CRRI

वार्षिक प्रतिवेदन
ANNUAL REPORT
2012-13

भाकृअनुप
ICAR

केंद्रीय चावल अनुसंधान संस्थान

भारतीय कृषि अनुसंधान परिषद

Central Rice Research Institute

(Indian Council of Agricultural Research)

CRRI

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कटक (ओडिशा) ७५३ ००६, भारत

Central Rice Research Institute

Indian Council of Agricultural Research

Cuttack (Odisha) 753 006, India

Correct Citation
CRRI Annual Report 2012-13
Central Rice Research Institute, Cuttack

ISBN 81-88409-13-8

Published by
Dr. Trilochan Mohapatra
Director, CRRI

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August 2013

Laser typeset at the Central Rice Research Institute, Indian Council of Agricultural Research, Cuttack (Odisha) 753006, India, and printed in India by the Print-Tech Offset Pvt. Ltd., Bhubaneswar (Odisha) 751024. Published by the Director for the Central Rice Research Institute, ICAR, Cuttack (Odisha) 753006.

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CRRI

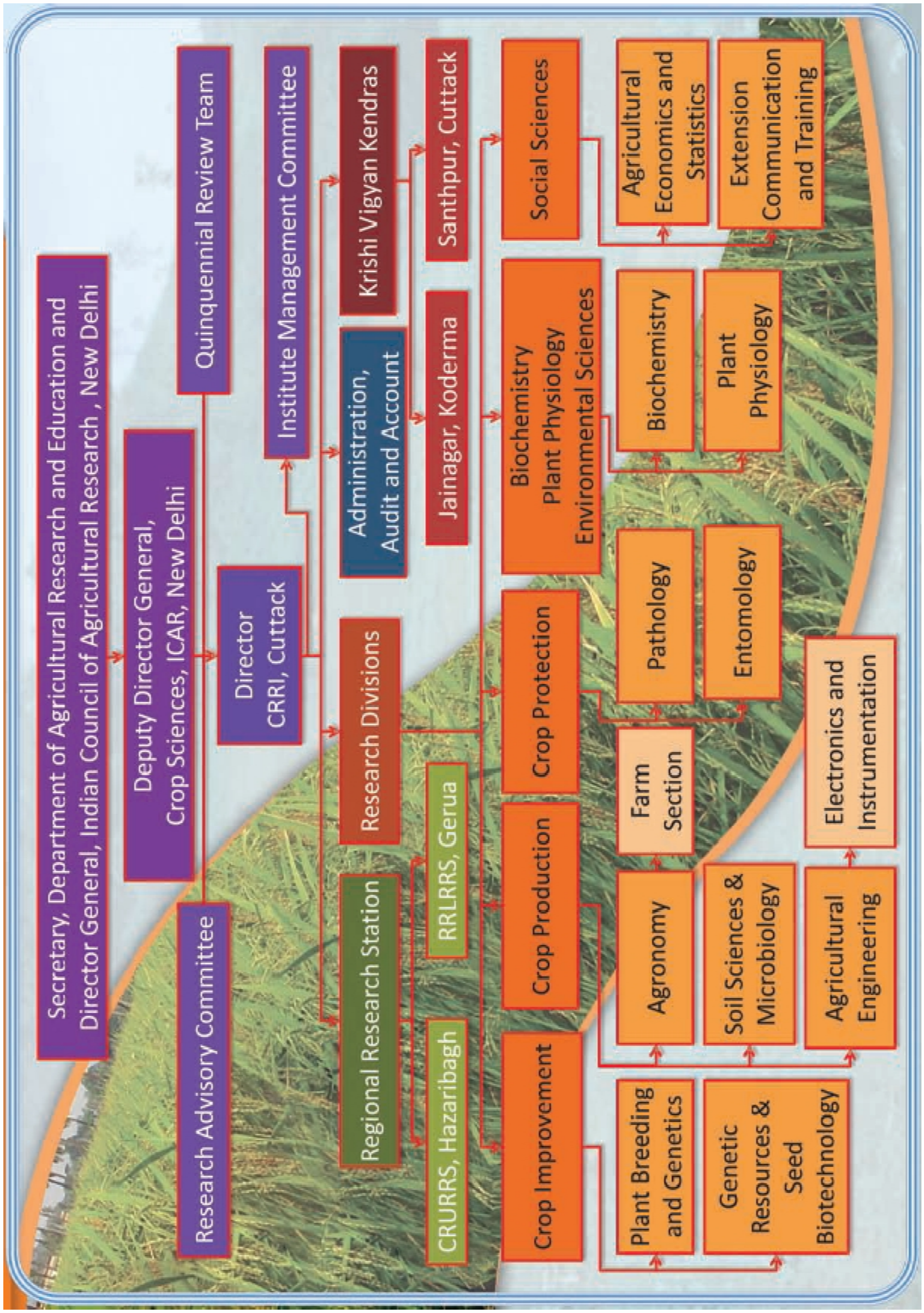
PREFACE

India accounts for 20 per cent of world's rice production. It reached a record high of 104.7 million tonnes in 2012-2013 crop year. The country exported about 10 million tonnes of rice last year, earning valuable foreign exchange. Since 1950, the increase in production has been more than 350 per cent. Most of this increase was the result of an increase in yield. The scope of increasing rice area is limited rather a decreasing trend in total rice area was observed in the last decade. By the end of 9th five year plan the total area under rice was 44.60 m ha that declined to 42.63 m ha by the end of 11th five year plan. It is estimated that the demand for rice will be 121.2 million tonnes by the year 2030, 129.6 million tonnes by 2040 and 137.3 million tonnes by 2050 for internal consumption. In the wake of global warming and climate change, the area under rice is likely to shrink further due to other sectoral competition, sea level rise and declining allocation of water to agriculture. Against this background, sustained increase in rice production needs all the ingenuity in rice science blended with policy backup. Central Rice Research Institute is nourishing rice research and its application for development of new climate resilient varieties and production technologies, and their dissemination. Reducing the cost of cultivation, enhancing the resource use efficiency, farm mechanization and drudgery reduction, designing effective crop protection strategies, technology dissemination, and capacity building are being pursued with vigor. As the nodal monitoring agency, CRRI is actively and continuously providing technology backstop to the mega rice development programme "Bringing Green Revolution in Eastern India" of the Department of Agriculture & Cooperation, Government of India, New Delhi. The CRRI Annual Report for 2012-13 is a compilation of the progress made in the last one year on all the above aspects. As the premier rice research institute in the country, CRRI will continue striving hard for achieving excellence and nourishing rice innovations for sustaining national food security and prosperity.

The guidance and inspiration received from Dr. S. Ayyappan, Hon'ble Secretary, DARE and Director General, ICAR, New Delhi, Dr. S. K. Datta, Deputy Director General (Crop Science), ICAR, New Delhi, Dr. E.A. Siddiq, Chairman, QRT, Dr. R.B. Singh, Chairman, RAC and the members of QRT and RAC are gratefully acknowledged. I acknowledge the support extended by Dr. R.P. Dua, Assistant Director General (FFC), ICAR, New Delhi for successfully implementing the institute activities. I appreciate the efforts of Heads of Division, OICs of Regional Research Stations, Publication Committee, Administration, Finance and Publication Unit of the Institute for compiling, and editing the Annual Report. My sincere thanks are due to all the staff of the institute for their whole-hearted support in carrying out institute's activities. I hope that this report will be useful for policy makers, researchers, development functionaries, farmers, farmwomen and students.

(T. Mohapatra)
Director

ORGANOGRAM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Agricultural Engineering
Electronics and Instrumentation

कार्यकारी सारांश

विभिन्न राज्यों में विमोचन हेतु सीआरआरआई द्वारा विकसित दो सिंचित, तीन ऐरोबिक, एक उथली निचलीभूमि तथा एक गहरेजल के लिए उपयुक्त सात किस्मों की सिफारिश की गई।

ओडिशा तथा पश्चिम बंगाल के सिंचित मध्यम भूमि में बोने के लिए सीआर धान ३०४ की पहचान की गई। यह किस्म १२५ दिनों में पक कर तैयार होती है एवं इसका पौध गिरता नहीं है। इसका दाना छोटा व मोटा होता है एवं कुटाई करने के बाद चावल कम टूटते हैं। इसकी उपज क्षमता ५.० टन प्रति हेक्टेयर है। इसमें खाने पकाने तथा कुटाई के अच्छे गुण हैं।

झारखंड, महाराष्ट्र तथा आंध्र प्रदेश के सिंचित पारितंत्रों के लिए सीआर धान ३०५ (सीआर २७०६) की पहचान की गई। इसका पौध गिरता नहीं है तथा १२५ दिनों में पक कर तैयार होता है। इसका दाना लंबा पतला है एवं इसकी औसत उपज क्षमता ४.८ टन प्रति हेक्टेयर है।

छत्तीसगढ़ तथा बिहार में एरोबिक किस्म के रूप में विमोचन हेतु सीआर धान २०१ (सीआर २६९६-आईआर ८३९२०) की पहचान की गई। यह किस्म ११०-११५ दिनों में पक कर तैयार होती है एवं इसका पौधा अर्द्ध बौना है। इसका दाना छोटा व मोटा होता है एवं इसकी उपज क्षमता ४.३ टन प्रति हेक्टेयर है।

ओडिशा तथा झारखंड में ऐरोबिक परिस्थिति में खेती करने के लिए सीआर धान २०२ (सीआर २७१५-१३ आईआर ८४८८७-बी-१५४) की पहचान की गई। यह किस्म ११५ दिनों में पक कर तैयार होती है एवं इसका पौधा अर्द्ध बौना है। इसका दाना छोटा व मोटा होता है, बालियां मध्यम एवं घनी होते हैं तथा इसकी उपज क्षमता ४.३ टन प्रति हेक्टेयर है।

तमिलनाडु तथा झारखंड में ऐरोबिक परिस्थिति में खेती करने के लिए सीआर धान २०४ (सीआर २६९६- आईआर ८३९२०) की पहचान की गई। यह किस्म ११० दिनों में पक कर तैयार होती है एवं इसका पौध अर्द्ध बौना है। इसका दाना मध्यम पतला होता है, बालियां मध्यम एवं इसकी उपज क्षमता ४.३ टन प्रति हेक्टेयर है।

ओडिशा तथा पश्चिम बंगाल के वर्षाश्रित उथली निचलीभूमि में विमोचन के लिए सीआर धान ४०७ (सीआर २४५९-१२-८) की पहचान की गई। यह किस्म १५० दिनों में पक कर तैयार होती है एवं इसका पौधा गिरता नहीं है। इसका दाना लंबा व मोटा होता है, कुटाई के बाद चावल अधिक नहीं टूटते हैं। इसमें खाने पकाने तथा कुटाई के अच्छे गुण हैं तथा इसकी उपज क्षमता ५.० टन प्रति हेक्टेयर है।

ओडिशा तथा असम के गहराजल क्षेत्रों में खेती करने के लिए सीआर धान ५०५ (सीआर २६८२-४-२-२-२-१) की पहचान की गई। यह किस्म १६२ दिनों में पक कर तैयार होती है एवं इसका दाना मध्यम पतला होता है, जलनिमग्नता सहिष्णु है, दीर्घीकरण क्षमता है तथा इसकी उपज क्षमता ४.५ टन प्रति हेक्टेयर है।

ओडिशा में वर्ष २०१२ के दौरान पारितंत्र तथा लक्षण-विशेष वाली ग्यारह किस्में विमोचित की गई जिसमें सत्यभामा (उपराऊंभूमि), सुमित (उथली निचलीभूमि), जलमणि एवं जयंतिधान (गहराजल), ह्यू (सिंचित), लुणा संखी एवं लुणा बरियल (तटीय लवणीय), प्यारी (ऐराबिक), पूर्णभोग (सुगंधित) तथा दो जीवाणुज अंगमारी प्रतिराधी किस्में शामिल हैं। बीज उत्पादन प्रयोजन के लिए उन्नत ललाट तथा सुधरित तपस्विनी अधिसूचित की गई।

ओडिशा, असम, झारखंड तथा अरुणाचल प्रदेश से तीन सौ निन्यानबे जंगली तथा खेती योग्य चावल जननद्रव्य संग्रहित किए गए। दस हजार दो सौ जननद्रव्य वंशों को कृषि-आकारिकी विशेषताओं के लिए लक्षण-वर्णन किया गया। ५५०० से अधिक चावल जननद्रव्य प्रतिविष्टियों को सीआरआरआई, कटक के राष्ट्रीय सक्रिय जननद्रव्य केंद्र में मध्यम अवधि के लिए सुरक्षित रखा गया। ५४ एसएसआर चिन्हकों का प्रयोग करते हुए ओ.रुफिपोगन तथा ओ.निवारा के छब्बीस प्रतिविष्टियों का आण्विक विविधता के लिए अध्ययन किया गया।

पच्चीस किस्मों के छह सौ इक्यावन क्विंटल प्रजनक बीजों का उत्पादन किया गया। तीन लघु अवधि के सीएमएस वंश जैस वीरेंद्र ए, शताब्दी ए तथा सहभागी धान को डब्ल्यूए साइटोप्लाज्मिक पृष्ठभूमि में विकसित किया गया तथा छोटे पैमाने पर इनका बीज उत्पादन किया जा रहा है। दो संपोषकों सीआरएमएस ३१बी तथा सीआरएमएस ३२बी को ४ जीवाणुज अंगमारी प्रतिरोधी जीनों सहित पिरामिड किया गया। सीआरएमएस ३१ए तथा सीआरएमएस ३२ए एवं उनके संपोषकों वंशों का विशिष्टता प्राप्त करने के लिए दो सह-प्रमुख तथा एक प्रमुख माइटोकोनड्रियल आधारित चिन्हक का विकास किया गया है। सीआरआरआई विकसित संकर चावल अजय, राजलक्ष्मी तथा सीआर धान ७०१ के जनक वंशों का विशिष्टता प्राप्ति के लिए तेरह माइक्रोसैटेलाइट चिन्हकों की पहचान की गई।

सीआरआरआई विकसित संकर चावल अजय, राजलक्ष्मी तथा सीआर धान ७०१ के जनक वंशों की वृद्धि तथा बीज उत्पादन के लिए निजी कंपनियों से चार नये समझौता किए गए।

अर्द्ध-गहराजल परिस्थिति में सीआर ३००८-बी-६-७-१-१ का प्रदर्शन श्रेष्ठ रहा और ५.५ टन प्रति हेक्टेयर की औसत उपज मिली एवं सीआर २४३२-बी-१३-१-१-१-१ से ५.११ टन प्रति हेक्टेयेर की उपज मिली जबकि चेक किस्म वर्षाधान से ४.१२ टन प्रति हेक्टेयर की उपज मिली। सीआरआरआई, कटक में गहराजल परिस्थितियों में आशाजनक प्रविष्टियां जैसे सीआर २६८३-४५-१-२-१-२, सीआर ३८३६-१-७-४-१-१, सीआर २६८२-१-१-५-१-१ की उपज ४.५ टन प्रति हेक्टेयर से अधिक रही। आरआरएलआरआरएस, गेरुआ में सीआरएल ६८-१४१-१-३-१-१ से सर्वाधिक ५.१७ टन प्रति हेक्टेयर उपज मिली और सीआरएल ७०-३८-२-२-१-१ से ५.०० टन प्रति हेक्टेयर उपज मिली।

लवणीय परिस्थिति के अंतर्गत किसानों के खेतों में लुणासंखी की तुलना में सीआर २८१५-४-२७-४-एस-१-१-१ तथा सीआर २८१५-४-२३-५-एस-२-१-१ की उपज आशाजनक पायी गयीं। माइक्रोसैटेलाइट चिन्हकों के मान्यकरण के लिए *साल्टोल* क्षेत्र से अन्नापूर्णा x एफएल ४७८ संकर का अनुक्रम विश्लेषण किया गया। शामिल किए गए वंशों में लवणता सहिष्णुता का उच्च स्तर देखा गया।

सिंचित परिस्थिति में तीन आशाजनक नई पौध प्रकार जीनप्ररूपों जैसे सीआर ३७०५-२-११-१, सीआर ३७०७-१-१-६ तथा सीआर २९९६-२१-१ की पहचान हुई जिनकी उपज क्षमता ८.० टन प्रति हेक्टेयर से अधिक रही। उथली निचलीभूमि परिस्थिति में तीन आशाजनक नई पौध प्रकार जीनप्ररूपों जैसे सीआर २६८३-७-१-२-३-१, सीआर ३६९६-१-२-१-१-१ तथा सीआर २६८२-७-१-१-१ की पहचान हुई जिनकी उपज क्षमता १२.० टन प्रति हेक्टेयर से अधिक रही।

चार जीनप्ररूपों जैसे सीआर ३००५-७७-२, सीआर ३००६-८-२, सीआर ३००५-२३०-५ तथा सीआर २७११-७६ को भूरा पौध माहू प्रतिरोधी पाया गया। बहुविध नाशकजीव प्रतिरोधिता परीक्षण के तहत सीआर २७११-७६ को भूरा पौध माहू, पीला तना छेदक, गाल मिज तथा पत्ता मोड़क प्रतिरोधी पाया गया। सीआर २४८२-१०-४-३-२ को आच्छद अंगमारी के प्रति मध्यम

प्रतिरोधी पाया गया जबकि सीआर २९१६-१५-४-२-३ को आच्छद विगलन प्रतिरोधी पाया गया। सीआर २६५७-४६-३-२-१ पत्ता मोड़क प्रतिरोधी पाया गया।

संकर एपो/आईआर ६४ से व्युत्पन्न, मध्यम अवधि (१२० दिन) एवं १२० सेंटीमीटर पौध ऊंचाई तथा वांछित दाना गुण वाली एक नई प्रजनन वंश सीआर ६२४-२०७-बी-१-बी को राष्ट्रीय समन्वित परीक्षण के अंतर्गत ओडिशा एवं झारखंड में आशाजनक पाया गया। तीन अत्यधिक शीत सहिष्णु जीनप्ररूपों एसी ४३२८१, एसी ४३२६१ तथा गीतांजलि की पहचान की गई जो ४ डिग्री सेल्सियस में ३० से अधिक दिनों तक जीवित रह सकते हैं।

सात अत्यधिक तापमान दबाव सहिष्णु जीनप्ररूपों जैसे सीआर ३५६४-१४-३-१-१, सीआर ३५६१-२-१-१-१, सीआर ३५६४-२-१-२-१, सीआर ३५६४-१-१-१-१, सीआर ३५६४-१०-२-२-१, सीआर ३५६४-८-३-१-१, सीआर ३५६१-१-१-१-१-१ में वृद्धि अवस्था के दौरान बेहतर सहिष्णुता स्तर (८२ प्रतिशत से अधिक) पाया गया तथा इनमें से सीआर ३५६४-१-१-१-१ को अखिल भारतीय समन्वित चावल उन्नयन परियोजना के माध्यम से एवीटी १-आईएमई में आगे बढ़ाया गया। इसकी औसत उपज क्षमता ५.८ टन प्रति हेक्टेयर है।

पांच आशाजनक अधिक उपज वाली, अर्द्ध-बौना, छोटा दाना एवं सुगंधित किस्मों जैसे सीआर २९४७-१८, सीआर २९३४-३५, सीआर २९४७-१ की पहचान की गई जिनकी उपज क्षमता ४.५ टन प्रति हेक्टेयर से अधिक है तथा इन्हें राष्ट्रीय परीक्षण के लिए नामित किया गया। ओडिशा के १३७ पारंपरिक सुगंधित लघु दाना चावल भूमिजातियों के बीच आनुवंशिक संबंध स्थापित करने हेतु पीसीआर आकलन के साथ २४ हाइपर परिवर्तनीय चावल माइक्रोसैटेलाइट चिन्हकों का उपयोग करते हुए प्रत्येक में से दो क्रोमोसोम का आनुवंशिक विविधता अध्ययन किया गया।

नवीन एवं एआरसी १००७५ (उच्च प्रोटीनयुक्त दाना के लिए दाता) के बैक क्रॉस संख्या से पीएलएन-३१, ३२, ३७ तथा ११६ को अधिक उपज क्षमता वाली तथा अधिक प्रोटीनयुक्त दाने वाली स्वीकार्य पौध प्रकार के रूप में पहचाना गया।

एक श्रेष्ठ इंडिका चावल किस्म पूसा बासमती-१ में फोस्फोमानोस आइसोमरेस जीन का समिश्रण किया गया। इसके अतिरिक्त, इंडिका चावल किस्मों पीबी-१ तथा बीपीटी ५२०४ में जस्ता वाहक जीन शामिल किया गया।

पेनीसेटम ग्लाकुम इयुकेरियोटिक ट्रांस्लेशन इनिशिएशन फैक्टर ४ए वाली स्वर्णा के ट्रांसजेनिक वंश में अंकुरण एवं पौध अवस्था के दौरान लवण सहिष्णुता का उच्च स्तर देखा गया। पीजी-ईआईएफ४ए में एंटिऑक्सीडेंट इनजाइम के क्रियाकलापों में वृद्धि परिलक्षित हुई। यह पाया गया कि प्रोटीन निमार्ण के पोस्ट ट्रांस्क्रिप्शनल स्तर में शामिल होने वाले कारकों जैसे इयुकेरियोटिक ट्रांस्लेशन इनिशिएशन फैक्टर ४ए पौधों में लवण सहिष्णुता के लिए क्रियाशील हैं।

अन्य किस्मों की तुलना में, उपराऊभूमि चावल किस्मों सीआरआर ४५१-१-बी-२-१, सीआरआर ६७७-२ तथा सीआरआर ६४६-बी-९३-१-बी-३ में नत्रजन की कम मात्रा (२० किलोग्राम नत्रजन प्रति हेक्टेयर) के प्रयोग करने पर भी अच्छी उपज प्राप्त हुई तथा अधिक दौजियां भी हुई। सालुमपिकिट, वीएलडीटीआई, कालिया, सुखवान, आरआर ५१७-३४-१-१ तथा सीआरआर ४५५-१०९ को आशाजनक सूखा सहिष्णुता जीनप्ररूपों के रूप में पहचाना गया।

आरआरएलआरआरएस, गेरुआ में विभिन्न पारितंत्रों के लिए ५.० टन प्रति हेक्टेयर से अधिक उपज क्षमता वाली आशाजनक एवं उपयुक्त किस्में जैसे वर्षाश्रित उथली निचलीभूमियों (सीआरएल १-१२-२२-६-१-१, सीआरएल १३-६६-६-३-१-पीआर, सीआरएल १-१३-१३-२३-२-२-१, सीआरएल १-१२-२२-६-१-१, सीआरएल ७७-४-१-२-१-१, सीआरएल ९८-१५-६-३-१) गहराजल परिस्थिति के लिए (सीआरएल ६८१४१-१-१-१) तथा अर्द्ध-गहराजल परिस्थिति के लिए (सीआरएल ६८१४१-१-१-१) विकसित की गईं तथा राष्ट्रीय परीक्षण हेतु नामित की गई।

विभिन्न आर्द्रता अवस्थाओं अर्थात ऐरोबिक तथा जलनिमग्नता के तहत दीर्घकालिक उर्वरीकरण उपचारों के कारण मिट्टी की कार्बन एवं नत्रजन खनिज के अंतर का मूल्यांकन किया गया। जलनिमग्न परिस्थिति की अपेक्षा ऐरोबिक परिस्थिति में संभावित खनिज एवं खनिजीकरण का दर अधिक पाया गया। इससे लंबे समय में ऐरोबिक प्रणाली में कार्बन एवं नत्रजन की मात्रा में नुकसान हो सकता है और इससे पता चलता है कि मिट्टी की मौजूदा नत्रजन मात्रा में सुधार हेतु जैविक एवं अजैविक दोनों स्रोतों का उचित परिमाण में नत्रजन का प्रयोग करना चाहिए।

नियंत्रित नत्रजन विमोचन तथा नाइट्रीकरण क्रियाकलाप अवरोध के कारण यूरिया के माध्यम से नत्रजन प्रयोग की तुलना में नीम प्रलेपित यूरिया के प्रयोग से नाइट्रेट रिसाव तथा नाइट्रस ऑक्साइड का उत्सर्जन कम रहा। यूरिया एवं नीम प्रलेपित यूरिया के माध्यम से सिफारिश की गई नत्रजन की मात्रा की अपेक्षा नत्रजन आधारित लीफ कलर चार्ट के प्रयोग से नत्रजन का उद्ग्रहण अधिक पाया गया।

पूर्वी भारत में खेती की जाने वाली स्थानीय चावल किस्में एवं अधिक उपज देने वाली पौध किस्मों के पत्तों के वर्णक्रमीय मूल्यांकन के आधार पर विभिन्न पारितंत्रों के लिए चावल में नत्रजन प्रबंधन हेतु एक पांच सूची वाली अनुकूलित लीफ कलर चार्ट पैनेल विकसित की गई। यह सस्ता होने के साथ आसानी से उपयोग किया जा सकता है जिसमें नत्रजन प्रयोग संबंधी सूची ओडिआ, हिंदी तथा अंग्रेजी के सरल भाषा में एक पुस्तिका में उपलब्ध कराया गया है जिसे किसान आसानी से अनुपालन कर सकेगें। इसके अनुपालन से, किसान फसल की वास्तविक मांग के अनुसार नत्रजन का प्रयोग कर पाएगें और अधिक उपज प्राप्त होगी तथा १०-२० किलोग्राम प्रति हेक्टेयर नत्रजन के प्रयोग में कमी होगी।

१९८३ से २००८ के समय श्रृंखला के दौरान विभिन्न आर्द्र मौसम (जून से नवंबर) का मासिक मान्यकृत वर्षा सूची आंकड़ा प्राप्त करने हेतु ओडिशा के १६८ वर्षामापी केंद्रों का उपयोग किया गया। परिणामस्वरूप, २६ बाइनरी मास्क एक साथ प्रस्तुत की गई तथा विभिन्न वर्गो (कोई जोखिम नहीं, मध्यम जोखिम तथा गंभीर जोखिम) का सूखा जोखिम मानचित्र तैयार किया गया।

चावल-मक्का-लोबिया तथा चावल-मूंगफली-लोबिया फसल प्रणाली आधारित विभिन्न पोषक प्रबंधन विकल्पों का मूल्यांकन किया गया। इन विकल्पों में से, केवल सिफारिश की गई उर्वरक मात्रा के प्रयोग की तुलना में जब ७५ प्रतिशत सिफरिश की गई उर्वरक (आरडीएफ ७५) मात्रा के साथ फसल अवशेष को मिलाया गया तब ११.०१ टन प्रति हेक्टेयर की सर्वाधिक चावल तुल्यांक उपज प्राप्त हुई। इस प्रकार के उपचार अर्थात आरडीएफ ७५ एवं फसल अवशेष को मिलाने से ७७,३४५ रुपये की शुद्ध आय मिली।

एक केंद्रीय नलिका प्रकार का २-३ किलो क्षमता वाला चावल भूसी कंबस्टर का डिजाइन एवं निमार्ण किया गया। आरंभिक परिक्षणों में पानी को उबालने से पता चला कि इस कंबस्टर से लगातार दो घंटे तक ताप ऊर्जा मिल सकती है और १३-१५ प्रतिशत दर पर थर्मल कार्यक्षमता प्रदान करता है।

चावल की खेती के लिए एक दो कतार वाले एवं ६, ९ एवं १२ सेंटीमीटर चौड़े एल आकार का ब्लेड सहित स्वचालित निराई यंत्र का विकास एवं परीक्षण किया गया। नवीन किस्म को खेत में २५ x २५ सेंटीमीटर की पौध दूरी कायम रखने पर इस निराई यंत्र का प्रदर्शन बहुत अच्छा पाया गया।

उपज तथा ऊर्जा के उचित प्रयोग के लिए धान का युगल कतार वाला शुष्क सीधी बुआई एवं सीड ड्रिल द्वारा २:१ के अनुपात में ढैंचा तथा कोनो वीडर द्वारा ढैंचा का समावेश और लीफ कलर चार्ट आधारित नत्रजन प्रबंधन वाली एक संसाधन संरक्षण प्रौद्योगिकी की पहचान की गई।

चावल मछली पारितंत्र में बिन मछली फसल में एक दिन के बाद पौध ऊत्तक में क्लोरपाइरिफास का अवशेष स्तर ०.००३० मिलीग्राम प्रति किलोग्राम पाया गया जबकि फसल सहित मछली में ०.००२७ मिलीग्राम प्रति किलोग्राम स्तर पाया गया। बिन मछली की तुलना में, मछली संवर्द्धन प्रणाली में छिड़काव करने के १२वें दिन बाद पौध ऊत्तक में अवशेष स्तर ५२ प्रतिशत तक घट गया।

दो चावल-मछली फसल प्रणाली नमूनों (वर्षाश्रित निचलीभूमि तथा बहुस्तरीय गहराजल नमूना) को २१ छोटे प्रक्षेत्रों (०.१३-०.८ हेक्टेयर क्षेत्र) में सफलतापूर्वक विस्तार किया गया। इन नमूनों को समझौते के द्वारा ओडिशा के तटीय क्षेत्रों के आठ प्रक्षेत्रों में तथा पश्चिम बंगाल के सुंदरवन क्षेत्र के तेरह प्रक्षेत्रों में विकास किया गया। पश्चिम बंगाल के सुंदरवन क्षेत्र में पारिवारिक श्रम सहित शुद्ध आय २७,५०० से १,०५,५०० रुपये प्रति हेक्टेयर प्रति वर्ष के बीच रही जबकि ओडिशा के तटीय क्षेत्रों के किसानों की शुद्ध आय बिना श्रम लागत के ८८,९०० से २३७,००० रुपये प्रति हेक्टेयर प्रति वर्ष के बीच रही।

बुआई करने के सात दिन बाद, विभिन्न खरपतवार, चौड़े पत्ते वाले घास आदि के नियंत्रण के लिए आविर्भाव पश्चात सल्फ्यूरन यूरिया नई शाकनाशी, फ्लुक्टोसल्फ्यूरन का २५ ग्राम प्रति हेक्टेयर दर पर प्रयोग बहुत अच्छा रहा और ९० प्रतिशत तक खरपतवारों का नियंत्रण हो सका।

रोपाई करने के १५ दिनों बाद शाकनाशी मिश्रण जैसे एजिमसल्फ्यूरन + बाइस्पाइरिबैक सोडियम (२२ अ ३० ग्राम प्रति हेक्टेयर) एवं पेनाक्सुलोम + साइहालोफ्यूटिल (१२० ग्राम प्रति हेक्टेयर) के प्रयोग से प्रमुख खरपतवारों का असरदार नियंत्रण हो सका तथा दोनों का नियंत्रण कार्यक्षमता क्रमशः ९२.४ प्रतिशत एवं ९१.६ प्रतिशत रहा। एजिमसल्फ्यूरन + बाइस्पाइरिबैक सोडियम से उपचारित खेतों से ४.९० टन प्रति हेक्टेयर की उपज प्राप्त हुई।

ओडिशा के केंद्रपाड़ा जिले के राजनगर प्रखंड से ३ किलोमीटर x ३ किलोमीटर के दायरे से मृदा नमूने संग्रह किये गये। ०.३१ से २०.६१ डीएस प्रति वर्गमीटर मिट्टी की ईसी में विभिन्नता मिली। पोषकतत्वों में से मिट्टी में उपलब्ध फास्फोरस एवं पोटाश की मात्रा अधिक थी जबकि सभी मिट्टी नमूनों में नत्रजन की मात्रा कम पाई गई। एआरसीजीआईएस १० का उपयोग करते हुए प्रमुख पोषकतत्वों तथा मिट्टी ईसी के लिए स्थान-विषयक विशलेषण किया गया। प्रमुख पोषकतत्वों के लिए साधारण क्रिगिंग का प्रयोग करके मिट्टी लवणता तथा उर्वरता मानचित्र का विकास किया गया।

भुवनेश्वर की अम्लीय, मखराला मिट्टी में विभिन्न मृदा प्रबंधन मिश्रणों के साथ तीन सहिष्णु चावल किस्मों (ललाट, चंदन तथा नवीन) तथा एक ग्राह्यशील चावल किस्म का मूल्यांकन किया गया। चूना, मैंगेनीज, जस्ता तथा पोटाश के मिश्रित प्रयोग से सर्वाधिक उपज मिलने के साथ जड़ों, कोंपलों में लौह की मात्रा कम हुई तथा लौह स्थानांतरण भी कम हुआ।

बियुवेरिया बासियाना तथा मेटार्हाजियम एनिसोप्लिए प्रत्येक के तीन वियुक्तों को धान भूसी तथा आरा धूल पर २ प्रतिशत डेक्स्ट्रोस के साथ बड़े पैमाने पर उत्पादन किया गया। खेत परीक्षण के दौरान लुणा सुवर्णा चावल किस्म में पत्ता मोड़क के संक्रमण होने पर बियुवेरिया के चूर्णन सूत्रणों (८ x १००० बीजाणुओं प्रति मिलीलीटर) तथा मेटार्हाजियम के चूर्णन सूत्रणों (१.७५ x १००००००-१.७५ x १०००००००० बीजाणुओं प्रति मिलीलीटर) से पत्ता मोड़क की संख्या में भारी कमी हुई।

ओसिमम सांक्टम (तुलसी) के तेल के प्रयोग से पाइरिक्यूलारिया ग्रिसिया, हेलमिंथोस्पोरियम ओराइजे तथा कर्वूलारिया लूनाटा का कोनिडायल अंकुरण पूरी तरह से खत्म हुआ। एगल मार्मेलोस (बेल) के जलीय निचोड़ का ०.०१ प्रतिशत संकेंद्रण प्रयोग से पाइरिक्यूलारिया ग्रिसिया का कोनिडायल अंकुरण संपूर्ण बंद हुआ। वियुक्त मिश्रण के वर्णक्रम विश्लेषण के आधार पर एगल मार्मेलोस से सक्रिय सिद्धांत के अलगाव एवं पहचान से पता चला कि सक्रिय संघटक एक डी-लिमोनिन है।

जीनप्ररूप जैसे एवीटी-१-आईएमई-१२३१, एवीटी-१-३३०६, एवीटी-२-३२०५, एनएसडीउब्ल्यूएसएन-३५२९, एनएसडीउब्ल्यूएसएन-३५३१, एनएसडीउब्ल्यूएसएन-३५३२, एएल, तथा आईएसटीवीटी-१९२८, एएल तथा आईएसटीवीटी-१९३२, आईवीटी-१३३आईएमई, डीएचएएमएएस-२ए प्रध्वंस प्रतिरोधी पाये गये तथा एवीटी-१-बीटी-२१०१, एवीटी-१-आईएम-१५०९ जीवाणुज पत्ता अंगमारी प्रतिरोधी पाये गये। चार जीनप्ररूप जैसे आईआर ७१६०६-२-१-१-३-३-१-१, पंखारी २०३, पीटीबी १८ तथा पीटीबी २१ को असम में विलंबित साली मौसम में राइस टुंग्रो रोग प्रतिरोधी पाया गया।

निचलीभूमि में आच्छद अंगमारी रोग के संक्रमण की रोकथाम के लिए एजोक्सिट्रोबिन १.० मिलीलीटर प्रति लीटर पानी में मिलाकर प्रयोग सबसे अच्छा रहा। पूजा किस्म का इंडोफाइटिक पेनिसिलियम तथा डेंड्रीफाइला से माइसेलिआल वृद्धि घट गई तथा राइजोक्टोनिया के स्क्लेरोतिया की संख्या में कमी हुई। दोनों इंडोफाइटों के कारण चावल पौध की वृद्धि महत्वपूर्ण रूप से हुई।

सीआरआरआई के दो जीनप्ररूपों आईसी संख्या ३२४१७१, ३२६४३० तथा किसानों की सात किस्में असनचुड़ी, बाइगणमंजी, चंपा, चंपेइसाली, बालीभंजन-टी, गंजेइजोल-पी तथा हरिशंकर भूरा पौध माहू के विरुद्ध प्रतिरोधी पाए गए और इनका स्कोर १ था। सीआरआरआई के भूरा पौध माहू प्रतिरोधी दाताओं एसी३५१८१ (सालकाथी) तथा एसी३५१८४ (धोबानंबरी) की पृष्ठभूमि में चार प्रजनन वंशों जैसे सीआर२७११-७६, सीआर३००५-७७-२, सीआर३००६-८-२ तथा सीआर३००५-२३०-५ सीआरआरआई तथा एआईसीआरपी के परीक्षण में भूरा पौध माहू के प्रति अत्यधिक प्रतिरोधी पाए गए।

सरसा, एआरसी ५९८४, एआरसी ५९८५, एआरसी ५९८६, एआरसी ५९८७, एआरसी ५९८८ तथा फाल्गुन की पृष्ठभूमि में विकसित नौ प्रजनन वंशों को ग्रीनहाउस परिस्थिति में गालमिज के प्रति अत्यधिक प्रतिरोधी पाया गया।

गालमिज जैवप्ररूप परिक्षण के अंतर्गत, एआरसी ५९८४ (गालमिज ५), आरपी २३३३-१५६-८ (गालमिज ७), आरपी २०६८-१८-३-५ (गालमिज ३), अभय (गालमिज ४) तथा अग्नि (गालमिज ८) को सीआरआरआई जैवप्ररूप, गालमिज २ के प्रति अत्यधिक प्रतिरोधी पाया गया।

२००१ से २०११ के दौरान प्रकाश जाल आंकड़ों के विश्लेषण से पता चलता है कि हरा पौध माहू की संख्या पिछले वर्षों में घट रही है। छह सप्ताह की अवधि के अंतराल मौसमी आंकड़ों के हरा पौध माहू की संख्या के लॉग मूल्य का विश्लेषण करने पर प्रकाश जाल पकड़ों के २९ प्रतिशत आरएच II के बारे में पता चला।

नाशककीटों पर प्रयोग किए जाने वाले कीटनाशकों के दीर्घकालिक प्रयोग के प्रभाव के परीक्षणों से पता चला कि रबी और खरीफ दोनों मौसम के दौरान करताप के प्रयोग से कीटों से होने वाली क्षतियां कम हुई और सर्वाधिक उपज प्राप्त हुई। केवल कवक एवं एक्टिनोमाइसेटस्स् के अलावा, करताप से बीजाणुओं के समूहों एवं उनके क्रियाकलाप को नुकसान नहीं हुआ। चावल जड़गांठ सूत्रकृमि, मेलोडोगाइन ग्रामिनाकोला की संख्या २०१० के आंरभिक वर्ष की तुलना में पिछले सभी वर्षो में, कार्बेजाडिम के प्रयोग के अलावा सभी उपचारो में कम पाया गया।

अधिक कार्बन एवं तापमान परिस्थिति में क्लोरपाइरिफास के विसरण पर किए गए अध्ययन से पता चला कि व्यापक परिस्थिति के तहत यह १४

दिनों तक व्याप्त रहा जबकि अन्य उपचारों में विसरण करने के सात दिन बाद इसकी पहचान नहीं हो सकी।

सिट्रोनेला, क्राउन तथा बेल के तेल के प्रयोग से भंडारित धान कीट राइजोपर्था डामिनिका से छह महीनों तक सुरक्षा मिली।

ओडिशा के कटक जिले के सांकिलो गांव में आईपीएम पद्धति के तहत स्वर्णा किस्म पर किए गए परीक्षण से किसानों की खेतीपद्धति की ६.२१ टन प्रति हेक्टेययर उपज तुलना में ७.१ टन प्रति हेक्टेयर की सर्वाधिक उपज मिली। पूजा किस्म में आईपीएम खेती पद्धति अपनाने पर अधिक उपज मिली। स्वर्णा किस्म में आईपीएम खेती पद्धति अपनाने पर ११,६२५ रुपये प्रति हेक्टेयर आय मिली जबकि पूजा से ९,७५० रुपये प्रति हेक्टेयर आय मिली।

झारखंड के उपराऊंभूमि चावल खेतों में अंजलि किस्म पर किये गये अध्ययन से पता चला कि आईपीएम खेती पद्धति वाले खेतों में कम व शुष्क खरपतवार हुए जबकि बिन आईपीएम खेती पद्धति खेतों में ऐसा नहीं हुआ। बनाहा गांव में आईपीएम खेती पद्धति वाले खेतों से औसत उपज २.३ टन प्रति हेक्टेयर मिली जबकि बिन आईपीएम खेती पद्धति खेतों की उपज १.८६ टन प्रति हेक्टेयर मिली।

नाशककीटों के विरुद्ध मूल्यांकन किए गए ग्यारह कीटनाशकों में से इमिडाक्लोप्रिड १७.८ प्रतिशत ३०० ग्राम प्रति हेक्टेयर दर पर सबसे श्रेष्ठ कीटनाशक (५.१२ टन प्रति हेक्टेयर) रहा तथा सल्फोक्साफ्लोर २४ प्रतिशत ३७५ ग्राम प्रति हेक्टेयर के समान पाया गया।

पीआई-९ तथा पीटा-२ जीन में प्रतिपूरक प्रतिरोधी स्पेक्ट्रम देखने को मिला तथा झारखंड में मूल्यांकन किए गए प्रध्वंस रोगजनक संख्या के सभी रोगप्ररूपों को अलग कर दिया गया। पूर्वी भारत में चावल के प्रध्वंस रोग के प्रभावी प्रबंधन के लिए पीआई-९ तथा पीटा-२ के मिश्रण में अच्छी क्षमता है।

चावल के आठ नाशककीट स्क्रीपोफोगा इंसरतुलास, एस.इनोटाटा, चिलो सप्रेसालिस, सेसमिंया इंफरेंस, नेफोटेटिक्स वीरेंस, ट्रायबोलियम कास्टानियम तथा सिटोट्रोगा सेरेलेला के डीएनए बार कोडिंग का कार्य समाप्त हुआ तथा 'बोल्ड' (जीव जैवविविधता डेटाबेस) प्रणाली में जमा कर दिया गया है।

धान की अग्नि एवं नालबोरा किस्मों के रांची व पूसा में उगाने पर प्राप्त चावल के दानों (उष्णा) को पानी में भिगोने पर वे ज्यादा समय में नरम हुए जबकि कटक तथा गेरुआ से प्राप्त दाने कम समय भिगोने पर भी खाने लायक नरम हो गए।

शर्बती तथा ललाट की वृद्धि अवस्था के दौरान लौह के ५ पीपीम दर पर पत्तों में फेरिटिन प्रोटीन सर्वाधिक मात्रा में जमा हुआ।

लवणीय जल से जलाक्रांत (६ डीएस प्रति वर्गमीटर) होने के ४५ दिनों बाद एसी३९४१६(ए) १०० प्रतिशत जीवित पाई गई।

तीन सब१ किस्मों, स्वर्णा-सब१, आईआर ६४-सब१ तथा सावित्री-सब१ में से आईआर ६४-सब१ में सर्वाधिक ७.५ प्रतिशत उत्तरजीविता पाई गई, इसके बाद स्वर्णा-सब१ में ५८ प्रतिशत तथा सावित्री में ५१ प्रतिशत पाई गई। सावित्री सब १ में फास्फोरस की मात्रा अधिक देने से उत्तरजीविता बढ़ गई।

वृद्धि अवस्था सूखा दबाव परिक्षण के दौरान, ६२० जननद्रवय वंशों में से, १८० जननद्रव्यों में मृदा आर्द्रता मात्रा ५.३९ से ९.६ प्रतिशत तथा ९० सेंटीमीटर जल स्तर पर मृदा आर्द्रता तनाव ३५ से-६५ किलो पास्कल की परीस्थिति सूखा सहिष्णु पाई गई और एसईएस स्केल में इनका स्कोर ० एव १ रहा।

दो प्रकाश तीव्रताओं, सामान्य प्रकाश (१०० प्रतिशत) तथा ७५ प्रतिशत प्रकाश तीव्रता के तहत अधिक उपज देने वाली किस्मों एवं भूमिजातियों समेत १४९ चावल जीनरूप की खेती की गई। ४७ जीनप्ररूपों को सामान्य प्रकाश में खेती की गई फसल की अपेक्षा ७५ प्रतिशत प्रकाश तीव्रता के प्रति सहिष्णुता के लिए छांव में उपज हानि हेतु पहचान की गई। कम प्रकाश हेतु सरला, वंदना, गोविंदा तथा सत्यम में उपज हानि लगभग १० प्रतिशत के बीच रही जबकि सरस्वती में यह ५० प्रतिशत रही।

कटक जिले के टांगी चौद्वार प्रखंड के वर्षाश्रित समूह में पंद्रह परिणाम प्रदर्शनियां, प्रशिक्षण एवं बैठकों समेत तीन प्रणाली प्रदर्शनों का आयोजन किया गया। विभागों के बीच एक समग्र दृष्टिकोण एवं अभिसरण की व्यवस्था के विकास के लिए संस्थान में साझेदारी बैठक का आयोजन किया गया।

कटक जिले के सांकिलो गांव में चावल की खेती में लैंगिक संवेदनशील उपायों की परिकल्पना एवं परीक्षण कार्य आरंभ किया गया। खरीफ में रोजाना क्रियाकलापों के विश्लेषण से यह पता चला कि महिला किसान घर तथा खेतों में लगभग १८ घंटे काम करती हैं और सिर्फ ६ घंटे विश्राम करती हैं जबकि पुरुष किसान केवल साढ़े सात घंटे काम करते हैं। चावल की खेती में महिला किसानों को स्वास्थ्य संबंधी समस्याओं जैसे कमर दर्द का सामना करना पड़ता है। इसके अतिरिक्त बीज, अनाज भंडारण की समस्या तथा दौनी करने, ओसाई, जल की कमी की भी समस्यायें हैं।

यह पाया गया है कि किस्म चयन, सिंचाई, उत्पाद की बिक्री एवं वित्तीय प्रबंधन के लिए अधिकांश महिलाओं से राय ली जाती है किंतु पौध सुरक्षा उपायों, उर्वरक प्रयोग, प्रक्षेत्र उपकरण की खरीद में कभी-कभी उनकी राय ली जाती है तथा पुरुष उनकी राय को बहुत मुश्किल से स्वीकार करते हैं।

ओडिशा के किसानों के बीच पूजा चावल किस्म सबसे श्रेष्ठ एवं लोकप्रिय किस्म रही जबकि झारखंड में संकर चावल अभिषेक, असम में रणजीत एवं छत्तीसगढ़ में आईआर-६४ पसंद किया गया।

सीआरआरआई में प्रदर्शन परीक्षण खेतों में सीआरआरआई के किस्मों के निष्पादन से पता चला कि २०१२-१३ के रबी तथा खरीफ दोनों मौसम में संकर धान राजलक्ष्मी से क्रमशः ७.३ टन एवं ७.२ टन प्रति हेक्टेयर की सर्वाधिक उपज मिली।

टी-ईडीपी माड्यूल विकसित करने के अंश के रूप में, ओडिशा के पुरी जिले के साक्षीगोपाल प्रखंड का चयन किया गया तथा एक व्यावसायिक योजना तैयार की गई। इससे होने वाले कुल लाभ का आकलन लगभग १३,२५,५२५ रुपये किया गया है तथा वापसी भुगतान के बाद ८,८४,९९२ रुपये की अतिरिक्त राशि मिली। इस योजना के अनुसार द्वितीय वर्ष से लाभ मिलने लगा।

त्रिपुरा राज्य के आंकड़ों के विश्लेषण से पता चला कि किसान स्वर्णा, पूजा, नवीन, तथा एनडीआर-९७ की खेती करते हैं तथा चावल की खेती वाले क्षेत्र में व्यापक रूप से इनकी खेती की जाती है। उसी प्रकार, छत्तीसगढ़ राज्य के विश्लेषण से पता चला कि सीआरआरआई विकसित किस्में जैसे शताब्दी, तपस्विनी, अंजलि, तथा अन्नदा की खेती राज्य में की जाती है।

पश्चिम बंगाल राज्य के चावल उत्पादन के पूर्वानुमान के लिए १९६०-६१ से २००९-१० की अवधि के दौरान राज्य के चावल उत्पादन आंकड़ों का विश्लेषण 'एरिमा' नमूना का उपयोग करते हुए किया गया तथा पश्चिम बंगाल राज्य का वर्ष २०१९-२० के लिए १६,५५२ हजार टन चावल उत्पादन होने का अनुमान लगाया गया है।

अठारह राज्यों का २००६-०७ की अवधि के दौरान चावल की खेती की लागत संबंधी आंकड़ों का संग्रह किया गया एवं उन्हें कंप्यूटरीकृत कर दिया गया है।

EXECUTIVE SUMMARY

Seven CRRI cultures that include irrigated (2), aerobic (3), shallow lowland (1) and deepwater (2) were recommended for their release in different states.

CR Dhan 304 is identified for release in Odisha and West Bengal for irrigated medium land. It matures in 125 days with non-lodging plant habit. It produces short bold grain with high head rice recovery and grain yield capacity of 5.0 t/ha. It also exhibits good cooking and milling qualities.

CR Dhan 305 (CR 2706) is identified for irrigated ecosystems of Jharkhand, Maharashtra and Andhra Pradesh. It is non-lodging type and matures in 125 days and has long slender grains with an average grain yield potential of 4.8 t/ha.

CR Dhan 201(CR 2696-IR 83920) is identified for release as an aerobic variety in Chhattisgarh and Bihar. Maturity duration of the variety is 110-115 days with semi-dwarf plant type. It produces short bold grain with grain yield capacity of 4.3 t/ha.

CR Dhan 202 (CR 2715-13-IR 84887-B-154) is identified for release in Jharkhand and Odisha for aerobic condition. Maturity duration of the variety is 115 days with semi-dwarf plant type. It produces short bold grain, medium and dense panicle with grain yield capacity of 4.3 t/ha.

CR Dhan 204 (CR 2696-IR 83920) is identified for release in Jharkhand and Tamil Nadu for aerobic condition. Maturity duration of the variety is 110 days with semi-dwarf plant type. It produces medium slender grain with grain yield capacity of 4.3 t/ha.

CR Dhan 407 (CR 2459-12-8) is identified for release in Odisha and West Bengal for rainfed shallow lowland. It matures in 150 days with non-lodging plant habit and produces long bold grains with high head rice recovery. It has good cooking and milling qualities. It has an average grain yield capacity of 5.0 t/ha.

CR Dhan 505 (CR 2682-4-2-2-2-1) is identified for deepwater areas of Odisha and Assam. It matures in 162 days and has medium slender grains, submergence tolerance, elongation ability and has an average grain yield capacity of 4.5 t/ha.

Eleven ecosystem and trait specific varieties released in 2012 for Odisha which include upland (Satyabhama) shallow lowland (Sumit), deepwater (Jalamani, Jayantidhan), irrigated (Hue), coastal saline (Luna Sankhi, Luna Barial), aerobic (Pyari), aromatic (Poorna Bhog) and two bacterial blight resistant varieties, Improved Lalat and Improved Tapaswini were notified for seed production purpose.

Three hundred ninety nine wild and cultivated rice germplasm collections were made from Odisha, Assam, Jharkhand and Arunachal Pradesh. Ten thousand two hundred germplasm lines were characterized for agro-morphological characters. More than 5500 accessions of rice germplasm were conserved in National Active Germplasm Site at CRRI, Cuttack for medium term storage. Molecular diversity of twenty six accessions of *O. rufipogon* and *O. nivara* was studied using 54 SSR markers.

Six hundred fifty-one quintals of breeder seed belonging to twenty-five varieties were produced. Three short duration CMS lines i.e. Virendra A, Satabdi A and Sahabhagidhan A in WA cytoplasmic background has been developed and are being multiplied in small scale. Two maintainers, CRMS 31B and CRMS 32B has been pyramided with 4 BB resistance genes. Two co-dominant and one dominant mitochondrial based marker have been developed to distinguish CRMS31A and CRMS32A and their maintainer lines. Thirteen microsatellite markers were identified to distinguish parental lines of CRRI bred hybrid rice Ajay, Rajalaxmi and CR Dhan 701.

Four new MoUs were signed for multiplication of parental lines and seed production of CRRI bred rice hybrids, Ajay, Rajalaxmi and CR Dhan 701.

Under semi-deepwater condition CR 3008-B-6-7-1-1 performed best with an average yield of 5.51 t/ha followed by CR 2432-B-13-1-1-1-1(5.11 t/ha) against the best check Varshadhan (4.12 t/ha). Under deepwater conditions promising entries like CR 2683-45-1-2-1-2, CR3836-1-7-4-1-1, CR2682-1-1-5-1-1 had yield capacity of >4.5 t/ha at CRRI, Cuttack. CRL 68-141-1-3-1-1 had the highest grain yield of 5.17 t/ha followed by CRL 70-38-2-2-1-1 (5.00 t/ha) at RRLRRS, Gerua.

In farmers' field, under saline condition CR2815-4-27-4-S-1-1-1 and CR2815-4-23-5-S-2-1-1 were found promising compared to check variety Luna Sankhi.

Simple sequence repeat analysis for validation of microsatellite markers in the *Saltol* region from Annapurna x FL 478 cross was made. The introgression lines showed an increased level of salinity tolerance.

Three promising new plant type (NPT) genotypes CR 3705-2-11-1, CR 3707-1-1-6, CR 2996-21-1 were identified with grain yield capacity of more than 8.0 t/ha under irrigated condition. Under shallow lowland condition three promising NPT genotypes, namely CR 2683-7-1-2-3-1, CR 3696-1-2-1-1-1 and CR 2682-7-1-1-1 were found to have grain yield capacity of more than 12.0 t/ha.

Three genotypes CR 3005-77-2, CR 3006-8-2, CR 3005-230-5, CR 2711-76 were found to be resistant against brown planthopper. CR 2711-76 was identified with multiple pest resistance (BPH, YSB, gall midge and leaf folder) in multiple resistance screening trial. CR 2643-1-4-3-1 was found to be moderately resistant to sheath blight, while CR 2482-10-4-3-2 was resistant to BPH and sheath rot, and CR 2916-15-4-2-3 was resistant to sheath rot. CR 2657-46-3-2-1 found to be moderately resistant to leaf blast.

A new breeding line, CRR 624-207-B-1-B derived from the cross Apo/IR64, of mid-early duration (120 days) with intermediate height (112 cm) and desirable grain quality characteristics, found promising under national coordinated trials in Odisha and Jharkhand. Three highly cold tolerant genotypes AC43281, AC43261 and Geetanjali were identified that could survive for more than 30 days at 4^0C.

Six promising high temperature stress tolerant genotypes CR 3564-14-3-1-1, CR 3561-2-1-1-1, CR 3564-2-1-2-1, CR 3564-1-1-1-1, CR 3564-10-2-2-1, CR 3564-8-3-1-1, CR 3561-1-1-1-1 were identified to have better tolerance level (> 82%) at reproductive stage and among these CR 3564-1-1-1-1 has been promoted to AVT 1–IME through the AICRIP with an average grain yield of 5.8 t/ha.

Five promising high yielding semi-dwarf short grain aromatic cultures CR 2738-2, CR 2947-18, CR 2934-35, CR 2713-35, CR 2947-1 with grain yield capacity of more than 4.5 t/ha were identified and nominated for national testing. Genetic diversity study with PCR assays utilizing 24 hyper variable rice microsatellite markers, two from each chromosome has been made for establishing genetic diversity and genetic relationship among the 137 traditional aromatic short grain rice landraces of Odisha.

PLN- 31, 32, 37 and 116 were detected with acceptable plant type, high yielding ability and high grain protein content from the back cross population from ARC 10075 (donor for high grain protein content) and Naveen.

The phosphomannose isomerase (pmi) gene was introduced into an elite *indica* rice cultivar, Pusa Basmati-1. Besides this, the zinc transporter gene was incorporated into *indica* rice cultivars PB-1 and BPT 5204.

Transgenic lines of Swarna with *Pennisetum glaucum* eukaryotic translation initiation factor 4A (*PG-eif4A*) showed increased salinity tolerance at germination and seedling stage. Enhanced activity of antioxidant enzymes (SOD and APX) was observed in *PG-eif4A* over-expressed transgenic lines of Swarna. It was evident that, factors involved in post transcriptional level of protein synthesis, like Eukaryotic Translation Initiation Factor 4A (*eIF-4A*), are also actively involved in salinity tolerance in plants.

The upland rice cultures CRR 451-1-B-2-1, CRR 677-2, CRR 433-2-1 and CRR 646-B-93-B-3 produced better yield and more tillers than the other cultures under low N (20 kg N/ha) application. The promising drought tolerant genotypes identified are Salumpikit, VLDT1, Kalia, Sukhawan, RR 517-34-1-1 and CRR 455-109.

The promising cultures with grain yield capacity of more than 5.0 t/ha are found suitable for different ecosystems at CRLRRS, Gerua (CRL 1-12-22-6-1-1, CRL 13-66-6-3-1-PR, CRL 1-13-23-2-2-1, CRL 77-4-1-2-1-1 CRL 98-15-6-3-1 for rainfed shallow lowlands, CRL 68-141-1-1 for deepwater condition and CRL 68-141-1-3-1-2 for semi-deepwater situation) and were nominated for national testing.

The differences in carbon (C) and nitrogen (N) mineralization kinetics of soil due to long term fertilization treatments under different moisture regimes, i.e. aerobic and submergence was evaluated. The potentially mineralizable C (C_0), potentially mineralizable N (N_0) and rates of mineralization were higher under aerobic as compared to submergence condition. This could lead to rapid loss of C and N from the aerobic system in the long run and warrants a judicious N application strategy through integration of both organic and inorganic sources for improving current N supplying capacity of soil.

Leaching of NO_3 as well as N_2O-N emission were lower with application of neem coated urea as compared to N application through urea due to controlled release of N and inhibition of nitrification activity. Leaf colour chart based N application also recorded higher N uptake than the recommended dose of N applied through urea and neem coated urea.

A five panel customized leaf colour chart (CLCC) for N management in rice for different ecosystems was developed on the basis of spectral evaluation of leaves of high yielding varieties and local cultivars grown in eastern India. It is a cheap and easy to use handy tool provided with N application schedule in a folder with instructions in English, Hindi and Odia in simple language which can be easily followed by the farmers. By using this, farmers can adjust the N application to actual crop demand, achieve higher yields and reduce the N application by 10-20 kg/ha.

Time series of rainfall data (1983–2008) from 168 rain gauge stations of Odisha were used to derive monthly Standardized Precipitation Index (SPI) of different wet season months (June – November). The resulting 26 binary masks were stacked together and drought risk maps of different classes (no risk, moderate risk and severe risk) were generated.

Different nutrient management options on the rice-maize-cowpea and rice-groundnut-cowpea cropping system was evaluated. Among the nutrient management options highest rice equivalent yield of 11.01 t/ha was achieved when 75 per cent of recommended dose of fertilizer (RDF_{75}) along with crop residue incorporation (CRI) was made compared to application of recommended dose of fertilizer only. Highest net return of Rs. 77,345/- was also realised with this treatment in RDF_{75}+CRI in rice.

A central tube type rice husk combustor of 2-3 KW capacity to hold up to 4.5 kg of husk was designed and fabricated. Preliminary tests through water boiling revealed that the combustor could provide heat energy continuously for two hours at 13-15% thermal efficiency.

A two-row self propelled weeder was developed and tested with 6 cm, 9 cm and 12 cm wide L type rotary blade on variety Naveen. The weeder performed well under the plant spacing of 25 x 25 cm.

A resource conservation technology involving paired row dry direct seeding of rice and Dhaincha in 2:1 ratio with seed drill followed by incorporation of Dhaincha by Cono weeder and LCC based N management was identified as most promising in terms of yield and energy use.

The residue level of chlorpyrifos in plant tissue after one day in rice fish ecosystem was less in the crop with fish (0.0027 mg/kg) compared to the crop without fish (0.0030 mg/kg). After 12th day of spray, the residue level in plant tissue reduced by 52% with fish culture compared to 23.3% reduction without fish.

Two rice-fish farming systems models (rainfed lowland and multitier deepwater models) were successfully extended in 21 small farms (0.13-0.8 ha area). The models were developed through MoUs in eight farms in coastal areas of Odisha and 13 farms in Sundarban area of West Bengal. The net income ranged from Rs. 27,500 -1, 05,500 /ha/year with family labour in Sundarban area of West Bengal. In coastal areas of Odisha, the farmers realized net income in the range of Rs. 88,900 -2, 37, 000/ha/year without the labour cost.

Flucetosulfuron, a new post-emergence sulfonyl urea herbicide, showed excellent control of predominant grassy weeds, sedges and annual broad leaf weeds when applied 7 days after sowing at 25 g a.i./ha with weed control efficiency of 90%.

Herbicide mixtures *viz.,* Azimsulfuron + Bispyribac sodium (22 + 30 g a.i./ha) and Penoxsulam + Cyhalofop butyl (120 g a.i./ha) applied at 15 days after planting were found effective for controlling predominant weeds with weed control efficiency 92.4% and 91.6%, respectively. The highest grain yield (4.90 t/ha) was recorded in the plots treated with Azimsulfuron + Bispyribac sodium.

Grid wise (3 km x 3 km) soil samples were collected from the Rajnagar block of Kendrapara district of Odisha. Soil EC varied from 0.31 to 20.61dS/m. Among macronutrients, available P and K were high in soils, whereas, N was low in almost all the soil samples. Spatial analysis for soil EC and major nutrients was performed using Arc GIS 10 fitting different variogram models. Finally, soil salinity and fertility map for major nutrients was developed using ordinary kriging.

Three tolerant (Lalat, Chandan and Naveen) and one susceptible cultivars of rice were evaluated in a acidic laterite soil at Bhubaneswar having DTPA extractable Fe 400 ppm (iron toxic soil) with different combinations of soil management. Combined application of lime, Mn, Zn and K resulted in highest grain yield as well as lowest Fe concentration in root, shoot and Fe translocation.

Three isolates each of *Beauveria bassiana* and *Metarhizium anisopliae* were mass-produced on rice husk and saw dust supplemented with 2% dextrose. Wettable powder formulations of *Beauveria* (8×10^3 spores/ml) and *Metarhizium* (1.75×10^6 - 1.75×10^7 spores/ml) spp. effected 73.19-78.79% and 80.42-87.23% mortality of leaf folder (LF), respectively in a field testing of rice variety Luna Suvarna infested by LF.

Formulated product of *Ocimum sanctum* essential oil exhibited complete inhibition of conidial germination in *Pyricularia grisea, Helminthosporium oryzae* and *Curvularia lunata.* Aqueous mother extract of *Aegle marmelos* showed complete inhibition in *P. grisea* conidia at 0.01% concentration.

Isolation and identification of active principle from *A. marmelos* based on spectral analysis of the isolated compound revealed that the active constituent is d-limonene.

The genotypes AVT-1-IME-1231, AVT-1-3306, AVT-2-3205, NSDWSN-3529, NSDWSN-3531, NSDWSN-3532, AL and ISTVT-1928, AL and ISTVT-1932, IVT-1337IME, DHAMAS-2a were found resistant against blast and AVT-1-BT-2101, AVT-1-IM-1509 were found resistant against BLB. Four genotypes, *viz*., IR 71606-2-1-1-3-3-1-2, Pankhari 203, PTB 18 and PTB 21 were found resistant against rice tungro disease in late *sali* season in Assam.

Azoxystrobin had the best result in terms of prevention of infection of sheath blight disease in lowland applied @ 1.0 ml/L of water.

Endophytic *Penicillium* and *Dendryphiella* from rice var. Pooja restricted mycelial growth and reduced the number of sclerotia of *Rhizoctonia* sp. Rice plant growth was significantly enhanced by both the endophytes.

Two genotypes from CRRI, IC No. 324171, 326430 and seven farmers' varieties Assanchudi, Baiganmanji, Champa,Champeisiali, Balibhanjana-T, Ganjeijola-P and Harishankar showed resistant reaction of score 1 against BPH. Four breeding lines namely, CR 2711-76, CR 3005-77-2, CR 3006-8-2 and CR 3005-230-5 in the background of BPH resistant donors of CRRI AC 35181 (Salkathi) and AC 35184 (Dhobanumberi) were found highly resistant against BPH at CRRI and in the AICRP trials.

Nine breeding lines developed in the background of Sarasa, ARC 5984, ARC 5985, ARC 5986, ARC 5987, ARC 5988 and Phalguna were found highly resistant to gall midge under greenhouse condition.

Under gall midge biotype trial, ARC 5984 (GM 5), RP 2333-156-8 (Gm 7), RP 2068-18-3-5 (Gm 3), Abhaya (Gm 4) and Aganni (Gm 8) were found highly resistant to CRRI biotype, GM 2.

Analysis of light trap data from 2001-2011 indicated that green leafhopper (GLH) population is declining over the years. RH II alone could explain 29 % of the light trap catches when analyzed with log value of GLH population of six weeks lag period weather data.

Trials on effect of long term use of pesticide on insect pests indicated that both during *rabi* and *kharif* application of cartap resulted in lowest insect damage and highest grain yield. Trend of Microbial biomass carbon observed was in the order of Pretilachlor > Carbendazim > Chlorpyriphos > Cartap > Control. Cartap did not harm the maximum groups of microbes and their activity except fungi and actinomycetes. Population of rice root knot nematode, *Meloidogyne graminicola* decreased over the years compared to the initial year of 2010 in all the treatments except where Carbendazim was applied.

Studies on dissipation of chlorpyriphos under elevated CO_2 and temperature condition indicated that it persisted over 14 days under ambient condition, while in other treatments, it was undetectable after seven days of spray.

The oils of citronella, crown and bael could effectively protect the stored paddy from the lesser grain borer, *Rhyzopertha dominica* for six months.

Trials undertaken at Sankilo village, Cuttack district of Odisha with variety Swarna under IPM practice had significantly higher grain yield (7.1 t/ha) as compared to farmer's practice (6.21 t/ha). Variety Pooja with IPM practice also recorded significantly higher yield. The additional return in IPM plots grown with Swarna variety was computed to be Rs.11,625/ha, while in Pooja the return was Rs.9,750/ha.

Studies in upland rice (cv. Anjali) fields of Jharkhand indicated low dry weed biomass in IPM field compared with the non IPM field. Average grain yield of IPM plot was 2.37 t/ha and non IPM 1.86 t/ha in village Banaha.

Among the eleven insecticides evaluated against insect pests, Imidacloprid 17.8% @ 300 g/ha was the best insecticide (5.12 t/ha) and at par with Sulfoxaflor 24% @ 375 g/ha.

Pi9 and *Pita-2* gene exhibited complementary resistance spectrum and excluded all the pathotypes of blast pathogen population evaluated at Jharkhand. A combination of *Pi-9* and *Pita-2* has potential for effective management of rice blast disease in Eastern India.

DNA bar-coding of eight insect pests of rice, *Scirpophaga incertulas*, *S. innotata*, *Chilo suppressalis*, *Sesamia inference*, *Nephottetix virescens*, *Tribolium castanium* and *Sitotroga cerealella* was completed and the same has been submitted to BOLD (biodiversity of life database) system.

Increase in soaking time was noticed in samples of Aghoni and Nalbora obtained from Pusa (Bihar) and Ranchi (Jharkhand); there was no increase in samples grown at Cuttack (Odisha) and Gerua (Assam).

Both Sharbati and Lalat, accumulated maximum ferritin protein in the flag leaf at 5 ppm of Fe in the growth medium.

The cultivar AC 39416 (A) was found highly tolerant (100% survival) to water logging of saline water (6 dS/m) after 45 days of water logging.

Among the three SUB1 cultivars (Swarna-Sub1, IR 64-Sub1 and Savitri-Sub1), survival was greater in IR 64-Sub1 (75%), followed by Swarna-Sub1 (58%) and Savitiri-Sub1 (51%). The survival greatly increased with higher doses of phosphorous mainly in Savitri-Sub1.

Out of 620 germplasm lines exposed to vegetative stage drought stress, 180 were observed to be drought tolerant with SES score '0' and '1' under soil moisture content 5.39 to 9.76 % and soil moisture tension -35 to -65kPa below 30cm soil depth and water table depth below 90 cm.

One hundred forty nine rice genotypes including HYVs and landraces were grown under two light regimes-normal light (100%) and 75% light intensity; 47 genotypes were identified for their tolerance to 75% light intensity in terms of yield loss under shade over the crop grown under normal light. The yield loss due to low light varied from about 10% in Sarla, Vandana, Govinda and Satyam to 50% in Saraswati.

Fifteen result demonstrations, three method demonstrations including trainings and meetings were organized in a rainfed cluster of Tangi-Choudwar block of Cuttack district. A Stakeholders' meeting was held at the Institute for developing a holistic approach and mechanism of convergence among the departments.

Designing and testing of gender sensitive approaches in rice farming was undertaken in Sankilo village of Cuttack district, Odisha. From daily activity clock analysis during *kharif*, it was found that farm women worked for about 18 hours in the household and farm activities with only 6 hours rest period as compared to 7½ hours of rest by their male counterparts. The major problems faced by farm women in rice farming were health hazards (low back pain), storage problem of grains and seeds, threshing, winnowing and water scarcity.

It was found that majority of women were consulted in activities like varietal selection, irrigation, sale of produce and financial management, but rarely consulted in plant protection measures, fertilizer application, and buying of farm equipment but their suggestions were hardly accepted by their male counterparts.

