CSSRI

वार्षिक प्रतिवेदन
Annual Report
2013-14

CENTRAL SOIL SALINITY RESEARCH INSTITUTE
KARNAL – 132 001 (INDIA)

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PREFACE

Government of India in its policy statement has emphasized that agricultural land being diverted to other sectors of economy will be compensated through reclamation of degraded lands. Since salt affected soils constitute a major fraction of degraded lands, reclamation and management of salt affected soils can help to achieve the objective underlining this policy statement. Reclamation and management of 6.73 M ha salt affected soils in the country would not only turn a threat into an opportunity but will also contribute significantly in achieving food and nutritional security. The institute has already developed a basket of credit worthy location specific technologies which can be applied to reclaim all kinds of salty lands in the country. Nevertheless, institute is conscious of problems expanding its tenterhooks to new areas in the irrigation commands and also of their increasing complexity with multiple stresses emerging with passage of time. Besides, solutions acceptable only one/two decades back do not find favour as several new challenges have emerged only recently. It has placed a great responsibility on the institute to search for new technologies that are acceptable to the people in terms of economics besides being environmental and farmer's friendly.

During the year 2013-14, we pursued on-going programmes and also spent considerable time in thinking, discussing and planning new research activities to sustain agriculture in saline environment. It was also the year when considerable emphasis was laid on infrastructural development and renovation. Amongst many important achievements, formulation of "CSR-BIO" a potential bio-growth enhancer in normal and sodic soils was commercially licensed and MoUs were signed with three industrial firms for its large scale production and marketing. An integrated farming system model developed for livelihood security of small farm holders has been tested and finalized under farmer's participatory mode. New research initiatives include carbon sequestation, solid waste utilization, use of highly saline water through bio-saline agriculture, efficacy of pressurized irrigation for rice-wheat system and studies on salt tolerance of rootstocks of guava and mango.

To disseminate institute technologies to the farming community as well as providing farmers an opportunity to purchase seeds of promising crop varieties, two *Kisan Melas* were organized during the year. The *kharif Kisan Mela* was organized at Nain farm (Panipat district) on 15th October, 2013. It was inaugurated by Dr. A.K. Sikka, DDG (NRM), ICAR, New Delhi. *Rabi Kisan Mela* was organized at the institute on 10th March, 2014, which was inaugurated by Padma Bhushan Dr. R.S. Paroda, Former Director General, ICAR, New Delhi and Chaiman, Haryana Kisan Ayog. On March 1, 2014, the Foundation Day of the institute was celebrated with a Foundation Day Lecture by Dr. V.N. Sharda, Member, ASRB, New Delhi.

A number of human resource development and capacity building programmes were organized during the year. One week international training on land drainage for the Engineers from Iraq was organized from April 15- 21, 2013. Eighteen senior engineers from the Department of Irrigation and Reclamation, Government of Iraq led by Mr. Nabeel Jassim Mohammed, Senior Chief Engineer, participated in the training programme. The training was organized under the aegis of India Iraq Economic Cooperation Council (IIECC), New Delhi. It was inaugurated by Dr. J.S. Samra, CEO, National Rainfed Area Authority (GOI), New Delhi. Two weeks international training programme on Use of Poor Quality Water in Agriculture for member countries of Afro-Asian Rural Development Organization (AARDO) was conducted during December 11-24, 2013. Dr. A. K. Sikka, DDG (NRM), New Delhi inaugurated the programme, His Excellency Er. Wassfi Hasan El Sreihin, General Secretary, AARDO, New Delhi presided over the function. Dr. Gurbachan Singh, Chairman, ASRB, New Delhi inaugurated the 21 days Summer School on 'Technological Innovation for Shaping Future Agriculture in Salt Affected Areas' on June 4, 2013. A Brainstorming Session on Climate Change Impact on Salt Affected Soils and Crop Productivity to Commemorate the Earthday-2013 was inaugurated by Sh. Paritosh Tyagi, Former Chairman, Central Pollution Control Board, GOI and Chairman IDC Foundation. A stakeholders meeting on promoting resilient diversification option through maize and climate smart practices was organized at the Institute under the auspicious of CGIAR Research Programme on Climate Change, Agriculture and Food Security (CCAFS) on 20th May, 2013. The meeting was inaugurated by Hon'ble Dr. R.S. Paroda, Chairman, Haryana Kisan Ayog. A team of sixteen stakeholders from four African countries *viz;* Tanzania, Kenya, Ethiopia and Zimbabwe visited the Institute on 09.05.2013 under the auspices of Australian Council of International Agricultural Research (ACIAR). Five days' training programme for CADA Officers on Use of Modern Tools in Water Management was organised during August 19-23, 2013, which was inaugurated by Dr. Rameshwar Singh Project Director, DKMA, New Delhi. A three days Regional Expert Consultation Meeting on Best Practices and Procedures of Saline Soil Reclamation System in SAARC Region was organized jointly by SAARC Agriculture Centre, Dhaka and CSSRI, Karnal during November 27-29, 2013 which was inaugurated by Dr. I.P. Abrol, Director, Centre for Advancement of Sustainable Agriculture, New Delhi.

A National Symposium was organized by the Indian Society of Coastal Agricultural Research, Canning Town (West Bengal) in collaboration with CSSRI, Karnal at the Regional Research Station, Bharuch during December 11-14, 2013 to deliberate the issues pertaining to problems related to soil, water, crop and livestock and devise strategies to overcome them for maximizing production in the coastal regions, particularly under the climate change scenario. The symposium was inaugurated by Dr. N.K. Tyagi, former Member, ASRB, New Delhi. The XXIII biennial workshop of AICRP on Management of Salt Affected Soils and Use of Saline Water in Agriculture was held at UAS, Raichur during June 20-22, 2013. Prof. S.S. Khanna, Ex-Vice Chancellor and Ex-Advisor, Planning Commission was the Chief Guest while Prof. B.V. Patil, Vice-Chancellor, UAS, Raichur presided over the function.

Several programmes were organized to transfer the institute technologies and to popularize the use of Hindi in transfer of technologies and administration. Nine field exhibitions were organized at various places comprising of research institutions and developmental agencies highlighting the technologies on reclamation and management of salt affected soils and use of poor quality waters in agriculture. A total of 2729 stakeholders in 86 groups visited the Information Technology Centre and Institute Research Experimental farm. They were explained the field studies and research works going on at the institute and provided technical know-how for reclamation and management of salt affected soil and poor quality water. Six farmers' day was organized at the farmers' field.

We had the opportunity to receive a number of dignitaries and experts and to show and discuss with them our research experiments and plans. The notable visitors who visited the institute and Regional Research Stations during this period included Dr. S Ayyappan, Secretary DARE and DG, ICAR; Dr. J.S. Samra, CEO, NRAA, New Delhi; S. Pripuran Singh Hear, Former Indian Ambassador to Iran; Dr. A.K. Sikka, DDG (NRM), ICAR New Delhi; Dr. R.S.Paroda, Chairman, Haryana Kisan Ayog; Dr. R.B. Singh, President, NAAS, New Delhi; Dr. A.R. Pathak, Vice-Chancellor, NAU, Navsari; Dr. J.S.Sandhu, Agriculture Commissioner, Govt. of India; Dr. B. Mohan Kumar, ADG (A &AF), ICAR, New Delhi, Dr. S.K.Chaudhari, ADG (S&WM), Dr. N.K. Tyagi, former Member, ASRB, New Delhi; Dr. B. Mishra, former Vice Chancellor of SKUAST, Jammu; Sh. Paritosh Tyagi, Former Chairman, Central Pollution Control Board, GOI and Chairman IDC Foundation and Dr. K.D. Kokate, DDG (Ag. Extn.).

