 20 x 15 cm) and three establishment methods *viz*., system

**Table 5 Yield (t/ha) and oil content (%) of groundnut under groundnut-*toria* cropping system as affected by different vermicompost**

| Treatment | Groundnut | | | *Toria* | |
|---|---|---|---|---|---|
| | Pod | Stover | Oil | Seed | Stover |
| FYM @ 10 t/ha + RP @ 150 kg/ha | 3.53 | 5.19 | 41.43 | 0.51 | 1.20 |
| VC (Banana stem) @ 7.5 t/ha + RP @ 150 kg/ha | 3.67 | 5.52 | 41.54 | 0.53 | 1.26 |
| VC (Paddy straw) @ 7.5 t /ha + RP @ 150 kg/ha | 3.79 | 5.30 | 41.20 | 0.60 | 1.33 |
| VC (Mixed grass) @7.5 t/ha + RP @ 150 kg/ha | 3.47 | 4.63 | 41.05 | 0.52 | 1.20 |
| VC (Maize stalk) @7.5 t/ha + RP @ 150 kg/ha | 3.63 | 4.45 | 41.22 | 0.54 | 1.28 |
| Control | 2.31 | 4.38 | 39.48 | 0.34 | 0.68 |
| CD at 5% | 0.61 | 0.67 | NS | 0.12 | 0.37 |

of rice intensification (SRI), integrated crop management (ICM) and conventional rice culture (CRC) under *in situ* fertility management of lowland rice (IR-64). Soil fertility was managed by periodic recycling of all the crops and weeds biomass in the fields. Result revealed that maximum rice grain yield was recorded 4.91 t/ha and 4.96 t/ha with spacing of 20 x 20 cm and integrated crop management (ICM), respectively (Table 1).

**Table 1 Effect of *in situ* fertility management on grain yield of rice (t/ha)**

| Establishment methods | Spacing | | | |
|---|---|---|---|---|
| | 25x25 cm | 20x20 cm | 20x15 cm | Mean |
| SRI | 4.83 | 4.81 | 4.53 | 4.72 |
| ICM | 4.97 | 5.24 | 4.67 | 4.96 |
| CRC | 4.57 | 4.68 | 4.37 | 4.54 |
| Mean | 4.79 | 4.91 | 4.52 | |

**Effect of soil acidity amelioration practices on different maize varieties**

A field experiment was carried out under the project "Development of sustainable maize production technology for acid soils of NE India" to study the effect of three ameliorating practices (row application of lime @ 500 kg/ha, FYM @ 10 t/ha, row application of lime@ 250 kg/ha + FYM @ 5 t/ha) compared with control (recommended dose of NPK) over five varieties of maize (Vijay Composite, RCM 1-1, RCM 1-3, RCM 75 and RCM 76). Among ameliorating practices highest grain yield (4.07 t/ha) was recorded with row application of lime @ 250 kg/ha + FYM @ 5 t/ha followed by row application of lime @ 500 kg/ha (Table 2). There was no significant effect on grain yield of maize among different varieties though RCM 1-3 recorded highest grain yield. The variety RCM 1-3 recorded higher grain yield with the furrow application of lime@ 250 kg/ha + FYM @ 5 t/ha.

**Performance of lentil under *utera* cropping in rice fallows**

The experiment was conducted during 2011 in *kharif* season with varieties *viz*., Shahsarang1, IR64, Lampnah and Vivek dhan82 under organic management practices. Shahsarang1 yielded maximum (4.50 t/ha) grain yield followed by Lampnah (4.27 t/ha) and other varieties. Four varieties (L303, L304, L305 and L307) of lentil were tested under *utera* cropping. Among the four varieties, L305 (1.12 t/ha) yielded highest seed followed by L304 (0.98 t/ha) and L303 (0.91 t/ha).

**Influence of organic and inorganic nutrient sources on fodder yield**

Field experiment was conducted during 2011 to study the effect of organic and inorganic sources of nutrient supply on productivity of fodder crops. The nutrient sources were organic (FYM 10 t/ha supplemented with rock phosphate 30 kg $P_2O_5$ /ha) and inorganic (80:60:40, N:P:K and comparison was made with control (no manure and no fertilizer). Three cuttings were taken and green fodder yield were recorded. Maximum fodder yield was recorded under organic sources of nutrient supply followed by inorganic (Table 3). Among the fodder crops, Napier recorded highest green fodder yield (161.59 t/ha) followed by Guinea grass (120.89 t/ha).

**Residue management and conservation tillage in rice-based system**

Data presented in Table 4 revealed no significant difference in grain and straw yield of rice due to different tillage practices indicating the similar effect

**Table 2 Effect of ameliorating practices on grain yield (t/ha) of different varieties of maize**

| Variety | Treatment | | | | |
|---|---|---|---|---|---|
| | Recommended NPK | Lime (500 kg /ha) | FYM (10 t/ha) | Lime (250 kg /ha) + FYM (5 t/ha) | Mean (Variety) |
| Vijay | 2.96 | 3.57 | 3.43 | 3.61 | 3.39 |
| RCM1-1 | 3.33 | 3.87 | 3.08 | 4.12 | 3.60 |
| RCM1-3 | 3.18 | 4.12 | 3.80 | 4.32 | 3.86 |
| RCM 75 | 2.77 | 3.87 | 3.28 | 4.19 | 3.53 |
| RCM 76 | 2.49 | 3.78 | 3.80 | 4.11 | 3.54 |
| Mean (Treatment) | 2.95 | 3.84 | 3.48 | 4.07 | |
| CD (*P*=0.05) for Treatment (T) = | 0.35 | | | | |
| CD (*P*=0.05) for Variety (V) = | NS | | | | |
| CD (*P*=0.05) for T x V = | NS | | | | |

**Table 3 Response of organic and inorganic sources of nutrient on green fodder yield (t/ha)**

| Treatments | Broom | Congo | Napier | Guinea | Mean |
|---|---|---|---|---|---|
| Control | 41.14 | 78.86 | 121.90 | 99.05 | 85.24 |
| Organic | 55.24 | 99.43 | 208.57 | 156.19 | 129.86 |
| Inorganic | 52.19 | 92.19 | 154.29 | 107.43 | 101.52 |
| Mean | 49.52 | 90.16 | 161.59 | 120.89 | |
| CD ($P = 0.05$) for grasses (G) | = 27.54 | | | | |
| CD ($P = 0.05$) for treatment (T) | = 15.51 | | | | |
| CD ($P = 0.05$) for G x T | = 31.04 | | | | |

**Table 4 Growth, yield attributes and yields of rice as influenced by various tillage practices**

| Treatments | Chlorophyll Index | No. of panicles /m² | 1000 seed wt. (g) | Grain yield (t/ha) | Harvest Index |
|---|---|---|---|---|---|
| Conventional - Conventional | 37.5 | 319 | 24.3 | 5.30 | 41.0 |
| FRB – FRB | 37.2 | 285 | 25.7 | 4.56 | 41.5 |
| Conventional - FRB | 32.9 | 338 | 24.2 | 6.32 | 43.5 |
| Conventional – Zero Tillage | 31.1 | 355 | 25.4 | 6.21 | 43.2 |
| SE (m) | - | 4 | 0.3 | 0.359 | - |
| CD ($P$=0.05) | - | 13.7 | 1.2 | 1.24 | - |

of zero tillage with that of conventional tillage. The grain yield was 5.30 t/ha under zero tillage, while it was 4.90 t/ha under conventional tillage with residue removal.

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

Data presented in table 4 reveals that the highest grain yield was obtained under conventional - furrow raised bed (FRB) tillage system followed by the conventional - zero tillage system (Fig 1). Straw yield of rice followed the similar trend as that of grain yield. The lowest grain yield was recorded under FRB - FRB tillage system followed by conventional- conventional tillage system. The tallest plant, maximum tiller number, panicle numbers and grain per panicle were recorded under conventional-zero tillage.

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

The data showed in table 5 reveals that the maize MEY was recorded highest under zero tillage (4.17 t/ha), followed by conventional tillage (3.05 t/ha). The straw yield followed the similar trend. Maize equivalent yield under residue management practices was highest under maize + groundnut (residues removal) (4.99 t/ha) followed by maize + groundnut residue retention (4.78 t/ha). The lowest MEY was recorded under maize + in-situ G.M. (residue retention) (2.29 t/ha).

The soil moisture content at 0-45 cm depth was marginally higher under conventional tillage over zero


**Fig 1 Crop performance under different tillage practices**

**Table 5 Growth, yield attributes and yields of maize as influenced by tillage and intercropping/residue management**

| Treatments | Maize grain yield (t/ha) | Soybean seed yield (t/ha) | Groundnut seed yield (t/ha) | MEY* | Straw yield (t/ha) |
|---|---|---|---|---|---|
| Conventional | 2.09 | 1.10 | 1.19 | 3.05 | 10.18 |
| Zero tillage | 3.13 | 1.26 | 1.39 | 4.17 | 10.26 |
| CD(*P*=0.05) | - | - | - | 0.332 | NS |
| **Residue management** | | | | | |
| Maize sole (residue removal) | 3.43 | - | - | 3.43 | 9.42 |
| Maize sole (residue retention) | 3.61 | - | - | 3.61 | 9.82 |
| Maize + soybean paired (residue removal) | 2.17 | 1.10 | - | 3.49 | 7.33 |
| Maize + soybean paired (residue retention) | 2.20 | 1.26 | - | 3.71 | 7.12 |
| Maize + groundnut paired (residue removal) | 2.61 | - | 1.89 | 4.99 | 7.25 |
| Maize + groundnut paired (residue retention) | 2.00 | - | 1.39 | 4.78 | 7.12 |
| Maize + in-situ green manure (residue removal) | 2.59 | - | - | 2.59 | 6.60 |
| Maize + in-situ,green manure (residue retention) | 2.29 | - | - | 2.29 | 6.67 |
| CD (*P*=0.05) | - | - | - | 0.351 | 0.802 |

*Maize equivalent yield

tillage. The moisture content of the soil gradually increased from 30 DAS and slightly decreased in 90 DAS (Figs 2 & 3).

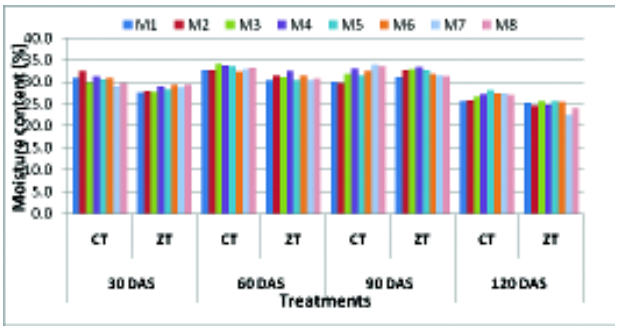



**Fig 2 Profile water storage in residue management treatments under conventional and zero tillage during growth of maize crop**

**Scaling up of Water Productivity in Agriculture for Livelihoods (SWPAL) through teaching cum demonstration**

A total of 20 farmers' training programme and 4 trainers' training programme were conducted successfully in different ICAR Centres, villages, KVKs of northeastern hill region under SWPAL. Out of 20 farmers' training programme, 8 training programmes were conducted by different divisions of ICAR Research Complex, Umiam in different villages, 7 in Manipur centre, 3 trainings in Arunachal Pradesh Centre and 2 trainings at Tripura centre. Most of the training programmes were conducted in remote villages/ areas. It was observed that farmers in these areas had poor access to such trainings because of the remoteness of the area, lack of awareness and education. Another important aspect of these programmes is that, some of the trainings were


**Maize + Soybean** **Maize + Groundnut** **Maize + *In situ* green manure**

**Fig 3 Crop performance under different tillage and residue practices**

organized in collaboration with State Departments (Soil & Water Conservation), NGOs where large number of farmers participated and also shown keen interest. Besides, technical sessions, field exposure/ demonstration programmes were also arranged as requested by the farmers.

The trainers training programme was also conducted successfully at two different centres *viz*., two at ICAR Research Complex for NEH Region, Umiam and two at Manipur centre. The participants were from KVKs, NGOs, and RAs.Besides technical session, field visit / demonstration were also arranged.

**Farmers Training Programme under SWAPAL**

**Farmers' training programme on "*Fishery based integrated water management*" at Tripura Fisheries Training Institute, Udaipur, South Tripura from 1st – 7th February, 2012**

**Farmers training programme on "*Integrated Water Management for Sustainable Agriculture*" at KVK, Tamenglong District, Manipur Centre from 9th – 15th January, 2012**

## AGROFORESTRY

### Evaluation of agroforestry systems in the mid hills of Meghalaya

Productivity of ginger and turmeric under the canopy of matured stand of *Schima wallichii* was assessed. Ginger var Nadia and Turmeric variety Megha Turmeric1 was cultivated in the interspaces of *Schima wallichii* on the small terraces. Yield of turmeric and ginger were 11 t/ha and 8.52 t/ha, respectively.

More than 25 year old agroforestry systems were evaluated for their long term effect on soil health. Twenty seven soil physical, chemical and biological properties were evaluated for six agroforestry systems were evaluated. Landuses such as *Jhum*, Pine forest and maize based agriculture were also included for comparative analysis. Soil quality index was estimated by data reduction (through principal component analysis) followed by use of scoring function, weight assignment and finally use of additive model. For the conservation and ecosystem function, highest SQI was estimated for Alder + Large cardamom (0.858) followed by Alder + Tea + Black Pepper (0.758), Alder + Ginger (0.756), Gumhar + Turmeric (0.755). All the Alder based landuse systems had better impact on soil health as compared to other agroforestry systems, Jhum and pure pine stand.

**Table 1 Quantification of landuse effects on soil health attributes**

| Landuse | Soil Quality Index (SQI) |
|---|---|
| Alder + Tea + Black Pepper | 0.758$^{b}$ |
| Silver oak + Pineapple | 0.732$^{bc}$ |
| Som + Broom +Pineapple | 0.735$^{bc}$ |
| Alder +Large cardamom | 0.858$^{a}$ |
| Alder + Ginger | 0.756$^{b}$ |
| Gumhar + Turmeric | 0.755$^{b}$ |
| *Jhum* | 0.637$^{d}$ |
| Agriculture (Maize) | 0.751$^{b}$ |
| Pine forest | 0.705$^{c}$ |

Means in the column followed by common letters (a-c) are not statistically different at 5% level of significance.

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

#### Tree – crop interaction

Two paddy varieties *viz*., Bhalum 1 and Bhalum-2 were tested under the tree canopy of *Alnus nepalensis*.

Bhalum1 recorded more yield (1.78 t/ha) than Bhalum2 (1.04 t/ha) of Shasharang was 2.74 t/ha. The groundnut yield under *Gmelina arborea* was 1.57 t/ha.

**Fig 1 Upland paddy with MPTs**

**Fig 2 Low land paddy**

### Livestock production

A total of 1,202 kg poultry (4 batches), 238 kg pigs (2 nos.), 2,539 liters milk, 94 kg fish (2 ponds), and 12 nos. of goat kids were obtained.

### Evaluation of lentil varieties under different conditions

Four varieties of lentil *viz*., PL639, L4147, VL4 and VL120 were tested under different conditions like (a) providing irrigation (2 times), (b) Mulching (5-6 kg of *Indigofera tinctoria* biomass) and (c) no mulching and no irrigation. The crop was sown on 9 November 2011 and harvested on 24th March 2012. About 20-25 kg of vermin-compost in each plot (40 $m^2$) was applied at the time of sowing. The treatment was replicated thrice.

The results indicated that among the four lentil varieties, varieties, L4147 out performed (352 kg/ha) while VL4 recorded minimum yield (245 kg / ha). Irrespective of lentil, the field provided with irrigation shown higher yield compared to other two situations. The interaction effect reveals that the lentil variety L4147 with irrigation registered maximum yield (425 kg/ha) whereas VL4 recorded minimum yield (196 kg/ ha) under no mulch and no irrigation condition (Table 1).

**Table 1 Yield of lentil varieties**

| Variety (V) | Yield (kg/ha) under different conditions (T) | | | Mean |
|---|---|---|---|---|
| | Irrigated | Mulched | No. mulch & no irrigation | |
| PL 639 | 331 | 300 | 294 | 300 |
| L 4147 | 425 | 325 | 306 | 352 |
| VL 4 | 310 | 269 | 156 | 245 |
| VL 120 | 313 | 306 | 256 | 292 |
| Mean | 383 | 300 | 253 | |
| | V | T | V X T | |
| CD (*P*=0.05) | 12.1 | 10.5 | 21.0 | |

### Evaluation of *Mucuna pruriens* germplasm for their growth and productivity

Data of the 26 genotypes of *Mucuna pruriens* were analyzed with IC83195 as check which was found to be the best check genotype among the five checks evaluated in the year 2010-11. Highest seed yield was obtained from UPMP06 (1.634 t/ha) followed by UPMP11 (1.214 t/ha), WBNMP03 (1.180 t/ha) and WBNMP06 (0.835 t/ha). Yield of IC83195 was 0.586 t/ha. Yield of all these genotypes were statistically different from each other at 5% level of significance. Number of clusters per plant was highest for WBNMP02 (86 Nos), which was significantly (at 5% l.s.) higher than UPMP06 (77 Nos), WBNMP06 (70 Nos) and SKMMP02 (60 Nos). Genotypic coefficient of variation was maximum for seed yield (76.87) followed by inflorescence length (59.83) and clusters per plant (54.72). Heritability broad sense ($h^2$) more than 90% was estimated for yield, clusters per plant, 100 seed weight and days to flower initiation. Heritability was lowest for pod width (12.16%).

## SOIL SCIENCE

### Assessment of quality of soils under different farming systems in hilly ecosystem of Meghalaya

Land use (natural forest, mixed plantation forest, horti-silvi-pastoral system and orchard) impacts on quality characteristics of soils located contiguously in hill slopes (38-46%) of Meghalaya (25°41´ 21'' N latitude and 91° 55' 25'' E longitude, 1080 above MSL, rainfall 2439 mm/annum) was studied. Land use systems affected the quality of acidic *Inceptisols* in sub-tropical hill zone of Meghalaya. Conversion of forest land to other land uses *viz*., mixed plantation forest, horti-silvi-pastoral system and orchard significantly reduced the pH (0.26-0.52 unit), organic carbon (SOC, 17.4-32%), microbial biomass carbon (MBC, 19.3-28.2%) and activity of acid phosphates enzyme (32.6-43.5%) in soil. MBC and enzyme activities significantly ($P$<0.01 to $P$<0.001) correlated with SOC and pH. The enzymes studied were significantly ($P$<0.001) inter-correlated. Higher pH, SOC, MBC and enzyme activities in forest soil is due to positive impact of surface cover, vegetation, and lack of tillage and fertilization.

### Effect of nutrient management practices on maize yield and soil organic carbon (SOC)

Effect of different nutrient management practices on maize yield and soil organic carbon was studied under the institute project "Impact of nutrient management practices on carbon dynamics of acid soil". Field experiment on maize (var. RCM-76) as test crop was conducted with 15 different treatments combinations of nutrient management (Inorganic, organic and integrated). It was observed that 100% NPK along with lime (0.5 t/ha) gave maximum yield (3.2 t/ha) compared to other nutrient management practices. Application of 50% NPK and lime (0.5 t/ha) along with organic sources of nutrient could give better yield than 50% NPK and lime alone. Organic treatment could not sustain the yield of crop in the first year of experiment. Soil samples from the maize field was analyzed for soil organic carbon (SOC) and it indicated that 50 % of NPK along with vermi compost @ 5 t/ha had more significant effects on SOC (1.77 %) as compared to others nutrient management practices and it was at par with the organic treatments (1.87 and 1.90 %) in the first year of experiment. Effect of lime on the improvement of SOC was not recorded in the initial year of experiment.

### Phosphate and water use efficiency of different rice cultivars under rainfed low land condition in acid soils of Meghalaya

Field experiment (*kharif*-2011) on genotypic response of four lowland rice cultivars (namely Shahsarang, Ngova, RCPL-75 and RCPL-1-160) to phosphatic fertilizers showed that under natural fertility condition (absolute control), genotype Ngoba produced highest grain yield (3.82 t/ha) while RCPL-1-75 registered lowest yield (2.83 t/ha). However, under fertilized condition, genotypes Shahsarang and RCPL-1-160 registered significant increase in grain yield from 3.16-3.28 t/ha (in control) to 5.41-5.56 t/ha (60-90 kg P/ha along with N and K) (Fig 1).

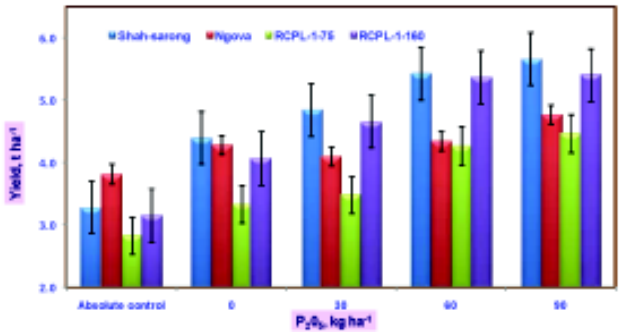



**Fig 1 Differential response of low land rice genotypes to phosphorous fertilization**

Diffogram studies reflected significant response of genotypes to different P fertilizers doses on grain yield production of rice (Figs 2a & 2b).

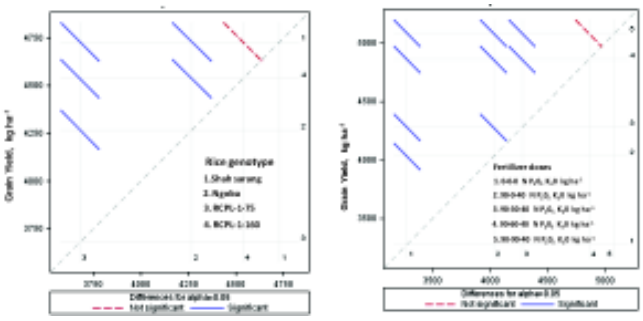


**Fig 2 Diffogram showing the effect of genotypic variation (a) and differential fertilizer response (b) to grain yield of rice. Small horizontal and vertical lines represent four genotypes (Fig 2a) and five fertilizer doses (Fig 2b) while bold lines passing through the squares diagonally represent significant (solid lines) or non-significant (dash lines) differences among the genotypes (Fig 2a) as well as differential fertilizer doses (Fig 2b).**

Quantification of different components of water balance (*through field water balance approach*) showed that a total of 1261-1275 mm of water input in the form of rainfall was received during crop growth seasons. Out of the total rainfall received, percolation and underbund seepage loss accounted for 66-73% while crop used consumptively only 27-34% as actual ET (AET) losses. Similarly, varietal and phosphorus doses had significant influence on crop water productivity ($WP_{ET}$) which varied from 0.83 to 1.51 g grain per liter water.

**Effect of soil amendments and fertilizers on crop productivity and soil health-an integrated approach**

**Maize**

Residual effects of agricultural lime at varying rates (from 12.5 % LR up to 75% LR) applied in the first year were prominent in the third year maize crop productivity, which varied from 1.43 t/hato a maximum of 3.98 t/ha. Diffogram studies exhibited significant differences in maize grain yield under various treatment combinations. Residual effect of lime applied at higher doses (@50-75% LR) was prominent only in the 3rd season maize crop (3.1-3.3 t/ha). However, with lower doses of lime (@ 25% LR), comparable yield (3.0 t/ha) to higher doses (50-75% LR) could be achieved. Residual effect of lime at lower doses (@12.5% LR applied once in three years interval integrated with regular application of 100% recommended NPK and FYM @ 5 t/ha in the 3rd year crop produced significantly higher yield (3.98 t/ha) compared to all other treatments. However, residual effect of lime (@12.5% LR) was conspicuously absent on regular application of poultry manure @ 2.5 t/ha along with 100% NPK in the third year maize crop (yield, 2.28 t/ha) unlike previous two season performance. Thus, it can be inferred that liming (at lower doses -12.5% LR) should be done once in two years with poultry manure while with FYM, liming once in three years interval is sufficient to achieve the optimum maize productivity. Increase in soil pH (0.25-0.45 unit), Ca and Mg contents (by 10-21%), and considerable reduction in ex. Al content in the sub-surface layers (15-45 cm) compared to surface (=15 cm) and deeper (>45cm) layers along the soil profile revealed that downward movement of surface application of agricultural lime (12.5-75%LR) required at least three years to ameliorate sub-soil (15-45cm) acidity related constraints in medium textured acid soils of Meghalaya.

**Turmeric**

Turmeric was grown for 3 years (2009-2011) on the same field with various treatment combinations. The 3rd year rhizome (fresh) yield reflected significant variation across the treatment combinations (Fig 3). For three consecutive years, integration of weed biomass (*Ambrosia* spp.*)* @ 1.5 t/ha (dry wt. basis) used as mulch and 100% recommended doses of NPK along with residual effect of agricultural lime (@ 20% LR) applied once in 3 years produced maximum rhizome yield (fresh wt. of 20.8 t/ha). Regular yearly application of weed biomass (*Ambrosia* spp.*)* along with 100% NPK without lime also produced over 18 t/harhizome yield. In absolute control (zero external input), turmeric productivity couldn't exceed even 4 t/ha. Other treatment combinations including FYM (5 t/ha) and poultry manure (2.5 t/ha), weed biomass and 100% NPK fertilizers also resulted in significant increase in rhizome yield over absolute control (Fig 3). Thus, the residual effect of lime (once applied in 3 years) with locally available weed biomasses can be exploited as mulch in integration with organic and inorganic nutrient sources for getting higher productivity of turmeric in the acid soils of Meghalaya.

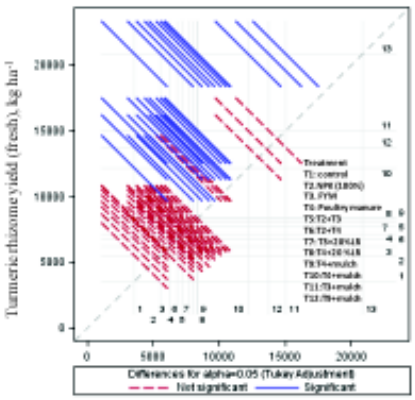



**Fig 3 Diffogram showing the integrated effect of amendments (organic and inorganic) and fertilizers on rhizome yield of turmeric crop**

Application of weed biomass (*Ambrosia* spp.) alone, poultry manures (2.5 t/ha) along with lime (12.5% LR) increased micro-aggregation (17-21%) of soil. Liming (20% LR) increased macro-aggregation. Similarly, water stable aggregates, mean weight diameter, structural coefficient, saturated hydraulic conductivity, plant available water content etc. were increased considerably (11-27%) on application of amendments (organic manures & lime) either alone or in integration with weed biomass (Fig 4).

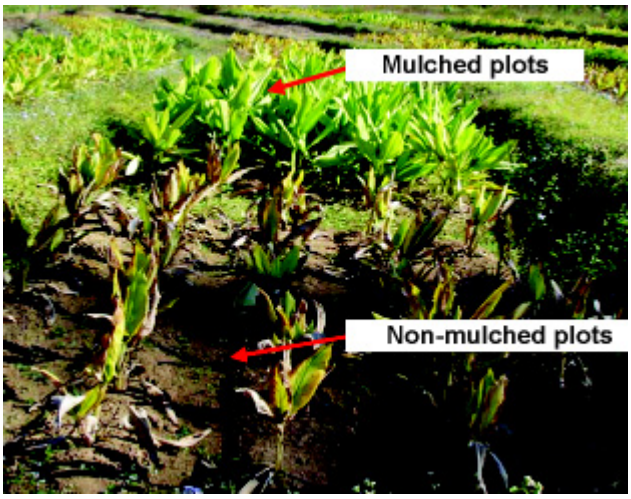



**Fig 4 Effect of weed biomass application on variability of turmeric growth at maturity**

### Comparative evaluation of effectiveness seed pelleting and furrow application of lime on maize

In a field trial in 2011, the effect of lime (furrow application and seed pelleting) alone or in combination with NPK and FYM application on maize yield was evaluated on an acid Alfisol of Meghalaya. Application of recommended NPK dose resulted in 53.2% yield improvement, and liming @ 300 kg/ha (furrow application) caused 32.4% yield increase over control. Combined application of NPK + lime resulted in 147% yield increase while application of FYM @ 5 t/ha along with NPK + lime further increased the yield up to 291% over control. Seed pelleting with lime was also tested but the effect was not found significant; however, this technique needs further experimentation with some changes in method of seed pelleting. These results suggested that liming (furrow application) along with integrated nutrient management practices can significantly increase the crop productivity on acidic soils of Meghalaya.

## Climate change impact and adaptation strategies in hill agriculture of northeast India (NPCC)

### Case study of Cherapunjee, Meghalaya

Cherapunjee of Meghalaya is the wettest place on the earth. Therefore, the rainfall pattern over the last 32 years was analysed. As was observed from the annual rainfall for the period 1969-2000 (Fig 1). The highest rainfall was recorded in the year 1974 (23442.4 mm) and lowest was in the year 1978 (6910.9 mm). As per analysis of the pre-monsoon, monsoon and post-monsoon period, the annual rainfall is showing decreasing trend (Fig 2).

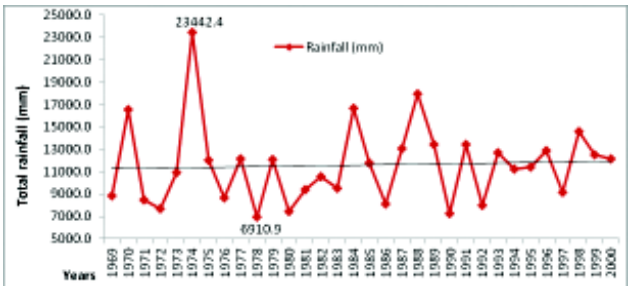



**Fig 1 Long term annual rainfall pattern over 32 years at Cherrapunjee, Meghalaya**

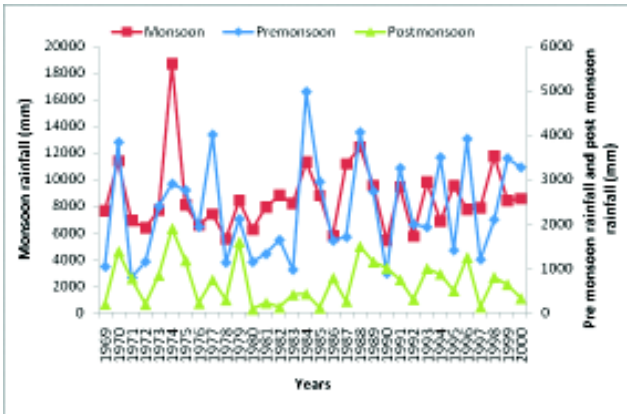



**Fig 2 Seasonal distribution of rainfall over a period of 32 years at Cherrapunjee, Meghalaya**

The number of extreme events ( = 100 mm/ day ) over a period of 32 years indicated that the year 1974 recorded the highest number of extreme rainy days (118 days) whereas, the year 1990 recorded the lowest number of extreme rainy days (Fig 3). Hence, the number of extreme rainy days showed decreasing pattern over the decades.

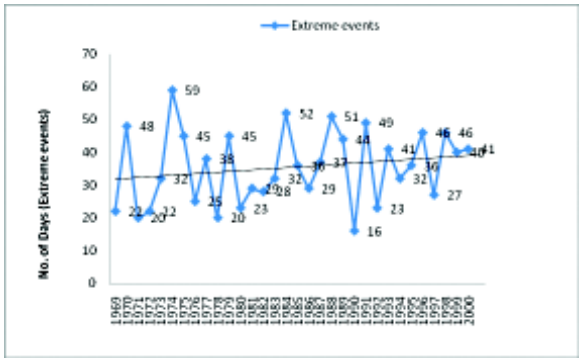



**Fig 3 Number of extreme rainy days (= 100 mm/ day ) over a peeriod of 32 years at Cherrapunjee, Meghalaya**

### Temperature

The annual maximum temperature indicated increasing trend whereas, annual minimum temperature indicated decreasing trend (Fig 4).

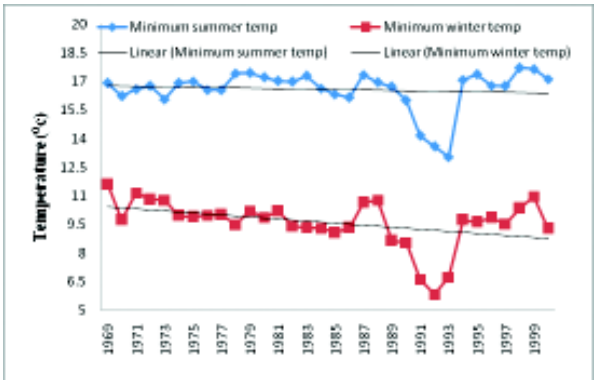



**Fig 4 Average annual temperature of Cherrapunjee, Meghalaya**

From the graph it can be visualised that maximum temparature in summer and winter were increasing and minimum temparature in summer and winter were decreasing and thus widening the gap, which may have negative impact on agriculture.

### Evaluation of adaptation strategies to climate change for important crops of the NEH region

#### Rice

The rice varieties *viz*., Vivek Dhan 82, IURON, IET 20957, Bhalum 1, IR 64, Mendri and Shahsarang-1 were grown in pots (9.61 litres capacity) under elevated temperature (1.5±0.25 $^0$C) and ambient temperature (Table 1)**.** At elevated temperature IURON recorded maximum height and yield (302 g/pot) whereas, Bhalum 1 showed stunted growth. Even at ambient temperature, Bhalum 1 could not perform better due to disease and pest attack, however at elevated temperature, pest and disease problem was minimum.

#### Maize

The maize varieties *viz*., Vijay composite, DA 61A, hybrid HQPM 1 and local variety were grown in pots (9.61 liters capacity) under elevated temperature (1.5±0.25 $^0$C)and ambient temperature**.** Local variety recorded the maximum height and grain weight (67 g/cob) at elevated temperature whereas, the hybrid maize HQPM1 recorded minimum height (157 cm) and grain weight (40 g) at elevated temperature. At ambient temperature, HQPM 1 suffered maximum damage due to disease and pest attack, however at elevated temperature, pest and disease problem was minimum.

#### Cauliflower

The growth and yield of cauliflower grown in pots (9.61 liters capacity) was recorded under two temperature treatment head weight and ascorbic acid under elevated temperature were 255 g and 22 %, respectively as compared to 115 g and 20 %, respectively under ambient temperature.

### Identification of rice varieties suitable for late transplanting to overcome early drought

Field experiment was conducted with seven short duration rice. These were transplanted at 10 days interval starting from 17$^{th}$ Jul up to 17$^{th}$ Aug and varieties *viz*., IET 20204, Vivek Dhan 82 and Vivek Dhan 62 had the potential for late transplanting. IET 20957 and Sahabhagi had moderate potential for late transplanting. It may be mentioned here that mid July is the optimum time for rice transplanting at mid altitude. But in third and fourth transplanting panicle did not emerge in IR64 and Shahsarang.

Variety Shahsarang 1 recorded maximum yield when transplanted in first and second (17$^{th}$ and 27$^{th}$ Jul) date (Fig 5). When transplanting was delayed beyond 27$^{th}$ Jul, the variety Shahsarang 1 could not produce any grain mainly due to its longer duration (192 day) that coincided with low temperature at the reproductive stage. Similar was the condition with of IR 64. On the other hand variety Vivek Dhan 82 recorded lower grain yield but it was almost similar to Shahsarang 1 when transplanted in the first and second (17$^{th}$ and 27$^{th}$ Jul) date. The interesting point to note was that the variety Vivek Dhan 82, when transplanted late up to 17$^{th}$ Aug, produced significantly high and acceptable grain yield compared to other varieties. This was mainly due to its shorter duration. Therefore, Vivek Dhan 82 seems to be most resilient and suitable variety for late transplanting and higher yield at mid-altitude of Meghalaya.

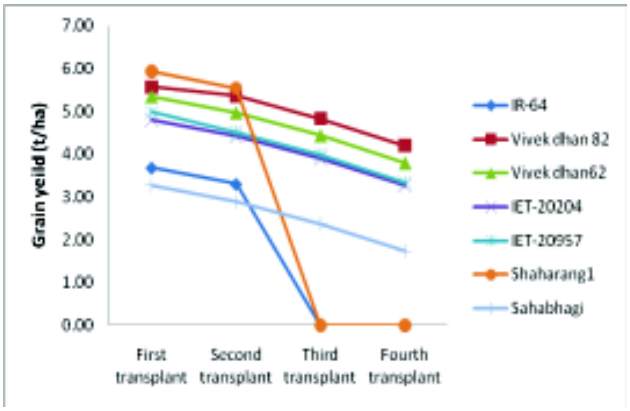



**Fig 5 Yield of different varieties on different dates of transplanting**

## FARMING SYSTEM RESEARCH

### Dairy based farming system (FSW-1)

Dairy based farming system was evaluated on a micro watershed of 1.39 ha area including 0.45 ha forestland. The area under planned land use is 0.94 ha of which 0.22 ha terrace area is under annual fodder crops and remaining under broom and guinea grass. The average slope of the watershed is 32.02%. The bottom 1-5 terraces were utilized for production of annual fodders with maize + cowpea – cowpea and maize – cowpea cropping sequence. The terrace riser area was utilized for the production of guinea grass while 2500 $m^2$ sloppy area was under broom grass which gave 17.0t green leaves and eatable tender shoots during lean period. Four milch cows and their calves were maintained in the system. Fodder crops/ grasses were grown in the micro-watershed, produced fodder for year round availability for the dairy animals. The crop wise green fodder yield presented in table1 revealed total 28.04 t green fodder production from the watershed of which maximum green fodder of 17.0 t recorded from broom grass leaves.

**Table 1 Fodder production**

| Name of fodder | Yield (t) |
|---|---|
| Maize | 3.94 |
| Cowpea | 0.18 |
| Rice bean | 0.06 |
| Guinea grass | 4.05 |
| Broom grass | 17.0 |
| Oat | 2.81 |
| Total green fodder | 28.04 |

Cultivated fodder crops like maize, cowpea, rice bean and perennial guinea grass were utilized as green fodder from Jun to Nov. During lean period, broom grass was available for 4 months i.e, Dec to Mar. The remaining 1 month i.e. Apr, only paddy straw and few amounts of new shoots coming from guinea grass was used to feed the animals. During May, 50% green fodder was available from guinea grass. An analysis of fodder production and requirement revealed that total green fodder from forage crops was 28.04 t while the requirement for the dairy animals was 31 t showing a deficit of (-) 2.96 t. Total concentrate, paddy straw and medicine was arranged from open market costing to ₹ 1,10,942.50. Keeping in view farmer's family in the watershed, all labour were considered as farmer's works, only concentrate, paddy straw and medicine was procured from the market and milk yield considered to be the farmer's income (Table 2).The milk yield obtained from the system was 5985 litre (assuming farmer's requirement was 415 litre) giving gross return of ₹ 1, 72,283.00. Besides 48 t of FYM produced from cow dung, urine, crop residues and weed biomass in the system. Considering family labour as a system of employment for dairy based farming, total cost of feed, concentrate and medicine was ₹1,10,942.50 with annual income of the system (₹ 1,72,283.00) registered net income of ₹ 61,340.50.To increase nutritional quality of fodder, cowpea varieties were evaluated in the watershed. Three varieties of oats for green fodder during Feb and Mar were grown in the watershed showed potential of green fodder yield of 33.3 t/ha with Kent and AOSC 3 (28 t/ha). Lowest green fodder was obtained with AOSC 4.

**Table 2 Balance sheet of dairy based system**

| Particulars | Area (ha) | Production (t) | Requirement (t) | Surplus/ Deficit | Value (₹ ) |
|---|---|---|---|---|---|
| **A. Green fodder** | | | | | |
| (a)Annual fodder | 0.12 | 6.99 | - | - | - |
| (b)Perennial grass | 1.27 | 21.05 | - | - | - |
| **Total (A)** | **1.39** | **28.04** | **31.0** | **(-) 2.96 t** | **(-) 2,967.00** |
| **B. Feed, dry fodder and medicine** | | | | | |
| (a) Concentrate | - | - | 4.59 | (-) 4.59 | (-) 68,880.00 |
| (b) Paddy straw | - | - | 18.25 | (-) 8.25 | (-) 41,062.50 |
| (c) Medicine | - | - | - | | (-) 1,000.00 |
| **Total (B)** | **-** | **-** | **22.84** | **(-) 22.84** | **(-) 1,10,942.50** |
| **C. Output** | | | | | |
| (a) Milk | 4 cows | 5985 litre | 415.00 | (+) 5570.00 | (+) 1,39,250 |
| (b) Cow dung | | 48.00 t | 30.00 t | (+)18.00 t | (+) 36,000 |
| **Total (C)** | | | | = | **(+) 1,75,250.00** |
| **Gross income (A + C)** | | | | = | **(+) 1,72,283.00** |
| **Net income (A + C – B)** | | | | = | **(+) 61,340.50** |

**Silvi-pastoral system (FSW-3)**

Silvi-pastoral system was established on 2.94 ha area in forest land of 2.05 ha with planned land use 0.90 ha. The average slope of the area is 32.18%. The top portion of the micro-watershed was utilized for broom grass to fulfill the requirement of fodder for the animal during lean period and to get broom sticks as well as fuel woods in the form of stick. An area of 0.74 ha was planted with broom, recorded green fodder of 28.0 t out of which 4.62 t green leaves were used for cow and goat from November to February.

Twenty goats (5 males, 15 females) were maintained in this system. The goats were allowed to graze for 3 hours per day and green fodder @ 3 kg per adult along with 250 g of concentrates per adult were given. The goats consumed a total of 3.6 t guinea grass, 2.16 t *Symingtonia* leaves and 0.46 t of concentrate. Poultry (400 broilers) chicks were also reared in three cycles as subsidiary source of income. The total body weight was 920 kg with average body weight 2.0 kg per bird during 1st cycle and 2nd cycle the average body weight was recorded to be 2.3 kg per bird while during 3rd cycle the average body weight was recorded to be 2.1 kg per bird. The gross income from system was ₹ 1,37,000.00. The expenditure of ₹ 52,680.00 on feed, concentrate and price of day old chicks resulting into a net profit of ₹ 84,320.00 from the watershed (Table 3).

**Table 3 Cost benefit analysis of Agro-pastoral model**

| Particulars | No | Weight (kg) | Value (₹) |
|---|---|---|---|
| **A. Output** | | | |
| Goat | 20 | 300.00 | 45,000.00 |
| Poultry | 400 | 920.00 | 92,000.00 |
| **Total** | | | **1,37,000.00** |
| **B. Input** | | | |
| Feed and concentrate for goat | - | 0.81 t | 14,580.00 |
| Feed for broiler | - | 1.60 t | 28,800.00 |
| Price for day old chicks | 400 | - | 8,000.00 |
| Medicine | - | - | 1,300.00 |
| **Total** | | = | **52,680.00** |
| **Gross income** | | = | **1,37,000.00** |
| **Net income** | | = | **84,320.00** |

**Agro –pastoral system (FSW-4)**

Agro-pastoral system was in 0.64 ha area having an average slope of 32.42 % with forest land 0.06 ha and planned land used area of 0.58 ha. Terracing enhanced surface area by 28.2 %, resulting in 0.49 ha area of terraced land and 0.33 ha terrace risers respectively. The terrace area was utilized for growing cereals, oilseeds, spices and vegetables. About 75 % of the area was brought under 200 % cropping intensity which resulted into production of 3060.46 kg rice equivalent yield (REY) excluding guinea grass from the system (Table 4). It was observed that rice-*toria*-French bean registered the maximum total system productivity followed by turmeric + bottle gourd. The lowest yield of groundnut and *toria* showed minimum values of total system productivity. Output per $m^2$ in the W-4 watershed revealed that amongst crop component, maximum output of ₹ 34.24/ $m^2$ was realized with turmeric followed by bottle gourd (₹ 12.26 /sqm). In general maximum output was realized from vegetables/spices crop. Rice crop registered ₹ 2.27/ $m^2$ output. (Table 5). Lowest output of ₹1.46 / $m^2$ was observed with black gram and toria (₹ 1.48/ $m^2$) in the watershed.

**Table 4 cropping pattern and production in Agro-pastoral system**

| Cropping system | Area ($m^2$) | Production (kg ) | | | System productivity REY (kg) |
|---|---|---|---|---|---|
| | | *Kharif* | *Rabi* | Summer | |
| Rice–*toria*–French bean | 1,100 | 251.5 | 81.00 | 844.5 | 1256.00 |
| Maize – black gram | 364 | 180.00 | 15.25 | - | 323.40 |
| Ginger + French bean | 370 | 96.25 | 29.00 | - | 221.50 |
| Groundnut – *toria* | 174 | 15.65 | 2.30 | - | 51.55 |
| Turmeric + cucumber | 160 | 241.00 | 43.10 | - | 525.10 |
| Turmeric + bottle gourd | 132 | 259.50 | 231.30 | - | 680.91 |
| Guinea grass | 3500 | | 32,000.00 | - | 3,200.00 |
| Guinea grass | 2,700rmt. | | 23,000.00 | - | 2,300.00 |
| Total | | | | | 8,458.46 |

In an integrated approach with crops and livestock components, revealed that the maximum income was realized from cow milk (₹ 1,54,875.00). The system could generate 304 man days employment amounting to ₹ 30,400.00 was added with the cost of other input amounting to ₹ 1,27,278 (Table 5). The gross and net incomes of ₹ 2,01,413.00 and ₹ 74,134.00 respectively gave an input – output ratio 1.28. The cow dung produced in the Agro-pastoral system (48t) was utilized for the production of crops. Production of guinea grass on terrace risers in the lower and middle part of the watershed and broom on the top portion of the

watershed provided green fodder sufficient for 8 months for the dairy unit without any extra input/ management cost.

**Table 5 Output relationship in W-4 watershed**

| Particulars | Yield/ unit (kg) | Values (₹) | Output (₹/ m²) |
|---|---|---|---|
| **A. Crop** | | | |
| Rice | 251.00 | 2,505.00 | 2.27 |
| Toria | 81.00 | 1,620.00 | 1.48 |
| Ginger | 96.25 | 1,925.00 | 5.20 |
| French bean | 873.5 | 8,735.00 | 6.79 |
| Maize | 180.00 | 2,700.00 | 7.42 |
| Black gram | 15.25 | 533.75 | 1.46 |
| Groundnut | 15.65 | 469.50 | 2.69 |
| Turmeric | 500.00 | 10,000.00 | 34.24 |
| Cucumber | 43.10 | 431.00 | 2.69 |
| Bottle gourd | 231.30 | 1,619.10 | 12.26 |
| Guinea grass | 32,000.00 | 16,000.00 | 4.58 |
| Total A | = | 46,538.35 | 81.08 |
| **B. Animals** | | | |
| Milk | 6195 lit | 1,54,875.00 | - |
| Sale of calves | - | - | - |
| Total B | = | 1,54,875.00 | - |
| **Grand Total (A + B)** | = | 2,01,413.00 | - |
| **C. Input Cost** | | | |
| Fertilizer | 4.7 q | 4,543.00 | - |
| Concentrate | 48.89 q | 73,335.00 | - |
| Paddy straw | 60.00 q | 18,000.00 | - |
| Medicine | - | 1,000.00 | - |
| Labour charges | 114+ 160 = 304 | 30,400.00 | - |
| **Total C** | = | **1,27,278.00** | - |
| **Gross Income (A + B )** | | **2,01,413.00** | - |
| **Net Income(A + B – C)** | | **74,134.00** | - |

Production of grasses on terraces risers, although reduced the yield of main crop but the yield reduction was compensated with the continuous availability of green fodder for the animals in the micro-watershed.

## BIODIVERSITY OF PLANT PATHOGENS IN NEH REGION

New reports based on molecular evidence (ITS1-5.8S-ITS2 sequence) *viz*., *Rhizoctonia solani*AG 1-IB was reported on marigold (*Tagetes patula*), *Basella alba* and *Mucuna pruriens* (Fig 1). Phylogenetic analysis was conducted for final placement of isolates in specific AG subgroups. Fluorescent microscopy was used for determination of nuclear number using DAPI (2-(4-amidinophenyl)-1H -indole-6-carboxamidine) staining (Fig 2). Molecular characterization of *R. solani* on soybean has also been done; isolates were also collected from organically grown crops and characterized. True identity of powdery mildew pathogens on cucurbits has also been established using light and scanning electron microscopy.

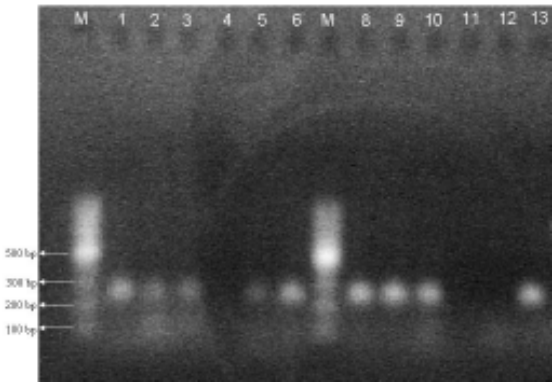



**Fig 1 AG determination using specific primers**

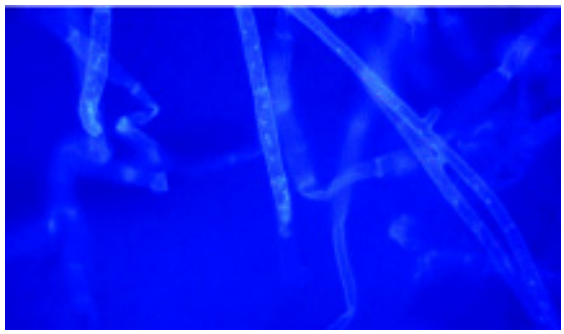


**Fig 2 Nuclear staining using DAPI**

### AICRP on Mushroon: Cultivation of Shiitake mushroom

Shiitake (*Lentinula edodes*) strain MLrecorded 45% BE on *Sal* wood (*Shorea robusta*) saw dust supplemented with 5% wheat bran (Fig 3) in 183 days.

### Strain evaluation of oyster mushroom

**Fig 3 Shitake (*L. edodes*) strain**

Six *Pleurotus* strains codes PL-11-01 to 06 were tested during Nov 2011- Jan 2012. The highest fresh mushroom yield per 100k g dry paddy straw was recorded in PL11-03 (74kg) closely followed by PL-11-02 (73 kg).PL 11-04 was at par ($P$=0.05) with PL11-02 and PL11-03 and recorded 64.4kg yield. PL11-01 recorded 52.4 kg while PL11-05 and PL11-06 gave very poor yields i.e. 38.5 and 30.8 kg, respectively. Mean average temperature ranged 9-19.5ºC and average RH (%) ranged 48 to 88.5 during cropping

## AGRICULTURAL MECHANIZATION

### Feasibility testing of arecanut sheller

A TNAU make arecanut sheller (Fig 1) was tested for its feasibility with dry arecanut. The results are presented in table 1 along with the working parameters.

**Table 1 Performance parameters of arecanut sheller**

| | |
|---|---|
| Nut length (mm) | 50.0 |
| Nut width (mm) | 28.66 |
| 1000 nut weight (g) | 9.75 |
| Cylinder speed (rpm) | 300 |
| Blower speed (rpm) | 1500 |
| Shelling capacity (kg/h) whole nut with shell | 75 |
| Shelling capacity (kg/h) nut without shell | 20 |
| Shelling efficiency (%) | 79.09 |
| Whole nut loss (%) | 0.69 |
| Broken nut loss (%) | 23 |

**Fig 1 Test run of arecanut sheller**

### Commercialization of farm tools and machineries

Through AICRP FIM and Revolving Fund Scheme, a number of improved tools and implements were commercialized in the NEH Region. The manually operated tools and implements include maize sheller, long handle weeders, cono weeder, wheel hoe, fruit harvester, groundnut decorticator, winnower, SRI row marker, adjustable row marker, seed drills and paddy thresher. Animal drawn implements being fabricated are MB plough, light ridger plough and bund former. The implements (1524 numbers) worth 22,765/= were fabricated and supplied during Apr, 2011 to Mar, 2012.

### Evaluation of beehive charcoal briquettes

Experiments were conducted to determine the burning characteristics of beehive charcoal briquette with respect to its density and composition. Five treatments were chosen with different density constituted from five different compositions of charcoal, mud and cowdung. Proximate analysis of each briquette was carried out (Table 2). Combustion test was conducted on a test platform with adequate supply of air and loss of weight was recorded at two minutes interval. The study revealed that Normalised Burn Rate (NBR) varied exponentially with density ($NBR = 26.17e^{-0.0059*DEN}$). Higher density briquettes showed lower NBR and vice versa. Total Burning Time increased exponentially with increasing density ($NBR = 26.17e^{-0.0059*DEN}$). After considering all the input costs, it was calculated that an entrepreneur can earn approximately ₹ 21,000 per month with an average production of 6000 briquettes at a selling price of ₹ 10/ briquette.

### Power tiller operated pneumatic planter

A power tiller operated pneumatic planter was designed and fabricated. It consisted of a main frame, pneumatic metering mechanism, three zero till tines, suction fan attached with main driving pulley of power tiller and a driving mechanism from ground wheel. It was operated on the field to find out the slip of power tiller wheel and found that a maximum of 15% slip was there when operated at tine depth of 100 mm. The tine depth in this machine can be adjusted between 100 – 150 mm and width between 200 – 600 mm. The suction fan of the planter can develop 7 kPa of negative pressure at a speed of 6000 rpm which is sufficient to pick a range of crop seeds such as corn, soybean,

**Table 2 Proximate analysis of beehive briquettes**

| Treatment | Density kg/m$^3$ | Moisture content % (DB) | Volatile matter % (DB) | Fixed carbon % (DB) | Ash content % (DB) |
|---|---|---|---|---|---|
| Briquette 1 | 645 | 10.8 | 9.3 | 47.4 | 32.5 |
| Briquette 2 | 625 | 10.5 | 9.4 | 51.5 | 28.6 |
| Briquette 3 | 465 | 8.9 | 10.2 | 59.5 | 21.4 |
| Briquette 4 | 388 | 8.5 | 7.3 | 68.4 | 15.8 |
| Briquette 5 | 677 | 8.6 | 6.4 | 48.9 | 36.1 |

pigeon pea, rice bean, cowpea etc. The planter has been tested in laboratory with soybean seeds and found that at maximum suction pressure (6 kPa) miss index was 8.25 % and multiple index was 3.3%.

**Design of a reciprocating weed cutter for hill orchards**

A simple low-cost reciprocating weed cutter was designed with a cutter bar width of 400 mm. It consisted of handle, frame, reciprocating cutter bar, tension wire, spring and two wheels (Fig 2). The equipment is faster and less energy intensive compared to traditional tools.

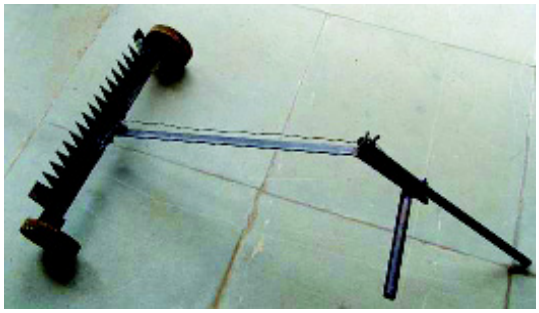


**Fig 2 Reciprocating weed cutter**

**Modeling of hill streams and developing technologies for effective filtering and harvesting of stream flow**

Three micro-catchments were identified for the study and stream gauging stations were established for each of the watershed. The watersheds were delineated and maps were prepared using GPS (Fig 3).

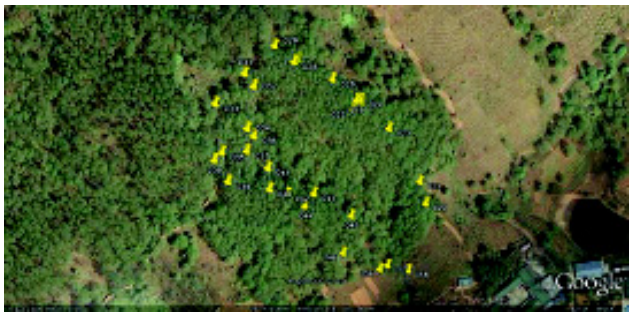


**Fig 3 Watershed AEW-1 delineated from Google Earth using GPS**

The stage level data and rainfall for 10 years were analysed and corresponding hydrographs and hyetographs were developed. Information on soil, vegetation, land use pattern, slope, sub surface formations etc. of the watersheds were collected. A multiples regression equation was developed for predicting the total flow of a micro-watershed by giving input data on rainfall, watershed area and land use pattern (percentage cover under forest, agriculture and fallow land). The final regression equation is as follows:

$Y = 0.0038\ X_1 + 4.9\ X_2 - 0.36\ X_3 - 0.45 X_4 + 12.24$

($R^2 = 0.9938$)

Where, Y= total flow (mm)

$X_1$= rainfall (mm)

$X_2$= watershed area (ha)

$X_3$= forest cover (%)

$X_4$= area under cultivation (%)

Apart from these, six rainwater harvesting ponds of size 2 x 3 x 1.5 $m^3$ were constructed and lined with different lining materials such as silpaulin, nylon, LLDPE plastic sheets, ferro-cement and clay to study their durability and comparative performance on maintenance of water quantity and quality.

**Development and techno-socio-economic evaluation of environmentally compatible rainwater harvesting mechanisms with focus on water quality and multiple uses**

Thirty villages were selected across Meghalaya using statistical sampling methods for water quality studies. As part of characterization of existing water sources, water samples were collected from 12 villages and analysed for different chemical parameters. Fig 4 depicts the results of water quality analysis conducted on water samples collected from sites in and around the Research Complex. L1, L2, L3, L4 and L5 are water samples collected from various rainwater harvesting ponds lined with different materials, while N1, N2, N3 and U1 denotes water samples from other sources.

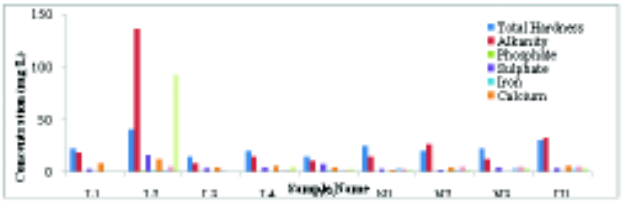



**Fig 4 Comparison of physico-chemical parameters of water samples collected from various sources**

A computer software based Decision Support System (DSS) was developed in Visual $C^{++}$ platform (Fig 5) to predict the possible end use of water such as drinking water, animal use, domestic use, irrigation, groundwater recharge etc. Sites for construction of rainwater harvesting structures (18 nos.) lined with different materials have been identified. Pond construction has been completed in 3 places and under

progress in 8 sites. A multi-media horizontal flow sequential filtration system for storm-water has been designed and fabricated. The filtration media including sand, gravel and bio-fibres have been procured and tested for its hydraulic and water quality improving efficiency against different combinations and proportions.

