ANUAL REPORT

वार्षिक प्रतिवेदन

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2010-2011




चावल अनुसधांन निदेशालय
Directorate of Rice Research
Rajendranagar, Hyderabad - 500 030

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ISBN No. 81-7232-2

Correct Citation:
Directorate of Rice Research (DRR) 2010
Annual Report 2010-11
Directorate of Rice Research
Rajendranagar
Hyderabad - 500 030, India

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Published by:
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Designed & Printed by:
Balajiscan Private Limited
A.C. Guards, Hyderabad - 500 004
Tel : +91-40-23303424 / 25
www.balajiscan.com

Preface

I am pleased to place before you the Annual Report for the period 2010-11, the sixth one during my tenure as the Project Director.

The year 2010-11 was a good year in terms of rice production in the country after the setback of 2009-10. For the country as a whole, the rainfall for the season was 102 per cent of its long period average. The estimated rice production in the country this year as per the second advance estimate, is at 94.11 million tonnes, an increase of about 15 per cent over 2009-10 levels and still lower than the record production of 99.1 million posted during 2008-09.

Progress of research during the period under report has been very satisfactory. Five hybrids and six new varieties were released for cultivation across the country and 25 varieties were notified by 8 State release committees. Five cultures were identified by the Variety Identification Committee. Marker assisted breeding is aggressively followed to pyramid resistance genes against BB, blast, RTV, gall midge and brown planthopper; introgressing yield related QTLs, and improving parental lines of popular hybrids. Efforts have been intensified to develop new plant type varieties. Resource conservation technologies like SRI, alternate wetting and drying (AWD), aerobic rice cultivation are being probed into for wider adoption. Organic rice cultivation is explored for niche markets and exports. More genes for pest resistance are being identified and linked markers developed for effective introgression. Compatibility of insecticides and fungicides for better tank mixing has been studied. Biocontrol agents like microbes and entomopathogenic nematodes are being studied extensively. Need and demand based training programmes are being organized regularly.

A mega net-work project on National Initiative on Climate Resilient Agriculture (NICRA) was initiated this year with a total funding of over Rs. 4 crores. Functional Genomics of Rice (DBT), Development of Biotic Stress Resistant Rice through marker assisted backcross breeding (DBT), Decision Support System for insect pests of major rice cropping systems (NAIP) and Development and maintenance of Rice Knowledge Management Portal (NAIP) projects have been in progress. Human Resource Development in form of training students leading to their M.Sc. and Ph.D. degrees, formal and informal training courses and participation in seminars and symposia was given the adequate thrust.

On Transfer of Technology front, seven MOU were signed between DRR and private sector seed companies for taking up seed production of DRR developed rice hybrids. Unique rice germplasm have been registered and unique gene sequences deposited in the data bases. More than 600 Front Line Demonstrations were organise on various new technologies in different ecosystems.

A summary of these activities is presented in this Annual Report.

July 2011
Hyderabad

(B.C. Viraktamath)
Project Director

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समन्वित अनुसंधान

फसल सुधार

- फसल मानक, अधिसूचना एवं किस्म विमोचन, केंद्रीय उप-समिति द्वारा सामान्य खेती के लिए छत्तीस किस्मों का विमोचन किया गया। इनमें 6 किस्मों यथा आई.जी.के.वी.आर 1, आई.जी.के.वी.आर 2, चिनसुरा धान 1, सी.आर.धान 501, सी.आर धान 601 एवं आर.सी.आर.सी.मणिफौ 1 तथा 5 संकर यथा इंडम 200-017, यू.एस.312, 27 पी 11, सी.आर.एच.आर 32 और राजलक्ष्मी का केंद्रीय किस्म विमोचन समिति द्वारा किया गया। 8 राज्यों में 25 किस्मों का विमोचन राज्य किस्म विमोचन समितियों के द्वारा अनुमोदित किया गया।
- विविध पारिस्थितिकी प्रणालियों के लिए किस्म पहचान समिति द्वारा आइ.ई.टी.19972 (एस.जे.आर 5), आई-ई.टी 20220 (सी.आर.2285-6-6-3-1), आई.ई.टी. 20827 (एम.ए.यू.बी 171), आई.ई.टी 20716 (वी.एन.आर 204) और आई.ई.टी 20735 (वी.एन.आर 202) किस्मों की पहचान की गयी।
- तीन वर्षों (2008-10) के परीक्षणों में 4 संकर सहित 25 संवर्ध विविध पारिस्थितिकी प्रणालियों के लिए आशाजनक पाए गए।
- विभिन्न परीक्षणों में संबंधित उत्तम परीक्षण किस्मों की तुलना में समग्र औसत उपज के आधार पर बारह संकर यथा यू.एस. 314, 26 पी 27, एच.आर.आई 172, एन.के. 6303, आर.एच 09011, ए.आर.आर.एच 3626, के.पी.एच.272, एक्स.आर. 97939, एक्स.आर.99982, यू.एस. 305, के.पी.एच.199 और एक्स.आर. 97747 आशाजनक पाए गए।

फसल उत्पादन

सस्य विज्ञान

- 54 स्थानों में आयोजित 260 प्रयोगों में सर्वोत्कृष्ट जीनोप्रकारों (72 एपीटी-2 संवर्ध) का अपनी नत्रजन उपयोग क्षमता के लिए परीक्षण किया गया और 12 आशाजनक संवर्धों की पहचान की गयी।
- वर्षाधारित उपरीली पारिस्थितिकी प्रणाली में पोषक अनुसूची 60:40:40:500एन:पी:के:लाइमकि.ग्रा/हे और जिंकसल्फेट ($ZnSO_4$) के 0.5% पर्णीय छिडकाव के साथ धान + सूर्य सन (अंतर फसल एवं समावेशन) के उगाने में अनाज उपज और मृदा स्वास्थ्य को बढाने में आशाजनक पाया गया।
- धान में ग्लाइफोसैट (बुआई के पूर्व) के साथ बेनसल्फरान मेथल+ प्रिटिलाक्लोर (बुआई के उपरांत) के प्रयोग द्वारा व्यापक रूप में अपतृण नियंत्रण में उत्तम परिणाम दर्ज किये गये।
- वायुजीवी धान के लिए 100-125% नत्रजन का प्रयोग + आविर्भाव के पूर्व शाकनाशी का प्रयोग + धान ढैंचा (1:1) + बुआई के 60 दिनों को बाद हाथ से निराई या बुआई के 25-30 दिनों के बाद 2,4 डी-एन.ए. का प्रयोग आशाजनक पाया गया।
- धान में अपतृण की समस्या वाराणसी और जगदलपुर प्रांतों में धान की शुष्क रोपाई की स्थिति में अधिक पायी गयी, जबकि राँची और छाता में बुआई के धान में अधिक थी।
- धान और मकई में 50% घासपात से ढकने और मकई के साथ धान की शुष्क रोपाई (खरीफ) और मकई की शुष्क रोपाई (रबी) ज्यादा लाभदायक प्रणाली पायी गयी।

मृदा विज्ञान

- तीन स्थानों (मांड्या, मारुटेरु और टिटाबार) पर 22 वर्षों तक किये गये अनुसंधान में अनुमोदित उर्वरक की मात्रा (100% NPK ZnS) के साथ 5 टन/हे की दर से गोबर की खाद के प्रयोग से और मांड्या में गोबर की खाद की जगह 50% NPK के प्रयोग से धान उत्पादकता, पोषक संचयन और मृदा उर्वरता में महत्वपूर्ण सुधार हुआ है।
- उन खेतों के अलावा जिनमें पोटाश और कैल्शियम (P&K) उपचार के बिना खेती की गयी हो, सभी अन्य गोदावरी डेल्टा के खेतों में धान की उत्पादकता में 11-251 कि.ग्रा./हे/वर्ष की दर से सुधार हुआ या स्थिर रहा जबकि असम घाटी (टिटाबार) में 2-39 कि.ग्रा/हे/वर्ष की दर से कमी पायी गयी और पठारी प्रांत (मांड्या) में 15-107 कि.ग्रा./हे/ वर्ष की दर से अधिक पायी गयी और गोबर की खाद को पूरक (INM) के रूप में प्रयोग करने पर सुधार हुआ। मांड्या के वर्तमान अनुमोदित उर्वरकों की पुनरीक्षा की आवश्यकता महसूस की गयी।
- मांड्या, मारुटेरु और टिटाबार प्रांतों में कुछ चयनित किसानों के खेतों में मृदा पोषकता की आपूर्ति, धान की उत्पादकता, पोषकतत्वों की आवश्यकता, उपयोगिता की दक्षता और उर्वरकों की सिफारिश में स्थानों के अनुरूप परिवर्तन पाये गये, जहाँ आर.डी.एफ. के 40:20:20 एन.पी.के/हे. के सामान्य प्रयोग की जगह 32-84 कि.ग्रा. एन, 15.28 कि.ग्रा. फास्फेट (P_2O_5) और 17-44 कि.ग्रा. पोटाश (K_2O)/हे. के प्रयोग की सिफारिश की गयी। मांड्या में 6.4 ट/हे. धान की उपज लक्ष्य के लिए 100:50:50 NPK/हे. की जगह 67-86 कि.ग्रा. नत्रजन, 28.48 कि.ग्रा.फास्फेट और 42-88 कि.ग्रा. पोटाश/हे के प्रयोग की सिफारिश की गयी। प्रचलित अनुमोदित उर्वरक मात्रा और कृषकों के द्वारा व्यवहार में लायी जाने वाली उर्वरक पद्धतियों की तुलना में स्थान विशिष्ट पोषक प्रबंध श्रेष्ठतर पाया गया।
- कानपुर की क्षारीय मृदाओं में 100% तक जिप्सम प्रयोग से उपज और पोषक संचयन में महत्वपूर्ण सुधार हुआ। गोबर की खाद के साथ या उसके बिना पूरक के रूप में 50 कि.ग्रा.

जिंकसल्फेट/हे. ($ZnSO_4$) और लोहे (30 कि.ग्रा Fe-EDTA) के संयुक्त प्रयोग से धान उत्पादकता में एन.पी. और के. की उपयोग क्षमता में सुधार हुआ।

- 11 स्थानों में उच्च जस्ता और लोहा के लिए 185 कल्चर (Cultures) के परीक्षण से सामान्य जीनोप्रकारों में चेक किस्मों की उत्पादकता तथा जस्ते और लोहे की अंर्तवस्तु में भिन्नता पायी गयी। उच्च लोहे और जस्ता अंतर्वस्तु के लिए मोनकंपू में नजवारा समूह, कराइकल में पथानी 23 और जोडुमनी, कानपुर में स्वर्ण सब 1, बंकुरा में मनी और फैजाबाद और खुदवानी में क्रमश: एन.डी.आर. और सुगंधित संवर्ध थे।
- वायुजीवी धान प्रणाली में उपज हानि के बिना जल उत्पादकता (कि.ग्रा.धान/उपयोग किया गया मि.मी. जल) 3.9 से 4.8 कि.ग्रा. अनाज तक पाया गया और सिंचाई 100% संचित पटल वाष्पणप (CPE) के बराबर इष्टतम पाया गया। प्रतिबंधित आपूर्ति के द्वारा क्रमश: लगभग 12-16 प्रतिशत सिंचित जल की बचत होगी।
- RBCS में सात स्थानों में फसल अवशेष प्रबंधन पर आयोजित अध्ययन से पाया गया था कि पुआल के निकाल देने की तुलना में पुआल के उपयोग (अकेले,एम/बी संवर्ध, जी एम या एन) से पोषकों की ग्रहण शक्ति, मृदा पोषक संतुलन (12 कि.ग्रा. N एवं P तथा 25-45 किग्रा. पोटाश/हे.) और SOC की 0.2-0.45% अंर्तवस्तु में वृद्धि थी। पुआल का फसल पोषकों में योगदान 20-48 कि.ग्रा. N, 6-23 कि.ग्रा. P_2O_5 और 14-50 कि.ग्रा. पोटाश/हे. था।
- टिटाबार (असम) और रांची (झारखंड) की निचली धान पारिस्थितिकी में आम्लीय मृदाओं के लिए पी एवं के की मात्रा को दुगुना करने से फसल में सुधार हुआ। टिटाबार में आम्लीय मृदाओं के लिए आई.ई.टी.10016, डब्ल्यू.एल 21, जया, आई.ई.टी.20974 और आई.ई.टी 21519 आशाजनक पाये गये जबकि रांची में आई.ई.टी-21582, आई.ई.टी-21531 और आई.ई.टी-21519 से उच्च अनाज उपज प्राप्त हुई।
- 148 प्रतिनिधि कृषि क्षेत्रों में आयोजित पौष्टिक स्थिति के अध्ययन में घाघ्राघाट में पी के लिए, टिटाबार में एन एवं के के लिए करैकल में एन एवं पी के लिए और मांड्या में सभी पोषक तत्वों के लिए पोषकों की आंतरिक क्षमता विषम पाया गया।
- 5 स्थानों में आयोजित अध्ययन के परिणामों के आधार पर अधिकतम स्थानों में उच्च उपज किस्मों (HYVs) के लिए 120,60,50, कि.ग्रा. एन.पी.के/हे. तक प्रभावी था। समाश्रयण विश्लेषण द्वारा संकरों और उच्च उपज किस्मों के लिए अनुमानित पौष्टिक आवश्यकताओं में 14-30 कि.ग्रा.- एन, 3-10 कि.ग्रा. P_2O_5 और 9-28 कि.ग्रा. पोटाश/टन अनाज के रूप में भिन्नता पायी गयी।

पादप-क्रिया विज्ञान

- प्रकाश ऊष्मीय सूचक पर एक अध्ययन में बोआई के दो विभिन्न तिथियों के कारण पुष्पण में आगुआई, CDD,CNP, जैव पदार्थ और अनाज की उपज में कोई महत्वपूर्ण भिन्नता नहीं पायी गयी।
- बाली बन्ध्यता, उच्च सांद्गता अनाज और उपज पर डाटा के आधार पर पाया गया था कि सभी स्थानों में 0.4 ppm की दर से बोरान के प्रयोग के प्रति आई.टी- 20979, आई.ई.टी- 21114 और आई.ई.टी. 21519 की प्रतिक्रिया सकारात्मक था।
- शुष्क सहयता के लिए सर्वोत्कृष्ट वंशक्रमों की छानबीन पर एक अध्ययन में पी.ए.6129 और अन्नदा के साथ इक्कीस संवर्धों की छानबीन से पाया गया था कि सूखे की स्थिति में आई.ई.टी-20708 और आई.ई.टी-20710 से क्रमश: चार और तीन स्थानों में उच्च अनाज उपज दर्ज किया गया जबकि आई.ई.टी.21281 और आई.ई.टी.21076 क्रमश: चार और तीन स्थानों में सूखा ग्रसित हुए।
- जलाप्लावन सहयता के लिए प्रवेशित उप 1 जीन के जीवित रहने की प्रतिशतता, स्वास्थ्य लाभ करना और उपज में सुधार हुआ।
- सभी स्थानों में सभी जीनोप्रकारों के औसत विकिरण उपयोग क्षमता (आर.यू.ई) 0.33 दर्ज हुई थी। आई.ई.टी.21429 और लता की परिपक्वता की दशा में न्यूनतम विकिरण उपयोग क्षमता थी और आई.ई.टी.20884 की 0.37 पर अधिकतम विकिरण उपयोग क्षमता थी।

फसल संरक्षण

कीट विज्ञान

- परपोषी पादप प्रतिरोधिता अध्ययन द्वारा विविध कीट नाशक जीवों के प्रति 53 प्रविष्टियों और दाताओं को आशाजनक के रूप में पहचाना गया। फुदके के परीक्षण द्वारा कटक से पाँच प्रजनक वंशक्रमों और डी.आर.आर. में विकसित आर.पी.4918-230 एस (स्वर्णा ओ. निवारा) सहित छ: आशाजनक प्रविष्टियाँ पायी गयीं। गंगई (गालमिड्ज) परीक्षणों के द्वारा 7 आशाजनक प्रविष्टियाँ पहचानी गयीं और गंगई (गालमिड्ज) विशिष्ट परीक्षणों द्वारा 7 से 8 जीवसंख्या के प्रति आई.एन.आर.सी. 1997 और आई.एन.आर.सी.3021 की प्रतिरोधिता की पुष्टि की गयी। गालमिड्ज पर विषाक्तता संघटन अध्ययन द्वारा सकोली और पट्टांबी में जी.एम. और जी.एम 11 जीनों के विरुद्ध 50% से अधिक जीव संख्या विषाक्त पायी गयी।
- तना छेदक, पत्ता मोडक, भूरा फुदका, सफेद पीठवाला फुदका और आर्मी वर्म के नियंत्रण में बुप्रोफेजिन 20% + एसिफेट 50% डब्ल्यू.पी. (आर.आई.एल 049/एफ 1) से अंतर्विष्ट एक नया सम्मिश्र उत्पाद को 1000 ग्रा/हे की दर से प्रयोग करने पर प्रभावी पाया गया।

- तना छेदक और पत्ता मोडक से हानि धान की साधारण बोआई विधि की तुलना में सीधी रोपाई विधि में अधिक थी।
- तना छेदक प्रबंध के लिए हर 9 पंक्तियों के बाद एक सुप्रभाव्य किस्म (पूसा बासमति) की बोआई से मुख्य फसल में तना छेदक से हानि में कमी हुई।
- फुदके के प्रबंध के लिए पारिस्थितिकी इंजीनियरी (ई.ई.एम.पी.) पर परीक्षणों ने दर्शाया कि वीथिमार्गों से युक्त भूखण्डों में परभक्षी मिरिड बगों की सख्या में वृद्धि पायी गयी।
- संघटित नाशकजीव प्रबंध (आई.पी.एम.) मापांक के मायकरण पर कृषि क्षेत्रों पर नाशकजीव प्रबंध परीक्षणों में एकल रासायनिकों के प्रयोग द्वारा भूरे फुदका और गंगई (गालमिड्ज) जीव संख्या का प्रभावी नियंत्रण किया जा सकता है।

पादप रोग विज्ञान

- विविध परीक्षण संवर्धन-गृहों (एन.एस.एन 1, एन.एस.एन 2, एन.एस.एन.एच, एन.एच.एस.एन.) के अधीन प्रमुख रोगों के प्रति प्रतिरोधिता के लिए मूल्यांकित परीक्षण प्रविष्टियों में एक से अधिक रोगों के प्रति प्रतिरोधिता दर्शानेवाली प्रविष्टियॉ निम्नानुसार थीं : एन.एस.एन-1 में आई.ई.टी. 21660, आई.ई.टी. 21674, आई.ई.टी. 21693, आई.ई.टी. 21281, आई.ई.टी. 21289, आई.ई.टी. 21299, आई.ई.टी. 21300, आई.ई.टी. 20114, आई.ई.टी. 20923, आई.ई.टी. 20930, आई.ई.टी. 20935, आई.ई.टी. 21403, आई.ई.टी. 21404, आई.ई.टी. 21405, आई.ई.टी. 21413, आई.ई.टी. 21415, आई.ई.टी. 20884, आई.ई.टी. 21476, आई.ई.टी. 21478 और आई.ई.टी. 21477 एन.एस.एन-1 में आई.ई.टी. 21871, आई.ई.टी. 21872, आई.ई.टी. 21873, आई.ई.टी. 21354, आई.ई.टी. 21341, आई.ई.टी. 21342, आई.ई.टी. 21708ए आई.ई.टी. 21709, आई.ई.टी.21976, आई.ई.टी. 21967, आई.ई.टी. 21735, आई.ई.टी. 21946, आई.ई.टी. 21912, आई.ई.टी. 22179, आई.ई.टी. 22203, आई.ई.टी. 22221, आई.ई.टी. 22050, आई.ई.टी. 22051, एन.एस.एन.-एच. में आई.ई.टी. 21752, आई.ई.टी. 21756, आई.ई.टी. 20955, आई.ई.टी. 21740, आई.ई.टी. 21744, आई.ई.टी. 21375, आई.ई.टी. 21377, आई.ई.टी. 21378, आई.ई.टी. 21383 और आई.ई.टी. 21393: एन.एच.एस.एन. में आई.ई.टी. 21771, आई.ई.टी. 21800, आई.ई.टी. 21801, आई.ई.टी. 21811, आई.ई.टी. 21812, आई.ई.टी. 21817, आई.ई.टी. 21829, आई.ई.टी. 21832 और डी.एस.एन. में आर.पी.पैथों-2, आर.पी.पैथों-3, आर.पी.पैथों-5, आर.पी.पैथों-11, आर.पी.बायो पैथों-4, टेटेप, वी.एल.-31438, सी.आर.-2429-5ए सी.आर.-2430-10, सी.आर.-2428-6, सी.आर.-2450-2, सी.आर.-2437-31, सी.आर.-2430-11, सी.आर.-2450-23, सी.आर.-2428-9, दहरनगरा, सी.बी.-05-022, सी.बी.-06-135, सी.बी.-05-031, सी.बी.-07-103, सी.बी.-07-115, टी.एन.आर.एच.233, रासी, अजया, आर.टी.एन.आर.एच-10, रागोल (आर.जी.एल-7001) एवं आर.जी.एल-7002.
- पाँच रोगों यथा झोंका, पत्ता अंगमारी, जीवाणुज अंगमारी, भूरा धब्बा और टुंग्रो के प्रति प्रतिरोधिता के लिए देश के 11 स्थानों पर खरीफ, 2010 के दौरान 317 जननद्गव्य प्रतिष्टियों का परीक्षण किया गया। आशाजनक प्रविष्टियॉ थीं: एक्सेसन नं.4981,2485,3030,4599, 4805,247, 4063 ए, 242, 264, 2634, 3873 ए, 4042ए, 4059 ए, 4082, 4648, 4725, 245, 2298, 4113, 4899 और 256 (झोंके के लिए), एक्सेशन नं.232, 2595, 3689, 231,239, 2247, 2287, 4368, 4405,4535 और 5883 (पत्ता अंगमारी के लिए), एक्सेशन नं. 244, 2142, 2569बी, 2595, 2632, 2836, 4288, और 5103 (आर.टी.वी. के लिए), एक्सेशन नं.4498, और 4522 (भूरे धब्बे के लिए), एक्सेशन नं. 4981, 2485 और 4725 ने झोंका और जीवाणुज अंगमारी रोगों के प्रति प्रतिरोधिता दर्शायी। एक्सेशन नं.2595 ने पत्ता अंगमारी और धान टुंग्रो रोग के प्रति प्रतिरोधिता दर्शायी और 2247 ने पत्ता अंगमारी और भूरे धब्बे रोग के प्रति प्रतिरोधिता दर्शायी। केवल एक प्रविष्टि 4020 ने तीन रोगों जैसे झोंका, जीवाणुज अंगमारी और भूरे धब्बे के प्रति प्रतिरोधिता दर्शायी।
- झोंके की विषाक्तता पैटर्न के अनुवीक्षण के लिए विभिन्न बोआई तिथियों के साथ बाईस स्थानों में अंतर्राष्ट्रीय भेद दर्शी, आर.आई.एल, दाता और वाणिज्य संवर्धों के बच्चीस संवर्धों का मूल्यांकन किया गया।
- देश भर में 19 स्थानों में एक्स.ए-13 और एक्स ए.-21 के अलावा एकल जीनों में अधिकतम जीनों ने सुप्रभाव्य प्रतिक्रिया दर्शायी। रायपुर और पट्टांबी के सिवा सभी दो जनी वंशक्रम संयोगों ने प्रतिरोधी प्रतिक्रिया व्यक्त की। सभी स्थानों में तीन या चार जीनी वंशक्रमों के संयोगों ने नयी कि स्मों में उसी प्रकार के जीनों के पिरामिडिंग की उपयोगिता को सुझाते हुए प्रतिरोधी प्रतिक्रिया दर्शायी।
- रोग प्रेक्षण संवर्धन-गृह में खरीफ मौसम में, झोंका, भूरे धब्बे और पत्ता गलन जैसे विभिन्न रोगों की तीव्रता पिछेती बोआई फसलों में अधिक थी जबकि पत्ता अंगमारी ग्रस्तता अगेती बोआई फसलों में थोडी अधिक थी।
- अधिकतम स्थानों में पत्ता अंगमारी, भूरे धब्बे और पत्ता गलन की तीव्रता को कम करने में दो नये सूत्र याने हेक्साकोनाजोल 75 डब्ल्यू.जी. (आर.आई.एल-012 एफ1) और क्रेसेक्जिम मेथिल 40% + हेक्साकोनाजोल 8% डब्ल्यू.जी. (आर.आई.एल-068/एफ 148 डब्ल्यू.जी.) बडे प्रभावी थे। गला झोंका, कूटकलिका और पत्ता जला के प्रति क्रेसेक्जिम मिथिल 40% + हेक्साकोनाजोल 8% डब्ल्यू.जी. (आर.आई.एल-068/एफ 148 डब्ल्यू.जी.) के यौगिक पदार्थ बडा प्रभावी पाया गया।
- पत्ता अंगमारी, तना छेदक और पत्ता मोडक के प्रति हेक्साकोनाजोल की जैविक प्रभावोत्पादकता को हेक्साकोनाजोल (पत्ता अंगमारी के लिए प्रभावी तथा अनुमोदित कवकनाशी) और फलुबेंडामाइड (तना छेदक और पत्ता मोडक के प्रति प्रभावी तथा अनुमोदित कीटनाशक) का यौगिकों का प्रभाव नहीं पाया गया।
- कटक और पांडुचेरी आइसोलेट के लिए व्युत्पन्न राइस टुंग्रो बसिलिफाम वाइरस (आर.टी.बी.वी.) के ओ.आर.एफ-IV अनुक्रमों को भी एन.सी.बी.आई. डाटाबेस (एक्सेशन नं. एच.एम-149532 और एच.एम-149531) में प्रस्तुत किया गया। कटक, पांडुचेरी और हैदराबाद के आइसोलेट से आर.टी.बी.वी. के ओ.आर.एफ-1 अनुक्रमों को प्रवर्धित और कृंतकीकरण (क्लोण्ड) किया गया है।

अग्रणी अनुसंधान

जी.ई.वाई- सिंचित पारिस्थितिकी के लिए धान में उपज और तनाव प्रतिरोधिता संबंधी आनुवंशिक विकास

- स्वर्णा/ओ.लांगिस्टामिनेटा के आठ, नौ वंशक्रमों ने पत्ता अंगमारी के प्रति प्रतिरोधिता दर्ज की, 39 ओ. रुफिपोगोन. प्रविष्टियों, 18 जंगली धान की प्रविष्टियों 106123, 106265, 106087, 104760, 105909, 106123, 106477, 106285, आई.आर.जी.सी. 30615, आई.आर.जी.सी. 106136 और ओ. लांगिस्टेमिनेटा ने कोई राइस टुंग्रो वाइरल लक्षण नहीं दर्शाये।
- भूरे पत्ता अंगमारी (बी.एल.बी.) के प्रति प्रतिरोधिता के लिए एक्स.ए-5 और एक्स.ए-13 से भिन्न एक नये अप्रभावी जीन को ओ.लांगिस्टेमिनेटा से बी.पी.टी-5204 में प्रवेशित किया गया।
- एस.आर.ए.सी.34997 में एकल अप्रभावी जीन, बी.एम-72 में एकल प्रभावी जीन, आई.सी-346255 और ए.सी.सी.2148 में एक प्रभावी और एक अप्रभावी जीन, सी.आर-57, एम.आर-1523 तथा ए.सी.सी-2148 में अतिरिक्त अप्रभावी जीनों के प्रवेश ने भूरे फुदके के प्रति प्रतिरोधिता प्रदान की, जबकि आई.सी. 346255, ए.सी.सी.-2148 और .एस.आर.ए.सी.-34997 में एक एकल अप्रभावी जीन को सफेद पीठवाले फुदके की प्रतिरोधिता को नियंत्रण करने में सक्षम पाया गया है।
- सीधी रोपाई तथा बोआई की अवस्था में सबिता और अन्य प्रविष्टियाँ आई.आर-79906-बी-5-3-3, आई.आर-788575-बी1-बी-1-1, सी.आर-691-58 और बी-644 एफ.एम.आर-6-0-0 आशाजनक पायी गयीं। बोआई की अवस्था की तुलना में सीधी बीज रोपाई के अधीन अथिरा, स्वर्णप्रभा, एस-467, कलिंगा-II, एस-147, एस-194 आदि ने 10% उपज की श्रेष्ठता दर्शायी।
- सीधी रोपाई की अवस्था में अधिकतम उपज अभिलक्षणों और उपज संघटकों के लिए उच्च से मध्यम वंशागतता के साथ निम्न से उच्च आनुवंशिक विकास देखा गया।
- डब्ल्यू.ए-सी.एम.एस. के लिए जननक्षम प्रत्यावर्तक जीनों की पहचान के लिए जननद्गव्य 10 पर आर.एफ-4 के स्थान के लिए प्रत्याशी जीन चिह्नक एस.सी.-1246 तथा एस.एस.आर.चिह्नक एस.सी.390 और जननद्गव्य 1 पर चिह्नक एस.सी-364 तथा एस.सी.368 का विकास किया गया और 231 प्रसिद्ध प्रतयावर्तक वंशक्रमों का 91% दक्षता के साथ अनुसमर्थन किया गया।
- दानों की अच्छी गुणवत्ता और सफेद पीठवाले फुदके के प्रति प्रतिरोधी बीस संकर धान अनुरक्षकों की पहचान की गयी।
- 226 किस्मों के प्रजनक बीजों और 9 धान संकरों के पैतृक वंशक्रमों के उत्पादन के फलस्वरूप 4603, 95 क्विंटल लक्ष्य के खिलाफ 6095.01 क्विंटल प्रजनक बीजों का कुल उत्पादन प्राप्त किया गया।
- मार्गदर्शकों के अनुसार 86 रिफरेन्स किस्मों के साथ पंद्गह कैंडिडेट किस्मों, 28 रिफरेन्स किस्मों के साथ 8 फार्मर्स किस्मों और 11 रिफरेन्स किस्मों के साथ 6 एक्सटेंट किस्मों का परीक्षण किया गया और 29 आवश्यक तथा 33 अतिरिक्त डी.यू.एस. लक्षणों का लक्षण-वर्णन किया गया।
- 20 लक्षणों की पहचान के लिए एन.बी.पी.जी.आर. से प्राप्त 317 जननद्गव्य प्रविष्टियों की जाँच करके कृषि रूपात्मक लक्षण- वर्णन किया गया।
- खरीफ 2010 के दौरान 30 गुणात्मक तथा परिमाणात्मक लक्षणों के लिए जंगली जातियों की 20 प्रविष्टियों सहित 3200 जननद्गव्य प्रविष्टियों की जाँच की गयी और लक्षण वर्णन किया गया।
- सहभागी बीज उत्पादन के अधीन 15 गाँवों/ तांडों में 20 किसानों की पहचान की गयी और सुधरी सांबा मसूरी, कृष्ण हंसा, अक्षयधान, वरधान, संपदा, डी.आर.आर. धान 38, डी.आर.आर. धान 39 और सुगंधित धान के 1200 क्विंटल गुणवत्ता बीज का उत्पादन किया गया।
- धान जीनो प्रकारों में 9.00 टन उपज प्राप्त करने के लिए इष्टतम सोर्स और सिंक परिमाण क्रमश: 200 और 1400 पाया गया।

जी.ई.क्यू- देशी खपत और निर्यात के लिए आनुवंशिक गुणवत्ता विकास

- बासमति प्रजनक पदार्थ में पहचाने गये आशाजनक संकर निम्न प्रकार हैं- तरौरी बासमति/ पी.आर.2116, सुगंधमति/बासमति 217, आई.ई.टी-17280/टाइप-3, रणबीर बासमति/ आई.ई.टी-17920, आई.ई.टी-18022/ आई.ई.टी. 18297, वसुमति/ बी 95-1/ वसुमति2, टाइप-3/ पी.ए.यू-2888-3-2-1-1-1, तरौरी बासमति/बी 95-1, आई.ई.टी.-17280/ पूसा बासमति-1, गौरव/पी.जी.बी., बासमति कोटा/आई.ई.टी.-6311, 96380/ आई.ई.टी.16310, रणबीर बासमति/ आई.ई.टी.-17920 और आई.ई.टी.-17294/ यामिनि.
- समयुग्मनजी अवस्था में उन्नीस बीसी 1एफ8 वंशक्रमों में एक्स ए 21 एवं एक्स ए 24 वंशक्रमों और 8 वंशक्रमों में क्रमश: एक्स ए 21 या एक्स ए 13 निहित थे। इनमें बीसी 1एफ8 में 54 आशाजनक प्रविष्टियों की पहचान की गयी जबकि अन्य बीसी प्रजननों में 252 एकल पादपों का चयन (एस.पी.एस) और आगे के मूल्यांकन के लिए किया गया।
- छोटे और मोटे दानों के अर्थ बौनी, उच्च उपज क्षमता (>4.5 ट/हे) और भूरे धान में मध्यम अवधि, उच्च लोहा (3.12 मि.ग्रा./100 ग्रा.) और जस्त (4.0 मि.ग्रा./100 ग्रा) युक्त सांबा मसूरी/ चिट्टिमुत्यालू के संकर से व्युत्पन्न एक वंशक्रम की पहचान की गयी। इसके दानों के गुणवत्ता लक्षण अर्थात एच.आर.आर% (67.5%), मध्यम ए.एस.वी. (5.01), ए.सी. (24.05%) तथा मंद सुगंधित थे।

- भूरे धान में लोहा और जस्त के स्थानों के साथ केंडिडेट जीन संबद्ध थे। उनमें पीली धारी जैसे वाहक, जस्त परिवहन, जडआई.पी. (जडआर.टी/ आई.आर.टी संबंधी प्रोटीन) और एन.आर.ए.एम.पी. (सहज प्रतिरोधिता से संबद्ध माइक्रोफेज प्रोटीन) सम्मिलित थे।
- खरीफ 2010 के दौरझ्रिंन 15 भौतिक - रासायनिक लक्षणों दाने वाले धान के लक्षणों का निर्धारण किया गया। उनमें अनेक, विभिन्न गुणवत्ता प्राचलों के केलिए आशाजनक पाये गये जिनमें उच्च पूर्ण चावल की 188 प्रविष्टियाँ, मध्यम तथा वांछनीय मात्रा में अमाइलोस की 233, तेज सुगंधित की 179, पारभासी दोनों की 96, और सभी प्रविष्टियाँ 73.5 परिमाण विस्तार क्षमता की सम्मिलित थीं। उच्च पूर्ण चावल प्राप्ति के साथ और मध्यम अमाईलोस मात्रा से युक्त एक सौ इकसठ कृषिजोपजातियाँ दर्ज की गयीं।
- उपयोग किये गये 56 एस.एस.आर. चिह्नकों में से 27 ने 2-5 एलीलों को सम्मिलित करते हुए बहुरूपीयता दर्शाये। सादृश्य गुणांक के आधार पर यू.पी.ए.जी.एम.ए. का प्रयोग करते हुए किये गये सामूहिक विश्लेषण ने 96 सुगंधित सुगंधित छोटे दानों के धान को दो प्रमुख समूहों में विभाजित किया। समूह 1 में 60 जीनो प्रकार सम्मिलित थे जिन का 1ए, 1बी, 1डी तथा 1ई जैसे पाँच उप-समूहों में उप-वर्गीकरण किया गया, समूह II में 36 जीनो प्रकार सम्मिलित थे जिनका IIए, II बी, II सी तथा II डी जैसे चार उपसमूहों में उप-वर्गीकरण किया गया।

धान सुधार के लिए जैव-प्रौद्योगिकी का विकास और प्रयोग

- उपज वृद्धि के क्यू.टी.एल. के मानचित्रण के लिए ओ.रुफिपोगान, ओ.निवारा और ओ.मेरिडियोनालस का उपयोग करते हुए तीन जीवसंख्याओं का विकास किया गया। स्वर्णा, के.एम.आर-3 तथा बी.पी.टी.-5204 प्रापी वंशक्रमों में उपज संबंधी ट्रेइट में बहुत अधिक भिन्नता पायी गयी।
- ओ.निवारा से उपज क्यू.टी.एल.- क्यू.एल.डी.पी.-83 के अंश स्वर्णा/ ओ.निवारा प्रवेशित वंशक्रम आई.ई.टी.-21542 को ए.वी.टी-I आई.एम. में बहुस्थानीय परीक्षणों में आशाजनक पाया गया।
- क्रोमोसोम 2 पर ईशु-शर्करा फॉस्फेट सिंथेस जीन को बाली के ऊपरी अर्ध भाग के मुख्य शाखाओं पर दानों को भरने से महत्वपूर्ण रूप से संबद्ध पाया गया और क्रोमोसाम 11 पर वाहक जीन पर आधारित और एक सी.जी. चिह्नक को निचले अर्ध भाग की प्रधान शाखाओं, ऊपरी अर्ध भाग की गौण शाखाओं और बाली के निचले अर्ध भाग में दानों को भरने से संबद्ध पाया गया।
- हेटिरोसिस भविष्यवाणी के लिए उपयुक्त उच्च बहुरुपयी सूचना मूल्यों से समाविष्ट 12 हाइपरवेरियबुल एस.एस.आर. मार्कर के एक से (एच.आर.एम-12469, एच.आर.एम-20866, एच.आर.एम-11570, एच.आर.एम-16006, एच.आर.एम-24217, एच.आर.एम-23595, एच.आर.एम-24383, एच.आर.एम-18770, एच.आर.एम-25754, एच.आर.एम-16606, एच.आर.एम-6740 और एच.आर.एम-13131), की पहचान की गयी।
- श्वसन से संबद्ध माईटोखोंड्रिएल जीनों को लक्ष्य बनाते हुए ग्यारह प्राइमर जोडों ने डब्ल्यू.ए.- सी.एम.एस. के ए.पी.एम.एस 6 ए और उनके अनुरक्षक ए.पी.एम.एस 6बी वंशक्रम के बीच में बहुरूपिता दर्शायी गयी।
- ट्रेइट के लिए 30.7% लक्षण प्ररूपी (फेनोटाइपिक) योगदान देने वाले तापमान श्लेषीकरण (जी.टी.) के लिए प्रधान क्यू.टी.एल. की क्रोमोसाम 6 पर पहचान की गयी। 11.2% लक्षण प्ररूपी योगदान देने वाले एक क्यू.टी.एल. की भी क्रोमोसाम 8 पर पहचान की गयी।
- एस-381 के लिए निम्नतम लवणता ग्रहणशील सूचक का रिकार्ड दर्ज हुआ जिसके स्थान में 100 एम.एम.एन.ए.सी.एल पर 3-1 (के), 166 (एस) और 14 (के) थे। तनाव की अवस्था में सभी वंशक्रमों में अनाज उपज में कमी पायी गयी मगर 100 एम.एम.एन.ए.सी.एल पर एस-381, 166 (एस), 3-1 (के) और 14 (के) के लिए कम निरोधी पाये गये।
- पीले तना छेदक के प्रति उच्च् प्रतिरोधी ग्यारह आशाजनक सी.आर.वाई-1 एसी के साथ आई.आर 64 की पारजीनी टी-3 वंशक्रमों की पहचान की गयी यथा आई.सी. 5-4-20-2, ए.आई.सी. 3-2-81, ए.आई.सी. 3-2-8-3, ए.आई.सी. 3-5-27-1, ए.आई.सी. 2-6-3-1, ए.आई.सी.3-5-7-1, ए.आई.सी.3-5-7-3, ए.आई.सी.5-4-21-1 एवं ए.आई.सी.3-5-31-1। इन वंशक्रमों में डेड हार्ट और व्हाइट इयर्स न्यूनतम थे। चयनित वंशक्रमों को अंतर्विष्ट जैव-सुरक्षा मूल्यांकन के लिए पेश किये गये।
- तीन अलग-अलग परीक्षणों द्वारा बी.पी.टी-5204 की पृष्ठभूमि में आर.डी.29-एटी.डी.आर.ई.बी.1ए जीन के वाहक पारजीनी पादप को विकसित किया गया। शुष्क सहयता प्राचल के लिए टी-3 वंशक्रमों के शुष्कन प्रयोग ने दर्शाया कि उनमें से कुछ वंशक्रम पानी की निकासी के 14 दिनों के बाद भी शुष्कता के प्रति उच्च प्रतिरोधी हैं।

आर.यू.ई.- संसाधन एवं निवेश उपयोग दक्षता

- तीन जुताई प्रबंध प्रणालियों के अधीन यथा बिना पतवार से ढके शून्य जुताई पर शुष्क रोपण, 50% पतवार से ढके शून्य जुताई पर शुष्क रोपण और गीली जुताई की अवस्था में अंकुरित बीजों की सीधी रोपाई में अनाज की उपज में भिन्नता ज्यादा महत्वपूर्ण न थी (4.54 टन/हे. से 4.74 ट/हे.) जबकि किस्मीय भिन्नता महत्वपूर्ण थी।
- 50% पतवार ढकने के द्वारा शून्य जुताई पर शुष्क रोपण से 34,100 हे. अधिकतम शुद्ध लाभ तथा बी:सी अनुपात (2.86) दर्ज किया गया। इसके बाद के स्थान बिना पतवार ढके शून्य जुताई पर शुष्क रोपण से (रु.33,460/हे. तथा 2.62) और गीली

जुताई में अंकुरित बीजों की सीधी रोपाई से (रु 29,420/हे. तथा 1.63) दर्ज हुए।

- बोआई की पारंपरिक विधि में उच्च उपज सूचक मूल्यों की पहचान की गयी। कृषिजोपजाति की तुलना में फसल की स्थापना प्रणाली का स्थान महत्वपूर्ण पाया गया और 75% अर्जविक और 25% जैविक खाद के प्रयोग से महत्वपूर्ण स्तर पर उच्च अनाज की उपज (5.51 ट/हे.) पायी गयी। स्पष्ट नहीं था।
- चावल सघनीकरण प्रणाली (श्री) ने अधिकतम पोषक उपयोग दाता (क्रमश: नत्रजन, पोटाश और कैल्शियम के लिए 59,410 और 47 कि.ग्रा. दाने/कि.ग्रा. उद्ग्रहण किया।) दर्शायी। चावल स्धनीकरण प्रणाली (श्री) जैविकी और पारंपरिक प्रणाली की तुलना में क्रमश: एन, पी. तथा के. का उद्ग्रहण 51-56, 387-394 तथा 40-43 कि.ग्रा. दाने/कि.ग्रा. था।
- जैव चावल सघनीकरण प्रणाली (श्री), आर्गनिक कार्बन (1.39%) और मौजूद K_2O (565 कि.ग्रा./हे.) की मात्रा महत्वपूर्ण स्तर पर अधिक थे। इसके बाद के स्थान में चावल स्घनीकरण (श्री) (क्रमश: 1.21% और 444 कि.ग्रा./हे.) और पारंपरिक विधि (क्रमश: 1.14% और 350 कि.ग्रा./हे) में थे।
- पी.- उर्वरक के प्रयोग क कारण पाँच विशिष्ट विकास और अनाज उपज पैटर्न देखे गये। विस्तृत विवरण की आवश्यकता है।
- धान की किस्में आई.ई.टी-20716 और आई.ई.टी-20710 ने कम पी-स्थिति पर उच्च पी.सहयता दर्शायी और 0-पी स्थिति पर 2.69 से 3.03 ट/हे. की उच्च अनाज उपज दर्ज की गयी। फिर भी, 50-60 कि.ग्रा. P_2O_5/हे. के उच्च पी स्तर पर इन किस्मों ने लगभग 5.43-5.83 ट/हे. मात्र की उपज दर्ज की।
- धान की किस्में पी.ए.सी.-835, पी.ए.सी.-837, आई.ई.टी.-20727, आई.ई.टी.-20734, आई.ई.टी.-21298 और डी.आर.आर-एच-3 ने 0-पी (1.05-2.06 ट/हे.) के स्तर पर मध्यम निम्न पी सहयता दर्शायी, उन्होंने फिर भी, उच्च पी-स्तरों (5.81-7.02 ट/हे.) पर उच्चतम अनाज उपज दर्ज की। पी.ए.सी-835, पी.ए-6129, सी.एस.आर-3 ने उच्चतम अनाज उपज दर्ज की। पी.ए.सी-835, पी.ए-6129, सी.एस.आर-3 ने 10-20 कि.ग्रा. P_2O_5/हे. के निम्न पी. स्तरों पर 139.25, 218.83 कि.ग्रा. अनाज/ कि.ग्रा. P_2O_5की उच्च प्रतिक्रिया दर्ज की जबकि अन्य किस्मों ने निम्न मूल्यों (54.87-131.06 अनाज/कि.ग्रा. P_2O_5) को दर्ज किया।
- धान- मक्का प्रणाली ने रु.49,556/हे. का अधिकतम शुद्ध लाभ और 1.72 बी:ई अनुपात दर्ज किया जबकि धान-गेहूँ प्रणाली ने रु 37,253/हे और 1.33 बी:सी अनुपात दर्ज किया।
- वायुजीवी शुष्कभूमि जुताई अवस्था में छ: धान की किस्मों/ संकरों (तुलसी, राशि, कृष्ण हंसा, त्रिगुणा, के.आर.एच-2 और पी.ए-6201) का परीक्षण किया गया जिनमें के.आर.एच-2 ने 3.80 ट/हे. की अधिकतम अनाज की उजप दर्ज किया जिसके बाद का स्थान 3.68 ट/हे. उपज पर पी.ए.-6201 का था।

एस.एस.पी.धान प्रणाली उत्पादकता का टिकाऊपन

- जुताई (गिली जुताई तथा शुष्कभूमि जुताई) और सिंचाई के स्तरों (निरंतर जलमग्नता, 150 तथा 125% संचित पटल बाष्पण (सी.पी.ई) के समकक्ष सिंचाई के प्रति प्रतिक्रिया के लिए 16 जीनोप्रकारों के मूल्यांकन करते हुए रबी 2010 में किये गये एक क्षेत्र अध्ययन द्वारा पाया गया कि निरंतर जलमग्नता की अवस्था में शुष्कभूमि तुताई की तुलना में गीली जुताई से 30% उच्च उत्पादकता दर्ज हुई जबकि सिंचित जल की आपूर्ति (125-150% संचित पटल वाष्पण (सी.पी.ई)) में कमी के कारण उत्पादन में अंतराल कम हो गया।
- सीमित जल की आपूर्ति के अधीन गीली तुताई की अवस्था में जीनो प्रकारों में राशि, आई.आर-64, आई.आर-36 और अक्षयधान आशाजनक थे जबकि आई.ई.ई.टी.-19828 और धान संकर सहयाद्गि-3 ने वायुजीवी प्रणाली (शुष्कभूमि जुताई) के अधीन अच्छा प्रदर्शन किया। औसत जल उत्पादकता 3.3- 5.6 कि.ग्रा. अनाज/हे. थी जो नियंत्रित जल आपूर्ति द्वारा 36-44% कम सिंचाई के अधीन 900-1150 कि.ग्रा. अनाज की जल आवश्यकता में निवल घटाव था मगर 0.4-0.5 ट/हे. उपज की हानि हुई।
- रबी मौसम में निरंतर जलमग्नता के अधीन गहरे रिसाव द्वारा जल की हानि लगभग 690 और 350 मि.मी. थी जिसे नियंत्रित जल की आपूर्ति द्वारा परोक्ष रूप से न्यूनतम किया जा सकता था।
- एच.वाई.वी. (वरधान) के मामले में खरीफ मौसम (2010) में पोषक तत्वो के प्रयोग की प्रतिक्रिया केवल एन तक सीमित था। जबकि संकरों ने गीली जुताई तथा शुष्कभूमि जुताई दोनों अवस्थाओं में एन और के दानों के प्रयोग के लिए प्रतिक्रिया दर्शायी।
- उच्चतम उपज (वायुजीवी प्रणाली के अधीन 5.2 ट/हे.) पर पोषक उद्ग्रहण आवश्यकता 20.3, 7.6 और 25.9 कि.ग्रा./एन.पी.के/ट अनाज के स्तर पर फसल द्वारा 105, 40 और 136 कि.ग्रा/हे. एन पी.के. संचित पाए गए।
- दर्ज की गयी अनाज की उपज, जल की आवश्यकता और उसकी उत्पादकता के आधार पर, एच.वाइ.वी. वरधान के लिए बरसात के मौसम में चिकनी मिट्टी में 75% सी.पी.ई. के समकक्ष की सिंचाई इष्टतम प्रतीत हुआ है और अधिक उपजाऊ संकर (पी.ए-6444) के लिए उपज की हानि के बिना दोनों प्रणालियों के अधीन 75-100% सी.पी.ई. जल की आवश्यकता इष्टतम थी जबकि इसमें बचत सिंचित जल में लगभग 13-21 प्रतिशत थी।
- धान में जैविक कृषि पर पाँच साल के अध्ययन में जैविक कृषि के अधीन अनाज की उपज खरीफ में 5वीं फसल में और रबी में

10वीं फसल में अजैविक के तुलनात्मक स्तर तक गयी। जैविक खादों के प्रयोग से मृदा के भौतिक, रासायनिक एवं जैविक गुणधर्मों में महत्वपूर्ण सुधार पाया गया। मृदा गुणवत्ता सूचकों यथा पोषक, माइक्रोबाइल और समग्र टिकाऊपन के सूचक प्रणाली के द्वारा जो प्रयोग के अंत में जैविकों से 1.63 थी जबकि उर्वरकों के प्रयोग के खेतों में 1.33 थी।

- 2010 के बरसात के मौसम में एन उपयोग की दक्षता में जीनोप्रकार की परिवर्तिता पर एक अनुसंधान अध्ययन में उच्च उत्पादकता और मृदा एवं प्रयुक्त नत्रजन (100 कि.ग्रा.एन/हे.) की उच्च उपयोग क्षमता के साथ किस्में राशि (अगेती किस्म), वरधान, जया, तथा पी.ए-6444 (मध्यम अवधि की किस्में) और स्वर्णा (पिछेती परिपक्वता के समूह की किस्में श्रेष्ठ पायी गयीं।)
- कार्बन जीवाधार की उपयोग क्षमता की रूपरेखा का उपयोग करते हुए केरल के धान उगाये जाने वाले कुट्टनाड प्रांतों से संग्रहित प्रतिनिधिक अम्लीय लवण मृदाओं में मृदा-सूक्ष्म वनस्पति की अभिलाक्षणिक विविधता का अध्ययन किया गया। परीक्षित 31 कार्बन जीवाधारों (सबस्ट्रेट्स) में से सूक्ष्मजीवों ने 22 सबस्टेटों का उपयोग कर लिया। उन 22 सबस्ट्रेटों में 6 मोनोसैकेराइड, 5 डाईसैकेराइड, ट्राइसैकेराइड्स में हर एक में एक-एक,पोली सैकेराइड और कार्बोक्सिलेट के साथ-साथ 6 पोली आल्कोहॉल और 2 ग्लको पाइरानोसाइड भी सम्मिलित थे। सूक्ष्मजीवों की पर्याप्त मात्रा में उपस्थिति थी और वे समान रूप से वितरित थे जो विविध, स्वस्थ मृदा प्रणाली का सूचक (जातियों की समृद्धि 22, विविधता सूचक 08.14 और समानता 0.606) था।
- धान की उपज और नत्रजन उपयोग क्षमता पर विभिन्न नत्रजन उर्वरकों के स्रोत और कृषिजोपजातियों के प्रभाव पर एक अनुसंधान अध्ययन में यूरिया और डी.ए.पी. की तुलना में अमोनियम सल्फेट को उत्तम नत्रजन स्रोत के रूप में पाया गया।
- समृद्ध संकर के.आर.एच-2 और किस्म कृष्ण हंसा की उत्पादकता पर समृद्ध (एन तथा पी 10% की दर से) खाद (कृमि वनस्पतिक खाद, कुक्कुट खाद 5.0 ट/हे.की दर से) के प्रयोग के प्रभाव को खरीफ 2010 के दौरान मूल्यांकन के लिए खरीफ 2010 के दौरान किये गये अनुसंधान अध्ययन में समृद्ध खादों ने अनुमोदित उर्वरकों की मात्रा के बराबर प्रदर्शन किया।
- 2010 के बरसात के मौसम में छिडकाव सूत्रीकरण के रूप में एक नया जस्त स्रोत उत्पादक माइक्रोनाइज्ड जिंक आक्साइड की तुलना मानकीकृत स्रोत जिंक सल्फेट और चेलेटेड जिंक के साथ करते हुए मूल्यांकित किया गया। यह उत्पाद उसकी तुलना में समकक्ष या जिंक पोषक और धान उत्पादकता में सुधरे हुए रूप में आशाजनक पाया गया था।

सी.सी.आर- जलवायु परिवर्तन के प्रति फसल की प्रतिक्रिया का निर्धारण तथा प्रबंधन

- आवधिक तापमान तनाव अवस्था में आई.ई.टी. 20924, आई.ई.टी.20935, आई.ई.टी.20734, आई.ई.टी.20893, आई.ई.टी.20907 और आई.ई.टी.20905 में झिल्लिका की क्षति, पर्णहरित, प्रकाश संश्लेषण और जल संबंध और बालियों की शूकिका उर्वरता और पराग निषेचन जैसे शरीरक्रिया संबंधी प्रतिक्रियाएँ सापेक्ष रूप से उत्तम पायी गयीं।
- जलाभाव के तनाव से प्रकाश संश्लेषण, चालकल और वाष्पोत्सर्जन की दर में महत्वपूर्ण कमी पायी गयी और अक्षय धान और राशि में इन प्राचलों में महत्वपूर्ण पुनर्लाभ पाया गया। के 10.3% की दर से प्रयोग द्वारा जलाभाव के तनाव के अनुहरण द्वारा अक्षय धान, आई.ई.टी. 19830, आई.ई.टी.22029 और आई.ई.टी.22030 में शुष्क पदार्थ (डी.एम) पुन: संग्रहण (रीमोबिलाइजेशन) और उसकी सक्षमता की पुष्टि की गयी।

एच.आर.आई- कीटनाशक जवों के प्रति परपोषी पादप प्रतिरोधिता और उसका प्रबंध

- पादप-गृह अध्ययन में गंगई (गालमिड्ज) जैव प्रकार 4 और 4 एम के प्रति विभिन्न अ.भा.स.चा.सु.प. के राष्ट्रीय स्क्रीनिंग परीक्षणों और अन्य स्रोतों द्वारा छानबीन किये गये 1416 प्रजनक वंशक्रमों और और जननद्गव्य प्रविष्टियों में से क्रमश: 35, 30 और 45 प्रविष्टियों ने यथा आई.सी.114788, आई.एन.आर.सी.17459, आई.एन.आर.सी.17494 सभी तीन जैवे प्रकारों के प्रति प्रतिरोधिता दर्शायी। तीन संवर्ध आर.पी.4929-बीके, आर.पी.4930-बी.ए. और जीन पिरामिडिंग कार्यक्रम द्वारा व्युत्पन्न आर.पी.4930 भी सभी तीनों जैव प्रकारों के प्रति प्रतिरोधी पाये गये।
- तना छेदक के प्रति मूल्यांकित बीसी2एफ4 में आई.आर64/आई.आर75870-5-8-5-बी-1-बी (ओ.ग्लाबेरिमा से व्युत्पन्न) के 250 वंशक्रमों में से चार वंशक्रमों के लिए डेडहार्ट और व्याइट इयर डेमेज (<10% डी.एच और <5% डब्ल्यू.ई), 21 वंशक्रमों के निम्न डी.एच (<10% डी.एच) और 5.1-10% डब्ल्यू.ई. पाया गया।
- कांचघर में भूरे फुदके (बी.पी.एच) के प्रति 2400 प्रविष्टियों का मूल्यांकन किया गया जिनमें आई.ई.टी. 21616, 21617, 22064, 22158, 22129, 21725, 22203, 22163, आर.आई.एल 8-188, सी.आर 2711-76, एन.डब्ल्यू.ज.आर-4105, सी.आर 2711-139 और सी.आर 2711-149 सहित 19 प्रविष्टियाँ और स्वर्णा x ओरिजा निवारा के 6 प्रवेशित वंशक्रम आशाजनक पाये गये जबकि सफेद पीठवाले फुदके के प्रति एक हजार नौ सौ बहत्तर प्रविष्टियों का मूल्यांकन किया गया और आई.ई.टी-20694, 20780, 20990, 21108, 20698, 20775, 19470, 20328, 20874, 20873, 20835, 21151, 20906, 21071, 20991, 20994, 21109, 21110, 20124, 21094,

20370, 21232, 21235, 21214, 21194 सहित 40 प्रविष्टियों और सी.ई260 ने 3.0 से कम क्षति अंक दर्शाया।

- दोनों फुदकों के प्रति मूल्यांकित सात सौ तीस जननद्गव्य प्रविष्टियों में से दस प्रविष्टियाँ यथा, ए.सी.सी. नं.4656, 4368, 4647, 4567, 3164, 3681, 4339, 3767 बी, 4067 और 5345 भूरे फुदके के प्रति आशाजनक पायी गयीं और 5 प्रविष्टियाँ यथा, 2658, 4288, 3328, 3338 और 3627 सफेद पीठवाले फुदके के प्रति <3.0 क्षति अंक के साथ आशाजनक पायी गयीं।

एच.आर.पी- रोगजनकों के प्रति परपोशी पादपों की प्रतिरोधिता और उनका प्रबंध

- पत्ता झोंका के प्रति प्रतिरोधिता के लिए यूनीफाम ब्लासट नर्सीरी बेड पर मूल्यांकित 2153 धान के वंशक्रमों में से 235 वंशक्रम झोका रोग के प्रति प्रतिरोधी पाये गये।
- पत्ती झोंका के प्रति प्रतिरोधिता के लिए खरीफ 2010 में यूनिफाम ब्लास्ट नर्सरी (यू.बी.एन) में छानबीन की गयी 317 जननद्गव्य प्रविष्टियों में से प्रविष्टियों 4981, 2485 और 4725 ने पत्ता झोंका और जीवाणुज पत्ता अंगमारी रोगों के प्रति प्रतिरोधिता दर्शायी। प्रविष्टि 2595 ने पत्ता अंगमारी और राइस टुंग्रो रोग के प्रति प्रतिरोधिता दर्शायी जबकि 2247 ने पत्ता अंगमारी और भूरे धब्बे के प्रति प्रतिरोधिता दर्शायी। प्रविष्टि 4020 ने तीन रोगों- झोंका, जीवाणुज अंगमारी और भूरे धब्बे के प्रति प्रतिरोधिता दर्शायी।
- 2009 के दौरान जीवाणुज अंगमारी के प्रति आशाजनक पायी गयी अडतालीस जननद्गव्य प्रविष्टियों को दो भिन्न आईसोलेट (पंतनगर से डी.एक्स-200 और आंध्र प्रदेश से डी.एक्स-161) और चार प्रविष्टियाँ यथा, 36311, 346884, 352833 तथा 334179 के साथ पुन: मूल्यांकित किये जाने पर दोनों जीवाणुज अंगमारी (बी.बी.) के प्रति अन्होंने उच्च प्रतिरोधिता दर्शायी।
- 2009 के दौरान सारे भारत में विभिन्न स्थानों पर राष्ट्रीय छानबीन नर्सरी में आशाजनक पायी गयी इकतालीस प्रविष्टियों को एकत्रित कर, काँचघर की अवस्था में जीवाणुज अंगमारी रोगजनकों के बहु (4) आईसोलेट के साथ पुन: मूल्यांकित किया गया। इनमें एन.एस.एन-1 से चार प्रविष्टयाँ और एन.एस.एन-2 से 6 प्रविष्टियाँ आशाजनक पायी गयीं।
- जीवाणुज अंगमारी प्रतिरोधिता के लिए के.एम.आर-3 और ओरिजा रुफिपोगान के बीच संकरों से पायी गयी दो सौ तीस प्रविष्टियों, स्वर्णा और ओ. निवारा से 85 प्रविष्टियों (के वंशक्रम) की काँच घर में छानबीन की गयी। एक प्रविष्टि (अंक 3) अत्यधिक प्रतिरोधी और अन्य 3 मध्यम स्तर पर प्रतिरोधी (अंक 5) पायी गयीं। स्वर्णा और ओ.निवारा संकरों की प्रविष्टियों में से एस वंशक्रमों में 5 और के वंशक्रमों में 13 प्रविष्टियाँ आशाजनक पायी गयी।
- कांच घर में टुंग्रो विषाणु रोग के प्रति इकहत्तर ओरिजा रुफिपोगान प्रविष्टियों की छानबीन की गयी और 39 प्रविष्टियों ने टीका लगाने के बाद 15 दिनों तक कोई विषाणुक लक्षणों को नहीं दर्शाया। 18 प्रविष्टियों ने टीका लगाने के 30 दिनों के बाद भी कोई लक्षण नहीं देखा गया। इनमें केवल 12 प्रविष्टियों (यथा 106123, 106265, 106087, 104760, 105909, 106123, 106477, 106285, आई.आर.जी.सी. 30615, आई.आर.जी.सी. 106136 और एक ओ.लांगिस्टेमिनेटा प्रविष्टि) ने प्राथमिक छानबीन में विषाणुक कणिका की अनुपस्थिति दर्शायी। बाकी प्रविष्टियों में विशिष्ट टुंग्रो रोग लक्षणों को नहीं पाया गया लेकिन आर.टी.बी.वी. की उपस्थिति के लक्षणों को दर्शाया।