During this period, Dr. D.K. Sharma and his team received Hari Om Ashram Trust Award 2010-11, and Other Scientist also got the various awards and recognition. The institute scientists published 86 peer reviewed research papers in international and national Journals while 7 books and manuals were also brought out. Nine technical reports and 15 bulletins and folders were published by the institute. Under various faculty improvement programmes, institute scientists had the opportunity to visit international organizations in 19 visits.

The XII plan EFC was approved. A major highlight is that 4 new AICRP centres (Bathinda, Panvel, Vyttila and Port Blair) were sanctioned for reclamation and management of inland and coastal salinity. A number of colleagues retired from service after rendering meritorious service to the institute during this period. We wish them a very healthy and happy retired life. Two principal Scientists, two senior scientists and two scientist joined the institute. We congratulate them and wish them all the best for their future professional advancement.

The guidance and overwhelming support received from Dr. S. Ayyappan, Secretary, DARE and DG, ICAR; Sh. Arvind Kaushal Addl. Secretary, DARE, and Secretary, ICAR; Dr. A.K. Sikka, DDG (NRM), Dr. B. Mohan Kumar ADG (A&AF) and Dr. S.K. Chaudhari, ADG (S&WM) is gratefully acknowledged. Dr. Anil R. Chinchmalatpure, OIC (PME), Dr. A.K.Bhardwaj, Dr. Anshuman Singh and Dr. Randhir Singh (Chief Technical Officer) shared the major responsibility of synthesizing, editing and getting the annual report printed. I had a special word of thanks for them. Dr. S.K. Tyagi and Dr.R.S. Tripathi helped in Hindi translation of the Executive Summary of the report. The efforts of these and other colleagues who provided the material for timely publication of the report are highly appreciated.

I firmly believe that the information contained in the report would not only update the readers and our peers about the institute's activities but would be quite useful to them as many recent scientific and technical developments have been included. While our esteemed readers including researchers/planners and other stakeholders may take note of our achievements during the year 2013-14, any feedback and suggestions/comments from them is welcome so that the same can be incorporated in our future publications. We would continue to strive hard to refine our research programmes to meet the goals set in under the new policy framework by Government of India and in serving the farming community in the coming years.

June 25, 2014

(D.K. Sharma)
Director

CONTENTS

सारांश

वर्ष 1969 में करनाल (हरियाणा) में स्थापित केन्द्रीय मृदा लवणता अनुसंधान संस्थान एक प्रमुख अनुसंधान संगठन है यह देश के विभिन्न कृषि पारिस्थितिकी क्षेत्रों में लवणता प्रबंधन एवं कृषि में निम्न गुणवत्ता वाले जल के प्रयोग पर बहुविषयक अनुसंधान कार्यों के लिए समर्पित है मुख्यालय में बहुविषयक अनुसंधान कार्यक्रम चार विभागों–मृदा एवं फसल प्रबंध, सिंचाई एवं जलनिकास अभियांत्रिकी, फसल सुधार और प्रौद्योगिकी मूल्यांकन एवं प्रसार द्वारा संचालित किये जाते हैं। विभिन्न कृषि जलवायु क्षेत्रों की विनिर्दिष्ट अनुसंधान आवश्यकताओं को पूरा करने के लिए संस्थान के तीन क्षेत्रीय अनुसंधान केन्द्र–केनिंग टाउन (प. बंगाल), भरूच (गुजरात) और लखनऊ (उत्तर प्रदेश) क्रमशः समुद्र तटीय लवणता, लवणग्रस्त वर्टीसोल और छिछले जल स्तर वाली मध्य एवं पूर्वी सिंधु–गंगा के मैदानों की क्षारीय मृदा संबंधी समस्याओं के निदान हेतु कार्यरत हैं। संस्थान में एक अखिल भारतीय समन्वित परियोजना लवणग्रस्त भूमियों के प्रबंधन और खारे पानी के कृषि में प्रयोग हेतु विभिन्न पारिस्थितिकी क्षेत्रों–आगरा, कानपुर, हिसार, इंदौर, बीकानेर, वापटला, गंगावटी और त्रिचुरापल्ली में कार्यरत हैं। संदर्भित अवधि के लिए विभिन्न महत्वपूर्ण क्षेत्रों में संस्थान की कुछ प्रमुख अनुसंधान उपलब्धियाँ निम्नांकित हैं।

केन्द्रीय हरियाणा में लवण प्रभावित मिट्टी का मानचित्रीकरण और लक्षण

हरियाणा के कैथल जिले की लवण प्रभावित मिट्टी के मानचित्रीकरण और लक्षण वर्णन के लिए रिमोट सेंसिंग और जीआईएस का उपयोग किया गया। क्षारीय और लवणीय मिट्टी ने कुल भौगोलिक क्षेत्रफल का क्रमशः 6.8 व 4.4 प्रतिशत भाग शामिल किया। ब्लॉक वार वितरण ने दर्शाया कि कैथल और कलायत ब्लॉक के बाद पूंडरी, राजोंद, गुहला और सिवान ब्लॉक में काफी क्षेत्र है। जबकि कैथल उपखण्ड में कुल भौगोलिक क्षेत्र का 9 प्रतिशत भाग तथा गुहला और सिवान ब्लॉक में यह केवल 2.3 प्रतिशत लवण प्रभावित है।

आंशिक रूप से सुधरी क्षारीय मिट्टी में धान–गेहूँ फसल प्रणाली में फसलों की उत्पादकता पर संसाधन संरक्षण

आंशिक रूप से सुधरी क्षारीय मृदाओं में मिट्टी और जल प्रबंधन द्वारा फसल उत्पादकता को बढ़ाने और मृदा स्वास्थ्य को बनाये रखने के लिए संसाधन संरक्षण प्रौद्योगिकियों जैसे धान की सीधी बुआई (डीएसआर), कम जुताई, मृदा में अवशेष प्रबन्धन के मूल्यांकन पर एक अध्ययन किया गया। 0.4 हेक्टेयर क्षेत्र में 12960 लीटर/घण्टा/एकड़ के निर्वहन दर और 2 किलोग्राम से. मी. दवाब व 90 प्रतिशत की एकरुपता गुणांक वाली एक छोटी फव्वारा सिंचाई प्रणाली स्थापित की गई। गेहूँ की फसल में सिंचाई का समय निर्धारण 7 दिनों की संचयी पैन वाष्पीकरण के आधार पर किया गया। फव्वारा सिंचाई प्रणाली ने सतही सिंचाई प्रणाली की तुलना में 38.85 प्रतिशत पानी बचाया। सतही सिंचाई प्रणाली के तहत जीरो टिलेज के साथ पुराल पलवार में गेहूँ की अधिकतम उपज (5.38 टन प्रति हे॰) प्राप्त हुई जबकि छोटी फव्वारा सिंचाई के तहत जीरो टिलेज के साथ पुराल पलवार में यह (5.13 टन प्रति हे॰) हुई। गेहूँ में पारंपरिक सिंचाई की तुलना में छोटी फव्वारा प्रणाली के प्रयोग द्वारा विद्युत ऊर्जा की 2.16 प्रतिशत बचत की जा सकती है। फव्वारा व फसल अवशेष प्रबंधन के साथ डीएसआर के अंतर्गत धान की उपज सतही सिंचाई के साथ पारम्परिक धान रोपाई के समान थी। इससे 57.9 प्रतिशत जल की बचत हुई। सतही सिंचाई के साथ संसाधन संरक्षण तकनीक के अंतर्गत जल उत्पादकता 0.95 किलोग्राम प्रति घन मीटर थी जो कि फव्वारा सिंचाई के साथ धान की सीधी बुआई में बढ़कर 2.18 किलोग्राम प्रति घन मीटर हो गई।