**Fig 5 DSS for suggesting end use of water based on water quality**

### AICRP on Application of Plastics in Agriculture (APA)

An elevated platform (Fig 6) of 3 m height and 1 × 1m platform area was fabricated to evaluate the gravity fed drip irrigation system. The platform can be adjusted within 1.5 to 3.0 m height.It is equipped with worm gear system with automatic locking arrangements. It can accommodate a water tank of 1000 litres capacity. The thermo-dynamic designs of the experimental set up have been completed for the latter project.

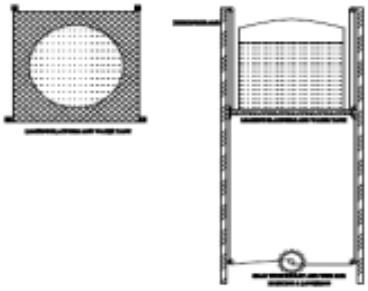


**Fig 6 Elevated platform for gravity fed drip irrigation**

## SOCIAL SCIENCES

### Estimating marketing efficiency of horticultural commodities under different supply chains in northeast India

Studies on marketing of anthurium flower in Mizoram was undertaken to examine the efficiency of new marketing models in horticultural sector in NEH region. The investment analysis considering the economic life of seven years under shed house indicated a Net Present Value (NPV) of ₹ 611268 with benefit Cost (B/C) ratio of 1.86 and Internal Rate of Return (IRR) of 46 per cent. The financial analysis for hi-tech plantation showed a Net Present Value (NPV) of ₹ 695734, benefit cost ratio of 2.09 and Internal Rate of Return (IRR) of 44 per cent indicating anthurium cultivation as a profitable venture.

### Marketing channel

All the sample anthurium growers in Mizoram are members of ZO- Anthurium Grower's Society and they market their produce through Bangalore based exporter, ZOPAR Export Ltd. A large volume of the cut flower is sold to wholesalers in other states like Kolkata, Delhi, Mumbai and Bangalore and a very small quantity of flowers are sold in state itself. The prominent marketing channel followed by anthurium grower in Mizoram is given in Table 1

**Table 1 Marketing channel of anthurium in Mizoram**

| Particulars | Supply chain |
|---|---|
| Channel 1 | Producer – ZOPAR (Wholesaler) – Wholesaler/Retailer in other states |
| Channel 2 | Producer – Retailer – Consumer |

The number of stem purchased by ZOPAR Export Ltd. from ZO- Anthurium Grower's Society (ZAGS) and sold to other states in 2008-09 is 717480 stems (98.91 %) worth ₹ 5089475. The number of stems sold in the Mizoram is only 7890 (1.09 %), worth ₹ 31560.

Anthurium is sold outside Mizoram to states like Kolkata, Bangalore, Mumbai and Delhi. The flower is transported through air after proper packing. Marketing costs and marketing margins per stem of anthurium flower for Channel 1 in Mizoram were 45.42 %, 37.31%, 37.38 % and 38.33% in Kolkata, Bangalore, Mumbai and Delhi respectively. Total marketing expenses incurred by farmer is worked out to be ₹ 0.79 per stem, of which cleaning and sorting consumed highest share of the marketing cost incurred by producer. Post harvest losses rank second, followed by cost of packing material and then transportation. The producer, on an average receives ₹ 10.20 per stem. It is observed from the table that producer fetches ₹ 9.41 per stem as his net margin.

The ZOPAR has to incur a total marketing cost of ₹7.82 (37.72 %), ₹ 11.90 (47.19 %), ₹11.70 (47.08 %) and ₹ 11.12 (45.28 %) to market one stem of anthurium flower in Kolkata, Bangalore, Mumbai and Delhi, respectively. This cost included packing cost, air-freight from Aizawl and marketing cost at destination. The ZOPAR's selling price of one stem of anthurium flower is found to be ₹ 20.72, ₹ 25.22, ₹ 24.86 and ₹

24.55 in Kolkata, Bangalore, Mumbai and Delhi, respectively. However, ZOPAR fetches ₹ 2.70 (13.05 %), ₹ 3.12 (12.36 %), ₹ 2.96 (11.89 %) and ₹ 3.32 (13.17 %) as profit or margin.

Marketing efficiency was found to be higher in Channel 1 (0.65) than in Channel 2 (0.63). Forced to sell to ZOPAR due to absence of other market was ranked as the first major constraints (with a mean score of 79.67) followed by low price, high cost of packaging, inadequate market information, lack of technology to retain freshness of flower, frequent emergence of new hybrid, lack of storage facilities, high rate of damage during transit, transportation and non-availability of market credit. High transportation charge was ranked as the first major constraints followed by high cost of packing and packing material, less number of flights from Aizawl, frequent cancellation of flight, lack of storage facilities, low supply of flower in winter, high post harvest loss due to bad practice by farmers, high rate of damage in transit and lack of technology to retain freshness of flower are the major problems and constraints in anthurium marketing.

**Socio-economic dynamics of changes in *jhum* system in north eastern hills region**

Secondary data on major agricultural crops *viz*. rice, food grain, and pulses were collected from Govt. publications for the period 2001 to 2011 from eight selected districts spread over seven states of the region excluding Assam. Compounded growth has been worked out to see the performance of these crops over the period as well as to give policy suggestions for enhancing production of these crops. The food availability in the selected districts were also worked out for the Triennium ending (TE-2011) with respect to 2011 population (Table 2).

During the period 2001-2011, total rice area in the *jhum* dominant districts of NE Region shown in the above table indicates that West Garo Hills has the highest growth rate (1.04) followed by Upper Subansiri (0.28) others shown negative growth rate. The reason behind the decrease in area in most of the districts is that farmers are not finding rice crop as a profitable one and it has been replaced by horticultural crops. Most of the districts showed positive growth rate in rice production except Mon, Tamenglong and Saiha (Table 3).

The area of food grain in most of the selected districts showed negative growth rate which has great implication in the food security of the region (Table 4). Therefore, technological interventions are necessary particularly resource conservation technology (RCT) to ensure food availability for this region.

**Table 2 Compounded growth rate for rice area (000' ha.)**

| District | 2001 | 2002 | 2003 | 2009 | 2010 | 2011 | CGR% |
|---|---|---|---|---|---|---|---|
| West Garo Hills | 37.42 | 38.61 | 38.76 | 46.53 | 46.61 | 46.67 | 1.04 |
| South Garo Hills | 9.02 | 9.08 | 9.14 | 8.44 | 8.43 | 8.43 | -0.41 |
| Dhalai | 31.83 | 33.98 | 31.74 | 27.03 | 25.00 | 28.00 | -1.05 |
| Mon | 14.80 | 15.10 | 14.58 | 13.77 | 13.58 | 12.53 | -0.34 |
| North Sikkim | 1.40 | 0.85 | 0.85 | 1.00 | 1.00 | 1.00 | -0.29 |
| Tamenglong | 29.01 | 28.54 | 28.84 | 27.45 | 16.40 | 27.45 | -1.07 |
| Upper Subansiri | 4.50 | 4.35 | 4.52 | 5.84 | 4.33 | 4.17 | 0.28 |
| Saiha | - | - | - | 1.91 | 1.93 | 1.49 | -9.80 |

**Table 3 Compounded growth rate for rice production (000' tonnes)**

| District | 2001 | 2002 | 2003 | 2009 | 2010 | 2011 | CGR % |
|---|---|---|---|---|---|---|---|
| West Garo Hills | 58.92 | 68.04 | 69.32 | 99.32 | 99.62 | 100.25 | 2.35 |
| South Garo Hills | 10.59 | 10.65 | 11.56 | 10.72 | 10.78 | 11.48 | 0.11 |
| Dhalai | 59.65 | 64.11 | 62.42 | 60.97 | 60.00 | 59.00 | -0.03 |
| Mon | 20.77 | 21.00 | 19.86 | 24.90 | 17.88 | 24.52 | 0.72 |
| North Sikkim | 1.46 | 0.68 | 0.68 | 1.07 | 1.07 | 1.14 | 0.51 |
| Tamenglong | 29.44 | 26.98 | 29.30 | 24.04 | 13.06 | 22.71 | -2.14 |
| Upper Subansiri | 3.60 | 3.50 | 4.70 | 11.61 | 8.15 | 8.52 | 5.29 |
| Saiha | | | | 0.72 | 1.66 | 1.98 | -14.73 |

**Table 4 Compounded growth rate for food grain area (000' ha)**

| District | 2001 | 2002 | 2003 | 2009 | 2010 | 2011 | CGR % |
|---|---|---|---|---|---|---|---|
| West Garo Hills | 48.94 | 48.70 | 48.93 | 54.63 | 54.73 | 54.79 | 0.61 |
| South Garo Hills | 10.43 | 10.48 | 10.54 | 10.81 | 9.88 | 9.89 | -0.14 |
| Dhalai | 34.48 | 35.87 | 33.65 | 28.48 | 27.24 | 27.54 | -1.22 |
| Mon | 23.78 | 27.00 | 25.00 | 23.09 | 23.84 | 23.06 | -0.22 |
| North Sikkim | 6.65 | 5.61 | 5.61 | 5.20 | 7.38 | 5.74 | -0.05 |
| Tamenglong | 18.51 | 17.53 | 33.34 | 32.21 | 24.10 | 32.46 | 1.60 |
| Upper Subansiri | 8.16 | 6.81 | 7.07 | 8.66 | 6.77 | 6.70 | -0.08 |
| Saiha | - | - | - | 2.87 | 2.63 | 2.20 | -8.89 |

The reason for decrease in area due to the change in cropping pattern from food grain to the horticultural crops in the respective districts as well as less cultivation of food grain crops in the upland/ *jhum* land.

The CGR for food grain production (Table 5) in all the selected districts have been found positive and the highest being the Upper Subansiri of Arunachal Pradesh followed by West Garo Hills of Meghalaya. The adoption and diffusion of superior germplasm of different field crops particularly rice and maize are the reason for increasing foodgrain production in selected districts.

The compound growth rate of pulse production of the selected districts indicate that the North Sikkim district witnessed the highest growth rate (8.13) followed by Tamenglong (1.58%), West Garo Hills (0.52%) and Mon (0.10%). The other four districts shown negative compound growth rate may have great implication on the availability of pulses. Hence, there is a need for immediate intervention for providing technical and financial support through appropriate policy measures to increase pulse production of the districts.

Analysis of production and requirement of rice revealed that all the districts are deficit in requirement of rice except Dhalai district of Tripura (Table 6).Total rice production of the northeast states (excluding Assam) is 225.05 thousand tonnes and the requirement

**Table 5 Compounded growth rate for food grain production (000' tonnes)**

| District | 2001 | 2002 | 2003 | 2009 | 2010 | 2011 | CGR % |
|---|---|---|---|---|---|---|---|
| West Garo Hills | 74.08 | 81.22 | 82.62 | 109.43 | 109.66 | 110.23 | 1.83 |
| South Garo Hills | 11.84 | 11.88 | 12.88 | 13.19 | 12.20 | 12.90 | 0.34 |
| Dhalai | 62.14 | 65.80 | 64.23 | 62.41 | 62.23 | 60.31 | -0.08 |
| Mon | 31.72 | 38.00 | 39.00 | 38.40 | 27.94 | 40.39 | 0.16 |
| North Sikkim | 8.91 | 4.21 | 4.21 | 6.81 | 8.52 | 6.81 | 1.01 |
| Tamenglong | 25.92 | 18.99 | 35.46 | 28.61 | 22.94 | 29.38 | 0.09 |
| Upper Subansiri | 7.59 | 6.91 | 8.27 | 14.79 | 10.94 | 11.58 | 2.99 |
| Saiha | | | | 1.00 | 2.39 | 2.71 | -14.19 |

**Table 6 Production and requirement of rice districts (in '000 tonnes)**

| District | Total population (2011 Census) | Average Production 2009-2011 | Requirements | Surplus/Deficit (Triennium ) | Surplus/ Deficit (%) |
|---|---|---|---|---|---|
| Upper Subansiri | 83205 | 9.43 | 13.06 | -3.64 | -27.87 |
| Tamenglong | 140143 | 19.94 | 22.00 | -2.07 | -9.40 |
| West Garo Hills | 642923 | 99.73 | 100.94 | -1.21 | -1.19 |
| South Garo Hills | 142574 | 10.99 | 22.38 | -11.39 | -50.8 |
| Saiha | 56366 | 1.45 | 8.85 | -7.40 | -83.61 |
| Mon | 250671 | 22.43 | 39.36 | -16.92 | -42.98 |
| North Sikkim | 43354 | 1.09 | 6.81 | -5.71 | -83.84 |
| Dhalai | 377988 | 59.99 | 59.34 | 0.64 | 1.078 |
| Total selected district | 1737224 | 225.05 | 272.74 | -47.69 | -17.48 |
| NE Region excluding Assam | 14418710 | 2053.57 | 2263.732 | -210.156 | -9.28 |

Rice requirement @ 157 kg/ head/ annum

is 272.74 thousand tonnes, hence, there is a deficit of 47.69 thousand tonnes.

As per as the foodgrain requirement (Table 7) of the selected districts all the districts are found deficit barring the Tamenglong district having marginal surplus (5.03 tonnes). The overall food grain deficit percentage (46.91%) in the selected districts is more as compared to northeastern region (4.94%) which signifies that the selected districts should be given priority as well as policy support for increasing the production of food crops.

Total pulses requirement of the north east hill states excluding Assam was worked out to be 263.14 thousand tonnes against the production of 94.04 thousand tonnes leaving the deficit of 64.26 percentages. The picture in the selected districts as per the availability of pulses and requirement is not different. All the districts were found deficient ranged from 17.96 to 94.17 %.

The overall deficit in the selected districts was found to be higher (74.16 %) as compared to the NE Region excluding Assam (64.26%).

**Economic assessment of improved technology of horticultural crops in NEH region**

Data were collected from 120 farmers of Dimapur district of Nagaland and Ri-bhoi district of Meghalaya where different horticultural projects and schemes were implemented by ICAR/ KVKs under various Central and State Government schemes (Considering Pulses requirement @ 18.25 kg/head/annum). From each district 60 farmers were interviewed about the economic benefits received from improved technology as well as level of adoption. The highest net income was received from improved Technology which was found to be ₹ 314700 per hectare in the turmeric followed by capsicum (₹ 302500/ha) and tomato (₹ 237500/ha). In farmers' practice it was worked out to be ₹ 189000/ha from capsicum followed by tomato (₹ 172000/ha) and turmeric (₹ 74250/ha). Out-put ratio was the highest in turmeric under improved technology (5.44) whereas; in farmers' practice it was estimated highest in capsicum (3.91).

Ranking of technology on the basis of preference of the farmers indicated that among all the technology, variety was ranked first whereas, plant protection was the second preferred technology. Post- harvest management had ranked third. Fertilizer management was found least preferred technology since most of the farmers expressed unwillingness for use of chemical fertilizer. In case of tomato and capsicum farmers apply small quantity of DAP. The highest complete adoption was recorded in tomato (32%) followed by ginger (25%) and turmeric (22%). The partial adoption includes mostly variety and the plant protection measure which was recorded highest in the turmeric (95%) followed by ginger (80%). The data on diffusion of technology were collected and analysed. In case of turmeric, additional 10 farmers had taken seed from the fellow farmers. Hence, adoption and diffusion was recorded highest (50%).

**Developing agricultural databank and estimation of parameters of importance in NEH Region**

Secondary data on production of major agricultural and horticultural crops from the period 2005-06 to 2010-11 has been collected from various published sources. Data were analyzed and compounded growth rate has been calculated to evaluate the performance of different crops over the period (Table 8).

**Table 7 Food grain requirement of the North East (excluding Assam)**

| District | Total population (2011 Census) | Average Production 2009-2011 | Requirements | Surplus/Deficit (Triennium ) | Surplus/ Deficit (%) |
|---|---|---|---|---|---|
| Upper Subansiri | 83205 | 7.37 | 14.58 | -7.21 | -49.45 |
| Tamenglong | 140143 | 29.59 | 24.56 | 5.03 | 20.48 |
| West Garo Hills | 642923 | 54.72 | 112.67 | -57.96 | -51.44 |
| South Garo Hills | 142574 | 10.19 | 24.99 | -14.79 | -59.18 |
| Saiha | 56366 | 2.56 | 9.88 | -7.32 | -74.08 |
| Mon | 250671 | 23.33 | 43.93 | -20.60 | -46.89 |
| North District | 43354 | 6.11 | 7.60 | -1.49 | -19.60 |
| Dhalai | 377988 | 27.75 | 66.24 | -38.49 | -58.10 |
| Total selected districts | 1737224 | 161.63 | 304.45 | -142.82 | -46.91 |
| NE Region excluding Assam | 14418710 | 2571.8 | 2705.51 | -133.72 | -4.94 |

Food grain requirement @ 175.25 kg/ head/ annum

**Table 8 State-wise production of rice in NER, (2005-2006 to 2010-2011): ('000 tonnes)**

| States | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | CGR (%) |
|---|---|---|---|---|---|---|---|
| Arunachal Pradesh | 146.2 | 146.2 | 158.1 | 163.9 | 190 | 233.9 | 4.01 |
| Assam | 3552.5 | 2916 | 3319 | 4008.5 | 3593.5 | 4152.4 | 1.99 |
| Manipur | 386.1 | 386.1 | 406.2 | 397 | 265.09 | 521.74 | 0.44 |
| Meghalaya | 151.9 | 200.2 | 200 | 203.9 | 201.36 | 204.5 | 1.90 |
| Mizoram | 99.2 | 29.5 | 15.7 | 46 | 46.3 | 50.2 | -1.20 |
| Nagaland | 263.1 | 263.5 | 290.6 | 345.1 | 345.1 | 381.36 | 3.58 |
| Sikkim | 21.5 | 21.5 | 22.9 | 21.7 | 21.45 | 20.97 | -0.23 |
| Tripura | 552.9 | 620.5 | 624.6 | 627.1 | 640.9 | 640.9 | 1.04 |
| Total NER | 5173.4 | 4583.5 | 5037.1 | 5813.2 | 5303.71 | 6205.97 | 1.86 |

Source: Ministry of Agriculture, Govt. of India, NEDFI and state Govts.

During 2006- 2011, Arunachal Pradesh (4.01) showed the highest growth rate in rice production followed by Nagaland (3.58) and Assam (1.99).

Except Mizoram (-1.20) and Sikkim (-0.23) all other states showed positive growth rate in rice production leading to increased rice production in the region.All other states have shown positive growth rate in food grain production leading to increase foodgrain production in this region Assam being highest (3.33) followed by Nagaland (2.62) and Manipur (2.39) (Table 9)..

During the period 2006-2011, it was found that, in pulse production, Manipur (10.69) showed the highest growth rate followed by Assam (3.46) and Tripura (3.25). The possible factors in gaining the highest growth rate of Manipur may be increase in area under gram and improved varieties of pulses introduced by different organizations and state departments. On the other hand, Mizoram (-7.80) and Nagaland (-0.83) showed the negative growth rate which means there is a need to emphasize pulse production in those two states (Table 10).In vegetable production, Nagaland

**Table 9 State-wise production of total food grains in NER, (2005-2006 to 2010-2011)(Production: '000 tonnes)**

| States | 2005-06 | 2006-07 | 2007-08 | 2008-09 | 2009-10 | 2010-11 | CGR (%) |
|---|---|---|---|---|---|---|---|
| Arunachal Pradesh | 240.9 | 245.7 | 248.5 | 255.8 | 249.6 | 333.67 | 2.13 |
| Assam | 3677.8 | 3060 | 3470 | 4143.0 | 3939.6 | 5179 | 3.33 |
| Manipur | 398.5 | 398.5 | 421.8 | 415.0 | 390.47 | 592.7 | 2.39 |
| Meghalaya | 183.1 | 231.5 | 231.8 | 236.3 | 233.2 | 236.4 | 1.64 |
| Mizoram | 129.8 | 56.3 | 19.1 | 58.9 | 80.25 | 85.4 | 0.11 |
| Nagaland | 424.8 | 436.2 | 473.2 | 514.2 | 524 | 568.32 | 2.62 |
| Sikkim | 100.3 | 100.3 | 111.6 | 107.5 | 109.11 | 103.41 | 0.45 |
| Tripura | 563.6 | 630 | 633.3 | 634.7 | 648 | 652 | 1.01 |
| Total NER | 5718.8 | 5158.5 | 5609.3 | 6365.4 | 6174.23 | 7750.9 | 2.74 |

Source: Ministry of Agriculture, Govt. of India, NEDFI and state Govts.

**Table 10 State-wise production of total pulses in NER, (2005-2006 to 2010-2011) (' 000 tonnes)**

| States | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | CGR (%) |
|---|---|---|---|---|---|---|---|
| Arunachal Pradesh | 8.3 | 8.3 | 8.3 | 9 | 14 | 9.05 | 2.61 |
| Assam | 54 | 59 | 63 | 64.5 | 76 | 80 | 3.46 |
| Manipur | 4.5 | 4.5 | 7.2 | 6.5 | 4.321 | 24.20 | 10.69 |
| Meghalaya | 3.6 | 2.9 | 3.3 | 3.9 | 3.9 | 4.1 | 2.13 |
| Mizoram | 7.9 | 5.8 | 2.7 | 3.6 | 2.98 | 3.0 | -7.80 |
| Nagaland | 39.7 | 45 | 41.6 | 39.7 | 42.1 | 36.46 | -0.83 |
| Sikkim | 6.1 | 6.1 | 11.6 | 11.8 | 5.45 | 8.75 | 1.84 |
| Tripura | 5.6 | 5.3 | 4.7 | 4.4 | 7.06 | 8.0 | 3.25 |
| Total NER | 129.7 | 136.9 | 142.4 | 143.4 | 155.81 | 173.56 | 2.32 |

Source: Ministry of Agriculture, Govt. of India, NEDFI and state Govts.

(21.99 %) showed the highest growth rate followed by Mizoram (12.43 %) and Sikkim (9.08 %) while Arunachal Pradesh (-2.41) and Tripura (-2.17) showed the negative growth rate (Table 11).

The increase in growth rate in most of the states is due to adoption of improved technologies of vegetable cultivation demonstrated by different central and state govt. organizations. In fruit production, Nagaland (24.35 %) has shown the highest growth rate followed by Arunachal Pradesh (6.67 %) and Mizoram (6.51 %). Due to introduction of Horticultural Technology Mission and introduction of superior variety and hybrids of different fruit crops, all the states have increased their fruit production significantly (Table 12).

**Enhancing livelihood of rural women through livestock production**

The study was conducted in Meghalaya and total respondents were 250 women farmers to find out the probability of adoption of improved piggery related technologies by women farmers. Outcome variable was categorical i.e. adoption or non-adoption of the technologies related to piggery and the predictor variables were age, education, level of aspiration, management orientation, level of decisiveness and level of participation related to piggery. The study revealed that given the predictor variables, the probability of adoption of the technologies related to the piggery was more which was analysed through logistic regression analysis. Through the analysis, the Wald statistic significance for all the predictor variables under the study was found out. All the co-efficient were significantly different from zero which meant that all the predictors making significant contribution to the prediction of adoption of technologies related to piggery by women farmers and it could be inferred as exponential â was greater than 1 for all the predictor variables, the probability of odds of outcome variable i.e. adoption of piggery related technologies by women farmers increased and all the predictor variables were significant in contributing to increase the probability of adoption of the piggery technologies.

**Table 11 State wise production of vegetables in NER, (2005-2006 to 2010-2011) (‘ 000 tonnes)**

| States | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | CGR (%) |
|---|---|---|---|---|---|---|---|
| Arunachal Pradesh | 105.1 | 110 | 110 | 110 | 110 | 70.87 | -2.41 |
| Assam | 1352.1 | 4449.5 | 4474.2 | 2916.7 | 3946.8 | 4010.8 | 5.93 |
| Manipur | 189.1 | 91.8 | 113.7 | 174.3 | 174.3 | 175.5 | 2.48 |
| Meghalaya | 231.7 | 345.4 | 352.5 | 415.8 | 415.8 | 425.23 | 4.77 |
| Mizoram | 66 | 31.3 | 51.9 | 114.4 | 114.4 | 171.12 | 12.43 |
| Nagaland | 19.6 | 44.6 | 63.5 | 78.3 | 78.3 | 330.4 | 21.99 |
| Sikkim | 13.2 | 80.8 | 95.9 | 98 | 45.59 | 75.20 | 9.08 |
| Tripura | 525.1 | 415.9 | 423.6 | 294.7 | 373.3 | 422.54 | -2.17 |
| Total NER | 2501.9 | 5569.3 | 5685.3 | 4202.2 | 5258.49 | 5681.66 | 4.60 |

Source: Ministry of Agriculture, Govt. of India, NHB and state Govts.

**Table 12 Production of fruits in NER, (2005-2006 to 2010-2011) (‘ 000 tonnes)**

| States | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | CGR (%) |
|---|---|---|---|---|---|---|---|
| Arunachal Pradesh | 105.1 | 107.8 | 107.9 | 108 | 108 | 297.32 | 6.67 |
| Assam | 1352.1 | 1392.2 | 1410.8 | 1574.77 | 1854.03 | 1890.25 | 3.33 |
| Manipur | 189.1 | 229.1 | 273.7 | 341.91 | 341.91 | 345.21 | 5.65 |
| Meghalaya | 231.7 | 234.3 | 235.2 | 294.81 | 294.81 | 295.80 | 2.68 |
| Mizoram | 66 | 179.7 | 219.6 | 123.07 | 185.49 | 201.13 | 6.51 |
| Nagaland | 19.6 | 31.9 | 53 | 151.27 | 151.27 | 209.54 | 24.35 |
| Sikkim | 13.2 | 13.4 | 13.9 | 15.67 | 18.49 | 20.08 | 4.02 |
| Tripura | 525.1 | 525.4 | 525.6 | 477.18 | 477.18 | 643.94 | 0.79 |
| Total | 2501.9 | 2713.8 | 2839.7 | 3086.68 | 3431.18 | 3903.2 | 3.80 |

Source: Ministry of Agriculture, Govt. of India, NHB and state Govts.

## TRANSFER OF TECHNOLOGY

### Demonstrations under NICRA

Based on the benchmark survey and the PRA exercises conducted at the village Nongthymmai, Ri-Bhoi district, critical issues were observed and subsequently scope for taking upon demonstrations under NICRA was explored. There was no linkage between different enterprises *viz*., crop, livestock, fishery, mushroom etc. thus carbon cycling was not properly enhanced. Ultimately, survey revealed farmers' lack of awareness towards scientific crop and livestock production technologies, seasonality of agriculture and resource use efficiency.

### Livestock production

The improved breed of pig (*T & D)* was introduced andthe body weight of the piglets increased to average weight of 25 kg in 2 ½ months in comparison to the local breeds and traditional method of rearing. The improved breed (Assam Hill Goat) showed improved performance (30 kg increase in weight in 6 months) under given climate conditions and farmers became aware of goat rearing through the demonstration which may supplement meat requirement of the village in case of increased temperature. The Kuroiler birds were of free range type and of 6 months old having an average weight of 350 g. Both male and female birds respectively developed a body weight of about 2.90 kg and 2.50 kg and the mortality due to very low temperature was reduced to a greater extent because of improved housing, mineral supplementation and low cost healthcare management in comparison to broiler or local strains.

### Crop production

Under crop intensification for augmenting the production and enhancing soil fertility and health based on spatial and temporal utilization, pulse crop Pea (var.Vikash) cultivation was demonstrated in the farmers' field. Before the demonstration, farmers gave least importance to the pulse crops especially in rice fallow and presently, they have understood about the importance of pulse and oil seed crops which greatly enhance the year round production and enhance the soil nutrient status by fixing nitrogen and facilitating soil organic matter content.

### Vegetables cultivation

Two poly-houses were constructed for off-season vegetable production and for raising vegetables at a seedling stage in nursery. Potato seed tubers were distributed for demonstration in the farmers' field. Likewise, tomato hybrid seed and cucumber hybrid seed were also distributed for demonstration in the farmers' field. The crops were cultivated in the raised bund after rice cultivation in an area of 1 ha each to ensure irrigation efficiency and nutrient efficiency. The performance of the crops was better in comparison to the local crops with traditional practices without nursery management.

### Organic manure supplementation

For supplementation of organic manure and efficient use of available biomass and crop residues etc. subsequently, enhancing carbon cycling, 10 vermi-composting unit (10x3x2 ft) were constructed with low cost fabricated tanks along with thatch roof and 15 kg of earthworm culture was released @ 1.5 kg/tank. Farmers were given training and demonstration on vermicompost technology. Production of sufficient vermicompost would reduce farmers' dependence on chemical fertilizer beside improving soil health.

## Livelihood Improvement and Empowerment of Rural Poor through Sustainable Farming Systems in North East India, NAIP Component 3 (SRLS)

### SRI and ICM method of paddy cultivation in Dhalai, Tripura and South Garo Hills

A total of 1143 nos. of farmers in Marachera and Balaram cluster under Dhalai district (Tripura), were given rice seeds of Pusa-44, Samba Mashuri and Naveen @ 1kg/kani (0.16 ha) for SRI cultivation (Fig 1). Similarly, a total of 120 farmers were provided with Ranjit variety of paddy in South Garo Hills (Meghalaya). Farmers followed the SRI method of rice cultivation right from raising of nursery, use of single seedlings, wide spacing, cono-weeding, drainage/irrigation channel at 2 m interval etc. About

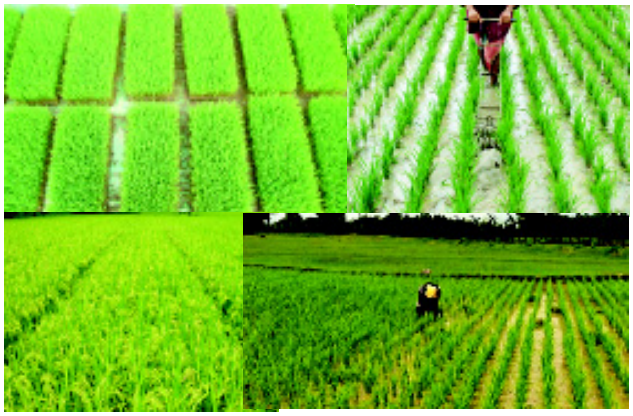


**Fig 1 SRI at South Garo Hills and Dhalai**

90% farmers were satisfied with the SRI method due to the increase in productivity. Average productivity of local variety under conventional practice in South Garo Hills district was 1.5 t/ha and in Dhalai District it was 2.1 t/ha. After introduction of Ranjeet variety through SRI average productivity went up to the 4.8 t/ha in South Garo hills whereas, in Dhalai (Tripura) after the introduction of Naveen variety through SRI the productivity went upto 3.7 t/ha.

**Zero tillage *toria*- a success in Tamenglong, Manipur**

*Toria* (M27) was introduced in 114.8 ha area through Zero tillage technique in the selected villages in Tamenglong district of Manipur. The average yield of *toria* under zero tillage was 0.80 t/ha/yr. Farmers are also extracting the oil from their own seeds with the oil expeller provided by the ICAR (NAIP). The zero tillage cultivation of *toria* is gaining popularity in the adjacent districts too. The advantages of zero tillage in *toria* are timely sowing is possible (October-November), conserve soil moisture and require less water, saves tillage cost and the soil is protected from erosion due to the retention of surface residues and reduce organic matter depletion. A total of 304 households were benefited by this technology. Net income realized were about ₹ 10,000/ha.

**Fish + duck / pig based farming system in South Garo Hills, Meghalaya**

Seventy seven households in 11 villages of Sibbari cluster, South Garo Hills, Meghalaya were selected for fish + duck (Sonali) / pig (Hampshire) based farming system (Fig 2). New ponds were constructed and old small ponds were renovated scientifically. Due to this intervention fish productivity increased to 4.2 t/ha and individual farmers earned a net income of about ₹ 18000/- from their pond (25m x 25m). Duck (Sonali) gave about 150 eggs/annum as compared to 110-120 from local one and villagers sold egg @ ₹ 6-7/egg. The improved Hampshire breed gave two furrowing in a year with 8-10 piglets/furrowing. Farmers sold piglets after 3 months @ ₹ 1750/piglet. Some farmers also sold vermincompost @ ₹ 6/kg. Banana (Var. Malbhog) started giving fruits and farmers could harvest 23 kg/plant. Arecanut, citrus and guava are in vegetative stage.

**Fig 2 Fish + duck / pig based farming system in South Garo Hills**

**Agro-forestry based farming system models at Dhalai, Tripura**

Agro-forestry based farming system models were developed in the district of Dhalai in the two clusters of Balaram and Maracherra in a total area of 12.71 ha involving 64 farmers (Fig 3). Silvi-horti systems with vegetables, ginger, pineapple etc in association with forest tree (*Tectona grandis*), fruits plants*viz*.,banana, lemon, mango, cashewnut etc and plantation crops (arecanut, coconut) were developed in the undulated area which remained fallow for a long period. Introduction of vegetables such as cabbage (12.76 t/ha), okra (2.87 t/ha) was profitable. Banana (var. Sapri, Champa) started giving fruits and farmers could harvest 26 kg/plant, pineapples (var. Kew) around 3714 nos/ha etc. There was aquaculture intervention in the land use systems as developed. The productivity of fishes has increased from 0.5 t/ha to 3.5 t/ha.

**Fig 3 Agro-forestry based farming system models at Dhalai, Tripura**

**Terracing for *Panikheti* in Mon, Nagaland**

Under natural resource management, terracing for panikheti in Lampong Sheanghah village (Mon District) was done not only to enhance rice productivity but also to introduce second crop which otherwise used to be kept fallow by the farmers. A total of 15

Households were involved covering an area of 6.2 ha with a net cultivable area of 4.9 ha under terrace cultivation. Terracing was followed in the lower part of the hillock with slope of about 30%. All the terraces were made at a vertical interval of 1m keeping intact the topmost soil. Irrigation channels were prepared to divert water from the stream. For nutrient management, a thick row of hedgerow species like *Tephrosia candida* and *Crotolaria* spp. were planted and the green biomass was used as mulch in terraces. Two rice varieties Shahsarang and Lampnah were cultivated which showed the productivity enhancement by 3 fold (3.39 t/ha) as compared to the indigenous landraces, i.e. Rakchu having the productivity of 1.2 t/ha in wet land condition.

**Training, Demonstration and Field day**

Two days farmers training cum field day on **z**ero tillage pea, lentil and *toria* in rice fallow was organized at the Division of Natural Resource Management, ICAR research complex for NEH Region, Umiam, Meghalaya during 20-21st Mar 2012(Figs 1 & 2). More than 150 farmers from different districts of Meghalaya attended the programme. Conventionally, after *kharif* rice, fields remain fallow in lowland, mainly due to excess moisture owing to seepage from surrounding hillocks in mid altitude.

**Fig 1 Farmers visiting experimental plot pea under zero tillage**

**Fig 2 Furrow opener being demonstrated by Dr. S. V. Ngachan, Director, ICAR RC-NEH, Umiam**

A simple drainage channel of 30 cm depth and 20 cm width at 5 m interval creates the favourable soil moisture situations. Practical demonstration on zero tillage technology including varieties, cultivation practices such as maintaining 20-40 cm stubble height, herbicide application (Glyphosate 4ml/litre water), opening narrow furrow with furrow opener, placing fertilizer and seed, pest and diseases management, tools and implements, etc. were given to the farmers.

**'Rice Day' observed at ICAR-RC, Umiam**

To popularize climate resilient rice production technology 'Rice Day' was observed on17th October, 2011 in Lowland Agronomy Farm. About 100 farmers from different Districts of Meghalaya participated in the programme and interacted with the scientists. Farmers were told about the improved rice varieties, farm tools and machineries, various approaches for resources conservation like minimum/zero tillage, efficient residue management, crop diversification for enhancing productivity and climate resilience in rice.

**Field demonstration of SWM practices for climate resilient agriculture**

For promoting climate resilient agriculture and demonstrating options for resource conservation a number of interventions were undertaken in Nongthymmai village during 2011-12. Field demonstration of rain water harvesting structure such as farm pond (one new pond 20 x 20m x 1.5 m (Fig 3), one renovated pond 30 x 18m x 1.5 m), micro rain water harvesting structure *jalkund* (5 x 4 x 1.5 m) were demonstrated in farmers field for promoting life saving irrigation during dry season and diversifying farm activities. It will be possible to cultivate high value vegetables and *rabi* crops with harvested water in farmers field. Two pig sheds were also made in pond dyke for providing concept of integrated farming system.

**Fig 3 Farm pond excavation at Nongthymmai village**

Zero tillage pea cultivation were demonstrated in about 1 ha area in Nongthymmai village. After rice harvest, the excess water was drained through provision of drainage channel at 10m interval. Furrow opener was used to open a narrow furrow in between standing stubbles and pea was sown after application of 20:40:40 kg NPK/ha. Urea spray 2 % at vegetative stage and flowering stage was advocated for better growth and higher yield. Farmers were distributed with sprayer, rose can, tulu pump etc. A total of about 50 farmers were involved in demonstration programme under zero tillage pea and lentil including 20 farmers from south Garo Hills, Meghalaya. Farmers were happy with the performance of crops. They sold pea @ ? 30-40/kg as green pea.

**Training programme on 'Carbon Management in Agriculture for Mitigating Greenhouse Effect' organized**

An eight day training programme on'Carbon Management in Agriculture for Mitigating Greenhouse Effect'for scientists/SMS etc. was conducted under HRD Componentof NICRA during 1-8 Feb, 2012. A total of 30 participants attended the programme. Resource persons from reputed Institutes like CRIDA, IISS, IARI, IIPR, BCKV etc. were invited for the programme.

**Mobilizing mass media support for sharing agro-information**

The Project on 'Mobilizing Mass Media Support for Sharing Agro-Information' actively involved in generating awareness among the mass and helped in increasing the visibility and access of achievements in agricultural research through various print and electronic media. Review and scanning through the news items coverage in the print media in the field of agriculture for the period of January 2011 to January 2012 revealed that a total news space of 12,324 $cm^2$ appeared in 47 news items. Broadly, 11 different subjects of agricultural sciences were highlighted. The crop husbandry area got the highest number of news items- 17 [4774.5 $cm^2$], followed by the water management (9 news items with a of space 1194.5 $cm^2$). The crop husbandry and water management areas were widely published in The Shillong Times (3), The Meghalaya Times (4), The Meghalaya Guardian (3), the Eastern Chronicle,The Times of India (2), The Assam Tribune, The Sikkim Mail, and The Sikkim Express (2 each). Three video films on success stories and one audio capsule were produced in this year.

## ANIMAL PRODUCTION

**Effect of different holding time, cooling rate and freezing rate on post-thaw semen quality in boar**

The objective of the study was to find out suitable cooling rate and freezing rate for developing optimum freezing protocols for cryo-preservation of boar semen. A total of 25 semen ejaculates were collected from adult Hampshire cross boars in a sterilized bottle insulated with thermos flask. The gel-fraction free whole semen was immediately brought to the laboratory and physiological and morphological characteristic were evaluated. The semen ejaculates having more than 80% sperm motility used for further processing. After evaluation, semen sample were diluted in BTS (Belts Ville Thawing Solution) extender at the rate of 1:1 and kept in water bath at 35ºC for 30 minutes. For slow cooling and holding with seminal plasma three different hold time and cooling temperature were followed to obtain maximum post-thaw motility. After holding, the semen samples were centrifuged at 3000 rpm for 10 min at 15°C and sperm pellet was obtained. The sperm pellet was diluted with extender–I containing 10% lactose and 20% egg yolk at 1:1 and slowly cooled to 5°C for 1 hour. The extended semen was further diluted with equal volume of the extender -II containing 10% lactose, 20% egg yolk and 6% glycerol, and kept at 5°C for 1 h equilibration. During equilibration, extended semen filled in the 0.5 ml medium straw (IMV technologies, France) and sealed with PVC (poly vinyl chloride) powder at 5°C.

The semen filled straws were subjected to different freezing rate using programmable biological freezer (Thermo-scientific, USA). After freezing, the straws were plunged into goblet containing liquid nitrogen and transferred to liquid nitrogen container for storage. Thawing of straw was done at 50°C for 15 seconds to know the post thawing motility. The results revealed that the diluted semen hold at 25ºC for 1 hour in BOD incubator and gradually reduce the temperature to 15°C at rate of 0.5 C/min and hold at 15°C for 1 hour is the suitable holding time and temperature for the boar semen. The post thaw sperm motility and viability were evaluated as per standard method. Further, the post thaw sperm motility and viability was significantly ($P$<0.05) higher in the freezing rate of 40ºC/min when compared to freezing rate of 20ºC/min and 60ºC/min (Table 1). The study recommended that the freezing rate of 40ºC/min is suitable for freezing of boar semen in the programmable freezer.

**Table 1 Post-thaw semen quality of boar semen in different freezing rate**

| Parameter | | Freezing rate | | |
|---|---|---|---|---|
| | | 20ºC/min | 40ºC/min | 60ºC/min |
| Motility (post thaw) | | 53.75 | 55.76 | 50.34 |
| Viability | Live | 59.45 | 61.53 | 56.57 |
| | Dead | 41.34 | 38.56 | 43.52 |

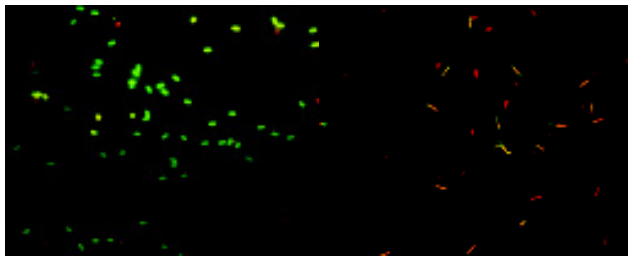


**Fig 1 DNA integrity and mitochondrial membrane potential of boar spermatozoa**

**Assessment of sperm plasma membrane integrity, mitochondrial membrane potential (MMP) and DNA damage porcine spermatozoa at three different freezing rates**

After primary evaluation, 22 gel-fraction free semen semen sample were diluted in BTS (Belts Ville thawing solution) extender and kept holding at 35ºC for 30 minutes, 24ºC for 1 hour. The sperm pellet was diluted with extender–I & II containing 10% lactose and 20% egg yolk, 3 % glycerol and kept at 5ºC for 1 h equilibration. The semen filled straws were subjected to different freezing rate using programmable biological freezer (Thermo-scientific, USA). In manual freezing, immediately equilibration, the semen filled in the 0.5 ml straws and sealed with PVC powder. The filled straws were kept in liquid nitrogen vapors for 10 minutes where straw rack was kept at 4 cm above the $LN_2$ level. Then the straws were transferred to $LN_2$ container. The cryo-preserved straws were thawed at 50ºC for 15 seconds for assessment of post thawing motility and other parameters. The sperm plasma membrane integrity, mitochondrial membrane potential and DNA damage was assessed using CFDA/PI, JC-1 and acridine orange staining (Fig 1). The study recorded significantly higher sperm plasma membrane integrity and mitochondrial membrane potential and lower DNA damage in 40ºC/min freezing rate than that of 20ºC/min and 60ºC/min (Table 2). The plasma membrane, mitochondrial and DNA damages were significantly higher during the manual freezing as compared to programmable freezing.

**Ovarian biometry and oocytes retrieval in pigs**

The present basic studies in porcine ovaries were carried out. The porcine ovaries from local abattoir were collected in normal saline supplemented with antibiotics. A total of 130 ovaries were evaluated for their morphometric observations and oocytes retrieval by aspiration method (Fig 3). The weight of the ovaries averaged 5.29±1.345 g; the ovary had mulberry like appearance due to multiple follicles and/or corpora lutea. The no. of follicles per ovary averaged 9.50±3.25, whereas, no of active corpora lutea averaged 5.73± 2.30 with 3.37±1.10 corpus albicans. A total of 8.75 ± 2.25 oocytes could be recovered per ovary. The per cent of A, B, C and D grade oocytes collected were 36, 38, 15 and 11%, respectively. The culturable oocytes accounted for 74 %.

**Fertility potential of pubertal gilts supplemented with zinc and copper**

The present investigation was conducted to assess the capabilities of pubertal cross-bred gilts for successful reproduction by supplementation of Zn:Cu @ 200:20 ppm and inducing early sexual maturity and estrus for maximizing the piglet crop. The pubertal cross-bred Hampshire gilts (Hampshire x *Khasi*local) (n=10) reared under additional supplementation of Zn:Cu @ 200:20 ppm from 3rd to 6th month of age.

**Table 2 Sperm membrane integrity, mitochondrial membrane potential and DNA damage**

| Parameters | | Freezing rate | | | Manual freezing |
|---|---|---|---|---|---|
| | | 20ºC/min | 40ºC/min | 60ºC/min | |
| Membrane integrity | Intact | 54.78 | 54.75 | 49.67 | 45.98 |
| | Damaged | 46.23 | 43.25 | 50.36 | 57.7 |
| Mitochondrial membrane potentiality | High | 21.43 | 26.23 | 19.43 | 16.78 |
| | Low | 79.24 | 74.87 | 80.78 | 83.01 |
| DNA | | 0.79.12 | 0.74.23 | 0.78.47 | 1.78 |

Pigs at 5-6 months of age with average live body weight of 56.3 ± 4.7 kg were administered with PMSG [1000 IU, I/M] followed by 500 IU HCG (I/M) after 88-92 h of PMSG administration and were examined for standing estrus and inseminated artificially. The animals were slaughtered on day 3 post insemination and the observations were recorded. The oviducts and each uterine horn were flushed separately using DBPS with 0.4% BSA and antibiotics, and the flushings were examined for embryos/ova under stereo zoom microscope. The embryos collected were evaluated for morphology as well as quality. The results showed that 80% animals responded to treatment and the time of onset of estrus from PMSG administration was 61.30 ± 3.22 h with estrus duration of 38.5± 4.25 h. The average weight of the ovaries was 6.245± 2.154 g. Total no. of CL including both the ovaries were 21.5± 3.25, anovulatory follicles averaged 3.30± 1.30. Total no. of embryos/ova recovered from both the oviducts and uterine horn averaged 10.25± 3.50 showing a recovery rate of 47.67%. The unfertilized ova averaged 2.15± 0.18. The percentage of morulla, 8 cell, 4 cell and 2 cell embryos recovered were 72.33, 17.49, 5.25 and 2.68%, respectively. 65.35% embryos were graded as very good quality (A Grade), 23.85 % as good quality (B grade) and 11.25% as poor quality. The results showed that pubertal gilts may attain the capability of successful reproduction with acceptable response as early as at 6 months of age with a body weight of 60 kg, if managed properly.

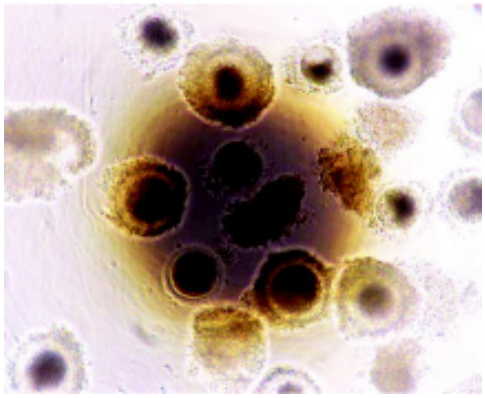


**Fig 3 Oocytes collected from porcine ovaries from Slaughter house**

### Performance of three bred cross pigs

The objective of the study was to produce three breed cross including *Khasi* Local, Hampshire and Duroc for lean meat production and evaluate the performance under the sub-tropical hill eco-system where the Duroc breed was used as terminal boar producing three breed cross of 25% *Khasi* local, 25% Hampshire and 50% Duroc genetic inheritance.

The average litter size at birth was 8.87 ±0.45 and litter size at weaning was 7.23 ± 0.29. The body weight of three breed cross piglet was significantly ($P$<0.05) higher as compared to cross breed pigs (*Khasi* local X Hampshire) at 30, 60, 90, 120, 160 and 240 days (Table 3).

**Table 3 Growth performance of three breed cross pig**

| Age | Body weight (kg) | | |
|---|---|---|---|
| | Male | Female | Total |
| **A. Pre-weaning body weight (n=60)** | | | |
| At birth | 1.147 ± 0.0 | 1.033 ± 0.0 | 1.140 ± 0.0 |
| 15 days | 3.95 ± 0.41 | 3.70 ± 0.23 | 3.83 ± 0.24 |
| 30 days | 5.45 ± 0.34 | 5.28 ± 0.56 | 5.32 ± 0.46 |
| 45 days | 6.85 ± 0.35 | 6.20 ± 0.46 | 6.63 ± 0.78 |
| 60 days | 9.89 ± 1.23 | 9.35 ± 1.56 | 9.52 ± 1.43 |
| **B. Post weaning body weight (n=20)** | | | |
| At 90 days | 15.45 ± 1.51 | 14.10 ± 1.60 | 15.28 ± 1.34 |
| 120 days | 21.90 ± 2.60 | 20.55 ± 1.55 | 20.63 ± 2.56 |
| 150 days | 30.45 ± 5.15 | 28.78 ± 2.34 | 29.40 ± 2.51 |
| 180 days | 38.70 ± 3.11 | 36.90 ± 2.45 | 37.30 ± 3.83 |
| 210 days | 48.20 ± 4.20 | 46.20 ± 3.78 | 47.75 ± 5.57 |
| 240 days | 50.10 ± 5.32 | 48.23.30 ± 5.12 | 49.10 ± 4.23 |

### Growth performance of pig and fish under integrated pig-fish system

The growth performance of pig and fish in integrated pig-fish system was studied. The pond was applied with cow dung and lime at the rate of 5000 kg and 1200 kg per ha, respectively as basal dose. In the composite fish culture, the species composition and ratio was Catla 2.5, Grass carp 2.5, Mrigal 3.0 and Common carp 2.0. The fishes were stocked at a density of 6000 nos/ha. No supplementary feed was given to fish. The fingerlings were stocked in the month of April and harvested after 8 month. The weight increment of Catla, Mrigal, Grass carp and Common carp were 207, 265, 286 and 166 g, respectively. Weaning piglets of crossbred 75% (Hampshire x *Khasi* local), were integrated with fish culture @ 30 pigs/ha water area. For 0.05 ha pond area, 2 piglets were integrated. The pig was fed with standard ration in recommended quantity and the growth rate was recorded based on the monthly body weight throughout the study period. Pig dung, urine and washings of the pig sty were

directly released in to the pond. The pig was offered 1, 2, 2.5 kg of concentrate feed per day at 2 -4, 4-6 and 6-8 months of age, respectively.

The average dung production by a pig weighing less than 50 kg and 50-90 kg was 2.5 kg and 5 kg per day, respectively. Pig manure contains approximately 39.65 per cent dry matter. The average crude protein, crude fiber, ether extract, total ash and nitrogen free extract content of pig dung was 4.23, 39.10, 3.80, 23.06 and 29.83 per cent, respectively. The average level of N, P and K in dried pig manure was 0.9, 0.7 and 0.6 per cent, respectively.

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

### Mineral status of blood samples of dairy cattle in Meghalaya

A total of 416 blood samples were collected from all the seven districts of Meghalaya and were analyzed for mineral contents using atomic absorption spectrophotometer. The average concentration of Ca and phosphorus was 5.90 ± 0.18 and 3.87 ± 0.14 mg/dl, respectively which were lower than the normal values. Similarly Mg concentration in blood samples was also found to be lower (1.07 ± 0.87 mg/dl) than the normal values (1.70 – 2.50 mg/dl). The level of Cu, Zn, and Mn were found to be 65.74 ± 12.87, 15.32 ± 3.79 and 1.17 ± 0.58 mg/dl as against their normal range of 50 – 120, 80 – 150 and 1.5 – 2.5 mg/dl. Maximum deficiency was reported in the level of Zn. However, the average Fe concentration was found within the normal range (102.49 ± 15.65 mg/dl). Out of total serum samples analyzed, 40, 57 and 32 per cent samples showed the efficiency of Ca, P and Mg, respectively. While Cu, Zn, Fe and Mn deficiency was reported in 36, 77, 21 and 12 per cent serum samples, respectively.

### Proximate analysis of local fodders of Meghalaya

A total of 450 commonly used green fodders (pasture herbages, grasses and tree leaves) were collected from all the seven districts of Meghalaya. District wise proximate composition of mixed fodder and proximate analysis of individual fodder were evaluated and presented in tables 4 and 5.

**Table 4 District wise proximate analysis of composite fodder samples**

| Districts | CP | CF | EE | NFE | Ash |
|---|---|---|---|---|---|
| Ri-Bhoi | 10.49 ± 1.06 | 34.58 ± 2.87 | 1.98 ± 0.65 | 42.46 ± 3.54 | 10.69 ± 0.87 |
| East Khasi Hill | 9.88 ± 1.54 | 35.45 ± 1.68 | 2.65 ± 1.55 | 4.32 ± 2.54 | 11.25 ± 1.02 |
| West Khasi Hill | 11.34 ± 2.04 | 32.54 v 1.99 | 2.87 ± 1.54 | 39.58 ± 2.14 | 12.58 ± 0.98 |
| Jaintia Hill | 10.65 ± 1.58 | 35.22 ± 2.54 | 1.87 ± 1.05 | 41.25 ± 2.54 | 10.75 ± 0.86 |
| East Garo Hill | 9.44 ± 0.39 | 33.54 ± 0.72 | 2.02 ± 0.65 | 43.67 ± 0.68 | 11.30 ± 0.34 |
| West Garo Hill | 11.80 ± 0.64 | 30.06 ± 0.93 | 2.11 ± 0.90 | 45.51 ± 0.90 | 10.50 ± 0.39 |
| South Garo Hill | 10.50 ± 0.39 | 31.75 ± 0.91 | 1.96 ± 0.10 | 43.36 ± 0.68 | 11.95 ± 0.35 |

**Table 5 Proximate analysis of common fodder samples**

| Fodder | CP | CF | EE | NFE | Ash |
|---|---|---|---|---|---|
| Para grass | 9.01 | 34.06 | 2.23 | 42.93 | 11.75 |
| Broom grass | 9.43 | 35.44 | 1.79 | 43.26 | 10.07 |
| Napier grass | 9.05 | 35.00 | 1.98 | 44.23 | 9.72 |
| Small Broom grass | 8.66 | 35.21 | 1.83 | 42.71 | 11.57 |
| Leg creeper (*Clitoria* sp) | 13.49 | 31.85 | 2.26 | 38.40 | 13.99 |
| Small Aruna grass | 10.05 | 30.46 | 2.20 | 45.05 | 12.24 |
| Large Aruna Grass | 9.85 | 33.65 | 1.86 | 41.00 | 13.64 |
| Dinanath grass | 10.64 | 40.29 | 1.97 | 38.03 | 9.07 |
| Local grass | 9.18 | 33.23 | 1.84 | 43.70 | 12.03 |
| Mixed grass | 8.89 | 31.44 | 2.00 | 45.56 | 12.08 |
| Maize | 8.45 | 26.69 | 1.99 | 53.19 | 9.67 |
| *Albizia* sp | 18.94 | 16.15 | 2.89 | 56.12 | 5.90 |
| *Ficus* sp | 16.05 | 28.69 | 2.69 | 40.45 | 12.10 |
| *Sesbania* sp | 24.41 | 28.26 | 2.63 | 38.94 | 5.76 |
| Jackfruit foliage | 13.45 | 21.30 | 2.31 | 53.49 | 9.44 |

**Analysis of soil samples of Meghalaya**

A total of 254 soil samples, collected from different districts of Meghalaya were analyzed for soil pH, organic contents, micro and micronutrient status (Fig.1). Eighty nine percent of the soil samples showed the pH less than 5.5. Nitrogen was low in 44% of the samples.

Among the macro nutrients, phosphorous and Ca+Mg were the most deficient elements with their deficiency in 63% and 82% samples, respectively. Among the micro nutrients, Zn was deficient in majority (66%) of the samples.

**Estrus synchronization and artificial insemination in Assam hill goats**

Estrus synchronization in Assam hill goats available in Meghalaya was attempted (n=12) using intra vaginal progesterone sponge for 12 days followed by removal of sponge and subsequent administration of 225 µg/ animal I/M injection of tiaprost trometamol. 66.66% (n=8) animals responded to treatment and were inseminated artificially with extended liquid buck semen. Interval between PG administration and estrus was 69.50 ±9.50 hrs; estrus duration was 29.50 ± 6.50 hrs with 70.14% and 75.00% conception and kidding rate, respectively.

**Effect of three different extenders on freezing quality of goat semen**

Semen was collected from four Assam Hill goat bucks aged between 18 to 24 months at weekly intervals using standard artificial vagina for goat. A restrained doe was used as a mount during semen collection. The ejaculates having volume, 0.3 ml or more and mass activity +++ or more were considered for freezing. The ejaculates collected from Assam Hill bucks were pooled. Ten ejaculates from each buck were used to study the effects of extender on quality of frozen semen. Three extenders *viz.,* Tris, TES-Tris and Egg yolk phosphate were used with some modifications to find out the best extender for freezing of semen.

The mean sperm motility in neat semen of Assam Hill bucks immediately after pooling was found to be 81.50 ± 0.76 per cent. The sperm motility in Tris, TES-Tris and EYP extenders was found to be 74.00 ± 1.24, 65.00 ± 1.29 and 69.00 ± 0.99 percent, respectively after equilibration and 67.50 ± 1.34, 55.50 ± 1.74 and 59.50 ± 1.74 percent, respectively after freezing. The mean per centage of live sperm in neat semen after pooling was found to be 90.30 ± 0.70 in Assam Hill bucks. In Tris, TES-Tris and EYP extenders the per centage of live sperm of Assam Hill bucks was 80.10 ± 1.33, 71.30 ± 1.31 and 75.60 ± 0.94 respectively after equilibration and 73.60 ± 1.28, 61.50 ± 1.60 and 65.40 ± 1.70, respectively after freezing.

The incidence of swollen acrosome in Tris, TES-Tris and EYP extenders after freezing was 11.80 ± 0.38, 17.10 ± 0.52 and 15.70 ± 0.36 per cent, respectively and the incidence of separating acrosome in frozen semen was 0.40 ± 0.16, 0.90 ± 0.17 and 0.70 ± 0.21 per cent, respectively. The incidence of entirely lost acrosome after freezing of semen was 3.10 ± 0.52, 4.10 ± 0.31 and 3.30 ± 0.30 per cent, respectively. The total incidence of acrosomal changes in frozen semen was 15.30 ± 0.68, 22.10 ± 0.45 and 19.70 ± 0.33 per cent, respectively.