आई.पी.एम- समेकित नाशकजीव प्रबंध

- एक बूँद (गीला करना और सहौषध बेधना) के प्रभाव पर अध्ययनों से उस पदार्थ के 200 मि.ली. को टैंक मिक्स के रूप में जोडने से फुदकों के प्रति बुप्रोफेजिन और झोंका रोग के प्रति ट्राईसाईक्लोजोल की स्थायी विषाक्तता में वृद्धि पायी गयी।
- जैव विविधता पर घासपातनाशी और उर्वरक प्रयोग प्रणाली के प्रभाव पर अध्ययनों ने प्रदर्शित किया कि निम्नतम पोष स्तर डाफिनया पर घासपातनाशी के प्रयोग का प्रभाव था और उसके बाद के प्रभावित स्थान में चिरोनोमिड् थे। फोस्पोकंपोस्ट उपचार किये गये भूखंडों पर विविधता के लिए शानोन सूचक (1.48) अधिकतम था और अनिलोफोस उपचार के भूखण्डों पर निम्नतम (1.08) था।
- पत्ता मोडक की गतिकी- परपोषी पादप- कीटनाशक अन्योग्य क्रिया पर क्षेत्र स्तरीय अध्ययन में पाया गया कि नियो-निकोटिनाइड उपचार में इल्ली की कालावधि कम हो गयी और इन कीटनाशकों के छिडकाव ने पत्ता मोडक प्रौढों के जम जाने के बर्ताव पर कोई असर नहीं था।
- 25 पी.पी.एम. विषैले सांद्गण पर विभिन्न धान पारिस्थितिकियों से संगृहीत सत्रह बी.टी. आइसोलेट ने 48 एच अवधि में 100% के लिए 18.8 के स्तर पर पत्ता मोडक इल्लियों की मृत्यु दर दर्शायी।
- लुधियाना, कपुर्तला, कौल, कर्नाल, मेरठ, नगीना और पंतनगर से संगृहीत रोगजनक कूट कलिका फंगस आइसोलेट ने रोगजनकों की उपस्थिति की पुष्टि की इनकी पुष्टि डी.एन. एक्स्ट्रेक्सन के द्वारा सी.टी.ए.बी विधि द्वारा की गयी। विशिष्ट आई.टी.एस. प्राइमर युस्टिलागिनाडिया वाइरेन के साथ सक्रिय विकासशील माइसिलियन से डी.एन.ए. रोग निर्धारण और पुष्टि के लिए निकाला गया।
- पत्ता झोंका तीव्रता, गला झोंका क्षति को नियंत्रित करने और अनाज की उपज को बढाने के लिए सभी तीनों मात्राओं (180+40, 225+50 और 270+60 ग्रा.ए.आई/हे.) पर परीक्षित कवकनाशी आई.सी.एफ-110 महत्वपूर्ण रूप से प्रभावी पायी गयी।

- जीवाणुज प्रयोगों में तीनों वैटामिन (थियामिन हाइड्रोक्लोराइड, पैरीडोक्सैन-हाइड्रोक्लोराइड और निकोटिनिक अम्ल) और उनके सम्मिश्रण को प्रभावी पाया गया। तीन वैटामिन (हर एक 10 एम.एम.) को सब से उत्तम पाया गया और उसके बाद का स्थान निकोटिनिक एसिड (50 एम.एम.) का था।
- पादप गोलकृमि पर अध्ययन से पाया गया नवगाँव से संगृहीत सी.वी. गुर्जरी बालियों में गोलकृमि लदान >50 गोलकृमि/5 बीज के साथ वंगबल, बारापानी और नवगाँव प्रांतों से संगृहीत बालियों में सफेदनोक गोलकृमि की उपस्थिति थी। संक्रमित बीजों से पौध घर में उगाये गये पादपों में विशिष्ट सफेद नोक लक्षणों का प्रदर्शन किया।
- मूलगांठ गोलकृमि एम. ग्रमिनिकोला के पैस्चूरिया पेनेट्रान (आईसोलेट पी.एम.आई-1) बीजाणु के लिए संक्रामकता के प्रेक्षण से दर्शाया गया कि द्वितीय चरण किशोर उपत्वचा (जे2) के साथ शीघ्र संबद्ध जीवाणुज बीजाणु (22.46 बीजाणु/जे2) और धान के पौधों में बाधाग्रस्त बीजाणुओं जे2 को टीका लगाने से गोलकृमि के अंदर जीवाणुओं की बढोत्तरी हुई जिसके फलस्वरूप बीजाणु पूरित मादा का गठन होता है।
- द्विबीज (टोमाटो) और एकबीज (धान) परपोषियों में मूलगाँठ नेमोटोड एम.ग्रामिनिकोला और एम.इनकोग्निटा की दो जातियों के संकर संदूषण और अंडनिक्षेपण के बर्ताव से प्रदर्षित हुआ था कि गाल की संख्या तथा आकार टोमाटो की तुलना में धान में कम/ छोटा था।
- धान (मेलोइडोजीन ग्रामिनिकोला) तथा टोमाटो (एम.इनकोग्निटा) और सफेद नोक वाले गोलकृमि (अफेलेनखोइड्स बेसेई) से संगृहीत मूलगाँठ की जीव संख्या आण्विक लक्ष्ज़ण वर्णन से पाया गया कि जीन बैंक में प्रविष्टियों की संबंधित जातियों के डी.एन.ए. अनुकम के साथ इन गोलकृमि जीव संख्या राइबोसोमल जीन (18 एस, 5.8एस और 26 एस) के आई.टी.एस. क्षेत्र के डी.एन.ए. अनुक्रमों ने 98-100% सहधर्मिता दर्शायी जिससे उनकी जाति पहचान की पुष्टि मिली।
- संगरोध गोल कृमि पर अनुसंधान से पता चला कि इस वर्षा के दौरान निर्यात किये गये कुल 10449 धान बीज नमूनों में से 1565 नमूनों में सफेद नोकवाले गोलकृमि अफेलेनखोइड्स बेसेई मौजूद था।
- परिवेशी तथा उत्थापित सी.ओर (700 पी.पी.एम.), बिना कोई छत के कक्षें (ओ.टी.सी) में बढाये गये पौधों के बीच गोलकृमि के व्यापन मं कोई महत्वपूर्ण अंतर नहीं पाया गया।
- खेती की प्रणालियों के प्रभाव पर अध्ययन से देखा गया कि चावल सघनीकरण प्रणाली (श्री) के अधीन पादप परजीवी गोलकृमि जीवसंख्या अधिक थी लेकिन रासायनिक उर्वरकों के प्रयोग के भूखण्डों की तुलना में जैविक-श्री के भूखण्डों में कम थी।
- क्षेत्र अनुभव ने दर्शाया कि बूटिंग अवस्था में चार कीटरोग जनक गोलकृमि आइसोलेट (स्टेइनेरनेमा एसियाटिकम, एस.ग्लासेरी, हेटेरोर्हीष्डिटिस इंडिका और ओस्यिअस एस.पी.) 1x105 की दर से संदूषित किशोर/एम2 की प्रयुक्ति से पीले तना छेदक के कारण व्हाइट इयर का प्रभाव महत्वपूर्ण रूप से कम था।
- पाँच ई.पी.एन.आइसोलेट्स (स्टेइनेरनेमा एसिया टिकाऊ, एस.थेर्मोफिलम, एसग्लासेरी, ओस्चेलिअस एस.पी. और हेटेरोरहब्डिटिस इंडिका) का प्रयोग संदूषण किशोर/एम2 1x105 की दर से करने पर पौधा घर में हरे फुदके की मुत्य महत्वपूर्ण ढंग से अधिक हुई। अनुपचारित नियंत्रण की तुलना में स्टेइनेरनेमा थेर्मोफिलम, एस.ग्लासेरी और हेटेरोरहब्डिटिस इंडिका आइसोलेट के प्रयोग से भी महत्वपूर्ण स्तर पर भूरे फुदके कीटों की मृत्यु अधिक हुई।
- ई.पी.एन. के बडे परिमाण में उत्पादन के प्रीाव पर अध्ययन ने सूचित किया कि इन विवो उत्पादन प्रणाली में संदूषित किशोर उत्पादन पर आरंभिक टीकों का गल्लेरिया मेल्लोनेल्ला इल्लियों पर प्रभाव था। परीक्षित दोनों ई.पी.एन. (स्टेइनेरने या थेर्मोफिल्म और हेटेरोहब्डिटिस इंडिका) जातियों के लिए 25 से 100 आई.जे/कीट इल्लियाँ से संतति तक टीकों की मात्रा को बढाने से प्रतिकीट इल्लियों से संतति का उत्पादन बढते गया। नमूने गोलकृमि केनोर्हब्डिटिस एलिगन्स के संवर्धन और अनुरक्षण के लिए सामान्य तौर पर प्रयुक्त माध्यम गोलकृमि माध्यम (एन.जी.एम) ने उसकी वृद्धि और निकटता से संबद्ध ई.पी.एन., ओस्चिअस एस.पी. के गुणन में समर्थन दिया और संतति का उत्पादन टीका लगाने के चार दिनों के अंदर पाया गया।

टी.टी.आई- प्रशिक्षण, प्रौद्योगिकी हस्तातंरण के प्रभाव विश्लेषण

- धान की खेती में समेकित नाशकजीव प्रबंधन (स.ना.प्र) की जानकारी पर अध्ययन से पाया गया कि अस्सी प्रतिशत किसानों द्वारा स.ना.प्र. के एक या दो संघटकों का प्रयोग किया जाता है। सत्तर प्रतिशत किसान प्रतिरोधी किस्मों के बारे में नहीं जानते हैं और चालीस प्रतिशत किसान सहज शत्रुओं के बारे में जानते हैं जिनमें केवल 20-30% किसान ही उन्हें पहचान सकते हैं। अधिकतम किसान कीटनाशकों के विषाक्त प्रभाव के बारे में नहीं जानते हैं।
- धान की खेती की प्रणाली में टिकाऊपन पर अध्ययन से पता चला कि निरंतर एक ही किस्म के उपयोग, अजैविक उर्वरकों के असंतुलित प्रयोग, वैज्ञानिक जल प्रबंध प्रक्रिया का प्रयोग नहीं करना, समस्यात्मक मृदाओं के प्रति ध्यान और गोबर एवं हरी खाद के उपयोग की अपर्याप्तता, रासायनिक नाशीजीव-मारकों का अत्यधिक प्रयोग, मृदाओं के सुधार का प्रयास न करना, किराये का श्रम, काश्तकारी कृषि तथा सूचना और आत्मनिर्भरता के

अभाव के कारण टिकाऊ कृषि प्रणालियों का अंगीकरण निम्न स्तर पर है।

- लर्न राइस-मूडेल एक बहु-आयामी ई.लर्निंग प्लाटफाम है जिसे मूडेल प्लाटफाम में विकसित किया गया है। इसके लिए कुल 12 ई.लर्निंग पाठ्यक्रमों का विकास अंग्रेजी में किया गया और इस ई.लर्निंग प्लाटफाम का संचालन 2011-12 के दौरान किया जायेगा।
- भागीदारी विधि के अधीन अपनायी यगी विभिन्न धान अनुसंधान परियोजनाओं के सामान्य लाभ/ उद्देश्य ये पाये गये कि आनुवंशिक पदार्थों के विनिमय, मूल्यांकन, विमोचन तथा उपयोग, धान प्रौद्योगिकियों का अंगीकरण तथा प्रसार, संसाधन बॉाट लेना तथा सूचना के आदान-प्रदान के लिए थे। राष्ट्रीय स्तर के धान सहभागी परियोजनाओं के संबंध में डी.आर.आर. के सहभागी परियोजनाओं पर लिहाज किया जायेगा जो बीज उत्पादन और विपणन के लिए लक्षित थे।
- बाह्यनिधिक जैव प्रौद्योगिकी विभाग (डी.बी.टी.) परियोजना के अधीन कुछ चयनित तांडाओं और गाँवों में 59 हितकारी किसानों को सम्मिलित करते हुए वेर्मीकंपोस्ट इकाइयों की स्थापना की गयी और बीज उत्पादन, समेकित पेस्टनाशी प्रबंध (आई.पी.एम) और समेकित पोषक प्रबंध (आई.एन.एम.) क्रिया विधि को अपनाना, किस्मीय प्रदर्शन जैविक और जैव प्रौद्योगिकी विधियों और संकर बीज उत्पादन जैसे उपयोगी प्रौद्योगिकी के व्यावहारिक प्रयोग को अपनाये गये।
- राष्ट्रीय कृषि अभिनव परियोजना (एन.ए.आई.पी.) निधिक आर.के.एम.पी. के अधीन लगभग 2500 रीयूजबुल लर्निंग ओब्जेकट्स (आर.एल.ओ), धान के विभिन्न पक्षों पर 12 उपागम लेख, 15 राज्यों से संबंधित 15 स्टेट्स पेपर्स, 12 ई-लर्निंग पाठ्यक्रम और अनेक मंच जैसे आर.के.एम.पी. वेबसाइट, मूडेल में ई-लर्निंग, जावा में ई-लर्निंग (लर्न राईस), जूमला में ई-लर्निंग कम्युनिटीस ऑफ प्राक्टीस (सी.ओ.पी), रिकीपेडिया, डी.आर.आर. के प्रशिक्षण डाटा बेस प्रबंध पद्धति, www.ear_rkmp.in, www.13r.in विकसित किये गये।
- धान उत्पादन प्रौद्योगिकी संबंधी विभिन्न पक्षों पर दस प्रशिक्षण कार्यक्रमों की योजना बनायी गयी उनका आयोजित और मूल्यांकन किया गया जिनके द्वारा 247 व्यक्तियों को प्रशिक्षित किया गया। ज्ञान प्रबंधन, उपकरण, ज्ञान प्रबंधन सहयोग, विषयवस्तु विकास पर धान संबंधी ज्ञान प्रबंधन पोर्टल के एक अंग के रूप में पंद्गह कार्यशालाओं का आयोजन किया गया।
- देश के 18 राज्यों और छः धान पारिस्थितिकियों को सम्मिलित करते हुए विभिन्न धान उत्पादन प्रौद्योकियों को मूल्यांकित करने और प्रदर्शित करने के लिए 700 एफ.एल.डी. का आयोजन किया गया। आंध्र प्रदेश, तमिल नाडु, उत्तर प्रदेश राज्यों में सुधरी सांबा मसूरी, अक्षय धान और संपदा जैसी डी.आर.आर. किस्मों पर कृषि क्षेत्र स्तरीय (आन फाम) परीक्षण किये गये।

Executive Summary

Coordinated Research

Crop Improvement

- Thirty six varieties were notified for general cultivation by the Central Sub-Committee on Crop Standards, Notification and Release of Varieties. Among these, 6 varieties *viz.,* IGKVR 1, IGKVR 2, Chinsurah Rice 1, CR Dhan 501, CR Dhan 601 and RC Maniphou 1 and 5 hybrids *viz.,* INDAM 200-017, US 312, 27P 11, CRHR 32 and Rajalaxmi were the central releases, while 25 varieties were released by different State Variety Release Committees in 8 states.
- Variety Identification Committee identified IET 19972 (SJR 5), IET 20220 (CR 2285-6-6-3-1), IET 20827 (MAUB 171), IET 20716 (VNR 204) and IET 20735 (VNR 202) for different ecosystems.
- In three year (2008-10) testing, 25 cultures including 4 hybrids were found promising for different ecosystems.
- Twelve hybrids *viz.*, US 314, 26P27, HRI 172, NK 6303, RH 09011, ARRH 3626, KPH-272, XR 97939, XR 99982, US 305, KPH 199 and XR 97747 were found promising on the basis of overall mean yield advantage over the respective best checks in different trials.

Crop Production

Agronomy

- In 260 experiments conducted at 54 locations, elite genotypes (72 AVT-2 culture) belonging to 17 groups were tested for their N use efficiency and 12 promising cultures were identified.
- Growing of rice + sun hemp (intercropping and incorporation) along with nutrient schedule of 60:40:40:500 or 60:60:40:500 N:P:K:Lime kg/ha and foliar spray of 0.5.% $ZnSO_4$ was found promising for enhancing grain yield as well as soil health under rainfed upland ecosystem.
- Bensulfuron-methyl+pretilachlor (post-planting) in conjunction with glyphosate (pre-planting) recorded best broad spectrum weed control in transplanted rice.
- Application of 100-125% nitrogen+pre-emergence herbicide application+Rice: Dhaincha (1:1) + hand weeding at 60 DAS or 2,4 D-Na application at 25-30 DAS was found promising for aerobic rice.
- Weedy rice problem was moderate to severe in Varanasi, Jagdalpur, Ranchi and Chatha areas. In Varanasi and Jagdalpur area, the problem was more in dry seeded rice, while in Ranchi and Chatha it was more in transplanted rice.
- Dry seeding of rice *(Kharif)* and maize *(Rabi)* under dry seeding with 50% mulch and location specific varieties of Rice and Maize was found more profitable system than dry seeding without mulch or wet seeding under puddled condition.

Soil science

- The 22nd year of study conducted at 3 locations (Mandya, Maruteru and Titabar) indicated significant improvement in rice productivity, nutrient accumulation and soil fertility with the incorporation of 5 tonnes / ha of FYM in addition to recommended fertilizer dose (100% NPKZnS) in all the locations and with the substitution of 50% NPK by FYM at Mandya.
- Rice productivity improved @ 11 – 251 kg grain /ha/year or remained stable in the Godavari delta system (Maruteru) with all treatments except those without P and K, while it declined in Assam valley (Titabar) @ 2-39 kg/ha/year, and more intensely in the plateau region (Mandya) @ 15 – 107 kg/ha/year and improved

with FYM as supplementary or substitution dose (INM)

- Selected studies in farmers fields revealed considerable site variations in soil nutrient supply, rice productivity, nutrient requirement, use efficiency and fertilizer recommendations for target yields of 6.5 t/ha at Titabar (32 - 84 kg N, 15-28 kg P_2O_5 and 17 – 44 kg K_2O / ha) as against the blanket RDF of 40:20:20 NPK/ha. At Mandya, it varied from 67-86 kg N, 28-48 kg P_2O_5 and 42 – 88 kg K_2O / ha compared to 100:50:50 NPK/ha for target yield of 6.4 t/ha. Site specific nutrient management (SSNM) was superior to the currently recommended blanket fertilizer dose and farmers' fertilizer practices.
- Screening of 185 cultures across 11 locations revealed location specific promising cultures for high Fe and Zn content such as Njavara group at Moncompu, Pathani 23 and Jodumani from Karaikal, swarna sub 1 at Kanpur, Bhutmuri at Bankura and few NDR and scented cultures at Faizabad and Khudwani, respectively. There was no significant relationship between Zn and Fe content and grain yield.
- The study on nutrient and water requirement for aerobic rice (non-puddled, direct sown and near saturated field water regime) indicated significant response to only N at DRR and for N and P at Kanpur. Water productivity (kg grain / mm water used) ranged from 3.9 to 4.8 kg grain and irrigation equivalent to 100% of cumulative pan evaporation (CPE) appeared to be optimum for aerobic rice system without yield loss.
- The fourth year results on screening of rice genotypes for acid soils in lowland rice ecosystem at Titabar (Assam) and Ranchi (Jharkhand) indicated variable genotype response to lime application and Fe toxicity stress. Doubling the dose of P and K improved crop P and K nutrition at Titabar. IET 10016, WL 21, Jaya, IET 20974 and IET 21519 were promising for acid soils at Titabar, while IET 21528, IET 21531 and IET21519 produced higher grain yields at Ranchi.

Physiology

- In a study on photothermic indexing, there were no significant differences in terms of earliness in flowering, CDD, CNP, biomass, and grain yield between the two sets of sowing dates.
- Based on the data on spikelet sterility, high density grains and yield it was found that IET 20979, IET 21114, and IET 21519 showed a positive response to boron application @ 0.4 ppm across the locations.
- In a study for screening elite lines for drought tolerance, twenty one cultures along with PA 6129 and Annada, it was found that IET 20708 and IET 20710 recorded high grain yield at four and three locations respectively under dry spell, while IET 21281 and IET 21076 were drought susceptible at four and three locations respectively.
- Introgression of sub I gene for submergence tolerance improved the survival percentage, recovery and yield.
- The mean RUE recorded for all genotypes across locations was 0.33. IET 21429 and Lalat had minimum radiation use efficiency at maturity, and IET 20884 had maximum radiation use efficiency of 0.37.

Crop Protection

Entomology

- Host plant resistance studies identified 53 entries and 8 donors as promising against various insect pests. Planthopper screening revealed six promising entries including fives

breeding lines from Cuttack and RP 4918 – 230S (Swarna/*O.nivara*) developed at DRR. Gall midge screening trial identified 7 promising entries and gall midge special screening trial confirmed resistance in INRC 1997 and INRC 3021 against 7 to 8 populations. Virulence composition study on gall midge revealed more than 50% of the populations to be virulent against *Gm4* and *Gm11* genes, at Sakoli and Pattambi.

- A new combination product containing Buprofezin 20% + Acephate 50% WP (RIL-049/F1) applied @ 1000 g/ha was effective against stem borer, leaf folder, BPH, WBPH and army worm, besides registering higher grain yields
- The trial on influence of rice cultivation systems on insect pest incidence (IRCP) trial revealed higher damage of stem borer and leaf folder in direct seeded rice compared to normal transplanting method.
- The study on effect of organic manures on pest incidence (EOMP) showed that recommended fertilizer dose treatment resulted in highest grain yield despite high pest pressure and damage.
- The trial on Trap crop for stem borer management (TCSB) confirmed that planting one row of susceptible aromatic variety after every 9 rows resulted in significantly less stem borer damage in main crop.
- The trial on Ecological engineering for management of planthoppers (EEMP) showed an increase in numbers of predatory mirid bugs in plots with alleyways but no significant differences due to enhanced floral diversity.
- On-farm pest management trial on validation of IPM modules revealed that BPH and gall midge populations could be managed effectively with single need based application of chemicals.

Plant Pathology

- Among the test entries evaluated for resistance against major diseases under various screening nurseries (NSN 1, NSN 2, NSNH, NHSN and DSN) the entries showing resistance to more than one disease were: IET 21660, IET 21674, IET 21693, IET 21281, IET 21289, IET 21299, IET 21300, IET 20114, IET 20923, IET 20930, IET 20935, IET 21403, IET 21404, IET 21405, IET 21413, IET 21415, IET 20884, IET 21476, IET 21478 and IET 21477. **in NSN1;** IET 21871, IET 21872, IET 21873, IET 21354, IET 21341, IET 21342, IET 21708, IET 21709, IET 21976, IET 21967, IET 21735, IET 21946, IET 21912, IET 22179, IET 22203, IET 22221, IET 22050 and IET 22051 **in NSN 2;** IET 21752, IET 21756, IET 20955, IET 21740, IET 21744, IET 21375, IET 21377, IET 21378, IET 21383, and IET 21393 in **NSN H;** IET 21771, IET 21800, IET 21801, IET 21811, IET 21812, IET 21817, IET 21829 and IET 21832 **in NHSN** and RP Patho-2, RP Patho-3, RP Patho-5, RP Patho-11, RP Bio Patho-4, Tetep, VL- 31438, CR 2429-5, CR 2430-10, CR 2428-6, CR 2450-2, CR 2437-31, CR 2430-11, CR 2450-23, CR 2428-9, Daharnagra, CB 05-022, CB 06-135, CB 05-031, CB 07-103,CB 07-115, TNRH 233, Rasi, Ajaya, RTNRH -10, Ragole- (RGL-7001) and RGL-7002 in **DSN.**
- Three hundred and seventeen germplasm accessions were screened in *Kharif*, 2010 for resistance against five diseases, *viz*., blast, sheath blight, bacterial blight, brown spot and tungro at 11 locations in the country. The promising accessions were: Acc. Nos. 4981, 2485, 3030, 4599, 4805, 247, 4063A, 242, 264, 2634, 3873A, 4042A, 4059A, 4082, 4648, 4725, 245, 2298, 4113, 4899 and 256 (for blast); Acc. Nos 232, 2595, 3689, 231, 239, 2247, 2287, 4368,

4405, 4535 and 5883 (for sheath blight); Acc. Nos. 244, 2142, 2569B, 2595, 2632, 2836, 4288 and 5103 (for RTV). Accession No.4498 and 4522 (for brown spot). Accession numbers 4981, 2485 and 4725 were resistant to blast and bacterial leaf blight diseases. Accession number 2595 showed resistance against sheath blight and rice tungro disease and 2247 against sheath blight and brown spot disease. One Accession 4020 showed resistance against three diseases like blast, bacterial blight and brown spot.

- Field monitoring of virulence was carried out in twenty five cultivars of international differentials, RILs, donors and commercial cultivars at twenty two locations for *Pyricularia grisea (blast)*. Cluster analysis of *P.oryzae* revealed that all these locations formed four major groups and there was considerable variation in reaction within each group. For *Xanthomonas oryzae* pv. *oryzae (bacterial leaf blight)*, the trial consisted of twenty two near isogenic lines (IRBB lines) with different bacterial blight resistance genes and their combinations and different checks and was conducted at 19 different hot spot locations across the country. Most of the single genes except *xa13* and *Xa21* showed susceptible reactions in most of the locations. All the lines with two gene combinations showed resistant reaction in most of the locations except Raipur and Pattambi. Most of the lines with three and four genes combinations showed resistant reactions across the locations suggesting the usefulness of pyramiding such genes in new varieties.
- Two new formulations i.e. Hexaconazole 75 WG (RIL-012/F1) and Kresoxim methyl 40% + Hexaconazole 8% WG (RIL-068/F148WG) were very effective in reducing the intensity of sheath blight, brown spot and sheath rot at most of the locations. The combination product Kresoxim methyl 40% + Hexaconazole 8% WG (RIL-068/F148WG) was very effective against neck blast, false smut and leaf scald.
- The integrated disease management trial results indicated that the effectiveness of integrating disease specific resistant / moderately resistant or susceptible varieties with 100 % or 2/3rd RDN along with need based fungicidal protection in case of fungal diseases like blast and sheath blight, and nitrogen management in case of bacterial leaf blight.
- Coat protein 3 sequences of *Rice tungro spherical virus* (RTSV) generated for Cuttack, Kanyakumari and Puducherry isolates (Accession Nos. HM149529, HM149530, HM627634) and ORF-IV sequences of *Rice tungro bacilliform virus* (RTBV) for Cuttack and Puducherry isolates (Accession nos. HM149532 and HM149531), were submitted in NCBI database. These sequences were used for studying the molecular diversity of RTSV and RTBV present in India.

Lead Research

The lead research programme is organized under ten main themes and the progress of work has been summarized themewise as under:

GEY – Genetic enhancement of yield and stress resistance in rice for irrigated ecology

- Eighty nine derived lines of Swarna / *O.longistaminata* cross were reported resistant to leaf blast; 18 *O. rufipogon* rice accessions including 106123, 106265, 106087, 104760, 105909, 106123, 106477,106285, IRGC 30615, IRGC 106136 and *O. longistaminata* did not show any rice tungro viral symptoms.
- A new recessive gene different from *xa5* and *xa13* for BLB resistance was introgressed from *O. longistaminata* into BPT 5204.
- Single recessive gene in SRAC 34997, single dominant gene in BM 72, one dominant and one recessive gene in IC 346255 and ACC 2148, duplicate recessive genes in CR 57 MR 1523 and ACC 2148 conferred resistance to brown planthopper; while a single recessive gene has been found controlling white backed planthopper resistance in IC 346255, ACC 2148 and SRAC 34997.
- Sabita and five other accessions IR 79906-B-5-3-3, IRT8875-53-2-2-2, IR 79906-B-5-3-3, IR 79906-B-5-3-3, IR 788575-B1-B-1-1, CR 691-58 and B 644F-MR-6-0-0 were found promising under direct seeding as well as transplanted condition. Aathira, Swarna Prabha, S- 467, Kalinga II, S-147, S-194 *etc.*, exhibited more than 10% yield superiority under direct seeding condition when compared to their performance under transplanted condition.
- High to moderate heritability coupled with low to high genetic advance was observed for most of the characteristics of yield and yield components under direct seeded condition.
- Candidate gene marker SC1246 and SSR marker SC390 for Rf4 locus on chromosome 10 and SSR markers SC364 and SC368 for Rf3 locus on chromosome 1 were developed for identification of fertility restorer genes for WA-CMS and were validated in 231 known restorer lines with 91% efficiency
- Twenty hybrid rice maintainer lines with good grain quality and having resistance to white backed planthopper were identified.
- Breeder seed production of 226 varieties and parental lines of 9 rice hybrids resulted in a total production of 6095 quintals of breeder seed against a target of 4604 quintals.
- Fifteen candidate varieties with 86 reference varieties, 8 Farmers' varieties with 28 reference varieties and 6 Extant varieties with 11 reference varieties were tested as per the guidelines and characterized for 29 essential and 33 additional DUS descriptors.
- Agro-morphological characterization of 317 germplasm accessions received from NBPGR was carried out for 20 characters.
- 3200 germplasm accessions including 20 accessions of wild species were characterized for 30 qualitative and quantitative characters.
- Under participatory seed production, more than 20 farmers were identified in 15 villages/*tandas* and a total quantity of 1200 quintals of quality seed of Improved Samba Mahsuri, Krishna Hamsa, Akshyadhan, Varadhan, Sampada, DRR Dhan 38, DRR Dhan 39 and Sugandhamati were produced.
- Optimum source and sink sizes were found to be 200 and 1400 respectively to achieve 9.0 ton yield in rice genotypes.

GEQ - Genetic enhancement of quality for domestic and export purposes

- The promising crosses identified in the basmati breeding material included Taroari Basmati / PR 116, Sugandhamati/Basmati 217, IET

17280/Type 3, Ranbir Basmati/IET 17920, IET 18022/IET 18297, Vasumati/B95-1//Vasumati*[2], Type 3/PAU 2888-3-2-1-1-1, Taroari Basmati/B95-1, IET 17280/Pusa Basmati-1, Gaurav/PGB, Basmati Kota/IET 16313, IET 12021/PB1//Bas 6311, 96380/IET 16310, Ranbir Basmati/IET 17920 and IET 17294/Yamini.

- Nineteen BC_1 F_8 lines were found to possess *Xa21* and *xa13* genes in homozygous condition; 24 lines and 8 lines contained only *Xa21* or *xa13* in homozygous condition respectively. Among these a total of 54 promising entries in BC_1F_8 were identified, while another 252 single plant selections (SPS) were made in other BC generations for further evaluation.
- One line derived from a cross between Samba Mahsuri/Chittimuthyalu with short bold grains, semi dwarf with high yield potential (> 4.5 t/ha) and medium duration with high Iron (3.12 mg/100 gm) and Zinc (4.0 mg/100 gm) in brown rice was identified with good grain quality characters *viz*. HRR (67.5%), intermediate ASV (5.01), AC (24.05%) with mild aroma.
- The candidate genes associated with the loci for iron and zinc in brown rice included Yellow Stripe –like transporters; zinc transport; ZIP (Zrt/Irt related protein) and NRAMP (Natural Resistance –Associated Macrophage Protein).
- Two hundred and seventy seven aromatic short and medium grain rices were characterized during *kharif* 2010 for 15 physico-chemical characters. Many of them were found promising for different quality parameters which included 188 entries with high head rice, 233 for intermediate and desirable amylose content, 179 with strong aroma, 96 with translucent grains and all entries with volume expansion of >3.5. One hundred sixty one cultivars were reported with high head rice and intermediate amylose content.
- Of the 56 SSR markers used, 27 showed polymorphism involving 2 to 5 alleles. Cluster analysis performed using UPAGMA based on similarity co-efficient resolved the 96 aromatic short grain rices into two major clusters with cluster I consisting of 60 genotypes sub grouped into five sub-clusters such as IA, IB, IC, ID and IE; with cluster II consisting of 36 genotypes sub grouped into 4 sub-clusters namely IIA, IIB, IIC, and IID.

ABR - Application of biotechnology tools in rice

- Three populations using *O.rufipogon, O.nivara* and *O.meridionalis* were developed for mapping yield enhancing QTLs. Large amount of variation was generated for traits related to yield in the recipient lines Swarna, KMR3 and BPT 5204.
- IET 21542, an introgression line of Swarna / *O.nivara* which has part of the yield QTLs *Qyldp8.3* from *O. nivara* was found promising in multilocation testing in AVT 1 IM.
- Sucrose phosphate synthase gene on chromosome 2 was found significantly associated with filling of grains on primary branches of upper half of the panicle and another CG marker based on transporter gene on chromosome 11 was identified to be associated with filling of grains on primary branches of lower half; secondary branches of upper half and lower half of the panicle.
- A set of 12 hypervariable SSR markers (HRM12469, HRM20866, HRM11570, HRM16006, HRM24217, HRM23595, HRM24383, HRM18770, HRM25754, HRM16606, HRM6740 and HRM HRM13131) possessing high polymorphic information content values (> 0.75) were identified to be suitable for heterosis prediction.
- Eleven primer pairs targeting the mitochondrial genes associated with respiration displayed polymorphism between the WA-

CMS lines APMS 6A and its maintainer APMS 6B.

- Major QTL for gelatinization temperature (GT) on chromosome 6 which contributes to the 30.7 % phenotypic contribution to the trait was identified. For grain breadth, a QTL on chromosome 8 which contributes 11.2% phenotypic contribution was also identified.
- Lowest saline susceptibe index was recorded for S-381 followed by 3-1(K), 166(S) and 14(K) at 100mM NaCl. Grain yield decreased in all the lines under stress condition but lesser inhibition was found for S-381, 166(S), 3-1(K) and 14(K) at 100mM NaCl.
- Eleven promising T_3 lines transgenic IR64 with *Cry1Ac* gene *viz.*, IC 5-3-20-1, IC 5-4-20-1, IC 5-4-20-2, AIC 3-2-8-1, AIC 3-2-8-3, AIC 3-5-27-1, AIC 2-6-3-1, AIC 3-5-7-1, AIC 3-5-7-3, IC 5-4-21-1 and AIC 3-5-31-1 were identified, which are highly resistant to yellow stem borer. In these lines the dead hearts and white ears were minimal. Selected lines are advanced to contained biosafety evaluation.
- Three events of transgenic plants in the background of BPT5204 carrying the *RD29- At-DREB1a* gene were developed. Dry down experiment of T_3 lines for drought tolerance parameters showed that some of the lines are highly tolerant to drought even after 14 d of withdrawal of water.

RUE – Enhancing resource and input use efficiency

- Grain yield differences under three tillage management systems *viz.*, dry seeding without mulch under zero tillage, dry seeding with 50% mulch under zero tillage and direct seeding of sprouted seed under puddled conditions were non-significant (4.54 t/ha to 4.74 t/ha), while varietal differences were significant.
- Maximum net profit of Rs. 34100/ha and B:C ratio (2.86) were recorded by dry seeding with 50% mulch under zero tillage followed by dry seedling without mulch under zero tillage (Rs. 33460/ha and 2.62) and direct seeding of sprouted seed under puddled condition (Rs. 29420/ha and 1.63).
- Higher harvest index values were noticed in SRI (47) for recording higher grain yield over conventional method of transplanting (43) Mean over the cultivars and method of crop establishment application of 75 % inorganic + 25 % organic gave significantly higher grain yield (5.51 t/ha).
- SRI recorded maximum nutrient use efficiency (59, 410 and 47 kg grain/ kg for N, P and K uptake, respectively) compared to SRI organic and conventional methods which recorded 51-56, 387-394 and 40-43 kg grain/ kg N,P and K uptake, respectively.
- Organic carbon (1.39 %) and available K_2O (565 kg/ha) were significantly higher with SRI-organic followed by SRI (1.21 % and 444 kg/ha, respectively) and conventional method (1.14 % and 350 kg/ha, respectively)
- Five distinct growth and grain yield patterns were observed due to application of P-fertilizers.
- Rice varieties IET-20716 and IET-20710 exhibited higher P-tolerance at low P-status and recorded higher grain yield of 2.69 to 3.03 t/ha at 0-P level. However, at higher P-levels of 50-60 kg P2O5/ha, these varieties recorded yields of only about 5.43 – 5.83 t/ha.
- Rice varieties PAC-835, PAC-837, IET- 20727, IET – 20734, IET 21298 and DRR-H3 exhibited marginal low P tolerance at O-P (1.05 – 2.06 t/ha); they however, recorded the highest grain yields, at higher P-Levels (5.81 – 7.02 t/ha). At lower P-levels of 10-20 kg P_2O_5/ha, PAC-835, PA-6129, CSR-3 recorded higher response of 139.25, 218.83 kg grain/kg P_2O_5, while others recorded lower values (54.87 –

131.06 grain/kg P_2O_5).

- Rice-maize system recorded maximum net profit of Rs. 49,556/ha and B:C ratio of 1.72 while rice-wheat system recorded net profit of Rs. 37,253/ha and B:C ratio of 1.33.
- Six rice varieties/hybrids (Tulsi, Rasi, Krishana Hamsa, Triguna, KRH-2 and PA 6201) were tested under aerobic unpuddled condition in which KRH-2 recorded maximum grain yield of 3.80 t/ha followed by PA 6201 of 3.68 t/ha.

SSP – Sustaining rice system productivity

- In a field study conducted in *rabi* 2010 evaluating 16 genotypes for responses to tillage (puddled and non puddled) and water regimes (continuous submergence, irrigation equivalent to 150 and 125% of cumulative pan evaporation (CPE), up to 30% higher productivity was recorded in puddled soil over non puddled conditions under continuous flooding, while this yield gap narrowed with decreasing supply of irrigation water (125 – 150% of CPE).
- Among the genotypes, Rasi, IR 64, IR 36 and Akshayadhan were promising in puddled conditions under limited water supply, while IET 19828 and rice hybrid Sahyadri 3 performed better under aerobic system (non - puddled soil). Average water productivity ranged from 3-3 – 5.6 kg grain/ha. mm with a net reduction in water requirement by 900 – 1150 l/kg grain under regulated supply of 36 – 44% less irrigation water, but with an yield penalty of 0.4 – 0.5 t/ha
- Water loss through deep percolation was about 690 and 350 mm during *rabi* season under continuous flooding, which could be indirectly minimized by regulated water supply.
- Response to nutrient application in *kharif* season (2010) was limited to only N in case of HYV (Varadhan) while hybrids responded to N and K application under both puddled and non puddled conditions. At the highest yield (5.2 t / ha under aerobic system) the crop accumulated 105, 40 and 136 kg/ha of NPK at nutrient uptake requirement of 20.3, 7.6 and 25.9 kg NPK / t of grain.
- Based on the recorded grain yields, water requirement and its productivity, irrigation equivalent to 75% of CPE appeared to be optimum in wet season in a clay soil for HYV Varadhan and between 75 – 100% CPE water for the higher yielding hybrid (PA 6444) under both systems of tillage without yield loss, while saving about 13 – 21 per cent of irrigation water.
- In a five year study on organic farming in rice, grain yields under organic farming reached comparable levels with inorganics in the 5th crop during *kharif* and by 10th crop in *rabi*.
- Significant improvement with organics in soil physical, chemical and biological properties was also observed as indicated by soil quality indices *viz.*, nutrient, microbial and overall sustainability index of the system, which was 1.63 with organics as against 1.33 with fertilizer applied plots at the end of the experiment.
- In an exploratory study conducted in wet season 2010 on genotype variability in N use efficiency, varieties Rasi (early duration), Varadhan, Jaya and PA 6444 (mid duration) and Swarna of late maturing group were superior with higher productivity and utilization efficiency of both soil and applied nitrogen (100 kg N/ha).
- The functional diversity of soil microflora in representative acid saline soils collected from Kuttanad rice growing region of Kerala was studied using carbon substrate utilization profiles. Among the 31 carbon substrates tested, the microorganisms' utilized 22 substrates consisting of 6 monosaccharides, 5 disaccharides, one each of trisaccharide, polysaccharide and carboxylate along with 6 polyalcohols and 2 glucopyranosides. The microorganisms were also present in abundant

quantity and evenly distributed indicating a diverse, healthy and robust soil system (species richness 22, diversity index 0.814 and evenness 0.606).

- In an exploratory study on the effect of different sources of N fertilizers and cultivars on the yield of rice and nitrogen use efficiency, ammonium sulphate was observed to be the best source of nitrogen in comparison to urea and DAP.
- In a field study undertaken during *Kharif* 2010 to evaluate effect of enriched (N and P@10%) manures (vermin compost, poultry manure applied @5.0t/ha) on productivity of rice hybrid KRH-2 and variety Krishna Hamsa, the enriched manures performed on par with the recommended fertilizer dose.
- Micronized zinc oxide, a new product of zinc source, was evaluated in wet season 2010 in comparison to standard sources zinc sulphate and chelated zinc as spray formulation. The product was observed to be promising for rice with comparable or improved zinc nutrition and rice productivity.

CCR–Assessing and managing crop response to climate change

- Physiological responses such as membrane injury, chlorophyll, photosynthesis and water relations and spikelet fertility and pollen fertility were found to be relatively superior in IET 20924, IET 20935, IET 20734, IET 20893, IET 20907 and IET 20905 during terminal heat stress situation.
- Water stress significantly reduced photosynthesis, conductance and transpiration rates and significant recovery in these parameters was seen in Akshaydhan and rasi. Dry matter (DM) remobilization and its efficiency were confirmed in Akshaydhan, IET 19830, IET 22029 and IET 22030 by mimicking water stress using KI @ 0.3%.

HRI – Host plant resistance against insect pests and its management

- Of the 1416 breeding lines and germplasm accessions nominated in various National Screening Trials of AICRIP and other sources screened against gall midge biotypes 1, 4 and 4M, under greenhouse conditions 35, 30 and 45 entries were found to be resistant, respectively. Three germplasm accessions *viz.,* IC 114788, INRC 17459, INRC 17494 displayed resistance to all three biotypes. Three cultures, RP 4929-BK, RP 4930-BA, and RP 4930-derived from gene pyramiding programme were also found resistant to all three biotypes.
- Of the 250 lines of IR64/IR75870-5-8-5-B-1-B (derived from *O.glaberimma*) in BC_2F_4 evaluated against stem borer, four lines had low dead heart and white ear damage (<10% DH and <5% WE), 21 lines with low DH (<10%DH) and 5.1-10% WE.
- 2400 entries were evaluated against brown planthopper (BPH) in glasshouse, out of which 19 including IET 21616, 21617, 22064, 22158, 22129, 21725, 22203, 22163, RIL 8-188, CR 2711-76, NWGR-4105, CR 2711-139 and CR 2711-149 and 6 introgression lines of Swarna X *Oryza nivara* were promising, while against WBPH, one thousand nine hundred and seventy two entries were evaluated and 40 entries including IET 20694, 20780, 20990, 21108, 20698, 20775, 19470, 20328, 20871, 20873, 20835, 21151, 20906, 21071, 20991, 20994, 21109, 21110, 20124, 21094, 20370, 21232, 21235, 21214, 21194 and CE 260 showed damage score of less than 3.0.
- Of the seven hundred and thirty germplasm accessions evaluated against both plant hoppers, ten accessions *viz.,* ACC No. 4656, 4368, 4647, 4567, 3164, 3681, 4339, 3767B, 4067 and 5345 were found promising against BPH and 5 accessions *viz.,* 2658, 4288, 3328, 3338 and 3627 were promising against WBPH with a damage score of < 3.0.

HRP-Host plant resistance against pathogens and its management

- Among the 2152 rice lines evaluated on uniform blast nursery beds for resistance against leaf blast, 235 lines were resistant to blast disease.
- Screening of 317 germplasm accessions in *Kharif*, 2010 for resistance against leaf blast in uniform blast nursery (UBN) revealed that the accessions 4981, 2485 and 4725 showed resistance against blast and bacterial leaf blight diseases. Accession 2595 showed resistance against sheath blight and rice tungro disease, while 2247 was resistant to sheath blight and brown spot. Accession 4020 showed resistance to three diseases, blast, bacterial blight and brown spot.
- Forty eight germplasm accessions found promising against bacterial blight(BB) during 2009, were re-evaluated with two different isolates of *Xoo* (DX-200 from Pantnagar and DX-161 from Andhra Pradesh) and four accessions *viz.*, 316311, 346884, 352833 and 334179 were found to be highly resistant to both isolates of the BB pathogen.
- Forty one accessions found promising in National screening nurseries at different locations across India during 2009 were pooled and re-evaluated with multiple (4) isolates of BB pathogen under glasshouse condition. Four entries from NSN-1 and 6 entries from NSN-2 were found to be highly promising
- Screening of breeding material consisting of two hundred and thirty entries from the cross between KMR3 and *Oryza rufipogon*, 142 entries (S lines) from cross between Swarna and *O. nivara* and another 85 entries (K lines) from Swarna and *O. nivara* for resistance to bacterial blight was carried out. One entry was highly resistant (score 3) and 3 others were moderately resistant (score 5). Among entries of cross between Swarna and *O. nivara*, 5 in S lines and 13 in K lines were found highly promising.
- Seventy one *Oryza rufipogan* accessions were screened against rice tungro virus disease in the glass house and 39 accessions did not show the viral symptoms till 15 days after inoculation. 18 accessions did not show any symptoms even after 30 days after inoculation. Of these, only 12 accessions (106123, 106265, 106087, 104760, 105909, 106123, 106123, 106477, 106285, IRGC 30615, IRGC 106136 and one O. *longistaminata* accession) showed absence of viral particles in primary screening. Rest of the accessions showed the presence of RTBV, though they did not reflect typical tungro disease symptoms.

IPM - Integrated pest management

- Studies on the effect of 'Ek Boond" (wetting and penetrating adjuvant) revealed that addition of 200 ml of the product as tank mix enhanced the persistent toxicity of buprofezin to plant-hoppers and tricyclazole against blast disease.
- Studies on impact of weedicide and fertilizer application practices on biodiversity showed that weedicide application had impact on Daphnia which are the lowest trophic strata followed by Chironomids. The Shannons index for diversity was highest for phosphocompost treated plots (1.48) and least for anilophos treated plots (1.08).
- In the field study on dynamics of leaf folder – host plant-insecticide interaction, the larval duration was reduced in neo-nicotinoid treatments and the sprays of these insecticides did not affect the settling behaviour of leaf folder adults.
- Seventeen *Bt* isolates recovered from different rice ecosystems at 25 ppm toxin concentration, exhibited mortality of leaf folder larvae in the range of 18.8 to 100% at 48 h period.
- Pathogenicity of false smut fungus isolates collected from Ludhiana, Kapurthala, Kaul, Karnal, Meerut, Nagina and Pantnagar was confirmed through DNA extraction using CTAB method from actively growing

mycelium for detection and confirmation of the pathogen with *Ustilaginoidea virens* specific ITS primers.

- The test fungicide ICF-110 was found significantly effective at all the three tested doses (180+40, 225+50 and 270+60 g *a.i.* /ha) in checking the leaf blast severity, neck blast incidence and increasing the grain yield over the control.
- Field experiment revealed the efficacy of three vitamins (Thiamine hydrochloride, Pyridoxine hydrochloride and Nicotinic acid) and their combination against bacterial leaf blight disease. The combination of three vitamins (at 10 mM each) was the best followed by Nicotinic acid (50 mM).
- Studies on phytonematodes revealed the presence of white-tip nematode *(Aphelenchoides besseyi*) in the panicles collected from Wangbal, Barapani, and Nawagam areas with maximum nematode load (> 50 nematodes / 5 seeds) in panicles of cv. Gurjari collected from Nawagam. Plants raised from infested seed in greenhouse exhibited typical white-tip symptoms.
- Observations on infectivity of *Pasteuria penetrans* (isolate PMI 1) spores to root-knot nematode, *Meloidogyne graminicola* showed that bacterial spores readily attached (22.46 spores/J2) to the cuticle second stage juveniles (J2) and the bacterium multiplied well inside the nematode when spore encumbered J2 were inoculated on rice plants resulting in the formation of spore filled females.
- Cross infectivity and oviposition behaviour of two species of root-knot nematodes *M. graminicola* and *M. incognita* in dicot (tomato) and monocot (rice) hosts revealed that the gall number as well as size was small on rice when compared to that on tomato.
- Molecular characterization of populations of root-knot nematodes collected from rice (*M. graminicola*) and tomato (*M. incognita*) and white-tip nematode (*A. besseyi*) revealed that DNA sequences ITS regions of ribosomal genes (18s, 5.8s & 26s) of these nematode populations showed 98-100% homology with the DNA sequences of accessions of respective species in the gene bank confirming their species identity.
- Investigations on quarantine nematodes revealed that out of a total of 10449 samples of rice seeds imported this year 1565 showed the presence of the white-tip nematode, *A. besseyi.*
- There was no significant difference in nematode penetration between plants maintained at ambient and elevated CO_2 (700 ppm) Open Top Chambers (OTC).
- Studies on influence of cultivation practices showed that the population of plant parasitic nematodes was more under SRI but less in Organic-SRI plots than in plots applied with chemical fertilizers.
- Field experiments showed that application of four entomopathogenic nematode (EPN) isolates (*Steinernema asiaticum, S. glaseri, Heterorhabditis indica* and *Oscheius sp*) @ 1 x 10^5 infective juveniles/m^2 at booting stage resulted in significantly lower incidence of white ears due to yellow stem borer.
- Five EPN isolates (*S. asiaticum, S. thermophilum, S. glaseri, Oscheius sp. and H. indica*) caused significantly high mortality of green leafhopper in greenhouse when applied @ 1 x 10^5 infective juveniles/m^2. *S. thermophilum, S. glaseri* and *H. indica* isolates also caused significantly high BPH insect mortality compared to the untreated control.
- Studies on mass production of EPNs revealed the influence of initial inoculums on infective juvenile yield in *in vivo* production system on larvae of *Galleria mellonella*. The progeny production per insect larvae increased with increase in inoculums dosage from 25 to 100 IJs/insect larvae for both the EPN (*S.*

thermophilum and *H. indica)* species tested. The NGM (Nematode Growth Medium) medium commonly used for culturing and maintenance of model nematode *Caenorhabditis elegans* supported the growth and multiplication of closely related EPN, *Oscheius* sp. and progeny production observed within four days of inoculation.

TTI - Training, transfer of technology impact analysis

- Awareness study on Integrated Pest Management in Rice Farming revealed that the eighty percent of the farmers adopted one or two components of IPM. Seventy percent of the farmers were not aware of the resistant varieties and forty percent farmers were aware about the natural enemies of whom only 20-30% of the respondents could identify them. Most of the farmers were not aware of the toxic effects of pesticides.
- Sustainability study in the rice farming system revealed low level of adoption of sustainable farming practices owing to continuous deployment of single variety, imbalanced use of inorganic fertilizer, non- practice of scientific water management, inadequate attention to problem soils and use of green manures, excessive application of chemical pesticides, non-use of soil amendments, dependency of hired labour, tenant farming and lack of information and self reliance.
- Learn Rice–Moodle is a multi-dimensional e-learning platform developed in Moodle Platform for which a total of 12 e-learning courses were developed in English and this e-learning platform will be piloted during 2011-12.
- The common interest/objective of the various rice research projects under partnership mode were found out to be for exchange, evaluation, release and use of genetic materials, adoption and dissemination of rice technologies, promoting resource sharing and information exchange. In case of national level rice partnership projects, the partnership projects of DRR considered which were for seed production and markerting.
- Useful technological interventions like establishment of Vermicompost units were undertaken selected tandas and villages and various aspects of technology interventions like Seed Production, IPM and INM practices, Varietals demonstration, Biological and Bio-technological methods and Hybrid Seed Production covering 59 beneficiary farmers were demonstrated, under the externally funded DBT Project
- Under NAIP funded RKMP, around 2500 Reusable Learning Objects (RLOs), 12 approach papers on various aspects of Rice and 15 Status papers related to 15 states, 12 e-learning courses and several platforms like RKMP Website, E-learning in Moodle, E-learning in Java (Learn Rice), E-learning in Joomla, Communities of Practice (CoPs), Rikipedia, Training Data Base Management System of DRR, www.ear-rkmp.in, www.i3r.in were developed.
- Ten training programs were planned, organized and evaluated on various aspects of Rice Production Technologies through which 247 persons were trained. Fifteen workshops were conducted as part of Rice Knowledge Management Portal on Knowledge Management Tools Knowledge Management Collaboration, Content development workshop.
- 700 FLDs were conducted for evaluation and demonstration of various rice production technologies covering 18 states and six rice ecosystems of the country.
- On farm trials were conducted on DRR varieties viz., Improved Samba Mahsuri, Akshaydhan & Sampada in the states of Andhra Pradesh, Tamil Nadu, Uttar Pradesh.

Introduction

Directorate of Rice Research was established as All India Coordinated Rice Improvement Project (AICRIP) at Hyderabad in 1965 by the Indian Council of Agricultural Research. It had its initial mandate of organizing multi-location national testing programme for varietal and other crop management technologies developed across the country involving funded and voluntary centres. The AICRIP was elevated to the status of Directorate of Rice Research from August 1975 with added mandate of pursuing research on irrigated rice for strengthening and stabilizing rice production. Now, AICRIP with 47 funded and over 90 voluntary centres forms the largest of research networks on a single crop. In addition, DRR initiates network research projects of national importance and coordinates these activities.

Mandate

- To organize, coordinate and monitor multi-location testing at national level to identify appropriate varietal and management technologies for all the rice ecosystems
- To conduct basic, strategic and anticipatory research in the major thrust areas of irrigated rice aimed at enhancement of production, productivity and profitability while preserving environmental quality
- To develop, organize, coordinate and monitor research networks relating to problems of national and regional importance
- To serve as major center for exchange of research material and information
- To accelerate the pace of technology transfer through development and adoption of innovative extension training models, self learning modules and through organizing formal training courses, frontline demonstrations, exhibitions, farmers' day etc.
- To develop linkages with national, international and private organizations for collaborative research programmes
- To provide consultancy services and undertake contractual research

Significant achievements

Since 1968 till date, more than 946 rice varieties have been released for various agro-ecological systems prevalent across the country through multilocation testing. Of these, 60 varieties have been developed by the Directorate. Of the 946 varieties, 18% are for rainfed shallow lands, 17% belong to irrigated medium duration group followed by irrigated early duration (16%), irrigated mid-early (13.2%), rainfed uplands (13%), scented rice (6.4%), irrigated hills (4.5%), semi-deep water (4%), irrigated saline/alkaline soils (4%), deep water (1.5%) and rest are for the other rice ecologies. Through the hybrid rice research network, 46 hybrids have been released. Of the varieties released under AICRIP, 19 are being cultivated in 25 other rice growing countries worldwide. These high yielding varieties and hybrids cover over 80% of the rice area.

Achievements during 2010-11

- Thirty six rice varieties were notified for commercial cultivation by the Central Sub-Committee on Crop Standards, Notification and Release of Varieties. Of these, six varieties *viz.*, IGKVR 1, IGKVR 2, Chinsurah Rice 1, CR Dhan 501, CR Dhan 601 and RC Maniphou 1 and 5 hybrids *viz.*, INDAM 200-017, US 312, 27P 11, CRHR 32 and Rajalaxmi were the central releases, while 25 varieties were released by State Variety Release Committees

in 8 states.

- Eighty nine lines of Swarna / *O.longistaminata* cross were reported to be resistant to leaf blast. Thirty nine *O. rufipogon* accessions did not show rice tungro viral symptoms.
- The variety Sabita and five other gentotypes (IR 79906-B-5-3-3, IR 79906-B-5-3-3, IR 79906-B-5-3-3, IR 788575-B1-B-1-1, CR 691-58 and B 644F-MR-6-0-0) were found promising both for direct seeded as well as transplanted condition.
- Candidate gene marker SC1246 and SSR marker SC390 for Rf4 locus on chromosome 10 and SSR markers SC364 and SC368 for Rf3 locus on chromosome 1 were developed for identification of fertility restorer genes for WA-CMS and these were validated with 231 known restorer lines with 91% efficiency.
- Breeder seed production of 226 varieties and parental lines of 9 rice hybrids was under taken during the year. A total production of 6095 quintals of breeder seed was produced against a target of 4603 quintals.
- Fifteen candidate varieties with 86 reference varieties, 8 Farmers' varieties with 28 reference varieties and 6 Extant varieties with 11 reference varieties were tested as per the guidelines and characterized for 29 essential and 33 additional DUS descriptors.
- A semi-dwarf medium duration line derived from a cross between Samba Mahsuri/ Chittimuthyalu with short bold grains, with high yield potential (> 4.5 t/ha) with high Iron (3.12 mg/100 gm) and Zinc (4.0 mg/100 gm) in brown rice was identified with good grain quality characters *viz*. HRR(67.5%), inter-mediate ASV (5.01), AC (24.05%) with mild aroma.
- An introgression line of Swarna/*O.nivara* (IET 21542), with the yield QTLs Qyldp8.3 was found promising in multilocation testing in AVT 1 IM.
- Growing of rice + sun hemp (intercropping and incorporation) along with nutrient schedule of 60:40:40:500 or 60:60:40:500 N:P:K:Lime kg/ha and foliar spray of 0.5.% $ZnSO_4$ was found promising for enhancing grain yield as well as soil health under rainfed upland ecosystem.
- Maximum net profit of Rs. 34100/ha and B:C ratio (2.86) were recorded by dry seeding with 50% mulch under zero tillage followed by dry seedling without mulch under zero tillage (Rs. 33460/ha and 2.62) and direct seeding of sprouted seed under puddled condition (Rs. 29420 / ha and 1.63).
- Application of 100-125% nitrogen + pre-emergence herbicide application + Rice: Dhaincha (1:1) + hand weeding at 60 DAS or 2,4 D-Na application at 25-30 DAS was found promising for aerobic rice.
- Long term fertilizer studies indicated significant improvement in rice productivity, nutrient accumulation and soil fertility with the incorporation of 5 tonnes / ha of FYM in addition to recommended fertilizer dose (100% NPKZnS).
- Under limited water supply, the genotypes Rasi, IR 64, IR 36 and Akshayadhan were promising in puddled conditions, while IET 19828 and rice hybrid Sahyadri 3 performed better under aerobic system (non - puddled soil). Average water productivity ranged from 3-3 – 5.6 kg grain/ha. mm with a net reduction in water requirement by 900 – 1150 l/kg grain under regulated supply of 36–44% less irrigation water, but with an yield penalty of 0.4 – 0.5 t/ha.
- In a study on screening elite lines for drought

tolerance, twenty one cultures along with PA 6129 and Annada were evaluated and it was found that IET 20708 and IET 20710 recorded high grain yield at four and three locations respectively under dry spell, while IET 21281 and IET 21076 were drought susceptible at four and three locations, respectively.

- Physiological responses such as membrane injury, chlorophyll, photosynthesis and water relations and spikelet fertility and pollen fertility were found to be relatively superior in IET 20924, IET 20935, IET 20734, IET 20893, IET 20907 and IET 20905 during terminal heat stress situation.

- In host plant resistance studies, 53 entries and 8 donors were identified as promising against various insect pests. Planthopper screening revealed six promising entries including five breeding lines from Cuttack and RP 4918 – 230S (Swarna/*O.nivara*) developed at DRR.

- Studies on impact of weedicide and fertilizer application practices on biodiversity showed that weedicide application had impact on Daphnia which are the lowest trophic strata followed by Chironomids. The Shannons index for diversity was highest for phosphocompost treated plots (1.48) and least for anilophos treated plots (1.08).

- Screening of 317 germplasm accessions for resistance against leaf blast in uniform blast nursery (UBN) revealed that the accessions 4981, 2485 and 4725 were resistant to blast and bacterial leaf blight diseases. Accession 2595 showed resistance against sheath blight and rice tungro disease, while 2247 was resistant to sheath blight and brown spot. Accession 4020 showed resistance to three diseases, blast, bacterial blight and brown spot.

- The integrated disease management trial results indicated that the integration of disease management practices like growing disease specific resistant / moderately resistant or susceptible varieties with 100% or 2/3rd recommended dose of Nitrogen (RDN) along with need based fungicidal protection in case of fungal diseases like blast and sheath blight, and nitrogen management in case of bacterial leaf blight were effective in checking the disease severity / incidence and improving the grain yield.

- Studies on influence of cultivation practices showed that the population of plant parasitic nematodes was more under SRI but less in Organic-SRI plots than in plots applied with chemical fertilizers.

- Field experiments showed that application of four entomopathogenic nematode (EPN) isolates (*Steinernema asiaticum, S. glaseri, Heterorhabditis indica* and *Oscheius sp*) @ 1 x 10^5 infective juveniles/m^2 at booting stage resulted in significantly lower incidence of white ears due to yellow stem borer.