किसान की भागीदारी में सुधारी गई क्षारीय भूमि पर बहुउद्देशीय कृषि मॉडल का निष्पादन

कई उद्यमों/घटकों के साथ बहु उद्यम कृषि मॉडल छोटे खेतों में पानी, पोषक तत्व और ऊर्जा के एकीकृत प्रयोग के माध्यम से उच्च उत्पादकता और लाभप्रदता को पाने के लिए मार्ग प्रशस्त कर सकता है। मॉडल की स्वीकार्यता, व्यवहार्यता और स्थिरता को जांचने के लिए किसान की भागीदारी में केन्द्रीय मृदा लवणता अनुसंधान संस्थान करनाल के फार्म पर इसका मूल्यांकन किया गया। यह पाया गया कि बहुउद्देशीय कृषि प्रणाली में विभिन्न घटकों के सह उत्पादों/अवशेषों के पुनर्चक्रण से उत्पादन लागत में कमी की जा सकती है और यह आय व रोजगार का एक नियमित साधन है। दो हेक्टेयर भूमि से 3,03,486 रूपये के औसत खर्च के साथ 5,29,317 रूपये का औसत राजस्व प्राप्त हुआ। इस प्रकार 2,25,831 रूपये का शुद्ध लाभ प्राप्त हुआ। जुलाई 2011 से जून 2013 की अवधि में फसल घटकों से कुल 2,15,127 रूपये व सहायक घटकों से 3,14,191 रूपये की सकल आय प्राप्त हुई। मछली घटक 4.80 लागत–लाभ अनुपात के साथ काफी लाभप्रद है। एक वर्ष में मछली उत्पादकता 3.8 टन प्रति हेक्टेयर आंकी गई। एक्वा तालों से प्रजाति वसूली क्रमशः कॉमन कार्प > ग्रास कार्प > कतला > रोहू > म्रिगल के क्रम में प्राप्त हुयी। मछलियों का औसत भार 750 से 1000 ग्राम के बीच पाया गया।

हरियाणा में उपसतह जल निकासी परियाजनाओं का मूल्यांकन

सिवानामाल (जिला जींद) और मोखराखेड़ी (जिला रोहतक) में नव स्थापित भूमिगत जल निकास प्रणाली के प्रभाव का मूल्यांकन किया गया। इन जगहों के कई ब्लॉक में नियमित रूप से पंप सुविधा लागू नहीं की गई है फिर भी चयनित स्थानों

पर सुधार नजर आता है। मई 2013 के दौरान मोखराखेड़ी परियोजना क्षेत्र के चयनित ब्लॉकों में भूजल गहराई, जल निकास तथा जल की गुणवत्ता के विभिन्न मापदंडों के परिणाम दर्शाते हैं कि अपर्याप्त पम्पिंग के कारण जल स्तर ऊपर तथा उच्च लवणता 1.66 से 21.1 डेसी सीमन प्रति मीटर रही। अत्याधिक लवणीय निष्कासित जल (ईसी > 20 डेसी सीमन प्रति मीटर) का एसएआर भी (8.3 से 62.2) बहुत अधिक था।

हरियाणा में जलवायु परिवर्तन के प्रभाव को कम करने के लिए भूजल संसाधन प्रबंधन

यह परियोजना हरियाणा में भूजल निकास को कम करने के नवीन कृषि हस्तक्षेप व भूजल जलभृत की प्राकृतिक रिचाजिंग पर उसके प्रभाव का विस्तृत पानी और नमक संतुलन विश्लेषण के माध्यम से अध्ययन करने के लिए शुरू की गई। विभिन्न फसल प्रणालियों के तहत भूजल पुनर्भरण पर पातन और सिंचाई का प्रभाव जांचने के लिए दो अध्ययन स्थलों ताजे जल के लिए केन्द्रीय मृदा लवणता अनुसंधान संस्थान को फार्म व उथले लवणीय भूजल के लिए नैन फार्म का चयन किया गया। मानसून की अवधि के दौरान अधिक वर्षा और सिंचाई द्वारा अगस्त से अक्तूबर 2013 के बीच प्राकृतिक रिचार्ज होने से सभी प्रेक्षण कुओं में जल स्तर में वृद्धि पायी गई। जुलाई और अगस्त के दौरान समान रूप से वितरित वर्षा में भी धान की फसल को पानी की आवश्यकताओं के प्रमुख हिस्से को पूरा कर भूजल की खिंचाई में कमी ला कर घट रहे भूजल स्तर को और अधिक गिरने से रोकने में योगदान दिया। कृषि की दो तकनीकों जुताई और शून्य जुताई दशाओं में धान की सीधी बुआई को अपनाया गया। सिंचाई का समय निर्धारण 15, 30 व 45 कि. पास्कल चूषण पर आधारित था जिसे इरोमीटर द्वारा लगातार मापा गया। मृदा मैट्रिक संभाव्य के पूर्वनिर्धारित स्तर 15 से. मी. गहराई पर पहुंचते ही सिंचाई की गई। लगातार सिंचाई किए जाने से फसल उत्पादन में वर्षा जल का लाभप्रद उपयोग नहीं हुआ। अन्य भूखंडों की तुलना में शून्य जुताई धान में अधिक जल उत्पादकता (0.28 कि. ग्रा. प्रति घन मीटर) पायी गई।

गैर खाद्य फसलों में अपशिष्ट जल का उपयोग

सफेदा *(एयूक्लिप्टिस टिरिटिकोरनिस)* और नींबू धास *(सिमबोपोगन फल्कयूओससं)* को लगातार अपशिष्ट जल को निपटाने के लिए सुरक्षित संभाव्य विकल्प के रूप मे मूल्यांकन किया गया। अपशिष्ट जल सिंचाई द्वारा नलकूप सिंचाई और वर्षा आधारित स्थितियों की तुलना में वृक्षों के विकास में सुधार हुआ। हालांकि विकास में उल्लेखनीय वृद्धि अपशिष्ट जल सिंचाई की बढ़ती आवृत्ति के साथ केवल आई डब्ल्यू/सीपीई अनुपात 2.0 तक ही दर्ज की गई। नलकूप जल और अपशिष्ट जल सिंचाई की बढ़ती आवृत्ति 0.6 से 1.2 आई डब्ल्यू/सीपीई तक नींबू घास की ताजा और सूखे बायोमास में क्रमशः 3.03 से 4.13 और 3.53 से 4.76 कि. ग्रा. प्रति घन मीटर की वृद्धि हुई। नींबू घास की आवश्यक तेल उपज में भी आई डब्ल्यू/सीपीई अनुपात 1.2 तक अपशिष्ट जल प्रयोग को बढ़ाने और उसके उपरांत नलकूप व सीवेज को चक्रीय मोड में प्रयोग करने पर वृद्धि हुई। हालांकि नलकूप जल और अपशिष्ट सिंचाई की निम्न व्यवस्थाओं और मोड में अपशिष्ट जल के प्रयोग में हुई वृद्धि के साथ नींबू घास के आवश्यक तेल में भारी धातुओं की मात्रा में वृद्धि हुई परन्तु यह वृद्धि अनुमेय स्तर के भीतर ही रही।