Among the Odisha farmers, Pooja was rated to be the best performer and most popular rice variety, while in Jharkhand, it was hybrid rice followed by Abhishek; in case of Assam (bodoland territory), it was Ranjit; and in case of Chhattisgarh, the highest rated variety was IR-64.

The performance of CRRI varieties under on-station demonstration showed that both during *rabi* and *kharif* 2012-13, hybrid Rajalaxmi gave the highest yield of 7.3 t/ha and 7.2 t/ha, respectively.

As part of developing T-EDP module, Sakhigopal block of Puri district, Odisha was selected and business plan was developed. The gross profit was estimated to be Rs. 13,25,525 and after repayment, the retained surplus was found to be Rs. 8,84,992. The breakeven point was achieved after second year.

Data analysis for Tripura state revealed that varieties like Swarna, Pooja, Naveen, and NDR-97 have covered maximum area among the varieties grown by farmers. Similarly, data analysis for Chhattisgarh state revealed that CRRI varieties like Shatabdi, Tapaswani, Anjali and Annada were cultivated in the state.

Rice production data of West Bengal for the period 1960-61 to 2009-10 was analyzed using ARIMA models for forecasting and the forecasted rice production for the year 2019-20 was found to be 16,552 thousand tonnes.

State wise (18 states) cost of cultivation data on rice for the period 2006-07 to 2009-10 were collected and digitized.

Photo: Pritesh Sundar Roy

INTRODUCTION

CRRI was established by the Government of India in 1946 at Cuttack, as an aftermath of the great Bengal famine in 1943, for a consolidated approach to rice research in India. The administrative control of the Institute was subsequently transferred to the Indian Council of Agricultural Research (ICAR) in 1966. The Institute has two research stations, one at Hazaribag, in Jharkhand, and the other at Gerua, in Assam. The CRRI regional substation, Hazaribag was established to tackle the problems of rainfed uplands, and the CRRI regional substation, Gerua for problems in rainfed lowlands and flood-prone ecologies. Two Krishi Vigyan Kendras (KVK) also function under the CRRI, one at Santhapur in Cuttack district of Odisha and the other at Jainagar in Koderma district of Jharkhand. The research policies are guided by the recommendations of the Research Advisory Committee (RAC), Quinquennial Review Team (QRT) and the Institute Research Council (IRC). The CRRI also has an Institute Management Committee (IMC), for formulating administrative policies.

Mandate

The goal is to improve the income and quality of life of rice farmers in India.

The Mandate of the institute are:

- Conduct basic, applied and adaptive research on crop improvement and resource management for increasing and stabilizing rice productivity in different rice ecosystems with special emphasis on rainfed ecosystems and the related abiotic stresses.
- Generation of appropriate technology through applied research for increasing and sustaining productivity and income from rice and rice-based cropping/ farming systems in all the ecosystems in view of decline in per capita availability of land.
- Collection, evaluation, conservation and exchange of rice germplasm and distribution of improved plant materials to different national and regional research centres.
- Development of technology for integrated pest, disease and nutrient management for various farming situations.
- Characterization of rice environment in the country and evaluation of physical, biological, socio-economic and institutional constraints to rice production under different agro-ecological conditions and in farmers' situations and develop remedial measures for their amelioration.
- Maintain database on rice ecology, ecosystems, farming situations and comprehensive rice statistics for the country as a whole in relation to their potential productivity and profitability.
- Impart training to rice research workers, trainers and subject matter/extension specialists on improved rice production and rice-based cropping and farming systems.
- Collect and maintain information on all aspects of rice and rice-based cropping and farming systems in the country.

Thrust Areas

- Germplasm collection, characterization of genetic diversity and gene function assignment. Designing, developing and testing of new plant types, super rice and hybrid rice for enhanced yield potential.
- Identification and deployment of genes for nutrient deficiency, tolerance to submergence, drought, salinity and biotic stresses and productivity traits.
- Intensification of research on molecular host parasite/pathogen interaction to design suitable control strategy.
- Understanding the pest genomics for biotype evolution, off-season survival and ontogeny for integration into a control strategy.
- Developing nutritionally enhanced rice varieties with increased content of pro-vitamin A, vitamin E, iron, zinc and protein.
- Improvement of short-grain aromatic rice and organic management of aerobic rice.

Research Achievements

Released a total of 100 rice varieties including three hybrids for cultivation in upland, irrigated, rainfed lowland, medium-deep waterlogged, deepwater and coastal saline ecosystems. In addition, seven varieties have been identified for release in different states.

Developed interspecific hybrid derivatives including *O. sativa* and *O. longistaminata* with tolerance to bacterial leaf blight (BLB).

Maintains more than 30,000 accessions of rice germplasm including nearly 6,000 accessions of Assam Rice Collection (ARC) and 5,000 accessions from Odisha. Compiled Passport information on more than 30,000 germplasm.

Used RFLP/RAPD and other DNA markers for genetic analysis of bacterial blight, blast and gall midge resistance.

Used marker-assisted selection for pyramiding BLB resistance genes and for developing BLB-resistant rice cultivars.

Developed a rice-based farming system including rice-fish farming system integrating multiple enterprise initiatives with a rationale for ensuring food and nutritional security, stable income and employment generation for rural farm family.

Knowledge-based N management strategy for increasing N-use efficiency for rainfed lowlands including use of integrated N management involving use of both organic and inorganic sources of N-fertilizer. Developed several agricultural implements such as manual seed drill, pre-germinated drum seeder, multicrop bullock and tractor drawn seed drill, flat disc harrow, finger weeder, conostar weeder, rice husk stove, mini parboiler and power thresher with the sole aim of reducing both drudgery and cost of rice cultivation.

Evaluated, developed and tested several plant products with pesticide potential against field and storage insects and pathogens.

Identified biochemical and biophysical parameters for submergence and other abiotic stress tolerance in rice.

Developed crop modelling of G x E interaction studies that showed that simulation of crop growth under various environments could be realistic under both irrigated and favourable lowlands situations.

Developed suitable rice production technologies for rainfed uplands, lowlands and irrigated ecosystem including production technologies for hybrid rice and scented rice that were field tested and transferred to farmers.

Evaluated and popularized CRRI varieties through frontline demonstrations (FLD) in farmers' fields.

Provided farmers' advisory service through regular radio talks and TV telecasts on rice production technologies.

Developed 15 training modules for farmers and extension workers.

Imparted short-term and long-term training for personnel from the State Departments of Agriculture, State Agricultural Universities (SAU) and other educational institutions.

Imparted advance training and research leading to Masters (M.Sc.) and Doctoral degrees (Ph.D.).

Linkages

The CRRI has linkages with several national and international organizations such as the Council for Scientific and Industrial Research (CSIR), Indian Space Research Organization (ISRO), SAUs, State Departments of Agriculture, NGOs, Banking (NABARD), and the institutes of the Consultative Group for International Agricultural Research (CGIAR), such as the International Rice Research Institute (IRRI), Philippines and International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India.

Location

The Institute is located at Cuttack about 35 km from Bhubaneswar airport and 7 km from the Cuttack railway station on the Cuttack-Paradeep State Highway. The institute lies approximately between 85°55′48" E to 85°56′48" E longitudes and 20°26′35" N to 20° 27′ 20" N latitudes with the general elevation of the farm being 24 m above the MSL. The annual rainfall at Cuttack is 1,200 mm to 1,500 mm, received mostly during June to October (*kharif* or wet season) from the southwest monsoon. Minimal rainfall is received from November to May (*rabi* or dry season).

GENETIC IMPROVEMENT OF RICE

Exploration, Characterization and Conservation of Rice Genetic Resources

Collection of wild species and weedy rice from Assam

An exploration for collection of wild and weedy rice was made in four districts of Assam, namely Sonitpur, Karbi Anglong, North Lakhimpur and Jorhat in collaboration with NBPGR Regional Station, Thrissur. During the survey, entire Brahmaputra valley of both Upper and Lower Assam were covered and 40 accessions of wild (mostly *Oryza rufipogon)* and their introgressed lines (weedy rice) were collected. Kakao bao, a fully long awned traditional deepwater rice was also collected as it was cultivated along the Brahmaputra valleys as a preferred glutinous variety for its valued red kernel and good cooking quality. Some of the naturally introgressed lines (the *spontaneas)* were also collected. The typical *O. rufipogon* grows luxuriantly along the shallow water bodies of perennial water source with underground rhizomatous stubbles and radical leaves which form a mat on the ground in undisturbed fallow lowland with uneven maturity of its lax panicles. The introgressed lines have long fully awned, robust panicle with highly shattering grains and weak rooting at nodes. *O. rufipogon* is locally called as 'Bonaria or Uri Dhol Ghas'. They grow in ponds/dams/canals as pure stand and are also found in the cultivated fields as weedy introgressed lines, the *O. spontaneas.* The tribals collect these mixed introgressed rices from knee-deep water in undisturbed perennial water bodies. Wild rice is not found in Karbi Anglong district possibly because of high altitude (>90 to 200 mt.), less annual rainfall (<1000 mm) and non-availability of deep water bao rice growing areas.

Collection of wild rice from Jharkhand

Exploration and collection of wild rice germplasm was undertaken from Lohardaga, Latehar, Palamu and Garhwa districts of Jharkhand in collaboration with

Collection of weedy rice in Sonitpur district, Assam

A complete plant of Oryza rufipogon Brahmaputra valley Assam

NBPGR base centre, Cuttack. A total of 34 accessions comprising *O. rufipogon* (23) and *O. nivara* (11) were collected from 29 sites covering 23 blocks. The district wise collections include 6 accessions from Lohardaga, 7 accessions from Latehar, 11 accessions from Palamu and 10 accessions from Garhwa (6 blocks). It was observed that wild rice was not available beyond the altitude of 400 msl. Occurrence of *O. nivara* and *O. rufipogon* was frequent in Palamu and Garhwa districts compared to Lohardaga and Latehar districts where they were observed rarely.

O. nivara is commonly grown in swampy areas/ margin of rice fields. The height of the plant is less than 90cm.The panicles are partially enclosed, compact. The grain shatters before maturity. The panicles are similar with cultivated rice except awn. *O. nivara* flowers earlier than *O. rufipogon*. *O. rufipogon* usually grows in margin of ponds. The height is more than 150cm. The panicles are lax and much exerted. Awns are longer than *O. nivara*. Natural introgression occurs between *O. nivara* and cultivated rice (*O. sativa*) and the introgressed lines are similar with cultivated rice having awn. These lines are very common in cultivated rice fields.

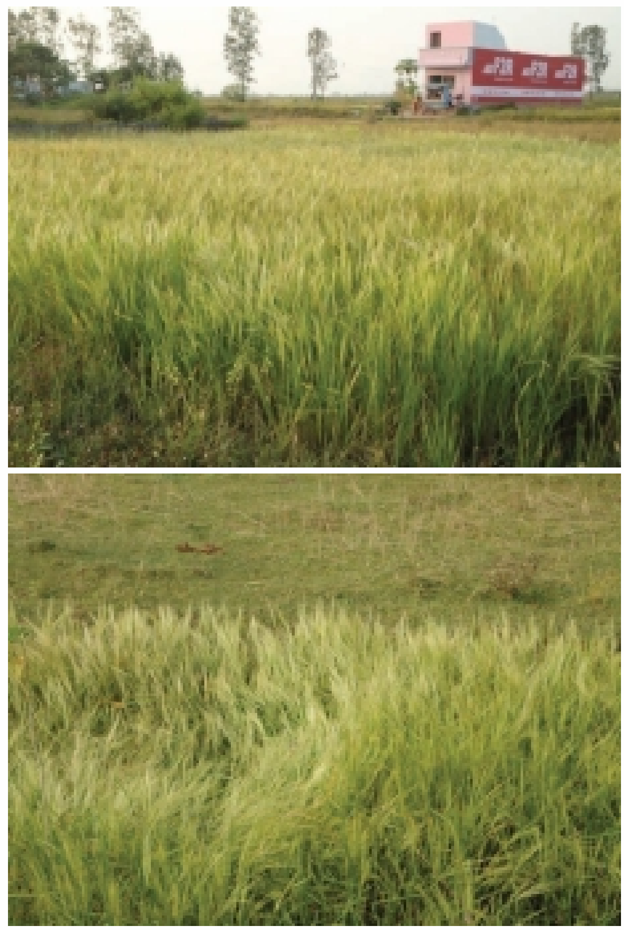
Collection of extra-early duration varieties and weedy rice from Odisha

An exploration and collection of rice germplasm of extra-early duration (60-90 days) commonly known as 'Biali dhan' was conducted from the north and central part of Odisha. During the survey, the districts of Puri, Jajpur, Cuttack, Bhadrak, Balasore, Dhenkanal, Angul, Jagatsinghpur, Kendrapara and Nayagarh were covered and a total of 18 accessions of cultivated rice and 114 accessions of wild and weedy rice were collected. Among the prominent landraces collected are Nandi Keri, Sathika, Kalakeri, Dhalashree and Brahmanei. These are cultivated in upland having very early maturing duration. Farmers broadcast the seeds in mid June, then ladder the field 6 to 9 days after germination and again after 20 days they do the beushening. The crop is harvested by end of August or 1st week of September.

Some of the naturally introgressed lines with *O. nivara* and *O. rufipogon* (the *spontaneas*) were also collected. The spontaneas collected from upland fields grown with early duration varieties (Biali dhan) are with black coloured grains, whereas the introgressed lines collected from long duration cultivar (Sharad dhan) fields had red husk and red awns. People call *O. rufipogon* in local language as 'Bandha balunga' which usually grows in ponds/dams/canals as pure stand and 'Bila balunga' to those which are found in the cultivated fields as weedy introgressed lines, the *spontaneas*.

Collection of known landraces for submergence tolerance from coastal Odisha

An exploration and collection programme was undertaken in collaboration with NBPGR to collect

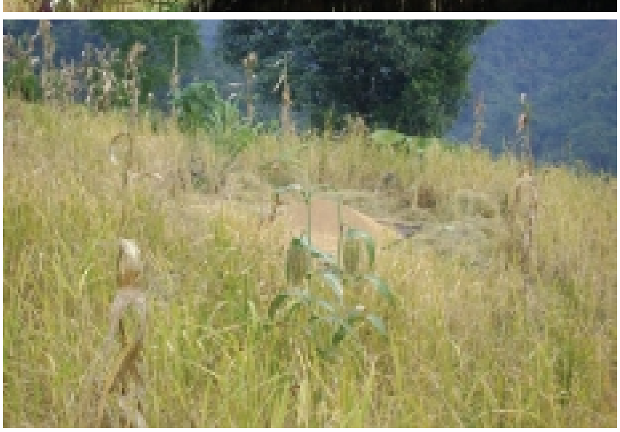


Occurrence of weedy rice in farmers' field

germplasm from flood prone areas of Odisha. A total of 125 accessions were collected from 52 sites covering 22 blocks in 7 districts of Odisha. The district wise collections made include Cuttack-17, Kendarpara-19, Jagatsinghpur-4, Jajpur-13, Balasore-30, Nayagarh-9 and Puri-33. The known flood and submergence tolerant landraces collected are Balia Dadha, Kakudimanji, Champa, Bhutia, Bankoi, Gudmatia, Putia Ajana, Mugudi, Champeisali, Khoda, Kakharua, Agnikumari, Ayurman, Bagada Champa, Baikoili, Bangalaxmi, Bhundi, Bhuta, Dhalaputia, Dhoba Kakiri, Durga Khoda, Gouri, Janglijhata, Kalaputia, Khajara, Laxmisar, Madankathia, Mugei, Mundakoya, Nalimedhi, Nalipateni, Pahada bhanga, Rabana, Rahaspanjar, Rajballav, Ranjei, Samuli and Udasiali. Farmers informed that the crops raised with these varieties can usually withstand submergence for 1 -3 weeks even under turbid flood water.

Collection of hill rice germplasm from Arunachal Pradesh

A joint exploration was undertaken with NBPGR Regional Station, Shillong for collection of hill rice germplasm from East Kameng, Papum Pare and Kurung Kumey districts of Arunachal Pradesh. The explored region was hilly to mountainous and the altitude of the collection sites was ranging between 135 to 1425 m above mean sea level. The farmers practice *jhum* cultivation and grow rice on steep hill slopes by cutting and burning the forests. Hill rice is usually sown during second week of April and harvested during first to second week of October. The farmers usually grow two/three different types of rice in the same field and they harvest it as mixture. Both white and red kernel rice genotypes were collected. A few rice accessions such as Taba, Kilung and Serpung were popular among the farmers in all the districts. Sixty eight hill rice germplasm grown in *jhum* lands were collected from the villages of three districts (East Kameng 38; Papum Pare 12; Kurung Kumey 18 and Lower Subansiri 1).

An overview of jhum rice cultivation

Harvesting of panicles by hand from an intentionally grown rice admixtures

Characterization of the germplasm for agro-morphological traits and molecular aspects

A set of five hundred released varieties acquired from different states of India were grown in the field during *kharif* season for morpho-agronomical characterization. Among the quantitative characters recorded, the leaf length varied from 24.8 cm (VL221) to 69.0 cm (Sonamani) and leaf width from 0.7 cm (Kharavela) to 2.0 cm (Varshadhan). The plant height varied from 60 cm (VL221) to 172.4 cm (Sudha). Days to fifty per cent flowering varied from 56 (Kalyani-2) to 140 (Bhagirathi). Long Panicles (>30 cm) were observed in Nuadhusara, Sonamani, Haryana Basmati, Basmati 370, Rambha, Pantdhan-4, Basmati 564 and Nuakalajeera. High panicle weight (>5 g) was recorded in Matangini, Golak, Jogen, Purnendu, Uphar, Pusasugandh-5, Mahalaxmi, Mandakini and Dandi. High grain number/panicle (>250) was recorded in Kanchan, Rajendra Mahsuri, Mahanadi, MTU1075, Nuadhusara, Luna sampad and MTU 1071. Thousand grain weight was recorded highest in Bhalum-2 (35.5g) and lowest in RTN-5 (9.5 g). Grain length varied from 6.3 mm (Kasturi) to 11.6 mm (Pusabasmati-1121).

A set of 2045 accessions of CRRI rice germplasm of primitive and native collections were grown, multiplied and characterized. They were regenerated for seed increase as well as for periodic replacement in gene bank. The morpho-agronomical characterization data

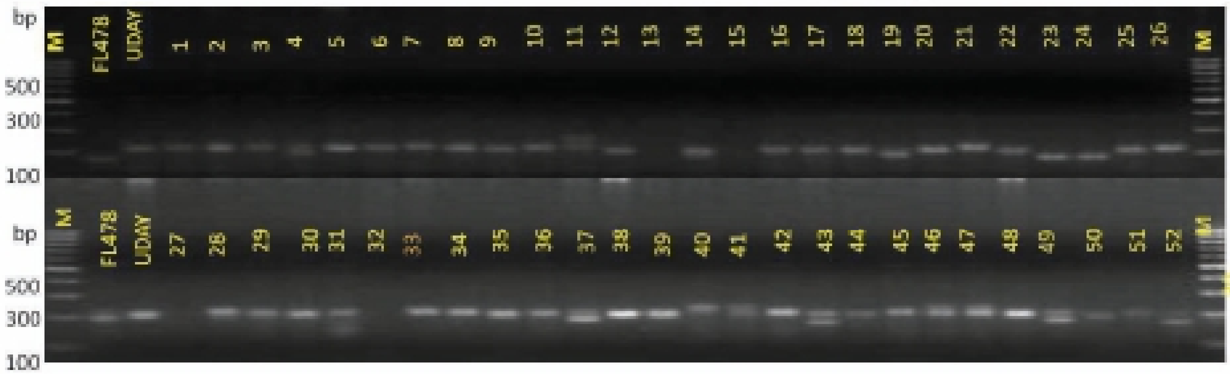


Fig 1. Agarose gel showing screening of Saltol gene using linked marker (RM8094) in 49 germplasm lines along with three salt tolerant varieties. M: 100 bp DNA ladder marker; Lane1-49: rice germplasm lines collected from saline areas; 50: Luna Sampad, 51: Luna Suvarna, 52: Sonamani

as per the descriptors were recorded and a systematic database was created.

Assessment of genetic diversity in 49 rice germplasm collected from the Sunderbans along with four CRRI released saline tolerant varieties were completed using STMS markers (Fig 1). Out of three markers, two markers, RM8094 and RM3412 showed polymorphism.

Conservation of rice germplasm and supply to researchers

Five thousand one hundred accessions of rice germplasm are being conserved in three layer aluminum pouches in Gene Bank of the Institute. Two thousand five hundred twenty five accessions of rice germplasm were supplied to different institutes/organizations and researchers for their utilization.

Establishment of national rice resource database

A set of 3055 accessions of national rice germplasm received from NBPGR were multiplied and characterized during *kharif* 2012. Fresh seeds were harvested, processed and deposited back at NBPGR after regeneration and recording of morpho-agronomical characterization data as per the descriptor.

Maintenance Breeding and Seed Quality Enhancement

Panicle progeny rows of 24 varieties were grown and evaluated in the field as well as laboratory for maintenance breeding during the year (Table 1). A large number of progenies were selected for consideration as nucleus seed for the purpose of breeder seed production (Table 2).

A total of 651.35 quintals of breeder seed was produced comprising of 25 varieties during the year.

Table 1. Panicle progeny rows evaluated and selected for nucleus seed

Variety name	Panicle progenies evaluated	No. of progeny lines selected
Annada	400	356
Ratna	450	302
Kshitish	400	351
Shatabdi	400	364
Geetanjali	350	259
Naveen	450	362
CR Dhan 10	450	358
CR Boro Dhan 2	300	264
CR 1009 (Savitri)	400	369
CR 1018 (Gayatri)	400	364
Pooja	450	408
Swarna sub-1	450	401
Sarala	400	335
Moti	300	256
CR Sugandhdhan 3	300	243
Lunishree	250	218
Utkal Prabha	250	209
Luna Sampad	250	213
Luna Suvarna	250	221
Ketekijoha	400	248
Padmini	250	231
Phalguni	400	385
Reeta	250	216
Nua Chinikamini	250	207

Table 2. Breeder seed production of rice varieties

Variety name	Production during *rabi* 2011-12 (q)	Production during *kharif* 2012	Total production (q)
Annada	8.90	–	8.90
Ratna	11.50	–	11.50
Kshitish	17.30	–	17.30
Shatabdi	31.70	–	31.70
Geetanjali	–	1.50	1.50
Naveen	26.30	–	26.30
CR Dhan 10	7.40	6.00	13.40
CR Boro Dhan 2	12.60	–	12.60
CR 1009 (Savitri)	–	33.00	33.00
CR 1018 (Gayatri)	–	19.00	19.00
CR 1017 (Dharitri)	–	6.60	6.60
Pooja	–	158.70	158.70
Swarna-Sub1	–	230.00	230.00
Sarala	–	37.50	37.50
Moti	–	4.80	4.80
Lunishree	–	6.30	6.30
Utkal Prabha	–	5.10	5.10
Luna Sampad	1.00	3.20	4.20
Luna Suvarna	1.20	1.85	3.05
Keteki joha	–	8.70	8.70
Padmini	–	2.80	2.80
Reeta	–	4.20	4.20
Nua	–	1.20	1.20
Chinikamini CR Dhan 70	–	3.00	3.00
Grand Total (in quintals)			651.35

Utilization of new alleles for primary and secondary gene pool of rice

Sixty collections of AA genome wild species are being maintained and conserved as field gene bank in the net house for their true identity, out of which 17 are *O. nivara*, 20 are *O. rufipogon* and rest are *O. sativa* f. *spontanea* type. Apart from these, two drought tolerant accessions of *O. nivara* (AC100476 and AC100374) and one accession of *O. brachyantha* (AC1086) are being maintained. In an attempt to transfer yellow stem borer (YSB) resistance gene from wild source i.e. *O. brachyantha*, about six thousand five hundred fifty pollinations were effected with pollen of recurrent parent *O. sativa* var. Savitri and 11 BC_2F_1 embryos were inoculated successfully in ¼ MS medium. The crossability ranged from 0.33-0.49. Five new BC_2F_1 of *O. sativa* var. Savitri/*O. brachyantha* were generated and are being grown for further evaluation against YSB. All together 16 BC_2F_3 and 30 new BC_2F_2 populations were screened against YSB at vegetative and reproductive stages under artificial condition. The fertile backcross derivatives (disomic) of *O. sativa* var. Savitri/*O. brachyantha* were grown in the field for further selection and evaluation for different traits like high tillering, hardy stem, purple base (leaf sheath), erect leaves and narrow to wider leaves. Seven hybrids of BC_2F_1 of *sativa/brachyantha* were identified based on chromosome number, rolled leaf (8), twisted leaf (5), pseudo-normal (11), profuse tillering (6), narrow leaf (7) and dwarf type (2). Two pre-breeding lines of Savitri/*brachyantha*//Savitri derivatives were used as donor for broad and erect leaf with large panicle. New F_1s were generated using BPH resistant accessions of *O. rufipogon* (AC100174 and AC100444) after initial screening. New F_1s were generated using CR-1009 and Swarna as female parent and *O. nivara* (AC100476, AC100374) as drought tolerant donor male parent. These F_1s were grown in the net house and data were recorded.

Molecular diversity of twenty six accessions of *O. rufipogon* and *O. nivara* was studied using 54 SSR markers. There were 165 bands out of which 135 were polymorphic (81.8%).

The dendrogram segregated the 26 accessions and four released varieties into two distinct groups, and all of them were distributed between 30 units, thus proving their suitability for diversity analysis (Fig 2). There were two major groups, 29 accessions in one and only one in a separate group. The major group was further discriminated into several minor, sub-minor, mini, sub-minis, micro and sub-micro clusters showing existence of large genetic diversity among them. Only one accession of *O. nivara* collected from Midnapore (West Bengal) showed 12% genetic similarity. It was also observed that *O. nivara* collected from Puri and *O. nivara* collected from Khurdha were most closely related showing 78% similarity.

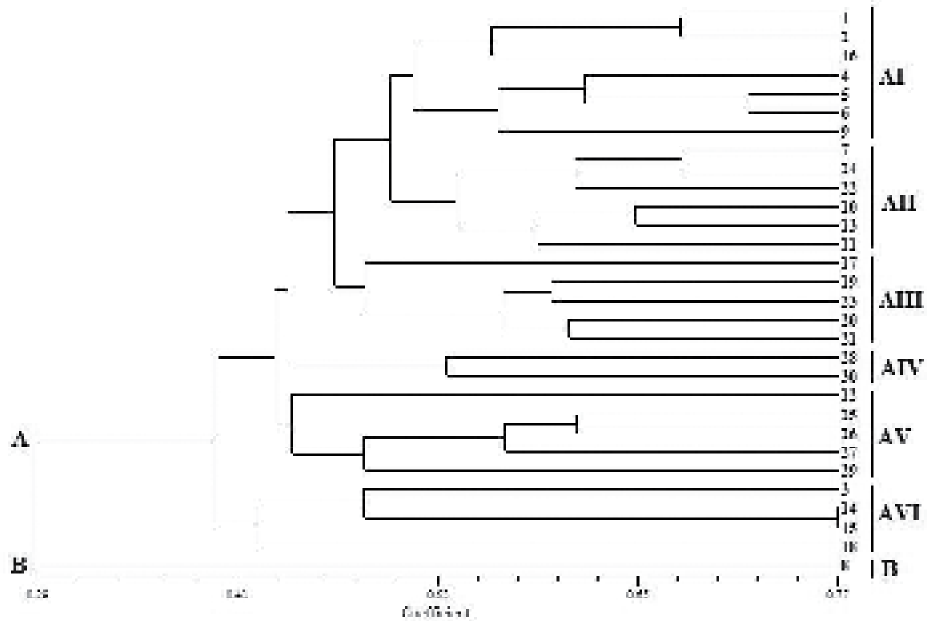


Fig 2. Dendrogram constructed based on 54 STMS markers

Hybrid Rice for Different Ecologies

Development and evaluation of test cross/ backcross hybrids

Four hundred and thirty test crosses involving eight CMS lines were grown in TCN for evaluation during *rabi* and *kharif* 2012 and 35 heterotic combinations with >80% spikelet fertility were identified besides 45 promising sterile combinations. Around 200 new test crosses were made and evaluated in *rabi* 2013. Test crosses for some of the fertile combinations with high spikelet fertility and good yield potential were repeated, and flowering behavior of the parental lines for synchronization were studied.

Maintenance, evaluation and multiplication of CMS lines

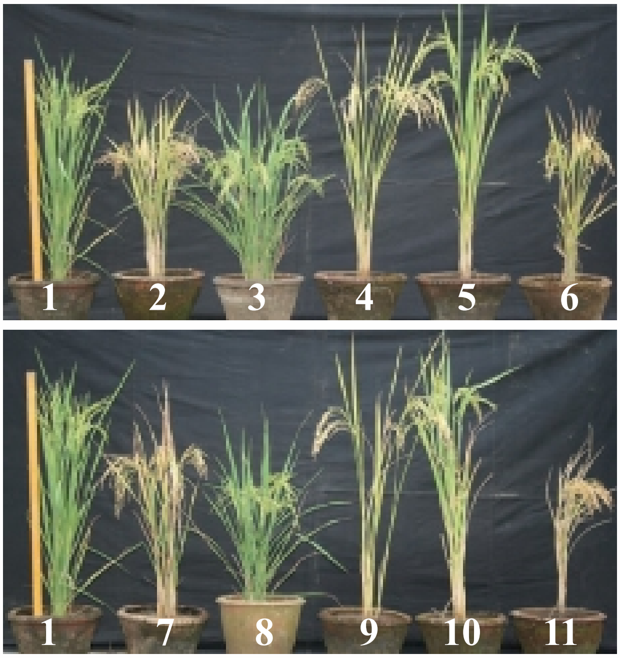
Twelve CMS lines including six CRRI bred CMS lines were evaluated for agro-morphological and floral characteristics during *rabi* and *kharif* 2012, and were maintained through manual hand crossing. CRMS 31A and CRMS32A were multiplied in larger quantity during both the seasons of 2012 (> 300 kg seeds of each). Six CMS lines were taken up for small scale multiplication for further utilization in *rabi* and *kharif* 2013. Short duration backcrosses of Virendra, Shatabdi and Sahbhagidhan were multiplied in small scale field production. Evaluation of stigma receptivity of eight CMS lines was conducted during two consecutive seasons.

Transfer of characters into CMS lines

During *kharif* 2012, introgression of *saltol* and *sub1* genes into four BB resistant gene pyramided maintainers (CRMS31B and CRMS32B) was advanced to BC_3F_1 (for *saltol*) and BC_2F_1 (for *sub1*) backcross generations. Intermating between BC_3F_1-*saltol* and BC_2F_1- *sub1* was done during *kharif* 2012 to combine both genes into same genetic background. Pyramiding of four BB resistant genes in restorers, IR42266-29-3R and CRL22R were advanced to BC_3F_1 and BC_1F_1 generations, respectively. Test crosses and backcrosses of CRMS31B and 32B (4 gene pyramids for BB as recurrent parents) with the respective CMS lines were advanced. Conversion of partial restorers Gayatri and Mahalaxmi into complete restorers was advanced to BC_1F_1 generation.

Status of back crossing to develop new CMS lines

One hundred and twenty backcrosses were advanced including 35 new backcrosses involving long duration, short duration, drought tolerant and 4 BB resistant gene pyramids of CRMS31B and CRMS32B.



Variaability for plant height and duration in double haploid recombinants

CRMS31B x CRMS24B

1 - CRMS24B parent
2 - Short ht., medium duration
3 - Short ht., long duration
4 - Tall, medium duration
5 - Tall, long duration
6 - CRMS31B parent

CRMS32B x CRMS24B

1 - CRMS24B parent
2 - Short ht., medium duration
3 - Short ht., long duration
4 - Tall medium duration
5 - Tall long duration
6 - CRMS32B prent

A few long duration short statured plants were selected from anther culture derived plants of the cross combinations, CRMS31B/CRMS24B and CRMS32B/CRMS24B and test crosses were made to develop promising CMS lines in the late duration. All were evaluated in test cross nursery for sterility; six promising sterile test crosses were advanced to BC_1F_1 during *rabi* 2013. Some of the promising lines with stable male sterility, out crossing, good floret opening, panicle and stigma exsertion were identified (Table 3).

Seed production of hybrids

Hybrid seeds of 14 combinations were produced including the three released hybrids during *kharif* and *rabi* 2012 (total>400 kg seed). Flowering behavior and synchronization of nine long duration hybrid combinations was studied during *kharif* and *rabi* 2012. Production of nine hybrid combinations was taken up during *rabi* 2013. Hybrid seed production in farmer's fields in collaboration with a private seed company was taken up near Bhubaneswar in an area of 50 acres to demonstrate the feasibility of hybrid seed production in Odisha.

Restorer and maintainer breeding

About 1550 single plant progenies from both population improvement and recombination breeding (52 crosses) were grown in pedigree nursery and 60

Table 3. Promising sterile backcross derived lines advanced during 2012

BCN No.	Recurrent parent	Remarks
BCN^{6}12A	HR26-73	Medium duration
BCN^{6}17A	HR34-7	Medium duration
BCN^{6}39A	CR2234-75	Medium duration
BCN^{5}52A	PS 92B (69) (Kalinga)	Purple leaf
BCN^{5}71A	CRMP 2-1-614 (79)	Medium duration
BCN^{5}166A	Shatabdi	Short duration
BCN^{5}206A	Abhishek	Short duration, drought tolerant
BCN^{5}199A	CR2234-1020 (WA)	Good floret opening
BCN^{5}200A	CR2234-1020 (Kalinga)	Good floret opening
BCN^{3}99A	A-180-12-1(87)	Short duration, drought tolerant
BCN^{5}187A	Sahabhagidhan	Short duration, drought tolerant
BCN^{5}180A	CR 2234-834 (WA)	Good floret opening and stigma exsertion
BCN^{1}212A	31B-GP-39	31B Gene pyramid with 4 BLB genes
BCN^{1}213A	32B-GP- 62	32B Gene pyra mid with 4 BLB genes

desirable lines were used in crossing programme. Three maintainer and two medium duration restorer populations were grown in *rabi*, three maintainer, and four restorer populations were grown in *kharif* 2012. Random mating cycles were constituted for *rabi* 2013. Nine new F_1 combinations between promising 'R' lines were grown and their F_2 population was raised, and selections were made during *kharif* 2012.

Evaluation of Hybrids

National hybrid rice trial-MLT of hybrids

The MLT of released hybrids was conducted during *kharif* 2012 to identify suitable hybrids in mid-late duration. A total of 21 test entries including three checks (one hybrid and two varieties) were evaluated. In this trial, Rajalaxmi recorded highest yield in the medium group and CRHR-32 was the top yielder in mid-late group.

Evaluation of rice hybrids/varieties of private companies

During *kharif* 2012, a trial was conducted to evaluate the hybrids/ varieties of private companies along with the CRRI bred hybrids. A total of 14 test entries including four checks (three hybrids and one variety) were evaluated. Among all the entries tested, CR Dhan 701 recorded the highest yield (Table 4).

Screening of NPTs, breeding lines and INGER lines for the presence of *Rf3* and *Rf4* genes

Seventy upland, 30 NPT, 31 INGER entries and 86 Mahalaxmi and Gayatri derivatives were screened for the presence of *Rf4* and *Rf3*. None of the upland cultures, five NPTs, 39 Mahalaxmi and Gayatri derivatives and two lines from INGER materials were positive for both the genes.

Identification of mitochondrial specific markers for distinguishing CMS and maintainer lines

Two co-dominant and one dominant mitochondrial based marker have been developed to distinguish CRMS31A and CRMS32A and their maintainer lines.

Identification of polymorphic markers for distinction of CRRI bred hybrid varieties

A total of 80 STMS markers were screened for the differentiation of CRRI bred hybrid rice varieties and their parents, from which eight markers (RM490, RM163, RM302, RM480, RM481, RM71, RM206 and RM1233) showed polymorphism between the parents

Table 4. Evaluation of rice hybrids/varieties of private companies

Entry Name	DFF	Plant height (cm)	Spi Fert. (%)	EBT/ m^2	Grain yield (kg/plot)	Grain yield (t/ha)	Grain type	Purity score (UNI)	DIS	INS	
									BB	SR	LF
Arize prima	106	116.9	79.2	294.15	9.92	6.40	MS	1	0	0	0
BS6444G	108	117.4	75.01	296.3	10.09	6.78	MS	1	0	0	1
RH1531	96	115.5	80.1	295.2	10.07	6.76	LS	1	0	1	1
RH10422	96	112.9	68.03	276.3	9.99	6.71	LS	2	1	5	0
RH10428	100	117.3	72.05	282.9	10.27	6.90	LS	2	1	5	0
Lal Basmati	120	120.4	81.6	301.8	7.22	4.85	LS	2	5	0	1
Kudrat -2	96	116.3	72.6	259.7	6.48	4.35	LS	1	0	0	0
Kudrat-3	106	108.6	77.7	329.6	7.78	5.22	LS	2	0	0	1
Kudrat-4	114	119.4	80.8	261.9	7.48	5.00	MS	2	0	0	1
Naveen	98	114.9	81.1	342.9	7.41	4.97	MS	1	5	0	1
RH664 plus	100	120.8	73.7	270.8	10.18	6.84	LS	1	1	0	0
Ajay	104	114.8	82.1	285.2	10.78	7.25	LS	1	1	0	0
Rajalaxmi	104	115.0	81.6	320.7	10.6	7.12	LS	1	1	0	1
CRDhan-701	116	120.2	83.1	299.6	10.93	7.35	MS	1	0	0	0
CD ($P < 0.05$)						1.16					
CV%						16.96					

of Ajay and Rajalaxmi. However, polymorphism between the parents of CRHR32 was observed with five STMS markers (RM490, RM163, RM302, RM480 and RM481).

Development of High Yielding Genotypes for Rainfed Shallow Lowland

Creation of variability through hybridization and backcrossing, selection, and evaluation of new and existing segregating materials suitable for rainfed shallow lowland

A crossing programme was taken up to develop high yielding variety possessing submergence and drought tolerance to make it climate resilient for rainfed lowland ecosystem. Five tropical *japonica* derivatives possessing heavy panicle, strong culm, thick and long top leaves were chosen as donor parents with yield traits and the other genotypes like Savitri-Sub1, NDR359 and Ranjit as superior varieties. Fifteen F_1s were generated for next year hybridization combining submergence/drought tolerance (Table 5). From earlier cross combinations, 250 promising single plants from 25 populations of F_2 generations were selected and kept separately for raising F_3 generation. Sixty promising single plants from F_5 lines were selected and advanced to F_6 generation. Eighty five promising lines were bulked for initial yield evaluation.

MABC breeding for incorporation of abiotic (submergence and drought) and biotic (BB) tolerance/ resistance into popular shallow lowland varieties

In the popular shallow lowland varieties Savitri and Ranjit, submergence and bacterial blight disease tolerance were targeted through marker assisted backcrossing approach. Hybridization was completed for Savitri-Sub1 with Swarna BB pyramided line and Ranjit with Swarna-Sub1 and F_1 seeds were collected for *kharif* season hybridization for combining a third donor into the F_1 parent.

Development of doubled haploid lines from derivatives of tropical *japonica*/elite *indica* crosses for shallow lowlands

Doubled haploid of the TJ derivatives/Savitri-Sub1//MTU1010, TJ derivatives/Savitri-Sub1//Tapaswini pyramided line and TJ derivatives/CR 3299-11-1//Lalat pyramided line cross combinations were targeted to combine the desirable features of the three parental combinations. Three F_1s have been generated using the first two parents and the third parent will be combined in the next *kharif* season through anther culture approach.

Male sterility facilitated recurrent selection for improvement of biotic (BB, stem borer and leaf folder) and abiotic (submergence and drought) stress tolerance

Different donors were used for incorporation of various traits to the recipient genetic male sterile line. The donors for different traits were BB resistance, stem borer resistance, leaf folder resistance, submergence tolerance, yield under drought and high yield from new plant type rice. Resistance and high yield trait have been incorporated from the donor sources *viz.*, bacterial blight from CRMAS 2232-85, stem borer from Nalihazara, leaf folder from Nadiaphula, submergence from Swarna-Sub1, drought Qtls from IR64 NIL lines and yield gene from two new plant type lines. The F_1 seeds from male sterile lines have been harvested for generation advancement during next *kharif* season.

Table 5. F_1s generated for hybridization combining submergence/drought tolerance

CR2683-45-1-2/Savitri sub1	CR2687-2-3-5-2-1/ Ranjit
CR2683-28-12-1-4/Savitri sub1	CR2683-15-5-2-1/ Ranjit
CR2687-2-3-5-2-1/Savitri sub1	CR2682-2-3-1-1-1/NDR359
CR2682-2-3-1-1-1/Savitri sub1	CR2683-15-5-2-1/NDR 359
CR2678-5-3-2-1-1/Savitri sub1	CR2683-7-2-3-1-1/NDR 359
CR2683-15-5-2-1)/Ranjit	CR2683-28-12-1-4/ NDR359
CR2683-45-1-2/ Ranjit	CR2687-2-3-5-2-1/ NDR359
CR2683-28-12-1-4/ Ranjit	

Development of mapping population, phenotyping, genotyping and mapping genes/ QTLs for reproductive stage drought tolerance

The mapping population for reproductive stage drought tolerance has been advanced to F_6 generation. Four hundred recombinant inbred lines of the cross CR143-2-2/Krishnahamsa was advanced to F_6 generation during *kharif* season. Each line was found to be almost uniform.

Trials under All India Coordinated Rice Improvement Programme (AICRIP)

Initial variety trial for rainfed shallow lowland was conducted with 61 test entries generated at different breeding centers of the country and three check varieties. The experimental mean yield was 4.87 t/ha with 124 days to flowering and 281 panicles/m^2. Highest grain yield of 6.48 t/ha was recorded from IET23159 followed by 6.29 t/ha and 6.19 t/ha from IET23168 and IET23148, respectively.

Initial variety trial for deepwater rice was conducted with 34 test entries generated at different deepwater breeding centers of the country and three check varieties. The experimental mean yield was 3.81 t/ha with 143 average days to flowering and 199 panicles/ m^2. Highest grain yield of 5.25 t/ha was recorded from IET22993 followed by 5.23 t/ha and 5.01 t/ha from IET22986 and IET22991, respectively.

Trials under international network for genetic evaluation of rice (INGER)

International rainfed lowland observational nursery (IRLON)

The 35th International rainfed lowland observational nursery comprised of 102 entries including the check varieties which were grown for assessment of the entries based on flowering duration, overall phenotypic acceptability, grain yield and submergence tolerance. Top five entries identified after evaluation were IR10L151, B11586F-MR-11-2-2-11, IR10L325, CT21423-17P-2P-1SR-2 and IR10L357.

Green super rice for rainfed lowland yield trial (GSR-RFLL)

The GSR-RFLL trial was conducted during *kharif* 2012 to evaluate the promising GSR for Cuttack situation. The best entries observed were WANXIAN 7777, SAGC-05, HHZ5-SAL 10-DT1, HUA 564 and HHZ17-DT 6-SAL.

Promising genotype identified for release

CR2459-12-8 (IET 21974) developed through hybridization from Swarna/IR64 was recommended by Variety Identification Committee (VIC) for central release for the states of Odisha and West Bengal for the rainfed shallow lowland. It has total duration of 150 days, long bold grain, plant height of 102 cm, head rice recovery (HRR) of 63.6 %, amylose content 23.5%, test weight of 22.8 g, average grain yield capacity of 5.2 t/ha.

Standing crop and grains of CR 2459-12-8

Development of Improved Genotypes for Semi-deep and Deepwater Ecosystems

Identification of new sources of submergence tolerance

Two new crosses *viz.*, IR42/AC 20431 and IR42/IC 258990 were made using IR42 as recurrent parent and IC258990 and AC20431B as donors having three weeks of submergence tolerance during *kharif* 2012.

Selection and generation advancement of available breeding material suitable for semi-deepwater situations

One thousand single plant progenies (F_3-F_6) from 131 cross combinations along with 3 F_2 bulks were grown under semi-deepwater conditions (Table 6). At the time of maturity, 848 single plant selections were made from 93 cross combinations on the basis of tolerance to water logging, photo sensitivity, plant height, field tolerance to bacterial blight, stem borer and other plant and panicle characters during *kharif* 2012. Thirty two uniform progenies were bulk harvested to

Table 6. List of breeding materials grown and selections made during *kharif* 2012

Generation	Progenies/ bulks grown	SPS	Bulks selected
F_2	3 (bulks)	186 (3)*	
F_3	138(20)	79(18)	
F_4	416(58)	272(46)	
F_5	375(43)	305(15)	
F_6	71(10)	6(1)	32(7)
Total	1000 (131)	848 (93)	32(7)

**No. in parentheses indicate no. of crosses*

evaluate their yield performance in the next season.

Selection and generation advancement of available breeding material suitable for deepwater areas

During *kharif* 2012, three hundred and twenty single plant progenies (F_4-F_6) were grown. At the time of maturity 181 single plant selections were made from 34 cross combinations on the basis of moderate elongation ability, good kneeing ability, high panicle and grain number, photo sensitiveness, plant height, field tolerance to bacterial blight disease, stem borer and leaf folder attack. Besides these selections, 25 uniform lines were bulk harvested to record their yield performance in the next season.

Evaluation of available advance breeding lines for yield and other traits under semi-deep and deep water conditions

Evaluation of advance breeding lines under semi-deepwater conditions (station trial) at CRRI, Cuttack

Forty five advanced breeding lines were evaluated in a 7x7 simple lattice design with two replications along with four checks (Sabita, Purnendu, Varshadhan and Dinesh) under semi-deepwater conditions during *kharif* 2012 at CRRI, Cuttack. Among the different entries, CR3008-B-6-7-1-1 performed the best with an average yield of 5.51 t/ha followed by CR2432-B-13-1-1-1-1 (5.11 t/ha) and CR2518-B-B-2-1-1-1 (4.62 t/ha) against the best check Varshadhan (4.12 t/ha) (Table 7.)

Evaluation of promising genotypes under semi deepwater conditions at RRLRRS, Gerua, Assam

Twenty six entries from different cross combinations along with two check varieties (Sabita and Purnendu) were evaluated in a randomized block design with three replications during *kharif* 2012. Among the different entries, CRL 67-131-1-3-1-1 gave the highest grain yield of 4.08 t/ha followed by CRL63-25-1-6-1-1 and CRL 77-32-3-3-1-1 with an average grain yield of 3.76 t/ha against the best check variety Sabita (2.69 t/ha).

Evaluation of advance breeding lines under deepwater conditions (Station trial) at CRRI, Cuttack

Table 7. Performance of entries under semi-deepwater conditions (station trial) during *kharif* 2012

Designation	Date of flowering	Days to 50% flowering	Plant height (cm)	EBT/ m^2	Grain number/ panicle	Plant weight (g)	Grain yiled (t/ha)	Survival (%)
CR3008-B-6-7-1-1	9.11.12	155	179.9	164	215	5.23	5.51	100
CR2432-B-13-1-1-1-1	12.11.12	158	142.6	174	211	6.43	5.11	97.5
CR2518-B-B-2-1-1-1	14.11.12	160	170.2	170	193	3.85	4.62	96.9
CR3008-B-13-1-1-1	5.11.12	151	169.9	154	206	5.15	4.56	97.9
CR2593-1-1-1-1	6.11.12	152	141.4	151	232	5.53	4.50	100.8
Varshadhan (c)	6.11.12	152	192.6	152	155	4.53	4.12	98.6
Purnendu (c)	13.10.12	128	138.3	126	162	3.45	3.53	97.3
Sabita (c)	24.10.12	139	181.0	127	131	4.20	3.46	99.1
Expt. Mean	-	150	170.5	146	189	4.5	3.30	-
LSD ($P < 0.05$)	-	2.6	10.5	28	81	2.1	0.76	-
CV (%)	-	0.9	3.1	9.5	15.5	14.9	11.4	-

Station trial was conducted comprising 18 elite fixed lines and 3 checks. The performance of 12 entries was promising as compared to the three check varieties. Promising entries with > 4.5 t/ha were CR 2683-45-1-2-1-2, CR3836-1-7-4-1-1, CR2682-1-1-5-1-1, CR3608-11-2-1 CR3607-13-2-1-1-1 and CR2682-1-1-5-1-1-1-1.

Evaluation of advance breeding lines in preliminary variety trial under deepwater conditions at RRLRRS, Gerua, Assam

Sixteen promising entries along with two check varieties (Dinesh and Padmanath) were evaluated under deep water conditions in randomized block design with three replications. Among the 16 entries tested under deep water conditions at RRLRRS, Gerua, CRL68-141-1-3-1-1 gave the highest grain yield of 5.17 t/ha followed by CRL70-38-2-2-1-1 (5.00 t/ha) and CRL68-2-1-1-1-1 (4.14 t/ha) against the best check variety Dinesh (3.32 t/ha).

Evaluation of elite cultures from national and international trials for semi-deep and deep water ecosystems at CRRI, Cuttack

National semi deepwater screening nursery (NSDWSN)

Sixty one entries along with three check varieties (Sabita, Purnendu and Varshadhan) were evaluated under semi deepwater conditions. The entry No. 3544 (IET23052) performed best with an average grain yield of 6.12 t/ha followed by entry No. 3506 (IET23017 with 6.10 t/ha) and entry No. 3542 (IET23050 with 5.34 t/ha) against the best check Varshadhan (3.94 t/ha). All these varieties had more than 95% survival.

Initial variety trial-semi deepwater (IVT-SDW)

Sixteen entries along with three check varieties (Sabita, Purnendu and Varshadhan) were evaluated under semi deepwater conditions. Among the different entries, entry No. 510 (IET22675) performed best (3.94 t/ha) followed by entry No. 516 (IET22662 with 3.83 t/ha) against the best check Varshadhan (3.82 t/ha).

Advancev variety trial-semi deepwater (AVT-SDW)

Seven entries along with three check varieties (Sabita, Purnendu and Varshadhan) were evaluated under semi deepwater conditions. Among the different entries, entry No. 407 (IET21858) performed best (4.67 t/ha) followed by entry No. 404 (IET21854 with 4.47 t/ha) against the best check Varshadhan (4.40 t/ha).

Initial variety trial-deepwater (IVT-DW)

Thirty four entries including three check varieties (Jalmagna, Dinesh and Durga) were evaluated under deepwater conditions. Among the different entries, entry No. 611(IET22993) was top yielder (5.30 t/ha) followed by entry No.601 (IET22986 with 5.32 t/ha) and entry No.607 (IET22991 with 5.00 t/ha). The mean grain yield ranged from 1.9 to 5.3 t/ha. Two entries, IET22993 and IET23004 were observed to have high seedling survival which was better than the check varieties, Jalmagna and Dinesh.

Performance of entries nominated in AICRIP trials during 2012

One high yielding rice variety CR Dhan 505 was identified for deepwater ecosystem of Odisha and Assam. One entry CR2437-B-2-1-1-1 (IET 23055) nominated under National Semideepwater Screening Nursery was promoted to IVT-SDW and another entry CR2416-12-1-1-1 (IET 22302), which was nominated to IVT-DW was promoted to AVT-DW. Six deepwater rice cultures, CR2416-12-1-1, CR2681-147-1-1, CR2251-1-1-1-3, CR2679-4-2-1-1-1, CR3599-3-2-1-1 and CR3604-5-2-1-1-1 were advanced under national yield trial and exhibited superiority in many states.

Breeding Rice Varieties for Coastal Saline Areas

Evaluation of germplasm and salt-tolerant elite lines under salinity stress

Screening for reproductive stage salt-tolerance

During *kharif* 2012, 174 rice genotypes were evaluated for salinity tolerance at reproductive stage at EC of 6-8 dS/m. Of these, 26 genotypes with <25% yield reduction and 28 genotypes with 25-50% yield reduction under salt stress over the control were identified for further evaluation after classifying them in different duration groups.

Evaluation of elite lines in salinity micro-plots

During *rabi* 2012, 14 short-duration salt-tolerant elite lines were evaluated for their yield performance under salinity stress in simulated condition. The salinity was maintained at EC10-12 dS/m during seedling-vegetative stage and 4-6 dS/m during reproductive stage. CR2815-4-23-1-S-4-1-1 produced highest grain yield of 268 g/m^2, followed by CR2815-4-27-4-S-2-1-1(217 g/m^2), CR2815-4-26-1-S-5-2-1 (209 g/m^2) and

CR2815-4-23-5-S-2-1-1 (196 g/m^2). Susceptible check IR 29 did not survive under the salt stress. Tolerant check FL 478 gave grain yield of 162 g/m^2.

Evaluation of elite lines in farmers' field

Fourteen salt tolerant genotypes were evaluated in farmers' field under saline condition (EC=6-8 dS/m) at Ersama and Astaranga. The grain yield of the best performing line CR2815-4-27-4-S-1-1-1 at the two locations was 3.22 and 3.92 t/ha followed by 3.23 and 3.30 t/ha for CR2815-4-23-5-S-2-1-1 as compared to 3.50 and 3.41 t/ha for the check variety Luna Sankhi.

Hybridization and selection for high yielding salt-tolerant lines

For kharif season

F_1 seeds were generated during *kharif* season from the crosses using Pokkali (AC39416A), tolerant to salinity, water-logging and anaerobic germination and popular high yielding varieties, Savitri, Gayatri and Varshadhan as the female parents. In addition, F_4-F_8 progenies from 10 different cross combinations involving salt-tolerant donors FL478, FL496, SR 26B, Rahspunjar and Nona Bokra were evaluated and 800 single plants as well as 80 bulk populations were selected.

For rabi season

F_2 progenies of eight crosses involving Khandagiri, Abhishek, Shatabdi, Naveen, Annapurna and Vandana as female parents, and FL 478 and Hasawi as salt-tolerant donors were evaluated for salinity tolerance at seedling stage (EC 10-12 dS/m), and 1100 single plants were found tolerant.

Development of mapping population for detection of QTLs for salt-tolerance

Single seed descent method was followed for the development of RILs from Swarna/Kamini and Naveen/Chettivirippu (AC39394) from 350 F_2 lines. Kamini and Chettivirippu (AC39394) are moderately tolerant to salinity at seedling and reproductive stages.

Evaluation of mapping population for salt-tolerance at seedling stage

Phenotyping of an advanced backcross population for QTL analysis for salt tolerance at seedling stage was made. The F_1 plants from a cross between susceptible recurrent parent IR64 and tolerant donor Pokkali (AC41585) were backcrossed with the recurrent parent for three generations. This was followed by selfing and single-seed descent to generate 200 BC_3F_3 lines. From these, 190 $BC_3F_{3:4}$ lines along with the parents were evaluated for salinity tolerance at EC 12 dS/m.

Analysis of variance showed significant differences for shoot length (cm), percentage increment of shoot length, Na-K ratio, NDVI (normalized difference vegetation index) readings at 16 and 25 days after soaking of seeds for germination and SES score. Under salinized condition, Na-K ratio was positively correlated (r=0.61) while NDVI reading (25 days) (r=-0.75), shoot length (r=-0.47) and increment of shoot length (-0.63) was negatively correlated with the SES score. Normal distribution revealed polygenic nature of the component traits such as Na-K ratio (0.13-2.39), shoot length (19.27-50.95 cm), percentage increment of shoot length (0.13-38.99) and NDVI reading at 25 days (0.0-0.77). Some promising transgressive segregants in respect of low Na-K ratio and greater increment of shoot length were obtained. Normal distribution in most of the tolerance related traits indicated the involvement of quantitative trait loci, suggesting further scope of detecting new genes/QTLs for seedling stage salt-tolerance.

Graphical genotyping of segregants for the *Saltol* region

Thirty seven tolerant and moderately-tolerant (SES= 3-5) F7 lines derived from the Annapurna × FL478 cross were subjected to SSR analysis for validation of the microsatellite markers in the Saltol QTL region. Saltol region in chromosome 1 was graphically presented for 37 lines (Fig. 3). FL 478 specific marker alleles for different loci situated from 10.8 Mb to 12.7 Mb region in chromosome 1 was found in all the lines tested except three either in homozygous or in heterozygous condition. The 34 tolerant and moderately tolerant lines sharing a common segment from the donor FL 478 might carry the *Saltol* QTL either in homozygous or heterozygous condition in this region. However, absence of marker alleles specific to FL 478 in the Saltol region of three of the phenotypically tolerant lines clearly suggested that *Saltol* region did not contribute to salt tolerance in theses lines. Their salt tolerance in the absence of the *Saltol* QTL was supposed to be attributed to some other QTLs inherited from Pokkali. Whole genome graphical genotyping of FL478 and its tolerant derivatives is required for gaining further insight into different regions inherited from Pokkali that could be responsible for tolerance reaction. All lines developed in this study with or without Pokkali and

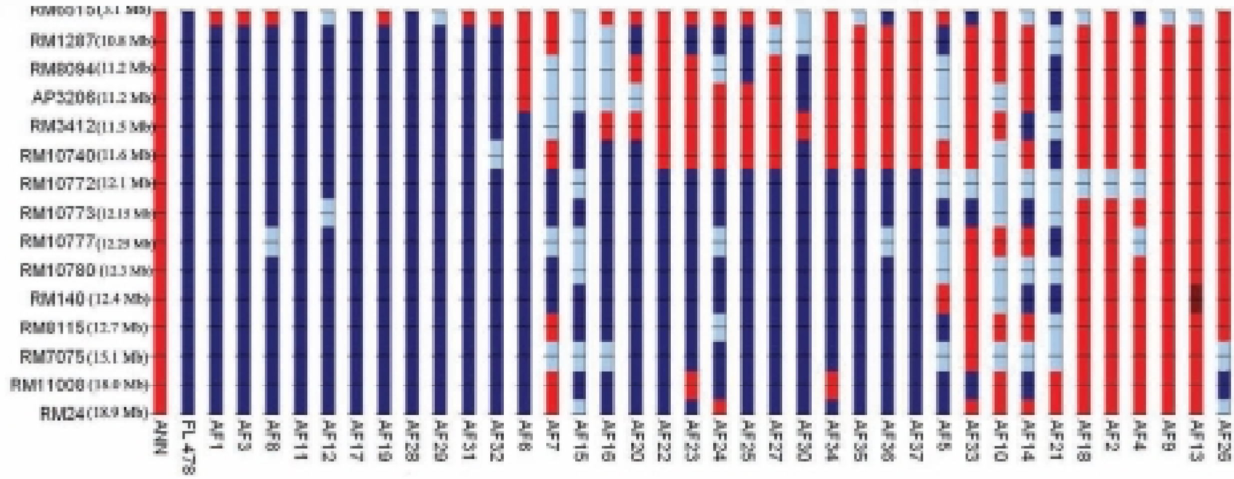


Fig 3. Graphical representation using GGT 2.0 of Saltol QTL (11.2-12.4 Mb) inside the short arm of chromosome 1 in 'Annapurna' (ANN), 'FL 478' and 37 lines (1-37), salt tolerant at seedling stage, derived from 'Annapurna x 'FL 478'

FL478 alleles in the *Saltol* QTL region, showed better crop establishment under salt stress and were found suitable for cultivation in the dry season for ensuring higher productivity and profitability in the coastal West Bengal and Odisha.

AICRIP trial

Thirty three entries for CSTVT were grown in farmer's field at Ersama, where the soil pH and ECs were 7.2 – 7.6 and 6.7- 16.4 dS/m, respectively. Highest grain yield of 2.59 t/ha was recorded in CR2461-1-30-1-1 (IET22637) followed by RP 4948-300-30-2-1-1-1-1 (IET21935). The checks CST7-1 and Jaya yielded 2.14 and 1.46 t/ha, respectively.

On-farm evaluation of newly released rice varieties for coastal saline areas

Performance of three recently-released high-yielding varieties namely Luna Suvarna, Luna Sampad and Luna Barial were evaluated in the *kharif* season at three locations under coastal saline situation in Sundarbans, West Bengal. Luna Suvarna produced significantly higher grain yield than SR 26B at one location, while at the remaining two locations it was comparable to SR 26B. It performed well under medium salinity (field water EC2.4-6.7 dS/m) and slightly alkaline pH (7.6-8.2) with varying water depth of 6-47.3 cm. Average grain yield of Luna Suvarna and SR 26B over the three locations was 4.21 and 3.99 t/ha, respectively.

Development of Super Rice for Different Ecologies

Evaluation of new plant type/advance generation under irrigated condition

In *kharif* 2012 (AYT) five genotypes were found with high grain yield. CR3723-3-1-1 showed highest yield of 9.4 t/ha followed by CR3727-3 (8.78 t/ha), CR3722-1-1(7.86 t/ha), CR3851-2-1 (7.35 t/ha) and CR3852-4-1 (7.27 t/ha) against 4 checks (Annada, Naveen, IR-64 and Swarna). Similarly in *rabi* season, CR3724-1, CR3725-4-1 and CR3728-2 recorded higher grain yield of 8.01, 6.70 and 6.60 t/ha, respectively. It was analyzed that there were appreciable number of ear bearing tillers, long panicles, longer and wider top three leaves (TTL) and moderately high grain number which contributed to higher grain yield in comparison to checks. Apart from grain yield, CR3723-3-1-1 registered long panicle and long top three leaves along with medium bold grains; CR3727-2-2-1 with long TTL, panicle length and fertile grains; IR78629-57-3-3-9-4 with wide flag leaf, appreciable EBT and high grain weight; CR3852-4-1 with high EBT, TTL and grain weigh; CR3725-4 with more TTL and CR3728-2 with erect leaf and bold grains recorded more grain yield. However, these genotypes bear only moderate grain number although fertility percentage is high. The culm strength was also moderate to withstand lodging in nutrient rich environment.

Few promising lines identified under OYT have been retested under AYT. Out of these lines the most promising lines found were CR3705-2-11-1 (9.68 t/ha), CR3707-1-1-6 (8.31 t/ha), CR2996-21-1 (8.10 t/ha), CR2996-2-1-1-5 (7.10 t/ha), CR2996-2-1-3-2 (7.11 t/ha) and CR2996-55-3 (6.84 t/ha).

Biotic stress screening

Forty eight promising NPT genotypes were scored twice for blast resistance at vegetative stage, *viz.,* after one month of sowing and 43 days after sowing. CR3727-12-1-1 was found tolerant with average score 2 and two genotypes *viz.,* CR3728-2-1 and IR 82489-7-2-2-1 recorded average blast score 3 against the susceptible check score 9.

Critical investigations on morpho-physiological traits for designing super rice for irrigated ecosystem

Five hundred different genotypes including tropical *japonicas* (with WC genes), their derivatives, ARC and other exotic lines were screened in an augmented block design with four checks (Annada, Naveen, IR-64 and Swarna) for potential morpho-physiological traits and their prospective use as donor/parental lines for development of super rice.

However, most of the tropical *japonica* genotypes were tall type. EC496864 (96.0 cm), EC497024 (98.2 cm) and EC496890 (97.0 cm) were dwarf type with relatively high grain yield.

- *High culm diameter (an indicator for lodging resistance):* The genotypes *viz.,* EC391239 recorded highest Culm diameter (12.19 mm) followed by EC491274 (11.81 mm), EC491231 (11.31 mm), EC491320 (11.10 mm) and EC491335 (11.03 mm).
- *High tiller number:* EC491173 registered highest tiller (17.2) followed by EC491164 (16.2), EC496864 (13.0), EC491218 (12.0) and EC491219 (12.0).
- *No. of fertile grains:* EC491179 (247.2), EC491313 (213.0), EC491416 (169.8) and EC491205 (161.6).
- *1000 Grain weight:* EC491282 (47.5 g) followed by EC491388 (43.4 g), EC491360 (42.7 g), EC491395 (42.2 g) and EC491390 (41.9 g).
- *Leaf erectness:* EC491327, EC491393, EC491402, EC491404 were registered with highly erect flag leaf architecture.
- *Wide Leaf:* EC491328, EC491327, EC491436 and EC 491338 were found with considerable wide leaf (> 2.4 cm).

Flag leaf and subsequent leaves were important for synthesis and translocation of assimilate for high grain number and weight. In this context, EC491156 was found with longest top three leaves (57.8 cm) leaf followed by EC491149 (53.6 cm), EC491372 (52.9 cm), EC491378 (52.6 cm) and EC491320 (52.2 cm).

However, grain is the product of several component characters EC491222 (1256 g/m^2) was found with highest grain yield followe d by EC491205 (1018 g/m^2), EC491266 (984 g/m^2) and EC91441 (979 g/m^2) which could be utilized as donors for overall improvement including grain yield.

Hybridization of potential genotypes with promising TJ, TJ derivatives and others in irrigated ecology for yield, ideal plant traits and biotic stress tolerance

Twenty eight crosses were made involving potential genotypes with promising TJ, TJ derivatives, and others) in irrigated ecosystem for yield, ideal plant traits and biotic stresses tolerance. Similarly, genotype with heavy panicle type (average panicle wt. 7.0 g) was backcrossed with CRMAS 2232-85 (Swarna background) to transfer heavy panicle type to popular variety Swarna.

Selection and generation advancement of segregating generations

Generation advancement was made in different generations with number of single plant selections having promising super traits. In F_6 generation 400 lines were grown. Some of them were found highly promising *viz.,* CR3856-45-11-2-1-5 and CR3856-50-2-3-2-1 with grain number as high as 680 with 80% fertility (average fertile grain no. 370 and 309 in CR3856-45-11-2-1-5 and CR3856-50-2-3-2-1, respectively). Similarly, other promising selections *viz.,* CR3856-18-12-3-1-1 (highest grain no. 636 and average fertile grain no.334), CR3857-14-3-12-1-1(highest grain no. 576 and average fertile grain no.325), CR3856-18-12-1-1-1(highest grain no.538 and average fertile grain no. 230) and CR3856-44-22-2-1-7 (highest grain no.444 and average fertile grain no 342) were recorded with more than 75% fertility and advanced for preliminary yield trial (Table 8). An ideal plant type CR3856-44-22-2-1-5 was selected in F_6 with super rice traits, *viz.,* very strong culm, medium dwarf height, long and wide top three leaves, 400 average grain number with 78% fertility and 20 g thousand grain weight.

Table 8. Promising selections in F_6 showing high grain number

Genotypes	No. of fertile grains/panicle (highest)	No. of sterile grains/panicle (highest)	Total no. grains (highest)	Fertility (%)	1000 grain weight	Average no. of fertile grains
CR3856-45-11-2-1-5	542	141	683	79.3	15.9	370
CR3856-50-2-3-2-1	560	128	688	81.4	19.0	309
CR3856-18-12-3-1-1	520	116	636	81.7	18.1	334
CR3857-14-3-12-1-1	432	144	576	75.0	18.1	325
CR3856-18-12-1-1-1	402	136	538	74.7	16.4	230
CR3856-44-1-3-1-1	443	51	494	89.6	20.6	306
CR3856-44-22-2-1-7	391	53	444	88.0	18.4	342
CR3856-44-22-2-1-5	379	107	486	77.9	19.5	373
Swarna	173	33	206	84.0	15.75	145

Development of super rice for relatively less favourable ecosystem

Shallow lowland

During *kharif* 2012, thirty three fixed lines of superior single plant progenies of inter sub-specific derivatives and *indica-indica* cross derivatives were planted along with three check varieties for evaluation. The super rice lines have been designed by utilizing heavy panicle, strong culm and high spikelet per panicle with moderate tiller number, thick dark long, and upright top leaves and semi tall plant height. Tropical *japonica* lines were selected with the above desired traits containing 'WC' gene and were hybridized with popular lowland *indica* varieties. Results of initial yield evaluation trial conducted during *kharif* season showed highest yield of 14 t/ha from CR2683-7-1-2-3-1 followed by 13.3 t/ha and 12.5 t/ha from CR3696-1-2-1-1-1 and CR2682-7-1-1-1, respectively. Average panicle weight of 9 g was obtained from CR2683-7-1-2-3-1 with 28 g seed test weight and strong culm along with broad, and thick boot leaf. The other promising genotype CR2682-7-1-1 also exhibited a heavy panicle with 8.2 g average panicle weight with 425 spikelets/panicle.

Favourable upland

Nineteen NPT lines were evaluated under transplanted condition during *kharif* 2012. Three weeks after transplanting, the crop was maintained under rainfed condition. Entry no. IR73963-86-1-5-2-2 was found to be highest yielder (5.06 t/ha) followed by IR 74714-141-3-3-2-3 (5.02 t/ha) and IR 73973-27-1-1-2

CR-3856-44-22-2-1 an ideal super rice plant type

Promising super rice genotypes with heavy panicle and high grain number

(5.00 t/ha), IR 73930-313-2-2 (4.37 t/ha), IR 72967-12-2-3 and IR 73893-71-2-6-3 (4.35 t/ha). In relation to plant type, nine entries exhibited semi-spreading plant type and rest 11 were erect type. Eight entries showed erect type of flag leaf orientation, nine entries showed semi-erect type and rest two showed parallel orientations.