Organization and Infrastructure Facilities

Directorate of Rice Research is one of the constituent crop based Institutes of the Indian Council of Agricultural Research under direct supervision of the Deputy Director General for Crop Sciences (Fig 1). For fulfilling its mandate effectively, DRR is organized into four sections and ten units along with centralized service wings and Administration. AICRIP activities are integrated into the mandate with senior most scientists of each discipline acting as the PIs of the programme. Research and Institutional activities are planned and guided by Research Advisory Committee and Institute Management Committee while the progress is critically evaluated by the Quinquennial Review Committees.

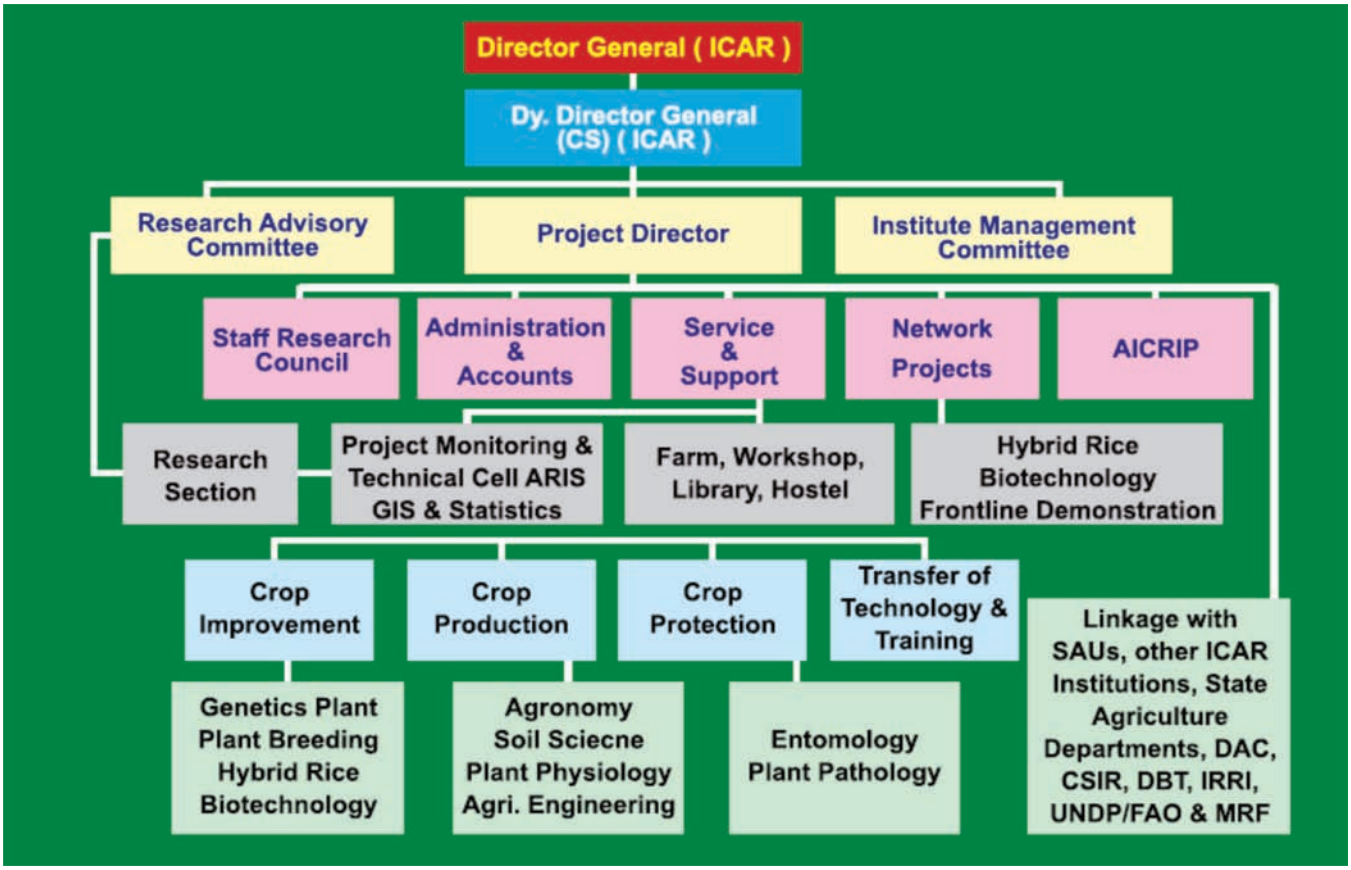


Fig 1. Organogram of DRR

The Directorate has well equipped laboratories with state of the art equipments, centrally air cooled greenhouses, biosafety transgenic greenhouses, growth chambers, well laid out experimental farm and digital enabled library facilities.

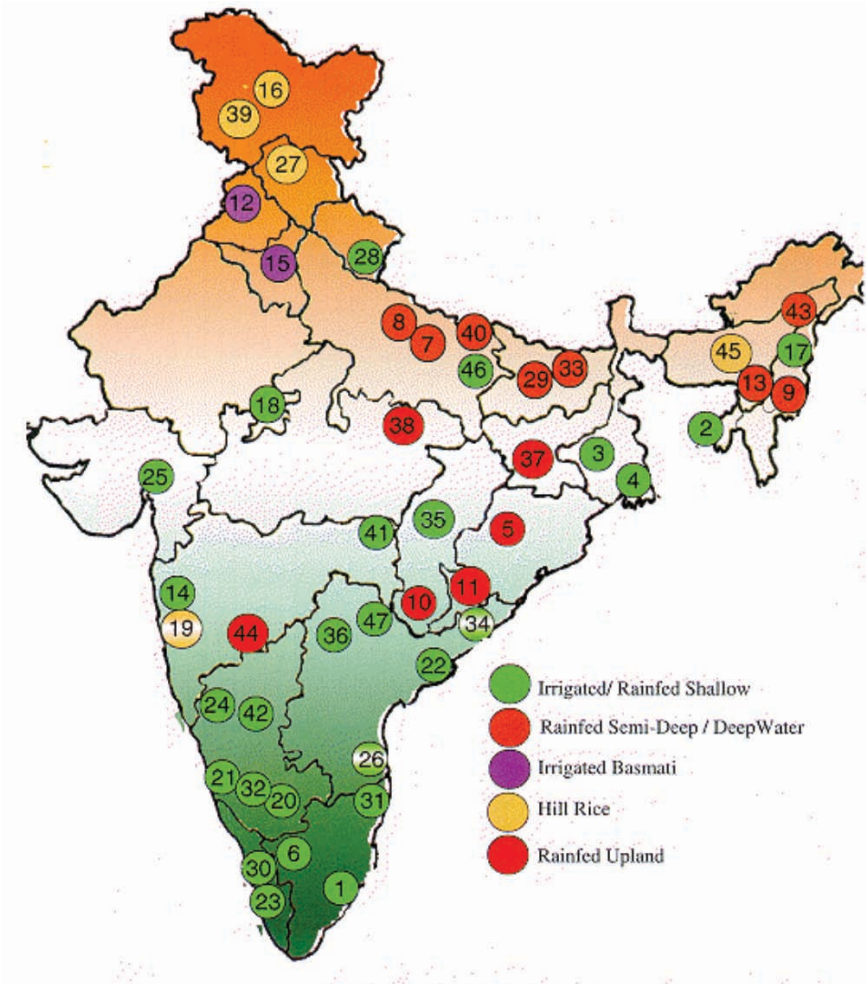
DRR also coordinates rice research at 47 funded (Fig. 2) and over 90 voluntary centres under AICRIP.

Budget allocation during 2010-11 with actual expenditure

Centre	Plan		Non-Plan	
	Amount sanctioned	Amount spent	Amount sanctioned	Amount spent
DRR Headquarters	520.00	520.00	1261.65	1261.65
AICRIP Rice	1700.00	1700.00	-	-
Total	2220.00	2220.00	1261.65	1261.65

Cadre strength of Scientists, Technical and Administration, SS grade staff

S.No.	Cadre	Sanctioned	Filled	Vacant
1	Scientists(Excluding Project Director)	72	51	21
2	Administration	34	30	04
3	Technical	56	50	06
4	Supporting	42	21	21



AICRIP funded centres conducting rice research under DRR coordination. (Details of the centres are provided in Table)

Weather and crop season

As per the Indian Meteorological Department (IMD), for the country as a whole, the seasonal rainfall from first June to 30th September, 2010 was 102% of its long period average (LPA) of 89cm. As a whole, 173 districts, nearly one-third, received deficient rains this monsoon after a drought year, otherwise there was excess to normal rain fall across the country. On the brighter side, 240 districts (40%) received normal rains and the remaining 173 districts experienced excess rainfall in the June-September summer monsoon season. Temporally, June saw less than average rainfall across the country, monsoon picked up in July and August and peaked unusually in September flooding many parts of the country.

The estimated rice production in the country this year as per the third advance estimate, is 94.01 million tonnes, an increase of about 15 per cent over 2009-10 levels but lower than the record production of 99.1 million posted during 2008-09. Fall in production figure as against the target of 102 million tones for this year was mainly due to drought conditions over north-eastern region and untimely rains and floods in the southern part of the country. (Source: Economic Survey of India 2010 - GOI).

Significant Research Findings

Co-ordinated Research

Crop Improvement

Plant Breeding

Hybrid Rice

Crop Production

Agronomy

Soil Science

Plant Physiology

Crop Protection

Entomology

Plant Pathology

Significant Research Findings

Coordinated Research

Crop Improvement

Plant Breeding

New Varieties Released - During 2010, a total of 36 varieties have been released for general cultivation. Among these 11 varieties have been released by the Central Sub-Committee on Crop Standards, Notification and Release of Varieties of which 6 are varieties and 5 are hybrids. The varietal releases are IGKVR 1 and IGKVR 2 for irrigated mid early and medium duration, Chinsurah Rice 1 for irrigated medium, CR Dhan 501 for semi deep water, CR Dhan 601 for boro areas and RC Maniphou 1 for irrigated hills. Of the hybrids released, INDAM 200-017 and US 312 are for irrigated mid early and 27P 11 for irrigated medium while CRHR 32 is for rainded shallow lowlands and Rajalaxmi (earlier released and notified in 2006 for irrigated situation) for boro areas. State Variety Release Committees have released 25 varieties in 8 states (Table 1). These include 8 from Andhra Pradesh, 2 from Chhattisgarh, 1 from Gujarat, 2 each from Karnataka and Kerala, 4 from Meghalaya, 5 from Odisha and 1 from Uttar Pradesh. Ecosystem-wise 3 varieties are released for rainfed upland, 6 for rainfed shallow lowland, 11 for irrigated, 3 for saline soils and 1 each for aromatic and aerobic situation.

Table 1: Varieties released by Central and State variety release committee during 2010-11

Sl. No	Variety Name IET No Designation Cross Combination	Year of Release/Notification No.	FD (Days)	Eco-System	Grain Type	Yield (kg/ha)	Reaction to pest / diseases	Recommended State/Region
Central Releases								
1	CR Dhan 501 19189 CR 2008 -111 Savitri/Padmini	2011 283 (E)	128	SDW	LB	4048	MR- Bl	Semi deep water areas of Uttar Pradesh, Assam
2	CR Dhan 601 18558 CRG 1190 -1 Jaya/IR 64	2011 283 (E)	135	Boro	MS	5588	R-Bl, RTV, MR-BS	Boro areas of Odisha, West Bengal, Assam
3	CRHR 32 20852 CR Dhan 701 CRMS 31A/ CRL 22	2010	112	RSL	MS	5429	R-Bl	Rainfed shallow lowlands of Bihar, Gujarat
4	IGKVR -1 19569 R 1124 -258—3-86-1 R 320 -300/ Cheptigurmatia	2011 283 (E)	92	IRME	LB	5188	R- Bl, GM	Irrigated areas of Chhattisgarh, Madhya Pradesh, Odisha

Sl. No	Variety Name IET No Designation Cross Combination	Year of Release/Notification No.	FD (Days)	Eco-System	Grain Type	Yield (kg/ha)	Reaction to pest / diseases	Recommended State/Region
5	IGKVR-2 19795 R 1243-1224-578-1 Mahamaya/ NSN 5	2010	103	IRM	LS	5031	MR-Bl, BLB, BPH, WBPH	Irrigated areas of Chhattisgarh, Odisha, Bihar
6	INDAM 200 - 017 20419 -- IAHS 24 A/ IASN 707 R	2010	96	IRME	LB	6604	MR-Bl, SB, LF	Irrigated area s of Maharashtra, Andhra Pradesh
7	Chinsurah Rice 19140 CN 1383 -5-11 Pankaj/IET 4786	2010	106	IRM	LS	4956	MR-Bl, WBPH	Irrigated areas of Odisha, West Bengal, Andhra Pradesh, Tamil Nadu, Gujarat
8	Rajalaxmi 19600 CRHR 5 CRMS 32A/ IR 42266-29-3R	2006 1572 (E)	128	Boro	LS	5845	MR-Bl, BLB, SB, BPH	Boro areas of Assam, Odisha
9	RC Maniphou 11 20193 RCM 21 Prasad/IR 24	2011 283 (E)	103	HRIR	LS	5680	R-Bl.	Irrigated hilly areas of Meghalaya, Manipur
10	US 312 19513 -- F 1/M 66	2010 2137 (E)	98	IRME	MS	5760	R-Bl, MR-BS	Irrigated areas of Bihar, Uttar Pradesh, West Bengal, Tamil Nadu, Karnataka
11	27P11 19766 -- R 826F/ R 849	2010	104	IRM	MS	5675	--	Irrigated areas of Karnataka, Maharashtra
State Releases								
Andhra Pradesh								
12	Akshaya 20953 BPT 2231 BPT 43 58/IR 64	2011 283 (E)	118	RSL	MS	6180	MR-Bl, ShBl, BS	Rainfed shallow lowlands of Andhra Pradesh

Sl. No	Variety Name IET No Designation Cross Combination	Year of Release/Notification No.	FD (Days)	Eco-System	Grain Type	Yield (kg/ha)	Reaction to pest / diseases	Recommended State/Region
13	Bhavapuri Sannalu 21466 BPT 2270 BPT 5204/CR 15 MR1523	2011 283 (E)	130	RSL	MS	5960	MR-Bl, BLB, BS	Rainfed shallow lowlands of Andhra Pradesh
14	Jagtial Mahsuri 19574 JGL 11470 JGL 418/ Gedongibeton	2011 283 (E)	106	IRM	MS	6750	MR-Bl, BLB, BPH, GM	Irrigated areas of Andhra Pradesh
15	Karimnagar Samba 20155 JGL 3855 Samba Mahsuri/ ARC 5984// Kavya	2011 283 (E)	110	IRM	MS	7000	MR-Bl,BLB, ShBl, BS	Irrigated areas of Andhra Pradesh
16	Motigold 21698 NP 1024 PRN 55/ PRN 14	2010	105	-	MS	4827	--	Irrigated areas of Andhra Pradesh
17	Sonal 21252 NP 3114 N 6/ PRN 48	2010	95	IRME	MS	5513	--	Irrigated areas of Andhra Pradesh
18	Sugandha Samba 21045 RNR 2465 Early Samba/ RNR 19994	2011 283 (E)	103	SCR	MS	3747	R-Bl.	Irrigated areas of Andhra Pradesh, aromatic rice
19	Vamsadhara 19131 RGL 11414 RGL 4166/ MTU 7029	2011 283 (E)	130	RSL	MS	6500	MR-Bl	Rainfed shallow lowlands of Andhra Pradesh

Sl. No	Variety Name IET No Designation Cross Combination	Year of Release/Notification No.	FD (Days)	Eco-System	Grain Type	Yield (kg/ha)	Reaction to pest / diseases	Recommended State/Region
Chhattisgarh								
20	Maheshwari 19796 R 1244-1246-1-605-1 Mahamaya/ Abhaya	2010	106	IRM	LS	5299	R-Bl, GM MR-BS	Irrigated areas of Chattisgarh
21	Indira Barani Dhan-1 21205 R1835-RF-38 Swarna/ IR 4223	2010	82	AER	MS	4426	T-SB	Limited water situations of Chattisgarh
Gujarat								
22	NAUR 1 20115 NVSR 20 GR4/ Pusa 2 -48-24	2010	95	IRME	LS	6000	MR-Bl, BLB, ShR, SB	Irigated areas of Gujarat
Karnataka								
23	Mugad Siri 1253 -- -- BPT 5204/ Kavya	2010	105	IRM	--	4750	MR-Bl	Irigated areas of Karnataka
24	Raksha 21610 KMP 105 Field Collect ion during Production Oriented Survey	2010	95	IRME	MB	4500	MR-Bl	Irigated areas of Karnataka
Kerala								
25	Pratheeksha 18660 KAUM 108 - 262-1 IET 4786/ MO 8 (Aruna)	2010 733 (E)	80	IRE	LB	5500	R-Bl, MR-ShBl, BS, BPH, GM	Irrigated areas of Kerala

Sl. No	Variety Name IET No Designation Cross Combination	Year of Release/Notification No.	FD (Days)	Eco-System	Grain Type	Yield (kg/ha)	Reaction to pest / diseases	Recommended State/Region
26	Vytilla 8 -- -- IR 47310-94-4-3-1/ CSR 10	2010 733 (E)	85	IRSA	MB	4200	--	Saline areas of Kerala
Meghalaya								
27	Bhalum 3 21318 RCPL 1-115 Epiyo/ IR 75502-24-1-1-B	2010	105	RUP	LB	3800	MR –SB	Rainfed uplands of Meghalaya
28	Bhalum 4 21319 RCPL 1-116 Epiyo/ IR 72777-35-1-1	2010	102	RUP	LB	3800	R-Bl, MR-SB	Rainfed uplands of Meghalaya
29	Megha SA 1 - RCPL 1-76	2010	120	RSL	SB	3200	R-Bl, MR-SB	Rainfed shallow lowlands of Meghalaya
30	Megha SA 2 - RCPL 1-160 Chandan / PAU 139-48-1-1-1-3-1-1	2010	113	RSL	LB	3750	R-Bl, MR-SB	Rainfed shallow lowlands of Meghalaya
Odisha								
31	Luna Sampad 19470 CR2095-181-1 Mahsuri / Chakrakonda	2010	113	IRSA	MB	3800	R-Bl, MR-ShBl, BS, SB, BPH, LF	Saline areas of Odisha
32	Luna Suvarna 18697 CR 2096-71-2 Mahsuri / Ormundakan	2010	108	IRSA	LS	3750	R-Bl, MR-ShBl, BS, SB, BPH, LF	Saline areas of Odisha

Sl. No	Variety Name IET No Designation Cross Combination	Year of Release / Notification No.	FD (Days)	Eco-System	Grain Type	Yield (kg/ha)	Reaction to pest / diseases	Recommended State/Region
33	Nua Chinikamini 18394 CR 2580 Selection from local variety	2010	121	SCR	SB	3400	R-RTV, GM, MR - Bl, BS, SB	Rainfed shallow areas of Odisha
34	Phalguni 18720 CRAC 2224 - 1041 Doubl ed haploid of KRH 2	2010	87	RUP	LS	4250	R-Bl, GM, LF, MR-RTV, ShBl, BS, GLH, SB, BPH, WBPH	Rainfed uplands of Odisha
35	Reeta (CR Dhan 401)19969 CR 780-1937-1-3 Savitri/IR 44	2011 283 (E)	117	RSL	LB	5210	R-Bl, WBPH	Rainfed shallow lowlands of Odisha
Uttar Pradesh								
36	NDR 2065 17476 NDR 2065 Pantdhan 4/ Saket 4// NDR 2018	2010	98	IRM	LB	5250	R-Bl, WBPH, GM	Irrigated areas of Uttar Pradesh

Co-ordinated Varietal Testing - Forty one varietal trials and 6 hybrid rice trials were conducted as 706 experiments at 115 locations (46 funded, 69 voluntary centres) in 27 states and 2 Union Teritorries in all 5 regions of the country. Hybrid rice experiments were also conducted by 6 private seed companies. The 47 trials were constituted with 970 entries including 88 experimental hybrids and checks. After three year (2008-2010) testing, 25 cultures including 4 hybrids were found promising for different ecosystems (Table 2). Of the promoted entries from AVT 1 to AVT 2, the most promising ones are listed in Table 3.

Table : 2 Promising entries for different ecologies based on three year testing (2008-2010) in Varietal Trials

S. No	IET No. / Designation	Source Trial	Cross Combination	FD (Days)	Grain Type	Yield (Kg/ha)	Reaction to pests/diseases	Suitable for
1	20863 (CRR 455 - 109)	AVT VE – DS	Kalinga III / WAB 56 - 50	67	SB	1676	--	Upland areas of Jharkhand
2	20048 (NDGR 201)	IVT - SDW	Local selection from Pansar (Land race)	124	SB	3112	--	Semi deep water areas of Uttar Pradesh
3	20706 (CR 2080 -3-2-5-2)	IVT - DW	Sam Son Polo / Jalnidhi	151	MS	4203	R-RTV	Deep water areas of Odisha.
4	20878 (OR 1734 -1-1)	AVT - VE -TP	Subhadra / NDR 1006	87	SB	5288	--	Irrigated areas of Karnataka
5	21106 (OR 1777 -4)	AVT - 2E -TP	P 677 - 50-103 - 2-9 / Badami	88	MS	4727	MR - GLH	Irrigated ar eas of Odisha, Maharastra, Kerala
6	20710 (Indam 200 - 022) Hybrid	AVT - 2E -TP	--	84	MS	4601	MR - WBPH	Irrigated areas of Madhya Pradesh
7	20727 (US 382) Hybrid	AVT 1 - IME	--	93	LB	5727	MR - NBl, WBPH	Irrigated areas of Karnataka
8	20716 (VNR 204) Hybrid	AV T 1 - IME	--	95	LS	5704	MR - LBl, BLB, GLH	Irrigated areas of Chhattisgarh, Tripura and Tamil Nadu
9	20923 (OR 2327 - 23)	AVT 2 - IM	OR 1206 -26-2 / IR 62140	108	LS	5114	MR - LBl, ShBl,S hR	Irrigated areas of Gujarat, Tripura and Tamil Nadu.

S. No	IET No. / Designation	Source Trial	Cross Combination	FD (Days)	Grain Type	Yield (Kg/ha)	Reaction to pests/diseases	Suitable for
10	20926 R1521-1950-6-843-1	AVT -2 IM	R827-2871 Rastic BR 240-47	109	SB	5172	-	Irrigated areas of Andhra Pradesh, Gujarat, Maharashtra, Bihar
11	20915 (UPR 2937-9-3-1)	AVT 2 - IM	SPRLR 83030-7-3-2-1-2-3 / Pant Dhan 4	101	LB	5199	MR-LBl	Irrigated areas of Andhra Pradesh, Tamil Nadu , Chhattisgarh.
12	20735 (VNR 202) Hybrid	AVT 2 - IM	--	102	MS	5460	MR-GLH	Irrigated areas of Uttarakhand, Chhattisgarh, Tamil Nadu.
13	19886 (CN 1272-55-105	AVT 2 - L	Swarna / IR 36 // Mohan / Khitish	118	SB	5673	R-GMB4	Irrigated areas of Andhra Pradesh, Bihar, Maharashtra, Karnataka.
14	20760 (CN1340-76-1-BNKR-23-7-1)	AVT 2 - L	IR 42 / Patnai 23	116	SB	5358	MR-NBl, ShR	Irrigated areas of Bihar, West Bengal
15	20827 (MAUB-171)	AVT 2 - BT	Pusa Basmati 1 / Type-3	114	LS	4031	MR-RTV	Basmati growing areas of U ttar Pradesh, Jammu & Kashmir
16	19800 (PDKV Shriram)	IVT-ASG	Selection from local rice variety Jai Shiram	98	SS	3333	--	Irrigated areas of Uttar Pradesh, Chhattisgarh, Gujarat, Andhra Pradesh, Karnataka

S. No	IET No. / Designation	Source Trial	Cross Combination	FD (Days)	Grain Type	Yield (Kg/ha)	Reaction to pests/diseases	Suitable for
17	20466 (NDR 6239)	IVT-ASG	Selection from Kalanamak (Nichlaul)	112	MS	2772	--	Irrigated areas of Karnataka, Gujarat
18	20819 (HPR 2598)	AVT 2 - E(H)	SR 17271-HB 522-57-2 / IR 66160-5-2-3-2	94	LS	3773	MR-BLB	Irrigated low elevation hills of Himachal Pradesh
19	20803 (VL 31329)	AVT 1 - M(H)	IR 64 / *O. rufipogon*	95	LS	5037	--	Irrigated medium elevation hills of Uttarakhand
20	20806 (VL 31335)	AVT 1 - M(H)	IR 32809-26-3-3 / IR 39292-142-3-2-3	98	LS	4592	MR-BLB	Irrigated medium elevation hills of Uttarakhand
21	20955 (VL 7620)	AVT 1 - U(H)	VR 539-2 / VL 89-6036 // VL 6636	76	LS	2008	MR-LBl, NBl, ShBl.	Upland hills under low and medium elevation in Uttarakhand
22	20957 (VL 7742)	AVT 1 - U(H)	VR 539-2 / VR 921-2-2-1	86	LS	2648	--	Upland hills under medium elevation in Uttarakhand
23	20959 (VL 7820)	AVT 1 - U(H)	VR 533 / VL 89-5137	86	SB	2638	MR-ShBl	Upland hills under medium elevation in Uttarakhand
24	21214 (CR2624-IR 55423-01)	AVT 2 – ME (Aerob)	UPL RI 5 / IR 12979-24-1 (Brown)	93	SB	4283	MR-ShR	Aerobic areas of Jharkhand, Chhattisgarh
25	21205 (R 1835-RF-38)	AVT 2 – ME (Aerob)	Swarna / IR 4223	82	MS	3573	MR-BS	Aerobic areas of Gujarat, Tamil Nadu

Table 3: Promising cultures in Advance Variety Trials 1, *Kharif* 2010

IET No. Designation	Yield (kg/ha)	FD (days)	Grain type	Yield advantage % over checks				Tolerance to biotic stress
Direct Seeded Early				Annada	RC	LC		
21638 TJP 48	2340	76	LS	54.15	41.56	38.05		
21625 CR 2698	1822	85	LB	20.02	10.22	7.49		MR -BPH, GLH
Irrigated Very Early				Jaldidhan 6	RC	LC		
21288 RR 347 -5	4289	74	SB	33.28	5.04	--		
21278 JDP -13 -1- RR419 -7	4068	77	MS	26.41	--	--		MR -RTV
Irrigated Early				Annada	RC	LC		
21626 CR 2699	5148	91	LB	30.19	40.88	12.94		MR -ShBl, WBPH,
21630 CR 2707	5065	86	SB	28.09	38.61	11.12		MR - WBPH
Irrigated Mid Early				IR 64	PA 6201	RC	LC	
21415 27P31 (H)	5847	96	LB	21.96	12.53	21.46	19.86	MR -LBl, NBl
21582 OR 2172 -7	5172	95	LS	7.88	--	7.44	6.03	MR -BS
Irrigated Medium				Jaya	KRH 2	RC	LC	
IET 21426 MEPH -109	5651	100	LS	26.65	11.90	44.42	15.56	
IET 21510 HKR.06 -47	5475	101	LS	22.70	8.42	39.92	11.96	MR - WBPH
IET 21009 OR 2324 -8	5320	103	MS	19.22	5.35	35.95	8.79	
Irrigated Late				Swarna	RC	LC		
21477 OR 2328 -5	5696	113	SB	19.04	23.69	14.76		MR -BLB, RTV
20884 CB 05022	5332	117	MS	11.45	15.79	7.44		MR - ShBl , BLB, WBPH
Boro				Gautam	IR 64	K.Hamsa	LC	

IET No. Designation	Yield (kg/ha)	FD (days)	Grain type	Yield advantage % over checks				Tolerance to biotic stress
21255 NPH 924 -1	6134	129	LS	25.77	26.68	27.47	12.46	
Basmati				Pusa Basmati 1	Taroari Basmati			
IET 21665 RP 3644 -1-19-5-5	4295	109	LS	26.57	46.32			MR -BS
IET 21669 HUBR 10 -9	4115	109	LS	21.24	40. 15			-
IET 21660 NDR 6244	4102	110	LS	20.86	39.71			MR -LBl, NBl, ShR
Aromatic Short Grain				Badshabhog	Kalanamak	LC		
21053 NDR 9542	3871	112	MS	57.9	55.9	37.1		
21044 CR 2616 -3-3-3-1	3547	93	MS	44.7	42.9	25.6		
Low Elevation Irrigated Early Hills				Vivekdha n-82	RP 2421	LC		
21390 VL 31290	3929	94	LS	44.8	39.9	20.6		MR -LBl
21386 HPR 2529-4	3782	104	LS	39.4	34.6	16.1		--
21393 VL 31449	3755	96	SB	38.4	33.7	15.3		MR -LBl
Medium Elevation Irrigated Early Hills				Vivekdhan-82	RP 2421	LC		
21392 VL 31284	4128	93	MS	55.4	65.7	89.5		MR -LBl, ShBl
21384 HPR 2557	3995	95	MS	50.4	60.4	83.4		--
21393 VL 31449	3837	93	SB	44.4	54.0	76.1		MR -LBl
Medium Elevation Irrigated Medium Hills				Vivekdhan-62	HPR 2143	LC		

IET No. Designation	Yield (kg/ha)	FD (days)	Grain type	Yield advantage % over checks				Tolerance to biotic stress
21383 VL 31451	4913	112	SB	151.2	17.7	22.6		MR -LB l, NBl, ShBl
21375 HPR 2625 (DH(D)24)	4845	98	MS	147.6	16.1	20.9		MR -LBl, ShBl, BS,ShR
Low Elevation Upland Hills				Vivekdhan -154	Sukara dhan 1	LC		
21326 VL 7954	1904	77	LS	117.1	12.2	24.9		
21318 RCPL -1-115	1901	98	LB	116.7	12.0	24.7		
Medium Elevation Upland Hills				Vivekdhan -154	Sukara dhan 1	LC		
20955 VL 7620	2569	83	LS	40.1	80.2	80.7		MR -LBl, NBl, ShBl
Early Aerobic				Rasi	MAS 26	LC		
21680 CB 05 -754	4362	94	SB	17.28	10.96	11.39		MR -BS
Mid Early Aerobic				IR 64	MAS 946	LC		
21686 R 1570 -2649 -1-1546 -1	3668	85	MS	16.96	22.59	11.69		MR -NBl, WBPH
21692 CR 2696 -IR 83920 -B-B-CRA -103 -14 -1-1-1	3468	79	SB	10.59	15.9	5.6		MR -NBl, WBPH

INGER Observational Nurseries -Thirteen IRRI coordinated INGER Observational Nurseries involving 864 elites lines from diverse origin were evaluated at 46 test locations. Some of the superior INGER entries identified are presented below:

International Irrigated Rice Observational Nurseries (IIRON) **Module 1** : Singkil, IR 80905 -50-1-3-2, IR 75288 -144-1-3, OM -6161and ADT(R) 47 . **Module 2:** IR 79218 -43-2-1-2, IR 79504-53-3-2-3, OM 5629 and IR 81358 -98-1-3-2-3	**International Rice Soil Stress Tolerance Nursery (IRSSTN)** **Module 1** : AT 401, IR 66946 -3R-178-1-1 (FL 478), IR 71829 -3R-10-3 **Module 2:** AT 401, IR 72593 -B-13-3-3-1, IR 45427-2B-2-2B-1-1
International Finegrain Aromatic Rice Observational Nursery (IRFAON) YN 2991 -2-1-1-3, IR 62266-42-6-2, IR71146 -97-1-2-1-3 and IR 78119-24-1-2-2-2	**International Rice Heat Tolerance Nursery (IRHTN)** IR 65192 -4B-17-3, I R 6 and Peh -Kuh -Tsao -Tu (ACC 8237)
International Upland Rice Observational Nursery (IURON) IR 72860 -107-3-1-2, IR 82639 -B-B-3-3 and IR 82635 -B-B-82-2	**International Cold Tolerance Nursery (IRCTN)** Barkat (K 78-13), IR 83222 -25-4-6-2-1, K 39 -96-1-1-1-2
Aero bic Rice Observational Nursery (AERON) IR 82639 -B-B-140-1, UPL RI-7 and IR62141-114-3-2-2-2 (PSB RC80)	**International Rice Blast Nursery (IRBN)** IRBL 5 -M/RL, IRBL 7-M/RL and IRBL 9-W/RL, CNAX 4602 -6-3-3-2-1and CT 18244-7-7-1-1-5-2
International Temperate Rice Observational Nursery (IRTON) IRAT 248 and IR 83243 -2-1-12-5-1-1	**International Rice Tungro Nursery (IRTN)** ASD 7 (ACC 6303), Palasithari 601 (ACC 12069) and Balimau Putih (ACC 17204)
International Rice Lowland Yield Nursery - Submergence Set (IRLYN-SS) IR 66876 -11-NDR 1 -1-1-1, IR 82355-5-2-3 and PSB RC 68	

Hybrid Rice

Six hybrids *viz.*, US 312, INDAM 200 017, CRHR 32, Rajlaxmi, NK 5251 and 27P11 were released and notified by CSCCSN & RV during 2010 for commercial cultivation in different states of the country. Rajlaxmi, though it was released earlier for Odisha was again notified during 2010 for its cultivation in the Boro areas of Assam and Odisha. During the year six hybrid rice trials with 88 hybrids were tested in 6 to 30 locations.

Initial Hybrid Rice Trials - Four Initial Hybrid Rice Trials (IHRT) *viz.*, early, medium-early, medium and medium slender grain type were conducted with 9, 27, 19 and 16 entries respectively at 25 to 30 locations. Promising hybrids identified include US 314, 26P27 and HRI 172 (early); NK 6303, RH 09011 and ARRH 3626 (medium early); KPH-272, XR 97939 and XR 99982 (medium); US 305, KPH 199 and XR 97747 (slender grain).

Multilocational evaluation of released/ identified hybrids (MLT) - In order to find out the suitability of already released/ identified hybrids to more number of locations in respective states, representing different agro – climatic regions of the country, a separate multilocational trial consisting of seven hybrids in mid early and medium maturity groups were organized along with national varietal checks (IR64 for mid early and Jaya for medium), national hybrid checks (PA6201 for mid early and KRH 2 for medium) and local checks at 26 locations, representing different states. Two medium maturing hybrids *viz.,* PAC 835, PAC 837 recorded more than 10 percent yield advantage over the best varietal check and 5 percent yield advantage over the best hybrid check. None of the hybrids in the mid early group showed the required yield superiority over both the best varietal or hybrid checks.

Disease and insect reaction of IHRT entries -In IHRTE, JKRH-2007 was found promising for brown planthopper, gall midge and stem borer; HRI-172 was found resistant to gall midge and stem borer under field conditions. In IHRT-ME, DRH-005 was promising for both gall midge and stem borer. Three hybrids viz., NK-9273, Bisco-803 (IHRT-M) and GK5016 (IHRT-ME) were resistant to leaf blast. Many entries showed moderate level of resistance to leaf blast, sheath rot, bacterial leaf blight, rice tungro virus and grain discoloration as given below.

Insect pest and disease reaction of hybrid entries in IHRT trials, Kharif-2010

Insect Pest	Hybrids
Resistant	
Brown planthopper	JKRH 2007 (E)
White backed planthopper	KPH 199 (MS)
Gall midge	JKRH 2007, HRI172 (E); DRH 005, RH 09011, GRH3, GK 5016 (ME)
Leaf blast	NK 9273, Bisco 803 (M); GK 5016 (ME)
Moderately resistant	
Leaf blast	NPH 909, PAC 8107, HRI 172 (E); DRH 834,US 346, HRI 171 (ME); KSL 320070H, KPH 272 (M); NPH 23, XR 97754 (MS)
Sheath rot	KPH 216,US 346, GK 5016 (ME); GK 5015, PAC 8555, DRRH 74, XR 97939, KPH 272 (M); 27P63, US 305 (MS)
Bacterial leaf blight	CNRH 102 (ME); 27P61, XR 97754, US 303 (MS)
Rice tungro virus	NSPL 30, US 321 (M); DRH 005, TNRH 193 (ME), TNRH 180 (MS)
Grain discoloration	NPH 909, HRI 172, VRH 606, JKRH 2007, PAC 8107, JRH 21, JRH 25, 26P27 (E); CNRH 102, DRH 005, HRI 173, NK 6303, DRH 834 (ME)

E: IHRT E,ME:IHRT ME, M: IHRT M, MS:HRT MS

Crop Production (Tables to be added in this section)

Agronomy

Nitrogen use efficiency of rice varieties **-** In 260 experiments conducted at 54 locations elite genotypes (72 AVT-2 culture) belonging to 17 groups were tested leading to identification of 12 promising cultures *viz*., IET 19800 in aromatic short grain, IET 20863 and IET 20871 in very early direct seeded upland, IET 20716 and IET20727 in medium early, IET 20915,IET 20935 and IET 20924 in medium, IET 21208 in medium early (aerobic), IET 20800 and IET 21299 in late and IET 20048 in shallow deep water situation with better response to nitrogen (NVT). No cultures were promising in early hill (irrigated), medium hill (irrigated), upland hill (direct seeded), basmati, early direct seeded ,very early (transplanted), early (transplanted), IHRT medium slender ,deep water, and alkaline and inland salinity tolerant. Most of the cultures were found performing well at 100% of N while cultures IET 20812 and IET 20114 were found promising at 50% of N; . IET 20822.IET 20859,IET 20863, IET 20871, IET 20924, IET 20205, IET 19886,IET 20760,IET 20761, IET 20748, IET 20370, IET 20330 and IET 20640 were promising at 150% of N.

Cultural Management trials **-** Growing of rice + sun hemp (intercropping and incorporation) along with nutrient schedule of 60:40:40:500 or 60:60:40:500 NPK Lime kg/ha and foliar spray of 0.5.% $ZnSO_4$ was found promising for enhancing grain yield as well as soil health under rainfed upland. For boro areas under early planting situation, planting of single seedling per hill of 25 days old seedlings at 25x25 cm spacing was found suitable for better grain yields. Under late planting conditions, 45 day old seedlings at closer spacing of 20x10 cm with three seedlings/hill was found superior. Under system of rice intensification, planting of 10 day old seedlings followed by 4 times cono weeding was found effective in increasing grain yield. Application of 100-125% nitrogen + pre-emergence herbicide application + Rice: Dhaincha (1:1) + hand weeding at 60 DAS or 2,4 D-Na application at 25-30 DAS was found promising for aerobic rice. Irrigation schedule of 150% CPE along with N_{120} P_{60} K_{50} or N_{120} P_{30} K_{100} depending on initial soil nutrient status was found to be economical for aerobic rice cultivation. Use of mechanical transplanter with transplanting of 15 day old seedlings of high yielding varieties under recommended fertilizer dose and other production practices increased grain yields over farmers practice.

Weed management **-** Bensulfuron-methyl + pretilachlor (post - planting) in conjunction with glyphosate (pre-planting) recorded best broad spectrum weed control in transplanted rice. Penoxsulam 24 SC @ 0.025kg a.i/ha followed by its lower dose (0.0225kg a.i/ha) and pyrazosulfuron - ethyl 10 WP @ 0.020kg a.i (20DAS) were found effective for controlling weeds in direct seeding rice under puddled condition. Under dry direct seeded rice in canal irrigated areas, metamifop and pretilachlor were found to be effective. Survey on weedy rice indicated that weedy rice problem was moderate to severe in Varanasi, Jagdalpur, Ranchi and Chatha areas. In Varanasi and Jagdalpur area the weedy rice problem was more in dry seeded rice, where as in Ranchi and Chatha it was more in transplanted rice. The yield loss varied from 5-10 to 30-50%.

Rice based cropping systems **-** Under rice-wheat system, hybrids PA 6444 and KRH-2, MTU 1010 at Rajendranagar, PA 6201, KRH 2 at DRR and CO RH -3 at Coimbatore followed by wheat in *rabi*, performed better. Mandya Vijaya, Rasi,

Krishnahamsa, Triguna, Akshayadhan and Varadan (4.63 – 4.85t/ha) at DRR; TJP – 48 (3.83 t/ha) at Tuljapura; IET 21299, IET 20800, BPT-5204 and Silwamani (2.67 – 3.04 t/ha) at Patna (ICAR-PARISAN); Naveen (4.26t/ha) at Ranchi; Govind and NDR-359 at Nagina; Mahamaya, Swarna and Bamleshwari (5.52 – 5.85 t/ha) at Raipur; and PAU-201, IR 88633-1-23-B and PR-120 at Ludhiana, performed well and were significantly superior to rest of the cultivars tested. It was established that dry seeding of rice (Kharif) and maize (Rabi) under dry seeding with 50% mulch with location specific varieties of Rice and Maize was a more profitable system than dry seeding without mulch or wet seeding under puddled condition.

Soil Science

Long time fertilizer studies - The 22nd year of study conducted at 3 locations (Mandya, Maruteru and Titabar) indicated significant improvement in rice productivity with the supplementation of recommended fertilizer dose (RFD) of 100% NPKZnS with 5 t/ha FYM in rabi and kharif in all the locations and with the substitution of 50% NPK by FYM at Mandya. There was a corresponding increase in nutrient accumulation in dry matter and improvement in soil nutrient status and organic carbon. Response to P and K was significant and that of Zn and S at Titabar, while 50% reduction in PK or NPK dose from RFD decreased rice yields by 0.8 to 1.2 t/ha. Average accumulation of N, P_2O_5 and K_2O in the dry matter was 42, 21 and 33 kg at Mandya, and 48, 9 and 32 kg at Titabar which amounts to 11.6, 5.8 and 9.2 kg and 11.2, 2.2 and 7.6 kg NPK per ton of grain indicating unusually very low accumulation of N and K at Mandya and of all the nutrients at Titabar. Rice productivity growth (linear) improved @ 11 – 251 kg grain /ha/year or was near stable in the Godavari delta system (Maruteru) with most of the treatments except those not supplied with P and K (@ -12 to -20 kg/ha/yr) while in Assam valley (Titabar) and plateau region (Mandya) the productivity declined in most of the treatments @ 2-39 kg/ha/year at Titabar and more intensely at Mandya @ 15 – 107 kg/ha/year. With the application of FYM+RFD and / or with INM treatments (FYM) the growth was positive at all the locations and correspondingly sustained or improved soil fertility. At Mandya, however, mismatch of yield trends with soil fertility changes suggests for analysis of other soil parameters and a relook into current fertilizer recommendations.

Rice productivity in relation to internal supply capacity of nutrients in farmers' fields - This trial was conducted in farmers' fields around few selected centres at Mandya, Maruteru and Titabar, to assess variability in soil nutrient supply, its relationship with rice yields at current fertilizer practices, and to fine-tune the fertilizer nutrient requirement for specific target yields in a given environment. Nutrient uptake requirement / t of grain ranged from 13.6-16.9, 2.7-4.4 and 9.2-14.4 kg N, P_2O_5 and K_2O at Titabar and 10.5 - 15.5 kg N, 4.5-8.5 kg P_2O_5 and 17.7- 26.3 kg K_2O at Mandya with RFD showing considerable variation among the farm sites. The yields were less by 22-85% and up to 32% with farmers' fertilizer practices, respectively at these locations compared to RFD with corresponding variations in nutrient uptake, nutrient utilization and recovery efficiencies. Fertilizer recommendations for target yield of 6.5 t/ha at Titabar varied with sites from 32 - 84 kg N, 15-28 kg P_2O_5 and 17 – 44 kg K_2O / ha as against the blanket RFD of 40:20:20 NPK/ha, while at Mandya it varied from 67-86 kg N, 28-48 kg P_2O_5 and 42 – 88 kg K_2O / ha as against 100:50:50 NPK/ha for target yield of 6.4 t/ha. Site specific nutrient management (SSNM) was superior to the

currently recommended blanket fertilizer dose or the soil test-based recommendation (uniform dose followed) and farmers' fertilizer practice at both the locations.

Management of micronutrients in rice-wheat system in sodic soil - This trial was initiated in *kharif* 2009 at Kanpur to study the direct, residual and cumulative effects of micronutrients on the nutrition and productivity of rice wheat cropping system in sodic soils. With few modifications the trial was conducted in *kharif* 2010 which showed significant response to gypsum application in terms of yield and nutrient accumulation at both 50 and 100% of requirement. Micronutrient management of supplementing zinc at 50 kg $ZnSO_4$/ha or combined application of zinc and iron (30 kg Fe-EDTA / ha) with or without organic manures improved rice productivity and utilization efficiency of nutrients like N, P and Fe that resulted in reduced requirement of these nutrients including zinc.

Screening of rice germplasm for high iron and zinc contents - The study was conducted at 11 locations screening 185 cultures which also included four varieties (checks) promising for high Zn and Fe content to study the influence of environment on rice productivity and micronutrient contents. The effect was significant influencing rice productivity and Zn contents in the brown rice and total uptake across locations and genotypes, while that of Fe varied between locations with strong interaction effects of genotypes and locations. The relationship, however, between Fe and zinc contents in brown rice and grain yield was not significant despite observed variations in grain yields and micronutrient contents in all the common set of genotypes evaluated. Several location specific promising cultures for high Fe and Zn content were identified which included the Njavara group at Moncompu, Pathani 23 and Jodumani from Karaikal, swarna sub 1 at Kanpur, Bhutmuri at Bankura and few NDR and scented cultures at Faizabad and Khudwani, resectively.

Nutrient and water requirement for aerobic rice cultivation - The study initiated in *kharif* 2010 indicated no effect of water regimes on the performance of aerobic rice (non-puddled, direct sown and near saturated field water regime) at DRR and Kanpur. Response to applied nutrients was significant for N at DRR and for N and P at Kanpur increasing grain yield by 0.3 – 0.6 to 1.2 t / ha. Application of nutrients improved N and K accumulation up to 60 and 100 kg / ha, respectively at DRR and increased uptake of all the nutrients up to 120, 60 and 50 kg/ha of NPK application at Kanpur. At the highest yield level of 5.2 and 4.0 t / ha at DRR and Kanpur, the nutrient uptake requirement was estimated to be 20.3, 7.6 and 25.9 Kg and 18.4, 5.4 and 21 kg NPK /t grain at DRR and Kanpur. Water productivity (kg grain/mm water used) ranged from 4.0 – 4.6 at Kanpur and 3.9 to 4.8 kg grain / mm water at DRR depending on the water regime, based on which irrigation equivalent to 100% of cumulative pan evaporation (CPE) appeared to be optimum for aerobic rice system at the test locations without yield loss and saving, 16.3 and 12.5 per cent of irrigation water, respectively.

Management of crop residues in rice based cropping systems - The trial to study the influence of different residue management strategies on crop yield and soil fertility was conducted at seven locations under two different rice based cropping systems during the previous *rabi* and *kharif* seasons. In the rice –wheat cropping systems at Faizabad, Ghaghraghat and Kanpur, straw (5 t/ha) + green manure (5 t/ha) incorporation

resulted in the highest yields and nutrient uptake for both *rabi* and *kharif* crops. Maximum enhancement in nutrient use efficiencies, accumulation of soil available NPK and soil organic carbon was also observed with the same treatment at these locations. In the rice –rice system at Chinsurah, similar positive effect on crop yields and soil parameters was observed with incorporation of straw along with microbial inoculum.

Screening genotypes suitable for acid soils and related nutritional constraints - The fourth year results on screening of rice genotypes for acid soils in lowland rice ecosystem at Titabar (Assam) and Ranchi (Jharkhand) indicated variable genotype response to lime application and Fe toxicity stress. Liming influenced the productivity of rice under lowland conditions significantly at both locations. Doubling the dose of P and K did not give additional yield advantage though it increased grain P and K uptake at Titabar. Based on the observations on crop productivity and uptake of major nutrients, IET 10016, WL 21, Jaya and IET 20974 were promising for acid soils while IET 21519 was tolerant to Fe toxicity at Titabar. IET 21528, IET 21531 and IET21519 gave higher grain yields in the acid soils of Ranchi.

Nutritional status of rice in farmers' fields in relation to productivity - The results of this study organized in representative farm sites (148) around Ghagraghat, Mandya, Titabar, Maruteru and Karaikal representing Indo-gangetic plains, Brahamputra basin, southern plateau region and Godavari / Cauvery delta indicated wide variability among farm sites in rice productivity, soil nutrient supply and nutrient use efficiency of genotypes. Average rice productivity was highest at Titabar followed by Maruteru, Karaikal, Ghaghraghat and Mandya reflecting broadly the soil quality status. Nutrient harvest index calculated across farmers' fields at these sites indicated steep variation for all the nutrients and low nutrient harvest index at Mandya and Titabar due to poor nutrient concentration in the grain and straw

Nutrient requirement of recently released varieties and hybrids of different duration groups - The results indicated differential response of genotypes to nutrient application which was specific to different test environments. Overall, the yield response was significant up to 120, 60, 50 kg NPK /ha for HYVs at most of the locations, while there was no response to P application at Chinsurah. Based on the nutrient accumulation and yield response to fertilizer application, the estimated nutrient uptake requirements for hybrids and HYVs across the locations ranged from 15 – 24 kg N, 5-11 kg P2O5 and 15 – 43 kg K_2O per ton of grain production. By regression analysis, the nutrient requirement of the test cultures ranged from 14 - 30 kg N, 3 – 10 kg P_2O_5, and 9 – 28 kg K_2O/t grain. K requirement was high at DRR based on uptake for the highest recorded yield of HYVs, but optimum by statistical method. At Karaikal, however, it was high for both genotype groups.

Studies on partitioning of zinc and iron in rice and prospects of enrichment - The first year of study conducted at Aduthurai, Karaikal, DRR and Maruteru indicated that culture Aghonibora (promising for high Zn and Fe content) was most productive at DRR and Aduthurai. Response to zinc application was significant at Aduthurai, DRR and Karaikal, and for iron spraying at Maruteru. Organic manuring along with micronutrients was most productive at all the locations. Micronutrient (Zn, Fe) content in the tissue varied with the genotypes with Aghonibora

recording highest zinc content in all plant parts at harvest time at Karaikal and was second best next to ADT43 for both zinc and iron contents at Aduthurai at PI stage. Varietal variations for micronutrient accumulation (uptake) were recorded at Aduthurai where Aghonibora accumulated maximum Fe and Zn in the biomass. Application of micronutrients improved iron uptake in grain at Karaikal and of both nutrients at Aduthurai. Much of the nutrients were located in stem portion and only 6 – 16% and 18 - 22% of Fe and Zn translocated to the grain. Among the varieties Aghonibora was most promising with improved zinc and iron accumulation in grain upon micronutrient application at Aduthurai and that of iron at Karaikal.

Plant Physiology

Photothermic indexing **-** A set of 29 genotypes were selected and the seedlings sets were sown 15 days early to that of normal sowings. There were no significant differences in earliness in flowering, cumulative degree days (CDD), cumulative nycto period (CNP), biomass and grain yield between the two sets of sowing dates. It was found that IET 20924 and IET 20935 were superior and consistent across the locations for the second consecutive year for relative photoinsensitivity. Other cultures such as IET 20524, IET 20556 IET 20945 and IET 20601 were superior to checks Jaya, Lalat, NDR 359, and Hybrid PHB-71.

Boron and spikelet fertility **-** Six IET cultures with Rasi as check variety were evaluated at ten locations. to study the response to boron applied at the time of anthesis @ 0.2 ppm, 0.4 ppm, 0.8 ppm and control. Based on the data on spikelet sterility, high density grains and yield it was found that IET 20979, IET 21114, and IET 21519 showed a positive response to boron application @ 0.4 ppm across the locations.

Elite lines for drought tolerance **-** Twenty one IET cultures along with hybrid PA 6129 and Annada were evaluated to study the impact of dry spells in rain fed upland situation. Annada and IET 20708 recorded higher yield stability index and low percent thermostability. The effect of low osmotic potential germination was severe at 10 bars. All the entries with the exception of IET 2129 (48%) and IET 21637 (67%) recorded germination above 70%. Among the 21 IET cultures along with PA 6129 and Annada, it IET 20708 and IET 20710 recorded high grain yield at four and three locations respectively under dry spell, similarly, IET 21281 and IET 21076 were drought susceptible at four and three locations, respectively.

Near isogenic lines for submergence tolerance **-** This trial was conducted at three locations. Higher biomass was found in Swarna sub I followed by Sambamahsuri and IR 64 irrespective of control and submergence situations at all the three locations. In all the entries under study, it was found that introgression of sub I gene for submergence tolerance improved the survival percentage, recovery and yield.

Radiation Use Efficiency **-** The mean RUE recorded for all genotypes across locations was 0.33. IET 21429 and Lalat had minimum radiation use efficiency at maturity, and IET 20884 had maximum radiation use efficiency of 0.37. Based on the mean TDM recorded at maturity for all the centres and mean RUE, IET 21478, IET 21479 and IET 21476 could be identified as genotypes with high biomass production and high RUE.

High temperature tolerance in rice genotypes **-** A total of 23 IET entries were included in this trial along with Jaya and Triguna. Exposure to high temperature caused marked reduction in 1000 grain weight of rice genotypes. The number of filled grains per panicle was reduced under high

temperature stress and it varied across locations and genotypes. At DRR centre, the data on leaf photosynthetic characteristics indicated that the mean photosynthetic efficiency, rate of transpiration, stomatal conductance and internal CO_2 concentration were significantly affected by high temperature during grain filling stage. IET 20734, IET 20893, IET 20907 and IET 20905 were least affected by high temperature stress, while IET 20907, IET 21009, IET 21523, IET 20924, Triguna, IET 21513 and IET 20894 recorded >30% yield reduction. Jaya, IET 20114, IET 21510, IET 20935, IET 21528, IET 21519 and IET 20735 were are the genotypes most affected by high temperature (><40% reduction over control).

Crop Protection

Entomology

Entomology coordinated programme consisted of eight major trials on various aspects of rice involving 313 experiments conducted at 47 locations (36 funded + 11 voluntary) in 24 states and one union territory.

Host plant resistance – The studies included seven screening experiments with 1368 entries comprising of 846 pre-breeding lines, 104 hybrids and 392 germplasm accessions evaluated against 12 insect pests in 174 valid tests (46 greenhouse reactions +128 field reactions). Fifty three entries (3.9% of the tested) and 8 donors (2.0%) were identified as promising against various insect pests (Table 4). Planthopper screening revealed six promising entries including fives breeding lines from Cuttack and RP 4918 – 230S (Swarna/*O.nivara*) developed at DRR. Gall midge screening trial (GMS) identified 7 promising entries and gall midge special screening trial (GMSS) confirmed resistance in INRC 1997 and INRC 3021 against 7 to 8 populations. Virulence composition study on gall midge revealed more than 50 % of the populations to be virulent against *Gm4* and *Gm11* genes, at Sakoli and Pattambi.

Table 2 . Promising entries identified against various pests in AICRIP 2010-2011

S. No	Pest	Trial	Promising entries
1	Planthoppers	PHS	CR 2711 -76 (Salkathi), CR 2711 -149, RP Bio 4918 -230 (Swarna/ *O. nivara*), CR 2711-114, CR 2711 -139, CR 2712 -12
		NSN	**NSN1:** IET Nos 21510, 21625, 21627, 21633, MAS 26, MAS 946 and IR64 **NSN2:** IET 21725 and 22129 **NSN Hills:** IET 21378 **NHSN:** IHRT -E-04, IHRT-ME -31 and IHRT -MS -06
		GEMP	ACC Nos 5345, 4656, 4067, 3627, 3026, 3016, 2914, 2836, 2834, 2780, 2638

S. No	Pest	Trial	Promising entries
2	Gall midge	GMS	JGL 17578, JGL 17974, JGL 6266, JGL 17190*, JGL17653, RP4953 -BA, JGL17788
		GMSS	IN RC 17459*, INRC17494*, IC114788*, KD 5 -3-14, RCM 10, RCM 9
		NSN	**NSN1** : IET Nos 21193, 21119, 21278, **NSN2** :IET 22044, 22165, 22027, 21727 and 22252 **NHSN** : IHRT -E-02, IHRT -E-04, IHRT -ME -03, IHRTME -04, IHRT E -12, IHRT-ME -20 and IHRT -ME -23
		GEMP	**Acc No s.** 4067, 3016, 2638, 2684 and 5310
3	Leaf folder	LFST	RP 4645 -688 (ARC15831/INRC3021), INRC3021, TKM 6, LF293, W1263
		NSN	**NSN1** : IET Nos. 21405, 21406, 21411, 21422, 21523, 21540, 21208 **NSN2** : IET Nos. 21865, 21867, 21896, 21703, 21961, 22018, 21927, 21911, 22022, 22083, 21284 **NHSN** : IET 21764
		GEMP	ACC Nos : 2494, 3643, 4647, 4648, 4740, 4805, 3418
4	Multiple Resistance	GEMP	ACC Nos. 2654, 3091, 3795, 4430
		MRST	RP 4683 -32-1-684*, RP 4687 -52-2-1192* , RTNRH - 10, CB 06 - 535, CB 06 -563, RP 4686 -48-1-935* , RP 4687 -52-2-1197*
		NSN1	**NSN1** : IET Nos. 20934, 21528, 21510, 21478, 21190, 21289, 21106 **NSN2:** IET Nos . 21961, 22018, 21725, 21918, 22044, 22050
		NSN2	IET Nos. 20351, 20561 and 20340

Chemical control studies – Multi-location screening of newer insecticides revealed that the newer insecticide combination product containing Buprofezin 20% + Acephate 50% WP (RIL-049/F1) at the highest tested dose of 1000 g/ha was effective against stem borer, leaf folder, BPH, WBPH and army worm and it also registered the second highest grain yield among the treatments. Pesticide compatibility trial (PCT) revealed that rynaxypyr applied alone was the best treatment followed by its combination with tricyclazole, both in terms of reducing pest and disease incidence as well as superiority in yield increase over the control.

Influence of agronomic practices on rice pest management - The trial on influence of rice cultivation systems on insect pest incidence (IRCP) reported higher damage of white ear (15.25%) and leaf folder (14.14%) in direct seeded rice as compared to normal transplanting method. Hybrids registered higher leaffolder (13.05%) damage and lower dead hearts as compared to the varieties. In the trial on effect of organic manures on pest incidence (EOMP) studied at 6 locations, highest grain yield was obtained from recommended fertilizer dose treatment at four locations, despite high pest pressure and damage.

Vermicompost application resulted in variable performance across locations. The trial on trap crop for stem borer management (TCSB) in the second year of testing confirmed that planting one row of susceptible variety (Pusa Basmati) for every 9 rows of main crop resulted in significantly lower dead heart and white ear damage.

Biocontrol and biodiversity studies - In the studies on monitoring of pest species and their natural enemies (MPNE), four species of stem borer were observed in varying composition and three species of egg parasitoids *viz., Tetrastichus schoenobii*, *Telenomus dignus* and *Trichogramma japonicum,* were recorded. In case of leaf folder, three species *viz., Cnaphalocrocis medinalis*, *Marasmia patnalis* and *Brachmia* sp., were reported from 6 centres and *Apanteles* was the most prevalent parasitoid resulting in 16 to 76 % larval parasitisation. The planthopper ratios and population of its predator were reported from two centres. Gall midge parasitisation was reported in the range of 15.6 to 58.4 % from four locations. A new trial initiated on ecological engineering for management of planthoppers (EEMP) with the objective of managing hoppers through increased natural enemy fitness, showed an increase in mired bugs in plots with alleyways at Kaul, while at Mandya no significant differences were observed between plots with and without enhanced floral diversity.

Integrated Pest Management - Studies carried out through on-farm pest management (OIPM) trial on validation of IPM modules at three locations, revealed that BPH and gall midge populations could be managed effectively with single need based application of chemicals.

Light trap data reported from 22 centers suggested that BPH and WBPH were the most abundant pests while widespread occurrence of leaf folder, stem borer and gall midge was also observed.

Plant Pathology

Host plant resistance studies - Five national screening nurseries comprising of 1030 entries of advanced breeding lines and new rice hybrids, were evaluated for their reactions to major rice diseases at 53 locations. The promising entries identified against each disease and also the lines showing multiple disease resistance under various nurseries are listed in Table 5.