**Superovulatory response in cattle under subtropical conditions of Meghalaya**

Superovultion was attempted under subtropical conditions of Meghalaya in 6 cyclic crossbred HF cows from day 9 of estrus cycle, using FSH-P 400mg in 08 split tapering doses and $PGF_2\alpha$ (Cloprostenol @5 00 mcg I/M ) with 5th injection of FSH. The mean

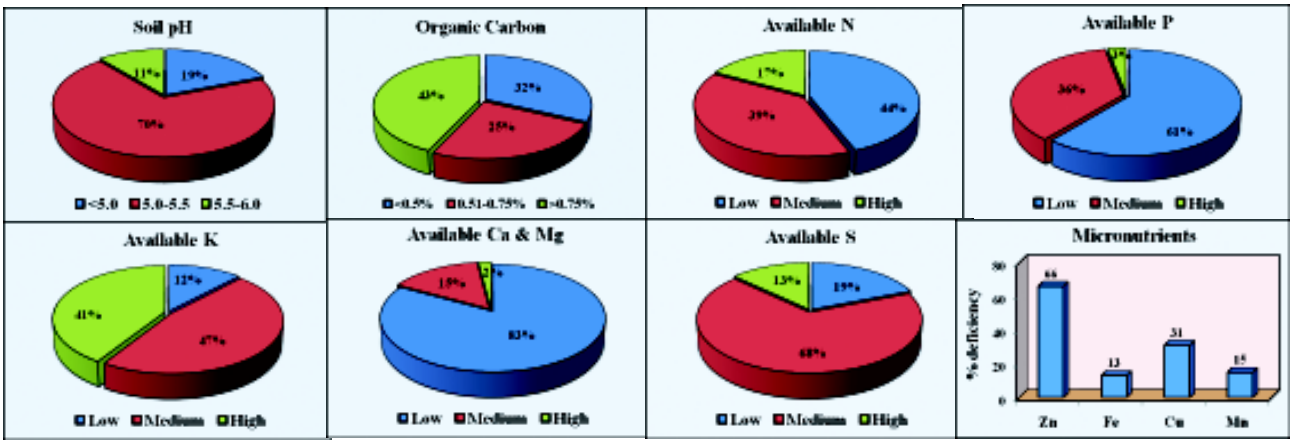



**Fig.1 Soil samples of Meghalaya**

ovulation rate, anovulatory follicles, viable embryos and total ova/ embryos recovered were found to be 8.83±1.54, 3.06±0.69, 3.89±1.71and 5.33±1.70, respectively.

## FISHERIES

### Growth response, gonadal maturation and carcass composition of the siluroid, *Heteropneustes fossilis* (bloch), fed with pelleted feeds at elevated water temperature

The experiment tested with four treatments involving animal viscera based pelleted feed derived from goat and pig at 50% incorporation and at temperature 17 and 32°C, whereas, a fifth group at 32°C and sixth group at 17°C fed with control diet (at 0% incorporation of animal viscera) served as control, with two replication each. The results after 60 days trial indicated that, *H. fossilis* (Fig 1) attained maximum weight gain of 72.62±3.39 g ($P$<0.05) when reared at 32°C and fed with goat viscera based feed (40.01% protein content) followed by feeding the fishes with pig viscera based feed (33.65% protein; weight gain 56.94±2.16 g) at the same temperature regime. Lowest feed conversion ratio (1.83±0.15), highest protein utilization (39.11±2.05%) and significant increase in gonado-somatic index were observed in the treatment 32±0.5°C and fed with goat viscera based feed. Further, in the same treatment group, carcass protein content of 46.97% ($P$<0.05) was recorded and surprisingly fishes fed with goat viscera based diet at lower temperature (17±0.5°C) showed the second highest protein content (42.54%). Overall, study suggested that, *H. fossilis* reared at comparatively elevated temperature (32±0.5°C) effectively utilized the feed and grew faster compared to lower temperature. Further, *H. fossilis* was found to prefer goat viscera based pelleted diet to the pig viscera based and control diets.

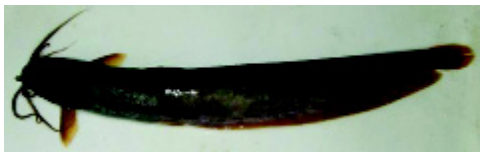


**Fig 1 *Heteropneustes fossilis***

### Growth performance of common carp fed with azolla and fish meal based feed at elevated water temperature

Two feeds were tested under ambient (20°C) and elevated water temperature (30°C) for studying the growth performance of common carp having initial body weight of 31.6±1.07 g. Sixty days after rearing, the animals fed with fish meal based palleted diet at 30°C attained growth of 90±1.01g which was significantly ($P$<0.05) higher than other tested diets at both elevated and ambient water temperature. The FCR of 2.12, specific growth rate of 1.25% and total weight gain of 3.5 g/fish was observed in the experimental tank where fishes were fed with fish meal based pelleted diet at 30°C. Overall the study suggested that common carp reared at elevated water temperature (30°C) and fed with fish meal based feed significantly contributes in growth enhancement, probably the fish at increased temperature tends to accept more feeds compared to low water temperature.

### Thermal tolerance, oxygen consumption and stress response of endangered Chocolate Mahseer at higher temperature

Considering the potential of Chocolate Mahseer in aquaculture, investigation on temperature tolerance, oxygen consumption and stress response in this high valued fish species at three different temperatures (24, 27 and 30°C) was studied for 45 days. Acclimated fishes (Mean±SE:18.5±0.5 g) were subjected to constant rate of increase (for CTmax) at the rate of 1.0±0.5°C/min until loss of equilibrium (LOE) was reached, which was designated as critical thermal maxima (CTmax). A similar experimental set up was used for performing lethal temperature tests (LTmax) to know the lethal tolerance limit in relation to acclimation temperatures (24, 27 and 30°C). LTmax was determined by observing the cessation of operculum movement (Table 1).

**Table 1 Critical and lethal temperatures (max) recorded in the fish captive-reared at different temperature regimes**

| Temperature regime (°C) | CT max (°C) | LT max (°C) |
|---|---|---|
| 24 | 31±0.8 [a] | 36±0.3[b] |
| 27 | 33±0.6 [a] | 38±0.3 [b] |
| 30 | 36±0.6 [a] | 41±0.6 [b] |

Values are presented as mean±S.E of replication. Means in the same row with different superscripts are significantly different from each other ($P$<0.05).

Dissolved oxygen concentration decreased significantly ($P$<0.05) with increasing water temperatures. However, there was no significant

difference in pH irrespective of the rearing temperatures. Stress responses in Chocolate Mahseer occur as a consequence of the released stress hormones, causing changes in the blood and tissue chemistry. When this fish was constantly reared at 24°C and then subjected to increasing temperature, the glucose secretion (9.48±0.07 mmol/l) was significantly more while touching LTmax than fishes reared in other tested temperatures ($P$<0.05) (Table 2).

**Table 2 Water quality parameters in experimental tanks having different rearing temperature**

| Water quality parameters | Experimental tanks | | |
|---|---|---|---|
| | 24°C | 27°C | 30°C |
| pH | 7.24±0.6 | 7.0±0.5 | 7.6±0.7 |
| DO (mg $l^{-1}$) | 6.4±0.2 | 5.8±0.6 | 5.2±0.5 |
| Alkalinity (mg $l^{-1}$) | 45±5.6 | 35±7.1 | 35±4.3 |
| Hardness (mg $l^{-1}$) | 50±9.2 | 46±8.1 | 45±8.8 |
| Chloride (mg $l^{-1}$) | 30±2.1 | 30±2.5 | 30±2.2 |
| Chlorine (mg $l^{-1}$) | 0.0±0.0 | 0.0±0.0 | 0.1±0.01 |
| Free $CO_2$(mg $l^{-1}$) | 25±2.9 | 28±8.1 | 30±1.5 |
| Nitrate (mg $l^{-1}$) | 0.017±0.001 | 0.011±0.001 | 0.029±0.002 |
| Phosphate (mg $l^{-1}$) | 0.101±0.012 | 0.110±0.011 | 0.135±0.001 |

*Values are presented as mean± S.E.

### Species diversification for sustainable aquaculture in NEH region

The two minor carps, *L. bata* and *L. gonius* were successfully reared in pond under mid altitude condition and growth performance was satisfactory. There was weight gain of 40 - 50 g during the winter months (Dec-Feb). The golden mahseer (*Tor putitora*) was successfully reared in a mono culture system at the institute fish farm (Fig 3). However, its performance was poor in pond culture system under the mid altitude climatic condition. In 6 month the growth increment was 50-60 g.

**Fig 3 Golden mahseer**

### Culture of Amur Common carp

Few breeders' seeds of Amur common carp procured from UAS, Hebbal, Bangalore were reared to maturity in mid hill condition. Non availability of quality fish seed is reported to be one of major cause for poor fish production in the northeast region. Therefore, a preliminary attempt was made to rear the Amur fry to the size of fingerling in a 30 days pond based cage culture trial along with local stock of common carp for comparison. The fry of both the species were reared in 1×1×1 m low-cost bamboo made cage (Fig 4). The growth increment in terms of length and weight for Amur were observed to be 8.5% & 20% respectively; while the local common carp showed a length increment of 4.5% and weight increment of 13.3%, demonstrating better performance of Amur common carp over the local stock of Common carp. In one of the trials the pond raised Amur common carp attained an average weight of 100 g and a maximum weight of 150 g in 120 days rearing period.

**Fig 4Low-cost cage for pond based cage experiment**

## POULTRY SCIENCE

### Studies on reproductive and egg quality traits of Japanese quail

The reproductive and egg quality traits of Japanese quail under deep litter system of rearing was studied in the agro-climatic condition of Meghalaya. The results of reproductive and egg quality traits (Fig 1) of Japanese quail were found to be optimum and are presented in the Table1.

**Fig 1 Japanese quail eggs**

**Table 1 Reproductive and egg quality traits of Japanese quail in agro-climatic condition of Meghalaya**

| Traits | Values |
|---|---|
| Age at first egg (days) | 49.17±1.56 |
| Hen day egg production (%) | 36.10± 1.03 |
| Fertility (%) | 86.34 ±2.36 |
| Hatchability on TES (%) | 75.12 ±1.06 |
| Egg weight (g) | 11.97±0.15 |
| Shape index | 75.35±1.50 |
| Albumen index | 0.15±0.01 |
| Haugh unit | 94.21±1.04 |
| Yolk index | 0.38±0.01 |
| Shell thickness with membrane(mm) | 0.28±0.02 |

### Studies on meat quality traits of Turkey and Japanese quails

The different carcass qualities of Turkey (Fig 2 & 3) and Japanese quails reared under deep litter system at market age were studied. Data are presented in the table 2.

**Fig 2 Dressed Turkey**

**Fig 3 Dressed Japanese quails**

**Table 2 Carcass qualities of Turkey and Japanese quail at market age**

| Traits | Values | |
|---|---|---|
| | Turkey | Japanese quail |
| Dressed yield (%) | 75.35±1.00 | 71.30±2.53 |
| Giblet yield (%) | 3.29±0.29 | 4.75±0.12 |
| Breast | 26.70±1.41 | 33.18±0.89 |
| Back | 17.80±1.01 | 25.43±0.85 |
| Thigh | 16.70±0.94 | 13.49±0.78 |
| Drumstick | 14.10±0.82 | 9.09±0.52 |
| Wing | 15.80±0.98 | 8.96±0.43 |
| Neck | 8.90±0.75 | 9.85±0.69 |

### Studies on the adaptability and performance of Emu in the agroclimatic condition of Meghalaya

Three months old Emu (*Dromaius novaehollandiae*) chicks (Fig 4) were procured from College of Veterinary Science, Sri Venkataswara Veterinary University, Rajendranagar, Hyderabad and introduced as an alternate poultry species in the institute poultry farm. The average body weight of Emu chicks at 3 months of age was recorded to be 4.5 kg.

**Fig 4 Emu chicks in the institute's poultry farm**

### Studies on supplementation of different herbal powders as feed additives for quality broiler chicken production

Different herbal powders *viz. Gingiber officinale*, *Allium saivum*, *Curcuma longa,Mentha arvensis,Ocimum sanctum,Emblica officinalis, Azadirachta indica*, *Spilanthes paniculata, Mimosa pudica, Argyreia nervosa, Schimia wallichii, Tithonia diversifolia* and *Bryophylum pinnata* as feed additives for quality broiler chicken production were evaluated. Among these herbal powders *E. officinalis* and *A. indica* enhanced the performance of broilerat 0.5 - 1% levels.*A. sativum*, *E. officinalis and A. indica* at 0.5% level of supplementation were found to reduce the blood cholesterol level in broiler chicken.

## ANIMAL HEALTH

### 1. Identification of porcine pathogens of viral etiology

A total of 88 tissue samples of porcine origin from Meghalaya, Silchar, Mizoram, Patna, Darbhanga, Bhopal, Gurgaon, Sitapur and Jalandhar were screened for presence of CSFV (Classical swine fever virus ) (Fig 1)., PRRS (Porcine respiratory and reproductive syndrome) (Fig 2)., PCV (Porcine circo virus) (Fig 3), and PPV (Porcine parvovirus) (Fig 4). Straight and nested PCR's were standardized against the following genes for rapid detection of porcine diseases with a viral etiology

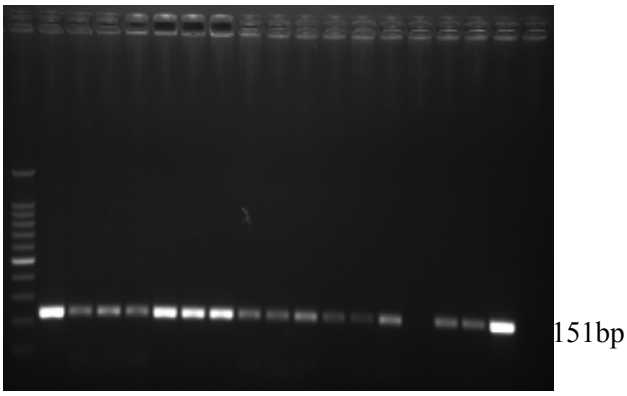



**Fig1 Amplification of CSFV specific 5'NTR gene from the serum samples**

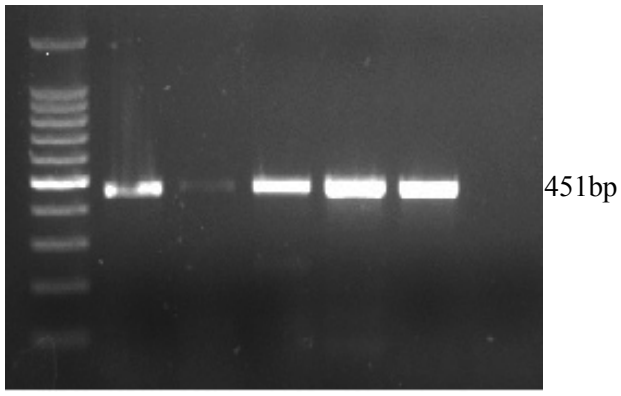



**Fig 2 Amplification of PRRSV specific (ORF-6) gene from the swab samples**

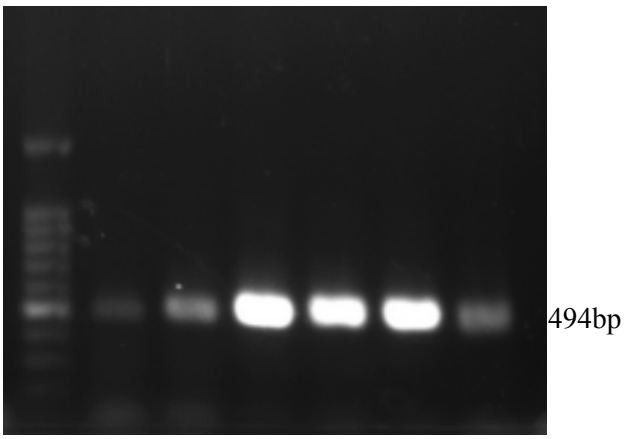



**Fig 3 Amplification of ORF-2 gene of PCV-2**

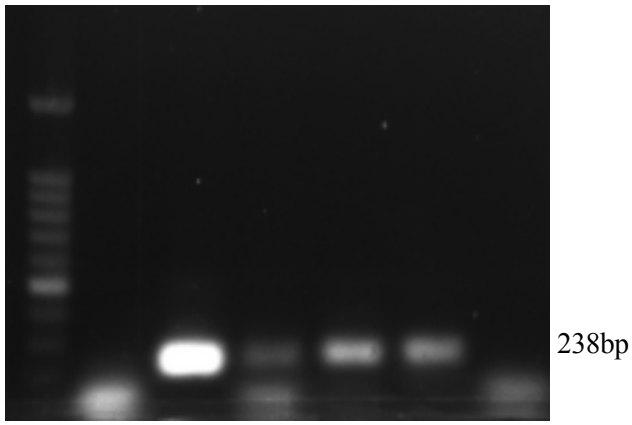



**Fig 4 Amplification of VP-2 gene of PPV**

Sequencing of representative isolates was done to determine identity and retrieve sequence based information. A total of 17 swab samples, 45 tissue samples and 6 serum samples were collected and screened for PRRSfrom suspected samples. Of these 10 swabs were found positive for PRRS, 8 tissue samples were found positive for PRRS and 4 serum samples were found positive for PRRS.Regarding PRRS, it is an exotic disease that has been reported first time in India. Suspected samples have been sent to the High Security Animal Disease Laboratory, Bhopal for confirmation and further action leading to notification. Two rare swine viral diseases *viz.,* porcine parvo virus and porcine circo virus were diagnosed in porcine tissue materials. RT PCR's were standardized and deployed for screening of the samples.

Identification of CSFV by PCR was done in porcine serum samples. This study would help in understanding the extent of phylogenetic variation.

**2) Reticuloendothelial virus (REV) insertion in turkey pox virus**

Identification of a REV insertion sequence in turkey pox virus isolates was done (Figs 5 & 6). It has been seen that the insertion could mean a horizontal gene transfer and sequencing of the insert along with the flanking regions could help us in understanding the basis of acquisition.

The isolated poxviruses from turkey were positive for envelope gene (807bp) as shown and REV integration site (370bp) indicating the presence of reticuloendotheliosis virus in the poxvirus genome.

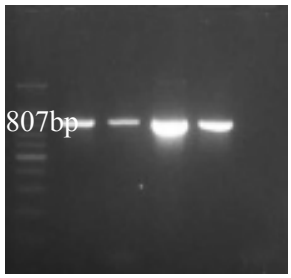



**Fig 5 Env gene of REV**

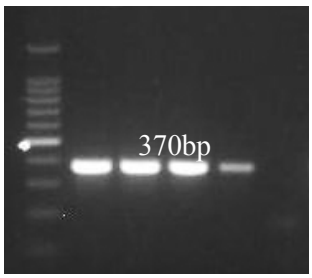



**Fig 6 Amplicon showing gene for insertion site of REV**

**3) Detection of rotaviruses of human and animal origin**

Extraction of dsRNA of rotavirus from fecal samples were carried out by conventional and

extraction kit (Qiagen) methods. Previously, the dsRNA of rotavirus was extracted with phenol: choloroform:isoamyl alcohol (25:24:1) method. Extraction of dsRNA of rotavirus by using kit is much more superior and less time consuming than the conventional method. The extracted RNA was then subjected to SDS-PAGE followed by silver staining to determine the presence of rotavirus. The dsRNA of rotavirus was also loaded on agarose gel (0.8%) stained with ethidium bromide and it has been found that all the segments of rotavirus could be clearly visualized at 300 ng and above concentration of RNA. A total of 113 fecal samples consisting piglets (66), goats (17) and poultry (30) were collected from different farms located in and around ICAR, Barapani and screened for detection of rotavirus. Additionally, 12 fecal samples were collected from children's admitted to the two different hospitals in Shillong. A total of 6 samples from piglets and 5 samples from children were found to be positive for rotavirus by SDS-PAGE and agarose gel (Figs 7 & 8).

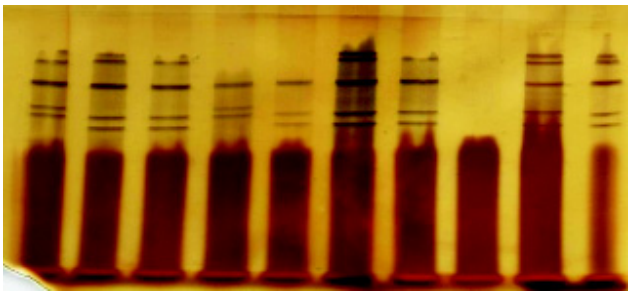


**Fig7 Electropherogram of rotavirus in SDS-PAGE**

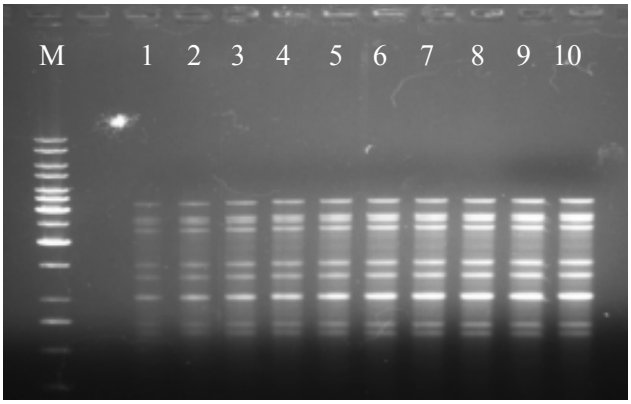



**Fig 8 Electropherogram of rotavirus in 0.8% agarose gel**

**4) Diagnosis of enteric pathogens from diarrhoeal samples**

A total of 197 diarrhoeal fecal samples (cattle -26, piglets -101 and poultry -70) were collected from different farms located in and around ICAR, Barapani and processed for isolation of *Escherichia coli* and *Salmonella* spp. using standardized protocol. One hundred and six isolates of *E. coli* and 9 Salmonella were recovered from these fecal samples. It was found that 25 isolates were positive for *stx1* gene and 12 for *stx2* gene. All together 30 *E.coli* isolates were serotyped into 12 serogroups as O5, O6, O14, O56, O59, O76, O89, O95, O101, O108, O167 and O172 with 5 untypable and 1 rough strain. Majority of the isolates belong to O95 (4 isolates) and O108 (4 isolates) serogroups (Figs 9 & 10).

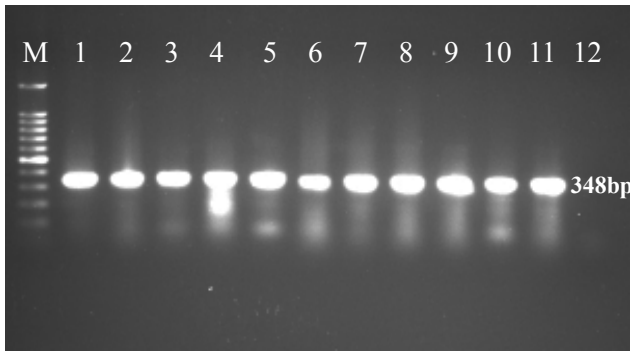



**Fig 9 PCR showing *stx 1* positive *E. coli* isolates recovered from clinical samples**
**Lane M- 100 bp DNA ladder Lane 1-11: *Stx1* Positive *E. coli* samples**

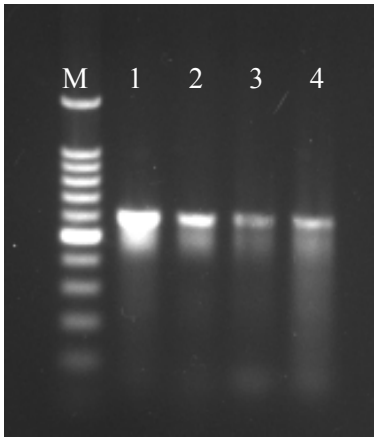



**Fig10 PCR showing *stx 2* positive *E. coli* isolates recovered from clinical samples**
**Lane M- 100 bp DNA ladder Lane 1-4: *Stx2* Positive *E. coli* samples**

Fifty one isolates of *E. coli* were tested for antimicrobial sensitivity test by disc diffusion method and found interesting results that maximum isolates were resistant to almost all antimicrobials. Sensitive antimicrobials to cattle and piglet *E.coli* isolates are ceftriaxone, ofloxacine, sparfloxacin, gentamycin and imipenem. However, poultry *E.coli* isolates were more sensitive to ceftriaxone and imipenem.

**5) Immunomodulatory effects of CpG *inovo* in chickens**

The work on immunomodulation was initiated in Gramapriya and Vanaraja birds. The protocol for *in ovo* injection was standardized using trypan blue dye. The eggs were injected with 20mg of CpG per eggs on the 18$^{th}$ day of embryogenesis.

The chicks hatched from different groups (Table 1) were monitored for maternal antibodies against Newcastle Disease virus for 18 days post hatch. The antibody titre was monitor by HI assay. The virulent ND virus was titrated to determine the $EID_{50}$ and then challenge the chicks with 2.5 $EID_{50}$ on 21 days post hatch when the maternal antibody titre wanes.

**Table 1 Hatching percentage of chicks in CpG treated and control group**

| Group | Hatching % |
|---|---|
| Gramapriya with CpG | 69%(22) |
| Gramapriya control | 59%(18) |
| Vanaraja with CpG | 75%(24) |
| Vanaraja control | 65%(20) |

The chicks were monitored for 10 days post challenge and record the clinical signs and symptoms. The pooled serum and PBMCs from each group were collected on day 0, 7, 14, 21 post challenge to study the level of antibody and cytokine expression.

The protection percentage from various groups was calculated after the observation period of 15 days as was shown to be variable as given in Table 2.

**Table 2 Protection rate against NDV in various groups with and without CpG**

| Groups | No. died | Protection % |
|---|---|---|
| Gramapriya with CpG | 2(12) | 83 |
| Vanaraja with CpG | 2(14) | 85 |
| Control without CpG | 12(20) | 40 |
| Vaccinated without CpG | 4(18) | 77 |
| Placebo control | 0(20) | 100 |

The work is continuing to standardise the ELISA for detection of levels of IgY and IgA response against NDV and also the level of some important cytokine genes responsible for innate immune response.

**6) Standardization of Chicken Embryo Fibroblast (CEF) and Chicken Kidney Cell (CKC) culture**

The laboratory culture of cell was standardized forvirus isolation by using 9$^{th}$-11$^{th}$ day old embryonated eggs for CEF and 21 day old embryonated eggs for CKC culture. The confluent monolayer could be obtained within 26-30 hrs for CEF and 56-60 hrs for CKC as shown in the Figs 11 & 12.

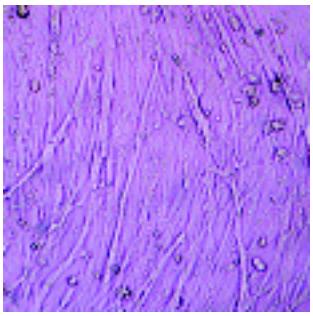


**Fig11 CEF culture at 30 hrs**

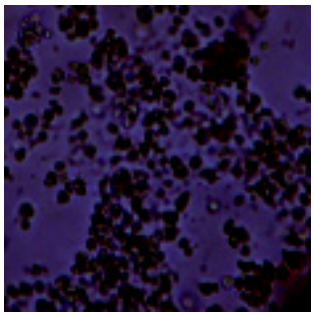


**Fig 12 CKC culture at 56 hrs**

**7) Standardization of MTT assay**

The method for determining the cell mediated immune response was standardized by separating the peripheral blood mononuclear cells (PBMCs) from heparinised chicken whole blood and incubated in vitro with antigen at 37°C for 72 hrs. The stimulated cells form formazan crystals on adding MTT dye which can be measured spectrophotmetrically (Figs 13 & 14).

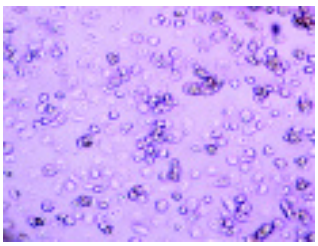


**Fig13 PBMC culture at 72 hrs**

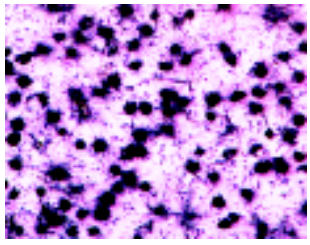


**Fig14 Formazan crystal in PBMC**

**8) Molecular microbiological characterization of fermented foods of north eastern Hill Region**

A total of 49 samples of fermented foods comprising fermented soybean, fish, bamboo shoots, etc. were collected from various parts of the North-eastern region including Meghalaya, Manipur, Nagaland, Assam and Tripura. Results of microbiological analysis from 27 samples tentatively identified 11 Lactic Acid Bacteria, 3 *E. coli* and 6 *Staphylococcus* spp.

**9) Effect of heavy water ($D_2O$) on bacterial growth**

To understand the biological effect of heavy water on growth of prokaryotic organism, experiments were set up with Brain Heart Infusion broth containing 20% $D_2O$ and *Escherichia coli* as model prokaryotic

organism. Initial results indicated reduced growth of *E. coli* upto 48 h in broth culture, followed by a sharper decline till 72 h compared to control broth cultures. Further experiments conducted up to 24 h also revealed a reduction in bacterial growth in heavy water containing broth vis-à-vis control (Fig 15).

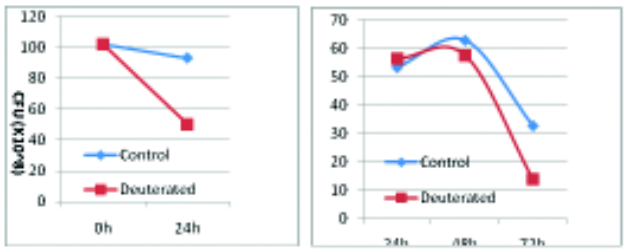



**Fig 15 Growth characteristics of bacteria using deuterated and non deuterated media**

**10)Antimicrobial resistance in plant pathogenic *Pseudomonas fluorescence* isolates (First Report)**

*Pseudomonas fluorescence* isolates that were pathogenic for plants were obtained from Division of Plant Pathology, ICAR RC for NEH Region. These isolates were screened for phenotypic resistance against 14 different antimicrobials used in veterinary and human. Initial results from five isolates suggested natural resistance against a number of antimicrobials especially Piperacillin-Tazobactam combination.

**11) Investigation and evaluation of ethno veterinary medicines through biological activity screening of medicinal plants**

**Investigation:** Investigation of ethno-veterinary practices was taken up in some districts of Manipur *viz*. Chandel, Bishenpur, Imphal East and West, Thoubal and Ukhrul, Meghalaya: Ribhoi- Umroi Nongrah, Umroi Madan, Saitsama village of Jaintia hills.

**Screening:** Antibacterial properties of eight plant species, selected on the basis of folklore medicinal reports practiced by the tribal people of northeast India. In-vitro antibacterial properties of alcoholic (Ethanolic and methanolic) and aqueous extracts of leaves of eight plant species, were assayed against four foodborne pathogens *viz.* Gram positive (*Staphylococcus* sp. and *Listeria* sp.*)* and Gram negative *(Escherichia coli* and *Salmonella)* using both agar well diffusion and disc diffusion method. Among the eight plants tested, four plants *viz*. *Centella asiatica, Eupatorium cannabium, Galinsoga parviflora* and *Clerodendrum serratum* showed a significant control of the growth. The maximum inhibitions were observed in *Galinsoga parviflora* against *Staphylococcus and Listeria* sp.*,* followed by *Clerodendrum serratum*, *Centella asiatica* and *Eupatorium cannabium.*The different extracts differed significantly in their antibacterial properties with the methanolic extract being more effective followed by ethanolic extract. Aqueous extract showed least activity. The results highlight that some of the studied plants had potential antibacterial properties (Fig 16).

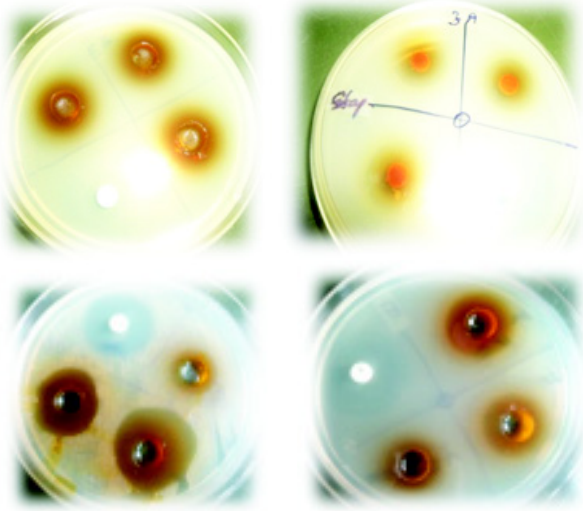


**Fig 16 Antibacterial properties shown by agar well diffusion**

**12) Extended-spectrum α-lactamases, characterization of multidrug resistance and antibiotic resistance integrons recovered from *Escherichia coli* isolates of swine in northeast India. (First Report)**

Analysis of 125 faecal samples from apparently healthy swine of four farms located in Northeast India have been done. Antibiotic sensitivity against 9 groups of antibiotics (25 agents) and ESBL identification were undertaken. MDR genes and integrons genes ($bla_{TEM}$, $bla_{CTX-M}$, $bla_{SHV}$, $bla_{OXA}$, *aac*, *aad*A, cat, *sul*1, *sul*2, *str*A, *tet*A, *tet*B) were further typed by PCR using specific prime, Plasmid profiling, RFLP, RAPD were done. Overall $bla_{TEM}$ was the commonest genotype (85.7%), $bla_{CTX-M}$ (61.9%), $bla_{OXA}$ (17%) and $bla_{SHV}$ was absent. One or multiple resistance genes were detected; *sul*2 (100%), *str*A (95.2%), *tet*A (92.9%), *sul*1 (76%), *aad*A (71.4%) and *tet*B (50%) followed by cat (42.9%) and *aac* (26.2%), all were likely plasmid-encoded and transmissible. Antibiotic resistance integrons detected were *intI1* (76.2%) and *intI2* (26.2%). RFLP and RAPD results gave a very diverse and heterogeneous nature of the isolates. This study is the first report of

molecular characterization of ESBL, MDR, integrons of E. *coli* isolates from swine in Northeast India and highlights the alarming prevalence of MDR *E. coli* isolates in faeces of apparently healthy pigs on study farms (Figs 17 & 18).

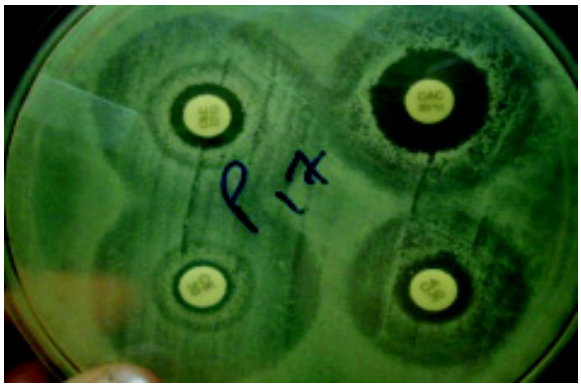


**Fig 17 Phenotypic characterization of ESBL**

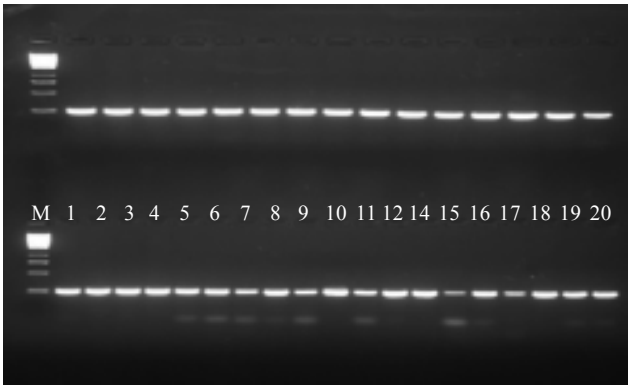



**Fig18 Sul 2 positive sample**

### 13)Piglet diarrhoea and *Escherichia coli* infection

A total of 305 faecal samples from diarrhoeic piglets have been screened so far, out of which 271 (88.85%) isolates of *E.coli* were recovered. The clinical samples were collected from Meghalaya (118), Nagaland (67), Mizoram (52) and Assam (68). Recovery rate of *E.coli* from the samples are 102 (86.44%), 60 (89.55%), 47 (90.38%) and 62 (91.18%) from the state of Meghalaya, Nagaland, Mizoram and Assam, respectively. The findings (Fig 19)indicated that occurrence of diarrhoea in pigletsvary from place to place. However more than 80% *E.coli* isolates *E.coli*was showed causative agent for the occurrence of diarrhoea and any one of the known *E.coli* pathotypes may be responsible for the disease manifestation. From the serotyping results of the *E.coli* isolates, it can be inferred that the serotype O43 was most prevalent whereas O20 and rough serotypes constituted the least number of isolates.

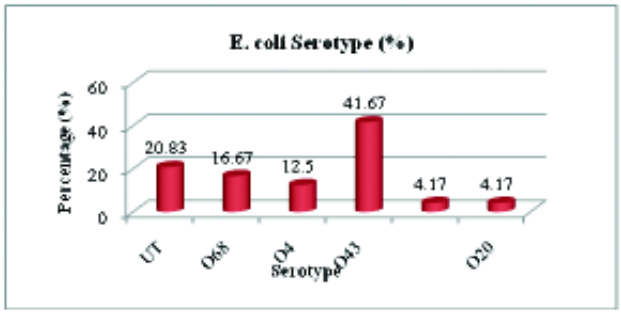



**Fig 19 Graphical representation of *E.coli*serotype involved piglet diarrhoea**

### 14) Characterization of *Listeria monocytogenes*

Based on the bands produced with reference strains, primers OPA 03, OPA 07, OPA 09, OPA 10 and OPA 18 were used for RAPD fingerprinting of 30 *L. monocytogenes* isolates. The gel profile was obtained and the total number of bands was manually counted and recorded in terms of presence (1) or absence (0) of a particular gene band. The data scored were used to generate the dendogram using the software NTSYS Pc (Ver. 2.2). All the 30 isolates could be divided into three main clusters *viz*. group 1 consisting of LM5, LM7, LM15, LM 27, LM8, group 2 consisting of LM1, LM2, LM11, LM13, LM14, and LM6. LM9, LM28, LM3, LM4, LM16, LM12, LM10, LM20, LM24,, LM29, LM21, LM25, LM22, LM23, LM26, LM17, LM19, LM18 and group 3 consisting of LM 30. It could infer that among the three groups 1 and 2 were related to each other whereas group 3 represent a separate group which is not related to 1 and 2 (Fig 20). LM30 isolate was recovered from water sample, others were of fish origin.

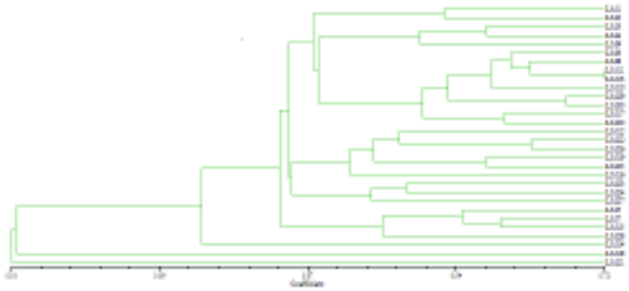


**Fig 20 Dendogram profile of 30 *L. monocytogenes* isolates obtained by OPA primer series**

### 15) Diagnostic services rendered

i) Nasal swab (20), oral swabs (20) and serum samples (5) were collected from Kyrdemkulai pig farm from the cases which showed the symptoms of abortion, still birth, pneumonia, diarrhea and fever. All these

samples were processed for detection of Classical Swine Fever (CSF) and Porcine Respiratory and Reproductive Syndrome (PRRS) virus by RT-PCR. Both these viruses are found to be positive in these samples. PRRS is reported for the first time in India and samples have been sent to the HSADL, Bhopal for confirmation.

ii) Samples of pine lappet moths submitted by Entomology Division, ICAR, Umiam for investigation of bacterial pathogen were processed for isolation of causative agent. The samples were found to be positive for *Bacillus* spp.

iii) Different ante mortem and post mortem poultry samples were collected from ICAR, Tripura centre on suspicion of bird flu and submitted to HSADL, Bhopal which was confirmed.

iv) An outbreak of colibacillosis and IBD were investigated at poultry farm having 20% mortality. Processing of samples revealed *E.coli* and *Salmonella* spp. Antibiotic and supportive treatment controlled the outbreak.

v) Turkey poxvirus infection: The recurring Poxvirus infection in turkey (Fig 21) was reported from the organized farm of poultry where both the forms occurred in individual bird. Scab samples of the affected birds were collected and DNA was isolated. The primer for specific avian poxvirus was used to amplify the P4b genes and RFLP analysis of the poxvirus was done (Fig 22).

**Fig 21 Lesions of poxvirus infection in turkey (Cutaneous and diphtheritic)**

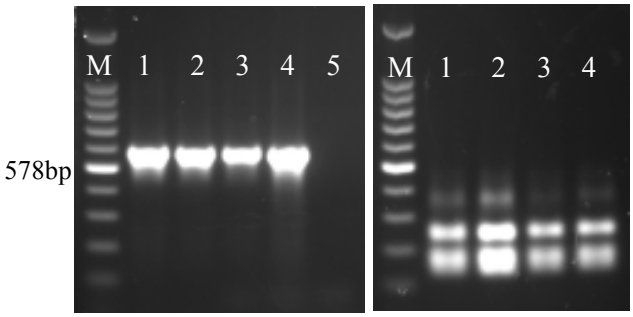



**Fig 22 (A)PCR amplification of P4b gene in clinical samples, (B). RFLP analysis of amplified P4b gene from clinical samples and FPV vaccine strain**

vi) IBD mixed infection with *E.coli*: The mortality of broiler birds from two organized farms in Ri-bhoi district of Meghalaya with 30% mortality in a flock of 745 birds (4-5 wks) was investigated. The carcasses were brought for post-mortem examination and the samples were collected for laboratory diagnosis. The lesions were suspected to be of IBD infection mixed with *E.Coli* as shown in the Figs 23 & 24, which was confirmed by isolating the *E.coli* organism and characterised by cultural and biochemical pattern.The samples were also subjected to isolation of the RNA and cDNA synthesis to detect the IBD virus VP2 gene and the amplified product of 478 bp from the samples confirmed the presence of IBD virus as shown in the Fig 25.

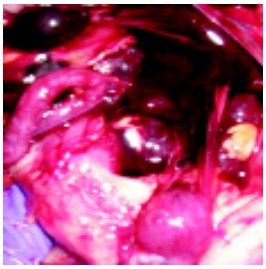


**Fig 23 Fibrinous covering of liver**

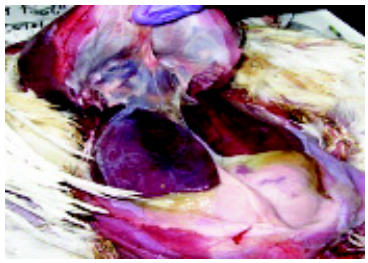


**Fig 24 Enlarged bursa**

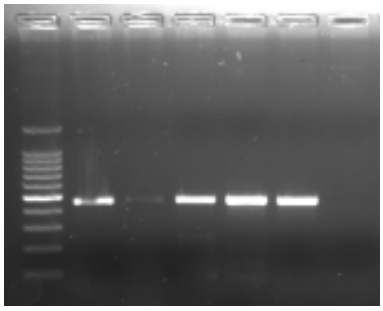


**Fig 25 VP2 gene of IBDV**

The *E.coli* isolates were resistant to 18 antibiotics (S25, AM10, N30, Cd10, A25, Ex10, K30, Cx30, P10, Tr30, O30, Sf300, VA30, Cb100, At30, SZ100, As10/10, Mt5) and sensitive to Ak30 and CEA30/10 that were usually used for antibiogram (Fig 26) reveal the growing resistance of microorganisms to many different antibiotics.

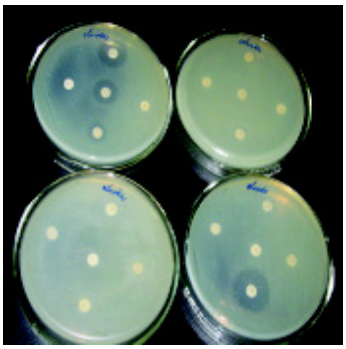


**Fig 26 Antibiogram of *E.coli***

vii) An outbreak of sudden fish mortality

at the Raj Bhavan, Shillong was referred to the division and laboratory investigation was carried out which revealed presence of *Aeromonas* spp, *Vibrio* sp and *E. coli* in fish and water samples. Coliform counts of the water samples from the three ponds were quite high. It was presumed that high BOD levels could be responsible for the same.

viii) Cattle sera sent by Animal Husbandry Department, Govt of Meghalaya were screened for Brucellosis and were found negative.

**16) Detection of haemoprotozoan infections in animals of north-eastern region**

For detection of haemoprotozoan infections in animals of north-eastern region, a total of 117 nos. of blood samples were collected from organized cattle farms of Meghalaya, Nagaland, Mizoram, Sikkim, slaughter houses in and around Shillong and dogs of Assam. Blood samples of Mithun were collected from NRC on Mithun, Nagaland. These blood samples were screened for detection of haemoprotozoan infections by examination of Giemsa stained blood smears and polymerase chain reaction using specific prime? All blood samples of cattle collected from organized cattle farms were found negative for haemoprotozoan infections either by examination of Giemsa stained blood smears or PCR, except one blood sample of cattle of Assam which was found positive for *Babesia bigemina* infection by microscopic examination and PCR (Fig 27). Out of 50 blood samples of dogs collected from Assam, *Babesia canis* (Fig 28) infection was detected in 2.00% and 34.00% dogs after examination of Giemsa stained blood smears and PCR, respectively.*Babesia gibsoni* (Fig 29) infection was detected in 12.00% dogs after examination of Giemsa stained blood smears and PCR. Blood samples of Mithun were found negative for haemoprotozoan infections.

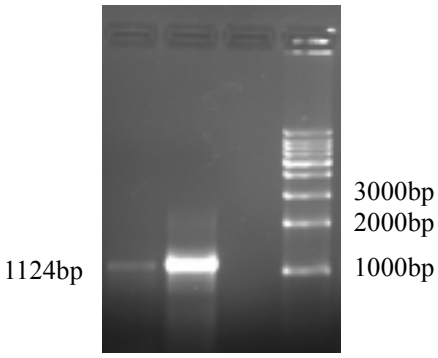



**Fig 27 L1,sample positive for *B. bigemina* (expected PCR product 1124bp)**

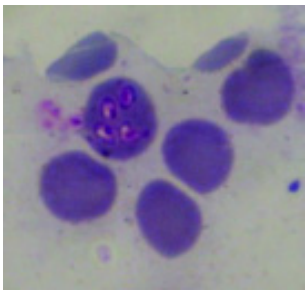


**Fig 28 *Babesia canis* in RBC of infected dog**

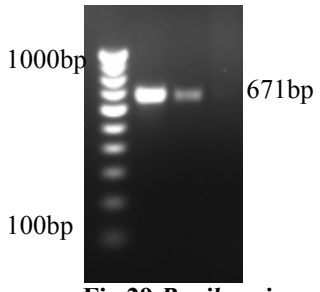



**Fig 29 *B. gibsoni* (expected PCR product 671bp)**

**17) Epidemiological studies on gastrointestinal parasitism in Meghalaya and other orth-eastern States**

The epidemiological studies on G.I. parasitism were undertaken in different places (Like Umbir, Umden Mission, Umdoh, Mawpanshaid, Umroi madan, Umden villages etc. and ICAR Research farm) of Meghalaya to determine the prevalence of gastrointestinal parasitism and intensity of infection in terms of mean EPG in goats, pigs and cattle by coprological examination. Post mortem examination of G.I. tracts of goats was done to determine the prevalence of gastrointestinal helminthes. Faecal samples of cattle, pigs, yaks and mithuns were also collected from Nagaland, Mizoram, Arunachal Pradesh and Sikkim. Overall prevalence of gastrointestinal parasites during 2011-12 has been presented in table-3.

**Table 3 Overall prevalence of gastrointestinal parasites during 2011-12**

| Animal | State | Positive (%) |
|---|---|---|
| Goat | Meghalaya | 38.20 |
| Pig | Meghalaya | 34.00 |
| | Nagaland | 51.56 |
| | Mizoram | 29.58 |
| Cattle | Meghalaya | 30.05 |
| | Nagaland | 22.72 |
| | Mizoram | 30.00 |
| Mithun | Nagaland | 29.03 |
| Yak | Arunachal Pradesh | 26.31 |
| | Sikkim | 20.00 |

In Meghalaya, *Strongyle* spp. (72.91%), *Strongyloides* sp. (41.51%), *Eimeria* sp. (41.22%), *Trichuris* sp. (13.58%) and *Moniezia* sp. (9.67%) were detected in faecal samples of infected goats . In pigs, *,Ascaris suum* were predominant (61.29%) followed by *Strongyle* sp. (45.90%), *Trichuris* sp. (16.25%) and *Strongyloides* sp. (9.30%). *Balantidium coli* was

detected in 41.3 % pigs. In cattle, *Strongyle* sp. were predominant (70.87 %) followed by *Strongyloides* sp.(28.61%), *Moniezia* sp. (18.04%), *Toxocara vitulorum* (6.18%), *Nematodirrus helvetianus* (4.63%)and *Trichuris* sp. (3.86%). Gastrointestinal helminthes of goats as detected by necropsy examination

A total of 75 gastrointestinal tracts of goats were examined and 52 (69.33%) goats were found positive for gastrointestinal parasitic infections. The predominant helminth was *Haemonchuscontortus* (88.46%), followed by *Oesophagostum* sp. (73.07%), *Trichuris* sp. (42.30%),*Moniezia* sp.(13.46%) and Amphistome (7.69%).

### 18) Detection of mange infestation in pigs of Meghalaya

A total of 52 numbers of suspected skin scrapings of pigs were collected from organized and unorganized pig farms and from pigs brought for slaughter to pig slaughter house of Shillong. Out of these 5 (9.61%) pigs were found infested with *Sarcoptes scabiei* var. *suis* (Figs 30 & 31) after microscopic examination of skin scrapings.

**Fig 30 Skin lesion of pig in mange infestation**

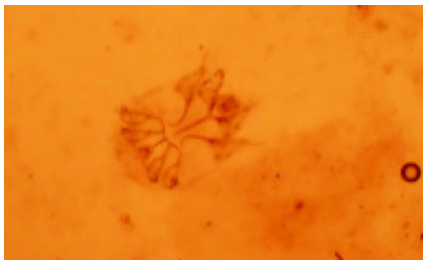


**Fig 31 Diagnosis of *Sarcoptes scabiei* var. *suis***

### 19) Antihelmintic efficacy of plants against parasites of livestock

Aqueous extracts of one plant (local name-Jasat) when evaluated by using egg hatch assay showed effectiveness against *Strongyloides* spp.

## ANIMAL NUTRITION

### A. Feeds and Fodder

#### Fodder production under cultivable lowland

On an average, each of 10 years old *Parari* plants (density-2500 plants/ha) provided 24.2 kg of foliage as fodder (~28.05% DM and ~9.0% CP; on DM basis) during the winter fodder scarceness period. The native grasses grown in the inter space provided 29.85 t/ha (14.62% DM and 9.67% CP) additional fodder during the period of monsoon and till late October in 3-4 cuttings. From cultivable plain lowland area, the improved varieties of perennial grasses *viz.*, Congosignal, Napier, Hamil and Guinea collectively yielded 58.09 t/ha fodder with average DM content of 14.88%) in four cuttings. Similarly, from terraced area at Dairy Unit, cumulative fresh fodder production was 78.17 t/ha in four cuttings.

#### Fodder production from upland terraced area

Soybean, rice bean and non-legume fodders, cowpea maize, jowar, job's tear and bajra were grown as annual leguminous fodder during the *kharif* season. At about 60 days, the fodder yields were 21.63, 25.11 and 18.64 t/ha from soybean, ricebean, cowpea respectively. Additionally after 150 days of sowing, 24.74 q/ha grain yield was also recorded from the soybean. Other crops like maize, job's tear, jowar and bajra were sown during Apr-May2011, yielded 44.34, 32.0, 29.15 and 38.52 t/ha respectively fresh fodder in single cut.

#### Groundnut fodder production under the tree shade in lowland plain area

Cumulative fodder yield of 39.42 t/ha (4 cuttings) with average 21.18% DM was recorded from perennial groundnut (*Arachis pintoi*) which was transplanted ten years ago in cultivable plain lowland under the tree shed. Besides providing excellent quality fodder, it can also be grown on the risers of terraced land (acidic soils) to check the soil erosion and for aiding the atmospheric nitrogen fixation.

#### Production of bajra and cowpea fodders

Under the acidic soil conditions in the terraced upland in mid altitude of Meghalaya, cultivation of bajra alone or with cowpea with use of lime and FYM as soil amendments as *kharif* fodder was studied. Different treatments like application of lime (10% of LR, 0.5 t/ha; T-1), lime (10% of LR) plus FYM (5t/ha, T-2) and lime (10% of LR) plus FYM (10t/ha, T-3)

had beneficial effect on the yield and quality of fodder (Table 1).

**Production of oat fodder**

Among other winter fodders, oats is an important crop. For its effective cultivation under acidic soil and moisture stress conditions, some treatments like control (C), lime (10% of LR, furrow application @ 0.5 t/ha; L), FYM (5t/ha; F) and lime plus FYM (FL) were applied. Oats (var. Kent) was sown during the mid of November, 2011 in three terraces. The fodder was harvested twice at 42 and 72 day after sowing. As compared to down terraces, the effect of various treatments was prominent in the top terrace, but the fodder yield was less due higher degree of moisture stress (Fig 1).

**Fig 1 View of oat fodder produced from C, L, F and FL treatments in the moisture stressed top terrace**

The yields of fodder under different treatments (Table 2) showed the positive impact of lime and FYM application on the production and quality of fodder from oats in the rain fed cultivation. Another potential fodder crop of barley was also tried in the moisture stressed terraced upland. The fresh fodder yield (t/ha) at 50 d was 85, 98, 96 & 115 in similar treatments indicating that application of lime and FYM is beneficial.

**Production of berseem and lucerne fodders**

In an attempt to develop package of practices for cultivation of best quality of leguminous fodders during the winter season, berseem var. Vardaan and lucernevar. Chetak (Fig 2) procured from IGFRI were tried and found suitable for the upland terraced area under the climatic condition of Meghalaya.

**Fig 2 Berseem (var. Vardaan) in early stage of growth (left) and Lucerne (var. Chetak) ready for harvesting after 6th cut (right)**

**Table 1 Effect of lime and FYM application on the quality and yield (t/ha) of fodder from bajra alone or with cowpea**

| Particulars | Treatments | | | | | |
|---|---|---|---|---|---|---|
| | Bajra | | | Bajra+cowpea | | |
| | T-1 | T-2 | T-3 | T-1 | T-2 | T-3 |
| Fodder yield (single cut @50 d; fresh basis; t/ha) | 35.40 | 45.80 | 51.90 | 38.20 | 52.60 | 57.40 |
| % DM | 23.81 | 23.64 | 24.62 | 22.87 | 23.08 | 22.97 |
| % CP | 9.07 | 9.76 | 10.02 | 11.87 | 12.05 | 12.61 |

**Table 2 Production parameters (average values) of oats fodder under different treatments and stages of harvest**

| Treatments | Plant height (m) | DM (%) | Fresh yield (t/ha) | DM yield (t/ha) | CP yield (t/ha) |
|---|---|---|---|---|---|
| First cut (42 days) | | | | | |
| C | 0.53 | 14.67 | 12.5 | 1.82 | 0.19 |
| L | 0.60 | 14.94 | 14.5 | 2.16 | 0.23 |
| F | 0.68 | 14.61 | 15.6 | 2.27 | 0.24 |
| FL | 0.67 | 14.69 | 18.6 | 2.72 | 0.29 |
| Second cut (72 days) | | | | | |
| C | 1.03 | 27.80 | 22.5 | 6.16 | 0.54 |
| L | 1.22 | 28.35 | 26.3 | 7.40 | 0.64 |
| F | 1.28 | 26.98 | 28.4 | 7.58 | 0.72 |
| FL | 1.40 | 28.31 | 34.7 | 9.82 | 0.88 |

In another study, berseem and lucerne were sown during 2nd week of November, 2011 in the upland terraces at Animal Nutrition Farm. The fodders were harvested after 70 days (1st cut) and interval of 20 days subsequently. On fresh weight basis, the average cumulative yields (t/ha) of fodder of berseem from 4 cuts were 8.6, 11.5, 9.5 and 23.3 from non-irrigated and 10.5,15.4,13.6 and 32.4 from irrigated treatments of control, lime, FYM and lime+FYM respectively. Similarly for lucerne, the values were 8.9, 10.2, 10.0 and 24.3 from non-irrigated and 9.9, 11.8, 13.5 and 30.7 from irrigated respective treatments. Different treatments like application of lime (0.5t/ha; L), FYM (10t/ha; F) and lime plus FYM (FL) had beneficial effect on the fodder yield. Lifesaving irrigation further increased the production of fodder.

**Use of effluent from cattle shed for mixed fodder production during winter**

Dairy shed effluents being rich in nutrients, could effectively be used for the cultivation of fodder during winter scarcity period. Mixed/inter fodder cropping of mustard, oats and berseem was attempted in the field receiving the washings/drainage from the dairy shed. Mustard was harvested (single cut) as major fodder after the 50 days of sowing and the oats and berseem were harvested subsequently after every 15-20 days period (Fig 3). The fodder yields (q/ha) on fresh basis were 256 for mustard, 125, 192 and 205 for oats and 83, 126 and 176 for berseem in first to third cuts respectively. In second plot mustard was harvested in 1st cut at 50d of sowing and oats and berseem were harvested subsequently after 25 days.Total fodder yield (t/ha) on fresh basis was 117.6 with 27, 55.9 (14+22.5+19.4) and 34.7 (8.9+11.3+14.5) respectively from mustard, oats and berseem. The drainage/washing from a dairy shed having 20 cows produced approximately 3000 L of effluent daily which could be very good source for amelioration of acidic pH and irrigation for fodder crops during dry winter season and if harvested and used properly it can irrigate ~100 $m^2$ of fodder cropped area every day.

**Fig 3 Mixed cropping of mustard, oats and berseem for winter fodder production, mustard is ready to harvest (left), and oats and berseem in subsequent cuts (right)**

**Conservation of fodders as silage**

The availability of quality fodder for ruminant animal production during winter lean season in Meghalaya is a major constraint. Usually such animals are given as paddy straw based diets with supplementation of concentrate mixture.

**Maize silage**

Maize is a fodder crop which can be preserved as silage.Surplus green maize fodder available during August and September can be ensiled to get the excellent quality silage. Maize fodder (29.75% DM) with common salt (0.5%, fresh basis) produced good quality silage for feeding of dairy cows (Fig 4).

**Fig 4 Appearance of prepared maize silage**

**Broom grass silage**

Local grasses having ~25% DM can be ensilaged under the conditions of Meghalaya. Abundantly available broom grass foliage was conserved with use of common salt (0.5%), maize flour (2-4%) and lactobacillus inoculum as silage (Fig 5). for feeding of ruminant animals during winter lean season.