आस्ट्रेलिया और भारत में जलरूद्यता, लवणता और तत्त्व विषाक्तता के लिए गेहूँ का सुधार

निम्न जीनोटाइप में अंतर प्रतिक्रिया के साथ सामान्य और क्षारीय मृदा दोनों में जलरूद्यता ने अनाज पैदावार को कम किया। सामान्य सूक्ष्म भूखंडों में जीनोटाइप केआरएल 210 में उच्चतम उपज प्रदान की इसके बाद डीवी डब्ल्यू 17, केआरएल 238, केआरएल 3–4 और केआरएल 240 का स्थान रहा। जलरूद्यता के कारण अनाज की उपज में सबसे अधिक कमी एन डब्ल्यू 4018 में 42 प्रतिशत रही जबकि केआरएल 210 और खरचिया 65 में न्यूनतम कमी क्रमशः 13 व 15 प्रतिशत दर्ज की गई। जलरूद्य मृदाओं में अनाज की उपज के हिसाब से केआरएल 210 का निष्पादन सबसे अच्छा रहा इसके बाद क्रमशः केआरएल 3–4, खरचिया 65 और डीवी डब्ल्यू 17 का स्थान रहा। क्षारीय मृदाओं में केआरएल 3–4, केआरएल 210, केआरएल 99 और खरचिया 65 सबसे अच्छा निष्पादन देने वाली प्रजातियाँ रहीं। अनाज की उपज में न्यूनतम कमी केआरएल 210 (3 प्रतिशत), वीचए 1146 (4 प्रतिशत) और केआरएल 3–4 (9 प्रतिशत) प्रजातियों की रही। जलरूद्य क्षारीय मृदाओं में उपज में अधिकतम कमी क्रिचाउफ (48 प्रतिशत) और डुकूला 4 (46 प्रतिशत) प्रजातियों की रही।

गंगा बेसिन में जलवायु परिवर्तन को कम करने और फसलों की उत्पादकता को बढ़ाने के लिए कृषि भूमि उपयोगों में कार्बन ज़ब्ती सम्भाव्य

जलवायु परिवर्तन, विकासशील देशों में खाद्य सुरक्षा और आजीविका के लिए भविष्य में गंभीर खतरे की ओर इंगित करता है। कार्बन ज़ब्ती जलवायु परिवर्तन के परिणामों को कम करने के लिए व्यवहार्य विकल्पों में से एक है। एक प्रयोग में नाइट्रोजन, जुताई और अवशेष प्रबंधन में गेहूँ–हरे चने–मक्का और धान–गेहूँ फसल प्रणाली में कार्बन ज़ब्ती बढ़ाने के लिए चालकों के रूप में प्रयोग किया गया। परिणाम दर्शाते हैं कि नत्रजन की संस्तुत मात्रा के साथ अगर जैविक साधन को जोड़ दिया जाए तो कुल बायोमास में वृद्धि हुई जबकि नत्रजन के लिए जैविक साधन का प्रतिस्थापन या गोबर की खाद के एकल प्रयोग द्वारा कार्बन ज़ब्ती और बायोमास में कमी दर्ज की गई। उपरोक्त खेत में पारम्परिक जुताई के साथ जहाँ एक तिहाई अवशेषों का समावेश किया गया, वहीं गेहूँ की फसल की कार्बन ज़ब्ती व कुल बायोमास अधिकतम था और यह एक तिहाई अवशेष बनाए रखने के साथ शून्य जुताई में सबसे कम था। उपरोक्त खेत में धान की फसल में किसानों

द्वारा की जाने वाली (संरक्षण तकनीक के साथ गेहूँ अवशेष को हटाकर + पंक्ति दशा में प्रतिरोपित धान) क्रिया में कार्बन ज़ब्ती व सकल बायोमास अधिकतम था इसके बाद शून्य जुताई + संपूर्ण अवशेष के साथ जिसमें पारम्परिक जुताई के साथ धान की सीधी बुआई की गई थी का क्रम था।

बागवानी फसलों में लाभ बढ़ाने के लिए पर्यावरण अनुकूलन सीएसआर जैव का प्रभाव

उत्तर प्रदेश के बाराबांकी जनपद में बागवानी फसलों को उगाने वाले लघु व सीमांत किसानों के खेतों पर एक लागत प्रभावी सीएसआर जैव को प्रयोग किया गया। वर्ष 2011–13 की अवधि में दो प्रमुख केला व टमाटर उगाने वाले क्षेत्रों में सीएसआर जैव को अपनाने व न अपनाने वालों पर इसके वातावरण को विषाक्त करने वाले फन्जीसाइड रसायनों के उपयोग को कम करने व टमाटर और केले जैसी वाणिज्यिक फसलों में लाभ बढ़ाने के लिए मूल्यांकित किया गया। सीएसआर जैव को अपनाने व न अपनाने व टमाटर की हिमसोना व केले की जी 9 प्रजाति को उगाने वाले 100–100 किसानों से आंकडे एकत्र किए गए। परिणामों ने दर्शाया है कि इसको अपनाने वाले टमाटर और केले की उपज में क्रमशः 22.4 व 15.6 प्रतिशत की वृद्धि हुई। इसके द्वारा टमाटर और केले की सकल लाभ में भी क्रमशः 20.1 और 17.4 प्रतिशत की वृद्धि हुई। न अपनाने वालों की तुलना में टमाटर और केले में पौध संरक्षण रसायनों के उपयोग में भी क्रमशः 47.3 व 33.4 प्रतिशत की कमी आई। इसको न अपनाने वालों की तुलना में अपनाने वालों के केले के गुच्छों की औसत उपज 15 प्रतिशत अधिक पाई गई। अपनाने वालों की औसत लागत 1.60 लाख प्रति हेक्टेयर थी जो कि न अपनाने वालों से 8.5 प्रतिशत कम थी।

सौराष्ट्र, गुजरात की तटीय लवणीय मृदाओं में तकनीकी उपायों का प्रभाव

निरंतर प्रयासों द्वारा भरूच, आणंद, अहमदाबाद और जामनगर जिलों के तटीय क्षेत्रों में लवण सहिष्णु हरबेसियम कपास किस्मों की खेती का प्रसार करने में मदद मिली है। सीएपीसी के माध्यम से किसानों की प्रतिक्रिया प्राप्त करने के बाद खरीफ 2013 की अवधि में एक गैर सरकारी संगठन ने कपास की दो लाइन जी कपास 23 व जी कपास 25 का क्षेत्र प्रदर्शन एवं प्रभाव अध्ययन आरंभ किया। अध्ययन ने दर्शाया कि लवणीय मृदा के बारा ट्रैक और भाल क्षेत्र (राजपुरा) में हरबेसियम कपास ने वर्षा आधारित हालातों में अच्छी अनुकूलनशीलता और उपज दी जिससे संकेत मिला कि ये इस क्षेत्र के अनुकूल हैं। किसानों के खेतों से प्राप्त उपज संस्थान के क्षेत्रीय अनुसंधान केन्द्र भरूच के सामनी प्रयोगात्मक फार्म से प्राप्त उपज के बराबर थी।