Field resistance of genotypes to brown spot disease was carried out under natural conditions without inoculation. IR74714-141-3-3-2-3, IR72967-12-2-3 and IR72969-143-5-3-6 showed resistance while IR74714-141-3-3-2-3 and IR73896-51-2-1-3 showed minimum disease symptoms.

Resistance Breeding for Multiple Insect-pests and Diseases

Culture identified by variety identification committee (VIC) for central release

CR2644-2-6-4-3-2 (IET22117) derived from the cross between Tapaswini and IET 16611 was identified for irrigated areas of Odisha and West Bengal under mid-early duration by variety identification committee. In region III (Eastern India), it showed superiority in performance with yield advantage of 13.4%, 7.54% and 14.56% over national check (IR64), regional check (Lalat) and local check, respectively. This culture also stood first among all the inbreds and second among all the hybrids and inbreds taken together in region III (Eastern) in AVT 2-IME trial, *kharif* 2012 of AICRIP. It stood first in Madhya Pradesh, second in Andhra Pradesh and Odisha, third in Bihar, fourth in Maharashtra and fifth in Kerala among all the hybrids and inbreds taken in AVT 2-IME, *kharif* 2012 of AICRIP. In AVT 1-IME trial, *kharif* 2011 of AICRIP, this culture stood first in West Bengal, second in Rajasthan and fifth in Odisha among all the hybrids and inbreds taken together. This culture is moderately resistant to sheath blight, brown spot, rice tungro disease and gall midge biotype1.

Bacterial blight resistant varieties released and notified for Odisha

Two bacterial blight resistant varieties-Improved Lalat and Improved Tapaswini developed through marker assisted breeding were released and notified for Odisha in 2012.

Improved Lalat [CRMAS2621-7-1 (IET21066)]

It was developed from the cross between Lalat and IRBB 60. This was developed through marker assisted selection by pyramiding of four resistance genes (*Xa4, xa5, xa13 and Xa21*) into Lalat. This variety is suitable for growing in the "Bacterial blight" endemic areas in the state. It has long slender grains, high head rice recovery with intermediate amylose content having 130 days duration (medium maturity group).

Improved Tapaswini [CRMAS2622-7-6 (IET21070)]

It was developed from the cross between Tapaswini and IRBB 60. This was developed through marker assisted selection by pyramiding of four resistance genes (*Xa4, xa5, xa13 and Xa21*) into Tapaswini. This variety is suitable for growing in the "bacterial blight" endemic areas in the state. It has short bold grains and high head rice recovery with intermediate amylose content having 130 days duration (medium maturity group).

Breeding materials found to be promising for various biotic stresses in AICRIP trials of 2012

CR3005-77-2, CR3006-8-2, CR3005-230-5 and CR2711-76 were found to be resistant in planthopper screening trial. CR2711-76 was identified with multiple pest resistance (BPH, YSB, gall midge and leaf folder) in multiple resistance screening trial (MRST). CR2643-1-4-3-1 (IET22118) was found to be moderately resistant to sheath blight. CR2482-10-4-3-2 (IET21709) showed resistance to BPH and sheath rot. CR2916-15-4-2-3 (IET23166) showed resistance to sheath rot. CR2657-46-3-2-1 (IET23007) was found to be moderately resistant to leaf blast.

Generation of breeding materials for resistance to multiple insect-pest resistance

In order to develop breeding materials with resistance to multiple biotic stresses in high yielding background, thirty two crosses were made involving elite varieties Naveen, Pooja and donors for resistance/tolerance to various biotic stresses such as IC516210, BJ 1, IET16952, Aguiha anarelo and Kataribhog for RTD ; Tetep, IET 20230, IET 20755, IET 19346, IET 17885 and Jogen for sheath blight; CR2711-76, CR2711-114 , CR2711- 149, CR3005-230-5 and CR3006-8-2 for BPH; CRMAS2232-71 for BB; CRMAS2619-9 and CRMAS2620-1 for blast; AC42568 and Nalihazara for YSB.

Evaluation of earlier developed breeding lines in diseases/insect-pests screening nurseries

The foundation population of the crosses involving genetic male sterile line and 13 sheath blight tolerant donors IET17885, IET17886, IET19346, Jogen (AC40922), Mansarovar (AC40844), Manoharsali (AC40509), ASD 18 (AC40865), IET20755, IET20737, IET20443, IET20553, IET19140 and IET20230 were grown for male sterility facilitated recurrent selection approach. Out crossed seeds were collected from 320 male sterile segregants to constitute the next round of open pollinated population. The male fertile segregants were screened in sheath blight screening nursery under artificial inoculation. Observations on disease progress were recorded periodically and 120 sheath blight resistant plants were selected for further testing.

Three hundred and fifteen breeding lines were evaluated for resistance to rice tungro disease (RTD) under simulated tungro epiphytotic condition in field situation. Forty two breeding lines were found to be highly resistant (Score 1) to RTD.

Three hundred and eighty three single plant progenies (F_5 generation) from nine cross combinations were grown for generation advance and selection during *rabi* 2012. On the basis of plant and panicle characters, 241 single plants were selected at the time of flowering and maturity. These selected plants (241) were grown during *kharif* 2012. At the time of maximum tillering all the progenies were artificially inoculated with virulent bacterial blight field isolate from the CRRI farm. On the basis of disease resistance, plant and panicle characters, 262 single plants were selected from nine cross combinations.

Multiple biotic (blast, BB, gall midge) and abiotic (submergence and salinity) stress tolerant lines were developed in the background of Tapaswini, Lalat, IR64 and Swarna through marker assisted backcrossing. Three hundred and twelve lines in BC_3F_4 generation with various combinations of multiple resistant genes were evaluated.

Fifty three advanced breeding lines were screened in the net house for BPH resistance with artificial insect pressure, out of which five lines from Sambamahsuri / Salkathi and Pusa44 / Salkathi showed high degree of resistance.

Out of 40 entries screened against gall midge, six lines from Swarna/Sarasa, Tapaswini/ARC 5984, Sambamahsuri/Phalguna and Sambamahsuri/ Velluthacheera showed high degree of resistance.

New nominations for AICRIP trials

CR2647-5-2-1 for IVT-IM, CR2655-18-2-3 for IVT-RSL, CR2916-10-2-1 for NSDWSN, CR2646-24-2-3-1 for IVT-DW, CR3808-28-2, CR3808-60-13, CR3808-60-9, CR3420-7-2 and CR2916-15 for DSN were nominated for AICRIP trials of 2013.

Breeding for Higher Resource Use Efficiency (Irrigated/Water limited Ecology)

Evaluation of germplasm for yield and phenotypic acceptability

Two hundred and thirty five elite fixed cultures and genotypes were evaluated for yield and related traits. Based on their duration and phenotypic acceptance, fifty six genotypes were selected for further evaluation and seven genotypes were analyzed for its grain quality characteristics (Table 9).

Table 9. Grain quality characteristics of rice varieties with higher resource use efficiency

Variety	Hull* (%)	Mill (%)	HRR (%)	KL (mm)	KB (mm)	L/B	Grain type	ASV	WU (ml)	VER	KLAC (mm)	ER	AC (%)
WITA-12	75.5	67.5	51.5	6.23	2.06	3.02	LS	3.0	118	4.00	10.6	1.70	17.5
CRK26-1-2-1	77.00	68.00	51.00	6.90	1.72	4.01	LS	4.01	84	4.00	12.8	1.85	22.00
F4-7-3	75.00	65.00	40.00	7.22	1.70	4.24	LS	6.50	282	4.00	12.90	1.78	20.80
Shatabdi	77.50	66.50	48.00	6.22	1.73	3.59	LS	3.00	95	4.00	10.80	1.73	23.20
CRK-27	77.00	66.00	476.00	5.28	2.44	2.16	SB	4.00	92.	4.00	9.40	1.78	24.00
CRK-26	75.50	66.00	52.50	5.54	2.11	2.62	MS	4.00	108	4.00	10.30	1.85	25.60

*Hull: Hulling, Milling %: Milling, HRR: Head Rice Recovery, KL: Kernel Length, KB: Kernel Breadth, L/B: Length-Breadth Ratio, ASV: Alkali Spreading Value, WU: Water Uptake, VER: Volume Expansion Ratio, KLAC: Kernel Length After Cooking, ER: Elongation Ratio, AC%: Apparent Amylose Content, LS: Long Slender, SB: Short Bold, MS: Medium Slender.

Advance Yield Trial (AYT)

Thirty six genotypes were evaluated under direct seeded condition. Among the 130-140 days duration group WITA 12, WITA 8 and Khandagiri gave the highest grain yield (6.7 t/ha). Among the 120-130 days duration group *viz.,* Annada, IR64, Sahabhagidhan and Phalguni recorded grain yield of 5.05 -6.50 t/ha.

Breeding for direct seeded condition

Seeds of F_5 generations of eight crosses involving parents ADRON 111 and ADRON 125 adapted to wetland direct seeded conditions along with Shatabdi, Annada, Pusa Basmati 1 mutant and Lalat were grown and 176 single plants were selected for advancing the generation in coming boro season.

Generation of breeding materials for early duration

Ten crosses were attempted for irrigated ecosystem, wherein Naveen was crossed with CR2601-1-2, Sahbhagidhan, WITA8, Shatabdi, CR689-16-2, Banskath and B6144FMR7167. One hundred and sixty seven advanced breeding lines were derived from crosses involving genotypes like IR 64, Pusa 44, Shatabdi, Pooja, Vandana, Parijat, Tapaswini, Lalat, Banskathi, ADRON 111, ADRON 125 and ADRON 131. Eight crosses involving Naveen, CR2601-1-2, CR2921-6-3, Sahbhagidhan, WITA8, Shatabdi, CR689-16-2, Paskathi, and B6144FMR7 for irrigated condition were attempted. Five other crosses were also made each for drought, heat and cold tolerence.

Screening for drought condition

Five hundred germplasm lines collected from various national and international sources were evaluated out of which, 50 genotypes mostly from early maturity duration (120 days) were evaluated under natural upland situation. Five genotypes *viz.,* CR-514, RR-354-1, RR 151-4, DK-12 and RR-166-645 performed better with grain yield of 0.54, 0.53, 0.51, 0.49 and 0.41 t/ha in comparison to Sahabhagidhan (0.41 t/ha). Out of these genotypes CR-514 was having drought score of 2 and DK-12 was having score 1. The same set of lines were tested under normal irrigated situation and DK-12 performed best with 5.34 t/ha followed by RR 3654-1(3.35 t/ha).

One hundred seventy five fixed cultures were evaluated. Fifteen elite cultures were identified. Fifteen cultures were grown along with four checks (Annada, IR 64, Naveen and Swarna). The best three cultures are N306 (6.84 t/ha), R255 (5.59 t/ha) and N301 (5.33) which out yielded best yielding Check Swarna (4.35 t/ha).

Hybridization for drought tolerance

Two identified drought tolerant genotypes *viz.,* Brahman Nakhi and Naliakhura were used as donor for hybridization with six female parents involving wild rice as well as few popular varieties *viz., O. rufipogon, O. nivara, O. brachyantha*, Swarna, Pooja and Naveen.

Wide hybridization

Three promising lines of Savitri/*O. brachyantha*/ Savitri derivatives have been identified . Ten drought tolerant promising lines of 125 days maturity duration were tagged at flowering stage. Thirty *O. sativa/O. nivara* derivative lines were tested in field as well as under rainout shelter condition for drought tolerance at vegetative stage. Further, 16 crosses were attempted involving drought tolerant lines with high yielding diverse genotypes including tropical *japonicas*.

Screening for tolerance to cold

Two hundred twenty genotypes from CRRI gene bank representing collections from colder regions were first evaluated in field conditions in Dec, 2011 for seedling stage cold stress tolerance and the tolerant genotypes were further screened for confirmation in cold chamber of RGA at 4^0C for more than 15 days. Genotypes, AC432181, AC43291, Geetanjali, Kalinga III, Annada, AC43261 and AC43259 were found tolerant to cold stress. Out of this AC43281, AC43261 and Geetanjali survived for more than 30 days at 4^0C whereas, Kalinga III could survive only for 20 days at 4^0C.

Screening for tolerant to cold under field condition

Genotypes on first day at 4^0 C

Genotypes after 30 days at 4^0 C

Creation of variability for cold and heat tolerance was done by attempting the crosses like MTU 1010/ Geetanjali/CR3564-1-1-1-1(Vijetha/N22); Sahabhagidhan/Geetanjali//CR3564-1-1-1-1/ Geetanjali/CR 3564-1-1-1-1//Naveen) and Geetanjali/ CR3564-1-1-1-1//Lalat.

Breeding for water limited (aerobic) condition

Observational yield trial

During *rabi* 2012, one hundred three entries were grown in an augmented design with three checks *viz.*, Pyari, IR64 and Sahbhagidhan. Culture IR84887-B-157-38-1-1-2 recorded highest yield of 4.1 t/ha. This genotype flowers in 90 days and matures in 115 days. This was followed by genotypes IR84898-B-171-32-1-1-2 (3.94 t/ha), IR84887-B-157-38-1-1-1 (3.91 t/ha), IR84887-B-158-7-1-1-2 (3.90 t/ha), IR83927-B-B-278-5-9-1-3 (3.57 t/ha), IR84882-B-120-46-1-1-1 (3.46 t/ha) and IR83871-B-B-240-5-1-1-1 (3.37 t/ha). All these genotypes mature within a range of 115- 120 days duration.

Selection and evaluation of segregating materials

Eighty five promising single plants from selected 1320 lines (F_4 to F_5) were generation advanced during *kharif* season. Derivatives of six crosses in F_4 generation were raised in pedigree nursery. The parents were Lalat, Naveen, CR143-2-2, IR64, Apo and MTU 1010. Forty two promising lines were advanced to F_6 generation from 110 lines raised during *kharif* 2012. Seventeen promising lines of F_7 generation were bulked for OYT trials.

Evaluation of fixed lines (F_6 lines) for NUE

Thirty improved fixed lines were evaluated during *rabi* 2012 for their nitrogen use efficiency (NUE) in split plot design with nitrogen efficient checks ADT 43 and Vijetha at four N level i.e. N_0, N_{60}, N_{120} and N_{180}. The agronomic NUE of different lines, response to higher N level and yield at different N levels along with yield attributes and chlorophyll concentration were estimated based on SPAD values. Based on grain yield at native (without applied N) and at different dose of applied N, agronomic N use efficiency (AE_N) of each lines were estimated and top few lines along with efficient checks ADT 43 were identified (Table 10).

Evaluation of pre screened rice cultivars for N use efficiency

Eight long duration (>135 to 155 days) and eight medium duration (125 to 135 days) pre-screened N use efficient rice cultivars were evaluated during *kharif* 2012 for their N use efficiency at five N level i.e. N_0, N_{30}, N_{60}, N_{90} and N_{120} with uniform application of 40: 40 P_2O_5 and K_2O. The nitrogen non-responsive check taken for long duration was Sabita and medium duration was Dubraj. The top NUE varieties based on Agronomic N use efficiency were identified (Table 11).

Medium duration

Evaluation of performance of few promising lines at moderate and recommended N level

Performance of fifteen promising fixed lines (F_7) were recorded during *kharif* 2012 along with six efficient checks Birupa, Tapaswini, Vijetha, Lalat, Pusa 44 and Indira at N_{40} and N_{80} level with 40 kg/ha of P_2O_5 and K_2O in both the treatments. Few lines were found to be very promising even at moderate level of N i.e. N_{40} with

Table 10. Grain yield (t/ha) at various N level and agronomic N use efficiency of few promising lines during *rabi* 2012

Entry	Grain Yield (t/ha) at various N level				Agronomic N use efficiency		
	N_0	N_{60}	N_{120}	N_{180}	AE_N 1	AE_N 2	AE_N 3
CR3494-1-1-1-1	3.23	5.28	7.27	6.74	34.14	33.66	19.50
CR3562-7-2-1-1	2.85	5.05	6.95	6.67	36.75	34.17	21.23
CR3504-12-2-1-1	3.45	5.07	5.58	6.17	26.91	17.71	15.09
CR3501-8-2-1-1	3.36	5.47	6.43	7.48	35.10	25.52	22.86
CR3510-12-1-1-1	3.42	5.80	6.11	6.27	39.77	22.44	15.86
CR3504-18—1-3-1	3.49	5.84	6.76	6.63	32.84	26.22	17.48
CR3497-7-1-2-1	3.21	5.46	6.44	6.56	37.46	26.93	18.63
CR3562-7-2-1-1	3.80	5.64	5.88	6.85	30.66	17.35	16.91
CR3549-5-1-1-1	3.57	5.74	6.70	7.17	36.20	26.09	20.00
ADT 43	3.27	5.40	6.55	6.31	35.50	27.37	16.89
Vijetha	3.44	5.84	6.21	6.33	40.00	23.16	16.08

AE_N1= N at 60kg., AE_N2= N at 120kg., AE_N3= N at 180kg.

Table 11. Grain yield (t/ha) at various N levels and agronomic N use efficiency of selected rice cultivars

Cultivars	N_0	N_{30}	N_{60}	N_{90}	N_{120}	AE_{N1}	AE_{N2}	AE_{N3}	AE_{N4}
Ranjit	3.42	4.67	5.87	6.70	7.76	41.9	41.0	36.5	36.2
Gayatri	3.32	4.62	5.85	7.08	7.57	43.6	42.2	41.8	35.5
Swarna	3.25	4.18	5.49	6.23	7.05	44.4	44.0	37.6	35.0
Salivahana	3.48	4.58	5.66	6.68	7.42	36.7	36.4	35.6	32.9
Sabita	3.23	3.92	4.35	4.74	5.23	23.0	18.6	16.7	16.7
Surendra	3.37	4.55	5.57	6.01	6.62	39.6	36.7	29.4	27.1
Birupa	3.49	4.48	5.32	5.80	6.55	32.8	30.4	25.6	25.4
Vijetha	3.24	4.43	5.57	5.77	6.41	39.8	38.8	28.0	26.4
Pusa 44	3.64	4.57	5.32	5.89	6.53	31.0	27.9	25.0	24.0
Indira	2.98	3.85	4.49	5.22	5.69	29.1	25.1	24.9	22.6
Dubraj	2.91	3.58	3.91	4.02	4.27	22.1	16.6	12.2	11.3

AE_N1= N at 30kg., AE_N2= N at 60kg., AE_N3= N at 90kg., AE_N4= N at 120kg.

a grain yield of > 5.2 t/ha that were better than the efficient checks (Table 12).

Development of mapping population for identification of genes/QTLs for nitrogen use efficiency

F_1 seeds were harvested from the hybridization made among N use efficient Ranjit, Gayatri and Pooja with N use inefficient Sabita in photosensitive cultivars. Also crosses were made among N use efficient Birupa and Indira with inefficient Daya in photo-insensitive cultivars.

Generation of new breeding materials for improving NUE

Sixteen crosses were made using high N use efficient genotypes as recipient with better plant types having long panicles and high grain number, and bacterial

Table 12. Performance of promising N use efficient F_7 lines at N_{40} and N_{80} level

Entry	*Cross combination*	Grain yield (t/ha)	
		N_{40}	N_{80}
CR 3506 - 1-2-3-2-1	IR 36 /Tapaswini	5.5	6.2
CR 3516 -2-1-3-1-1	Birupa/Pusa 44	5.3	5.8
CR 3568 -38-1-1-2-1	IR 36/Lalat	5.2	5.9
CR 3525-1-1-1-1-1	Vijetha/Divya	5.8	6.7
CR 3496 -4-4-1-1-1	Lalat/ Vijetha	5.6	6.8
Tapaswini	-	4.8	6.2
Vijetha	-	4.6	5.6
Lalat	-	4.3	5.2

blight resistance for improving N use efficiency with improved BB resistance and high sink size (Table 13).

Evaluation, selection and advancement of breeding materials during rabi and kharif 2012 for NUE

Around 1200 single plant selections of different segregating generations was evaluated at moderate N level (N_{60}) during *rabi* and 720 plants were selected for further advancement. These were from 65 cross combinations (F_6-210; F_5-172; F_3 -120 and F_2-218). Similarly, these single plant selections were evaluated at moderate N level during *kharif* (N_{40}) and selection of 560 plants was made under moderate N level with higher grain yield and better plant types with good phenotypic acceptability (F_7-180; F_6-108; F_4-110 and F_3-165).

Breeding for heat tolerance

Twenty two tolerant germplasm lines along with tolerant checks N 22 and Dular, besides four popular irrigated varieties Shatabdi, Naveen, Lalat and IR 64 were evaluated under delayed sowing and transplanting for heat stress tolerance at reproductive stage (Table 14). Based on spikelet fertility % under high temperature stress, 16 genotypes were found to be tolerant with SES score 1 i.e. > 80% and 12 genotypes were moderately tolerant with SES score 3 i.e. > 60 <

Table 13. Crosses made for improving nutrient use efficiency with better plant type

Gayatri/Tapaswini MAS	Gayatri/CRM 2231-37	Gayatri/L 604	Gayatri/EC 24
Gayatri/Lalat MAS	Ranjit / EC 78	Ranjit/CRM 2231-37	Ranjit/L 1025
Ranjit/NPT 320	Ranjit / EC 24	Ranjit / EC 22	Ranjit/ EC 25
Ranjit/Tapaswini MAS	Ranjit /NPT 301	Pooja/ EC 25	*Pusa 44* / CRM 2231-37

Table 14. Evaluation of prescreened heat tolerant genotypes under delayed sowing

Entry	Cross combination	Grain Yield (t/ha)	Spikelet fertility %	SES score
CR3564-14-3-1-1	Vijetha/N 22	4.81	84.55	1
CR3561-2-1-1-1	Surendra/Annapurna	4.85	83.02	1
CR3564-2-1-2-1	Vijetha/N 22	4.73	82.67	1
CR3564-1-1-1-1	Vijetha/N 22	5.13	82.32	1
CR3564-10-2-2-1	Vijetha/N 22	4.88	82.182	1
CR3564-8-3-1-1	Vijetha/N 22	5.07	82.02	1
CR3561-1-1-1-1	Surendra/Annapurna	4.80	82.15	1
CR3549-1-2-1-1-	ADT 43/Annapurna	5.10	80.54	1
N 22	-	3.12	82.80	1
Dular	-	3.62	76.40	3
Naveen	-	4.52	76.87	3
Shatabdi	-	4.34	73.80	3
Lalat	-	4.40	78.60	3
IR64	-	5.26	74.70	3

80%. The most tolerant genotypes were AC39843 (82.61%), AC11462 (82.35%), AC10976 (82.17%) and N 22 (81.03%). The most susceptible genotypes to heat stress were AC9741 (76.95%), IR64 (76.24%) and Dular (77.14%).

Evaluation of promising heat tolerant F_6 lines under delayed sowing

Thirty promising F_6 lines were evaluated under late sown conditions to evaluate their performance and heat stress tolerance under high ambient temperature during reproductive stage (flowering) along with susceptible and tolerant genotypes for heat stress. Out of these lines eighteen are derivative of tolerant checks N 22 and Annapurna with popular irrigated cultivars whereas, twelve were from cross derivative of popular irrigated rice varieties. The flowering date and maximum day and night temperature were correlated and based on spikelet fertility percentage scoring for heat stress was made. Most of the derived lines with N 22 and Annapurna combinations were highly tolerant to heat stress with score 1 whereas, susceptible check Naveen, Lalat, IR64 and Shatabdi showed a score of 3 in SES, that was moderately tolerant. Tolerant check N 22 showed highly tolerant reaction whereas, Dular showed moderately tolerant reaction.

Generation of new breeding material for heat tolerance

Ten crosses were made with newly identified genotypes with popular irrigated rice cultivars. The crosses are Naveen/ AC39834, Naveen/ AC39843, Naveen/AC39969, Tapaswini/ AC39969, Tapaswini/ AC39843, Lalat/ AC39834, Lalat/ AC39969, Pusa 44/ AC39969, IR64/ AC39793 and Gajapati/ AC39969.

Evaluation, selection and advancement of breeding materials

Evaluation, selection and advancement of breeding materials - F_2 (164), F_5 (128), F_6 (130), F_7 (625) under delayed sowing were made during *rabi* 2012 and heat tolerant plants with high spikelet fertility and other agronomic features were selected. During *kharif* 2012 selection and generation advancement was made for F_3 (110), F_6 (70), F_7 (72), F_8 (480) materials with good agronomic features.

Advancement of mapping populations for identification of heat tolerant genes/QTLs

Four mapping populations of Shatabdi/ Annapurna, Surendra/Annapurna, Tapaswini/ Annapurna and Tapaswini/Dular were advanced as per the SSD method from F_2 to F_3 and F_3 to F_4, respectively with a population size of more than 200.

The heat tolerant line CR3564-1-1-1-1 (IET 35315) has been promoted to AVT 1–IME through the AICRIP with an average yield of 5.8 t/ha over all the locations tested.

AICRIP Trials

IVT-IM

This trial was conducted with 64 entries with NC NDR 359 (1620), RC NDR 8002 (1651) and improved Tapaswini (1664) as local check. The mean yield of 4.71 t/ha was obtained. The entry no 1661 was top yielder with 7.35 t/ha followed by 6.26 t/ha (entry no 1640) and 6.21 t/ha (entry no 1641). The yield varied between 2.36 t/ha (entry no 1643) to 7.35 t/ha. The yield of national, regional and local checks were 4.93 t/ha, 4.06 t/ha and 4.69 t/ha, respectively.

AVT 1 IM

This trial was conducted with 16 entries including national (NDR 359), hybrid (Hybrid KRH 2), regional (NDR 8002) and local checks (Improved Lalat). The average yield of 4.76 t/ha was obtained that ranged from 3.25 t/ha (entry no. 1511) to 6.39 t/ha (entry no. 1501). The entry no. 1501 was top yielder with 6.39 t/ha followed by entry no. 1507 (RC) with 6.10 t/ha and Entry No. 1502 with 5.93 t/ha. The yield of national, hybrid, regional and local checks were 3.26 t/ha, 4.38 t/ha, 6.10 t/ha and 4.05 t/ha, respectively.

AVT 2 IM

This trial was conducted with NDR 359 as national check (1403), KRH 2 as hybrid check (1405), NDR 8002 as regional check (1409) and Satyakrishna as local check (1412). The mean grain yield of the entries were 4.87 t/ha and yield level ranged from 2.97 t/ha (1403) to 6.03 t/ha (1409). The top yielder was entry no. 1409 (NDR 8002-RC) followed by entry no. 1411 with 6.00 t/ha and entry no. 1404 with 5.87 t/ha. The yield of national, hybrid, regional and local checks were 2.97 t/ha, 4.10 t/ha, 6.03 t/ha and 4.71 t/ha, respectively.

Breeding for Aroma, Grain and Nutritional Quality

Development of high yielding good grain quality aromatic genotypes with short/long slender grain and biotic resistance

In order to develop high yielding aromatic genotypes, 635 single plant selections from 31 cross

Table 15. Performance of promising aromatic cultures under AYT

Entry	Cross Combination	Plant height (cm)	Grain yield(t/ha)
CR2937-18-7-1-1-1-1-1	Swarna / Geetanjali	113.3	4.47
CR2935-5-1-5-2-1-1-1	Padmini / KDML105	161.0	4.43
CR2945-1-1-3-1-2-1-1	CRM 2203-2 / Dubraj	110.6	4.14
CR2947-1-1-5-1-2-1-1	CRM 2203-4 / Dubraj	111.5	4.04
CR2939-5-16-2-4-3-1-1	IR36 / Basmati370	104.5	4.02
CR2937-18-13-1-4-1-1	Swarna / Geetanjali	97.5	3.73
CR2947-1-1-7-3-1-2-1	CRM 2203-4 / Dubraj	118.5	3.69
CR2938-6	CR 689 / Kalanamak	121.7	3.55
CR2934-7-4-8-3-2-1-6	Geetanjali / Dubraj	102.9	3.52
CR2939-5-15-5-1-3-1-2	IR36 / Basmati370	100.9	3.46
Basmati-370		158.7	2.96
Kalanamak		151.5	1.68

combinations in F_3 to F_7 generations were made and 110 bulks were harvested. In an advanced yield trial, 30 aromatic, semi dwarf, high yielding promising breeding lines belonging to six crosses were evaluated in which five cultures recorded yield of more than 4 t/ha (Table 15).

Evaluation of breeding material with slender grain and desirable grain quality

One hundred and twenty single plant selections belonging to eight cross combinations were made based on their agro-morphological and slender grain characters. Ten new crosses were attempted with Sharbati as quality donor and Jaya, Pankaj, Pusa 44 as HYVs. In a replicated trial, 27 promising cultures were evaluated, out of which five genotypes having more than 4.5 t/ha yield capacity with slender grain were identified.

Evaluation of aromatic cultures under AICRIP trials

Seventy four genotypes were evaluated under four AICRIP trials *viz.*, IVT-BT with 20 entries, AVT-1BT with 13 entries, IVT-ASG with 27 entries, AVT-1 ASG with 14 entries. Eight entries with promising performance were identified (Table 16).

Nomination for promising cultures for national testing

Five promising high yielding semi dwarf aromatic cultures having grain yield potential of more than 4.5 t/ha were nominated for AICRIP trial IVT-ASG (Table 17).

Table 16. Performance of entries under IVT ASG

IET no.	DFF	Plant height (cm)	No. of panicles/ m^2	Grain yield (t/ha)
23189	128.5	100.9	267.0	5.33
23187	119.0	135.9	218.0	4.65
23186	117.5	130.0	188.5	4.65
23193	119.5	113.9	224.5	4.37
22648	123.5	115.9	243.5	4.35
23204	144.0	124.9	222.5	4.28
22649	125.0	111.5	234.5	4.17
23192	143.5	122.2	190.0	4.04
Ketekijoha	133.5	133.0	315.0	3.18
Kalanamak	118.0	178.1	209.0	2.83
Badshabhog	129.5	173.5	257.5	2.75
CD ($P< 0.05$)				0.64

Table 17. Promising aromatic cultures nominated for AICRIP trial IVT-ASG

Designation	Cross Combination	DFF	Grain yield	Grain yield t/ha
CR2738-2	CR689-116-2/ Kalanamak	120	MS	4.78
CR2947-18	CRM2203-4/Dubraj	120	MS	4.90
CR2934-35	Geetanjali /Dubraj	118	MS	5.04
CR2713-35	Swarna/Geetanjali	115	MS	4.90
CR2947-1	CRM2203-4/Dubraj	106	MS	4.50

Evaluation of basmati breeding material

Segregating population belonging to cross combinations involving Taraori Basmati, Basmati 386 with CR 689-116, NLR 34449, Basmati 370, CRM 2203-4 were evaluated and 69 single plant selections were made. Photo insensitive aromatic breeding material from CR2939 (IR 36/Basmati-370) with medium slender grain and CR2983-6-2 (Pusa Sugandh 2/Basmati-386) with long slender grain were evaluated in the *rabi* season and from the segregating population of five semi-dwarf lines with uniform stand having more than 9 mm kernel length were identified for further evaluation and nomination to national basmati trial.

Performance of promising entries in national trials

IET-21840, a promising aromatic culture with medium slender grain and high HRR was promoted to AVT-2 ASG for third and final year of AICRIP evaluation.

Three aromatic short grain cultures CR2713-179 (IET-22648), CR2713-35 (IET 23192) and CR2713-180 (IET-22649) were promoted to second year trial in AVT-1 ASG.

New varieties released/identified

Poornabhog

IET 18008/CRM2203-4, a semi dwarf culture with long slender grain developed through mutation breeding from Pusa Basmati-1 was released by SVRC, Odisha and was notified by CSC on CSN & RV, Government of India. It has maturity duration of 145 days, plant height of 100 cm, HRR of 68.8 %, amylose content 23.8%, test weight of 19 g , average grain yield capacity of 5.0 t/ha and suitable for shallow lowlands.

CR Sugandh dhan 907

IET-21044 (CR2616-3-3-3-1), semi dwarf aromatic short grain culture developed through hybridization from Pusa44/Dubraj was recommended by VIC for central release for the states of Chhattisgarh, Odisha, Gujarat and Andhra Pradesh. It has maturity duration of 145-150 days, plant height of 89 cm, HRR of 63.3%, amylose content 20.3%, test weight of 15 g, average grain yield capacity of 4.2 t/ha and suitable for shallow lowlands. The notification proposal was submitted to CSC on CSN&RV for consideration and committee recommended for release and notification subject to submission of nutrition profile which was duly complied.

Standing crop and grain of aromatic variety Poornabhog

Standing crop and aromatic short grain of CR Sugandh Dhan 907

Identification and mapping of genes/QTLs associated with grain aroma

Eight hundred fifty single plant selections of F_6 generation mapping population belonging to the cross (Pusa 44/Kalajeera and Gayatri/Kalajeera) were collected to raise the F_7 population for phenotyping.

Genetic diversity in aromatic short grain rice of Odisha

Genetic diversity study with PCR assays utilizing 24 hyper variable rice microsatellite markers, two from each chromosome was done for establishing genetic diversity and genetic relationship among the 137 (including 4 checks) traditional aromatic short grain rice landraces of Odisha.

A total of 110 alleles were recorded for the 24 primer pairs in the 137 genotypes under study. The number of

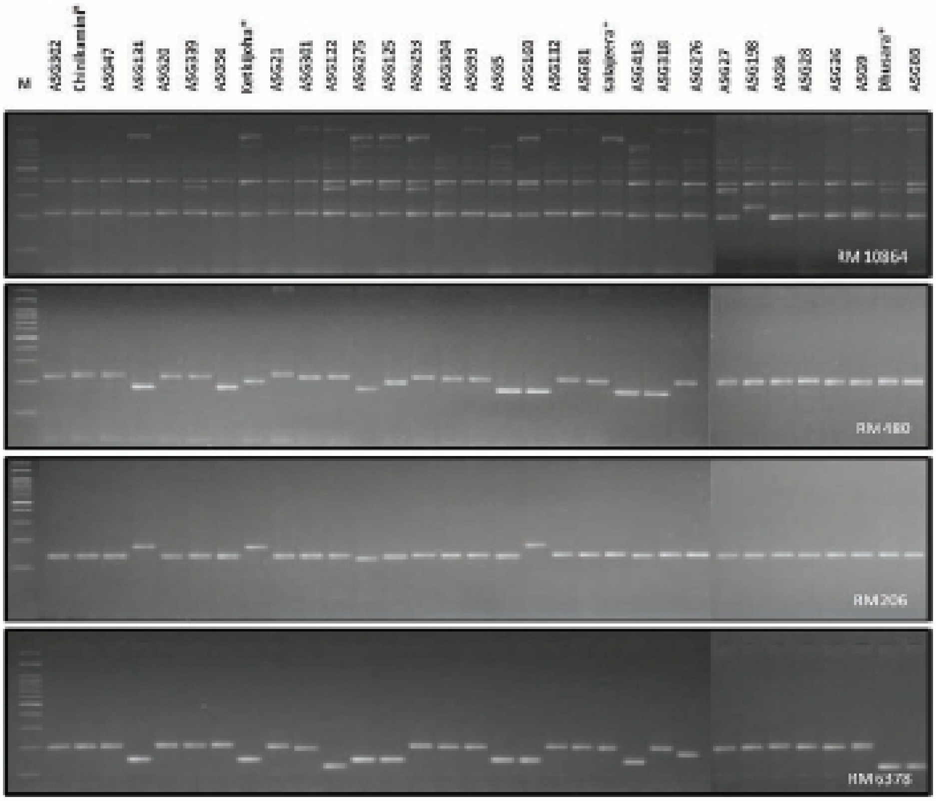


Fig 4. Genetic diversity

Aromatic short grain diversity

alleles varied from 2-12 for the markers tested. The PIC values for different markers ranged from 0.124 to 0.965 with a mean value of 0.553 and all the markers showed polymorphism. The mean value of 0.553 indicates high variability in the populations.

There was good variation in morphological characters also and the range for plant height was from 157 cm to 184 cm, panicle length from 18 to 31 cm and grain yield potential from 2.8 to 4.6 t/ha.

Biofortification of popular high yielding rice varieties with additional levels of iron and zinc through conventional approach

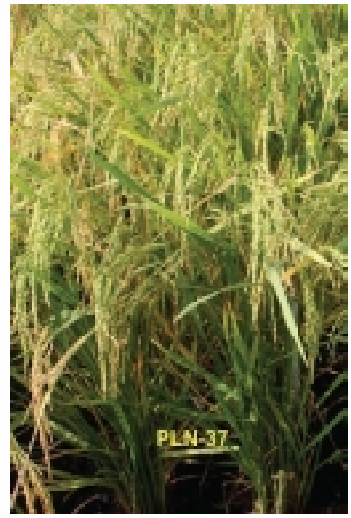
In order to develop genotypes with higher level of micronutrient (Iron and Zinc), SSD population in F_5 (12341 single plants belonging to 30 crosses involving Pusa 44, Gayatri, NDR 359, PR 118, PR 111, BPT 5204, Savitri, Sarala, Swarna and MTU 1071, Azucena, Jalamagna, Basmati-370, Dhusara and Chinikamini) were advanced and 550 single plant selections were made. During *rabi* season promising single plant collection from BPT-5204/Azucena (CR3702) and Gayatri / Azucena (CR3703) were grown and samples from 5 fixed line selections were sent to DRR for validation.

Capitalization of prominent landraces of rice in Odisha through value chain approach of pure lines of Machhakanta, Haladichudi and Kalajeera with desirable agro-morphological characters were identified for molecular analysis.

Development of elite lines with high grain protein content in high yielding background

Around 350 single plants and 30 bulk population (F_7-F_8) derived from 10 cross combinations involving high grain protein content donors, have been selected in *kharif* 2012 and planted in *rabi* season for evaluation.

ARC10075 (donor for high grain protein content) was crossed with high yielding popular variety, Naveen. A mapping population (BC_3F_3) from this cross was developed by three consecutive backcrossing with recurrent parent Naveen, followed by single seed descent. Two hundred lines (PLN-1 – PLN-200) from this population along with parents were planted and evaluated for yield, yield attributing traits and grain protein content. Normal distribution (Kolmogorov-Smirmov test) in the mapping population was observed for all traits such as maturity duration (109-130 days), plant height (100-157 cm), number of panicles/ plant (4-18), panicle length (20.67-33.0 cm), spikelets/panicle (27.5-189.5), seed yield/ plant (8.5-39.7 g), Grain protein content (5.95-12.15%) and single grain protein (0.76 to 2.25 mg). Grain protein content(%) and single grain protein content did not show any significant correlation with grain yield. Recombinants PLN- 31, 32, 37 and 116 were detected with acceptable plant type, high yielding ability and high grain protein content. Promising lines with both high grain protein content (>10%) and high single grain protein content (>2 mg) were identified along with plant height and duration (Table 18).



Introgression lines with high GPC and desirable yield traits

Improvement of Rice through *in vitro* and Transgenic Approaches

Indicator of pollen uninucleate stage of CR Dhan 701 for anther culture

The length between the flag leaf and second leaf in the spike was 8-10 cm which coincided with the

Table 18. Promising BC_3F_3 lines derived from ARC10075/Naveen cross

Sl.No.	Duration	Plant height (cm)	GPC (%)	Single grain protein content (mg)	Grain protein yield/plant (g)
PLN-31	113	126	10.83	2.25	2.62
PLN-32	117	123	12.15	2.23	1.70
PLN-36	114	105	11.07	1.91	1.65
PLN-37	118	130	11.56	2.15	1.86
PLN-97	118	130	11.00	1.95	1.42
PLN-98	114	126	11.58	1.95	2.47
PLN-99	117	138	11.69	2.16	1.80
PLN-100	111	120	10.59	2.08	2.73
PLN-106	116	122	11.38	1.93	3.17
PLN-108	109	110	11.51	2.04	1.43
PLN-114	117	133	10.97	1.82	3.28
PLN-116	115	121	11.86	2.09	3.24
Naveen	125	116	8.10	1.47	1.80
ARC10075	130	159	11.20	2.25	1.60

uninucleate stages of the pollen. The indicator was fixed for early to late uninucleate stages of the pollen for which the position of the anthers were in the middle of the spikelet.

Standardization of media components and physical conditions for generation of doubled haploids via callusing from anthers of CR Dhan 701

The uninucleate anthers of hybrid rice variety, CR Dhan 701 responded 18-20% to callus induction in N6 semi-solid media supplemented with 2,4-D (2.0 mg/l), BAP (0.5 mg/l) and 3% maltose after 3-4 weeks of culture incubated in dark. MS and SK-1 media supplemented with different concentrations and combinations of growth regulators (BA, 0.1-0.5 mg/l; NAA, 1.5-3.0 mg/l) and concentrations of carbohydrates (sucrose and maltose; 3% -6%) did not show any promising response to callus induction. The panicles pretreated at 10°C for two days and eight days responded better as compared to 6 and 10-days of incubation. After 1- 2 week on callus induction medium, the calli were subcultured into MS media containing different concentrations of Kn (0.5-1.0 mg/l), BAP (0.5-2.0 mg/l) alone or in combinations along with NAA (0.25-0.5 mg/l) and 3% sucrose/ maltose for shoot bud regeneration. Subsequently, the light yellowish calli turned in to green colour which developed in to green shoot buds in the MS media supplemented with Kn 0.5- 1.0 mg/l + BAP 1.5 mg/l + NAA 0.5 mg/l + sucrose 30 g/l after 2-week culture showing 84.4% shoot regeneration at 25±2°C under 16-h photoperiod. After 4-weeks, micro shoots formed the roots grown in MS+ Kn 0.1-0.5 mg/l+ NAA 1.0-2.0 mg/l+ sucrose 30-50g/l. A high percentage of shoots (96%) rooted in the medium contain-ing half strength MS basal salts with MS+ Kn 0.1 mg/l+ NAA 1.0 mg/l+ sucrose 50g/l after 11-12 days of culture at 25±2°C under 16-h photoperiod.

During *kharif* season, about 1500 anthers were cultured in N6 media supplemented with 2,4-D (2.0 mg/l) and BAP (0.5 mg/l) out of which 270 responded for callus induction. A total of 220 calli cultured on to MS media supplemented with Kn 0.5 mg/l + BAP 1.5 mg/l + NAA 0.5 mg/l + sucrose 30 g/l showed 186 green shoot regeneration followed by rooting out of which 44 plants were transferred to the net house. Thereafter, 24 plants survived showing promising growth; panicle emergence and seed set from which 1, 13, 8 and 2 were found to be haploid, diploids, polyploids and mixploids, respectively. Different variants of doubled haploids (DH) for grain size were recorded.

Ploidy status in doubled haploid lines derived from CR Dhan 701

Grain diversity in doubled haploid lines derived from CR Dhan 701

Evaluation of ploidy status using SSR markers

Four SSR markers (RM163, RM480, RM481and RM490) differentiating the parental lines of CR Dhan 701 were used to evaluate the ploidy status of 20 anther-derived plants out of which 2 markers (RM163 and RM480) could discriminate diploid line (like the

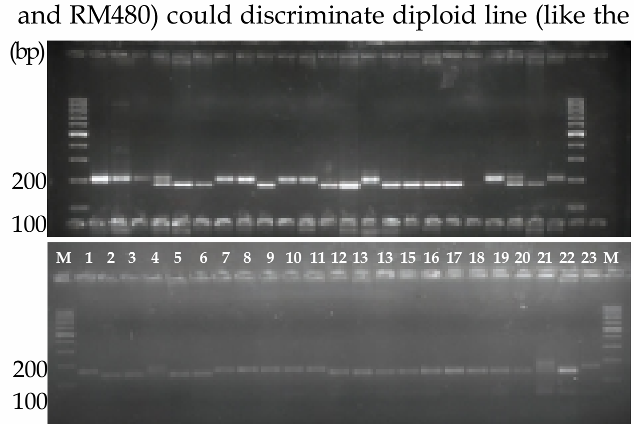


Fig 5. Discrimination of diploid lines using STMS markers, M : marker (100bp); 1-20: anther derived green plants; 21-CRDhan 701; 22:CRMS31A:CRL22R

donor, CR Dhan 701) from other ones (Fig.); no markers were found suitable to identify the DHs from polyploids and mixploids.

Efficiency of callusing/regeneration in ratoon vis-a-vis main crop of rice hybrid CR Dhan 701 through anther culture

The efficiency of callusing/regeneration in ratoon vis-a-vis main crop of rice hybrid CR Dhan 701 through anther culture were studied from which it was observed that the anthers derived from the ratoon plants showed lower response for callus growth than the main crop cultured in the media of similar composition (N6 + 2, 4-D 1.5mg/l + BAP 0.5 mg/l + 3% sucrose). However, no shoot bud regeneration was observed from the calli derived from the ratoon plants cultured for 8-10 weeks while plants regenerated from the calli of the main crop within 3-4 weeks of culture.

Field evaluation of DHs lines of elite hybrid rice variety(s)

A total of 429 doubled haploid lines (243 and 186 from CRHR5 and CRHR7, respectively) were evaluated during *rabi* 2012. One hundred and sixty seven doubled haploids of these were evaluated during *kharif* 2012 and 45 promising doubled haploids were selected for further evaluation during *rabi* 2013.

Development and Use of Genomic Resources for Genetic Improvement of Rice

Development of mapping populations (RILs) for yield traits and BPH resistance

The mapping populations (F_4, F_5 and F_6) for yield traits and BPH resistance (F_6) from different crosses (CR662-2211-2-1/WAB 50-56 for *per se* yield, PDKV Shriram/Heera for grain number, AC38562/ Pimpudibasa for 1000 grain weight, TN1/ Dhobanumbari for BPH resistance) were grown in the field during *kharif*. The F_5, F_6 and F_7 selfed seeds from corresponding lines were harvested during December, 2012 for further generation advancement and phenotyping.

Evaluation of genotypes for blast resistance

One hundred and eighty five rice genotypes, mostly belonging to eastern India and having known blast reaction at Hazaribag but unknown genetic constitution, were re-evaluated in an outdoor blast nursery to group them into resistant (no visible symptoms or hypersensitive flecks), moderately resistant/susceptible (typical susceptible lesions but diseased leaf area not exceeding 2%) and susceptible (diseased leaf area above 5%) classes of which 65 genotypes were found resistant, 71 moderately resistant/susceptible and 49 susceptible. Different sets of rice varieties in each category with un-ambiguous scores were selected for association mapping during the wet season of 2012. DNA was isolated from each and prepared for *Pi* gene based marker analyses. Gene based markers like SNPs and STS for *Pi9, Pi2, Pita/Pita-2, Piz, Piz-t* and *Pib* have been selected on the basis of previous study for association mapping.

Evaluation of genotypes for drought stress tolerance

Fifty upland rice genotypes were evaluated for drought tolerance under rainout shelter facility during 2012 *kharif* at CRURRS, Hzaribag. Based on leaf rolling and drying score (SES), the genotypes were grouped for drought tolerance. Only eight genotypes were found to have good drought tolerance with a score of 3. Majority of the genotypes (27) were moderately drought tolerant, scored 5. Seven genotypes were moderately susceptible (score 7) and eight genotypes were highly susceptible (score 9). Based on canopy temperature, biomass and leaf drying score, the promising drought tolerant genotypes identified were Salumpikit, VLDT1, Kalia, Sukhawan, RR517-34-1-1 and CRR455-109.

Fifty rice genotypes were evaluated under rainout shelter during *rabi* 2012 at CRRI, Cuttack. These genotypes were subjected to severe drought stress starting from 30 days old crop at CRRI, Cuttack. The drought scores and recovery data were recorded as per SES scale of 0-9. Besides, EVV, SPAD and RWC% data were recorded. Twenty six genotypes showed drought tolerance with score of 0-3 at seedling stage.

Fifteen hundred ninety genotypes were direct seeded at Santhapur during *kharif* 2012. Only fifty two genotypes showed drought tolerance with score of 0-1 at flowering stage.

Evaluation of rice genotypes for salinity stress tolerance

Seven hundred twenty two genotypes were evaluated for salinity tolerance during *rabi* 2012 at Ersama, of which 258 showed salinity tolerance with score of 3-5 at seedling stage. One hundred sixty out of 822 genotypes showed salinity tolerance with score of 3-5 at seedling and flowering stage during *kharif* 2012 in farmer's field.

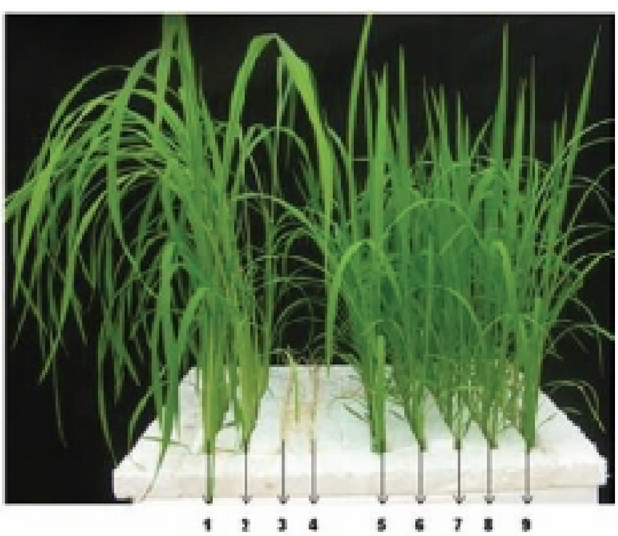
Evaluation of rice genotypes for submergence stress tolerance

Six hundred eighty one genotypes were evaluated in four batches for submergence tolerance (14 days of complete submergence) during *kharif* 2012. Only 24 genotypes showed tolerance with > 50% survival.

Salinity tolerance in rice

Towards functional validation of eukaryotic translation initiation factor 4A isolated from Pennisetum glaucum (PG-eif4A)

Transgenic lines of Swarna with *Pennisetum glaucum* eukaryotic translation initiation factor 4A (*PG-eif4A*) showed increased salinity tolerance at germination and seedling stage (160 mM NaCl~16 dS/m). However, *PG-eif4A* over-expressed transgenic lines could survive only at 30 mM NaCl (~3 dS/m) at reproductive stage, able to set seed and produced higher number of filled grains as compared to non-transgenic WT Swarna. Enhanced activity of antioxidant enzymes (SOD and APX) was also observed in *PG-eif4A* over-expressed transgenic lines of Swarna. It is evident from our experiment that, factors involved in post transcriptional level of protein synthesis, like eukaryotic translation initiation factor 4A (*eIF-4A*), are also actively involved in salinity tolerance in plants.



Seedling stage salinity screening of rice plants in hydroponics 1) FL478 (Tolerant Control), 2) Pokkali (Tolerant Control), 3) IR29 (Susceptible Control), 4) WT Swarna, 5) T3-9, 6) T3-12, 7) T3-32, 8) T3-40, 9) T3-101

Development of Resilient Rice Varieties for Rainfed Direct Seeded Upland Ecosystem

Development of new varieties combining desirable traits both from adapted and unadapted sources

Hybridization, generation and evaluation of breeding lines

Twenty four (24) new crosses (including multiple cross and backcross) were made for the development of resilient varieties for rainfed direct seeded upland (Table 19). Out of these 24 crosses, F_1s of 10 crosses were generation advanced during *rabi* 2013. A total of 2781 segregating breeding lines of different generations (F_3 to F_8) from 187 crosses were evaluated during *kharif* 2012 and based on duration, plant type, panicle

Table 19. List of crosses made during *kharif* 2012

S. No.	Crosses
1	(Anjali/CR2340-11// IR64//IR64/ Sukhawan) x (Vandana/ CT9993-5-10-1-M // ARB7/ WAB 880-1-38-20-23-P2-HB)
2	Kalinga III/TJP 48// Kalinga III
3	RR 166-645/TJP 48// RR 166-645
4	RR 51-1/TJP48// RR 51-1
5	Anjali / MAULS 21
6	MAULS 21/ Anjali
7	Sadabahar/ MAULS 21
8	Sadabahar/ IR84984-83-15-481-B
9	MAULS 11/ Anjali
10	MAULS 11/ IR84984-83-15-481-B
11	Abhishek/ IR84984-83-15-481-B
12	MTU 1010/ WITA 12
13	Bhalum 3/ IR64
14	RCPL 1-128 / IR 64
15	Sahbhagi dhan / IR 87707-446-B-B
16	Kataktara/ Swarna
17	Abhishek/ MTU-1010
18	Benibhog/ CH-45
19	Brown gora/ IR-36
20	CR Dhan 40/ IR-36
21	Sushk Samra/ Heera
22	Brown gora/ Naveen
23	Sahbhagidhan/ Hazaridhan
24	Vandana/ Hazaridhan

Table 20. Selections from previously generated breeding populations for rainfed uplands at Hazaribag, *kharif* 2012

Generation	Cross	Progenies grown	SP selected	Bulk selected
F_8	23	37		26
F_7	26	68	17	20
F_6	30	76	51	
F_5	30	199	147	
F_4	28+19	368+698	233+587	
F_3	31	1335	763	
Total	187	2781	1798	46

characters and reaction to abiotic and biotic stresses 1798 single plants and 46 bulk selections were made (Table 20), of which 802 lines were grown at Cuttack during 2013 *rabi* season for generation advance and seed multiplication.

Entries promoted and new nominations in AICRIP trials

Considering the yield advantage under drought, the entries IET22020, IET22744 and IET22743 were promoted for advance testing in AVT-VE (2nd year) and IET23377, IET23379, IET23380, IET23383, IET22747, IET23345, IET23419 were promoted to AVT (1st year). Thirty promising entries developed at this station have been nominated for initial varietal testing under AICRIP trials during 2013 *kharif* season.

Promising breeding line identified for irrigated ecosystem

A new breeding line, CRR624-207-B-1-B (IET22097) derived from the cross Apo/IR64, of mid-early duration (120 days) with intermediate height (112 cm) and desirable grain quality characteristics, found promising under national coordinated trials in the states of Odisha and Jharkhand. Averaged over three years, it showed 12.3%, 6.5% and 13.5% yield superiority to the national, regional and local checks, respectively. This entry is resistant to leaf blast, moderately resistant to brown spot and drought, has high HRR (64.9%), intermediate ASV (4.0), acceptable AC (22.09%) and soft GC (41).

Identification of novel sources of resistance to drought and associated biotic stresses, and improvement of popular varieties for major abiotic (drought) and biotic (blast) stresses through introgression of known QTLs/genes

Development of mapping populations, foreground and background selection with phenotyping

Marker-assisted backcross breeding approach was employed to improve further drought tolerance of popular upland variety CR Dhan 40 in terms of grain yield under stress. For the introgression of grain yield under stress QTLs *DTY1.1* and *DTY12.1*, crosses were made between CR Dhan 40 and donors (IR86918-B-305 and IR84984-83-15-481-B for *DTY1.1* and *DTY12.1*, respectively). A total of 14 and 10 F_1s of the two crosses were raised during *rabi* 2013 and hybrid status was confirmed with the linked markers, RM431 and RM27981 for DTY1.1 and DTY12.1, respectively (Fig 6 A and B).

Hybridization was initiated to introgress blast resistance genes (*Pi9, Pita-2 and Piz-5*) in two varieties, namely, Sahbhagidhan and Naveen. F_1s were checked for hybridity with linked SSR markers AP5930, RM7102 and AP5659 for *Pi9*, *Pita-2* and *Piz-5*, respectively

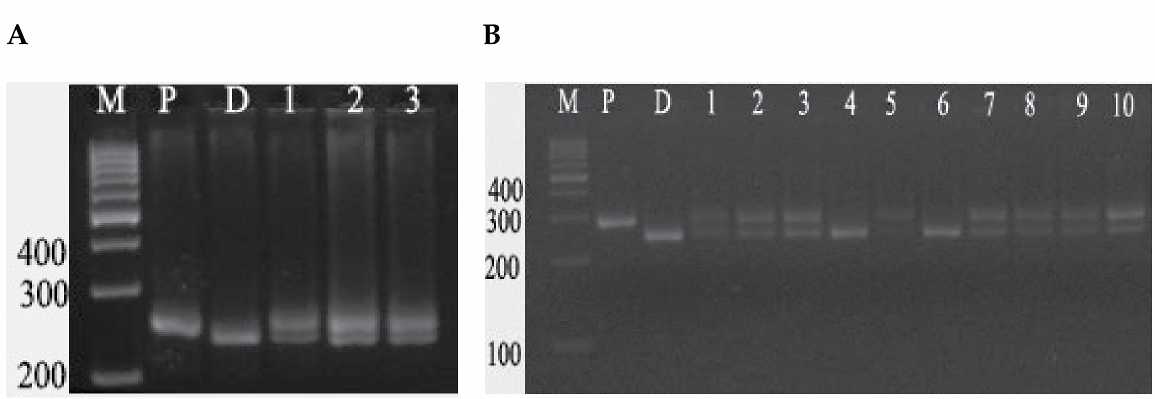


Fig 6. F_1s between CR Dhan 40 x DTY1.1 donor (A) and CR Dhan 40 x DTY121.1 donor (B) showing heterogzygosity for the linked markers

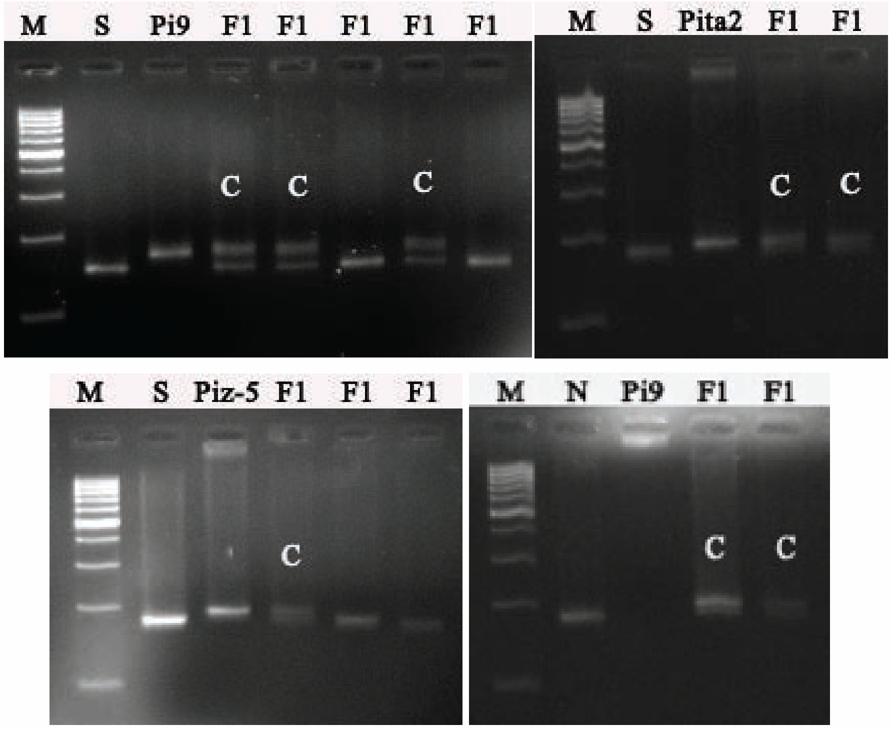


Fig 7. F_1s between Sahbhagidhan and Pi9, Pita-2 and Piz-5 donor (a-c) and Naveen and Pi9 donor (d) showing heterogzygosity for the linked markers

(Fig 7) and the confirmed plants were advanced for further hybridization during *rabi* 2013.

A recombinant inbred line (RIL) population of Kalinga III/ Salumpikit was developed to identify the QTLs for drought tolerance related traits including grain yield under stress. Two hundred and twenty nine RILs of this population were evaluated under both stress condition during *kharif* 2012. The analysis of variance indicated significant variations for all the traits measured (Table 21). Transgressive segregation in both directions was observed for most traits, indicating that both parents transmitted favorable alleles for each trait. The phenotypic distributions in the RIL lines for most of the traits fitted a normal distribution except grain yield, indicating the quantitative nature of inheritance. For genotyping of the population DNA extraction of the 229 RILs was done along with parents. Two new populations (Kalinga III/VLDT1 and K-III/CR143-2-2) of 350 lines each were generation advanced in F_5 following SSD method.

Table 21. Trait means, ranges, SD and F-statistic for grain yield and its components among RILs of Kalinga III x Salumpikit

Trait	Kalinga III	Salumpikit	RILs		Standard deviation	F-Statistic
			Range	Mean		
Days to flower	64	96	55-109	81.1	9.2	9.858**
Plant height (cm)	88.9	113.4	76.9-148.0	113.6	13.9	3.349**
Biomass (g/plot)	121	229	47.8 – 406.6	168.6	55.2	2.367**
Panicle length (cm)	20.1	21.8	17.6-32.5	22.3	2.1	2.547**
Filled grains per panicle	24	50	0 - 77	43.0	12.8	2.084**
Percent spikelet sterility	77.41	42.9	27.7 - 100	51.8	12.5	2.279**
Drought score (SES)	7	3	2 - 8	5.2	1.2	1.619**
Grain yield (kg/ha)	295	851	0 - 1467	406.9	327.9	4.051**

A population of 176 RILs of Kalinga III x Moroberekan, developed by single seed descent method, for abiotic and biotic stress tolerance was evaluated for blast and brown spot in nurseries during *kharif* 2011 and 2012. Leaf blast scores (SES scale 0-9) ranged from 0 to 7 and mean diseased leaf area (DLA) up to 50% in the population during 2012 with a skewed distribution towards resistance (Fig 8) indicating that resistance is governed by several genes/QTLs. Susceptible parent (Kalinga III) also appears to have minor genes as several transgressive segregants with higher diseased leaf area were observed in the population.

This population was also evaluated for brown spot for the second consecutive season. Unlike blast, most of the RILs had a susceptible reaction, with only 16 among them exhibiting lower disease scores than resistant check Ch 45 (Fig 9).

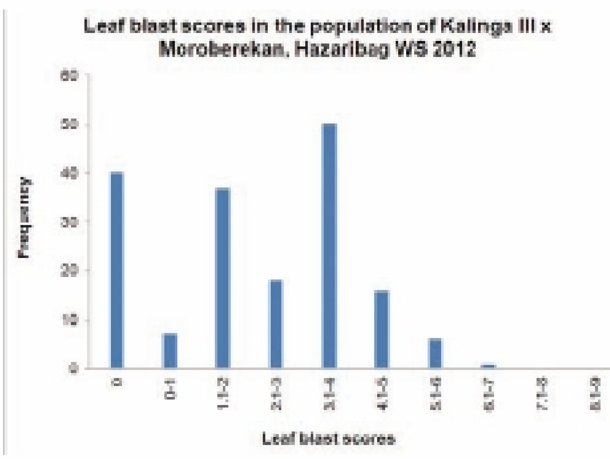


Fig 8. Distribution of Kalinga III x Moroberekan RILs for leaf blast score

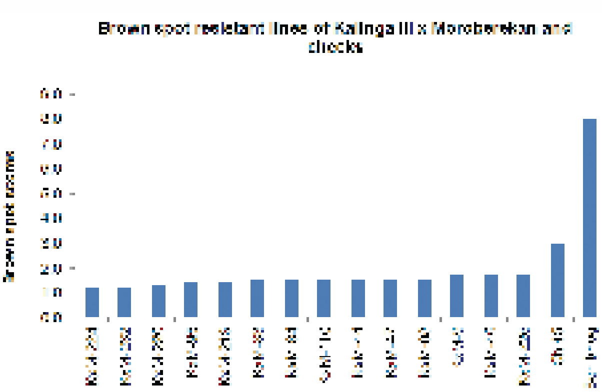


Fig 9. Distribution of Kalinga III x Moroberekan RILs for brown spot score

Identification of genotypes with multiple stress tolerance and productivity

Evaluation of germplasm and elite lines (including coordinated trials) for abiotic stresses and yield under stress

AICRIP trials

IVT-VE

Eighteen entries along with three checks of very early maturity duration were evaluated under rainfed uplands. There was deficient rainfall only in the month of July and short drought spells in the month of September corresponding to grain filling stage. The top yielding entries in the trial were RP5334-6-2-B (2.47 t/ha), CRR451-15-B-A1 (2.31 t/ha) and CRR616-B-2-54-1 (2.27 t/ha) which were significantly better than highest yielding check Vandana (1.75 t/ha) (Table 22).

IVT-E

Forty entries including checks were evaluated. Best entry RP5125-9-6-2-1(2.85 t/ha) out yielded the national check Sahbhagidhan by 29%. Other promising entries were CR2994-5-3-2-1(2.64 t/ha) and CR3693-1-1 (2.571 t/ha) but statistically at par with the best check Sahbhagidhan (2.21 t/ha).

AVT and IVT-IME

In AVT2-IME, CR2706 (6.63 t/ha) was the best entry given 6.6% higher yield than the hybrid check PA6201 (6.22 t/ha). Other promising entries were NVSR-178 (6037) and UPR 3413-8-2-1(5.96 t/ha). In AVT1-IME trial, two entries TRC 2008-6 and HRI-176 (5.89 t/ha) were found as top yielders followed by rest of entries including checks and both entries gave 13.1%, 23.2%, 33.3% and 59.4% more yield than all checks including hybrid, national, regional and local checks. In IVT-IME trial, CN1782-18-1-9-MLD (6.25 t/ha), RP 5212-41-4-3-1 (5.60 t/ha), and CR 3564-1-1-1-1 (5.40 t/ha) were the top yielding entries out yielding the best check IR 64 (5.00 t/ha).

IR 64 NIL Drought

The trial was composed with 3 IR64 NIL-DRT entries developed at IRRI by introgressing grain yield under stress QTLs *qDTY2.2*+*qDTY4.1* along with recurrent parent IR64 were evaluated both under stress and control condition. In rainout shelter drought was imposed at 60 DAS and severe stress generated corresponding to growth stage flowering to grain

Table 22. Promising entries under AICRIP trials conducted at Hazaribag during *kharif* 2012

Trial	Promising entry	Grain yield (t/ha)		CD(0.05)	CV (%)
		Best check	Mean		
IVT-VE	RP 5334-6-2-B (2477) CRR 451-15-B-A1 (2318) CRR 616-B-2-54-1(2273)	Vandana (1.75)	1.81	0.43	11.6
IVT-E	RP5125-9-6-2-1(2857) CR2994-5-3-2-1(2643) CR3693-.31-1(2571)	Sahbhagidhan (2.21)	1.82	0.53	14.5
AVT2-IME	CR2706 (6630) NVSR-178 (6037) UPR 3413-8-2-1 (5963)	IR64 (5.40)	5.27	0.62	7.2
AVT1-IME	TRC 2008-6 (5856) HRI-176 (5856) KPH-385 (5270)	IR64 (4.75)	4.69	0.78	10.3
IVT-IME	CN1782-18-1-9-MLD- (6250) RP 5212-41-4-3-1-1-1-B (5600) CR3564-1-1-1-1 (5400)	IR64 (5.00)	4.25	0.79	9.4

filling. The soil moisture tension was monitored with tensiometer which, went down up to -46 Kpa. The NILs out-yielded the recurrent parent IR64 by 400-425% under severe stress and there was no significant yield difference under control (Table 23).

INGER Nursery (IURON)

Sixty two entries along with checks were evaluated in unreplicated design under direct seeded rainfed uplands. Based on drought response, spikelet fertility and phenotypic acceptability, the promising entries identified from the nursery were B 11576F-MR-18-2 (2.2 t/ha), CT 15673-8-2-3-3-1-M (2.16 t/ha), IR 82635-B-B-143-1 (1.84 t/ha) and UPLRi7 (1.76 t/ha) (Table 24).

Evaluation of germplasm and elite lines (including coordinated trials) for blast, brown spot and bacterial blight

Blast resistance

Thirty two North-East and Eastern Indian rice germplasm accessions were screened for the presence of nine major blast resistance (*R*) genes, *Piz, Piz-t, Pik, Pik-p, Pik-h, Pita/Pita-2, Pib, Pi9* and one susceptible *pita* geneusing a set of ten SNP and gene based STS markers. They were also evaluated for resistance to blast in the UBN. Among the 32 accessions, 13 were positive for *Piz* gene and six for *Piz-t* gene. Six accessions were positive for *Pik* gene, seven for *Pik-p* and 16 for *Pik-h*

Table 23. Performance of IR64 NILs (AICRIP) under Stress and Non-stress conditions, Hazaribag *kharif* 2012

IET No.	Designation	DTF-Control	DTF-Stress	PHT-Control	Grain yield (t/ha)	
					Control	Stress
22836	IR 87707-445-B-B-B	88	95	108	5.60	0.59
22835	IR 87707-182-B-B-B	86	93	105	5.64	0.62
22837	IR 87707-446-B-B-B	89	95	111	5.25	0.55
	IR 64	86	94	95	5.37	0.11
Mean		85	93	106	5.05	0.38
CD (P< 0.05)		1.0	2.47	5.6	0.91	0.15

Table 24. Promising entries of IURON

Designation	Grain Yield (t/ha)	DTF (days)	PHT (cm)	PACP	DRS	SPFERT
B 11576F-MR-18-2	2.20	77	125	3	3	1
CT 15673-8-2-3-3-1-M	2.16	76	112	1	3	1
IR 82635-B-B-143-1	2.00	71	94	3	3	1
IR 78933-B-24-B-B-4	1.84	74	87	5	3	1
UPLRi7	1.76	77	102	3	3	1
Anjali	1.40	67	92	1	3	1

gene. One accession, Atte thima, was positive for three of *Pik* multiple genes. The *Pib* gene appeared to be commonly present and was detected in 31 of 32 germplasm lines. The gene specific STS marker for *Pi9* gene produced positive bands in only two germplasm, Kalchatti and Bachi thima. Uniform Blast Nursery (UBN) analysis showed that out of 32, six genotypes were resistant (R), 10 moderately resistant (MR) and 16 susceptible. Presence of *Piz-t, Pita/Pita-2* and *Pi9* gene ensured a resistant reaction in outdoor blast nursery, whereas genotypes carrying *Pib* was susceptible when present alone.