**Fig 5 Appearance of broom grass silages**

### QPM maize fodder silage

Currently, quality protein maize (QPM) has been promoted among the farmers by our institute. It is believed that QPM is superior in quality for feeding of animals; however, the information on the influence of QPM silage feeding is sparse. Therefore, fodder from normal maize (NM) and QPM (seeds: courtesy Dr. A. Pattanaik) were grown in the farm at Animal Nutrition Experimental area. At milky stage, fodders were harvested and silages were prepared with Lactobacillus inoculum in HDPE bags. After two months of incubation, the bags were opened and silages were observed for their quality. Both silages were greenish yellow to brown in colour (Fig 6), having good aroma with 4.1-4.3 of pH. The percent DM, CP, Ash and OM contents were 29.76, 7.86, 9.11 and 90.89 in NM silage and 30.09, 7.56, 8.93 and 91.07 in QPM silage respectively.

**Fig 6 Appearance of silage prepared from QPM**

### B. Performance of crossbred dairy animals

In the existing experimental dairy unit of Animal Nutrition, about 35 crossbred animals (lactating-14 and heifers & calves-21) were maintained on the fodder produced from 1.0 ha area and feeds like- paddy straw and concentrates were procured from outside. Out of total production area under fodder, improved perennial grasses and annual fodder crops were grown in 0.7 and 0.3 ha respectively. The lactation performance has been given in the Table 3.

**Table 3 Lactation performance of herd comprising of crossbred cows**

| Attributes | Value |
|---|---|
| Number of cows | 13.50 |
| Total cows in lactation (average/month) | 10.78 |
| Total milk production of herd (l) | 42,357.00 |
| Herd average (milk yield in l/d/head) | 8.60 |

### C. Goat Nutrition

#### Tree leaves based complete feed block

During the lean season, tree leaves can be good fodders for the goats. Moreover, if these are fed in compact feed block form, may provide an alternate balanced feeding strategy. With this hypothesis, a study was planned to evaluate the complete feed blocks (CFB) and feeding cum digestibility trial in goats (Fig 7) was carried out with total mixed ration in mash or CFB form. The diets contained conc mix (40 parts), leaves of jackfruit (30 parts) and *Ficus* (30 parts). These feeds were highly palatable in goats.

**Fig 7 Feeding of complete diets prepared from jack fruit and ficus leaves in goats**

### D. Dairy Cattle Nutrition

#### Broom grass supplementation on the feed intake and milk yield in dairy cattle

During lean period, the dairy cows largely depend upon paddy straw as primary fodder apart from the concentrate feeds. Broom grass foliage could be used as a good fodder during the scarcity months of December to March in Meghalaya. Therefore, present study was undertaken to elucidate the effect of supplementation of broom grass foliage during the winter scarcity period.

Eight lactating crossbred HF dairy cattle (2-4 lactation, 374 kg average BW) were distributed in 4 groups (2 animals in each group). The animals in different groups were randomly given diet containing 6 kg concentrate mixture (17% CP and 70% TDN; estimated values) with paddy straw *ad lib* without broom grass foliage (T-1, control), 4 kg broom grass foliage (T-2), 8 kg broom grass foliage (T-3), and *ad lib* broom grass foliage without paddy straw (T-4). In a cross over design, each observation lasted 10 days preliminary feeding followed by 5 days collection period. The results (Table 4) reveal beneficial impact

of broom grass foliage supplementation at 4 kg level, as there was increase of DM intake, DM digestibility and milk yield. Further increase at 8 kg level did not show improvement and *ad lib* broom grass foliage without paddy straw proved unproductive as it caused reduction in above parameters. It may be inferred that use of broom grass foliage at ~25% level (of DM intake basis) improves the performance of dairy cows.

**Table 4 Average intakes, digestibility of DM and milk yield in HF crossbred dairy cows on supplementation of varying levels of broom grass foliage**

| Dietary treatments | DMI (kg/d/h) | DMI (kg/ 100kg BW/d/h) | DM digestibility (%) | Av. milk yield (4% FCM kg/d/h) |
|---|---|---|---|---|
| T-1 | 10.29 | 2.75 | 68.72 | 11.00 |
| T-2 | 10.55 | 2.82 | 70.32 | 12.38 |
| T-3 | 9.98 | 2.67 | 67.75 | 10.75 |
| T-4 | 9.62 | 2.57 | 63.86 | 9.69 |

**Job's tear stover based complete feed block for feeding of growing calves**

Among different ingredients the decorticated grains from Job's tear (Fig 8) was identified as promising local feed resource in Meghalaya. The stover of Job's tear is generally wasted in the fields. To find out its feeding value for ruminant production different processing technologies were attempted in the present study. Three groups of growing HF crossbred calves of 3-5 moths age were offered 3 diets having estimated 12% CP and 58% TDN. Three treatments viz., chopped Job's tear stover and concentrate mixture, offered separately (T-1), chopped Job's tear stover and water soaked concentrate mixture (*sani,* T-2) and complete feed block (CFB) prepared (Fig18) from Job's tear stover and concentrate mixture (T-3) were used. Animals in all treatment were also given one kg grass fodder daily. The average refusal of roughage was 35, 21 and 11.7% in treatments T-1, T-2 and T-3 respectively. The intake was improved in both *sani* and CFB with concurrent improvement in digestibility and growth. The ADG (g/d) was 410, 435 and 479 during 70 days long feeding on respective treatments.

**Fig 8 Job's tear crop and its stover based complete feed blocks**

## E. Pig Nutrition

**Local feed resource based pig feeding**

To study the utilization of locally grown feed resources *viz.*, squash fruit, *Alocacia* foliage, tubers and leaves of sweet potato in finisher pigs, a feeding trial was conducted in two groups of animals. Squash fruit, *Alocacia* foliage and tubers and sweet potato tuber and leaves were chopped, mixed in a fixed ratio and cooked before final mixing with grain portion. The grain based conventional diet served as control (C) and other which received above ingredients replacing 25% of grain portion served as treatment diet (T) diet. The composition of diets were adjusted for achieving 13% CP and 3000 kcal ME/kg level for entire feeding period of 30 days. The daily allowance was offered twice, half in morning and other in the evening.

The results revealed (Table 5) that the replacement of these resources at this level enhanced the intake of DM with concurrent reduction in coefficients of digestibility for dry matter, organic matter, protein and

**Table 5 Performance of pigs fed on locally available feed resources**

| Particulars | Control | Treatment |
|---|---|---|
| Average DM Intake (g/d) | 1864 | 1927 |
| Average daily gain (g/d) | 496 | 481 |
| Feed conversion efficiency | 3.76 | 4.01 |
| DM digestibility (%) | 76.25 | 71.38 |
| OM digestibility (%) | 79.11 | 74.09 |
| CP digestibility (%) | 74.66 | 72.82 |
| CF digestibility (%) | 18.15 | 13.86 |

fibre. In finisher pigs, growth rate may be maintained by replacement of grains by these resources up to a level of about 25%.

**F.Development of probiotics for livestock and poultry**

Fecal samples were used for isolation of bacterial strains by lactobacillus selective culture technique. Fecal isolate of lactobacillus having probiotic potential was grown on large scale and used for feeding in different animal species.

Eight, 3-4 months old kids (Assam local hill goat) were allotted to 2 groups and given 100-200g/d concentrate mixture having estimate 20% CP and 72%TDN, without (control; T-1) or with probiotic supplementation (T-2) and free grazing. The supplementation of probiotics improved growth with overall weight gain of 4.13 and 5.67 kg, and ADG of 34.6 and 47.1g in the respective groups. Three groups each having five improved crossbred weaned piglets were given grain-based diets without probiotic supplementation (control, G1), with lactobacillus isolate (G2) and lactobacillus isolate plus yeast (G3). The supplementation of probiotics, improved the ADG and the values were 386, 423 and 421g in control, probiotic and probiotic+50 ppm Zn fed groups during 125 day long feeding trial. During the digestibility trial the DMI (kg/d) were 2.23, 2.27 & 2.34 and values for percent digestibility of DM, CP and CF were 66.8, 69.1 and 70.6; 70.1, 70.7 and 72.2; 13.9, 15.4 & 16.3 in respective groups. One fecal isolate of lactobacillus having probiotic potential was grown on large scale and used for feeding in kuroiler and Vancobb broiler chicks in two separate feeding experiments. Experimental feeding was initiated at about 2 weeks of age.

The diet for kuroilers having 21% CP and 3000 Kcal/kg ME was comprised of yellow maize, soybean meal, groundnut cake, fishmeal, mineral mixture, and probiotic supplement in the proportion of 61.5, 8, 19, 8, 3 and 0.5 respectively. Whereas, the diet of broilers having 20% CP and 2980Kcal/kg ME was comprised of yellow maize, soybean meal, groundnut cake, mustard oil cake, berseem meal, lime stone, DCP, mineral mixture, salt and probiotic supplement in the proportion of 60 25, 4, 4, 1, 1,1, 2, 0.25 and 1.75 respectively. The diets were free of probiotic supplement (G-1, control) whereas the diets of other groups of chicks contained lactobacillus (G-2) and lactobacillus plus saccharomyces sp (G-3). The experimental feeding was continued for 11 and 7 weeks in kuroilers and broilers respectively. From the data (Table 6) and blood parameters it is noticeable that the isolated organism had beneficial impact on the performance of the chicks.

**Table 6 Average values of different parameters of chicks on supplementation with probiotics (lactobacillus isolate)**

| Particulars | Groups of chicks | | |
|---|---|---|---|
| | G-1 | G-2 | G-3 |
| **Kuroiler** | | | |
| Average BWG (g/bird) | 1916 | 2005 | 2067 |
| Total feed consumption (kg) | 119 | 116 | 120 |
| Feed conversion efficiency | 3.31 | 3.05 | 2.96 |
| Cost of feeding (₹/kg BWG @₹21/kg) | 55.20 | 52.06 | 51.51 |
| **Broiler (Vancobb)** | | | |
| Average BWG (g/bird) | 2466 | 2603 | 2697 |
| Total feed consumption (kg) | 175 | 195 | 198 |
| Feed conversion efficiency | 2.52 | 2.40 | 2.36 |
| Cost of feeding (₹ /kg BWG @₹21/kg) | 52.92 | 50.49 | 49.51 |

# ARUNACHAL PRADESH

## WEATHER REPORT

The period from Apr 2011 to Mar 2012 recorded a normal weather condition in terms of temperature but a below normal rainfall trend. Following were the variations in weather parameters recorded at Agro-met Observatory, Gori Research Farm, at Basar (Table1). Two additional Automatic Weather Stations i.e. one under IMD and other under NICRA were established at the Research Farm, Gori and Experimental Farm, Bam, respectively.

The mean monthly maximum temperature varied from 17.1ºC in Jan to 28.9ºC in Aug. The mean monthly minimum temperature varied from 6.8ºC in Jan, 2012 to 21.5ºC in Jul, 2011. Highest maximum temperature recorded for a single day was 35.1ºC on 12th Aug 2011, and lowest temperature recorded was 4.8ºC on 13th Jan 2012.

The total rainfall recorded during Apr 2011 to Mar 2012 was 1787.1 mm which was below normal value of 2361 mm. The total rainy days were 105 which were below normal value of 142 days. Fig 1 shows the monthly rainfall trend.

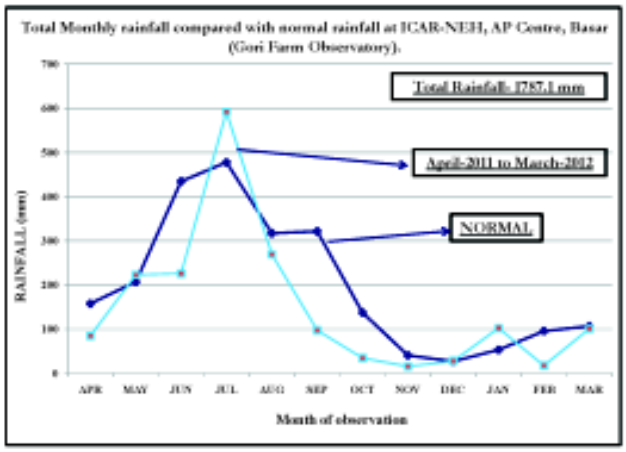



**Fig 1 Monthly rainfall trend compared to normal during Apr 2011 to Mar 2012**

## CROP PRODUCTION

### RICE

#### Evaluation of rice varieties

In lowland, 40 entries were grown. The highest no of panicle/m$^2$ (198) was recorded in RCPL 1-401. In upland, 16 entries were tested. The highest no. of panicle/m$^2$ was in IR 46 (160) followed by RCPL 1-412 (140). The highest grain yield was recorded in

**Table 1 Monthly weather data from Apr 2011 to Mar 2012 and their comparison with normal**

| Months | Mean max. temp. (°C) | Normal max. temp. (°C) | Mean min. temp. (°C) | Normal min. temp. (°C) | Monthly rain (mm) | Normal monthly rain (mm) | Total rainy days | Normal rainy days |
|---|---|---|---|---|---|---|---|---|
| Apr | 22.3 | 22.6 | 14.6 | 14.9 | 84.4 | 158.6 | 12 | 5 |
| May | 25.9 | 25.8 | 17.7 | 17.5 | 222.4 | 213.3 | 12 | 11 |
| June | 27.4 | 27.5 | 20.2 | 20.4 | 225.8 | 428.4 | 14 | 11 |
| July | 28 | 28.1 | 21.5 | 21.6 | 592.1 | 485.6 | 21 | 14 |
| Aug | 28.9 | 28.8 | 20.9 | 21.2 | 269 | 321.8 | 8 | 15 |
| Sep | 27.9 | 27.9 | 19.8 | 20 | 97 | 317.5 | 8 | 20 |
| Oct | 26.1 | 26.3 | 17 | 17.4 | 34.2 | 132.6 | 3 | 21 |
| Nov | 23.3 | 23.5 | 11.1 | 11.4 | 15.4 | 41.3 | 2 | 15 |
| Dec | 19.7 | 19.7 | 8.2 | 8.2 | 27.4 | 26.4 | 3 | 15 |
| Jan | 17.1 | 16.9 | 6.8 | 6.8 | 101.9 | 48.0 | 10 | 8 |
| Feb | 17.7 | 17.4 | 8.8 | 8.9 | 17 | 84.6 | 2 | 4 |
| Mar | 20.2 | 20.1 | 11.4 | 11.1 | 100.5 | 103.2 | 10 | 3 |
| Mean/Total | 23.7 | 23.7 | 14.8 | 15.0 | 1787.1 | 2361.3 | 105 | 142 |

RCPL 1-128 and RCPL 1-413 (2.0 t/ha) followed by RCPL 1-303(1.8 t/ha). The highest plant height of 148 cm was in RCPL I-147 followed by 120 cm in RCPL 1-473.The highest grain yield was recorded in RCPL 1-1609 (3.2 t/ha) and RCPL 1-303 (2.5 t/ha)

**Collection, screening and improvement of *jhum* rice**

Selected 14 local *jhum* rice varieties were grown for study and characterization as per DUS testing guidelines. The highest plant height was recorded in Bamtere (144 cm) and lowest in Amchiri (105 cm); the highest number of EBT/hill was observed in Ampu (9) and lowest in SARS 1 (3); number of panicle/$m^2$ was recorded highest in Ampu (65) and lowest in SARS 1 (42). The number of spikelets/panicle was recorded highest in Bali white (203) and lowest in Yabar (80). Similarly, all other 56 characters were recorded for all the 14 rice cultivars.

**Residue management for improving crop productivity**

Different residue management treatments *viz.,* 100% crop residues, 100% weed biomass, 50% crop residues + 50% weed biomass, 50% crop residues and 50% weed biomass was assigned to main plot and two fungi i.e.,*Trichoderma* and *Pleurotus* were applied in sub plots. Local rice var. *Mipun* was used as test variety for the study. The growth and yield attributes were recorded higher in 50% weed biomass and 50% crop residues with highest yield of 3.90 t/ha followed by 100% weed biomass (3.79 t/ha). The lowest yield was harvested with 100% crop residues (2.83 t/ha). *Trichoderma,* recorded 3.60 t/ha and *Pleurotus* 3.21 t/ha yield.

During the winter, mustard var. TS 38 was sown with same treatment combinations. Among the various residue management practices, 50% crop residue and 50% weed biomass recorded the yield of 1.10 t/ha followed by 100% weed biomass (1.02 t/ha). The lowest yield was recorded when mustard was grown with 100% crop residues (0.84 t/ha). The fungi used as decomposing agents i.e. *Trichoderma* recorded the highest yield of 1.05 t/ha followed by *Pleurotus* 0.90 t/ha.

## DISEASES

**Screening of rice germplasm/varieties against rice leaf blast**

One hundred thirty four rice entries were screened under uniform blast nursery (UBN) pattern (Fig 2). Only ten entries showed resistance reaction while

**Fig 2 Rice under UBN**

twenty three entries showed tolerant reaction and one hundred and one entries showed susceptible reaction with moderate disease pressure of LSI 5.5.

**AICRP on screening nurseries for host plant résistance against leaf blast**

Under National Screening Nursery 1 (NSN 1), 171 entries were evaluated in UBN pattern. Disease pressure was low with LSI of 3.98. Under National Screening Nursery Hills (NSN- H), 79 entries of NSN-H were evaluated in UBN pattern and showed moderate disease pressure with LSI of 3.9.

## MAIZE

**Evaluation of growth performance and weed dynamics of various intercrops with maize**

Maize was intercropped with cowpea, French bean and blackgram at 1:1, 1:2 and 1:5 row proportions (Fig 3). The growth parameters were recorded higher on sole maize. However, the dry matter accumulation/plant, maize equivalent yield (MEY) and land

**Fig 3 Maize/blackgram with 1: 5 row proportion**

equivalent ratio (LER) were recorded higher on maize/cowpea 1:5 row proportions followed by maize/black gram 1:5. Sole crop was harvested with maize (4.34 t/ha), cowpea (5.15 t/ha), French bean (4.0 t/ha) and black gram (1.28 t/ha). The lowest weed density and weed dry weight were measured on sole cowpea. However, weed control efficiency was recorded highest for sole cowpea followed by maize/cowpea 1:5.

## PULSES

### FIELD PEA

**Evaluation of field pea varieties against diseases**

Four varieties of pea (Fig 4) *viz.,* Azad Pea 1, Arkel, DS 10 and VL 42 were sown on 19th Nov 2011. Azad pea 1 germinated in 8.3 days followed by DS 10 (9 days). The highest green pod yield was recorded with Azad pea 1 (3.3 t/ha) followed by Arkel (1.6 t/ha). However, lowest yield was harvested from DS 10 (0.6 t/ha).VL 42 took longest time (80.7 days) to get 50% flower, whereas, Azad pea 1 took 54 days. The occurrences of rust and pod rot were noticed earlier in Azad pea 1 followed by Arkel. Similarly, the incidences of rust and pod rot were severe in case of Azad pea 1 followed by Arkel. However, lowest incidences of rust and pod rot were noticed in VL 42.

**Fig 4 Screening of pea varieties**

### BLACK GRAM

**Impact of different weed control measures in black gram**

Black gram was imposed with different weed management practices. Among the various treatments, weed free recorded 1.38 and 3.44 t/ha of grain and stover yield, respectively followed by twice weeding at 15 and 25 days after sowing (DAS) i.e., 1.32 and 3.31 t/ha, respectively over control (0.77 and 2.19 t/ha, respectively). Among the weedicide treatments, pendimethalin and fluchloralin at 1.5 l/ha were inferior to same chemicals with one additional hand weeding at 25 DAS. Harvest index ranged from 0.26 to 0.32. Among the weed parameters, weed dry weight (WDW) at harvest was nil with 100% weed control efficiency on weed free followed by twice weeding (9.6 g/m$^2$ and 83.7%, respectively). The highest WDW was recorded in control (59.2 g/m$^2$).

## OILSEEDS

### TORIA

**Evaluation of toria varieties against location specific diseases**

Four toria varieties *viz.,* TS 36, TS 38, TS 46 and M 27 were sown at two different dates i.e., on 1st and 15th Nov 2011. It was recorded that TS 36 registered 57.9% higher seed yield followed by TS 46 (12.6%) over M 27. Among the different dates, early sowing at 1st Nov recorded 7.40% higher seed yield then sown on 15th Nov 2011. Among the varieties, incidence of alternaria blight was recorded 15.8% lower in TS 36 and TS 46 compared to M 27 and TS 38. However, M27 was tolerant to white rust. Sowing dates had no impact in incidence and severity of alternaria blight and white rust.

### MUSTARD

**Effect of tillage and mulches on growth and yield of mustard**

Mustard variety TS 38 (Fig 5) was sown in split plot design. Main plots were assigned for tillage *viz*., conventional tillage, minimum tillage and no tillage and sub plots were assigned for mulches *viz.,* paddy straw, maize stubble, *Imperata cylendrica* and no mulch. The highest yield of 1.21 t/ha was obtained with minimum tillage followed by conventional tillage (1.12 t/ha) and least with no tillage (0.93 t/ha). Similarly, among the mulches, higher seed yield was harvested with maize stubbles (1.24 t/ha) followed by paddy straw mulch (1.21 t/ha). However, lowest yield of 0.84 t/ha was recorded with no mulch. In contrary to yield, weed dry weight (WDW) varied with the imposed treatments and interestingly, no tillage recorded lowest weed dry weight (22.0 g/m$^2$) followed by minimum tillage (24.8 g/m$^2$), however, higher WDW was recorded on conventional tillage (30.0 g/


**Fig 5 Mustard under minimum tillage**

$m^2$). Among the mulches, lowest to highest WDW was recorded with *I. cylendrica*<paddy straw mulch<maize stubbles<no mulch (10.6, 16.5, 17.6 and 57.6 g/$m^2$, respectively).

## HORTICULTURE

## FRUITS

### CITRUS

**Performance of *Khasi* mandarin under drip irrigation and mulching**

The experiment was laid out on split plot design. Main plots were allotted for irrigation levels (i.e. $L_1$: 1.0 Epan through drip, $L_2$: 0.8 Epan through drip, $L_3$: 0.6 Epan through drip and $L_4$: 1.0 Epan with flood irrigation (FI)) and sub plots were mulched i.e., $M_1$: No mulch, $M_2$:Black polythene mulch (BPM; 40 µ thickness), $M_3$: Transparent polythene mulch (TPM; 40 µ thickness), $M_4$: Paddy straw mulch (PSM; 20 kg/tree). All the growth parameters like plant height, stem girth, no. of branches and canopy spread were recorded significantly higher on drip irrigation at 1.0 Epan followed by drip irrigation at 0.8 Epan. Among the mulches, black polythene mulch (Fig 6) recorded higher growth attributes over other mulch. Yield attributing parameters *viz.,* no. of fruits/plant, fruit weight, fruit girth and fruit volume was recorded highest when plants were supplied drip irrigation at 1.0 Epan along with black polythene mulch with fruit yield of 78 kg/plant. However, lowest yield was in flood irrigation trees with no mulch (51 kg/tree).

**Fig 6*Khasi* mandarin with black polythene mulch**

**Efficacy of different methods for controlling lichens in *khasi* mandarin**

Manual cleaning with 3 different methods *viz.,* hand plucking, cotton cloth cleaning and iron brush, along with the application of *Trichoderma viride* and Coltex (2 ml/l) were carried out. Among the six treatments imposed on *Khasi* mandarin to reduce the menace of lichen. It was recorded that the application of coltex along with manual cleaning with cotton cloth has reduced the lichen growth. However, the application of *Trichoderma viride* after cleaning with iron brush was observed to be the least effective. The lichen growth was measured by recording dry weight of lichen.

### PINEAPPLE

**High Density Planting (HDP)**

Fifteen hundred pineapple suckers and crowns collected from different parts of West Siang district were planted under high density planting (Fig 7) *viz.,* 30 x 60 x 90 cm (across the slope), 30 x 45 x 60 cm (across the slope) and 30 x 45 x 60 cm (along the slope) as followed by farmers. The result showed that planting of pineapple in 30x60x90 cm showed better growth attributes like plant height (86 cm), no. of leaves (64), canopy (138 cm) and formed more no. of daughter suckers (4). But it was also observed that man-days requirement for intercultural operations (weeding, manuring, earthing up) were comparatively lower across the slope than the along the slope planting.

**Fig 7 Pineapple under HDP**

### STRAWBERRY

**Establishment of agro techniques**

Strawberry (*Fragaria* x *ananassa* Duch) runners were imposed with three different pruning treatments *viz.,* pruned upto two leaves, four leaves and un-prunned and executed with and without dipping in Bavistin solution (2 g/l) before transplanting into poly bags. It was observed that pruning upto two leaves along with Bavistin dip treatment showed better survival rate and early establishment followed by four leaves. These plantlets were planted in main field during last week of Dec 2012. Approximately 500 numbers of healthy runners were planted in geometry of 45 x 45 cm in 15 cm raised beds. The runners with the aforementioned pruning treatments were planted in separate beds. The observations taken in the second week of Feb showed that the runners pruned up to four leaves stage were established earlier than other pruned treatments. Similarly, growth attributes such as number of leaves, canopy, no. of flowers etc were also recorded higher with the same treatment.

## VEGETABLES

### CABBAGE

**Effect of different levels of nitrogen, *Azospirillum* and *Trichoderma* on cabbage**

In a split-split plot design experiment four levels of nitrogen (0, 50, 100 and 150 kg/ha) were assigned to main plot, three levels of *Azospirillum* (0, 1.25 and 2.50 kg/ha) were applied in sub plots and *Trichoderma harzianum* was applied in sub-sub plot[with and without root dipping and soil application (5 g/kg of FYM)]. Healthy seedlings were planted in second week of October. Growth and yield attributes were recorded. The crop was harvested thrice in 10 days interval. The head weight was recorded highest in $N_{150}$:$A_{2.5}$:$T_{RD}$(1063 g/plant) followed by $N_{100}$:$A_{2.5}$:$T_{RD}$ (994 g/plant) over control.

### INSECT PESTS

**Study the pest dynamics of cabbage under mid hill conditions**

Cut-worms were observed on up to one month old cabbage plants. Infestation were recorded on two varieties (Rareball and Purple) grown in the farm. The infested plants were made on count to estimate the infestation. An infestation level of 32% was found on the variety 'Rareball' while on 'Purple' it was up to 45%. Larvae of *Pieris rapae* were 1 to 2 larvae/10 plants; infestation was not severe. Flea beetle was also found in some places in farmers' field.

### FRENCH BEAN

**Performance of French bean under different spacing**

A field trial was conducted to evaluate the effect of different spacing treatments on the growth and yield parameters of French bean. Nine different spacing (plant to plant) treatments were imposed *viz*., 5 cm, 10 cm, 15 cm, 20 cm, 25 cm, 30 cm, 35 cm, 40 cm and 45 cm. The row to row spacing was fixed at 30 cm. Before land preparation, 5 t/ha of FYM was applied in the entire area of experiment and recommended dose of NPK/ha were applied at the time of sowing. The highest green pod yield was recorded at the spacing of 15 cm (4.6 t/ha) followed by 20 cm (4.1 t/ha).

### COWPEA

**Effect of nutrient management on growth and yield**

Cowpea variety CP04 was sown in split plot design where potassium was applied in main plot and phosphorus in sub plot. It was recorded that growth and yield attributes was recorded higher when cowpea was grown with 100% P and K. Similarly, crop was harvested with 4.42 and 12.37 t/ha of green pod and stover yield on 100% P and K over control (2.99 and 7.80 t/ha respectively). From the study it was noticed that as phosphorus and potassium level decreased from recommended dose (60: 40 kg P and K/ha, respectively), yield of green pod and stover yield reduced drastically. But, harvest index did not follow any trend and ranged from 0.24 to 0.28.

## SPICES

### GINGER

**Standardization of organic growing of ginger**

Ginger was sown during June under six treatments *viz.,* $T_1$: Vermicompost (VC; 2.5 t/ha), $T_2$: Poultry manure (PM; 1.25 t/ha), $T_3$: Swine manure (SM; 3.0 t/ha), $T_4$: Cow dung manure (CDM; 10.0 t/ha), $T_5$: Farm yard manure (FYM; 10.0 t/ha) and $T_6$: Control and replicated thrice to study the effect of organic nutrients on growth and yield attributes of ginger. Growth attributes were higher with VC followed by PM. The highest rhizome yield was recorded from VC (25.5 t/ha) followed by PM (23.4 t/ha) while, lowest in control (15.5 t/ha).

**Growth and yield performance of ginger and turmeric under land configuration and mulching**

Ginger and turmeric were grown under ridge and furrow (R&F) and flat method, and crops were imposed with three mulches *viz.,* Paddy straw mulch (PSM), *Crotalaria* leaf (@ 5.0 t/ha) and no mulch. R&F method of planting recorded 18.4 and 33.0% higher yield (22.18 and 27.36 t/ha, respectively) than traditional flat method (18.74 and 20.57 t/ha, respectively). Among the mulches, higher rhizome yield of ginger and turmeric was recorded with *Crotalaria* leaf mulch 22.65 and 26.90 t/ha, respectively.

## TUBER CROPS

### COLOCASIA

Eighteen cultivars of colocasia were collected and evaluated for their yield potential. Yield was highest in APTC 5 followed by Muktakeshi (17.4 t/ha). Least yield was recorded in TRC 1 (10.73 t/ha).

### TAPIOCA

Among the eight varieties of tapioca evaluated, Sree Rekha had higher yield (37.6 t/ha) followed by H 226

(35.5 t/ha). The lowest tuber yield was recorded in Sree Jaya (28.0 t/ha) followed by Sree Vijay (29.8 t/ha).

### SWEET POTATO

Among the eight cultivars of sweet potato, highest yield was recorded with ST 12 (23.57 t/ha) followed by Sourin (21.60 t/ha). However, lowest yield was with BDSP 13 (9.47 t/ha).

### DISCOREA

Nine landraces of Discorea were collected and evaluated for their performance. Among these, highest yield was recorded in APTD (23.4 t/ha) followed by APTD 6 (21.2 t/ha). However, lowest yield attributes with lower yield was recorded in TRC 1.

## VETERINARY EXTENSION

### Pig farming practices and adoption level of pig farmers in West Siang district of Arunachal Pradesh

All the circles of West Siang district were surveyed and data were collected by personal interview through interview schedules. The farmers were asked to give their opinion about adoption of feeding practices on four point continuum scale and scores were allotted. The perceived constraints were categorized and ranking was done based on frequency.

**Farming practices**

a. **System of rearing:** The system of rearing depends on the topographic location. In majority of the areas the system of rearing was based on scavenging system (87.5%) followed by (7.7%) semi intensive (7.7%) and intensive system (4.8%). Cent percent of the farmers kept the hog (castrated male) in intensive system.
b. **Housing:** The housing for pigs depends on the availability of the material in the area. About 95.2% of the respondents prepared *kuccha* house of locally available material and 4.8% were cemented type. Majority of the farmers used bamboo (68.42%), followed by wooden planks (26.78%) and cement concrete (4.8%). Dimension of the traditional pig housing system was average height of the house 1.09±0.389 m, average length 2.53±0.21 m, breadth1.967 ±0.02 m.
c. **Feeding**: Pig feeding was based on the availability of resources like household waste, agricultural byproducts and locally available tubers in the region. 11.9% of the farmer provided stall feeding whereas 88.1% provided scavenging cum evening ration. Out of 11.9% farmers, 100% provided stall feeding for fattening purpose.
d. **Health care:** It was found that majority of the farmers never did vaccination of their pigs (95.2%). Only 10.1% practiced deworming of pigs using indigenous traditional method. In the study area, majority of the farmers reported heavy mortality of pigs (82.2%) during the month of August to October.
e. **Breeds:** In the study area the local breeds (99.3%) and crossbred pigs (18.7%) were observed. Cent percent of the farmers practiced natural method of breeding. However, majority of the farmers reported age at first estrus was around 9 months (89.88%) and average litter size at birth was 6.22 ± 0.02.
f. **Marketing:** Majority of farmers sold 2-3 months old piglets (89.13%) @ ₹ 1500 to 2000/piglet, and 62% of the respondent reported their income in between ₹ 6000-8000/annum by sale of pigs.
g. **Marketing channel:** The 78.2% of the farmers reported that they sold their piglets directly in market or to customer. For fatteners, 67% sold their pigs to middle men and finally to butcher and 33% sold directly to the butcher.
h. **Adoption level of different practices:** During the study, it was found that the highest level of adoption (57.50%) was in feeding and the least adoption (12.50%) was recorded in health practices.
i. **Constraints:** The major constraints were non-availability of medicine and vaccine (89.17%) and high cost of feeds (87.6%) in the study area.

## NICRA

## CROP SCIENCES

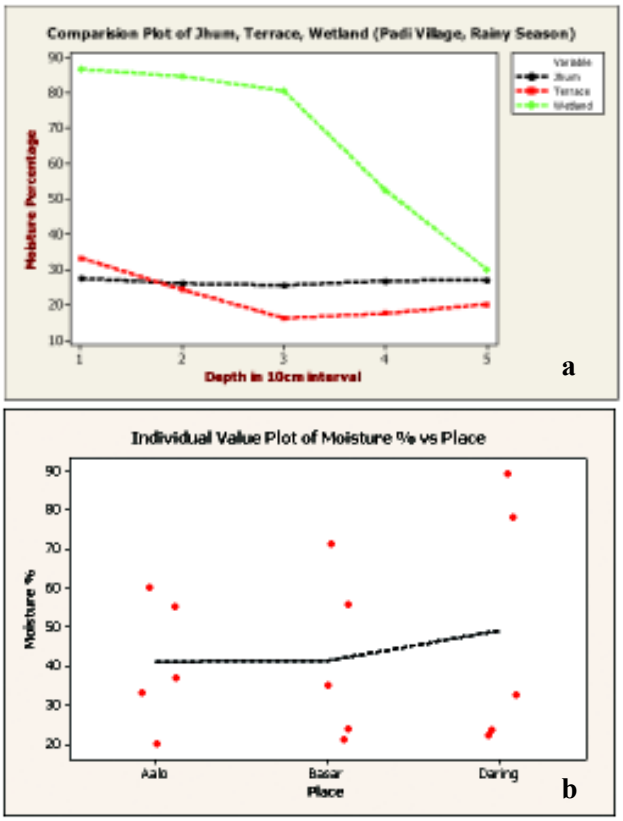
### Effect of tillage and residue management on moisture conservation and carbon sequestration in maize based cropping system

Mustard was sown with three tillage methods such as conventional (CT), minimum (MT) and no tillage (NT) in main plot and residue removal and residue retention in sub plot. The experimental findings depicted that MT gave the seed yield of 0.98 t/ha which were statistically at par with CT (0.95 t/ha). However, the lowest yield was recorded with NT (0.78 t/ha). This confirmed that MT registered 26.1% higher yield followed by CT (21.4%) over NT. Similarly, residue retention registered higher yield (1.00 t/ha) over

residue removal (0.80 t/ha). Residue retention registered 24.8% higher seed yield over residue removal.

**Soil moisture wise contingency crop planning to enhance climate resilience in NE Region (lowland/ upland/*jhum* land)**

The soil samples were collected in four seasons *viz.,* pre-monsoon (Mar-Apr), monsoon (Jul-Aug), post-monsoon (Sept.-Oct) and winter (Dec-Jan) and from six soil depths *viz*., 10 cm, 20 cm, 30 cm, 40 cm, 50 cm and 60 cm. The comparative analysis of various soil samples collected from different locations with different land-use *viz.,* Upland, *jhum,* WRC and terrace were done (Figs 8 a and b).




**Figs 8 a & b Comparison of soil moisture at different land forms and in different circles of the district during pre-monsoon season**

## ANIMAL SCIENCES

### PIGS

**Morphometric characteristic:** The indigenous/ *desi* pigs had black coat colour (58.67%) and black coat colour with white strips in the forehead and legs region (41.44%). Cent percent had pointed snout and hoof line with erected ears (86.67%). The pigs had concave top line (71.66%), bristle length (4-7cm) long (77.66%). Average ear, body length, front girth, hind girth & tail length of piglets were 6.2 ± 0.21 cm, 41.79 ±0.53 cm, 38.38 ± 0.57 cm, 41.42 ± 0.02 cm and 10.72 ± 0.71 cm, respectively. Average ear, body length, front girth, hind girth and tail length of sow were 8.7 ± 0.33 cm, 67.9 ± 1.32 cm, 80.3± 1.62 cm, 83.3 ± 1.42 cm and 25 ± 0.23 cm, respectively.

## IMPORTANT EVENTS

**Workshop:** One day workshop on 'Climate Change, its Impact and Mitigation Strategies' was organized at on 6th January, 2012, where 80 participants attended the workshop.

**Brainstorming session:** 'Development of agriculture and role of KVKs' was organized on 5th January, 2012.

**Kisan Mela:** 'Kisan Mela' was organized on 7th January, 2012, where 500 farmers of the states were benefited.

**Training**

Three farmers' trainings *viz.,*'Strategic water management for sustainable production of field crops', 'Improving agriculture production through efficient water management' (2 nos.) under scaling up of water productivity in agriculture for livelihood (SWPAL) project under Ministry of Agriculture were organized during 09th to 15th Sep, 2011, 6th to 12th Mar, 2012 and 16th to 22nd Mar, 2012. Altogether, 150 participants (50 participants/training) from different circles of West Siang, East Siang, Upper Subansiri and East Kameng attended the trainings. The topics covered were water management on different crops; rain water harvesting; judicious use of harvested water; climate change and its impact on agriculture; improved methods of farming; SRI; soil and water management in terrace and wet land; post harvest and value addition; role of agromet advisory; role of agroforestry for carbon sequestration; conservation agriculture; contingent crop planning; use of improved varieties; selection of varieties as per topography and weather condition; mulch technology; mushroom cultivation; livestock farming etc. Technologies available at centre were showcased. At the end of the day feed back were collected from participants. It was reflected from the feedback that they were very much satisfied.

A three days training programme entitled "Integration of different components, its introduction and management under IFS" was conducted from 1st

to 3rd Feb, 2012 at Daporijo a project site under NAIP. Altogether 25 participants from Gusar and Dumporijo circles of Daporijo attended the training.

**Fig 9 Construction process of *Jalkund***

A hands on training on 'Mushroom production technology' was conducted during 1st to 3rd Feb, 2012. Altogether 80 participants attended the training.

**Fig 10 Demonstration of drip cum mulch in *Khasi* mandarin**

# MANIPUR

## WEATHER REPORT

The highest temperature of 35.6°C was recorded on 11th Jul, 2011. The lowest maximum temperature of 16.9°C was recorded on 2nd Jan, 2012. Annual rainfall recorded during the year 2011-12 was 1576.8 mm. The monthly rainfall was highest in Jun, 2011 (383.2 mm) whereas, Dec 2011 was the driest month with 0 mm rainfall. The maximum relative humidity of 100% was recorded on 14th Jun, 2011, 9th Aug, 2011, 17thand 16th Sep, 2011 and 2nd Jan, 2012 whereas the minimum relative humidity of 17 % was recorded on 12th Feb, 2012. Maximum daily average wind speed of 11.8 km/hr was observed on 15th Mar 2012 (Table 1).

**Table 1 Agro-meteorological data (monthly average) from Apr 2011 to Mar 2012**

| Month | Temp (°C) | | RH (%) | | Wind speed (km/h) | Total rainfall (mm) | No. of rainy days | Bright Sunshine (hrs) |
|---|---|---|---|---|---|---|---|---|
| | Max | Min | Morning | After noon | | | | |
| Apr | 28.2 | 15.5 | 81.0 | 53.3 | 5.8 | 38.9 | 5 | 5.8 |
| May | 28.2 | 19.2 | 85.8 | 68.0 | 5.2 | 274.7 | 13 | 5.2 |
| Jun | 29.8 | 22.0 | 92.2 | 80.5 | 3.4 | 383.2 | 20 | 3.4 |
| Jul | 30.7 | 22.0 | 92.3 | 77.5 | 3.5 | 298.8 | 14 | 3.5 |
| Aug | 30.4 | 21.8 | 92.9 | 77.6 | 3.0 | 278.4 | 18 | 3.0 |
| Sep | 30.3 | 21.4 | 89.4 | 70.1 | 4.5 | 146.6 | 10 | 4.5 |
| Oct | 28.7 | 17.8 | 87.3 | 61.5 | 5.9 | 49.3 | 4 | 5.9 |
| Nov | 27.0 | 9.2 | 86.2 | 47.6 | 8.3 | 1.3 | 0 | 8.3 |
| Dec | 24.0 | 5.6 | 87.5 | 48.0 | 6.9 | 0 | 0 | 6.9 |
| Jan | 22.0 | 5.2 | 84.6 | 50.0 | 5.9 | 26.4 | 3 | 5.9 |
| Feb | 26.0 | 5.8 | 75.8 | 35.2 | 7.5 | 6.0 | 1 | 7.5 |
| Mar | 28.7 | 11.1 | 79.8 | 44.5 | 7.1 | 73.2 | 6 | 7.1 |

## RICE

### Breeding for medium duration rice genotypes suitable for lowland and upland conditions of Manipur

### Selection of promising lines from segregating and subsequent population

$F_4$ populationsfrom the crosses *viz.,* IR64 x SARS9, IR64 x Phungphamah, IR64 x SARS1, IR64 x Phougak, KD 2-6-3 x Yungra Makrei, KD 2-6-3 xWang Shim Makel and KD 2-6-3 x Phougak (Figs 1a & b), were evaluated for yield, diseases, insect resistance, and other parameters. About 200 lines were selected from $F_4$ segregatingpopulation for desirable characters under low land condition. Population of $F_6$ generation from four crosses *viz*., RCM 9 x Manuikharamui, RCM 10 x Akhanphou, Taothobi x RCM 10 and Akhanphou x RCM10 was raised in low land rainfed area and evaluated for yield, resistance to disease and insect-pests and other parameters.

### Station trial on high yielding medium duration rice genotypes

A preliminary yield trial was conducted with 18 advanced breeding lines of rice along with 2 popular checks under lowland transplanted conditions. Six promising lines *viz*., MC34-5-12-33-03-26 (8.40 t/ha), MC34-1-30-75-11-131 (8.26 t/ha), MC34-9-7-7-77-96-02 (8.19 t/ha) and MC34-4-13-45-82-70 (7.94 t/ha) showed significantly higher yield than the local checks RCM9 (6.66 t/ha) and Leimaphou (6.02 t/ha).

In another trial, eight advanced breeding lines of rice along with three popular checks were evaluated under lowland transplanted conditions. One line MC34-10-3-30-75-16-1, was promising and showed higher yield (7.97 t/ha) than all the local checks *viz*., RCM10 (6.89 t/ha), RCM9 (6.39 t/ha) and Leimaphou (5.92 t/ha). This line was moderately resistance to neck and leaf blast.

### Evaluation of rice genotypes for paddy cum fish culture in *kharif*

Twenty five advance lines of rice were tested along with two checks. Majority of them were tall types for

**Figs 1a & b Promising segregants of IR64**

the purpose of paddy cum fish culture. All these lines were tested for yield, tallness, strong culm, reaction to disease and insect-pests. Entries *viz*., MC 34-4-9-1-23-46 (7.58 t/ha), MC 34-1-26-28-8-4 (7.36 t/ha), MC34-1-11-1-89-03-16 (7.35 t/ha), MC34-7-1-14-13-56-46 (7.22 t/ha), MC34-7-6-2-72-92-90 7.22 t/ha), MC34-7-18-1-101-16-36 (7.0 t/ha), MC34-4-4-1-5-51-11 (7.0 t/ha), MC34-10-9-34-34-6 (6.75 t/ha) and MC34-4-3-9-31-18 (6.53 t/ha), were found promising as compared to checks varieties i.e. KD2-6-3 (5.90 t/ha) and Akhanphou (5.86 t/ha).

**Akhanphou - a high value rice germplasm line of Manipur**

A popular local cultivar, Akhanphou has tolerance to biotic and abiotic stresses, adaptation, and desirable taste. With the help of DRR, Rajendranagar, Hyderabad, precise phenotying and genotyping for blast was carried out. It was found completely resistant for leaf blast under uniform blast nursery (UBN) continuously for two seasons. It was screened with markers linked to seven known blast resistant genes *viz., Pi1, Piz, Pita/Pita2, Pi40, Pi54, Pi9* and *Pi2* and marker allelic pattern was compared with the monogenic lines containing those particular genes and it was found positive for four major blast resistant genes such as *Pita/Pita 2*, *Pi40*, *Pi54* and *Pi2*. It was also found tolerant to low phosphorus conditions when screened at DRR and genotyped for presence/absence of *Pup,* the only QTL known to have been reported till date to confer low-P tolerance. The work to find it out in Akhanphou is under progress. Therefore, keeping in view the above facts, this highly valuable local germplasm line will be protected by registering with NBPGR, New Delhi.

**RCM 13: A pre-released short duration rice culture**

RCM 13 (IET No. 22828), a derivative of the cross between Leimaphou x Akhanphou having short duration (days to 50% flowering-75days) trait was found suitable for pre-*kharif* /early *kharif*/main *kharif* (contingency variety). It has desirable soft cooking (low amylose content-11.70%) quality characters preferred by the people of north eastern hill region. So far low amylose content has been reported in traditional land races. It is the first evolved culture having very low amylose content. It has several merits over traditional long duration land races as it matures in about 95-105 days and it will be very much suitable for different cropping systems. Seed demand has been increasing in valley districts due to its unique taste and short duration nature.

## AICRP

Three upland trials of AICRP *viz.,* AVT-1-U-H (10 entries), AVT-2-U-H (7entries), IVT-U- H (10 entries) were evaluated for their comparative performance under upland (direct seeded) conditions during *kharif* 2011. In AVT-1-U-H, entry HPR-2559 (3.40 t/ha), was observed for significantly higher yield than the local check, Bhalum1 (2.69 t/ha), as well as National check Vivek dhan154 (2.59 t/ha). In case of AVT-2-U (H), entry RCPL1-115 (3.72 t/ha), was observed for significantly higher yield than the local check, Bhalum1 (2.10 t/ha), regional check Sukaradhan1 (2.68 t/ha) as well as national check, Vivek dhan 154 (2.76 t/ha). Entry VL7852 (2.68 t/ha) was observed for significantly higher yield than the local check Bhalum-12.10 t/ha). In case of IVT-U (H), National check, Vivekdhan 154 (3.16 t/ha), was observed for significantly higher yield than the local check, Bhalum1 (2.22 t/ha). No other entry was observed for higher yield than the national check. Vivekdhan154 was also observed to be extra early type as 50 % flowering was observed in 65 days.

## Research Complex Regional Trial (RCRT)

**Low land (Transplanted)**

Three trials *viz.,* RCRT LL-1(18 entries), RCRT LL-II (14 entries) and RCRT LL-III (13 entries) were conducted under low land transplanted conditions in Manipur valley during *kharif* 2011. In LL1, two entries *viz.,* RCPL1-401 (6.34 t/ha) and RCPL1-400 (6.38 t/ha), showed significantly higher yield as compared to the RCM 9 (5.16 t/ha). Both these entries were at par with RC Maniphou11 (5.58 t/ha). In LL-II trials, none of the entries was significantly higher yielding than the local check, RC Maniphou11 (4.57 t/ha). In LL-III trials, only one entry i.e., RCPL1-471 (5.82 t/ha), recorded significantly higher yield over the best check RC-Maniphou11 (4.80 t/ha).

**Upland (Directed Seeded)**

Two trials *viz.,* RCRT UL-I (9 entries) and RCRT UL-II (10 entries) were taken under upland conditions at Langol farm during *kharif* 2011. In UL-I trial, Bhalum-3 (3.38 t/ha) and RCPL1-130 (3.20 t/ha) gave significantly higher yield than the best checks Bhalum 1 (2.31 t/ha) and RCM5 (2.25 t/ha). In case of UL-II, Bhalum3 (3.01 t/ha), showed significantly higher yield as compared to the best checks Bhalum-1 (2.31 t/ha) and RCM5 (2.25 t/ha).

**Frontline demonstrations on rice var. RC Maniphou11**

FLD programme was undertaken during *kharif*, 2011 with released high yielding, blast resistant rice variety RC Maniphou 11(IET No. 20193). Ten demonstrations were taken in Imphal West and East, Churachandpur, Tamenglong and Ukhrul districts. Fifteen progressive farmers were selected in consultation with the State Agricultural Department. Leimaphou, a high yielding popular variety (taste preference), was taken as check variety. RC Maniphou-11 gave a yield advantage of 43% over the check. The highest yield (7.50 t/ha) was obtained in Imphal West with average yield of 6.85 t/ha. Since there is shortage of good quality high yielding varieties with locally accepted taste, it would help greatly in increasing the rice production of the state.

## DISEASES

**Evaluation of rice germplasm against different diseases at seedling stage**

Three hundred and thirty six lines/varieties of rice were evaluated for their reaction against leaf blast, bacterial blight and brown spot diseases. For leaf blast, the disease score varied from 1 in Allechiso, Chupu wingrice, Apaghi june, Makhara 11, Kemeste, Chala TSSIA, Otsok Khira, Chingphou, Koyajang, Tengu bepher, Charailu and Atukumupu to 9 in Bhuman, RCM 12, RD5-2-8, Tssok, Myku Duikungmei and SL76. All other lines were free from blast. All the lines were free from brown spot diseases except Sapal maso and Maisajang in which disease score of 2 and 1 was recorded, respectively. The highest bacterial leaf blight disease score of 9 was recorded in Chingphou, Thangmoi, Chakhao local and SS/Chakhao. The lowest bacterial leaf blight score of 1 was observed in Younyo Kangru, Khatuthi, Matamah, Chingphouren amubi, Khangamra, Runya, Acefoghsyo ripit, Chupu wingrice, Desek youso, Apaghi june, Moirangphou Khonembi, Basmati 370, Rozose phek, Kenyo, Ztsukmutasa, MC26-6-2-3, Naga special-2, Imsatang makongching, Laza Tssok, Neikado ulhn Tsia and Chinapati. Out of the 197 entries screened under field conditions, most of them had bacterial blight infection. The highest score of 9 was recorded in TekumTssok, kene, Wazhuho phek, Chah Tssia, Tssok Mayko and Yunyokan stco. The brown spot diseasescore varied from 8 in Kerebe Phek, Laza Tssok, Laispoh, Hokha Tssok and Jaksemla to 7 in Allechisho, Chupu Wing Rice, Phugcham Mah, Tekum Tssok, Wazhuho Phek, Mipin, Chalha Tssia, Ronga 1, Leisemjang, Aya mao mah, Meron Tssok, Phouren , Pondejhum, Mayamoisoida, Yengulo, Kishal, Rishegri, Alechiso, and Machan Kaoyeng. The entries on which leaf blast was recorded at nursery stage were free from the disease after transplanting.

**Screening of rice entries under national screening nursery (NSN–H) against multiple diseases**

Seventy seven entries (NSN-H) sent by DRR Hyderabad were screened for multiple diseases. All the entries were free from leaf blast. The neck blast score varied from 7 in RASI and Improved Samba Mahsuri to 5 in Vikramarya, CH45 and entry 3007 (VL31618). The bacterial blight reaction in different entries varied from 9 in 3510 (VL 8094) to 7 in entries 3508 (VL8051), 3604 (VL8292), KD263, 3102 (HPR2589), 3108 (VL31450), HPR2143, Improved Sambha Mahsuri and RASI. The entries exhibiting score of 1 were 3509 (VL8116), 2801 (HPR 2529-4), 2808 (VL31449), 3401 (VL7954), 3407 (VL7852), 3602 (VL8204), 3610 (HPR2645), 3206 (VL31401), 3207 (VL31348), 3004 (UPR3575-11-2-2), 3006 (VL31616), 3007 (VL31618), 3011 (HPR2615), 3301 (VL31724), 3304 (UPR3573-4-2-1), 3305 (VL31600), 3308 (VL31611), 3314 (HPR2612), 3105 (VL31452), Sukaradhan1, Vivekdhan-154 and IR-50. The disease score for brown spot varied from 7 in entry HPR 2656 to 6 in HPR 2143 followed by 5 in HPR 2618 to 4 in entry RP2421 and KD 263. The reaming entries were either free from brown spot or exhibited a score of 1. All entries were free from sheath rot and rice tungro virus.

## MAIZE

**Evaluation of genotypes under foothill conditions**

Thirty four genotypes of maize along with two checks were evaluated for yield and its component traits. Analysis of variance showed highly significant genotypic differences for yield and its related traits except ear diameter, number of kernel rows and 100-kernel weight. Genotypes BC1 and BC5 recorded shorter duration for days to 50% tasseling and days to 50% silking in comparison to both the checks, Pusa Composite and Local Red. The lowest plant height was measured in genotype BC5 (132.1 cm) followed by SC 4 (149.7 cm). The highest seed yield/plant was recorded in the genotype BC3 (120.1g) followed by SC7 (113.3 g). In genotype BC3, seed yield/plant was contributed by the highest plant height (236 cm) while the maximum ear length (15.4 cm) and cob weight (138.5 g) had significant direct contribution to the seed

yield/plant (113.3 g) in the genotype SC7. The genotype M15 showed the highest kernel rows/ear.

**Collection of maize germplasm lines from north eastern hill region**

Sixty nine germplasm lines of maize were collected from three major states of NEH region *viz.,* Manipur, Nagaland and Sikkim. Those lines had extensive variability for yield related traits such as length of cob, diameter of cob, number of kernels/ row and number kernel rows/ear. The germplasm (Fig 2) will be useful for breeding programme.

**Fig 2 Variability in maize germplasm**

## PULSES

### PIGEON PEA

**Evaluation and advancement of segregating generations of interspecific crosses of pigeon pea**

$F_3$ and $F_4$ progenies derived from crossing between pigeon pea cultivars *viz.,* ICPL 88034, UPAS 120 and its wild relative i.e., *Cajanus scarabaeoides* were evaluated. The test material was kept free from any insecticidal spray throughout the crop season. Out of the 288 $F_3$ progenies, 52 progenies were found promising, derived from the cross ICPL 88034 x *C. scarabaeoides* and UPAS 120 x*C. scarabaeoides*. A promising progeny, 10268-1, showed maximum number of primary branches/plant (19), high seed yield/plant (28.90 g) and lesser pod damage (10.71%). Maximum number of pods/plant (189) was observed in the progeny 10254-2. Seeds/pod ranged from 3.4 to 5.6 in $F_3$ promising progenies of both the interspecific crosses. Whereas, damaged seeds/pod was found to vary from 0.0 to 0.2. The highest seed yield/plant was 37.67 g with minimum pod damage (7.25%) and damaged seeds/pod (0.0) in the progeny 10258-2 that was derived from the cross UPAS120 x *C. scarabaeoides*. Other characters such as plant height (154 cm), primary branches/plant (8), pods/plant (138), seeds/pod (5) and pod length (5.8 cm) were also desirable in the same progeny. A promising progeny 10129-3 showed the lowest pod damage (3.3%) and damaged seeds/pod (0.0), although pod length (6.9 cm) and seed yield/plant (15.38 g) were higher. Total 236 $F_4$ progenies, derived from the interspecific crosses between ICPL 88034 x *C. scarabaeoides* and UPAS 120 x*C. scarabaeoides* were selected for yield and its attributing traits but more emphasis was given on selection for the lowest per cent pod damage and damaged seeds/pod. Out of them, 29 promising progenies showed the least percentage of pod damage (4.26-10.00) by pod borers and almost had lower per cent of seed damage by Bruchid (storage pest). Some progenies were free from damage by Bruchid. However, those progenies were lower seed yielding (4.4- 14.15 g/plant) except two progenies (progeny No. 232-2 and 230-181-1). Four progenies *viz.,* 123 (2)-1, 235-4-1, 234-3-2, 230-185-2 showed lesser damage by Bruchid as well as pod borers with other desirable characters such as pods in cluster, hairy pods, long pods etc.

**Evaluation of long duration pigeon pea genotypes in foothill conditions**

Fourteen genotypes of long duration pigeon pea, collected from Manipur were evaluated under foot hill conditions for seed yield and its contributing characters. Among them, RCMP 6 showed the shortest duration for days to 50% flowering (99 days), shortest plant height (133.1 cm) and the lowest primary branches/plant (7.9). The genotype RCMP4 recorded the highest seed yield/plant (39.5) and maximum number of pods/plant (94). However, RCMP7 showed the maximum plant height (186.9 cm). The highest primary branches/plant was found in genotype RCMP7. Whereas, the maximum seeds/pod (5.6) and pod length (7.9 cm) were registered in the genotype RCMP 10. The highest mean pod damage (26.23%) was recorded in the genotype RCMP1, whereas lowest mean pod damage was observed in RCMP7 (9.69%) and RCMP 9 (9.95%). The highest mean pod damage was noticed in RCMP18 (56%), whereas the lowest mean pod damage (22.5%) was found in RCMP7. Similarly, maximum pod damage by pod boring weevil was recorded in RCMP8 (17.5%), while the lowest mean pod damage was registered in RCMP16 (2%).

### MUNG BEAN

**Partial purification and biochemical characterization of acid phosphatase enzyme from germinated mung bean seeds**

Extraction, partial purification and bio-chemical characterization of acid phosphatase in local mung been germplasm (seed) was undertaken as a step towards understanding its properties. The experimental results showed that the protein content and enzyme activity decreased in the partial purification steps, whereas, the specific activity increased in the

purification process. In the purification step, specific activity was 1.3 units/mg protein, purification was 2.6 foldand recovery of the enzyme was 58.90%**.** To study the effect of reaction time on enzymatic activity, acid phosphatase activity increased slowly from 10 to 40 minutes of incubation and thereafter the activity decreased gradually. The enzyme was found to be active over a wide range of temperature (30-80$^{o}$C) and maximum enzyme activity was observed at 80$^{o}$C. The result showed thermostable property of acid phosphatase. After 80$^{o}$C, enzyme activity decreased noticeably indicating that the protein undergoes an irreversible denaturation beyond 80$^{o}$C. In the study on effect of pH on enzyme activity, it was revealed that the activity increased from pH 3 to 5.2 and the optimum pH was 5.2. In the present study, pH might have influenced the enzyme activity either by changing the ionization of the enzyme substrate complex or various groups of the enzyme molecule which may affect the affinity of the enzyme for the substrate or by changing the ionization of the substrate to the enzyme. The enzyme activity was also measured at different substrate (p-NPP) concentration from 0.1mM to 12mM. The results showed that with an increase in substrate concentrations from 0.1 to 0.8mM, there was a corresponding increase in the rate of reaction and linear relationship was obtained at 2 to 14mM. According to Lineweaver Burk hypothesis, both Michaelis Menten Constant ($K_m$) and maximum velocity of the enzyme ($V_{max}$)value were calculated. The $K_m$ value was 0.38mM and $V_{max}$ was 1.2 µmoles/min/mg protein. This result shows that mung bean acid phosphatase has higher affinity with p-NPP and therefore favoured reaction rate. Hence, consumption of germinated mung bean would be helpful for adapting organic phosphorous into available phosphorous that involved in many biological functions such as cell growth and division.