Table 5: **Promising entries identified against various diseases**

S.No	Disease	No. of entries tested	Trial	Promising entries identified
1	Leaf blast	136	NSN -1	IET Nos. 21413*, 21415*, 21404*, 21411, 21403*, 21291, 20716, 21660*, 21592, 21299*, 20935*, 21405*, 20915, 20930*, 20114*, 20894, 20923*, 21422, 21298, 21558, PA6129 and IR 64.
		521	NSN -2	IET Nos. 21341*, 22047, 21857, 22243, 21342*, 21920, 22051*, 21946*, 21862, 21913, 22204, 22234, 22203*, 22245, 21872*, 21925, 21905, 21731, 21924, 21856, 21733, 21912*, 21650, 22214, 22115, IR 64 and Ajaya*.
		61	NSN -H	IET Nos. 21751, 20955*, 20818, 21740*, 21375*, 21382, 21756*, 21383*, 21752*, 21739, 2139 2, 21393*, 21319, 21320, 20958, 21390, IR64 and Sukaradhan -1.
		82	NHSN	IET Nos. 21807, 21806, 21787, 21801*, 21810, 21770, 21774, 21800*, 20755, 21829, 21812*, 21771* 21783 and NHC.
		106	DSN	CB -05-022, Daharnagra*, CB -06-135, TNRH 222, Tetep*, RP Patho -3*, VL -30919, VL -8158, IR64, CR 2437-31*, VL -31320, Ajaya*, CR-2430 -10, CB06-137, TNRH -206, VL -31290, CR2428-6, VL - 1296, CB -05-031, TNRH233*, RPBioPatho -4, VL PR -1, RTN RH -10, CR 2450 -2*, RP Patho -2*, C101 LAC, RPBioPatho -3, VL -7853, RNR -2440), CB 00 -15-64, CB08 -534, CB 06 -563, CR 2421 -28, VL -1438,CB -06-535, VL-31228 and Rasi*.
2	Neck blast	136	NSN -1	IET Nos. 21405*, 21413*, 21660*, 20859, 20935*, 21693*, 20760, 21299* and 21425.
		521	NSN -2	IET Nos. 22187, 22174, 21708*, 21883, 21986, 22138, 1890, 21891, 21976*, 22181, 21967*, Dinesh, Badshabhog and CR1009.
		61	NSN -H	IET Nos. 21383*, 21750, 21752*, 21754, 21756* and 20955*.
		82	NHSN	IET Nos 20755, 21771*, 21777, 21784, 21817* and 21819.

S.No	Disease	No. of entries tested	Trial	Promising entries identified
		106	DSN	RGL -7001*, VL-31438, CR 2437 -31*, CR 2450 -23, C B 07 -103*, RP Bio Patho -4*, CR 2428 -14, RTNRH-10, Ajaya*, CB05 -022, RGL -7002*, Daharnagra* and RP Patho -3*.
3	Sheath blight	136	NSN-1	IET Nos. 21476*, 21626, 21190, 21299*, 20884*, 20923*, 21564, 21693*, 21433, 21185, 21300*, 20735, 21702 and 21478*.
		521	NSN-2	IET Nos. 21860, 22221*, 21735*, 21852, 21231, 22179*, 21346, 21941, 21942, 22191, 21991, 21714, 22155, 21707, 21705 and Jalmagna,
		61	NSN-H	IET Nos. 21764, 20955*, 21741,21378*, 21740*, 21742, 20959, 21383*, 21392, Vikramarya, Swarnadhan, Nidhi, Benibhog and Vivekdhan 62
		82	NHSN	IET Nos. 21782, 21808, 21811*, 21807, 21820, 20759, 21804, 21832*, NVC, Ajaya* and Benibhog.
		106	DSN	CR 2429 -5, CB 07- 103, CR 2450 -5, RP Patho -3, CR 2430 -11, CR 2450-2*, CB 05-031*, CR 2427 -26, CR 2450 -23, RP Patho -5, RP Patho -11, CR 2428 -9, CB 05-022*, CR 2437 -31, Tetep*, RP Biopatho -4 and CB 07-115*.
4	Brown spot	136	NSN-1	IET Nos. 21680, 21679, 21289*, 20930*,20937, 21577, IET 21208, 21576, 21582, 21205, 21665, 21674*, 21281* and 21300*
		521	NSN-2	IET Nos. 21888, 21912*, 20370, 22050*, 21871*, 21874, 21875, 22197, 22198, 21873*, 21968, 21946*, 21919, 22100, IR 64 and Rasi*.
		61	NSN-H	IET Nos. 21744*, 21375*, 21377*, IET 21763.
		82	NHSN	IET 21771* and IET 21772.
		106	DSN	RP Patho -1, RP Patho -3, RP Patho -2, VL -8167, RNR -C28, RP Patho -4, BPT 5204, CR 2429 -5, CB 06- 105, CB 05-219, CB 05-031*, RNR -2378, VL -8158, RP Patho -6, RP Patho -7, RP Patho -8 RP Patho -11, Rasi* and BPT 5204

S.No	Disease	No. of entries tested	Trial	Promising entries identified
5	Sheath rot	136	NSN-1	IET Nos. 21693*, 20760, 20937, 20761, 21660*, IET 21289*, 21587, 20923*, 21214 and 21575
		521	NSN-2	IET Nos. 22179*, 21976*, 21916, 22173, 22176, 22180, 22221*, 21267, 22050* and 22051*
		61	NSN-H	IET Nos. 21752*, 21753, 21758, 21375* and 21377*.
		82	NHSN	IET Nos. 21816, 21793, 21811*, 21821, 21832*, 21817*, 21800*, 21801*, 21812* and 21827.
		106	DSN	CB 07-115*, Ragolu -RGL-7001*, RP Patho -10, RP Patho -3, CR 2428 -9, CB 05-022*, CB 05-31, RP Patho -5 and CR 2430 -11.
6	Glume discolouration	136	NSN-1	IET Nos. 21185, 21683, 21660*, 21663, 20842, 20863, 21281*, 21291, 19886, 21299*, 21114, 20710, 20893, 20894, 20923*, 20935*, 20937, 21582, 21587, 21406, 21422, 21434, 21469, 21477*, 21702, 21205, 21620, 21633, 21638, 20878.
		521	NSN-2	-
		61	NSN-H	-
		82	NHSN	IET Nos. 21770,21771*, 21772, 21774, 21775, 21776, 21778, 21780,21781, 21783, 21784, 21785 21787 and NHC,
		106	DSN	RP Patho -1, RP Patho -2, RP Patho -3, RP Patho -4, RP Patho -6, RP Patho -7, RP Patho -8, RP Patho -9, RP Patho -10, RP Patho -11, RP Biopatho -3, RP Biopatho -4, B 95-1, IR 64, C101 LAC, C101 A51, RNR -C28, RNR -2440, RNR -2435, RNR -2781, RNR -2354, VL -7876, VL -8158, VL -8167, VL -30919, VL - 31228, VL -31296, VL -31320, VL -31341, VL -31342, VL -31348, VL -31430, VLPR -1, VLPR -4, VLPR -7, 48VLPR -8, CR 2421 -28.

S.No	Disease	No. of entries tested	Trial	Promising entries identified
7	Leaf Scald	136	NSN-1	IET Nos. 21692, 21281*, 21289*, 21299*, 20893 and 21214, 21669, 21686, Narendra 97 and Aditya.
		521	NSN-2	IET Nos. 21871*, 21887, 21893, 21347, 21715, 21997, 21999, 22008, 21727, 21730, 21734, 21939, 21942, 21943, 21945, 21933, 22170, 22187, 22208, 22211, 22235, 22255, 22022, 22131 and Nidhi.
		61	NSN-H	IET Nos. 20812, 20822 and 20826.
		82	NHSN	IET Nos. 21779, 21816, 21821, 21822, 21832*, 21446 and Vikramarya
		106	DSN	RP Patho -8, RP Patho -10, RP Biopatho -3, VL -31290 and CR 2450-2*.
8	Bacterial blight	136	NSN-1	IET Nos.21674*, 20884*, 21513, 21469, 21577, 21575, 21299*, 21477*, 20934, 21476*, 20716 and 21478*.
		521	NSN-2	IET Nos.21347, 21967*, 21709*, 21342*, 21966, 21869, 21341*, 21977, 21871*, 21706, 21872*, 21975, 22151, 22170, 2226, 21859, 21354*, 22203*, 21974, 22171.
		61	NSN-H	IET Nos.20819, 21752*, 20806, 21377* and 21378*
		82	NHSN	IET Nos.21447, 21780, 21829*and 21826.
		106	DSN	Ajaya*, RP Bio-226, CR 2428 -9, CR 2421-1, CR 2437 -31, CR 2430 -10, CR 2450-2*, CB 07-103*, CR 2429 -5, Ragolu - RGL-7001*, RGL -7002, CR 2428 -6, CR 2421 -9, CR 2421 -8, CB 06-135* and CB 05-022*.
9	Rice tungro virus	136	NSN-1	IET Nos. 20827, 20841, 21281*, 20114*, 21587, 21411, 21434, 21475, 21476*, 21278 and 21613
		521	NSN-2	IET Nos. 21878, 21879, 21965, 21909, 21865, 21873*, 21887, 21354*, 21340, 20706, 21708*, 21709*, 21718, 22001, 22002, 21954, 21972, 21235, 21726, 21735* and 21928.
		82	NHSN	IET Nos. 21781, 21805, 21814, 21815, 21831, 21793, 21818 and 21823.
		106	DSN	RP Patho -2, CR 2429 -5, VL -8167, VLPR -8, CB 07-115*, TNRH 233* and RGL-7001*.

Pathogenic variability studies – These included trials on *Pyricularia grisea and Xanthomonas oryzae* pv. *Oryzae.* Against, *P. grisea,* twenty five cultivars of international differentials, RILs, donors and commercial cultivars were evaluated at twenty two locations with different dates of sowing. Tadukan, Raminad str 3, Tetep, IR 64, C 101 LAC, BL – 245, BL -122, C 101 A51, C 105 TTP – 4- L23 and RIL 29 recorded less blast disease across the locations with SI < 4. *O .minuta*, A-57, Kanto 51, Dular, C 101 PKT, RIL 10, Rasi, Usen, Calaro, NP 125 and Zenith recorded moderate disease with SI 4-5. Cluster analysis of *P.oryzae* reactions on the selected genotypes revealed that all these locations formed four major groups. Group one consisted of Raipur and Doda, group two consisted of Titabar, group three consisted of Karjat and group four consisted of 4 sub groups comprising of Nawagam, Hazaribagh, Nellore, Coimbatore and DRR, Gudalure, Pattambi and Jagdalpur under another sub group where as Rajendranagar, Malan, Barapani were under another subgroup and Lonavala, Upper shillong, Ponnampet, Gaghraghat, CRRI and Almora were under one sub group of main group four. There was a considerable variation in reaction at locations within each group. Against *X. oryzae pv.oryzae,* the trial consisting of twenty two near isogenic lines (IRBB lines) with different bacterial blight resistance genes and their combinations and different checks was conducted at 19 different hot spot locations across the country. Most of the single genes except xa13 and Xa21 showed susceptible reactions in most of the locations. All the lines with two gene combinations showed resistant reaction in most of the locations except Raipur and Pattambi. Most of the lines with three and four genes combinations showed resistant reactions across the locations suggesting the usefulness of pyramiding such resistances in new varieties.

Chemical control studies - Among the newer fungicides screened, Hexaconazole 75 WG (RIL-012/F1) and a combination product, Kresoxim methyl 40% + Hexaconazole 8% WG (RIL-068/F148WG) effectively reduced the intensity of sheath blight, brown spot and sheath rot at most of the locations. The combination product was also very effective against neck blast, false smut and leaf scald. Pesticide Compatibility trials showed that combining hexaconazole (effective and recommended fungicide for sheath blight) with flubendamide (effective and recommended insecticide against stem borer and leaf folder) did not inhibit the biological efficacy of hexaconazole.

Integrated Disease Management - The integrated disease management trial results indicated that the integration of disease management practices like growing disease specific resistant / moderately resistant or susceptible varieties with 100 % or 2/3rd RDN along with need based fungicidal protection in case of fungal diseases like blast and sheath blight, and nitrogen management in case of bacterial leaf blight were promising in checking the disease severity / incidence and improving the grain yield.

Production Oriented Survey

Production oriented survey (POS) on different aspects of rice cultivation and farmers practices was conducted during crop season of 2010 by 23 AICRIP centres in 17 states *viz* Andhra Pradesh, Bihar, Chhattishgarh, Gujarat, Haryana, Jammu and Kashmir, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, Orissa, Puducherry, Punjab, Tamil Nadu, Tripura, Uttar Pradesh and West Bengal. The survey was conducted by the scientists of Directorate of Rice Research and its cooperating centers located in different states belonging to different State Agricultural Universities and department of Agriculture. A

total of 125 scientific staff and 73 officials from the different States Department of Agriculture surveyed 129 Districts in 17 States. According to Indian Meteorological department, during 2010 crop season period, out of 597 meteorological districts for which data are available, 173 districts (29%) received deficient rains, while 11 districts got scanty falls this season. On the brighter side, 240 districts (40%) received normal rains and the remaining 173 districts experienced excess rainfall in the June-September summer monsoon season. There was untimely rain during the maturity period of the rice crop in many parts of south Indian states and this resulted in the loss of yield to some extent. The area under hybrid rice is increasing in many places viz., Haryana, parts of UP, MP, Jharkhnad, Maharashtra. SRI cultivation is gaining momentum in places like Tamil Nadu, Puducherry and Tripura. The diseases like blast (both leaf blast and neck blast), brown spot, sheath blight, sheath rot, false smut, grain discolouration and bacterial blight are widely prevalent across different states. Sheath blight has become a major problem in Andhra Pradesh, parts of Bihar, Haryana, parts of Uttar Pradesh and Puducherry. Similarly, false smut of rice is widely prevalent in moderate intensities in many parts of country especially on hybrids. Severe incidence of false smut was recorded in Haryana, parts of Andhra Pradesh and parts of Uttar Pradesh. Khaira disease due to zinc deficiency was moderate to severe in parts of Haryana and Madhya Pradesh. Among the insect pests, stem borer, leaf folder and brown plant hopper were widely prevalent in most of the states. Stem borer was in moderate to severe intensities in parts of Andhra Pradesh, Puducherry, Jharkhand and Uttar Pradesh. The incidence of leaf folder was moderate to severe in states like Haryana, Andhra Pradesh and Puducherry. Similarly, moderate to severe incidence of brown plant hopper was noticed in Haryana and parts of Puducherry. WBPH was recorded in severe intensity in parts of Haryana. There was increased incidence of termites and rats in some of the states like Andhra Pradesh, Jharkhand and Bihar.

Lead Research

GEY - Genetic enhancement of yield and stress resistance in rice for irrigated ecology

GEQ - Genetic enhancement of quality for domestic and export purposes

ABR - Application of biotechnology tools in rice

RUE - Enhancing resource and input use efficiency

SSP - Sustaining rice system productivity

CCR - Assessing and managing crop response to climate change

HRI - Host plant resistance against insect pets and its management

HRP - Host plant resistance against pathogens and its management

IPM - Integrated pest management

TTI - Training, transfer of technology impact analysis

Lead Research

The lead research programme at the Directorate of Rice Research is being organized under ten major thematic areas and the progress of work under each theme is summarised below:

GEY - Genetic enhancement of yield and stress resistance in rice for irrigated ecology

Redesigning the *indica* rice plant type by introgressing the traits for higher yield potential and disease and pest resistance from tropical *japonica* and wild rices

Generation of breeding material led to the identification of 2214 single plant selections from 183 F_2 populations, 982 single plants from 5692 progenies of 103 crosses in F_3 generation, 621 plants from 2052 F_4 lines of 128 crosses, 789 lines from 2325 F_5/F_6 lines derived from *indica*/*indica*, *indica*/ tropical *japonica* crosses.

BPH and WBPH resistance: Of the 140 lines of Samba Mahsuri/CSR 27//Improved Samba Mahsuri in F_5 generation, six lines were resistant and 19 were moderately resistant to BPH and WBPH. The BC_1F_3 populations of BPH resistant progenies having the genes *Bph17*, *Bph20*, *Bph21*, *Bph22* and *Bph23* were evaluated and superior plants for yield and its traits were selected.

Stem borer tolerance: The lines 0810396, 0810359, 0810379, 0810308, OLS9, O810322, OLS 181 and 0810259 showed low dead heart damage of 12.7, 18.9, 32.0, 14.3, 20.5, 22.9, 22.9 and 18.4%, respectively compared to the damage level of 86% in the recurrent parent Swarna.

Blast resistance: Thirty seven lines of Samba Mahsuri/CSR 27//Improved Samba Mahsuri and 89 lines of Swarna/*O.longistaminata* were found resistant to leaf blast.

BLB resistance **:** A new recessive gene for BLB resistance was introgressed from *O. longistaminata* into Samba Mahsuri. The molecular analysis indicated that it is different from *xa5* and *xa13*.

RTD resistance**:** Seventy one *O. rufipogon* accessions along with TN1 and Vikramarya were inoculated with rice tungro virus by insect transmission. Thirty two accessions showed typical tungro symptoms 15 days after inoculation. Of the 39 accessions which did not show the symptoms initially upto 15 days of inoculation (dpi), 21 accessions exhibited viral symptoms at 30 dpi. Primers used for the detection of RTBV in these plants were from the ORF-IV region of RTBV. Of the 18 wild rice accessions, 106123, 106265, 106087, 104760, 105909, 106123, 106477,106285, IRGC 30615, IRGC 106136 and *O. longistaminata* showed absence of viral particles, while rest of the accessions showed the presence of RTBV but did not show typical tungro disease symptoms. Accession 106109 showed the viral symptoms and particles upto 15 and 30 dpi but it recovered completely in later stages. Symptoms were completely masked 45 days after inoculation and PCR studies also suggested the absence of viral particles.

Breeding rice varieties for boro areas

Twenty two cold tolerant genotypes from West Bengal were collected and 9 successful crosses were made utilizing the local cultivars of boro and popular high yielding varieties. Around 1350 germplasm accessions are under evaluation for cold and heat tolerance. Eleven F_1s were advanced to F_2 generation and 4 F_2 populations and 6 F_3 populations were evaluated at BHU, Varanasi; RAU, Pusa and RARS, Titabar. Two hundred ninety two single plant selections were made to advance the breeding material.

Breeding rice varieties for resistance to planthoppers

Genetic studies on BPH resistance in F_2 populations revealed presence of a single recessive gene in SRAC 34997; single dominant gene in BM 72; one dominant and one recessive gene in IC 346255 and ACC 2148; duplicate recessive genes in CR15 MR 1523 and ACC 2148 conferring BPH resistance. Similarly, a single recessive gene has been found controlling WBPH resistance in the donors IC 346255, ACC 2148 and SRAC 34997. A set of 5-6 elite promising lines were identified in crosses of Samba Mahsuri/ HSBC 19, Swarna/ Mudgo and MTU 1065/CB 20090.

Breeding rice for enhanced phosphorus use efficiency

One hundred and fifty genotypes comprising of released varieties, breeding lines and germplasm accessions along with 5 checks *viz.,* Rasi, IR 64, Improvd Samba Mahsuri, Jaya and Swarna were evaluated in augmented design under varying doses of phosphorus to study the tolerance to low phosphorus and response to its application. Tolerant genotypes including checks took longer time to mature under phosphorus stress. Swarna which is tolerant to low P took 14 days more than normal for 50% flowering followed by IR 64 (8 days), Rasi (7 days), Improvd Samba Mahsuri (6 days) and Jaya (4 days). More than 150% increase in number of tillers/hill was recorded in many germplasm accessions when grown under recommended dose of phosphorus compared to 22.69% in Swarna indicating good response to phosphorus application but sensitiveness under low P. Plant height and panicle length was reduced in sensitive genotypes but magnitude was less in tolerant genotypes.

Development of high yielding rice varieties for conservation agriculture

Differential response of genotypes with respect to yield and yield components as well as the physiological traits was studied in 50 genotypes under puddled transplanted and direct seeded condition. Rasi, Sabita, Aathira, Kalinga II, Swarna Prabha, ASD19, Amruth and Shakuntala performed better under direct seeded condition. *Oryza rufipogan* introgression lines *viz.,* S 467, S 478 and S 194 also exhibited superior performance under direct seeded condition. Under transplanted condition, IR 64, Aathira, PMK 2, GAUR 2, Amruth, Jaishree, Shakuntala, S 473, S 381, S 215 and S 194 recorded superior *per se* performance. The yield penalty of genotypes under direct seeded condition varied from – 2.28 % (S-106) to - 67.91% (GR-8) as compared to the transplanted condition. However, some of the genotypes like Aathira, Swarna Prabha, S 467, Kalinga II, S 147 and S 194 exhibited more than 10% yield superiority under direct seeding condition when compared to their performance under transplanted condition. Sabita and six other accessions IR 79906-B-5-3-3, IR 78875-53-2-2-2, IR 78875-B1-B-1-1, CR 691-58 and B 644F-MR-6-0-0 were promising under direct seeding as well as transplanted condition. Among them, Sabita was identified to possess weed suppressive ability with early seedling vigor and higher shoot biomass under direct seeding condition.

Standardization for the screening of rice germplasm for anaerobic germination was done to identify the genotypes which can tolerate the untimely flooding under direct seeded conditions.

The genotypic and phenotypic co-efficient of variation (GCV, PCV), heritability (h^2) and genetic

advance as per cent of mean (GAM) were estimated for all the 13 characteristics of yield, yield components and physiological traits under transplanted as well as direct seeded condition (Table-6) . High to moderate heritability coupled with low to high genetic advance as percent of mean was observed for most of the characteristics under direct seeded condition. Correlation analysis was done separately under direct seeding as well as under transplanted conditions. Under direct seeded conditions, the characters *viz.*, shoot biomass, number of tillers and productive tillers, specific leaf area *etc.*, showed positive correlation with plot yield indicating that these traits may be considered during selection. The shoot biomass is an important indicator for early seedling vigour. Under transplanted condition, the correlations among various characters are positive but non-significant indicating the need for creation of sufficient variability for the traits.

Table 6 : Genetic Variability Parameters for 13 characteristics of genotypes for conservation agriculture

Character	Transplanted condition				Direct Seeded Condition			
	GCV	PCV	h² (bs)	GAM	GCV	PCV	h² (bs)	GAM
Days to 50% flowering	8.76	8.77	0.9915	18.02	14.09	14.10	0.9944	29.00
Plant Height (cm)	18.71	18.83	0.9641	38.31	17.96	18.12	0.9475	36.66
Shoot Biomass (g)	17.06	18.49	0.6560	32.42	29.25	30.08	0.8535	58.60
No. of Tillers	21.43	22.87	0.7050	41.35	12.66	17.91	0.2495	18.42
Productive Tillers	16.34	19.05	0.6812	28.88	6.28	13.67	0.0817	5.94
Panicle Length (cm)	6.03	7.29	0.4817	10.27	8.56	9.06	0.7346	16.65
Single Plant Yield (g)	23.16	24.47	0.4192	45.13	34.62	34.88	0.0586	70.79
Sterility (%)	46.71	47.27	0.7400	95.08	42.29	42.89	0.9211	85.90
Leaf Area (cm²)	19.32	20.47	0.9325	37.56	31.99	33.06	0.8298	63.75
Lead Thickness (mm)	14.90	18.95	0.7312	24.14	52.98	54.75	0.8307	105.60
Specific Leaf Area	4.22	9.46	0.3498	3.88	13.80	17.73	0.3388	22.13
Specific Leaf Weight	6.17	15.0 5	0.0764	5.20	19.06	22.60	0.0798	33.11
Plot yield (g)	33.37	34.77	0.9210	67.79	48.74	49.99	0.9509	99.564

Development and evaluation of three line hybrids

Four hundred fifty entries were grown in the source nursery and 250 test crosses were made. Out of 150 test crosses evaluated, 17 maintainers (NWGR 3045, R 1218-509-2-452-1, CR 2624-IR55423-101, WGL 309 NDR 1131, JGL 16259, CR 2604,CB 06-137, CB 05-755,R1207-4-290-1, UAS ARB7, CR 2605, CR 2601, CB 05-754, UAS ARB7, R 1249-1499-2-834-1, CB 05758, CR 2624-IR55423-01) and 28 restorers (20773, CB 0015-24, CR 2499-68-10, CR 2632-IR83614-503-B, CR 2597, CR 2631, IR 74370-3-1-1, CRR 615-PR27699-B-D808-4-4, KADAMBA, R 1207-4-290-1, R1218-509-2-452-1, R 1218-598-1-281-1, R 1218-598-1-281-1, UAS ARB 6, 2634-IR74371-54-1-1, RP 4092-126-75-11-4, CB 06-122, UPR 2965-6-1-1, CB 05-022, OR 1898-32-69, OR 2162-5, NWGR –30-45, NWGR 3132, CN 1272-55-105, CR 2511, CB 06550, CR 2499-68-10, UPR 3027-10-2-1, were identified. Of the 48 hybrid

combinations evaluated, APMS-6A/NRI-38, IR 79156A/NRI-38, IR79156A/PNR-2-49, IR79156A/50-10, IR58025A/50-10 and IR79156A/S-215 were promising.

DRRH-65 with Samba Mahsuri grain type and quality was promoted to third year of testing in HRT-MS trial. The hybrids DRRH 68 (mid early) and DRRH 54 (medium) were promoted for further testing in AVT-1 trials.

Based on the fine mapping information, convenient PCR based markers from the microsatellite motifs and candidate genes were developed. Candidate gene marker SC1246 and SSR markers SC390 for Rf4 locus on chromosome 10 and SSR marker SC364 and SC368 for Rf3 locus on chromosome 1 were developed and validated in 200 known restorers and 34 maintainers (93.2%) along with reported markers for Rf3 and Rf4 locus.

Genetic improvement of maintainers and development of CMS-line

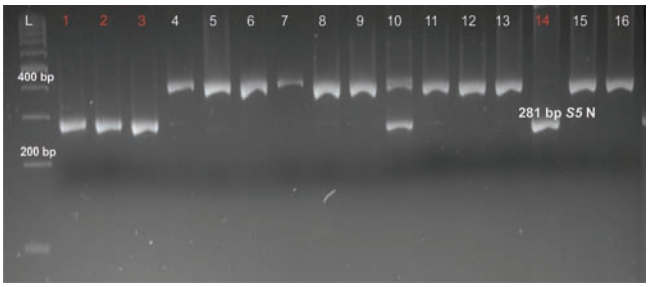
Of the 120 maintainers developed, 29 entries were tested for grain quality and resistance to brown planthopper and white backed planthopper. One line showed tolerance to white backed planthopper. The promising maintainers were CR-2502-40, CR-2624-IR55423-01, NDR-1131, CR 2604, C 305-755, PAC 807, CR 2605 and CR 2601 (Fig 3).

Fig 3. A promising genotype with good stigma exsertion

Fourteen maintainers with medium/long slender grain type, relatively short stature and good *per se* performance with good tillering ability are in different stages of CMS conversion programme.

Exploitation of inter sub-specific heterosis in rice

Around 250 test crosses, 100 paired crosses and 30 varietal crosses were made. Twenty test crosses were identified for further evaluation. Seventy tropical japonica lines were screened with molecular marker *S5* Indel and 20 lines were identified to possess *S5* neutral allele (Fig 4)



Screening for the presence of wide compatibility gene *S5* neutral allele

These 20 lines were utilized in inter sub-specific hybridization. These tropical japonica lines were also tested for their fertility restoration status with the help of molecular markers RM6100 (linked to *Rf4* gene), RM10313 (linked to *Rf3* gene) and identified restorers were crossed with the set of CMS lines.

Breeding of parental lines and hybrids suited to aerobic and salinity conditions

Screening of 95 IRRI lines, CMS lines along with check entries resulted in the identification of 20 genotypes performing well under limited water irrigated condition. These were CR 2707-185-16-1-1-1, IR 84887-B-152-CRA-121-1, Apo, KRH 2, DRRH 3, IR 79156B, APMS 6B, PUSA 5B, IR 58025B, DRR 6B, IR 83927-B-B-278-CRA-5-1-1, PAC 837, NK 5251, CR 691-58,CR 2706-171-14-1-4-1, IR 78875-P-31-B-1-4, IR 83870-B-B-231-CRA5-1-1, CR 2707-183-1-1-1-1, CR 2707-185-10-1-4-1 and

IR 84887-B-152-CRA-121-1. Around 40 test crosses were made with aerobic lines (IRRI lines). Similarly 100 test crosses were attempted between proven salt tolerant lines and two CMS lines.

National Seed Project

Breeder seed production of rice varieties and parental lines of rice hybrids as per the DAC indent was organized at 35 centres across the country, involving 226 varieties and parental lines of 9 rice hybrids (Table 8). A total production of 6095.01 quintals of breeder seed was produced against a target of 4603.95 quintals which included 61.55 quintals of breeder seed of parental lines of 9 rice hybrids. At DRR centre, 20 varieties (Table 7) and parental lines of DRRH-2 were included with a total production of 257.50 quintals against the target of 169.20 quintals.

Table 7 Breeder Seed Production at DRR Hyderabad, *Kharif* 2010 (Quantity in quintals)

Name of variety	Actual allocation as per BSP-I	Actual Production	Surplus (+) Deficit (-)	Name of variety	Actual allocation as per BSP-I	Actual Production	Surplus (+) Deficit (-)
Akshyadhan	5.00	6.00	+1.00	Mandya Vijaya	7.00	7.00	-
Dhanrasi	7.00	3.50	-3.50	Prasanna	30.00	25.00	-5.00
Improved Samba Mahsuri	23.00	90.00	+67.00	Rasi	11.00	15.00	+4.00
IR 36	5.00	5.00	-	Sampada	5.00	8.00	+3.00
IR 64	10.00	11.00	+1.00	Sonasali	6.00	6.00	-
Jarava	0.50	1.00	+0.50	Sugandhamati	1.00	15.00	+14.00
Jaya	28.00	45.00	+17.00	Swarna	20.00	8.00	-12.00
Kasturi	1.00	1.00	-	Vasumati	1.00	1.00	-
Krishna Hamsa	4.00	5.00	+1.00	Vikas	0.20	1.00	+0.80
Mahsuri	3.00	4.00	+1.00	IR 20	1.50	-	-1.50

Table 8. Variety wise Breeder Seed Production during *Kharif*, 2010
(as per DAC indent - Quantity in quintals)

SNo	Hybrid / variety	Produced By	Year of release	Actual allocation as per BSP-I	Actual Production	Surplus (+) Deficit (-)
I.	**Hybrids :**					
1.	**DRRH-2**	DRR, Hyderabad	2005			
	1. IR 68897 A	DRR, Hyderabad	-	1.50	1.50	-
	2. IR 68897 B	DRR, Hyderabad	-	1.00	1.00	-
	3. DR 714-1-2R	DRR, Hyderabad	-	0.50	0.50	-
2.	**Pusa RH-10:**	IARI Reg. Stn., Karnal	-			
	1. A Line	IARI Reg. Stn., Karnal	-	11.10	6.00	-5.10
	2. B Line	IARI Reg. Stn., Karnal	-	5.00	1.70	-3.30
	3. R Line	IARI Reg. Stn., Karnal	-	5.00	1.30[$]	-3.70
3.	**KRH-1:**	UAS, Bengaluru	-			
	1. A Line	UAS, Bengaluru	-	1.00	1.00	-
	KRH-2 :	UAS, Bengaluru	-			
	1. A Line	UAS, Bengaluru	-	8.00	24.00	+16.00
	2. B Line	UAS, Bengaluru	-	3.50	5.00	+1.50
	3. R Line	UAS, Bengaluru	-	4.00	10.00	+6.00
4.	**Pant Sankar Dhan-1:**	GBPUAT, Pantnagar	-			
	1. A Line	GBPUAT, Pantnagar	-	0.25	0.25	-
	2. UPRI 93-287R	GBPUAT, Pantnagar	-	0.70	1.25	+0.55
	Pant Sankar Dhan-3	GBPUAT, Pantnagar	-			
	1. A Line	GBPUAT, Pantnagar	-	2.00	2.00	-
	2. B Line	GBPUAT, Pantnagar	-	1.00	1.00	-
	3. R Line	GBPUAT, Pantnagar	-	2.50	0.90	-1.60
5.	**Sahyadri-1:**	RARS, Karjat	-			
	1. A Line	RARS, Karjat	-	2.00	2.10	+0.10
	2. B Line	RARS, Karjat	-	1.00	1.20	+0.20

SNo	Hybrid / variety	Produced By	Year of release	Actual allocation as per BSP-I	Actual Production	Surplus (+) Deficit (-)
	Sahyadri-2:	RARS, Karjat	-			
	1. A Line	RARS, Karjat	-	0.25	0.30	+0.05
	2. R Line	RARS, Karjat	-	0.10	0.15	+0.05
	Sahyadri-3:	RARS, Karjat	-			
	1. A Line	RARS, Karjat	-	0.15	0.20	+0.05
	2. R Line	RARS, Karjat	-	0.15	0.20	+0.05
		Grand Total (Hybrids)		**50.70**	**61.55**	**+10.85**
II.	**Varieties:**					
1	Aathira	KAU, Pattambi	2006	0.60	2.00	+1.40
2	Abhishek	CRURRS, Hazaribagh	-	15.00	49.20	+34.20
3	ADT (R)48	TNAU, Coimbatore	-	0.15	0.15	-
4	ADT 36	TNAU, Coimbatore	1981	1.00	1.00	-
5	ADT 37	TNAU, Coimbatore	1987&	21.00	21.00	-
6	ADT 39	TNAU, Coimbatore	1988	6.00	6.00	-
7	ADT 43	TNAU, Coimbatore	1998	10.00	10.00	-
8	ADT 44	TNAU, Coimbatore	2000	0.20	0.20	-
9	ADT 45	TNAU, Coimbatore	2001	2.00	2.00	-
10	Aiswarya	KAU, Pattambi	-	0.40	0.50	+0.10
11	Akshyadhan	DRR, Hyderabad	-	5.00	6.00	+1.00
12	Anjali	CRURRS, Hazaribagh	2001	3.00	10.80	+7.80
13	Annada	CRRI, Cuttack	1987	5.00	7.70	+2.70
14	ASD 16	TNAU, Coimbatore	-	1.10	1.05	-0.05
15	Aswathy	KAU, Pattambi		0.20	0.20	-
16	Bahadur	AAU, Jorhat	2000	15.00	15.00	-
17	Bamaleshwari	IGAU, Raipur	2000	16.00	16.00	-
18	Barani Deep	NDUAT, Faizabad	2001	6.00	2.50	-3.50

SNo	Hybrid / variety	Produced By	Year of release	Actual allocation as per BSP-I	Actual Production	Surplus (+) Deficit (-)
19	Barh Avrodhi	NDUAT, Faizabad	1995	7.00	1.00	-6.00
20	Basmati 370	RRS, Kaul	1973	15.00	16.00	+1.00
21	Basmati 386	RRS, Kaul	1994	6.50	-	-6.50
22	Bhadra (MO-4)	RRS, Moncompu	-	10.00	10.79	+0.79
23	Bhogavathi	ARS, Radhanagari	-	2.50	16.38*	+13.88
24	Bhrigu Dhan	RWRC, Malan	-	0.10	0.25	+0.15
25	Birsa Vikas Dhanl 09	BAU, Ranchi	-	5.00	2.00	-3.00
26	Birsa Vikas Dhan 110	BAU, Ranchi	-	5.00	2.00	-3.00
27	Chandrahasini	IGAU, Raipur	-	18.00	18.00	-
28	China 988	RWRC, Malan	-	0.20	0.10	-0.10
29	Cotton Dora Sannalu	BAU, Ranchi, JNKVV, Jabapur ANGRAU, Hyderabad IGAU,Raipur	2000	500.00	612.00	+112.00
30	CR Boro Dhan 10	CRRI, Cuttack	-	6.00	6.00	-
31	CR Boro Dhan 2	CRRI, Cuttack	-	5.50	6.30	+0.80
32	CR Dhan-70	CRRI, Cuttack	-	1.00	2.10	+1.10
33	CR 1014	CRRI, Cuttack	1988	9.00	9.90	+0.90
34	Durga	CRRI, Cuttack	-	3.00	3.00	-
35	CR Sugandh Dhan 3	CRRI, Cuttack	-	0.50	2.10	+1.60
36	CSR 23	CSSRI, Karnal	-	0.30	12.00	+11.70
37	CSR 27	CSSRI, Karnal	-	12.00	13.50	+1.50
38	Yamini	CSSRI, Karnal	-	27.00	35.00	+8.00
39	Naina	CSSRI, Karnal	-	5.50	40.00	+34.50
40	Danteshwari	IGAU, Raipur	2000	19.00	23.00	+4.00
41	Daya	OUAT, Bhubaneshwar	-	0.50	-	-0.50
42	Dhanrasi	DRR, Hyderabad	-	7.00	3.50	-3.50
43	Erra Mallelu	ANGRAU, Hyderabad	-	11.00	11.00	-

SNo	Hybrid / variety	Produced By	Year of release	Actual allocation as per BSP-I	Actual Production	Surplus (+) Deficit (-)
44	Gajapati	OUAT, Bhubaneshwar	-	0.15	0.30	+0.15
45	Gayathri	OUAT, Bhubaneshwar	-	6.50	-	-6.50
46	Geetanjali	CRRI, Cuttack	2005	3.50	4.20	+0.70
47	Gontra Bidhan 1	BCKVV, Nadia	-	10.00	80.00	+70.00
48	Govind	GBPUAT, Pantnagar	1982	4.50	20.00	+15.50
49	GR 11	GAU, Nawagam	1977	3.00	3.00	-
50	Gurjari	GAU, Nawagam	1998	1.00	1.00	-
51	Harsha	KAU, Pattambi	-	0.10	0.50	+0.40
52	Haryana Basmati-1	RRS, Kaul	-	5.00	-	-5.00
53	HBC-19	RRS, Kaul	1996	4.00	8.00	+4.00
54	HKR 47	RRS, Kaul	2005	90.00	100.00	+10.00
55	HKR 120	RRS, Kaul	-	1.50	-	-1.50
56	HKR 127	RRS, Kaul	-	0.10	85.00	+84.90
57	HP 2143	RWRC, Malan	-	3.50	4.50	+1.00
58	HPR 1068	RWRC, Malan	-	1.00	5.10	+4.10
59	HPR 1156	RWRC, Malan	-	0.30	3.50	+3.20
60	IET 1410	SKUAS&T, Chatha	-	0.15	0.80	+0.65
61	IET 7191	UAS, Bengaluru	1987	4.50	10.00	+5.50
62	IET 14845	UAS, Bengaluru	-	0.60	0.60	-
63	Improved Pusa Basmati	IARI, Reg. Stn., Karnal	-	32.00	32.00	-
64	Improved Samba Mahsuri	DRR, Hyderabad	-	23.00	90.00	+67.00
65	Improved White Ponni	TNAU, Coimbatore		0.30	0.30	-
66	Indrayani	ARS, Vadagaon	-	10.00	No Information	
67	Intan	UAS, Bengaluru	1975	7.50	10.00	+2.50
68	IR 20	DRR, Hyderabad	1970	1.50	-	-1.50

SNo	Hybrid / variety	Produced By	Year of release	Actual allocation as per BSP-I	Actual Production	Surplus (+) Deficit (-)
69	IR 36	DRR, Hyderabad IGAU, Raipur BAU, Ranchi JNKVV, Jabalpur	1981	155.00	199.00	+44.00
70	IR 64	DRR, Hyderabad, IGAU, Raipur BAU, Ranchi JNKVV, Jabalpur	1992	242.00	262.90	+20.90
71	IR 30864	UAS, Bengaluru	-	3.50	6.00	+2.50
72	Jajati	OUAT, Bhubaneswar	-	3.00	3.00	-
73	Jaldidhan6	CRRI, Cuttack	-	1.20	1.80	+0.60
74	Jal Lahari	NDUAT, Faizabad	-	2.00	8.50	+6.50
75	Jarava	DRR, Hyderabad	2005	0.50	1.00	+0.50
76	Jaya	DRR, Hyderabad UAS, Bengaluru	1968	53.00	59.00	+6.00
77	Polasa Prabha	ANGRAU, Hyderabad	1998	7.50	10.00	+2.50
78	Jagtial Sannalu	ANGRAU, Hyderabad	2002	47.00	50.00	+3.00
79	Jhelum	RRRS, Khudwani	-	1.00	5.00	+4.00
80	Jogesh	OUAT, Bhubaneswar	-	3.00	3.00	-
81	Jyothi	KAU, Pattambi	1972	64.00	65.00	+1.00
82	Kanchan	KAU, Pattambi	-	0.25	3.00	+2.75
83	Kanchana	OUAT, Bhubaneshwar	-	3.50	3.50	-
84	Karjat 3	RARS, Karjat	-	1.00	1.20	+0.20
85	Karjat 7	RARS, Karjat	-	1.50	1.80	+0.30
86	Karma Mahsuri	IGAU, Raipur	-	71.00	72.00	+1.00
87	Kasturi	DRR, Hyderabad	-	1.00	1.00	-
88	Kavya	ANGRAU, Hyderabad	1991	1.00	2.00	+1.00
89	Keshava	ANGRAU, Hyderabad	-	0.50	1.00	+0.50
90	Ketekijoha	CRRI, Cuttack, AAU, Jorhat	-	7.00	7.50	+0.50
91	Khandagiri	OUAT, Bhubaneshwar	-	63.00	63.00	-

SNo	Hybrid / variety	Produced By	Year of release	Actual allocation as per BSP-I	Actual Production	Surplus (+) Deficit (-)
92	Khitish	CRRI, Cuttack	-	11.00	7.10	-3.90
93	Mandya Vani	UAS, Bengaluru	-	0.20	-	-0.20
94	Abhilash	ARS, Mugad	-	5.00	6.00	+1.00
95	Konark	OUAT, Bhubaneshwar	-	7.00	7.00	-
96	Kranthi	JNKVV, Jabalpur	1976	20.00	500.00	+480.00
97	Krishna Hamsa	DRR, Hyderabad	2001	4.00	5.00	+1.00
98	Lachit	AAU, Jorhat	1987	8.00	11.94	+3.94
99	Lalat	OUAT, Bhubaneshwar, BAU, Ranchi	1988	90.00	77.00	-13.00
100	Luit	AAU, Jorhat	1998	5.00	10.46	+5.46
101	Lunishree	CRRI, Cuttack	1992	2.00	3.00	+1.00
102	Mahamaya	IGAU, Raipur	1995	126.00	128.00	+2.00
103	Mahsuri	DRR, Hyderabad AAU, Jorhat	1972	18.00	17.42	-0.58
104	Malaviya Dhan 1	BHU, Varanasi	-	6.50	7.00	+0.50
105	Malaviya Dhan 2	BHU, Varanasi	-	6.50	7.00	+0.50
106	Manaswini	OUAT, Bhubaneshwar	-	6.00	6.00	-
107	Mandya Vijaya	DRR, Hyderabad	1986	7.00	7.00	-
108	Manhar	GBPUAT, Pantnagar	-	3.00	-	-3.00
109	Matta Triveni	KAU, Pattambi	-	0.30	1.00	+0.70
110	MO 5 (Asha)	RRS, Moncompu	-	0.20	0.10	-0.10
111	Moti	CRRI, Cuttack	-	3.00	4.20	+1.20
112	MTU 1031	ANGRAU, Hyderabad	2001	1.00	1.00	-
113	MTU 1032	ANGRAU, Hyderabad	2001	11.00	11.00	-
114	MTU 1075	ANGRAU, Hyderabad	-	6.00	6.00	-
115	Mukthi	UAS, Bengaluru	-	1.00	2.00	+1.00
116	Narendra Dhan 97	NDUAT, Faizabad	1992	11.50	12.00	+0.50

SNo	Hybrid / variety	Produced By	Year of release	Actual allocation as per BSP-I	Actual Production	Surplus (+) Deficit (-)
117	Narendra Jal Pushp	NDUAT, Faizabad	-	2.00	4.50	+2.50
118	Narendra Mayank	NDUAT, Faizabad	-	2.00	3.80	+1.80
119	Narendra Usar 3	NDUAT, Faizabad	2000	5.00	22.00	+17.00
120	Narendra8002	NDUAT, Faizabad	2005	19.00	30.00	+11.00
121	Naveen	CRRI, Cuttack	1993	46.00	20.60	-25.40
122	NDR 359	NDUAT, Faizabad	1993	27.00	70.00	+43.00
123	Swarnamukhi	ANGRAU, Hyderabad	-	6.50	7.00	+0.50
124	Nua Kalajeera	CRRI, Cuttack	-	31.00	21.70	-9.30
125	Padmini	CRRI, Cuttack	-	3.00	6.00	+3.00
126	Pant Dhan 10	GBPUAT, Pantnagar	1992	14.50	32.00	+17.50
127	Pant Dhan 11	GBPUAT, Pantnagar	1992	1.50	18.00	+16.50
128	Pant Dhan 12	GBPUAT, Pantnagar	1994	32.00	52.00	+20.00
129	Pant Dhan 16	GBPUAT, Pantnagar	2001	21.00	20.00	-1.00
130	Pant Dhan 19	GBPUAT, Pantnagar	2001	0.15	40.00	+39.85
131	Pankaj	AAU, Jorhat	-	2.00	2.40	+0.40
132	Parijat	OUAT, Bhubaneshwar	1976	7.00	7.00	-
133	PAU 201	PAU, Ludhiana	-	92.00	105.00	+13.00
134	Phule Samrudhi	ARS, Radhanagari	-	3.00	-	-3.00
135	PKV HMT	ZARS, Sindewahi	-	32.00	60.00	+28.00
136	PKV Kamang	ZARS, Sindewahi	-	0.50	12.00	+11.50
137	PNR 381	IARI Reg. Stn., Karnal	-	0.10	9.00	+8.90
138	PNR 519	IARI Reg. Stn., Karnal	-	0.50	0.50	-
139	Pooja	CRRI, Cuttack	1999	62.00	70.00	+8.00
140	Poornima	IGAU, Raipur	1995	11.00	11.40	+0.40
141	Prabhat	RAU, Pusa	-	5.00	18.00	+13.00

SNo	Hybrid / variety	Produced By	Year of release	Actual allocation as per BSP-I	Actual Production	Surplus (+) Deficit (-)
142	Pratikshya	OUAT, Bhubaneshwar	-	22.00	22.00	-
143	Prasanna	DRR, Hyderabad	-	30.00	25.00	-5.00
144	PR 106	PAU, Ludhiana	1978	2.50	4.50	+2.00
145	PR 111	PAU, Ludhiana	1994	22.00	23.50	+1.50
146	PR 113	PAU, Ludhiana	2000	36.00	37.50	+1.50
147	PR 114	PAU, Ludhiana	2000	45.00	48.00	+3.00
148	PR 115	PAU, Ludhiana	2000	12.00	13.50	+1.50
149	PR 116	PAU, Ludhiana	2000	19.00	24.00	+5.00
150	PR 118	PAU, Ludhiana	2003	53.00	54.00	+1.00
151	Punjab Basmati 1	PAU, Ludhiana	-	0.60	-	-0.60
152	Pusa 44	IARI Reg. Stn., Karnal	1993	50.00	80.0	+30.00
153	Pusa 834	IARI Reg. Stn., Karnal	1995	20.00	8.90	-11.10
154	Pusa Basmati 1	IARI Reg. Stn., Karnal	-	50.00	50.00	-
155	Pusa 677	IARI Reg. Stn., Karnal	-	0.20	0.20	-
156	Pusa 1121	IARI Reg. Stn., Karnal	2003	50.00	70.00	+20.00
157	Pusa Sugandh 2	IARI Reg. Stn., Karnal	2001	26.00	24.00	-2.00
158	Pusa Sugandh 3	IARI Reg. Stn., Karnal	2001	40.00	40.00	-
159	Pusa Sugandh 5	IARI Reg. Stn., Karnal	2004	40.00	45.00	+5.00
160	Rajashree	RAU, Pusa	1987	12.00	25.00	+13.00
161	Rajendra Bhogavati	RAU, Pusa	-	0.15	45.00	+44.85
162	Rajendra Kasturi	RAU, Pusa	-	6.00	7.00	+1.00
163	Rajendra Mahsuri	RAU, Pusa	-	33.00	44.00	+11.00
164	Rajendra Suwasini	RAU, Pusa	-	5.00	7.00	+2.00
165	Rajendra Sweta	RAU, Pusa	-	16.00	10.00	-6.00
166	Ramachandi	OUAT, Bhubaneshwar	1998	5.00	5.00	-

SNo	Hybrid / variety	Produced By	Year of release	Actual allocation as per BSP-I	Actual Production	Surplus (+) Deficit (-)
167	Ranbir Basmati	SKUAS&T, Chatha	-	0.15	0.80	+0.65
168	Rani Dhan	OUAT, Bhubaneshwar	-	20.50	20.50	-
169	Ranjeet	AAU, Jorhat	1994	22.00	25.24	+3.24
170	Rashmi	JNKVV, Jabalpur	2001	60.00	29.00	-31.00
171	Rasi	DRR, Hyderabad	1977	11.00	15.00	+4.00
172	Ratna	CRRI, Cuttack	1970	9.00	7.10	-1.90
173	Richa	JNKVV, Jabalpur	-	1.00	19.50	+18.50
174	RP 2421	RWRC, Malan	-	7.50	3.50	-4.00
175	Saket 4	NDUAT, Faizabad	-	1.00	-	-1.00
176	Samaleshwari	IGAU, Raipur	-	9.00	20.50	+11.50
177	Samba Mahsuri	ANGRAU, Hyderabad	1986	205.00	250.00	+45.00
178	Sampada	DRR, Hyderabad		5.00	8.00	+3.00
179	Sarala	CRRI, Cuttack	2001	21.00	22.20	+1.20
180	Sarathi	OUAT, Bhubaneshwar	-	1.00	1.00	-
181	Sashi	RRS, Chinsurah	-	0.20	0.20	-
182	Satya	ANGRAU, Hyderabad	-	2.00	2.00	-
183	Sarjoo 52	NDUAT, Faizabad	1980	28.00	74.00	+46.00
184	Savithri	CRRI, Cuttack	-	30.00	34.00	+4.00
185	Shatabdi	CRRI, Cuttack. RRS, Chinsurah	2000	92.00	56.80	-35.20
186	Shushk Samrat	NDUAT, Faizabad	-	6.50	3.50	-3.00
187	Sidhanta	OUAT, Bhubaneshwar	-	3.00	3.00	-
188	Sita	RAU, Patna	1972	6.00	6.00	-
189	Somasila	ANGRAU, Hyderabad	2000	6.00	6.00	-
190	Sona Mahsuri	ANGRAU, Hyderabad	1982	27.00	27.00	-
191	Sonasali	DRR, Hyderabad		6.00	6.00	-

SNo	Hybrid / variety	Produced By	Year of release	Actual allocation as per BSP-I	Actual Production	Surplus (+) Deficit (-)
192	Srikakulam Sannalu	ANGRAU, Hyderabad		20.00	20.00	-
193	Sugandhamati	DRR, Hyderabad	2004	1.00	15.00	+14.00
194	Sujata	RAU, Pusa	1984	0.30	0.50	+0.20
195	Surekha	ANGRAU, Hyderabad	-	0.30	1.00	+0.70
196	Surendra	OUAT, Bhubaneswar		7.00	7.00	-
197	Swarna	DRR, Hyderabad, ANGRAU, Hyderabad, IGAU, Raipur BAU, Ranchi	1982	340.00	343.00	+3.00
198	Swarna Sub 1	CRRI, Cuttack		78.00	8.00	-70.00
199	Tapaswini	CRRI, Cuttack		1.50	2.10	+0.60
200	Tawi	SKUAS&T, Chatha		0.10	0.50	+0.40
201	Tella Hamsa	ANGRAU, Hyderabad	1971	25.00	30.00	+5.00
202	Thanu	UAS, Bengaluru	-	5.00	15.00	+10.00
203	Tunga	UAS, Bengaluru	-	2.00	11.00	+9.00
204	Type 3	GBPUAT, Pantnagar	1973	0.10	3.50	+3.40
205	Upahar	OUAT, Bhubaneshwar		2.50	2.50	-
206	Uma	RRS, Moncompu	1998	19.00	23.83	+4.83
207	Utkal Prabha	CRRI, Cuttack	-	11.00	10.80	-0.20
208	Vandana	CRURRS, Hazaribagh	2002	15.00	19.60	+4.60
209	Varsha Dhan	CRRI, Cuttack		3.00	24.00	+21.00
210	Varundhan	RWRC, Malan	-	0.10	0.35	+0.25
211	Vasumati	DRR, Hyderabad	2001	1.00	1.00	-
212	Vasundhara	ANGRAU, Hyderabad		24.00	25.00	+1.00
213	Vijetha	ANGRAU, Hyderabad		225.00	250.00	+25.00
214	Vikas	DRR, Hyderabad		0.20	1.00	+0.80
215	Virender	CRURRS, Hazaribagh	-	3.50	9.90	+6.40

SNo	Hybrid / variety	Produced By	Year of release	Actual allocation as per BSP-I	Actual Production	Surplus (+) Deficit (-)
216	Vivek Dhan 62	VIHA, Almora	-	1.20	2.00	+0.80
217	Vivek Dhan 154	VIHA, Almora	-	1.50	2.00	+0.50
218	VL Dhan 65	VIHA, Almora	-	1.50	2.00	+0.50
219	VL Dhan 85	VIHA, Almora	-	1.00	2.00	+1.00
220	VL Dhan 207	VIHA, Almora	-	1.50	1.50	-
221	VL Dhan 208	VIHA, Almora	-	2.00	2.00	-
222	VL Dhan 209	VIHA, Almora	-	1.50	1.50	-
223	VL Dhan 221	VIHA, Almora	-	1.50	1.50	-
224	VTL 6	RRS, Vytilla		0.10	0.10	-
225	Warangal Sannalu	ANGRAU, Hyd		63.00	70.00	+7.00
226	Warangal Samba	ANGRAU, Hyd		3.50	4.00	+0.50
Grand Total (varieties)				**4553.25**	**6033.46**	**+1406.21**
Overall Grand Total				**4603.95**	**6095.01**	**+1417.06**

Multilocational evaluation of germplasm

Agro-morphological characterization for 20 characters was carried out in 317 germplasm accessions received from NBPGR at DRR and 7 centers and screening for biotic stresses at 2 hot spot locations. The frequency distribution for some of the traits in germplasm accessions is tabulated (Table 9). Apart from characterization, 600 and 1200 germplasm accessions were multiplied during *kharif* 2010 and *rabi* 2011, respectively at DRR.

Table 9. Frequency distribution of qualitative traits of 317 germplasm accessions, *Kharif*, 2010

Character	Character State	Frequency	Character	Character State	Frequency
Early plant vigor	Poor-1	45	Collar colour	Pale green-1	302
	Good-2	268		Green-2	4
	V. good-3	-		Purple-3	8
Basal leaf sheath color	Green-1	272	Stigma color	Others-4	-
	Purple lines-2	22		White-1	21
	Light purple-3	3		Light green-2	289
	Purple-4	13		Yellow-3	4
	Others-5	-		Light purple-4	-
Leaf blade color	Light green-1	39	Apiculous color	Purple-5	-
	Green-2	132		White-1	13
	Dark green-3	136		Straw-2	245
	Purple tips-4	3		Brown-3	46
	Purple margins-5	4		Red-4	2
	Purple-7	1		Red apex-5	0
	Others-8	-		Purple-6	8
Leaf pubescence	Glabrous-1	309	Awning	Purple apex-7	2
	Intermediate-2	-		Others-8	0
	Pubescent-3	6		Absent-0	289
Ligule color	White-1	298		Short & partly awned-1	24
	Purple lines-2	10		Short & fully awned-5	1
	Purple-3	6		Long & partly awned-7	-
	Others-4	-		Long & fully awned-9	2
Ligule shape	Acute-1	2	Hull color	Straw-1	256
	2-cleft-2	301		Golden-2	22
	Truncate-3	9		Golden brown-3	12

Character	Character State	Frequency	Character	Character State	Frequency
Panicle exsertion	Well exs.-1	284		Brownish furrows on straw-4	5
	Mod. exs.-3	18		Purple-5	6
	Just exs.-5	9		Purple furrows on straw-6	
	Partly exs-7	3		Brown (tawny)-7	3
	Enclosed-9	1		Black-8,	-
Panicle type	Compact-1	4	Auricle colour	Others-9	9
	Intermediate-5	298		Pale green-1	233
	Open-9	9		Purple-2	41
Collar colour	Pale green-1	302	Internode colour	Others-3	43
	Green-2	4		Green-1	37
	Purple-3	8		Light gold-2	245
	Others-4	-		Purple lines-3	6
				Purple-4	29
				Others-5	-

DUS tests in rice

Second DUS Test in rice was conducted for first year during the Kharif 2010 at DRR (Hyderabad), CRRI (Cuttack), TNAU (Coimbatore) and AAU (Jorhat). A total of 15 candidate varieties, 6 extant varieties and 8 Farmers' varieties (Table 10). Were received from Protection of Plant Varieties and Farmers' Rights Authority (PPV&FRA). Fifteen candidate varieties were tested at DRR, and CRRI with 86 reference varieties. Eight farmers varieties were tested at DRR, while four varieties each were tested at Jorhat and Coimbatore with 28 reference varieties. Six extant varieties were tested at DRR, while three varieties each were tested at Jorhat and Coimbatore with 11 reference varieties.

Characterization of new Reference Collection of Rice varieties (RCV) Eleven new reference collection of varieties (RCVs) *viz.*, Akshyadhan, Vardhan, Sampada, DRR H2, DRR H3, DRR Dhan 38, DRR Dhan 39, KMP 148, KMP 105, GAR 13 and Karjat 184 received from different centres /states of the country were characterized at DRR, Hyderabad, CRRI, Cuttack, TNAU, Coimbatore, IARI Regional station, Karnal, and AAU, Jorhat (Table 10). A total of 328 Reference Collection of Varieties (RCVs) was grown for multiplication during Rabi 2011. Thus, the total number of RCVs characterized is 625 since 2002 to till date.

Table 10. Details of the Farmers' varieties and reference varieties in 2nd DUS test, *Kharif* 2010

Sl. No	Farmers variety	Reference variety
1	Muskaan	Annada, Sugandamathi, Dinesh
2	Chhohartu	Ketekijoha, VL Dhan 206, SKAU 337,
3	Gandakasala	Vivekdhan 62, CTH 3, IET 8116, Karthika
4	Veliyan	Vasumati, Shanthi, Cottondora sannalu, Taraori Basmati, Kasturi
5	Jeerakasala	Remanika, Mukthi, Pavithra, Suganda, krishnanjana, Phule Mawal, CH 988
6	Thondi	CO 47, Rudra
7	Chennellu	PTB 5, Suphala
8	Chomala	Nidhi, Prakash

Increasing yield potential by manipulating source and sink

Source and sink size increased with increasing nitrogen levels from 0-200 kg/ha. Among the varieties, source size was highest in Varadhan and lowest in hybrid PA-6444, while the sink size was highest in hybrid Sahyadri-4 and lowest in Akshyadhan. Yield showed a linear relationship with sink size and biomass, suggesting attempts can be made to increase the sink size in modern genotypes.

GEQ - Genetic enhancement of quality for domestic and export purposes

Genetic enhancement of quality rice varieties through conventional and molecular breeding approaches

Generation of breeding material - The promising crosses in the advance generation of basmati breeding material included Taraori Basmati/PR 116, Sugandhamati/Basmati 217, IET 17280/Type 3, Ranbir Basmati/IET 17920, IET 18022/IET 18297, Vasumati/B95-1//Vasumati*2, Type 3/PAU 2888-3-2-1-1-1, Taroari Basmati/B95-1, IET 17280/Pusa Basmati-1, Gaurav/PGB, Basmati Kota/IET 16313, IET 12021/PB1//Bas 6311, 96380/IET 16310, Ranbir Basmati/IET 17920 and IET 17294/Yamini.

Evaluation of BLB introgression lines in various backcross generations - Three hundred sixty eight BLB introgression lines from various backcross generations (BC_1F_5, BC_1F_8, BC_2F_5, BC_3F_5, BC_4F_4) were evaluated in a pedigree nursery. All the lines were inoculated for BLB as well as genotyped with the help of molecular markers for the presence of *Xa21* and *xa13* resistance to BLB. Among the 104 BC_1F_8 lines, 19 lines were found to possess *Xa21* and *xa13* genes in homozygous condition (Table 11). 24 lines contained only *xa13* while 8 lines had *Xa21*(Table 12). *A* total of 54 promising entries in BC_1F_8 were identified, while another 252 single plant selections were made in other BC generations for further evaluation.