Presence of the *Pi9* gene in another set of 47 rice germplasm accessions, known to be resistant to blast at Hazaribag, was determined using dominant sequence tagged site marker 195R-1/195F-1 derived from the Nbs2-*Pi9* candidate gene and resistance confirmed by inoculating rice germplasm with a mixture of aggressive isolates of *M. oryzae*. The *Pi9* gene was found in six rice germplasm accessions from Eastern India.

A set of 927 rice germplasm provided by NBPGR; 1050 advanced breeding lines of constituting the national screening nurseries NSN 1, NSN 2, NSHN, NSN(H) and DSN; 84 entries of the International Rice Blast Nursery and 25 monogenic differentials were screened for leaf blast in the UBN. Among the NBPGR germplasm, 181 were highly resistant, others were moderately to highly susceptible. Twenty five advanced breeding lines of early and very early duration, developed for the direct seeded upland ecosystem were part of the national coordinated nurseries. Since incorporation of blast resistance is inherent in the varietal development programme for drought prone situations, most of the breeding lines promoted to METs have blast resistance at Hazaribag. These advanced breeding lines had lower blast severity index compared to the check Vandana (Table 25 and Table 26) across 21 locations where they were evaluated during 2012.

Brown spot resistance

Among the 514 genotypes screened for resistance to brown spot, only nine showed resistant reaction (Table 27). Among the 1052 lines consisting of NSN 1, NSN 2, DSN and NHSN, 208 were resistant and the rest were

Table 25. Performance of early duration (AVT-E, DS) advanced breeding lines in multi-location trials for blast resistance

IET No. Photo: Pritesh Sundar Roy	Designation	Cross combination	Bl Hzb	Bl SI*
22740	CRR 635-3-2	Vandana /Poornima	0	5.0
22747	CRR 617-B—3-3	Vandana/UPLRi7	4	4.8
23336	CRR 599-4-1	RR 166-645/RR 345-2	0	5.0
23339	CRR 614-4-1	IR55419-4*2/Way Rarem	0	4.4
22586	CRR-648-B-673-1B	IR78875—2/IR 64	0	4.5
23345	CRR 680-B-B-25-4	IR78875-176—2/IR 78875-207-3	0	4.0
23346	CRR 554-3-1-1	Vandana/Swarna	0	4.9
23347	CRR 599-6-1	RR 166-645/RR 345-2	0	5.1
23353	CRR 452-23-1-1-1-1	Vandana /RR 222-1	3	4.7
	Vandana	Check	4	5.4

*Severity index based on 21 locations

Table 26. Performance of very early maturity duration (IVT-VE, DS) advanced breeding lines in multi-location trials for blast resistance

IET No.	Designation	Bl Hzb	Bl SI*
23373	CRR 596-8-1	0	4.4
22032	CRR 505-14-B-RR1-B	0	4.5
22743	CRR 616-B-2-54-1	0	4.9
23375	CRR 507-11-B-2	4	5.0
23376	CRR 539-119-B-B	0	5.0
23377	CRR 523-2-2-1-1	3	4.4
22020	CRR 451-1-B-2-1	0	4.9
22744	CRR 617-B-47-3	0	4.5
23379	CRR 676-1	0	5.4
23380	CRR 427-21-2	0	5.3
23381	CRR 508-5-B-2-1	0	4.8
23382	CRR 482-1-2-1	0	4.4
23383	CRR 451-15-B-A-1	0	4.5
23384	CRR 499-11-2-12-1	0	4.9
23385	CRR 507-11-B-91-4	4	5.4
Check	Vandana	4	5.4

*Severity index based on 21 locations

Table 27. Distribution of brown spot scores in breeding lines and screening nursery

Nursery	0-3 (R)	4-5 (MR)	6-9 (S)	Total
NSN-1	103	88	2	193
DSN	38	86	0	124
NHSN	22	87	2	111
NSN-2	45	405	174	624
Germplasm	9	387	118	514
Breeding lines	10	28	1	39

moderately resistant (666) or susceptible (178). Low scoring entries for brown spot across the 12 hot spot locations were CR2547-62-316, CR2389-5-2-1-1, CR2706 (R84895-B-CRA-171-32-1-2-1), CR2641-26-1-2-2, CR2996-1-14-29-3-1, CR3001-IR86931-B-578-CR5-5-2 and CRHR 34 in NSN1 and CR2683-15-5-3-1-1, CR3607-12-1-1-1, CR2683-7-2-3-1-2 and CR2687-13-5-3-4 in NSN 2.

Bacterial blight resistance

Six hundred nine lines consisting of NSNI, NHSN, DSN and IRBBN with some breeding lines were grown to screen against BLB in transplanted condition. Artificial inoculation was done with clipping method 25 DAT. Based on lesion length and disease scores 212 lines were rated as resistant (Table 28). CR254762-316, CR2378-13-4-1-1, CR2389-5-2-1-1, CR2304-5-7-2-3-1 and CR2683-5-3-2-1-1 had lower scores compared to resistant check Ajaya at Hazaribag and across 27 hot spot locations in India.

Table 28. Distribution of bacterial leaf blight scores among the entries of different nurseries

Nursery	0-3 (R)	4-5 (MR)	6-9 (S)	Total
NSN-1	103	67	23	193
DSN	46	51	27	124
NHSN	31	49	32	112
IRBB	32	30	13	75

Evaluation of elite lines for their response to low N and P

An experiment was initiated during *kharif* 2012 to evaluate the performance of twelve elite rice cultures including two released varieties for rainfed uplands. Three N levels (20, 40 and 60 kg N/ha) were assigned to the main plots and twelve cultures to sub-plots in a split plot design. Rice cultures/varieties were evaluated with an objective to identify the genotype exhibiting good performance under low N application. Interaction effects were found to be non-significant between varieties and N levels, response to N was recorded up to 60 kg N/ha. N levels influenced tillers and panicle bearing tillers per unit area but panicle weight could not be influenced by the N levels. Highest yield was obtained with CRR646-B-93-B-3 followed by CRR433-2-1. Next in order were CRR617-B-47-3 and CRR451-1-B-2-1 (Table 29).

Interaction effects for grain yield and yield attributing parameters were observed to be non-significant. Tillers per unit area, however, differed due to interactions of varieties and N levels (Fig 10).

Rice cultures CRR451-1-B-2-1, CRR677-2, CRR433-2-1 and CRR646-B-93-B-3 produced better yield and more tillers than the other cultures under low N (20 kg N/ha) application (Fig 11). Variations were also caused in number of days taken for 50% flowering and ultimately in maturity. These changes in flowering behaviour are shown graphically in Fig. 6. In majority

Table 29. Effect of graded levels of N and genotypes on grain yield and yield attributes of upland rice (Hazaribag, 2012)

Treatment	Tillers/m²	Panicles/m²	Wt/pan (g)	Grain yield (t/ha)
N-Levels				
20	241	178	2.25	1.32
40	266	212	2.37	1.62
60	237	259	2.50	1.83
CD 5%	16	52	ns	0.18
Varieties				
CRR455-109	248	219	2.06	1.68
CRR427-21-2	255	205	2.59	1.44
Vandana	252	185	2.27	1.32
Anjali	214	176	2.08	1.25
CRR451-1-B-2-1	226	214	2.11	1.80
CRR677-2	238	209	2.09	1.66
CRR507-11-B-1	248	186	2.38	1.36
CRR617-B-47-3	280	299	2.31	1.82
CRR616-B-2-66-2	225	188	2.38	1.24
CRR596-8-1	228	213	2.46	1.39
CRR433-2-1	323	257	2.73	1.98
CRR646-B-93-B-3	239	246	3.00	2.17
CD (P < 0.05)	25	65	0.26	0.21

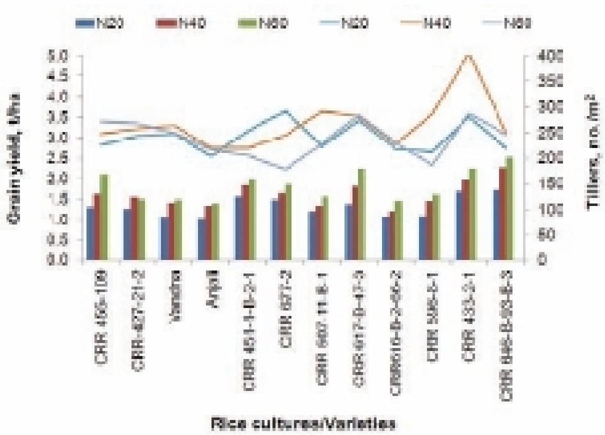


Fig 10. Grain yield (t/ha) and tillers (no./m²) as influenced by rice cultures and graded levels of N

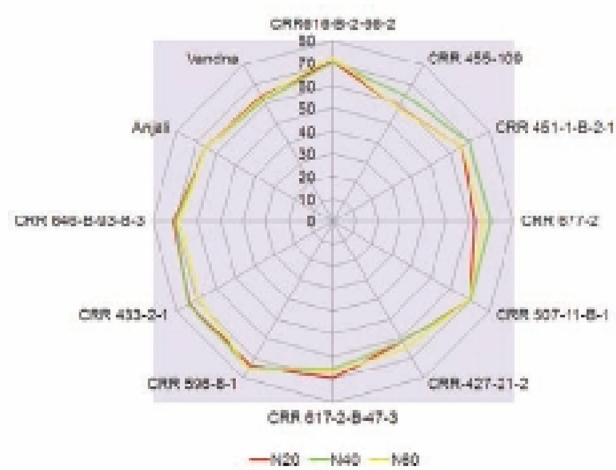


Fig 11. Effect of graded levels of N and rice cultures on 50% flowering (days)

of rice cultures, N application did not influence 50% flowering (Anjali, Vandana, CRR596-8-1, CRR507-11-B-1 and CRR616-2-B-66-2). Varieties exhibiting variations did not show a fixed pattern of change.

Development of Rice Genotypes for Rainfed, Flood-prone Lowland

Maintenance of rice germplasm

Rice germplasm involving 757 accessions were grown for viability maintenance during *kharif* 2012. Observations on days to 50% flowering, plant height and grain yield were recorded. The germplasm lines grown were 150 accessions of deepwater, 129 accessions of semi-deepwater/*Asra* rice, 384 accessions of traditional *Sali*, 60 accessions of traditional *joha* rice and 34 accessions of traditional *boro* rice.

Creation of variability through hybridization for boro rice

Eight single crosses were attempted during *boro* 2012-13. The crosses were: IR 83222-165-1-1-1-1-1-1/Mahsuri, IR 83222-165-1-1-1-1-1-1/Krishna Hamsa, K 39-96-1-1-1-2/BPT5204, K 39-96-1-1-1-2/Swarna, ACC 16684/Swarna, ACC 16684/Krishna Hamsa, ACC 16684/BPT5204 and Chandrama/Swarna.

Evaluation and selection of segregating material for boro rice

Two hundred forty plant progenies derived from 26 crosses were evaluated in F_5 and 60 progenies were selected based on plant type, panicle and grain characteristics and field tolerance to pests and diseases.

Preliminary yield trial for boro rice

Out of 24 uniform breeding lines evaluated, seven promising cultures were nominated to AICRIP for IVT-Boro (*boro* 2012-13) (Table 30).

Preliminary yield trial of rice varieties for rainfed lowland

Twenty eight uniform breeding lines for rainfed shallow lowland situation, twenty six uniform cultures for semi-deepwater ecosystem and sixteen uniform cultures for deepwater ecosystem were evaluated during *kharif* 2012 (Table 31).

Out of the 20 rice entries nominated from RRLRRS, Gerua to AICRIP for national testing during *kharif* 2012, four entries got promoted from IVT to AVT 1 (2 entries in AVT-L, 1 in AVT-DW, 1 in AVT-ASG) and 1(one) entry got promoted from NSDWSN to IVT-SDW level. The entry CRL77-3-1-1-1 ranked 1st in IVT-L across the locations.

Creation of variability through hybridization for *boro* rice

Eight single crosses were made during *ahu* 2013. The crosses were: Banglami/Swarna, Hasakumora/BPT5204, Kalamanik/Abhishek, Luit/Jaldidhan 6, (v) Luit/Swarna, Kalong/Jaldidhan 6, VLD 221/Luit and VLD 65/Banglami.

Evaluation of breeding material in INGER nurseries

During *kharif* 2012, two INGER nurseries, *viz.* IRLON 2012 and GSR-RFL were evaluated. The promising entries identified were Wanxian 77, Huanghuazhan, Hua 564, IR10L182, SACG4, 6527, YJ20, SACG4 and ZGY1.

Table 30. Performance of promising cultures in preliminary *boro* yield trial

Designation	Parentage	Days to 50% flowering	Grain yield (t/ha)
CRL 1-1-3-3-1-2	IR64/Chandrama	144	4.82
CRL 1-1-19-4-3-2	IR64/Chandrama	146	4.79
CRL 2-12-7-2-3-2	IR64/Ranjit	151	5.40
CRL 2-41-6-3-1-1-3	IR64/Ranjit	147	5.40
CRL 2-41-6-7-1-1-7	IR64/Ranjit	155	5.20
CRL 13-15-17-2-1-9	Mahisugandha/Tapaswini	155	5.15
CRL 13-15-17-2-1-11	Mahisugandha/Tapaswini	152	5.31
Krishna Hamsa (Check)		143	4.25
IR 64 (Check)		146	4.29
Chandrama (Check)		156	4.60

Table 31. Performance of promising cultures in preliminary yield trial, *kharif* 2012

Designation	Parentage	Days to 50 % flowering	Grain yield (t/ha)	Grain type	Nominations for testing under AICRIP
CRL1-12-22-6-1-1	IR64/Chandrama	115	5.82	MS	IVT- RSL (*kharif* 2013)
CRL13-66-6-3-1-PR	Mahisugandha/Tapaswini	111	5.31	MS	
CRL1-13-23-2-2-1	IR64/Chandrama	105	5.42	MS	
CRL77-4-1-2-1-1	Sabita/Ranjit	123	5.04	MS	
CRL98-15-6-3-1	Sonjul/Ranjit//Pusa44	121	5.24	MB	
Chandrama (Local check)		112	4.93		
CRL68-141-1-3-1-1	Barh Awarodhi/Ranjit	127	5.12	MS	IVT- DW (*kharif* 2013)
CRL67-9-1-1-1-1	Utkalprava/Panikekoa	128	3.31	MS	
CRL77-32-3-3-1-1	Sabita/Ranjit	128	3.74	MS	
CRL69-28-2-2-2-2	Panikekoa/Ranjit	130	3.26	MS	
CRL70-44-2-2-1-1	Budumani/Ranjit	128	3.81	MS	
Jalamagna (National check)		147	3.13		
Dinesh (Regional check)		146	3.29		
Padmanath (Local check)		134	3.09		
CRL98-80-3-1-1	Sonjul/Ranjit//Pusa44	129	3.12	MB	NSDWSN (*kharif* 2013)
CRL80-27-2-1-2-1	Pusa44/Sabita	121	3.05	LS	
CRL63-25-1-6-1-1	Jajati/Pratikshya	119	3.76	MS	
CRL67-131-1-3-1-1	Utkalprava/Panikekoa	121	4.08	MS	
CRL68-141-1-3-1-2	Barh Awarodhi/ Ranjit	127	5.12	MS	
Sabita (National check)		119	2.69		
Purnendu (Regional check)		139	1.91		
CRL96-37-1-1-1	Pankaj/Pusa44	125	5.04	MS	IVT- L (*kharif* 2013)
CRL74-50-1-PR-3	Pankaj/Podumani	117	4.08	LS	
CRL70-38-2-2-1-1	Budumani/Ranjit	122	4.95	MS	
CRL74-92-4-1-1-1	Pankaj/Podumani	118	5.04	MS	
CRL98-69-1-1-1	Sonjul/Ranjit//Pusa44	120	4.37	MB	
Ranjit (Local check)		128	3.91	MS	
CRL74-89-2-4-2	Pankaj/KDML105	117	4.10	MS	IVT- ASG (*kharif* 2013)
CRL16-66-18-2-PR-1	Mahisugandha/Chandrama	114	4.11	MS	
Ketekijoha (Local check)		118	3.45	MS	

Photo: Pritesh Sundar Roy

ENHANCING THE PRODUCTIVITY, SUSTAINABILITY AND RESILIENCE OF RICE BASED PRODUCTION SYSTEM

Enhancing Nutrient Use Efficiency and Productivity in Rice Based System

Carbon and nitrogen mineralization kinetics in soil of rice-rice system under long term application of chemical fertilizers and farmyard manure

An incubation study was conducted with the soils collected from a 41 year old of rice-rice system to evaluate the differences in C and N mineralization kinetics of soil due to long term fertilization treatments-control (Non fertilized), N, NPK, FYM (Farm yard manure), N+FYM and NPK+FYM, and to assess the C and N mineralization rates of soil under different moisture regimes, i.e. aerobic and submergence. The results revealed that the potentially mineralizable C (C_0), potentially mineralizable N (N_0) and rates of mineralization (dC_{min}/dt and dN_{min}/dt) were higher under aerobic condition as compared to submergence (Table 32). Combined application of chemical fertilizer and FYM (NPK+FYM, N+FYM) showed higher C_0, N_0 and rates of mineralization than the others. Higher values of microbial and mineralization quotients were also observed in NPK+FYM and N+FYM. Long term application of FYM along with inorganic fertilizer maintained soil organic C pool and improved the N supplying capacity of soil in comparison to fertilizer alone and FYM alone.

Higher rates of C and N mineralization observed under aerobic condition could lead to rapid loss of C and N from the aerobic system in long run; this warrants for a judicious N application strategy through integration of both organic and inorganic sources for improving current N supplying capacity of soil and maintaining soil organic C pool in aerobic system.

Effect of N management strategy on N_2O emission, N leaching and N uptake in aerobic rice

Field experiment was conducted with variety Apo in *rabi* season of 2012 to investigate the effect of different N management strategies *viz.*, no N Control, recommended dose of N through urea, recommended dose of N through neem coated urea, LCC based N

Table 32. Potentially mineralizable C (C_0) and potentially mineralizable N (N_0) in soils (0-15 cm) under different long term fertilization and moisture regimes

	C_0 (mg/kg)		N_0 (mg/kg)	
Treatments	Aerobic	Submergence	Aerobic	Submergence
Control	1016	711	44.5	18.6
N	1115	789	45.5	24.8
NPK	1313	980	52.9	29.0
FYM	1214	866	44.7	25.3
N+FYM	1504	1220	53.4	32.6
NPK+FYM	1855	1175	59.4	35.8
Mean	1336	957	50.1	27.7
LSD (P<0.05)				
M		176		6.9
F		110		5.1
MxF		286		14.3

Table 33. N_2O emission, N leaching and N uptake in aerobic rice under different N management strategies

Treatments	Total N applied (kg/ha)	Total N_2O-N (kg/ha)	Total N leached beyond 45 cm(kg/ha)	Total N uptake (kg/ha)
T_1	0	0.61±0.076	3.4 ±1.07	11.56
T_2	120	1.12 ±0.094	14.3 ±3.09	33.7
T_3	120	0.88 ±0.081	11.6 ±3.08	40.23
T_4	110	1.05 ±0.131	10.0 ±3.13	37.66
T_5	110	0.93 ±0.086	8.6±2.08	47.88
T_6	120	0.96±0.062	7.1 ±2.06	27.06
LSD (P<0.05)				5.7

T_1-N Control, T_2 - recommended dose of N through urea, T_3 - recommended dose of N through neem coated urea, T_4 - LCC based N application through urea, T_5 - LCC based N application through neem coated urea and T_6 - recommended dose of N through urea and farm yard manure in 1:1 ratio

application through urea, LCC based N application through neem coated urea and recommended dose of N through urea and farm yard manure in 1:1 ratio on N_2O emission, N leaching and N uptake in aerobic rice. Results revealed that 3.4 -14.3 kg N/ha leached beyond 45 cm and 0.61 to 1.12 kg N/ha N_2O-N emitted during the season in the aerobic system and the highest loss was observed in the treatment where recommended dose of N was applied through urea. Leaching of NO_3 as well as N_2O-N emission were lower with application of neem coated urea (recommended dose of N through neem coated urea and LCC based N application through neem coated urea) as compared to (recommended dose of N through urea and LCC based N application through urea) due to controlled release of N and inhibition of nitrification activity (Table 33). Populations of denitrifies, NH_4 oxidizer, NO_2 oxidizer and denitrifying enzyme activity were lower in treatments applied with neem coated urea as compared to urea. LCC based N application also recorded higher N uptake than the recommended dose in both urea and neem coated urea.

Standardization of LCC for N application in some popular medium to long duration varieties grown in Eastern India

A field experiment with the varieties Varshadhan, Swarna *Sub 1* and Pooja was conducted in *kharif* 2012 with different N application strategies comprising real time–fixed dose approach and fixed time-adjustable dose approach using LCC. After harvest of the crop, data on biomass (grain and straw), yield were recorded. Results revealed that N application schedule, based on real time fixed dose approach of LCC performed better in terms of yield and nitrogen use efficiency as compared to recommended fertilizer application schedule, and fixed time adjustable dose approach. However, the critical colour number of LCC for application of N varied with the variety. LCC based N application (33% N at basal and 33% as and when LCC<3) recorded a higher yield both in Varshadhan and Pooja where as in case of Swarna *Sub 1* treatment with 33% N at basal and 33% as and when LCC<4 resulted highest yield. Among the varieties Varshadhan recorded highest agronomic as well as physiological N use efficiency.

Development of customized leaf colour chart for nitrogen management in rice for different ecosystems

A five panel customized leaf colour chart (CLCC) for N management in rice for different ecosystems was developed on the basis of spectral evaluation of leaves of hundreds of HYVs and local cultivars grown in

MoU signed with M/S Nitrogen parameters, Chennai for commercialization of CLCC eastern India under different levels of N applications. It is a cheap and easy to use handy tool provided with N application schedule in a folder. By using this, farmers can adjust the N application to actual crop demand, achieve higher yield and reduce the N application by 10-20 kg/ha. The CLCC contains instructions in English, Hindi and Odia in simple language which can be easily followed by the farmers. An MoU was signed with M/S Nitrogen parameters, Chennai for manufacturing and distributing the CLCC. Trainings were imparted to 130 state government officials of Odisha and SMS of different KVKs of Zonal Project Directorate VII, Jablapur (MP) regarding the use of CLCC.

Development of soil nutrient map of Nischintakoilli and Mahanga block of Cuttack district

Grid wise (2 km x 2 km) soil samples were collected from Nischnitakoilli and Mahanga block of Cuttack district of Odisha during 2011-12. The available soil N, P and K were determined. The grid points were digitized in Arc-GIS 10. Variogram analysis was performed using ARC-GIS geostatistical analyst, using appropriate semivariograms, the available N, P and K values were interpolated by kriging; the map generated (Fig 12) provided the regions and loops of fertility status and explains heterogeneity in the region.

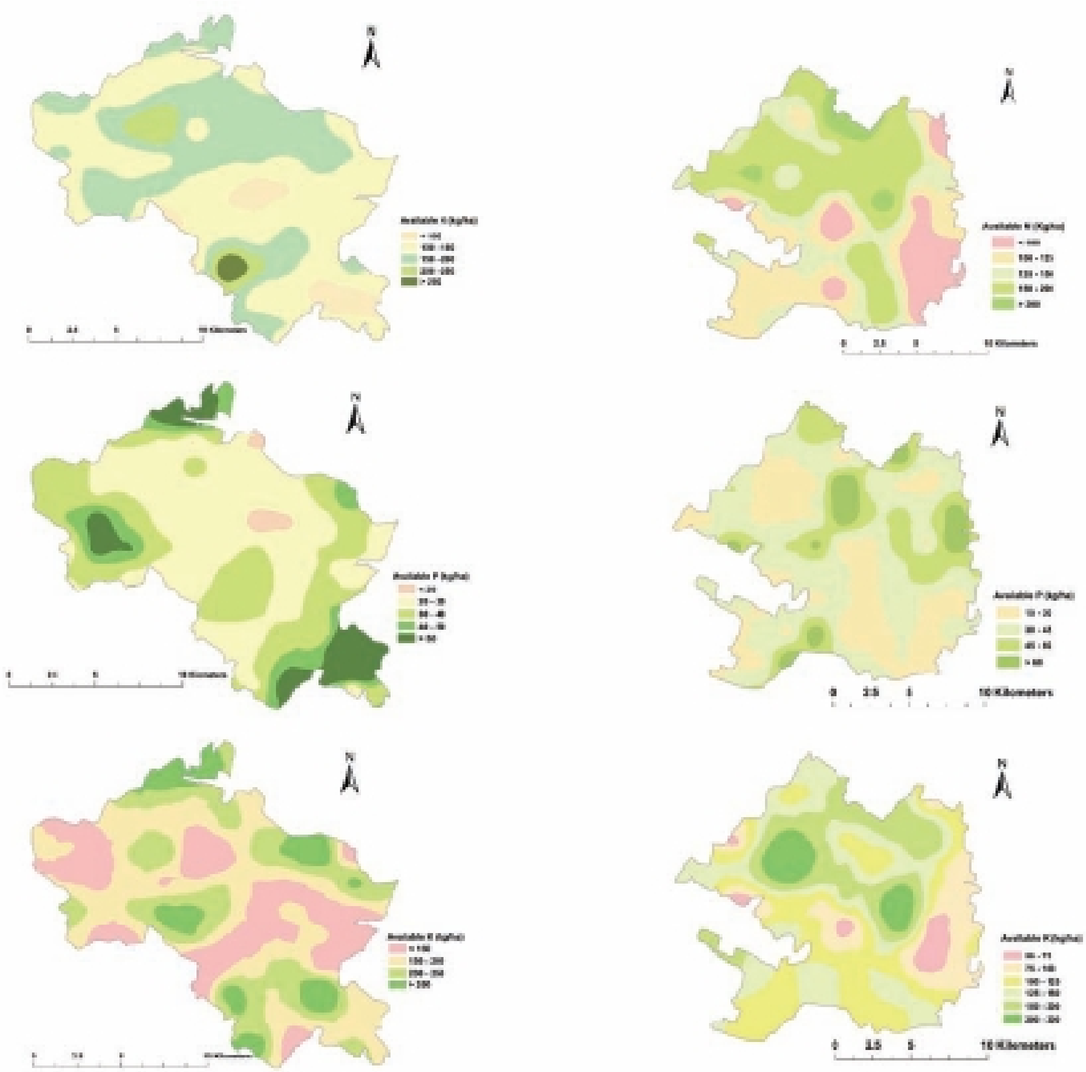


Fig 12. Krigged map of available soil N, P and K of (A) Mahanga and (B) Nischintakolli blocks of Cuttack district, Odisha

Studies of spatial variability of soil nutrient and rice yield

On-farm omission plot trials were conducted in 2012 *kharif* season at 10 locations (Kolanpur, Dingeswar, Nischintakoilli, Adhanga, Pithapada, Baunapati, Bauram, Sigmapur, Lakhinarayanpur and Mahajanpur) of Nischintakoilli and Salepur block of Cuttack district with five treatment combinations (NPK, NP, PK and NK and absolute control) to quantify the variability of grain yield and nutrient uptake in N, P and K. The plot size for each treatment was approximately 250 m^2. The rice variety Pooja was used at all the locations. The amount of yield increase obtained upon a missing nutrient fertilization nearly equivalent amount of yield loss as aloofness of that particular nutrient as compared to complete fertilization. Grain yields in nutrient omission plots were in the order of PK (2.54-3.64 t/ha), NP (2.77-4.01 t/ha), NK (3.10-3.94 t/ha) and NPK (3.43-4.46 t/ha). Out of 10 locations, response to applied N was observed at all the locations whereas, response to P and K application was observed at six and four locations, respectively.

Effect of biochar alone or in combination with fly ash on plant growth and yield

Rice husk biochar was prepared to integrate the concepts of waste management, nutrient management in rice ecosystem as well as carbon sequestration in tropical regions. A study was planned to determine the effect of biochar pyrolysis temperature on properties of biochar and effect of biochar alone or in combination with fly ash on plant growth and yield of rice.

Biochar preparation

Rice husk was pyrolyzed at four different temperatures (200, 300, 400 and 500°C) in an anaerobic combustor with limited oxygen supply for 8 hours and weight loss was recorded at 2 hours interval (Fig 13). It was observed that weight reduction was lowest at 200°C and the sample could reach only 75.72% of original weight after 8 hours of pyrolysis. Stable biochar (40% weight of raw husk) was obtained in 8 hours at 300°C (39.25%), 6 hours at 400°C (37.6%) and 2 hours at 500°C (38.23%).

The biochar produced was ground and used with fly ash in different proportions for pot experiment. The pot experiment consisted of 10 treatments replicated thrice. The treatments comprised of absolute control, NPK at recommended dose of fertilizer (RDF), NPK+0.5% bio-char, NPK+1.0% bio-char, NPK+1.5% bio-char, NPK+5% fly ash, 10% fly ash+ 1% bio-char, 5% fly ash+ 1% bio-char, 30% fly ash+ 1% bio-char and N (50%) + 30%fly ash+1.0% bio-char. *Kharif* 2012 data suggest that biochar has positive effect on rice grain yield. Application of rice husk Biochar @ 1.5 % in addition to recommended dose of NPK (RDF) showed positive response in terms of yield over control and RDF. Application of 1.5% biochar with RFD recorded maximum yield (38.43 g/hill) followed by application of 1.0 % biochar (36.64 g/hill).

Agro-Management for Enhancing Water Productivity and Rice Productivity under Water Shortage Condition

A field experiment was conducted during 2012-13 studying the adaptability of 16 elite genotypes/ varieties/hybrids of short (100-115 days) and medium (116-135 days) duration under limited water condition. Standard practices of aerobic rice cultivation were followed while growing all varieties. Measured quantity of irrigation water was applied maintaining soil moisture regime at 40-45 kPa at 30 cm root zone depth of soil.

Results showed that among the OPV / inbred, CR Dhan 200, Sahbhagidhan and Annada were at par with Apo producing 3.65-4.05 t/ha. Hybrids, PAC 801 (5.75 t/ha), PHB 71 (5.72 t/ha), Ajay (4.45 t/ha) and Rajalaxmi (4.20 t/ha) emerged promising in this condition. Among promising lines, PVS 2 (3.80 t/ha) and PVS 12 (3.85 t/ha) were superior to other genotypes. Crop productivity was higher in Apo (3.5 $g/m^2/day$) followed by Ajay, CR Dhan 200 and Sahbhagidhan. Water productivity (4.84 g grain / kg water applied) and water application efficiency

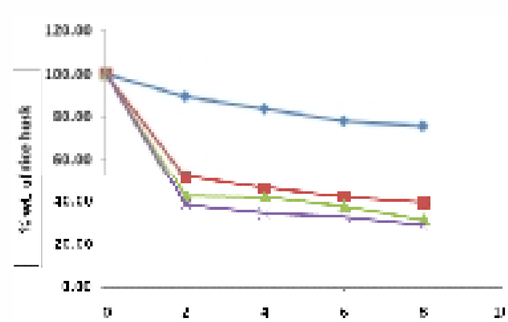


Fig 13. Trend of weight loss of rice husk at different temperatures

(34.42%) were also higher in Apo followed by Sahbhagidhan and CR Dhan 200. Higher LWP (- 4.5 to - 4.4) supplemented similar views in Apo followed by Ajay, CR Dhan 200 and Rajalaxmi ensuring greater yield potential even under water limited conditions.

Crop Weather Relationship Studies in Rice for Development of Adaptation Strategies under Changing Climatic Scenario

Drought risk assessment of Odisha based on standardized precipitation index

Time series of rainfall data (1983–2008) from 168 rain gauge stations of Odisha were used to derive monthly standardized precipitation index (SPI) of different wet season months (June-November).The monthly SPI values were interpolated to map spatial patterns of meteorological drought. These maps were exploited to assess the drought risk by categorizing them into a binary mask of 1 (drought) and 0 (no drought) for all the 26 years. The threshold SPI value of "0.99 and below was assigned a value of 1 and the rest were assigned a value of 0. The resulting 26 binary masks were stacked together and drought risk maps of different classes were generated. The stacked binary mask, yielded pixel values in the range of 0-7. These pixel values represent the frequency of monthly drought occurrence. The areas having a pixel value of "0" throughout the 26 years were classified as no risk. Pixels having the threshold of "1-4" were classified as moderate and more than four were classified as severe risks (Fig 14). The resultant map indicated moderate drought risk for most of the areas in Odisha.

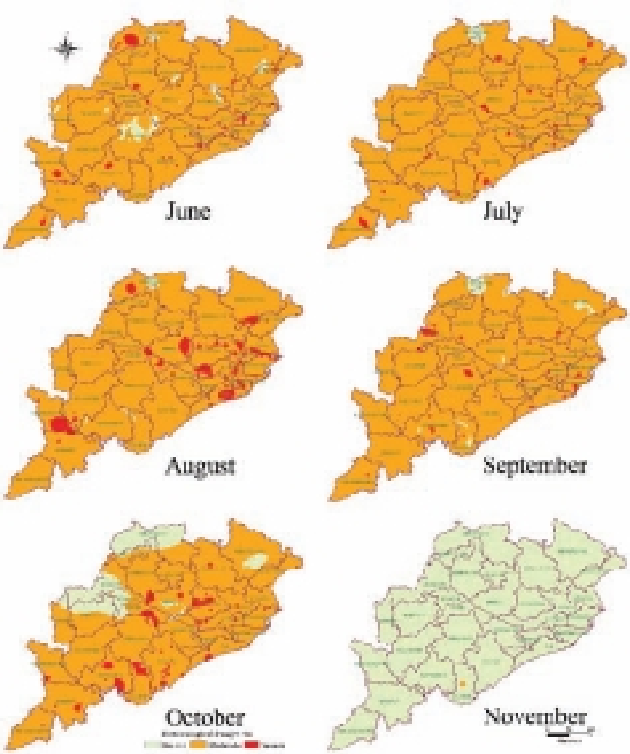


Fig 14. Meteorological drought risk maps of Odisha based on monthly standardized precipitation index

Rice canopy level radiation interception studies under different date of sowing

A field experiment was conducted during *kharif* 2012 with methods of establishment (wet direct seeding, transplanting and modified SRI) in the main plot and date of main field sowing/ nursery sowing (1st week of June, 3rd week of June, 1st week of July and 3rd week of July) in sub plot and variety (Pooja and Naveen) in sub sub plot in order to study the canopy level radiation interception. The results revealed that methods of establishment were not having any significant effect on grain yield while dates of sowing and variety had a significant effect on rice grain yield (Table 34). There was no significant interaction among methods of establishment, sowing date and variety.

Table 34. Effect of establishment method, date of sowing and varieties on rice grain yield

Treatment	Grain yield (t/ha)
Establishment method	
Wet direct seeding	5.77
Transplanting	6.07
Modified SRI	6.00
LSD (P=0.05)	NS
Date of sowing	
1st week of June	6.15
3rd week of June	6.21
1st week of July	5.89
3rd week of July	5.56
LSD (P<0.05)	3.02
Variety	
Pooja	6.21
Naveen	5.69
LSD (P<0.05)	1.99

Development of Sustainable Production Technologies for Rice Based Cropping Systems

System based nutrient management in rice based cropping system

A field experiment was initiated in the *kharif* 2012 to study the effect of different nutrient management options on the rice-maize-cowpea and rice-groundnut-cowpea cropping system. The experiment was laid out in a split plot design with two cropping systems i.e. rice-maize-cowpea and rice-groundnut-cowpea in main plots and 5 system based nutrient management option i.e. control-control-control, RDF-RDF-RDF, RDF_{75}+ crop residue incorporation of previous crop (CRI) - RDF-RDF, RDF_{75}+CRI- RDF+ straw mulch (SM) - RDF and RDF_{75}+CRI-RDF+SM-RDF_{50} in subplots replicated thrice. Results showed that at initial stage of crop growth RDF registered comparatively higher values of growth parameters like dry matter, LAI, SLA and growth rate compared to control though comparable with RDF_{75}+CRI treatment (Table 35). A significantly higher grain yield and yield attribute were recorded with RDF or RDF_{75}+CRI over control. Significantly higher straw and biomass yield was recorded with RDF compared to RDF_{75}+CRI treatment in rice but both the treatments were at par in case of grain yield.

In the second crop of the sequence, significantly higher grain yield was recorded with RDF+SM plots compared to RDF applied plots in maize except where rice was treated with crop residue. In groundnut, though straw mulched plots recorded higher pod yield, it did not differ significantly from RDF applied plots. The system productivity of rice-groundnut was significantly higher than rice-maize cropping system. Among the nutrient management options highest REY of 11.01 t/ha was achieved with RDF_{75}+CRI- RDF+SM treatment, which was significantly higher than unfertilized and RDF plots but was at par with that of other fertilizer treatments. Highest net return of Rs.77,345 was realised in RDF_{75}+CRI in rice followed by RDF+SM in maize/ groundnut crop. Therefore, RDF_{75}+CRI in rice followed by RDF+SM in maize could increase the overall land productivity and economic returns.

Crop/varietal diversification in rice based cropping system for climate change adaptation

A field experiment was conducted during 2012-13 on crop/varietal diversification in rice based cropping system for climate change adaptation involving seven different cropping systems i.e. rice-rice, rice-green gram, rice-horse gram, rice-coriander, rice-toria, rice-*Lathyrus* and rice-black gram on rainfed rice based system. The experiment was laid out in randomized complete block design and replicated thrice. The cropping systems represent traditional and recent cropping systems in Eastern India. Three-rice varieties of different durations (Naveen, Gayatri and Swarna) were transplanted during *kharif* season. Swarna variety (1^{st} July), damaged artificially (31^{st} August) assuming aberrant weather conditions like drought or flood, farmers usually face in rice growing season. After harvesting of rice crops, non-rice crops were directly sown on residual moisture to evaluate the production potential of the system so as a contingent crop calendar in respect to crop or varietal diversification under rainfed rice can be developed.

Table 35. Productivity of component crops and the system (rice equivalent yield, REY) of RBCS (rice based cropping system) under nutrient management options

Cropping system	*kharif* (t/ha)	*rabi* (t/ha)	Cropping System (t/ha)
Rice - Maize - Cowpea	4.53	4.73	8.89
Rice – Groundnut - Cowpea	4.51	6.16	10.67
CD (p =0.05)	NS	0.62	0.82
Nutrient management			
Control - Control - Control	3.79	2.27	6.05
RDF - RDF - RDF	4.71	5.66	10.37
RDF_{75} + CRI - RDF - RDF	4.72	5.81	10.53
RDF_{75} + CRI – RDF + SM – RDF	4.83	6.17	11.01
RDF_{75} + CRI - RDF + SM - RDF_{50}	4.52	6.42	10.95
CD (P<0.05)	0.37	0.41	0.57

Performance of rice varieties sown on 1st July was comparatively better than varieties sown during August. Naveen and Swarna sown on 1st July gave 11.82% and 32.31% higher yield, respectively as compared to the crop sown on 1st August. However, Gayatri sown on 1st July produced significantly higher grain yield (5.52 t/ha). After artificially damaging Swarna, a short duration rice variety Annada performed better (2.1 t/ha) as compared to other non-rice crops. System productivity was highest (6.65 t/ha) when non-rice crops were sown after harvesting of Gayatri, as its grain yield was highest under normal weather conditions. Apart from this, black gram after short duration rice varieties resulted in higher (5.92 t/ha) system productivity followed by green gram (5.74 t/ha). Among seven cropping systems, rice-black gram, rice-toria, rice-green gram and rice-horse gram require fewer inputs and are also less risky, which probably makes them more suitable for resource poor small farmers.

Farm Implements and Post Harvest Technology for Rice

Study of field performance of CRRI weeding and planting implements

Field efficiency of CRRI weeders

A field efficiency was tested for CRRI weeding implements with Naveen variety during 2012-13. Weeding done with star cono weeder gave significantly higher ear bearing tillers (196/m^2), grain yield (4.08 t/ha) and water use efficiency (WUE) (0.60 kg/m^3) although its cost of operation was higher than the power weeder (5.8%). However, highest net returns were obtained from chemical weeding (Rs.18,965/ha) followed by star-cono weeder (Rs.18,040/ha). The study showed that when chemical weeding is not adopted, self propelled power weeder and star cono weeder are the better substitutes to hand weeding and economical (Table 36).

Field efficiency of planting machines

A field experiment was conducted to study the field efficiency of planting machines with respect to productivity, WUE and net returns using Gayatri variety. Water use efficiency and grain yield were not affected by planting methods (Table 37). However, there was a significant cost reduction due to mechanical planting (Rs.1,134/ha) compared to manual transplanting (Rs.6,355/ha). Highest net return (Rs.33,450/ha) was obtained from planting by drum seeder, followed by self propelled transplanter (Rs.33,357/ ha). Cost of self propelled transplanter was highest on per unit area basis, whereas, cost of planting was lowest in case of sprouted drum seeder. The study showed that planting of rice by sprouted drum seeder is most economical and gave maximum returns.

Development of a rice husk combustor for thermal energy application

A central tube type rice husk combustor of 2-3 KW capacity to hold upto 4.5 kg of husk was designed and fabricated. The combustor works on gasification principle and on natural draft. On batch mode, after filling it with dry husk, a burning twig is used to initiate the combustion process. It takes 5-7 minutes to produce combustible volatiles which burn with a reddish flame for about 40 minutes and thereafter the carbon burns for about 20 minutes thereby producing heat energy for thermal application. In order to facilitate the combustor to work on semi continuous mode to prolong the

Table 36. Effect of weeding methods on productivity, WUE and net returns

Weeding implement	Area covered (ha/hr)	Ear bearing tillers/m^2	Grain yield (t/ha)	WUE (kg/cum)	[1]Net returns (Rs./ha)
Star-cono weeder	0.035	196	4.08	0.60	18040
Finger weeder	0.021	178	3.87	0.57	13755
Manual weeding	0.014	192	3.96	0.58	13000
Power weeder	0.075	186	3.78	0.56	14930
Chemical weeding	-	188	3.93	0.58	18965
No weeding	-	132	1.8	0.27	-520
CD (P<0.05)	-	8.91	0.46	0.067	445.28

[1] Rate of paddy= Rs. 1050/q Rate of straw=Rs. 100/q

Table 37. Effect of planting methods on productivity, WUE and net returns

Planting process	Area covered (ha/hr)	[1]Cost of cultivation (Rs./ha)	GrainYield (t/ha)	GWUE* (kg/cum)	[2]Net return (Rs/ha)
Manual drum seeder (dry seed)	0.04	39,086	5.28	0.642	31309
Drum seeder (sprouted seed)	0.12	36,840	5.31	0.645	33450
Manual transplanter	0.032	39,600	5.22	0.634	30240
Self propelled transplanter	0.205	38,078	5.35	0.650	33357
Manual (root washed seedling)	0.0036	50,563	5.36	0.651	21357
CD ($P<0.05$)	-	414.57	-	-	612.62

* ET of Gayatri=823mm; [1] Includes cost of 1 weeding by cono weeder
[2] Rate of paddy = Rs.1100/q, Rate of straw = Rs. 150/q

combustion process, the burnt ash was slowly removed intermittently at the bottom with the help of a rotor mechanism and fresh husk was fed from top. Preliminary tests through water boiling revealed that the combustor could provide heat energy continuously for two hours at 13-15% thermal efficiency.

Development of a single-row power weeder

A single row power operated weeder was designed and developed. The machine consists of a petrol start kerosene run 1.03 KW engine, an engine mounting frame, the main frame, transmission system, jaw type clutch assembly, clutch control lever, handle, two transport wheels, rotary tine assembly, a support wheel and a rubber flap. The power from engine pulley is transmitted to the rotary blade unit through a belt and then to the pulley and chain-sprocket system. Engine speed of 3600 rpm is reduced to 470 rpm at rotary blade.

Single row power weeder

Development of a two-row power weeder

A two- row self propelled weeder was developed and tested with Naveen variety of paddy, sown in row spacing of 20 x 20 cm and 25 x 25 cm. It was tested with 6 cm, 9 cm and 12 cm wide L type rotary blade rotating at 325 rpm. Forward speed of machine was 1.5 kmh^{-1}. Twelve cm wide rotary blade performed well in terms of weed destruction in both the spacings but plant damage was higher in 20 cm (28.96%) row spacing as compared to 25 cm (3.35%) (Table 38).

Fabrication of seed boxes with cup feed metering mechanism, transmission system, clutch system and float for 8 rows power operated paddy seeder for wet land conditions

Cups of different sizes having diameter of 7, 8, 9, 11, 12 and 14 mm were fabricated for power operated paddy seeder. The seeder comprised of frame, eight seed boxes, each box having cup metering wheels with 10 cups in a

Table 38. Field performance of 2-row power weeder

Blade width (cm)	20 cm row space			25 cm row space		
	Field capacity (ha/hr)	Plant damage (%)	Weed destruction (%)	Field capacity (ha/hr)	Plant damage (%)	Weed destruction (%)
6	0.06	1.08	30.7	0.078	0.30	33.77
9		3.94	47.31		1.81	46.77
12		28.96	68.75		3.35	69.48

wheel, one axle and float. The row to row spacing was kept at 20 cm and hill to hill distance was 15 cm. The transmission system having a speed ratio of 60:1 by means of worm gear, sprocket and riveted roller type chain mechanism with clutch and float was fabricated for the power operated seeder. During lab testing, seed per hill was found optimum with cup having 8 mm diameter (1-2 seeds per hill). During field testing of 8 row drum seeder its field capacity was found to be 0.245 ha/hr with operating efficiency of 85%.

Dry direct seeded rice with paired row dhaincha and mixing of dhaincha with cono weeder

Resource Conservation Technologies and Conservation Agriculture (CA) for sustainable rice production

Resource conservation treatments with integration of farm implements, residue retention and nutrient management were imposed under direct seeded and transplanted rice during *kharif* 2012 and *rabi* 2012-13. The resource conservation treatments broadly include, (i) wet direct seeded rice by drum seeders + LCC based N management, (ii) zero tillage + residue retention, (iii) dry direct seeded rice + paired row dhaincha + mixing of dhaincha with cono weeder+ LCC based N management, (iv) zero tilled transplanting, (v) residue retention and incorporation in transplanted rice and (vi) transplanting through transplanter + LCC based N management during *kharif*. The variety Pooja was grown during *kharif* season.

Initial characteristics of soil revealed that the surface soil total carbon, organic and microbial biomass carbon were 7.6±0.4 g/kg, 5.1±0.2 g/kg and 547.5±41.6 mg/kg, respectively, which were gradually decreased with increasing soil depth up to 60 cm. Readily mineralizable C, water soluble carbohydrate C and acid hydrolysable C were also high in 0-15 cm soil depth. The range of this soil labile C indicates that soil status was good and soils were biologically active. Soil pH was in the range of 6.7-7.1. Total N and Olsen P in surface soil were 0.072%, and 22.8 mg/kg, respectively.

The microbial biomass carbon (MBC), water soluble carbohydrate carbon (WSC) and acid hydrolyzable carbon (AHC) varied in the range of 87.5- 353.4, 34-89.1, 248.3-662.7 mg/kg and 83.1-369.9, 69.2-81.7, 279.6-685.3 mg/kg; under direct seeded and transplanted condition, respectively, during *kharif* 2012. The highest labile C pool was found in the green manure and crop residue retention treatment under direct seeded and transplanted condition, respectively. The readily mineralizable carbon (RMC) and organic carbon (OC) varied in the range of 37.6-294.1 mg/kg and 4.5-5.1 g/kg, 46.5-325.7 mg/kg and 4.9-5.0 g/kg, under direct seeded and transplanted condition, respectively. The highest active pool was found in the green manure treatment under direct seeded and transplanted condition.

The methane emission was found highest in crop residue treatment (67.1 kg/ha) and the lowest value

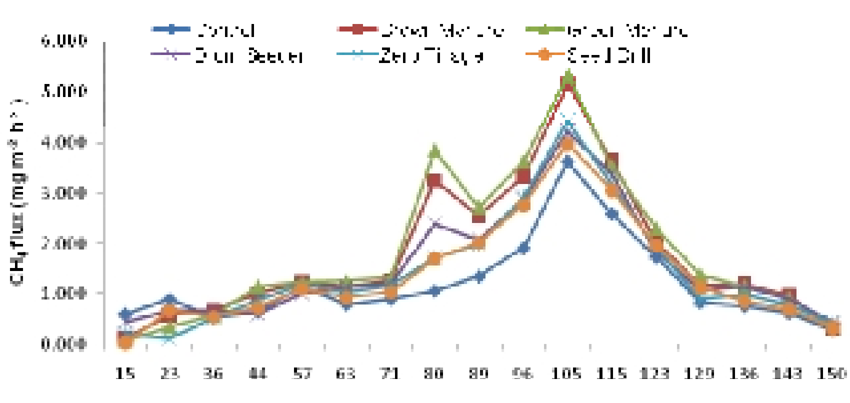


Fig 15. Methane emission from rice (cv. Pooja) in kharif 2012 in direct seeded condition under different RCTs

was found in the control (51.6 kg/ha) in transplanted condition. On the other hand, in DSR treatment the highest emission was obtained in green manure treatment (72 kg/ha) and the lowest emission was obtained in the control (42.7 kg/ha) (Fig 15).

Input energy under different DSR and transplanted rice treatments were quantified during *kharif* 2012, considering the activities of preparatory tillage by power tiller, manual puddling or puddling by power tiller, direct sowing of seeds by seed drill or manual sowing, transplanting by transplanter or manual transplanting, seed energy, fertilizer applications, fertilizer inputs, weeding by cono-weeder or manual weeding, herbicide and pesticide application, manual harvesting or harvesting by harvester. Under transplanted rice the highest input energy was required in control and the lowest energy required for zero tillage-transplanting treatment. On the other hand, under direct seeded condition the highest energy was required in control and the lowest energy required for green manure and brown manure treatment.

Output energy was calculated through energy from grain yield, straw yield and husk. Out of all the treatments, under transplanted condition the highest energy was obtained in green manure treatment and the lowest energy obtained in control. On the other hand, under direct seeded condition the highest energy was obtained in green manure and brown manure treatment and the lowest energy was obtained in zero tillage treatment.

In DSR, grain yield varied non-significantly from each other in different treatments except zero tillage. However, there were 25% saving of N in green manuring and brown manuring treated plots than control. Apart from this, there was saving of 22% energy in drum seeded sown plots than manual seeding. Although, there was significant reduction in yield under zero tillage treated plots than other treatments, but there was significant savings of energy by 43% than control. In transplanted condition also grain yield did not vary significantly in all the treatments except in zero tillage where yield was significantly low. There was 25-35% saving of energy in terms of chemical fertilizer used in residue retention and green manure treatments without compromising yield.

Among different RCTs, paired row dry direct seeding of rice and dhaincha with seed drill followed by weeding and incorporation of dhaincha by Cono weeder and LCC based N management was most promising.

Diversified Rice-based Farming System for Livelihood Improvement of Small and Marginal Farmers

Refinement/improvement for training and popularization of integrated farming system models

Irrigated Medium Lands (Farm size- 1 acre)

With the aim of further improvement, mushroom and nutritional garden enterprises were integrated in the model developed earlier. These enterprises helped in further stabilizing the system productivity by providing additional income and employment opportunities. After an early crop of rice cv. Sahbhagidhan, submergence tolerant rice variety Swarna Sub-1 was transplanted in the 1st week of July. During the dry season aromatic rice variety Kudrat was grown. Three rice crops together (Swarna Sub-1, Naveen and Sahbhagidhan) produced a total grain yield of 14.5 t/ha. On the bunds more than 1.2 tonnes of vegetables and fruits were produced. Around 2 q of fish and 2000 fingerlings were harvested from the system and generated an income of Rs. 25,000. As a whole the system could produce about 14 q of food crops, 2 q of fish, 2 q of meat, 15 q of vegetables and 10 q of fruits besides, 15 to 20 q of rice straw (used for animal feed) annually to ensure food and nutritional security, stable income on short and long term basis and year round employment of farm family.

Waterlogged and deepwater areas (Farm size- 1 ha)

The grain yield of rice variety Gayatri during *kharif* was 6.3 t/ha and Pooja was 5.8 t/ha in rainfed medium-deep water (up to 50 cm water depth) in the upper part of the field. In the deepwater situation (more than 50 cm water depth) at lower end of the field, the grain yield in Varshadhan and Durga were 5.5 t and 4.8 t/ha, respectively. The yield of various *rabi* season crops grown with harvested rainwater after *kharif* season rice, were 3.9 to 6.5 t/ha in vegetables (bitter gourd, okra) and 3.3 t/ha in rice (cv. Shatabdi). The productivity of other field crops in upland (Tier I and II) was in the range of 11.3-38.6 t/ha in various vegetable crops during *rabi* and 5.3-8.0 t/ha during *kharif* seasons, 42.2 t/ha in bottle gourd on platform, 9.7-11.5 t/ha in tuber crops and 11.6-14.7 kg fruits/plant in fruit crops. The fish yield was 0.86 t/ha at a stocking density of 6,000 fingerlings/ha. Among the bird components, poultry birds (breed-Vanaraja) attained average weight of 1.9 kg within 90 days, while ducks (breed-Khaki Campbell) recorded an average weight of 1.5 kg/year.

Studies on rice-fish interactions

Pesticide residue in rainfed lowland rice-fish ecosystem was studied during the *kharif* season with transplanted rice var. Varshadhan and two fish species, common carp and magur. Insecticide, chlorpyrifos was sprayed @ 0.05 % *a.i.* at the heading stage of the crop in both rice-fish and rice alone fields. Fish mortality was not recorded and the fishes were harvested after 30 days of spraying. The grain yield of rice ranged from 4.5-6.0 t/ha. The residue level in plant tissue after one day was less with fish (0.0027 mg/kg) compared to without fish (0.0030 mg/kg). After 12th day of spray, the residue level in plant tissue reduced by 52% with fish culture (0.0013 mg/kg) compared to 23.3% reduction without fish (0.0023 mg/kg). The chlorpyriphos residue in fish muscle tissue was found much higher in common carp (0.027 mg/kg) than that of magur (0.012 mg/kg). The chlorpyriphos residue level in plant tissue was below the prescribed ADI level, but was higher in case of common carp fish tissue.

Popularization of rice-fish farming system

The two rice-fish farming system models (rainfed lowland and multitier deepwater models) were successfully extended to 21 small farms (0.13-0.8 ha area). Eight farms in coastal areas of Odisha through MoUs, with Regional Centre for Development Cooperation (RCDC), Bhubaneswar and 13 farms in Sundarbans area of West Bengal with Vivekananda Institute of Biotechnology, Sri Ramakrishna Ashram, Nimpith. Various components like rice, fish, duck, vegetables, tuber crops, fruit crops and vermicompost were integrated in the farms. The net income ranged from Rs 27,500 -1,05,500/ha/year with family labour in Sundarbans area of West Bengal. In coastal areas of Odisha, the farmers realized net income in the range of Rs 88,900 -2, 37, 000/ha/year without the labour cost.

Efforts are being made to popularize the highly productive rice-fish integrated farming system model in irrigated ecology thorough print as well as electronic media (News Papers, T.V and All India Radio). The model was exposed to farmers, NGOs, agri-enterpreneurs, financial institutions, extension personnels, researchers as well as policy makers from time to time via field visits, well planned training programmes and kisan melas and press briefs to create public awareness for its effective and speedy transfer.

Management of Rice Weeds by Integrated Approaches

Study on weed population and dynamics during *kharif* season

Study on weed population dynamics during *kharif* revealed that *Echinochloa colona* was the most prevalent weed species (occupying 61% of total weed population) at early vegetative stage i.e., at 30 days after sowing (DAS) in direct-sown rainfed shallow lowland rice fields. Another grassy weed, *Leptochloa chinensis* along with sedges *viz., Cyperus difformis* and *Fimbristylis miliacea* and broad leaf weeds, *Ludwigia octovalvis* and *Sphenoclea zeylanica* were predominant (89% of total weed population) at 60 DAS. In intermediate lowlands, the major weed species at 30 DAS were *Echinochloa colona, Cyperus iria* and *Fimbristylis miliacea* (78% of total weed population). However, *Leersia hexandra,* Cyperus *haspan, Ludwigia octovalvis* and *Commelina benghalensis* were the dominant weed species (81% of total population) recorded at 60 DAS. The mean relative density of major weed species in direct-sown summer rice at 30 DAS were *Echinochloa colona* (8.7%), *Cyperus difformis* (26.1%), *Fimbristylis miliacea* (14.5%), *Sphenoclea zeylanica* (27.5%) *Marsilea minuta* (23.2%). In case of transplanted rice, it was observed that *Cyperus difformis* was the most prevalent weed species (occupying 33% of total weed population) followed by *Sphenoclea zeylanica* (25%) at early vegetative growth stage (30 DAT). But the dominance of *Leptochloa chinensis* (21%) was recorded at maximum tillering stage (60 DAT).

Screening of germplasm against weed competitiveness

One hundred and twenty early maturing rice germplasms (95-115 days duration) with five checks *viz.,* Vandana, Anjali, Heera, Annada and Kalinga III were screened in augmented design with four blocks at KVK, Santhapur for weed competitiveness during wet season. The germplasm *viz.,* IR 83929-B-B-291-2-1-1-2, IR 82589-B-B-63-2-148-1, IR 83750-B-B-145-4-174-3, IR 83750-B-B-145-4-174-2, IR 84899-B-184-18-1-1-1, IR 83375-B-B-117-1-222-1, IR 84887-B-153-33-1-1-3, IR 84887-B-157-38-1-1-3, IR 83929-B-B-291-4-1-1-3, IR 83750-B-B-145-4-174-2 and Abhisek were found to be weed competitive with average plant height ranged from 92-99 cm, total weed biomass (dry weight basis) at 45 days after sowing varied from 18.6-29.6 g/m^2 and grain yield in the range of 301-473 g/m^2.

Effect of low dose herbicide on weed control and grain yield

The efficacy of new low-dose high-efficacy herbicide *viz.,* Flucetosulfuron along with herbicide mixtures *viz.,* Penoxulam + Cyhalofop butyl and Azimsulfuron + Bispyribac sodium in conjunction with recommended herbicides *viz.,* Pretilachlor and Pyrazosulfuron ethyl were evaluated during *kharif*, 2012 in wet direct-sown as well as transplanted rice (variety Pooja). *Echinochloa colona*, *Cyperus difformis* and *Sphenoclea zeylanica* were found to be the predominant weed species in wet direct-sown rice fields at 30 days after sowing (DAS). The grassy weeds constituted 61% of the total weed population along with sedges (24%) and broad leaf weeds (15%) in weedy plots. Experimental results revealed that Flucetosulfuron, a new post-emergence sulfonylurea herbicide, showed excellent control of predominant grassy weeds, sedges and annual broad leaf weeds when applied 7 days after sowing at 25 g *a.i.*/ha with weed control efficiency (WCE) of 90%. However, the differences in grain yields due to application of Flucetosulfuron at 25 g *a.i.*/ha (4.64 t/ha) and Azimsulfuron + Bispyribac sodium at 22 + 30 g *a.i.*/ha (4.58 t/ha) were comparable showing their effectiveness for controlling weeds in wet direct-sown rice field. The yield reduction due to weed competition in weedy plots was more than 45%.

In transplanted rice field, a mixed population of different weed species *viz., Echinochloa colona, Echinochloa crus-galli, Cyperus difformis, Fimbristylis miliacea, Sphenoclea zeylanica, Ludwigia adscendens* and *Marsilea minuta* were recorded at 30 days after transplanting (DAT). The grassy weeds constituted 27% along with sedges (31%) and broadleaf weeds (42%) of the total weed population in weedy plots. Experimental results revealed that the herbicide mixtures *viz.,* Azimsulfuron + Bispyribac sodium (22 + 30 g *a.i.*/ha) and Penoxsulam + Cyhalofop butyl (120 g *a.i.*/ha) applied at 15 days after planting were found effective for controlling predominant weeds with weed control efficiency of 92.4% and 91.6%, respectively. Among the tested herbicides, the highest grain yield (4.90 t/ha) was recorded in the plots treated with Azimsulfuron + Bispyribac sodium (22 + 30 g *a.i.*/ha) and it was at par with Penoxsulam + Cyhalofop butyl (4.76 t/ha). The yield reduction due to weed competition in weedy plots was more than 40%.

The effect of herbicides on soil microbes was studied during both *kharif* and *rabi* seasons. It was observed that the maximum count (CFUx10^6/g of soil) of aerobic (1.70) and anaerobic heterotrophs (1.30), FLNFB (0.40), fungi (0.04) and actinomycetes (0.21) were recorded in Flucetosulfuron (25 g *a.i.*/ha) treated plots during *kharif*. However, the plots treated with Bispyribac sodium (35 g *a.i.*/ha) and weed free checks (except heterotrophs) harboured the lowest frequency for same group of microbes. During *rabi*, it was found that Flucetosulfuron (25 g *a.i.*/ha) affect the soil microbial biomass carbon as the reduction was recorded MBC and population of heterotrophs (aerobes, anaerobes), fungi, actinomycetes and asymbiotic nitrogen fixer also reduced 10 - 15% with respect to initial soil. Bispyribac sodium showed negative affect to fungi (1.63) and actinomycetes (3.14) at 20 days of application with control (2.77 and 3.61, respectively). However, tank mix application of Azimsulfuron + Bispyribac sodium (22 + 30 g *a.i.*/ha) did not affect the population dynamics of these groups of microbes.

Management of Problem Soils for Enhancing the Productivity of Rice

Development of soil salinity and fertility map

Grid wise (3 km x 3 km) soil samples (60) were collected from the Rajnagar block of Kendrapara district. Soil samples were analyzed for pH, electrical conductivity (EC, 1:2). Major nutrients i.e. available nitrogen (N), phosphorus (P) and potassium (K) were estimated. It was found that soil EC (1:2) varied from 0.31 to 20.61 dS/m. Soil samples collected from the mangrove forest area were found to be having high EC. Among macronutrients, available P and K were high in soils whereas N was low in almost all the soil samples which ranged from 104.6 to 217.7 kg/ha. Spatial analysis was performed using Arc GIS 10. Variogram modelling was done for the grid wise data of soil EC, available N, P and K. Different variogram models (Spherical, Exponential, Circular, Gaussian, Hole effect, Stable) were tested for each of the above mentioned variables. Spherical model was found to be suitable for available N with a range of 4.0 km, whereas exponential model was fitted with a range of 3.8 km for available K.

Soil salinity map was prepared by using the modelled variogram parameters. Ordinary kriging technique was used to interpolate the grid soil data to unsampled locations and finally preparing the soil salinity map (Fig 16). Spatial variability for major nutrients N, P and K was also studied using the same technique as described in case of soil salinity. Spherical variogram was found to be best for available P and K, whereas Gaussian variogram was most suitable for available N for predicting the values at unsampled locations using kriging.

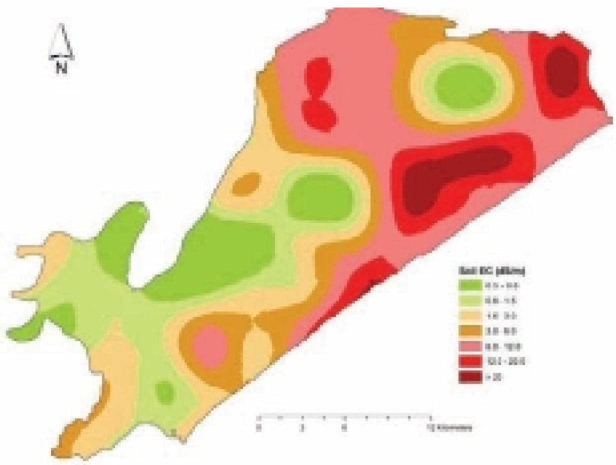


Fig 16. Soil Salinity map of Rajnagar Block

Developing management strategies for site specific iron toxicity

A field experiment at Central Farm of Orissa University of Agriculture and Technology, Bhubaneswar was carried out in acidic laterite soil having DTPA extractable Fe 400 ppm, for developing management options to combat Fe toxicity in rice. Three tolerant (Lalat, Chandan and Naveen) and one susceptible (Sebati) cultivars of rice were grown with six different combinations of soil management including control, lime, Mn, excess Zn, excess K and lime+Mn+Zn+K. Shoot and root biomass, Fe concentration in root and shoot were measured at panicle initiation stage, Fe translocation from root to shoot was calculated. Lowest shoot and root weight were recorded in susceptible cultivar Sebati, whereas highest root and shoot weight was obtained in Chandan. Fe concentration in root and shoot and Fe translocation was highest in Sebati and was lowest in Lalat. Lalat, Naveen and Chandan recorded 19.37, 15.81 and 10.28% higher grain yield, respectively as compared to Sebati. Combined application of lime, Mn, Zn and K resulted in highest grain yield as well as lowest Fe concentration in root, shoot and Fe translocation, resulting lowest Fe toxicity as compared to control.

Bio-Prospecting and Use of Microbial Resources for Soil, Pest and Residue Management

Mass production, formulation and field testing of effective entomopathogenic fungi against leaf folder of rice

Mass production of entomo-pathogenic fungi

Three isolates each of *Beauveria bassiana* and *Metarhizium anisopliae* were mass-produced on rice husk and saw dust (1:1, w/w) supplemented with 2% dextrose. The organisms produced 8 x 10^9 spores/g medium.

Formulation of *N. rileyi* and *M. anisopliae*

To develop wettable powder formulations, dried conidial powder of above three isolates (8 x 10^9 spores/g) of *N. rileyi* containing 0.1% carboxymethyl cellulose (CMC) was mixed with bentonite + glucose (7: 1), talc + glucose (7: 1), bentonite + sucrose (7: 1) and talc + sucrose (7: 1) to attain 8 x 10^8 spores/g. Similarly wettable powder formulations of *M. anisopliae* were prepared by following the same procedure.

Field testing

In *kharif*, the wettable powder formulations of above three isolates of *Beauveria* and *Metarhizium* spp. were tested in separate fields of rice variety Luna Suvarna infested by leaf folder. The *Beauveria* (8 x 10^3 spores/ml) and *Metarhizium* (1.75 x 10^6 - 1.75 x 10^7 spores/ml) spp. effected 73.19-78.79% and 80.42-87.23% mortality of leaf folder, respectively.

Molecular characterization of *Beauveria* and *Metarhizium*

Out of 20 (OPM 1-20) RAPD primers, only two i.e. OPM2 and OPM6 primers revealed polymorphic regions of one isolate of each of the *Beauveria* and *Metarhizium*. Two sets of ISSR primers *viz.*, (844A and B) and (HB8 and 9) also differentiated those same isolates. These oligo-sets will be useful to monitor the two pathogens from other commercial pathogens.

Characterization of phosphate solubilizing (PSF) and siderophore producing fungi (SPF) from rice rhizosphere

Phenotyping and 18S rDNA identified six potent fungal isolates (*Talaromyces stipitatus*, *T. stipitatus*, *Penicillium verruculosum*, *Cordyceps bassiana*, *Alternaria alternata* and *Aspergillus* sp.) from rice ecology of CRRI farm which produced 49.12–546.48 µg/ml P from Ca-phosphate. They also produced the PGP enzymes *viz.*, amylase, pectinase, gelatinase, caseinase, tributyrin hydrolase, lecithinase and siderophore orfamide etc. These isolates were submitted to NCBI, USA (18S gene sequence) and IMTEC, Chandigarh, India (culture) and accession numbers received (Table 39).

Molecular characterization of cry and salt tolerance genes

The *cry1, cry2, cry3, cry4, cry5* and *cyt* of Bt effective against Lepidoptera, Lepidoptera/Diptera, Coleoptera, Diptera, Lepidoptera/Coleoptera and Diptera were checked by PCR amplification. Among them, *cry4* and *cyt* genes were present in 23.5%, and *cry1, cry4* and *cry5* were present in 5.1% population. The *ect*AB, *pro*BA and *pro*H genes in *Bacillus*, *Staphylococcus, Actinobacterium*, *Moraxella* and *Staphylococcus* spp. and *eco*C gene (275 bp) in 46 *Bacillus* spp. were identified.