## OILSEEDS

## GROUNDNUT

### All India Coordinated Research Project on Groundnut

Twelve bold seeded groundnut varieties (A series) were tested. The var. ICGS76 was the best yielder (3.41 t/ha) followed by NRCG-CS268 (2.84 t/ha). The lowest yield was observed in var. TPG41 (1.23 t/ha) (Fig 4). In another trial, 14 confectionary groundnut varieties were evaluated. The maximum yield was recorded in TG37-A (3.31 t/ha), followed by ICGS76 (3.27 t/ha) as compared to lowest yield (1.83 t/ha) in GG16 (Fig 5). Among 18 advanced groundnut varieties (C-series) tested, ICGS76 gave the maximum yield (3.37 t/ha), followed by K134 (3.32 t/ha) as against the lowest yield

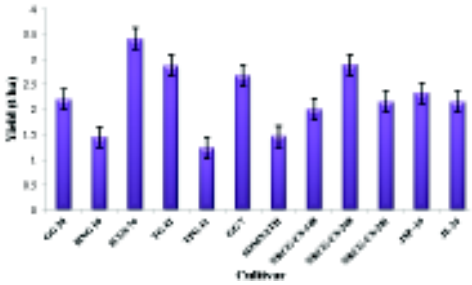


**Fig 4 Series A**

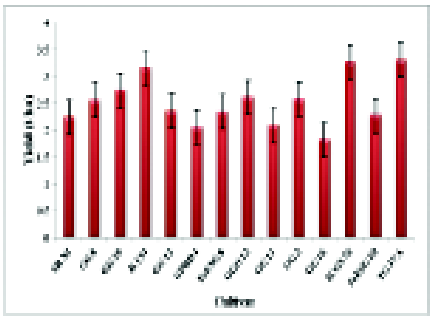


**Fig 5 Series B**

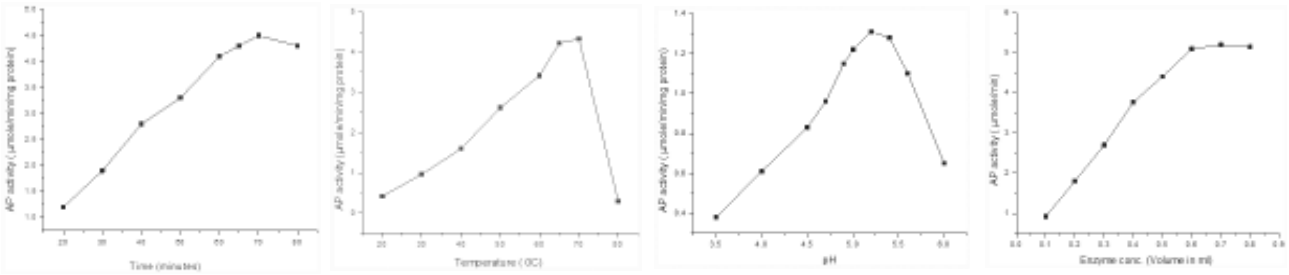


**Fig 3 Effect of reaction time, temperature, pH and substrate concentration on acid phosphatase activity**

(1.32 t/ha) obtained in GG14 (Fig 6). Of 18 varieties (D-Series) evaluated, ICGS76 was the highest yielder (3.34 t/ha) followed by NRCGS268 (2.81 t/ha) as compared to lowest yield (1.07 t/ha) in BG3 (Fig 7).

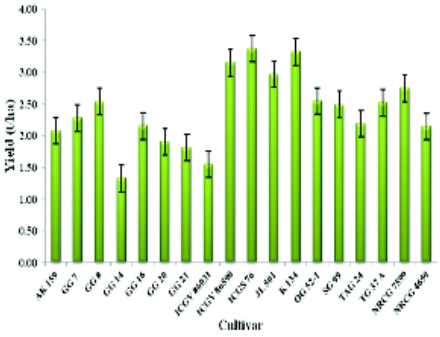



**Fig 6 Series C**

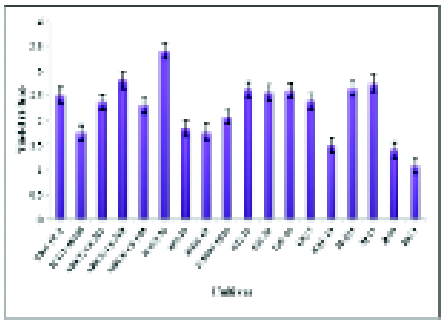


**Fig 7 Series D**

### Boron nutrition in groundnut

The efficacy of different commercial formulations of boron on growth and yield of groundnut (ICGS76) was studied. The result revealed that the soil application of Solubor @ 10 kg/ha was the best and gave maximum yield (3.60 t/ha), followed by soil application of Borosol (3.4 t/ha), Chemibor (3.07 t/ha) and Maxibore @ 10 kg/ha (2.90 t/ha) against the lowest yield (2.40 t/ha) in control.

## HORTICULTURE

## FRUITS

## CITRUS

### Standardization of DUS testing guidelines

To standardize the DUS testing protocol for three citrus species *viz.*, *Citrus reticulata*, *C. sinensis* and *C. aurantifolia*, two orchards of *Khasi* mandarin were selected in Tamenglong district of Manipur. The perusal of the data revealed that the range for length and width of leaf lamina was 6.04-8.10 cm and 2.43-3.31 cm, respectively. In all cases, petiole wing was present and flowers were hermaphrodite in nature. More than 4 stamens were observed per petal. Weight, diameter and length of fruits varied between 101.31 to 159.90 g, 38.00 to 70.50 mm and 32.62 to 66.90 mm, respectively. Shape of fruit base was concave collared with truncate shaped fruit apex. Fruit surface texture was smooth, colour of cotyledon and albedo was green and white, respectively. The juice content in endocarp varied between 21-44% with a TSS: acid ratio from 8.34-12.21.

## PASSION FRUIT

### Organic package for passion fruit based cropping system

A new plantation of passion fruit (Yellow variety) was established on the ridges of the terraces. The intercrops *viz.,* pineapple (Kew), turmeric (Megha Turmeric 1), ginger (Nadia), capsicum (Thai Wonder), brinjal (RCMB-10), okra (BSS-596) and amaranthus (Local) were evaluated under different combinations of bio-organic inputs. The maximum yield of passion fruit (23.63 t/ha), ginger (28.45 t/ha), capsicum (9.27 t/ha) and brinjal (18.45 t/ha) were recorded with the application of Vermicompost (6.5 t/ha) + *Azospirillum* (20 kg/ha) + PSB (20 kg/ha) + AM (65 kg/ha) whereas, highest yield of okra (3.58 t/ha) was found in FYM (20 t/ha) + *Azospirillum* (20 kg/ha) + PSB (20 kg/ha) + AM (65 kg/ha). Recommended dose of inorganic fertilizers showed maximum yield in pineapple (44.21 t/ha) and turmeric (24.60 t/ha).

## VEGETABLES

## TOMATO

For paddy fallow condition in Manipur, high yielding pre-released variety Selection 11 was developed and tested in AICRP (V). The trial for Selection 11 at farmer's field is under progress. During 2011-12, MCTR5 (Fig 8) (38.3 t/ha), MCTR3 (37.9 t/ha), MCTR4A (36.8 t/ha), RCT 1 (36.8 t/ha), MCTR

**Fig 8 MCTR-5**

4B (36.7 t/ha), RCT 3 (36 t/ha) and RCT 2 (35.5 t/ha) were found promising as compared to check variety DVRT2 (35.2t/ha).

## BRINJAL

Eight promising genotypes of brinjal (long purple type) were evaluated along with released variety Arka Keshav for resistance to bacterial wilt. Among them, maximum yield (31.94 t/ha) was recorded with RCMB7, followed by RCM10 (30.40 t/ha) as compared to 16.82 t/ha in Arka Keshav. RCMB 10 was found to be moderately resistant to bacterial wilt. RCMB10 was proposed for inclusion in the All India Varietal Trial under AICRP (V) during 2012-13.

## COLOCASIA

Experiment was conducted with clonal selections (RCMC 1 to 10) under foothill condition. Among the different clones, the RCMC 1 was the best for yield (31.37 t/ha), followed by RCMC4 (29.38 t/ha) and RCMC 5 (28.31 t/ha). The RCMC 5 was found moderately resistant to leaf blight. RCMC1 was introduced at farmers' field under OFT programme of KVKs.

## SPICES

## TURMERIC

The experiment was undertaken to develop suitable varieties of turmeric for Manipur by clonal selection form potential indigenous germplasm. A total 26 advance breeding lines of $F_8$ generation were evaluated. The accession RCMT7 performed best (31.89 t/ha), followed by RCMT4 (31.03 t/ha). Among the other clones, RCMT14 (24.99 t/ha), RCMT3 (24.35 t/ha) and RCMT5 (24.10 t/ha) were also found promising. In terms of curcumin content, RCMT7 (8.5%), RCMT 23 (7.45%), RCMT13 (7.35%) and RCMT12 (7.10%) were found promising.

## CHILLIS

### Genetic diversity of King chilli landraces of Manipur using microsatellite marker

Twenty two King chilli landraces were collected from different parts of Manipur, including one from Nagaland. In addition, two commercial capsicum varieties (Thai Wonder and Yellow King) were included in the study. Thirty eight SSR primers were used for charcaterization of landraces. Similarity revealed 88% similarly between RCMKC1 and11, whereas very low level of similarity (65%) existed between Thai Wonder and Yellow King (*Capsicum annuum*). Cluster analysis was used to group the genotypes and to construct a dendogram. Nine distinct groups (Fig 9) resulted out of analysis of pooled SSR marker data. The dendogram revealed that the genotypes that are derivatives of genetically similar types clustered together. The result of principle component analysis was similar to UPGMA analysis. The Manipur landraces were found to be different from Nagaland genotype included in the study. The Nagaland Local has similarity with RCMKC7 and RCMKC9. Both the landraces were collected from Ukhrul district.Among the Manipur genotypes, RCMKC7 was found to be different from rest of the group. The landraces collected from Chatrik village of Ukhrul and Thingkeu village of Churachandpur was also found to be different from other Manipur landraces.

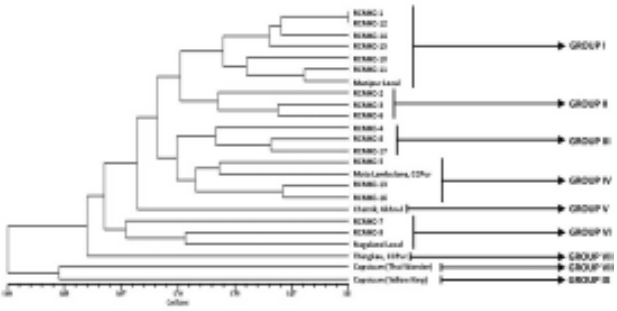


**Fig 9 Dendrogram showing diversity of King chilli genotypes**

## DISEASES

### Studies on diseases of King Chilli (*Capsicum chinense*) and their management

The survey was carried out in localities around Imphal to assess the incidence of different fungal and viral diseases in King chilli. The fungi isolated and identified from King chilli were *Cercospora capsici*, *Colletotrichum capsici*, *Glomerella cingulata*, *Corynespora cassicola* and *Phoma destructiva*. There is sporadic occurrence of virus diseases in the field. The symptoms consisted of inward rolling of leaves, shoestring, yellow mosaic and necrotic rings on leaves. To find out the seed borne nature of the viruses, the seed was extracted from virus infected plants. The seeds were sown under insect proof net to observe the expression of symptoms on newly emerged leaves. Out of the 2000 plants observed in the nursery, none showed expression of symptoms, thereby indicating that the viruses are not transmitted through seed. The virus

inducing shoe stringing symptoms was transmitted to 7 healthy plants of King chilli and there was shoe stringing of King chilli leaves. The plants showing different symptoms were tested using polyclonal antisera against *Potato virus Y* (PVY), *Cucumber mosaic virus* (CMV) and *Bean common mosaic virus* (BCMV). Bean common mosaic virus has not been reported from chilli. On the basis of comparison of the absorbance readings of the negative controls (healthy samples) with the absorbance readings of the samples, none of the plants were infected with either *Potato virus Y* or *Cucumber mosaic virus* or *Bean common mosaic virus*. The samples from plants exhibiting different symptoms were thin sectioned and analyzed with transmission electron microscope at North Eastern Hill University, Shillong. Analysis of the photographs did not reveal the presence of virus particles or inclusion bodies. The crude virus extract of different virus infected King chilli samples was also subjected to Transmission Electron Microscopy and it revealed the presence of flexuous virus particles which means that the virus belonged to genus *Potyvirus* of family Potyviridae.

## POST HARVEST TECHNOLOGY

### Evaluation of the stability of *sohiong* squash

The study was carried out to ascertain the effect of different temperature and storage conditions on the stability of squash of *Prunus nepalensis* (an important indigenous fruit of Manipur and Meghalaya). Squash was prepared as per the FPO specification. The storage conditions were 0°C Day Light ($T_1$), 35°CDay Light ($T_2$), 0°C Dark Light ($T_3$), 25°CDark Light ($T_4$) and 35°CDark Light ($T_5$). Observation on TSS, total sugar, titratable acidity, pH and total anthocyanin content was recorded at one month interval for 3 months. Statistically non-significant differences were observed in the studied parameters and the variation was so narrow that almost a constant TSS, total sugar, titratable acidity and pH value were observed during the experimentation period. However, significant change was observed in total anthocyanin content (Fig. 10) with respect to different temperature and storage conditions as well as duration of storage, where 0°C Dark retained the maximum anthocyanin (150 mg/100 ml) and 35°C Day retained the least anthocyanin content (130 mg/100 ml). The changes might have occurred due to degradation and polymerization of red pigments or due to effect of fructose produced by the hydrolysis of sucrose. The least change in the TSS, acidity, pH and total sugar of the squash during storage reflected that the product was stable and there was no biochemical and microbial spoilage.

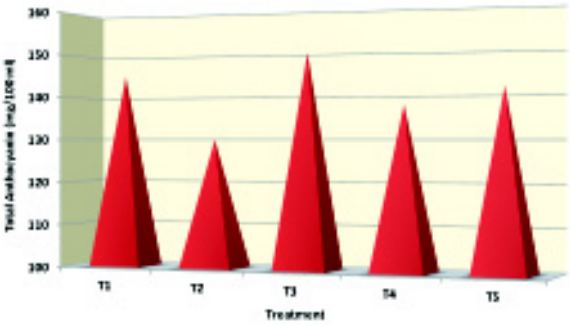



**Fig 10 Changes in total anthocyanin content of *sohiong* squash**

### Value addition in underutilized horticultural crops

The recipe for different value added products (Figs 11-14) were standardised. The list of the products developed were as given below

*Citrus jambhirri* : Juice, Ready to serve, Squash, Sweet pickle, Hotpickle

*Passiflora edulis* : Juice, Ready to serve, Squash, Ice cream, Powder

*Averrhoa carambola*: Squash, RTS, Blended juice with passion fruit

*Prunus nepalensis* : Squash, Ready to serve, Jam, Powder

*Elaeagnus umbellata*: Squash, RTS, Blended juice with passion fruit

*Emblica officinalis* : Juice, Candy

*Capsicum chinense* : Pickle

In addition, spray drying technique for *Ananas comosus*, *Prunus nepalensis* and *Passifloraedulis* was standardized.

**Fig 11 Spray dried powder from pineapple, *sohiong*& passion fruit**

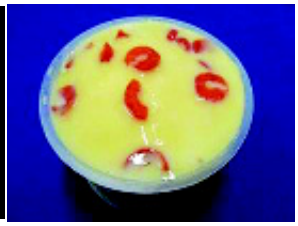


**Fig 12 Passion fruit flavoured ice cream**

**Fig 14 Value added products from Japanese silverberry**

## TECHNOLOGY MISSION (MM I)

### Horticulture based cropping system for livelihood improvement of hill farmers in Manipur

Blocks of banana (Grand Naine), orange (*Khasi* mandarin), lemon (Kachai Lemon), passion fruit (Kaveri) and pineapple (Kew) were developed. The orange, lemon and passion fruit plantations are still at vegetative stage. Banana var. Grand Naine and pineapple var. Kew showed a potential yield of 42.50 t/ha and 45.66 t/ha, respectively. The standardization of suitable intercrops under horticulture based cropping system was done. In the first experiment, cucumber var. Tohfa-786 was evaluated with four different trellis system *viz.,* bower system, espalier system, single wire system and telephone system. In terms of yield and number of fruits per vine, espalier (kniffin) system of trellis was found most suitable for cucumber in paddy fallow of Manipur valley.

### Protected cultivation package for watermelon

The experiment was undertaken to standardize the low-cost protected cultivation package for watermelon to avoid frost injury and shorten the gestation period. Hybrid varieties *viz.,* Namdhari and H20 were transplanted under low-cost poly tunnel and open field condition. The fertilizers were applied through fertigation and soil application. Irrigation was applied through drip method. Maximum yield (35.5 t/ha) was recorded with poly tunnel and soil application of fertilizers, followed by poly tunnel and fertigation (28.2 t/ha) and control plots (15 t/ha). The results indicated that the gestation period can be shorten by one month by using low cost poly tunnel as compared to open field condition.

### Standardization of life-saving irrigation technology for different horticultural crops

Water is the most scarce commodity in Manipur during winter season. In this backdrop, the present experiment on low cost drip irrigation in cauliflower var. White Flash was undertaken. The crop was irrigated for 2 hours daily and at an interval of 2 days, 3 days and 4 days. Maximum curd formation was recorded with irrigation at 3 days interval. Maximum yield (16.9 t/ha) was observed with daily irrigation, followed by irrigation at 2 days interval (16.2 t/ha), but the difference was statistically non-significant. Therefore, drip irrigation for 2 hours at two days intervals can be recommended for cauliflower under Manipur valley. Another experiment has been undertaken to standardize the micro-irrigation requirement of cucumber var. Alamgir CT 380. The crop was irrigated daily and 2, 3, 4, 5 and 6 days interval through low cost drip irrigation. Need based irrigation was included as control. Espalier system of trellising was followed for the crop. The experimental results revealed that, drip irrigation for 2 hours at 2 days interval recorded maximum yield (29.7 t/ha) of cucumber as compared to 8.5 t/ha in control, indicating a great scope for large scale cultivation of cucumber in paddy fallow.

**Table 2 List of trainings and demonstrations**

| Topic of the Training/Demonstration | Number |
|---|---|
| Improved production and rejuvenation package for *Khasi* mandarin, Kachai lemon and large winged orange (Heiribob) | 8 |
| Improved production technology of passion fruit | 1 |
| Scientific production technology for vegetables | 4 |
| Technology for seed tuber production (TPS) | 1 |
| Mushroom production technology | 2 |
| Improved production package of turmeric and ginger | 2 |
| Value addition of fruits and vegetables | 4 |
| Farmers' field day on cabbage | 1 |

**Fig 15 Community based value addition of King chilli**

**Fig 16Off-season vegetables farming**

### National network project on integrated development of Jatropha

Under the R&D programme, local exploration was conducted for collection of local genotypes of Jatropha in Manipur. All total 21 local germplasm lines (MNJ 001 to MNJ021) were collected, out of which, three accessions (MNJ 001, MNJ 006 and MNJ017) were found to be promising for oil content (> 40%). Different trials *viz.,* Progeny Trial, Zonal Trial, Multi locational Trial, National Trial I, National Trial III and Local Trial were conducted and promising accessions were identified (Table 3).

In addition, research was undertaken to standardize the package of practices for Jatropha under Manipur condition. Under spacing trial, the maximum fruit yield and seed yield for both MNJ002 (1010 g/plant and

**Table 3 List of trials on jatropha**

| Name of the trial | Year of planting | No. of genotype | Promising genotype(s) |
|---|---|---|---|
| Progeny Trial | July, 2006 | 13 | MNJ002, TFR01 and JIP-13 |
| Zonal Trial | Aug., 2006 | 6 | JIP-13 |
| Multilocational Trial | July, 2007 | 10 | Plants are still at vegetative stage |
| National Trial I | Aug., 2006 | 6 | TFRI-01 |
| National Trial III | Aug., 2008 | 7 | Plants are still at vegetative stage |
| Local Trial | Aug., 2006 | 16 | MNJ-001, MNJ-002 and MNJ-006 |

600 g/plant, respectively) and MNJ005 (748 g/plant and 479 g/plant, respectively) was recorded with plants spaced at 3 m X 3 m. However, due to higher population, plants spaced at 2 m X 3 m distance produced maximum fruit as well as seed yield in both MNJ-001 (1411.67 kg/ha and 825 kg/ha, respectively) and MNJ-005 (1231.67 kg/ha and 801.67 kg/ha, respectively).

## SEED TECHNOLOGY

### Feasibility study on scientific production and storage of farmers' saved seed in major crops

In rice varieties RC Maniphou-7 and RC Maniphou10, the off types could be reduced to 0.48% as compared to 20.83% and 8.93%, respectively under farmers' field conditions. The yield advantage due to seed quality was as high as 22.65% over those using locally saved seeds. In maize, the purity of the variety could be maintained to certification standard. The maize variety, Pusa Composite-3, seed was produced with time isolation by *rabi* sowing in Thoubal and Imphal West district and was maintained upto 7$^{th}$ generation and purification (selection) to obtain certifying level quality saved seeds. In rapeseed, Sep to Oct sowing with zero tillage technique, isolation could avoid outcrossing. In M 27, rapeseed early sowing during Sep-Oct maintained the purity level within permissible limit under Indian Minimum Seed Certification Standards. Seeds stored under desiccated condition in low cost RC seed bin maintained the minimum standards and seed health quality for more than two sowing seasons when compared to the ambient traditional storage (ambient) practice which maintained the quality hardly for eight months. Seed moisture in RC-Seed Bin was maintained at 10.5% in rice, 10.7% in maize and 8.25% in rapeseed.

### Maintenance breeding of crop varieties

Two varieties for pre *kharif viz*., RC Maniphou 4 and RC Maniphou5 and four main *kharif* varieties *viz*., RC Maniphou6, RC Maniphou7, RC Maniphou10 and RC Maniphou 11 were taken. In maize, composite variety Pusa Composite 3 has been maintained since 2005 with time isolation by sowing during *rabi*. Rapeseed variety M 27 was maintained for 6 years with purity level through early sowing and selection. During the year, altogether 2719 kg basic and labelled seeds were produced. RC Maniphou4 (1155 kg) and RC Maniphou5 (1680 kg) were produced as pre *kharif* varieties. 3770 kg of basic seeds of RC Maniphou7, 900 kg of RC Maniphou10 were produced. Seeds of RC Maniphou-6 (90 kg) and newly released RC Maniphou11 (390 kg) were under nucleus seed stock production through panicle row selection. In addition, 7944 kg labelled seed of different rice varieties were produced. In maize, 60 kg of basic seed of Pusa Composite3 was produced. In rapeseed (M27), pure seed was maintained by early sowing and 80 kg of breeder quality seed and 590 kg foundation seed was produced. In groundnut, variety ICGS 76 (210 kg seed) and in soybean, varieties JS 335 (250 kg) were maintained. In addition to this, 300 local rice germplasm lines are also maintained.

### Development of seed storage practice: use of botanicals in seed storage

In order to develop sustainable low cost medium seed storage technology for different crops, studies were conducted in major crops *viz*., rice, maize, soybean, rapeseed and pea. The effect of botanicals in seed storage was assessed. There was reduction in storage pests with application of locally available botanicals *viz*., *Artemisia parviflora*, *Goniothalamus sesquidedalis, Plectranthus ternifolius* and *Vitex negundo*. These botanicals, when applied to the storage pests exhibited knock down effects showing repellent action but no lethality of the insects was noticed. Efficacy period of the plants tested was 5-12 days. Seed viability too declined beyond the permissible limit after the second sowing season. However, storage of treated seeds with powders of the above plants under desiccated conditions through charcoal could reduce the moisture and thereby the infestation of macro and micro organisms too. Desiccated conditions could maintain seed quality up to two sowing seasons and retain the mycloflora at negligible level (0 after 8-20 months). Among the four plant species, *Plectranthus ternifloius* (26.5)was found to be most effective in reducing the seed micoflora against control (34.3).

**Development of seed production packages in important crops**

For self pollinated crops like rice, peas, legumes, not much problem were noticed if some recommended standards are adopted for seed source, site selection, roguing, handling and storage. In outcrossed crops like maize, rapeseed and mustard, time isolation were more practicable than the distance isolation. For maize (open pollinated varieties), time isolation by *rabi* planting (Oct-Jan) was found suitable both for pollination and post harvest operations. Early planting (Aug to Oct depending on soil moisture) was suitable for rapeseed, (M 27) in the uplands. For this variety, seed produced under zero tillage practice was also suitable for time management (early sowing) besides maintaining the high seed quality level. Seed production studies in wetland rice found that the spacing of 20 cm × 10 cm with a gap of 0.5 m after every 1.5 m gave better seed yield of 3.7 t/ha. In pre-*kharif,* yield of RC Maniphou 6 was 3.5 t/ha, RC Maniphou 4 (3.34 t/ha), RC Maniphou 5 (3.10 t/ha). In *kharif* varieties, higher yields of RC Maniphou 7 (3.77 t/ha), RC Maniphou 10 (4.62 t/ha) and RC Maniphou 11 (3.77 t/ha) were also recorded. In maize good seed under *rabi* (Jan) sowing was obtained as intercrop with field pea. In rapeseed, the sowing in the valley and in the hill gave a yield of 0.5 t/ha. Spacing of 40 cm × 30 cm was found better in soybean (JS 335) over closer spacing. In groundnut, early sowing during first pre-monsoon (Apr-May) was favourable to escape leaf spot disease for better seed health. Earlier than May sowing of soybean gave poor seed set and yield as well as seed health due to rust infection.

## NICRA

## CROP SCIENCE

**Survey, collection and screening of cold and drought tolerant rice germplasm**

Five rice varieties *viz*., Leimaphou, RC Maniphou 7, RC Maniphou10, CAUR1 and RC Maniphou11 were screened for cold tolerance by late sowing on different dates i.e., 3rd and 22nd August, 2011. In early sown condition, RC Maniphou 10 gave better seed set percentage (55.55 %) followed by RC Maniphou 7 (30.27 %). Again in late sown conditions, RC Maniphou7 (8.03 %) had better seed set percentage than other varieties. The maximum temperature ranged from 22.3 to 32.6 $^0$C and minimum temperature ranged from 6.9 to 18.5$^o$C during the flowering stage in the first sowing. For the second sowing, maximum temperature ranged from 20.9 to 28.7$^o$C and minimum temperature range from 1.9 to 11.6$^o$C during the flowering stage. The performance of the varieties declined with lowering of the temperature.

**Fig 17 Grow out test of farmers' own rice**

**Study on effect of submergence on growth and yield of rice**

Submergence tolerance study of rice was carried out on five varieties such as RC Maniphou 6 (RCM 5), RC Maniphou 4 (RCM 7), RC Maniphou 7 (RCM 9), Taothabi (local floating rice) and Akutphou. Varieties with 60, 45, 30 and 20 days old seedlings were half submerged for 5, 10, 15 days and full submergence for 5, 10, 15 days. Among the varieties, 60 days old seedlings of Taothabi had the highest plant height of 114.33 cm in 15 days under half submergence followed by Akutphou with 98.67 cm with 15 days half submergence. The highest grains/plant was found in the variety RC Maniphou 7 with 914.34 filled grains in 5 days half submergence followed by RC Maniphou 4 with 800 filled grains in 10 days half submergence of 60 days old seedling. Seed set percentage was highest in 60 days old seedlings RC Maniphou 7 in 15 days half submergence followed by RC Maniphou4 with 84.67 % 60 days old seedling. The weight of seed per panicle was highest in RC Maniphou 4 with 5.27 g followed by RC Maniphou 6 with 3.41 g half submerged for 10 days in 60 days old seedling. It was found that seedling with longer duration showed better performance than the shorter duration seedling either submerged for half or full submergence.

**Fig 18 Own maize seed production by a farmer with time isolation (*rabi* sowing)**

**Impact of climatic factors on production and productivity of tomato**

For efficient crop planning and water management under the existing trend of climate change, the trend analysis of daily average weather variables at Manipur Centre (24°45'N, 93°54'E, 774 m above MSL) using Mann-Kendall test and Sen's slope method, showed varied annual trends. Increasing trend was observed for annual average of both $T_{max}$ (0.0055°C/day) and $T_{min}$ (0.0244°C/day); whereas, annual average of $T_{max}$ and $T_{min}$ was 26.63°C/day and 14.51°C/day, respectively. In case of annual rainfall, no. of rainy days and annual average relative humidity, increasing trend was observed (3.04 mm/year, 0.071 days/year and 0.166%/day, respectively). The normal annual rainfall was found to be 1430.7 mm whereas, the average number of rainy days was found to be 97.00 days/year. The annual average of $RH_{Mean}$ was found to be 75.09%/day. However, the coefficient of variation w.r.t. distribution of rainy days was 12.11%, indicating that the pattern is not irratic (CV=20%). The results revealed that there is an increasing trend in the temperature, emphasizing to develop varieties with crop diversification to withstand the heat and cold tolerance simultaneously.

**Impact of weather parameter on population build up of aphids on cruciferous crops**

In mustard, aphid population showed its presence throughout the cropping season. During vegetative stage aphids were observed on leaves and with the onset of reproductive phase the population shifted from foliage to inflorescence. From last week of Oct, population started increasing and reached to its peak level in the first week of December (4-10 Dec) when mean maximum and minimum temperature, morning and evening relative humidity, wind velocity, morning and evening cloud cover and sunshine hrs were 25.0°C and 8.8°C, 87.71and 55.57%, 2.2 km/hr, 6 and 4 okta and 5.96 hrs. The correlation between aphid population and weather parameters in mustard showed no relationship.

In cole crops, aphid appeared in the last week of December (25-31 Dec) with an average population of 1.34, 0.68 and 0.8 on cabbage, cauliflower and broccoli, respectively, The peak level of aphid infestation (average population 362.56, 224.56 and 157.7 on cabbage, cauliflower and broccoli, respectively) was attained in 3rd week of March (11-17 March) when mean maximum and minimum temperature, morning and evening relative humidity, wind velocity, morning and evening cloud cover, sun shine hrs and rainfall were 27.81 and 10.83°C, 82.29 and 41.0%,7.04 km/hr, 3.43 and 4.57,7.54 hrs and 0.00 mm, respectively. Aphid population in cabbage, cauliflower and broccoli was positively and significantly correlated with temperature and wind speed. Major insect pests observed were same on cabbage, cauliflower and brocolli.

Cabbage butterflies (*Pieris brasssica* and *P. candida*)infestation was more on cabbage than cauliflower and broccoli. Aphid (*Brevicorryne brassicae, Lipaphis erysimi*), Diamond back moth (*Plutella xylostella*),Cabbage green semilooper (*Trichoplusia ni*) were also recorded. In mustard, saw fly (*Athalia lugens proxima*), cabbage butter flies (*Pierisbrassicae* and *Pieris canidia*), pea pod borer (*Lampides boeticus*), and Bihar hairy caterpillar were major pests.

## ANIMAL SCIENCE

**Performance of CB piglets (Hampshire & Yorkshire) and Vanaraja birds**

Performance of 15 CB piglets distributed among beneficiaries of Imphal West (4) and Tamenglong (3) was assessed. Growth rate was better in the valley of Imphal West district; this indicated better availability

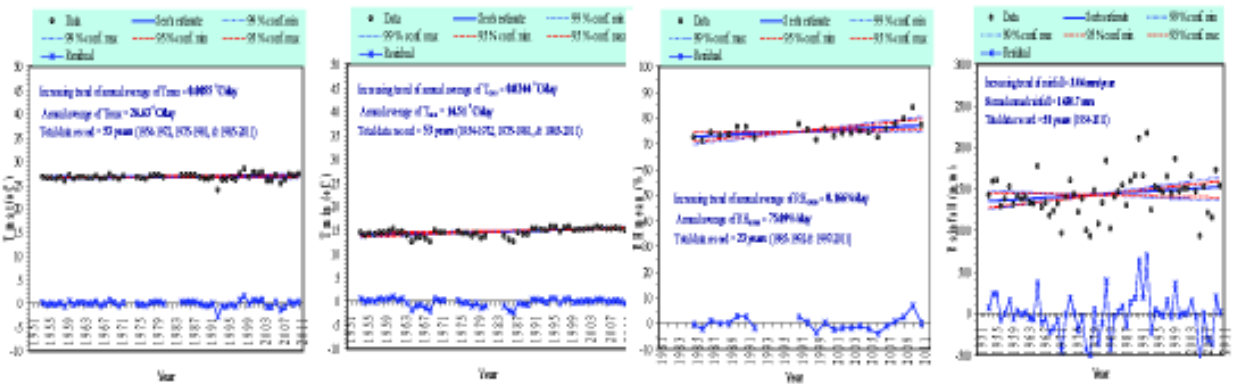


**Fig 19Trend analysis of daily average weather variables at Manipur centre**

of food resources from various sources and provided better nutrition. Average daily weight gain in Hampshire CB male was 13 g/day at 3 to 4 months and in female 4 g/day. In HSR X YSR, 51 g/day in male and in female 12 g/day. The piglets were vaccinated against Hog cholera and FMD. De-worming for internal parasite was accomplished with Piperazine liquid and Albendazole. There was no mortality up to 4 months. The overall morbidity recorded was 55% and major clinical conditions recorded were anorexia (55%), diarrhoea (15%) and skin disease (5%). Cocidiosis and ascariasis were common among the piglets. In poultry, Vanaraja birds under semi-confinement system of rearing attained body weight (g) of 906.07, 1516.03 and 2906.87 at 10, 16 and 40 wks, respectively. Age at sexual maturity was 162-175 days. Marketing age reached in 12- 15 weeks.

## FISHERY

### Induced breeding of *Bangana dero* in extended breeding season

*Bangana dero* is an indigenous minor carp of Manipur. It is a seasonal spawner that spawns only in river during June-July. An attempt was made to breed the fish in mid September i.e., beyond normal breeding season by induced breeding using synthetic hormone, Wova, FH at different doses. Two doses of Wova FH @ 0.5/kg and 0.6/kg were tested. Three sets of spawners of each dose at the ratio of 1:1 were selected for the induced breeding experiment. The selected doses were injected on the dorsal muscle above the lateral line. After the injection, the brooders were released in circular breeding and 6-7 hours after injection, the fish showed responses of behavioural changes and released eggs. Fertilized eggs were hatched out between 24-48 hrs after fertilization. The fertilized eggs underwent development and young hatched larvae measured 4.2 mm long and 1.5 mg in weight. They did not take exogenous food for about 72 hours at 25°C. The yolk sac was fully absorbed on the 4 day and the hatchlings grew to 5.5-6.0 mm.

### Suitable larval rearing and grow out culture techniques of *Clarias magur*

*Clarias batrachus* now known as *Clarias magur* is commonly known as Ngakra in Manipur. The aim of the present study was to find out suitable larval rearing and grow out culture techniques. Highest growth rate (0.053/day), percentage growth rate (131.6%), specific growth rate (59.78) and survival rate (84.2%) of *C. magur* was obtained in fish stocked in a pond having 0.80 cm water depth.

### Standardization of seed production and culture techniques of some potential indigenous fish species of manipur for aquaculture

#### *Bangana dero*

*Bangana dero* fries having 0.85±0.1g weight and 5.1±0.1cm length were stocked in 3 different earthen ponds having 88 sq m area in different stocking densities i.e., 65, 88 and 132 fishes @ 8,000/ha, 10,000/ha and 15,000/ha, respectively. Fishes were fed with pelleted feed having 30% CP @ 5% body weight per day. Fish samples were weighed at every 10 days intervals and feeding rate was adjusted according to the new body weight record. The growth rate in all treatments was found to be high and there was no significant difference in the growth rate. The highest growth rate was found in fish stocked @10,000/ha. The survival rate in the different stocking densities was over 80%.

**Fig 20 *Bangana dero***

#### *Clarias magur*

The study attempted to develop simple techniques for breeding and hatching of *Clarias magur*. The female broods of 120-140 g weight range were selected for induced breeding. Wova-FH was used as hormone for induced breeding of fish. Injections were administered @ 8 ml/kg body weight of the fish intramuscularly, in the dorso-lateral region of the female body. The sperms were pooled and diluted with 3 ml of physiological saline to prepare a sperm suspension. At the end of the desired latency period of 19 hrs, the females were stripped individually into dry and pre-weighed petri plates to record the stripped egg weight. Three subsamples of each 250-300 mg egg were weighed and mixed with 4-5 drops of sperm suspension. After thorough washing with water, they were released into the round fibreglass tub of 250 l capacity provided with flow-through water system for 2-3 min and shower to increase dissolved oxygen. Ten to fifteen fresh and cleaned water hyacinths were suspended in tubs as substrate to hatch the eggs. 9-92% hatching were obtained. After 3 days of hatching first feeding was given. Live zooplankton was used as food up to

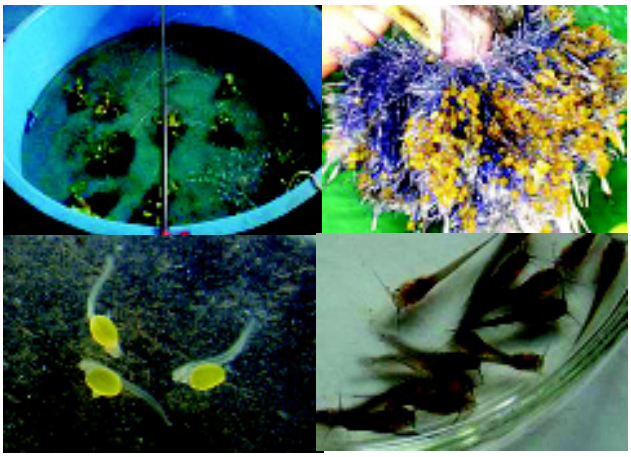


**Fig 21 Breeding and hatching of *Clarias magur***

satiation level. Fry remained into the cistern for 2 days then they were transferred into the nursery pond.

### *Devario acuticephala* breeded in laboratory

*Devario acuticephala* is an endemic fish that occurs in hill streams and paddy fields of Senapati and Ukhrul districts of Manipur at about 800 m AMSL. This species is likely to be restricted to small hill streams with substrates of gravel/variably-sized rocks and some marginal or over-hanging vegetation. Thirty fish fries having 20-22 mm were collected from Litan area of Ukhrul district in May 2010 and were stocked in a rectangular fibreglass tank having 80 litres of water capacity. The fishes reached 35-40 mm in 3 months rearing and matured. During culture period, the fishes were fed thrice with zooplankton, freeze-dried tubifex worm and artificial diet.

## POULTRY

### Poultry mega seed project

Under the project, a total of 15,184 DOC and 643 grown up chicks (4 -5 wks. old) were provided to 633 farmers (@ 25 birds per family) of nine districts of Manipur.

### Performance of Vanaraja and Gramapriya in the backyards

The Vanarajaand Gramapriya birds were reared under backyard free-range conditions in nine districts of Manipur as well as in two districts of Mizoram, one each in Assam and Nagaland states. The breed named Vanaraja attained average body weight (g) at 16, 24 and 40 weeks of age were 1563.91, 2429.20 and 2706.53, respectively under semi intensive system while 1382.61, 2073.20 and 2391.46, respectively were recorded in the open range management with a mortality of less than 4 % at the farmer's field level. The Gramapriya, attained an average body weight (g) of 1283.07, 1675.61 and 2148.32 at 16, 24 and 40 weeks of age under semi intensive system while 1233.52, 1601.65 & 2193.30 g, respectively in the open range management with a production of 41 eggs at 40 weeks of age. They attained sexual maturity at 166 days; reached 50% production by 205days and had recommendable liability records of 83.73 %. The mortality per cent was less than 5% indicating low rate mortality in the farmer's field. The per cent fertility and hatchability of total egg set of Vanaraja and Gramapriya were 72.89, 65.56 and 76.34, 68.61and attained sexual maturity at 169 & 166 days, respectively. The egg weight (g) at 24 and 40 wks and egg production (nos.) up to 40 and 72 weeks of Vanaraja and Gramapriya were 40.15, 51.0, 42.13, 51.19, 44, 49, 121 & 153, respectively. The above moderate level of production from the backyard was achieved by feeding household wastes, agricultural by products with supplementation of locally available tender leaves of weeds and grasses, calcium source powders, field snails etc. The Vanaraja and Gramapriya strain laid eggs weighing about 17 g heavier than the indigenous chicken. Vanaraja bird weighed about 1.92 kg more than local chicken.

## AGRICULTURAL EXTENSION

### Role of mass media in farm technology dissemination among the farmers of Manipur

The mass media All India Radio (AIR), Doordarshan Kendra (DDK), Sangai Express and Poknapam are taken for analysis from January to June 2011. The secondary data revealed that 123 agricultural topics were narrow casted in DDK. In case of AIR, 22 agricultural programmes were broadcasted. Both All India Radio and Doordarshan Kendra (DDK) create awareness on the agricultural programmes. In Sangai express, 20 per cent of the agriculture programmes createed knowledge and 80 percent are of awareness creation only. Similarly, 95 per cent of agricultural programmes in Poknapam is of awareness generation only. The awareness generation here meant awareness on training programme, workshop, seminar, reports of field day, farmers fair and exhibition. Further, the Doordarshan Kendra (DDK) and All India Radio (AIR) created knowledge on agriculture and allied activities. In the DDK, the agriculture programme covered horticulture (39.5%), field crops (29.5%), animal

husbandry (13%), plant protection (6%), reports and viewers' letter (7.5%). In case of AIR, the agriculture programme covered field crops (31.8%) followed by plant protection (27.2%), horticulture (22.7%) and social science (18.1%).No programme was observed on animal husbandry and allied activities in AIR.

**Adoption of soil and water conservation measures**

The analysis through PRA in Khongampat Mayai Leikai village revealed that 70 per cent of the farmers had farm ponds. The farm ponds were of small size. Ninety per cent of the farmers were lifting water from the farm ponds manually. The farm ponds are utilized for growing fishes for home consumption. This water from the farm ponds were also utilized for growing vegetables in kitchen garden. The tillage and broad bed and furrow were practised by more than 50 per cent of the farmers. The catch pits were also made in the farm to conserve water and to recharge the ground water. Occasionally mulching was practiced by banana leaf for establishment of the crop by 20 per cent of the farmers. None of the farmers practiced agro forestry, green manuring, roof water harvesting and paddy cum fish culture in the village. These findings revealed that farmers have to be taught the basic soil and water conservation measures through KVKs and the state extension personnel.

**Livelihood improvement and empowerment of rural poor through sustainable farming systems in north east India (NAIP-III)**

During *kharif* 2011-2012, the progamme "Quality saved seed production" was taken up in the four cluster villages *viz*., Noney, Reangkhong, Awangkhul and Tupul Charoi Chagotlong in rice, groundnut and soybean. The average yield of RC Maniphou10 during the season ranged from 3.0 t/ha in Awangkhul village to 4.0 t/ha in Noney village as against the local check yield of 2.9 t/ha. The recorded yield of groundnut (var. ICGS 76) was 1.25 t/ha cultivated in 1 ha land covering 10 no of farmers. Soybean gave satisfactory yield of 1.87 t/ha. Though agriculture in the district was mono-cropped keeping the lands mostly fallow during the *rabi* season, zero tillage technique in rapeseed M 27 allowed farmers to plant 15 days earlier than usual. Since the cost of land preparation is nil, it generated higher net income. During the year 2011-12, cultivation of rapeseed M27 under zero tillage was in 41 ha area in four villages of the cluster by 95 farm families. The yield performance in four villages ranged from 0.04 t/ha to 0.10 t/ha with a combined average yield of 0.29 t/ha. This year, the programme was poor due to the lack of rainfall. Potato was also cultivated in a total area of 2.8 ha covering 121 farm families in the cluster villages of theproject sites. Seventy eight farm families adopted pea cultivation in 3.1 ha area and crop performed poorly under minimum tillage practices in cluster villages.An area of 0.8 ha for cabbage cultivation *var.* Rareball was adopted by 14 farm families with an average yield of 10.36 t/ha.Likewise, tomato (var. F1 Samrudhi) cultivation in 0.8 ha area by 18 farm families showed that one farm family may gain a gross return of Rs.5000-6,900 depending on the cultivated operational area. In the model mini polyhouse established at 3 cluster villages with farm families, 150 nos of capsicum plants (var. California Wonder) and 150 nos. tomato plants (var. Nidhi) were planted. Tomato and capsicum gave yields of 80kg and 10-16kg/season with net incomes of ₹ 2400 and ₹ 1000 – 1600, respectively.

**Fig 22 Seed production for rice (RC Maniphou 10)**

**Fig 23 Zero tillage cultivation of rapeseed (M27)**

## TRIBAL SUB-PLAN (TSP)

***Jhum* improvement through agro-forestry, horticulture, livestock and fisheries intervention in Manipur**

The programme was implemented in five hill districts of Manipur *viz.,*Chandel, Churachandpur, Senapati, Ukhrul and Tamenglong. Improvement of *jhum* areas was the main focus of the programme.Since the various components are interlinked, interventions were carried out in an integrated way. Under the programme, training and demonstration programmes were conducted on different aspects of jhum improvement like improved production technology of fruits, vegetables and spices, community agro-forestry plantation in the jhum areas, nursery management of vegetable crops, soil and water conservation measures and water harvesting (Jalkund), community based value addition in fruits and vegetables, low cost vermicomposting technique, nutritional garden, mushroom cultivation, bee keeping, piggery, backyard poultry production, composite fish

culture and integrated farming system etc. The programmes created good impact on the farmers.

**Fig 24 Glimpses of TSP activities**

### Improved technology of groundnut production

One training programme and 14 demonstrations were conducted on improved technology of groundnut production for the tribal farmers at Chandel, Churachandpur, Ukhrul, Tamenglong and Imphal West.

### Scientific maize production technology

One training programme on scientific maize production technology was organized at ICAR Research Complex for NEH Region, Manipur Centre in collaboration with Directorate of Maize Research, New Delhi. The beneficiaries were trained on various aspects of improved package of practices for maize. Critical inputs like seeds and bio-organic inputs were distributed among the participants.

**Fig 26 Training and demonstration activities in maize**

# MIZORAM

## WEATHER REPORT

The average maximum monthly temperature (30.5°C) was recorded in Aug 2011 and the average minimum monthly temperature (12.9°C) in Jan 2012 (Table 1 & Fig 1). The mean monthly minimum (35%) and maximum (98%) relative humidity was recorded on Feb 2012 and Jun 2011, respectively. The annual rainfall was recorded to be 2462.4 mm during 2011-12 along with 149 rainy days. In the month of Jul 2011, there were 28 rainy days and in Aug 585.7 mm rain was recorded.

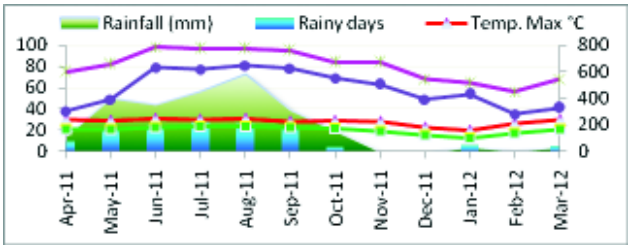



**Fig 1 Weather data at ICAR- RC for NEH Region, Kolasib**

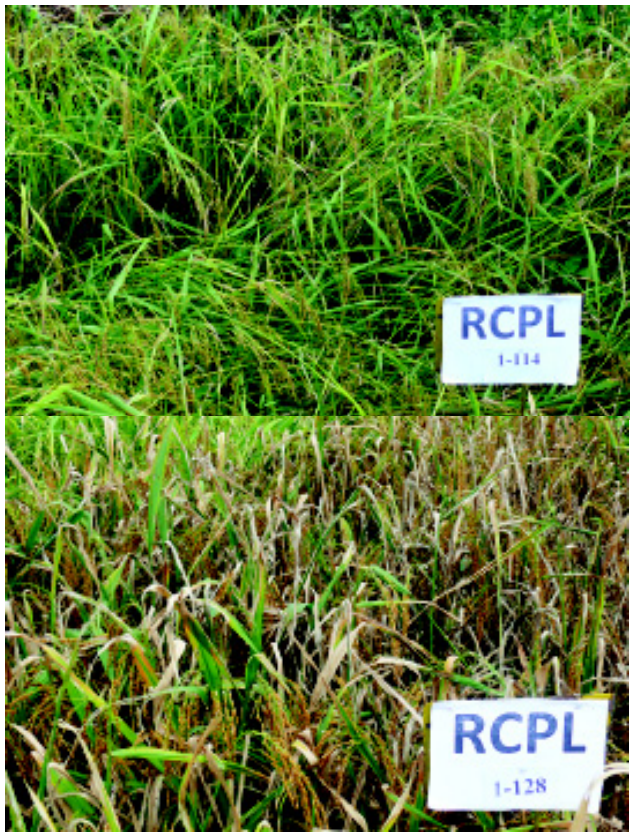



**Table 1 Mean monthly weather parameters from Apr'11 to Mar' 12**

| Months | Temperature (°C) | | Relative humidity (%) | | Rainfall (mm) | Rainy days |
|---|---|---|---|---|---|---|
| | Max. | Min. | Max. | Min. | | |
| Apr | 30.29 | 21.04 | 75 | 38 | 116.4 | 10 |
| May | 29.35 | 20.34 | 82 | 49 | 403.5 | 22 |
| Jun | 30.33 | 22.67 | 98 | 79 | 354.9 | 24 |
| Jul | 30.10 | 23.00 | 97 | 77 | 455.9 | 28 |
| Aug | 30.51 | 23.16 | 97 | 81 | 585.7 | 26 |
| Sep | 28.17 | 22.42 | 95 | 78 | 313.3 | 23 |
| Oct | 28.75 | 21.34 | 84 | 69 | 157 | 4 |
| Nov | 27.59 | 19.03 | 84 | 63 | 0 | 0 |
| Dec | 22.88 | 15.18 | 68 | 49 | 0 | 0 |
| Jan | 20.22 | 12.88 | 65 | 54 | 33.5 | 6 |
| Feb | 26.14 | 16.58 | 56 | 35 | 9.5 | 1 |
| Mar | 30.25 | 20.53 | 68 | 41 | 32.7 | 5 |
| Total | | | | | 2462.4 | 149 |

## CROP SCIENCE

### RICE

### RCRT trial I (Upland)

Nine upland rice varieties were evaluated. The maximum grain yield (2.81 t/ha) was recorded with RCPL1-114 which was significantly higher than rest of the varieties (Table 2& Fig 2).

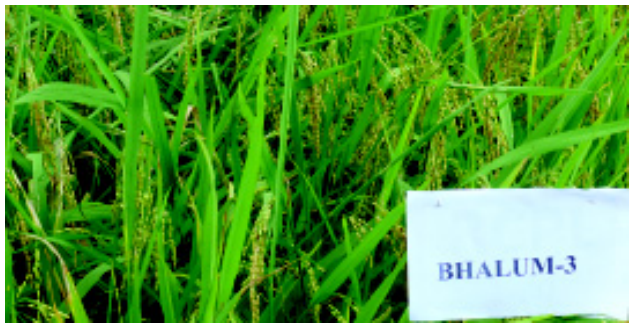



**Fig 2 High yielding rice varieties developed at institute**

**Table 2 Performance of different varieties of rice under upland RCRT I**

| Entries | Panicle wt.(g) | Panicle length(cm) | No. of grains/panicle | 1000seed wt. | Grain yield (t/ha) |
|---|---|---|---|---|---|
| RCPL 1-114 | 42.3 | 23.7 | 156 | 29.3 | 2.81 |
| RCPL 1-128 | 43.3 | 26.0 | 189 | 20.4 | 2.49 |
| RCPL 1-129 | 32.7 | 26.5 | 141 | 27.0 | 2.05 |
| RCPL 1-130 | 30.7 | 27.3 | 112 | 30.0 | 2.24 |
| RCPL 1- 412 | 37.0 | 26.0 | 142 | 23.9 | 0.89 |
| RCPL 1- 413 | 45.3 | 22.0 | 120 | 26.4 | 1.05 |
| Bhalum 1 | 31.7 | 25.7 | 148 | 28.3 | 1.16 |
| Bhalum 3 | 37.3 | 23.7 | 109 | 29.0 | 2.55 |
| Lampnah | 22.3 | 23.0 | 101 | 22.1 | 0.81 |
| SEm± | 3.70 | 1.02 | 14.79 | 1.81 | 0.02 |
| CD (*P*= 0.05) | 11.11 | 3.07 | 44.36 | 5.43 | 0.07 |

**RCRT trial II**

In another trial, 10 upland rice varieties were evaluated. The maximum grain yield was recorded with Bhalum 3 (2.24 t/ha) which was significantly higher than other varieties (Table 3).

**Low land (RCRT-III)**

Sixteen varieties of low land rice were evaluated. Significantly higher numbers of seeds/panicle (176) and grain yield (5.37 t/ha) was recorded by RCPL 1-304 which was at par with RCPL 1-307 (Table 4).

**Table 3 Performance of different varieties of rice under upland RCRT II**

| Entries | Panicle wt.(g) | Paniclelength(cm) | No. ofgrains/panicle | 1000seed wt. | Grain yield (t/ha) |
|---|---|---|---|---|---|
| RCPL 1-80 | 52.0 | 23.3 | 171.7 | 26.7 | 1.41 |
| RCPL 1-82 | 56.0 | 24.8 | 186.3 | 26.5 | 1.30 |
| RCPL 1-90 | 37.3 | 22.7 | 124.7 | 26.5 | 1.24 |
| RCPL 1-93 | 34.7 | 24.7 | 128.0 | 29.3 | 0.98 |
| RCPL 103 | 42.3 | 22.0 | 166.0 | 26.4 | 0.95 |
| RCPL 1-111 | 42.7 | 25.8 | 155.0 | 27.0 | 0.71 |
| IR 46A | 41.5 | 24.5 | 111.5 | 32.4 | 0.82 |
| Bhalum 1 | 31.7 | 25.7 | 148.0 | 28.3 | 1.16 |
| Bhalum 3 | 37.3 | 23.7 | 109.0 | 29.0 | 2.24 |
| Lampnah | 22.6 | 23.3 | 114.0 | 22.3 | 0.92 |
| SEm± | 5.7 | 0.5 | 20.5 | 1.4 | 0.03 |
| CD (*P*= 0.05) | 13.0 | 1.2 | 46.6 | 3.2 | 0.07 |

**Table 4 Performance of different varieties of rice under low land (RCRT-III)**

| Entries | Pant height (cm) | No. of tillers /plant | Panicle wt. (g) | Panicle length (cm) | No. of seeds / panicle | 1000 seed wt. (g) | Grain yield (t/ha) |
|---|---|---|---|---|---|---|---|
| RCPL 1 - 300 | 115.5 | 9.3 | 49 | 24 | 160 | 32.5 | 2.70 |
| RCPL 1 - 302 | 100.8 | 10.2 | 35 | 24 | 103 | 25.4 | 2.65 |
| RCPL 1 - 303 | 92.8 | 9.9 | 39 | 25 | 114 | 27.5 | 2.45 |
| RCPL 1 - 304 | 109.6 | 10.2 | 41 | 28 | 176 | 28.9 | 5.37 |
| RCPL 1 - 307 | 94.9 | 9.7 | 32 | 28 | 167 | 27.5 | 5.06 |
| RCPL 1 - 308 | 95.4 | 11.5 | 35 | 25 | 100 | 24.2 | 0.65 |
| RCPL 1 - 400 | 108.0 | 8.6 | 51 | 30 | 142 | 26.3 | 2.18 |
| RCPL 1 - 401 | 102.4 | 7.2 | 44 | 28 | 151 | 25.7 | 3.58 |
| RCPL 1 - 403 | 108.1 | 8.0 | 65 | 30 | 168 | 29.2 | 3.48 |
| RCPL 1 - 408 | 116.2 | 7.0 | 53 | 26 | 139 | 31.5 | 3.91 |
| RCPL 1 - 410 | 114.9 | 8.6 | 30 | 25 | 112 | 26.3 | 0.92 |
| RCPL 1 - 167 | 165.3 | 7.1 | 15 | 30 | 54 | 25.9 | 0.63 |
| RCPL 1 - 187 | 105.8 | 8.3 | 35 | 23 | 142 | 26.4 | 1.09 |
| RCPL 1 - 417 | 159.6 | 8.6 | 53 | 31 | 112 | 27.0 | 0.30 |
| RCM 21 | 99.5 | 8.7 | 37 | 28 | 103 | 26.6 | 1.30 |
| Shasarang | 100.3 | 8.7 | 35 | 25 | 157 | 25.1 | 1.58 |
| SEm± | 5.22 | 0.71 | 2.83 | 1.26 | 7.91 | 1.09 | 0.12 |
| CD(*P*= 0.05) | 15.5 | 2.12 | 8.43 | 3.75 | 23.5 | 3.25 | 0.35 |

### Performance of rice varieties under *jhum* condition

Five varieties and one local land race were evaluated under *jhum* condition. They were sown with a spacing of 20x15cm. Bhalum 3 recorded the maximum yield followed by Bhalum 2 and IURON514 (Fig 3).

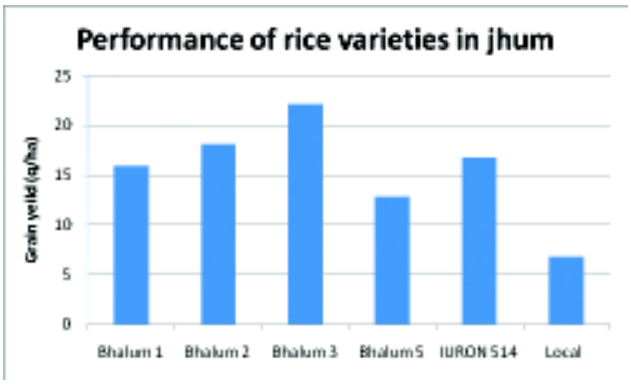



**Fig 3 Performance of rice under *jhum* condition**

### Yield performance of different land races of rice under upland condition

Eighteen upland rice land races were evaluated for their yield potential using recommended agronomic practices. Significantly highest grain yield was observed with MZR 19 (4.97 t/ha) (Table 5). Heaviest panicle was observed with MZR 24 (36g) which was at par with MZR 20 (35.5 g), MZR 31 (35.5g), MZR 29 (35g) and MZR 40 (34g). The longest panicle was observed with MZR 31 (31.5 cm).