रबी के मौसम में तटीय लवणीय मृदाओं में गेहूँ और जीरे का निष्पादन

संस्थान की गेहूँ प्रजातियों (केआरएल 210) और जीरा (गुजरात जीरा–जीसी 4) को भाल क्षेत्र के तटीय लवणीय क्षेत्रों में उगाया गया। 7.8 डेसी सीमन प्रति मीटर लवणता पर जीरे की 0.94 टन प्रति हेक्टेयर व गेहूँ कि 3.62 टन प्रति हेक्टेयर उपज प्राप्त हुई। लवणीय परिस्थितियों में इन फसलों के अच्छे निष्पादन की वजह से किसानों का रूझान इन फसलों की तरफ हुआ। तटीय गुजरात के जनपद जूनागढ़ के तीन खंडों में लवणता की 7.5 से 7.8 डेसी सीमन प्रति मीटर में गेहूँ (केआरएल 210) की उपज 3.4 से 4.0 टन प्रति हेक्टेयर मिली जबकि भाल क्षेत्र के लवणीय क्षेत्रों में लवणता सीमा 5.4 से 6.24 डेसी सीमन प्रति मीटर में जीरे की जीसी 4 प्रजाति ने 0.90 से 0.94 टन प्रति हेक्टेयर उपज प्रदान की।

लवण सहिष्णुता के लिए लवणीय वर्टीसोल में प्रक्षेत्र फसलों का प्रजनन व मूल्यांकन

अपर्याप्त सिंचाई सुविधाओं के साथ बारा जल की कमी वाला क्षेत्र है और यहाँ का भूजल भी लवणीय है। इस प्रकार कम पानी की आवश्यकता वाली लवण सहिष्णु फसलों की पहचान करने का कोई भी प्रयास किसानों को आर्थिक लाभ प्राप्त करने के लिए एक मार्ग प्रशस्त करेगा। कपास की दो प्रजातियों जी कपास 23 (हरबेसियम) और जी वेब 120 (हरबोरियम) ने 12 डेसी सीमन प्रति मीटर की लवणता स्तर तक वृद्धि, बोयोमास, उच्च मोनापोडिया, सिमपोडिया और बॉलस की संख्या के संदर्भ में अच्छी प्रतिक्रिया दिखाई। पोटाशियम सामग्री के बेहतर रखरखाव के साथ मिलकर सोडियम व पोटाशियम के कम सॉट ने इन ंबबमेपवदे को सोडियम और पोटाशियम अनुपात को कम स्तर (लवणता सहिष्णु के लिए एक बेहतर सूचक) को बनाये रखने में मदद की। पर्न ऊतक में उच्च प्रोलाइन सामग्री के साथ–साथ कम सोडियम/पोटाशियम अनुपात के साथ बेहतर पानी की स्थिति को बनाये रखने और विकास तथा उत्पादकता मदद मिली। आस्साटिक पदार्थों की उच्च राशि जैसे चीनी व प्रोलाइन के साथ सोडियम और क्लोराइड और उच्च क्लोरोफिल सामग्री के कम ग्रहण ने बेहतर संयंत्र पानी की स्थिति के लिए अग्रणी बेहतर आस्माटिक विनिमय में जीबीएवी 120 और जी खटिया 23 की उच्च बीज कपास उपज को दर्शाया। इन मानकों के आधार पर नमक सहिष्णुता के लिए कपास की इन चार accessions जी कपास 23 > बीएवी 120 > बीएबी 109 > जीएसएचवी 99/307 को क्रम से रखा जा सकता है।

तटीय पर्यावरण में खारा जल कृषि की स्थिरता व प्रभावों का आंकलन

भौतिक पर्यावरण पर खारे जल के कृषि पर प्रभावों के आंकलन व खारे जल के प्रतिकूल प्रभाव को कम करने के लिए पश्चिम बंगाल के तटीय क्षेत्रों में उत्तरी 24 परगना जिले में इस परियोजना को लागू किया गया। खारे पानी का जलीय कृषि क्षेत्र और ताजा जल के तालाब की मृदा और जल की लवणता में परिवर्तन के संदर्भ में एक अध्ययन किया गया जिसमें यह पाया गया कि मछली फार्म से सटे हुए धान के खेतों में मृदा लवणता मछली फार्म से दूर के खेतों की तुलना में अधिक थी। इस क्षेत्र में मछली उत्पादन के

लिए प्रयोग किये गये। अच्छे जल वाले तालाब भी खारा जल कृषि से प्रभावित थे। खारे जल वाले तालाबों से दूर के तालाबों की तुलना में (जो मछली तालाब खारे जल मछली फार्म से सटे हुए थे) जल और मृदा में उच्च लवणता देखी गई। अच्छे जल के मछली तालाब व उसके आस–पास की कृषि भूमि में मृदा एवं जल की लवणता वृद्धि खारे जल की जलीय कृषि से खारे जल के रिसाव के कारण हो सकती है। ताजा जल जलाशयों और उसके आस–पास की कृषि भूमि में मृदा एवं जल लवणता के बनने को खारे जल निकायों के तटबंध के बाहरी पक्ष में गहरी खाइयाँ बनाने तथा खारे जल निकायों के आतंरिक पक्ष में पालिथीन चादर के स्तर लगाने से रिसाव क्षति को नियंत्रित करके न्यूनतम किया जा सकता है।

पश्चिमी बंगाल की तटीय मृदाओं में रबी फसलों की सौर ऊर्जा संचालित ड्रिप सिंचाई पर खारे पानी का प्रभाव

ड्रिप सिंचाई में खारा पानी के उपयोग के साथ रबी फसल की उपयुक्ता का मूल्यांकन करने के लिए लोबिया, चुकंदर, भिण्डी और इंमससं फसलें फरवरी के पहले सप्ताह में बोई गई। फसल मौसम के अंत में मई 2013 की अवधि में तीन बार अचानक बाढ आई। लोबिया में कीड़े (चीटियां) व जल भराव के कारण भारी क्षति हुई। चुकंदर और basella फसलों में जल भराव के कारण इनके विकास में कमी आई। केवल भिण्डी की फसल ने मृदा लवणता, पानी की कमी और पानी के ठहराव जैसे हालातों का अच्छी तरह सामना किया। सभी फसलों की ऊपज का प्रचलित बाजार मूल्य लेने के बाद भिंडी बराबर ऊपज (ओइवाई) में परिवर्तित कर दिया गया। उच्चतम बराबर उपज भिंडी (0.42 कि.ग्रा. प्रति पौधा) की प्राप्त हुई इसके बाद basella (0.19 कि.ग्रा. प्रति पौधा) व चुकन्दर (0.07 कि.ग्रा. प्रति पौधा) का स्थान रहा। इसलिए तटीय लवणीय मृदाओं में ड्रिप सिंचाई के अंतर्गत भिण्डी सबसे उपयुक्त रबी फसल रही।

तटीय कृषि पारिस्थितिकी तंत्र में धान–कपास फसल प्रणाली में अवशिष्ट नमी के उपयोग, मृदा स्वास्थ्य और फसल की ऊपज पर संरक्षण जुताई का प्रभाव