Table 11. Promising BLB Pyramided Resistant lines with Xa21 & xa13 Identified through Molecular Markers, Kharif 2010

BLB Pyramided Resistant lines with *Xa*21 and *xa*13 resistant genes in homozygous condition in BC_1F_8 generation			
Taroari Basmati genetic background		Vasumati genetic background	
BPL-02	RP 4693 -39-2-4-1-1-1	BPL-74	RP4695 -212-1-1-3-1-2
BPL-03	RP4693-39-2-1-1-1-1	BPL-76	RP4695 -212-1-1-4-1-1
BPL-05	RP4693 -44-5-1-1-1-1	BPL-78	RP4695 -212-1-1-1-1-1
BPL-06	RP4693- 44-5-1-1-2-1	BPL-79	RP4695- 212-1-1-1-2-1
BPL-08	RP4693 -44-5-2-2–2	BPL-81	RP4691 -326-1-1-1-1-1

Taroari Basmati genetic background		Vasumati genetic background	
BPL-14	RP4693 -44-5-3-1-1-2	BPL-82	RP4691 -326-1-1-2-1-1
BPL-16	RP4693 -44-5-3-1-2-2	BPL-104	RP4691 -441-1-1-1-1-1
BPL-42	RP4693- 89-2-1-1-1-1	Basmati 386 genetic background	
BPL-43	RP4693 -89-2-1-1-1-2		
BPL-53	RP4693 -101-3-1-1-1-2	BPL-94	RP4694 -130-1-1-1-1-1

Table 12. Promising BLB Pyramided Resistant lines with Xa21 or xa 13 identified through molecular markers, *Kharif* 2010

BLB Pyramided Resistant lines with *xa13* resistant gene in homozygous condition in BC_1F_8 generation			
Taroari Basmati genetic background		Vasumati genetic background	
BPL-15	RP4693- 44-5-3-1-1-1	BPL-67	RP4695- 212-1-1-2-1-2
BPL-25	RP4693 –86-1-2-1-1-1-2	BPL-68	RP4695- 212-1-1-2-1-3
BPL-47	RP4693 -96-2-1-1-2-1	BPL-69	RP4695 -212-1-1-2-2-1
BPL-48	RP4693 -96-2-1-1-3-1	BPL-70	RP4695 -212-1-1-2-2-2
BPL-54	RP4693- 101-3-2-1-1-1	BPL-71	RP4695 -212-1-1-2-2-3
BPL-57	RP4693 -101-3-3-1-1-1	Basmati 386 genetic background	
BPL-58	RP4693- 101-3-1-2-1-1	BPL-62	RP4694- 126-1-1-1-2-1
BPL-59	RP4693- 101-3-1-3-1-1	BPL-63	RP4694 -157-2-1-1-1-1
BPL-60	RP4693 -101-1-3-1-2-1	BPL-96	RP4694- 193-3-1-1-2-1
BPL-61	RP4693 -101-5-1-2-1-1	BPL-97	RP4694 -193-3-1-1-3-1
		BPL-98	RP4694 -193-3-1-1-3-2
		BPL-99	RP4694 -193-3-1-2-1-1
BLB Pyramided Resistant lines with *Xa* 21 resistant gene in homozygous condition in BC_1F_8 generation under Taroari Basmati genetic background			
BPL-1	RP4693 –39-1-2-1-1-1	BPL-32	RP4693 –86-7-1-1-1-1-4
BPL-21	RP4693 –55-5-2-1-2-1	BPL-33	RP4693 –86-1-2-1-2-1
BPL-29	RP4693 –86-7-1-1-1-1	BPL-34	RP4693 –86-1-2-1-2-2
BPL-31	RP4693 –86-7-1-1-1-1-3	BPL-36	RP4693 –86-1-2-1-2-4
BPL-30	RP4693 –86-1-2-1-4-1		

Marker assisted convergent breeding for bacterial leaf blight and blast resistance: F_1's of 130 plants developed in the background of Vasumati, Basmati 386, Taroari Basmati and Improved Pusa Basmati 1 were tested for BLB (*Xa21, xa13*) and blast (*Pik*^{h}). The positives in homozygous condition were used for backcrossing. Thirteen F_1's were found to contain 3 genes (*Xa21, xa13* & *Pik*^{h}) in homozygous condition and the rest of the plants were in different combinations of homozygous and heterozygous conditions. The F_1's containing *Xa21*, *xa13*, *Pik*^{h} in homozygous condition were utilized in backcrossing with Vasumati, Vallabh Basmati, IET 18006, Pusa Sugandh 4, Sugandhamati and Super Basmati.

Molecular characterization of aromatic rice varieties (both basmati and non-Basmati) using EST-SSR markers: Molecular diversity analysis of 30 basmati and 16 non-Basmati aromatic rice was carried out using 26 hyper-variable SSR markers. The PIC values of the markers ranged from 0.170 (RM42) to 0.729 (RM28102) with an average of 0.53 per marker. Both the aromatic groups could be discriminated by either single (RM28102) or combination of two (RM577 + RM30) markers. Based on the similarity co-efficient values, genotypes were classified into two major clusters with 70% dissimilarity revealing presence of high diversity. RM 27507 located on chromosome 12 differentiated ASGLLRs from most of the BLLRs (Figure 4). A combination of two markers (RM577, RM30) located on chromosomes 1 and 6 also clearly differentiated both the groups. Nine genotypes, *viz*. Basmati Mehtra, Basmati 427, Shyamjira, Basmati Bahar, Basmati 62, Basmati Surkh 89-15, Basmati 334, Amrutbhog and RB2816 can be differentiated with the markers RM251, RM42, RM42, RM3, RM14, RM287, RM577, RM166 and RM24654 respectively. Seventeen genotypes can be distinguished by using a combination of two markers.

Fig 4. SSR marker RM 27507 can distinguish Aromatic short grain local land races (ASGLLRs) and Basmati local land races (BLLRs)

1-Neelabati (ASGLLR); 2-Kalajeer (ASGLLR); 3-Bishnubhog (ASGLLR); 4-Sheetalkani (ASGLLR); 5- Lectimachi (ASGLLR); 6-Tulasihganti (ASGLLR); 7- Basmati Mehtra (BLLR); 8-Tulasikanti (BLLR); 9- Basmati Sathi (BLLR); 10- Basmati 443 (BLLR); 11- Basmati 397 (BLLR); 12-Basmati 334 (BLLR); 13- RB 2816 (BLLR); 14- Basmati 213 (BLLR); 15- Basmati 410 (BLLR); 16- Basmati 6129 (BLLR); 17- Kanakjeer-B (ASGLLR); 18- Basmati Sufaid (BLLR); 19- Basmati 208 (BLLR); 20- Kanakjeer (ASGLLR); 21- Basmati 427 (BLLR); 22- Basmati Bahar (BLLR); 23-Basmati 62 (BLLR), and 24-Basmati Kamon (BLLR).

A cluster analysis using UPGMA based on similarity coefficients was done to resolve the phylogenetic relationships among the different aromatic rice genotypes. The analysis classified aromatic rice genotypes into two major clusters (I&II) with a dissimilarity value of 70% between these two clusters. The first cluster consisted of 27 genotypes (16 ASGLLRs and 11 BLLRs) and the second cluster included the remaining 19 genotypes (19 BLLRs). The first cluster was again sub-divided into five sub clusters IA, IB, IC, ID and IE consisting of 6, 9, 4, 3 and 5 genotypes respectively. The second major cluster was subdivided into four sub clusters viz. IIA, IIB, IIC and IID with 6, 7, 3 and 4 genotypes.

Development of a new functional marker for kernel length and kernel length after cooking - To circumvent the problems of reported CAPS marker (SF28) in MAS, a simpler PCR based marker system (DRR-GL) was developed targeting SNP in second exon of *GS3* which consumes less time, cost and easy to adapt for marker assisted breeding programs (Figure 5 a&b) Validation of this marker in segregating population as well in 33 important basmati varieties and 120 different non aromatic varieties revealed its perfect co-segregation with kernel length as well as with kernel length after cooking (KLAC).This marker system (DRR-GL) would be a good alternative to the existing marker for improving the rice grain quality (kernel length and KLAC) as well as quantity (grain weight and crop yield).

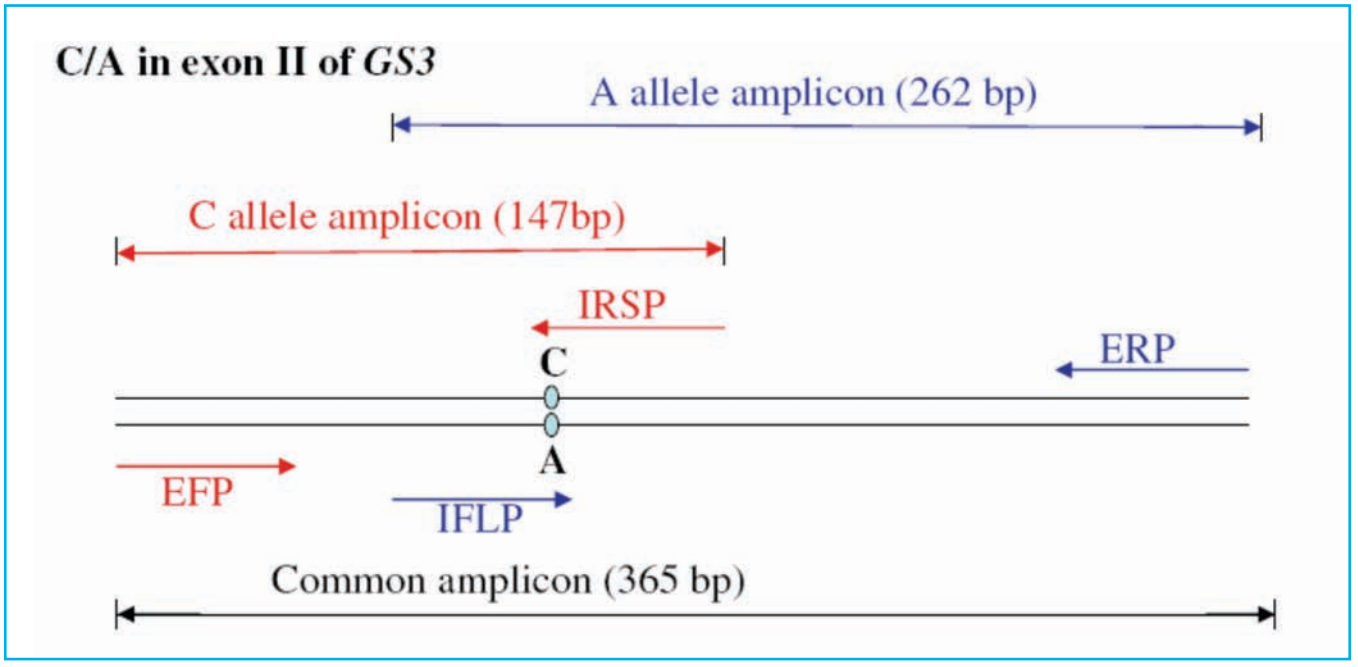


Figure 5a: Schematic illustration of the development of PCR based marker DRR-GL targeting a SNP at the second exon of GS3 locus.

This multiplex marker assay consists of two external primers (EFP and ERP) flanking the SNP and one internal primer targeting the C allele (IRSP) while the other internal primer targets the A allele (IFLP). The external primers EFP/ERP amplify a region of 365 bp as a common fragment in both dominant and recessive alleles, while the allele-specific primer pairs, EFP/IRSP and ERP/IFLP, amplify regions of 147 and 262 bp respectively.

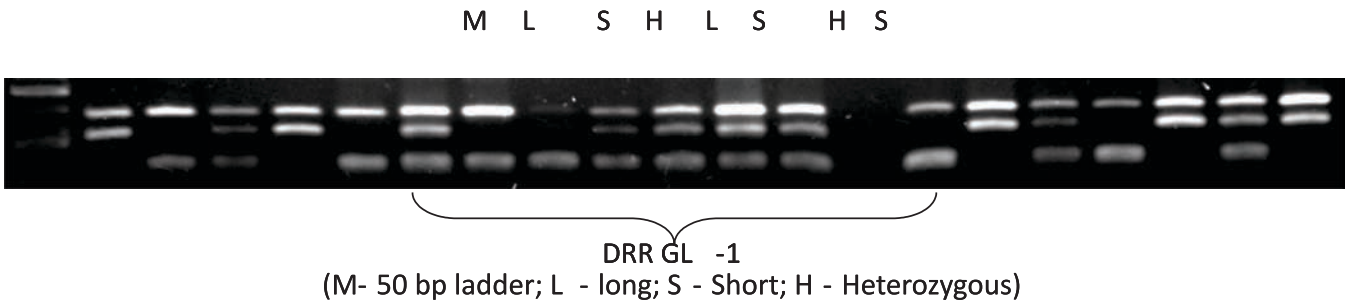


Figure 5b: DRR-GL amplification pattern in F2 population.

F2 mapping population derived from the cross between RB2816 Badshabhog (short-grain type having low KE) and Pusa 1401-97-7-1-5 (long grain type having high KE) was utilized to validate the DRR-GL marker system. The amplified fragments were scored as C allele, A allele and heterozygous. While analyzing the rice varieties Jeeraga Samba and Basmati 370 were used as positive controls for short and long kernel length respectively. M 100-bp ladder; PI RB2816 Badshabhog ; P2 Pusa 1401-97-7-1-5; 1-50 F2 population samples; S short grain; L long grain; Asterisk recombination

Identification and mapping of tightly linked SSR marker for aroma: By selecting the genomic region from the BAD2 gene responsible for aroma trait in rice, the SSR marker named ARSSR-3 was developed (Fig 6) as an alternative to the earlier reported allele specific multiplex markers for regular use in breeding programmes. It assists in MAS as well as marker assisted introgression of aroma trait into the genetic background of elite lines, since it is very close to the gene. The utility of the marker was amply validated in two BC_1F_1 populations of Taroari Basmati and Basmati 386 (Fig 7).

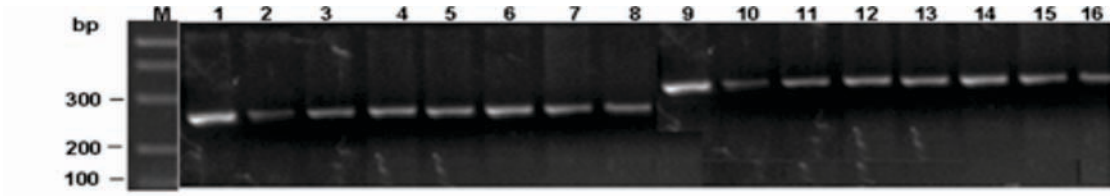


Fig 6. Agarose gel showing marker distinguishing between (1-8) and non aromatic (9-16) rice varieties.

1-Tarori Basmati, 2-Basmati 370, 4-Type 3, 5-Pusa Basmati, 6-Haryana Basmati, 7-Dehradun Basmati, 8-Kasturi, 9-Jaya, 10-Samba Mahsuri, 11-IR 64, 12-Swarna, 13-Vijeta, 14-TN-1, 15-Kavya, 16-Rasi

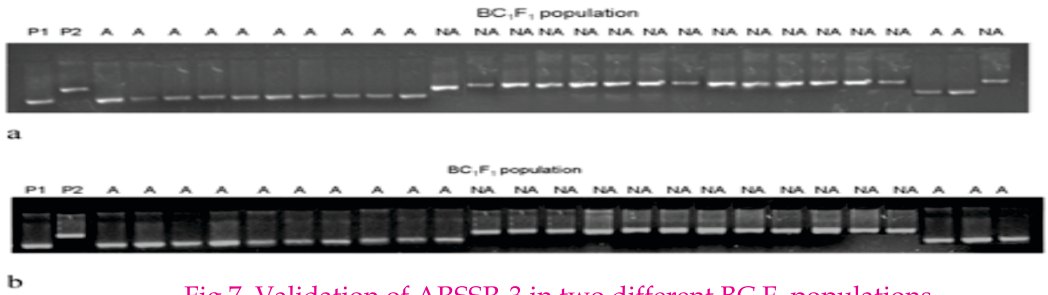


Fig 7. Validation of ARSSR-3 in two different BC_1F_1 populations.

A, P1= Taroari Basmati, P2= B95-1: b P1= Basmati 386, P2= B95-1. The PCR fragments were loaded in to 3% agarose gel. A= Aromatic, NA= Non aromatic; phenotyping of each plant was carried out with gas chromatography in three replications

Evaluation of elite aromatic lines for quality: Thirty eight basmati, 29 aromatic short grain elite lines were evaluated for 15 physico-chemical characters to identify the promising quality cultures. Among these, forty two entries recorded high head rice recovery (HRR) while 24 exhibited moderate HRR. Desirable and intermediate amylose content (AC) was recorded in 58 entries. Thirty three lines possessed medium gel consistency while 6 showed soft gel consistency. The promising entries include IET Nos. 21660, 21665, 21669, 21953, 21954, 21959, 21961, 21960 in Basmati group; 21044, 21053, 21057, 21260, 21261, 21264, 21267, 21271 in aromatic short grain category.

Evaluation of non-basmati elite lines for quality: One hundred and ninety two advance non-basmati elite cultures were evaluated in 18 trials *viz.*, AVT VE DS (6), AVT 1E DS (7), AVT VE TP (5), AVT 2 E TP (5), AVT 1 E TP (6), AVT 1 ME (27), AVT 2 M (18), AVT 1 M (18), AVT 2 L (9), AVT 1L (9), AL & ISTVT (15), AVT 2 E Aerobic (7), AVT 2 ME Aerobic (5), AVT 1 NIL Sub (2); IHRT E (9), IHRT ME (27), IHRT M (19) and IHRT MS (16). These were assessed for 14 physico-chemical characters. As many as 148 entries recorded high (>60%) HRR while 53 entries showed moderate (51-59%) HRR. Promising entries identified for desirable and intermediate AC and medium to soft gel consistency included 147 and 83, respectively. Overall, twenty five elite cultures in the third year of testing in different ecosystems merit attention possessing quality grain and cooking characters in addition to yield, resistance to biotic stresses All the following promising entries could form a source for improving the quality characters Table 13

Table 13. Quality characters of promising entries in non-basmati trials, *Kharif* 2010

IET No.	Mill (%)	HRR (%)	KL (mm)	KB (mm)	L/B ratio	Grain type	Grain chalk	ASV	AC (%)	GC (mm)
20863	71.1	68.6	5.47	2.32	2.37	SB	VOC	5.0	23.31	22
20706	68.0	63.3	6.05	1.91	3.16	LS	A	5.0	24.15	27
20048	67.5	56.0	5.75	2.33	2.47	SB	VOC	3.0	24.19	32
20878	72.3	69.6	5.66	2.42	2.33	SB	VOC	5.0	23.94	36
21106	70.8	68.0	5.44	2.16	2.51	MS	VOC	4.0	21.93	24
20710*	72.6	71.3	5.71	2.26	2.52	MS	VOC	4.0	22.14	45
20727*	70.8	65.0	6.08	2.15	2.82	LB	VOC	4.0	22.50	43
20716*	71.5	64.3	6.68	1.95	3.42	LS	VOC	4.0	24.15	46
20923	70.3	64.9	6.46	2.10	3.07	LS	VOC	5.0	24.33	37
20926	69.6	43.8	5.54	2.39	2.39	SB	VOC	7.0	23.94	23
20915	69.6	52.0	6.30	2.43	2.59	LB	VOC	5.0	24.39	22
20735*	73.0	58.3	5.78	2.11	2.73	MS	VOC	5.0	23.70	23
19886	70.2	61.0	5.08	2.37	2.14	SB	VOC	4.0	23.64	22
20760	71.0	50.9	5.04	2.48	2.03	SB	VOC	4.0	22.68	46
21214	67.1	64.6	5.41	2.30	2.35	SB	VOC	4.0	23.06	45
21205	71.7	69.3	5.97	2.12	2.81	MS	A	4.0	23.22	45

* Hybrids

Enhancing nutritional quality of rice through bio-fortification

F_2 seed of the 48 crosses grown in *kharif* were analysed for the iron and zinc content in brown rice and crosses which showed high iron content (mg/100 gm) were Improved Samba Mahsuri / Madhukar (2.93), Improved Samba Mahsuri/Type 3 (2.52), IR 64/Chittimuthyalu (3.12), PR 116/ Chittimuthyalu (3.20), PR 116/Ranbir Basmati (2.97), Mandya Vijaya / Jalapriya (2.96) while high zinc content (mg/100 gm) was noticed in improved Samba Mahsuri / Madhukar (4.13), IR 64/ Chittimuthyalu (4.32), PR 116/ Chittimuthyalu (5.11), PR 116/Suraksha(4.09) and Mandya Vijaya/Jalamagna (4.73).

Thirty land races collected from Manipur, Karnataka and Maharashtra and grown at DRR were analysed for the Iron and Zinc contents of brown rice. The entries with high iron content (mg/100 gm) were Munga (2.25), Pandy (2.08), Akutphou (2.01), and Gandhasali (1.93) and high zinc content (mg/100 gm) were Moirongphou, Phou Dum (3.31), Munga (3.11), and Sharavathi (3.04). The lines which showed both high iron & zinc were Munga (2.25 & 3.11), a short bold grain type from Maharashtra, and Akutphou (2.01 & 2.90) a long bold grain type from Titabar and these lines can be used in breeding programme for getting high iron and zinc lines.

One line derived from a cross between Samba Mahsuri/Chittimuthyalu with short bold grains, semi dwarf with high yield potential (> 4.5 t/ha) and medium duration with high iron (3.12 mg/100 gm) and zinc (4.0 mg/100 gm) in brown rice was identified with good quality characters *viz.*, good HRR% (67.5%), intermediate ASV (5.01), AC (24.05%) with mild aroma.

Mapping of chromosomal regions associated with Fe and Zn content in rice grains: Using two F_2 mapping populations Samba Mahsuri/ Chittimuthyalu and Samba Mahsuri/Ranbir Basmati loci associated with iron and zinc content in the seeds were mapped following selective genotyping approach. Three loci were mapped in Chittimuthyalu on chromosomes 3, 4 and 8 associated with Fe and Zn content in grains and four loci were mapped in Ranbir Basmati on chromosome 3, 4, 6 and 12. The candidate genes associated with the loci related to iron and zinc in brown rice are Yellow Stripe –like transporters; zinc transport; ZIP (Zrt/Irt related protein) and NRAMP (Natural Resistance – Associated Macrophage Protein). Two loci from chromosome 3 and one locus from chromosome 4 were found to be common between the two donors associated with iron and zinc metabolism.

Mapping and validation in alternate population: The loci identified and associated with iron and zinc in the two donors *viz.*, Chittimuthyalu and Ranbir Basmati were validated in $F_{2:3}$ of Swarna/ Madhukar. Parental polymorphism with 67 microsatellite markers derived from the above loci showed 67.2% (45 markers) polymorphism between the two parents (3 monomorphic; 19 poor amplification). A set of 192 $F_{2:3}$ lines were evaluated for their iron and zinc content in the brown rice. Iron content in 100g of brown rice ranged from 1.22 to 7.09 mg/100 g and zinc content ranged from 1.68 to 5.07 mg/100g (Swarna: iron 2.93 mg/100g; zinc:2.28 mg/100g and Madhukar: iron 4.72 mg/100g; zinc:2.85 mg/100g)

Morphological and molecular characterization of aromatic short and medium grain rice germplasm

Two hundred and seventy seven aromatic short and

medium grain rices were characterized during *kharif* 2010 for 15 physico-chemical quality characters. Many of them were promising for different quality parameters *viz.*, 188 entries with high HRR, 233 with intermediate and desirable amylose content, 179 with strong aroma, 96 with translucent grains, and all entries with volume expansion of >3.5. One hundred sixty one entries showed high HRR and intermediate amylose content.

Polymorphism study for ninety six aromatic short grain rices revealed that, of the 56 SSR markers used 27 showed polymorphism involving 2 to 5 alleles. The banding pattern was converted into binary matrix and cluster analysis performed using UPAGMA based on similarity co-efficient resolved the 96 ASG genotypes into two major clusters with 74% dissimilarity. Cluster I consisting of 60 genotypes showing 73% dissimilarity was further grouped in to five sub-clusters such as IA,IB,IC,ID and IE consisting of 19,18,2,19 and 2 accessions respectively. Cluster II consisting of 36 genotypes showing 69% dissimilarly with other clusters was sub grouped into 4 sub-clusters namely IIA, IIB, IIC, and IID and the number of genotypes are 3,19,8 and 6 respectively. These results were supported by physico-chemical and cooking quality traits, disease resistance and further showing synchrony with important agronomic traits (Table 14).

Table 14. Genetic diversity based on molecular markers in aromatic short grain rices

Clusters	Genotypes	Characters	Total
I A	Suhklaphool, RAU 3043, Barang, Shyamjira, Rukminibhog, Lalkanhu, Bindli, Sitabhog, Kankjeer - A, Badshaha, RAU 3036, RAU 3048, ASGPC 38, RK395 Kubrimoher, Adamchini B, Kanakjeer B, Dhaniya B, Loungchoosi B and Bhantaphool B	Medium panicle no., intermediate AC, low KLAC	19
I B	Banspatri, Bhulasapiri, Thukrasuna, Ratnasundari, Bayasabhog, Munibhog, Chitarsing, Dudaya, Dudhraj, Jhilisafri, Ramkali, Rajin12, Tulsibhog, Tenduphool, Champaran Basmati 2, Bishnubhog, Lectimachi and Maguraphulla B.	Medium panicle no., intermediate AC, GC; high KLAC	18
I C	Kota basmati and Gopalbhog	Low panicle no., intermediate ASV, blast resistance	2
I D	RAU 3014, Gangabarud, Dhobaluchi, RR 399 sel from Raja bhog, RD 934 Dubraj, RK 2512 Kadamphool, RC 781 Chinor, Tulasikanthi, RD 1025 Dudgi, RB 287 Dubraj Bandi, Chhabiswa, IGSR 3140, Sujatha, Magura, Nagri, IGSR 216, Khudijoha, PDKV Sriram and Mongara phool	Medium panicle no., medium to high KLAC, intermediate AC, ASV	19
I E	RAU 724-48-33 and Gatia	120 days to 50% flowering, intermediate AC, ASV; low KLAC, susceptibility to pest and disease	2
II A	RAU 3054, Manisi and Kapoorchinni	Intermediate AC,ASV; medium GC, susceptible to BPH and WPH.	3

Clusters	Genotypes	Characters	Total
II B	Kalakanhu, NDR 65, Juhibengali B, RAU 3074, RAU 3056, Atmashital, Ambemohar 157, Karpu rakranti, Konjoha1, Kunkunijoha, Govindbhog, Kamod, Joha, Kolajoha 2, Khosakanl, Dubraj, Sheetalkani, Bokuljoha and Heerakani	MR to Bl, medium panicle no., 115-120 days to 50% flowering, intermediate ASV, AC; medium GC	19
II C	Jala, Kalanamak, Durgabhog, Basnaghan, Kaminibhog, Kalijira 81, Jeerakalasala and Kalanamak 3	115-120 days to 50% flowering, medium panicle number	8
II D	Neelabati, NDR IRRI 3131, Katribhog, Basmati B, Kalanamak1 and ASGPC 14	120 days to 50% flowering, intermediate ASV, AC; low KLAC	6

Estimation of 2 ap content (2 ap area / TMP area x100): Ninety six aromatic short grain rices were analyzed to estimate the 2 ap content in collaboration with IICT, Hyderabad. Among these, Juhibengal-A, Barikunja, Khosakani, Kala Namak (Nichlaul), Boga Joha, Bhanta Phool A, Bhugri Joha, Kalajira, RAU 3079, Ambemohar, RAU 3049, Loung Choosi A, RAU 3041, RK 1019 (Sel from Krishnabhog), Dhanprasad, Kola Joha 1, IGSR-2-1-46, Chini Kapoor, Kanika bhog recorded high levels of 2 ap content > 2 (2.01 to 3.64).

DBR - Application of biotechnology tools for rice improvement

Introgression of yield enhancing genes from wild species to rice using molecular markers

Developing, characterizing, mapping yield QTLs and evaluating introgression lines from crosses between elite lines and wild progenitors: Three populations using *O.rufipogon, O.nivara* and *O.meridionalis* were developed for mapping yield enhancing QTLs. Large amount of variation was generated for traits related to yield in the recipient lines Swarna, KMR 3 and Samba Mahsuri in the cross combinations of BC2F6 of Swarna/*O. nivara* IRGC 81832 (RPBio 4918); BC_2F_5 and BC_2F_6 of Swarna/*O. nivara* IRGC 81848; BC_3F_2 of Samba Mahsuri/O. *rufipogon* WR119 (RPBio 4920); KMR 3/*O. rufipogon* WR120 (RPBio 4919); BC_2F_2 of Swarna, Samba Mahsuri, IR 58025 B each crossed to *O. meridionalis* and BC_2F_3 of IR 58025B/ *O. meridionalis*. Seven hundred fifty F_3 lines were phenotyped for yield releated traits and further genotyped with 4 sub QTL markers to fine map yld2.1.

Mapping population with 300 F_2 plants derived from 8 F_1s obtained from a cross between a dense (more than 60 secondary branches per panicle, sbp) and a lax panicle plant (less than 30 sbp) in line 166 was developed to map dense panicle trait. The F_2 plants were grouped into 3 classes based on the number of sbp. Nineteen plants had less than 30 sbp, 14 plants had more than 60 sbp and 267 plants were intermediate with 31 to 60 sbp. Twenty three SSR markers were polymorphic between the parents.

Swarna/*O.nivara* introgression line IET 21542 which has part of the yield QTLs *Qyldp8.3* from *O. nivara* has been found promising in mulilocation testing in AVT 1 IM. One hybrid with KMR 3/*O.rufipogon* IL as restorer possessing a sub QTL of *yld2.1* from *O. rufipogon* gave the highest yield in DRR station trial. Other elite introgression lines tolerant to drought, salinity, bacterial leaf blight,

blast and brown planthopper and those performing well in SRI and direct seeded condition and lines with high iron and zinc concentration in grains, were identified.

The highest concentration of 30 ppm zinc and 170 ppm Fe was reported in Swarna/*O. nivara* BC_2F_3.

Identification of genes for grain filling in rice (*Oryza sativa L.*)

Depending on the position on the panicle, the grain filling differs for spikelets on primary branches and secondary branches of upper and lower portions in rice. With an objective of identifying candidate genes associated with grain filling process across the panicle, candidate gene (CG) based mapping approach was attempted in F_2 population derived from the cross between 'Rasi', a rice variety known for its good grain filling and IC114927, a local landrace. The grain filling (%) was characterized for 444 F_2 individual plants across the panicle. Within the F_2 population, thirteen plants were identified with >90% grain filling across the panicle. For 120 markers designed from 1 kb upstream and within the candidate genes reported to be involved in translocation process, 18.3% polymorphism was observed. Using selective genotyping approach comprising 24 individuals from each group, two associated CG markers were identified. Further analysis of the mapping population showed CG marker based on sucrose phosphate synthase gene on chromosome 2 to be significantly associated with filling of grains on primary branches of upper half of the panicle and another CG marker based on transporter gene on chromosome 11 to be associated with filling of grains on primary branches of lower half; secondary branches of upper half and lower half of the panicle. Both the positive alleles were contributed by the variety 'Rasi'. (Fig 8).

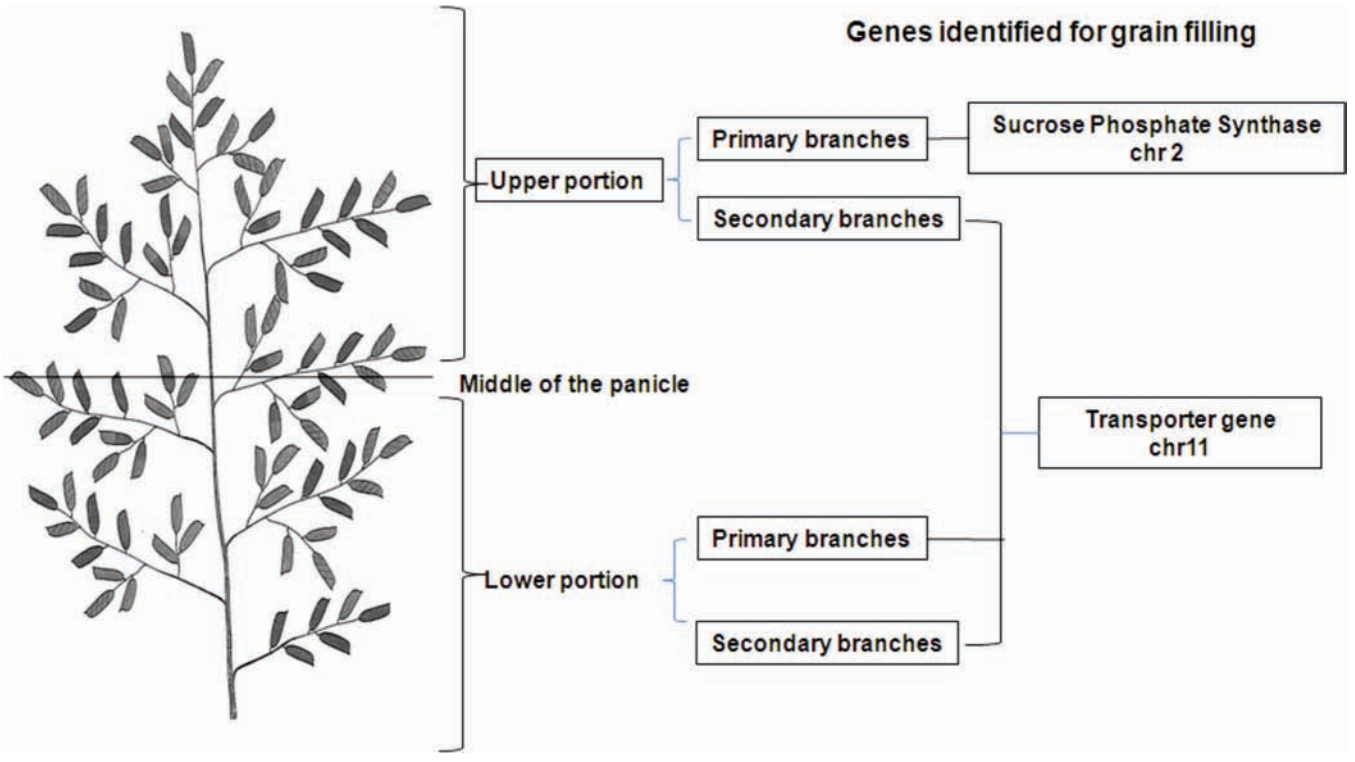


Fig 8. Genes identified for grain filling

Application of biotechnological tools for understanding molecular basis of yield heterosis and WA-CMS trait in rice

A set of 80 hypervariable genomic SSR markers were selected from rice SSR database available online at http://www.gramene.org. These markers were checked for their amplification pattern in a set of 10 rice varieties and a total of 50 markers showing robust and clear amplification were identified. These markers were then validated for their utility in prediction of grain yield heterosis in a set of 40 heterotic experimental hybrids derived by crossing 5 elite WACMS lines and 8 elite restorer lines. A set of 12 hypervariable SSR markers (HRM12469, HRM20866, HRM11570, HRM16006, HRM24217, HRM23595, HRM24383, HRM18770, HRM25754, HRM16606, HRM6740 and HRM13131) were identified to be highly informative with high PIC values (> 0.75). The selected 12 hyper-variable genomic SSRs mentioned above were validated in a set of in a set of 40 hybrids derived by crossing five WA-CMS lines and eight restorers in a L x T fashion. Standard heterosis for per-day productivity was calculated for the hybrids, which was then correlated to the coefficient of marker-polymorphism values calculated for each hybrid. The 12 hyper-variable SSR markers were observed to be highly informative for heterosis prediction (r = 0.78).

Targeting the key mitochondrial genes associated with respiration (which have been earlier implicated with CMS trait in many plant species), a set of 48 PCR primer pairs were designed. These included the genes from *nad* complex, *atp* complex, *cox* complex and the genomic regions which have been earlier implicated with the trait of WA-CMS trait by various research groups. When these were utilized for amplification of the WA-CMS line, IR 58025A and its cognate, isonuclear maintainer line, IR 58025B, 43 primer pairs displayed amplification, while five did not display amplification. Twelve out of the 43 primer pairs targeting the mitochondrial genes *nad1, nad3, nad4, nad7, atp6* and *cox2* displayed polymorphism between APMS 6A and APMS 6B (Fig 9).

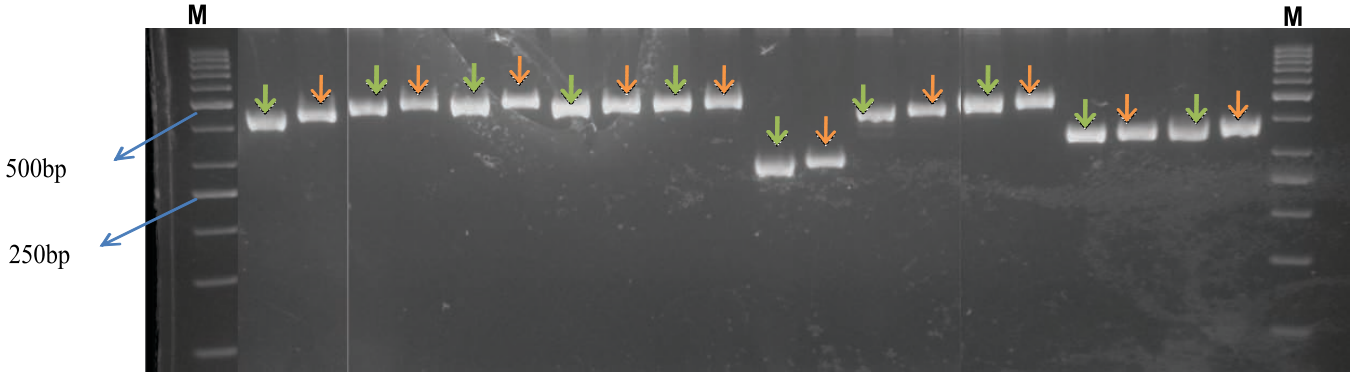


Fig 9. Amplification pattern of a set of primer pairs targeting the mitochondrial genes associated with respiration in the WA- CMS line, APMS 6A (green arrow) and its cognate, isonuclear maintainer line APMS 6B (orange arrow). M – 50 bp ladder.

Development of molecular markers for important quality traits in rice

Ten crosses have been made between parents with contrasting grain and cooking quality traits. These crosses were advanced to further generation to make recombinant inbred lines. Polymorphic survey across the parents led to identification of 239 polymorphic markers uniformly distributed across whole genome. Major QTL for GT on chromosome 6 resulting in 30.7% phenotypic contribution for the trait was identified. For grain breadth, a QTL on chromosome 8 which contributed to 11.2% phenotypic contribution was also identified. Identification of QTLs for various quality traits are in the progress. Efforts are in way to fine map and saturate the searching in the QTLs in the whole genome. The map position of markers and QTL positions identified through single and interval mapping are given in the (Fig 10).

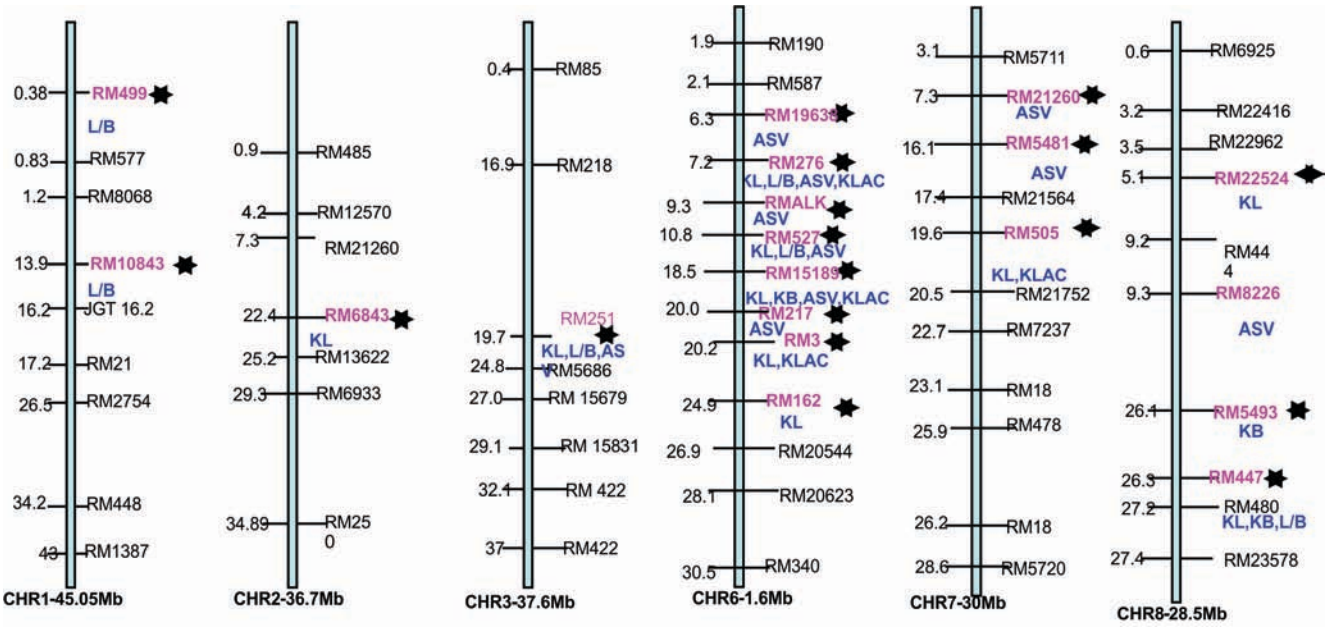


Fig 10 . Location of significant QTLs for various cooking quality traits

Gene discovery and "allele-mining" for water limiting conditions and salt tolerance in rice

Salinity: A set of 87 entries were studied for the estimation of salt stress susceptibility index (SSI) adopting the formula of Fischer and Maurer (1978). On the basis of scoring S-381, S-478, 50-13 and 3-1(K) showed no inhibitory effect of NaCl on growth at 100mM NaCl and it was similar to control after one month NaCl exposure. S-478, 50-13 and 3-1(K) showed similar growth as of control at 150mM NaCl even after one month exposure to NaCl. Lowest SSI was recorded for S-381 followed by 3-1(K), 166(S) and 14(K) at 100mM NaCl. Grain yield measured in terms of grain weight per plant decreased in all the lines under stress condition but lesser inhibition was found for S-381, 166(S), 3-1(K) and 14(K) at 100mM NaCl. Lines showing <=50% reduction in grain yield under stress and 3-1(K) can be selected as tolerant genotypes for salinity stress.

Among Swarna ILs chlorophyll content decreased at 150 and 200mM NaCl and remained unchanged for 248(S), 166(S), 231K, 3-1(K) and 14(K) and a drastic increase was found for 75(S) at 50mM NaCl.

Drought: For drought stress 2D-gel electrophoresis was done in tolerant variety Vandana and sensitive variety IR 64. Differentially expressed spots were selected and MS/MS analysis was done to identify protein.

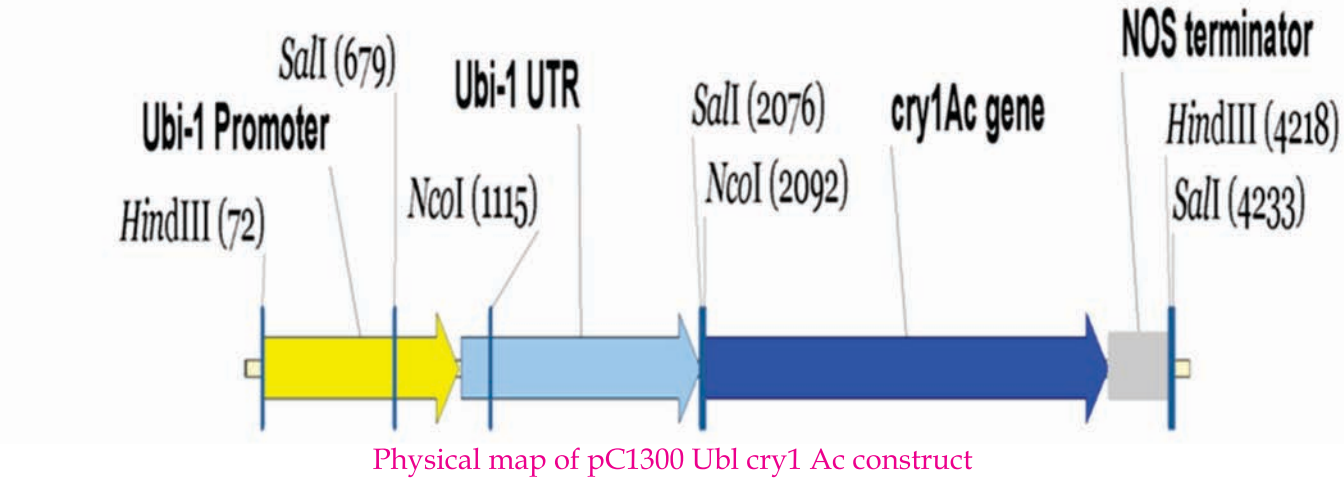
A single and very dense GIN was found for the genes (39) which are common to both drought and saline stresses. Total 57 transcription factors were reported for 39 genes among which MYBCORE was bound to maximum number of promoters (19),

Genetic improvement of rice against biotic and abiotic stresses through transgenic approach

Development of transgenic rice of elite indica varieties with cry1Ac gene resistant to yellow stem borer and leaf folder:

Advancement of Bt rice lines: Three events (IC-5, AIC-2 and AIC-3) of Bt transgenic rice with Cry1Ac in the background of IR64 were generated. All these lines were advanced to T3 generation to get homozygous lines. Molecular confirmation of these events with PCR was completed and most of these plants are confirmed to be in homozygous condition.

Quantification of Cry1Ac protein through ELISA in transgenic Bt rice: About 250 Bt homozygous transgenic plants from 25 lines were selected for estimation of Cry1Ac endotoxin by ELISA (Envirologix Inc.) kit. The expression of Cry protein in leaf/stem samples of rice plants varied from 51.27 to 173.20 ng/gm of leaf/stem tissue in T_3 plants.

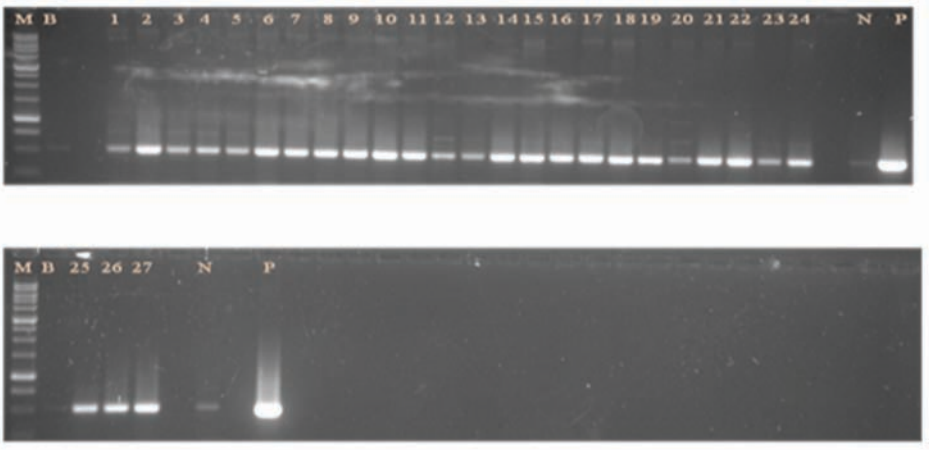


Physical map of pC1300 Ubl cry1 Ac construct

Insect bioassay: Twenty five lines of T3 from the events IC-5, AIC-2 and AIC-3 were subjected to whole plant bioassay for YSB resistance under controlled caged conditions by releasing 2 neonate larvae of *Scirpophaga incertulas* (yellow stem borer) per tiller. Damage by the released larvae in individual plants was recorded 10 and 30 days after infestation. IC 5-3-20-1, IC 5-4-20-1, IC 5-4-20-2, AIC 3-2-8-1, AIC 3-2-8-3, AIC 3-5-27-1, AIC 2-6-3-1, AIC 3-5-7-1, AIC 3-5-7-3, IC 5-4-21-1 and AIC 3-5-31-1 showing no dead hearts (DH) or white ears (WE) have been advanced to next generation (Fig 10a).

Generation of new Bt transgenic rice events with Cry1Ac gene: About 6,000 embryogenic calli of B95-1 were transformed by Agrobacterium strain LBA4404 carrying the binary vector pC1300-Cry1Ac-Act. In total, 70 putative transgenic plants were regenerated of which 27 plants were found PCR positive by using Cry Ac gene specific primer of 523 bp fragment (Fig10b).

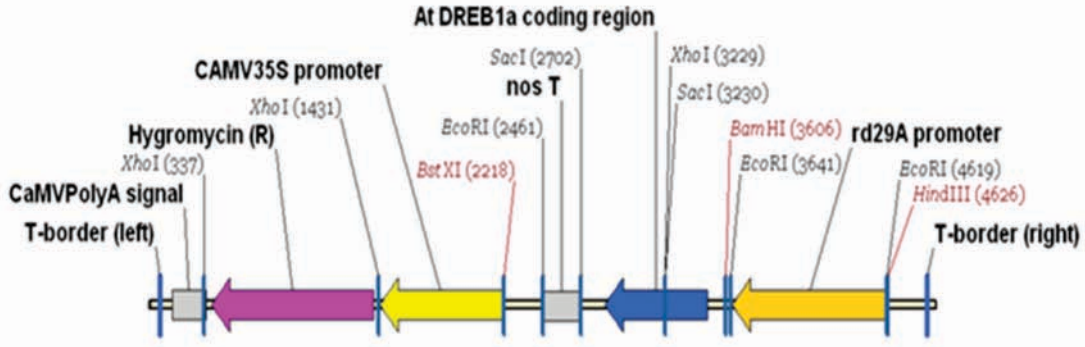
Fig. 10a & b Transgenic Plants (T3) under bioassay and showing resistance against YSB in glass house



PCR analysis putative transgenic plants of B-95 with Cry1Ac gene

Development of transgenic rice of elite indica varieties with DREB1a gene tolerant to drought

Three independent events of transgenic rice (BD-33, BD-38 and BD-45) in the background of Samba Mahsuri were developed by transforming with *Agrobacterium* strain LBA4404, containing the binary vector pC1200-Rd29A-DREB1a. Progenies of all the three plants were advanced by screening through PCR at different generations (like T1, T2 and T3). Homozygous plants from 6 lines of BD-33, 4 lines from BD-38 and 3 lines from BD-45 were selected for further advancement, for gene expression and for evaluation studies against drought and salinity stress tolerance in next generation. Drought tolerance parameters such as PEG treatment, chlorophyll content, proline content indicated that some of the lines showed tolerance to drought. The dry-down experiment also clearly indicated that transgenic plant carrying the *RD29- At-DREB1a* gene was highly expressive under drought conditions (Fig 11).



pC1200-Rd29A-DREB1a (Linear)

Linear map of pC1200-Rd29A-AtDREB1a

Fig:8a: M-Marker, B- Blank, N- Negative control, 1-23 are T2 homozygous BD 33-24 series; P- Positive control

Fig:8b: M-Marker, B- Blank, N- Negative control, 1-24 are T2 homozygous BD 45-3 series; P- Positive control

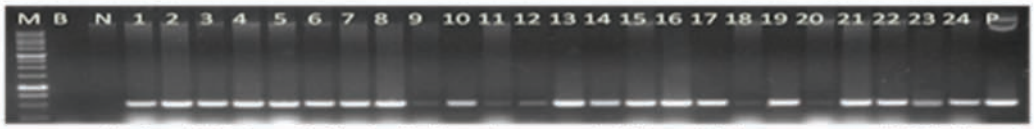


Fig:8c: M-Marker, B- Blank, N- Negative control, 1-24 are T2 homozygous BD 38-18 series; P- Positive control

PCR analysis of homozygous lines of transgenic BPT5204 with DREB1a gene

Fig : 11 Development of transgenic rice of elite indica varieties with DREB1a gene tolerant to drought

Molecular breeding for parental line improvement in rice

In order to improve the parental lines of hybrids for pest and diseases resistance, the F_1 plants of RPHR 1096 and DRR 9B introgressed with genes for BLB (*Xa33t*) Blast (*Pik*^{h}) and BPH (*Bph18t*) were back crossed to produce BC_1F_1. Around 100 breeding lines were screened for the presence of *Rf4*, *Rf3* and Wc genes with the help of linked molecular markers (RM 6100 for *Rf4*, RM 10315 for *Rf3*, S5 InDel for *S5* neutral allele) and lines with different gene combination were identified. The restorer lines *viz.*, KMR-3R, Ajaya-R, GQ-86, GQ-58, GQ-64-1, DR714-1-2R, 945-1-2, SG 17-118-3, SG-27-175, SG-27-177, Shrabani and 255 showed the presence of all *Rf4*, *Rf3* and *Wc* genes. Identified lines were crossed with the set of CMS lines and their pollen and spikelet fertility and other agro morphological traits were studied to identify restorers, partial restorers and maintainers. DRCP-102 restorer genetic male sterile population were raised and male sterile plants were identified and crossed with donors possessing BLB, Blast, BPH and GM.

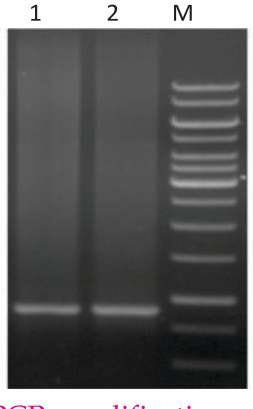


Fig 12. RT-PCR amplification of *CP3* of two RTSV infected rice samples collected from Puducherry. M-1Kb DNA ladder, 1&2- PCR amplification of tungro infected rice samples.

Suppression of rice tungro virus through RNA interference

Studies were carried out on the RTV (Rice tungro virus) genomics through analysis of four *CP3* gene sequences of RTSV of Cuttack, Puducherry, Hyderabad and Kanyakumari isolates. Indian isolates of RTSV shared a high degree of sequence identity at nucleotide (92-100%) and amino acid (97-100%) level with each other suggesting that RTSV population in India represented similar genetic architecture. Sequencing and sequence analysis of *CP3* sequences from Puducherry isolate suggested that the sequence variation observed in this study was not present within the site (Figs. 12 & 13) and 100% identity was observed in nucleotide sequences.

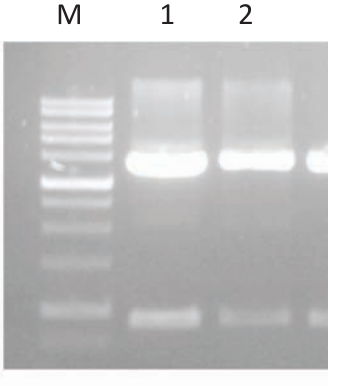


Fig 13. EcoRI restriction analysis of the recombinant plasmids. M-1Kb DNA ladder, 1&2-released *CP3* gene from pDrive vector.

Coat protein 3 sequences of RTSV generated for Cuttack, Kanyakumari and Puducherry isolates (Accession Nos. HM149529, HM149530, HM627634) and ORF-IV sequences of *Rice tungro bacilliform virus* (RTBV) generated for Cuttack and Puducherry isolates (Accession nos. HM149532 and HM149531) were submitted in NCBI database. Primers were designed to amplify the ORF-I region of RTBV. PCR conditions were standardized and ORF-I sequences of RTBV was amplified from Cuttack, Puducherry and Hyderabad isolates (Fig 14). Sequences obtained will be useful for RTBV diversity studies in India.

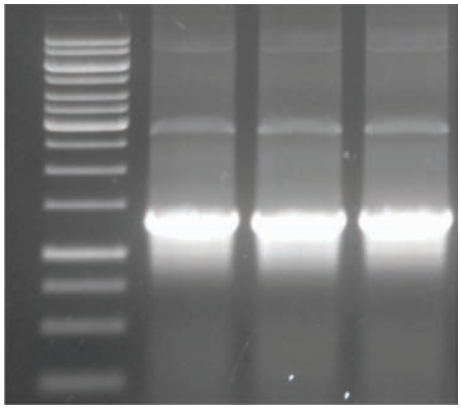


Fig 14. A gel showing PCR amplification of ORF-I region of RTBV. M-1Kb DNA ladder, 1,2 and 3- PCR band obtained from Cuttack, Puducherry and Hyderabad isolates respectively

Use of different softwares for determination of the potent siRNAs from the CP gene of RTSV- Various online bioinformatics tools were exploited to screen the siRNAs rich regions of *CP*3 and identify potent siRNA sequences within the truncated *CP*3 gene sequence. DEQOR, MWG siRNA design tool and siRNA tool available at whitehead institute were used for screening of gene sequence to see the siRNAs richness.

Development of RNAi inducing binary vector constructs - For this a binary construct of truncated *CP*3 was developed. The pDrive clone consisting *CP*1-*CP*3 genes was restricted with BamH1 enzyme to release the 648 bps truncated *CP*3 gene [Fig 15]. The fragment released having size of 648 nucleotides was gel purified. The binary vector pGA3626 was linearized with BamH1 restriction enzyme. The gel purified fragment containing the *truncated CP3* gene released from the pDrive clone was cloned in the pGA3626 vector. Confirmation of the clone was done by colony PCR. It was again reconfirmed by restriction with BamH1 enzyme, to release the truncated *CP*3 gene [Fig16]. The presence as well as orientation in the above clone was confirmed by sequencing. Recombinant plasmid carrying the *truncated CP3* gene construct was mobilized into *Agrobacterium*. Colonies, obtained on antibiotic selection plate were screened by colony PCR using specific primers to amplify the ~500 bps internal region of truncated *CP3* gene [Fig 17]. The positive clones are being used for *Agrobacterium* mediated rice transformation.

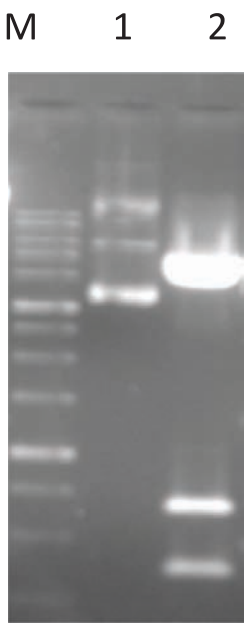


Fig 15. Drive clone consisting *CP*1-*CP*3 genes restricted with BamH1 enzyme to release the 648 bps truncated *CP*3 gene fragment. M-1Kb DNA ladder, 1- restricted fragments including 648 bps of Tr*CP*3 fragment.

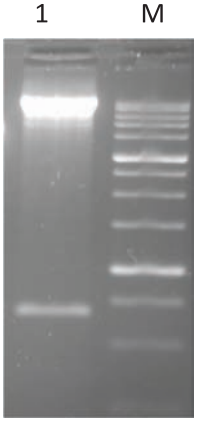


Fig 16. BamH1 restriction analysis of the recombinant pGA3626 binary vector plasmid. M-1Kb DNA ladder, 1 -released truncated *CP*3 gene fragment from pGA3626 vector.

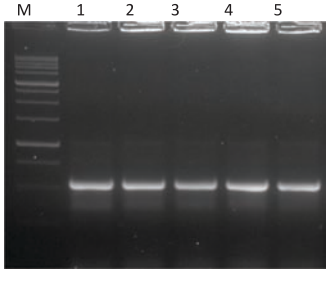


Fig 17 A gel showing Agrobacterium colony PCR of truncated *CP*3 region of RTSV. M-1Kb DNA ladder, 1 to 5- PCR amplification of different Agrobacterium clones. reaction on a set of differentials.

PROJECT COMPLETION REPORT

DST \ No: SR/SO/PS-09/2006 (2007-2010): Fine mapping of fertility restorer genes for WA-CMS system of rice and its application for identification of restorers

Of the various cytoplasmic genic male sterility (CMS) systems in rice, WA-CMS (Wild Abortive) is being widely used in commercial hybrid rice production. Though the inheritance of fertility restoration (*Rf*) in the WA-CMS system has been extensively investigated, reports regarding the number, position and effects of these *Rf* genes are variable depending on the restorer used. As the popularity of hybrid rice technology is on the rise in India, with the availability of new technology and information viz., sequence information of rice genomes and positional cloning, a project was sanctioned by DST to fine map the gene(s) for fertility restoration in the popular Indian restorer/s, so as to use the information for routine marker assisted selection (MAS). Two loci *Rf4* of chromosome 10 and *Rf3* of chromosome 1 have consistently reported across several studies. For fine mapping of *Rf4* and *Rf3* loci, several markers were designed based on SSRs and putative candidate genes from the available sequence information of both indica and japonica genomes from the databases and mapped in in ~1000 F_2 individuals of KRH2 hybrid (IR58025A / KMR3). Two local linkage maps have been constructed corresponding to *Rf3* and *Rf4* loci on chromosomes 1 and 10 with polymorphic markers. For *Rf3* locus, a 10.4 cM genetic map and a 14.1cM genetic map for *Rf4* locus were generated. Two QTLs were identified on chromosome 1 *viz.*, a QTL (qWARF-1-1) between the developed markers SC368 and SC363 (LOD 12.3) explaining 31% of phenotypic variance and another QTL (qWARF-1-2) close to SC373 marker (LOD 4.7) with additive effect. In the same population for *Rf4* locus on chromosome 10, two QTLs were detected, a major QTL (qWARF-10-1) was identified explaining 40% phenotypic variance between the genic markers SC1240 and SC1246 (LOD 3.5) and the other QTL (qWARF-10-2) was identified between the reported marker RM25654 and developed marker SC400. The developed marker system was validated in 231 restorers and 34 maintainers SC1246/SC1240 for *Rf4* locus and SC363/SC368 for *Rf3* locus with efficiency of 91% for identification of restorers.