## MAIZE

### Performance of land races of maize collected at Mizoram

Thirty eight land races of maize (Fig 4) were evaluated using recommended agronomic practices. Among the landraces three showed a yield potential of 4.0-4.5 t/ha. Four land races had grain yield potential of 2.5-3.0 t/ha. The variety RCM 76 produced a grain yield of 3.5 t/ha

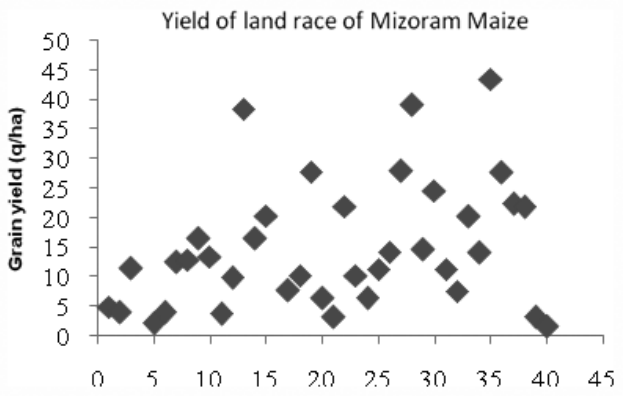



**Fig 4 Performance of land races of maize**

### Evaluation of maize based cropping system under *jhum*

In order to evaluate contingency cropping system for *jhum* condition, maize was intercropped with various other crops for its yield maximization and risk

**Table 5 Performance of different land race of rice under upland condition**

| Land races | Panicle wt(g) | Panicle length (cm) | No. of seeds/panicle | Test wt (g) | Yield (t/ha) |
|---|---|---|---|---|---|
| MZR 18 | 19.5 | 25 | 82.5 | 17.665 | 0.45 |
| MZR 19 | 32.0 | 30.5 | 166 | 28.375 | 4.97 |
| MZR 20 | 35.5 | 30.5 | 211 | 22.925 | 2.46 |
| MZR 21 | 20.0 | 26 | 82.5 | 26.65 | 0.31 |
| MZR 22 | 17.0 | 28 | 107 | 25.325 | 2.52 |
| MZR 23 | 9.5 | 28 | 65.5 | 23.175 | 0.70 |
| MZR 24 | 36.0 | 24 | 154 | 29.55 | 0.25 |
| MZR 25 | 25.5 | 30 | 139 | 30.325 | 1.12 |
| MZR 26 | 18.5 | 30.5 | 89.5 | 21.25 | 0.78 |
| MZR 27 | 29.5 | 30.5 | 137 | 28.675 | 3.98 |
| MZR 28 | 22.0 | 23 | 154.5 | 22.225 | 0.29 |
| MZR 29 | 35.0 | 29 | 126 | 27.525 | 3.15 |
| MZR 31 | 35.5 | 31.5 | 152 | 28.525 | 3.68 |
| MZR 33 | 24.0 | 29.5 | 142 | 25.925 | 0.39 |
| MZR 34 | 16.5 | 22.5 | 131.5 | 18.1 | 1.45 |
| MZR37 | 20.0 | 25 | 139.5 | 22.475 | 0.51 |
| MZR 38 | 17.5 | 22.5 | 146.5 | 21.675 | 1.74 |
| MZR 40 | 34.0 | 25 | 127 | 22.7 | 2.47 |
| SEm± | 1.02 | 1.12 | 5.79 | 1.08 | 0.92 |
| CD (*P*= 0.05) | 2.49 | 2.73 | 14.1 | 2.64 | 2.23 |

avoidance with cropping system. Maximum maize yield was observed with maize intercropped with rice-bean, while maximum maize equivalent yield was recorded in maize/cowpea intercropping (Table 6).

**Table 6 Yield of maize intercrop under *jhum* condition**

| Cropping system | Maize (t/ha) | Intercrop (t/ha) |
|---|---|---|
| Maize sole | 1.22 | - |
| Maize+soybean (1: 1) | 1.24 | 0.39 |
| Maize+rice bean (2: 1) | 1.25 | 0.32 |
| Maize+French bean (2: 1) | 0.89 | 0.57 |
| Maize+cow pea (2: 1) | 1.00 | 0.70 |
| Maize+ red gram (2: 1) | 1.28 | 0.59 |
| Maize+sweet potato (2: 1) | 1.02 | 0.77 |
| Maize+ sesamum (1: 1) | 1.08 | 0.27 |

## DISEASES

### Survey and surveillance of maize diseases

Survey and surveillance of diseases of *rabi* maize was done at the seed production field during *rabi* season. Four diseases were recorded with varying disease intensity (Table 7).

**Table 7 Diseases recorded in *rabi* maize**

| Pathogen | % Incidence |
|---|---|
| Turcicum leaf blight ( *Exserohilum turcicum*) | 30 - 40 |
| Maydis leaf blight (*Bipolaris maydis*) | 10-15 |
| Septoria leaf blotch (*Septoria maydis*) | 2-4 |
| Grey leaf spot (*Cercospora zeae-maydis*) | 2-3 |

## WHEAT

### Performance of different varieties of wheat during *rabi*

Six varieties of wheatwere evaluated for their yield potential during *rabi* season. VL 892 recorded significantly highest grain yield of 2.69 t/ha followed by HS 422 (2.64 t/ha) (Table 8 & Fig 5). Tallest plants were observed in HS 422 (100.7 cm) while DBW 14 (77.4 cm) recorded shortest plant. The variety DBW 14 came to flowering and maturity early but recorded lowest yield(Table 8& Fig 5).

**Fig 5 Evaluation trial on wheat**

## PULSES

### Black gram

Ten black gramvarieties were evaluated for their yield potential under *kharif* condition. Significantly maximum number of pods per plant (57.5) and higher grain yield of 1.26t/ha were recorded with RC BG 6 compared to other varieties and was at par with RC BG3 (1.12 t/ha) and RC BG4 (1.10 t/ha) in grain yield (Table 9).

### Green gram

Fifteen varieties (Table 10) of green gram were evaluated for their yield potential under *kharif* condition. The highest grain yield of 0.60 t/ha was recorded with RCGG 15 which was at par with RCGG 5 and RCGG 13 and significantly higher than rest of the varieties.

**Table 8 Performance of different varieties of wheatduring *rabi* of 2011-12**

| Entry | Plant height (cm) | No .of tillers / plant | Length of awn (cm) | No. of grains | Panicle length (cm) | 50% flowering | Yield (t/ha) |
|---|---|---|---|---|---|---|---|
| DBW 14 | 77.4 | 4.13 | 7.51 | 36.80 | 9.15 | 82.3 | 1.87 |
| GW 175 | 83.6 | 4.27 | 9.36 | 40.27 | 9.23 | 84.6 | 2.35 |
| VL 892 | 94.7 | 4.53 | 6.50 | 51.87 | 9.22 | 88.6 | 2.69 |
| HS 422 | 100.7 | 2.93 | 8.07 | 70.40 | 10.57 | 89.0 | 2.64 |
| HS 295 | 96.7 | 4.33 | 8.67 | 63.67 | 10.93 | 89.3 | 2.41 |
| HW 2045 | 97.6 | 4.07 | 8.51 | 44.00 | 10.09 | 89.0 | 1.96 |
| SEm± | 1.95 | 0.17 | 0.26 | 1.76 | 0.25 | | 0.05 |
| CD (*P*= 0.05) | 4.15 | 0.35 | 0.55 | 3.75 | 0.54 | | 0.12 |

**Table 9 Performance of different lines of black gram during *kharif* 2011**

| Entries | Plant height (cm) | No. of pods /plant | No of branches /plant | Grain yield (t/ha) |
|---|---|---|---|---|
| RC BG1 | 25.7 | 51.6 | 3.0 | 0.89 |
| RC BG2 | 19.8 | 56.7 | 3.5 | 1.02 |
| RC BG3 | 22.1 | 41.3 | 2.2 | 1.12 |
| RC BG4 | 25.0 | 41.6 | 2.4 | 1.10 |
| RC BG5 | 23.3 | 49.5 | 3.0 | 0.65 |
| RC BG6 | 22.3 | 57.5 | 3.1 | 1.26 |
| RC BG7 | 31.1 | 48.5 | 2.7 | 1.07 |
| RC BG8 | 20.8 | 52.7 | 2.6 | 0.69 |
| RC BG9 | 15.6 | 56.3 | 3.3 | 0.86 |
| RC BG10 | 18.3 | 44.1 | 2.9 | 0.85 |
| SEm± | 0.88 | 1.37 | 0.10 | 0.09 |
| CD (*P*=0.05) | 1.84 | 2.86 | 0.22 | 0.18 |

**Table 10 Performance of different varieties of green gram during *kharif***

| Entries | Plant height (cm) | No of branch /plant | No of pod /plant | Yield (t/ha) |
|---|---|---|---|---|
| RCGG 1 | 38.7 | 2.1 | 23.7 | 0.36 |
| RCGG 2 | 34.9 | 1.9 | 18.4 | 0.30 |
| RCGG 3 | 37.1 | 2.3 | 24.9 | 0.43 |
| RCGG 4 | 38.8 | 1.9 | 18.9 | 0.48 |
| RCGG 5 | 38.1 | 2.4 | 23.1 | 0.60 |
| RCGG 6 | 34.1 | 1.8 | 21.9 | 0.49 |
| RCGG 7 | 36.8 | 2.3 | 24.3 | 0.36 |
| RCGG 8 | 43.3 | 1.9 | 27.0 | 0.57 |
| RCGG 9 | 38.7 | 2.5 | 26.9 | 0.42 |
| RCGG 10 | 40.5 | 2.1 | 26.1 | 0.47 |
| RCGG 11 | 35.9 | 2.1 | 19.9 | 0.44 |
| RCGG 12 | 43.9 | 2.1 | 23.0 | 0.47 |
| RCGG 13 | 38.3 | 2.0 | 19.0 | 0.59 |
| RCGG 14 | 36.6 | 2.0 | 19.5 | 0.44 |
| RCGG 15 | 39.4 | 1.8 | 17.2 | 0.60 |
| SEm± | 1.04 | 0.13 | 0.71 | .01 |
| CD (*P*=0.05) | 2.12 | 0.28 | 1.45 | .03 |

## CROPPING SYSTEM

### Integrated nutrient management in maize-soybean cropping system

The experiment consisted of nine treatments *viz.*, $T_0$-Control, $T_1$-100% recommended dose (RD), $T_2$-50% RD, $T_3$-50% RD+5t farm yard manure (FYM), $T_4$-50% RD+2.5t vermicompost, $T_5$-lime+FYM+ vermicompost, $T_6$-5t FYM, $T_7$-2.5t vermicompost and $T_8$-Lime alone. The residual effect of treatments was also evaluated in succeeding soybean crop. Plant height was significantly higher in 100% RDF (209.6 cm) followed by 50% RDF along with 5t of FYM (207.9 cm) compared to control (Table 11). Among the INM practices, 100% RDF with FYM and vermicompost hadsignificant effects on LAI over control. Lowest LAI was recorded in maize crop that received no fertilizer/ manurial application. The root biomass and root volume also was higher in 100% RDF (18.85 g/plant and 98.54cm$^3$) followed by the INM practices of 50% RDF along with 5t of FYM compared to control.

**Table 11 Effect of integrated nutrient management on growth attributes of maize**

| Treatments | Plant height (cm) | Leaf area index | Root biomass (g/plant) | Root volume (cm$^3$) |
|---|---|---|---|---|
| $T_0$- Control | 190.3 | 4.16 | 14.35 | 76.43 |
| $T_1$-100% RD | 209.6 | 5.26 | 18.85 | 98.54 |
| $T_2$-50% RD | 202.0 | 4.80 | 16.95 | 84.23 |
| $T_3$-50% RD+5 t FYM | 207.9 | 4.97 | 18.26 | 94.55 |
| $T_4$-50% RD+2.5t vermicompost | 205.9 | 4.95 | 17.61 | 91.84 |
| $T_5$-Lime+FYM+ vermicompost | 198.9 | 4.52 | 16.59 | 82.00 |
| $T_6$-5t FYM | 203.8 | 4.88 | 17.25 | 88.89 |
| $T_7$-2.5t vermicompost | 199.3 | 4.80 | 17.08 | 86.90 |
| $T_8$-Lime alone | 196.1 | 4.36 | 15.95 | 78.93 |
| CD (*P*=0.05) | 0.49 | 0.170 | 0.431 | 4.650 |

The yield attributes of maize was significantly higher in 100% RDF followed by the INM practices. Cob length was higher in 100% RDF (21.4 cm) followed by INM practices of 50% RDF with 5 t FYM (20.2 cm), 50% RDF with 2.5t vermicompost (20.0 cm). Lower cob length was observed under the control. Cob girth, cob weight, no. of grains/cob and 100 grain weight were higher in 100% RDF followed by the INM 50% RDF with 2.5t vermicompost. Lower cob girth, cob weight, no. of grains/cob and 100 grain weight were observed under control (Table 12& Fig 6). Grain yield was significantly higher in 100% RDF (7154 kg/ ha) followed by 50% RDF with 5 t FYM (6915 kg/ha) and control had lower grain yield. The stover yield was higher in 100% RDF followed by the INM practices of 50% RDF with 5 t FYM compared to the control. The harvest index was not significantly influenced by the treatments(Table 13). For residual effects on soybean, the yield/pot was higher in the 100% RDF (147.89 g) followed by 50% RDF along with 5t FYM (126.16 g). The lower yield was resulted in the control (40.91 g)(Table 14& Fig 7 & 8).

**Table 12 Effect of integrated nutrient management on yield attributes of maize**

| Treatments | Cob length (cm) | Cob girth (cm) | Cob wt. (g) | No. of grains /cob | 100 grain wt. (g) |
|---|---|---|---|---|---|
| $T_0$- Control | 16.5 | 13.5 | 237 | 435 | 25.1 |
| $T_1$- 100% RD | 21.4 | 15.3 | 271 | 608 | 28.5 |
| $T_2$- 50% RD | 19.2 | 14.8 | 252 | 527 | 27.6 |
| $T_3$- 50% RD+5t FYM | 20.2 | 15.3 | 264 | 566 | 28.0 |
| $T_4$- 50% RD+2.5t vermicompost | 20.0 | 15.3 | 258 | 552 | 27.9 |
| $T_5$- Lime+FYM+vermicompost | 18.0 | 14.3 | 242 | 453 | 26.5 |
| $T_6$- 5t FYM | 19.6 | 14.9 | 254 | 543 | 27.1 |
| $T_7$- 2.5t vermicompost | 18.7 | 14.5 | 245 | 475 | 26.9 |
| $T_8$- Lime alone | 17.2 | 13.8 | 240 | 445 | 25.8 |
| SEm± | 0.20 | 0.13 | 2.23 | 5.39 | 0.12 |
| CD (*P*=0.05) | 0.40 | 0.26 | 4.57 | 11.04 | 0.25 |

**Table 13 Effect of integrated nutrient management on yield of maize**

| Treatments | Grain yield (kg/ha) | Stover yield (kg/ha) | Harvest Index |
|---|---|---|---|
| $T_0$- Control | 5467 | 9115 | 0.35 |
| $T_1$- 100% RD | 7154 | 11113 | 0.39 |
| $T_2$- 50% RD | 6207 | 10205 | 0.39 |
| $T_3$- 50% RD+5t FYM | 6915 | 10738 | 0.39 |
| $T_4$- 50% RD+2.5t vermicompost | 6352 | 10341 | 0.39 |
| $T_5$- Lime+FYM+ vermicompost | 5732 | 9480 | 0.38 |
| $T_6$- 5t FYM | 6125 | 9898 | 0.38 |
| $T_7$- 2.5t vermicompost | 6030 | 9592 | 0.38 |
| $T_8$- Lime alone | 5588 | 9292 | 0.37 |
| SEm± | 95.38 | 47.12 | 0.009 |
| CD (*P*=0.05) | 195.38 | 96.52 | NS |


**Fig 6 Best treatments compared with the control ($T_0$)**

**Table 14 Residual effect of nutrients on succeeding crop of soybean**

| Treatments | Plant height (cm) | No. of pods /plant | No. of clusters /plant | Yield (g/pot) |
|---|---|---|---|---|
| $T_0$- Control | 50.80 | 50.85 | 16.35 | 40.91 |
| $T_1$- 100 % RD | 70.13 | 60.12 | 25.73 | 147.89 |
| $T_2$- 50% RD | 65.73 | 55.45 | 19.27 | 92.05 |
| $T_3$- 50% RD + 5 t FYM | 68.53 | 58.14 | 24.73 | 126.16 |
| $T_4$- 50% RD+ 2.5 t vermicompost | 67.00 | 57.67 | 22.53 | 108.42 |
| $T_5$- Lime+FYM+ vermicompost | 53.21 | 55.12 | 18.25 | 71.66 |
| $T_6$- 5t FYM | 66.47 | 56.03 | 21.87 | 103.66 |
| $T_7$- 2.5t vermicompost | 56.78 | 55.73 | 19.00 | 82.48 |
| $T_8$- Lime alone | 52.13 | 53.25 | 17.27 | 62.60 |
| CD (*P*=0.05) | 0.91 | 2.13 | 1.31 | 20.57 |

**Fig 7 Residual crop of soybean in pot culture**

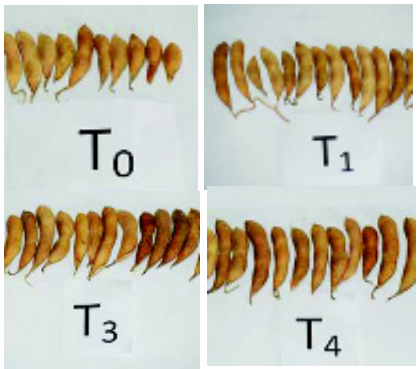



**Fig 8 Best treatments compared with the control ($T_0$) treatment**

## HORTICULTURE

## CHOW-CHOW

### Evaluation of germplasm

Among 13 genotypes planted, only 4 genotypes, all from Mizoram, grew and fruited in Kolasib conditions. The yield (Table 15) was maximum in Local 4 (from Aizawl) followed by Local 2 (Fig 9) (from Kawnpui), Local 1 (from Kolasib) and Local 3 (from Aizawl). The yield potential of these local genotypes under Kolasib conditions is only 30% (18-23 t/ha) compared to commercial yield potential. Although Kolasib climate is not suitable for commercial cultivation of chow-chow, yet the domestication of these genotypes for next 5-10 years would facilitate acclimatization and thereby explore the possibilities of chow-chow cultivation under warmer climatic conditions of Kolasib. Fruiting was observed twice, i.e. during May-Jun and Dec-Jan in Kolasib as against single fruiting in Sihphir (a locality of commercial production).

**Table 15 Performance of local chow-chow genotypes under warmer climate of Kolasib**

| Genotype | Season | | Total | Yield potential (t/ha) |
|---|---|---|---|---|
| | Winter Fruit wt (kg/hill) | Rainy Fruit wt (kg/hill) | Fruit wt (kg/hill) | |
| Local-1 (LG-Sl) | 10.6 | 11.4 | 22.1 | 18.2 |
| Local-2 (LG-S) | 12.3 | 13.4 | 25.7 | 21.2 |
| Local-3 (DG-Sl) | 10.5 | 11.0 | 21.5 | 17.7 |
| Local-4 (DG-S) | 12.7 | 14.6 | 27.2 | 22.5 |

LG-Sl: light green-spineless fruit surface
LG-S: light green-spiny fruit surface
DG-Sl: dark green-spineless fruit surface
DG-S: dark green-spiny fruit surface

**Fig 9 Local 2**

### Integrated nutrient management

A INM trial with 11 treatments (Table 16) was conducted at Sihphir, Aizawl for two cropping seasons during 2010 and 2011 to evaluate the effects of various sources and doses of nutrients on plant growth, fruiting and fruit yield of chow-chow. The uniform doses of FYM @8 kg, lime @500 g, $K_2O$ @300 g and Trichoderma @25 g was applied to each pit during first week of Jan each year. The plant growth (vine length and no. of nodes/vine) was maximum in T1 followed by integrated doses (Table 17). Moreover, single fruit weight, fruit volume, fruit density, no. of fruits and fruit yield were increasing, in general, with integration of various sources of organic nutrients and found maximum in T11 (N @250 g/pit, $P_2O_5$ @150 g/pit, PSB @50 g/plant and vermicompost @10 kg/pit). Vermicompost and pig manure significantly increased the fruit density, fruit weight and yield (T4, T5, T6, T7, T8, T9, T10 and T11). The fruit quality and yield were better in organic nutrient sources (vermicompost @10 kg/pit and pig manure @10 kg/pit) and bio-fertilizer (PSB @25-50 g/pit) along with N @250 g/pit, $P_2O_5$ @150 g/pit, $K_2O$ @300 g/pit and Trichoderma formulation @25 g/pit.

**Table 16 Various treatment combinations for INM trial at Sihphir, Mizoram**

| Treatments | N (g/pit) | $P_2O_5$ (g/pit) | PSB (g/pit) | VC (kg/pit) | PM (kg/pit) | Treatments | N (g/pit) | $P_2O_5$ (g/pit) | PSB (g/pit) | VC (kg/pit) | PM (kg/pit) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| T1 | 500 | 300 | - | - | - | T7 | 250 | 300 | - | 10 | - |
| T2 | 250 | 150 | 25 | - | - | T8 | 250 | 150 | 25 | 5 | - |
| T3 | 250 | 150 | 50 | - | - | T9 | 250 | 150 | 25 | 10 | - |
| T4 | 250 | 150 | - | - | 5 | T10 | 250 | 150 | 50 | 5 | - |
| T5 | 250 | 150 | - | - | 10 | T11 | 250 | 150 | 50 | 10 | - |
| T6 | 250 | 300 | - | 5 | - | | | | | | |

N: nitrogen; $P_2O_5$: phosphorus; PSB: phosphate solublizing bacteria; VC: vermicompost; PM: pig manure

**Table 17 Effects of various sources and doses of nutrients on plant growth and yield of chow-chow at Sihphir, Mizoram**

| Treatment | Vine length (cm) | No. of nodes /vine | Fruit length (cm) | Single fruit weight (g) | Fruit volume (ml) | Fruit density (g/ml) | No. of fruits / hill | Fruit wt kg/ hill | Yield (t/ ha) |
|---|---|---|---|---|---|---|---|---|---|
| T1 | 215.5 | 22.6 | 14.1 | 338.5 | 346.3 | 0.978 | 160.3 | 54.3 | 44.8 |
| T2 | 188.1 | 19.8 | 14.1 | 341.5 | 347.1 | 0.984 | 166.8 | 56.9 | 47.0 |
| T3 | 192.8 | 20.3 | 14.1 | 340.4 | 347.3 | 0.980 | 162.8 | 55.4 | 45.7 |
| T4 | 193.9 | 20.3 | 14.1 | 363.2 | 358.6 | 1.013 | 180.5 | 65.6 | 54.1 |
| T5 | 195.9 | 20.5 | 14.2 | 368.9 | 364.2 | 1.013 | 180.2 | 66.5 | 54.9 |
| T6 | 201.2 | 21.2 | 13.9 | 381.7 | 365.6 | 1.044 | 192.8 | 73.6 | 60.7 |
| T7 | 205.5 | 21.6 | 14.0 | 383.7 | 367.3 | 1.045 | 196.4 | 75.4 | 62.2 |
| T8 | 194.5 | 20.4 | 13.9 | 379.6 | 363.4 | 1.044 | 198.3 | 75.3 | 62.1 |
| T9 | 193.8 | 20.4 | 14.0 | 384.9 | 371.1 | 1.037 | 197.5 | 76.0 | 62.7 |
| T10 | 195.0 | 20.5 | 14.2 | 378.7 | 366.0 | 1.035 | 199.6 | 75.6 | 62.4 |
| T11 | 200.8 | 21.1 | 14.2 | 393.6 | 374.1 | 1.052 | 203.3 | 80.0 | 66.0 |
| Average | 197.9 | 20.8 | 14.1 | 368.6 | 361.0 | 1.020 | 185.3 | 68.6 | 56.6 |
| CD at 5 % | 14.4 | 1.7 | NS | 14.8 | 8.5 | 0.024 | 21.6 | 16.6 | 10.2 |

## FRENCH BEAN

### Genotypic variation for economic trials among germplasm of vegetables French bean (*Phaseolus vulgaris L.*) in Mizoram

Sixty-five germplasm of French beans (pole-type) were evaluated for qualitative and quantitative traits during 2010 and 2011. Among qualitative traits, the genotypes varied greatly for flower colour, tender pod colour, pod shape, dry seed colour, stem and petiole colour and leaf venation (Fig 10-15). Ten genotypes, all from Mizoram, showed better pod yield potential (>13.5 t/ha) which are MZFB 27 (18.42 t/ha), MZFB 30 (17.60 t/ha), MZFB40 (16.06 t/ha), MZFB 48 (15.59 t/ha), MZFB 44 (14.78 t/ha), MZFB 32 (14.49 t/ha), MZFB38 (14.30 t/ha), MZFB 29 (14.08 t/ha), MZFB 51 (13.76 t/ha) and MZFB47 (13.66 t/ha). A unique line (MZFB44) and their three segregant sister lines (MZFB45, MZFB46 and MZFB48) with purple-pod containing higher anthocyanin, an antioxidant (14-18 fold) and good yield potential.

**Fig 10 Variation in flower**

**Fig 11 Pod colour**

**Fig 12 Purple and green colour stem**

**Fig 13 Variation in seed colour and shape**

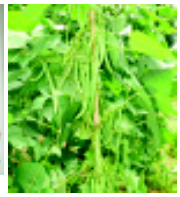


**Fig 14 MZFB 27**

**Fig 15 MZFB 44 (BSK/YR/SBS-1)**

### Collection, evaluation, characterization and documentation of local germplasm

Thirty-six local collections of various vegetables and spices have been allotted IC number by NBPGR, New Delhi. Among them, 10 collections belong to each of turmeric and cowpea; six of French bean; three each of vegetable mustard and cucumber; and one each of chinese kale, tomato, amaranth and chilli.

## CHILLI

### MZNC 1 (IC 590813): A unique primitive line of *Capsicum chinense* Jacq.

MZNC 1 (Fig 16) is a shade loving, compact shrubby perennial plant type, approximately 80-110 cm in height, 70-90 cm in spread (frame size) with glossy-green lustrous leaves. The flowers are complete, actinomorphic and pentamerous. The fruits are upright on long slender stalk, small, almost round, pungent, buttery in taste and turn red on maturity. It has profuse flowering (50-60 DAT) and fruiting; fruit weight ranges from 0.225-0.345 g; size varies from 0.71-0.94 in diameter; yields1200-1850 fruits

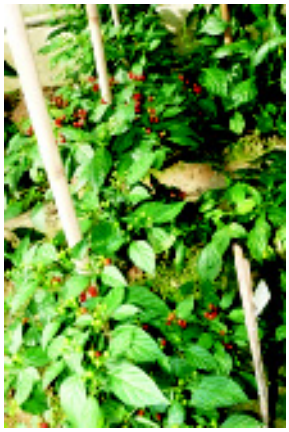


**Fig 16 MZNC-1**

yielding (400 g of fruits/plant) under net-house conditions in 8 months. Like traditional King Chilli (Naga chilli), seed viability of MZNC is very poor. It has potential breeding value and hence could be used as a genetic resource in future breeding programmes to improve the agronomic traits, productivity and quality of common chilli (*Capsicum annuum* L.).

## SPICES

## TURMERIC

### Evaluation of turmeric genotypes

In order to study the interaction of genotype and environment (GxE) on growth and quality characters, different varieties/genotypes of turmeric were evaluated. The maximum yield was recorded in Megha turmeric1 (4.17 t/ha), followed by Duggirala (40.0 t/ ha), IISR Pratibha (40.0 t/ha), Rajendra Sonia (38.0 t/ ha) and Roma (37.1 t/ha). However, dry matter content was highest in Rashmi (22.86%) followed by Roma (21.76 %) and IISR Allepy Supereme (21.56 %).

## DISEASES

### Screening against Taphrina leaf blotch and Colletotrichum leaf spots

Twenty-five diverse genotypes of turmeric were screened against leaf spot and leaf blotch diseases caused by *Colletotrichum curcumae* and *Taphrina maculans*, respectively. Among 25 genotypes; Rajenra Sonia, Megha turmeric 1, Suranjana and Local 7 were found to be resistant against leaf blotch and *Colletotrichum* leaf spot (Table 18). Yield was recorded highest for IC-0588797 (46.6 t/ha) followed by Local4 (42.9 t/ha) and Megha turmeric 1(38.4 t/ha).

## GINGER

### Evaluation of ginger genotypes

In order to study the interaction of genotype and environment (GxE) on growth and quality characters, different varieties/genotypes of ginger were evaluated. The leaf area was highest in Nadia (44.0cm) followed by Himgiri (40.13cm) and Nisapui Local (39.5 $cm^2$). The maximum yield was recorded in Himgiri (18.1 t/ ha) followed by Nadia (15.5 t/ha), Varda (14.1 t/ha) and Mahima (13.0 t/ ha).

## Network Project on Management of Ginger Soft Rot

### Surveillance for disease free areas in the state

Sample of ginger plants were collected from 10 different villages*viz.*,Bairabi, Bukpui, Kawnpui, Nisapui,North Chaltlang, Pangbalkawn, Sethawn, Temple Kawnpui, Thingdawl and Zotlang Kawnpui covering 44 farmers' field. The survey included 39 *jhum* and 5 terraced fields. The soft rot pathogen *Pythium* sp was recovered from 50% of samples. The disease and pest incidence ranged from 3.73% to 46.0% which was highest in Bukpui followed by Pangbalkawn area.

### Pot trial to control soft rot pathogen in ginger

The pots were filled with fine soil, sand and FYM in the ratio of 3:1:1 and ginger rhizomes were planted. The pots were given water immediately after planting and repeated every third day by rose-can as per need.

**Table 18 Screening of turmeric genotypes/varieties under Kolasib condition**

| Name of genotype | P.D.I. *Colletot richum* leaf spot | Leaf blotch | Yield (t/ha) | Name of genotype | P.D.I. *Colletot richum* leaf spot | Leaf blotch | Yield (t/ha) |
|---|---|---|---|---|---|---|---|
| Megha turmeric 1 | 01.92 | 00.00 | 38.40 | IC 0588790 | 00.00 | 33.08 | 23.60 |
| Suranjana | 01.30 | 00.27 | 27.80 | Local 4 | 02.35 | 16.15 | 42.90 |
| Narendra Haldi-1 | 01.07 | 05.42 | 26.70 | IC 0588791 | 00.00 | 23.29 | 32.80 |
| IISR-Allepy Supreme | 28.73 | 00.00 | 30.30 | Local7 | 02.96 | 01.60 | 28.60 |
| IISR Kedaram | 22.79 | 04.00 | 25.00 | IC 0588792 | 01.82 | 11.43 | 27.10 |
| IISR Pratibha | 22.33 | 00.00 | 26.53 | Local10 | 06.67 | 00.00 | 27.20 |
| Duggirala | 27.25 | 00.00 | 23.57 | Local11 | 08.57 | 00.00 | 36.20 |
| BSR2 | 01.22 | 03.73 | 17.23 | IC 0588793 | 04.21 | 19.09 | 27.10 |
| Rajenra Sonia | 00.82 | 01.83 | 23.00 | IC 0588794 | 32.24 | 00.00 | 27.30 |
| Rashmi | 07.92 | 23.36 | 24.80 | IC 0588795 | 04.00 | 29.09 | 29.40 |
| Roma | 32.89 | 00.00 | 26.00 | IC 0588796 | 04.21 | 35.56 | 35.60 |
| IC-0588788 | 00.00 | 43.74 | 32.30 | IC 0588797 | 04.00 | 50.70 | 46.60 |
| IC-0588789 | 00.00 | 52.36 | 32.70 | | | | |

The water soluble fertilizers @ 0.25% (NPK 19:19:19) was sprayed at 45 and 60 days after planting. Highest germination percentage was recorded in $T_5$. Maximum yield and low percentage of disease incidence was recorded in $T_4$. Moreover, $T_1$ produced lowest yield (1.220 kg/pot) and highest percentage of disease incidence (Table 19).

**Table 19 Mean percentage of rhizome germination, disease incidence and yield under pot culture**

| Treatment | Rhizome germination (%) | Disease incidence (%) | Yield kg/pot |
|---|---|---|---|
| T 1 Control | 86.33 | 14.00 | 1.220 |
| T 2 Hot Water Treatment (HWT) | 76.00 | 11.50 | 2.800 |
| T 3 HWT+ Strobilurins ST | 80.52 | 5.02 | 3.000 |
| T 4 Strobilurins (ST)+COC | 89.23 | 4.33 | 3.720 |
| T 5 HWT+*T.har*(SA)+COC | 92.00 | 6.50 | 2.100 |

HWT- Hot Water Treatment; ST- Strobilurins; COC- Copper Oxy Chloride; T.har- Trichoderma; S.A-soil application

### Field trial for control of soft rot pathogen

The experiment was laid out in RBD with 3 replications. Healthy rhizome bits/fingers were cut into small pieces of 2.5-5.0 cm length weighing about 20-25 g each having two good buds. The normal cultural practices were followed. $T_4$ produced highest yield (5.82 kg/plot) followed by $T_3$ and $T_2$. The disease incidence was highest in control followed by $T_2$ and these treatments produced lowest yield of 3.312 kg/ plot and 4.752 kg/ plot, respectively (Table 20).

## DISEASES

### Survey to study intensity of diseases on horticultural crops

Based on a systematic survey conducted on diseases of different crops in Mizoram, the diseases recorded and their intensity are given in Table 21.

**Table 21 Diseases of important plants and their disease intensity in Kolasib, Mizoram**

| Crop | Disease (Pathogen) | Disease Intensity (%) |
|---|---|---|
| Megha turmeric 1 | Leaf spot (*Colletotrichum curcumae*) | 10.00 |
| Ginger cv. Nadia | Leaf blotch (*Taphrina maculans* Syd. Butler) | 05.00 |
| | Leaf spot (*Phyllosticta zingiberi* Ramakr.) | 40.00 |
| | Virus (Wheat streak mosaic virus ) | 40.00 |
| | Banded leaf blight (*Rhizoctonia solani* Kuhn) | 10.00 |
| | Bacterial wilt (*Ralstonia solanaciarum*, Biovar-3) | 10.00 |
| | Soft rot (*Pythium* spp.) | 05.00 |
| | Root knot nematode (*Meloidogyne* spp.) | 02.00 |
| Banana cv. Giant Cavendish | Black Sigatoka (*Mycosphaerella fijiensis* Morelet) | 10.00 |
| | Yellow Sigatoka (*Mycosphaerella musicola* Mulder) | 08.00 |
| | Moko disease (*Ralstonia solanaciarum*) | 05.00 |
| | Bunchy top virus (BBTV) | 02.00 |
| Khasi Mandarin | Sooty mold (*Capnodium citri* Berk. & Desm.) | 70.00 |
| | Scab (*Elsinoe fawcetti* Bitance and Jenkins) | 40.00 |
| | Powdery mildew (*Oidium tingitaninum* (Carter) Subr.) | 10.00 |
| Arecanut | Fruit rot (*Phytophthora arecae* Pethybr.) | 40.00 |
| | Seedling leaf blight | 20.00 |
| Guava cv. Allahabad Safeda | Stem canker (*Physalospora psidii* Stev. & Pier.) | 70.00 |
| | Wilt (*Fusarium* spp.) | 15.00 |
| | Fruit scab (*Elsinoe* sp.) | 03.00 |
| Oil palm | Leaf spot (*Pestalotia* sp.) | 05.00 |
| Moong bean | Powdery mildew (*Erysiphe polygoni* DC.) | 70.00 |
| Tomato | Damping off (*Pythium* spp.) | 30.00 |
| | Phytophthora blight (*P. infestans* (Mont.) de Bary) | 25.00 |
| | Alternaria blight (*A. solani* Jones and Gront) | 20.00 |
| | Bacterial wilt (*Ralstonia solaraciarum*) | 05.00 |
| Carrot | Root knot nematode (*Meloidogyne* spp.) | 10.00 |
| French bean | Rust (*Uromyces appendiculatus*) | 40.00 |
| | Dry root rot (*Macrophomina phaseolina* Gold.) | 05.00 |
| Frangipani (*Plumeria* sp.) | Rust (*Coleosporium plumeriae* Pat.) | 80.00 |
| Mustard | Powdery mildew (*Erysiphe cruciferarum*) | 80.00 |
| Papaya | Ring spot (Papaya ringspot virus, PRSV) | 50.00 |
| | Leaf curl (Papaya leaf curl virus, PLCV) | 30.00 |
| | Powdery mildew (*Oidium caricae* Noack) | 10.00 |

**Table 20 Mean percentage of rhizome germination, disease incidence, yield and shoot borer incidence**

| Treatment | Rhizome germination (%) | Disease incidence (%) | Yield kg/plot | Shoot borer attack (tillers & rhizomes) |
|---|---|---|---|---|
| T 1 Control | 77.8 | 16.7 | 3.312 | 5.1 |
| T 2 Hot Water Treatment (HWT) | 62.5 | 14.8 | 4.752 | 4.9 |
| T 3 HWT+ Strobilurins ST | 75.3 | 7.2 | 5.344 | 4.7 |
| T 4 Strobilurins (ST)+COC | 78.4 | 5.4 | 5.824 | 3.8 |
| T 5 HWT+*T.har*(SA)+COC | 81.3 | 6.1 | 4.487 | 4.2 |

## MUSHROOM

### Biodiversity

Fungal forays were undertaken in the forests and markets of Kolasib. Twenty wild specimens were collected including *Schizophyllum commune* (Fig 17),*Pleurotus* spp., *Trametes* spp., *Termitomyces* spp, *Crinipellis* spp, *Clavulinopsis* spp, *Marasmius* spp, *Macrolepiota* spp, *Lenzites* spp., *Oudemansiella* spp, *Tricholoma* spp and *Ganoderma* spp (Fig 18). The fleshy fungi were collected from different habitats such as forest, decaying wood, rotting plant parts etc. and also from markets. The identification of each sample was done with the help of standard manuals and preserved in 5.0% formaldehyde. Preliminary market survey of Kolasib revealed that state is rich in wild edible fleshy fungi. Each pack of *Schizophyllum commune* Fr. had approximately 40g humid weight and was sold for Rs. 40/-.

**Fig 17*Schizophyllum commune***

**Fig 18 *Ganoderma lucidum***

### Low cost technology for oyster mushroom (*Pleurotus florida*) cultivation

Spawn requirement was drastically reduced with a little precautions and hygiene when completely colonized substrate was used as spawn. Moong bean pod husk was used as substrate and mushroom flushes were harvested three times during the cropping period. Cumulative yield and biological efficiency(Fresh weight of fruit body/Dry weight of substrate x 100)of each stage of spawning was recorded (Table 22).

## ANIMAL SCIENCE

### Studies on bovine bacterial mastitis

The incidence of clinical and sub-clinical mastitis in cows is studied in 14 different farms. Out of 69 animals examined using modified California mastitis test (MCMT), 12 animals (17.39%) were found positive for sub-clinical mastitis and 7 animals (10.14%) were found positive for clinical mastitis (Table 23 & 24).

### Isolation of causative organism from infected cases

Out of 19 positive samples staphylococcus (16), *E. coli* (6) and streptococcus (4) organism were isolated. The isolate were highly sensitive to enrofloxacin and gentamicin and resitant to tetracycline and cloxacillin. Four farms were selected in Kolasib district for

**Table 22 Cumulative yield and biological efficiency of oyster mushroom (*Pleurotus florida*) under Kolasib condition**

| Treatment | Colonization duration (days) | Harvesting after colonization (days) | | | Cumulative yield* (g) | Biological efficiency* (%) |
|---|---|---|---|---|---|---|
| | | First | Second | Third | | |
| Commercial spawn (2.5%) used in main crop | 13 | 10 | 16 | 25 | 303.33 | 82.62 |
| Complete colonized substrate used as spawn from main crop | 13 | 10 | 17 | 26 | 316.67 | 84.90 |
| Complete colonized substrate used as spawn from second crop | 13 | 14 | 16 | 24 | 320.00 | 80.00 |
| Complete colonized substrate used as spawn from third crop | 13 | 14 | 16 | 26 | 305.00 | 81.26 |

**Table 23 Incidence of mastitis in cows at different places of Mizoram**

| Place | Animal examined | | | Quarter samples examined | | | Presence of blind teat | |
|---|---|---|---|---|---|---|---|---|
| | No. | Positive | % | No. | Positive | % | No. | % |
| Saiha | 8 | NIL | NIL | 32 | NIL | NIL | NIL | NIL |
| Kolasib | 26 | 10 | 38.46 | 104 | 25 | 24.03 | 5 | 26.31 |
| Durtlang | 16 | 3 | 18.75 | 64 | 12 | 18.75 | NIL | NIL |
| Sihphir | 11 | 2 | 18.18 | 44 | 2 | 4.54 | 2 | 4.54 |
| Sairang | 8 | 4 | 50 | 32 | 8 | 25.00 | NIL | NIL |

**Table 24 Incidence of bovine mastitis in relation to number of lactation**

| Lactation number | Sub-clinical | | Clinical | |
|---|---|---|---|---|
| | No. of animals affected | % | No. of animals affected | % |
| 1 | NIL | NIL | NIL | NIL |
| 2 | 5 | 41.66 | 4 | 57.14 |
| 3 | 1 | 8.33 | NIL | NIL |
| 4 | 1 | 8.33 | 1 | 14.28 |
| 5TH | 2 | 16.66 | 2 | 28.57 |
| 6TH | 2 | 16.66 | NIL | NIL |
| 7TH | 1 | 8.33 | NIL | NIL |
| TOTAL | 12 | 100.00 | 7 | 100.00 |

conduction of field trial of herbal drugs i.e., Mastilept. Out of 8 positive cases of sub-clinical mastitis all the positive cows responded well to the treatment.

### Studies on piglet diarrhoea of bacterial origin in Mizoram

A total of 23 diarrheic faecal/rectal swabs were collected from Aizawl and Kolasib districts. Out of 23 faecal samples, 22 strains of *E. coli* and one Salmonella is isolated. Twenty two numbers of *E.coli* strains were subjected to antibiotic sensitivity and the isolates were sensitive to gentamicin, norfloxacin (76.92%) followed by enrofloxacin, cephotaxime and the isolates were resistant tocloxacillin, nitrofurantroin, ampicillin, amoxicillin and sulphomethaxazole (Table 24).

### Serotype of the isolated *E.coli* strains

Twenty two numbers of *E.coli* strains were subjected to serotyping at Central Research Institute, Kasauli, Himachal Pradesh. Out of 22 numbers of *E.coli*,8 nos. of *E.coli* strains were 060 (2), 05, 036, 082, 092, 0103, 0154 and the rest of the E.colistrains were untypable (UT).

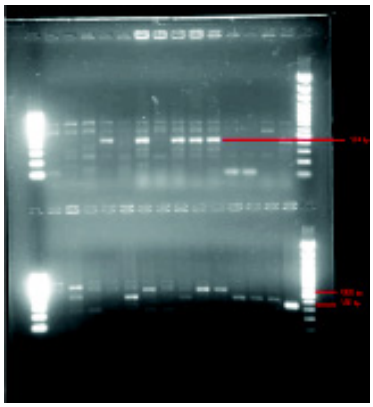


**Fig 19 Detection of stx 2 gene by Polymerase chain reaction (PCR), Lane 1-6,9-14,15-28 = Test isolates; Lane 7 = Negative control; Lane 8 = Positive control**

### Performance of Vanaraja dual purpose birds in Mizoram condition

Vanaraja chicks of 200 nos. were procured from ICAR Manipur Centre and the parent stocks were assessed for the laying capacity and maximum body weight gain under ICAR farm conditions. The age at first laying was 16 weeks while the body weight at the start of laying was 2.5 kg. The body weight of matured males at 16 weeks was 3.66 kg. Coccidiosis was encountered among the chicks during the rainy season and treated with amprolium. Frequent changing of litter material helped controlling the disease. The chicks of some batches below 3 weeks of age were also affected by Bacillary White Diarrhoea which was treated with

**Table 25Antibiogram of microorganism isolated from piglet faecal samples**

| Place | No. of isolates | No. of *E. coli* strains sensitive to | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | ENR | NA | G | C | CTX | AMP | NOR | CL |
| Kolasib | 13 | 9 (69.23) | 7 (58.84) | 10 (76.92) | 1 (76.92) | 8 (61.53) | - | 10 (76.92) | 4 (30.76) |
| Aizawl | 10 | 6 (60) | 4 (40) | 6 (60) | 6 (60) | 7 (70) | - | 4 (40) | - |

ENR: Enrofloxacin; NA: Nalidixic Acid; NOR: Norfloxacin; CL: Cephalexin; C: Chloramphenicol; AMP: Ampicillin; G: Gentamicin; CTX: Cefotaxime

**Table 26 Numbers of *E.coli* strains subjected to detection of genes by PCR**

| Total no. of samples tested | *EST* | *ELT* | *STX-1* | *STX-2* | *HLY* |
|---|---|---|---|---|---|
| 22 | 1 | - | - | 4 | - |

cotrimoxazole. Curled Toe Paralysis was also seen among the growers of 3-4 weeks of age and treated successfully with vitamin B complex. Cannibalism, common among adults, was controlled by providing more space, providing 1 gram common salt/litre of drinking water and regular debeaking. All the chicks were vaccinated against Ranikhet disease.

## NAIP

### Livelihood improvement through sustainable farming systems NAIP- III

### Improvement of livelihood by production of dual purpose Vanaraja breed

Two hundred day old poultry birds of Vanaraja procured from ICAR Manipur Centre and are being reared at ICAR Kolasib for laying and multiplication for further distribution under this project. 15 nos. of poultry houses were constructed. More than 900 nos. of varying ages of Vanaraja chicks from different batches/generations has been distributed to more than 60 nos. of selected beneficiaries at the adopted Theiva village, Saiha district (Fig 20A).

### Improvement of livelihood through mixed farming

Fifteen pig-sties were constructed and 20 piglets of improved breed (Hamshires and Yorkshire) of pig were distributed to 15 farmers (Fig. 20B) after giving training on scientific production of pigs (Table 27).

**Fig 20 Distribution of (A)Vanaraja chicks (B) Yorkshire to farmers**

## NICRA

### Collection of indigenous soil water conservation practices

The indigenous soil and water conservation methods practiced by farmers were banana pseudo stem cover shade, pot/polythene cultivation, mulching bamboo irrigation, valley cultivation, Spot application of irrigation (Fig 21 a & b).

**Fig 21 (a) Spot application of irrigation**

**Fig 21 (b) Banana pseudo stem cover shade**

**Table 27 Increase in income and employment through mixed farming**

| Intervention | Baseline income, ₹/hh/yr | Enhanced income, ₹/hh/yr | Baseline employment man days/yr/hh | Enhanced employment man days/yr/hh |
|---|---|---|---|---|
| Crop | 15000 | 25000 | 160 | 220 |
| Livestock | nil | 45000 | - | 135 |
| Poultry | 6500 | 9500 | 45 | 60 |
| Piggery | 9500 | 21400 | 60 | 90 |

**Training and demonstration of Soil Testing Kits**

One hundredfarmers from different parts of Mizoram were selected and given training and demonstration on soil testing kits developed by ICAR Research Complex of for NEH Region, Umiam. Farmers were also given training on on-farm analysis of different soil chemical parameters such as pH, EC, N, P, K etc., (Fig 22)


**Fig 22 Distribution of soil testing kits**

**In-situ demonstration of water harvesting structure (*Jalkund*)**

A total of 50 *Jalkund* of various capacities were constructed in various parts of Kolasib and Aizawl districts. Forty numbers of 30000 litre (5x4x1.5m) and ten numbers of 75,000 litre (8.5x6x1.5m) were constructed for cultivating annual and perennial crops.

**Demonstration of pig and poultry management**

Eleven beneficiaries were selected and pig sty was constructed for each of them. They were provided with 150 kgs concentrated feed and two piglets/beneficiary. Twelve beneficiaries were selected under poultry management and each beneficiary received 20 Vanaraja chicks and 210 kgs of layer feed.

# NAGALAND

## WEATHER REPORT

The highest maximum temperature of 34.7°C was recorded on 28th Jul'11 while the lowest minimum temperature of 5.1°C was on 21st Dec'11. The mean monthly maximum and minimum air temperatures varied from 20.9°C to 31.1°C and 9.7°C to 24.9°C, respectively. Jan 2012 was the coolest month and Aug 2011 was the hottest month. The average monthly maximum and minimum relative humidity varied from 74.6% to 85.4% and 6.5% to 64.7%, respectively. The total rainfall received during the year 2011-12 (Apr'11to Mar' 12) was 1641.4 mm and the total rainy days were 121. The monthly rainfall was the maximum in Jun'11 (474.2 mm). No rainfall occurred during Nov and Dec'11. The average monthly wind speed varied from 0.26 kmph (Jul'11) to 27.31 kmph (Apr'11). Apr and May had high wind velocity. Soil temperatures were recorded both in the morning and evening at 5 cm, 15 cm and 20 cm depths. The soil temperature showed a decreasing trend along the soil depth. Total monthly evaporation was found to vary from 39.9 mm (Jan'12) to 101.8 mm (Apr'11) (Table 1).

and 4.79 t/ha, respectively than control Ranjit (4.68 t/ha). In another trial with 13 lowland paddy varieties, IET 16313 recorded highest yield (5.56 t/h) followed by IET 18572 (5.23 t/ha).

**Effect of crop establishment methods and fertility levels on growth, yield and quality of rice in rice-lentil cropping system**

A field experiment was carried out during *kharif* season, 2011-12 in split-plot design (SPD) with three replications. Three crop establishment methods *viz*., system of rice intensification (SRI), integrated crop management (ICM) and conventional rice culture (CRC) and five fertility levels (control, 100% RDF,100% RDF+crop residues, 100% RDF ON and 100% RDF ON+crop residues; where ON represents organic nitrogen (120 kg/ha) through farm yard manure) were allotted to the main and sub-plots, respectively. SRI recorded significantly highest yield attributes and yield followed by ICM while CRC showed the lowest yield attributes and yield. In fertility levels, 100% RDF+crop residues recorded significantly highest yield attributes and yield followed by 100% RDF, 100% RDF ON+crop residues as compared to control due to better integrated nutrient management (Table 2).

**Table 1 Average monthly weather parameters from Apr '11 to Mar '12**

| Air temperature (°C) | | Relative humidity (%) | | Pan evaporation (mm) | Total rainfall (mm) | Soil temperature (°C) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 5 cm | | 15 cm | | 20 cm | |
| Max | Min | Max | Min | | | Max | Min | Max | Min | Max | Min |
| 20.9 (Jan'12) – 31.1 (Aug'11) **(28.35)** | 9.7 (Feb'12) – 24.9 (July'11) **(18.21)** | 74.6 (Feb'12) – 85.4(Aug'11) **(80.18)** | 6.5 (Feb'12) – 64.7 (July'11) **(40.83)** | 39.9 (Jan'12) – 101.8 (April'11) **(917.1)** | **1641.4** | 11.4 (Jan'12) – 23.9 (Oct'11) **(19.92)** | 3.9 (Jan'12) – 17.2 (July'11) **(11.8)** | 21.4 (Jan'12) – 33.5(Oct'11) **(29.68)** | 14.9 (Jan'12) – 27.8 (Sept'11) **(22.65)** | 19.7 (Jan'12) – 34.7 (June'11) **(28.83)** | 15.5 (Jan'12) – 27.9 (July'11) **(23.10)** |

(mean values are given in parentheses with bold letters)

## CROP SCIENCE

### RICE

**RCRT trials**

Thirty paddy lines were tested under lowland. Line 1-149 recorded highest yield (6.34 t/ha) while 1-417, 1-302 and 1-308 recorded higher yield of 5.34, 5.10

### MAIZE

**Effect of mulching, liming and INM on *rabi* maize var. DA61-A under rainfed condition**

A field experiment was carried out during *rabi* season with maize var.DA61A (Fig 1) in a SPD with three replications. The main plots were control and mulch, and the sub-plot were with FYM having four levels (control, 4, 8 and 12 t/ha), and the sub-sub plots

**Table 2 Effect of crop establishment methods and fertility levels on yield attributes yield of rice in rice-lentil cropping system**

| Treatments | Panicle length (cm) | Grains/ panicle (no.) | Grain yield (t/ha) | Straw yield (t/ha) | Biological yield (t/ha) | Harvest index (%) |
|---|---|---|---|---|---|---|
| **Crop establishment methods** | | | | | | |
| SRI | 27.3 | 523.1 | 3.65 | 3.21 | 6.86 | 53.21 |
| ICM | 26.2 | 492.8 | 3.40 | 3.20 | 6.60 | 51.52 |
| CRC | 24.6 | 356.7 | 2.90 | 2.57 | 5.57 | 52.10 |
| SEm | 0.42 | 23.22 | 0.16 | 0.27 | 0.40 | 2.16 |
| CD (*P*=0.05) | 1.63 | 91.16 | 0.64 | 1.05 | 1.56 | 8.47 |
| **Fertility level** | | | | | | |
| Control | 24.1 | 402.0 | 2.41 | 2.18 | 4.59 | 52.51 |
| 100% RDF | 28.0 | 489.6 | 3.55 | 3.23 | 6.78 | 56.4 |
| 100% RDF+crop residues | 29.0 | 518.6 | 3.70 | 2.99 | 6.69 | 55.3 |
| 100% RDF ON | 25.5 | 435.0 | 2.57 | 2.30 | 4.87 | 52.77 |
| 100% RDF ON+crop residues | 24.5 | 405.8 | 2.52 | 2.41 | 4.93 | 51.11 |
| SEm | 0.55 | 22.81 | 0.16 | 0.20 | 0.25 | 2.56 |
| CD (*P*=0.05) | 1.60 | 66.57 | 0.47 | 0.59 | 0.74 | 7.48 |

were with four levels of liming (control, 0.2, 0.4 and 0.6 t/ha). Liming recorded significantly higher yield attributes and yield (Table 3). The increased levels of FYM increased the yield attributes and yield.

**Fig 1*Rabi* maize var. DA-61-A**

## MUSTARD

### Response of fertility levels on Indian Toria [*Brassica juncea* (L.)Czern and Coss.]under rainfed condition

An experiment was carried out during *rabi* season having four fertility levels (control, 100% RDF, 125% RDF and 150% RDF, where RDF was 60:40:40:30 kg/ha of N:P:K:S) in the main plots and three varieties (M27, TS38 and TS36) in the sub-plots (Fig 2). All the growth parameters were maximum with 150% (grain yield=0.85 t/ha) RDF followed by 125% RDF (grain yield=0.74 t/ha) and 100% RDF (grain yield=0.71 t/ha). Among the varieties, TS38 showed

**Table 3 Effect of mulching, liming and INM on *rabi* rainfed maize var. DA61A**

| Treatments | Cob/plant (no.) | Grains/row (no.) | Cob length (cm) | Rows/cob (no.) | Grain yield (t/ha) | Harvest index (%) |
|---|---|---|---|---|---|---|
| **Mulching** | | | | | | |
| Control | 1.06 | 25.07 | 11.09 | 11.68 | 1.92 | 49.61 |
| Mulch | 1.26 | 31.77 | 17.82 | 14.03 | 2.53 | 50 |
| SEM | 0.03 | 1.57 | 0.97 | 0.46 | 0.19 | 0.63 |
| CD (*P*=0.05) | 0.11 | 6.78 | 4.21 | 2.01 | 0.45 | NS |
| **Farm yard manure (t/ha)** | | | | | | |
| 4 | 1.04 | 25.83 | 11.95 | 11.54 | 2.08 | 47.33 |
| 8 | 1.19 | 29.39 | 14.58 | 12.78 | 2.26 | 50.04 |
| 12 | 1.33 | 30.03 | 16.83 | 14.25 | 2.33 | 52.04 |
| SEM | 0.03 | 1.72 | 1.23 | 0.94 | 0.11 | 0.52 |
| CD (*P*=0.05) | 0.08 | 3.5 | 2.5 | 1.92 | 0.25 | 1.2 |
| **Liming (t/ha)** | | | | | | |
| Control | 1.11 | 24.16 | 11.83 | 11.44 | 1.85 | 48.33 |
| 0.2 | 1.18 | 26.78 | 14.48 | 12.8 | 2.21 | 48.77 |
| 0.4 | 1.18 | 30.7 | 14.7 | 12.96 | 2.23 | 50.44 |
| 0.6 | 1.23 | 32.04 | 16.8 | 14.23 | 2.61 | 51.66 |
| SEM | 0.01 | 0.75 | 0.57 | 0.43 | 0.11 | 0.51 |
| CD (*P*=0.05) | 0.06 | 3.26 | 2.45 | 1.85 | 0.23 | 1.05 |

**Fig 2 Toria crop at flowering stage**

higher values of growth and yield attributes *viz*., plant height, leaves/plant, no. of branches/plant that was at par with TS36 in all growth stages. Varieties also showed significant variation in siliquae/plant, siliqua length and seed/siliqua. The variety TS38 recorded highest yield (0.89 t/ha) followed by TS36 (0.76 t/ha) and M27 (0.72 t/ha).

## LINSEED

### Effect of fertility levels and seeding rate on linseed under rainfed condition

An experiment was carried out during *rabi* season, 2011-12 in a factorial RBD having 12 treatment combinations: four levels of fertility *viz*., control $F_0$, $F_1$ (20:10:10:10 kg of NPKS), $F_2$ (40:20:20:20 kg of NPKS), $F_3$ (60:30:30:30 kg of NPKS)/ha and three seed rates, $S_1$ (20 kg), $S_2$ (30 kg), $S_3$ (40 kg)/ha. All the growth attributes, entire yield attributes *viz.,* no. of capsule/plant and no. of seeds/capsule and, seed and straw yield increased significantly from $F_0$ to $F_3$ levels. Seed rate increase, decreased the plant height, no. of branches/plant, no. of capsules/plant, and no.of seeds/capsule while significantly increasing the grain yield from 20 kg to 30 kg/ha; however, further increase in seed rate decreased the grain yield (Table 4).

## RICE BEAN

### Effect of levels of lime application on growth, yield and quality of rice bean

A field experiment was carried out during the *kharif*,2011-12, laid out in SPD with three replications. Four levels of lime, *viz.,* control, 0.2, 0.4 and 0.6 t/ha were under the main plots and four varieties of rice bean such as RBS16, RBS53, PRR2 and RCRB4 were under the sub-plots (Fig 3). Increased levels of lime increased the yield of the rice bean. Lime application @0.6 t/ha recorded significantly higher yield attributes and yield followed by 0.4 and 0.2 t/ha. Among the varieties, RBS53 recorded significantly higher yield attributes and yield crop than other varieties (Table 5). PRR2 recorded significantly lower yield attributes and yield compared to other varieties due to its lower yield potential.