तटीय कृषि पारिस्थितिकी तंत्र में धान–कपास फसल प्रणाली के तहत अवशिष्ट नमी के उपयोग, मृदा स्वास्थ्य और फसल की ऊपज पर संरक्षण जुताई के प्रभाव ने दर्शाया कि पारम्परिक और कम जुताई उपचारों की तुलना में शून्य जुताई से उपज में 10 से 23 प्रतिशत की कमी आंकी गई। दूसरे उपचारों की तुलना में शून्य जुताई से थोक घनत्व में वृद्धि देखी गई। 80 प्रतिशत से अधिक उर्जा अकार्बनिक उर्वरक के प्रयोग में प्रयुक्त हुई। धान–धान प्रणाली धान–कपास प्रणाली से उर्जा के उपयोग में अधिक कुशल थी। धान–कपास प्रणाली में धान–धान प्रणाली की तुलना में पैदावार में अधिक कमी थी परन्तु धान–धान प्रणाली के तहत कम जुताई अन्य उपचारों की तुलना में सबसे अधिक दक्ष था।

तटीय लवणग्रस्त मृदाओं में धान आधारित फसल प्रणाली के लिए फसल स्थापना की विधियों का मूल्यांकन

मुख्य भूखंड में खरीफ धान की फसल की स्थापना शुष्क दशा में सीधी बुआई और पानी भरकर रोपाई की तीन विधियाँ (सीधी बुआई/हाथ से बुआई), सामान्य बुआई और मेड़ों पर बुआई द्वारा की गई। रबी फसल में सरसों और मक्का का समावेश कर एक प्रयोग किया गया। 28 मई 2013 को 15.27 डेसी सीमन प्रति मीटर के स्तर पर सीधी बुआई खरीफ धान (अमलमाना) का प्रयोग किया गया जिसमें जून के महीने में मानसून वर्षा के कारण लवणता स्तर कम होकर 4.84 प्रति डेसी सीमन रह गया। मई के अन्तिम सप्ताह में धान की शुष्क सीधी बुआई अगस्त के तीसरे सप्ताह से सितम्बर के प्रथम सप्ताह तक की बाढ़ की हालातों से बच सकती है। पानी भरकर रोपाई में 5.08 टन प्रति हेक्टेयर की उच्चतम उपज पायी गई। इसके बाद धान की सीधी बुआई में 4.93 टन प्रति हेक्टेयर और बिना जुताई रोपाई में 4.55 टन प्रति हेक्टेयर का स्थान रहा। शुद्ध आय और आय–व्यय अनुपात सीधी बुआई में अधिकतम 2.74 रहा।

पुरस्कार और सम्मान

- दिनांक 16 जुलाई 2013 को परिषद के 85वें स्थापना दिवस समारोह के अवसर पर 'किसानों की आजीविका की सुरक्षा हेतु उत्तर प्रदेश में क्षारीय मृदा की उत्पादन क्षमता के दोहन' विषय पर कार्य के लिए डा. दिनेश कुमार शर्मा, वी.के. मिश्रा, ए.के. नायक और वाई.पी. सिंह को भारतीय कृषि अनुसंधान परिषद, नई दिल्ली द्वारा प्रतिष्ठित हरिओम आश्रम ट्रस्ट पुरस्कार 2010–11 से सम्मानित किया गया।
- 22 से 26 अक्तूबर 2013 को केन्द्रीय शुष्क क्षेत्र अनुसंधान संस्थान, जोधपुर में आयोजित मृदा विज्ञान की भारतीय सोसायटी, नई दिल्ली के 78 वें वार्षिक सम्मेलन में डा. अनिल चिंचमलातपुरे, डा. ए.के. नायक और जी गुरूराजा राव को "संसाधन हीन लवणग्रस्त मृदाओं के स्वामी किसानों को टिकाऊ आजीविका प्रदान करने के लिए मृदा और जल संसाधनों के प्रकृति एवं सुधार व प्रबंधन विकल्पों के विकास में उनके योगदान के लिए उन्हें मृदा विज्ञान में उत्कृष्टता के लिए प्रतिष्ठित आईएसएसएस–डा. जे.एस.पी. यादव मेमोरियल पुरस्कार 2013 से सम्मानित किया गया।
- डा. एस.के. चौधरी, प्रमुख, मृदा व फसल प्रबंधन प्रभाग को 22 से 26 अक्तूबर 2013 को काजरी, जोधपुर में आयोजित मृदा विज्ञान की भारतीय सोसायटी के 78वें

वार्षिक सम्मेलन में मृदा विज्ञान 2013 के सोसायटी के फैलो के रूप में सम्मानित किया गया।

- डा. एस.के. झा, सहायक मुख्य तकनीकी अधिकारी को मृदा रसायन के पर्यावरण विज्ञान के क्षेत्र में उनके उत्कृष्ट योगदान के लिए कृषि एवं प्रौद्योगिकी bioved अनुसंधान संस्थान द्वारा फैलोशिप अवार्ड 2013 से सम्मानित किया गया।
- डा. एस. एल कृष्णमूर्ति, वैज्ञानिक को जैव विविधता एडवांसमेंट ऑफ साइंस (एफएवीएसी) एसोसिएशन के फैलो के रूप में सम्मानित किया गया।
- डा. रंजय कुमार सिंह, वरिष्ठ वैज्ञानिक को संयुक्त राज्य अमेरिका भारत शिक्षा फाउंडेशन (यूएसआईइएफ) नई दिल्ली द्वारा फुलब्राइट एलयूमिनी अवार्ड से सम्मानित किया गया।
- डा. दिनेश कुमार शर्मा, निदेशक तथा डा. बी. माजी, संस्थान के क्षेत्रीय अनुसंधान केन्द्र केनिंग टाऊन के अध्यक्ष को 11 से 14 दिसम्बर 2013 को केन्द्रीय मृदा लवणता अनुसंधान संस्थान के क्षेत्रीय अनुसंधान के भरूच में आयोजित तटीय कृषि अनुसंधान की भारतीय सोसायटी की 10वीं राष्ट्रीय संगोष्ठी में तटीय कृषि अनुसंधान की भारतीय सोसायटी के फैलो के रूप में सम्मानित किया गया।
- डा. सत्येन्द्र कुमार, वरिष्ठ वैज्ञानिक को मार्च 2014 में कृषि अभियंताओं की भारतीय सोसायटी के वार्षिक सम्मेलन में सोसायटी द्वारा डिसटिंगविश सर्विस सर्टिफिकेट से सम्मानित किया गया।