Diversity of plant growth promoting fluorescent pseudomonads in CRRI paddy soil

Fluorescent pseudomonads (n=99) were isolated from rhizospheric soil of six varieties (Gayatri, Sadabahar, Abhishek, Chandrama, Naveen and Hazaridhan) of rice grown in CRRI field. Varietal influence was observed on the population density of fluorescent pseudomonads in rice. The variety Gayatri (6.06 log CFU/g soil) and Hazaridhan (5.55 log CFU/g soil) harboured maximum counts of Fluorescent pseudomonads than other varieties. Higher number of isolates from the rhizosphere of Gayatri variety produced IAA (51.47 %), phosphate solubilisers (61.7%) and siderophore producer (53.12 %). More than 50% of isolates inhibited the fungal (*Rhizoctonia solani*) and bacterial (*Xanthomonas oryzae*) pathogen of rice. The best isolate for almost all functional traits was NF8 which was identified as *Pseudomonas fluorescence*. The 16S-RFLP also supported the diversity among fluorescent pseudomonads.

Extreme-tolerant plant growth promoting rhizobacteria (PGPR) from rice ecosystems of Bhitarkanika, CRRI and Sundarbans soils

Extreme-tolerant plant growth promoting rhizobacteria (PGPR) (n=139) were isolated from rice ecology of Bhitarkanika, CRRI and Sundarbans. Extreme-tolerant bacteria were more prevalent in the Bhitarkanika (100%) followed by Sundarbans (97.5%); however, more mesophililes were present in CRRI (72.46%) paddy soil. Nearly all isolates were tolerant to UV exposure (30-45 minutes), 80% were halotolerant to 5-15% NaCl, 79% and 95% isolates were psychrotolerant (4˚C) and thermotolerant (45˚C), respectively.

Out of these isolates 62, 95 and 30% were oligotrophs, alkalophilic (pH 9) and acidophilic (pH 4), respectively. Of these 97, 30 and 42% were screened as ammonia, IAA and siderophore producers respectively, however very low frequency (4%) of isolates solubilizing phosphate. Finally, 19 extreme-tolerant PGPR which showed more than one functional traits were identified. The 16S-RFLP using two tetracutter (*AluI* and *HaeIII*) showed genetic diversity among the isolates. Among them, *Paenibacillus* spp (SHU53) inhibited both *R. solani* and *X. oryzae*. PCR amplification showed that none of isolates had nitrogen fixation gene (*nifH*) and antibiotic producing genes for DAPG, phenazine and pyoluteorin.

Table 39. Cataloging of potent PSF and SPF from rice rhizosphere

Isolate no.	Gen Bank acc. no.	MTCC acc. no.	Organism (strain)
PF-1	JX122729	FJ624271	*Talaromyces stipitatus* (CRRI-59)
PF-2	JX122730	FJ624271	*Talaromyces stipitatus* (CRRI-60)
PF-3	JX122731	HQ608070	*Penicillium verruculosum* (CRRI-61)
PF-4	JX122732	AJ564813	*Cordyceps bassiana* (CRRI-62)
PF-5	JX040476	AB470913	*Alternaria alternata* (CRRI-70)
PF-6	JX122733	HQ832961	*Aspergillus* sp. (CRRI-63)

Soil and Crop Management for Productivity Enhancement in Rainfed Upland Ecosystem

Evaluation of rice varieties, stand establishment methods and crop geometry under post-flood situation in rainfed lowland ecosystem

Three rice varieties, *viz*., (i) Anjali, (ii) Luit and (iii) Naveen; three crop stand establishment methods, *viz*., (i) double transplanting, (ii) normal transplanting and (iii) direct wet sown; and two spacings – 20 cm x 15 cm and 15 cm x 15 cm were evaluated at RRLRRS, Gerua during 2012 late *sali* season. The crop was planted on 12 September, 2012. The plant height, days to 50% flowering, number of panicles per unit area, number of grains per panicle, grain yield, straw yield differed significantly with crop establishment methods. Significantly higher grain yield was observed under normal transplanting than under direct wet sowing. Though significantly higher number of panicles per unit area was recorded in direct wet sown crop, it yielded less due to more number of unfilled grains per panicle and low test weight. Double transplanting of rice did not cause any increase in grain yield over normal transplanting which was due to less number of panicles per unit area. Crop geometry had significant effect on grain yield and yield attributes, namely, number of panicles per unit area and number of grains per panicle.

The interaction effects among variety, stand establishment methods and spacing were found significant only in respect of number of panicles per unit area, number of grains per panicle and grain yield. Transplanting of Naveen at 15 cm x 15 cm spacing recorded grain yield of 4.27 t/ha which was at par with double transplanting at 15 cm x 15 cm spacing (4.36 t/ha). Under direct wet sown condition, Luit at 15 cm row spacing recorded grain yield of 2.71 t/ha, however, Naveen yielded less (0.79 t/ha) which was due to higher rate of spikelet sterility.

Response of direct seeded rice to NPK in clay loam and red sandy soil

Performance of a set of six promising elite direct seeded rice cultures/varieties (CRR596- 8-1, CR523-2-2-1-1, CRR632-34-1, CRR635-3-2, Sahbhagidhan and Sadabahar) was evaluated in clay loam soils during 2012 with three different levels of N, P and K *viz.*, low ($N_{30}P_{20}K_{10}$), moderate ($N_{60}P_{40}K_{20}$) and high ($N_{90}P_{60}K_{30}$). Low to moderate application of NPK caused substantial variations in grain yield of cultures CR596-8-1 & CRR632-34-1. Further increase in NPK level resulted in marginal improvement in productivity of the same varieties. Other rice cultures/varieties (CR523-2-2-1-1, CR635-3-2, Sahbhagidhan and Sadabahar), however, responded well to high level of NPK.

Influence of different seed rates and row spacing on productivity of direct seeded rice

A field experiment was conducted to optimize the seed rate and row spacing for direct seeded rice under aerobic conditions. Four seed rates (25, 30, 35 and 40 kg/ha) assigned to main plots and three row spacing (20, 25 & 30 cm) assigned to subplots and replicated thrice in a split plot design. Spacing and seed rate did not show any significant variations in yield.

Suitable P sources for higher efficiency of AMF inoculums

An experiment was initiated during 2009 *kharif* with an objective of identifying suitable P source for higher activities of AM-inoculum in terms of P uptake and growth promotion by upland rice. Soil-root based AMF inoculum was applied (@1.25 t/ha) under different P sources *viz.*, (i) 100% P (@ 20 kg P_2O_5/ha) as DAP, (ii) 100% P as Purulia Rock Phosphate (PRP) containing 18-20% P_2O_5, (iii) 50% P as DAP and 50% as PRP. AMF population dynamics throughout the study period (2009-2012) was monitored. Effects of AMF inoculation under different P sources were evaluated for P uptake, yield attributing characters and grain yield of upland rice variety Vandana. Half of the P as DAP and half as PRP supported highest population growth of native AMF with additive effect when AMF inoculum was applied. This concomitantly led to significantly higher colonization (AMF), P uptake and grain yield of rice.

Identification of AM-supportive Agro-management (Tillage & sowing date)

An experiment was conducted during *kharif* 2012 to work out AM-supportive agro-management practices involving tillage and sowing date. Minimum tillage (MT-sowing seed using seed-drill in once tilled soil) was compared with conventional tillage (CT- sowing behind tractor operated plough in primary and secondary tilled soil) at two sowing dates (12 June and 26 June) using rice variety Sahbhagidhan. Minimum tillage supported higher population build up during crop season over conventional tillage irrespective of sowing date.

SSR marker based differentiation of two rice genotypes with differential AM responsiveness

Two rice varieties *viz.*, Sathi 34-36 and Vandana were identified for polymorphism survey with SSR markers. The variety Sathi 34-36 represents fast growth rate (higher nutrient demand), strong AM responsiveness with moderate root length density and higher P demand, while other variety (Vandana) has fast-medium growth rate (medium nutrient demand), moderate AM responsiveness with moderate root length density and lower P demand. Sathi 34-36 and Vandana were screened for parental polymorphism with 92 SSR markers. Sixteen SSR primers showed polymorphism (Fig 17).

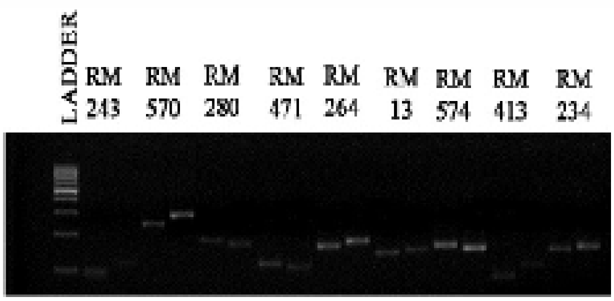


Fig 17. Polymorphism between Sathi and Vandana using RM Markers 100bp Ladder was used

Performance of drought tolerant breeding lines under direct seeding

A participatory varietal selection trial was conducted under direct seeded condition. The crop was sown on 30 June, 2012 with 10 entries (IR83388-B-B-108-3, IR83383-B-B-129-3, IR82589-B-B-84-3, IR83383-B-B-129-4, IR82635-B-B-145-1, IR83377-B-B-93-3, IR83373-B-B-47-4, IR83383-B-B-141-2,) with 4 checks (Sahbhagidhan, Abhishek, IR64 and MTU1010). Fertilizer was applied @ 80:30:30 in three splits and the crop was managed with two hand weeding. The crop suffered reproductive stage drought stress. None of the new drought tolerant cultures surpassed the yield levels of the drought tolerant checks Sahbhagidhan or the yield check Abhishek but three of them gave grain yields higher than the drought susceptible IR64 or MTU 1010. The culture IR83888-BB-108-3 was the best performing (3.67 t/ha) entry under direct seeded conditions.

RICE PESTS AND DISEASES-EMERGING PROBLEMS AND THEIR MANAGEMENT

Management of Rice Diseases in Different Ecosystems

Evaluation of the efficacy of new molecules of fungicides against blast

Foliar blast was reduced to a minimum of 5% by Propiconazole 25% EC spray @ 2.5 ml/l and a maximum of 8.5% by Tricyclazole 75% WP treatment @ 0.6 g/l spray at 80% disease pressure in the susceptible variety HR 12. However, grain yield was recorded highest (2.72 t/ha) under Carbendazim 50% WP @ 2 gm/l treatment followed by 2.60 t/ha in Propiconazole 25% EC @1ml/l treatment while in the control grain yield recorded was 1.21 t/ha.

Spectrum of fungitoxicity of new plants

Among the four new plants (*Eclipta prostrata* L., *Ludwigia perennis* L., *Commelina benghalensis* L. and *Synedrella nodiflora* L.) tested against conidial germination of three pathogens *viz., Pyricularia grisea*, *Helminthosporium oryzae* and *Curvularia lunata* of rice, only aqueous extract of leaves of two plants *viz., E. prostrata* and *C. benghalensis* produced complete inhibition of conidial germination (2%) but only at the concentration of 100%. In addition to the above two plants, *L. perennis* also produced complete inhibition of conidial germination in ethanolic extract at a concentration of 100%.

Evaluation of botanical formulations against rice blast

Formulated product of *O. sanctum* essential oil (EO) exhibited complete inhibition in conidial germination against *P. grisea, H. oryzae* and *C. lunata* up to 0.01% FA (B+) with different concentrations of EO. *Aegle marmelos* aqueous mother extract (AME) in combination with formulating agent FA(A+), showed complete inhibition in *P. grisea* conidia at 0.01% concentration but only at 0.1% in *H. oryzae* and *C. lunata* with all tested combinations of AME.

Partial purification and isolation of active ingredient

Isolation and identification of active principle from *Aegle marmelos* was accomplished. The isolated and purified compound was subjected to Ultraviolet (UV), Infrared-spectroscopy (IR), Nuclear magnetic resonance spectroscopy (for both ^{1}H-NMR and ^{13}C-NMR), Mass spectroscopy and elemental analysis. Spectral analysis of the isolated compound revealed that the active constituent in *Aegle marmelos* was d-limonene (Fig 18).

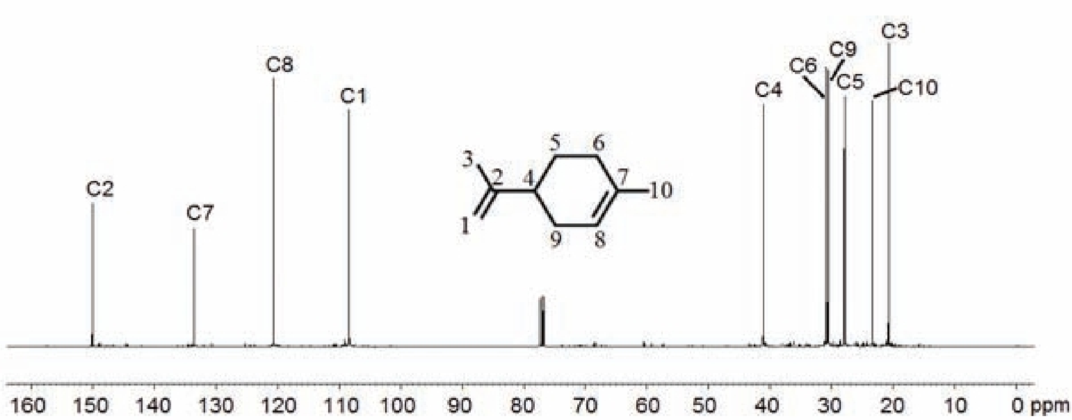


Fig 18. ^{13}C NMR spectrum of purified active compound separated using column chromatography

Identification of resistant/tolerant donors against rice pathogens

Rice germplasm lines were screened during *kharif* 2012 against BLB, sheath blight and blast using standard evaluation technique. Among them 3 lines got score 1 and 180 lines got score 3 against BLB; 20 lines got score 3 against sheath blight; 11 lines got score 1 and 64 lines got score 3 against blast (Table 40). Total 135 germplasm lines (67 previous year selected materials + 23 IRBB differentials+45 tolerant varieties) were maintained in field during *rabi* season.

Identification of sources of resistance/ tolerance against sheath blight disease of rice

Out of the 335 entries tested in AICRIP national screening nurseries for their resistance against sheath blight disease, no entry was found to be resistant. Fifty one entries showed moderate resistance and 82 entries showed tolerance. Remaining entries showed susceptible to highly susceptible reactions.

Out of the 10 genotypes, namely IET17885, IET17886, IET19140, IET20230, IET20443, IET20553, IET20775, ADT 39 and Mansarovar received from Crop Improvement Division, CRRI, Cuttack and tested at Research farm of RRLRRS, Gerua, Assam during *sali*/ *kharif*, 2012, one entry (IET 17886) was found to be moderately resistant while 3 entries, *viz*., IET 17885, IET 20443 and Mansarovar showed tolerance to sheath blight disease.

Identification of sources of resistance against rice *tungro* disease

Sixty five rice genotypes comprising of promising, recommended indigenous rice varieties and breeding lines were evaluated for resistance against *tungro* disease in late *sali* season under natural disease pressure. Four genotypes, *viz*., IR 71606-2-1-1-3-3-1-2, Pankhari 203, PTB 18 and PTB 21 showed resistant reaction and sixteen genotypes, *viz*., CR2482-10, CR2643-1, CR2644-2, CR2647-5, CR2649-7, CR2652-14, CR2654-17, CR2656-11, IC516579, IR68068-99-1-3-3-3, IR71606-1-5-3-4-3-3-3, Jaymati, Matiyaburushu, Swarna, Swarna *Sub1* and Purnendu showed moderately resistant reaction. Out of the 958 entries tested in AICRIP national screening nurseries for their resistance against rice *tungro* disease, no entry was found to be resistant. Ninety two entries showed moderate resistance and the remaining entries showed tolerance to highly susceptible reaction.

Eighteen high yielding, promising and recommended rice varieties were evaluated in a replicated trial for their resistance against RTD in early *ahu* under natural condition. The highest incidence of

Table 40. Identification of resistant/tolerant donors against rice pathogens

Disease	No. of genotypes screened	Resistance (No. of genotypes)	Genotypes screened
Blast	2058 (From AICRP) IARI, CRRI	Resistant (11) (SES score 1) Moderately resistant (64) (SES score 3)	AVT-1-IME-1231, AVT-1-3306(AEROBICS), AVT-2-3205(AEROBICS), NSDWSN-3529, NSDWSN-3531, NSDWSN-3532, AL&ISTVT-1928, AL&ISTVT-1932, IVT – 1337IME, IVT-AEROBICS-3423, DHAMAS-2a
BLB	1136	Resistant (3) (SES score 1) Moderately resistant (180) (SES score 3)	AVT-1-BT-2101, AVT-1-IM-1509, RP-PATHO-7
Sheath blight	1136	Moderately resistant (20) (SES score 3)	AVT-1-IM-1509, IVT-DW- 627, IVT-DW- 629, IVT-DW- 630, IVT-RSL- 327, NSDWSN-3504, IVT-E-TP-1019, IVT-E-TP-1028, IVT-E-TP-1037, CSTVT(CONTD.)-556, IVT-AEROBICS-3447, SWARNA SUB1, IVT-DW -2803, IHRT-M-15/124, IHRT-M-22/108, IHRT-ME-3/111, IHRT-ME-5/125, IHRT-ME-6/109, IHRT-MS-12/109, IHRT-MS-9/120

RTD (34.29%) was observed in the cultivar TN 1. Only five varieties, *viz*., Anjali, Jaya, Jaymati, Kalong and Swarna showed moderate resistance against RTD. Remaining 13 varieties were found susceptible to the disease.

Efficacy of fungicides against rice sheath blight

Six fungicides including mixed formulations namely, Trifloxystrobin 25%+Tebuconazole 50% (Navito 75 WG@ 0.8g), Kresoxim methyl (Ergon 44.3 SC@ 2ml), Azoxystrobin (Amistar 25 SC@ 2ml), Tricylazole (Beam 75 WP@ 1.2g), Carbendazim (Bavistin 50 WP@ 2g), Propiconazole (Tilt 25 EC@ 2ml) along with control were evaluated against artificially inoculated sheath blight disease in the lowland rice variety Tapaswini. All the fungicides could control/ prevent the growth of *Rhizoctonia solani* till 8th day after spray. Azoxystrobin had the best result in terms of prevention of infection, may be due to its higher self life. Yield did not vary significantly among the treatments. But, Trifloxystrobin 25%+Tebuconazole 50% treatment gave the highest yield of 5.78 t/ha compared to control plots which produced 4.95 t/ha of paddy.

Rice-Endophyte Interaction with Pathogens in Response to Environment

Endophytic *Penicillium* and *Dendryphiella* from rice var. Pooja slowed down/restricted mycelial growth and reduced the number of sclerotia of *Rhizoctonia* sp. (Table 41). Rice plant growth was significantly enhanced by both the endophytes. Isolated endophytes were identified, their nucleotide sequences were submitted to NCBI- Gene Bank and following Gene Bank accession numbers for five endophytes were received KC515384; KC515385; KC690012; KC690013; KC690014.

Further, two endophytes, namely *Meyerozyma guilliermondii* (isolate ID E65) and *Dendryphiella* species (isolate ID Swarna-1) were isolated from seeds of Pooja and Swarna, respectively. Gene Bank accession numbers for endophyte isolate Swarna-1 provided was KC832510.

Differential occurrences of diseases were observed in different plots of the rice variety Pooja at CRRI, Cuttack. In lowland the incidence of diseases like false smut, sheath rot, bacterial leaf blight, narrow brown leaf spot and seed discoloration were observed.

The rice variety Sarala had severe incidence of narrow brown leaf spots, sheath rot and bacterial leaf blight. *Curvularia spp*. from leaf spots on *Paspalum scrobiculatum* was pathogenic to rice.

The seedling blight of rice (c.o. *Sclerotium* spp.) was observed in irregular patches. Initially about 30 per cent seedlings of rice cultivars Shatabdi, Naveen, Varshadhan and Durga at CRRI farm were affected by it. Gene Bank accession numbers for nucleotide sequences of isolated pathogens were: KC832503, KC832504, KC832505 and KC832506.

Identification and Utilization of Host Plant Resistance in Rice against Major Insect and Nematode Pests

Brown plant hopper (BPH), gall midge (GM) and yellow stem borer (YSB)

Two hundred rice genotypes from CRRI germplasm collections were mass-screened against BPH and GM

Table 41. Endophytes associated with rice cultivars and their impact on rice pathogens

Isolate ID	Isolated from seeds of rice var.	Organism	Impact on rice pathogens
E62	Pooja	fungal environmental samples	Effective against pathogenic *Cochliobolus miyabeans* (c.o. brown spot) and *Rhizoctonia sp.*
E64	Pooja	*Penicillium*	Effective against pathogenic *Cochliobolus miyabeans* (c.o. brown spot) and *Rhizoctonia sp.*
E69	Pooja	Endophytic ascomycota fungus	Effective against pathogenic *Cochliobolus miyabeans* (c.o. brown spot) and *Rhizoctonia solani* sp.
E109	Lunishree	*Fusarium sp.*	Effective against pathogenic *Fusarium*. 60% inhibition in vitro
E178	Lunishree	Fungal endophyte	Effective against pathogenic *Fusarium*
E183	Lunishree	*Gibberella sp.*	Effective against pathogenic *Fusarium*
E191	Lunishree	*Penicillium*	Effective against pathogenic *Fusarium*

under greenhouse condition. Genotypes IC No. 324171 and 326430 showed resistant reaction of score 1, whereas 11 genotypes, i.e., IC324171, 326430, 336983, 283262, 282825, 279374, 356419, 337517, 346002, 337545 and 267428 showed resistant reaction of score 3. However, none of these accessions showed resistant reaction against GM.

Two hundred farmers' varieties were mass-screened against BPH and GM under greenhouse condition and against YSB under field condition. Entries like, Assamchudi (REG.2011/740), Baigan manji (SSTL No.405), Champa (SSTL No. 490), Champeisiali (REG.11/1109), Balibhanjana-T (REG.2011/860), Ganjeijota-P (REG 11/1249) and Harishankar (REG.2011/952) were found highly resistant against BPH with score 1. Baigana manji-K (SSTL No. 293), Champa (SSTL No. 218), Champeisali-P (SSTL No. 889), Dhulashree (SSTL No. 1174), Dhanshree (SSTL No. 775), Dhoia bankoi (SSTL No. 504), Haladi gundi (SSTL No. 1207) and Harishankar (SSTL No. 1077) were found highly resistant with score ranging from 0–1. Two varieties, namely, Dhanshree (Reg.-11/775) and Dhob-Sarian (Reg-11/1047) showed less than 10% DH.

White backed plant hopper (WBPH)

A total of 121 genotypes were screened against WBPH in greenhouse condition including TN1 and IR 64 as susceptible, and resistant checks, respectively as per the standard evaluation system. Only two genotypes, PSS80 and BNO42703 showed resistant reaction of score 3 whereas, 11 genotypes namely, PSS83, PSS99, BNO42666, BNO42677, BNO42678, BNO42680, BNO42681, BNO42692, BNO42693, BNO42695 and BNO42720 were found moderately resistant with score 5.

Rice leaf folder (LF)

Among the 240 accessions screened under artificial infestation against leaf folder, IC282818 had shown less than 5% leaf damage. The result needs further evaluation for confirmation of resistance.

Rice root knot nematode (RRKN)

Sixty-eight genotypes were screened in greenhouse condition against RRKN as per standard evaluation system. Two genotypes, namely, IC298563 and IC311010 were found moderately resistant with score 3.

Evaluation of breeding lines

BPH: Four breeding lines namely, CR2711-76, CR3005-77-2, CR3006-8-2 and CR3005-230-5 in the background of BPH resistant donors AC35181 (Salkathi) and AC35184 (Dhoba numberi) were found highly resistant against BPH at CRRI as well as in the AICRP, DRR, Hyderabad.

GM: Nine breeding lines developed in the background of Sarasa, ARC5984, ARC5985, ARC5986, ARC5987, ARC5988 and Phalguna were found highly resistant to gall midge under greenhouse condition.

Biotype study

Genotypes of known BPH resistant genes, i.e. *bph 2, BPH 17, bph 4, bph 6, bph 7, bph 8, bph 9 Bph 1+, Bph 18, bph 2+Bph 3 and BPH 20/21* were screened for their reaction against BPH population maintained in the greenhouse. No genotype with known genes was found resistant except for *Ptb* 33 which showed high resistance of score 1. Similarly, under gall midge biotype trial, ARC 5984 (Gm 5), RP 2333-156-8 (Gm 7), RP 2068-18-3-5 (Gm 3), Abhaya (Gm 4) and Aganni (Gm 8) were found highly resistant to CRRI biotype, Gm 2 with no silver shoot formation as against 80% silver shoot in the susceptible check TN1.

Bio-ecology and Management of Pests under Changing Climatic Scenario

Population trend of green leaf hopper based on light trap data

Analysis of light trap data from 2001-2011 indicated that green leafhopper (GLH) population is declining over the years. RH II alone could explain 29 % of the light trap catches when analyzed with log value of GLH population of six weeks lag period weather data. Six weeks lag period data related to RH II, SSH, Max. T, Min. T together could explain 35% of GLH population trend.

Influence of rainfall and temperature on YSB incidence

With the decrease in rainfall towards 34 standard meteorological week (SMW) (Aug.19 onwards), moth trapping was observed indicating brood emergence. However, high brood emergence was not observed, which could be due to rain during 40-45 SMW followed by fall of temperature (Min.) towards 46 SMW (Fig 19). Moth trapping was observed from 3rd SMW during *rabi* season. High brood emergence was experienced when

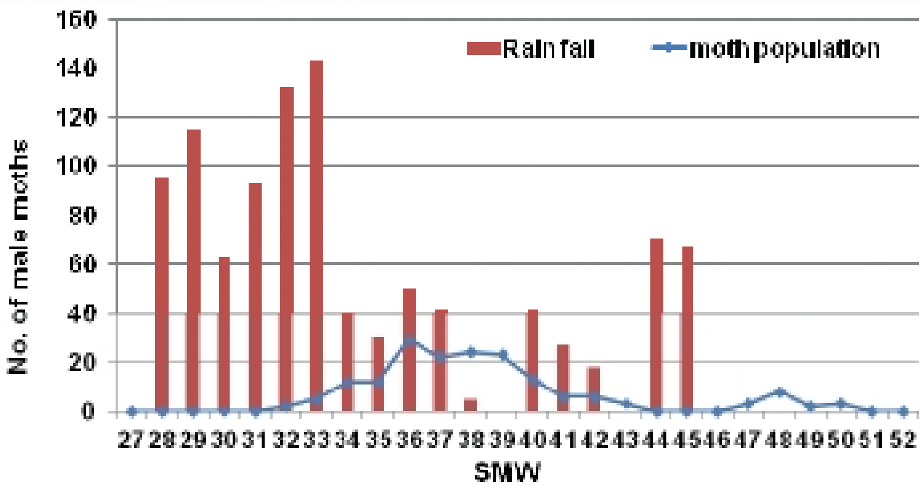


Fig 19. Influence of Rainfall and temperature on YSB population during kharif, 2012

minimum temperature exceeded 14.7°C with maximum temperature varying between 26.1 – 29.6°C. More moths were trapped during *kharif* from low lying areas of long duration varieties and nearby plots, and also around scented rice plots.

Effect of high temperature on the multiplication of BPH

BPH thrived and multiplied well at a temperature of 30 ± 3°C. Eggs hatched after 7 days of egg laying. With the rise in temperature, there was a gradual decrease in the number of eggs laid. The percentage of egg hatching decreased and the incubation period increased. At a temperature regime of 40-42°C, there was no egg laying.

Effect of long term use of pesticides on insect pests

Two insecticides, one fungicide and one herbicide were applied in the field during *rabi* and *kharif* 2012 to study their effect on insect pests, soil microbes and nematodes. Result of the study indicated that Cartap recorded the lowest dead heart (DH), white ear head (WEH), gundhi bug damage, leaf folder (LF) damage and highest grain yield during both the seasons of study. All the treatments registered significantly less damage due to insect pests compared to the control (Table 42). Cartap proved to be the best in reducing the insect infestation.

Table 42. Effect of long term use of insecticide, fungicide and herbicide on insect pests

Treatment with % a.i and dose g/ha	%DH *Rabi*	% DH *Kharif*	%WEH *Rabi*	%WEH *Kharif*	%LF *Rabi*	%LF *Kharif*	% G. bug damage *Rabi*	% G. bug damage *Kharif*	Yield t/ha *Rabi*	Yield t/ha *Kharif*
Cartap@1kg a.i./ha	4.05 (11.60)	3.87 (11.35)	4.0 (11.52)	3.62 (10.97)	3.12 (10.15)	3.0 (9.95)	9.25 (17.69)	8.75 (17.19)	5.73	5.25
Chlorpyriphos @0.5kg a.i./ha	4.72 (12.54)	4.12 (11.71)	4.75 (12.58)	4.0 (11.53)	4.0 (11.52)	3.7 (11.08)	9.95 (18.38)	10.12 (18.55)	5.42	5.20
Carbendazim@0.1%	7.27 (15.64)	6.35 (14.59)	7.15 (15.50)	6.3 (14.53)	6.12 (14.32)	5.65 (13.74)	13.0 (21.13)	12.87 (21.02)	5.31	4.88
Pretilachlor @0.75kg a.i./ha	7.37 (15.75)	6.50 (14.72)	7.25 (15.61)	6.67 (14.97)	6.5 (14.76)	6.1 (14.30)	13.95 (21.93)	13.30 (21.38)	5.21	4.53
Control	8.32 (16.76)	8.0 (16.42)	8.27 (16.71)	7.90 (16.32)	7.50 (15.88)	7.97 (16.39)	15.42 (23.11)	14.87 (22.68)	4.53	4.26
CD (P<0.05)	0.67	0.39	0.47	0.31	0.83	0.55	0.75	0.76	0.81	0.72

Data within parantheses are angular transformed values

Effect of long term use of pesticides on soil microbial activity

Trend of MBC observed was in the order of Pretilachlor>Carbendazim>Chlorpyriphos>Cartap> Control (Table 43). Cartap did not harm the maximum groups of microbes and their activity except fungi and actinomycetes (2.62) each with respect to control (4.36) and moreover, 39.7% of urease activity was increased. Chlorpyriphos and Pretilachlor were presumed to be safer pesticides as they did not harm the groups of microbes and their activities. Carbendazim affected badly the fungi and actinomycetes groups compared to control. The two fold decrease of population of denitrifier, nitrifier and oligotrophs was observed from *kharif*, 2008 (initial control) to *kharif*, 2012.

Effect of long term use of pesticides on Rice RKN populations

Population of rice root knot nematode, *Meloidogyne graminicola* decreased over the years compared to the initial year of 2010 in all the treatments except where Carbendazim was applied, whereas population of rice root nematode increased (Table 44).

Dissipation of chlorpyriphos under elevated CO_2 and temperature condition

Effect of elevated CO_2 (550 ppm) and temperature (2°C) were studied to investigate the persistence of chlorpyriphos. Dissipation pattern was similar irrespective of the treatments. But dissipation rate was higher for CO_2+temperature treated pots. It was observed that chlorpyriphos persisted over 14 days in the tune of 0.0026 µg/g only under ambient condition. In other treatments, chlorpyriphos was undetectable after 7 days of spray. Combined effect chlorpyriphos and elevated CO_2 and temperature on soil enzyme activities was also studied and it was observed that soil microbial biomass carbon, Fluorescein diacetate and dehydrogenase activities had responded negatively for first few days of the pesticide spray. Thereafter, no effect was observed with relation to pesticides. But enzyme activities were better for elevated CO_2 as well as elevated CO_2 and temperature treated pots compared to ambient conditioned pots (Fig 20).

Evaluation of botanicals as grain protectants

Eight botanical oils *viz*., til (*Sesamum indicum* L.), karanja [*Pongamia pinnata* (L.) Pierre], bael (*Aegle marmelos* Corr.), castor (*Ricinus communis* L.), citronella [*Cymbopogon citrateus* (DC.) Stapf.], crown oil (resin of *Shorea robusta* Roth.), mustard (*Brassica campestris* L.) and groundnut (*Arachys hypogea* L.) were extracted using

Table 43. Trends of soil microbial enzyme in long term pesticides paddy treated paddy soil

Treatments	MBC	DHA	FDA	U	AcP	AlP
Cartap hydrochloride	277.21	13.18	24.06	74.480	95.74	24.01
Chlorpyriphos	511.07	12.21	24.57	45.64	96.88	17.74
Carbendazim (Bavistin)	730.98	13.76	23.76	55.77	86.69	16.13
Pretilachlor	982.65	34.16	18.77	67.92	89.36	30.21
Control	196.68	16.36	24.28	53.31	99.61	16.52

MBC- Microbial biomass carbon (µg MBC/g of soil); DHA- Dehydrogenase (µg TPF/g soil/h); FDA-Fluorescindiacetate (µgFDA/g soil/h); U-Urese (mg Urea/g soil/h); AlP-Alkaline phosphatase and AcP- Acidic phosphatase (µg p-nitrophenol/g soil/h).

Table 44. Changes in the soil population of nematodes in long term pesticide trials

Nematodes Per 100 cc soil	RKN (*Meloidogyne graminicola*)			RRN (*Hirschmanniella* spp.)		
Year	2010	2011	2012	2010	2011	2012
Cartap hydrochloride	19.50	1.50	4.17	28.75	34.75	446.75
Chlorpyriphos	19.25	1.75	45.83	49.00	32.00	359.00
Carbendazim (Bavistin)	30.00	7.25	179.17*	167.50	91.25	646.75
Pretilachlor	35.00	8.25	16.67	185.75	96.75	392.50
Control	39.00	9.50	8.33	183.75	103.00	208.75

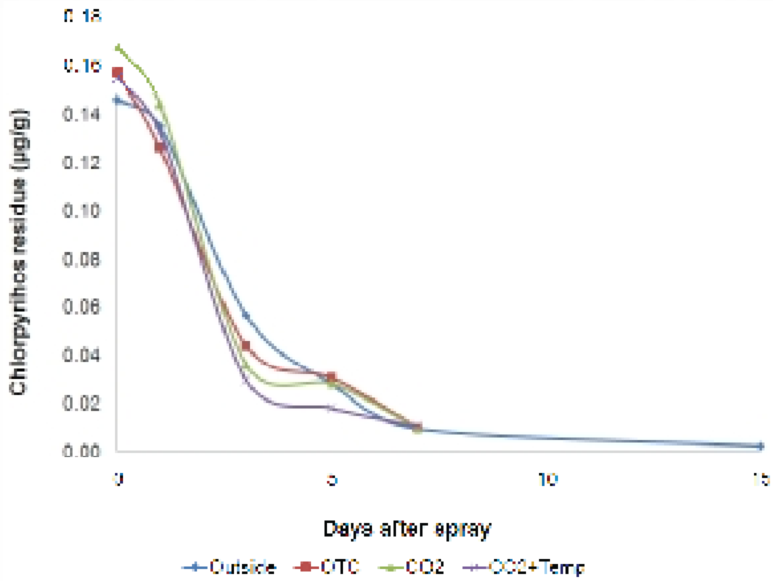


Fig 20. Persistence of chlorpyriphos under elevated CO_2 and temperature condition

Clevenger oil extraction apparatus and tested against lesser grain borer, *Rhyzopertha dominica* (Cramer.) under controlled conditions on variety Ratna. The oils of citronella, crown and bael could effectively protect the stored paddy from this pest for six months (Table 45).

Influence of agrochemicals on natural enemies/predators of rice pests

Under IPM spider population was more (3.0 spiders/sweep) compared to control plot (2.3 spiders/sweep). Among the chemicals, Sutathion (3.5 spiders/sweep) was less harmful to spiders as well as damselflies (8.5 insects/sweep). Carbofuran (6.5 spiders/sweep) and Cartap (6 spiders/sweep) also supported good population of spiders and damselflies.

Effect of dual cropping of *Azolla* and management of straw bundles on spider population

Azolla was applied as compost and as a dual crop. On an average 2.0, 2.6 and 1.8 spiders /sweep were observed in the *Azolla* compost, *Azolla* as dual crop and control plots, respectively at early tillering which increased to 3.0/sweep, 4.5/sweep and 2.0/sweep at late tillering stage of the crop. A maximum of 13 arthropods were recorded as compared to 9 species on control. *Tetragnatha maxillosa* (Boes. & Strand.) was the dominant spider under all the treatments. Odonate population was low in plot (3.3/sweep) compared to (5.6/sweep) in control plot. Observations for spider species were also taken on the stubbles. *Plexippus* spp. was the common spider in loose straw management. Three species of spiders were observed in the ratoon along with case worm and grasshoppers. Besides spiders, two predators *Andrallus spinidens* (Fabr.) and *Metioche* sp. were also observed.

Table 45. Adult population of lesser grain borer, *Rhyzopertha dominica* emerged in treated paddy grains

Treatment	Adult population 60 DAR	Adult population 120 DAR	Adult population 180 DAR
Til	17.63 (310)	21.22 (450)	33.62 (1130)
Karanja	13.05 (170)	17.64 (311)	22.14 (490)
Bael	10.51 (110)	13.80 (190)	07.24 (052)
Castor	13.41 (180)	16.74 (280)	20.89 (436)
Citronella	03.93 (015)	04.74 (022)	00.70 (000)
Crown	05.33 (028)	06.36 (040)	03.93 (015)
Groundnut	16.89 (285)	24.90 (620)	29.67 (880)
Mustard	16.71 (279)	24.09 (580)	28.64 (820)
Control	18.93 (358)	28.55 (815)	42.66 (1820)
SD ($P<0.05$)	3.97	6.48	12.13

DAR= days after release; Initial grain moisture-16%

Data in parenthesis are $\sqrt{X+0.5}$ transformation of original value dose @ 0.5% v/w; Initial release 10 pairs of adults

Influence of different rice cultivation practices on pests

Under aerobic rice condition, observations were taken on 18 cultures (100-125 days duration). The short horned grasshopper *Oxya velox* (Fabr.) was the important pest with the average population of 2 adults/sweep followed by the rice green semilooper *N. diffusa* (Fabr.). Population of *N. diffusa* was very negligible under irrigated ecosystem. The rice skipper *Parnara naso* (Moore) and *Pelopidas mathias* (Fabr.) were the other foliage feeders observed.

Under SRI method of cultivation 3.6% dead heart (DH) was observed in comparison to 8.9% under conventional method of cultivation, while white backed plant hopper (WBPH) population was 2-3 insects /hill under SRI compared to 15-20 insects /hill under conventional method. Besides these pests, damselfly population was more under conventional method of cultivation compared to the SRI crop.

DNA barcoding of major rice insect pests

DNA barcodes are generated using DNA barcoding primer COXI for eight insect pests of rice *viz.*, brown plant hopper [*Nilaparvata lugens* (Stal)], striped stem borer [*Chilo suppressalis* (Walk.)], green leaf hopper [*Nephotettix virescens* (Dist.)], yellow stem borer [*Scirpophaga incertulas* (Walk.)], white stem borer [*Scirpophaga innotata* (Walk.)], pink stem borer [*Sesamia inferens* (Walk.)], angoumois grain moth *Sitotroga cerealella* (Oliv.)]and red flour beetle [*Tribolium castaneum* (Herbst)]. These barcodes have been submitted to BOLD (biodiversity of life database) system and gene bank accessions obtained (Fig 21).

Formulation, Validation and Refinement of IPM Modules in Rice

Pest monitoring/surveillance in farmer's fields during *kharif* 2012 (Shallow rainfed lowland, Cuttack)

A survey was conducted for the incidence of major rice diseases and insect pests during *kharif* 2012 in Sankilo village of Nischintkoili, Cuttack. Diseases and insect pest incidences were recorded in rice varieties namely, Swarna, Gayatri, Pooja, Naveen and Parvati grown by the farmers. Insects namely, stem borer, leaf folder, gundhibug and diseases namely foot rot and blast were observed. In variety Swarna, stem borer infestation causing 6.35% DH, 6.1% WEH; 5.5% leaf folder; 6.5% foot rot, 5.3% blast infections were observed. In case of variety Pooja, pest infestations were 6.3%DH, 7.15%WEH, 5.65% leaf folder damage, 8.32% foot rot and 5.6% blast.

Pest monitoring/surveillance in farmer's fields during *kharif/sali* 2012 (Lowland, Assam)

A survey was conducted to record the incidence of major rice diseases and insect pests during *kharif*/*sali* 2012 in Burlutpar and Galdighala villages of Mukalmua block of Nalbari district of Assam. Diseases and insect pest incidences were recorded in varieties namely, Swarna, Rajalaxmi and Ranjit grown by the farmers. Insects namely, stem borer, leaf folder and diseases namely, brown spot, sheath blight were observed. In variety Swarna, stem borer infestation causing 6.21%

Fig 21. DNA barcodes of major insect pests of rice

DH, 5.8% WEH, 5.23% leaf folder, 6.36% brown spot, 12.36% sheath blight infections were observed. In case of hybrid rice Rajalaxmi, stem borer causing 7.4% DH, 6.08% WEH, 4.96% leaf folder and 4.81% brown spot infection were recorded. But, in case of variety Ranjit, stem borer causing 6.03% DH, 4.72% WEH and 6.64% BLB infections were observed.

Validation of IPM module in rainfed shallow lowland at Sankilo, Cuttack

An area of 30 acres was selected for validation of IPM modules in rainfed shallow lowland situation in Sankilo Village in Cuttack district. In IPM practice, farmers followed seed treatment with carbendazim @ 2g/ kg seed, before sowing in nursery in two popular varieties Swarna and Pooja along with clean cultivation and line transplanting. They followed need based applications of pesticides in the affected areas only. Carbendazim @ 2g/lit water against foot rot and blast. Cartap @ 1kg a.i./ha against YSB, LF and BPH, and need based foliar application of Chlorpyriphos @ 0.5 kg a.i./ha against gundhibug were used. Pheromone trap and auto confusion trap for monitoring purpose were installed and trichocards were used in the field for bio control of YSB and LF. Farmers were trained to identify the harmful and beneficial insects in their field. Regular field visits were followed to assess the insect pest infestation. In farmer's practice, they use pesticide in whole plot and in a schedule based manner, irrespective of pest incidence, at least 4-5 times in a season.

Variety Swarna with IPM practice had significantly higher yield (7.1 t/ha) as compared to farmer's practice (6.21 t/ha). Variety Pooja with IPM practice also recorded significantly higher yield (6.08 t/ha) compared to farmer's practice (5.34 t/ha). The dead heart, white ear head, leaf folder damage, gundhibug damage, extent of root rot and straw yield were significantly less and natural enemies population was significantly more in IPM practice in both the varieties tested (Table 46).

Average egg-mass parasitism of yellow stem borer through supplementary egg fixing indicated parasitism due to *Telenomus dignoides* in both IPM (30.5%) and non-IPM (8.0%) plots. Parasitism due to *Trichogramma japonicum* was 12.8% in IPM and 5.5% in non-IPM fields.

Economic evaluation of IPM at Sankilo, Cuttack

The additional return in IPM plots grown with Swarna variety was computed to be Rs.11625/ha, while in Pooja the return was Rs.9750/ha. Besides the additional returns, there was a cost saving of Rs.869/ha on both the varieties. Thus the total gain in IPM over non IPM was Rs.12494/ha and Rs.10619/ha in Swarna and Pooja, respectively.

Validation and promotion of IPM modules in farmer's fields for lowland in Assam

Thirty acres of lowland in a compact block was selected in the farmer's fields involving 25 farmers of the village, Galdighala of Mukalmua block of Nalbari district of Assam during *boro* 2012-13.

Table 46. Effect of IPM in shallow rainfed lowland rice during *kharif*-2012

Treatment	%Dead heart	%White ear head	%Leaf damage	%Gundhi bug damage	%Footrot	Natural enemies/m^2	Straw Yield t/ha	Grain Yield t/ha
Swarna IPM	4.05 (11.60)	4.5 (12.24)	3.33 (10.52)	6.5 (14.76)	4.5 (12.24)	4.2	10.82	7.10
Swarna Non-IPM	6.35 (14.59)	6.1 (14.30)	5.5 (13.56)	9.25 (17.69)	6.5 (14.76)	3.3	10.08	6.21
Pooja IPM	4.42 (12.13)	5.53 (13.58)	4.7 (12.52)	8.75 (17.19)	6.1 (14.30)	4.1	10.63	6.08
Pooja Non-IPM	6.3 (14.53)	7.15 (15.50)	5.65 (13.74)	10.13 (18.56)	8.32 (16.76)	3.5	9.81	5.34
CD ($P<0.05$)	1.12	1.01	1.08	2.03	1.5	0.5	0.71	0.56

Data in parentheses are angular transformed values

IPM interventions

The following interventions were made under IPM, treatment of seeds of Naveen and Luit with Carbendazim 50% WP (Bavistin) @ 2 g/kg seed, application of the insecticide Carbofuran 3%G @1.2 kg for nursery area for planting in one acre of land. Application of fertilizer at the dosage of 60:30:30 kg N P K/ha with basal dose of 30:30:15 kg N P K/ha in the main field before transplanting, top dressing with 15 kg N,15 kg K_2O per hectare after 30 days and 15 kg N per hectare after 60 days of transplanting; Need based spraying of Chlorpyriphos 20% EC (Tricel) @2.5 ml/l against stem borer, leaf folder; Cypermethrin 10% EC (Ustaad) against gundhi bug; Carbendazim 50% WP (Bavistin) @2.0 g/l against brown spot, bakanae and sheath blight diseases.

Farmers' practice

Farmer's practice involved his own seed of Naveen and Luit without seed dressing with fungicide. Application of fertilizers at the dosage of 40:20:20 kg NPK/ha where basal application of 20:20:15 kg NPK and top dressing with 20:5 kg N, K_2O/ha were undertaken, no application of fungicides and insecticides against diseases and insect pests in the main field after transplanting.

Diseases and insect pest incidences were recorded both in IPM and non-IPM plots. In case of Naveen IPM, 2.82% DH, 2.94% WEH due to stem borer, 2.75% leaf folder, 2.88% gundhi bug, 2.67% foot rot, 3.46% brown spot, 7.44% sheath blight infections were recorded; whereas in case of Naveen non-IPM, 6.3% DH, 6.18% WEH due to stem borer, 4.96% leaf folder, 8.54% foot rot, 7.33% brown spot, 11.26% sheath blight infections were found. In case of variety Luit, 3.61% DH, 4.35% WEH due to stem borer, 3.22% leaf folder, 2.76% foot rot, 3.87 brown spot and 6.59% sheath blight infections were recorded; but 7.52% DH,9.4% WEH due to stem borer, 5.83% leaf folder, 6.08% bakanae/foot rot, 8.45% brown spot and 9.13% sheath blight infections were observed in Luit farmer's practice. Weed infestation was found surpassing the growth of rice plants significantly, particularly in case of Luit under farmer's practice.

Validation and promotion of IPM components among upland rice farmers in Jharkhand

A trial was undertaken in farmer's field by taking a compact land in the village Banha and Dhodi in Chatra district.

IPM interventions

Seed Dressing with Bavistin @ 4 g/kg of seed, sowing with zero till machine, fertilizers (kg/ha (@): N-40, P-40, K-20, basal application@10:40:20, Nominee Gold (Bispyribac sodium) spraying @ 100 ml/acre 25 days after seeding, top dressing @ 15 kg N after 30 days of seeding, 15 Kg N after 60 days of seeding, one hand weeding, need based spray of Tilt, Beam 75 to control brown spot and blast, and need based application of insecticides on pest infestation.

Farmers' practice

Rice variety Dhusari (Village Dhodi) and Anjali (Village-Banha), were included using farmers' own seed without any seed dressing by fungicides. Broadcasting and again ploughing after 3 days called *Tiwai* in direct seeded crop, 20 kg N in the form of urea used as top dressing, no spraying of insecticides to control gundhi bug infestation were followed.

In IPM plot dry weed biomass was 86 g/sq.m compared with 192 g/sq.m in the non IPM field. The population of gundhi bug was 8.6/sq.m in non- IPM and 2.2/sq.m in IPM plot. Brown spot incidence recorded was 2% and 10% in IPM and non IPM fields, respectively. Average grain yield of IPM plot was 2.37 t/ha and non IPM 1.86 t/ha in village Banaha while in village- Dhodi yield of IPM plot 2.21 t/ha and non-IPM 1.65 t/ha. The benefit cost ratio was also calculated. The B:C ratio for village Banha was 1.89 and 1.73 with IPM and non-IPM practice, respectively while for village Dhodi the same was 1.24 and 1.19 for IPM and non-IPM plot, respectively.

Chemical control of insect pest of rice

Eleven insecticides were evaluated against insect pests of rice during rabi 2012, out of which Imidacloprid 17.8% @ 300 g/ha was the best insecticide (5.21 t/ha) and was at par with Sulfoxaflor 24%@ 375 g/ha (4.92 t/ha) and Thiamethoxam 25%@ 100 g/ha (4.85 t/ha) in increasing the grain yield over control (3.15 t/ha). The same eleven insecticides were evaluated against insect pest of rice during *kharif* 2012 out of which Imidacloprid 17.8% @ 300 g/ha was best insecticide (5.12 t/ha) and was at par with Sulfoxaflor 24%@375 g/ha (4.59 t/ha) and Thiamethoxam 25%@ 100g/ha (4.55 t/ha) in increasing the grain yield over control (3.11 t/ha).The dead heart and white ear head and gundhi bug damage was less in these treatment during both the seasons (Table 47).

Table 47. Testing of new insecticide against insect pest of rice during *rabi* and *kharif*, 2012

Treatment	% a.i	Dose g/ha	%DH R	%DH K	%WEH R	%WEH K	%G. bug damage R	%G. bug damage K	Yield t/ha R	Yield t/ha K
Imidacloprid	17.8	300	3.12 (10.15)	3.3 (10.46)	3.62 (10.97)	3.87 (11.35)	9.25 (17.69)	9.95 (18.38)	5.21	5.12
Sulfoxaflor	24	375	3.7 (11.05)	3.5 (11.78)	3.87 (11.35)	3.62 (10.97)	10.12 (18.55)	10.40 (18.81)	4.92	4.59
Thiamethoxam	25	100	3.87 (11.35)	4.26 (11.82)	3.86 (11.34)	4.3 (11.97)	10.13 (18.56)	10.63 (19.03)	4.85	4.55
Triazophos	40	625	4.1 (11.68)	4.2 (11.82)	3.87 (11.35)	4.5 (12.24)	10.4 (18.81)	11.2 (19.55)	4.80	4.51
Monocrotophos	36	1390	4.3 (11.96)	4.7 (12.52)	4.46 (12.20)	4.86 (12.74)	10.4 (18.81)	12.37 (20.57)	4.62	4.42
Buprofezin	25	700	4.6 (12.38)	4.86 (12.74)	4.7 (12.52)	5.2 (13.18)	10.63 (19.03)	12.78 (21.02)	4.38	4.30
Acephate	95	592	4.86 (12.74)	5.2 (13.18)	4.9 (12.79)	5.4 (13.43)	11.2 (19.55)	13.00 (21.13)	4.22	4.17
Dinotefuron	20	200	5.1 (13.05)	5.4 (13.43)	5.2 (13.18)	5.53 (13.58)	11.2 (19.55)	13.06 (21.14)	4.21	4.15
Acephate	75	800	5.2 (13.18)	5.53 (13.58)	5.4 (13.43)	5.6 (13.68)	12.87 (21.02)	13.61 (21.64)	4.15	4.05
Dinotefuron	20	150	5.4 (13.43)	5.66 (13.75)	5.53 (13.58)	5.66 (13.75)	13.00 (21.13)	14.87 (22.68)	4.08	3.92
Sulfoxaflor	24	313	5.6 (13.68)	5.8 (13.93)	5.8 (13.93)	5.76 (13.88)	14.93 (22.73)	15.43 (23.12)	3.85	3.83
Control	Water	500l	8.32 (16.76)	8.76 (17.21)	8.66 (17.11)	8.96 (17.41)	18.91 (25.73)	20.16 (26.65)	3.15	3.11
CD (P<0.05)			0.45	0.54	0.46	0.51	0.61	0.64	0.59	0.57

Data in parentheses are angular transformed values R = *Rabi*, K = *Kharif*, DH = Dead heart, WEH = White ear head, G.bug = Gundhi bug

Evaluation of new chemicals against insect pests of rice

In controlled release of insects, the new insecticide Sulfoxaflor did not show immediate knock-down effect against 4th instar leaf folder larvae at a concentration of 0.04%. However, the rate of feeding came down to almost nil towards 4th day of the treatment and the pupation was more quick than in untreated control plants. Only about 30% of the pupae were deformed, whereas normal emergence of adult was observed in rest of the pupae. The same concentration applied one day before oviposition of gall midge showed about 0-4 % silver shoot formation (SS) but when applied after two days of oviposition showed about 33% SS against 100% SS in untreated control. The efficacy was found equivalent to triazophos (Sutathion and Hostathion 40EC) but inferior to imidacloprid (Confidor 17.8% SL).

Under field condition

Sulfoxafor, applied @ 75 and 90 g a.i./ha at 15 and 30 days after transplanting (DAT) could not control the dead heart formation towards 50 DAT (70 and 73 % DH) as effectively as triazophos and imidacloprid (25 – 31% DH). But application at PI stage decreased the fomation of white earhead to 0.87 – 1.0% against 5.53% in untreated control. Accordingly, the effect was also visible on yield, i.e. 5.3 and 5.4 t/ha was recorded in both the concentrations of sulfoxaflor which was inferior to other two insecticides but superior to untreated control.

Effect of different crop establishment methods in bunded upland on rice diseases

Crop establishment methods (direct seeded vs. transplanting) and nutrient levels ($N:P_2O_5: K_2O$ =60: 40:20 and 80:40:20) affecting incidence and intensity of rice diseases under shallow rainfed drought prone system was studied with a set of four varieties susceptible to blast (Poornima), brown spot (RR 159-90), false smut (IR 83376-B-B-150-3) and bacterial blight (TN 1). Incidence of false smut and brown spot was higher in the direct seeded crop compared to the transplanted crop. On the other hand, incidence of neck blast and bacterial blight was less in direct seeded crop. False smut, blast and bacterial blight increased with higher level of fertilizer application. Mean values for yield under direct seeded and transplanted conditions revealed that the transplanted crop had 21.4% higher yield. Differences for grain yield under two fertility levels were, however, not significant.

Biotic Stress Management in Rainfed Upland Rice Ecosystem

Cultural management of false smut of rice under transplanted condition

Effect of transplanting dates and fertilizer levels on the incidence and intensity of false smut on rice hybrid PHB 71 was examined. The crop was grown in bunded upland (transplanted condition) under two dates of transplanting (24th July and 4th August) with three fertilizer regimes (N:P:K - 80 : 40 : 40, 100 : 60 : 40 and 120 : 60 : 40). Both disease incidence and disease severity were significantly reduced under late planting (4th August) but yield was also reduced. Fertilizer regimes tested had no substantial effect on disease (Table 48).

Analysis of the blast pathogen population

Virulence analysis of 72 isolates of *M. grisea* from Eastern India revealed that matching virulence to all monogenic differentials carrying different resistant genes were present in the pathogen population, though all the tested isolates were avirulent on resistant check Tetep. The frequency of virulence on different monogenic lines ranged from 5.5% to 85%. Very few isolates were virulent on *Pi-9* (5.5 %) and *Piz5* (Pi-2) (8.3%). Highest frequency of virulence was recorded on susceptible check Co-39; all the isolates recording susceptible reaction. Frequency of virulence among monogenic lines was highest on *Pi-a and Pita* (85% and 83.3%) followed by *Pikp, Pi-19(t), Pita, Pi-3* and *Pi-t* in that order. Out of 72 isolate phenotyped, the isolates Mo-ei-5, Mo-ei-43 and Mo-ei-103 belonging to Jharkhand are highly virulent as they exhibited compatibility with 21 out of 26 resistance genes.

Pi-9 and *Pita-2* gene exhibited complementary resistance spectrum and excluded all the pathotypes of the pathogen against the pathogen population evaluated. Since, the isolates were collected from a wide geographical region representing the different rice growing states of Eastern India, a combination of *Pi-9* and *Pita-2* has potential for effective management of rice blast disease by excluding all virulences. Vandana and Poornima were selected for development of NILs having these complementary R genes. Initially, *Pi-9* was used for hybridization with these varieties (*kharif* 2012). F_1 of the crosses were confirmed with marker AP 5930 and advanced for further backcrossing.

Table 48. Interactive effect of fertilizer dose and date of transplanting on false smut in rice (PHB 71), *kharif* 2012

Fertilizer dose(N : P : K)	Disease incidence (% panicles infected)			Disease severity (%) (based on 0-9 scale of SES)			Grain yield (t/ha)		
	TP24 July	TP4 Aug	Mean	TP24 Jul	TP4 Aug	Mean	TP24 Jul	TP4 Aug	Mean
80:40:40	63.40	29.75	46.58	17.25	6.23	11.74 b	6.63	4.02	5.33
100:60:40	54.01	29.24	41.63	11.96	5.75	8.86 a	6.84	4.24	5.54
120:60:40	54.35	27.07	41.03	13.01	6.27	9.64 a	7.32	4.62	5.97
Mean	57.25 b	28.69 a		14.07 b	6.08 a		6.93 b	4.29 a	
LSD (P<0.05), Fert. dose (F)			7.95			2.68			0.95
LSD (P<0.05), Date/Tr. (D/T)			6.49			2.19			0.78
LSD (P<0.05), F x D/T			11.24			3.80			NS

Development of NILS against specific lineage/ virulence

Hybridization was initiated to develop near isogenic lines of Poornima and Vandana having effective blast resistance genes. Foreground selection of F_1s of Poornima x IRBL9-w (*Pi-9*), Poornima x IRBLZ5-CA (*Piz-5*) and Vandana x IRBL9-w (*Pi9*) was completed using markers AP 5930 (*Pi9*) and AP 565-5. Marker for *Pita-2* did not distinguish between the parents and hence efforts are on to identify and use other polymorphic markers.

Rice variety Poornima was selected for development of pre-breeding lines in the Indica background with desirable agronomic traits and acceptable grain characteristics. Blast monogenic lines (C101 LAC for *Pi-1* and C101A51 for *Pi-2*) were identified to use as a resistant donor. Two crosses (Poornima/C101 LAC and Poornima/C101A51) were attempted during *kharif* 2012 (Table 49).

Management of Major Rice Diseases in Rainfed Flood-Prone Lowlands

Eco-friendly management of sheath blight disease using bio-control agents

The biocontrol agent *Trichoderma viride* (OUAT, Bhubaneswar) was found to reduce the sheath blight incidence by 49.5% followed by treatment with *T. viride* (Pest Control India) by 43.3% and the standard fungicide Validamycin 3% by 42.7%. The grain yield was highest (4.86 t/ha) in the treatment with *Trichoderma viride* (OUAT, Bhubaneswar) followed by 4.48 t/ha in the treatment with *T. viride* (Pest Control India) and 4.18 t/ha with Validamycin 3%, while it was 3.01 t/ha in control.

Management of sheath blight disease of rice using new fungicides

The new fungicide Azoxystrobin 25 SC (Amistar) @ 1.0 ml/l of water caused 52.5% reduction in sheath blight disease incidence. It was followed by Kresoxim methyl (Ergon 44.3 SC) @ 1 ml/lit and Trifloxystrobin 25%+ Tebuconazole 50% (Nativo 75 WG) @ 0.4g/l which reduced the disease incidence by 44.6% and by 44.4%, respectively. The grain yield was highest (4.75 t/ha) in treatment with Azoxystrobin 25 SC followed by 4.27 t/ha in the treatment with Kresoxim methyl (Ergon 44.3 SC) and 4.26 t/ha with Trifloxystrobin 25%+ Tebuconazole 50% (Nativo 75 WG), while it was found to be 2.78 t/ha in control.

Survey of virus and phytoplasma diseases affecting rice in rainfed, flood-prone lowlands with special reference to *tungro*

Incidence of rice *tungro* disease (RTD) was recorded in seven districts of Assam, *viz*., Barpeta, Bongaigaon, Cachar, Darrang, Dhubri, Kamrup and Nalbari. In the *boro* and *ahu* rice crops of *rabi* 2012, varieties Chandrama, Disang, IR 64, Luit, Naveen, Pratikshya, Ranjit, and Sahbhagidhan were found to be affected. In the *sali/ kharif* 2012 and *boro/rabi* 2012-13, rice varieties affected were Annada, Arize 6444, Bahadur, Baismuthi, China boro, DRRH 2, IR 64, Mahsuri, PAC 837, Ranjit and Sahyadri 4. RTD incidence in the variety Ranjit was found to be 8% and 2% in the villages Burha and Kanhitali, respectively in Darrang district. In most of the other places, incidence of the disease was less than 1%.

During *ahu/rabi* 2012, per cent incidence of RTD in rice varieties Naveen, Pratikshya, Sahbhagidhan and T(N)1 in the experimental farm of RRLRRS, Gerua was 15.9, 16.2, 27.8 and 19.2, respectively.

Transmission of virus and phytoplasma diseases using viruliferous vectors under greenhouse conditions

Incidence of RTD in *sali/kharif* 2012 season was apprehended in the villages Burha and Kanhitali under ADO Circle–Duni, Block–Sipajhar, District–Mangaldai, Assam. The varieties affected were Ranjit,

Table 49. Development of NILs against specific lineages / virulences of *M. grisea*

Crosses	No. of F_1 plants	No. of F_1 plants confirmed
Vandana x IRBL9-w (*Pi9*)	9	7
Poornima x IRBL9-w (*Pi9*)	25	13
Poornima x IRBLZ5-CA (*Piz-5*)	4	1
Poornima/C101 LAC (*Pi-1*)	3	-
Poornima/C101 A 51 (*Pi-2*)	2	-

Mahsuri and Baismuthi. In a 0.8 ha plot of the variety Ranjit in the village – Burha, about 8% of the plants were affected apparently by RTD, while in the village Kanhitali, about 2 % of the plants were affected in a 0.3 ha plot. RTD incidence was ascertained by transmitting the disease to 15 d-old seedlings of the variety 'Ranjit' and the susceptible host TN 1 using viruliferous green leafhoppers. Incubation period of the virus (es) in Ranjit and TN 1 was 48.6 and 41.3 days, respectively.

Mapping the distribution of rice *tungro* disease and differentiation of *tungro* isolates

In order to map the distribution of tungro and to differentiate tungro isolates into strains, collection, multiplication and maintenance of rice tungro isolates was initiated. Two isolates of tungro were collected, *viz*., Gerua isolate and Burha isolate. Isolates are being maintained in the variety T(N)1 through GLH transmission. Source cultivar for the Gerua isolate was CR Dhan 601 and for Burha isolate was Ranjit.

Survey on the incidence of major fungal and bacterial diseases of rice

Surveys were conducted in the farmers' fields of Kamrup, Barpeta and Nalbari districts and in the research farm of RRLRRS, Gerua during *sali*/*kharif* (2012-13) in different crop growth stages. In the Kamrup district, villages covered were Sarpara, Sandhya and varieties grown were Ranjit, Mahsuri, Swarna, and Bahadur. The incident diseases were sheath blight, bacterial leaf blight, brown spot and blast. Sheath blight and BLB occurred in all the four varieties. While brown spot incidence was the highest (12.85%) in Ranjit followed by blast incidence (11.5%) in Mahsuri.

In the Barpeta district, the villages covered were Chenga, Barbila, Kukarapar and the varieties grown were Mala, Baismuthi, IR36. Sheath blight, sheath rot, brown spot and false smut diseases were found to occur in the district. Incidence of sheath blight, sheath rot and brown spot was observed in all the three varieties. Sheath blight and brown spot were more frequent in the varieties Mala (7.64%) and Baismuthi (7.42%). Altogether 5.83% incidence of false smut was observed in the variety Baismuthi.

In the Nalbari district, villages covered were Burlutpar, Galdighala and varieties grown were Rajalaxmi, Swarna, Mahsuri. Incidence of both sheath blight and sheath rot diseases was observed in all the three varieties. Maximum incidence of sheath blight (6.34%) and sheath rot diseases (6.7%) was observed in varieties Swarna and Mahsuri, respectively.

In the experimental farm of RRLRRS, Gerua, incidence of sheath blight was 29% in Tapaswini and 23.6% in Swarna. Sheath rot incidence was 17% in Mahsuri followed by 8.8% in Kolajoha. Neck blast affected the varieties Akshaydhan, Mahsuri, IR 64, Chandrama and Swarna. There was 15.8% incidence of false smut in the variety Pooja.

BIOCHEMISTRY AND PHYSIOLOGY OF RICE IN RELATION TO GRAIN AND NUTRITIONAL QUALITY, PHOTOSYNTHETIC EFFICIENCY AND ABIOTIC STRESS TOLERANCE

Rice Grain and Nutritional Quality – Evaluation, Improvement and Mechanism and Value Addition

Identification and characterization of low glycemic index (GI) rice

Five rice varieties/cultivars *viz.,* Aghoni from Assam (sticky, low amylose, 5%) Abhilash from Karnataka (high amylose, 28%) Swarna Sub1 (submergence tolerant), Sahbhagidhan (drought tolerant), Nua Dhusara (aromatic short grain) were evaluated for their glycemic index values as per established procedure. None of the varieties had low GI value (<55). In fact, most of the tested varieties were of medium GI (55-70) type. The rice cultivar Abhilash showed relatively low GI (60.9) value.

Scaling up of the process of fortification of rice with iron and zinc

Studies were undertaken to enrich rice grains with iron and zinc, by which Fe content could be increased by 2-10 times and Zn by up to 2.6 times depending on variety. Rice variety Naveen was soaked in 1000 ppm of iron and zinc each and subjected to parboiling. The content of the two elements was determined in brown, milled and well washed milled rice prepared from the parboiled paddy grains. The washed milled rice grains of treated samples had 3-4 times more iron and zinc than the untreated control; for Fe, Control: 4.70 ppm and treated:19.05 ppm (in 1000 ppm Fe) and 19.47 ppm (in 1000 ppm Fe and Zn each); likewise for Zn, control:14.5 ppm and treated 73.7 ppm (in 1000 ppm Zn) and 49.3 ppm in 1000 ppm Fe and Zn treated samples). The presence of iron and zinc was found to cause reduction in the absorption of the other element.

Identification, characterization and promotion of *soak n eat* rice

The rice Aghoni was identified as a *soak n eat* rice earlier. With repeated cultivation at Cuttack, its soaking time increased from 40 min in 2008 to 90 min in 2010 at this institute. Later, two more *soak n eat* rice namely, Nalbora and Asham Biroin were identified in 2011 out of 32 Assam rice germplasm tested in our laboratory. A multi-location trial was initiated during 2012-13 in six states *viz.,* Odisha, W.B., Assam, Bihar, Jharkhand and Meghalaya to identify regions most suited for cultivation of *soak n eat* rice, so that the harvested grains do not show increase in soaking time in subsequent generations. Out of the surplus received from four sites, increase in soaking time was noticed in samples of Aghoni and Nalbora obtained from Pusa (Bihar) and Ranchi (Jharkhand); there was no increase in the samples grown at Cuttack (Odisha) and Gerua (Assam) (Table 50). The grains of Asham Biroin not only showed increase in soaking time after the first harvest, but also retained a hard core and hence have been discarded.

Screening of rice germplasm for micronutrient (Fe/Zn) and phytate content

A total of 185 rice germplasm lines were analyzed for grain micronutrient (Fe/Zn) content in brown rice. Iron content varied from 0.575 to 14.75 ppm while zinc content of the brown rice samples varied from 4.3 to 46.00 ppm. Thirty of the Fe/Zn rich germplasm were analyzed for grain iron and zinc content after 10% milling. Four of them retained more than 7 ppm grain Fe, while, nine of them were found to contain 25.20 to 35.11 ppm zinc.

Table 50. Soaking time of *soak n eat rice* varieties grown at different locations

Rice Variety	Soaking Time (min.) of samples from different locations			
	Cuttack	Gerua	Pusa	Ranchi
Aghoni Bora	45	45	65	60
Asham Biroin*	75	85	80	85
Nalbora	45	45	70	66

*Hard core remains

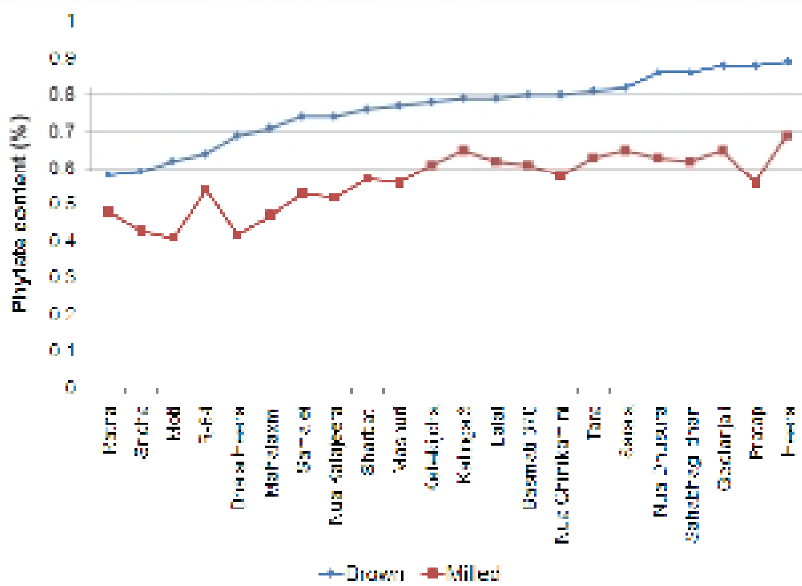


Fig 22. Phytate content in grains of different rice varieties

Phytic acid content of brown rice samples of 49 popular rice varieties was estimated. It varied from 0.23% to 0.94% (Fig 22). Milling of raw rice was found to result in 22 -31 % removal of phytate.