**Fig 3 Rice bean at flowering stage**

**Table 4 Effect of different fertility levels on growth, yield attributes on linseed**

| Treatments | Plant height (cm) | Pri. branch /plant (no.) At 90 DAS | Sec. branch / plant (no.) At 90 DAS | Capsules /plant (no.) At 90 DAS | Seeds/ capsules (no.) | Capsules yield /plant (g) | Seeds /plant (no.) | Yield (q/ha) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Seed yield | Straw yield | Biol. yield |
| **Fertility levels*** | | | | | | | | | | |
| $F_0$ | 75.34 | 8.77 | 69.34 | 107.27 | 7.49 | 12.74 | 355.75 | 0.35 | 0.55 | 0.90 |
| $F_1$ | 77.82 | 7.33 | 79.82 | 116.89 | 8.59 | 14.91 | 550.56 | 0.36 | 0.60 | 0.96 |
| $F_2$ | 78.89 | 6.33 | 80.89 | 137.14 | 8.68 | 15.91 | 590.80 | 0.38 | 0.67 | 1.05 |
| $F_3$ | 79.87 | 6.96 | 82.87 | 366.67 | 8.65 | 17.31 | 644.55 | 0.40 | 0.79 | 1.19 |
| **Seed rates*** | | | | | | | | | | |
| $S_1$ | 72.63 | 7.80 | 72.63 | 145.39 | 10.38 | 17.13 | 591.38 | 0.30 | 0.65 | 0.95 |
| $S_2$ | 79.56 | 6.89 | 78.56 | 136.84 | 8.79 | 16.15 | 489.85 | 0.32 | 0.60 | 0.92 |
| $S_3$ | 85.25 | 6.75 | 89.25 | 127.42 | 8.68 | 15.49 | 488.89 | 0.31 | 0.68 | 0.99 |

**Table 5 Effect of different levels of lime application on yield attributes and yield of ricebean cultivars**

| Treat-ments | Pod length (cm) | 1000-seed weight (g) | Pods/plant (no.) | Seeds/plant (no.) | Grain yield (t/ha) | Straw yield (t/ha) | Biological yield (t /ha) | Harvest index (%) |
|---|---|---|---|---|---|---|---|---|
| **Lime application (q/ha)** | | | | | | | | |
| Control | 6.45 | 66.17 | 24.67 | 88.18 | 0.40 | 0.49 | 0.89 | 47.38 |
| 0.2 | 6.68 | 66.58 | 31.36 | 72.68 | 0.55 | 0.59 | 1.14 | 46.95 |
| 0.4 | 6.54 | 68.42 | 35.50 | 101.54 | 0.93 | 0.90 | 1.83 | 49.67 |
| 0.6 | 6.97 | 69.08 | 33.63 | 106.55 | 0.84 | 0.82 | 1.65 | 52.42 |
| SEm± | 0.13 | 2.56 | 2.06 | 7.02 | 0.02 | 0.04 | 0.05 | 3.86 |
| CD(*P* =0.05) | 0.43 | NS | 7.13 | 24.28 | 0.06 | 0.15 | 0.17 | NS |
| **Varieties** | | | | | | | | |
| RBS16 | 6.57 | 67.08 | 25.28 | 82.15 | 0.65 | 0.67 | 1.32 | 46.51 |
| RBS53 | 6.86 | 68.33 | 27.06 | 81.22 | 0.88 | 0.86 | 1.74 | 49.36 |
| PRR2 | 6.81 | 67.42 | 42.84 | 102.33 | 0.41 | 0.43 | 0.84 | 50.22 |
| RCRB4 | 6.39 | 67.42 | 29.97 | 103.25 | 0.78 | 0.84 | 1.62 | 50.33 |
| SEm± | 0.18 | 2.00 | 1.74 | 5.70 | 0.04 | 0.04 | 0.06 | 3.02 |
| CD (*P* = 0.05) | NS | NS | 5.09 | 16.65 | 0.12 | 0.10 | 0.19 | NS |

## MUNGBEAN

### Effect of date of sowing, seeding rate and INM on summer mungbean var. TS21

A field experiment in SPD with three replications with mungbean var. TS21 (Fig 4) was carried out during the *kharif* season consisting two dates of sowing (5th and 15th Apr) under main plots and four seeding rates of 20, 25, 30 and 35 kg/ha under the sub-plots. The fertility levels were allotted in the sub-sub plots to evaluate their best applicability. 5th Apr sowing recorded significantly highest yield attributes and yield whereas, increased levels of seeding rate increased the yield; but the reverse was the case in yield attributes. The maximum yield was recorded with highest seed rate due to a higher plant population. In case of fertility level, 100% IN+50% ON recorded significantly the highest yield attributes and yield (Table 6).


**Fig 4Mungbean at pod formation stage**

**Table 6 Effect of sowing date, seed rate and INM on summer mungbean var. TS21**

| Treatments | Pod plant | Pod weight /plant (g) | Seed weight /plant (g) | Seeds/pod (No.) | 1000-seed weight (g) | Seed yield (t/ha) | Straw yield (t/ha) |
|---|---|---|---|---|---|---|---|
| **Sowing date** | | | | | | | |
| 5th April | 33.59 | 57.97 | 24.29 | 12.32 | 36.38 | 1.221 | 1.548 |
| 15th April | 30.94 | 53.82 | 21.87 | 10.79 | 35.34 | 0.977 | 1.479 |
| SEm | 0.48 | 0.66 | 0.41 | 0.15 | 0.72 | 0.34 | 0.20 |
| CD (*P*=0.05) | 2.94 | 4.03 | 2.52 | 0.89 | 4.37 | 2.07 | 1.22 |
| **Seed rate (kg/ha)** | | | | | | | |
| 20 | 33.72 | 58.53 | 22.81 | 11.78 | 35.26 | 0.958 | 1.477 |
| 25 | 31.52 | 56.83 | 21.60 | 12.09 | 35.23 | 0.964 | 1.480 |
| 30 | 29.82 | 54.29 | 19.56 | 12.12 | 36.36 | 1.001 | 1.521 |
| 35 | 28.99 | 52.93 | 19.35 | 12.22 | 36.60 | 1.094 | 1.577 |
| SEm | 0.34 | 0.64 | 0.24 | 0.16 | 0.43 | 0.19 | 0.15 |
| CD(*P*=0.05) | 1.05 | 1.96 | 0.73 | 0.49 | 1.34 | 0.58 | 0.47 |
| **Fertility levels** | | | | | | | |
| Control | 28.32 | 54.64 | 20.47 | 11.75 | 34.09 | 0.870 | 1.411 |
| 100 % IN | 31.55 | 57.83 | 23.25 | 12.30 | 35.31 | 1.050 | 1.607 |
| 100% IN+ 50% ON | 33.92 | 59.22 | 24.52 | 13.11 | 36.19 | 1.128 | 1.523 |
| S Em | 0.37 | 0.53 | 0.21 | 0.12 | 0.38 | 0.18 | 0.18 |
| CD (*P*=0.05) | 1.06 | 1.54 | 0.62 | 0.35 | 1.10 | 0.51 | 0.51 |

RDF: 20-40-20 NPK kg/ha and IN : Inorganic nitrogen, ON: organic nitrogen through vermicompost

## PEA

### INM in dwarf pea var. Azad

An experiment was carried out during *rabi s*eason with pea var. Azad in a SPD with three replications. Five fertility levels *viz.,* control, 100% IN, 100% ON, 100% IN+50% ON and 100% ON+50% IN were under main plots where, IN represents recommended dose of N, P, K and S (40-20-20-20 kg/ha) through inorganic fertilizers and ON represents recommended dose of N (40 kg/ha) through vermicompost. Four treatments of biofertilizers (Rhizobium+PSB+PGPR) and Zinc *viz.,* control, biofertilizer, zinc and biofertilizer+zinc were allotted to the sub-plots. Superimposition of 50% N organic (RD of N through vermicompost) to 100% NPK (RD of NPK through fertilizers) increased all growth, yield parameters (Table 7). It also significantly increased the no. of pods/plant whereas, it was closer to 100% ON+50% IN and 100% IN in number of grains/pod. 100% IN+50% ON application recorded the maximum grain and straw yields. Seed inoculations with biofertilizer and zinc application recorded higher grain and straw yields over the control.

## HORTICULTURE

## LILIUM

### Evaluation of lilium cultivars

Six varieties (Fig 5) of lilium (30x30cm) *viz.,* Sulpice, Brunello, Barasso, Acauplco, Lamacha, and Carmina were evaluated in RBD with four replications under shade net house. Days taken for bud emergence were earlier in Brunello (27.85 days) followed by Barasso (43.5 days). Barasso recorded significantly highest plant height (68.8 cm) while lowest was in Lamacha variety (42.6 cm). The number of leaves was the maximum in Brunello (81.8) and minimum in Lamacha (28.0). The number of buds was the highest in Brunello (3.8) while minimum in Barasso (1.8). Days taken for bud emergence were earlier in Acaulpco (75.15 days) while late in Carmina (118.5 days).


**Fig 5 Liliun under shed net house**

### Vase life study in Lilium

The effect of holding solution (3% sucrose+2ppm 8-HQ) and control (distilled water) on the vase life of the flowers of six vars. *viz*., Sulpice, Brunello, Barasso, Acauplco, Lamacha and Carmina at room temperature was studied (Fig 6) in a factorial CRD with three replications. The flowers were harvested with stalk length of 45 cm at colour development stage of the

**Table 7 Effect of INM on growth, yield attributes and yields of dwarf pea**

| Treat. | Plant height (cm) | | | Pri. branch/plant (no.) | | Dry matter /plant | Pods /plant (no.) | Seeds / pod (no.) | Seed yield (t/ha) (g) at harvest | Straw yield (t/ha) |
|---|---|---|---|---|---|---|---|---|---|---|
| | 30 DAS | 60 DS | 90 DAS | 60 DAS | 90 DAS | | | | | |
| **Main plots (Fertility levels)** | | | | | | | | | | |
| $M_0$ | 11.63 | 26.32 | 36.05 | 8.43 | 13.00 | 213.33 | 2.67 | 5.67 | 0.19 | 0.37 |
| $M_1$ | 12.21 | 26.47 | 38.31 | 9.00 | 13.72 | 278.75 | 3.47 | 6.89 | 0.26 | 0.52 |
| $M_2$ | 11.83 | 22.65 | 37.43 | 8.83 | 10.31 | 272.92 | 2.84 | 6.44 | 0.21 | 0.48 |
| $M_3$ | 12.78 | 27.49 | 38.99 | 9.14 | 13.08 | 399.59 | 3.3 | 6.73 | 0.33 | 0.72 |
| $M_4$ | 12.47 | 31.05 | 45.48 | 9.22 | 13.33 | 311.67 | 3.72 | 6.60 | 0.30 | 0.57 |
| **Sub plots ( Biofertilizer + micronutrient)** | | | | | | | | | | |
| $S_0$ | 11.70 | 26.18 | 37.66 | 8.91 | 13.31 | 277.67 | 3.05 | 6.43 | 0.26 | 0.51 |
| $S_1$ | 12.37 | 27.17 | 39.73 | 9.11 | 13.04 | 296.67 | 3.10 | 6.23 | 0.25 | 0.52 |
| $S_2$ | 12.21 | 25.74 | 39.33 | 8.97 | 13.51 | 289.00 | 3.19 | 6.64 | 0.27 | 0.54 |
| $S_3$ | 12.46 | 28.60 | 40.29 | 8.71 | 13.55 | 317.67 | 3.45 | 6.40 | 0.29 | 0.59 |

Main plots (Fertility levels): $M_0$: Control, $M_1$: 100% NPK, $M_2$: 100% $N_{organic}$, $M_3$: 100% NPK + 50% $N_{organic}$, $M_4$: 100% $N_{organic}$ + 50% NPK; Sub plots (Biofertilizers+micronutrients): $S_0$: Control, $S_1$: Biofertilizers, $S_2$: Zn @ 5 kg/ha, $S_3$: Biofertilizers+Zn.

first flower bud and kept in the solution. The highest length and diameter of the flower bud was recorded in Lamacha while, lowest was in Brunello variety. The maximum diameter of stem was observed in Barasso (0.67 cm) and minimum in Brunello (0.50 cm). The diameter of the flower was maximum in Lamacha (26.53 cm) and minimum in Brunello (21.55 cm). The days taken for bud burst and for full bloom were maximum in Barasso and minimum in Brunello (2.37 days). The minimum number days taken for full bloom were observed in Sulpice (3.75 days) and Brunello (3.75 days). The vase life of flowers was maximum in Barasso (14.27 days) and the minimum in Lamacha (8.87 days).

**Fig 6 Vase life studies in Lilium**

## ANTHURIUM

### Evaluation of Anthurium cultivars

Seven varieties of Anthurium *viz.,* Violet Heart, L'Amour, Queen Black, First Red, Cynthia, Anastacia and Red were evaluated at a spacing of 30x30 cm in RBD design with three replications under shade net house. Maximum plant height was recorded in L'Amour (20.67 cm) and Queen Black (20.67 cm) while, minimum was in Anastacia (15.67 cm) after 3 months. The number of leaves was maximum in Cynthia (7.67) and minimum in First Red (4.67) and Anastacia (4.67).

## COLOCASIA

### Collection, characterization and conservation of indigenous landraces of colocasia

Colocasia cultivars of 25 nos. collected from different districts of Nagaland and adjoining Assam were planted (RBD; three replications). All the lines germinated within 11 to 16 days after planting. Maximum plant height was recorded in line 18 (113.96 cm) and the minimum in line 6 (54.44 cm). The maximum plant span of 130 cm in line 7, minimum in line 3 (63.28 cm); maximum number of suckers in line 6 (6.0) and minimum in line 9 (0.71); maximum number of leaves (28.28) in line 2 and minimum of 5 leaves in line 7; maximum leaf length (60.11 cm) and leaf width (49.83 cm) in line 1, and minimum leaf length of 24.50 cm and width of 21.17 cm in line 2; highest petiole length of 101.72 cm in line 10 and lowest petiole length (39.14 cm) in line 7 were recorded. There was significant difference in the no. of cormels among the lines evaluated. The highest no. of cormels was recorded by the line 21 (14.25) and lowest was in line 5 (1.50). The maximum corm weight (715.83 g) was recorded in the line 4, and the minimum (64.50 g) in the line 5. The highest cormel weight (275.0 g) was recorded in the line 1 and the lowest (20.77 g) in the line 13. The maximum total corm weight of 1329.20 g was recorded in the line 18, and the minimum of 108.24 g was in line 5.

## TECHNOLOGY MISSION (MM-1)

### Propagation of quality seed and planting materials

During 2011-12, *Khasi* mandarin seedlings (1000 nos.), Assam lemon cuttings (7050 nos.), black pepper cuttings (1050 nos.), and 100 kg of French bean seeds were produced in the Institute Research Farm and distributed to the farmers.

**Table 8 Transfer of technology under Technology Mission (MM-1)**

| Topic of the training/demonstration | Number |
|---|---|
| Training on floriculture and landscaping for entrepreneurship development. | 1 |
| North-East Horti Farmers' Meet | 1 |
| FLD on rejuvenation of *Khasi* mandarin | 4 |
| FLD on improved production technology of *Khasi* mandarin | 4 |
| FLD on improved production technology of Assam lemon | 4 |

**Fig 7 Training on floriculture and landscaping**

**Fig 8 North-East Horti Farmers' Meet**

## SOIL HEALTH MANAGEMENT

### Soil and water conservation

Site-specific low-cost water harvesting structures (*Jalkund*, base flow harvesting, rooftop rainwater harvesting, fish ponds, and Modified Thai Jar (for kitchen gardening) and soil erosion control measures (contour and graded bunding, bench terracing, half-moon terracing, gully plugging, and trenching) were carried out in Dimapur, Peren, Wokha, Kohima, Phek and Mon districts of Nagaland for life saving irrigation, *in-situ* soil and moisture conservation under various projects (Fig 9).

**Fig 9 Diversion of irrigation channel under NICRA at Dhanshirpar village, Dimapur**

## AGROFORESTRY

### Evaluation of growth performance of *Jatropha curcas*

A total of 11 provenances were screened for the growth performance of *Jatropha curcas*. 'Molvum' genotype had highest seed oil (38.99%) followed by *Rangapahar* (37.51%) and *Piphema* (35.62%). *Molvum* source exhibited highest growth rate in terms of height, followed by *Piphema*, and *Rangapahar* seed source had the lowest growth. The diameter growth was highest in *Piphema*, followed by *Ruzaphema*. Similarly, no. of branches per plant was highest in *Molvum* (12.5 nos. /plant), followed by *Dhansiripar* (10 nos./plant). The crop productivity was significantly low in under storey *Jatropha* mainly due to heavy shade and competition for light, soil moisture and nutrients between woody perennial and annuals. Hence, intercropping is not suggested with *Jatropha*.

### Analyses of soil and plant samples from different districts of Nagaland

Soil samples of 2244 nos. from seven districts *viz.,* Dimapur, Peren, Kohima, Wokha, Mon, Tuensang and Phek were analyzed for N, P, K, OC and pH. The ranges of average N, P, K, OC and pH of soil samples were 62.7-2025.9 kg/ha, 3.42-24.73 kg/ha, 20.3-519.6 kg/ha, 0.07-6.62%, and 4.72-5.80, respectively.

### Effect of elevated temperature on soil carbon sequestration, microbial biomass and enzymatic activities under different land use

Soil samples from different land use pattern *viz.,* mustard-rice-maize, linseed- rice, green gram-groundnut-toria, lemon orchard (5 years old), linseed-rice-field pea (zero tillage), *jhum* land, terraced rice, agroforestry and non cultivated pasture land were collected. Initial nutrient analysis and elevated temperature ($42^0$C; for 1 month) treated soil samples revealed (Table 9) that all the parameters showed increasing trend due to heat treatment which might be due to the combined effect of heat induced mineralization of organic sources as well as cellular materials of psychrophilic and mesophilic organisms.

**Table 9 Nutrient analysis for initial and elevated temperature treated soil samples**

| Parameters | Initial | | $42^0$C treated | |
|---|---|---|---|---|
| | Range | Mean | Range | Mean |
| pH (1:2.5; Soil: Water suspension) | 4.28-5.92 | 4.86 | 4.59-5.88 | 5.09 |
| EC (dS/m) | 0.023-0.180 | 0.071 | 0.043-0.391 | 0.140 |
| Oxidizable organic carbon (%) | 0.22-1.22 | 0.56 | 0.27-1.19 | 0.58 |
| Mineralizable N (kg/ha) | 75.3-194.4 | 110.8 | 106.6-294.8 | 147.4 |
| Available P (kg/ha) | 41.5-380.9 | 122.9 | 46.5-365.8 | 129.2 |
| Available K (kg/ha) | 47.4-448.1 | 166.9 | 75.3-448.1 | 180.5 |

## ANIMAL PRODUCTION

### Mega Seed Project on Pig

Parent stock of Large Black and Ghungroo breeds of pigs are being reared under the project. A total of 623 numbers of piglets were born, of which 293 piglets were distributed to 95 farmers of Dimapur, Kohima, Wokha, Phek and Mon districts of Nagaland through four KVKs *viz.*, Dimapur, Phek, Wokha and Zunheboto (83 nos.) and 58 piglets through institute. Altogether 434 piglets were distributed and a sum of Rs. 9,04,660 were generated during the reporting year by selling the piglets and culled animals for meat purpose. To meet the demand of the piglets in the state, six big breeding units were also established at the farmers' field by participatory mode in Dimapur, Kohima, Wokha and Mokokchung districts of Nagaland and germplasms were supplied from the stock produced under Mega Seed Project (Fig 10).


**Fig 10 Pig breeding unit at Bade village (Dimapur district) and Mezoma village (Kohima district)**

### Comparative studies on productive and reproductive performances of pig breeds

The growth and reproductive performance of 25 gilts of Large Black cross and Ghungroo were monitored. The average daily weight gain was 176.67 g and 144.26 g during pre-weaning period and 361.73 g and 284.53 g during post-weaning period in Large Black and Ghungroo, respectively. At the pre-weaning period,the body weight in Large Black cross piglet was significantly higher as compared to Ghungroo pig; and during the post-weaning period, the body weight was similar up to six months. However, during the 7$^{th}$ month, the body weight was significantly higher in large Black cross than Ghungroo. The Large Black cross and Ghungroo pigs were performing similar in reproductive performance under identical management condition in Nagaland (Figs 11 & 12).

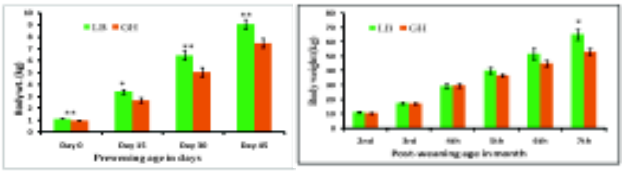


**Fig 10 Pre-weaning and post-weaning growth performance of Large Black and Ghungroo Gilts under identical management condition in Nagaland (** $p<0.01$, * $p<0.05$)**

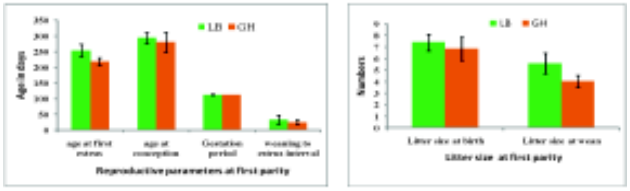


**Fig 11 Reproductive performance of Large Black and Ghungroo Gilts at first parity under identical management condition in Nagaland**

### Poultry seed project

The parent stock of Vanaraja and Gramapriya chicken were maintained in this project. During the reporting year, three new poultry units comprising of hatchery house, brooder-cum-grower house and layer house were constructed. A total 79,089 eggs were produced; of which 60,257 were set into hatchery unit and 38,401 chicks were produced with 82.85% fertility and 75.75% hatchability on the fertile eggs set. The chicks were reared for 3-4 weeks at the brooding unit and distributed to the beneficiaries at subsidized rate. A total of 26,177 day-old chicks were distributed to the beneficiaries of different districts of Nagaland and Arunachal Pradesh (Table 10). A sum of Rs. 12,15,058 (Rupees twelve lakh fifteen thousand and fifty eight) was realized as revenue by selling of chicks, eggs and culled birds.

**Table 10 Beneficiaries of the Poultry seed project**

| Particulars | Total nos. |
|---|---|
| No. of benefited farmers | 16899<br>(196 farmers in 7 districts) |
| Distribution through KVKs | 5168 (8 KVKs in 8 districts) |
| Distribution under the project NICRA/TSP/PD_ADMAS/ NAIP etc. | 4110 (4 districts) |
| Total no. of chicks distributed | 26177 |

## TRIBAL SUB-PLAN (TSP)

### Seed production program for rice, maize, toria and linseed

Under the TSP, quality seed production program of *rabi* maize, linseed and toria was initiated both in the farmers' field (in Vade village, Dimapur district) and in the Institute Research Farm during 2011-12. The total area selected for cultivation of *rabi* maize (rainfed condition) was about 2.0 ha. A total of 1.2t of quality maize seeds(var. RCM75 and RCM76) were produced to partially meet the huge demand of maize growing farmers. Quality seeds of toria var. TS36 and TS38, and linseed var. Garima and Neelam were also produced at ICAR Research Farm in an area of about 0.5 ha. The productivity of maize (var. RCM76), rapeseed (vars. TS36 and TS36), and linseed (var. Parvati) were 2.1 t/ha, 1.0 t/ha, 1.2 t/ha, and 0.8 t/ha, respectively. Under the TSP of Poultry Seed Project, 10 demonstration units for backyard poultry farming were established in farmers' field in a participatory mode in Dimapur, Wokha, Mokokchung and Phek districts of Nagaland. Each unit has the capacity to rear 400 numbers of birds under semi-intensive system (Fig 13). The evaluation and documentation of the performances of Vanaraja and Gramapriya in field condition is in progress.

**Fig 13 Distribution of chicks by Shri Pangny Phom, Parliamentary Secy., Govt. of Nagaland to the farmers for demonstration of backyard poultry farming in Longleng**

### Implementation of Tribal Sub Plan under PD_ADMAS in Nagaland

Under TSP component of PD_ADMAS funded project, animal health coverage was extended in Bade and Diezephe villages of Dimapur district and Longsa village of Wokha district. Complete health coverage was given to all the livestock including poultry and dog by organizing six numbers of animal health camps, regular follow up program, routine deworming, and distribution of feed supplementation for animals. Prophylactic measure was taken up against the prevalent diseases of livestock, namely, FMD in cattle and goat, CSF in pig, Rabies in dog and Ranikhet, and IBD in poultry. Animal health coverage was given to approx. 300 households comprising of 317 cattle, 761 pigs, 235 goats, 316 dogs and 4697 poultry birds. In addition to complete health coverage, about 1200 chicken were distributed to 90 beneficiaries of poor and marginal farming community. After the follow up treatment, the impact of the project was assessed and documentation is in progress (Fig 14).

**Fig 14 Animal health camp and training cum-workshop program organized at Bade village, Dimapur and Longsa village, Wokha district under Tribal Sub Plan of PD_ADMAS**

## NICRA

## CROP SCIENCE

### Production potential of rainfed maize cultivars under moisture stress condition for climate resilient agriculture

A field experiment was initiated in the Institute Farm under the project NICRA on the theme "Identification of temperature (drought/high temp.) tolerant rice and maize varieties for northeastern hill ecosystem during the *rabi* season of 2011-12 under rainfed condition. The treatments were: fertility levels with RDF of N, P, K (80-60-40 kg/ha) through inorganic fertilizers (urea, DAP and MOP), FYM @10 t/ha and lime @0.5 t/ha. Mulching was done to minimize the soil moisture loss and also to improve the water productivity. Five maize varieties *viz*., Nagaland local, Vijay composite, DA-61-A, DHM-117 and RCM-75 were grown. The treatment RDF+FYM+lime+mulch recorded the highest growth and developmental parameters such as plant height, no of leaves, stem girth and dry matter accumulation, root length (Fig 15), root volume (Fig 16) and CGR as compared to other treatments with the variety RCM-75.

### Improvement in the conventional soil conservation measures

Traditional method of '*Echo'* being used by the farmers of Wokha district, Nagaland for soil conservation was improved upon through scientific

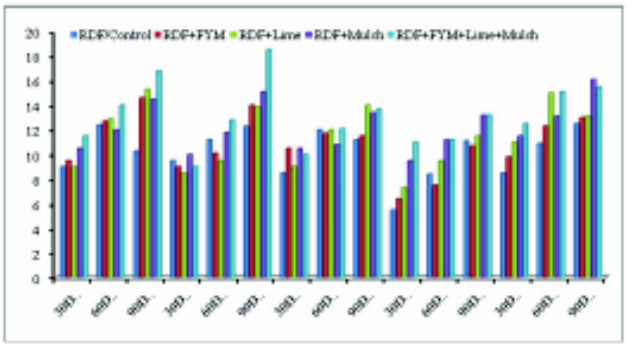


**Fig 15 Variation of root length (cm) in different varieties of maize**

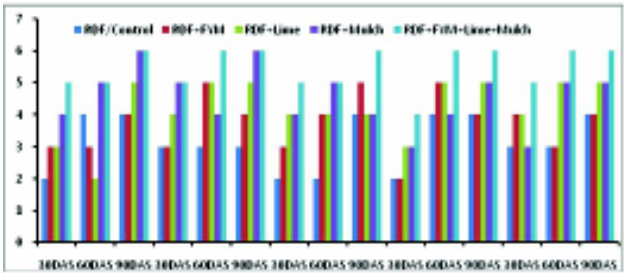


**Fig 16 Variation of root volume in different varieties of maize**

methods using contour and graded bunding. The bunds were stabilized by planting the nitrogen fixing *Tephrosia candida.* In this system, the soil erosion could be controlled up to 42% compared to control (Fig 17 & 18).

**Fig 17 Echo the traditional soil conservation method**

**Fig 18 Echo with scientific method**

### Integrated Agro-met Advisory Services (IAAS)

Bi-weekly (Tue and Fri) medium range forecast of weather was provided in Nagaland through e-mail, FAX, newspapers and radio. Weekly monsoon press release was prepared on every Wednesday. Mobile SMS on daily weather data was provided to 1191 progressive farmers across the state (Dimapur=590, Tuensang=76, Kohima=81, Mon=100, Mokokchung=49, Wokha=200, Phek=95).

### Development of non-forest waste lands through agro-forestry models

A total of 478 ha of degraded waste lands were rehabilitated through different agroforestry interventions in Mokokchung, Phek, Wokha, Kohima, Dimapur, Peren and Mon districts (Fig 19). Technology was transferred through various farmers' organizations, *viz*., Union of Cooperative Societies (UCOS) of Jalukie, Phek Farmers' Association, Organic Growers' Association of Molvum and Medziphema, Transforming Livelihood Intervention Society of Medziphema, RADS of Peren etc., NGOs (e.g. World Vision, Nandi Foundation), Naga Fragrance, Village Development Council, KVKs, and ATMA. The technology such as pineapple cultivation is well-accepted in the areas of Medziphema and Jalukie, whereas large cardamom orchards and kiwi plantation are abundantly practiced in Pfusro. Ginger and turmeric cultivation is also well-accepted in several parts of Nagaland.


**Fig 19 Development of non-forest waste lands through agro-forestry models**

### Standardization of ET estimation methods

Using the ASCE-FAO-56 Penman-Monteith model as the benchmark model, a total of 16 various ET estimation methods (FAO-24 Radiation, Hargreaves Radiation, Hargreaves Temperature, Priestley-Taylor, Jones-Ritchie, Makkink, Turc, Modified Jensen-Haise, Snyder et al. pan, FAO-24 pan, Cuenca pan, Allen-Pruitt pan, Snyder pan, Pereira et al. pan, Orang pan, and Raghuwanshi-Wallender pan evaporation) were evaluated using both the continuous daily timeseries and average timeseries weather data recorded at ICAR

Research Complex for NEH Region, Nagaland Centre. The Priestley-Taylor, Turc, Snyder et al. pan, FAO-24 pan, Snyder pan, and Pereira et al. pan evaporation models had restricted performances. Consequently, for an improved performance, all these models were standardized using a Genetic Algorithm based linear corrector transformation model. The main recommendations were: 1. Original models with continuous timeseries weather data: ASCE-FAO-56 Penman-Monteith, FAO-24 Radiation, Hargreaves Radiation, Hargreaves Temperature, Jones-Ritchie, Makkink, and Modified Jensen–Haise models; 2. Original models with average timeseries weather data: ASCE-FAO-56 Penman-Monteith, FAO-24 Radiation, Hargreaves Radiation, Hargreaves Temperature, Jones-Ritchie, Makkink, Cuenca pan, Allen-Pruitt pan, Orang pan,and Raghuwanshi-Wallender pan evaporation models;

3. GA-based models with continuous timeseries weather data: FAO-24 Radiation, Hargreaves Radiation, Hargreaves Temperature, Jones-Ritchie, Makkink, Turc, and Modified Jensen-Haise models; and 4. GA-based models with average timeseries weather data: All the models except Pereira *et al.* pan evaporation model (Figs 20 & 21).

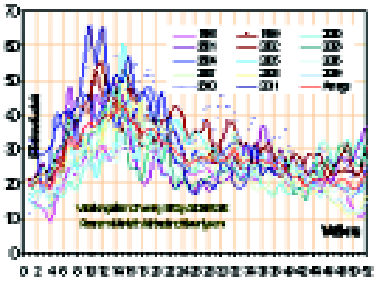


**Fig 20 Weekly variations in ET**

**Trend analysis of weather variables**

The trend analysis of ETo estimated by ASCE-FAO56-PM method revealsthat there was an increasing trend of ETo during the months of Feb to July and Oct, followed by a decreasing trend during Aug to Jan except Oct with an annual decreasing trend of 0.42 mm/year. The maximum increasing trend of 3.88 mm/month was observed in May followed by Apr (2.71 mm/month) and Feb (2.16 mm/month). Similarly, the maximum decreasing trend of 4.47 mm/month was

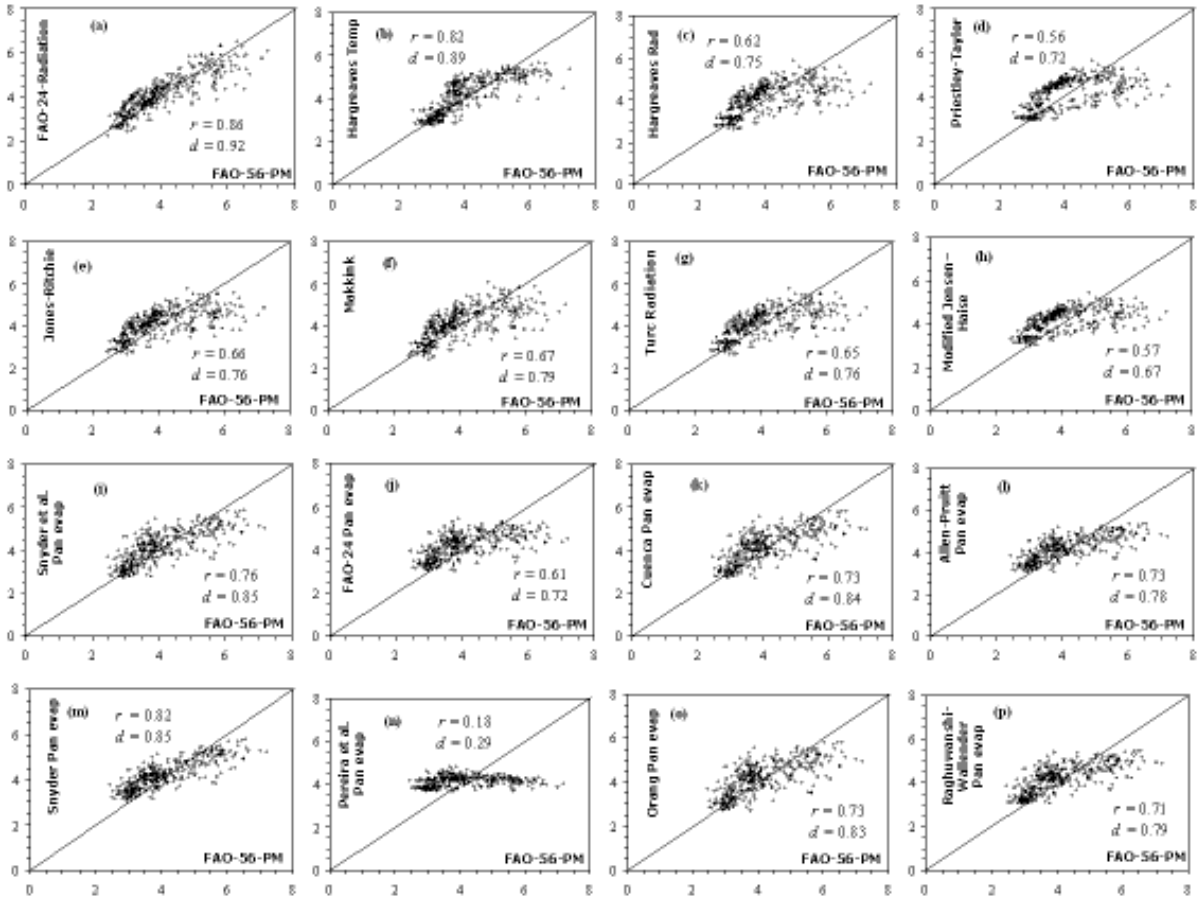



**Fig 21 Comparison of all the Genetic Algorithm-based models with respect to the ASCE FAO-56 Penmann–Monteith equation using average daily time series weather data during Jan. 1998–Sep. 2011 (ETo in mm/day).**

observed in Dec followed by Nov (2.52 mm/month). Conversely, there is an annual increasing trend of 0.156 °C in daily average $T_{max}$ and decreasing trend of 0.217 °C in daily average $T_{min}$, resulting in increasing trend in the difference between the daily maximum and minimum temperatures. This emphasizes to develop crop varieties which can withstand both the heat and cold stresses simultaneously. However, the trend analysis of the annual maximum (extreme) of $T_{max}$ and annual minimum (extreme) of $T_{min}$ shows that these trends are 0.033 °C/year and –0.183 °C/year, respectively. Similarly, an increasing trend in the total annual rainfall of 5.940 mm/year is observed without any trend in the total annual sunshine duration. However, these trends may change with the use of long-term data. Moreover, this study reveals that refinement of the existing ETo estimation models is a must for their application in different geo-meteorological and agro-ecological scenarios that affects the modeling performance under limited data-use conditions. It also reveals that for irrigation water management under Nagaland condition, the pan evaporation data should not be used, which underestimate the actual evaporation rate. Hence, this study can be useful for crop planning and water management under the existing trend of global climate change.

## ANIMAL SCIENCE

### Understanding the unique traits in indigenous pig and poultry which make them resilient to climate change and development of database (NICRA)

A survey (questionnaire method) of traditional pig and poultry production practices was conducted in the selected villages of Dimapur, Peren, Wokha, Mon, Phek and Kohima districts of Nagaland (Fig 22). A total of 260 respondents were interviewed. Among the respondents, 69.2% and 81% had pig and poultry, respectively as important livelihood options. Majority (60%) reared crossbred pigs, 50% local pigs and just 10% had initiated rearing of exotic pigs. The common feeding practices were stall feeding (60%), scavenging with morning and evening ration (7.8%) and scavenging (2.2%). Feed ingredients used by the farmers were mainly kitchen waste, concentrate mixture of broken rice, wheat bran, rice brew and maize along with colocasia, tapioca, sweet potato and many non-conventional grasses, tree leaves - either cooked or raw form. Production performance survey revealed the suitability and adaptability of Large Black cross types, Hampshire cross and indigenous Ghungroo in

**Fig 22 Survey on indigenous pig and poultry production systems in different districts of Nagaland**

the region. Common diseases affecting the pigs were piglet diarrhea (58.9%), swine fever (51.1%), endoparasite (46.7%), and ectoparasitic infestation/ mange (41.1%). Majority of people were engaged in rearing of local poultry (77.9%) and only 22.2% started to rear improved varieties. Among the dual purpose improved poultry varieties, the Vanaraja, Gramapriya and Kruoiler were suitable at different altitudes of Nagaland throughout the year. The most commonly occurring diseases were Ranikhet (61.7%), Bacillary white diarrhea (45.7%), infectious coryza (16.1%), ectoparasites/lice (9.9%), endoparasites (6.2%), and coccidiosis (6.2%) etc.

## NAIP

### Livelihood Improvement and Empowerment of Rural Poor through Sustainable Farming Systems in Mon District of Nagaland (NAIP)

Various technological interventions on scientific pig, poultry, and goat rearing; Water harvesting for multiple livelihood options; Terracing for wet rice cultivation; Rice and maize based cropping systems; Agroforestry interventions including horticultural orchard establishment and Skill up-gradation were undertaken in two clusters of Mon district, one of the most backward district of India recognized by the planning Commission, Govt. of India (Fig 23).

Various site-specific low-cost water harvesting structures (tanks, base flow harvesting, rooftop


**Fig 23 NAIP activities at Lampong Sheanghah village, Mon**

rainwater harvesting, fish ponds, and Modified Thai Jar (for kitchen gardening)), and soil erosion control measures (contour and graded bunding, bench terracing, half-moon terracing, gully plugging, and trenching) including mulching were carried out for life savingirrigation, in-situ soil and moisture conservation. About 120 ha of abandoned *jhum* land was rehabilitated using different integrated farming system (IFS) models. The created system capacity for storing water for lean period was 82.35 thousand cubic litre; whereas, the createdcapacity of fish ponds to conserve water was 1.244 million cubic litre. Within a span of four years, the total crop production of this area increased from 159 t/year (baseline) to about 362 t/year. Similarly, the crop productivity (average of all the crops cultivated) increased from 4.58 t/ha (baseline) to about 6.79 t/ha. Five apiculture units (total 30 hives) and six sewing machines were also given in the cluster after providing professional training to enhance family income.

**Livelihood improvement and empowerment of rural poor through sustainable farming systems in Mon district of Nagaland (NAIP- III)**

Livestock intervention through backyard poultry farming was initiated. Three demonstration units with capacity of 300 birds in each unit were constructed at Lampong Sheanghah village of Mon district, Nagaland. About 840 birds were distributed to another 40 beneficiaries for livelihood support. The feedback from the farmers was very much encouraging (Fig 24).

**Rural livelihood through improved variety of backyard poultry (Vanaraja) farming at Lampong Sheanghah village, Mon district, Nagaland**

**Animal Health**

The antibacterial sensitivity pattern against the *Escherichia coli* isolates was carried out in a total of 80 fecal samples obtained from piglet diarrhoea cases in field/farm condition in and around Dimapur district. A total of 18 different antibiotics disc were selected.

**Fig 24 Rural livelihood through improved variety of backyard poultry (Vanaraja) farming at Lampong Sheanghah village, Mon district, Nagaland**

The samples from the villages had highest sensitivity (=13mm) towards enrofloxacin (93.33%), ceftriaxone (86.66%), ofloxacin (73.33%), norfloxacin (40%), sulphafurazole (33.33%), cefotaxime (36.67%), sulphadiazine (30%), and amoxicillin (10%) while medium sensitivity (8-13 mm) was observed towards amoxicillin (90%), nitrofurantoin (90%), furazolidone (76.66%), sulphadiazine (73.33%), cefalexin (66.67%), norfloxacin (60%), oxytetracycline (30%) and trimethoprim (30%). The resistance pattern (0-8mm) was seen against the amphotericin, clotrimazole, cloxacillin, vancomycin and metronidazole. Farm samples showed highest sensitivity towards ceftriaxone (100%), norfloxacin (80%), enrofloxacin (80%), cefotaxime (66%), sulphadiazine (60%), amoxicillin (48%), ofloxacin (30%), and sulphafurazole (28%) and medium sensitivity towards trimethoprim (96%), sulphafurazole (72%), and ofloxacin (70%). The resistance pattern was observed for furazolidone, metronidazole, oxytetracycline, vancomycin, cloxacillin, clotrimazole and amphotericin.

# SIKKIM

## WEATHER REPORT

In Sikkim, the maximum rainfall of 774.4 mm was received during Jul, 2011 whereas minimum rainfall was recorded in Jan and Feb 2012. The maximum average temperature (27.36°C) was observed in Jun, 2011 and the minimum (13.65°C) in Jan 2012.The maximum relative humidity of 90.64 % was observed during Jul 2011 and the minimum of 82.67% in Mar 2012 (Table 1).

## CROP SCIENCE

### RICE

### Performance of released upland varieties under midhills

Six high yielding upland rice varieties *viz.,* Bhalum 1, Bhalum 2, Bhalum 3, Bhalum 4, RCPL412 and RCPL413 were tested under midhill conditions. The entries were tested in RBD with 4 replications having 3 rows in each replication. Five plants were randomly selected for data recording in each entry. The growth and the yield attributes are presented in table 2.

### RCRT Upland

Seventeen upland paddy lines (RCPL1-114, RCPL1-128, RCPL1-129, RCPL1-130, RCPL1-80, RCPL1-82, RCPL1-90, RCPL1-93, RCPL1-103, RCPL1-111, IR60080-46A, Bhalum 1, Bhalum 2, Bhalum 3, Bhalum 4, RCPL1-412 and RCPL1-413) were evaluated under midhills of Sikkim. The entries were grown in RBD with row to row and plant to plant distance of 25 cm and 15 cm, respectively. The data was recorded randomly on five plants. Among the entries, Bhalum 2 was earliest in maturity (127 days) followed by Bhalum 1 (128 days). Highest grain yield per plant recorded in Bhalum3 (29.26 g) followed by RCPL412 (28.46 g).

### RCRT Lowland

Thirty nine entries of lowland paddy were evaluated for assessing their suitability for cultivation under Sikkim lowland conditions. Out of it, three entries were

**Table 1 Mean monthly weather parameters from Apr'11 to Mar' 12**

| Months | Temperature °C | | Relative humidity (%) | | Bright Sunshine hours | Total rainfall (mm) |
|---|---|---|---|---|---|---|
| | Max | Min | Max | Min | | |
| Apr | 26.08 | 13.80 | 83.8 | 41.76 | 3.67 | 142.1 |
| May | 27.07 | 17.29 | 86.32 | 53.96 | 4.25 | 324.1 |
| Jun | 27.36 | 19.60 | 88.56 | 60.36 | 3.29 | 683.8 |
| Jul | 26.97 | 20.08 | 90.64 | 71.29 | 0.92 | 774.4 |
| Aug | 26.88 | 19.88 | 90.45 | 66.80 | 2.26 | 517.0 |
| Sep | 26.01 | 18.49 | 90.4 | 62.66 | 2.02 | 338.35 |
| Oct | 25.87 | 15.65 | 90.38 | 50.93 | 5.01 | 46.2 |
| Nov | 19.01 | 15.14 | 88.56 | 52.20 | 1.77 | 74.0 |
| Dec | 16.92 | 8.70 | 87.12 | 50.35 | 0.30 | 4.3 |
| Jan | 13.65 | 6.12 | 87.19 | 49.61 | 0.93 | 19.9 |
| Feb | 25.93 | 8.78 | 86.86 | 42.93 | 3.07 | 28.9 |
| Mar | 22.76 | 11.51 | 82.67 | 39.90 | 2.80 | 45.2 |

**Table 2 Yield and its related traits in upland paddy varieties**

| Entries | Panicles/m² | Panicle length (cm) | Grains /panicle | Days to 50% flowering | Days to 75% maturity | 100 grains weight (g) | Yield/ plant (g) |
|---|---|---|---|---|---|---|---|
| Bhalum 1 | 194.66 | 22.50 | 136.22 | 86.00 | 128.00 | 2.40 | 25.73 |
| Bhalum 2 | 187.33 | 21.82 | 150.77 | 85.33 | 127.66 | 2.60 | 28.06 |
| Bhalum 3 | 197.33 | 20.53 | 136.44 | 91.00 | 136.33 | 2.47 | 29.26 |
| Bhalum 4 | 188.00 | 19.24 | 125.77 | 89.66 | 135.66 | 2.36 | 21.88 |
| RCPL 412 | 194.66 | 19.53 | 165.44 | 96.33 | 135.66 | 2.28 | 28.46 |
| RCPL 413 | 185.33 | 20.73 | 188.00 | 95.00 | 135.33 | 2.23 | 21.82 |
| SEM | 16.86 | 0.71 | 14.03 | 0.38 | 0.32 | 0.16 | 1.89 |
| CD (*P*=0.05) | 53.13 | 2.25 | 44.21 | 1.22 | 1.03 | 0.52 | 5.96 |

rejected due to poor performance. Days to 50% flowering recorded lowest in entries RCPL1-470 (51 days), RCPL1-466, RCPL1-126, RCPL1-474 and RCPL1-475 (55 days each). Yield per plant recorded highest in RCPL1-473 (76.80 g) followed by RCPL1-417 (74.55 g).

## DISEASES

### Organic management of blast and sheath blight

The sheath blight pathogen *Rhizoctonia solani* was isolated from the diseased samples of rice plants. The pathogen was purified using hyphal tip method and cultured on PDA media. The pathogenecity was tested. The pathogen produced large oval spots on the leaf sheaths and irregular spots on leaf blades. The pathogen *R. solani* produced sclerotia and white colour colony which later became brown. The mycelium is pale to dark brown, relatively larger diameter with branching near the distal septum of the hyphal cells, often nearly at right angles in older hyphae. Different Trichoderma isolates collected from different districts of the Sikkim was studied for their antagonistic effect against *R. solani* using dual culture technique. Among the various isolates tested, the isolate T2 collected from Panthang was very effective in inhibiting the growth of sheath blight pathogen with 78.88% inhibition over control followed by T5 (75.18%), T3 (73.70%), T9 (73.33%), T28 (71.10%) and T25 (70.73%). The least per cent inhibition over control (42.22%) was observed in T33 isolate collected from ICAR farm Tadong.

## BUCKWHEAT

### Performance of local buckwheat cultivars under different levels of vermicompost

The aim of the study was to quantify the optimum doses of organic inputs (vermicompost) for profitable cultivation of local buckwheat cultivars. The experiment was conducted during *rabi* season (22 Nov sowing). The experiment was laid out in FRBD, assigning local cultivars *"Mithe* and *Tithe"* as a factor A and levels of vermicompost (control, vermicompost @ 1 t/ha, vermicompost @ 1.5 t/ha and Vermicompost @ 2.5 t/ha) as factor B. All the treatments were replicated thrice. Local cultivar *Tithe* was more responsive to vermicompost application compared to *Mithe*. *Tithe* cultivar gave approximately 20% higher grain yield compared to *Mithe* at same level of vermicompost. However, highest grain yield of both the local cultivars was recorded with the application of vermicompost @ 2.5 t/ha.

## OILSEEDS

## TORIA

### Effect of mulching and vermicompost on growth and productivity of *toria* var. M 27

A field experiment was conducted in post rainy season (Nov – Jan) in 2011-12.The treatments comprising of four levels of mulching {control, tree leaf (*Chilawney* + *Utis*) mulch @ 5 t/ha, maize stover mulch @ 5t/ha and paddy straw mulch @ 5 t/ha}as main plot treatments and three levels of vermicompost (control, vermicompost @ 1 t/ha and vermicompost @ 1.5 t /ha) as sub-plot treatments and replicated four times in spilt plot design. Combination of tree leaf (*Chilawney+Utis*) mulch @ 5 t/ha and vermicompost @ 1.5 t/ha recorded the maximum grain yield (1.29 t/ha) of toria.

## RAPESEED

### Genetic advancement of elite rapeseed material suitable for cultivation under Sikkim conditions

Nineteen single plant selections and one bulk selection were made from yellow sarson population (SSY-1) developed at the centre. The selection has been done on the basis of days to maturity, siliqua number and seed yield per plant (g). These have been tested under rainfed conditions.Toria population SKMT2a selection made from the segregating population of SCRT 1-1-1 was sown in isolation for its pure seed production. The population matured in about 100 days and produced yield approximately 1.2 t/ha.

## SOYBEAN

### Research Complex Regional Trial

Five entries of soybean developed at ICAR, Barapani were tested during *kharif*, 2011. The entries were grown in plot size of 2.25 $m^2$ with 3 replications in RBD. The data was recorded randomly on five plants. Entry RCS110 recorded highest yield (807.00 g) followed by Bragg (741.66 g). RCS1-10 was earliest in maturity (105 days) (Table 3).

## INSECT PEST OF OIL SEEDS

### Seasonal abundance of mustard aphid and saw fly with relation to abiotic factors and their management

Mustard aphid and saw fly (Figs 1 & 2) are major pests of rapeseed and mustard in Sikkim leading to poor yield of this crop. Therefore, an experiment was

**Table 3 Performance of soybean entries**

| Entries | Plant height (cm) | No. of primary branches / plant | No. of pods /plant | No. of clusters | Days to 50% flowering | Days to maturity | Yield per plot (g) |
|---|---|---|---|---|---|---|---|
| Bragg | 66.66 | 9.46 | 87.13 | 31.88 | 48 | 106 | 741.66 |
| RCS1-1 | 52.33 | 9.33 | 62.60 | 24.88 | 56.66 | 108 | 460.66 |
| RCS1-9 | 61.46 | 9.13 | 64.53 | 23.22 | 48 | 108 | 690.66 |
| RCS1-10 | 76.80 | 10.66 | 72.60 | 27.33 | 46 | 105 | 807.00 |
| JS93-05 | 38.20 | 7.00 | 38.66 | 13.88 | 40 | 111 | 328.33 |
| S.E + | 2.43 | 0.65 | 4.33 | 1.66 | 0.39 | 0.22 | 58.58 |
| C.D 5% | 7.93 | 2.12 | 14.13 | 5.42 | 1.28 | 0.72 | 191.05 |

conducted to study the seasonal abundance of mustard aphid and saw fly with relation to abiotic factors. The total area was divided into four plots and from each plot 10 plants were selected randomly to take observation of population of mustard aphid and saw fly at weekly interval. The meteorological data were also collected periodically. Aphids appeared first on 49$^{th}$ standard week and the population was found maximum on 2$^{nd}$ standard week (49.07 aphids/10 cm central shoot). The saw fly population appeared on 45$^{th}$ standard week and attained maximum on 47th standard week (1.57larvae/plant). The correlation study revealed that the population of aphid was significantly and negatively correlated with maximum temperature (r = - 0.67) and minimum temperature (r= -0.68). The population of saw fly was correlated positively i.e., the population increased with the increase in maximum temperature (r = 0.62) and minimum temperature (r = 0.64).Infestations of both the insects were not correlated with relative humidity and rainfall.

**Fig 1 Mustard aphid infestation**

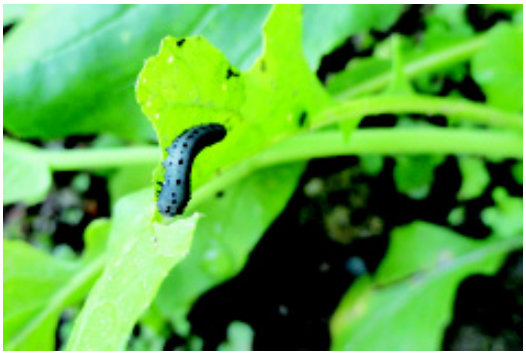


**Fig 2 Mustard sawfly infestation**

### Study of the foraging behavior of different insect pollinators in mustard

An experiment was conducted to study the foraging behavior of different insect pollinators in mustard (Figs 3,4 and 5). Two sq m plot of mustard crop was taken and the number of pollinators visiting to the plot in 10 minutes was recorded in different periods of the day. Observations were taken for 6 days continuously. Eleven insect pollinators such as *Apis cerana indica*, *Eristalis tenax*,*Eristalis himalayensis*, *Eristalis* sp., *Bombus breviceps*, *Habropoda* sp. and *Danaus chrysippusi*, syrphid fly, blue housefly (*Lucilia* sp), cabbage butter fly, rice skipperwere recorded. Some of them were nectars feeder and some pollen robbers. Among the visitors, *E. himalayensis, Apis cerana indica*, *Eristalis tenax*, *E.* sp and *Bombus breviceps* visited more. The visit of insect pollinators was influenced possitively by the SSH. The population of pollinators was less in cloudy and rainy days. The maximum population of all pollinators was observed during 10 AM to 11 AM (*A. cerana. indica*) followed by 11AM to 12 Noon. The maximum yield was recorded in the honey bee, *Apis cerana indica* pollinated crop followed by *E. tenax* and *E. himalayensis*.

## DISEASES

### Management of white rust in mustard under organic conditions

White rust caused by *Albugo candida* is an important pathogen inflicting severe losses to the mustard crop. The pathogen produces white rusty spots on the underside of the leaves. The pathogen also

Fig 3 *Apis cerana indica*

Fig 4 *Eristalis himalayensis*

Fig 5 *Bombus breviceps*

causes malformation of inflorescence. A field experiment was conducted using treatments such as *Trichoderma viridde* (Trichostar), onion 10%, garlic 10%, chiloley 10% ginger 10%, turmeric 10%, lantana 10%, cow urine 10%, neem oil 10% and metalaxyl against white rust incidence under organic condtions with control. Among the treatments Trichoderma seed, soil treatment and spray of metalaxyl @ 0.2% was very effective in reducing the disease with PDI of 21.55 compared to control (52.91 PDI). The number of plants bearing stag head were also very less (1) in metalaxyl treated plot followed by Trichoderma (3.66) and neem oil (3.66) treatments. The incidence was highest in control followed by onion (PDI 52.91). The highest number of stag head infected plants were observed in control (14.66) followed by onion (12.33), garlic (11.66), lantana (11) and cow urine (11) treated plots.

## PULSES

### URD BEAN

**Pahelo Dal-3(PD-3) an urd bean variety**

A new variety of Pahelo Dal 3 (SKMPD 3) developed at the centre was released by the Sikkim Seed Committee on 17-01-2012. Pahelo Dal (Green seeded urdbean) is a landrace of Sikkim. Unlike black seeded urd pulse, it is greenish in colour with bold seeds. The new variety has been developed by pureline selection form the local material. Gives an average yield of 0.95 t/ha. It is a 101 days variety which is suitable for the mid hills of Sikkim.

### RAJMASH

**Evaluation of germplasm**

Thirty five bush type rajmash entries were evaluated during pre-*rabi* 2011. The entries were grown in a plot size of 1.80 $m^2$ with three replications in RBD with three rows of each entry per replication. The data was recorded randomly on five plants from each entry in each replication. Out of 35 entries, 6 entries showed poor germination and therefore rejected for data collection. Among the entries SKR21, Naogaon Rajmash and SKR21 were earliest in maturity (112, 113 and 119 days, respectively). Yield per plant was highest for entries IPR 9-6-4 (12.10 g), Naogaon Rajmash 3 (11.23 g) and HUR 07-48 (10.32 g).

## FRUITS

### SIKKIM MANDARIN

### INSECT PEST

**Bio-rational management of insect pests**

Two orchards consisting of 20 trees were selected for the study. In one plot the practices like a) cleaning of orchard b) smearing of Bordeaux paste at the base of the trunk up to 1 m height c) frequent monitoring d) two spraying of Servo (Agrospray) @ 7 ml/l in the month of May for control of aphids and leaf miner and one spraying of *Bacillus thuringiencis* @ 2g/l when infestation of lemon butterfly starts. e) cleaning of trunk borer and bark eating caterpillar infested plants and insertion of iron wire to kill the larvae and insertion of cotton soaked in petrol or kerosene to the holes and plastered with soil and cow dung mixture f) installation of para pheromone trap were followed, and in another plot cleaning of orchard was done as done by the farmers. In the first plot the infestation of insect pests was less (2 lemon butterfly larvae per 50 shoots, 6.0% leaf miner infested shoots, 4.0% aphid infested shoots, 10% trunk borer and 10% bark eating caterpillar and 8% fruit fly infestation in comparison to other plot (11 lemon butter fly larvae/50 shoots, 30.0% leaf miner infested shoots, 18% aphid infested shoots, 60% trunk borer infestation, 40% bark eating caterpillar infestation and 30% fruit fly infested fruits. Fruit yield in treated plot was more (422.8 fruits/plant) in comparison to farmer's practice (238.4 fruits/plant).

## VEGETABLES

### CHOW-CHOW

**Genetic diversity study using morphological and RAPD markers**

Sixteen chow-chow collections of Sikkim (Fig 6) were analyzed for genetic diversity using morphological traits (both quantitative and qualitative) and RAPD markers. Considerable diversity was found among the collections for all the 15 traits studied. Highest fruit weight was exhibited by S8 (461g) followed by S9 (416g) and S1 (399 g). Highest dry matter content was found in S5. Out of the 30 primers tested, 12 were found to be polymorphic for all the collections generating a total of 25 bands (2 bands per primer).