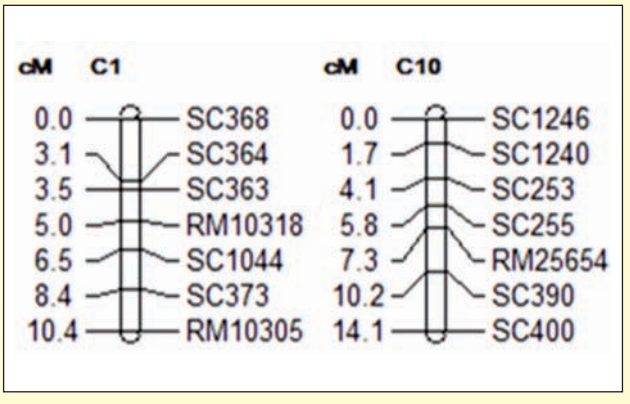


Fig 18. Local linkage maps of *Rf3* and *Rf4* loci

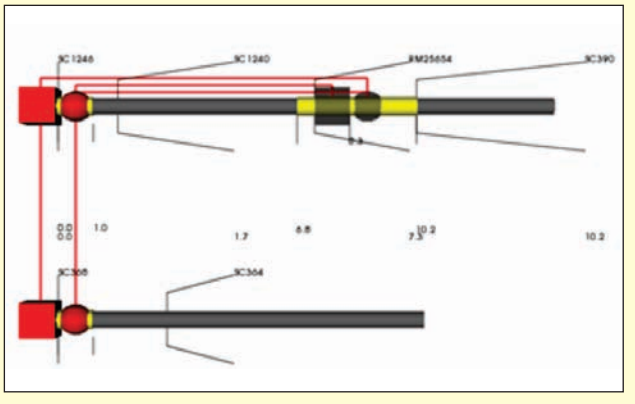


Fig 19. QTLs identified and their interaction in KRH2 mapping population

PROJECT COMPLETION REPORT

ICAR sponsored project entitled "Gene pyramiding for biotic stress resistance in rice"

Marker-assisted improvement of KMR-3R and KRH2 for bacterial blight resistance, grain type and yield: KMR-3R is a stable restorer line with medium-bold grain type and is the male parent of the popular public-bred Indian rice hybrid, KRH2. Since KMR-3R is highly susceptible to bacterial blight (BB) and possesses undesirable bold-grain type, it was crossed with a high-yielding, BB resistant, fine-grain type variety, Improved Samba Mahsuri possessing the major BB resistant gene, *Xa21*. The F_1s were backcrossed to KMR-3R and the BC_1F_1 plants were subjected to marker-assisted selection (MAS) for *Xa21* and two major fertility restorer genes, *Rf3* and *Rf4*. 'Triple' positive BC_1F_1 plants were selfed and their progeny were subjected to MAS for *Xa21* coupled with phenotype-based visual selection for agromorphological and grain quality traits. At BC_1F_5 generation, three backcross derived lines (BK9, BK49 and BK61) possessing higher yield than KMR-3R, tall plant stature along with fine-grain type were identified and crossed with IR598025A, the female parent of KRH2. The hybrids were completely fertile, possessed long-slender grain type, exhibited resistance to BB and displayed a yield advantage of 24 % over KRH2 under BB infection. (Fig. 20)

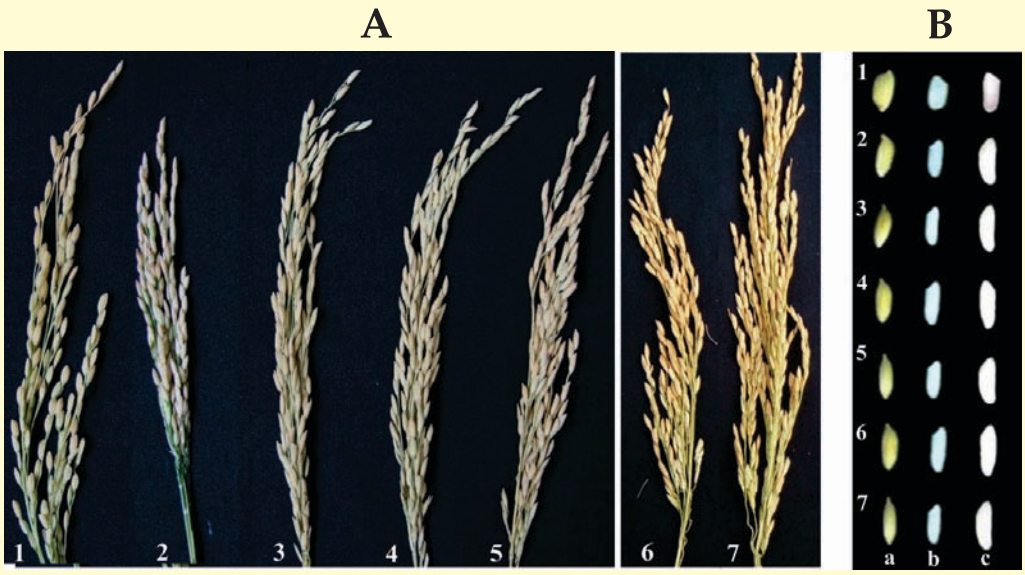


Fig 20. BC_1F_5 line # BK9, BK49 and BK61 (Improved KMR-3R) possess medium slender grain type similar to Samba Mahsuri

A: The backcross derived lines BK9 (3), BK49 (4), BK61 (5) and Improved KRH2 derived from the cross IR58025A/BK49 (7) possess compact panicle similar to Improved Samba Mahsuri (2) and better than KMR-3R (1) and original KRH2 (6).

B: The paddy (a), milled rice (b) and cooked rice (c) of the backcross derived lines BK9 (3), BK49 (4) and BK61 (5), Improved KRH2 derived from the cross IR58025A/BK49 (7) is similar to Improved Samba Mahsuri (2) and better than KMR-3R (1) and original KRH2 (6).

PROJECT COMPLETION REPORT

Promoter Mining for Identification of Novel Regulatory Elements of Candidate Genes in Rice for Biotic Stresses (DBT - RGYI)

- Three blast resistant genes - *Pi b, Pi ta, Pi K*^{h}, which showed resistance to most prevalent pathotypes in India and three bacterial blight resistant genes - *Xa21*, *xa5* and *xa13* were selected for the promoter mining study.
- Primers were designed using bioinformatic tools to amplify 2000 bp of up stream to the TSS of the selected genes.
- Twenty seven rice land races and 127 different accessions of wild rice species were selected for the promoter mining study. This material was phenotyped twice to know disease reaction.
- Four *Pik*^{h} promoter alleles were cloned from (2 resistant + 2 susceptible) land races and six other promoter alleles were cloned from wild rice species (3 resistance from *O. barthii, O. latifolia* and *O. rufipogon* and 3 susceptible genotypes from different accessions of *O. rufipogon*). Full length *Pik*^{h} gene promoter region was also cloned from Tetep for comparison.
- Four promoter alleles of *Pi ta* and *Pib* were also cloned from land races.
- A total of 19 promoter alleles were cloned for BLB genes i.e. *Xa21*, *xa5* and *xa13* genes from land races collected from IRRI.
- Promoter allele sequences were analyzed with the various bioinformatics tools like PLACE, MEME, W-AlignACE and weeder web. Results revealed presence of novel elements like ERELEE4 (ethylene responsive element) and SEBFCONSSTPR10A in the resistant *Pik*^{h} promoter allele and absence in susceptible alleles. Also, many SNPs and InDels which affect the various transcription factor binding sites were identified. The resistant *Pib* and *Pita* promoter alleles also showed the presence of several novel regulatory elements.
- The nucleotide polymorphism in the promoter regions for many of blast and BLB genes can be resource for development of functional markers.
- Alleles of *Pik*^{h} and *Pi ta* were also cloned from aforementioned ten genotypes. The sequence were submitted in genbank – NCBI (Accession numbers: GU258499-GU258508, GU269201-GU269204).
- *Pik*^{h} allelic region sequence was correlated with phenotypic data of the genotypes. Superior *Pik*^{h} allele was found in a land race – Boha Thulasi Joha which showed higher resistance than Tetep. This sequence has 7 SNPs when compared to reported *Pik*^{h} gene in Tetep, which could influence the function of the expressed protein of *Pik*^{h}. Various sequence based analyses for these alleles (i.e. evolutionary distance, phylogenetic tree and Ka/Ks value) confirmed that the wild species, which contain different kind of genome, had diverged more than rice land races.

RUE - Enhancing Resource and input use efficiency

Resource conservation technologies and its economics

During *kharif* 2010 ten rice varieties (Tulsi, Rasi, Triguna, IR 64, Vardhan, Krishana Hamsa, Sampada, Akshyadhan, PR 113 and Mandya Vijaya) were tested under three tillage management systems (M1-Dry seeding without mulch under zero tillage, M2-Dry seeding with 50% mulch under zero tillage and M3-Direct seeding of sprouted seed under puddled condition). Grain yield differences among tillage management systems were non-significant (4.54 t/ha to 4.74 t/ha) while varietal differences were significant (**Table 15)**. The maximum grain yield of 4.88 t/ha was recorded by Mandya Vijaya foallowed by Rasi (4.85 t/ha) (**Table 16)**. Interaction effects between tillage management system and varieties were non-significant. However, maximum grain yield (5.15 t/ha) was recorded by Mandya Vijaya with direct seeding of sprouted seeds under puddled condition.

Table 15: Performance of rice varieties under different tillage management systems, *Kharif* 2010

Varieties	Grain Yield (t/ha)			
	M1	M2	M3	Mean
Tulsi	4.42	4.29	4.54	4.42
Rasi	4.78	4.92	4.85	4.85
Triguna	4.52	4.84	4.96	4.77
IR-64	4.19	4.76	4.74	4.56
Vardhan	4.58	4.36	4.44	4.46
Krishna Hamsa	4.92	4.44	4.91	4.76
Sampda	3.99	4.18	4.30	4.16
Akshyadhan	4.57	4.29	5.07	4.64
PR 113	4.43	4.7	4.77	4.63
Mandya Vijaya	4.65	4.84	5.15	4.88
Mean	**4.54**	**4.56**	**4.74**	
C.D (0.05) Varieties	Tillage management system 0.25Tillage x varieties		NS NS	

Grain yield differences among tillage management systems were non-significant (5.77 t/ha to 5.92 t/ha) while in *rabi* maize grain yield differed significantly among different rice varieties. The maximum maize grain yield (6.13 t/ha) was recorded in Mandya Vijaya plot followed by Krishna Hamsa (6.00 t/ha). Interaction effects between tillage management system and varieties indicated that maximum grain yield (6.34 t/ha) of maize was recorded by dry seeding with 50 % mulch under zero tillage after Vardhan (Table-2)

Table 16. Grain Yields of Maize under different tillage management systems

Rice Varieties	Maize Yield (t/ha)			
	M1	M2	M3	Mean
Tulsi	5.97	5.84	5.55	5.79
Rasi	5.34	6.31	5.85	5.83
Triguna	6.17	5.91	5.76	5.95
IR-64	5.96	5.59	6.16	5.90
Vardhan	5.61	6.34	5.21	5.72
Krishna Hamsa	6.34	5.8	5.85	6.00
Sampda	5.66	5.57	5.93	5.72
Akshyadhan	5.78	5.88	5.74	5.80
PR 113	6.12	5.68	5.81	5.87
Mandya Vijaya	6.25	6.32	5.83	6.13
Mean	**5.92**	**5.92**	**5.77**	

C.D. (5%) Tillage x varieties 0.4 Tillage management system NS Varieties 0.23

During *Kharif* season, maximum net profit of Rs. 34100/ha and B:C ratio (2.86) were recorded by dry seeding with 50% mulch under zero tillage followed by dry seedling without mulch under zero tillage (Rs. 33460/ha and 2.62) and direct seeding of sprouted seed under puddled condition (Rs. 29420/ha and 1.63). During *Rabi* season, maximum net profit and B:C ratio (Rs. 38131/ha and 2.72) were obtained with dry seeding with 50 % mulch under zero tillage of maize followed by dry seeding without mulch (Rs. 38096/ha and 2.72) and direct seeding of sprouted seed under puddled condition (Rs. 36768/ha and 2.62). Among the tillage systems, the maximum B:C ratio of 2.79 was recorded by dry seeding with 50 % mulch followed by dry seeding without mulch (2.75) and direct seeding of sprouted seed under puddled condition (2.13) while among varieties, maximum B:C ratio of 2.73 was recorded by Mandya Vijaya – maize followed by 2.69 (Rasi – Maize). However, mean maximum B:C ratio of 3.27 was recorded with sowing of Rasi followed by maize by dry seeding with 50 % mulch under zero tillage.

System of Rice Intensification for boosting input use efficiency

Three varieties (Krishna hamsa, Vasumathi and KRH-2) were tested with six fertilizer combinations during *kharif* 2010. SRI method out yielded (5.37 t/ha) conventional method (4.34 t/ha). Mean over the cultivars and method of crop establishment application of 75 % inorganic + 25 % organic gave significantly higher grain yield (5.51 t/ha). The combination of 50% organic + 50% inorganic was comparable with 100 % inorganic fertilizer. Among the varieties tested, KRH-2 hybrid performed well yielding significantly higher (5.69 t/ha) than Krishna hamsa (4.72 t/ha) and vasumathi (4.17 t/ha). Varietal performances were significantly superior over normal method in all fertilizer combinations. Higher harvest index values in SRI (47) over conventional method of transplanting (43) were noticed for recording higher grain yield.

Grain yield from the organic and inorganic plots of SRI and conventional methods were 8.11, 8.16 and

7.21 t/ha, respectively (Table 17) during *rabi* 2009-10 with an yield advantage of 12 % during rabi season over conventional TP (Best management practice - BMP)., The straw yield and total dry mater were found higher in SRI- organic compared to conventional method. The amount of water applied in SRI treatment was found lower (34 -37 %) than that of conventional method. The water saving was higher when organics alone was used in SRI method.

Table 17. Grain yield and water consumption as influenced by different methods of crop establishment, *rabi* 2009-10

Treatments	Grain yield (t ha^{-1})			Water applied		
	25x25cm	25x15cm	Mean	mm/ha	WP(kg/m^3	(%)Water saved
SRI-ORG	8.16	8.06	**8.11**	1149	0.70	37
SRI	8.16	8.16	**8.16**	1207	0.67	34
Conventional TP	7.64	6.77	**7.21**	1835	0.39	-
Mean	**7.99**	**7.66**	**7.83**			
C.D (0.05%)		Se+_				
Main	0.630	0.16	Sub	0.23	0.07	
MXS	0.40	0.12	SXM	0.40	0.18	

Total N, P and K uptake ranged from 130-160, 18.6-20.7 and 174-207 kg/ha with mean values of 143, 19.8 and 188 Kg/ha, respectively. Zinc and iron uptake ranged from 370-401 and 823-1027 g/ha with mean values of 388 and 955 g/ha, respectively (Table-4). SRI recorded maximum nutrient use efficiency (59, 410 and 47 kg grain/ kg for N, P and K uptake, respectively) compared to the other two methods, SRI organic and conventional methods which recorded 51-56, 387-394 and 40-43 kg grain/ kg N,P and K uptake, respectively (Table-4). In case of Zn and Fe, the efficiency ranged from uptake of 19.6-21.4 and 8.0 - 8.8 Kg grain/ g, respectively, with mean uptake values of 20.5 and 8.3 Kg grain/g.

No significant differences were observed in soil pH, EC, available N and P_2O_5 values due to methods of crop establishment though SRI – organic recorded higher values of available nutrients compared to other two systems (Fig-1). Organic carbon (1.39 %) and available K_2O (565 kg/ha) were significantly higher with SRI-organic followed by SRI (1.21 % and 444 kg/ha, respectively) compared to conventional method (1.14 % and 350 kg/ha, respectively). There was a reduction in all the values with increasing depth. Compared to initial soil values, there was no decrease in the soil available nutrients though the yield levels were very high in SRI and SRI organic systems thus indicating that SRI did not exhaust the available soil nutrients even after six crop seasons (Fig 21).

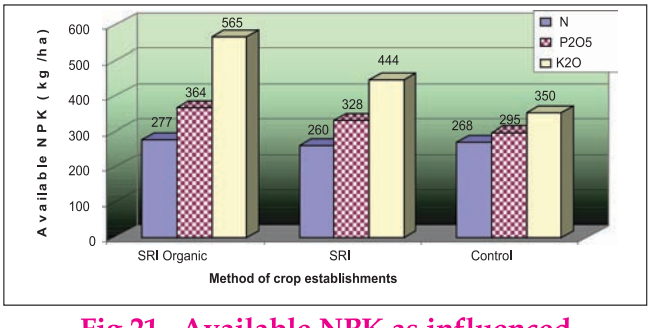


Fig 21. Available NPK as influenced by methods of crop establishment

Table 18. Total nutrients uptake and nutrient use efficiency of different methods of crop establishment

Treatments	Total nutrient uptake					Nutrient Use efficiency				
	kg/ha			g/ha		kg grain /kg nutrient uptake			(kg grain /g nutrient uptake)	
	N	P	K	Zn	Fe	NUE	PUE	KUE	ZnUE	FeUE
SRI-Organic	160	20.7	207	391	1015	51	394	40	21.4	8.1
SRI	139	20.1	182	401	1027	59	410	47	20.6	8.0
Control	130	18.6	174	370	823	56	387	43	19.6	8.8
Mean	143	19.8	188	388	955	55.5	397	44	20.5	8.3
C D	18.3	NS	NS	NS	NS	NS	NS	NS	NS	NS

Phosphorus use efficiency under abiotic stress conditions

During the year – *Kharif* 2010, thirty rice cultures were evaluated for their grain yield response, at graded levels of applied-P, from 0 - 60 kg P_2O_5 / ha, in a soil of low phosphorus availability status. Five distinct growth and grain yield patterns were observed due to application of P-fertilizers. Rice varieties IET-20716 and IET-20710 exhibited higher P-tolerance at low P-status and recorded higher grain yield of 2.69 to 3.03 t/ha at 0-P level. However, at higher P-levels of 50-60 kg P_2O_5/ha, these varieties yielded only about 5.43 – 5.83 t/ha. Whereas, rice varieties PAC-835, PAC-837, IET-20727, IET–20734, IET 21298 and DRR-H3 exhibited marginal low P tolerance at O-P (1.05 – 2.06 t/ha);, but recorded the highest grain yields, at higher P-Levels (5.81 – 7.02 t/ha).

The rice varieties IET-20341, IR-64, IET-20744 and PA-6129 while recording only marginal grain yields of 5.18 -5.88 t/ha, at higher P-levels, exhibited lower tolerance to low-P conditions (1.03–1.42 t/ha); while IET-20901, IET-20894, IET-21089, CSR – 23, IET-20752, Sabita, IET-20907, neither recorded lower P tolerance to low P- levels (1.14 to 2.36 t/ha); nor higher grain yields at higher P-levels (3.82 – 4-94 t/ha). The rice cultures CSR-36, IET 20742, Taorari Basmati at low-P levels, failed to flower and did not produce any grain yield.

The studies on grain yield response of rice varieties indicated that at lower P-levels of 10-20 kg P_2O_5/ha, PAC-835, PA-6129, CSR-3 recorded higher response of 139.25, 218.83 kg grain/kg P_2O_5, while others recorded lower values of (54.87 – 131.06 grain/kg P_2O_5. At medium P levels, in addition to PAC – 835 and PA- 6129; the rice hybrid DRR H-3, IET 20734, IET 21214 and CSR – 36 recorded higher response of 85.42-137.06 kg grain/kg P_2O_5; while at 50-60 kg P_2O_5/ha level, DRR H-3, PAC- 835 and IET-20734, IR-64 and PA-6129 exhibited the highest response of 78.71-117.01 kg grain/kg P_2O_5 , compared to other rice cultures (38.35 -87.60 kg grain/kg P_2O_5). The data on percent P content indicated that at lower P-levels PAC – 837, IET 20893, PAC 835 and IR – 64 recorded higher percent P of 0.104 to 0.139, while others recorded lower values (0 – 0.097). However, at 50-60 kg P_2O_5/ha, PAC – 835, IET 20776, DRR-H3, IET 20744 recorded higher percent –P content of 0.238 – 0.266, while others recorded lower values of 0.177 – 0.251. The results on uptake of P by rice crop at PI- stage indicated that at 0-P level, DRR-775, IET-20893, PAC – 837

and IET-20710 recorded higher P-uptake of 3.91 – 5.03 kg P/ha; while other recorded lower values of 0 - 2.97 kg P. At medium P-level, of 30-40 kg P_2O_5/ha, PAC-835, PA-6129, Sabita, DRR H-3, IET-20734 and IR-64 recorded higher P-uptake of 10.57-22.51 kg/ha ; while at 50-60 P_2O_5 / ha level, DRR H-3 recorded the highest P-uptake of 29.66-30.69 kg P, followed by PAC-835, Sabita, DRR-775, IR-64, IET-21298 , PAC-837, IET-20734, IET-20744, IET-20727 and IET-20716, which recorded 20.27-29.88 kg P/ha; while others recorded lower values (12.39-22.85 kg P).

Aerobic rice under unpuddled condition and its economics

During *Kharif* 2010, six rice varieties/hybrids (Tulsi, Rasi, Krishana Hamsa, Triguna, KRH-2 and PA 6201) were tested under aerobic unpuddled condition. KRH-2 recorded maximum grain yield of 3.80 t/ha followed by PA 6201 of 3.68 t/ha. The maximum grain yield of wheat 3.16 t/ha was recorded after KRH-2 while maximum grain yield of maize 5.83 t/ha was recorded after PA 6201 (Table 19).

Table 19. Performance of rice varieties (*Kharif*-2010) and maize/wheat during *Rabi* 2009-10 aerobic condition

Varieties	Grain Yield (t/ha)		
	Rice *(Kharif)*	Wheat *(Rabi)*	Maize *(Rabi)*
Tulsi	2.97	2.82	5.03
Rasi	3.1	2.67	5.1
Krishna Hamsa	2.93	2.5	5.13
Triguna	3.17	2.75	5.07
PA 6201	3.68	3.06	5.83
KRH-2	3.8	3.16	5.39
C.D. (0.05)	**0.04**	**0.27**	**NS**

Rice-maize system recorded maximum net profit of Rs. 49,556/ha and B:C ratio of 1.72 while rice-wheat system recorded net returns of Rs. 37,253/ha and B:C ratio of 1.33. In the experiment for developing optimum fertilizer schedule for aerobic rice, Hybrid PA 6444 recorded highest grain yield and was superior over all the test varieties. Fertilizer schedule of 150% recommended fertilizer dose (RFD) recorded highest grain yield (3.64/ha) significantly superior to other schedules of 100%, 50% RFD and control. The straw yield and yield attributes followed similar trend. The sedge population at 15 days after sowing ranged from 94/m^2 to a high 336/ m^2. The dry weed biomass varied between 15.5gm/ m^2. and 55.9gm/ m^2. Carfentrazone-ethyl 40 DF @ 35gm a.i./ ha controlled the sedge population effectively and reduced the sedge population and biomass to 1.97 - 9.53 g/ m^2.

SSP - Sustaining rice system productivity

Water productivity under integrated resource and crop management

Water productivity, averaged over varieties, ranged from 3-3 – 5.6 kg grain/ha. mm with net water requirement decreasing by 900 – 1150l/kg grain production with regulated water supply based on cumulative pan evaporation. About 36 – 44% less irrigation water was supplied under regulated irrigation water management which, resulted in mean yield loss of about 0.4 – 0.5 t/ha depending on the tillage system, indicating requirement of water at little more than 150% of CPE for minimizing yield loss during rabi season. Loss of water due to percolation was estimated to be about 3-6 mm per day in puddled soil and ranged from 12-16 mm/day up to early growth stage under aerobic system which reduced to 6-8 during maximum tillering stage to harvest. The mean water loss through deep percolation was about 350 and 700mm, respectively during rabi season under conventional flooded water regime,

which is indirectly minimized by resorting to regulated water supply.

In kharif 2010, response of recently released rice hybrid (PA 6444) and HYV (Varadhan) transplanted (25 d seedlings) to 2 conditions of land preparation (puddled and non puddled), three levels of irrigation water input based on cumulative pan evaporation (CPE) @ 75, 100, and 150% of CPE and 8 combinations of nutrient involving four levels of nitrogen (0, 60, 120, 180 kg N/ha), and three levels each of phosphorus (0, 30, 60 kg/ha) and potassium (0, 50, 100 kg/ha), was studied in terms of crop and water productivity and nutrient utilization efficiency.

Genotype responses to land preparation were apparent with variety Varadhan producing less grain yield under un-puddled situation by nearly 0.7 t/ha (13.5%) and that of straw by 2.2 t/ha (29%). Hybrid PA 6444 performed well under both soil conditions except for a loss in straw production by about 1.3 t/ha (18%) under un-puddled soil conditions.

Response to nutrient application was limited to only N in case of HYV, while hybrids recorded improvement in grain yield with N and K application under both conditions of land preparation. At the highest yield level of 5.2 t / ha, under un-puddled situation (aerobic), the crop accumulated 105, 40 and 136 kg/ha of NPK which works out to a nutrient uptake requirement of 20.3, 7.6 and 25.9 kg NPK / t of grain.

Water regimes marginally influenced crop productivity recording 0.2 – 0.4 t/ha improvement in grain yields with irrigation equivalent to 150% of CPE irrespective of varieties and land preparation and recording relatively lesser harvest index with less water input under puddled soil conditions. Productivity of water (kg grain/mm water used) ranged from 4.6 – 5.1 kg grain / mm and a requirement of 1960 – 2180 l/kg with 75% CPE irrigation as compared to 3.4 – 4.2 kg grain / mm and 2200 – 2950 l/kg grain with 150% CPE irrigation, respectively.

Based on the recorded grain yields, water requirement and its productivity, irrigation equivalent to 75% of CPE appeared to be optimum in wet season in a clay soil for the variety Varadhan and between 75 – 100% CPE irrigation water for the higher yielding hybrid (PA 6444) under both systems of land preparation with no yield loss, while saving about 13 – 21 per cent of irrigation water (Tables 20 & 21).

Table 20. Water productivity as influenced by tillage, water regimes and rice genotypes, *rabi* 2010

Parameters	Unpuddled			Puddled		
	CS	IR/CPE 125%	IR/CPE 150%	CS	IR/CPE 125%	IR/CPE 150%
Mean yield (kg/ha)*	5252	4784	4869	5493	4698	5028
Water supply (mm)**	1530	850	930	1680	1000	1080
Water productivity	3.43	5.63	5.24	3.27	4.70	4.66
Water requirement	2913	1777	1910	3058	2128	2148
Percolation loss (mm/ 70 days)	690	-	-	350	-	-
Water saved (%)	-	44.4	39.2	-	40.4	35.7

* Mean of 16 genotypes ** includes 200 and 50 mm water applied for land preparation

Table 21. Influence of tillage and water regimes on productivity of water, *kharif* 2010

	Water management	GY (kg/ha)	IW (mm)	WP (kg grain/ha.mm)	WR (l/kg grain)
Puddled					
PA 6444	IW/CPE-150%	5036	1225	4.111	2433
	IW/CPE-100%	4886	1070 (12.7)	4.566	2190(10.0)
	IW/CPE-75%	4699	965(21.2)	4.869	2054(15.6)
Varadhan	IW/CPE-150%	5164	1225	4.215	2372
	IW/CPE-100%	4979	1070 (12.7)	4.653	2149(9.4)
	IW/CPE-75%	4933	965(21.2)	5.112	1956(17.5)
Aerobic system					
PA6444	IW/CPE-150%	4824	1225	3.938	2540
	IW/CPE-100%	4834	1070 (12.7)	4.518	2213(12.9)
	IW/CPE-75%	4691	965(21.2)	4.861	2057(19.0)
Varadhan	IW/CPE-150%	4141	1225	3.380	2959
	IW/CPE-100%	4455	1070 (12.7)	4.164	2402(18.8)
	IW/CPE-75%	4445	965(21.2)	4.606	2171(26.6)

Figures in parentheses – per cent water saved

Organic farming for grain quality and soil health

During the wet season, grain yields with inorganics and integrated nutrient management (INM) were nearly stable (4.7- 5.5 t/ha) and superior to the organic treatment by 15-20% during the first two years, which improved (4.8-5.2 t/ha) in the later years comparable to that of inorganics. However, in the dry season, inorganics and INM were superior to organics for four consecutive years and were on par only in the fifth year (Table 22). No definite trend in pest incidence was noticed with regard to nutrient sources, while parasitism was relatively more under unprotected conditions. Relative abundance of plant parasitic nematodes was highest in plots maintained with 100% inorganics and lowest in plots with 100% organics. Moderate improvement in nutritional quality was recorded with organics especially in brown rice (by 5-16%) over inorganics. Polishing of rice reduced the quality improvement to 1-6%. Partial nutrient balance in case of N and P was more positive with organics (565 and 307 kg/ha for N and P, respectively) compared to inorganics (283 and 277 kg/ha for N and P, respectively) over 10 crop seasons. In case of K, balance was positive only with organics (280 kg/ha) and negative with inorganics (-428 kg/ha). Organic system significantly improved the soil quality indices (Nutrient, Crop and Microbial indices) and overall sustainability index of the soil was maximum with organics (1.63) compared to inorganics (1.33) after four years of study. Benefit: cost ratio was less with organics (1.09:1) compared to inorganics (1.37:1) in the first year which improved by fifth year to 1.99:1 in organics as compared to 1.75:1 in with inorganics.

Table 22. Grain yield (t/ha) as influenced by nutrient sources

Year	*Kharif (WS)*		*Rabi (DS)*		*Kharif (WS)*			*Rabi (DS)*		
	NPP	PP	NPP	PP	Inorg.	Org.	INM	Inorg.	Org.	INM
2004-05	4.50	4.8	3.38	3.43	5.47a	4.68b	5.00ab	3.79a	3.52b	4.28a
2005-06	4.31b	4.91a	3.08	3.26	5.35a	4.59b	5.15a	3.74a	3.10b	3.62a
2006-07	4.28b	4.84a	3.00	3.60	5.20a	4.85a	5.03a	3.81a	3.14b	3.77a
2008-09	4.49	5.01	3.27	3.17	5.33a	5.23a	5.12a	3.76a	3.27b	3.86a
2009-10	4.70	4.73	3.57	3.63	5.23a	5.36a	5.08a	4.18a	3.98a	4.13a

Figures within the same row with different letters in a particular season differ significantly (p=0.05)

Genotypic variability for nitrogen use efficiency

Preliminary results indicated significant response to N application with 42% higher grain yield at N 100 (5.36 t/ha) compared to N 0 (3.78 t/ha). Among the genotypes, in the early group, Rasi out yielded (4.59 t/ha) other varieties and Prasanna recorded the least both at N0 (2.9 t/ha) and N 100 (3.73 t/ha). In the medium duration group, Varadhan recorded maximum yield (6.01 t/ha) and MTU 1010 recorded the lowest yield (4.43 t/ha). This group recorded higher yields than early and late duration varieties. In the long duration group, Swarna recorded comparatively higher yield (4.58 t/ha) and the average yield of the group was on par with that of early duration varieties. The interaction effects were non-significant. In the medium duration group, Varadhan, Sampada and PA 6444 were promising at N0 and N 100 compared to other varieties as well as those of early and late maturing group. Overall, Rasi, Varadhan, Jaya and PA 6444 recorded higher nitrogen use efficiency.

Temperature changes on nitrogen dynamics

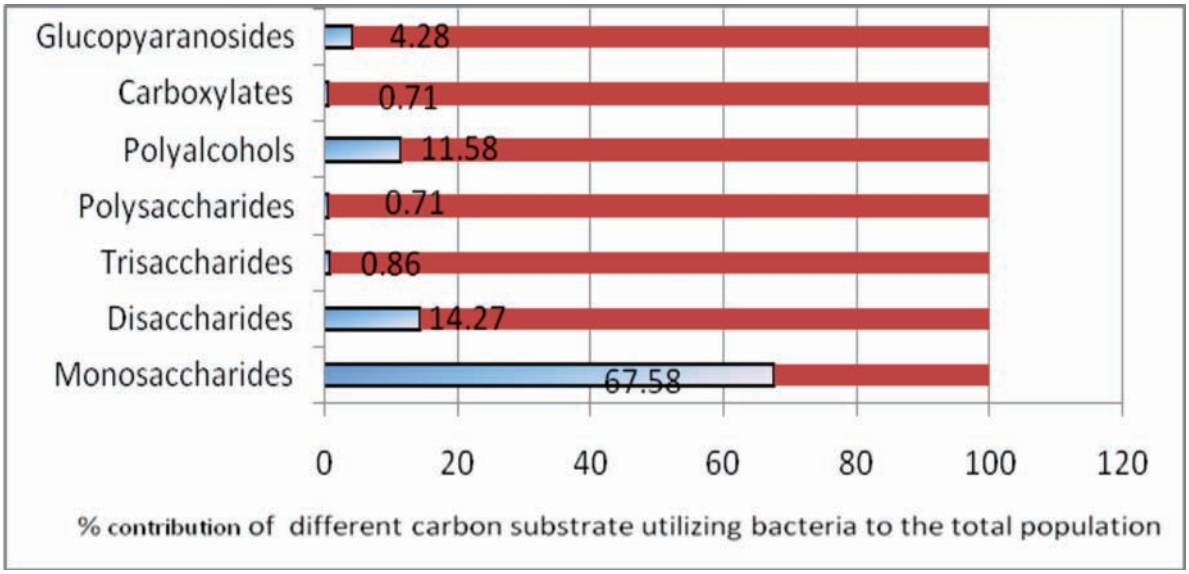
Field experiments were conducted in *kharif* and *rabi* with three rice cultivars (DRRH2, Varadhan and MTU 1075) for evaluating N sources (not clear) on the performance of rice crop. Though the cultivars did not differ significantly, MTU1075 recorded 8.5 and 10 per cent higher grain yield than Varadhan and DRRH2, respectively, attributable to more number of panicles/m^2. Of the three different N fertilizers tested, Ammonium sulphate application resulted in gave the maximum grain yield of 6.5 t/ha which was 12 and 28 per cent higher that of urea (5.8 t/ha) and DAP (5.1 t/ha), respectively. The data on nitrogen uptake indicated highest uptake values with the application of ammonium sulphate and with cultivar MTU1075. The nitrogen use efficiency (NUE) was highest in case of ammonium sulphate (54 kg grain/kg N applied), followed by urea (49 kg grain/kg N applied) and DAP (42 kg grain/kg N applied). Based on the data on grain yield, N uptake and NUE, ammonium sulphate is observed to be the best source of nitrogen in comparison to urea and DAP (not clear and no relation to title).

Assessment of soil quality

To study the effect of mineral enriched manures on productivity of hybrid KRH-2 and a high yielding variety Krishna Hamsa, six treatment combinations comprising of 5t/ha dose of composts viz vermi manure and poultry manure enriched with a 10 per cent of recommended nitrogenous and phosphate fertilizer dose, control and recommended dose of fertilizer were tested. A significant increase in grain and straw yield was noticed in all the treatments over control. The enriched manures produced yields lower than that of recommended dose of fertilizers with KRH-2. But with HYV Krishna hamsa, the yields were at par.

Rhizosphere microbial community composition and root exudation patterns

The carbon substrate utilization profiles of the microbial community revealed that among the 32 substrates tested, only 22 substrates were utilized by the soil microflora. The substrates utilized 6 monosaccharides, 5 disaccharides, 1 trisaccharide, polysaccharide and carboxylate each along with 6 polyalcohol and 2 glucopyranosides each accounting for 67.58, 14.27, 0.86, 0.71, 11.58, 0.71 and 4.28 percentage of the total microbial population.The Shannon index for this soil was 0.814. The richness of the microbial community was 22. Evenness in the soil was recorded as 0.606.



CCR – Assessing and managing crop response to climate change

Heat tolerance under ambient and elevated carbon dioxide

Wide variation in grain number / panicle was seen among genotypes. Akshaydhan had higher 1000 grain weight than rest of the genotypes under late sown condition. Seven of the genotypes studied (except Triguna and Phalguna) recorded harvest index (%) above 50 which is of significant value for revising the irrigation scheduling under late sown situations.

Based on incorporation of 3 years weather data for normal and late sown situation for 4 locations DRR, Maruteru, Pantnagar and Titabar in the Oryza 2000 model, it was observed that there were differences crop growth parameters at Maruteru and Titabar. Model simulated grain yield and dry matter weight were more in Maruteru compared to other 3 locations.

In *Kharif* 2010, 20 genotypes were studied for their response to terminal heat stress tolerance under an artificial tunnel system. Spikelet fertility and their corresponding grain filling in panicles of some of the genotypes (Fig 22) and the physiological responses such as membrane stability index, chlorophylls, water relations and photosynthesis indicated that, IET 20734, IET 20893, IET 20907 and IET 20905 were less affected by high temperature stress. Also, 260 crosses of N22 x IR64 were analyzed for SPAD, fluorescence studies and some of the best crosses identified for developing population. Relative heat tolerance nature of SM 219 based on physiological characters was identified (Tables 2 3 & 24).

Table 23: Rice genotypes under normal and late sown conditions during rabi 2009-2010

	Character	Nomal	Late	Sowing (s)	Genotypes (G)	S x G
1	Shoot wt.m^{-2} (g)	581	562	-	119**	-
2	TDM m^{-2} (g)	1277	1278	-	163**	-
3	Panicle no m^{-2}	454	402	48.7**	104**	146**
4	Panicle wt m^{-2} (g)	696	717	-	98.7**	-
5	Spikelet x 10^3 m^{-2}	55	53	-	13**	18**
6	Spikelets.pan	86	144	54.2**	27.8**	39.4**
7	Grain no x 10^3 m^{-2}	37	36	-	7.6**	8.1**
8	Chaff no x 10^3 m^{-2}	18	16	-	9.4**	9.9**
9	Grain no.pan	129	98	68.5*	39.8**	56.3**
10	Grain wt (g) m^{-2}	606	650	-	113**	-
11	Chaff wt (g) m^{-2}	51.7	47.4	_	28**	-
12	1000 grain wt (g)	17.06	18.37	1.19*	1.52**	2.14**
13	HI (%)	47.56	50.66	1.41*	3.83**	-

Table 24: relative heat tolerance nature of physiological traits in IR 64, SM 219 and N22

Character	IR 64	SM219	N22
Photosynthesis ($mmol.m^{-2}.sec^{-1}$	12.54A	11.87 A	9.75B
Transpiration (µg s^{-1} cm^{-2})	5.03AB	5.29A	4.00B
Leaf width (mm)	1.33A	1.77B	1.37A
Leaf thickness (µ)	0.62A	0.71B	0.62A
SPAD	36.17A	36A	33.27A
FV/FM	0.783A	0.785A	0.750B
Yield (g/plant)	6.1A	5.2B	6.1A

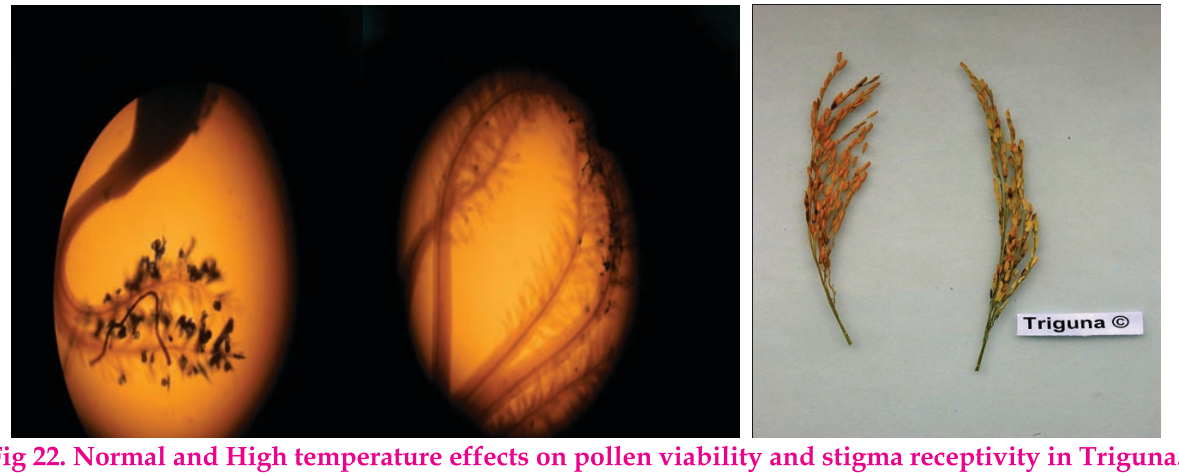
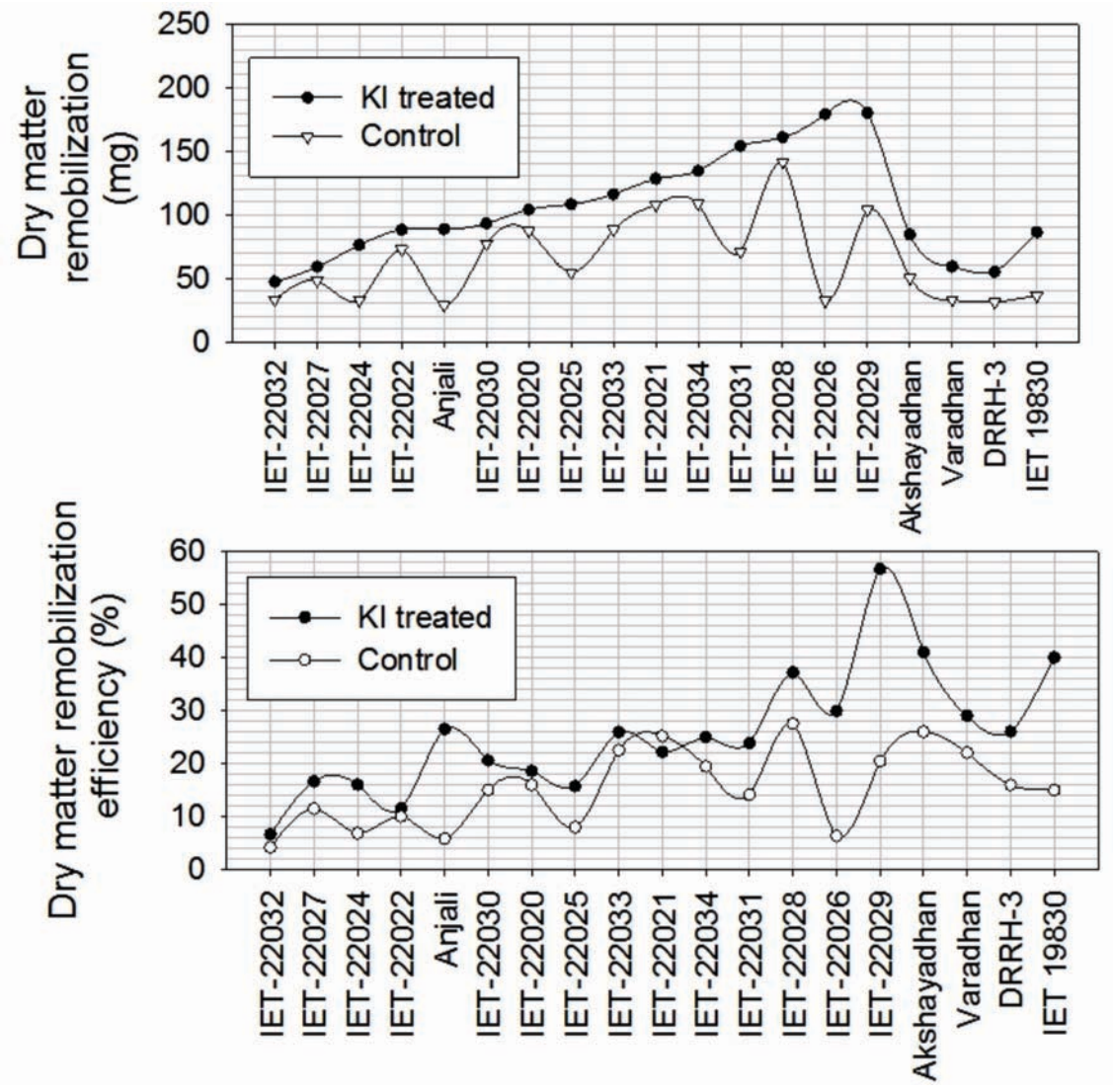
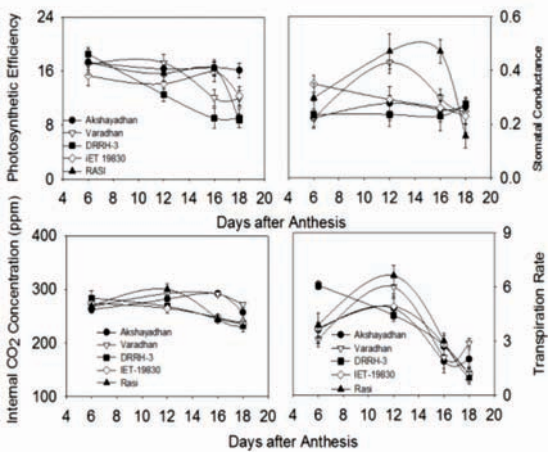


Fig 22. Normal and High temperature effects on pollen viability and stigma receptivity in Triguna. Corresponding panicles with grains under normal and heat stressed conditio

Post-anthesis water stress on stem carbohydrate reserve mobilization : During the *kharif* 2010 Potassium iodide was applied (@0.3%, to induce leaf senescence and mimic water stress, one week after anthesis. No significant differences were recorded amongst the IET cultures in grain filling duration which varied from 28 to 31 days in control plants and from 21 days to 31 days in KI treated plants. In IET-22032 and Anjali. application of KI resulted in 10 and 6 days reduction in grain filling period, respectively. Significant reduction in grain yield (g/m^2) was noticed due to KI treatment due to impaired photosynthesis resulting in non-availability of current photosynthates for seed filling. Highest reduction in grain yield was noticed in IET-22024 (52% reduction) , while IET-22022, IET-22032 and IET-22027 and IET-22028 also recorded significant reduction (>30%) in seed yield over control) indicating poor stem reserve remobilization capacity in these genotypes. IET-22029, IET-22031, IET-22030 and IET-22034, IET-19830 and Akshayadhan showed <15% reduction indicating better carbon remobilization in these genotypes. The dry matter remobilization efficiency was also higher in these genotypes



In a pot-culture experiment, water stress treatments were imposed by withdrawing irrigation after anthesis period. A gradual reduction in rate of photosynthesis, stomatal conductance, transpiration rate and internal CO_2 concentration were observed in all the rice varieties. Significant varietal differences were noticed in the extent of changes in these characteristics. The rate of photosynthesis was lower in lower leaves than flag leaf. A drastic reduction in PS rate was noticed in all varieties after 4 days of water stress imposition. (Table 25)



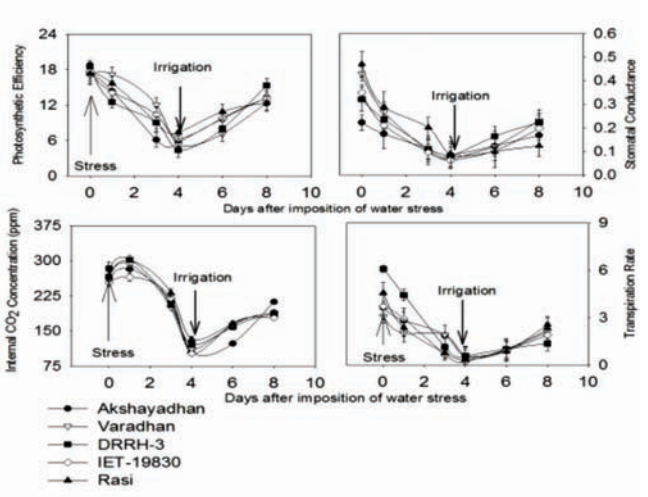


Table 25. Influence of water stress on some important chlorophyll fluorescence parameters measured 4 days after imposing water stress in different rice varieties.

Variety	Fv/Fm		Fv'/Fm'		f_{PSII}		qP		qN		ETR	
VARADHAN	Control	Stresed	Control	Stressed	Control	Stressed	Control	Stressed	Control	Stressed	Control	stressed
First Leaf	0.81	0.79	0.51	0.36	0.11	0.10	0.39	0.35	0.50	0.56	48.25	31.20
Second Leaf	0.78	0.81	0.50	0.32	0.04	0.02	0.05	0.06	0.62	0.66	16.00	11.21
Third Leaf	0.77	0.76	0.45	0.31	0.02	0.01	0.05	0.04	0.66	0.71	10.41	9.33
DRRH-3												
First Leaf	0.78	0.8	0.53	0.41	0.02	0.01	0.07	0.06	0.54	0.59	15.75	10.21
Second Leaf	0.77	0.75	0.58	0.38	0.01	0.01	0.02	0.03	0.42	0.45	11.01	5.66
Third Leaf	0.73	0.74	0.48	0.33	0.02	0.01	0.05	0.05	0.59	0.62	4.77	2.33
IET-19830												
First Leaf	0.81	0.76	0.65	0.51	0.18	0.12	0.15	0.14	0.27	0.28	88.33	77.00
Second Leaf	0.81	0.79	0.41	0.32	0.14	0.11	0.44	0.38	0.84	0.88	78.39	45.63
Third Leaf	0.80	0.74	0.35	0.30	0.13	0.06	0.37	0.36	0.85	0.91	57.10	14.30
RASI												
First Leaf	0.77	0.81	0.44	0.31	0.10	0.10	0.48	0.47	0.55	0.57	42.61	26.63
Second Leaf	0.75	0.8	0.42	0.33	0.02	0.01	0.05	0.06	0.67	0.71	9.56	5.63
Third Leaf	0.71	0.72	0.36	0.29	0.01	0.01	0.04	0.05	0.71	0.73	4.33	6.32
AKSHAYADHAN												
First Leaf	0.80	0.77	0.64	0.42	0.03	0.01	0.04	0.05	0.14	0.21	45.00	16.31
Second Leaf	0.80	0.76	0.59	0.34	0.04	0.01	0.07	0.06	0.42	0.49	17.83	10.23
Third Leaf	0.77	0.74	0.44	0.26	0.06	0.01	0.13	0.12	0.80	0.89	24.84	6.52

Development of AICRIP Database Management System

During the year, AICRIP MIS package was hosted successfully on local server and tested with sample and real data sets. Four user privileges viz., Project Director and Administrator, PIs of AICRIP, Center In-charges and Co-operators were tested for each form. Trial Indent form was tested for 4 user privileges and modified to fit with DRR requirement. New trial can be entered using add new trial / trial indent forms. Seed dispatch, confirmation, crop condition, trial information, RBD and Split, Screening pests and diseases, weather etc. were also tested for four user privileges. Reports were designed for all common forms from trial indent to data analysis.

Artificial neural networks (ANN) based forecasting model

Using artificial neural networks (ANN) based forecasting methodology, information on quantitative parameters of few rice varieties from physiology trials were classified using grain weight (yield). Similarly, in ANN for clustering, Clustering of varieties were carried out. 150 varieties were clustered into different clusters by running different ANN models by making use of MLP, RBF and SOFM methodologies. Artificial Neural Network (ANN) modelling methodology was also utilized for modelling rice production time-series data and further forecasting. Modelling and forecasting all-India rice production was carried out by utilising data on all-India rice area, production and yield for the period 1950-51 to 2008-09 along with all-India rainfall data for the months of June and July for the corresponding period. Based on the model, forecasting rice production was carried out and rice production for 2009-10 was estimated as 82.19 million tons in the beginning of the season.

HRI - Host plant resistance against insect pests and its management

Planthoppers **-** A total of 2400 entries from different screening nurseries like National screening nurseries, MRST, planthopper screening nurseries (PHS) and introgression lines and other breeding lines from basmati crosses, wild rices were evaluated against BPH through mass screening in the greenhouse. Nineteen entries including IET 21616, 21617, 22064, 22158, 22129, 21725, 22203, 22163, RIL 8-188, CR 2711-76, NWGR-4105, CR 2711-139 and CR 2711-149 and 6 introgression lines of Swarna X *Oryza nivara viz.*, 212(S), 215(S), 221(S), 224(S), 228(S) and 230(S) were found promising with damage score of less than 3.0.

Against WBPH, 1972 entries were evaluated and 40 entries including IET 20694, 20780, 20990, 21108, 20698, 20775, 19470, 20328, 20871, 20873, 20835, 21151, 20906, 21071, 20991, 20994, 21109, 21110, 20124, 21094, 20370, 21232, 21235, 21214, 21194 and CE 260 showed damage score of less than 3.0.

Among the seven hundred and thirty germplasm accessions evaluated against both planthoppers, ten accessions ACC No. 4656, 4368, 4647, 4567, 3164, 3681, 4339, 3767B, 4067 and 5345 were found promising against BPH and 5 accessions viz., 2658, 4288, 3328, 3338 and 3627 were promising against WBPH.

Stem borer **-** Two hundred and fifty lines of IR64/IR75870-5-8-5-B-1-B (derived from *O.glaberimma*) in BC_2F_4 were evaluated as three row material after artificial infestation to study the mechanism of tolerance to stem borer damage in wild rices/ germplasm and their derivatives. Based on damage at both vegetative and reproductive stages, four lines exhibited low dead heart and white ear damage (<10% DH and <5 % WE), while 21 lines showed low DH (<10%DH) and 5.1 to 10.0% WE.

Gall midge **-** Green house evaluation of 1416 breeding lines and germplasm accessions nominated in various National Screening Trials of AICRIP and other sources revealed that 35, 30 and 45 entries were found to be resistant against gall midge biotypes 1, 4 and 4M, respectively. Three germplasm accessions viz., IC 114788, INRC 17459, INRC 17494 displayed resistance to all three biotypes. Three cultures, RP 4929-BK, RP 4930-BA, and RP 4930-derived from gene pyramiding programme were also found resistant to all three biotypes.

Molecular basis of gall induction in rice **-** Genome wide transcriptional profiling using SSH library construction for TN1-GMB4 biotype and microarray analysis for Kavya - GMB4M interaction revealed a large number of differentially expressed genes (546 ESTs in SSH library and >1000 transcripts in microarray) in both approaches. Gall induction in both genotypes involved up-regulation of genes related to primary metabolism, nutrient relocation, cell organization and DNA synthesis in plants. Concomitantly, defense related secondary metabolism and signaling genes were suppressed but classical stress response genes were triggered during the interactions. Based on these studies 20 genes were selected and validated through Real Time PCR in three sets of compatible interactions involving TN1-GMB4M, Kavya-GMB4M and Suraksha-GMB4M. Kavya showed elevated defense response during the early hours of insect attack which was lacking in the other two genotypes. However, the gene expression pattern was similar in all the three genotypes at 120 h after infestation (Fig 23).

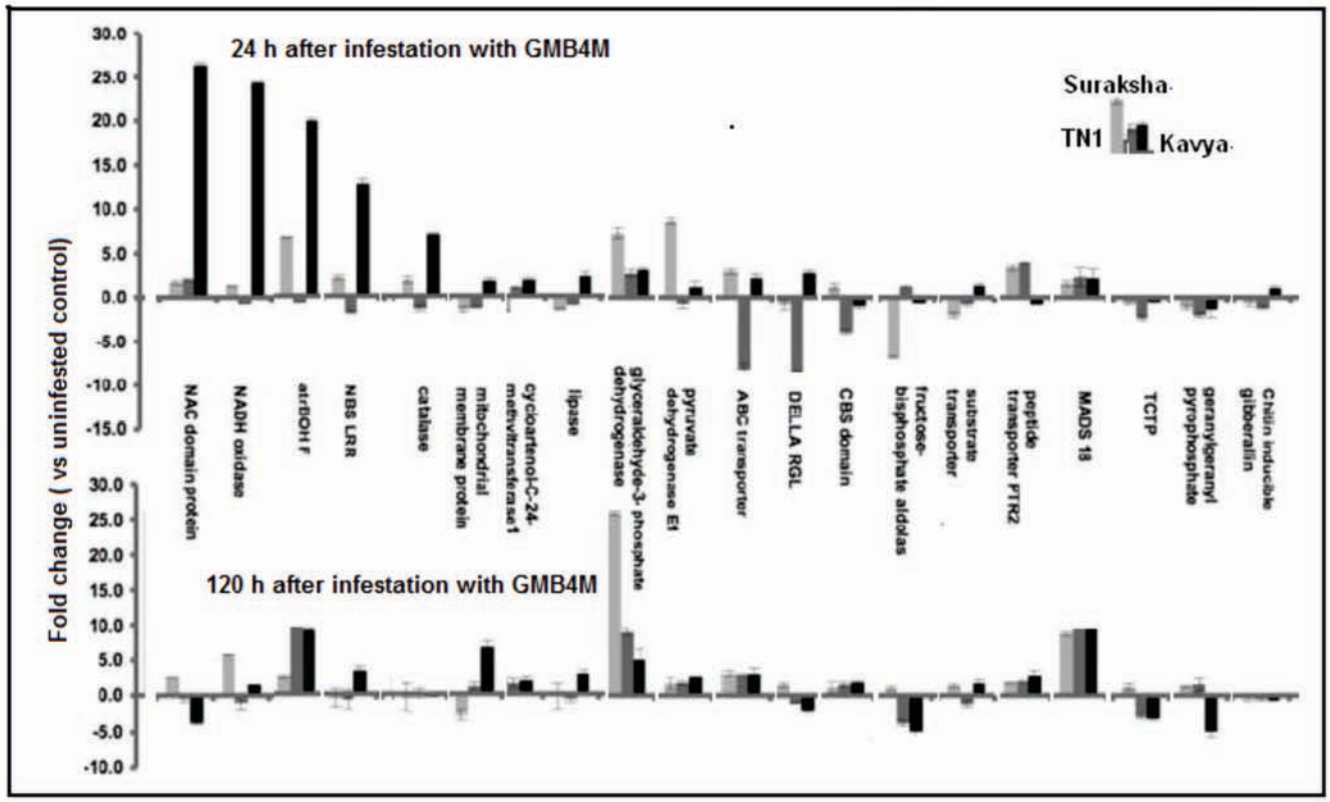


Fig 23. Real time PCR validation of 20 genes specifically modulated in rice varieties TN1, Suraksha and Kavya after 24 and 120 hours of infestation with gall midge biotype GMB4M.

HRP - Host plant Resistance against pathogens and its management

Various accessions of germplasm, differentials, introgressed lines received from various sources along with the relevant standard resistant and susceptible check varieties were evaluated under artificial inoculation against blast, sheath blight, bacterial blight and tungro. The details of the promising accessions against different diseases are given in Table 26.

Table 26. Promising entries identified against various diseases during *Kharif* 2010

S.No	Disease	Trial	Total tested	Promising accessions/lines
1	Leaf blast	Isogenic Lines, RILs, Differentials	24	9
		Parents of Hybrid rice	29	4
		IRBN	210	5
		TRP Lines	340	1
		Introgressed lines from wild rice	515	87
		Local trials	2215	150

S.No	Disease	Trial	Total tested	Promising accessions/lines
		NBPGR	317	Acc. Nos.4981, 2485, 3030, 4599, 4805, 247, 4063A, 242, 264, 2634, 3873A, 4042A, 4059A, 4082, 4648, 4725, 245, 2298, 2145, 4020, 4113, 4899 and 256.
2	Sheath blight	NBPGR	317	Acc Nos. 232, 2595 3689, 231, 239, 2247, 2287, 4368, 4405, 4535 and 5883.
3	Brown spot	NBPGR	317	Acc. No.4498 and 4522, 2247, 4020
4	RTV	NBPGR	317	Acc. No.2595
		Germplasm	131	Bokachakua, Lapyngngad, Borbora, Kunkunijoha, Vsr113, Arc6157, LPR106, Mikusiamang, HPR957, Konjoha 2, Bokulbora, Bogabordhan, H3816, Jatoo, China988, VL1990, Amanabao, Bogatulasijoha, Begonbisi, VHC803, Thapachini, ARC5988, Mangalapuram, Nadu chitrakar, Velum bala, Ptb 1, Waksal, Kothanadam, Mo 1 and PARIJAT
		IRTN	83	IR 62, IR 70, Moddai Karuppan (ACC 15471), Palasithari 601 (ACC 12069), Pankhari 203 (ACC5999), PTB 8 (ACC 6291), Balimau Putih (ACC17204), Barah (ACC 14527), Seratus Hari T36 (ACC 5346), Tjempo Kijik (ACC16602), Utri Merah (ACC16680), Utri Merah (ACC16682), Utri Rajapan (ACC 16684), IR 78187-6-2-3-3-3, Milagrosa (ACC5159), ARC 11554 (ACC 21473)
5	BLB	NBPGR	48	Acc. Nos. 4981, 2485, 4725, 4020 Acc. Nos. 316311, 346884, 352833 and 334179
		DRR (promising entries from NSN -1, NSN - 2 in 2009)	41	IET nos. 21066, 21069, 21070, 21299, 21516, 21099, 21675, 21676, 21677,

Glasshouse screening of breeding material consisting of two hundred and thirty entries from the cross between KMR3 and *Oryza rufipogon*, 142 entries (S lines) from cross between Swarna and *O. nivara* and another 85 entries (K lines) from Swarna and *O. nivara* for resistance to bacterial blight was carried out. one entry was highly resistant (score 3) and 3 others were moderately resistant (score 5). Among entries of cross between Swarna and *O. nivara*, 5 in S lines and 13 in K lines were found highly promising. In another experiment, of the 340 entries (F6 generation) including checks from a cross between CSR 27\BPT 5204\\RP Bio 226 evaluated along with checks, 313 entries were found to be highly resistant (with score 1-3). Only 14 lines and checks like Jalashri, Aghoni Bora, Salum Pirit, VPLR1-7, CR-143-2-2 and Kakro were found to be moderate to highly susceptible.