कार्यशाला, सेमिनार, प्रशिक्षण, स्थापना दिवस तथा किसान मेलों का आयोजन

- इराक अभियंताओं के लिए भूजल निकासी पर 15 से 21 अप्रैल 2013 को एक अंतर्राष्ट्रीय प्रशिक्षण आयोजित किया गया जिसमें श्री नबील जैसिम मोहम्मद, वरिष्ठ मुख्य अभियंता के नेतृत्व में सिंचाई और सुधार विभाग इराक सरकार के अठ्ठारह वरिष्ठ अभियंताओं ने भाग लिया।
- चार अफ्रीकी देशों तंजानिया, केन्या, इथोपिया व जिम्बाबवे के सोलह हितधारकों के एक दल ने संस्थान का दौरा किया। यह दल भारत में खेत मशीनीकरण प्रशिक्षण सहअध्ययन दौरे पर था।
- मक्का और जलवायु स्मार्ट प्रथाओं के माध्यम से लचीले विविधिकरण विकल्प को बढ़ावा देने के लिए 20 मई 2013 को जलवायु परिवर्तन पर हिताधिकारियों के लिए एक बैठक आयोजित की गई। बैठक का उद्‌घाटन हरियाण किसान आयोग के अध्यक्ष माननीय डा. आर. एस. परौदा ने किया। इसमें लगभग 250 किसानों, वैज्ञानिकों, विस्तार अधिकारियों और नीति निर्माताओं ने भाग लिया।
- पृथ्वी दिवस 2013 के मनाने के लिए 31 मई 2013 को लवणग्रस्त मृदाओं पर जलवायु परिवर्तन और उनकी फसल उत्पादकता के प्रभाव विषय पर पृथ्वी विज्ञान मंत्रालय, भारत सरकार द्वारा प्रायोजित एक बुद्धिशीलता सत्र आयोजित किया गया। इसमें लगभग 60 वैज्ञानिकों, प्रगतिशील किसानों और छात्रों ने भाग लिया।
- लवणग्रस्त क्षेत्रों में भविष्य कृषि को आकार देने के लिए तकनीकी के नवप्रर्वतन पर 4 से 24 जून 2013 की अवधि में 21 दिवसीय ग्रीष्मकालीन स्कूल का आयोजन किया गया। कृषि वैज्ञानिक भर्ती बोर्ड, नई दिल्ली के अध्यक्ष डा. गुरबचन सिंह के इस स्कूल का उद्‌घाटन किया। इस में दस राज्यों के 21 प्रतिभागियों ने भाग लिया।
- लवणग्रस्त मृदाओं और कृषि में लवणीय जल के उपयोग के प्रबंधन पर एआईसीआरपी की 23वीं द्विवार्षिक कार्यशाला 20 से 22 जून 2013 की अवधि में यूएएस, रायचूर में आयोजित की गई। प्रो. एस. एस. खन्ना, पूर्व कुलपति व पूर्व सलाहकार, योजना आयोग ने इस कार्यशाला का उद्‌घाटन किया।
- जल उपयोग दक्षता और फसल उपज के मूल्यांकन के लिए जीपीएस और जीआईएस पर जल प्रबंधन में आधुनिक उपकरणों के उपयोग पर काडा अधिकारियों के लिए 19 से 23 अगस्त 2013 को पांच दिवसीय प्रशिक्षण कार्यक्रम आयोजित किया गया। इस में 19 अधिकारियों/अभियंताओं ने भाग लिया। इस का उद्‌घाटन डा. रामेश्वर सिंह, परियोजना निदेशक, कृषि ज्ञान प्रबंधन निदेशालय, नई दिल्ली द्वारा किया गया।
- 13 से 27 सितम्बर 2013 के बीच संस्थान में हिन्दी पखवाडा मनाया गया। संस्थान के निदेशक डा. दिनेश कुमार शर्मा ने इसका उद्‌घाटन किया।
- 15 अक्तूबर 2013 को नैन गाँव (जिला पानीपत) में खरीफ किसान मेला आयोजित किया गया। मेले का उद्‌घाटन डा. ए. के. सिक्का उप महानिदेशक (एनआरएम) भारतीय कृषि अनुसंधान परिषद, नई दिल्ली ने किया। इस कार्यक्रम से लगभग 1000 किसान लाभांन्वित हुए।
- सार्क क्षेत्र में लवणीय मृदा सुधार प्रणाली की उत्तम पद्धतियों व प्रक्रियाओं पर सार्क कृषि केन्द्र ढाका और केन्द्रीय मृदा लवणता अनुसंधान संस्थान, करनाल द्वारा संयुक्त रूप से 27 से 29 नवम्बर 2013 को तीन दिवसीय क्षेत्रीय विशेषज्ञ बैठक आयोजित की गई। बैठक का उद्‌घाटन डा. आई. पी. अबरोल, निदेशक, सतत कृषि उन्नति केन्द्र, नई दिल्ली द्वारा किया गया।
- क्षेत्रीय अनुसंधान केन्द्र भरूच में 11 से 14 दिसम्बर 2013 को तटीय कृषि अनुसंधान की भारतीय सोसायटी केनिंग टाऊन (पश्चिमी बंगाल) द्वारा एक राष्ट्रीय संगोष्ठी का आयोजन किया गया। संगोष्ठी का उद्‌घाटन डा. एन. के. त्यागी, पूर्व सदस्य, कृषि वैज्ञानिक भर्ती बोर्ड, नई दिल्ली द्वारा किया गया।
- एनएआईपी की क्रियाशील परियोजना की उप–परियोजना 'साझा कृषि सूचना के लिए मास मीडिया सपोर्ट जुटाने के माध्यम से 30 जनवरी 2014 को संस्थान के क्षेत्रीय

अनुसंधान केन्द्र भरूच व औषधीय व सुगंधित पादप निदेशालय, आनंद द्वारा संयुक्त रूप से एक मीडिया मीट का आयोजन किया गया।

- कृषि में निम्न गुणवत्ता जल के उपयोग पर एफ्रो–एशियन ग्रामीण विकास संगठन के सदस्य देशों के लिए 11 से 24 दिसम्बर 2013 को दो सप्ताह के एक अंतर्राष्ट्रीय प्रशिक्षण कार्यक्रम का आयोजन किया गया। इस में बंगला देश, इराक, नाइजीरिया, ओमान, जोर्डन, चीन (ताइवाइन) श्रीलंका और सूडान के आठ प्रतिनिधियों ने भाग लिया। डा. आलोक कुमार सिक्का, उप–महानिदेशक (एनआरएम) नई दिल्ली ने प्रशिक्षण कार्यक्रम का उद्घाटन किया।
- 1 मार्च 2014 को केन्द्रीय मृदा लवणता अनुसंधान संस्थान का 45वें स्थापना दिवस मनाया गया जिसमें 'भारत में उत्पादन लागत को कम करने और निरंतर उत्पादकता सुनिश्चित करने के लिए भूमिक्षरण का प्रतिरोध' विषय पर डा. वी. एन. शारदा ने स्थापना दिवस व्याख्यान दिया।
- 10 मार्च 2014 को संस्थान में रबी किसान मेला आयोजित किया गया। मेले का उद्घाटन पद्मभूषण डा. आर. एस. परोदा, पूर्व महानिदेशक, भारतीय कृषि अनुसंधान परिषद, नई दिल्ली और अध्यक्ष, हरियाणा किसान आयोग द्वारा किया गया। मेले में हरियाणा, पंजाब और उत्तर प्रदेश के 3000 किसानों व स्कूल के छात्रों ने भाग लिया।