Biochemical and molecular analysis of contrasting rice germplasm for iron acquisition, translocation and assimilation

Accumulation of ferritin protein: Accumulation of ferritin protein and expression of corresponding gene was studied in two rice cultivars that differ in grain Fe content. Both Sharbati and Lalat, accumulated maximum ferritin protein in the flag leaf at 5 ppm of Fe in the growth medium beyond which the concentration declined; while the decline was gradual in Lalat up to 50 ppm, it was abrupt in Sharbati, showing almost complete inhibition at 15 ppm of Fe. Differential response of the cultivars to higher level of Fe might be due to the fact that the low Fe cultivar, Lalat, was perhaps inefficient in absorbing and translocating the element within the plant (Fig 23).

Development of protocol for mass screening for phytate in rice grain: A simple colorimetric protocol was developed for mass screening of phytate in rice grain. Phytate was first extracted from grain powder in dilute acid solution followed by heating on a boiling water bath. An aliquot of this solution was mixed with a colour forming reagent and the resulting colour was measured with a spectrophotometer. The results were validated with a standard colorimetric protocol of phytate estimation (R^2= 0.702).

Development of protocol for mass screening of iron in rice grain: A simple colorimetric protocol was developed for mass screening of Fe in rice grain. Iron was first extracted from grain samples in dilute acid solution followed by heating on a boiling water bath. An aliquot of this solution was mixed with a colour forming reagent and the developed colour was measured in a spectrophotometer. The results were validated with a standard colorimetric method for iron estimation (R^2=0.739).

Transcriptome analysis for expression of candidate genes involved in Fe homeostasis in different parts of seedlings and at grain filling stage of contrasting germplasm

Candidate genes of Fe homeostasis were studied for their expression in rice genotypes having different grain Fe content. Expression of the genes varied among the cultivars as well as different tissues within a cultivar (Fig 24).

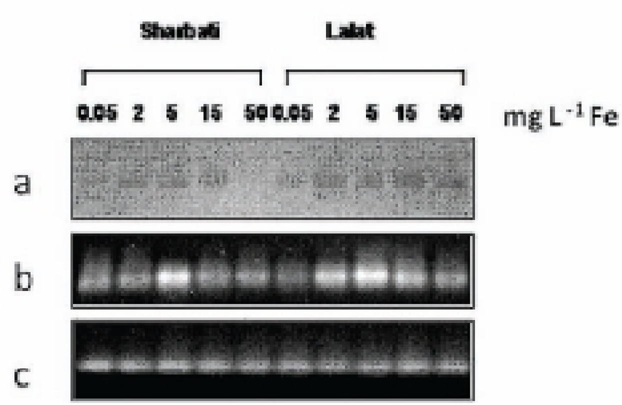


Fig 23. Effect of Fe level on ferritin protein accumulation (a) and ferritin gene expression (b) in the flag leaves at panicle emergence stage

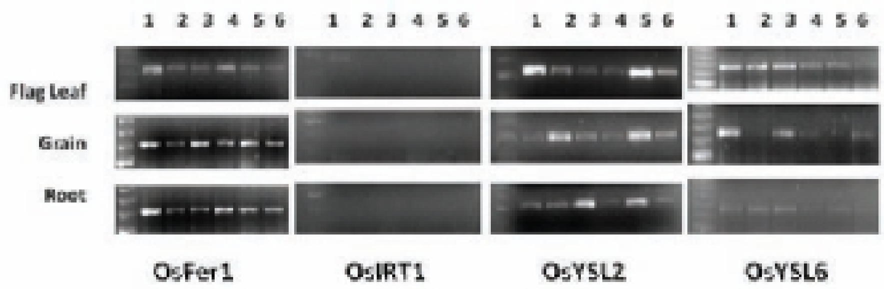


Fig 24. Expression of candidate genes in different tissues of rice cultivars (1=Sharbati, 2=Lalat, Kalinga III, 4= Bindli, 5= Durga and 6= Naveen) differing in grain Fe content

Phenomics of Rice for Tolerance to Multiple Abiotic Stresses

Testing of salinity tolerant rice genotypes for submergence tolerance and recovery under different light intensity

Fifteen rice genotypes were tested for submergence tolerance using saline water of 12 dS/m. After 10 days of submergence, water was drained out and shade treatment was provided with different layers of white cotton cloth. Shading decreased the intensity of light and temperature. Decrease of temperature varied from 1.1 to 2.0 degrees in different treatments. Light intensity in the range of 215 – 302 μ mole /m^2/s was found to be less injurious and helped the plant to survive. In control plants, light intensity was more than 1000 μ mole /m^2/s. Significant genotypic differences were observed in survival percentage. The genotypes tolerant to submergence showed greater survival in saline water compared to susceptible genotypes (Fig 25). The data indicated that submergence tolerant cultivars could withstand the submergence stress caused by saline water too. Survival chances increased provided light intensity was low during regeneration period.

Testing of submergence tolerant rice genotypes for waterlogging tolerance with saline water

Ten rice cultivars were subjected to waterlogging to a height of 35 cm using saline water (6 dS/m). After 30 days of waterlogging, survival percentage was zero in Varshadhan, Swarna, Swarna-Sub1, Savitri, Savitri-Sub1 and Gayatri. The genotype AC39416 (A) was found highly tolerant, followed by Ravana, while Kamini and Rashpanjar were found moderately tolerant with survival percentage of 100%, 82%, 64% and 55%, respectively after 45 days of waterlogging (Fig 26). The survival percentage under waterlogging with normal water was 100% in all the cultivars.

Role of phosphorus in improving submergence tolerance in rice with SUB1 QTL

Three rice cultivars with SUB1 *QTL* (Swarna-Sub1, IR64-Sub1 and Savitri-Sub1) were grown under four levels of phosphorous i.e. 20, 40, 60 and 80 Kg P/ha with fixed dose of N (60 kg/ha) and K (30 kg/ha). Among the three SUB1 cultivars, survival was greater in IR64-Sub1 (75%), followed by Swarna Sub1 (58%) and Savitri-Sub1 (51%). The survival percentage greatly increased with higher doses of phosphorous mainly in

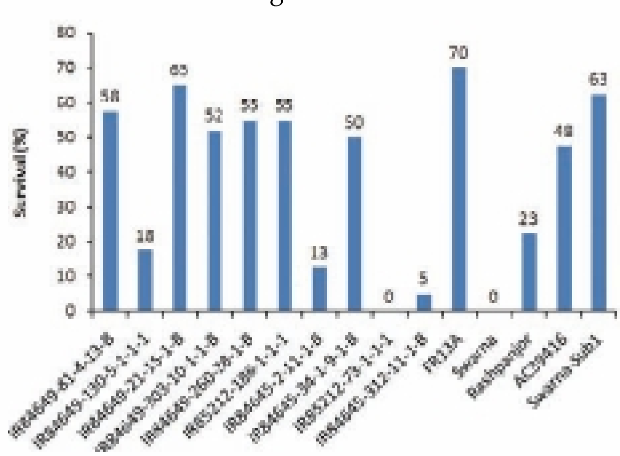


Fig 25. Genotypic differences in survival of rice under complete submergence with saline water

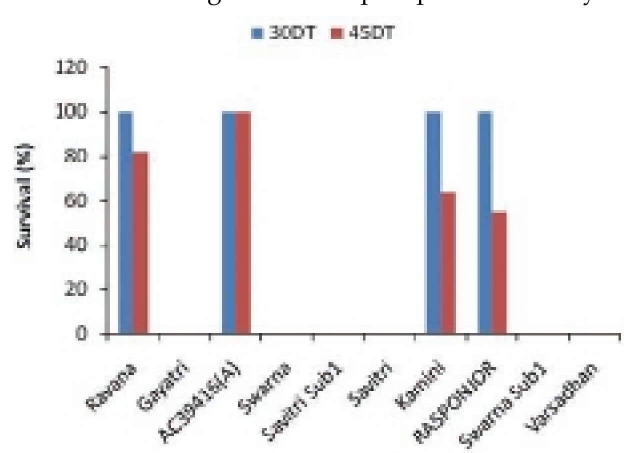


Fig 26. Survival of rice varieties under waterlogging with saline water after 30 and 45 days of treatment (30DT and 45DT)

Savitri-Sub1. In other two cultivars, greater phosphorous application did not show any effect on plant survival due to complete submergence. Plant height decreased due to the imposition of submergence stress in all the varieties irrespective of the application of phosphorous. However, panicle weight either increased or decreased in treated plots compared to the control plots. Panicle number decreased in all the varieties. The reduction was greater in Savitri-Sub1, followed by IR64-Sub1 and Swarna-Sub1. Application of phosphorous increased the number of total panicles per unit area under submergence only in Savitri-Sub1.

Additional doses of phosphorous caused increase in both straw and grain yield of only Savitir-Sub1 significantly (under submergence). Additional doses of phosphorous improved the numbers of fertile spikelets in Savitri-Sub1. Harvest index was greater under submergence compared to control only in Savitri-Sub1. Analysis of different yield parameters and yield under control condition revealed that application of 40 kg P/ha was most advantageous in getting greater yield from all the SUB1 genotypes. Application of 60 and 80 kg P/ha improved survival percentage only in Savitri-Sub1. Likely enhancement of yield was also noticed in Savitri-Sub1 under submergence due to the application of 60 and 80 kg P/ha. The data showed that decision to apply phosphorous might be taken depending upon the tolerance level of a particular variety. Application of 40 kg P/ha was sufficient for varieties with greater submergence tolerance such as Swarna-Sub1 and IR64-Sub1 to get yield advantage both under control and submerged conditions. Application of P @ 60-80 kg/ha was not economical for Savitri-Sub1 under control condition, but under submergence, the survival percentage as well as yield increased in Savitri-Sub1 compared to application of P at 20-40 kg P/ha.

Association of salinity tolerance with different physiological parameters

Relationships between survival percentage under salinity stress (EC 12 dS/m) and different physiological parameters were worked out using eight salt-tolerant rice landraces from coastal areas of West Bengal and Odisha along with Pokkali, AC39416, FL478 as tolerant and IR29 as susceptible checks. The survival percentage 10 days after the stress (DAS) showed significant positive correlation with *chlorophyll a* fluorescence parameters such as area (area above the fluorescence curve between F_0 and F_m), PI (performance index- which gives quantitative information on current state of plant performance under stress) and DF (driving force) on both 7 DAS and 10 DAS as well as F_m (maximum fluorescence yield) and F_v/F_m (which is directly correlated with photochemical efficiency of PS II) on 10 DAS (Table 51). The PI could be useful in differentiating the tolerance level of different genotypes. Proportion of green leaf to total leaf dry weight (10 DAS) had a strong positive correlation (**$P < 0.01$) with survival. The survival was positively correlated with K^+ content in leaf and stem (10 DAS) and Na^+ content in root (7 and

Table 51. Correlation coefficients between per cent survival (arcsine values) and different physiological parameters after 7 and 10 days of salinity (12 dS/m) stress treatment

Parameter	Duration of salinity stress		Parameter	Duration of salinity stress	
	7 days	10 days		7 days	10 days
Fo (Minimum fluorescence)	- 0.326	- 0.453	Root Na^+ content	0.867**	0.633*
Fm (Maximum fluorescence)	0.556	0.676*	Leaf Na^+ content	- 0.831**	- 0.716*
Fv/Fm	0.593	0.630*	Stem Na^+ content	- 0.625*	- 0.567
Area	0.690*	0.726*	Root $Na^+ : K^+$ ratio	0.367	0.140
ETo/CSo	0.599	0.708*	Leaf $Na^+ : K^+$ ratio	- 0.560	- 0.606*
PI (Performance index)	0.644*	0.723*	Stem $Na^+ : K^+$ ratio	- 0.495	- 0.650*
DF (Driving force)	0.636*	0.697*	Root dry weight	0.541	0.686*
Chlorophyll content	0.458	0.711*	Leaf dry weight	0.417	0.416
Root K^+ content	0.236	0.256	Stem dry weight	0.401	0.256
Leaf K^+ content	0.239	0.612*	Total dry weight	0.459	0.424
Stem K^+ content	0.415	0.768**	Proportion of green leaf	0.560	0.896**

* and** significant at P=0.05 and P=0.01 level, respectively (d.f. 9).

10 DAS), while it was negatively associated with Na^+ content in leaf (7 and 10 DAS) and stem (7 DAS) as well as Na^+: K^+ ratio in leaf and stem (10 DAS). This finding suggests that genotypes that could retain more Na^+ in root and transported relatively greater amount of K^+ and less amount of Na^+ to leaf and stem showed better tolerance to salinity stress.

The 'salinity factor index' (SFI) based on the salinity-induced changes in the PI during the period of stress and relative PI ($PI_{salinity}/PI_{control}$) were calculated and based on the SFI the tolerant genotypes were divided into distinct groups depending on their performance. The value of SFI was positive only in Kamini. The values of SFI between 0 and -0.500 were observed for Paloi, Pokkali, AC39416 and FL478 suggesting that the five genotypes have better salinity tolerance compared to others. The values of SFI were lower than -1.000 in Talmugur (1.216), Ravana (-1.260), Rashpanjar (-1.783) and Marisal (-2.016).

Breeding rice varieties for coastal saline areas

Performance of short-duration salt-tolerant cultures under salinity stress

A set of 14 short-duration salt-tolerant cultures were evaluated for grain yield and sterility percentage under salinity stress (10-12 dS/m during seedling-vegetative stage and 4-6 dS/m during reproductive stage) in simulated conditions. CR2815-4-23-1-S-4-1-1 gave the highest grain yield of 268 g/m², followed by CR2815-4-27-4-S-2-1-1 (217 g/m²), CR2815-4-26-1-S-5-2-1 (209 g/m²) and CR2815-4-23-5-S-2-1-1 (196 g/m²). FL 478 and CR Dhan 405 recorded the grain yield of 162 and 25 g/m², respectively. The sterility was the lowest in FL 478 (31.9%), closely followed by CR2815-5-1-3-S-1-2-1 (32.9%), CR2815-4-27-4-S-1-1-1 (37.5%), CR2815-4-23-1-S-4-1-1 (37.7%) and CR2814-2-4-3-1-1-1-2 (37.9%), which were comparable with FL 478. CR2815-4-7-1-1-1-1 recorded the highest sterility of 63.5%, followed by CR2815-4-26-1-S-4-1-1 (59.8%), CR2815-2-4-2-1-1-1 (54.1%), and CR Dhan 405 (51.5%). The susceptible check IR29 did not survive under salt stress.

On-farm evaluation of salt-tolerant elite lines

In *rabi*, 11 promising salt-tolerant lines along with two tolerant checks (FL 478 and CR Dhan 405) and a farmer variety were evaluated under on-farm trials at two locations. The soil (saturation extract) and field water EC values during the crop growth period were relatively low at Astarang (4.8-6.7 and 1.2-1.4 dS/m) than at Ersama (9.5-13.3 and 3.1-5.1 dS/m). In Ersama, the highest grain yield of 5.0 t/ha was recorded for CR2815-4-7-1-1-1-1, while the variety Naveen (grown by farmers) produced the lowest grain yield (2.41 t/ha) (Fig 27). Most of the entries produced significantly higher grain yield than the farmers' variety, but only one line i.e. CR2815-4-7-1-1-1-1 was superior to CR Dhan 405. In Astarang, none of the entries out-yielded the variety Samalai (grown by farmers) which is improved but salt sensitive genotype, because of low salinity. However, four entries produced significantly higher grain yield than CR Dhan 405. CR2814-3-1-6-5-1 and CR2815-4-27-1-1-1 were selected by the farmers in preference analysis. In *kharif*, 10 promising salt-tolerant lines along with two tolerant checks (SR 26B and CR Dhan 403) and farmer's variety were evaluated at the same two locations. Salinity levels during the crop growth period were moderate at Ersama (field water EC 3.42-8.01 dS/m) and very low at Astarang (field water EC 0.15-3.18 dS/m). The crop at Ersama also experienced submergence/severe water logging during vegetative stage. Accordingly, all the genotypes produced considerably higher grain yield in Astarang (2.82-3.8 t/ha) as compared to Ersama (0.33-1.92 t/ha).

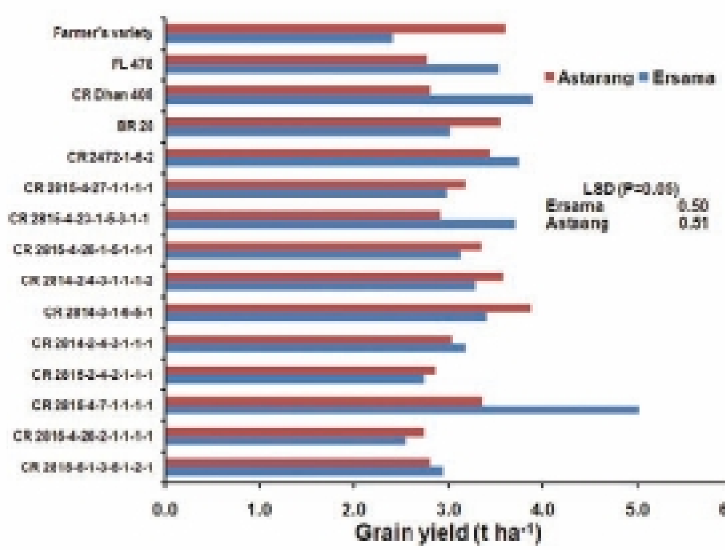


Fig 27. Evaluation of promising self tolerant lines in farmer's field at two locations

The highest grain yield of 1.92 and 3.80 t/ha was recorded for SR 26B in Ersama and Astarang, respectively. None of the entries was superior to SR 26B in terms of grain yield.

Farmer-managed baby trials

In *rabi*, performance of salt-tolerant rice varieties CR Dhan 405 and OM 6051 from Vietnam were evaluated under farmer's management at 20 locations in Ersama, using farmer's variety for comparison. Grain yield of CR Dhan 405 and OM 6051 was 3.81-5.80 t/ha (mean yield 4.90 t/ha) and 3.75-5.67 t/ha (mean yield 4.76 t/ ha), respectively. On an average, the two varieties recorded more than 20% higher grain yield as compared to the farmer's variety with 2.23-5.17 t/ha (mean yield, 3.96 t/ha). In *kharif*, performance of salt-tolerant rice varieties SR 26B and CR Dhan 402 was evaluated under the farmer's management at 13 locations in Ersama and Astarang. Grain yield of SR 26B and CR Dhan 402 was in the range of 2.25-4.37 and 2.50-4.27 t/ ha with the mean yield of 3.04 and 3.29 t/ha, respectively, as against 1.73-4.22 t/ha for the farmer's variety. On an average, the two varieties gave more than 30% yield advantage over the farmer's variety and in some cases the yield was almost doubled.

Method of crop establishment

In *rabi*, performance of direct wet seeded rice was compared with that of transplanted one on three different dates of sowing (December 19, 25 and 31) in an on-farm trial at Ersama under saline condition. In the transplanting treatments, sowing was done on the same dates and seedlings were planted on January 17, 23 and 29. In general, grain yield was significantly higher under transplanting (5.45-6.31 t/ha) than under direct wet seeding (3.95-4.82 t/ha), irrespective of the date of sowing. Delay in planting decreased grain yield under both the methods of crop establishment.

Effect of spacing and irrigation schedule on yield of watermelon in saline condition

Effects of two spacings (1.5 x 1.5 and 1.0 x 1.0 m) and three irrigation schedules (irrigation at 4, 6 and 8 days intervals) on yield of watermelon (cv. Sugar baby) were studied in farmer's field at Ersama under medium salinity. The yield was significantly higher under 1.5 m x 1.5 m (18.7-24.1 t/ha) than under 1.0 m x 1.0 m (16.3-20.9 t/ ha) spacing, irrespective of the irrigation schedule. The mean yield was highest (22.5 t/ha) when the crop was irrigated at 4-d intervals; increasing the irrigation interval, had a detrimental effect.

Effect of spacing and fertilizer levels on seed yield of sunflower in saline condition

Effects of different spacings (40x30, 30x30 and 20x30 cm) and fertilizer levels (80:40:40, 60:30:30 and 40:20:20 kg N:P_2O_5:K_2O/ha) on the seed yield of sunflower (cv. KBSH 1) were assessed in an on-farm trial in Ersama under medium salinity. The mean seed yield was highest (1.68 t/ha) with 80:40:40 kg N: P_2O_5:K_2O/ha. The yield decreased significantly when the fertilizer level was reduced to 60:30:30 kg N: P_2O_5:K_2O/ha. However, spacing treatments had no significant effect on the sunflower yield.

Rice Physiology under Drought and High Temperature Stress

Identification of potential donors for vegetative stage drought tolerance

Out of 620 germplasm lines exposed to vegetative stage drought stress, 180 were observed to be drought tolerant with SES '0' and '1' score under soil moisture content 5.39 to 9.76 % and soil moisture tension -35 to -65 kPa below 30 cm soil depth and water table depth below 90 cm (Fig 28). Fifteen landraces and 14 breeding lines of previous year were confirmed for their drought tolerance.

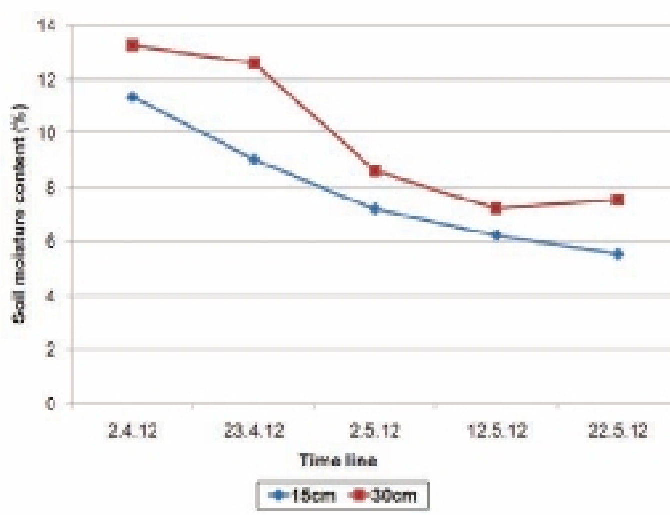


Fig 28. Soil moisture content and soil moisture tension during the stress period

Identification of potential donors for reproductive stage drought tolerance

Fifty four genotypes with two checks (CR143-2-2 and IR20) of 100-110 days duration, selected from vegetative stage drought tolerance experiment in previous years were dry direct seeded in the field during dry season. The genotypes in stress plot were exposed to reproductive stage drought at 65 days after sowing (15 days before flowering to 15 days after flowering) under ground water table depth below 75 cm with soil moisture content 10-13% and soil moisture tension of -55 to -60 kPa during the stress period.

Grain yield ranged from 2.67 to 4.92 t/ha under irrigated (I) and 0.25 to 2.20 t/ha under stress (S) conditions. Highest grain yield under irrigated condition was recorded in AC38567 and Lalat (4.90 t/ha) followed by RR 383-2 and IR 36 (4.80 t/ha), while under stress condition, eight entries out of 56 genotypes did not flower due to stress during flowering time, 14 entries had less than 0.5 t/ha grain yield and 34 entries were observed to be tolerant yielding more than 0.5 t/ha. CR143-2-2 recorded highest yield of 2.20 t/ha followed by RR 2-6 (1.92 t/ha), BVD-109 (1.73 t/ha), DRR-145 (1.67 t/ha) and Zhu 11-26 (1.60 t/ha). High yield in these genotypes might have been contributed by high moisture retention capacity (> 75%) during stress period, higher assimilate partitioning leading to high grain filling percentage (> 60%), least leaf death score of SES '0' and '1' and low drought susceptibility index (DSI) values (0.47 - 0.60).

Minimum yield reduction was realized in the genotypes which had the lowest DSI (0.47 to 0.62). The mean values of DSI close to or below one for grain yield in most of the promising genotypes indicated their relative tolerance to drought. Significant negative correlation obtained between DSI with grain yield under stress (S) and positive correlation between DSI with yield under irrigated control (I) conditions (Fig 29) indicated selection for this character under stress environment might result in decreasing susceptibility to stress.

Effect of temperature on yield and yield parameters

Sixteen genotypes were grown in pots to study the effect of temperature on yield and yield parameters. The average temperature at 50% flowering stage was 33-36°C at day time and 26.3°C at night, RH was 87-96%. IET 21404 gave highest grain yield/plant (60.0 g) followed by KRH -2 (53.9 g) and MTU 1010 (49.0 g) with higher number of panicles/plant (> 20). DRRH-3 though had highest grains/panicle and lowest sterility percentage, panicle number/plant was lowest (7) leading to lower grain yield compared to the aforementioned genotypes. However, IET 21411 had the lowest yield/plant (15.0 g) followed by IET 22116 (18.6 g).

Evaluation of genotypes combining high yield potential with improved drought tolerance under irrigated and rainfed upland condition

One hundred genotypes including entries from AICRIP were grown under rainfed upland condition at KVK, Santhapur and normal irrigated condition at CRRI, Cuttack to study their yield potential during *kharif* 2012. The crop experienced two drought spells of more than 10 days during tillering and for more than 20 days during anthesis period in rainfed upland.

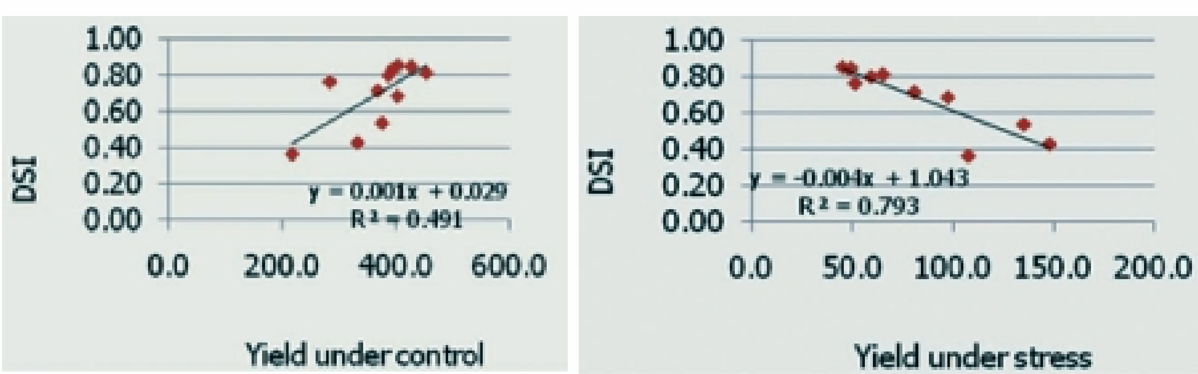


Fig 29. Correlation between grain yield with drought susceptibility index under irrigated, control and managed water stress conditions

Grain yield was drastically reduced by 64.4% under rainfed upland condition due to water stress during anthesis period and only 15 cultivars out of 100 could yield 0.5 to 2.75 t/ha, while rest of the genotypes gave less than 0.5 t/ha or zero yield. BVD-109 recorded highest grain yield of 2.75 t/ha followed by RR270-5, IC516130, Sahbhagidhan and CR-143-2-2 yielding more than 2.2 t/ha, while IR-20 had the lowest yield of 0.03 t/ha. Average grain filling percentage, relative water content and leaf area index at flowering were reduced by 34.1%, 15.0% and 26.3%, respectively, while days to 50% flowering (DFF) was shortened by 11 days (13.6%).

Out of 15 promising cultivars, BVD-109, IC-516130, Sahbhagidhan, CR 143-2-2, Jogesh, Garia and Gulmurali were commonly found to have better yield potential under both irrigated (more than 2.5 t/ ha) and rainfed upland (more than 1.5 t/ha) conditions, which might have been contributed by high HI of >0.35, high grain filling percent > 85% and higher LAI of > 3.0 under irrigated condition and 0.15 to 0.35 HI, more than 50% grain filling, LAI more than 2.0 and more than 55% water retention capacity during stress under rainfed condition. However, RR270-5 had a stable yield of 2.7 t/ha under both the conditions.

Physiological and biochemical traits associated with drought tolerance of rice

Fifty entries identified as vegetative stage drought tolerance were tested in field, rainout shelter and pot conditions for physiological and biochemical traits under stress and also tested for their root characteristics under pipe. Photosynthetic rate, chlorophyll content and soluble sugar decreased significantly in all the varieties subjected to moisture stress; maximum decrease was observed in the susceptible variety IR20. However, proline accumulation increased with the magnitude of the stress. The activity of antioxidative enzymes catalase, peroxidase and superoxide dismutase increased in relation to severity of moisture stress.

Thirty entries maintained high turgidity during severe stress (RWC > 70%) and recovered faster on re-irrigation because of their higher efficiency for drought tolerance. The varieties like Peta, Dular, Bala, Mahulata, Kalakeri, N-22 and CR143-2-2 were observed to be more tolerant compared to other genotypes in terms of physiological and biochemical parameters.

Evaluation of mapping population under reproductive stage drought stress

Three hundred ninety-six mapping population lines along with the parents (CR143-2-2 and Krishnahamsa) as check were grown under rainout shelter. Stress was imposed at reproductive stage to 55 days old plants (20 days before flowering in maximum number of lines). Days to 50% flowering (DFF) varied from 56 to 86 days; 10 lines flowered within 60 days, 165 lines in 61-70 days, 204 lines in 71-80 days and 17 lines in 81-86 days, while grain yield varied in the range of 27-250 g/m^2. Fourteen lines had grain yield of 200-250 g/m^2, 176 lines had 100-200 g/m^2, 265 lines had 50-100 g/m^2 and 69 lines had < 50 g/m^2. Among the parents CR 143-2-2 yielded maximum up to 210 g/m^2 and Krishnahamsa up to 133 g/m^2.

Connecting performance under drought with phenotype

Under IRRI (GCP)-CRRI (ICAR) collaborative project, 6 groups of total 439 entries were planted in staggered manner and stress was imposed at 70 days after 1st planting to have uniform flowering. After exposure to reproductive stage stress, among the different duration groups grain yield ranged from 0.6 t/ha to 4.5 t/ha under control condition and 0.11 t/ha to 2.46 t/ha under stress condition, while 111 entries did not flower under stress. IRGC 15565, IRGC 11700, IRGC 70468, IRGC 15516 and IRGC 43915 recorded highest yield of 4.3, 5.3, 4.6, 4.8, 6.0 and 4.2 t/ha under control condition in group 1, group 2, group 3, group 4, group 5 and group 6, respectively. Under stress condition, IRGC 69963, IRGC 10798 in group 1, IRGC 116996 in group 2, IRGC 32576 in group 3, IRGC 6349 in group 4, IRGC 34983 in group 5 and IRGC 64780 in group 6 commonly had better yield potential under both control and stress condition ranging from 2.1 to 6.0 t/ha under control and 0.2 to 2.6 t/ha under stress. The high yield potential of these varieties might be due to high water retention capacity (RWC 60-70 %) under stress, lower sterility (8.2 to 47.1%) and higher HI (0.14 to 0.31) compared to rest of the genotypes.

Targetting drought avoidance root traits to enhance rice productivity under water limited environment

Nine advanced breeding lines with two checks IR64 and Sahbhagidhan were exposed to reproductive stage (20 days before flowering) stress under field condition during *rabi* 2012. Highest grain yield was recorded in IR74371-54-1-1 (4.75 t/ha) followed by IR83376-B-B-130-3, IR 83377-B-B-48-3, IR83387-B-B-110-1 and IR 64 yielding more than 4.6 t/ha under irrigated condition with high HI of more than 0.50 and grain filling percent of 90-94%.Under stress condition, IR83376-B-B-130-3 recorded highest grain yield of 2.0 t/ha followed by IR83383-B-B-141-2, IR83380-B-B-124-3, IR83387-B-B-110-1, IR74371-54-1-1 yielding more than 1.8 t/ha with least yield in Sahbhagidhan 0.9 t/ha and lowest sterility in IR74371-54-1-1 (19.4%). High yield in these varieties under stress condition might have been contributed by high HI of more than 0.30, high grain filling of more than 66% and more number of panicles (> 250/m^2).

Six important root traits (root wt, root length, root volume, RLD, Rl /Sl and Rwt/Swt) were recorded before and after stress. The lines IR83380-B-B-124-3 and IR74371-54-1-1 had high performance for more than one trait before and after stress. IR83380-B-B-124-3 had superior mean performance for 5 traits except root weight before stress, and except root length density after stress, while IR74371-54-1-1 had high performance for 4 traits except Rl/Sl and R/S ratio before stress and Rl/Sl, R/S and RLD after stress. However, IR 83377-B-B-48-3 had better performance for 4 traits after stress. IR74371-54-1-1 with better yield potential under both control and stress showed significantly high *per se* performance for all the root traits.

National initiative on climate resilient agriculture

Characterization of Root traits under moisture stress

Eleven selected genotypes with two checks (CR143-2-2 and IR-20) were grown in PVC pipes to study the root characteristics under stress condition during dry season 2012. Twenty eight days old seedlings were exposed to moisture stress for 10 and 20 days and root samples were collected on 10 and 20 days after stress along with control sets. Observations on six root traits were taken on both the days. Root volume, root length and root length density (RLD) increased with increase in severity of drought stress. Root volume and root length increased in 7 genotypes, while root length density increased in 5 genotypes *viz.*, Bada Jangia, AC42994, AC42997, CR143-2-2 and AC43011under both 10 and 20 days after stress (Fig 30). Root biomass production under drought stress was reduced in comparison to control but, in CR143-2-2, AC42994, AC997, AC43011, AC43020 and Beekjer root biomass accumulation increased over control after 20 days after stress. Though root and shoot biomass decreased in most of the genotypes under stress, R/S ratio increased in seven genotypes with highest per cent increase in AC43011 followed by Bora, CR143-2-2, AC42997, AC42994, AC43020 and Bada Jangia (Fig 31). However, genotype AC42997, AC42994, AC43011, Bada Jangia and CR143-2-2 had high *per se* performance for more than one root traits under control and stress conditions.

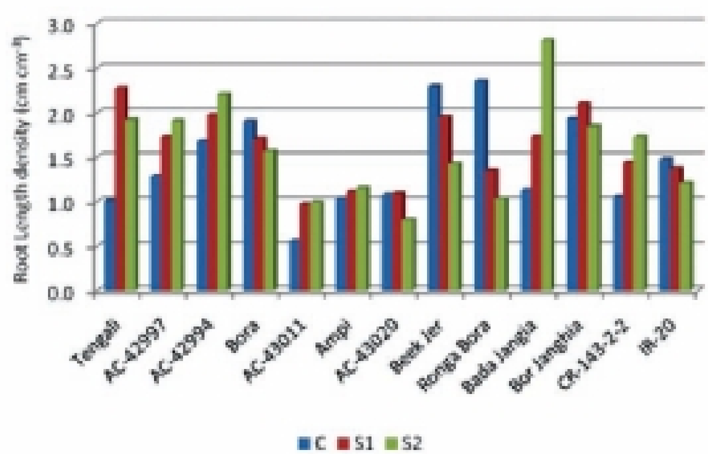


Fig 30. Root length density under control, 10 and 20 days after stress

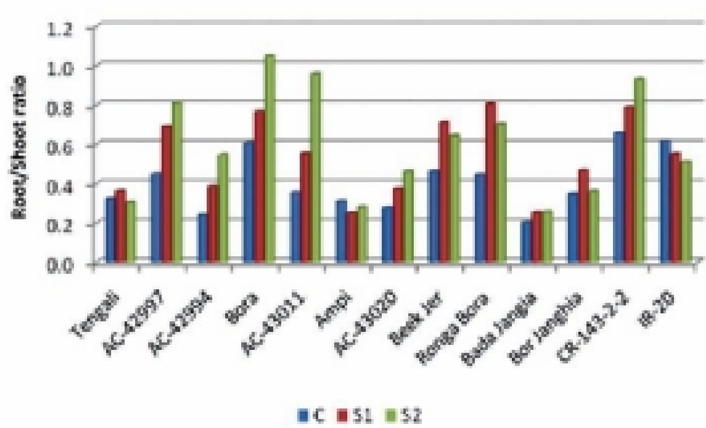


Fig 31. Root/Shoot ration under control, 10 and 20 days after stress

Screening and evaluation of advance breeding lines for drought tolerance under STRASA

Vegetative stage stress

Out of 75 lines in advanced yield trial of 100-120 days (AYT 100-120 d), 14 genotypes yielded more than 0.80 t/ha; the line R-RF-45 had highest yield of 1.2 t/ha followed by varieties MAS 99 and CB-00-15-64 with 1.04 and 1.0 t/ha, respectively with higher HI of 0.20 and moderate sterility level 35-50%.

Out of 28 lines in advanced yield trial of greater than 120 days (AYT GT 120 d), IR83373-B-B-25-3 recorded highest grain yield (0.88 t/ha) followed by IR83383-B-B-140-3 (0.81 t/ha). The check variety CR143-2-2 though had a moderate yield of 0.63 t/ha showed lowest sterility of 26%.

Reproductive stage stress

Ten promising lines of IR64 NILs were tested for reproductive stage stress. Highest grain yield was recorded in IR87707-182-B-B-B (1.41 t/ha) followed by IR87707-446-B-B-B (1.24 t/ha) and IR87706-215-B-B-B (1.22 t/ha) coupled with high HI (0.23 – 0.26), high grain filling (73.54 to 81.31%) and moderate panicle number (170-200/m^2).

Out of 8 Vandana NILs, IR90020:22-265-B recorded highest grain yield of 1.16 t/ha followed by IR84984-83-15-481-B (1.07 t/ha), IR90019:17-159-B (1.03 t/ha) and Vandana (0.95) coupled with moderate HI (0.20), moderate panicle number (275-300/m^2), lower sterility level (<35%) and high grain filling percentage (> 65%).

Evaluation and Improvement of Photo-synthetic Efficiency of Rice

Evaluation of rice genotypes for low light adaptability

A set of 149 rice genotypes including HYVs and landraces were grown under two light regimes: normal light (100%) and 75% light intensity; 47 genotypes were identified for their tolerance to 75% light intensity in terms of yield loss under shade over the normal light grown crop. The yield loss due to low light varied from about 10% in Sarala, Vandana, Govinda and Satyam to 50% in Saraswati (Table 52).

Effect of growth retardant (Paclobutrazol) on physiological efficiency and grain yield of rice

Physiological effect of the plant growth retardant paclobutrazol (PBZ) and its impact on the photosynthetic efficiency and yield was studied in three

Table 52. Yield loss (%) in the shade grown rice genotypes over the normal light grown crop

Genotype	Yield loss (%) in Shade over Light
Satyam	10.54
Govinda	10.57
Vandana	14.85
Naveen	16.82
Sahabhagidhan	23.89
Phalguni	24.03
Anjali	24.73
NC-0087	26.92
ADT-36	28.29
Udaygiri	29.89
Hajaridhan	30.58
Salumpikit	31.38
Suphala	31.88
VLD-61	33.99
Saket-4	35.13
Pusa-33	36.13
Virendra	37.22
Heera	37.37
Lalitgiri	42.33
ASD-16	42.90
Kalyani-II	44.00
NC2788	45.61
Shaktiman	45.87
Neela	46.43
Sattari	46.47
IR-72	47.12
Vanaprabha	47.42
Kalinga-III	48.41
Radhi	49.45
WGL-32100	24.84
Lunishree	25.55
Luna Sampad	28.04
Sonamani	35.95
Jaya	38.81
Konark	39.70
Hema	42.66
Satyakrishna	43.57
Deepa	44.59
Gajapati	48.13
Indira	48.14
Saraswati	49.52
Sarala	9.87
FR 13A	13.02
Ramchandi	20.71
Kanchan	23.19
Uphar	34.43
Sabita	48.09
Swarnaprabha (Tolerant Check)	23.33

rice varieties *viz.*, Varshadhan, Sarala and Durga. Seedlings were treated at the time of pricking out with soil applications of PBZ at concentrations of 0, 15 and 20 ppm. Seedlings of 25, 45 and 60 days were transplanted in the pot. PBZ inhibited the vegetative growth of rice seedlings. The height of treated seedlings decreased significantly over the control irrespective of variety and the age of transplanted seedlings. Reduction in the height of treated seedlings was recorded along with increase in tiller number per seedling. It appears that the photosynthate accumulated in the seedlings was utilized to increase their tillering efficiency rather than contributing to their height. Number of leaves and plant dry matter increased significantly in the treated pots compared to the control.

There was a significant increase in photosynthetic rate at flowering stage in Sarala treated with PBZ irrespective of the age of the seedling (Fig 32), while Varshadhan and Durga did not show any change. Grain yield and dry biomass per plant decreased in both

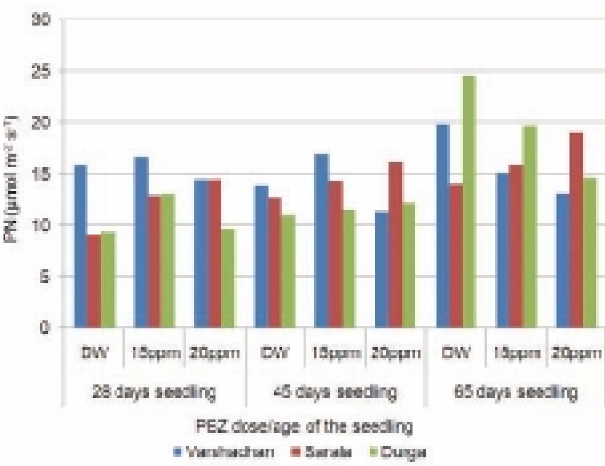


Fig 32. Effect of Paclobutrazol on the photosynthetic efficiency of rice varieties

treatments over control irrespective of the rice variety and age of the seedling. The reduced height and increased thickness of the young plant stem, as well as the accelerated leaf formation are the significant advantage of the PBZ treatment, contributing to the improvement of seedling quality at planting. Soil treatment of 15 and 20 ppm PBZ improved photosynthetic activity of Sarala.

Photosynthetic efficiency & yield of NPT lines

Among the nine NPT lines tested for photosynthetic efficiency and yield, N370 (CR3299-2-1-1-1-1) showed highest photosynthetic efficiency 39 micro mol CO_2 m^2g^{-1} followed by N -39 (IR72158-26-3-2-2-3-1) and N-76 (IR73896-51-1-1-3-1), however, the highest grain yield (65 g/plant) was recorded in N -39 (IR72158-26-3-2-2-3-1) followed by N-370 (CR3299-2-1-1-1-1) and N 301 (CR3299-11-1-3) (Fig 33).

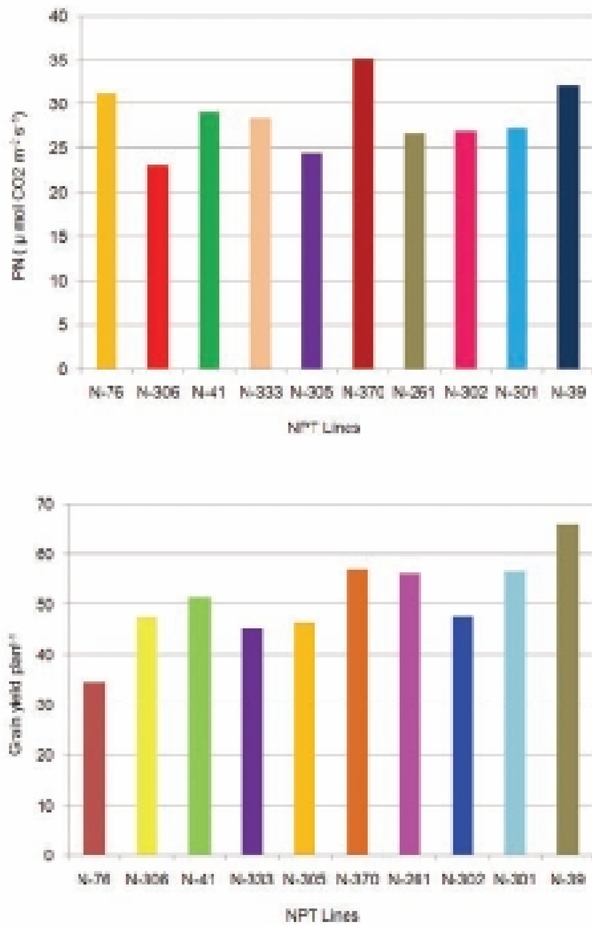


Fig 33. Photosynthetic rate and grain yield of NPT lines

[CR-3299-11-1-3(N-301), CR 3299-2-1-1-1(N-370), CR-3301-20-2-1(N-333), CR 3624-3-1-1(N-41), IR 77700-84-2-2-2(R-261) , CR 3300-1-2-1-1(N-305), CR-3299-11-1-3(N-302), IR-72158-26-3-2-3-1 (N-39), IR-72158-68-6-3-1-1 (N-306), IR-7389 6-51-1-1-3-1 (N-76)]

Physiological response of high temperature stress during anthesis in rice

Among the three rice varieties *viz.*, Shatabdi, IR-64 and N-22 (tolerant check) tested for physiological efficiency under high temperature (±4^{0}C above the ambient) during anthesis, the plants were grown under controlled environment with the temperature 4^{0}C above the ambient (30^{0}C). Observations on relative injury and respiration rate were recorded immediately after the exposure of plants to high temperature stress. Dry biomass, grain yield and sterility percentage were recorded at harvest stage. Shatabdi showed high temperature tolerance in terms of minimum membrane injury index. However, in terms of other characters like dry biomass production, grain yield and sterility percentage, IR-64 showed tolerance to high temperature stress (Table 53). The respiration rate of rice varieties increased during stress but the increase was highest in IR64 compared to Shatabdi and N22.

Table 53. Grain yield and other related parameters in rice genotypes exposed to high temperature

	Relative Injury (RI)	Respiratory rate (μ mol CO_2 absorbed m^{-2} s^{-1})	Dry Biomass (g $plant^{-1}$)	Grain Yield (g $plant^{-1}$)	Sterility (%)
N-22					
Control	26.562	0.415	20.38	10.96	12.88
Stress	27.324	0.440	20.17	09.71	17.44
Shatabdi					
Control	27.952	0.380	18.88	10.44	20.90
Stress	27.666	0.455	17.32	08.77	39.63
IR-64					
Control	34.832	0.593	47.89	23.37	20.08
Stress	40.540	0.958	39.62	17.96	30.16

SOCIO-ECONOMIC RESEARCH AND EXTENSION FOR RICE IN DEVELOPMENT

Socio-economic Approaches, Mechanism and Transfer of Technologies for Sustainable Rice Production

Development of model village, evaluation of interventions and recommendations

The development of rice-based model village, evaluation of interventions and recommendations were taken up in a rainfed cluster of Tangi-Choudwar block of Cuttack district. During the period, 15 result demonstrations, three method demonstrations including trainings and meetings were organized to expose the farmers to improved rice production technologies. The performance and impact were assessed which revealed that a very high percentage (94) of farmers of model village had derived various socio-economic benefits from the rice production technologies propagated by the institute. The farmers expressed their strong desire for rice mechanization especially, line transplanting by power operated transplanter (liked by 25%) and harvesting by reaper (liked by 16%). But high cost of power transplanter and reaper was the greatest impediment in the adoption of technology. The rice varieties namely Sahbhagidhan, Swarna Sub-1, Pooja, Ketekijoha, Varshadhan and Naveen (Table 54) which were liked

Table 54. Performance and motivational impact of some CRRI rice varieties

Name of the Variety	Average grain yield (t/ha)	Average B:C ratio	Average Satisfaction score in five point score (n=32)	Motivational factors and their strength (mean score) (n=32)	Providing seeds to others (f)
Varshadhan	4.63	1.58	4.3	High yield–4.8 Stand erect in deep water–4.6 Heavy grain weight–4.5 Suitable for value added products–4.0 Harvesting coinciding with labour availability–3.75	8
Sahbhagidhan	4.13	1.52	4.25	Promising solution for upland–4.85 Early maturity to meet food shortage–4.5 Market demand–4.05 High yield–4.0	3
Swarna Sub-1	4.49	1.46	4.56	High yield–4.75 Tolerant to flood–4.65 Stand erect throughout–4.2 Suitable to water rice–3.8	8
Pooja	4.60	1.57	4.5	High yield–4.4 Good taste and cooking quality–4.25 Market demand–4.0 Less cost of cultivation–3.5	4

Demonstration of implements in the model village

due to their various motivational traits may cover 40% of the *kharif* rice area in 2013.

The women group took up vegetable farming in *rabi* over an area of 300 m^2 which provided them a net income of Rs.3649/- which also included their household consumption. The group approach to vegetable farming has generated lot of awareness among the women folk and they are ready to replicate this farming in different locations of the cluster.

A Stakeholders' meeting was held on 23rd February, 2013 at the Institute by involving fourteen officers of the line departments, farmers and farm women of the cluster and scientists of the institute for developing a holistic approach and mechanism of convergence among the departments. An action plan developed for the purpose is being monitored from time to time for their effective participation.

Variety Pooja being harvested (A) and vegetable farming by women group (B) in rice-based model village

Stakeholders Meet for developing model village through convergence

Designing and testing of gender sensitive approaches in rice farming

Designing and testing of gender sensitive approaches in rice farming was undertaken in Sankilo village of Cuttack district. The village was selected after making due consultations with the households and finding the social climate relatively better in gender sensitiveness. Preliminary meetings and genders sensiti-

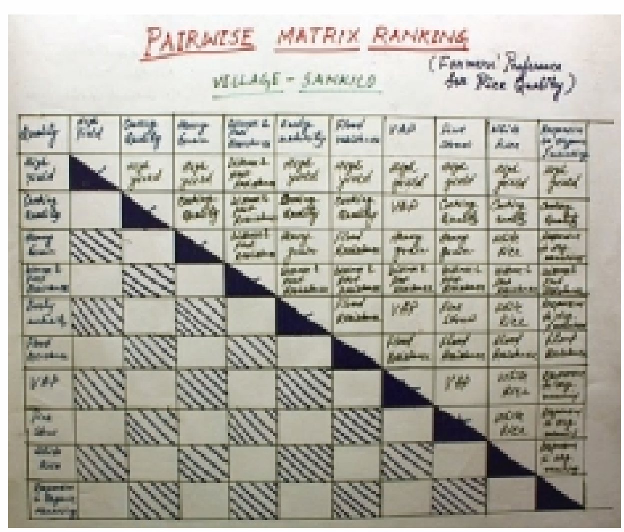
Identification of gender issues in rice farming through PRA

zation programmes were carried on to inform the households about the project objectives and drawing action plan. A PRA study was undertaken by involving both male and female key informants separately to identify major gender issues in rice farming. The following issues were identified.

- From daily activity clock analysis during *kharif*, it was found that farm women worked for about 18 hours in the household and farm activities with only 6 hours rest period as compared to 7½ hours of rest by their male counterparts. Similarly during *rabi* too, farm women took only 6 hours rest as compared to 8 hours rest by farmers.
- Pair-wise matrix ranking on preference for rice variety revealed that men preferred a variety for its 'disease-pest resistance' followed by 'yield' and 'cooking quality' out of ten identified parameters while women preferred 'high yield' followed by 'early duration' and 'cooking quality' of eight identified parameters of preference.
- Regarding workload in different calendar months, farmers perceived that they were heavily loaded with work during July-December when the field farm activities were more. In contrast, farm women were comparatively heavily burdened with household works and farm activities round the year.
- As regards to major problems being encountered, farm women faced health hazards (waist pain), storage problem of grains and seeds, threshing & winnowing, water scarcity, capital shortage for procurement of inputs and lack of technical knowledge & skills in rice cultivation. They wanted institutional credit facility, farm machineries on custom hiring basis and training on rice farming.

A bench mark survey of participating farm women (30) on their profile, involvement (both physical and management activities), access to productive resources, benefit from rice farming, gender relation etc. through a well developed interview schedule was carried out to understand the women and gender issues. The summary of the bench mark study is given below.

With regard to the extent of participation in major decision-making process in farm management activities, majority of women were consulted in activities like varietal selection, irrigation, sale of produce and financial management, but rarely consulted in plant protection measures, fertilizer application and buying of farm equipment (Table 55). But unfortunately, their suggestions were hardly accepted by their male counterparts.



Gender preference for rice quality

Table 55. Participation of farm women in decision-making related to rice farming (N=30)

Area of Decision- making	Have you been consulted		Have you suggested		Extent of your participation (N=30) Extent of suggestion accepted (Rating on 5 pt scale)						Who takes major decision		
	Yes	No	Yes	No	0	1	2	3	4	5	Men	Women	Both
Rice variety selection	28 (93.33)	2 (6.67)	28 (93.33)	0 (0.00)	0 (0.00)	3 (10.00)	11 (36.67)	9 (30.00)	5 (16.67)	0 (0.00)	14 (46.67)	11 (36.67)	5 (16.67)
Financial management	24 (80.00)	6 (20.00)	24 (80.00)	0 (0.00)	0 (0.00)	4 (13.33)	9 (30.00)	5 (16.67)	5 (16.67)	1 (3.33)	14 (46.67)	10 (33.33)	6 (20.00)
Buying farm equipments/ machinery	8 (26.67)	22 (73.33)	8 (26.67)	0 (0.00)	1 (3.33)	1 (3.33)	1 (3.33)	5 (16.67)	0 (0.00)	0 (0.00)	28 (93.33)	2 (6.67)	0 (0.00)
Quantity and type of fertilizers applied	4 (13.33)	26 (86.67)	2 (6.67)	2 (6.67)	0 (0.00)	2 (6.67)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	27 (90.00)	2 (6.67)	1 (3.33)
New farm practices	23 (76.67)	7 (23.33)	19 (63.33)	4 (13.33)	2 (6.67)	10 (33.33)	4 (13.33)	3 (10.00)	0 (0.00)	0 (0.00)	21 (70.00)	3 (10.00)	6 (20.00)
Irrigation management	27 (90.00)	3 (10.00)	24 (80.00)	3 (10.00)	0 (0.00)	9 (30.00)	11 (36.67)	2 (6.67)	2 (6.67)	0 (0.00)	17 (56.67)	3 (10.00)	10 (33.33)
Plant protection measures	2 (6.67)	28 (93.33)	0 (0.00)	2 (6.67)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	30 (100.00)	0 (0.00)	0 (0.00)
Selling surplus farm produce	25 (83.33)	5 (16.67)	25 (83.33)	0 (0.00)	0 (0.00)	5 (16.67)	12 (40.00)	5 (16.67)	1 (3.33)	2 (6.67)	14 (46.67)	8 (26.67)	8 (26.67)

- Almost all the farm women showed their interest in accessing productive resources for rice production like labour, capital, inputs, technologies etc. It was seen that about 47% succeeded in accessing the land and 40 per cent of farm women accessed up to 100 per cent of the family capital (Table 56). These were some positive indications of gender friendly social climate.
- The existing gender relation dynamics in household's chorus showed that the women partially shared the activities namely; livestock care, field work, child care etc. with male members of the family, while roles like washing/cleaning of utensils, clothes and house and gender relation in the selected village.

Capacity building of farm women in rice production

Table 56. Access of farm women to productive resources for rice production (N=30)

Resources		Have you shown interest in accessing the resources (N=30)		If yes, what is the % of success					
		Yes	No	0 (Nil)	1 (1-20%)	2 (21-40%)	3 (41-60%)	4 (61-80%)	5 (81-100%)
Land		30 (100.00)	0 (0.00)	0 (0.00)	1 (3.33)	1 (3.33)	4 (13.33)	10 (33.33)	14 (46.67)
Labour	Family	30 (100.00)	0 (0.00)	0 (0.00)	0 (0.00)	4 (13.33)	6 (20.00)	11 (36.67)	9 (30.00)
	Hired	22 (73.33)	8 (26.67)	0 (0.00)	8 (26.67)	6 (20.00)	4 (13.33)	4 (13.33)	0 (0.00)
Capital	Family	30 (100.00)	0 (0.00)	0 (0.00)	5 (16.67)	0 (0.00)	4 (13.33)	9 (30.00)	12 (40.00)
	Institute	14 (46.67)	16 (53.33)	5 (16.67)	6 (20.00)	3 (10.00)	0 (0.00)	0 (0.00)	0 (0.00)
Input	Fertilizer	22 (73.33)	8 (26.67)	20 (66.67)	2 (6.67)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
	Plant Protection Chemicals	4 (13.33)	26 (86.67)	4 (13.33)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
	FYM	30 (100.00)	0 (0.00)	1 (3.33)	0 (0.00)	4 (13.33)	8 (26.67)	11 (36.67)	6 (20.00)
Improved Technology		25 (83.33)	5 (16.67)	13 (43.33)	8 (26.67)	1 (3.33)	2 (6.67)	1 (3.33)	0 (0.00)
Market Accessibility		24 (80.00)	6 (20.00)	3 (10.00)	7 (23.33)	6 (20.00)	6 (20.00)	2 (6.67)	0 (0.00)
Irrigation		26 (86.67)	4 (13.33)	6 (20.00)	2 (6.67)	6 (20.00)	6 (20.00)	4 (13.33)	2 (6.67)

Feedback on Rice Production Technologies (RPTs) as perceived by different stakeholders

Feedback analysis on the performance of different rice production technologies (RPTs) and government programmes and schemes were collected randomly by accidental sampling from 120 visiting farmers from Jharkhand (30), Assam (20), Chhattisgarh (10) and Odisha (60) through a structured interview schedule (Table 57). Thirty nine per cent of them were having 11-20 years of experience in rice cultivation, while, 35 per cent were having above 20 years of experience. Almost half (51.67%) of them were in the BPL category and the rest (48.33%) were in APL category. The following are the major findings.

- Among the Odisha farmers, Pooja was rated to be the best performer and most popular rice variety followed by Sarala, Gayatri, Swarna, Lalat and Varshadhan, respectively. In case of Jharkhand, it was hybrid rice followed by Abhishek and Sita Shayamali; in case of Assam (bodoland territory), it was Ranjit followed by Mahsuri and Joha rice; and in case of Chhattisgarh, the highest rated variety was *IR-64* followed by Swarna, *MTU-1010* and Mahamaya.
- The performance rating of System of Rice Intensification (SRI) by the respondents was found to be 4.93 in the 5 point scale which was closely followed by Line transplanting (4.83) and traditional random transplanting (4.71). The performance rating score of broadcasting-cum-beushening method was found to be 3.54.Farmers stated that they started practicing SRI and line transplanting mainly through the BGREI programme. Regarding fertilizer application, most of the farmers (95.0%) were applying FYM along with chemical fertilizers. The application of chemical fertilizer in three splits in the rice crop was followed by only forty per cent farmers, but was perceived as best (with 4.85 score in 5 point scale) over the one or two spilt applications. This indicates that by and large farmers have become aware of the advantages of split application of fertilizers.

Table 57. Problems in rice production as perceived by the farmer stakeholders (N=120)

Perceived problems in Rice production	Total Weighted Score on the Severity	Mean weighted Score	Rank
Infestation of diseases and pests	497	4.14	I
Unavailability of quality seeds in time	479	3.99	II
Unavailability of labourers during cropping season	472	3.93	III
Erratic rainfall in rainfed areas	468	3.90	IV
High costs of farm inputs	449	3.74	V
Lack of irrigation facility	448	3.73	VI
Unavailability of reference materials for farmers	438	3.65	VII
Lack of proper technical knowledge & skills	421	3.51	VIII
Sale of paddy below minimum support price (MSP) fixed by the government	416	3.47	IX
Poor economic condition of farmers	401	3.34	X
Poor farmers-extension officers linkage	399	3.33	XI
Illegal practices by government officials for sanctioning loans and subsidy etc.	379	3.16	XII
Unavailability of sufficient numbers of farm implements/machineries	373	3.11	XIII
Crop damage due to drought or water scarcity	365	3.04	XIV
Unavailability of sufficient pesticides & fertilizers	364	3.03	XV
Flood and submergence after heavy rain	333	2.78	XVI
Illiteracy of farmers	292	2.43	XVII

- On farm mechanization, the performance of mechanical puddler, power operated reaper, combined harvester and power operated winnower were perceived excellently well. But in practice, their use was negligible, mostly due to high cost of machineries and/or non-availability of sufficient quantity of machineries in government outlets. None of the respondent farmers used rice seed drill. Only few farmers used rice transplanter and mechanical weeder as part of government demonstration and their responses on the performance of the machines were also not encouraging. Many of the respondent farmers were found not aware of the improved farm machineries, their availability and their advantages.
- Analysis on pest and disease infestation and their management revealed that farmers were mostly affected by the infestation of stem borer (95.8%), gundhi bug (76.7%) and BPH (59.2%). They applied chemical pesticides to control, which they perceived as the best management practice over any other IPM method like mechanical, biological and cultural methods. Awareness campaign on need-based pesticide applications and use of resistant rice varieties are the need of the hour.
- About the performance of various government programmes and schemes, rice procurement at minimum support price (MSP) was rated best (3.07 mean weighted score) by the farmers followed by the training programmes on rice (2.96) and demonstration on rice by ATMA (2.21). The major problems encountered by the farmers were infestation of diseases and pests (4.14 mean weighted score) followed by unavailability of quality seeds in time (3.99), unavailability of labourers during cropping season (3.93), erratic rainfall (3.90), high cost of farm inputs (3.74) and lack of irrigation facility (3.73).

Developing strategy for popularizing IPM in rice

In order to popularize the IPM technology, five neighbouring villages close to Sankilo were selected in Nishchintakoili block of Cuttack district. The basic information about the villages was recorded. The different rice varieties they grew were Pooja, Swarna, CR1018 and Sarala. Out of major insect pests, only 10% of the farmers were aware about stem borer and 20% of them were aware about the BPH. They were mostly unaware about other insect pests. Out of the total farmers (250) interviewed only 20% and 5% of them were aware about the incidence of sheath blight and blast, respectively. But they did not know about the name of the diseases or insects. There was 'lack of awareness on different insect pests and diseases of rice', 'non-availability of field level extension personnel to advise on pest control measures', 'non-availability of recommended pesticide at the time of requirement' etc.

Demonstration of CRRI rice varieties

The result of performance of CRRI varieties under on-station demonstration are as follows.

- During *rabi* 2012-13, it was observed that rice hybrid Rajalaxmi gave the highest yield of 7.3 t/ha while, Kamesh gave the lowest yield of 3.5 t/ha. The yield of other varieties in the demonstration in decreasing order of yield were Ajay (6.9 t/ha), Satyakrishna (6.5 t/ha), Naveen (5.9 t/ha), Chandan (5.8 t/ha), Swarna MAS (5.8 t/ha), IR64 MAS (5.1t/ha), Phalguni (5.0 t/ha), Sahbhagidhan (5.0 t/ha), Abhishek (4.9 t/ha), BPT 5204 Sub 1 (4.6 t/ha), Geetanjali (4.5 t/ha), Hazaridhan (4.5 t/ha), IR 64 Sub-1 (4.3 t/ha), Lalat MAS (4.1 t/ha) and Sadabahar (3.7 t/ha).
- During *kharif* 2012-13, it was observed that rice hybrid Rajalaxmi gave the highest yield of 7.2 t/ha. Ajay and CRHR 32 gave the yield of 6.7 t/ha and 5.8 t/ha, respectively. Among the aromatic varieties Nua Dhusara gave the highest yield of 4.2 t/ha, while Ketekijoha, Nua Kalajeera and Geetanjali gave the yield of 3.6, 3.3 and 3.2 t/ha, respectively. In upland situation the varieties Sahbhagidhan, Kamesh, Abhishek, Hazaridhan and Sadabahar gave the yield of 4.5, 4.3, 3.9, 3.7 and 3.61 t/ha, respectively. Under irrigated situation, the varieties Satyakrishna, Chandan, Naveen, Phalguni, Chandrama, Lalat MAS, IR 64 *sub-1* and IR 64 MAS gave the yield of 5.3, 5.1, 4.6, 4.5, 3.8, 3.8, 3.6 and 3.3 t/ha, respectively. In lowland situation, the variety CR Dhan 500 gave the highest yield of 6.0 t/ha while Reeta, Jayantidhan, Hanseswari and Jalamani gave the yield of 5.5, 4.5, 4.1, and 4.1 t/ha, respectively. Among the salt tolerant varieties *viz.*, Luna Suvarna and Luna Sampad gave the yield of 5.2 and 4.2 t/ha, respectively.

Characterization of Resources and Innovations to aid Rice Research and Develop Extension Models (Activity)

Designing general simulation model of diffusion of rice technologies in different rice ecosystems

One of the activities pertains to designing resource-characterization based general simulation model of diffusion of rice technologies. Knowing that the pattern of adoption varies with every fifty kilometres, twenty locales were selected following the grid sampling method. As per assumption, the locales are situated at the distance of 50 km grids from each other (Table 58). Questionnaire for diffusion of technology was developed and validated. Secondary data related to CRRI varieties were collected from different government agencies.

Develop business modules in rice technologies for entrepreneurship development of community level

Under the activity-develop resource-characterization based T-EDP modules of CRRI technologies for community level adoption, Sakhigopal block of Puri district was selected as the locale for this activity based on the reports of extent of mechanisation. The State Government has provided subsidy for the purchase of tractor (97), power tiller (76), reaper (43), power driven equipments (118), rotavator (56), transplanter (6), combine harvester (1), special power driven equipments (15) and hydraulic trailer (31). Using interview schedule market data was collected from ten agripreneurs of the locale. Further, as part of developing T-EDP module, business plan was developed and profitability projections were made (Table 59).

Collection of data through interview from agripreneurs

Table 58. Selected locations along with its grid position for designing general simulation model of diffusion of rice technologies

Name of Village	Grid	Latitude (North)	Longitude (East)
Khindo	100km W, 50+43kmN	21°17′29.23"	84°58′30.00"
Telkoi/Govindpur	50km W, 100km N	21°21′11.27"	85°27′14.86"
GhatGaon	100km N	21°21′11.27"	85°56′00.00"
Sundarpur	50km E, 100km N	21°21′11.27"	86°24′45.24"
Srijung	100km E, 100km N	21°21′11.27"	86°53′40.44"
JSPL Town Angul	100km W, 50km N	20°54′05.85"	84°58′30.00"
PuranaAlatuma	50km W, 50km N	20°54′05.85"	85°27′14.86"
Ambosara	50km	20°54′05.85"	85°56′00.00"
Korigan (Dhamnagar)	50km E, 50km N	20°54′05.85"	86°24′45.24"
Naikulsahi	100km E, 50km N	20°54′05.85"	86°53′40.44"
Malatiput	100km W	20°26′60.00	84°58′30.00"
Nuapatna	50km W	20°26′60.00	85°27′14.86"
CRRI	0km	20°26′60.00	85°56′00.00"
Jamapara	50km E	20°26′60.00	86°24′45.24"
Ratanpur, Tarapada	50+27km E	20°26′60.00	86°40′48.91"
Odagaon	100km W, 50km S	19°59′54.13"	84°58′30.00"
Kamaguru	50km W, 50km S	19°59′54.13"	85°27′14.86"
Gadachandapur, Bamanal	50km S	19°59′54.13"	85°56′00.00"
Naharana, Saharabedi	50km E, 50km S	19°59′54.13"	86°24′45.24"
Bilaspur	100km W, 100km S	19°32′48.07"	84°58′30.00"

Table 59. Profitability projections for custom hiring of the implements

Sl. No.	Particulars	Amount (Rs.)				
		1 Year	2 Year	3 Year	4 Year	5 Year
A	Revenue	31,60,200	31,60,200	31,60,200	31,60,200	31,60,200
B	Cost of service					
	Utilities	561,750	561,750	561,750	561,750	561,750
	Salaries/wages	269,000	269,000	269,000	269,000	269,000
	Repairs and maintenance	200,000	200,000	200,000	200,000	200,000
	Interest	406,485	338,186	259,299	168,182	62,939
	Depreciation	397,440	356,730	320,608	288,484	259,880
	TOTAL	1,834,675	1,725,666	1,610,657	1,487,416	1,353,569
C	Gross Profit/loss (A-B)	1,325,525	1,434,534	1,549,543	1,672,784	1,806,631
D	Income Tax	0	0	0	0	0
E	Net Profit/ loss	1,325,525	1,434,534	1,549,543	1,672,784	1,806,631
F	Repayment	440,533	508,832	587,719	678,836	784,079
G	Retained Surplus	884,992	925,702	961,824	993,948	1,022,552

The total cost of the project was found to be Rs. 1,834,675 while, the gross profit was Rs. 1,325,525. After repayment, the retained surplus was found to be Rs. 884,992. The break even point was achieved after second year (Fig. 34).