Seventy one *Oryza rufipogan* accessions were screened against rice tungro virus disease during kharif 2010 by insect transmission tests in the glass house. 32 accessions produced typical tungro symptoms after 12-15 days and 39 accessions did not show the viral symptoms till 15 days after inoculation. After the continuous observation of plants for viral symptoms, 18 accessions did not show any symptoms even after 30 days after inoculation. For further confirmation, these non symptomatic plants were studied for the presence of *Rice tungro bacilliform virus* (RTBV) particles with the help of molecular diagnosis. Only 12 accessions (106123, 106265, 106087, 104760, 105909, 106123, 106123, 106477, 106285, IRGC 30615, IRGC 106136 and one O. *longistaminata* accession) showed absence of viral particles in primary screening. Rest of the accessions showed the presence of RTBV, though they did not reflect typical tungro disease symptoms.

Mapping, identification and functional analysis of Rice Tungro Virus (RTV) resistance genes

The studies involved generation of F_1s for TN1 and Utri Rajapan. From the earlier studies, the major locus for rice tungro disease resistance was identified in the 17 Mb -19 Mb region of chromosome 7. Targeting ~ 2 Mb regions, 27 primers were designed based on putative candidate genes and microsatellite repeats. Among the several genes identified in 17 Mb -19 Mb region of chromosome 7, two putative candidate genes belonging to 'Disease resistance protein family' were targeted for primer design. For the first candidate gene, one primer detected polymorphism between the parents out of four primers and for the second gene, three primers were found to be polymorphic out of five primers designed. Out of 18 new primers designed based on microsatellite repeats, only two primers was polymorphic between the parents, TN1 and Utri Rajapan.

With the previously developed BC_1F_2 mapping population of TN1/Utri Rajapan//TN1, 295 BC1F2 individuals were evaluated for their reaction to rice tungro disease at glass house conditions. Based the typical disease symptoms of susceptible check TN1 (score 9); the reaction of each individual plant to tungro disease was scored (Fig 24).

Forty eight BC_1F_2 individual plants of TN1/Utri Rajapan//TN1 each showing resistant (score 3) and susceptible (score 7) reactions to tungro disease were assayed individually with 15 polymorphic markers. The recombination frequency calculated suggested SC211, SC234, SC232 and RM21583 to be closely associated with RTV resistance.

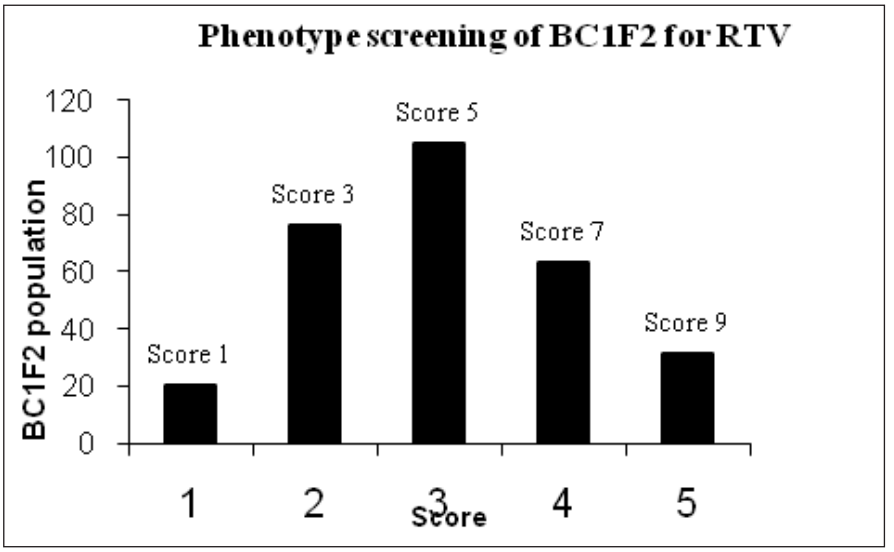


Fig 24. Disease resistance scores of 295 BC_1F_2individuals of TN1/Utri Rajapan//TN1

Pathogenic Variability in bacterial blight- Fifty four new isolates of bacterial blight (BB) pathogen from different geographical regions including 11 from Kaul (Haryana), 17 from Ludhiana (Punjab), 1 Pattambi (Kerala), 5 from Uttarakhand, 2 from Titabar (Assam), 1 from Nawagam (Gujarat), 12 from Nandyal (Andhra Pradesh) and 4 from Hyderabad were characterized for their reaction on a set of differentials (IRBB lines) under controlled conditions in the glass house. Most of the single genes were ineffective to various *Xoo* isolates. Many isolates from Ludhiana, Kaul and Uttarakhand were found virulent on BB resistance genes *xa13* and *Xa21*. Some of the isolates from Kaul, Ludhiana and Uttarakhand were found to be virulent on *xa13*+*Xa21* combination also. When clustered, at 30% dissimilarity level, it formed a major cluster and 8 small cluster (Fig 25). In the major cluster, the isolates from same place or nearby place, grouped together. Some of the isolates from Ludhiana, Hyderabad and Nawagam were different and formed separate cluster.

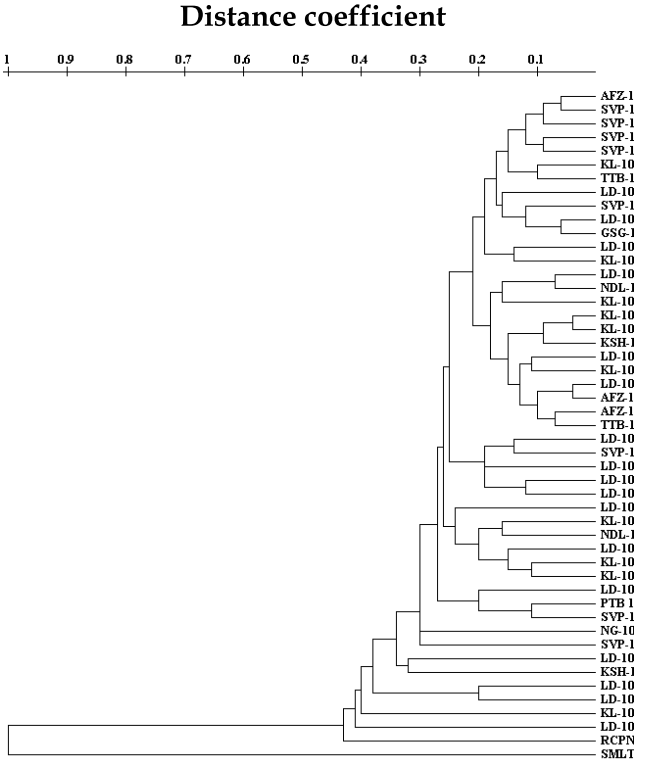


Fig 25. Dendrogram showing the relatedness of the BB pathogen isolates based on their reaction on a set of differentials.

IPM - Integrated Pest Management

Chemical control studies - Field evaluation of newer insecticides on rice variety TN1, included ten treatments replicated thrice in a randomized block design (RBD). The treatments consisted of new insecticide pre-mixture, Buprofezin 20% Acephate 50% WP (RIL-049/F1) at three doses, 800, 900 and 1000 g (T1, T2 and T3) compared with buprofezin-T4 (Applaud 25 SC) @ 200 g a.i./ha, acephate 75% SP @ 500 g a.i./ha (T5) and a new formulation of acephate, Acephate 95% SG-T6 (RIL-059/F1 95% SG) @ 562 g a.i/ha, dinotefuran 20 WG @ 40 g a.i./ha (T7), pymetrozine 50 WG @ 300 g a.i./ha (T8), the standard check insecticide monocrotophos-T9 (Monocrown 36 WSC) @ 500 g a.i./ha and untreated control (T10) without any insecticide application. Stem borer incidence ranged from 5.6 to 12.6% DH during 45 to 65 DAT. Monocrotophos application (Fig 26) was the best treatment (5.6 DH%) followed by acephate 75 SP (6.5% DH) and buprofezin + acephate @ 1000 g /ha (7.3% DH). Whorl maggot incidence and leaf folder infestation were very low and did not exceed 6.0%.

Effect of 'Ek boond' (wetting and penetrating adjuant) on the efficacy of insecticides - A glass house study on the effect of 'Ek Boond" (wetting and penetrating adjuvant) on the efficacy of buprofezin against planthoppers on TN1 variety of rice revealed that buprofezin applied @ 200 g a.i./ha along with 150 and 200 ml of the product showed significantly higher mortality of BPH as well as WBPH upto twenty one days after spraying compared to buprofezin applied alone (Fig 27). Similar results were obtained with respect to the efficacy of tricyclazole against blast disease.

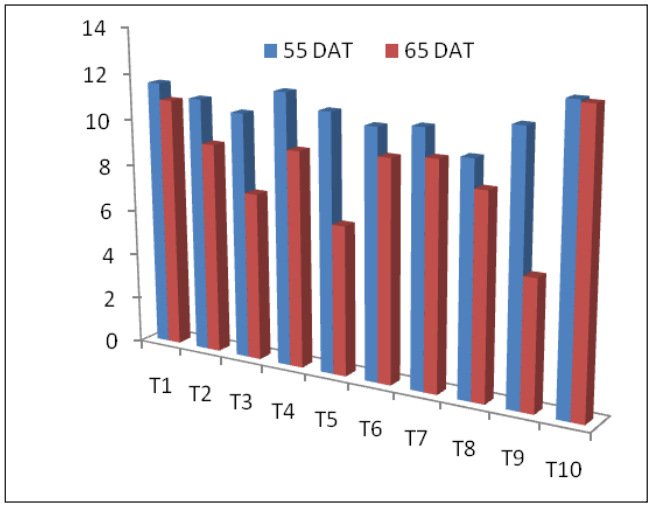


Fig 26. Efficacy of newer insecticides against stem borer in rice

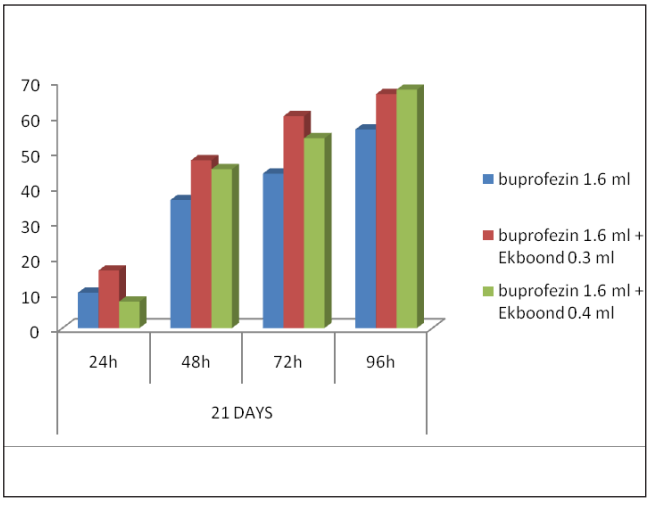


Fig 27. Effect of 'Ek boond' on the efficacy of buprofezin against BPH

Dynamics of leaf folder-host plant-insecticide interactions – Field studies were carried out on TN 1 variety in RBD design with 10 treatments replicated thrice during both *kharif and rabi* seasons. The leaf folder larval population at 65 DAT (Fig 28) was maximum in Thiamethoxam @ 25 g ai/ ha (60 larvae/ sq.m) followed by Phorate (58.67) and Imidacloprid @ 10 g ai/ ha (55) compared to cartap (16.67) and untreated control (41.00). Thiamethoxam treatment also showed maximum number of natural enemies. Experiments to delineate factors for resurgence of leaf folder showed that the neo-nicotinoids at all tested doses resulted in ~50% hatching of eggs whereas survival of 1st instars was more than 60%. Data on developmental toxicity revealed reduced larval duration in neo-nicotinoid treatments. (Fig 29). Maximum numbers of adults settled on Thiamethoxam treated plant followed by Imidacloprid treated plant compared to other treatments indicating that the sprays of these insecticides did not affect the settling behaviour of adults.

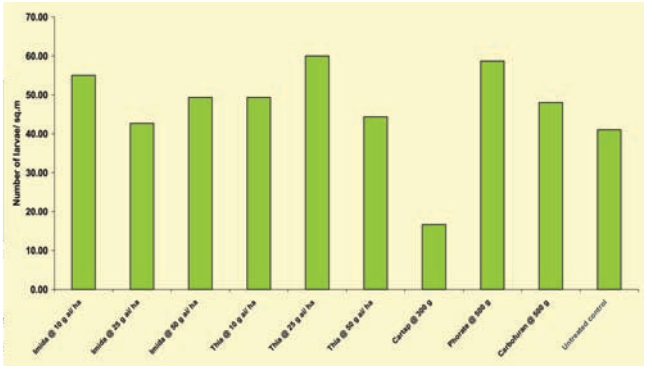


Fig 28. Leaf folder larval population during *Kharif* 2010

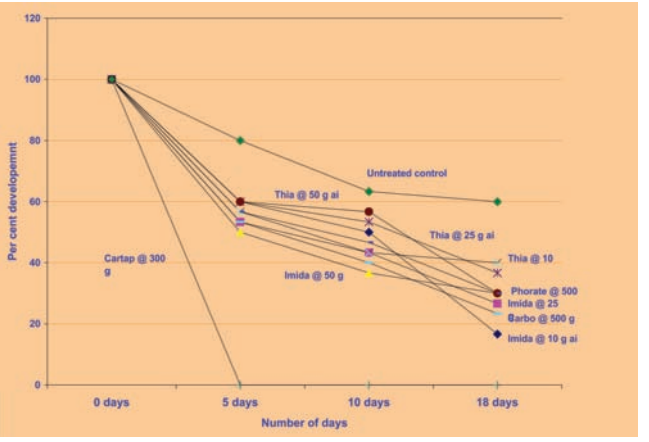


Fig 29 Effect of neo-nicotinoids on rice leaf folder development

Evaluation of newer fungicides against blast disease - The test fungicide ICF-110 was found significantly effective at all the three tested doses (180+40, 225+50 and 270+60 g a.i. /ha) in checking the leaf blast severity, neck blast incidence and increasing the grain yield over the untreated control. ICF -110 at 225+50 g a.i./ha checked the leaf blast disease severity to the extent of 51.8% and neck blast incidence to 82.8% and was found on par with its higher dose (270+60 g a.i./ha) and tricyclazole 75 WP (225 g a.i./ha), and superior to iprobenphos 48 EC (Kitazin) in checking both phases of blast and increasing the grain yield.

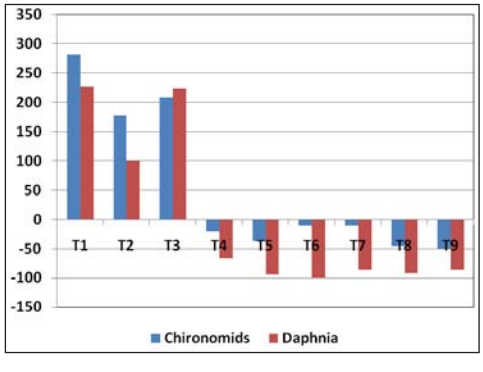
Efficacy of vitamins and combinations against bacterial leaf blight - In another field experiment carried out in collaboration with CCMB, Hyderabad, the efficacy of three vitamins (Thiamine hydrochloride, Pyridoxine hydrochloride and Nicotinic acid) and their combination was tested against bacterial leaf blight on rice variety TN1. Among the vitamins tested, combination of three vitamins (at 10 mM each) was the best followed by Nicotinic acid (50 mM). There was little toxicity especially in case of pyridoxine hydrochloride. However, the reduction in disease severity was not reflected in yield.

Table 27. Efficacy of vitamins and combinations against bacterial leaf blight

Treatments	Mean lesion length after different days of Inoculation (DAI)		Grain yield (kg/ha)	
	14 DAI	28 DAI	Vitamins+BB	Vitamins only
TH-50 mM	3.63b	4.41bc	2076.67ab	1736.67a
PH-50 mM	3.83b	4.7bc	1193.33c	1756.67a
NA-50 mM	3.67b	3.87c	1590bc	1846.67a
Mix of TH, PH & NA 10 mM	3.49b	4.8bc	1690abc	1543.33a
Mix of TH, PH & NA 3 mM	4.3b	5.74b	2130a	1966.67a
Control	7.33a	12.03a	1740ab	1740a
Uninoculated Control	-	-	1913.33ab	1913.33a
CV (%)	19.53	16.87	17.03	18.96
LSD (5%)	1.5539	1.8187	533.9	602.39

TH-Thiamine hydrochloride; PH-Pyridoxine hydrochloride; NA-Nicotinic Acid

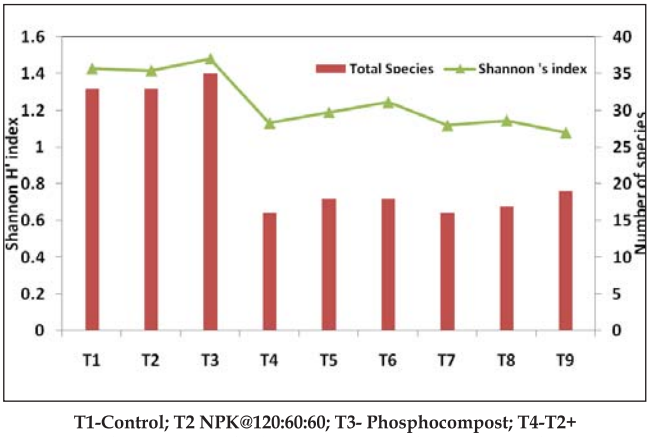
Biodiversity and Biological control - Field studies on biodiversity and impact of crop management practices were continued with specific target of studying weedicide and fertilizer application effects on biodiversity, during Kharif and Rabi 2010 – 2011. Data analysis revealed that the impact of weedicide application was more on Daphnia which are the lowest trophic strata followed by Chironomids. The population of Daphnia showed a reduction of 50 to 100 per cent in weedicide treated plots (Fig 30).



NPK@120:60:60; T3- Phosphocompost; T4-T2+Butachlor; T5-T2+Anilophos; T6-T3+Butachlor;T7-T3+Anilophos; T8-Butachlor; T9-Anilophos

Fig 30. Effect of fertilization and weedicide treatments on the aquatic fauna

Diversity of arthropods analyzed by the Shannon's diversity index showed a maximum of 35 arthropods in phosphocompost treated plots and a range of 16 – 19 arthropod species in weedicide treated plots (Fig 31). The Shannons index was highest for phosphocompost treated plots (1.48) and least for anilophos treated plots (1.08).



T1-Control; T2 NPK@120:60:60; T3- Phosphocompost; T4-T2+ Butachlor; T5-T2+Anilophos; T6-T3+Butachlor; T7-T3+Anilophos; T8-Butachlor; T9-Anilophos

Fig 31. Species richness and biodiversity in weedicide treatments 7 DAT

Studies on Bt isolates - Two hundred and eighty two soil / plant / diseased insect samples from rice ecosystems were collected for isolation of *Bacillus thuringiensis* (*Bt*) from A.P., Kerala, Karnataka, Kerala and Tamil Nadu. Twenty seven bacterial colonies recovered from samples were identified as *Bacillus thuringiensis* (*Bt*) based on colony morphology and microscopic studies. Out of these, 26 were found to produce bipyramidal crystals where as one isolate produced spherical type crystal. The *Bt* index calculated for the samples recovered from soil, plant and insect samples were 0.044, 0.136 and 0.190 respectively. In the bioassay studies , at 25 ppm toxin concentration, 17 *Bt* isolates recovered from rice ecosystems exhibited mortality of leaf folder larvae in the range of 18.8 to 100% at 48 h period (Table 28). Efforts were made to develop a more efficient artificial diet for rearing of pink stem borer, *Sesamia inferens* for laboratory, glass house and field experiments. When the larvae were fed on improved diet (Fig 32) there was significant enhancement in larval and pupal developmental period, percent pupation and pupal weight compared to the standard diet (Table 29)

Table 28. Toxicity of *Bt* isolates against neonate leaf folder larvae

S.No.	*Bt* isolate No.	*Bt* index	Crystal shape	Spore count / gm (x 10^{14})	Toxin content (%)	% mortality of leaf folder (25 ppm)
1.	R Bt16	0.33	Bipyramidal	4.0	1.6	18.8
2.	R Bt26	0.36	Bipyramidal	7.0	1.7	18.8
3.	R Bt18	0.33	Spherical	4.0	1.7	12.5
4.	R Bt39	0.33	Bipyramidal	0.5	1.9	12.5
5.	R Bt1	0.50	Bipyramidal	6.5	1.6	27.7
6.	R Bt11	0.36	Bipyramidal	19.5	1.9	37.5
7.	R Bt5	0.40	Bipyramidal	12	2.1	38.9
8.	R Bt4	0.21	Bipyramidal	5.0	2.1	50.0
9.	R Bt9	0.31	Bipyramidal	1.5	1.6	55.0
10.	R Bt2	0.25	Spherical	2.5	2.0	61.1
11.	R Bt6	0.27	Bipyramidal	11	2.0	65.4
12.	R Bt12	0.20	Bipyramidal	2.0	1.7	68.8
13.	R Bt32	0.43	Bipyramida1	1.5	1.8	68.8
14.	R Bt33	0.30	Bipyramidal	2.0	1.6	75.0
15.	R Bt3	0.25	Bipyramidal	9.0	1.3	83.3
16.	R Bt21	0.25	Bipyramidal	1.0	1.7	87.5
17.	R Bt46	0.50	Bipyramidal	5.5	2.1	100

Table 29. The growth and development of Pink stem borer on improved artificial diet

Diet	Larval weight (17thday)	Larval period	Pupal weight	Pupation (%)
Standard diet	101.9^{c}	27.8^{a}	179.2^{b}	86.6^{b}
Improved diet "G"	182.6^{a}	21.4^{c}	195.2^{a}	95.8^{a}
Baby corn cobs	189.3^{a}	20.3^{c}	198.6^{a}	97.6^{a}
Sorghum stalk	160.7^{b}	24.5^{b}	183.7^{b}	95.2^{a}
LSD (0.05)	15.2	3.1	6.4	7.6

Fig 32. Pink stem borer larvae feeding on improved semi synthetic diet

Decision Support Systems for insect pests major rice based cropping systems - Field growth rates for rice brown plant hoppers (BPH) and white backed planthopper (WBPH) were generated at three cropping system locations (Maruteru and Hyderabad- A.P., Mohanpur- W.B.). Feeding and survival of BPH was assessed on 7 weed species through honey dew test. However, BPH did not complete its lifecycle on any hosts indicating that immigration of adults into the area could be a key parameter for BPH model building. Population dynamics of plant hoppers *vis-à-vis* their 4 natural enemies were studied and the mortality rates quantified. Temperature thresholds were developed for different stages of both planthopper species.

Developmental duration of life stages and generation time was determined at five constant temperatures for the first time for leaf folder. Off season studies identified 12 alternate hosts for this pest. Damage potential of individual larva was also quantified.

Life table parameters like adult longevity, survival, egg laying frequency and total fecundity was determined for yellow stem borer (YSB). These parameters were used to develop a process based simulation model for rice YSB using location specific cropping system variables along with corresponding weather data.

Pathogenicity and variability studies on false smut (Ustilaginoidea virens) of rice – Pathogenicity of isolates collected from Ludhiana, Kapurthala, Kaul, Karnal, Meerut, Nagina and Pantnagar was confirmed through DNA extraction using CTAB method from actively growing mycelium for detection and confirmation of the pathogen with *Ustilaginoidea virens* specific ITS primers. Fifty inter simple sequence repeat (ISSR) markers were screened and ten markers (807, 808, 809, 810, 811, 812, 834, 835, 836, 840, 841 and 842) were selected as potential makers to study the variability of the isolates (Fig 33).

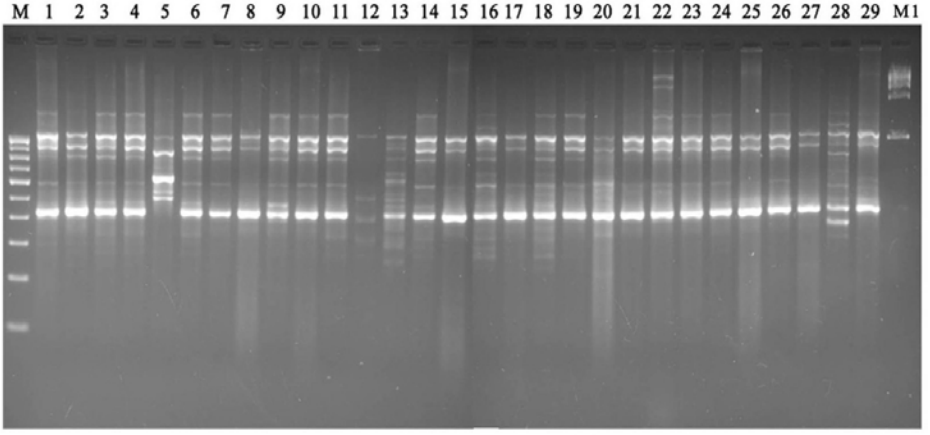


Fig 33. Variability study using ISSR marker 810.
Lane M- 100bp ladder; M1 –1 Kb ladder; Lane 1 to 29 – False smut isolates.

Investigations on phytonematodes

Diagnosis of field problems of phytonematodes- Analyses of rice panicles collected from ten different locations in the country revealed the presence of white-tip nematode (*Aphelenchoides besseyi*) in the panicles collected from Wangbal, Barapani, and Nawagam areas with maximum nematode load (> 50 nematodes / 5 seeds) in panicles of cv. Gurjari from Nawagam (Fig 34a). Plants raised from infested seed in greenhouse exhibited typical white-tip symptoms (Fig 34b). Hot water treatment with boiled water eliminated the nematodes in the infested seed.

Fig 34. White-tip nematode infected (a) panicles and (b) leaves

Biological control of phytonematodes: Observations on infectivity of *Pasteuria penetrans* (isolate PMI 1) spores to root-knot nematode, *Meloidogyne graminicola* showed that bacterial spores readily attached (22.46 spores/J2) to the cuticle second stage juveniles (J2) (Fig 35) and the bacterium multiplied well inside the nematode when spore encumbered J2 were inoculated on rice plants resulting in the formation of spore filled females. Observations on viability of spores in two formulations *viz* spore laden dry-root powder and dry-sand formulation stored in refrigerator revealed that *P. penetrans* spores remain viable even after twenty years of storage under refrigerated conditions.

Fig. 35 Attachment of *Pasteuria penetrans* spores (a) to the cuticle of second stage juveniles of *M. graminicola* and (b) swarming of spore encumbered juveniles.

Biological studies on root-knot nematode: Cross infectivity and oviposition behaviour of two species of root-knot nematodes *M. graminicola* and *Meloidogyne incognita* in dicot (tomato) and monocot (rice) hosts revealed reduced gall number as well as size on rice compared to that on tomato. The egg masses were protruded out from the root epidermis in both the host plants in case of *M. incognita*. In case of *M. graminicola*, the egg masses were observed inside the root tissue in rice where as in tomato, some egg masses were observed protruding out from the root surface.

Molecular studies on phytonematodes: Molecular characterization of populations of root-knot nematodes collected from rice (*M. graminicola*) and tomato (*M. incognita*) and white-tip nematode (*A. besseyi*) collected from rice was done to verify their identity. DNA sequences ITS regions of ribosomal genes (18s, 5.8s & 26s) of these nematode populations showed 98-100% homology with the DNA sequences of accessions of respective species in the gene bank confirming their species identity.

Investigations on quarantine nematodes- Investigations carried out in association with NBPGR Regional Station, Hyderabad, on quarantine nematodes revealed that out of a total of 10449 samples of rice seeds imported this year 1565 showed the presence of the white-tip nematode *A. besseyi.* These entries could be salvaged and released after hot water treatment.

Influence of elevated CO_2 on phytonematodes- No significant difference was observed in nematode penetration between plants maintained at ambient and elevated CO_2 (700 ppm) Open Top Chambers (OTC). Marginal increase in seedling weight and height was observed in plants maintained under elevated CO_2 compared to those under ambient CO_2condition.

Influence of SRI on soil nematodes: Analysis of nematodes from soil samples from experimental plots revealed that the total nematode population and population of plant parasitic nematodes was more under SRI as compared to irrigated system. Population of plant parasitic nematodes was less in Organic-SRI plots as compared to those applied with chemical fertilizers.

Evaluation of entomopathogenic nematodes (EPN) against rice pests

Field studies on efficacy of EPN against yellow stem borer: Field experiments revealed that four entomopathogenic nematode (EPN) isolates (*Steinernema asiaticum, S. glaseri, Heterorhabditis indica* and *Oscheius sp*) when applied @ 1 x 10^5 infective juveniles/m^2 at booting stage (Fig 36) resulted in significantly low incidence of white ears (12.97 to 14.81 %) in treated plots compared to the untreated control plots (22.26%).

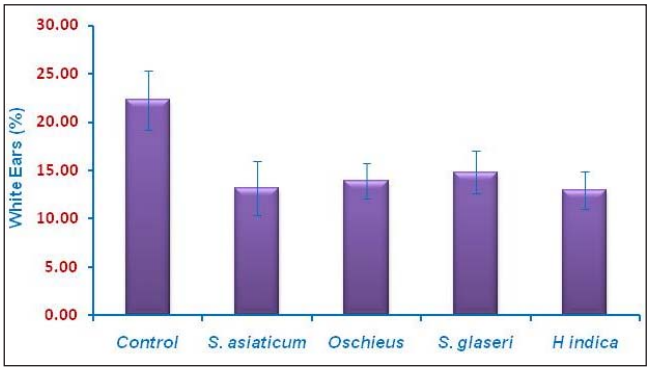


Fig 36. Effect of entomopathogenic nematodes on white ear damage caused by yellow stem borer

Greenhouse studies on EPN efficacy against leaf and planthoppers: Five EPN isolates (*S. asiaticum, S. thermophilum, S. glaseri, Oscheius sp. and H. indica*) when applied @ 1 x 10^5 infective juveniles/m^2 caused significantly high mortality of green leafhopper (26.33 to 49.33%) compared to the untreated control (4.00 %) four days after application. In another experiment, EPN isolates (*S. thermophilum, S. glaseri* and *H. indica*) caused significantly high mortality of brown planthopper compared to the untreated control. *S. glaseri caused* maximum mortality (65.33%) followed by *S. thermophilum* (61.33%).

Mass production of EPN: Influence of initial inoculums on infective juvenile yield in *in vivo* production system using larvae of *Galleria mellonella* was assessed. The observations on nematode multiplication revealed that progeny production per insect larvae increased with increase in inoculums dosage from 25 to 100 IJs/insect larvae for both the EPN (*S. thermophilum* and *H. indica)* species tested. The suitability of NGM (Nematode Growth Medium) was tested for culturing of entomopathogenic nematode *Oscheius* sp (DRR EPN1) in the laboratory. The medium supported the growth and multiplication of nematodes and progeny production observed within four days of inoculation. The phenomenon of *endotokia matricida* (hatching of juveniles inside the mother's body) was frequently observed on NGM plates (Fig 37) .

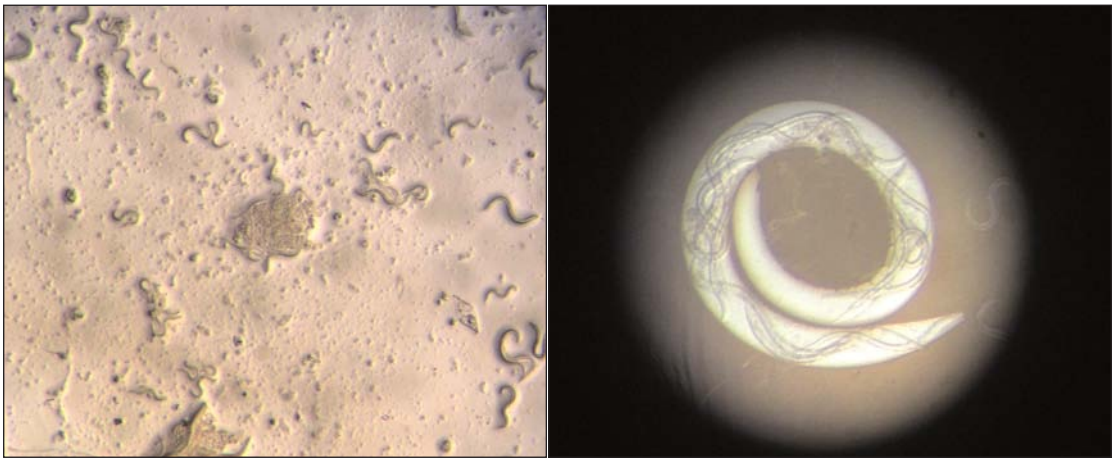


Fig 37. Reproduction of *Oschieus* sp on NGM agar plates

Molecular characterization of EPN isolates: Molecular characterization of EPN isolates based on DNA sequences of ITS regions of ribosomal genes was carried out. DNA sequences of isolates Sg1 and Hi2 showed complete homology with the gene bank accessions of *Steinernema glaseri* and *Heterorhabditis indica* species respectively, confirming their identity. The DNA sequence of isolate DRR EPN1 showed close similarity with accessions of *Oscheius* species.

TTI - Training, transfer of technology impact analysis

A study on awareness, perception and constraints in adoption of Integrated Pest Management in Rice Farming

Information was collected from hundred farmers through questionnaire and personal interview from Khammam, Mahbubnagar, Kadapa, Anantpur, Nizamabad and Kurnool districts of Andhra Pradesh. The major pest problems in these districts are stem borer, BPH, leaf folder, and among diseases blast and weed - *Echinocloa* Spp.

Seventy percent of the farmers opined that insect pest and disease problems increased in the last five years as compared to earlier years. Eighty percent of the farmers reported of adopting one or two components of IPM, while seventy percent of the farmers were not aware of the resistant varieties. Only 10-15 % farmers reported of using need based pesticides for pest and disease management. Forty percent farmers were aware about the natural enemies for major insect pests of rice but only 20-30% farmers could identify three of them namely dragon fly, damselfly and spiders. Most of the farmers were not aware of the toxic effects of pesticides while spraying. The respondents mostly had lower knowledge level on various IPM practices which resulted in lower level of adoption among the respondents. Hence, the farmers needed education and training on various aspects of IPM

Sustainable Rice production Practices: problems and prospects

A sustainability study was carried out in the traditional rice growing area of Nandyal taluk of Kurnool district Andhra Pradesh . Three mandals namely Nandyal, Sirvella and Bandi Atmakur were selected From these mandals five villages 1.Pandurangapuram (Nandyal mandal), 2. Govindalpalle 3. Kothapadu, 4.Verrareddypalle (Siruvella mandal) and 5. Bandi Atmakur (Bandi Atmakur mandal) and 150 farmers (30 farmers from each village) were chosen for the study. Personal interview schedules were used to elicit the information from the farmers. Additional information was gathered through discussion with experienced farmers, input dealers, extension officials of the line department, rice scientists affiliated with the agricultural research station, Krishi Vigyan Kendras (KVKs) and the Non

Governmental Organisations (NGOs) related to rice cultivation in that area..

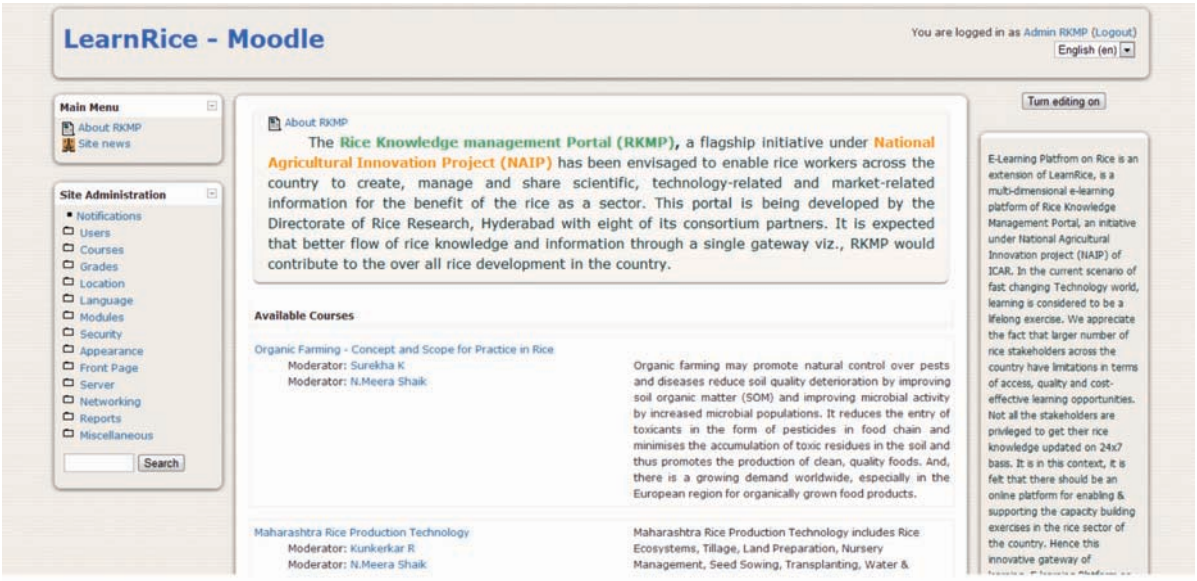
Based on the information collected (Table 30), the major factors responsible for low sustainability in the rice farming in this region were found to be - continuous use of single variety of BPT 5204 (100%), imbalanced use of inorganic fertilizer (72%), no scientific water management practice (70%), inadequate attention to problem soils (66%), inadequate use of green manures (64%), excessive application of chemical pesticides (61%), non-use of soil amendments (59%), dependency of hired labour (59%), tenant farming (55%) and lack of information and self reliance (49%).

Table 30. Adoption level of the dimensions of Sustainable Rice Farming

Dimensions of sustainable Rice Farming	Level of Adoption (in percentage; n=150)		
	Low	Medium	High
Ecological Dimensions			
Nutrient management	78.67	14.67	6.67
Water management	88.00	12.00	0.00
Integrated pest management	94.00	6.00	0.00
Economic Dimensions			
Land productivity	22.67	34.67	42.67
Input productivity	29.33	47.33	23.33
Crop yield Security	73.33	15.33	11.33
Social Dimensions			
Information self reliancy	82.67	11.33	6.00
Input self -sufficiency	74.67	8.00	17.33
Family food self -sufficiency	14.00	12.00	74.00

Applications of E-Learning in Agriculture: Designing an ODL Content Management System for Rice Technologies

Identification of the training and information needs along with critical analysis of e-learning opportunities and e-readiness for all the states were completed. Further, a comparison was made on Information needs, e-readiness and other factors of Andhra Pradesh, Tamil Nadu and Karnataka. A methodology was developed for assessing the learnability and usability of the Learning Content Management System (LCMS).



LearnRice – Moodle is a multi-dimensional e-learning platform developed in Modular Object-Oriented Dynamic Learning Environment (Moodle) Platform. A total of 12 e-learning courses were developed in English using this platform and moderators were allotted to their respective courses. Now this will be piloted during 2011-12. The URL of this platform is www.moodle.learnrice.in

An Exploratory Study on Partnerships: Impact and Implications for the Rice Sector

To achieve the objective of documenting and exploring the existing partnership formation cycles in rice sector, various International and National rice research projects were considered for the case study preparation. The information was gathered from the secondary sources. Tentative mapping of various partners/actors of rice technology value chain was carried out using the past projects in the rice sector. The whole chain was divided into technology development, technology dissemination, and technology adoption/utilisation.

Partnership formation cycle was operationalised in terms of partnership goal and purpose. Out of 28 projects considered for the study, eleven projects had the partnership goal to access new scientific knowledge from the private sector/public sector, two projects had it to reduce research costs by partnering with the private sector (public sector) and a majority of fifteen projects aimed to translate research outputs into accessible products for the poor.

Based on the functional categories of Spielman, Hartwich, And Grebmer (2008), the projects were classified. Maximum number of projects(12) were commercialisation partnerships, nine projects were of contracting partnerships, four were of resourcing partnerships, two were for frontier research partnerships and one project was for rice sector and value chain partnerships. Rice resourcing partnerships were employed mostly for accessing new scientific knowledge from the private sector and commercialisation partnerships were undertaken to translate research outputs into accessible products for the poor.

Various partnerships in rice technology dissemination based on the project mechanism like MoUs, Research Consortia, Project based collaboration with NGOs, contract farming are being documented. Also, partnerships of DRR like AICRIP, Bilateral collaborations, Research networks, Research consortia and Consultancy research are being documented.

Impact of Technology Interventions by DRR

1.DRR introduced Bacterial Leaf Blight resistant variety, 'Improved Sambha Mahsuri' (RP Bio 226)- A success story

A large area under the district of Nandyal, Andhra Pradesh is under the cultivation of Paddy since the last four decades. BPT 5204 variety is the single most popular variety being cultivated by the farmers of this region mainly because of its superior cooking quality. However, one major drawback of this variety is its susceptibility to pests and diseases. Since the last few years and this year the drawback got aggravated because of imbalanced use of fertilizers and indiscriminate application of chemical pesticides which have accentuated the pest and disease problems drastically affecting the yields in farmers fields. During the *kharif* 2010 season, the whole region witnessed the outbreak of dreaded Bacterial leaf blight disease and its impact was felt by more than 90% of the farmers. Conducive weather conditions also favoured the rapid spread of disease across this district.

Two years back, DRR, Hyderabad developed an improved version of BPT 5204 variety (Samba Mahsuri) with the help of marker assisted molecular technique imparting resistance in this variety to bacterial leaf blight in order to tackle this problem in an eco-friendly way without the intervention of chemical pesticides. This variety named as 'Improved Samba Mahsuri' performed well in the multilocation testing programme under AICRIP as well as in other experimental trials leading to its release for commercial cultivation in areas where the normal BPT 5204 is popular. So, during *kharif* 2010, this variety was distributed on a smaller scale in the Nandyal region to alleviate the plight of the farmers suffering from the ravages of BLB disease. The extension efforts paid off on a significant scale because in the entire BLB affected area of this region, the fields of farmers planted with this DRR variety were entirely free from the disease amidst fields with cent percent infestation. All the farmers of this district were a witness to the success of this DRR variety in warding off this challenging disease even under extreme infestation conditions.

Two significant developments have resulted from this successful DRR intervention. Several farmers expressed their willingness to adopt this variety in the coming season to produce seeds required for large scale cultivation of the variety in the kharif season of 2011. Also, Sri Biotech company with which DRR, Hyderabad has license agreement for multiplication of improved Sambha Mahsuri, has taken up the seed production on a massive scale to cater to the enhanced needs of the farmers for this variety.

2. Technology interventions through public-private partnership initiatives – Win-Win situation

DRR, Hyderabad participated in a Technology intervention programme implemented by BASIX Krishi Samruddhi Limited, with financial assistance from NABARD under farmers Technology Transfer Fund Programme (FTTF) at the Kakanur village, Mahbubnagar dist. The intervention was implemented through Veerabhadra Farmers' Club.

Three different technologies were introduced in the farmers' field viz.,Farmers Participatory Varietal Selection (12 varieties), Seed production and buy back (10 varieties) and System of Rice Intensification(SRI) during Kharif 2010.

A field day cum workshop was conducted on 15th of November for summarizing and exposing the benefits of the program to the farmers of the entire district. For this purpose two farmer representatives each from 64 existing farmers clubs were invited for the program. Apart from them AGM (DD), NABARD, Project Director DRR and other Scientists, Assistant Director of Agriculture, Shadnagar, Mandal Agriculture Officer, Kesampet and representatives from NGOs graced the event. Three fields were selected for the field exposure in which SRI, Seed plot and varietal selection plot were demonstrated. Later during workshop after the addresses from In-charge Director DRR, AGM (DD), NABARD and ADA, Shadnagar, a question - answer session was conducted where various field level problems were answered by Scientists.

Prior to this intervention the average Paddy yields in this village while cultivating the traditional paddy varieties like BPT, IR 64, Tella Hamsa etc., were 18-22 quintals/acre (22 bags). This intervention resulted in recording an average yield of 27 quintals/acre (35 bags) i.e. an average increase of 5-9 quintals/acre. SRI method has recorded on an average 20-30% more yields i.e., an increase of 6-8 quintals/acre than the normal. The intervention made the farmers aware of the latest improved varieties, management practices, merits of shifting from traditional paddy varieties to improved varieties and production of quality seeds. Also, the farmers have established a sustainable linkage with DRR, ensuring availability of reliable foundation seeds and technology for the future too.

3. Farmers Day at Mahbubnagar - Taking technology to doorstep of farmers

Farmers Day was organized at Kothakota Mandal in Mahboobnagar District, A.P for the benefit of Scheduled Caste and Scheduled Tribe farmers under DBT funded project on "Improving the livelihoods of SC/ST farmers through Rice Technological Interventions" on 30th November 2010. More than 200 farmers from 12 villages participated in the demonstration of cultivation of improved rice variety, Krishnahamsa in farmers' field. The farmers also shared their successful experience about cultivation of another DRR variety, Improved Samba Mahsuri resistant to BLB

and possessing quality equivalent to that of the locally popular, Samba Mahsuri (BPT 5204).

The project is being implemented by the DRR, Hyderabad and Youth for Action-*Krishi Vigyan Kendra*, Madanapuram, Mahaboob Nagar District. and will benefit 12 villages and *Tandas* (hamlets of ST farmers) of *Wanaparthy* and *Kothakota* Mandals of Mahabuboob Nagar district of Andhra Pradesh.

Under technological interventions during the 2010 *Kharif* season one of the useful technological intervention i.e. establishment of Vermicompost in selected tandas and villages were undertaken. This intervention was initially implemented in two tandas and one village. It was proposed to establish two bed type and one pit type unit. Vermi compost was demonstrated in the field of Chandraiah at Tomalapally of Pebbair Mandal, C.J.Babu and Geemya Naik at Rajapet Tanda of Wanaparthy Mandal.

During both *Kharif & Rabi* 2010-2011, under DBT DRR Project various aspects of technology interventions like Seed Production, IPM and INM practices, Varietals demonstration, Biological and Bio-technological methods and Hybrid Seed Production covering 59 beneficiary farmers were demonstrated in 63 acres of land to improvise Rice Based cropping system and thereby the livelihoods and house hold income of the SC/ST Farmers.

4. Commercialization of DRR varieties/hybrids – laboratory to industry approach

One of the major mandates of DRR, Hyderabad is to ensure timely supply and adequate quantities of its own developed high quality improved varieties to the rice farmers for their agricultural prosperity. The major requirement towards this objective is to develop suitable Public private partnership models and

linkages for mutual benefit and future sustainability. In this regard, during 2010-11 DRR embarked upon commercialization, production and marketing of DRR varieties / hybrids seed on payment basis through signing Memoranda of Agreements with five private companies for Improved Samba Mahsuri, DRRH-2 and DRRH-3 varieties. The agreement is valid for 5 years initially and renewable on mutually agreed terms and conditions. An amount of Rs. 18 lakhs was received as an upfront payment from the MoAs signed by DRR with the following companies:

1. Sri Biotech Laboratories India Ltd (Improved Samba Mahsuri)
2. Bioseed Research India Pvt. Ltd (DRRH-2 hybrid)
3. Ankur Seeds Pvt. Ltd(DRRH-3 hybrid)
4. Ganga Kaveri Seeds Pvt. Ltd (DRRH-3 hybrid)
5. Indian Foundation Seeds and Services Association (IFSSA). (DRRH-3 hybrid)

These partnership have already started giving positive results in terms of the high quality seeds produced by the company. It is excepted that these efforts will be helpful to promoted the public sector bred hybrids in a big way.

Institutional Activities

Technology Assessed and Transferred
Awards and Recognition
Linkages and Collaboration
Hindi Activities
Workshops Seminars, Summer Institutes
Publications
List of approved on going projects 2010-11
Participation of Scientists in National / International / Symposia / Conferences etc.,
Participation of Scientists in Training / Meetings
Deputations / Visitors
Personnel
Acknowledgment

Institutional Activities

TECHNOLOGY ASSESSED AND TRANSFERRED

Training Programmes Organized

During the year 2010-2011, 247 persons were trained through ten training programs on various aspects of Rice Production Technologies viz., System of Rice Intensification, Hybrid Rice production Technology, Integrated Rice Crop Management and one on Rice Production Technology for delegates from Afghanistan. Among these, two training programmes were sponsored by Directorate of Extension, Government of India.

Table : Training programs organized during 2010-11

S. No	Name of the Training Program	Dates & Duration	Sponsored by	Number of Participants
		Model Training Programs		
1	System of Rice Intensification	4-11th Aug. 2011 (8 Days)	DOE, GOI	25
2	Hybrid Rice production Technology	26th Oct-2nd Nov.2011(8 Days)	DOE, GOI	13
3	Integrated Rice Crop Management	8-12th Nov. 2011 (5 Days)	DRR, Hyderabad	12
4	Rice Production Technology Training for delegates from Afghanistan	9-10 March 2011 (2 Days)	FAO, New Delhi	12
			Total	62

Short Training courses				
5	Rice production Technology for Pani Panchayat office bearers, Orissa	13-01-2011 (One day)	WALAMT ARI, Hyderabad	45
6	Rice production Technology for Ongur sub-basin farmers of Tamil Nadu	21-02-2011 (One day)	Agribusiness Department, Tiruvanna malai, Tamil Nadu	40
7	Rice production Technology for retail center managers, KRIBCHO, Punjab and Haryana	24-03-2011 (One day)	KRIBCHO, Noida	10
8	Rice production Technology for nodal officers and APDS of AP community based Tank Management Project	25-03-2011 (One day)	Directorate of Agriculture, Andhra Pradesh	50
9	Rice Production Technology for M. Sc Students	30th March 2011 (One day)	Sambalpur university, Orissa	15
10	Rice Production Technology for progressive Farmers from Jharkhand	4-8 Feb. 2011 (4 days)	Birsa Agriculture University, Ranchi	25
			Total	**185**

Training at KVK Madhanapuram, Mahaboobnagar for S.C and S.T farmers.

Two days training program was organized and conducted for the benefit of the 40 SC/ST farmers and farm women of Mahaboobnagar district in collaboration with Krishi Vigyan Kendra, Madhanapuram under DBT funded project on "Improving the Livelihoods of SC/ST farmers through rice technology intervention" during 18-19 June 2010. The objective of the training was to provide the latest know-how and do-how of new technologies in rice based cropping system. The topics covered were Varieties and Hybrids suitable for the district, Integrated Nutrient Management, Crop Production Technologies, Farm Mechanization, Identification of Insect Pests & their management , including pulse and oilseed production.

On farm trial with DRR Rice varieties at National Level

On-farm trials were conducted with DRR rice varieties during Kharif 2010 in association with AICRIP co-operators. The performance of 'Improved Samba Mahsuri', a variety with inbuilt resistance to bacterial leaf blight (Xa21, Xa5 and Xa13) was demonstrated in two districts of Andhra Pradesh viz., West Godavari and Mahabubanagar. In West Godavari, cultivation of this variety was cost effective because of resistance to the Bacterial Leaf Blight, while in Mahaboobnagar which had relatively lower benchmark yields, Improved Samba Mahsuri exhibited a good yield advantage. IPM demonstrations resulted in average savings of Rs.1250/- per hectare. On farm trials were also conducted in Gujarat, Goa, Mandya, Kerala and Tamil Nadu with DRR varieties. Front Line Demonstrations(FLDs) on Improved Samba Mahsuri conducted in an area of 2.0 ha resulted in yield advantage of 32% compared to the local check at Anand in Gujarat.

Table: On Farm trial conducted with DRR varieties at National Level

S. No.	Name of Rice Varieties	Area (ha)	Local Check	Location	FLD Yield (t/ha)	Check Yield (t/ha)	% Yield Advantage
Andhra Pradesh							
1	Improved Samba Mahsuri	8.0	BPT 5204	West Godavari	4.20	3.90	7.60
2	Improved Samba Mahsuri	10.0	BPT 5204	Mahaboobnagar	4.95	4.25	16.47
3	IPM Practices	6.0	Normal Practice	Mahaboobnagar	4.64	4.29	8.10 Rs. 1250 per ha reduced cost of cultivation
4	Chemical weed management	4.0	Normal Practice	Mahaboobnagar	4.72	4.33	9.00 (Rs. 1500 per ha was saved towards labour)

S. No.	Name of Rice Varieties	Area (ha)	Local Check	Location	FLD Yield (t/ha)	Check Yield (t/ha)	% Yield Advantage
Gujarat							
1	Improved Samba Mahsuri	2.00	Local Check	Kheda	4.10	3.10	32.25
Karnataka							
1	Akshaydhan	2	MTU 1001	Mysore	7.2	5.8	22.4
Kerala							
1	Sampada	2.0	Jyothi, swetha, uma	Kadampazhippuram, Chittady, Othaloor, Vilayodi	4.71	422	11.85
Tamil Nadu							
	Akshaydhan	2	Local check	Bannari	4.85	6.15	-21.14
Uttar Pradesh							
	Sampada	5.0	Moti, Sarjoo 52, HUBR 21, HUR 105, HUR 4-3, BPT 5204, HUBR 2-1.	Chandauli, Varanasi, Sonbhadara,	5.97	6.22	-4.0
	Improved Samba Mahsuri	5.0	Moti, HUBR 2-1, HUR 2-1, BPT 5204, HUBR 2-1.	Chandauli, Varanasi, Sonbhadara	6.76	6.54	3.36

Frontline Demonstrations (FLDs) on Rice

During the year through the Frontline Demonstration programme, a cafeteria of rice technologies were demonstrated in 700 hectare area covering 18 states and six rice ecosystems of the country. FLDs were effective in creating the awareness about the potential of new rice varieties, hybrids and other management technologies. About 51% of the total FLDs were conducted in irrigated ecosystems, 37% in rainfed uplands, 6 % in shallow lowlands and 2% of the FLDs were covered under Saline, Coastal and Deepwater Ecosystems. The analysis of yield advantages obtained in various ecosystems revealed that across the ecosystems, FLD technologies resulted in impressive yield advantage. In case of irrigated ecosystems, the yield advantage was 19.34%, while in uplands and shallow lowlands, the yield advantages were 25.47%, and 39.10%, respectively. Overall, 30 promising technologies were identified from 14 states and their adoption by the farmers could result in significantly enhancing the farm level productivity.

Farmers Day at DRR, Rajendranagar, Hyderabad

DRR Celebrated the Farmers' day on 24th October 2010. About Six hundred and fifty farmers participated in this event from the districts of RangaReddy, Mahabubnagar, Warangal, and Nalgonda. Latest technologies of DRR were

displayed through posters and charts in exhibition. Along with the DRR fifteen other public and private organizations participated and technologies related to improved rice varieties, integrated pest management (IPM), integrated nutrient management (INM) and other rice production technologies were demonstrated in field. Question and Answer Session was organized on various aspects of rice production technology and information brochures were distributed among the farmers.

Three outstanding farmers who contributed to rice cultivation extensively were felicitated: Mr K. V. Krishna Rao, Raichur, Karnataka, for popularization of basmati rice cultivation, Mr V Ranga Rao (Zaheerabad, Medak District of Andhra Pradesh) for his work on water saving and a tribal woman farmer, Smt. Chinna Lakshmi (Mahbubnagar District of Andhra Pradesh) for propagation of new varieties.

DRR – Industry Meet 2010: ***Display of DRR Technologies & Services***

The first ever DRR – Industry Meet 2010 Display of DRR Technologies & Services was organized on 23 October 2010 with the prime objective to forge partnership with the private sector, to promote agri-business and to display the market ready rice technologies of DRR. 33 representatives from private companies besides the Heads of Sections of DRR, Members of ITMC & ITMU participated. The meeting offered a very good opportunity for an active interface between DRR scientists and private industry.

AGRITECH 2010 at ANGRAU, Hyderabad

DRR participated in the Agritech-2010 organized by Centre for Agriculture and Rural Development (CARD) at ANGRAU, Hyderabad from 15-18th June, 2010. Various rice technologies of DRR were displayed and explained to the farmers.

Visitors Services

During the year 2010-11, TTT planned and coordinated more than 80 visits for the national and international scientists, extension officials, students from various colleges, universities and farmers all over India. A total of 1502 visitors including 380 extension officials from various organization, 857 students, 278 farmers from all over the country and 37 foreigners from 18 countries were appraised of various rice production technologies and research activities of the Directorate

Kisan Call Centre

Kisan Call Centre was started by Department of Agriculture and cooperation, Ministry of Agriculture, Government of India on National level in January 2004 with a view to leverage the telecom infrastructure in the country to deliver extension services to the farming community. The purpose of the Kisan call centre is mainly to respond to issues raised by farmers instantly in local language on a continuous basis through toll free phone No 1551. DRR as a level II centre has been responding to AP farmers on various aspects of rice production technologies.

T.V. Programs and radio talks

In 2010-11, more than thirty five scientific talks on various aspects of Rice Production Technologies were proposed during quarterly rural program advisory committee meetings organized by AIR, Hyderabad. Ten scientific talks on various aspects of Rice Production Technology were delivered by DRR scientists that were broadcasted by AIR, Hyderabad.

Development and Maintenance of Rice Knowledge Management Portal

Vision 2025 document of DRR envisages bridging the yield gap by improving the access to

the rice knowledge amongst the rice stakeholders. Accordingly, a flagship initiative was taken up under Rice Knowledge Management Portal-RKMP (funded by NAIP). RKMP is expected to help strengthening communications infrastructure among the stakeholders, improving tools for collecting, using data and information, nurturing scientific communities in the field of rice in India. Some of the salient achievements made during this year are given below;

- Harnessing existing AICRIP set up through Knowledge Management Tools is one of the finest innovations of this project with in-built sustainability. State specific Launch Workshop were organized during 20-25 July 2010 in Uttar Pradesh, 09-12 August, 2010 in Tamil Nadu, 30 August-01 September in Maharashtra, 16-19 September in Andhra Pradesh, 21-24 September in Uttarakhand, West Bengal, Bihar and Manipur. So far 60% of EIS content has been collected for these states.
- Various off shoot applications were developed including platforms such as AICRIP Intranet (MIS for AICRIP), E-learning in MOODLE, Joomla and Java platforms, www.ear-rkmp.in, www.i3r.in, Communities of Practice, Training Data Base Management System of DRR etc. A

total of 12 e-learning courses are in place in all the three platforms. Three courses are built on local languages. Two offline CDs namely "In vogue Extension Tools and Techniques" and "ITKs in Rice Farming" were released.

- Around 2500 Reusable Learning Objects (RLOs) were developed in disciplines like Agronomy, Entomology, Pathology, Soil Science, Economics, Hybrid Rice and Post harvest technology for Extension Information System (EIS). These RLOs will be used along with 1800 state specific RLOs to make this portal one of the exhaustive semantic portal on a single crop. About 500 pages of the content have been translated into the local languages.
- 12 Approach papers on various aspects of Rice and 15 Status papers related to 15 states were developed with 1000 high quality objects. For all the rice growing states of the country, GIS Based map interfaces were developed. Area, production and productivity for all the all states for last five decades have been digitized. A 17 minutes documentary film was prepared on Diversity in Rice Production System. Sixty film clippings were prepared on various operations involved in rice production
- Forty years of AICRIP multi location trial data was digitized, indexed and tagged with more than 15000 AICRIP Datasets, useful for catering to data requirements of rice researchers of the country. Apart from this last two decades FLD results were digitized.
- "Expert Answers on Rice" a question answer platform (online/SMS based) was developed, piloted and refined. With 150 Rice Experts, the platform is ready for formal launch. i3R, a content management platform was prepared under Research Information System (RIS) for hosting rice related document such as conference papers, journal articles, book chapters, books/Bulletins, slide bank, conference proceedings and miscellaneous. It is a open platform to submit any kind of agriculture published material and Agrotagger running in the background automatically provides rich semantic interlinking between the documents.

Workshop on Knowledge Management Tools

(Jointly organized by ICRISAT and DRR)
14-15 December 2010
ICRISAT, Patancheru, Andhra Pradesh

The Platforms developed are given below:

- RKMP Website - The Rice Knowledge management Portal (RKMP), a flagship initiative under National Agricultural Innovation Project (NAIP) has been envisaged to enable rice workers across the country to create, manage and share scientific, technology-related and market-related information for the benefit of the rice as a sector.
- E-learning in Moodle - E-Learning Platform on Rice is an extension of LearnRice, a multi-dimensional e-learning platform of RKMP in MOODLE Platform.
- E-learning in Java (LearnRice) - E-Learning Platform on Rice is an extension of LearnRice, a multi-dimensional e-learning platform of RKMP in Java Platform.
- E-learning in Joomla - E-Learning Platform on Rice is an extension of LearnRice, a multi-dimensional e-learning platform of RKMP in Joomla Platform.
- Communities of Practice (CoPs) – A platform to capture knowledge from individual experts in rice research and development institutes..
- Rikipedia – It is Rice Knowledge Initiative under NAIP's Flagship Project RKMP aiming at capturing the implicit knowledge about rice that exists across the stakeholders.
- Training Data Base Management System of DRR - Central Data Base of Trainings conducted at DRR• - The acronym of EAR is Expert Answers on Rice. The Experts on Rice will provide Answers to the questions posed by different users/clients/stakeholders by using the three tier structure.
- - i3R is an acronym for India Rice Research Repository. i3R comes under Research Information System (RIS). i3R consists of Conference papers, Journal articles, Book chapters, Books/Bulletins, Slide bank, Conference proceedings and Miscellaneous.