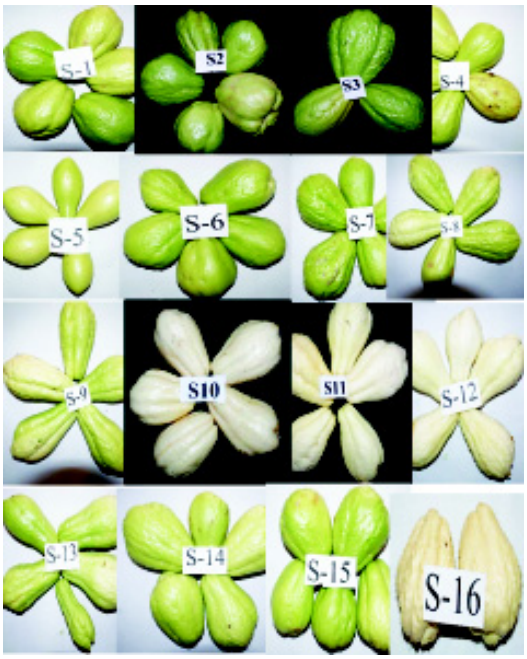



**Fig 6 Variability in local chow-chow genotypes of Sikkim (S1-S16)**

## SPICES

### GINGER

**Heavy metal analysis in ginger (*Zingiber officinale*) rhizomes of northeastern India**

Heavy metal analysis was done on 22 rhizomes samples collected from different locations of northeastern India. The samples were analyzed for concentration of volatile (As and Hg) and non-volatile (Pb and Cd) toxic heavy metals using Atomic Absorption Spectroscopy. Lead (Pb) and Cadmium (Cd) were detected in all the samples while one sample (Assam 2) showed detectable concentration of Arsenic (As). Samples from the state of Manipur showed highest mean concentration of Pb (0.96 ìg/g). Highest concentration of Cd was found in sample Nagaland 3 (0.06 ìg/g). All the heavy metal concentrations were below the permissible limits laid down by regulatory authorities (FDA). Among the four toxic metals analyzed in rhizomes collected from northeastern India, Pb contributed the most (>85%) of all the metals.

## DISEASES

**Network project on management of soft rot of ginger**

Survey and surveillance was conducted during 2012 in different districts of the state *viz.,* Assam Lingzey, Linkey, Thekabong, Changeysanti and Panthang of East Sikkim, Dzongu, Heeygyathang, Kabi and Pachey of North Sikkim and Namchi, Nandugoan, Temi daragoan, Denchung, Aifartor of South Sikkim and Ravangla and Soreng of West Sikkim to study the soft rot disease incidence. Disease diagnosis showed the prevalence of soft rot and also bacterial wilt, Fusarium dry rot. The highest incidence of rhizome rot was observed in East Sikkim district with 38.91% whereas, lowest incidence of disease was observed in north district (15.25%). It was also observed that the incidence was very less or nil in the fields where crop rotation is followed and disease free rhizome is used. Soil from different ginger growing areas was also collected and trichoderma was isolated from the rhizosphere soil. In total 34 Trichoderma sp were isolated from the rhizosphere soil and are being maintained.

Plant extracts like garlic, onion, Artemisia, chiloney, Eupatorium at 10% concentration were tested against *Pythium* sp. by poisoned against *Pythium* sp. food technique in-vitro. It was found that garlic at 10% and chiloney at 10% were most effective in controlling the growth of the soft rot pathogen with 58.88 and 53.70% inhibition over control (0%). The growth of the colony was dense in all the culture plates amended with different plant extracts except the one with chiloney where the growth was sparce. The pathogen covered the culture plates within 4 days of inoculation whereas, in case of the plates amended with garlic and chiloney it 6 and 15 days, respectively.

Eight different treatments were evaluated against soft rot of ginger during 2011. Among the treatments evaluated, the Trichoderma + hot water treatment was effective for controlling soft rot incidence followed by Neem cake + Hot water treatment. In Sikkim, three varieties of indigenous cultivars such as Gorubathaney,

Bhaisae, Majhauley are commonly cultivated. All the three varieties showed susceptibility with more than 60% incidence of soft rot.

## CARDAMOM

## DISEASES

### Characterization and bio-intensive management of *Collectotrichum gloeosporioides* the incitant of leaf blight in large cardamom

The in-vitro antagonistic effect of various Trichoderma isolates collected from various places in Sikkim was studied against *Collectotrichum gloeosporioides*. The maximum inhibition was noticed for the Trichoderma isolate T37 collected from ICAR farm at Tadong, Gangtok with 74.35% inhibition over control and was at par with T2 (69.20%) and T27 (66.65%) collected from Temi Daragaon and ICAR farm, respectively. Treatments like T21 (Pachey) and T36 (Nandugoan) also showed inhibition of 65.24 %and 65.24%, respectively. The minimum inhibition of (18.45%) was noticed for the isolate T18 from Pachey.

## ANIMAL HEALTH

### Prevalence of gastrointestinal helminthes of goat, cattle and yaks of Sikkim

Epidemiological studies on gastrointestinal helminthes of goat, cattle and yaks were carried out in four agroclimatic zones in all the seasons among animals maintained at organized and unorganized farms of Government/Private/ICAR Institute and also from animals maintained by livestock owners in different villages of Sikkim.

A total of 6824 animals were examined during the study period. An overall prevalence of 40.84% helminthic infestation was observed. Among the different animals examined, the occurrence of GI helminthic infestation was found to be higher in goats (63.08%) than that of cattle (30.58%) and yaks (17.72%). The mixed infestation of trematode, cestode and nematodes with coccidian oocysts were found higher in goats than in other animals. The mean eggs per gram(epg) of faeces values were also higher in goats as compared to cattle and yaks. The prevalence of GI-helminthes was higher in subtropical and high humid zone (46.63%) followed by temperate and humid areas (41.21%) as compared to sub-alpine low humid zone (32.23%) and alpine dry area ( 16.55%,). The helminthic infestation was higher during August to October with the highest in October (78.62%) in goats and in May in cattle (40.72%) compared to yaks. This may be due to high rainfall and favourable temperature (26-27$^{o}$C), which is congenial for the development of parasitic infestation. Monthly evaluation of the data revealed that strongyles especially *Haemonchus* was the most prevalent parasite in all three animals throughout the year in Sikkim.

The intensity of infestation in terms of epg ranged from 100-4200 in goats, 100-700 in cattle and 100-300 in yaks. The maximum epg in goats was recorded in the month of October (mean epg value 3000). In cattle, the intensity was maximumduring July to September (100-700), whereas, in yaks mean epg of 50.5 was found in November.

### Study on larvae

Pooled infested faecal samples of goat, cattle and yaks from various places were cultured for larval composition. Infested cultured larvae were separated using Bayermanns apparatus. The larvae were identifiedas *Haemonchus* sp., *Bunostomum, Nematodirus* and *Oesophagostomum* sp.,in all the zones in Sikkim. Maximum contamination of pasture with third stage larvae was recorded during August to November. *Haemonchus contortus* and *Oesophagostomum* were the predominant species followed by *Bunostomum, Nematodirus* and *Trichostrongylus* sp.

### Incidence of gastrointestinal parasites in different organized farms of Sikkim

The highest prevalence of parasitic infestation was seen in Govt. goat farm at Mangalbarey, West Sikkim (78.79 %) with epg range from 900-3900 followed by private goat farm at Lyngeypoyang, South Sikkim (67.39%) , ICAR Goat Farm, Tadong, East Sikkim (53.22%) and Govt. bull breeding farm, Jorethang, South Sikkim (23.40%). The prevalence at private yak farm, Gnathang, East Sikkim was 15.77%.

### Prevalence of gastrointestinal helminthes in goats as determined by necropsy examination

The 72 GI-tract of goats examined, helminthic infestation with an overall prevalence of 62.50% were detected. Among the various endoparasites, nematodes (61.11 %) were found highest followed by trematodes (33.33%) and cestodes (30.56 %). Among nematodes, *Haemonchus* sp. was predominant (61.11%) followed by *Oesophagostomum* (45.83%), *Bunostomum* sp. (29.17%), *Nematodirus* sp. (11.11%), *Trichuris* sp. (9.72%) and *Trochostrongylus* sp. (6.94%). Average

worm burden was higher during July -November (200.12 – 278.73) followed by June-July (150.55-200.12).

**Correlation of meteorological data with epg count**

Meteorological parameter such as mean minimum and maximum atmospheric temperature, mean relative humidity and total rainfall were collected from the meteorological station, Tadong, Gangtok for interpretation of the Bioclimatograph. Climatic factors were correlated with epg count by multiple regressions.

**Bioclimatograph of *Haemonchus* and *Trichostrongylus* sp.**

To see the effects of temperature, rainfall and relative humidity, bioclimatographs (Table 4) were prepared in which total rainfall (TRF) were plotted against the maximum temperature (Tmax) for *Haemonchus contortus* and average RH was plotted against Tmin (for *Trichostrongylus* sp. and minimum temperature for *Nematodirus filicolis*) for each month and the resultant points were joined by a closed curve. On these graphs, lines indicating the limits of climatic conditions most suitable for development, survival and dissemination of pre-infective stages of GIN were superimposed.

Based on published information the limits of suitable climatic conditions were taken as total monthly RF to the tune of 50 mm or more with average monthly Tmax ranging from 18 to 37 $^0$C for *H. contortus* and same rainfall with temperature ranging from 6 to 20$^o$C for *Trichostrongylus*. The RH considered for optimum development of parasites was >50%.

**Economic impact of gastrointestinal parasites in livestock of Sikkim**

Gastrointestinal parasites are known to cause significant economic losses due to reduced body weight, retarded growth, low milk yield and reduced reproductive efficiency in the livestock industry of India. In a preliminary study on milch cattle, in the village known as Melli- Meji gaon (1,600 ft. MSL) located in the East Sikkim, a net profit of ₹ 1930/- over a period of one month was recorded in the group which were naturally infested and subsequently treated with anthelmintics. The infected and untreated group showed net loss of ₹ 2240/- in terms of earnings from the milk produced over a period of 1 month.

**Molecular characterization of *Salmonella* isolated from foods of animal origin**

During 2011-12, 250 meat samples collected from the retail shops including Chevon, Pork and Beef were screened for the presence of *Salmonella* sp. Of the 250 samples comprising chicken (85), chevon (75), pork (50) and beef (40) screened for the presence of *Salmonella* sp., a total of 25 samples turned out to be positive for *Salmonella* sp, resulting in an overall incidence of 10%. Salmonella were recovered from 14.11% of chicken samples, 5.33 % of chevon, 12% of pork and 7.5% of beef samples. All the isolates were confirmed as Salmonella by biochemical characterization. Antibiotic sensitivity testing of isolates showed significant resistance among the isolates. Most effective antibiotics were colistin, gentamicin and Ciprofloxacin. Serotyping of the isolates was done. *S. typhimurium* was the most predominant serovar isolated from all types of meat screened.

**Evaluation of feeds and fodders of Sikkim in terms of their anti-methanogenic activities**

Volume of methane gas liberated during *in-vitro* fermentation was estimated at the end of 96 h of incubation from 72 different grasses commonly fed to livestock like tree fodders, shrubs, creepers, plant species of medicinal or aesthetic use, vegetative parts of spice crops of the region, aromatic plants, tree fruits having medicinal values etc.

**Table 4 Comparative prediction and testing of different bioclimatograph for GIN in goats in subtropical high humid zone of Sikkim**

| Climatological factor | Nematodes | Favourable period as per bioclimatograph | Months of high prevalence (Observed) | Months of high intensity(Observed) |
|---|---|---|---|---|
| (Tmax vs TRF) | *H. contortus* | Apr to Oct | May to Nov | Jun to Nov |
| (Tmax vs RH) | -do- | Feb to Oct | May, Jun, Jul and Aug | Jul to Oct |
| (Tmin vs TRF) | -do- | Apr, May, Jun, Sep to Oct | Aug, Oct | Aug to Nov |
| (Tmin vs RH) | -do- | Feb to Jun | Apr, Jun | May to Jun |
| (Tmin vs RH) | *Trichostrongylus* | Feb, Mar, Apr, May, Oct, Nov | Mar, Apr, Oct | Mar to Apr |
| (Tmax vs RH) | -do- | Dec, Jan | Dec | Dec |
| (Tmin vs TRF) | -do- | Apr, May, Jun, Oct | Apr | Apr to May |
| (Tmax vs TRF) | -do- | Nil | Nil | Nil |

Results showed a wide variability in gas production among samples at different time intervals. Inoculums pH ranged from 8.21 to 8.51 which differed significantly ($P$<0.01).It did not affect the fermentation pattern. Total gas production in various samples differed significantly ($P$<0.05) after 12, 24 and 96 h of incubation period. The chemical composition of fodder samples could not be correlated with volume of total gas and methane. However, an increasing trend of methane production in fodders containing low ether extract content could be noted. During study, 92.5% samples had non-significant methane production value.

**Nutritional evaluation of NB-21 hybrid Napier grass**

NB-21 variety of hybrid Napier green fodder (21.12% DM) was evaluated in a metabolism experiment in goats (BW 11.20±0.28 kg). The fodder contained 11.62, 2.45, 64.67, 41.51, 4.49, 0.49, and 0.17% of CP, EE, NDF, ADF, ADL, Ca and P, respectively. The dry matter (DM) intake of goats was 270.50±7.17 g/day, which came to 2.42 % of body weight (BW) and 45 g/kg metabolic body weight. DCP and TDN of the fodder was 7.10% and 52.25%, respectively. The experimental animals were in positive nitrogen, calcium and phosphorus balance. Thus NB-21 variety of hybrid Napier grass could meet the digestible protein requirement of the goats and there was a need for supplementary feed to meet the deficit in energy requirement.

**Evaluation of growth, productive and reproductive performance of Sikkim goat**

Sikkim local goat is an important animal in providing livelihood security to a large number of small and marginal farmers and landless labours in the state. One of the important traits of this breed is high prolificacy, where the twinning and triplet characters can be improved through selective breeding and feeding management. For this purpose an elite herd of Sikkim local goats (48 female and 12 buck) were procured from different localities of the state. A total of 18 kidding were recorded during the year. The highest kidding incidence was found in April and October (22.78%) followed by September (16.67%) and May (11.11%), respectively. It has been observed that maximum female came in heat in the month of May and June during the year.

Twinning incidence was 39 %. Out of 18 kiddings, 4 females were primiparous. In first kidding, 99% females gave single birth. The over all sex ratio of male and female was 1:2.13. However, it was slightly higher in twins (1:2.5) and slightly lower in single kidding (1:1.75).

Reproductive performance of Sikkim local goat was also recorded. Age at first service (days), weight at first service (kg), age at first kidding (days), weight at first kidding (kg), gestation period (days), service period (days) and inter-kidding interval (days) were 361.33±4.67, 14.17±0.44, 509.33±4.79, 18.77+0.65, 145.78+0.79, 184.24±1.50 and 241.56±9.67, respectively.

The overall average body weight of male and female kids at birth was 1.55±0.08 and 1.37±0.06 kg, respectively. The body weight at birth was highest in single male and female kids (1.63±0.15 and 1.60±0.06 kg) with overall 1.61±0.06 kg followed by twin male and female kids (1.48±0.08 and 1.21±0.05 kg). The overall average body weight at birth of kids (male and female kid) was 1.43±0.05 kg. The single male kid was heavier (1.63±0.15 kg) than single female kid and twins male and female kids. The twin male kids were heavier than twin female kids but inferior to single female kids.

The body height, body length, hearth girth and abdominal girth in male kids at birth was ranged from 20.5-27 cm, 19-26 cm, 19-24 cm and 18-26 cm with an average 23.63±0.89, 22.25±0.96, 22.13±0.74 and 22.88±0.97 cm and in female kids ranged from 19-26 cm, 20-25 cm, 18-28 cm and 18-26 cm with an average 21.24±0.58, 21.71±0.49, 20.71±0.73 and 21.24±0.62 cm, respectively.

**Milk production and composition in Sikkim local goats**

Data on milk production and composition were recorded on 16 Sikkim local goats. The milk production per goat ranged from 50-75 ml/day. The total milk yield/lactation ranged from 12-42 litters with an average 39.45±3.89 lts. The lactation length varied from 90-126 days with an average 96.50±1.32 days. In the milk the average fat, SNF, total protein and lactose at 4.41±0.38%, 9.37±0.26%, 3.64±0.12% and 5.03±0.11%, respectively. The milk yield and composition depends on fodder availability and stage of lactation of the animals. It was also observed that milk production in some females particularly in triplets mothers was not sufficient for kids. Milk production in first lactating mother was also recorded very less even not sufficient to kids.

# TRIPURA

## WEATHER REPORT

The maximum and minimum air temperatures varied from 24.7 to 33.7$^0$ C and 10.1 to 25.7$^0$ C, respectively (Table 1). April was the hottest and January was the coolest month of the year. The total rainfall received during 2011-12 was 2018.4 mm which is 16% less than the normal rainfall. About 71.5% rainfall was received during the monsoon period (Jun to Sep), 25.6% as a pre monsoon shower or summer monsoon (Apr & May). Only 3% of rainfall received during rest of the months. The maximum rainfall (460.3 mm) in a month was recorded in July with 16 rainy days. Relative humidity (RH) in the morning varied from 58 to 87% but in the afternoon 38 to 77 %. The months from June to September showed the highest RH. Humidity in the evening during winter season recorded lowest. Average monthlywind velocity was found to vary from 1.1 to 6.1 km/hr/day. During summer, wind speed was high. Monthly sunshine hour, on an average varied from 1.1 to 6.1 hr/day. Soil temperature was recorded at 5 and 20 cm depths both in morning and evening. Soil temperature showed an increasing trend along the depth. Wind in most of the times during morning was Westerly and Northerly or North Westerly in the evening.

The AAS Unit of ICAR Research Complex for NEH Region, Lembucherra received 5 days medium range weather forecast (76 nos.) from IMD and prepared Agromet Bulletin (71 nos.). Bi- weekly district wise bulletin disseminated to all field functionaries, farmers, electronic and print media through e-mail, personal contact.

**Table 1 Meteorological data of Lembucherra, Agartala, Tripura during 2011 - 12**

| Month | Air temperature$^o$C | | Soil temperature$^o$C | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Morning | | | Evening | | |
| | Max | Min | 5 cm | 10 cm | 20 cm | 5 cm | 10 cm | 20 cm |
| Apr | 33.7 | 21.6 | 25.5 | 27.0 | 28.1 | 25.5 | 27.0 | 28.1 |
| May | 33.0 | 23.6 | 25.6 | 26.9 | 28.0 | 25.6 | 26.9 | 28.0 |
| Jun | 32.1 | 25.7 | 26.6 | 27.8 | 28.9 | 26.6 | 27.8 | 28.9 |
| Jul | 31.7 | 25.6 | 26.5 | 27.9 | 29.0 | 26.5 | 27.9 | 29.0 |
| Aug | 31.6 | 25.1 | 26.7 | 27.5 | 28.5 | 26.7 | 27.5 | 28.5 |
| Sep | 32.6 | 25.1 | 27.4 | 28.7 | 29.7 | 27.4 | 28.7 | 29.7 |
| Oct | 32.1 | 23.9 | 26.4 | 27.7 | 28.8 | 26.4 | 27.7 | 28.8 |
| Nov | 29.3 | 17.3 | 21.4 | 23.0 | 24.7 | 21.4 | 23.0 | 24.7 |
| Dec | 25.5 | 11.7 | 17.3 | 18.5 | 19.8 | 17.3 | 18.5 | 19.8 |
| Jan | 24.7 | 10.1 | 16.5 | 18.3 | 18.9 | 16.5 | 18.3 | 18.9 |
| Feb | 29.2 | 11.3 | 18.1 | 19.5 | 21.1 | 18.1 | 19.5 | 21.1 |
| Mar | 33.3 | 21.4 | 25.5 | 27.0 | 28.1 | 25.5 | 27.0 | 28.1 |

| Relative humidity % | | Rainfall (mm) | Evaporation (mm/day) | Wind | | | Sun Shine hour | Cloud coverage | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Direction | | Speed (km/hr) | | | |
| Morn | Even | | | Morn | Even | | | Morn | Even |
| 77 | 65 | 202.1 | 291.9 | W | N | 5.8 | 6.9 | PC | PC |
| 80 | 69 | 315.0 | 252.8 | W | N | 4.9 | 5.0 | PC | PC |
| 87 | 74 | 410.4 | 115.8 | W | W | 6.1 | 0.8 | GC | GC |
| 85 | 73 | 460.3 | 115.1 | W | NW | 5.8 | 2.1 | PC | PC |
| 88 | 77 | 402.0 | 102.4 | W | NW | 5.0 | 2.3 | GC | PC |
| 85 | 68 | 170.0 | 129.1 | W | W | 3.6 | 5.5 | PC | PC |
| 81 | 67 | 40.8 | 137.0 | W | N | 1.9 | 7.3 | PC | PC |
| 74 | 64 | 0.0 | 102.8 | W | N | 1.1 | 7.4 | PC | PC |
| 58 | 71 | 0.0 | 94.1 | W | SW | 1.4 | 4.7 | GC | PC |
| 58 | 52 | 9.6 | 94.1 | W | N | 1.2 | 4.8 | PC | PC |
| 59 | 38 | 0.0 | 97.9 | W | N | 1.6 | 7.6 | MC | MC |
| 79 | 55 | 8.2 | 127.5 | W | NW | 4.3 | 6.4 | PC | MC |

## RICE

### Rice Improvement Programme

Ten entries were tested in AIRRIP. Highest yield (5.52 t/ha) was obtained in TRC 2008-4 (IET 22112) followed by TRC 2008-11 (IET 22531) and TRC 2008-3 (IET22111) that recorded yield of 5.31 t/ha and 5.17 t/ha, respectively.

Three trials *viz.,* IVT IME, IVT IM and IVT L were conducted in *kharif* 2011. Total 182 lines were evaluated under transplanted condition. In IVI IME, highest yield (6.68 t/ha) was obtained in CN 1780-4 followed by CR 2641-30 (6.44 t/ha) and OR2404-RKP (6.27 t/ha). Under the IVT IM trial, TRC 2008-3 produced highest yield (6-46 t/ha) followed by OR2320-3 (6.04 t/ha). Few lines were also evaluated in IVTL trial and maximum yield was recorded in XR 99986 (29 p 38) 5.21 t/ha) followed by CR2702-194 (4.38 t/ha). TRC 2008-1 was evaluated in AVTIL and its yield in the second year of evaluation was 4.99 t/ha. TRC 2008-5 (IET22113) entry was evaluated in AVT1IME which recorded 5.13 t/ha yield. Under the INGER nurseries two trials IIRON and ILRON were conducted. In IIRON, 101 entries were evaluated and the highest yield (7.5 t/ha) was observed in TRC-2005-1 (LC). Seventy six entries were evaluated under ILRON trial and the highest yield of 7.91 t/ha was recorded in one genotype code named as 36.

## SEED PRODUCTION

Total 5.3 t seed of different varieties was produced on farmers' fields to improve the availability of quality rice seeds to the farmers. Seeds of 11 varieties were produced. They were TRC 2005-1 (1350 kg), TRC 2005-2 (650 kg), MTU 1010 (200 kg), TRC 2008-1 (300 kg) TRC 2008-4 (200 kg), TRC 2008-5 (200 kg), Swarna sub 1 (450 kg), Bhalum 1, 2, 3 (1700 kg) and Sahbhagi (250 kg).

### Frontline demonstrations of mechanized seedling/ transplanting

During 2011-12 347 FLDs were organized in in South Tripura. The FLDs included demonstration of 8 row self propelled paddy transplanter and plastic drum seeder. Demonstrations were carried out with varieties *viz*., TRC 2005-1 (Gomati), TRC 2008-1, TRC 2008-4 and TRC 2008-5, with MTU 1010 and Swarna as check for paddy transplanter and TRC 87-251 for the plastic drum seeder. Average productivity of the FLD plots transplanted with the transplanter was 5.81 t/ha; whereas, manual transplanted plots had productivity of 5.26 t/ha. Thus, a productivity advantage of 550 kg/ha, 10.45% yield advantage over the manual transplanted plots was achieved. For transplanting with the machine one ha area required 1.5 hours and fuel consumption for 1 ha transplanting was 1.25 litre. Only?1800/ha was required for transplanting with the machine, whereas, in manual transplanting, minimum ? 7500/- was essential for transplanting 1 ha area. Thus, with the machine, there was a saving of ? 5700/ ha. With the plastic drum seeder the transplanting/sowing cost came down to ? 200 /ha, thus saving of ? 7300/ha on transplanting. Direct seeded plots with plastic drum seeder also showed 6.33% yield advantage over the manual transplanted plots. FLD direct seeded plots produced 4.47 t/ha in comparison 4.21 t/ha in manual transplanted plots.

## PULSES

### Varietal improvement

Single plant selections were made from F6 segregating population from urdbean x mungbean cross (SPS 5 x IPM 99-125). Single plants selections were made in segregating population of 9 different crosses in field pea. Two entries were nominated for IVT summer mungbean. TRCP 10, a field pea entry was promoted to AVT1 on the basis of yield superiority.

### AICRP MULLaRP

The coordinated trials were conducted on field pea, urdbean, mungbean and lentil. Three trials in field pea, one in urdbean, two in mungbean and one in lentil were conducted. In IVT tall field pea, highest yield was recorded in IPF 10-21 (2.69 t/ha) followed by PANT P183 (2.59 t/ha) and TRCP-10 (2.57 t/ha). Results of AVT (2 + 1) tall field trial revealed highest yield for NDP9-401 (2.47 t/ha) followed by Rachna (2.42 t/ha), TRCP -8 (2.39 t/ha) and IPFD 1-10 (2.37 t/ha) under the IVT dwarf field trial, IPFD 1-10 produced highest yield (2.38 t/ha) followed by HUDP-15 (2.18 t/ha).

IVT in urdbean registered maximum productivity for entry number 604 (1.95 t/ha) followed by 602 (1.810 t/ha).

Three entries viz., 503, 507 and 508 under AVT (2 + 1) of mungbean, produced 2.36, 2.34 and 2.25 t/ha, respectively yield. In IVT mungbean top trial, highest yield was obtained from entry number 574 (2.03 t/ha).

Under IVT lentil large seeded trial, entry DPL 62 recorded highest yield (1.43 t/ha) followed by PL 099 (1.25 t/ha).

**Effect of mulching and P nutrition on root nodule and productivity of field pea grown on tilla land under late sown condition**

A field experiment was conducted in post-rainy season (Nov- Mar) in 2011-12 to see the effect of mulching and P nutrition on root nodule and productivity of field pea grown on tilla land under late sown condition. The experiment was conducted in split plot design with 2 main plot treatments (control and mulching) and 4 P nutrition (control, 9, 18, and 27 kg P/ha), replicated thrice. There was significant effect of mulching on root nodule at 25, 50 and 75 DAS. Application of mulch increased the root nodules/plant compared to without mulch treatment at all growth stages. However, mulching failed to enhance seed yield. Application of P @ 27 kg/ha produced significantly higher number of root nodules/plant at all the growth stages compared to other treatments. However, number of root nodule showed the quadratic relationship with the application of P nutrition, thus indicating that, better root nodule formation requires an optimum supply of phosphorus to the plant.

## OILSEEDS

## GROUNDNUT

**Evaluation of recently released cultivars of groundnut**

Fourteen groundnut varieties (Table 2) were grown and NPK @ 40:60:50 kg/ha in combination with cow dung (5 t/ha) were applied. The highest pod yield was recorded in var. GG11 (1.8 t/ha).

**Groundnut in various intercropping options**

Groundnut (var. GG7) was grown in the intercropping with rice, mungbean and sesamum. The NPK dose applied was 40:60:50 kg/ha in combination with cow dung (5 t/ ha). Treatment combinations were $N_1$-Rice sole crop, $N_2$-Sesamum sole crop, $N_3$-Mungbean sole crop, $N_4$-Groundnut sole, $N_5$-Groundnut: Rice (2:2), $N_6$ - Groundnut: Sesamum (2:2) and $N_7$- Groundnut: Mung. It was observed that groundnut: rice (2:2) produced the maximum groundnut equivalent yield (1.52 t/ha).

**Evaluation of recently released cultivars with effect of green manuring**

Eleven varieties *viz.,* Kaushal, GG 2, SBXI, GG 4, GG 11, GG 8, TG 37 A, GG 13, GG6 and FeESG10 were grown and *Tephrosia indica* leaves (5 t/ha) were applied. Pod weight varied from 6.66 to 18.0 g/plant. The highest no of pod and pod weight was 19.00 and 18.00 g /plant respectively in var.GG7.

## DISEASES

Twenty-seven groundnut germplasm were evaluated for their disease reaction under natural conditions. The diseases like leaf spot and rust were found during *kharif*. Leaf spot disease was appeared in all the genotypes with high intensity except in lines *viz.,* NRCG 12174, NRCG 10564, NRCG 12393 and NRCG 3157, and disease ranged from 3 to 4 on 1-9

**Table 2 Productivity parameters of groundnut varieties**

| Varieties | Pods/plant | Pod wt. (g/plant) | Seed wt. (g/plant) | Plant wt. (g/plant) | Shelling (%) | Productivity(t/ha) | |
|---|---|---|---|---|---|---|---|
| | | | | | | Pod | Haulm |
| ICGS76 | 14.76 | 22.99 | 11.55 | 49.76 | 50.23 | 1.46 | 2.00 |
| GG2 | 13.74 | 16.77 | 7.88 | 75.11 | 46.98 | 1.74 | 1.50 |
| GG 13 | 13.86 | 16.55 | 10.44 | 94.22 | 63.08 | 1.50 | 1.98 |
| TG 37 A | 13.30 | 15.10 | 2.88 | 102.22 | 19.07 | 1.50 | 1.30 |
| FeESG10 | 14.53 | 16.33 | 4.55 | 146.10 | 27.86 | 0.60 | 1.50 |
| FeESG 8 | 14.73 | 17.88 | 5.99 | 87.21 | 33.50 | 0.63 | 1.62 |
| K 134 | 17.30 | 29.66 | 11.44 | 96.66 | 38.57 | 1.00 | 1.80 |
| GG6 | 13.43 | 15.55 | 4.77 | 68.33 | 30.67 | 0.61 | 1.26 |
| SBXI | 14.73 | 15.33 | 5.11 | 50.99 | 33.33 | 1.02 | 1.39 |
| GG11 | 13.20 | 21.80 | 6.22 | 96.66 | 28.53 | 1.80 | 2.50 |
| Kausha | 13.76 | 22.22 | 7.11 | 130.00 | 31.99 | 1.10 | 2.22 |
| GG 4 | 13.20 | 14.32 | 3.88 | 61.10 | 27.09 | 0.61 | 1.15 |
| GG2 | 21.50 | 20.66 | 7.32 | 57.77 | 35.43 | 0.62 | 1.10 |
| GG8 | 24.30 | 32.11 | 14.22 | 97.22 | 44.28 | 1.53 | 1.75 |
| SE ( ± ) | 1.45 | 2.27 | 0.81 | 9.86 | - | 0.52 | 0.56 |
| CD (*P*=0.05)) | 2.97 | 4.65 | 1.66 | 2.02 | NS | 1.07 | 1.15 |

scale, both under fertilized and unfertilized conditions. Rust was less in all genotypes.

## VEGETABLES

## TOMATO

### Management of leaf curl disease of tomato under field condition

### Characterization of disease causing organism

The virus causing leaf curl disease of tomato occurring in Tripura was characterized with the help of Advanced Centre for Plant Virology, IARI, New Delhi. The complete genome including betasatellite of an isolate (ToAg-1) of tomato leaf curl was cloned and sequenced. The full length DNA-A (JN387045) of ToAg-1 contained 2755 nucleotides and shared 94.7% sequence identity with *Tobaco curly shoot virus* (TbCSV). The betasatellite (JN638434) associated was identified as variant of *Tomato Leaf Curl Bangladesh betasatellite* (ToLCBDB), with which it shared 91.5% sequence identity. From the study it was found that leaf curl disease of tomato in Tripura was the associated effect of TbCSB and ToLCBDB, a new begomo virus complex, sharing 73.2 to 90.1% sequence identity with the other tomato leaf curl viruses of India.

### Evaluation of biopesticides developed at CTRI

Seedlings of tomato (var. BT10) were soaked in 1% solution of Menma and Shreya separately during transplantation. The treated plots were sprayed by the biopesticides (0.1% concentration) after one month of transplantation. The spraying was continued at 15 days interval up to the ripening stage of fruit biopesticide Menma was the best (Table 3).

**Table 3 Effect of CTCRI developed biopesticides against leaf curl disease of tomato**

| Biopesticides | Leaf curl (% infection) | Fruit no. | Fruit yield (kg/m$^2$) |
|---|---|---|---|
| Menma | 86.11 (4.81) | 433.67 (63.87) | 3.23 (0.65) |
| Shreya | 91.67 (8.33) | 440.67 (192.57) | 2.61 (0.90) |
| Control | 91.67 (8.33) | 403.33 (60.46) | 2.22 (0.37) |

* Figures in parentheses are SEDs ( ± )

## MUSHROOM

### Evaluation of different strains of paddy straw mushroom

Different strains of *Volvariella volvacea viz.,* VV 01, VV 02, VV 07, VV 08, VV 09 and VV-Tripura were evaluated. Spawning was done on 17.8.11. In each case, cube bed was prepared with 3 kg paddy straw. Mushrooms were harvested at button, egg and elongation stages at a time. Strain VV 01 failed to fruit. The results (Table 4) showed that VV07 and VV-Tripura were more productive than the others.

**Table 4 Evaluation of different strains of paddy straw mushroom**

| Strains | Days required for harvesting | Yield/bed of 3 kg straw | |
|---|---|---|---|
| | | Number | Wt. (g) |
| VV 02 | 11 | 37 | 193 |
| VV 07 | 10 | 156 | 473 |
| VV 08 | 11 | 54 | 273 |
| VV 09 | 12 | 77 | 193 |
| VV-Tripura (control) | 10 | 101 | 525 |

### Evaluation of different species of oyster mushroom

The experiment was conducted with different species of oyster mushrooms like *Pleurotus sajor-caju* (PSC), *P. florida*(FLO), *P. flabellatus* (PF)and *P. djamor* (PDZ). The mushroom species PF, PSC and FLO were isolated in Tripura from the mushroom grown from the procured spawn of Department of Horticulture, Tripura State and the *P. djamor* was isolated from the fruit body developed by the procured spawn from a mushroom entrepreneur of Agartala. The mushrooms were grown during different dates in winter and spring seasons in poly bags (Figs 1a & b). The results indicated that *P. djamor* could be grown well in December while *P. florida* and *P. flabellatus* in February under Tripura condition.


**Fig 1 a *Pleurotus djamor*; b. *Pleurotus flabellatus***

### Efficacy of lime in disinfecting straw

Lime (1%) was used to disinfect paddy straw. It minimized contaminants and favoured spawn run but the yield was low as compared to soaking in solution of carbendazim @ 75 ppm + formalin @ 500 ppm.

### Improvement of oyster mushroom

In order to improve oyster mushroom, hybridization programme was taken. In doing so, 146 single spore cultures were prepared from seven strains of five oyster mushroom species. Seventy one crossings were made and from which 24 hybridized mushroom cultures were prepared.

## JATROPHA

Fifty Jatropha collections from different places were sent to NBPGR for preservation.

### Progeny trial

Eighteen seed sources were planted on the 9th May, 2006 and growth characteristics estimated during 2011-12. The oil contents varied from 23.81 to 38.59%. The highest oil content was in MNJ 002 (Manipur) and the lowest in Mandipathar (East Garo Hills). Average seed yield was the maximum (2.092 t/ha) in a collection from Dimapara (South Garo Hills). The lowest (0.49 t/ha) was in collection from Madhya Pradesh. Primary, secondary and tertiary branches varied 2.66 to 3.55, 8.33 to 15.34 and 47.98 to 81.99, respectively.

### Agri-silviculture trial

In agri-silviculture system, upland rice showed an average productivity of 800 kg/ha and the seed yield of Jatropha (6 sources) varied from 0.865 to 1.72 t/ha and oil content from 23.81 to 38.36 %. The no. of primary, secondary and tertiary branches varied from 2.89 to 3.89, 10.78 to 18.66 and 116 to 209, respectively.

### Package of practices

Recommended fertilizers for Jatropha were 26 g urea, 100 g SSP, 16 g MOP and 1 kg cow dung/plant. The seed yield varied from 299 to 602 kg/ha. The oil contents varied from 23.81 to 38.56 %. Jatropha from Dharmanagar (North Tripura) showed the highest no of secondary and tertiary branches.

### Jatropha plantation from stem cutting

Stem cuttings collected from different places of Tripura were planted in 2007 and evaluated. A cutting collected from Amtali showed the comparatively high oil content (38.47%) with seed yield of 163 kg/ha.

## GOAT

### Prolificacy rate of Black Bengal goats at field and farm in West Bengal and Tripura

The prolificacy rate of Black Bengal goats at field and farm in West Bengal and Tripura is presented in Fig 2. In West Bengal, the prolificacy rate at field and farm was same, while the prolificacy rate at farm in Tripura was more as compared to that of the field in the present study.

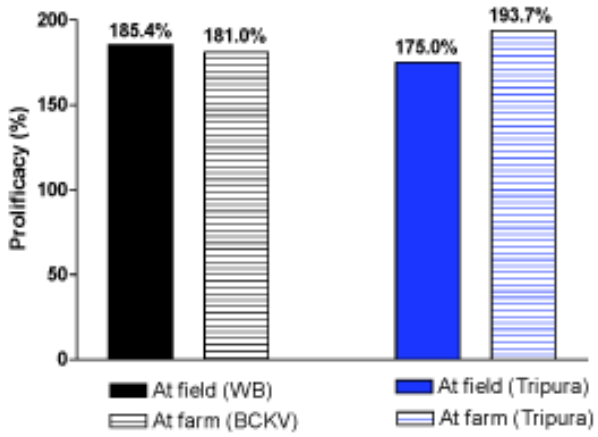



**Fig 2 Prolificacy rate of Black Bengal goats at field and farm in West Bengal and Tripura**

### Black Bengal goats are not always multiple ovular

The ovulation- one, two, three and four in one estrous cycle was recorded in 48.9%, 25.6%, 16.2% and 9.3% of goats. Thus, the multiple (two or more than two) ovulations in one estrous cycle were recorded in 51.1% of goats, while the incidence of single ovulation was in 48.9% of goats. Black Bengal goats were not multiple ovular during the estrous cycle.

### Effect of flushing on ovulation rate in Black Bengal goats

Twelve female non-cyclic Black Bengal goats were selected for the study from goat farm of ICAR, Tripura and divided randomly in two groups with six goats in each group. The goats (group-I) were fed according to the recommendations of NRC (2007) with an access of grazing on natural pasture and supplementary concentrate feeding. This group acted as control animals. The goats (group-II) under flushing regimen were fed 25% above the recommendation of NRC (2007) and considered as treatment group. Fresh drinking water was available ad libitum to all the goats. The flushing regimen brought more ($p<0.05$) number of goats into estrus (83.3%) with more ($p<0.05$) ovulation rate (12 ovulations from 6 goats in one estrous cycle, ovulation rate-200%) as compared to non-flushing control goats (33.3%) with less ovulation rate (3 ovulations from 6 goats in one estrous cycle, ovulation rate-50%).

### Evaluation of plasma progesterone and total estrogen profiles in cyclic Black Bengal goats with varied number of corpus lutea (CL)

The plasma progesterone and plasma total estrogen profiles in cyclic goats with one/two/ three CLs are documented in Fig 3 and 4. Plasma progesterone levels (0.95 +/- 0.08 ng/ml, 0.99 +/- 0.09 ng/ml and 1.05 +/- 0.10 ng/ ml for goats with one/ two/three CLs, respectively) did not vary ($P$>0.05) among the goats with one/ two/ three CLs in ovary during the estrous cycle (Fig 4). Similarly, plasma total estrogen levels did not differ ($P$>0.05) among the goats with one/two/ three CLs in ovary during the estrous cycle. Plasma progesterone and plasma total estrogen profiles during the estrous cycle may not be useful for determining ovulation rate in cyclic Black Bengal goats.

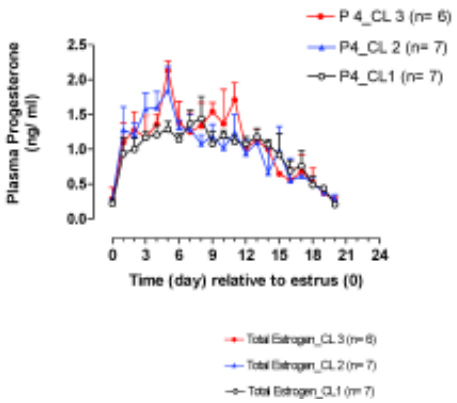



**Fig 3 Plasma progesterone profiles did not differ ($P$> 0.05) due to variation of number of CLs**

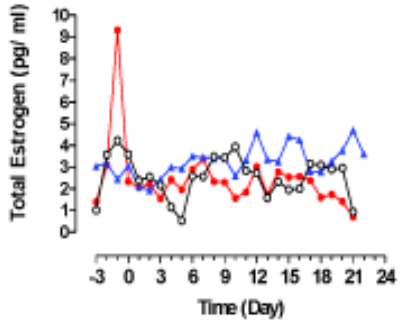



**Fig 4 Plasma total estrogen profiles did not differ ($P$> 0.05) due to variation of number of CLs**

### Number of kids born less than number of ovulation rate in Black Bengal goats

Number of kids born (1.43±0.12) was lower ($P$=0.007) than the ovulation rate (2.17±0.23) in Black Bengal goats. There was a loss of 34.10% ovum for getting successful fertilization, subsequent conception and ultimately kid born in the present study.

## PIGS

### Performance of Ghungroo and Hampshire crossbred pig under Tripura agro-climatic conditions

The average birth weights of Ghungroo (0.9 kg) and Hampshire cross (1.1 kg) piglets were higher as compared to Mali piglet (0.5 kg). The average body weights of Ghungroo and Hampshire crossbred pigs at 3 month, 6 month and 1 year of age were higher than Mali pig. The average body weight of Ghungroo pig at 1 year of age was 105 kg, while Hampshire crossbred pig showed average body weight of 135 kg at 1 year of age. The reproductive efficiencies in terms of age at puberty and litter size at furrowing of Ghungroo and Hampshire crossbred pigs were better than Mali pigs. A female ghungroo pig bears 5-6 pairs of teats with the ability to give birth of average 9 piglets at first farrowing (Figs 5 & 6). Behaviorally, Ghungroo pigs, irrespective of sexes, are very much docile and easy to handle. Especially, females showed an excellent mothering ability which is an important trait in relation to the piglet survivability.

**Fig 5 Ghungroo nursing pig with piglets**

**Fig 6 Hampshire crossbred pig with piglets**

### Partial separation of piglets from nursing sow to reduce mortality under Tripura agro-climatic conditions

About 30-40% piglet mortality during the first 3 weeks of life due to crushing by the nursing mother

was noted at farm. In view of reducing piglet mortality, it was planned to keep piglets with the mother for a period of 15 hours and then without the mother for 9 hours (8.00 pm to 5.00 am). The body weight of all piglets was recorded at 3 day interval from the first day of birth upto 25th day of age (Fig 7). There was no significant variation of mean body weight between the two groups. No mortality of piglet was recorded in either of the groups. Thus, the partial separation could be an effective way to reduce piglet mortality incidence at farm. The present finding warrants further investigation on more number of animals.

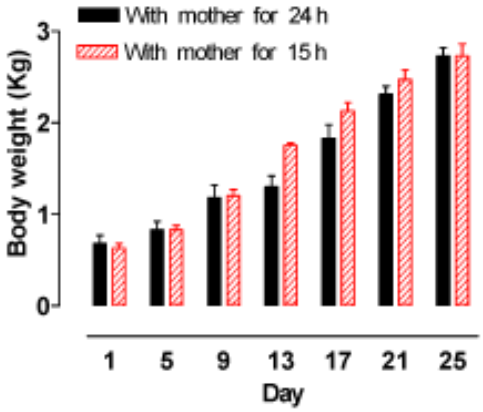



**Fig 7 Mean (± SEM) body weight of piglets**

### Effect of increasing room temperature on piglets during cold months

Fourteen newborn Ghungroo piglets along with two mother pigs were kept in two separate pens and exposed to natural environmental cold temperatures ranging from 7.2°C to 15.0°C during first 30 days of life (January-February, 2012) and thereafter at temperature range between 18. 5°C and 25.5°C during the next 30 days period (February-March, 2012). These piglets were served as control. In another group, seventeen Ghungroo piglets along with two mother pigs in another two pens were provided with artificial lighting arrangement for keeping the temperature between 17.0°C and 21.1°C in the pens during first 30 days of life (January-February, 2012) and between 24.1°C and 29.9°C for last 30 days of experimental period (February-March, 2012). These piglets were served as treatment group. Though there was no statistical variation in rectal temperature as well as body weight, both rectal temperature and body weight in treatment group (with light) were higher than the control group during the experimental period (Figs 8, 9 & 10).

**Fig 8 Ghungroo piglets with nursing sow under artificial lighting arrangement system**

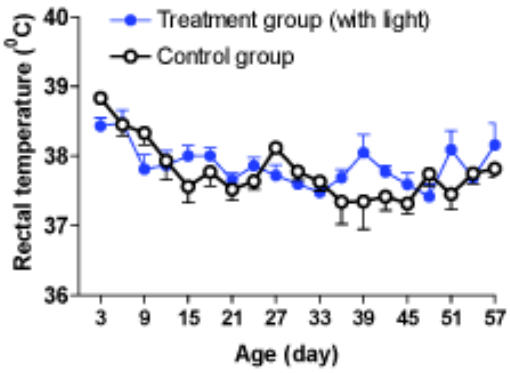



**Fig 9 Mean (± SEM) rectal temperature of piglets**

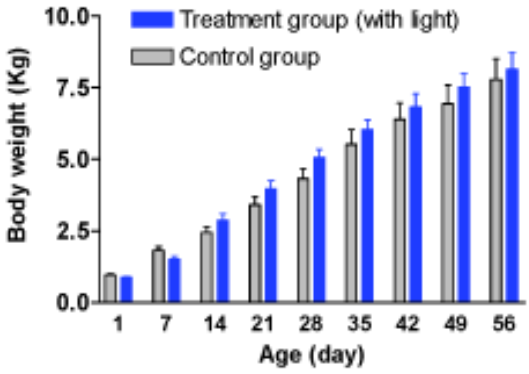



**Fig 10 Mean (± SEM) body weight of piglets**

## POULTRY SCIENCE

### Germplasm supply

A total of 1,871 nos. of good chicks of different varieties/lines of poultry were supplied to the farmers of different villages of Tripura. Out of these 637 chicks of DN cross were supplied to the Mogpuskurni (T.S.), Kumarghat (T.N.) and Lembucherra (T.W.); 778 chicks of ND cross to the KVK, Birchandermanu (T.S.), Mogpuskurni (T.S.), Kobrapara, Lembucherra, Baghma (T.S.) and Maheshkola (T.W.) and 456 chicks

of coloured broiler supplied to the Maheshkola (T.W.), Mogpuskurni (T.S.) and Holy Cross School, Agartala (T.W.).

**Performance of colored broiler female line × Tripura black (BN 50%) cross**

New cross (BN 50%) using Coloured broiler female line × Tripura black was generated to develop dual purpose variety for rural poultry production (Fig 11). The mean body weights at 20 weeks of age at the farm were: 2.024±0.045, 1.851±0.026 and 1.907±0.023 kg, respectively in male, female and overall mean, whereas the corresponding mean body weight at farmer's field were: 1.920±0.038, 1.760±0.032 and 1.824±0.026 kg, respectively. The mean body weights of BN cross were comparable with Vanaraja but higher than CARI Nirbheek, CARI Shyama, Gramapriya and lower than Giriraja. The age at first egg was 151 and 158 days, respectively at the farm and farmer's field. The egg weight at 40 weeks of age was 60.63±0.37 g, at the farm. The egg production upto 40 weeks of age was 38.81 eggs and 27.84 eggs, respectively at the farm and farmer's field. The percent mortality from 0-8 wks, 9-20 and 21-40 weeks of age were 6.55%, 5.42% and 3.11%, respectively. The percent mortality during brooding and growing age was slightly higher than DN (75% DR) and ND (75% DR) cross but the mortality during laying period was significantly low.

**Fig 11 Female and male birds of BN cross at the ICAR Tripura Centre Poultry Farm**

**Performance of Tripura black native germplasm × Dahlem Red (ND 50%) cross**

The performance of ND cross was evaluated at the poultry farm of ICAR Tripura centre. However, higher mean body weights than ND cross were observed in BN cross, Gramapriya, Vanaraja and Giriraja being the cross of broiler line. The age at first egg was 163 days, at the ICAR Lembucherra farm. The egg production upto 40 weeks of age were: 59.10 at the ICAR Lembucherra farm. The egg production at 40 weeks of age was comparable to Gramapriya but higher than all other varieties tested at this centre. The percent mortality during growing and laying stage was significantly higher than the previous generation of this cross evaluated at this centre.

**Mean performance of Dahlem Red**

The mean body weights of Dahlem Red were higher than Tripura black and Tripura brown native germplasm but lower than all the improved stock *viz*., Gramapriya, Vanaraja and Giriraja tested at this centre. The age at first egg was 151 days. The egg production upto 40 weeks of age was: 44.11 eggs. The egg production upto 40 weeks of age was lower than Gramapriya and ND cross but higher than Vanaraja, Giriraja, CARI Nirbheek and newly developed cross evolved at this centre. The percent mortality was significantly higher than Tripura black local indigenous germplasm of Tripura.

**Genetic improvement of growth and production traits of Japanese quail in agro-climatic conditions of Tripura**

The evaluation of performance of fourth generation was continued. The hatchability on total egg set was 65.62%. The overall mean body weight of 3, 4 and 5 weeks of age of coloured quail line was 116.62 ± 0.70, 159.61 ± 0.91 and 200.59 ± 1.29 g whereas, the corresponding mean body weights in white quail line were: 107.88 ± 0.48, 154.49 ± 0.64 and 185.23 ± 0.89 g, respectively. The egg weight at 18$^{th}$ weeks of age was 11.24 ± 0.13 g. and 11.18 ±1.24 g, respectively in coloured and white quail lines.

## FISHERIES

**Effect of incorporation of *Ompak bimaculatus* catfish in composite culture on water quality and fish yield**

Fish was stocked at the rate of 5,000 fish/ha in a pond of 300 m$^2$ size. The species composition was catla, 40%; rohu, 30%; mrigal, 15% and butter catfish, 15% (Fig 12); Mrigal was replaced with catfish at a density of 1500 fish/ha. The survival rate of fish in the

**Fig 12 Butter catfish (*Ompakbi maculatus*)**

treatment pond was 75%, 68.8%, 78.2% and 82.6% for Catla, Rohu, Mrigal and Pabda, respectively and 73.3%, 73.3% and 78.2% for Catla, Rohu and Mrigal, respectively in the control pond. The fish production was 2426 kg/ha in the treatment pond (with catfish), 220 kg of butter catfish and 2426 kg of carps. Total fish yield in the control pond (without incorporation of catfish) was 2606 kg/ha and found to be significantly ($P$<0.05) lower than treatment pond.

**Sediment nutrient status in fish cum pig farming**

The sediment quality of fish pond (integrated with pig) during and after culture operation was analyzed. The pH of the pond sediments ranged from 4.14 to 4.93 during culture operation and 5.41 to 5.56 after culture. The level of organic carbon in the sediment ranged from 0.47 to 0.87% during culture and 0.36 to 0.44% after culture. The available total nitrogen level was higher during culture (528-1131 kg/ha) as compared to after culture operation (335-416 kg/ha). The level of phosphorus in pond ranged from 11.31 to 13.83 kg/ha during culture and increased level (42.24-69.15 kg /ha) was observed after culture operation. The level of potassium was 95.9 to 151.8 kg/ha during fish culture operation, but this level increased up to 379.6 kg/ha after culture. The soil colour was grayish black and soil texture was sandy clay in nature throughout the culture operation. The results clearly showed change in pattern of nutrients during and after fish culture operations. After 210 days of culture, fish was harvested by repeated netting followed by de-watering of pond. The number of each species was counted and survival rate was found to be 72% for catla, 78% for rohu and 81.6% for mrigal. For each species ten fish was randomly sampled, individually weighed and measured for total length to estimate the growth and production, which was found to be 1520.4 kg/ha/year.

**Effect of stocking density on growth performance, survival and food conversion ratio of *Labeo bata* in net enclosure**

An experiment was conducted to evaluate the growth performance of *Labeo bata* in net enclosures at 3 different stocking densities *viz*., 10, 20 and 30/m$^2$. It was concluded that 20/m$^2$ was the optimum stocking density (SD) for rearing of fry to fingerling. Stocking density of 10/m$^2$ was very less although the growth rate was comparable to SD 20/m$^2$ but the FCR value was less indicating that the feed were not being used efficiently by the fishes (Table 5). At higher SD of 30/m$^2$, the growth rate was less and the FCR was more indicating that this was not a viable SD for rearing of fry to fingerlings. Hence, by seeing the growth performance and survivability it was concluded that 20/m$^2$ was the best stocking density for rearing of *L. bata* fry to fingerling stage.

**Table 5 Initial and final body weights, SGR, FCR and mean survival rates of *Labeo bata* fry held at 3 different stocking density**

| Parameters | SD 1=10/m$^2$ | SD2=20/m$^2$ | SD3=30/m$^2$ |
|---|---|---|---|
| Initial body wt.(g) | 0.57±0.06 | 0.57±0.06 | 0.57±0.06 |
| Final body wt.(g) | 14.84±0.47$^a$ | 14.68±0.63$^a$ | 10.89±0.87$^b$ |
| SGR | 2.62±0.001$^a$ | 2.60±0.004$^a$ | 2.28±0.014$^b$ |
| FCR | 1.48±0.07$^a$ | 1.32±0.035$^b$ | 1.36±0.076$^a$ |
| Mean survival rate | 91.99±5.28$^{ab}$ | 97.40±1.99$^a$ | 86.99±8.34$^b$ |

SD= stocking density, Different superscripts indicate statistically significant differences between means at $P$<0.05. Means were tested by ANOVA and ranked by Tukey's multiple range test.

**Growth performance of *Labeo bata* with different levels of grass carp and freshwater prawn**

The growth performance of *L. bata* with different level of grass carp and fresh water prawn was studied. In our study, we found that the growth of bata in pond 1 where grass carp was stocked at higher stocking (1/m$^2$) was significantly higher than the other group where stocking of prawn (1/m$^2$)was higher than grass carp (0.5/m$^2$). In pond 1, the mean growth was 21.8±22.5g and in pond 2 the mean weight of bata was 12.3±2.49g. This shows that *L. bata* is much more compatible with grass carp than fresh water prawn.

**Effect of feeding *Jatropha* seed meal on growth, survivability, hematological and biochemical parameters of *Catla catla***

An experiment was conducted to evaluate the effect of feeding *Jatropha* seed as replacement of fish meal on *Catla catla*. *Jatropha* seeds were dehulled and the kernels were detoxified by washing, heating and defattening. The resultant seeds were estimated for protein content which was 24.5%. The seeds were incorporated into fish feed by replacing fish meal @ 0% (Feed1), 25% (Feed2), 50% (Feed3), 75% (Feed4) and 100% (Feed5). The experimental fish was *Catla catla*. After one month of study it was observed that *Jatropha* could be incorporated in fish feed and catla could effectively utilize that as a protein source. However, *Jatropha* at higher level i.e. at 75% and 100% were not found to be suitable as it resulted in alteration of hematological and biochemical parameters of fish.

## NATIONAL AGRICULTURAL INNOVATION PROJECT

### Food security through enhancement of productivity and production of rice in Dhalai village

Under NAIP following activities were under taken

- For attaining higher productivity of rice through adoption of HYV: TRC 2005-1, TRC 2005-3, TRC 2008-1, TRC 2008-4, TRC 2008-5 & MTU 1010.
- Application of improved production technologies like SRI and ICM
- Two clusters in Balaram and Maracherra were taken that included 437 farmers
- Average productivity in demonstrations was 3.83 t/ha

### Improvement of livelihood by mushroom cultivation

Mushroom cultivation at Balaram and Maracherra villages was introduced by giving training and demonstration. The spawn and other requisite materials were supplied. Low-cost mushroom houses were made for progressive and interested farmers. Considerable number of farmers learned the techniques and produced mushroom for the first time. The farmers earned money from selling of fresh mushroom @ ₹ 80/kg in the local markets. During the year, 1780 number of spawn packets were used for mushroom cultivation. They produced 712 kg mushrooms and earned ₹ 6, 960 /- .

### Livelihood improvement by goat farming

The aim of the programme was to educate and support the farmers for better management of goat resources to improve rural livelihood. The activities included delivery of technical know-how on goat housing, providing good quality Black Bengal goats and organizing deworming-cum-treatment camps. A total of 72 female and 3 male goats were collected from West and South Tripura districts and provided to the farmers in Dhalai district for minimising inbreeding problem and increasing the new stock of Black Bengal goats in the area. Farmers showed keen interest for making goat house utilizing low-cost local materials and rearing goat with more care to fetch more income (Fig 13). Twenty six new goat houses were made by the farmers during the period under report.

**Fig 13 Goat house made by the farmer under NAIP program**

### Training on Rural Poultry Production

Training on Rural Poultry Production was imparted to 75 farmers of Moracherra village on 13.04.11 before distribution of chicks to the farmers. The training covered all aspects of rural poultry farming for enhancing poultry production like avoiding broodiness in case chicks are not required, formulation of balance ration using locally available cheap feed ingredients etc. The emphasis was also given how to reduce mortality by adopting biosecurity and better managemental practices.

### Environmental correlations with disease outbreak in rice crop

Survey of disease incidences were made during different times in 21 farmers fields of 4 areas. The results indicated that amongst the diseases,blast at growth stage 2-3 are common in all places, while, leaf spot was absent. The blast incidences varied from 1.1 to 1.75 scores in 0-9 point scale of IRRI, 96.

# 3. PUBLICATIONS

## MEGHALAYA (HQ)

### NATURAL RESOURCE MANAGEMENT

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Mr Raghuveer Singh, Scientist (Plant Pathology)
Dr Y. Ramakrishna (Farm Manager)

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Dr Bhabagrahi Sahoo, Scientist (Soil & Water Conservation Engineering)
Dr Manas Kumar Patra, Scientist (Animal Reproduction)
Dr A. Thirugnanavel, Scientist (Horticulture)
Mr Rakesh Kumar, Scientist (Agronomy)
Dr Dibyendu Chatterjee, Scientist (Soil Science)

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Dr S. Biswas, Senior Scientist (Plant Pathology)
Dr A. Haldar, Senior Scientist (Animal Reproduction)
Dr S. Malik, Senior Scientist (Poultry Science)
Dr S.P. Das, Senior Scientist (Plant Breeding)
Dr S.N. Bhowmik, Senior Scientist (Agril. Microbiology)
Mrs L. Sahoo, Scientist (Fishery Science)
Mr B.L. Meena, Scientist (Plant Breeding)
Mr C. Debnath, Scientist (Fishery Science)
Mrs H. Ranebennur, Scientist (Plant Pathology)
Dr G.S.Yadav, Scientist (Agronomy)

**SIKKIM CENTRE**
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Dr R.K. Avasthe, Principal Scientist (Soil Science)
Dr (Mrs.) Saroj Toppo, Senior Scientist (Animal Nutrition)
Dr H. Kalita, Senior Scientist (Agril. Entomology)
Dr Ramesh Chandra, Senior Scientist (LPM)
Dr Ashok Kumar, Scientist (S.S) (Horticulture)
Dr L.R. Chatlod, Scientist (Animal Health)
Dr R. Gopi, Scientist (Plant Pathology)
Mr Chandan Kapoor, Scientist (Plant Breeding)