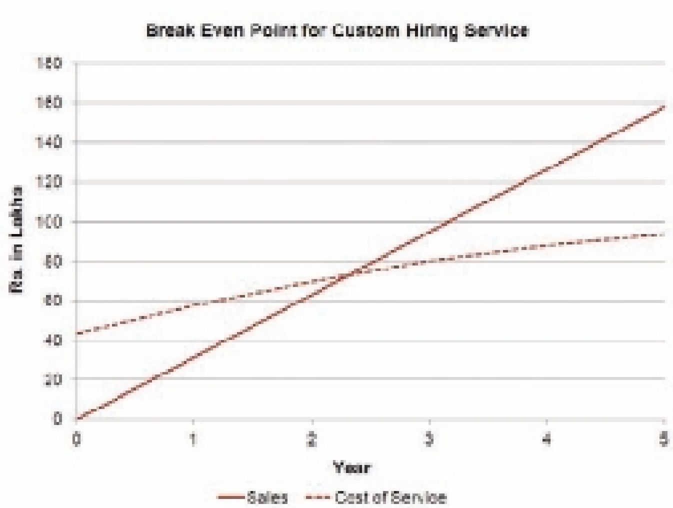


Fig 34. Break even point of project on custom hiring of the implements

Impact Analysis and Database Updation in Relation to Policy and Programmes on Rice

To estimate the area under CRRI varieties in different states of India

Data analysis for Tripura state revealed that varieties like Swarna, Pooja, Naveen, and NDR-97 were covered maximum area among the varieties grown by farmers. The coverage of modern varieties of rice in the state was 92% and *rabi/summer* rice accounts for 25% of total rice area. Jhum cultivation is prevalent in the state which accounts for 6% of total rice area in the state. CRRI released varieties were grown to the extent of 73100 ha in the state and accounted for 25% of total *kharif* HYV area and 48% of total *rabi/summer* rice area. Among them Pooja, Naveen, Shatabdi, Chandan and Tapaswani were grown to the extent of 38100 ha, 27900 ha, 4300 ha, 1600 ha and 900 ha, respectively in the state. Naveen and Shatabdi were grown in both *kharif* and *rabi/summer* seasons while Chandan was gaining popularity in rabi/ summer season. Pooja during *kharif* and Naveen during *rabi/summer* season were popular in all the districts. Tapaswini was popular in West Tripura district, while Shatabdi and Chandan were popular in both South and West Tripura districts.

Similarly, data analysis for Chhattisgarh state revealed that the coverage of HYV rice in the state was 63%. The *rabi/summer* rice accounts for only 3.2% of total area under rice. The rice varieties which covered maximum area were MTU-1010, Swarna, MTU-1001, Mahamaya, IR-64 and IR-36. These varieties covered about 55400 ha in the state. The CRRI varieties like Shatabdi, Tapaswani, Anjali and Annada covered to the extent of 29100 ha, 15400 ha, 9300 ha and 1100 ha, respectively. The variety Shatabdi is popular in districts like Raipur, Durg, Rajnandgaon, Sarguja, Kanker and Bilaspur while, Tapaswani variety was popular in Durg and Raipur districts. Further, Anjali is grown in Durg, Rajnandgaon and Jashpur districts, while Annada was grown in Rajnandgaon and Koriya districts.

To update the district-wise data base on area production and yield of rice in India

The West Bengal rice production data for the period 1960-61 to 2009-10 was analyzed using ARIMA models for forecasting and it was found that ARIMA (2,2,0) explained the rice production data in West Bengal better. This model has been used for forecasting the rice production for the year 2019-20. The estimated value for 2019-2020 was found to be 16552 thousand tonnes.

Collection and digitization of state wise cost of cultivation data of rice

State wise (18 states) cost of cultivation data on rice for the period 2006-10 were collected and digitized.

KRISHI VIGYAN KENDRAS

Santhapur, Cuttack

Front Line Demonstrations (FLD)

Rice : Under upland situation Sahabhagidhan (3.96 t/ha.) gave 32 per cent higher yield than local check Khandagiri (3.0 t/ha). In shallow lowland Pooja gave 4.52 t/ha, while in medium deepwater situation Varshadhan (4.85 t/ha) gave 22 per cent higher than local Budhathenga (3.96 t/ha). Scented rice Ketekijoha (3.24 t/ha) gave 15 per cent higher yield than local variety Haldigundi (2.82 t/ha).

Blackgram : Front line demonstration of variety TU 94-2 was conducted in five hectares of land involving 12 farmers on village Ganeshwarpur, Tangi-Choudwar. The average yield of 0.86 t/ha was recorded in demonstrated plots which was 36.5 per cent higher than local variety Mundibiri (0.63 t/ha).

Greengram : FLD of green gram variety PDM-139 alongwith Vitavax powder for seed treatment was given in five hectares of land involving 14 farmers of Khadibila village of Niali block. The average yield of 0.78 t/ha was recorded in demonstration plots which was 34.5 per cent higher than local variety Jhaimung (0.58 t/ha).

On Farm Trials (OFT)

Eighteen on-farm trials (OFT) were conducted on farmers' field. In the OFT "Assessment of hybrid variety Ajay and Rajalaxmi under SRI method of cultivation", yield of 7.32 and 7.10 t/ha were recorded in Ajay and Rajlaxmi, respectively while it was 6.10 t/ha in the farmers' choice variety Swarna under similar method of cultivation at Mangrajpur village of Badamba block, Odisha.

In another trial, co-culture of sesbania with rice variety Pooja at Jaripada village of Tangi-Choudwar, recorded yield of 4.91 t/ha which was 7.91 per cent higher than the yield obtained with application of chemical fertilizer only. In an OFT "Assessment of plantomycin, carbendazim and copper oxychloride mixture against rice disease complex" conducted at Sankilo village, Nischintakoili, Cuttack with variety Swarna, the average yield of 4.68 t/ha was recorded which was 15.38 per cent higher than farmer's practice (4.06 t/ha).

Training

During 2012-13, sixty two off and on-campus vocational training programmes were organized for 1813 farmers/farm women/rural youths and extension functionaries. The programmes were on "Scientific nursery raising of paddy", "Pest management in paddy nursery", "Integrated nutrient management in paddy", "Integrated weed management in paddy", "Water management in rice in rainfed situation", "Method of increasing nitrogen use efficiency", "Management of nutritional garden", "Method of planting and fertilizer management in rice", "Mechanical rice production", "Farmers club formation and its benefits", "Production technology of grafting, budding and layering for nursery management", "Fertilizer management and method of planting in pointed gourd", "Use of biofertilizer in vegetable production", "Insect pest management in tomato, brinjal, cole crops", "Role of micro-organism in agriculture production", "Method of soil sample collection", "Value addition in tomato and other vegetables", "Basin management in coconut garden", "In-

On-farm trial on rice disease management

Training programme for farmwomen on mushroom production

tegrated weed management in rabi pulses", "Acid soil management", "Formation and management of farmers' club", "Mushroom production technology", "Leadership development", "INM in banana", "INM in rabi rice", "IWM in rabi rice", "Use of small tools and agricultural implements for drudgery reduction" and "Improved technology for onion cultivation".

Training programmes, sponsored by Project Director, ATMA, Cuttack were conducted on "Vermicomposting", "Formation and management of farmer's club", "Mushroom Production Technology", "IWM in rice", "IPM in field crops", INM in field crops", and "Importance of balance nutrient in vegetables" while two trainings sponsored by Project Director, ATMA, Korea and ATMA Jashpur, Chhatisgarh were conducted on "Rice Production Technology".

Jainagar, Koderma

On Farm Trials (OFT)

Fifteen on-farm trials were conducted *viz.*, "Effect of brown manuring on the yield of paddy in upland (don 3)", "Evaluation of newly released short duration variety for DSR", "Evaluation of herbicides for DSR", "Assessment of improved variety of potato", "Evaluation of the feasibility of commercial cultivation of papaya", "Varietal evaluation of capsicum in Koderma district", "Varietal evaluation of *kharif* onion", "Effect of different type mulching in Brinjal", "Nutritional management of black Bengal goat", "Feeding of mineral mixture with pro-biotic animal feed supplement for high milk production", "Effect of supplementation of Pasu chocolate in milch Cow", "Hormonal Control of anestrous and assessment of feasibility and profitability of lac production (rangeeni lac) on different host trees".

Increase in grain yield was to the tune of 39, 33.75 and 28.01 per cent in case of Sahbhagidhan, CR Dhan 40 and Vandana over farmers' practice (2.19 t/ha), respectively. Sahbhagidhan was the most profitable with a net income of Rs. 23,200/ha and benefit-cost ratio of 2.24, followed by CR dhan 40 and Vandana. Increase in grain yield was to the tune of 36.97 & 11.66 per cent with application of Bispyribac sodium @ 30 g a.i./ha and application of pendimethalin @ 1.0 kg a.i./ha over farmers' practice (2.60 t/ha), respectively. Application of Bispyribac sodium was economically the most feasible with a net income of Rs. 26,200/ha BC ratio of 2.007. On Farm Trail (OFT) on 'Effect of brownmanuring on the yield of rice cv.Sahbhagidhan in medium land revealed that brown manuring (sowing of Dhaincha seed @ 40kg/ha and spraying of 2,4-D after 25 days) recorded highest grain yield in rice 3.33 t/ha with net income of Rs. 25 800/ha and BC ratio of 2.19.

Increase in tuber yield of potato was to the tune of 14.92 and 34.14 per cent with cv. Kufri Ashoka and K. Pukhraj over farmers' practice (190.21 q/ha). Deworming thrice in year and mineral mixture @10 gm. /goat/ day increased body weight by 22% and reduced the mortality by 5%. Mineral mixture 45 gm. per day for 60 days and Probiotic 10 gm. for 120 days increased milk production 12.5%. Black Bengal goats crossed with Beetal buck increased the kids' body weight from 1.5kg to 2.3 kg. Body wt. at 12 months of age was 11 kg to 19 kg. Regular supply of Urea-Molasses-Mineral Block (UMMB) as a lick, up to 60 days without interruption, produced about 28% more milk, increased feed intake,

On-farm trial on brown manuring

early conception, minimum repeat breeding and decreased intercalving intervals than those without supplementation. Full dose of Gynarich i.e. 5 ml increased ovarian activities and increased conception rate up to 50%.

Feasibility of capsicum cultivation in Koderma was tested. Performance of cv. Indra was better in respect of yield (1.22 t/ha), net return (Rs. 152600/ha), BC ratio (3.27), fruit size, quality of fruit, keeping quality. Incidence of insect pests and diseases were less over cv. Bharat and California wonder. *Kharif* onion, cv. Arka Niketan was better in respect of yield (28.4 t/ha), net return (Rs.109600/ha), BC ratio (4.38), bulb size, and less incidence of insect pest and disease over cv. Agrifound dark red and A. Kalyan. Mulching with black polythene in brinjal produced of yield (57.14 q/ha), net return (Rs.137,400/ha), BC ratio (2.66).

Training and other extension activities

In all 79 trainings programmes were conducted between April 2012 and March 2013 (On campus: PF-34, RY-10, EF-04; Off campus: PF-20, RY-07, EF-4; Sponsored-08) on "Weed management", "Resource conservation technologies, Cropping systems", "Crop diversification", "Integrated farming system", "Seed production", "Integrated crop management", "Production of low volume and high value crops", "Off-season vegetables nursery raising", "Export potential vegetables grading and standardization", "Layout and management of orchards", "Cultivation of fruit management of young plants/orchards", "Export potential of ornamental plants", "Production and management technology", "Dairy management", "Poultry management", "Disease management", "Feed management Production of quality animal products", "Goat farming", "Household food security by kitchen gardening and nutrition gardening", and "Minimization of nutrient loss in processing" in different disciplines (Agronomy, Horticulture, Livestock production and home Science/Women empowerment) and total no participants were 3924. KVK Koderma organized a 90-day residential training programmes for 35 village level workers during the year. Four sponsored training programmes were organized; two on 'Krishi kee naveentam taknikiyan' for practicing farmers and two for SHGs on mushroom production. In addition to this, KVK Koderma also organised seven field days, 16 farmers-scientists interactions, technology week, four kisan goshthies, four animal health checkup camps, four vaccination camps for cattle with raksha trio-vac, two vaccination camps for goat against PPR, 16 film shows and 47 news paper coverage.

Front Line demonstrations (FLD)

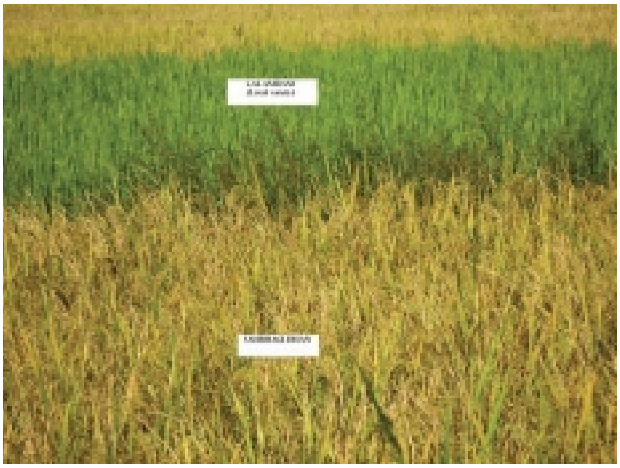
FLD on rice was conducted in 125 demonstrations covering 80 ha area with variety Sahbhagidhan. Increase in grain yield was to the tune of 51.9 per cent with balanced fertilization over local check (1.84 t/ha) and the B:C ratio of demonstration plot was 2.17. FLD on rice, cv. Abhishek, was conducted in 40 demonstrations covering 18 ha. Increase in grain yield was to the tune of 30 per cent with balanced fertilization over local check (2.96 t/ha) and the BC ratio of demonstration plot was 2.61. FLD on DSR was conducted in 35 demonstrations covering 20 ha area with variety Sahbhagidhan. Increase in grain yield was to the tune of 45.22 per cent with balanced fertilization over local check (1.72 t/ha) and the BC ratio of demonstration plot was 2.24.

Dr. T. Mohapatra addressing newly recruited VLWs trainees

Field day on Sahbhagidhan

KVK Koderma took up FLDs for chickpea (41 FLDS, 3.5 ha, with two varieties), black gram (7 FLDs, cv PU 31, 1 ha), linseed (25 FLDs, cv T3, 3 ha), lentil (10 FLDs, cv PL 4, 1 ha) tomato (cv Aninash 2 and A. Abha) and okhra (cv VRO 6). The FLDs recorded yield advantage of 27-41 per cent.

Sterilization of straw by hot water and oyster spawn, as an improved package of practice recorded 75 % higher yield of mushroom over farmers' practice (1.00 kg/ha). Net income was calculated Rs.902/bag with BC ratio of 5.8. Divyayan red (poultry) gained 2.5 kg to 3 kg in 11 months. These birds start laying from the age of 28 to 30 weeks. The women in the families are also a happier lot, as the Divyayan Red lays 230-250 eggs annually. Khaki Campbell duck male attained 1.3 kg body wt. in 12 weeks of age. The female lays 180 eggs in a year. The demonstration yield in terms increased 31% and egg production increased 119% with improved breed and disease management over desi duck which had a body wt. of 910 g in 12 weeks of age and production of 82 eggs in a year. Deworming of calves by Albendazole was done as per schedule (Ist dose 10-15 days after birth, 2nd dose after 40-45 days 3rd days after 70-75 days) and proper management practices. The result showed increase in body weight of calves by 21% and mortality rate of 64% over farmers practice (No deworming in calves). Cattle were vaccinated byRakshaTriovac (Trivalent). The survival percentage of cattle in that village increased to 95% from 45% as outbreaks of H.S, B.Q and F.M.D were frequent and farmers were not practising any control measures/ vaccination. Goats were vaccinated by Raksha- PPR. The survival percentage of goat in that village increased up to 98% from 40% as outbreak of PPR was frequently observed in the village.



Director SAMETI visiting demonstrations

Director, CRRI, releasing Krishi Margdarshika

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EVENTS AND ACTIVITIES

RAC, IMC, IRC, IJSC and SAC Meetings

Research Advisory Committee

The XVIII[th] Meeting of the Research Advisory Committee (RAC) was held at CRRI, Cuttack from 2 to 3 November, 2012 under the Chirmanship of Dr. RB Singh. The other members were Dr. CL Acharya, Dr. ML Lodha, Dr. R Sridhar and Dr. (Mrs.) Shailaja Hittalmani. Dr. BC Viraktamath, PD, DRR attended as special invitee.Dr. T Mohapatra, Director presented the highlights of the research achievements and infrastructural developments since the last RAC meeting. Dr. JN Reddy presented the details of the action taken report on the recommendations of the XVII[th] RAC. Dr. DP Sinhababu, Member-Secretary, Institute Research Council (IRC) highlighted the salient features of the programme of work approved by the IRC 2012. Heads of the divisions presented the research achievements of institute research programmes. The RAC members also visited field experiments and research laboratories.

Chairman and members, RAC interacting with the staff members in an open session

Institute Management Committee

The 23[rd]meeting of the Institute Management Committee (IMC) was held on 28 August, 2012 under the Chairmanship of Dr. T Mohapatra, Director, CRRI. Matters related to infrastructure development and budgetary provisions were discussed.The 24[th]meeting of the Institute Management Committee (IMC) was held on 23 February, 2013 under the chairmanship of Dr.T Mohapatra, Director, CRRI. Various issues related to administration, finance and research were discussed.

Institute Management Committee meeting in progress

Institute Research Council

The 30[th] meeting of the Institute Research Council (IRC) was held from 24 to 30 September, 2012 under the chairmanship of Dr. T Mohapatra, Director, CRRI. The scientists presented RPF III of XI[th] plan projects, achievement for March-September 2012 and targets for October 2012-March 2013.

Institute Joint Staff Council

The 6[th] IJSC meeting was held on 17 April, 2012 at CRRI, Cuttack and its 7[th] meeting at Gerua on 23August, 2012 under the chairmanship of the Director. Various administrative and financial matters were discussed and finalized.

SAC meetings of Krishi Vigyan Kendra

The 14[th] Scientific Advisory Committee meeting of the Krishi Vigyan Kendra, Santhapur was held on 23

March, 2013 under the chairmanship of Dr. T Mohapatra, Director, CRRI. On this occasion State Govt. officials of concerned departments, Heads of Division, CRRI; Head, CHES; Head, CARI, Bhubaneswar, farmers and farmwomen representative attended the meeting. The work done report of KVK for 2012-13 was discussed and an action plan for 2013-14 was finalized.

Participation in Symposia/Seminars/ Conferences/Trainings/Visits/ Workshops

Dr. KB Pun participated in the Review Meeting of BGREI and RKVY convened by the Director (Agriculture), Assam on 5 April, 2012 at Shilpagram, Guwahati.

Drs. T Mohapatra,Director, ON Singh, GJN Rao, SR Dhua, RN Rao, JN Reddy, M Jena, A Patnaik, SSC Patnaik, SK Pradhan, VD Shukla, NP Mandal and CV Singh attended the 47th Annual Rice Group Meeting at DRR, Hyderabad from 6 to 9 April, 2012.

Drs. SR Dhua, JN Reddy, P Swain, SSC Patnaik, B Bhattacharjee, BC Marndi, M Variar, VD Shukla and NP Mandal attended the Annual Group Meeting and planning for 2012-13 of STRASA at CSSRI, Karnal from 11 to 13 April, 2012.

Dr. JN Reddy participated in 2nd Review meeting of DBT India-IRRI Network Project "From QTL to variety: marker assisted breeding of abiotic stress tolerant rice varieties with major QTLs for drought, submergence and salt tolerance" held at CSSRI, Karnal on 12 April, 2012.

Dr. SR Dhua and Mr. RK Sahu attended the Annual Group Meeting of NSP (Crops) at Anand Agricultural University, Anand from 14 to 16 April, 2012.

Dr. VK Singh participated in the 5th International Federation for Information Processing (IFIP) World IT Forum (WITFOR 2012) at Vigyan Bhavan, New Delhi from 16 to 18 April, 2012.

Dr. T Mohapatra, Director attended the DAC meeting on BGREI at New Delhi on 25 April, 2012.

Dr. NN Jambhulkar attended the training programme on 'Statistical Tools for Molecular Breeding' organized by Barwale Foundation, Jalna, Maharashtra from 24 to 26 April, 2012.

Dr. SM Prasad attended the Zonal Workshop of KVKs of Zone-VII in Jabalpur, M.P. from 3 to 5 May, 2012 and presented Annual Progress Report 2011-12 and Annual Action Plan 2012-13.

Dr. BC Patra attended the 7th Annual review meeting of the DBT funded research project entitled "Establishment of National Rice Resource Database at National Bureau of Plant Genetic Resources (NBPGR), New Delhi on 5 May, 2012 and presented the annual progress report.

Dr. KB Pun participated in the 38th Zonal Research and Extension Advisory Committee meeting for *kharif* 2012 for the Lower Brahmaputra Valley Zone of Assam at Horticultural Research Station, Assam Agricultural University, Kahikuchi on 5 May, 2012.

Dr. NP Mandal attended a workshop on 'Upland Rice' at Hyderabad on 7 May, 2012.

Dr. M Variar attended the planning meeting of STRASA for 'Use of microbes for management of abiotic stresses in rice' at NASC Complex, New Delhi on 8 May, 2012.

Dr. NP Mandal attended annual review and planning meeting of the DBT's Twinning programme for the NE entitled 'Identification of major QTLs for grain yield under drought stress in Jhum rice varieties of North Eastern Region for use in marker assisted breeding to improve yield under drought (EAP 160)' held at ICAR Research Centre, Regional Station, Agartala on 9 May, 2012.

Drs. M Variar and VD Shukla attended the annual planning meeting of BGREI for Jharkhand at Ranchi on 19 May, 2012.

Dr. DP Sinhababu attended QRT Review meeting of PDFSR at OUAT, Bhubaneswar on 26 May, 2012 and provided inputs on farming System Research in the meeting.

Dr. SM Prasad attended the State level interaction meeting of BGREI at Bhubaneshwar on 28 May, 2012.

Dr. T Mohapatra,Director attended the review programme of BGREI in Eastern India along with Secretary (A&C), Govt. of India at Kolkata on 29 May, 2012.

Dr. KB Pun participated in the meeting convened by the Secretary, DAC to review the performance of BGREI programme in Assam and strategy for 2012-13 on 30 May, 2012.

Dr. VK Singh participated in the Global Conference on 'Horticulture for Food, Nutrition and Livelihood options-2012' at OUAT, Bhubaneswar from 28 to 31 May, 2012.

Dr. M Din attended a meeting in connection with review programme of Bringing Green revolution to Eastern India (BGREI) of Chhattisgarh State at Raipur on 2 June, 2012.

Dr. BN Sadangi attended the Vigilance Officer's review meeting at ICAR Research Complex, Patna on 4 June, 2012.

Drs. DP Sinhababu, DP Singh and SSC Patnaik visited Vivekananda Institute of Biotechnology, Sri Ramkrishna Ashram, Nimpith, West Bengal on 16 June, 2012 in the launching of a collaborative programme with CRRI.

Dr. NN Jambhulkar and Shri SK Rout attended 'SAS installation training cum workshop' at DWM, Bhubaneswar on 22 June, 2012.

Dr. Teekam Singh and Mr. BS Satapathy, RRLRRS, Gerua participated in the SAU-ICAR-CII Industry Regional Meet-2012 at College of Fisheries, CAU, Lembucherra, Agartala (Tripura) on 3 July,2012.

Dr. SG Sharma participated in the 'Rice bio-fortification meeting' organized by Harvest Plus held at NASC Complex, New Delhi on 6 July, 2012.

Dr. KS Rao attended Policy Dialogue on 'Priorities and possibilities of investment for accelerating agricultural growth and reducing poverty in Odisha' at DWM, Bhubaneswar on 6 July, 2012.

Dr. KS Rao participated in a meeting with Dr. SP Agnihotri, Additional Secretary & F.A., Ministry of Agriculture and Cooperation, Govt. of India at Odisha Farm Machinery Research & Development Centre, Satya Nagar, Bhubaneswar on 7 July, 2012 to discuss the progress of various schemes under RKVY.

Dr. T Mohapatra,Director attended the 'Dialogue on designer rice' at ICRISAT, Hyderabad from 9 to 10 July, 2012.

Dr. KS Rao attended 'Odisha research and delivery hub expert consultation meeting' organized byIRRI, Philippines at Mayfair Convention Center on 10 July, 2012.

Dr. R Raja attendedthe Training-cum-Workshop on rice for KVK Scientists of ZPD, Zone VII, Jabalpur as facilitator in the Nutrient management session on 11 July, 2012.

Drs. P Mishra and M Din participated in the 17th annual workshop of AICRP on RES' at Tamil Nadu Agriculture University, Coimbatore from 9 to 15 July, 2012.

Dr. T Mohapatra,Director attended the meeting of Regional Committee No.II at NAARM, Hyderabad from 19 to 20 July, 2012.

Dr. KB Pun participated in the brainstorming session on 'Flood mitigation strategies in Assam' at Assam Agricultural University, Jorhat on 25 July, 2012.

Dr. T Mohapatra attended the 'BGREI review meeting' at Kolkata on 26 July, 2012.

Drs. KB Pun and S Lenka participated in meeting of the 'Regional research coordination committee' for NEH Region at ICAR Research Complex, Umiam on 30 July, 2012.

Mrs. Sujata Sethy attended 21 days summer school on 'Gender mainstreaming for resilient agriculture' at DRWA, Bhubaneswar from 12 July to 7 August, 2012.

Dr. KS Rao being nominated by DDG (NRM) as a member (DPC) attended the meeting for merit promotion of scientists of Directorate of Water Management, Bhubaneswar on 17, 23 July and 2 August, 2012.

Dr. Rahul Tripathy attended 21 days summer school training on 'Forecast modeling in crops' at IASRI, New Delhi from 17 July to 6 August, 2012.

Dr. PC Mohapatra attended the stakeholders' workshop on 'Use of waste water' at DWM, Bhubaneswar on 8 August, 2012.

Dr. T Singh participated in the national seminar on 'Livelihood options for small and marginal farmers in fragile ecosystems' organized by ICAR research Complex for NEH Region, Umiam (Meghalaya) from 9 to 10 August, 2012.

Dr. M Din participated in awareness workshop for the Scientists and State Government Officers associated with BGREI Programme at Directorate of Agriculture, Raipur on 22 August, 2012.

Dr. T Mohapatra, Director visited ICAR Research Complex for NEH Region and discussed with the Director on collaboration in rice research and development in the North-east on 25 August, 2012.

Dr. T Mohapatra, Director attended in-session meeting of Consultative Committee of Ministry of Agriculture on 'BGREI' in the Committee Room of Parliament Annexe held under the Chairmanship of Hon'ble Agriculture Minister, Govt. of India at New Delhi on 27 August, 2012.

Dr. T Kasturi attended DST-NRDMS sponsored 21 days summer training programme on 'Geospatial technologies and applications' at the Department of Remote Sensing and GIS, TNAU, Coimbatore from 22 August to 11 September, 2012.

Dr. PC Mohapatra attended International Inception Workshop on 'Waste water management and application in agriculture' at DWM, Bhubaneswar on 30 August, 2012.

Dr. Annie Poonam, Member, State Level Monitoring Team, BGREI, attended awareness workshop of BGREI at Krishi Bhawan, Ranchi on 30 August, 2012 and visited Bokaro district for monitoring block demonstration of hybrid rice on 2 September, 2012.

Dr. Dipankar Maiti attended and presented report of QRT (2007-11) of the AINP on 'Soil-biodiversity: biofertilizer' at BCKV, Kalyani (WB) from 3 to 5 September, 2012.

Dr. T Mohapatra,Director attended the first meeting of 'Indian hybrid rice consortium' (IHRC) at NASC Complex, New Delhi on 6 September, 2012.

Drs. T Mohapatra,Director, GJN Rao, RN Rao, MJ Baig and MS Anantha attended '6th International hybrid rice symposium' at Hyderabad from 10 to 12 September, 2012.

Dr. T Mohapatra attended the 16th Annual Meeting of the 'Council for partnership on rice research in Asia' (CORRA) at ICRISAT, Hyderabad on 13 September, 2012.

Dr. KS Rao attended an awareness workshop for officers, scientists, IRRI partners associated with BGREI programme held at Lucknow on 19 September, 2012.

Mohammad Shahid attended a short course on "Application of nanotechnology in soil science and plant nutrition research" organized by the IISS, Bhopal from 18 to 27 September, 2012.

Dr. T Mohapatra,Director attended the review meeting of BGREI at Kolkata under the Chairmanship of Union Agriculture Minister, Govt. of India on 26 September, 2012.

Dr. ON Singh attended the 'General management training programme for the scientists' at Administrative Staff College of India, Hyderabad from 17 to 28 September, 2012.

Dr. JN Reddy attended the 2nd review meeting of DBT India–IRRI Network project 'QTL to variety' on 29 September, 2012.

Dr. Manish Chourasia attended Winter School on 'New Frontier of IPM in Rice and Rice based cropping system' at DRR, Hyderabad from 13 September to 3 October, 2012.

Dr. Yogesh Kumar attended the International Conference of 'Legumes Genetics and Genomics VI' at ICRISAT, Hyderabad held from 2 to 7 October, 2012.

Dr. KB Pun as a member of the Technical Committee on hybrid rice constituted by the Government of Assam, attended the meeting on 3 October, 2012 for the procurement of hybrid rice seeds for rabi 2012-13.

Dr. KS Rao attended the 5th meeting of the State Level Monitoring Team (SLMT) for Odisha regarding 'Bringing Green Revolution to Eastern India' held on 5 October, 2012 in Rajeev Bhavan, Bhubaneswar under the chairmanship of Sri R L Jamuda, Principal Secretary, Agriculture, Government of Odisha.

Drs. S Lenka and T Singh participated in the 39th Zonal Research & Extension Advisory Committee meeting for *rabi* 2012-13 for the Lower Brahmaputra Valley Zone of Assam held at Horticultural Research Station, Assam Agricultural University, Kahikuchi on 18 October, 2012.

Drs. R Raja and GAK Kumar attended the National Knowledge Network (NKN) annual workshop held at IIT, Bombay, Mumbai from 31 October to 2 November, 2012.

Dr. BC Patra attended the 8th progress review meeting of the DBT funded research project entitled "Establishment of National Rice Resource Database" held at Directorate of Rice Research, Hyderabad on 5 November, 2012.

Dr. T Mohapatra, Director, CRRI visited CRURRS, Hazaribag and KVK, Jainagar, Koderma from 6 to 7 November, 2012.

Dr. SM Prasad attended 'Seventh National Conference of KVK' at PAU, Ludhiana, Punjab, from 20 to 22 November, 2012.

Drs. TK Dangar and Upendra Kumar attended 53rd International conference of AMI on 'Microbial world: recent innovations and future trends' held at KIIT University, Bhubaneswar, Odisha from 22 to 25 November, 2012.

Dr. M Din attended the state level technical committee meeting organized by OFMRDC at Directorate of Agriculture, Bhubaneswar on 27 November, 2012.

Dr. PC Rath attended International Conference on 'Plant Health Management for Food Security' at DRR Hyderabad from 28 to 30 November, 2012.

Drs. BN Sadangi, ON Singh, PN Mishra, Urmila Dhua, Mayabini Jena, P Swain, Lipi Das and Sangeeta Mohanty attended Women in Agriculture Day on 4 December, 2012 at Guali, Tangi-Choudwar Block, Cuttack organized by Krishi Vigyan Kendra, Central Rice Research Institute, Cuttack, Odisha.

Dr. K Chattopadhya and BC Marndi went for monitoring of CRRI saline tolerant varieties in salt affected areas in Sundarbans from 30 November to 5 December, 2012.

Dr. KB Pun was invited as resource person in the DAC-sponsored model training course on 'IPM in Floriculture' at National Research Centre for Orchids, Pakyong, Sikkim on 30 November and 1 December, 2012.

Dr. Dipankar Maiti attended the National Training on 'Bioinformatics: Methods, Tasks & Applications in Microbial Research' conducted at NBAIM (ICAR), Mau, UP held from 4 to 15 December, 2012.

Dr. Nitiprasad Namdeorao Jambhulkar participated in the 16th ADNAT workshop organized by National Institute of Animal Biotechnology (NIAB) at Hyderabad from 6 to 16 December, 2012.

Dr. SR Dhua participated in the monitoring of the PPV&FRA project activities of the TNAU, Coimbatore on 8 December, 2012 as the chairman of the monitoring team.

Dr. KS Rao, BGREI, District in-charge, Ganjam district, Odisha visited Purusottampur, Ganjam, Hinjilikkutu and Sanakhemundi Blocks of Ganjam from 10 to 13 December, 2012 to attend crop cutting experiments under BGREI programme.

Dr. SR Dhua attended the Agribusiness camp at ICAR Research Complex, Ranchi on 14 December, 2012 as Secretary of the Institute Technology Management Committee, CRRI, Cuttack.

Dr. BC Patra attended DST sponsored one week training programme for scientists and technologists working in Government sector on 'Climate change, forest ecosystems and biodiversity: vulnerabilities and adaptation strategies' held at Indian Council of Forestry Research and Education, Dehradun from 17 to 21 December, 2012.

Dr. Nitiprasad Namdeorao Jambhulkar participated in an 'International Conference on Statistics and Informatics in Agricultural Research' organized by IASRI, New Delhi from 18 to 20 December, 2012 and presented a paper on 'Multiple Pattern Matching using Least Count of Pattern'.

Drs. BC Patra and P Swain attended the 37th Annual Conference of Orissa Botanical Society and P Parija Memorial National Conference on Recent Advances in Plant Biotechnology held at Ravenshaw University, Cuttack from 22 to 23 December, 2012.

Dr. T Mohapatra, Director attended 100th Indian Science Congress at Kolkata from 3 to 7 January, 2013.Dr. Mohapatra delivered a lecture as Lead Speaker on 6 January, 2013.

Dr. T Mohapatra, Director attended International conference on 'Increasing Agriculture Productivity and Sustainability in India: The future we want' at IIS, Bangalore from 8 to 9 January, 2013.

Dr. SR Dhua attended the review meeting of the 'Special Test' projects of the PPV&FRA at New Delhi on 11 January, 2013.

Drs. T Mohapatra, Director and Meera Kar attended RFD meeting at ICAR, New Delhi on 14 January, 2013.

Dr. T Mohapatra, Director attended Krishi Karman Awards, 2011-12 at Rashtrapati Bhavan, New Delhi on 15 January, 2013.

Mrs. Chanchila Kumari participated in eight day training programme at ICAR Research Complex for Eastern Region, Patna on 'Role of Women in Integrated Farming Systems' from 17 to 24 January, 2013.

Dr. M Din attended coordination committee meeting of AICRIP on renewable energy sources of agriculture and agro-based industries at MPUAT, Udaipur from 6 to 20 January, 2013 and presented the technical programme on solar energy and bio-conversion technology of CRRI center.

Dr. AK Nayak, P Bhattacharyya, R Raja, BB Panda, Rahul Tripathi, Md. Shahid, Sangita Mohanty, B Lal, Priyanka Gautam and Sushmita Munda participated in the annual workshop of NAIP Project on "Strategies to enhance adaptive capacity to climate change in vulnerable regions" on 22 January, 2013 at CRRI, Cuttack in which all consortium partners took part.

Dr. T Mohapatra, Director attended an International Symposium on 'Genomics in Aquaculture' at CIFA, Bhubaneswar from 22 to 23 January, 2013, and also delivered a lead lecture on 'Application of Genomics on Aquaculture'.

Dr. Mukund Variar chaired as Chief Guest of the farmers meet organized by Aakashvani at Ranchi on

23 January, 2013.

Dr. Mukund Variar delivered lectures on 'Natural Resources Management under changing climate' on 7 January and again on 29 January, 2013 during the ATMA sponsored training programs (Naveentam Krishi Takniki) conducted at KVK, Koderma.

Mr. Bhoopendra Singh participated in the three day training programme on 'Appropriate technology for promotion of market–led Horticulture' at BAU Ranchi from 4 to 6 February, 2013.

Drs. BB Panda, Sangita Mohanty and Mohammad Shahid attended 'International Conference on Bioresource and Stress Management, Science City, Kolkata, India from 6 to 9 February, 2013.

Drs. SG Sharma, Avijit Das and R. Raja participated in the XI Agricultural Science Congress on 'Agricultural Education: Shaping India's future' at OUAT, Bhubaneswar, Odisha from 7 to 9 February, 2013 organized by NAAS, New Delhi and ICAR, New Delhi.

Dr. SR Dhua attended the Indian Seed Congress-2013 at Gurgaon from 8 to 9 February, 2013.

Dr. AK Nayak and R Raja attended the National workshop on 'Fly Ash Management' at Bhubaneswar on 12 February, 2013 organized by Ministry of Environment and Forest, Government of India.

Dr. T Mohapatra, Director attended a symposium on 'Genomics for crop improvement' at IBAB, Bangalore from 19 to 20 February, 2013.

Drs. Mukund Variar, Dipankar Maiti & Yogesh Kumar attended the inaugural function of the Eastern Zone Regional Agricultural Fair and Agrotech Krishi Mela at BAU, Ranchi on 22 February, 2013.

Dr. KB Pun participated in the Scientific Advisory Committee (SAC) meeting of Krishi Vigyan Kendra, Nalbari district, Assam on 22 February, 2013.

Dr. S Lenka and Mr. BS Satapathy participated in the IVth Scientific Advisory Committee (SAC) meeting of Krishi Vigyan Kendra, Namsai, Lohit district, Arunachal Pradesh on 22 February, 2013.

Dr. SR Dhua attended the DUS Testing review meeting at IIVR, Varanasi from 28 February to 1 March, 2013.

Dr. Rahul Tripathy attended the national workshop on 'Foresight and Future Pathways of Agricultural Research through Youth in India' at NASC complex, New Delhi from 1 to 2 March, 2013.

Dr. T Mohapatra, Director attended Institute Management Committee of NRCPB, New Delhi on 6 March, 2013.

Drs. T Mohapatra, Director, KS Rao and BN Sadangi attended 'Heads of Divisions meeting' with Director General, ICAR, New Delhi on 11 March, 2013.

Drs. T Mohapatra, Director and SR Dhua attended the Breeder Seed review meeting at NBPGR, New Delhi on 12 March, 2013.

Dr. B Lal and Priyanka Gautam attended a national training on "Project Formulation, Risk Assessment, Scientific Report Writing and Presentation", held at Division of Agricultural Engineering, Indian Agricultural Research Institute (IARI), Pusa, New Delhi from 12 to 16 March, 2013.

Dr. T Mohapatra, Director attended Awareness workshop for scientists & state officials associated with BGREI programme during *rabi* season on 15 March, 2013 at Raipur, Chhattisgarh.

Dr. T Mohapatra, Director attended Directors' conference from 19 to 20 March, 2013 at New Delhi.

Participation in Exhibitions

The institute participated in following exhibitions for showcasing the CRRI technologies.

Farmers' Fair at Goudagope, Mahanga, Cuttack on 8 May, 2012.

Utkal- Banga Utsav 2012 at Sahabajipur, Chandaneswar of Balasore district during 14 to 20 August, 2012.

Shri Debi Prasad Mishra, Hon'ble Minister of Agriculture, Fisheries and Animal Resources Development, Govt. of Odisha and Dr. DP Ray, VC, OUAT visiting the CRRI stall at OUAT, Bhubaneswar

7th National Conference on KVKs held at Punjab Agricultural University, Ludhiana during 21- 23 November, 2012.

100th Indian Science Congress at University of Calcutta, Kolkata during 3 to 7 January, 2013.

Global Konkan Festival 2012 at Goregaon, Mumbai during 4 to 7 January, 2013.

Agricultural Science Congress at OUAT, Bhubaneswar during 7 to 9 February, 2013.

International Symposium at CRRI, Cuttack during 2 to 5 March, 2013.

State Agriculture Fair-Krishi Mahotsav at Bhubaneswar during 19 to 22 March, 2013

Shri Debi Prasad Mishra, Hon'ble Minister of Agriculture, Fisheries and Animal Resources Development, Govt. of Odisha and Dr. SK Datta, Deputy Director General (Crop Sciences), ICAR, New Delhi visiting the stall at CRRI, Cuttack

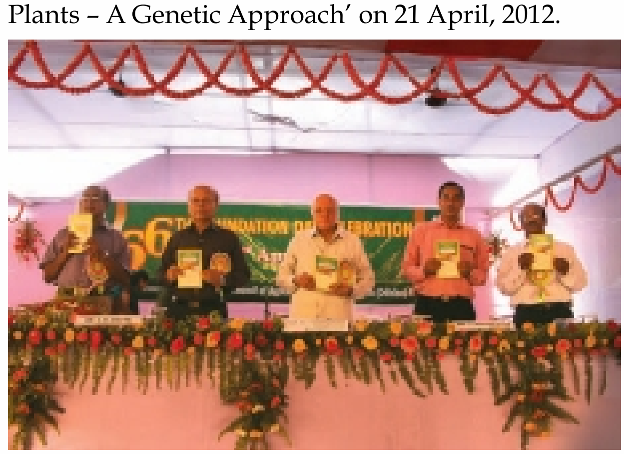
Organization of Events, Workshops, Seminars and Farmer's Day

CRRI Foundation Day

The 66th Foundation Day of CRRI was celebrated on 23 April, 2012. Prof. MS Swaminathan, Hon'ble Member of Rajya Sabha and chief guest of the programme appreciated the efforts of the institute in developing a good number of rice varieties for different ecosystems and emphasized on 'anticipatory research' and 'participatory research' for future development of rice production. While highlighting the need for an effective food security bill for India, he urged the rice scientists to make all out efforts to meet the estimated requirement of 150 million tonnes of rice by 2020. Prof. Swaminathan expressed his satisfaction on the all time record production of 100 million tonnes of rice during 2012 and suggested to prepare action plan to make farming more popular among women and youngsters of the society. Dr. SK Datta,Deputy Director General (Crop Sciences), ICAR, New Delhi and guest of honour of the function suggested to change rice farming into agribusiness ventures for generating higher income and employment opportunities.Dr. T Mohapatra, Director of the institute highlighted the significant achievements of the institute and future thrust areas of research. Nine outstanding retired scientists of CRRI and ten innovative farmers were felicitated on this occasion. The function was marked by releasing nine technical and popular bulletins.

Prof. MS Swaminathan, Hon'ble member of Rajya Sabha and Dr. SK Datta, Deputy Director General (Crop Sciences), ICAR, New Delhi lighting the lamp to inaugurate the Foundation Day

On the eve of the foundation day, Prof. BC Tripathy, Hon'ble Vice Chancellor, Ravenshaw University, Cuttack delivered the 3rd Foundation Day Lecture on 'Increasing Carbon and Nitrogen Use Efficiency of Plants – A Genetic Approach' on 21 April, 2012.



A view of Foundation Day Celebration

International Symposium

Association of Rice Research Workers (ARRW) ogranised an International Symposium on 'Sustainable Rice Production and Livelihood Security: Challenges and Opportunities' in collaboration with Indian Council of Agricultural Research, New Delhi; National Academy of Agricultural Sciences, New Delhi; International Rice Research Institute, Philippines and Central Rice Research Institute, Cuttack during 2 to 5 March, 2013 to celebrate its Golden Jubilee Year. The symposium was inaugurated by the Chief Guest, Shri Debi Prasad Mishra, Hon'ble Minister of Agriculture, Fisheries and Animal Resources Development, Govt. of Odisha. The other dignitaries present on this occasion included Padmashree Prof. EA Siddiq,Former Deputy Director General (Crop Science), ICAR; Prof. SK Datta, Deputy Director General (Crop Science), ICAR and Dr. JK Ladha, Principal Scientist, IRRI-India Office. The Chief Guest in his speech emphasized that efforts should be directed to enhance and sustain rice production and productivity under dwindling resources and changing climatic conditions; specific attention has to be given to breeding short duration varieties for different agro-climatic zones which should fetch good price in the market. He appreciated the hybrids, namely Rajalaxmi and Ajay developed by CRRI which have performed well in the State. Padmashree Prof. EA Siddiq, former Deputy Director General (Crop Science), ICAR, New Delhi delivered the key note address in the symposium. The Plenary Lectures were delivered by Padma Bhushan Prof. RB Singh, President, National Academy of Agricultural Sciences, New Delhi; Prof. SK Datta, Deputy Director General (Crop Science), ICAR, New Delhi; Prof. AK Tyagi, Director, National Institute of Plant Genome Research, New Delhi and Dr. T Mohapatra, Director, Central Rice Research Institute, Cuttack. Altogether 306 delegates from different parts of the country as well as from Bangladesh, Sri Lanka and Philippines participated in the symposium.

Shri Debi Prasad Mishra, Hon'ble Minister of Agriculture, Fisheries and Animal Resources Development, Govt. of Odisha lighting the lamp to inaugurate the symposium

Farmer's Fair

A Farmers' Fair on 'Mechanized Land Management and Variety Selection' was organized by the institute in collaboration with Mahanga Krushak Bikash Mancha on 8 May, 2012 at Goudagope village of Mahanga Block of Cuttack district.Inaugurating the Farmers' Fair, Dr. T Mohapatra, Director, CRRI, emphasized on mechanization, appropriate rice variety, and village level seed production etc. for economic development of farm families, which can help the farmers to bring country's 2nd Green Revolution. Various CRRI technologies were exhibited during the fair. Demonstration of farm machineries especially the laser leveler attracted a large number of farmers from the locality. A farmer-scientist interaction was also organized which helped the farmers to find solution to different problems related to rice and other crops. Besides scientists of CRRI, other dignitaries namely Prof. SK Nanda, Head Farm Implement and Machinery Division, CAET, OUAT, Bhubaneswar and Er Pradeep Paikray, Executive Engineer (Agriculture), Central Zone, Government of Odisha were also present and addressed the farming community. Nearly 300 farmers, farm women, rural youth and change agents of Goudagope village and nearby locality participated in this programme and five

Dr. T Mohapatra, Director, CRRI lighting the lamp to inaugurate the farmers' fair progressive farmers of the locality were felicitated by the Director, CRRI, Cuttack.

Stakeholders' Meet

The stakeholders' meet was organized by CRRI, Cuttack on Rice-based Model Village under the chairmanship of Dr. T Mohapatra, Director on 23 February, 2013. In this meeting, 10 representative farmers, 10 representative farmwomen of the cluster, 14 officials from state developmental departments, one financial institution (NABARD), one NGO, one farmers' organization and all the project personnel participated. After identification of the problems by the villagers, the officers and delegates from different developmental departments including voluntary organization put forth their views on the problems, intervention points and coordination mechanism on a convergence mode and to devise the action points for finding the possible solutions through different schemes of their respective departments. Based on the inputs recommended, action points were defined.

Stakeholders' meet in progress

Interface Meet

Central Rice Research Institute, Cuttack organized ICAR Institutes-SAU-State Department Interface Meet during 30 to 31 July, 2012 under the chairmanship of Prof. DP Ray, Vice-Chancellor, OUAT, Bhubaneswar. Shri RL Jamuda, IAS, Principal Secretary, Department of Agriculture, Govt. of Odisha was the Chief Guest. The meeting was attended by the Director, Agriculture and Food Production; Director, Soil Conservation; Director, Horticulture; Director, Fisheries; Director, CIFA; Director, DRWA, Bhubaneswar; Deans of OUAT; Heads of ICAR Regional Centres; Vice-President, Shakti Sugar, Dhenkanal; representatives from NGOs and farmers. Interactive sessions on the presentations made by Directors, exhibition and media meet were organized. Based on the interaction among state departments, farmers, industry representatives and others different researchable and development issues were identified which need to be addressed by ICAR institutes and OUAT, Bhubaneswar.

Interactive Meeting

An interactive meeting between the scientists of CRRI and NCIPM, New Delhi was held from 5 to 6 February, 2013 at CRRI, Cuttack for collaborative research on integrated biotic stress management in rice. The meeting was chaired by Dr. T Mohapatra and was attended by Dr. C Chattopadhyay, Director, NCIPM, New Delhi, Dr. A Prakash, Head along with other scientists of the Crop Protection Division, CRRI and scientists from NCIPM and IASRI, New Delhi. Based on the discussion, it was decided that, the collaborative research will be started with focus on location-specific IPM packages for rice, developing models to forecast appearance/infestation

ICAR Institutes-SAU-State Department Interface meet in progress

of major insect-pests and diseases on rice crop, assessment of losses/damages due to insect pests through remote sensing in rice vis-à-vis climate change and transfer, promotion of IPM technologies in rice and rice-based cropping systems.

Dhan Diwas

The CRRI, Cuttack observed Dhan Diwas at village Gopalpur in Mahanga block of Cuttack district on 2 December, 2012. Dr. T Mohapatra, CRRI, Director along with scientists of the institute visited farmer's field of the locality to seed plots and other plots followed by interaction in the fields among farmers and scientists.

Demonstaration of rice reaper

A demonstration of rice reaper was held to help the farmers adopt mechanization in rice harvesting. The Director chaired a meeting organized by Mahanga Krishak Manch, wherein a participatory evaluation of the efforts was conducted and strategies for raising rice production were discussed by scientist-experts and farmers. It was estimated that the participatory seed production model taken up by the institute would yield nearly 100 tons of quality seed of variety Pooja. The farmers wanted a sustained linkage between CRRI and farmers' organizations like Mahanga Krishak Manch for successful implementation of various on-farm programmes including expansion of participatory seed production of different rice varieties in coming years.

Agriculture Education Day

The Agriculture Education Day was observed on 9 November, 2012 at CRRI, Cuttack. More than 120 students and teachers from 12 educational institutions from Cuttack and Bhubaneswar participated. Several activities including inspirational talks, career counseling, exhibition on agriculture projects, speech and quiz competition were organized. A compilation entitled 'Miracles of Agricultural Science' was brought out and circulated among the students. Prof. B.C. Tripathy, Hon'ble Vice-Chancellor, Ravenshaw University addressed the participants on the 'Importance of biodiversity and basic research in biology'. Dr. T Mohapatra, Director chaired the closing ceremony and sensitized the students on 'Scope of agricultural science'. Prizes were distributed by the Chief Guest among the successful students and teams.

Kisan Mela

A Kisan Mela was organized by CRRI, Cuttack on 14 December, 2012 for confidence building and promotion of large scale utilization of fly ash in rice farming. One hundred progressive farmers from different districts, officials from the related Departments of Govt. of Odisha and representatives from the Thermal Power Industry participated in the mela. The farmers who participated in field demonstaration also shared their experiences on selected use of fly ash in rice cultivation. The participants visited the demonstration plots at village Chhagaon in Cuttack district.

Women in Agriculture Day

The KVK, Santhapur celebrated 'Women in Agriculture Day' at village Gualidiha in Tangi-Choudwar block of Cuttack district in Odisha on 4 December, 2012 on the theme 'Empowering farmwomen in rice processing.' Farmwomen interacted with the Director, CRRI and Chief Guest of the programme Dr. T Mohapatra, and other scientists from CRRI and the KVK,

Prize distribution by the Chief Guest Prof. BC Tripathy, VC, Ravenshaw University

Chief speaker, Smt. Nayana Mohanty addressing farmwomen

Santhapur. Smt.Nayana Mohanty was the Chief Speaker. In this programme,60 farmwomen from Gualidiha, Gurujang and Chatabar village, 300 farmwomen from nearby villages and 25 women trainees from Jharkhand participated.A leaflet in Odia entitled 'Dhana amala o prakriya karana re byabahruta bibhinna jantrapati' was released. Brainstorming session was conducted for farmwomen and prizes were distributed by the chief guest and chief speaker.

World Food Day

The World Food Day was celebrated on 16 October, 2012 at village Rajhansha (Routsahi) of Cuttack Sadar block. About 200 farmers and farmwomen participated in the programme that was organized by KVK, Santhapur. The Director, CRRI, Dr. T Mohapatra graced the occasion as Chief Guest. Head of the Divisions of CRRI, Scientists, State Govternment officials, AGM, NABARD, KVK scientists participated in this programme. The Director emphasized on increasing the food production by adopting different improved technologies. The participants were made aware about safe storage practices of food grain through exhibition. On this occasion, an information leaflet related to food security was released and distributed among the farming community.

A view of World Food Day celebration

Gopinath Sahu Memorial Lecture

The 21st Dr. Gopinath Sahu Memorial lecture was delivered on the topic 'Genes and Genomics for Crop Improvement' by Dr. Jitendra P Khurana, Professor of Plant Molecular Biology, University of Delhi, South Campus, New Delhi on 6 December, 2012 at CRRI, Cuttack which was organised by the Association of Rice Research Workers, Central Rice Research Institute,

Dr. Jitendra P Khurana, Prof. of Plant Molecular Biology, University of Delhi lighting the lamp to inaugurate the event

Cuttack. Dr. T Mohapatra, Director, CRRI graced the occasion as the Chief Guest. Dr. Sanjib Kumar Sahu, Member of Dr. Gopinath Sahu Memorial Trust was the Guest of Honour.

Hindi Fortnight

The Hindi Fortnight was celebrated at CRRI, Cuttack from10 to 25 September, 2012.Various competitions were conducted during this occasion among the staff of CRRI and the winners were awarded with cash prize and certificate.

Chief Guest Dr. Tara Dutt, IAS, Prinicpal Secretary, Govternment of Odisha giving away prize to the winners

Vigilance Awareness Week

The Vigilance Awareness Week 2012 was observed at CRRI, Cuttack as well as at CRRI Regional Station, Gerua from 29 October to 3 November, 2012. Shri GC Senapati, IPS, Ex-DG (Vigilance), Odisha and Chief Guest of the occasion addressed the staff of CRRI and gave certificate for participating in a debate competition in Hindi, English and Odia on 'Transparency in Public Procurement'.

Winner of debate competition receiving the prize from Shri GC Senapati, IPS, Ex-DG (Vigilance), Odisha

Review and Planning Workshop of National Initiative on Climate Resilient Agriculture (NICRA) Project

The review and planning workshop was held at Central Rice Research Institute, Cuttack on 16 January, 2013 in connection with finalization of the programme and review of the work done by CRRI under the NICRA project.Dr. B Venkateswarlu, Director, CRIDA, Hyderabad, and coordinator NICRA was the Chief Guest. Dr. M Maheswari, Head and overall Principal Investigator, NICRA, and Dr. M Srinivasa Rao, PS, CRIDA also took part in the event. Dr. B Venkateswarlu gave an account of the project work implemented by different centres and explained about the purpose of the meeting. Dr. RK Sarkar, PI, CRRI Centre, Cuttack presented the salient findings related to work progress, the XII Plan programme under NICRA, financial and infrastructure developmental issues related to the project. Based on the interaction, most important researchable issues were identified which would be addressed by the investigators of the project NICRA of CRRI Centre, while executing the work.

Review and planning workshop of NICRA project in progress

Annual workshop of NAIP - World Bank (GEF) project

The annual workshop of NAIP - World Bank (GEF) project entitled 'Strategies to enhance adaptive capacity to climate change in vulnerable regions' was held at CRRI, Cuttack during 22-24 January, 2013. The annual workshop was inaugurated by Prof. NVC Menon, Chairman, CAC and the function was presided over by Dr. T Mohapatra, Director, CRRI in which all the consortium partners took part and presented the results. On 23 January, 2013 the CAC and CIC meeting was held at CRRI, Cuttack. The meeting was chaired by Prof. NVC Menon, Chairman of the CAC committee, co-chaired by Dr. RP Mishra, National Coordinator, NAIP and attended by all the CAC members. Prof. Menon highlighted the significant achievements made by the project. Dr. T Mohapatra, Director, CRRI and Member, CAC appreciated the team work and significant achievements made in improvement of the livelihoods of vulnerable people in drought and flood affected areas. On 24 January, 2013, the World Bank team and Consortium Advisory Committee visited the project area in Ganjam district and reviewed the progress.

Prof. NVC Menon, Chairman, CAC lighting the lamp

Eastern India Rainfed Lowland Shuttle Breeding Network (EIRLSBN) Selection Activity

Under ICAR-IRRI collaborative Eastern India Rainfed Lowland Shuttle Breeding Network (EIRLSBN), breeders from Eastern India involved in the network *viz.,* Dr. SK Chetia from RARS, Titabar, AAU, Assam, Dr. KK Sharma, North Lakhimpur, AAU, Assam, Dr. PK Singh and Dr. SP Singh from BAU, Sabour, Bihar, Dr.(Ms.) Indrani Dana, RRS, Chinsurah, West Bengal, Dr. DN Bastia, OUAT, Bhubaneswar, Odisha and Dr. JN Reddy, CRRI, Cuttack along with Dr. B Collard and Dr. Yoichi Kato from IRRI, Philippines participated in the selection activity at CRRI, Cuttack during 16-17 November, 2012. Mr. Batseng Watre Momin, Ms. Baphiralin Kharshiing and Ms. Rita Bahun Mylliem Umlong from Department of Agriculture, Government of Meghalaya also participated in the meeting as special invitees. During the selection activity, single plant selections were made by the breeders from the segregating populations involving about 500(F_3-F_6) progenies as per their location specific requirements. The selected materials will be supplied to the cooperators for location specific evaluation.

Farmers' Day

Farmers' field day was organised at village-Parsawan, Block-Mayurhand Distt. Chatra on 15 October, 2012. Nearly 400 farmers from Parsawan and adjacent villages attended the field day. About 60 newly recruited village agricultural workers of Chatra and Koderma districts also attended the Farmers' day and interacted with the farmers and scientists to get a first-hand knowledge of the rice cultivation system under direct seeding. Farmer who had the best crop of demonstration was choosen as chief guest for the function to encourage the fellow farmers.

Director SAMETI, Govt. Of Jharkhand visited the demonstration area and instructed the department personnel to visit the direct seeded demonstration area. He also instructed that at least 25 farmers from each block of Hazaribag should visit and see the direct seeded crop of Sahbhagidhan at village Arabhusai. Two hundred farmers from different block of Chatra and Hazaribag subsequently visited the direct seeded demonstration area.

Director CRRI, after a visit to FLDs in Koderma

Training Programmes

The following State and National level training programs were organized during the year 2012-13.

Training programme on Hybrid and High Yielding Rice Production Technology sponsored by ATMA, Angul, Odisha during 12 to 18 June, 2012.

Participants of the training programme on 'Rice Production Technology' with the Director, Dr. T Mohapatra

Participants of the training programme on 'Improved Rice Production Technology' with the Director, Dr. T Mohapatra

Training programme on Rice Production Technology sponsored by ATMA, Madhubani, Bihar during 1-7 November, 2012.

Training programme on Rice Production Technology sponsored byATMA, Saraikela, Jharkhand during 23-27 November, 2012.

Training programme on Rice Production Technology for women farmerssponsored by Deputy Director, Soil Conservation, Ranchi during 1-7 December, 2012.

Training programme on 'Improved Rice Production Technology' sponsored by Project Director, ATMA, Koderma, Jharkhand during 20 to 24 January, 2013. Dr. NC Rath coordinated the programme.

Training programme on 'Rice Production Technology' sponsored by the Director of Agriculture, Bodoland Territory Council (BTC), Kokrajhar, Assam during 30 January to 5 February, 2013 and 13 to 19 March, 2013. Drs. SK Mishra and Lipi Das coordinated the programme.

Model Training Course (MTCs) on 'Rice Knowledge Management Portal – ICT application for rice ecosystems' sponsored by Directorate of Extension, Department of Agriculture & Cooperation, Ministry of Agriculture, Government of India, New Delhi during 12 to 19 February, 2013. Drs. GAK Kumar and NN Jambhulkar coordinated the programme.

Inauguration of Model Training Course (MTCs) on 'Rice Knowledge Management Portal – ICT application for rice ecosystems'

Training-cum-awareness programme on 'Protection of Plant varieties and Farmers' Rights Act-2001' with special reference to paddy was organized on 8 March, 2013. Dr. S R Dhua coordinated the programme.

Training-Cum-Workshop on Rice Programmes of KVKs during 11 to 12 July, 2012 jointly organized by Zonal Project Directorate, Zone-VII, Jabalpur and Central Rice Research Institute, Cuttack, Odisha. The participants were from Odisha, Chhattisgarh and Madhya Pradesh. Dr. GAK Kumar and Dr. SM Prasad coordinated the programme.

Participants of the training programme on 'Protection of Plant Varieties and Farmers' Rights Act-2001' with the Director, Dr. T Mohapatra

Exposure visit cum training programme for one hundred and eighty officials of various cadres (Deputy Directors, Sub Divisional Agricultural Officers, Taluka Agricultural Officers, Circle Agricultural Officers, Agricultural Supervisors and Agricultural Assistants) from Department of Agriculture, Govt. of Maharashtra in four batches came to CRRI under Crop Pest Surveillance and Advisory Project (CROPSAP-12) during 16 August to 6 September 2012. Dr. Anand Prakash, (PI, CROPSAP-12) & Head, Crop Protection Division and Mr. Somnath. S. Pokhare, Scientist, Crop Protection Division, coordinated the programme.

Participants of the CROPSAP-12

Exposure Visits

A total of 4633 visitors including farmers, farmwomen, students, agriculture officers and scientists from Odisha, Andhra Pradesh,Jharkhand, Meghalaya, Tripura, West Bengal, Tamil Nadu, Himachal Pradesh, Chhattishgarh, Uttar Pradesh, Assam and Bihar visited CRRI experimental plots, *Oryza* Museum and were addressed by the rice experts of the institute.

Distinguished Visitors

Prof. MS Swaminathan, Hon'ble Member of Rajya Sabha visited CRRI on 23 April, 2012.

Prof. MS Swaminathan, Hon'ble Member of Rajya Sabha inaugurates the Biotechnology wing of Crop Improvement Division

Dr. SK Datta, DDG (CS) visited CRRI on 23 April, 2012.

Dr. JP Tandon, Ex ADG (F&FC), ICAR visited CRRI on 26 April, 2012.

Dr. JS Sandhu, ADG (Seeds), ICAR visited CRRI on 5 May, 2012.

Drs. LC Song and Shin Young Sep, National Institute of Crop Sciences, RDA, Korea visited CRRI on 6 June, 2012.

Hon'ble Secretary, DARE & DG, ICAR, Dr. S Ayyappan visited the Institute on 27 July, 2012.

Hon'ble Secretary, DARE and DG, ICAR, Dr. S Ayyappan in discussion about important breeding material

Dr. KD Kokate, Deputy Director General (Agricultural Extension), ICAR, New Delhi visited CRRI on 29 July, 2012.

Dr. Charan Das Mahant, Hon'ble Minister of State for Agriculture & Food Processing Industries,Govt. of India visited CRRI on 5 August, 2012.

Dr. KD Kokate, DDG (Agricultural Extension), ICAR visiting the 'Oryza Museum'

Hon'ble Director General, International Rice Research Institute, Philippines, Dr. RS Zeigler visited CRRI on 7 September, 2012.

Dr. Manish Ranjan, Deputy Commissioner, Hazaribag visited CRURRS on 12 October, 2012.

Begum Matia Chowdhury, Hon'ble Minister of Agriculture, Bangladesh along with four member delegation visited CRRI on 9 November, 2012.

Dr. Saravanavel, Chief General Manager, NABARD, Dy-CGMs and DDMs of all districts of Jharkhand visited CRURRS, Hazaribag on 7 December, 2012.

Hon'ble Minister of State Dr. Charan Das Mahant observing the seed drills

Smt. Annapurna Devi, MLA, Koderma visited KVK and inaugurated 5 days training programme for progressive farmers and kisan mitras on '*Naveentam Krishi Takniki*' sponsored by ATMA, Koderma on 7 January, 2013.

Dr. RS Zeigler, Hon'ble DG, IRRI, Philippines visiting the field experiments

Hon'ble members of the Parliamentary Committee visiting 'Oryza Museum'

Begum Matia Chowdhury, Hon'ble Minister of Agriculture, Bangladesh examining a rice panicle

Mr. Nikori Kibanda (Coordinator RRCoE), Mr. Vincent Akulumuka, Dr. Hussein A Mansoor, Mr. Mohamed S Muya, Dr. Fidelis A Myaka and Arch. Edwin J Nnunduma from Tanzania visited CRRI, Cuttack on 28 January, 2013.

Dr. GS Khush visited CRRI, Cuttack on 10 February, 2013. He went through various research facilities at the CRRI, the *Oryza* Museum and the experiments in the field.

The Parliamentary Committee consisting of Hon'ble Members of Lok Sabha Shri Sanjay Singh Chauhan, Shri Premdas Katheria, Shri Sukhdev Singh Libra, Shri Narayan Singh Amlabe and Dr. Vinay Kumar Pandey 'Vinnu' visited CRRI, Cuttack on 12 February, 2013.

Dr. Ashok Gulati, Chairman, Commission on Agricultural Cost and Prices, New Delhi visited CRRI on 13 March, 2013.

Scientists from Tanzania along with Dr. T Mohaptra, Director and Heads of Division

Foreign Deputation

Drs. DP Singh, JN Reddy and M. Variar attended the 11th Annual Review and Screening Committee Meeting of the Consortium for Unfavorable Rice Environments (CURE) held at Bangkok, Thailand during 24 to 27 April, 2012.

Dr. T Mohapatra, Director attended the 3rd Workshop on Crop Sciences at Norwich, U.K. during 20 to 26 May, 2012.

Dr. T Mohapatra, Director attended the International Rice Commission Meeting at Montpellier, France during 3 to 4 July, 2012.

Dr. T Mohapatra, Director, attended the 2nd Global Science Forum on 'Structural transformations in the rice sector: Implications for research and development' during 11-12 October, 2012 at Los Banos, Laguna, Philippines.

Shri J Meher was deputed to International Rice Research Institute, Las Banos, Philippines during 1 September to 30 November, 2012 to undergo training on 'Phenotyping for high temperature and other abiotic stress tolerance and SNP genotyping in rice' funded by NAIP.

Dr. SK Dash participated in SCRIPD 2013 Connections Workshop at Surrey, United Kingdom during 5 to 8 February, 2013.

Seminar

Dr. KK Jena, International Rice Research Institute, Philippines delivered seminar on 'New plant architecture to increase yield potential of rice' on 26 July, 2012.

Prof. SK Sen, Indian Institute of Technology, Kharagpur delivered seminar on 'Identification of genetic mechanism operative in the WA cytoplasmic male sterile line in rice' on 15 September, 2012.

Dr. RK Singh, retired PS, CRURRS, delivered seminar on 'Accomplishment of NICRA project in UP' on 30 October, 2012.

Dr. R Srinivasan, PD, NRCPB, New Delhi delivered seminar on 'T-DNA TAG based cloning of genes and promoters' on 26 November, 2012.

Dr. Yogesh Kumar, Sr. Scientist, CRURRS, delivered seminar on 'Status report: Dissemination of new rice varieties in central and western parts of Jharkhand' on 30 November, 2012.

Dr. P Bhattacharyya, Sr. Scientist delivered seminar on 'Greenhouse gas emission for rice and mitigation options' on 16 February, 2013.

Six ARS probationary scientists of NAARM delivered seminar on 'PRA at village Bishwanathpur of Cuttack district' on 8 March, 2013 as part of their FET at CRRI.

AWARDS/RECOGNITION

CRRI bags Krishi Sansthan Samman

CRRI won the Krishi Sansthan Samman 2013 of Mahindra Samriddhi India Agri Awards (MSIAA) instituted by Mahindra and Mahindra Ltd. in partnership with Zee News. The MSIAA carries a cash prize of Rs. 2,11,000 and a trophy. Dr. T Mohapatra, received the award on behalf of the institute from Shri Tariq Anwar, Hon'ble Minister of State, Ministry of Agriculture and Food Processing Industries, Government of India in a ceremony held on 21 February, 2013 at Hotel Ashoka, New Delhi. The institute bagged this prestigious award for developing hybrid rice variety - CR Dhan 701 and drought tolerant variety Sahbhagidhan. CR Dhan 701 is first of its kind in the country having maturity duration of 145 days and suitable for shallow rainfed lowland ecosystem. It exhibits significant yield superiority over popular varieties in this ecosystem. It is also resistant to leaf blast and has medium-slender grains. Sahbhagidhan is suitable for water limited environments including rainfed uplands. It is resistant to leaf blast and moderately resistant to brown spot, sheath rot, stem borer and leaf folder with good cooking quality. This variety is widely adopted in Bihar, Jharkhand and other states of Eastern India.

Dr. T Mohaptra receiving Krishi Sansthan Samman 2013 of Mahindra Samridhi India Agri Award from Shri Tariq Anwar, Hon'ble Minister of State, Ministry of Agriculture and Food Processing Industries, Government of India

Dr. T Mohapatra has been elected Fellow of the Indian National Science Academy at the Annual General Meeting on 4 October, 2012.

Dr. T Mohaptra being presented the Fellowship Certificate from Dr. K Lal, President, INSA, New Delhi

Dr. Pratap Bhattacharyya received Lal Bahadur Shastri Outstanding Young Scientist Award, ICAR in 2012 in Natural Resource Management.

Dr. AK Nayak received Hari Om Ashram Trust Award for Outstanding Team research Award as a Team member, ICAR in 2012 in Natural Resource Management.

Dr. Annie Poonam received the SAP Young Scientist Award from the Society of Agricultural Professionals, C S Azad University of Agriculture and Technology, Kanpur on the occasion of 3rd National Symposium on 'Agriculture Production and Protection in context of Climate Change' held at Birsa Agricultural University on 3 November, 2012.