Licensing of technologies through MOA as a part of ITMU activity

DRR made MoAs with private companies for commercialization, production and marketing of DRR varieties / hybrids seed on payment basis in India. The agreement is valid for 5 years initially and renewable on mutually agreed terms and conditions. An amount of Rs. 18 lakhs was received as an upfront payment from the MoAs for Improved Samba Mahsuri, DRRH-2 and DRRH-3 signed by DRR with different seed companies.

Material Transfer Agreement

A system has been established for exchange of seed material to various institutes / agencies for research purpose through DRR-MTA form. Individual requests for import/export to NBPGR or exchange of seed material with any other agencies would not be entertained without ITMU permission. During 2010-11 three MTAs have been signed for exchange of seed materials and Rs. 20,200 received as PPH charges.

Academic activities

Fifteen students from 8 institutes completed their 6 months M.Sc biotechnology project work. In addition, an international training programme on "use of molecular markers in rice improvement" was organized for 3 students sponsored by Sam Higginbottom Institute of Agriculture, Allahabad during June 2010. During the year, seven students pursuing their PhD studies under the guidance of DRR scientists, were awarded degrees.

Table : List of students awarded Ph. D degree (2010-11)

S.No	Student	Title of the thesis	Guide	Year of Award	Discipline	University
1.	Mr. P. Nataraj Kumar	Identification and genetic characterization of novel BLB resistance gene (s) in rice.	Dr. B. Mishra	2010	Genetics	Osmania Univ. Hyd
2.	Mr. K. Srinivasa Rao	Improvement of hybrid rice parental lines for BLB and rice blast disease resistance through molecular breeding	Dr. B. Mishra	2010	Genetics	Osmania Univ. Hyd
3.	Ms. K. Sujatha	Identification and molecular mapping novel BLB resistance genes in rice.	Dr. B. Mishra	2010	Plant Sc.	Hyd Central Univ.
4.	Mr. Y. Hari	Improvement of hybrid rice parental lines through markers assisted selection.	Dr. B.C. Viraktamath	2011	Genetics	
5.	Mr.Manish K.Pandey	Introgression of bacterial resistance genes through molecular MAS in Basmathi rice.	Dr. N. Shoba Rani	2010	Botany	Osmania Univ. Hyd
6.	Mr. D. Nageshwar Rao	Heterosis combining ability and genotypic stability for morphological and biochemical traits associated with abiotic stress tolerance in rice	Dr. M.S. Ramesha	2011	Botany	Osmania Univ. Hyd
7.	Mr. A .Prasad Babu	Genomics of yield	Dr. N. Sarla	2010	Biotech nology	JNTU

Awards/Recognitions

Dr. E.A.Siddiq, Former Project Director, DRR & President, F & RS Foundation was felicitated on his being conferred the country's prestigious Civilian Award "Padma Shri" for the year 2010 on 10th February, 2011.

Dr. J. S. Bentur, PS, Entomology, was chosen as member of Task Force for Special Tests by PPV & FR Authority, MA, and GOI.

Best Papers/Poster Awards

Award	Authors	Title	Journal/Seminar/Symposium
Jawaharlal Nehru Award (Gold Medal and Citation)	Satendra Kumar Mangrauthia	Excellence in Postgraduate Agricultural Research for doctorate degree.	Indian Council of Agricultural Research (ICAR) Awards 2009
Best Research Paper Award	Somasekhar, N., Padmakumari, A.P., Katti, G. and Prasad J.S	"Infectivity of indigenous entomopathogenic nematodes to insect pests of rice"	Paper presented at National Symposium on "Emerging trends in pest management strategies under climate change scenario" held at OUAT, Bhubaneswar, December 20-21, 2010.
Best Oral Presentation award	**Srinivas Prasad**, Ratnamadhavi, K; Madan Mohan K, Balachandran SM and Virktamath BC	Pyramiding of three blast resistant genes (Pi1+Pi2+Pikh) using marker assisted selection into elite *indica* cultivar Sambamahsuri	Paper presented at National Symposium on Molecular Approaches for Management of fungal diseases of crop plants at IIHR Bangalore from 27-30th December, 2010
Borlaug Fellow for 2010	Vandana Rai		Norman E. Borlaug International Agricultural Science and Technology Fellowship Program of the U.S. Department of Agriculture.
Best poster award	Mallikarjuna Swamy B P, K Kaladhar, K Anuradha, Anil K Batchu, T Longvah, BC Viraktamath and N Sarla.	Enhancing iron and zinc concentration in rice grains using wild species.	15th Annual ADNAT convention and International Symposium on Genomics and Biodiversity, CCMB, Hyderabad. Feb 2011.

Sports Awards

DRR staff won medals in table tennis event for both men and women, kabaddi in ICAI Inter-Institutional sports competitions held during 20th to 25th August, 2010 on the occasion of NAARM foundation day.

Dr. K. Sruekha won gold in Table tennis (singles), **Dr. K. Surekha** and **Dr. G. Padmavathi** won gold in table tennis (doubles), **Mr. C. Sadanandam** won gold in carom (singles) and **Dr. P. Revathi** won bronze in long jump in the South zone sports meet held at Bangalore from 7-11, February 2011

Linkages and Collaboration in India and Abroad

DRR has established a strong network and collaboration with several research organizations in India and abroad. Under AICRIP, it has 47 funded centres affiliated to 22 state Agricultural Universities and Departments of Agriculture of 24 states and Union territories. Under DBT network on functional Genomics of Rice, DRR has linkage with other Universities and Institutions like University of Delhi, Centre for Cellular and Molecular Biology, Centre for DNA Fingerprinting and Diagnostics etc. DRR also has a strong linkage with the International Rice Research Institute, Philippines. Under the ICAR-IRRI collaborative project on Cereal System Intensification for South Asia (CSISA), DRR is participating in all the five activities of the project. A list of externally funded projects that support these collaborative projects is given in Table below

List of Externally funded projects

S.No	Title	Name of PI	Funding source	Duration	Budget in lakhs
1	Establishment of National Rice Resource Data base	Dr.B.C.Viraktamath / Dr. L.V. Subba Rao	DBT	2009-13	51.208
2	Improving the livelihoods of SC/ST Farmers through Rice Technology Interventions	Dr. Shaik Meera	DBT	2008-2011	9.38
3	Development of Biotic stress resistant rice through marker assisted breeding sub project- I A&B (DBSRR - GCP)	Dr. B.C. Viraktamath	DBT Project	2009-14	146.88
4	Functional Characterization of novel bacterial blight resistance genes from wild relative of Oryza spp FGR Ph II 2A	Dr. B.C. Viraktamath /Dr. R.M. Sundaram	DBT Project	2009-14	74.38
5	Identification of molecular markers linked to quality parameters in rice and their validation and utilization in marker assisted selection	Dr. N. Shobha Rani	DBT Project	2008-2011	39.23
6	Functional Validation of Identified candidate gall midge resistance genes FGR Ph II 4A	Dr. J.S. Bentur	DBT Project	2009-14	93.67

S.No	Title	Name of PI	Funding source	Duration	Budget in lakhs
7	Identification and functional validation of BPH resistance genes FGR Ph II 5A	Dr. J.S. Bentur	DBT Project	2009-14	39.8
8	Fine mapping of yield enhancing QTLs from wild rice FGR Ph II 1A	Dr. N. Sarla	DBT Project	2009-14	92.84
9	Functional analysis of gene regulatory networks during flower and seed development in rice FGR Ph II 7	Dr. S.M. Balachandran	DBT Project	2009-14	89.05
10	High resolution mapping, identification and functional analysis of rice tungro virus resistance genes FGR PH II 6	Dr. C.N. Neeraja	DBT Project	2009-14	59.18
11	Identification and functional analysis of novel blast resistance genes in rice FGR Ph II 3B	Dr. M.S. Prasad	DBT Project	2009-14	58.11
12	Application of EST derived micro satellite markers for prediction of yield heterosis and molecular characterization in rice hybrids	Dr. R.M. Sundaram	DBT-Fast track	2007-2010	17.93
13	Promoter mining for identification of novel regulatory elements of	Dr. Seshu Madhav	DBT-Fast track	2007-2010	22.66

AICRIP Centres

DRR is also the coordinating headquarters for the All India Coordinated Research Project on Rice also known as All-India Coordinated Rice Improvement Programme (AICRIP) with 47 funded and over 80 voluntary centres. These centers are affiliated to the State Agricultural Universities, State Departments of Agriculture, other ICAR Institutes, Private sector seed companies. List of Funded and voluntary centres are provided in the Tables.

Table: Funded AICRIP centres and staff positions at these centres during 2010-11

S.No	State	Centre	Total
1	Andhra Pradesh	Maruteru	9
2	Andhra Pradesh	Rajendranagar	6
3	Andhra Pradesh	Warangal	4
4	Assam	Jorhat/Titabar	7
5	Assam	Karimganj	1
6	Bihar	Patna	6
7	Bihar	Pusa	4
8	Bihar	Sabour	1
9	Chattisgarh	Jagdalpur	4
10	Chattisgarh	Raipur	5
11	Gujarat	Nawagam	7
12	Gujarat	Navasari	2
13	Haryana	Kaul	7
14	Himachal Pradesh	Palampur/Malan	6
15	Jammu & Kashmir	Khudwani	5
16	Jammu & Kashmir	R.S.Pura (Chatha)	4
17	Jharkhand	Kanke/Ranchi	4
18	Karnataka	Mandya	5
19	Karnataka	Gangavati	5
20	Karnataka	Brahmavar	2
21	Karnataka	Mugad	2
22	Karnataka	Ponnampet	2
23	Kerala	Moncompu	4
24	Kerala	Pattambi	7
25	Madhya Pradesh	Rewa	5
26	Maharashtra	Karjat	7
27	Maharashtra	Sakoli	2
28	Maharashtra	Tuljapur	2
29	Manipur	Imphal (Wangbal)	4
30	Meghalaya	Upper Shillong	4
31	Nagaland	Kohima	1
32	Orissa	Chiplima/Sambulpur	7
33	Orissa	Jeypore	1
34	Puducherry	Puducherry	5
35	Punjab	Ludhiana	5
36	Rajasthan	Kota	2
37	Tamil Nadu	Aduthurai	4
38	Tamil Nadu	Coimbatore	7
39	Tripura	Arudhutinagar	2
40	Uttar Pradesh	Nagina	1
41	Uttar Pradesh	Kanpur	2
42	Uttar Pradesh	Ghaghraghat	4
43	Uttar Pradesh	Varanasi	4
44	Uttar Pradesh	Faizabad	5
45	West Bengal	Bankura	4
46	West Bengal	Chinsurah	6
47	Uttaranchal	Pantnagar	6

Table: List of voluntary centres and number of trials conducted at these centres during 2010-**11**

	Center	Breeding	Hybrid	Agronomy	Soil Science	Physio logy	Ento mology	Path ology	Total
1	Aduthurai				2				2
2	Allahabad	3	5						8
3	Almora	7		2				7	16
4	Ambasamudram	1							1
5	Annamalainagar	2		2			0		4
6	Ambikapur	3							3
7	Arundatinagar			3			7		10
8	Banswara	6							6
9	Bangalore	2							2
10	Barapani	7		3				6	16
11	Basar	0		2				2	4
12	Bhubaneswar	14	5				9		28
13	Bilsapur	2							2
14	Bapatla	3		0					3
15	Bankura				1				1
16	Canning	0							0
17	Calicut	1							1
18	Cuttack	22		6			3	19	50
19	Chinsurah (Purulia)	0			3				3
20	Chakdaha			2					2
21	Dabhoi	3	5						8
22	Danti	2							2
23	Derol	4							4
24	DRR		5		3			21	29
25	Doda							13	13
26	Faizabad				4	3			7
27	Goa	1							1
28	Gerua	4							4
29	Gudulur	0						5	5
30	Gurudaspur	3							3
31	Gaghraghat				2				2
32	Hazaribagh	6		2				14	22
33	Hatwara					3			3
34	IARI	4		1					5
35	Iroisemba						5		5
36	Imphal (CAU)	2						3	5

	Center	Breeding	Hybrid	Agronomy	Soil Science	Physio logy	Ento mology	Path ology	Total
37	Jabalpur	0	5						5
38	Jagtial	2							2
39	Kalimpong	0							0
40	Karaikal	10	4	2	6	2	6	3	33
41	Karnal	2		1					3
42	Katrain	0							0
43	Kapurthala	3							3
44	Kolasib	0							0
45	Khudwani				1				1
46	Kota						0		0
47	Lamphalpat	6							6
48	Lembucherra	0							0
49	Lucknow	0		1					1
50	Lonavala							16	16
51	Machilipatnam	1							1
52	Majhera	2							2
53	Modipuram	3							3
54	Motto	0							0
55	Mudigere	6							6
56	Mezdi Phema	0							0
57	Mandya				5				5
58	Madurai						5		5
59	Moncompu				1				1
60	Nellore						8	23	31
61	North Lakimpur	3					0		3
62	Navsari			2				4	6
63	New Delhi						2	1	3
64	Parbhani			2					2
65	Palghar	1							1
66	Panvel	1							1
67	Paramakudi	4							4
68	Palampur	3							3
69	Patna - ICAR	4		2					6
70	Pondaghat	3							3
71	Port Blair	4						3	7
72	Pundibari	1							1
73	Radhanagari	2							2

	Center	Breeding	Hybrid	Agronomy	Soil Science	Physiology	Entomology	Pathology	Total
74	Ragolu	6					10	4	20
75	Rauni	3							3
76	Ranichouri	1							1
77	Raipur				3				3
78	Ranchi				1				1
79	Sabour			2					2
80	Sindewahi	9	4						13
81	Sirsi	8	3		0				11
82	Shirgoan	3							3
83	Sundernagar	0							0
84	Tirur	3						3	6
85	Trichy	0							0
86	Tirupathsram	2							2
87	Utukur	0							0
88	Vadagaon	1	2						3
89	Vyra	2	3						5
90	Vyttila	0							0
91	Varanasi(BHU)					3			3
92	Waraseoni	7							7
93	VNR Seeds		4						4
94	Nuziveedu Seeds		2						2
95	Zauri Seeds		2						2
96	Bayer Bio-Science Pvt.Ltd.			4					4
97	JK Agri Seeds		2						2
98	Kaveri Seeds		3						3
	Total	208	58	35	32	11	55	147	546

*Funded location for some disciplines

Significant Events

Meetings

Research Advisory Committee

The second meeting of the Research Advisory Committee of the Directorate of Rice Research was held on May 10, 2010. The following members attended the meeting.

Dr. P. Raghava Reddy	Vice Chancellor, Acharya NG Ranga Agricultural University	Chairman
Prof. J. L. Dwivedi	Senior Rice Breeder / Officer Incharge Crop Research Station (NDUA&T) Masodha, P.O. Dabhasemar Faizabad –224 133	Member
Dr. N.K. Singh	Principal Scientist National Research Centre for Plant Biotechnology, LBS Building, P usa IARI Campus, New Delhi – 110 012	Member
Prof. A. P. Sinha	Senior Rice Pathologist G.B. Pant University of Agriculture & Technology Pantnagar – 263 145, Uttaranchal	Member
Dr. K. S. Rao	Principal Scientist & Head Division of Crop Production Central Rice Research Institute Cuttack – 753 006	Member
Dr. K. Krishnaiah	Former Project Director, DRR H. No. 3-8-252, Chandrapuri Colony L. B. Nagar, Hyderabad – 500 074	Member
Dr. B.C. Viraktamath	Project Director, DRR, Hyderabad	Ex-Officio member
Dr. S. N. Shukla	Assistant Director General (FFC) Indian Council of Agricultural Research Krishi Bhawan New Delhi – 110 114	Ex-Officio Member
V. Krishna Rao	Progressive Farmer, Raichur, Karnataka	Member
Mr. Chandrashekar Bhadsalve	Progressive Farmer, Tahsil Karjat District Raigad – 401 101, Maharashtra	Member
Dr. C.S. Reddy	Principal Scientist, DRR Hyderabad – 500 030	Member Secretary

The Institute Research Council (IRC) meetings were held during 2nd to 5th June, 2010 under the Chairmanship of Project Director, Dr. B.C. Viraktamath. Experts from the respective disciplines were invited from different organizations to participate in the IRC meetings to critically evaluate the on-going research programmes and make suitable suggestions for improvement. Prior to the IRC meetings, pre-IRC meetings were conducted at the sections.

Section	Name of the expert
Crop Improvement	1) Dr. Ish Kumar, Syngenta Private Ltd 2) Prof. Sivaramakrishnan, Professor and Head Department of Biotechnology, ANGRAU
Crop Production	3) Dr.L. Jalapathi Rao, Registrar, ANGRAU
Crop Protection	4) Dr. K.V.Seshu Reddy, Research Head: Field Crops and support Programs, MAHYCO
Transfer of Technology & Training	5) Dr. S. S. Vinayagam, Director of RTP, NIRD

The Institute Research Council (IRC)

All the scientists presented the results of their research work done during 2009-10 and technical programme for the next year 2010-11. The Project Director along with the invited experts reviewed the progress made under institute's lead research projects. Six new projects were approved by the IRC during the meeting.

Institutional Biosafety Committee (ISBC)

The 12th IBSC meeting with the constituted members was held on 24th March 2011 under the chairmanship of Dr B C Viraktamath, Project Director at DRR. Dr. B.C. Viraktamath welcomed the members of DRR-IBSC and briefly mentioned that private sector companies were more aggressive in developing and testing of GM crops compared to the public sector research institutions. This was evident from the number of applications being submitted by the private sector for RCGM approval/clearance. He emphasized that the public institutions should not be complacent but equally be competitive and ready with the GM crops for commercialization.

1	Dr. B.C.Viraktamath	Project Director	Chairman
2	Dr. P.B. Kirti	Professor, Dept.of Plant Sciences School of Life Sciences, University of Hyderabad, Gachibowli Hyderabad – 500046.	DBT Representative
3	Dr. M. Sujatha .	Principal Scientist Directorate of Oilseeds Research Rajendranagar, Hyderabad – 500 030	Outside Expert
4	Dr. A. Debnath	Medical Officer National Academy of Agricultural Research Management (NAARM) Rajendranagar, Hyderabad – 500 030.	Member
5	Dr. N. Shobha RANI	Principal Scientist & Head (Crop Improvement) Directorate of Rice Research Rajendranagar, Hyderabad – 500 030.	Member
6	Dr. Gururaj Katti	Principal Scientist (Entomology) Directorate of Rice Research Rajendranagar, Hyderabad – 500 030.	Member
7	Dr. G.S. Laha	Senior Scientist (Plant Pathology) Directorate of Rice Research Rajendranagar, Hyderabad – 500 030.	Member
8	Dr. R. M. Sundaram	Senior Scientist (Biotechnology) Directorate of Rice Research Rajendranagar, Hyderabad – 500 030.	Member
9	Dr. S.M. Balachandran	Principal Scientist (Biotechnology) Directorate of Rice Research Rajendranagar, Hyderabad – 500 030.	Member Secretary

Dr. S.M. Balachandran presented the action taken report on the proceedings of the 11th IBSC Meeting held on February 10, 2010 and presented the progress of research work related to the following projects:

1. ICAR Network Project for Transgenic Crops: Rice (ICAR sponsored)

2. DBT Network Project on "Development and evaluation of salt and drought tolerant transgenic rice"

   Dr. R.M. Sundaram presented the progress of research work related to the project, "Development of indica rice with Beta carotene rich endosperm through marker assisted gene introgression and their evaluation" (Sponsored by DBT-Phase II).

In the meeting as many as nine new proposals for exchange of gene constructs/transgenic rice lines for field evaluation and initiation of transgenic development related to the ongoing and newly funded projects were discussed. The IBSC approved these proposals and requested the member secretary to submit applications individually in the prescribed format for RCGM/GEAC permission. Dr. Debnath offered his help to conduct medical tests for research personnel working with GM rice at DRR.

Institute Management Committee

The 15th Institute Management Committee meeting of DRR was held on 30.09.2010 at 11.30 am in the Committee Room of this Directorate. The constitution of IMC is as follows:

S. No.	Name of the Officer	Designation & Affiliation	Position
1	Dr. B.C. Viraktamath Dr. R.P Dua	Project Director, DRR, Hyderabad. Asst. Director General (FFC), ICAR, Krishi Bhawan, New Delhi.	Chairman Nominee, DG, ICAR.
2	Dr. R. Sudhakar	Director of Research, ANGRAU, Hyderabad.	Member
3	Dr. K.S. Varaprasad	Head, NBPGR Research Station Hyderabad	Member
4 5	Dr. R.N. Rao Dr. Y.G. Prasad	Principal Scientist, CRRI, Cuttack. Principal Scientist, CRIDA, Hyderabad.	Member Member
6	Shri. Chandrashekar Bhadsalve	Farmer's Representative, Karjat, Maharashtra.	Member
7	Shri. S.K.C. Bose	Finance & Accounts Officer, NAARM, Hyderabad.	Member
8	Shri. S. Balakamesh	Asst. Finan & Accts. Officer, DRR, Hyderabad.	Special Invitee
9	Dr. S.M. Balachandran	Principal Scientist, DRR, Hyderabad.	Member & Convener
10	Shri. Prakash Babu	Administrative Officer, DRR, Hyderabad.	Member Secretary

Vigilance awareness week

Hindi Activities

Hindi week was celebrated from 14-20th September, 2010 at DRR in accordance with the official language policy and rules and regulations.

Auditorium Inauguration

The DRR Auditorium was inaugurated by Dr. S. Ayyappan, Secretary (DARE) & DG (ICAR). Dr. S.K. Datta, DDG (CS), Dr. B. Mishra, former Director-DRR & VC, SKUAST, Jammu and many other dignitaries attended the function on **8th March, 2011.**

Workshop, Seminars, Summer Institutes

46th Annual Rice Group Meetings

The 46th Annual Rice Group Meetings held at DRR during 9-11 April 2011. The function was held at the newly constructed auditorium in DRR premises, Rajendranagar, Hyderabad. Dr R S Zeigler, Director General, International Rice Research Institute (IRRI), Philippines was the chief guest. The function was presided over by Dr. Swapan Kumar Datta, Deputy Director General (Crop Sciences), ICAR. About 450 rice researchers from India and abroad actively participated in this three days meetings. The research work of the last year was reviewed and new programmes were chalked out for the next year and beyond. During this annual meeting well renowned rice scientists, Padmashree Dr. E.A.Siddiq, Padmashree Dr. S.V.S.Sastry, and Dr. W. H. Freeman were felicitated for their significant contribution to rice science and towards serving the rice community.

Recommendations

The Variety Identification Committee recommended the 4 varieties - IET 19972 (SJR 5), IET 19816 (CR 2301-5), IET 20220 (CR 2285-6-6-3-1), IET 20827 (MAUB 171) and 2 hybrids - IET 20716 (VNR 204), IET 20735 (VNR 202).

Agronomy

Growing of rice + sunhemp + 60:40:40:500 or 60:60:40:500 kg/ha N:P:K:Lime and foliar spray of 0.5% ZnSO4 was found promising for rainfed uplands.Planting of 25 days old single seedling (DOS)/hill at 25 cm x 25 cm for early planting, while 45 DOS @ 3 seedlings/hill at 20 cm x 10 cm for late planting was better for productivity of *boro* rice.

Combination herbicides, bensulfuron-methyl + pretilachlor (6.6 GR+) @ 0.06 + 0.60 kg a.i./ha as post emergence in conjunction with glyphosate (41 EC) @ 0.75 kg a.i./ha pre-planting was found effective for weed management in rice based cropping system, under irrigated ecosystem.

Soil Science

For the dry sown aerobic rice grown in the Indo Gangetic Plains (Kanpur) and Deccan plateau (DRR), regulated supply of irrigation water equivalent to 100% of cumulative pan evaporation (CPE) and nutrient application, respectively of N P K 120 60 50 or 120 0 100 improved water productivity without yield penalty and saved 16 - 21% of irrigation water.

Straw utilization benefited rice productivity with positive soil nutrient balance of 12 kg N and P and 25-45 kg K20/ha, enhanced soil carbon content and contributed 20-48 kg N, 6-23 kg P2O5 and 14-50 kg K2O/ha to the crop.

Physiology

IET 20924 was physiologically superior with both photo insensitive and heat tolerance characteristics. Other useful photo insensitive line IET 20935; heat tolerance lines IET 20907; IET 21009 were indentified for developing climate resilient rice genotypes.

Entomology

An aromatic rice variety like Pusa Basmati can be used as trap crop by planting one row for every 9 rows of main crop to minimize damage by yellow stem borer with favourable benefit cost ratio.

Plant Pathology

The combination product (Flubendamide 3.5% + Hexaconazole 5% WG) @ 2 g/liter was effective against sheath blight, stem borer and leaf folder.

Seminars

Dr. T. Takabe from Meijo University, Nagaya, Japan delivered a seminar on "Metabolic engineering of osmoprotectant glycine betane in plant" on 9th September 2010.

Dr. David Hohnson, Agronomist, IRRI visited DRR and delivered a lecture on 11th February 2011.

Workshops

Rice Knowledge Management Portal (RKMP) is a flagship initiative which is undertaken by DRR (funded by NAIP). As a part of Rice Knowledge Management Portal activities, following workshops were conducted across the country.

Rice Knowledge Management Portal Activites

Organizer(s)	Details of Workshop/ Meetings/ Seminars/ Trainings	Duration (From-To)	No. of Personnel participated
ICRISAT, Hyderabad & DRR	Workshop on Knowledge Management Tools	Dec 14-15, 2010	85
UAS, Bengaluru & DRR	RKMP-IRRI Workshop on Knowledge Management Collaboration	Feb 18-19, 2011	120
Rice Research Station, Chinsurah	Content Development Workshop	1 day	100
BAU, Sabour, Bhagalpur	Content Development Workshop	1 day	80
RARS, Karjat	Content Development Workshop (Phase 1) at Karjat	1 day 31st March, 2010	40
RARS, Karjat	"Partners, Associate Scientists and Rice Stakeholders Meeting" at Karjat	Two days, 30-31st August, 2010	3
RARS, Karjat and IGKV, Raipur	Project progress review meeting at Raipur	One day, 10th Nov. 2010	32
RARS, Karjat and IGKV, Raipur	Content Development Workshop (Phase 1) at Raipur	Two days 23-24 March 2011	70
ZARS, Mandya	NAIP-RKMP Regional Launch workshop	31.07.2009	120
ZARS, Mandya	Content Development Workshop	09.03.2010	80
TRRI, Aduthurai	Content Development Workshop	2-3, Dec 2010	120
ICAR RC NEH, Umiam, Meghalaya	Co-PI centre level regional launch workshop	Sept., 17, 2009	60
ICAR RC NEH, Umiam, Meghalaya	Content development workshop (phase I)for for the states *viz.*, Assam and Meghalaya	March 18-19,2010	40
ICAR RC NEH Region, Manipur	Content Development Workshop (Phase -II) for the states of Manipur	December 10, 2010	45
Centre, Imphal IARI, New Delhi	GB Pant University, Pant Nagar	21-22 Sept 2010	100

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Sundaram RM, CN Neeraja, MS Madhav, SM Balachandran, AS Hariprasad and BC Viraktamath . 2010,. Genetic purity testing of rice hybrids and their parental lines using molecular markers, pp 517-521. *In:* (eds. K. Keshavulu, K. Jhansi Rani, Razia Sultana, B. Rajeswari and M. Ganesh). Seed Science and Technology: Principles and Practices. Acharya N.G. Ranga Agricultural University, Hyderabad. India.

Vandana Rai, N Tuteja and T Takabe. 2011. Transporters and abiotic stress tolerance in plants . In: Improving Crop Resistance to Abiotic Stress. (ed. N Tuteja). Wiley-Blackwell, Wiley-VCH Verlag GmbH & Co., Germany.

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Vishwakarma AK, Brajendra and KA Pathak. 2011. Upland Rice in Mizoram. In: Upland Rices in India. (eds RK Singh, NP Mandal, CV Singh, MS Anantha. Scientific Publishers). Jodhpur, India.

List ofapproved on going projects 2010-11

Code	Program / Project title	Project Leader & Associates
P1 : GEY/ : Genetic enhancement of yield potential and stress resistance in rice for irrigated ecology – Program leader : BC Viraktamath		
GEY/CI/BR/12	Redesigning the indica rice plant type by introgressing the traits for higher yield potential and disease and pest resistance from tropical japonica and wild rices.	T Ram SP Singh, CS Reddy, GS Laha, A PPadamakumari, D Krishanaveni , V. Jhansilakshmi, RM Sundaram, B Sreedevi, AS Hariprasad , Satendra kumar Mangrautia
GEY/CI/BR/9	Breeding varieties for Boro areas.	LV Subba Rao T Ram, N Shobha Rani, V Ravindra Babu, Ch Padmavathi, M Srinivas Prasad, R Mahendra Kumar
GEY/CI/BR/16	Breeding rice varieties for resistance to planthoppers	G Padmavathi V Jhansi Lakshmi, GSV Prasad, N Shobha Rani, BCViraktamath
GEY/CI/BR/14	Breeding rice for enhanced phosphorous use efficiency	VP Bhadana N Shobha Rani, T Ram, LV Subba Rao, GSV Prasad, P Krishnamurthy, D. Subramanyam, RM Sundaram, Brajendra.
GEY/CI/BR/17	Development of high yielding rice varieties for conservation agriculture	Suneetha Kota N Shobha Rani, Vijayapal Badana, P. Senguttuvel, S.P.Singh, M.B.B. Prasad Babu, B.C.Viraktamath
GEY/CI/HY/1	Development and evaluation of three line hybrids with better grain quality and resistance to major pests and diseases	BC Viraktamath AS Hari Prasad, P Senguttuvel, P Revathi, N Shobha Rani and CN Neeraja
GEY/CI/ HY/7	Exploitation of inter sub-specific heterosis in rice (*Oryza sativa* L.)	AS Hari Prasad P Revathi, RM Sundaram, T Ram and BC Viraktamath
GEY/CI/ HY/8	Breeding of parental lines and hybrids suited to aerobic and salinity conditions	P Senguttuvel AS Hariprasad, P Revathi, B. C. Viraktamath, R. Mahender Kumar, J.S.Prasad, Brajendra, Vandna Rai and R.K.Gautam (CSSRI)
GEY/CI/ HY/6	Genetic improvement of maintainers and development of CMS lines	K.B.Kemparaju B.C.Viraktamath,N Shobha Rani A.S.Hari Prasad,P. Senguttuvel,P.Revathi C.N.Neeraja, G.S.Laha, V. Jhansilakshmi

GEY/CP/ PP/8	Increasing the yield potential in irrigated rice : manipulating sources and sinks	P Raghuveer Rao R.Mahender Kumar, S.Ravichandran A.S. Ramprasad
P 2 GEQ/: Genetic enhancement of seed and nutritional quality for domestic and export purposes ***Programme leader : N. Shobha Rani***		
GEQ/CI/BR/11	Genetic enhancement of quality rice varieties through conventional and molecular breeding approaches	N Shobha Rani GS Varaprasad, LV Subba Rao, V Ravindra Babu, RM Sundaram, MS Madhav, CN Neeraja, GS Laha, M Srinivas Prasad, Jhansi Lakshmi and AS Rama Prasad
GEQ/ CI/BR/8	Enhancing nutritional quality of rice through bio-fortification	V Ravindra Babu N Shobha Rani, LV Subba Rao, B Sreedevi, K Surekha, CN Neeraja, G Padmavathi, T. Longvah (NIN), P. Hemashankari
GEQ/CI/BR/13	Genetic enhancement of aromatic short and medium grain rices	GS Varaprasad BC Viraktamath, N Shobha Rani, G Padmavathi, M Seshu Madhav, JS Bentur, V Jhansi Lakshmi, MS Prasad, GS Laha and ASR Prasad
P 3 ABR/ : Application of Biotechnology tools in Rice ***Programme leader : N. Sarla***		
ABR/CI/ BT/5	Introgression of yield contributing genes /alleles from wild species to rice using molecular markers	N Sarla N.Shobha Rani, Vandna Rai and P Krishnamurthy
ABR/CI/ BT/9	Genetic improvement of rice against biotic and abiotic stresses through transgenic approach	SM Balachandran AP Padmakumari, Ch Padmavathi, SR Voleti
ABR/CI/ BT/6	Identification of genes for grain filling in rice (*Oryza sativa* L.)	CN Neeraja SR Voleti,N Shoba Rani, LV Subba Rao, SM Balachandran, RM Sundaram, M Sheshu Madhav, GSV Prasad
ABR/CI/ BT/7	Application of biotechnological tools for understanding molecular basis of yield heterosis and WA-CMS trait in rice	RM Sundaram SM Balachandran, CN Neeraja, MS Ramesha, SR Voleti
ABR/CI/ BT/10	Gene discovery and "allele-mining" for water limiting conditions and salt tolerance in rice	Vandna Rai N Sarla, T Ram, D. Subramanyam, NK Singh (NRCPB) and RK Gautam (CSSRI)

ABR/CI/ HY/9	Molecular breeding for fertility restoration, wide compatibility and disease resistance in rice	P Revathi AS Hariprasad, P Senguttuvel, RM Sundaram and BC Viraktamath
ABR/CPT/ PATH/16	Suppression of Rice tungro virus through RNA interference	SK Mangrauthia CS Reddy, SM Balachandran, D Krishnaveni, CNNeeraja
P4 RUE/ : Enhancing resource and input use efficiency Program leader : SP Singh		
RUE/ CP/ AG/12	Resource conservation technologies to Improve input use efficiency and to sustain rice system productivity	SP Singh B Sreedevi, KV Rao, RM Kumar, PS Latha, GR Katti, N.Shobha Rani, B Nirmala, GS Laha, A Ramaprasad, N. Somasekhar, D. Subramanyam and Brajendra
RUE/ CP/ AG/12	Resource conservation technologies to Improve input use efficiency and to sustain rice system productivity	SP Singh B Sreedevi, KV Rao, RM Kumar, PS Latha, GR Katti, N.Shobha Rani, B Nirmala, GS Laha, A Ramaprasad, N. Somasekhar, D. Subramanyam and Brajendra
RUE/ CP/ AG/10	Evaluation of the system of rice intensification (SRI) for its potential to save water and sustaining rice productivity	R Mahender Kumar V Ravindra Babu, L V SubbaRao, K.Surekha, P.C.Latha, Ch Padmavathi, N. Somasekhar, M Sreenivas Prasad, P Raghuveer Rao P.Muthuraman, S.Ravichandran, B. Nirmala, Shaik N Meera, B. Sailaja, S.P.Singh and B.C.Viraktamath
RUE/ CP/ AG/9	Studies on enhancing Phosphorus-use efficiency and rice crop productivity under a-biotic stress conditons	P Krishnamurthy B.Sreedevi, P. C. Latha, P Raghuveer Rao, P. Hemasankari, P. Venkata Reddy (ANGRAU), G. Padmavathi, N.Sarla, Brajendra
RUE/ CP/ AG/11	Management of sulphur nutrition in rice under rice based cropping systems for improving / sustaining productivity	B Sreedevi SP Singh, P Krishnamurthy, KV Rao, T Ram, PC Latha, V Jhansilakshmi, D Krishnaveni, P Hemasankari , M Anji Reddy (JNTU)

P5 SSP/: Sustaining rice system productivity Program leader : KV Rao		
SSP/CP/SS/6	Enhancing productivity of water in irrigated rice through integrated resource and crop management.	KV Rao K Surekha, SP Singh, P Hemashankari
SSP/CP/SS/7	Organic farming in Irrigated rice – influence on plant growth, productivity grain quality and soil health.	K Surekha KV Rao, PC Latha, N Shobha Rani , V Jhansi Lakshmi, D Krishnaveni, RM Kumar, N. Somasekhar
SSP/CP/SS/9	Assessment of soil quality for improved rice productivity	Brajendra K.V. Rao, K. Surekha and P.C. Latha
SSP/CP/SS/8	Rhizosphere micriobial community composition and root exudation patterns as influenced by rice genotypes and soil types	PC Latha, SR Voleti, RM Sundaram, K Surekha and P Krishnamurthy
P6 CCR/ : Assessing and managing crop response to climate change Program leader : SR Voleti		
CCR/CP/SS/10	Impact of changing temperatures on nitrogen dynamics and use efficiency in rice	M.B.B.Prasad Babu P.C.Latha, K.V.Rao
Plant Physiology CCR/CP/PP/9	Physiological studies on heat tolerance due to ambient and Elevated carbon dioxide in rice	SR Voleti PR Rao, B.Sailaja, N Somasekhar ,N. Shobharani, CN Neeraja,PC Latha, KV Rao/K Surekha, Chitra shanker, D Krishnaveni, Shaik N Meera and M. Vanaja (CRIDA)
CCR/CP/PP/10	Influence of host anthesis water stress on stem carbohydrate reserve mobilization in rice	D Subrahmanyam P Raghuveer Rao, AS Hari Prasad
P7 HRI/ : Host-plant resistance against insect pests and its management Program leader : JS Bentur		
HRI/CPT/ ENT/17	Host-plant resistance to gall midge in rice	JS Bentur CN Neeraja, K Suneetha, J Nagaraju (CDFD), Suresh Nair (ICGEB)
HRI/CPT/ ENT/11	New sources, mechanisms and genetics of resistance to brown planthopper, *Nilaparvata lugens* and whitebacked planthopper *Sogatella furcifera*	V. Jhansilakshmi J.S. Bentur, G.Padmavathi, K.Surekha
HRI/CPT/ ENT/18	Insect-plant interactions with special reference to yellow stem borer	AP Padmakumari SR Voleti, T Ram and Y Kondala Rao

HRI/CPT/ ENT/12	Dynamics of leaf folder- host plant - insecticide interactions	Ch Padmavathi G Katti, P. Raghuveer Rao, LV Subba Rao, M. Mohan
P8 HRP/ : Host-plant resistance against Pathogens and its management ***Program leader : MS Prasad***		
HRP/CPT/ PATH/15	Assessment of host plant resistance to rice blast disease and management through botanicals	MS Prasad CS Reddy, GSV Prasad, SM Balachandran and MS Madhav
HRP/CPT/ PATH/13	Assessment of resistant sources and monitoring of pathogen virulence in bacterial leaf blight of rice	GS Laha D Krishnaveni, RM Sundaram, CS Reddy,T Ram
HRP/CPT/ PATH/14	Assessment of host plant resistance and strainal variation in rice tungro disease	D Krishnaveni GS Laha, CS Reddy, GSV Prasad, Chitra Shanker, CN Neeraja
HRP/CPT/ PATH/17	Biology of false smut disease of rice	D.Ladhalakshmi C.S.Reddy, G.S.Laha, Satendra Kumar Mangrutia, P. Senguttuvel
P9 IPM/ : Integrated Pest Management ***Program leader : JS Prasad***		
HRI/CPT/ ENT/3	Chemical control of rice insect pests as a component of rice IPM	Gururaj Katti V Jhansi Lakshmi, A.P. Padmakumari, Chitra Shanker and Ch. Padmavathi
HRI/CPT/ ENT/13	Invertebrate biodiversity of irrigated ecosystem, its functional significance and potential for natural control of pests	Chitra Shanker Gururaj Katti, GS Laha, P Krishnamurthy, M. Mohan
HRI/CPT/ ENT/16	Microbes and their toxins for sustainable pest management in rice	M. Mohan JS Prasad, SM Balachandran, Chitra Shanker, PC Latha, V Jhansi Lakshmi, Ch Padmavathi, AP Padmakumari
HRI/CPT/ ENT/14	Investigations on plant parasitic nematodes in rice	JS Prasad N. Somasekhar, KS Varaprasad(NBPGR) and Y. Kondala Rao
HRI/CPT/ ENT/15	Evaluation of Entomopathogenic Nematodes for the Management of Insect	N Somasekhar JS Prasad, AP Padmakumari and G.

P10 TTI/ : Training, Transfer of Technology impact analysis *Program leader : Mangal Sain*		
TTI/TTT/ EXT/4	Impact of frontline demonstrations on adoption of improved rice production technologies Viz., System of Rice Intensification	Mangal Sain P Muthuraman, Shaik N Meera, B. Nirmala
TTI/TTT/ EXT/5	Research – Extension Linkages in Rice	P Muthuraman Mangal Sain, S Ravichandran, Shaik N Meera and B Nirmala
TTI/TTT/ EXT/6	Applications of E-Learning in Agriculture: Designing an ODL Content Management System for Rice Technologies	Shaik N Meera Mangal Sain, P Muthuraman and B Nirmala
TTI/TTT/ ECON/1	Yield gaps and constraints in rice production- An econometric analysis	B. Nirmala Mangal Sain, Shaik N Meera and B Sailaja
TTI/ CP/ CA/2	AICRIP database management system for DRR	B. Sailaja All PIs of AICRIP S. Ravichandran, Shaik N Meera, B.Nirmala and A.S. Ramprasad
TTI/ TTT/ STAT/2	Development artificial neural network (ANN) base forecasting model for studying rice yield and production	S. Ravichandran, P Muthuraman, V Ravindra Babu, R Mahendra Kumar

List of approved new projects

S.No	Project Title	Principal Investigator and Associates
i)	Development of crop growth models for simulating climate change response in irrigated ecosystems.	S.Ravichandran D.Subramanyam, B.Sailaja, P.Raghuveer Rao
ii)	Development of suitable agronomic management practices for aerobic rice	B. Sreedevi S.P.Singh, T. Ram, Brajendra, P. Hemasankari
iii)	Assessment and improving nitrogen use efficiency in irrigated rice	K.Surekha K.V.Rao, VP Bhadana, CN Neeraja
iv)	A study on awareness, perception and constraints in adoption of Integrated Pest Management in rice farming	Mangal Sain P. Muthuraman, Shaik N Meera, S. Arun Kumar
v)	Sustainable rice production practices: Problems and prospects	P. Muthuraman Shaik N Meera, Mangal Sain, S. Arun Kumar, S. Ravichandran
vi)	An Exploratory Study on Partnerships: Impact and Implications for the Rice Sector	S. Arun Kumar Shaik N Meera, P. Muthuraman, Mangal Sain, B.C. Viraktamath

Participation of scientist in National / International / Symposia/ Seminars/ Conferences

Chaitanya U, LV Subba Rao, I Sudharshan, Kiran babu , Chiranjeevi , N Shobha Rani and BC Viraktamath. 2011 "Enhancing Seed Replacement Rate through Scaled up Production and Distribution of Quality Paddy Seed – A Public Private Partnership Model." National Seed Congress on Quality seeds for Prosperity. 28-30th January 2011. College of Agril. Pune. Mahatma Phule Krishi Vidyapeeth, Rahuri.

Gururaj Katti. 2010. Current status and potential of biopesticides in pest management in rice. Lead paper presented at the Third Conference on 'Biopesticides:Emerging trends" BET 2010 organised by Society of Biopesticide Sciences, India at Hisar from 19-21 October 2010.

Hemanth Kishore V, I Subhakar Rao, P Balaji Suresh, SK Mangrauthia, Chitra Shanker, SM Balachandran, BC Viraktamath, D Krishnaveni, CN Neeraja. 2010. Insilico analysis of qRTV-7 region for the identification of putative candidate genes for Rice Tungro Disease Resistance. Invited lecture in National conference on "Biotechnology, Bioinformatics and Bioengineering" organized by Society for Applied Biotechnology (India) in association with Cropgene Technologies (India) Dharmapuri, Tamil Nadu from 17-18 December, 2010. P.No.48

Kumar PK, Pande and S Ravichandran. 2011. Genetic analysis for wood parameters in *Dalbergia sissoo* Roxb. In Proc. National seminar on Advances in wood science and technology research: Recent trends, future challenges and opportunities, March 9-10, 2011, Forest Research Institute, Dehradun, India.

Ladha lakshmi D, GS Laha, S Ram Singh, A Karthikeyan, RM Sundaram and BC Viraktamath. 2010. False smut - an emerging disease of rice in India. National Symposium on Molecular Approaches for Management of fungal diseases of crop plants at IIHR Bangalore from 27-30th December, 2010

Madhav Maganti S, G Ramkumar, A K Biswal, K Madhan Mohan, K Sakthivel, AKP Sivaranjani, CN Neeraja, SM Balachandran, RM Sundaram. 2010. "True" Allele Mining of three major Blast Resistance Genes in Rice. Poster presented in 3rd International Rice Congress (IRC2010), 8-12 November 2010 at Vietnam National Convention Centre, Hanoi, Vietnam, Abstract Sequence No. A 4102.

Mahender Kumar R . 2010. Paper presented in National Seminar on SRI organized by NABARD, Natural Resources Management Center, Calcutta, 16th- 20th July 2010

Mahender Kumar R. 2010. Paper presented in National Symposium on "Sustainable Rice Production system under change

climate" 26th - 29th November 2010.

Mahender Kumar R. 2010. Research experiences in SRI. Paper presented in National Workshop on " SRI in India. 17-20 July 2010, Calcutta by NABARD National Resources Management Center.

Mahender Kumar R. 2010. Presented paper at National Workshop on SRI in India Stock –taking and future Directions in the context of food security and climate change. 21-22 December 2010, ICRISAT, Hyderabad.

Mallikarjuna Swamy B P, K Kaladhar, K Anuradha, Anil K Batchu, T Longvah, BC Viraktamath and N Sarla. Feb 2011. Enhancing iron and zinc concentration in rice grains using wild species. 15th Annual ADNAT convention and International Symposium on Genomics and Biodiversity, CCMB, Hyderabad. Abstracts P75 (Best poster award)

Mallikarjuna Swamy BP, N Naga Deepthi, G Haritha, G Sandhya, Naik, T Sudhakar, G Ashok Reddy, Vandna Rai, N Shobha Rani, BC Viraktamath, N Sarla. 2011. Mapping yield enhancing QTLs in BC2F2 of *O. sativa* cv Swarna x *O. nivara* and using derived elite lines for gene discovery and breeding. 15th Annual ADNAT convention and International Symposium on Genomics and Biodiversity, CCMB, Hyderabad. Abstracts P76

Mangal Sain. 2011. Paper presentation on "Objectives and Minimum Content Requirements of RKMP content development for Uttar Pradesh" during Content Development Workshop held at NDUAT, Faizabad from 26-27th March, 2011.

Manimaran P, AK Tyagi, BC Viraktamath and SM Balachandran. 2010. Promoter activity of rice pollen specific gene *OsiPP3* in transgenic rice. A.P.Science Congress and Annual Convention of Andhra Pradesh Academy of Sciences, 18-20, November, 2010, JNTU, Hyderabad. Abstr: pp.97.

Nagarjuna Kumar R, K Srinivas Reddy, MS Nathawat and B Sailaja. 2010. Climate Change Implications on Water Resources in India. Lead paper in National Seminar on " Engineering Agriculture for evergreen revolution during September 24-25th 2010 organised by Indian Society of Engineers in association with ANGRAU, Hyderabad, CRIDA, Hyderabad. P 61-68.

Pandey Manish K, G Ram Kumar, K Shaktivel, MS Madhav, RM Sundaram, GS Varaprasad, V Ravindra Babu, N Shobha Rani, AKP Sivaranjini. 2010. Diversity analysis using est-ssr and (gata)n motif specific ssr markers in indian basmati rices (o. sativa l.) Poster presented in 3rd International Rice Congress (IRC2010), 8-12 November 2010 at Vietnam National Convention Centre, Hanoi, Vietnam, Abstract Sequence No. 4105.

Pandey Manish K, N Shobha Rani, RM Sundaram, GS Laha, GS Varaprasad, K Srinivasa Rao, I Sudharshan, BC Viraktamath. 2010. "Marker-Assisted Introgression of Bacterial Blight Resistance into Elite

Indian Traditional and Evolved Basmati Rice (O. sativa L.)". Poster presented in 3rd International Rice Congress (IRC2010), 8-12 November 2010 at Vietnam National Convention Centre, Hanoi, Vietnam, Abstract Sequence No. 4100. Prasad Babu A, C Surendhar Reddy, BP Mallikarjuna Swamy, T Sudhakar, MS Ramesha, BC Viraktamath, N Sarla. 2010. Functional genomics and marker assisted backcrossing of a yield enhancing QTL *yld2.1* from *Oryza rufipogon* into a popular restorer KMR3. Third National Congress on Plant Breeding and Genomics Tamil Nadu Agricultural University, Coimbatore, July7-9, 2010.

Prasad JS and Katti G. 2010. Bio-rational pest management in rice. Lead paper presented in: National Symposium on Emerging trends in Pest Management under Changing Climatic Scenario, 20-21, organized by Society for Plant Protection and Environment, Department of Entomology, College of Agriculture, Orissa University of Agriculture and Technology (OUAT).

Prasad JS, M Jena and M Variar. 2010. Pest and disease scenario of rice under changed climate and management strategies. Proceedings of National Symposium on Sustainable rice production under changing climate". Nov 26-29, 2010, CRRI, Cuttack.

Raghuveer Rao P, D Subrahmanyam, B Sailaja, RP Singh, V Ravichandran, Padmini Swain, Somnath Saha, S Nadarajan, PJR Reddy, A Shukla, PC Dey, DP Patel, S Ravichandran, SR Voleti and BC Viraktamath. 2010. Paper presented on "Influence of boron on spikelet fertility under varied soil conditions in rice (*oryza sativa*.L)" pp 92. Science, Technology, education for prosperity 18-20 Nov., at JNTU, Hyderabad-85.

Ram T, V Jhansi Lakshami, Ramdeen and BC Viraktamath. 2010. Genetics of BPH resistance and development of resistant varieties for coastal saline areas in India. Poster presented in 3rd International Rice Congress from 9-11 November 2010 held at Vietnam National Convention Center, Hanoi, Vietnam.

Rao PR, D Subramaniyam, B Sailaja, RP Singh, V Ravichandran, , Padminiswain Somanath Saha, S Nadarajan, , PJR Reddy, A Shukla, , PC Dey, , DP Patel, , S Ravichandran, SR Voleti and BC Viractmath. 2010. Influence of boron on spikelet fertility under varied soil conditions in rice (Oryza sativa L). PP 92. Science, Technology, Education for Prosperity 18-20 Nov, at JNTU, Hyderabad -85.

Ratna Madhavi K, K Madhan Mohan, B Aruna Kanthi, BC Viraktamath, CS Reddy and M Srinivas Prasad. 2010. "Marker assited backcross breeding for the development of Blast and Bacterial leaf Blight resistance in the elite *indica* variety" Paper presented in The III National Congress on Plant breeding and genomics organized by TNAU Coimbatore 7-9th July, 2010.

Ravichandran S and V Ravindra Babu. 2011. "ANN modelling and its application in

clustering". Paper presented during the 13th Annual Conference of Society of Statistics, Computer and Applications organized at NAARM, Hyderabad during 24-26 February, 2011.

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Conference, Vietnam, Nov. 9-11, 2010. Abstract No. 3923.

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Surekha K, PC Latha, KV Rao, RM Kumar, N Shobharani, and BC Viraktamath. 2010. Organic Farming in Rice- Influence on Productivity, Grain Quality, Soil Health and Economic Returns. Paper (Poster) presented at 28th IRRC in 3rd IRC on "Rice for future generations" organized by IRRI at Hanoi, Vietnam during 8-12 November 2010. Abstract Sequence No. 3790.

Varaprasad GS and N Shobha Rani, 2011. Rice Quality. Presentation at National Seminar on Quality Measurement of Aromatic Rice by Electronic Nose and Vision System at Centre of Development of Advanced Computing, Kolkata on 31-1-2011.

Viraktamath BC and LV Subba Rao. 2010. Participated and presented a paper on "Genetic enhancement of rice yield potential under changing climate - A breeder's approach" at National Symposium on "Sustainable Rice Production system under changed climate from 27 to 29th Nov.2010 at CRRI , Cuttack.

Viraktamath BC, MS Ramesha, AS Hariprasad,

CN Neeraja, N Sarla and RM Sundaram. 2010. Biotechnological applications for hybrid rice improvement. International Rice Conference, Hanoi Nov 8-11, 2010 Abstract 3842, p78.

All India Radio talks

Mangal Sain (2010). Dhan kee phasal mae keedo ka prabandh. Radio talk prepared and broadcasted by all India radio Hyderabad on 23rd February 2010

Shobha Rani N. 2010. Radio Talk on "Rabi rice varieties and DRR's role", All India Radio (AIR), Hyderabad – 500 030 on 25th Nov, 2010.

Shobha Rani N. 2010. Radio Talk on "Rice varieties suitable for Telangana areas during Kharif season " , All India Radio (AIR), Hyderabad – 500 030 on 25th Nov, 2010.

Shobha Rani, N.2011. "Vari Vittanothpathi" Radio talk prepared for All India Radio on 6th January 2011.

Training/workshops attended within India

Drs. Brajendra, Latha PC, Mohan M, Neeraja CN, Padmakumari AP, Raghuveer Rao P , Sailaja B , Somasekhar N, Subba Rao LV , Subrahmanyam D , Sunetha K , Revathi P, Vandana Rai, Arun Kumar S and Sampath Kumar attended seven days training programme on "Statistical computing system for NARS-*Data Analysis using SAS*" at NAARM Hyderabad.

Balachandran SM and RM Sundaram attended ADNAT Symposium on, "Genomics and Biodiversity" at CCMB, Hyderabad, during 23-25, March, 2011.

Gururaj Katti participated in the five days Management Development Programme (MDP) on, "Managing quality in Agricultural Research System" organized at Indian Institute of Management, Lucknow from October 25-29, 2010.

Viraktamath BC, R Mahender Kumar, B Sailaja and K Surekha participated in the" RKMP-IRRI workshop on Knowledge Management Collaboration" organized by UAS-B, DRR (ICAR) and IRRI at UAS, Bengaluru during 18-19 February 2011.

Mahender Kumar R Visited the BLB infested areas in Sreevellapally Mandal of Kurnool district of A.P and evaluated the performance of R.P.Bio. Farmers advised proper management of BLB in these areas

Mahender Kumar R attended all the A.P SRI consortium meetings organized by DOA and WASSAN at DRR and Directorate of Agriculture

Mahender Kumar R Participated in State level NABARD meeting on Adoption SRI in A.P (31st December 2010).

Mahender Kumar R Participated in the NAIP-KM Project Workshop on Content Development organized by ICRISAT during 14-15 December 2010 at ICRISAT, Patancheru, Hyderabad, India .

Mahender Kumar R Participated in the National work shop on "SRI in India- Stock taking and Future directions in the context of Food Security and climate change" organised by WWF and ICRISAT during

21-22 December 2010 at ICRISAT, Patancheru, Hyderabad, India.

Mahender Kumar R participated in the" RKMP-IRRI workshop on Knowledge Management Collaboration" organized by UAS-B, DRR (ICAR) and IRRI at UAS, Bengaluru during 18-19 February 2011.

Mohan M attended one day training program on "Questel's search Engine for patent search" on 27th April 2010, organised by Siddhast IP Innovations at India Habitat Centre, New Delhi

Mohan M participated in brainstorming workshop on "Prospects of Nanotechnology in Agri-value Chain" on Feb 22nd, 2001, organised by NAARM, Rajendranagar, Hyderabad

Mohan M participated in Sensitization Training Workshop on "Bioinformatics and its various applications" from 8th to 12th Nov 2010 at NBAII, Bangalore

Neeraja CN participated in training workshop program on "*Crop Gene Expression Analysis and structural Bioinformatics*" from March 1-11, 2011 at NBPGR, New Delhi organized by National Agricultural Bioinformatics Grid (NAIP)

Prasad JS participated in Interface meeting on Data Sharing & Data Management, Nov. 23, 2010, NAAS, New Delhi.

Prasad Babu MBB attended a training program on "Use of ICT in PME of NAIP Projects" at MANAGE, Hyderabad during 07-11 Feb, 2011.

Prasad JS attended Directors' Conference, ICAR, New Delhi, Feb. 23-24, 2011.

Prasad JS participated in meeting of National Agricultural Bio-security network (NABN) institutions. Mar. 22-23, 2011.

Prasad JS participated in meeting on collaborative project on morphological and molecular characterization of rice root-knot nematode, July 29, 2010.

Prasad JS participated in workshop on "Approved use of pesticides in Agriculture", DAC, Min. of Agriculture, New Delhi, Aug. 30, 2010.

Sailaja B partcipated in "Geospatial World Forum 2011" during 18th 21st January 2011, NOVATEL, Hitex, Hyderabad.

Sailaja, B. participated in Interactive meet on 'Information and Communication Technology in ICAR' during November 3-4, 2010 at NASC Complex, New Delhi.

Sailaja B participated in the meeting on AGROWEB on 18th September 2010 at CRIDA, Hyderabad with Partner organisations.

Sundaram RM, SM Balachandran and AS Hariprasad attended ICAR-Industry Meet conducted by ICAR at New Delhi from 28-29 July 2010.

Sundaram RM and AS Hariprasad attended the ZTM and BPD meeting cum workshop conducted by ZTMU, CIFT-Cochin from 4-6 March 2011.

Suneetha K attended training programme on "Communication and Presentation skills for Scientists" sponsored by Department

of Science and Technology, New Delhi and organized by Xavier Institute of Management, Bhubaneswar from 23rd to 28th August, 2010.

Suneetha K participated in awareness programme on "Maintenance breeding in crop improvement, DUS testing for registration and protection of varieties under PPV & FR act and Geographical indications: Identification and process of registration" held at ANGRAU, Hyderabad from 27th to 29th January, 2011

Vandana Rai attended a CEG Training course "Molecular Tools for Crop Improvement" on 10-21 May 2010, at ICRISAT Campus, Hyderabad.

Vandana Rai attended one day partners meet on National Bioinformatics Grid at NBPGR, New Delhi on 7th August 2010.

Deputations/Visits Abroad

Dr Shaik N Meera, Senior Scientist visited IOWA State University, IOWA, USA for 22 days from 7-28, October 2010 to attend the training on NAIP sponsored project "Development and maintenance of Rice Knowledge Management Portal".

Dr J S Bentur, Principal Scientist visited IRRI , Philippines to participate in the International Workshop on "New paradigms in Rice hopper resistance" (18-31, October 2010).

Drs B. C. Viraktamath, Project Director**, N. Sarala, T. Ram and K. Surekha** Principal Scientists attended the 3rd International Rice Congress during 8-12 November, 2010.

Dr B. C. Viraktamath, Project Director was deputed to Sri Lanka for attending the 3rd BIMSTEC meeting at Kandy during 22-23 November, 2010.

Dr. Vandna Rai, Sr. Scientist deputed to Japan for a period of 3 months w.e.f 15.10.2010 to attend the DST-JSPS Science & Technology programme.

Distinguished Visitors

Name	Affiliation	Dates
Dr. S.S. Virmani	Ex-Head, PBGB, IRRI, Philippines	24th March, 2010
Dr. Bangali Baboo	National Director, NAIP, New Delhi	8th July, 2010
44 ARS probationers (90th batch of FOCARS)	NAARM, Hyderabad	5th August, 2010.
Team from US Consulate	US Embassy, Mumbai	22nd September, 2010.
Dr. D.S. Brar	Head, PBGB, IRRI	25th October, 2010
Karabi Datta	Dept. of Botany, University of Calcutta	29th October, 2010.
Team of administrative/accounts trainees	NAARM	20th November, 2010.
20 member participants of International Training Program me on "Natural Resource Management for Sustainable Livelihoods"	NIRD	18th November, 2010
Mozambique delegation	ICRISAT	20th December, 2010.
Sh. Tanay Joshi	JD, Department of Agriculture & Cooperation	28th December, 2010.
Dr.R.S.Zeigler	DG, IRRI	5th January, 2011.
DR. J. K. Ladha,	India Representative, IRRI-India Office	5th January, 2011.
Dr. David Hohnson	Agronomist, IRRI	11th February 2011
Dr David Shires	RKB, IRRI, Philippines	21st February, 2011.
Afghanistan Team		28th February, 2011.
Afghanistan officials	FAO,	9th March, 2011.
Dr. Zakavia L. Kanyeko and Dr. Y.P. Singh	IRRI, Tanzania	15th March, 2011.
Dr. Achim Doberman	DDG (Research), IRRI	
Dr. D.S. Brar	Head, PBGB, IRRI	
Dr. Melissa Fitzergald	Head, Quality Lab IRRI	
Dr. Finbarr Horgan	Entomologist, IRRI	
Dr. Ngachan	Director, ICAR Research Complex, Barapani	11th May, 2011.

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(as on 31-03-2011)

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