Miss Jayashree Rath, SRF won the Micromind Competition Award (3rd) during 53rd International Conference of AMI on 'Microbial world: recent innovations and future trends' held from 22-25 November, 2012 at KIIT University, Bhubaneswar, Odisha.

Mr. Avro Dey, a Ph D scholar working under Dr. Upendra Kumar received the Best Poster award for his poster entitled 'Population dynamics and characterization of selected plant growth promoting rhizobacteria from pesticide treated paddy soil' in National Conference on 'Utilization of microbes for sustainable development' held at OUAT, Bhubaneswar from 14-15 December, 2012.

Dr. PC Rath was awarded Fellow of Plant Protection Association of India (FPPAI) on 30 November 2012 in International Conference on Plant Health Management for Food Security, at DRR Hyderabad from 28 to 30 November 2012.

Best Stall Award

The stall of CRRI in the Eastern Zone Regional Agricultural Fair and Agrotech Krishi Mela held during 22- 24 February, 2013 at BAU, Ranchi was represented by Dr. Yogesh Kumar, Mr AN Singh (CRURRS) and Dr. Sudhanshu Sekhar (KVK, Koderma). The stall was awarded the third best stall award. Dr. Yogesh Kumar received the certificate from the Vice Chancellor Dr. MP Pandey on behalf of the Institution.

Dr. Pratap Bhattacharyya receiving Lal Bahadur Shastri Outstanding Young Scientist Award, ICAR

Dr. PC Rath receiving Fellow of Plant Protection Association of India (FPPAI)

Best PaperAwards

Best paper award in different categories were bagged by the following paper presentations:

ARRW Golden Jubilee International Symposium on 'Sustainable rice production and livelihood security: Challenges and opportunities', Cuttack, India, 2-5 March, 2013

LK Bose, D Swain, ON Singh, M Jenac and KS Behera for "Introgression of target genes from wild rice".

J Imam, S Alam, QS Mohammad, NP Mandal, D Maiti, TR Sharma and M Variar for "Incorporation of blast resistance into 'Sambha Mahsuri' an elite rice variety through marker assisted backcross breeding".

NN Jambhulkar and P Samal for "Modeling and forecasting of rice production in West Bengal using ARIMA model".

R Raja, AK Nayak, BB Panda, B Lal, Rahul Tripathi, Mohammad Shahid, V Kasthuri Thilagam, Sangita Mohanty, P Samal, Priyanka Gautam and KS Rao for "Effect of spatio-temporal variability in meteorological drought at block level rice productivity in Eastern Indian state of Odisha".

International Conference on 'Bioresource and Stress Management', Kolkata, India, 6-9 February, 2013

Panda BB, Raja R, Rao KS, Bandyopadhyay SK, Mohanty S, Nayak AK, Kumar Anjani, Tripathi R and Shahid Mohammad for "Adaptation strategy for sustainable livelihoods in terminal flood situations".

3rd International Agronomy Congress, New Delhi, India, 26-30 November, 2012

T Singh for "Sustainability of livelihood of tribal farmers through IFS models in participatory research programme in southern humid agro-ecosystem of Rajasthan".

Best Workers of CRRI-2012

Name	Designation	Category
Dr. Mayabini Jena	Principal Scientist	Principal Scientist
Dr. Avijit Das	Senior Scientist	Senior Scientist
Dr. Anjani Kumar	Scientist	Scientist/ Scientist (SS)
Dr. J.R. Mishra	Technical Office	Technical (T6,T7 & T8)
Shri A.K. Panda	T-4	Technical (T4 & T5)
Shri B. Medhi (RRLRRS, Gerua)	T-3	Technical (T1,T2 & T3)
Shri S.B. Nayak	Assistant	Administrative
Shri B.K. Maharana	AAO	Administrative
Shri N. Mohabhoi	PA	Stenographer/ Per. Assistant
Shri S. Marandi	SS Grade	SS Grade

COMMERCIALIZATION OF HYBRID RICE TECHNOLOGY

Hybrid rice technology aims to increase yield potential in rice beyond the level of high yielding, semi-dwarf inbred rice varieties. There is a need for partnership between the government and the private sector. The seed production of hybrids developed by CRRI, Cuttack were found to be commercially viable as there is large-scale demand. Private entrepreneurs have come forward to sign MoU with CRRI for production and marketing of the hybrids, Ajay, Rajalaxmi and CR Dhan 701 (CRHR 32).

Name of the variety/hybrid/technology	Name of the Institute/company	Period of MOU	Seed production & area coverage in Kh-13
Hybrid rice Ajay (CRHR-7)	PAN Seeds Pvt. Ltd., Kolkata	3 years (July, 2012 to June, 2015)	35 tons/2600 ha
Hybrid rice Rajalaxmi (CRHR-5)	PAN Seeds Pvt. Ltd., Kolkata	3 years (July,2012 to June, 2015)	30 tons/2400 ha
Hybrid rice Rajalaxmi (CRHR-5)	Nath Biogene(I) Ltd., Aurangabad, Maharashtra	3 years (June, 2012 to May, 2015)	Started commercialization
Hybrid rice CR Dhan 701 (CRHR-32)	Nath Biogene(I) Ltd., Aurangabad, Maharashtra	3 years (June, 2012 to May, 2015)	Started commercialization
Hybrid rice Ajay (CRHR-7)	Sansar Agropol Pvt.Ltd. Bhubaneswar	3 years (Sept., 2010 to Aug.,2013)	20 tons/1600 ha
Hybrid rice Rajalaxmi (CRHR-5)	Sansar Agropol Pvt.Ltd. Bhubaneswar	3 years (Sept., 2010 to Aug.,2013)	20 tons/1600 ha
Hybrid rice Ajay(CRHR-7)	Vikkys Agrisciences Pvt. Ltd., Hyderabad	3 years (Oct.,2012 to Sept.,2015)	15 tons/1200ha
Parental lines of Ajay- Hybrid	IFSSA, Hyderabad	5 years (April, 2010 to March,2015)	Parental lines
Parental lines of Rajalaxmi- Hybrid	IFSSA, Hyderabad	5 years (up to March,2015)	Parental lines
Hybrid rice Rajalaxmi(CRHR 5)	Delta Agrigenetics Pvt. Ltd., Hyderabad	3 years (Dec,2012 to Dec, 2015)	Started commercialization
Hybrid rice CR Dhan 701 (CRHR-32)	Delta Agrigenetics Pvt. Ltd., Hyderabad	3 years (Dec,2012 to Dec, 2015)	Started commercialization
Hybrid rice Ajay(CRHR-7)	Balaji Agri Biotech Pvt.Ltd. Paikmal, Odisha	3 years (May,2013 to April, 2016)	New MoU
Hybrid rice Rajalaxmi(CRHR 5)	Bharat Nursery Pvt. Ltd. 60A, Arabinda Sarani, Kolkata-5, West Bengal	3 years (June,2013 to May, 2016)	New MoU
Hybrid rice Ajay(CRHR 7)	Sai Shradha Agronomics and Husbandary Pvt. Ltd. Plot No.1811, Rench Sasan, Balanga, Puri-752114, Odisha	3 years (June,2013 to May,2016)	New MoU
Hybrid rice CR Dhan 701(CRHR-32)	Sri Sai Swarupa Seeds Pvt. Ltd., Ananthasagar(V), Warangal(Dt.) Andhra Pradesh	3 years (July, 2013 to June, 2016)	New MoU

IN-CHARGE AND MEMBERS OF DIFFERENT CELLS

Institute Management Committee

- Dr.(Ms) N Sarala, Directorate of Rice Research, Hyderabad
- Dr. Srinath Dixit, Central Research Institute for Dry-land Agriculture, Hyderabad
- Dr. Anand Prakash
- Dr. SG Sharma

Research Advisory Committee

- Dr. RB Singh, President, NAAS & Former Member, National Commission for Farmers
- Dr. CL Acharya, Ex-Director, Indian Institute of Soil Science
- Prof. (Mrs) Shailaja Hittalmani, Professor & Head, Dept. of Genetics & Plant Breeding, University of Agri. Sciences, GKVK Campus, Bangalore
- Dr. R Sridhar, Visiting Professor & Head, Dept. of Biotechnology, International Institute of Biotechnology & Toxicology, Chennai
- Dr. ML Lodha, Ex-Head, Dept. of Biochemistry, New Delhi
- Dr. Mruthyunjaya, Former, National Director, NAIP
- Dr. RP Dua, ADG (FFC), ICAR, New Delhi
- Dr. T Mohapatra
- Dr. JN Reddy
- Dr. BC Viraktanath (Special invittee)

Institute Joint Staff Council (IJSC)

- Dr. T Mohapatra, Director, CRRI, Chairman
- Dr. ON Singh, Member
- Dr. AK Nayak, Member
- Dr. (Ms) Annie Poonam, Member
- Shri BK Sinha, Member
- Shri SR Khuntia, Member
- Shri NC Parija, Secretary (Official Side)
- Shri Nishank Kumar Swain, Member
- Shri Subodha Kumar Sahu, Member
- Shri Dipti Ranjan Sahoo, Member
- Shri Khirod Ch. Bhoi, Member
- Shri Prahallad Moharana, Member & Secretary (Staff Side)
- Shri Bijay Kumar Behera, Member
- Shri Dambarudhar Das, Member

Shri Pravakar Bhoi, Member

Central Public Information Officer

- Sri Basant Kumar Sahoo

PME Cell

- Dr. DP Sinhababu
- Dr. (Mrs) Mayabini Jena
- Dr. TK Dangar
- Shri SSC Patnaik
- Dr. JN Reddy
- Dr. AK Nayak
- Dr. GAK Kumar
- Dr. (Mrs) Meera Kumari Kar
- Dr. NN Jambhulkar
- Shri Sunil Kumar Sinha
- Dr. Ramesh Chandra
- Shri Jagabandhu Sethi
- Shri Markanda Nayak

Women Cell

- Dr. (Mrs) Mayabini Jena
- Dr. (Mrs) S Samantaray
- Dr. (Mrs) Meera Kumari Kar
- Dr. (Ms) Bijoya Bhattacharjee
- Dr. (Ms) Sangita Mohanty
- Ms. Sabita Sahu
- Mrs. Nibedita Biswal
- Mrs. Snehalata Biswal
- Dr. (Ms) Jogamaya Pattanaik
- Dr. (Ms) Annie Poonam

Institute Grievance Cell

- Dr. T Mohapatra, Director, CRRI, Chairman
- Dr. ON Singh
- Shri BK Sinha
- Shri SR Khuntia
- Dr. AK Mukherjee
- Dr. PK Sahu
- Shri RK Behera
- Shri Bichitrananda Khatua
- Shri NC Parija

Institutional Bio-Safety Committee

- Dr. ON Singh
- Dr. (Ms) Bijoya Bhattacharjee
- Dr. R Srinivasan, Professor and Project Director, NRCPB, IARI, New Delhi
- Dr. GR Raut, Head, Department of Agri-Biotechnology, OUAT, Bhubaneswar
- Dr. J Dandapat, Head, Department of Biotechnology, Utkal University, Vanivihar, Bhubaneswar
- Dr. PK Mohapatra, Head, Biotechnology, Ravenshaw University, Cuttack
- Dr. SG Sharma
- Dr. (Mrs) Mayabini Jena
- Dr. L Behera
- Dr. N Das

PERSONNEL

Staff strength as on 31 March 2013

Category	CRRI, Cuttack			KVK, Santhapur			KVK, Koderma		
	Sanctioned	Filled	Vacant	Sanctioned	Filled	Vacant	Sanctioned	Filled	Vacant
Scientist	117	88	29	1	1	-	1	1	-
Technical	175	108	67	11	7	4	11	7	4
Administrative	94	75	19	2	1	1	2	-	2
Skilled									
Support Staff	163	59	104	2	1	1	2	2	-
Others	5	5	-	-	-	-	-	-	-
RMP	1	1	-	-	-	-	-	-	-
Total	555	336	219	16	10	6	16	10	6

Dr.Trilochan Mohapatra .... Director

Division of Crop Improvement

Dr.Onkar Nath Singh .... Head
Dr.G.J.N.Rao .... Pr.Scientist
Dr.S.R.Dhua .... Pr.Scientist
Dr.K.Pande .... Pr.Scientist
Dr.R.N.Rao .... Pr.Scientist
Dr.J.N.Reddy .... Pr.Scientist
Dr.B.C.Patra .... Pr.Scientist
Mr.Ashok Pattnaik .... Pr.Scientist
Dr.(Mrs.) S.Samantaray .... Pr.Scientist
Dr.Dasarathi Swain .... Pr.Scientist
Dr.(Mrs.)Meera Kar .... Pr.Scientist
Dr. Hatanath Subudhi .... Sr.Scientist
Dr.Sarat Ku.Pradhan .... Sr.Scientist
Dr.Lambodar Behera .... Sr.Scientist
Dr.Lotan Ku. Bose .... Sr.Scientist
Dr.(Ms)B.Bhattacharjee .... Sr.Scientist
Dr.K.Chattopadhyay .... Sr.Scientist
Dr.Sushant Ku.Dash .... Sr.Scientist
Sri R.K.Sahu .... Scientist (SG)
Sri S.S.C.Pattanaik .... Scientist (SG)
Sri B.C.Marndi .... Scientist (SG)
Shri J.Meher .... Scientist (SS)
Sri B.S.Subramanian .... Scientist(Absconded)
Sri Jawahar Lal Katara .... Scientist
Dr.RamlakhanVerma .... Scientist
Sri Soham Ray (w.e.f. 10.10.12) .... Scientist

Division of Crop Production

Dr.K.S.Rao .... Head
Dr.P.C.Mohapatra .... Pr.Scientist
Dr.D.P.Sinhababu .... Pr.Scientist
Dr.P.N.Mishra .... Pr.Scientist
Sri S.P.Patel .... Pr.Scientist
Dr.T.K.Dangar .... Pr.Scientist
Dr. P.K.Nayak .... Pr.Scientist
Dr.M.Din .... Pr.Scientist
Dr. Amal Ghosh .... Pr.Scientist
Dr.Sanjoy Saha .... Pr.Scientist
Dr.A.K.Nayak .... Pr.Scientist
Dr.P.Bhattacharyya .... Sr.Scientist
Dr.(Ms.)Annie Poonam .... Sr.Scientist
Dr.R.Raja .... Sr.Scientist
Dr.B.B.Panda .... Sr.Scientist
Dr.Rahul Tripathi .... Scientist
Dr.(Ms) Sangita Mohanty .... Scientist
Dr.Mohammad Shahid .... Scientist
Sri Anjani Kumar .... Scientist
Sri Upendra Kumar .... Scientist
Sri Banwari Lal .... Scientist
Dr.(Mrs.) Kasthuri Thilangam. V .... Scientist
Dr.(Mrs.) Sushmita Munda (w.e.f. 04.04.12) .... Scientist
Mrs.Priyanka Gautam .... Scientist

Division of Crop Protection

Dr.Anand Prakash .... Head
Dr.(Mrs.) Urmila Dhua .... Pr.Scientist

Dr.S.N.Tiwari .... Pr.Scientist
Dr.S.C.Sahu (retired on 28.02.13) .... Pr.Scientist
Sri K.S.Behera .... Pr.Scientist
Dr.(Mrs.) M.Jena .... Pr.Scientist
Dr.K.M.Das (retired on 30.06.12) .... Pr.Scientist
Dr.C.D.Mishra (retired on 30.06.12) .... Sr.Scientist
Dr. P.C.Rath .... Sr.Scientist
Dr.S.D.Mohapatra (w.e.f. 21.11.12) .... Sr.Scientist
Dr.A.K.Mukherjee (w.e.f. 08.01.13) .... Sr.Scientist
Mr.S.K.Singh (retired on 31.12.12) .... Scientist(S.S)
Dr.Totan Adak (w.e.f. 04.04.12) .... Scientist
Sri Berliner J .... Scientist
Sri Somnath Suresh Pokhare .... Scientist
Dr.Shashank P.R. (w.e.f. 10.10.12) .... Scientist

Division of Biochemistry, Physiology & Environmental Science

Dr.S.G.Sharma .... Head
Dr.D.P.Singh .... Pr.Scientist
Dr.R.K.Sarkar .... Pr.Scientist
Dr.(Mrs.) P.Swain .... Pr.Scientist
Dr. M.J.Baig .... Pr.Scientist
Dr. Avijit Das .... Pr.Scientist
Dr.(Mrs.)Neeta Dwivedi (relieved on 20.06.12) ....
.... Sr.Scientist
Sri Torit Baran Bagchi .... Scientist

Division of Social Science

Dr.B.N. Sadangi .... Head
Dr.P.Samal .... Pr.Scientist
Dr.N.C.Rath .... Pr.Scientist
Dr.G.A.K.Kumar .... Pr.Scientist
Dr.S.K.Mishra (w.e.f. 22.11.12) .... Sr.Scientist
Dr.(Mrs) Lipi Das .... Sr.Scientist
Sri Nitiprasad Jambhulkar .... Scientist

Central Rainfed Upland Rice Research Station, Hazaribagh

Dr.M.Variar .... O.I.C.
Dr.V.D.Shukla .... Pr.Scientist
Dr.D.Maiti .... Pr.Scientist
Dr. N.P.Mandal .... Pr.Scientist
Dr. C.V.Singh .... Sr.Scientist
Dr.Yogesh Kumar .... Sr.Scientist
Sri Anantha M.S. .... Scientist
Sri V.Karunakaran (relieved on 30.04.12) ....Scientist

Regional Rainfed Low Land Rice Research Station, Gerua, Assam

Dr.Khem Bahadur Pun .... O.I.C
Dr.N.Bhakta .... Sr.Scientist
Dr.Srikanta Lenka .... Sr.Scientist
Dr.Teekam Singh (w.e.f. 13.04.12) .... Sr.Scientist
Sri B.S.Satapathy .... Scientist

Krishi Vigyan Kendra, Santhpur, Cuttack

Dr.Shiv Mangal Prasad .... Sr.Scientist

Krishi Vigyan Kendra, Koderma

Dr.Vinay Kumar Singh ....Prog.Coord.

Administrative Staff

Sri S.R.Khuntia ....Chief F & Aco.
Sri B.K.Sinha ....Sr.Admn. Officer
Sri D.C.Sahoo .... Admn. Officer
Sri R.K.Ghsoh (retired on 30.06.12) . Asstt. Admn. Officer
Sri N.K.Dandapat (retired on 30.11.12) ...... Asstt. Admn. Officer
Sri M.D.Ojha (retired on 31.01.13) ... Asstt. Admn. Officer
Sri B.N.Nayak (retired on 28.02.13) . Asstt. Admn. Officer
Sri Basant Kumar Sahoo .... Asstt. Admn. Officer
Sri Sudhakar Dash .... Asstt. Admn. Officer
Sri Narayan Chandra Parija .... Asstt. Admn. Officer
Sri Sapan Kumar Mahana .... Asstt. Admn. Officer
Sri Sunil Kr. Sahoo .... Asstt. Admn. Officer
Sri Dillip Kumar Mohanty .... Asstt. Admn. Officer
Sri Lingaraj Panda .... Asstt. Admn. Officer
Sri G.Kalundia (retired on 30.04.12) Asstt. Director (O.L.)
Sri K.B.Agasti .... Private Secretary
Sri P.K.Moharana (retired on 28.02.13) Private Secretary
Sri A.K.Sethi .... Private Secretary
Sri S.N.Rout .... Private Secretary
Sri Saroj Kumar Ram .... Assistant
Sri Sanjaya Kumar Jena .... Assistant
Sri B.C.Tudu .... Assistant
Sri Faguram Soren .... Assistant
Sri N.K.Swain .... Assistant
Sri C.P.Murmu .... Assistant
Sri K.K.Sarangi .... Assistant
Sri Santosh Kumar Behera .... Assistant
Sri Satyabrata Nayak .... Assistant
Sri Subodha Kr. Sahoo .... Assistant
Sri Rabindra Kumar Behera .... Assistant
Sri Ramesh Chandra Das .... Assistant
Smt. Rojalia Kido .... Assistant
Sri Narayan Prasad Behura .... Assistant
Sri Sanjay Kumar Sahoo .... Assistant
Sri Munael Mohanty .... Assistant
Sri Saroj Kumar Nayak .... Assistant
Sri Dillip Kumar Parida .... Assistant
Sri Santosh Kumar Satapathy .... Assistant
Sri M.K.Sethy .... Assistant
Sri K.C.Behera .... Assistant
Sri Pravat Chandra Das .... Assistant
Sri A.K.Pradhan .... Assistant
Sri Vishal Kumar (w.e.f. 17.10.12) .... Assistant
Sri Sharbadwip Sen (w.e.f. 17.11.12) .... Assistant
Ms. Shilpa Kumari Agrawal (w.e.f. 25.09.2012 and relief from 20.10.2012) .... Assistant
Sri G.K.Sahoo .... Personal Assistant
Sri Nityananda Mohanty .... Personal Assistant
Sri Janardan Nayak .... Personal Assistant
Sri Jagabandhu Sethi .... Personal Assistant
Sri Trilochan Ram .... Personal Assistant
Sri A. Kullu .... Personal Assistant
Smt. Belarani Mahana .... Personal Assistant
Sri Narayan Mahabhoi .... Personal Assistant
Sri Daniel Khuntia .... Personal Assistant

Smt. Nirmala Jena .... Personal Assistant
Sri Manas Ballav Swain .... Personal Assistant
Smt. Snehaprava Sahoo .... Personal Assistant
Miss Sabita Sahoo .... Personal Assistant
Sri Manoranjan Swain .... Steno
Smt. Gourimani Dei .... U.D.C.
Sri Samir Kumar Lenka .... U.D.C.
Sri Sanjeeb Kumar Sahoo .... U.D.C.
Smt. Manasi Das .... U.D.C.
Sri Ramesh Chandra Naik .... U.D.C.
Sri Sunil Pradhan .... U.D.C.
Smt. Ambika Sethi .... U.D.C.
Sri Maheswar Sahoo .... U.D.C.
Sri Ranjan Sahoo .... U.D.C.
Sri B.K.Gochhayat .... LDC
Sri Harihar Marandi .... LDC
Sri Santosh Kr. Bhoi .... LDC
Sri Dhaneswar Muduli .... LDC
Sri Naba Kishore Das .... Security Officer
Sri D.K.Jena (retired on 31.05.12) ...... Security Supervisor

CRURRS, Hazaribagh, Jharkhand

Sri B.K.Moharana .... Asstt. Admn. Officer
Sri R.Paswan .... Personal Assistant
Sri Sanjeev Kumar (w.e.f. 28.09.12) .... Assistant
Sri C.R.Dangi .... U.D.C
Sri Amit Kumar Sinha .... L.D.C
Sri Arbinda Kumar Das .... L.D.C.
Sri Satish Kumar Pandey .... L.D.C

RRLRRS, Gerua, Assam

Sri Bahudi Bhoi .... Asstt. Admn. Officer
Sri Rama Chandra Pradhan .... Assistant
Miss Jali Das .... L.D.C.

K.V.K., Santhpur, Cuttack

Sri Bibhuti Bhushan Polai .... Stenographer Gr.III

Skilled Support Staff (SSS)

Sri Banamali Bhoi (retired on 30.04.12) .... SSS
Sri N.C.Barik (retired on 30.04.12) .... SSS
Sri R.N.Moharana (retired on 30.06.12) .... SSS
Sri Krupasindhu Das (retired on 30.09.12) .... SSS
Sri Baishnab Charan Behera (retired on 30.09.12) .... SSS
Sri Guruba Singh (expired on 15.10.12) .... SSS
Sri Atulya Bhoi (retired on 31.10.12) .... SSS
Sri Ganesh Das (retired on 31.10.12) .... SSS
Sri Rama Sigh (retired on 31.12.12) .... SSS
Smt. Parbati Singh (retired on 28.02.13) .... SSS
Sri Nadura Singh (retired on 28.02.13) .... SSS
Sri Nanda Sethi .... SSS
Sri Paramananda Bhoi .... SSS
Sri Bulu Naik .... SSS
Sri Bhaskar Bhoi .... SSS
Sri Surendra Nath Bhoi (Mali) .... SSS
Sri Budhia Rout .... SSS
Sri Sahadev Naik .... SSS
Sri Sankhai Soren .... SSS
Sri N.N.Jena .... SSS
Sri Purna Chandra Moharana .... SSS
Sri Ratnakar Das .... SSS
Sri Sundara Marandi .... SSS
Sri Bijaya Kumar Behera .... SSS
Sri Panchu Sahoo .... SSS
Sri Bipin Bihari Das .... SSS
Sri B.N.Beja .... SSS
Sri S.N.Patra .... SSS
Smt. Gurubari Dei .... SSS
Sri Budhimanta Sahoo .... SSS
Sri Pravakar Sahoo .... SSS
Sri Purna Chandra Sahu .... SSS
Sri Gadadhar Rout .... SSS
Sri Dambarudhar Das .... SSS
Sri Madan Mohan Nayak .... SSS
Abdul Barik Khan .... SSS
Sri Fakira Charan Sahu .... SSS
Sri Jogendra Biswal .... SSS
Sri Bhaskar Bhoi .... SSS
Sri Bauri Bandhu Barik .... SSS
Smt. Namasi Singh .... SSS
Sri Lawa Murmu .... SSS
Sri Sudhakar Parida .... SSS
Sri S.C.Mohanty .... SSS
Sri Alok Kumar Panda .... SSS
Sri Prafulla Bhoi .... SSS
Sri Akshya Kumar Bhoi .... SSS
Smt. Surubali Hembram .... SSS
Smt. Mukta Hembram .... SSS
Smt. Basanti Marandi .... SSS
Sri Kailash Chandra Ram .... SSS
Sri Dasia Naik .... SSS
Sri Krushna Naik .... SSS
Smt. Indulata Bewa .... SSS
Sri Prafulla Majhi .... SSS
Sri Jagabandhu Bhoi .... SSS
Sri Pravakar Bhoi .... SSS
Sri Anand Naik .... SSS
Sri Nanda Sahoo .... SSS
Sri Pravakar Bhoi (Nemato.) .... SSS
Sri Duryodhan Naik .... SSS
Sri Ajay Kumar Naik .... SSS
Sri Ganesh Chandra Sahoo .... SSS
Sri Bichitrananda Khatua .... SSS
Sri Rabindra Dalai .... SSS

CRURRS, Hazaribag, Jharkhand

Sri Rameswar Ram .... SSS
Sri Liladhar Mahato .... SSS
Smt. Sita Devi .... SSS
Sri America Oraon (retired on 31.08.12) .... SSS

RRLRRS, Gerua, Assam

Sri Manoranjan Das .... SSS
Sri Bhupen Kalita .... SSS

KVK, Santhpur

Sri Rama Pradhan .... SSS

KVK, Koderma

Sri Jitendra Prasad .... SSS
Sri Mukesh Ram .... SSS

Others (Canteen Staff), CRRI, Cuttack

Sri Arabinda Jena .... Manager Grade II
Sri Meru Sahu .... Bearer
Sri Markanda Nayak .... Bearer
Sri Madhaba Pradhan .... Bearer
Sri Nityananda Naik .... Wash Boy

Technical Staff

CRRI, Cuttack

Category I

Sri N. Bhattacharya .... Technical Officer
Sri K. C. Das .... Technical Officer
Sri G. C. Sethi .... Technical Officer
Sri R.K.Behera (retired on 30.04.12) ...... Technical Officer
Sri G. C. Sahoo .... Technical Officer
Sri S. N. Das .... Technical Officer
Sri Sanatan Baral (retired on 31.08.12) .. Technical Officer
Sri B.V.Das (retired on 31.07.12) .... Technical Officer
Sri Swinderjit Singh .... Technical Officer
Sri Swapneswar Jena .... Technical Officer
Sri P. K. Singh .... Technical Officer
Sri Bhagaban Behera .... Technical Officer
Sri H. C. Satapathy .... Technical Officer
Sri Aparti Sahoo .... Technical Officer
Sri K. C. Bhoi .... Technical Officer
Sri B.N.Nanda (retired on 28.02.13) .... Technical Officer
Sri S. C. Mohapatra .... Technical Officer
Sri R. K. Sethi .... Technical Officer
Sri M. N. Mallick .... Technical Officer
Sri J. C. Hansda .... Technical Officer
Sk. Abdul Samad .... Technical Officer
Sri S. S. Singh .... Technical Officer
Sri R. S. Jamuda .... Technical Officer
Sri Srikrishna Pradhan .... Technical Officer
Sri S. K. Behura .... Technical Officer
Sri A. K. Mishra .... Sr.Technical Assistant
Sri K. K. Suman .... Sr.Technical Assistant
Sri Arun Panda .... Sr.Technical Assistant
Sri Santosh Kuamar Ojha .... Sr.Technical Assistant
Sri J. P. Behura .... Sr.Technical Assistant
Mrs. Nibedita Biswal .... Sr.Technical Assistant
Sri K. C. Palaur .... Sr.Technical Assistant
Sri Akadashi Mallick .... Technical Assistant
Sri Nityananda Swain (retired on 31.01.13) Technical Assistant
Sri K. B. Rout .... Technical Assistant
Sri Judhistir Rout .... Technical Assistant
Sri Pranakrishna Sahu .... Technical Assistant
Sri Ramesh Chandra Bhoi .... Technical Assistant
Sri S.K. Mohapatra .... Technical Assistant
Sri Brahmananda Swain .... Technical Assistant
Sri Charan Naik .... Technical Assistant
Sri Meghananda Rout .... Technical Assistant
Mrs. Chintamani Majhi .... Technical Assistant
Sri Bansidhar Ojha .... Technical Assistant
Sri Kshirod Chandra Bhoi .... Technical Assistant
Sri A. K. Moharana .... Technical Assistant
Sri D. R. Sahoo .... Technical Assistant
Sri Arun Kumar Parida .... Technical Assistant
Sri Prahallad Moharana .... Technical Assistant
Sri Ramrai Jamunda .... Technical Assistant
Sri Prasanta Kumar Jena .... Technical Assistant
Sri Gauranga Charan Sahu .... Technical Assistant
Sri Kailash Chandra Mallick .... Technical Assistant
Sri Srinibas Panda .... Technical Assistant
Sri Parimal Behera .... Technical Assistant
Sri Nakula Barik .... Technical Assistant
Sri Bhakta Charan Behera .... Technical Assistant
Sri Mansingh Soren .... Technical Assistant
Sri Jogeswar Bhoi .... Sr.Technician
Sri A. C. Moharana .... Sr.Technician
Sri Ajaya Kumar Nayak .... Sr.Technician
Sri Pradeep Kumar Parida .... Sr.Technician
Sri Surendra Biswal .... Sr.Technician
Sri Susanta Kumar Tripathy .... Sr.Technician
Sri Debasis Parida .... Sr.Technician
Sri Pramod Kumar Ojha .... Technician
Sri Debaprakash Behera .... Technician
Sri Sesadev Pradhan .... Technician
Sri Gyanaranjan Bihari .... Technician
Sri Chandan Kumar Ojha .... Technician
Sri Ramudev Beshra .... Technician
Sri Baidyanath Hembram .... Technician
Sri Dularam Majhi .... Technician
Sri Pramod Kumar Sahoo .... Technician
Sri Keshab Chandra Das .... Technician
Sri A.C.Nayak .... Technician
Sri Bhagyadhar Pradhan .... Technician

Category II

Sri Prakash Kar .... Assistant Chief Technical Officer
Sri P. Jana .... Assistant Chief Technical Officer
Sri A.V.G. Sharma .... Assistant Chief Technical Officer
Dr. Ramesh Chandra .... Sr.Technical Officer
Dr Pradeep Kumar Sahoo .... Sr.Technical Officer
Sri A. K. Dalai .... Sr.Technical Officer
Sri S. M. Chatterjee .... Technical Officer
Sri R. K. Mishra .... Technical Officer
Sri B. K. Mohanty .... Technical Officer
Sri Sunil Kumar Sinha .... Sr.Technical Assistant
Sri Manoj Kumar Nayak .... Technical Assistant
Sri J. Sai Anand .... Technical Assistant
Sri Santosh Kumar Sethi .... Technical Assistant
Sri P. L. Dehury .... Technical Assistant
Sri Brundaban Das .... Technical Assistant
Sri S. B. Nag .... Technical Assistant
Sri Prempal Kumar .... Technical Assistant
Smt. Sandhyarani Dalal .... Technical Assistant
Smt. Rosalin Swain .... Technical Assistant
Smt. R. Gayatri Kumari .... Technical Assistant
Smt. Chandamuni Tudu .... Technical Assistant
Sri Smrutikanta Rout .... Technical Assistant
Sri Lalan Kumar Singh .... Technical Assistant
Smt. Baijayanti Nayak .... Technical Assistant
Miss Monika Majhi .... Technical Assistant
Sri Niraj Kumar Singh (relieved on 13.06.12) Technical Assistant

Category III

Sri K. K. Swain .... Chief Technical Officer
Sri Ravi Viswanathan (relieved on 18.10.12) Sr.Technical Officer

CRURRS, Hazaribag (Jharkhand)

Category I

Sri A. N. Singh .... Sr.Technical Assistant
Sri Ranjit Tirky .... Sr.Technical Assistant
Sri Arun Kumar .... Sr.Technical Assistant

Sri Sawan Oran .... Technical Assistant
Sri Ugan Saw .... Technician
Category II
Sri J. Terom .... Chief Technical Officer
Sri R. P. Sah .... Technical Officer
Sri D. Singh .... Technical Officer

RRLRRS, Gerua (Assam)
Category I
Sri Haladhar Thakuria .... Sr.Technical Assistant
Category II
Sri Bibhash Medhi .... Tech. Asst.

K.V.K., Santhpur, Cuttack
Category I
Sri Makardhar Behera .... T-3 (Tractor Driver)
Sri Arabinda Bisoi .... T-1 (Driver)
Category II
Dr J.R.Mishra .... T (7-8) SMS (Agril.Extension)
Mrs. Sujata Sethy .... T (7-8) SMS (Home Science)
Sri Dillip Ranjan Sarangi .... T-6 SMS (Soil Science)
Sri Tusar Ranjan Sahoo .... T-6 SMS (Horticulture)
Dr.Manish Chourasia .... T-6 SMS (Plant Protection)

K.V.K., Jainagar, Koderma
Category I
Sri Sanjay Kumar .... T-2 (Driver Vehicle)
Category II
Sri Manish Kumar .... T-4, Trg. Asst. (Agril.)
Sri Rupesh Ranjan .... T-4, Trg. Asst. (A.F)
Sri Mahammed Asif .... T-4. Computer (Asst.)
Category III
Mrs. Chanchila Kumari .... T (7-8), STA (H.S.)
Dr. Shudhanshu Sekhar .... T (7-8), STA (V. Sc.)
Sri Bhoopendra Singh .... T-6, SMS (Horticulture)

PROJECTS AND FINANCIAL RESOURCES

	Plan (2012-13) (Rs. in lakhs)				Non-plan (2012-13) (Rs. in lakhs)		
	B.E. 2012-13	R.E. 2012-13	Expenditure		B.E. 2012-13	R.E. 2012-13	Expenditure
Building	23.90	19.69	19.69	Building	0.00	0.00	0.00
Equipment	107.84	126.21	126.21	Equipment	0.00	5.00	4.99
IT	0			IT	0.00		
Library Books	0			Library Books	0.00	2.00	1.98
Furniture	0			Furniture	0.00	3.00	3.00
Total NR	131.74	145.90	145.90	TOTAL NR	0.00	10.00	9.97
T.A.	25	25.00	25.00	Establishment	2658.00	2158.00	2158.00
Research	110	167.38	167.38	Wages	300.00	242.00	241.99
Operational	90	74.97	74.97	Overtime	1.00	1.00	0.52
Infrastructure	57.45	67.56	67.56	Pension	650.00	500.00	500.00
Other (Ex.T.A.)	20	10.76	10.76	Pension ICAR	0.00	800.00	582.56
HRD	10	5.00	5.00	T.A.	10.00	13.00	13.00
Other Misc.	80	40.42	40.41	R & M(Equipment)	20.00	18.00	18.00
Total REC	392.45	391.10	391.09	R & M(Office Building)	49.00	51.50	51.50
Total Plan	524.19	537.00	536.99	R &M(Resdl. Building)	36.00	34.00	34.00
				R & M(Minor works)	10.00	9.00	9.00
				Contingencies	360.00	302.00	302.00
				Total REC	4094.00	4128.50	3910.57
				Total Non-plan	4094.00	4138.50	3920.54
				P Loans & Advance	30.00	13.12	13.12

	Target		Achievement
Revenue Receipt	52		89.82
TOTAL	52	0	89.82

WORK PLAN FOR 2012-13

Programme 1: Genetic improvement of rice: O.N.Singh/ J.N. Reddy

Exploration, characterization and conservation of rice genetic resources

Principal Investigator : B.C.Patra

*Co-Principal Investigators (Co-PIs) :*B.C. Marndi, H.N.Subudhi, S. Samantaray, J.L. Katara, J.N. Reddy, L.K. Bose, N. Mandal and N. Bhakta

Maintenance breeding and seed quality enhancement

Principal Investigator : S.R. Dhua

Co-Principal Investigators (Co-PIs) : R.K. Sahu, G.J.N. Rao, O.N. Singh, R.N. Rao, K. Pande, J.N. Reddy, A. Pattanaik, S.S.C. Pattnaik, L. Behera, S.K. Pradhan, U. Dhua, M. Jena, K.S. Behera, T. Bagchi, A. Poonam, C.V. Singh, N.P. Mandal, N. Bhakta and B.C. Marndi

Utilization of new alleles from primary and secondary gene pool

Principal Investigator : D. Swain

Co-Principal Investigators (Co-PIs) : L.K. Bose, H.N. Subudhi, S. Samantaray, P. Swain, M. Jena and K.S. Behera

Hybrid rice for different ecologies

Principal Investigator : R. N. Rao

Co-Principal Investigators (Co-PIs) : R.L. Verma, J.L. Katara, G.J.N. Rao, L. Behera, K.S. Behera , M.S. Ananta, N.P. Mandal, D. Maiti and S.S.Pokhare

Development of high yielding genotypes for rainfed shallow lowlands

Principal Investigator : S.K. Pradhan

Co-Principal Investigators (Co-PIs) : O.N. Singh, S.S.C. Pattnaik, J.N. Reddy, S.K. Dash, M.K. Kar, L. Behera, S. Samantaray , P. swain, K. Pande, J. Meher, N. Bhakta and A. Prakash

Development of improved genotypes for semi-deep and deep water ecologies

Principal Investigator : J.N. Reddy

Co-Principal Investigators (Co-PIs) : S.K. Pradhan, S.S.C. Pattnaik, K. Chattopadhyay, J.L. Katara,N. Bhakta, R.K. Sarkar, P. Swain and A. Prakash

Breeding rice varieties for coastal saline areas

Principal Investigator : K.Chattopadhyay

Co-Principal Investigators (Co-PIs) : B.C. Marndi, D.P. Singh, A.K. Nayak, A. Poonam, Bijaya Bhattacharjee, R.K. Sarkar, J. N. Reddy and A. Prakash

Development of Super Rice for different ecologies

Principal Investigator : S.K. Dash

Co-Principal Investigators (Co-PIs) : S.K. Pradhan, O.N. Singh, N.P. Mandal, M.S. Anantha, M.Variar, M. Kar, K. Pande, J. Meher, L. Behera, B.C. Marndi, P. Swain, M.J. Baig, L. K. Bose, M. Jena, S.S. Pokhare and J. Berliner

Resistance breeding for multiple insect - pests and diseases

Principal Investigator : M. K. Kar

Co-Principal Investigators (Co-PIs) : R.K. Sahu, J.N. Reddy, S.K. Pradhan, G.J.N. Rao, S.K. Singh, S.N. Tewari, M. Jena, T.Adak, L. Behera, S.C. Sahu, A. Prakash , S. Lenka and K.B. Pun

Breeding for higher resource use efficiency

Principal Investigator : K. Pande

Co-Principal Investigators (Co-PIs) : J. Meher, S.K. Dash, O.N. Singh,A.Ghosh, M.K. Kar, S.K. Pradhan, L.K. Bose, L. Behera, N. Bhakta, J.L. Katara, S. Samantaray, H.N. Subudhi, D. Swain, S.R. Dhua, G.J.N. Rao, A.K. Nayak, U. Dhua, A. Prakash, P. Swain and S.G. Sharma

Breeding for aroma, grain and nutritional quality

Principal Investigator : A. Pattanaik

Co-Principal Investigators (Co-PIs) : S.S.C. Pattnaik, G.J.N. Rao, K. Chattopadhyay, B.C. Marndi, S. Samantaray, L. Behera, S.G. Sharma, A. Das, T.B. Bagchi, Md. Shahid, K.S. Behera and T.Adak

Improvement of rice through in vitro and transgenic approaches

Principal Investigator : S. Samantaray

Co-Principal Investigators (Co-PIs) : G.J.N. Rao, B. Bhattacharyya, R.N. Rao and L.K. Bose

Development and use of genomic resources for genetic improvement of rice

Principal Investigator : L. Behera

Co-Principal Investigators (Co-PIs) : G.J.N. Rao, B. Bhattacharyya, M. Variar, S.C. Sahu, S.K. Pradhan, R.K. Sahu, M. Jena, N.P. Mandal, S.K. Dash, B.C. Marndi, J. Meher, K. Chattopadhyay, J.N. Reddy, P. Swain, S. Samantaray, M.S. Anantha, H.N. Subudhi and N.N. Jambhulkar

Development of resilient rice varieties for rainfed direct seeded upland ecosystem

Principal Investigator : N.P. Mandal

Co-Principal Investigators (Co-PIs) : M.S.Anantha, Y. Kumar, V.D. Shukla, M. Variar, D. Maiti, S.K. Dash P. Swain and C.V.Singh

Development of rice genotypes for rainfed flood-prone lowlands

Principal Investigator : N. Bhakta

Co-Principal Investigators (Co-PIs) : K.B. Pun, S.K. Pradhan, L.Behera and S.Lenka

Programme 2: Enhancing the productivity, sustainability and resilience of rice based production system : K.S.Rao/A.K.Nayak

Enhancing nutrient use efficiency and productivity in rice based system

Principal Investigator : A.K. Nayak

Co-Principal Investigators (Co-PIs) : S. Mohanty, Md. Shahid, P. Bhattacharya, R.Tripathi, A. Kumar, V. Kasthuri Thilagam, R. Raja, B. B. Panda, K S Rao, A. Ghosh, Priyanka Goutam, Banawari Lal, S. Munda and S.S. Pokhare

Agro-management for enhancing water productivity and rice productivity under water shortage condition

Principal Investigator : A.Ghosh

Co-Principal Investigators (Co-PIs) : K.S.Rao, P.Swain,, M.Din, C.V.Singh, B.B.Panda, A.Poonam, R.Tripathy, J.Berliner and P. Gautam

Crop weather relationship studies in rice for development of adaptation strategies under changing climatic scenario

Principal Investigator : R Raja

Co-Principal Investigators (Co-PIs) : B.B. Panda, A.K. Nayak, P. Bhattacharyya, M. J. Baig, R. Tripathi, K.S. Rao, Kasthuri Thilagam, P. Gautam, A. Kumar and B. S. Satapathy

Development of sustainable production technologies for rice based cropping systems

Principal Investigator : B.B. Panda

Co-Principal Investigators (Co-PIs) : R. Raja, A.K. Nayak, A. Ghosh, K.S. Rao, B. Lal, Md. Shahid and A. Kumar

Farm implements and post harvest technology for rice

Principal Investigator : P. C. Mohapatra

Co-Principal Investigators (Co-PIs) : P. Mishra, S. P. Patel, M. Din, P. Samal, S. Saha and T. Bagchi

Resource Conservation technologies and conservation Agriculture (CA) for sustainable rice production

Principal Investigator : P. Bhattacharyya

Co-Principal Investigators (Co-PIs) : A.K. Nayak, R. Tripathi, M. Din, K.S.Rao, B.B. Panda, R. Raja, S. Mohanty, Md. Shahid, A. Kumar, S. Saha, A. Ghosh, S Munda and B.Lal

Diversified rice-based farming system for livelihood improvement of small and marginal farmers

Principal Investigator : A. Poonam

Co-Principal Investigators (Co-PIs) : K. S. Rao, D. P. Sinhababu, Md. Shahid, M. Jena, P.K.Nayak, G.A.K. Kumar, N.N. Jambhulkar, S. M. Prasad, S.C. Giri (RC of CARI), M. Nedunchezhian (RC of CTCRI) and H. S. Singh (CHES of IIHR)

Management of rice weeds by integrated approaches

Principal Investigator : S Saha

Co-Principal Investigators (Co-PIs) : K. S. Rao, B. Lal, B. C. Patra, S. K. Das, K. S. Behera , U. Kumar and S. Munda

Management of problem soils for enhancing the productivity of rice

Principal Investigator : R. Tripathy

Co-Principal Investigators (Co-PIs) : Md. Shahid, A. K. Nayak, A. Kumar, S. Mohanty, Kasthuri Thilgam, R. Raja and D.P. Singh

Bio-prospecting and use of microbial resources for soil, pest and residue management

Principal Investigator : U. Kumar

Co-Principal Investigators (Co-PIs) : T K Dangar and K S Behera

Soil and crop management for productivity enhancement in rainfed upland ecosystem

Principal Investigator : C.V. Singh

Co-Principal Investigators (Co-PIs) : M.S. Anantha, Y. Kumar, V.D. Shukla, M. Variar, D. Maiti, S.K. Dash, P. Swain and V.K. Singh

Soil and crop management for productivity enhancement in rainfed flood-prone lowland ecosystem

Principal Investigator : B.S. Satapathy

Co-Principal Investigators (Co-PIs) : S.Saha, T. Singh, A.Kumar, K.B.Pun, S.Lenka and N.N.Jambhulkar

Programme 3: Rice pests and diseases-emerging problems and their management: A. Prakash / U. Dhua

Management of rice diseases in different ecologies

Principal Investigator : A.K.Mukherjee

Co-Principal Investigators (Co-PIs) : U. Dhua, S.N.Tewari, S.D. Mohapatra, S.K. Singh, T. Adak, J.Berliner, and S.S. Pokhare

Rice endophyte interaction with pathogens and pests in relation to environment

Principal Investigator : U.Dhua

Co-Principal Investigators (Co-PIs) : K. S. Behera and M.Jena

Identification and utilization of host plant resistance in rice against major insect and nematode pests

Principal Investigator : M. Jena

Co-Principal Investigators (Co-PIs) : K.S. Behera, A. Prakash, P.C. Rath, S.D.Mohapatra, J. Berliner, S.S. Pokhare , S.C. Sahu, R.K. Sahu,S.K. Pradhan and P.R.Shashank

Bio-ecology and management of pests under changing climatic scenario

Principal Investigator : K.S. Behera

Co-Principal Investigators (Co-PIs) : S.C. Sahu, R. Raja, M. Jena, P.C. Rath, S.D.Mohapatra, J. Berliner, S. S. Pokhare, S. Saha, U. Kumar, S.N. Tewari, A. Prakash, A. K. Nayak, N. N. Jambhulkar, T. Adak and P.R.Shashank

Formulation, validation and refinement of IPM modules in rice

Principal Investigator : P.C.Rath

Co-Principal Investigators (Co-PIs) : A. Prakash, K. S. Behera, M. Jena, S.D.Mohapatra, J. Berliner, S. S. Pokhare, U. Dhua, P. Samal, S. Saha, V. D. Shukla, S. Lenka, T. K. Dangar, T. Adak and P.R.Shashank

Biotic stress management in rainfed upland rice ecology

Principal Investigator : V. D. Shukla

Co-Principal Investigators (Co-PIs) : M.Variar, D.Maiti, C.V.Singh, N.P.Mandal, Yogesh Kumar and P.R.Shashank

Management of major rice diseases in rainfed flood prone lowlands

Principal Investigator : K B Pun

Co-Principal Investigators (Co-PIs) : U.Dhua, M.Kar, S.K.Singh, S.S.Pokhare S.Lenka, T.Singh and B.S.Satapathy

Programme 4: Biochemistry and physiology of rice in relation to grain and nutritional quality, photosynthetic efficiency and abiotic stress tolerance: **S.G.Sharma/D.P.Singh**

Rice grain and nutritional quality - evaluation, improvement, mechanism and value addition

Principal Investigator : A. Das

Co-Principal Investigators (Co-PIs) : S.G. Sharma, T.B. Bagchi, L. Bose, L Behera, B.C. Marndi, N. Bhakta, A. Pattanaik, P Mishra, A. Ghosh, U.Kumar and Md.Shahid

Phenomics of rice for tolerance to multiple abiotic stresses

Principal Investigator : R. K. Sarkar

Co-Principal Investigators (Co-PIs) : D. P. Singh, P.Swain, M.J.Baig and T.B. Bagchi

Rice physiology under drought and high temperature stress

Principal Investigator : P. Swain

Co-Principal Investigators (Co-PIs) : T.B. Bagchi, M.J. Baig, N. Dwivedi, S. K. Pradhan, J. Meher and J.L. Katara

Evaluation and improvement of photosynthetic efficiency of rice

Principal Investigator : M.J. Baig

Co-Principal Investigators (Co-PIs) : P. Swain, R. Raja and S.K. Pradhan

Programme 5: Socio economic research and extension for rice in development: **B.N.Sadangi/ P.Samal**

Socio-economic approaches, mechanism and transfer of technologies for sustainable rice production

Principal Investigator : L. Das

Co-Principal Investigators (Co-PIs) : B.N. Sadangi, P. Samal, N.C. Rath, G.A.K. Kumar, S.S.C. Pattnaik, S,Saha, M. Din, M. Jena, S.R. Dhua, H. N. Subudhi, P.C. Rath, N.N. Jambhulkar, S.M. Prasad, V.K.Singh, S.P.Patel, M.K.Kar and S.K.Mishra

Characterization of resources and innovations to aid rice research and develop extension models

Principal Investigator : G.A.K.Kumar

Co-Principal Investigators (Co-PIs) : B.N. Sadangi, L. Das, N.N. Jambhulkar, D.P. Sinhababu, M.Din, S.G. Sharma, M. Jena, R.N.Rao, S.R.Dhua and S.K.Mishra

Impact analysis and database updation in relation to rice technologies, policy and programmes

Principal Investigator : P.Samal

Co-Principal Investigators (Co-PIs) : N. N. Jambhulkar, B. N. Sadangi, G.A.K. Kumar, L. Das, O. N. Singh, S. K. Pradhan and M. Din

ONGOING EXTERNALLY AIDED PROJECTS (EAPS)

Number	*Title of the Project*	*Principal Investigator*	*Source of Funding*
EAP 27	Revolving fund scheme for seed production of upland rice varieties at CRURRS, Hazaribagh	V.D.Shukla	AP Cess
EAP 36	National Seed Project (Crops)	S.R.Dhua	NSP
EAP 49	Revolving fund scheme for breeder seed production	S.R.Dhua	NSP / Mega seed
EAP 60	Front line Demonstration under Macro-Management scheme of Ministry of Agriculture – New High Yielding Varieties	V.D.Shukla	DAC
EAP 99	Transgenic in crops	G.J.N.Rao	ICAR Network
EAP 100	Seed Production in Agricultural Crops and Fisheries– Mega Seed Project	S.R.Dhua	ICAR
EAP 104	Microbial diversity and identification	T.K.Dangar	ICAR Network
EAP 105	Nutrient management	T.K.Dangar	ICAR Network
EAP 106	Microbial bioremediation	T.K.Dangar	ICAR Network
EAP 108	Developing and disseminating resilient and productive rice varieties for drought prone areas of India - Hazaribag	M.Variar	IRRI (Rockfeller Foundation & Generation Challenge Program) - ICAR
EAP 119	Soil organic carbon dynamics vis'-a'-vis' anticipatory climatic changes and crop adaptation strategies	P.Bhattacharyya	ICAR (NAIP)
EAP 120	Towards development of a single cell C4 photosynthetic system in rice	M.J. Baig	ICAR (NAIP)
EAP 121	Developing Sustainable Farming System Models for Prioritized Micro 24Watershed in Rainfed Areas in Jharkhand	C.V. Singh	ICAR (NAIP)
EAP 122	Allele26 Mining and Expression Profiling27 of Resistance-and Avirulence-28genes in Rice Blast Pathosystem f29or Development of Race Non-Specific Disease Resistance	M. Variar	ICAR (NAIP)
EAP 123	Enhancing and stabilizing productivity of salt affected areas through incorporation of genes for tolerance of abiotic stresses in rice	D.P. Singh	IRRI (BMZ)- ICAR
EAP 125	Stress tolerant rice for poor farmers of Africa and South Asia – Drought prone rain-fed rice areas of South Asia – Hazaribag Centre	M.Variar	ICAR-IRRI(BMGF)
EAP 126	Stress tolerant rice for poor farmers of Africa and South Asia- Drought prone areas- CRRI Centre	O.N.Singh, P.Swain	ICAR-IRRI-(B&MGF)
EAP 127	Stress tolerant rice for poor farmers of Africa and South Asia- Submergence and Flood prone areas	J.N.Reddy, SSC Patnaik	ICAR–IRRI(B&MGF)
EAP 128	Stress tolerant rice for poor farmers of Africa and South Asia- Saline prone areas (STRASA)	D.P.Singh	ICAR – IRRI (B&MGF)

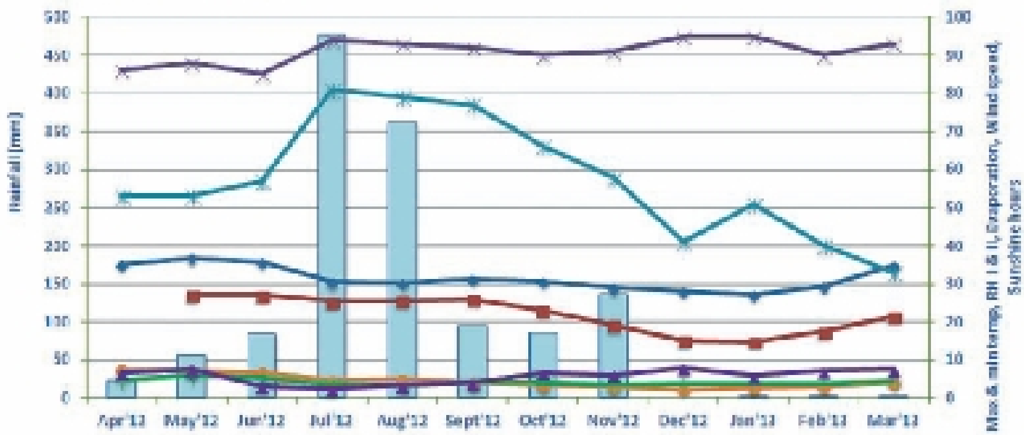
Number	Title of the Project	Principal Investigator	Source of Funding
EAP 129	Stress tolerant rice for poor farmers of Africa and South Asia- Socio-economic survey and impact assessment	P.Samal	ICAR-IRRI (B&MGF)
EAP 130	All India Network Project on Soil Biodiversity-Biofertilizers	D.Maiti	ICAR Network Project
EAP 131	Research into development of decision support system for major insects pests or rice and cotton	Mayabini Jena	ICAR (NAIP)
EAP 132	Gender issues of rice based production system and refinement of selected technologies in women perspective	Lipi Das	ICAR Network Project
EAP 133	Capitalization of prominent landraces of rice in Orissa through Value Chain Approach	A.Pattanaik	ICAR (NAIP)
EAP 134	Development and maintenance of rice knowledge management Portal	G.A.K.Kumar	ICAR (NAIP)
EAP 135	Bioprospecting of genes and allele mining for abiotic stress tolerance	G.J.N.Rao	ICAR (NAIP)
EAP 137	Establishment of National Rice Resources Database	B.C.Patra	DBT
EAP 138	Connecting performance under drought with genotype through phenotype association	P.Swain	IRRI-ICAR
EAP 139	Renewable Energy Sources for Agriculture and Agro-based Industries	P.N.Mishra	AICRP
EAP 140	Intellectual Property Management and Transfer/ commercialization of agricultural technology Scheme	S.R.Dhua	ICAR
EAP 141	DUS Testing and documentation	S.R.Dhua	PPV&FRA
EAP 143	Identification of molecular markers for enhanced *Arbuscularmycorrhiza* (AM) response and marker assisted selection of high AM responsive varieties for efficient phosphorus nutrition of upland rice	D. Maiti, A.Das, BCKV R.K.Singh N.P.Mandal	DBT
EAP 144	Livelihood promotion through integrated farming system in Assam	N.Bhakta	ICAR (NAIP)
EAP 145	Identification and functional analysis of genes related to yield and biotic stresses	S.C.Sahu, M.Jena L.Behera, R.K.Sahu	DBT
EAP 146	Confidence building and facilitation of large scale use of fly ash as an ameliorant and nutrient source for enhancing rice productivity and soil health	K.S.Rao, A.K.Shukla R.Raja	DST
EAP 147	Agro-techniques for sustaining productivity of wet direct sown summer rice in flood prone lowlands	S. Saha, K.S.Rao K.Panda, K.S. Behera B.B.Panda, L.Das	DST
EAP 148	Strategies to enhance adaptive capacity to climate change in vulnerable regions	K.S.Rao, B.B.Panda S.Mohanty, A.Pandit	ICAR (NAIP)
EAP 149	Awareness cum surveillance programme for management of major pest in Paddy	A. Prakash	Directorate of Agriculture & Food Production , Orissa, Bhubaneswar

Number	*Title of the Project*	*Principal Investigator*	*Source of Funding*
EAP 150	Development, dissemination and popularization of location specific IPM strategies in different rice agro-ecosystems	A. Prakash Totan Adak	NCIPM, ICAR
EAP 151	Hybrid Rice Research network	R.N.Rao	AICRP
EAP 152	Mapping and Marker Assisted selection for RTV resistant genes	M.K.Kar, G.J.N.Rao, J.Rao	AICRP
EAP 153	Development of molecular markers linked to genes for resistance to Brown Planthopper	R.K.Sahu, M.Jena L.Behera	AICRP
EAP 154	Development of new plant type varieties with higher yield and resistance to major pest & diseases	S.K.Pradhan	AICRP
EAP 155	From QTL to Variety: Marker Assisted Breeding of Abiotic Stress Tolerant Rice Varieties with Major QTLs for Drought, Submergence and Salt Tolerance	J.N.Reddy, O.N. Singh, D.P.Singh, R.K.Sarkar,P.Swain, N.P.Mandal,B.C.Marndi	DBT
EAP 156	Marker–assisted backcrossing for transfer of durable bacterial blight resistance into elite deepwater rice varieties	S.C.Pradhan,L.Behera K.M.Das, GJN Rao S.K.Das	DBT
EAP 157	CURE Salinity Project: Enabling poor rice farmers to improve livelihood and overcome poverty in South and Southeast Asia (A)-Salinity (B)-Submergence	D.P.Singh (A) J.N.Reddy(B)	IFAD through IRRI
EAP 158	National Initiative on Climate Resilient Agriculture for XIth Plan	R.K.Sarkar	ICAR
EAP 159	"Diversity of osmotolerant and biochemical strains of endophytic microorganisms of rice"INSPIRE Fellowship under "Assured Opportunity for Research Career (AORC)"	Supriya Sahu (T.K.Dangar)	DST
EAP 160	Identification of Major QTLs for Grain Yield under drought stress in 'Jhum' rice varieties of North Eastern Region for use in marker assisted breeding to improve yield under drought	N.P.Mandal	DBT
EAP 161	Monitoring of the new initiative of "Bringing Green Revolution to Eastern India (BGREI) under the Rashtriya Krishi Vikas Yojana"	K.S.Rao	DAC, GOI
EAP 162	Stress tolerant rice for poor farmers of Africa and South Asia - Sub grant, Seed (CRURRS, Hazaribagh)	N.P.Mandal M.Variar V.D.Shukla	IRRI-ICAR (STRASA)
EAP 164	Technology dissemination and adoption of water saving rice production (Aerobic rice and AWD system) to improve rice farming rural livelihood in water shortage regions	A.Ghosh	DST
EAP 165	Phenomics of moisture deficit and low temperature stress tolerance in rice	O.N.Singh S.K.Dash	

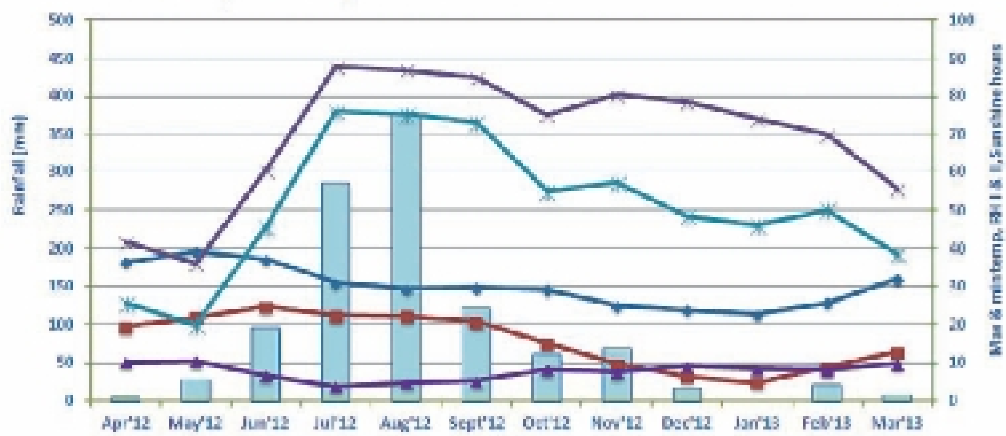
Number	Title of the Project	Principal Investigator	Source of Funding
EAP 166	Development, dissemination and popularization of location specific IPM strategies in different rice agro-ecosystem	V.D.Shukla	NCIPM (ICAR)
EAP 167	ICAR Net work project on Marker Assisted Selection for resistance to biotic and abiotic stresses in rice	N.P.Mandal	DRR, ICAR
EAP 168	Multi-institutional demonstration trials showing efficacy of liquid seaweed sap from *Kappaphycus alvarezii* and *Gracilaria edulis* on different crops	S.Saha	CSIR
EAP 169	Genetic Diversity of farmers' rice varieties collected from different parts of the State of Odisha, India	S.R.Dhua	PPV&FRA
EAP 170	GCP - Targeting Drought-Avoidance Root Traits to enhance Rice Productivity under Water Limited Environments	P.Swain	ICAR-IRRI
EAP 171	DUS- Special Test	S.R.Dhua	PPV&FRA
EAP 172	Characterization and evaluation of rice germplasm	B.C.Patra	NBPGR
EAP 173	Crop Pest Survellance and Advisory Project 2011-12 in Maharashtra	A. Prakash	Govt. of Maharashtra
EAP 174	Ploidy regulated expression of genes involved in mega-gametophyte development, apomixis and its component traits	M.J. Baig	DST

WEATHER

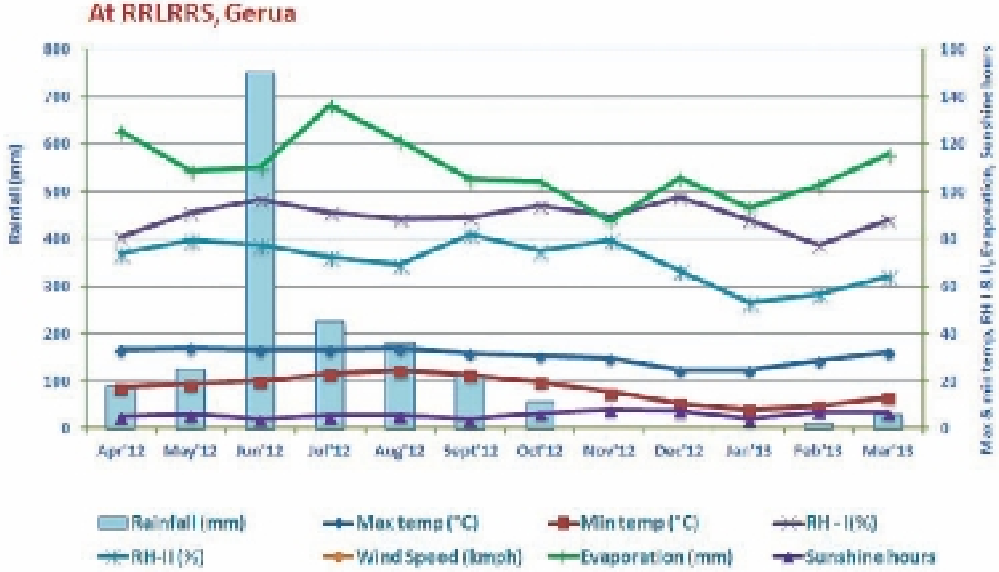
At CRRI, Cuttack



At CRURRS, Hazaribag



At RRLRRS, Gerua



ACRONYMS

AICRIP : All India Coordinated Rice Improvement Project
ATMA : Agricultural Technology Management Agency
AVT : Advanced Varietal Trial
AWD : Alternate Wetting and Drying
AYT : Advance Yield Trial
BB/BLB : Bacterial Leaf Blight
BPH : Brown Planthopper
Bt : *Bacillus thuringiensis*
CMS : Cytoplasmic Male Sterile/Sterility
CRIDA : Central Research Institute for Dryland Agriculture, Hyderabad
CRRI : Central Rice Research Institute, Cuttack
CRURRS : Central Rainfed Upland Rice Research Station, Hazaribag
CURE : Consortium for Unfavourable Rice Environment
DAC : Department of Agriculture and Cooperation
DAF : Days after Flowering
DAH : Days after Harvest
DAO : District Agricultural Officer
DARE : Department of Agriculture Research and Education
DAT : Day's After Transplanting
DTPA : Diethylene triamine penta acetic acid
DAS : Days after Sowing
DBN : Drought Breeding Network
DBT : Department of Biotechnology
DFF : Days to 50 % Flowering
DH : Dead Hearts
DRR : Directorate of Rice Research, Hyderabad
DST : Department of Science and Technology
EAP : Externally Aided Projects
EC/ECe : Electrical Conductivity
ET : Evapotranspiration
FLD : Frontline Demonstration
FYM : Farmyard Manure
g : Gram
GLH : Green Leafhopper
GM : Green Manuring / Gall Midge
GWUE : Grain Water Use Efficiency
h : Hour
ha : Hectare
HI : Harvest Index
HRR : Head Rice Recovery
HYV : High-yielding variety
ICAR : Indian Council of Agricultural Research
IDM : Integrated Disease Management
IJSC : Institute Joint Staff Council
IMC : Institute Management Committee
INGER : International Network for Genetic Evaluation of Rice
INM : Integrated Nutrient Management
INSA : Indian National Science Academy
IPM : Integrated Pest Management
IPR : Intellectual Property Rights
IRRI : International Rice Research Institute, Philippines
IVT : Initial Varietal Trial
Kg : Kilogram
KVK : Krishi Vigyan Kendra
L/l/ltr : Litre
LB : Long-bold
LCC : Leaf Colour Chart
LF : Leaf Folder
LS : Long-slender
LSI : Location Severity Index
MB : Medium Bold
MLT : Multilocation Trial
MS : Medium-slender
NAIP : National Agricultural Innovation Project
NARS : National Agricultural Research System
NBPGR : National Bureau of Plant Genetic Resources, New Delhi

NFSM : National Food Security Mission

NGO : Non-governmental Organization

NIL : Near-isogenic Lines

NPK : Nitrogen, Phosphorous, Potassium

NPT : New Plant Type

NRC : National Research Centre

NRCPB : National Research Centre for Plant Bio-technology, New Delhi

NSN : National Screening Nursery

NSP : National Seed Project

OFT : On-farm Trials

OUAT : Orissa University of Agriculture and Technology, Bhubaneswar

OYT : Observational Yield Trial

PI : Panicle Initiation

PMYT : Preliminary Multilocational Yield Trial

PVS : Participatory Varietal Selection

PYT : Preliminary Yield Trial

q : Quintal

QTL : Quantitative Trait Loci

RAC : Research Advisory Committee

RAPD : Random Amplification of Polymorphic DNA

RBD : Randomized Block Design

RCC : Reinforced Cement Concrete

RFLP : Restriction Fragment Length Polymorphism

RH : Relative Humidity

RIL : Recombinant Inbred Line

RRLRRS : Regional Rainfed Lowland Rice Research Station, Gerua

RTV/RTD : Rice Tungro Virus/ Disease

SAC : Scientific Advisory Committee

SAU : State Agricultural University

SB : Short-bold

SBN : Salinity Breeding Network

SES : Standard Evaluation System

SRI : System of Rice Intensification

STRASA : Stress Tolerant Rice for Poor Farmers in Africa and South Asia

t : Tonne

UBN : Uniform Blast Nursery

WBPH : White-backed Plant Hopper

WCE : Weed Control Efficiency

WEH : White Ear Head

WTCER : Water Technology Centre for Eastern Region

WUE : Water-use Efficiency

YSB : Yellow Stem Borer

ISBN 81-88409-13-8

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