क्षेत्र प्रदर्शनियाँ एवं भ्रमण

2013–14 के दौरान लवणग्रस्त मृदा और कृषि क्षेत्र में निम्न गुणवत्ता जल के उपयोग के प्रबंध पर समस्याग्रस्त क्षेत्रों में अनुसंधान संस्थाओं और विकास अभिकरणों के विभिन्न स्थानों पर 9 क्षेत्र प्रदर्शनियाँ लगाई गई। बड़ी संख्या में किसानों व विस्तार कर्मियों ने स्टालों का दौरा किया और संस्थान द्वारा विकसित प्रौद्योगिकियों की जानकारी ली। 86 समूहों में आये 2779 हितधारकों ने संस्थान के सूचना प्रौद्योगिकी केन्द्र और अनुसंधान प्रायोगिक फार्म का दौरा किया। उन्हें संस्थान में चल रहे शोध कार्यों के बारे में अवगत कराया गया और लवणग्रस्त मृदा और निम्न गुणवत्ता जल के सुधार और प्रबंधन की जानकारी उपलब्ध कराई गई। 2729 हिताधिकारियों में 22 समूह में आये 1948 किसानों, 12 समूह में आये 537 छात्रों, 35 समूह में आये 177 विस्तार कर्मियों, 17 समूहों में भारत और विदेशों से आये 67 वैज्ञानिकों और विषय–वस्तु विशेषज्ञों ने संस्थान का दौरा किया। किसानों के खेतों में 6 किसान दिवसों का आयोजन किया गया। ये किसान दिवस लवणीय व क्षारीय मृदा एवं जल के प्रबंधन व समग्र प्राकृतिक संसाधनों के प्रबंधन पर पारम्परिक ज्ञान को बढ़ाने की चेतना को जगाने से संबंधित थे।

किसान परामर्श सेवायें

मृदा लवणता, क्षारीयता व जल की गुणवत्ता से संबंधित किसानों की समस्याओं को सुनने के लिए संस्थान ने टोल फ्री नम्बर 180001801014 की सुविधा प्रदान की गई। 2013–14 के दौरान देश के विभिन्न भागों से कृषि के विभिन्न क्षेत्रों की 242 कॉल प्राप्त हुई और उन्हें समस्याओं का उचित समाधान प्रदान किया गया।

अंतर्राष्ट्रीय सहयोगी परियोजनायें

- अफ्रीका और दक्षिण एषिया के गरीब किसानों के लिए प्रतिबल सहिष्णु धान (आईआरआरआई व बी एम जी एफ द्वारा प्रायोजित)।
- आस्ट्रेलिया और भारत में जलरूद्यता, लवणता और अवयव विषाक्तता के लिए गेहूँ सुधार (एसीआईएआर आस्ट्रेलिया द्वारा प्रायोजित)।
- दक्षिण एशिया के लिए अन्न प्रणाली प्रयास (सीएसआईएसए) आईआरआरआई फिलीपिन्स एवं सीआईएमएमवाईटी मैक्सिको द्वारा प्रायोजित।
- सूखे जल भराव व लवण सहिष्णुता प्रमुख क्यूटीएल के साथ एबियोटिक प्रतिबल सहिष्णु धान प्रजातियों की मार्कर (चिन्हित) सहायक प्रजनन (डीबीटी भारत आईआरआरआई)

संस्थान के नये संबंध

- सिंगापुर राष्ट्रीय विश्वविद्यालय (एसएनयू) से जल उपचार के क्षेत्र में।
- दक्षिण एशिया में खाद्य सुरक्षा और जल संसाधनों के सतत उपयोग को बढ़ाने हेतु फसल प्रणाली मॉडलिंग में सार्क कृषि केन्द्र (एसएसी) और सीएसआईआरओ के साथ संबंध।
- वानिकी के माध्यम से अपशिष्ट जल के सतत प्रबंधन में वेधशाला बोर्ड, मेलबोर्न विश्वविद्यालय एवं सीएसआईआरओ आस्ट्रेलिया के साथ संबंध ।
- लवणग्रस्त क्षेत्रों के नक्शे बनाने व इनके लक्षणों की और अधिक सही जानकारी प्राप्त करने के लिए उपलब्ध तत्कालीन अन्तरिक्ष प्रौद्योगिकियों के लिए राष्ट्रीय सुदूर संवेदी केन्द्र (एनआरएससी) हैदराबाद एवं राजकीय सुदूर संवेदी उपयोग केन्द्रों (आरएसएसी) और एनबीएसएस एन्ड एलयूपी (आईसीएआर), नागपुर से संबंध।
- कुरूक्षेत्र विश्वविद्यालय, कुरूक्षेत्र, महाऋषि मारकन्डेश्वर विश्वविद्यालय मुलाना एवं दीनबन्धु छोटूराम विश्वविद्यालय/विज्ञान व प्रौद्योगिकी मुरथल (हरियाणा), राष्ट्रीय डेरी अनुसंधान संस्थान, करनाल से शैक्षिक संबंध।

संस्थान के प्रकाशन

प्रमुख जरनलों में संस्थान द्वारा 86 अनुसंधान आलेख, 63 पुस्तक अध्याय, 7 पुस्तक/मैनुअल, 15 बुलेटिन/फोल्डर, 6 प्रचलित आलेख छपवाये गये और विभिन्न सेमिनार, संगोष्ठी, सिमपोसिया व कान्फ्रेन्सों में 56 आलेख प्रस्तुत किये गये।

वैज्ञानिकों का विदेश भ्रमण कार्यग्रहण व सेवानिवृत्ति

ज्ञान व कुशलता को बढ़ाने हेतु संस्थान के 12 वैज्ञानिकों ने विभिन्न देशों जैसे बांग्लादेश, इसराइल, आस्ट्रिया, नेपाल, नीदरलैंडस, मलेशिया, फ्रांस, जोर्डन, फिलिपीन्स, थाईलैंड व मिश्र का दौरा किया। इस अवधि में 6 वैज्ञानिकों ने कार्यभार संभाला।

EXECUTIVE SUMMARY

Central Soil Salinity Research Institute (CSSRI) is a premier research organization established in 1969 at Karnal (Haryana). It is dedicated to pursue interdisciplinary researches on salinity management and use of poor quality irrigation water in different agro-ecological regions of the country. Multi-disciplinary research programmes at the main institute are conducted through four divisions, namely Soil and Crop Management, Irrigation and Drainage Engineering, Crop Improvement and Technology Evaluation and Transfer. To pursue specific research needs of different agro-climatic regions, the institute has three Regional Research Stations at Canning Town (West Bengal), Bharuch (Gujarat) and Lucknow (Uttar Pradesh) to deal with the problems of coastal salinity, salt affected Vertisols and alkali soils of the central and eastern Indo-Gangetic plains with shallow water table, respectively. The Coordinating Unit of AICRP on Management of Salt Affected Soils and Use of Saline Water in Agriculture is also located at the main institute and is functioning through eight research centres at Agra (Uttar Pradesh), Baptala (Andhra Pradesh), Bikaner (Rajasthan), Gangawati (Karnataka), Hisar (Haryana), Indore (Madhya Pradesh), Kanpur (Uttar Pradesh) and Tiruchirapalli (Tamil Nadu) representing different agro-ecological regions of the country. For the period under report, some major research achievements of the institute in different thrust areas are as under:

Mapping and characterization of salt affected soils in central Haryana

The mapping and characterization of salt affected soils of Kaithal district of Haryana was conducted using Remote Sensing and GIS. Sodic and saline soils covered 6.8% and 4.4% of total geographical area (TGA), respectively. Block wise distribution revealed significant areas in Kaithal and Kalayat blocks followed by Pundri, Rajound, Guhla and Siwan blocks. While Kaithal subdivision had 9% of TGA as salt affected Guhla and Siwan blocks had only 2.3% TGA as salt affected.

Resource conservation on crop productivity under rice-wheat cropping system on semi-reclaimed sodic soils

The study was conducted to evaluate the effect of resource conservation technologies viz., direct seeded rice (DSR), reduced tillage, residue incorporation in soil and water management in enhancing crop productivity and sustaining soil health of semi-reclaimed sodic soils. A mini-sprinkler irrigation system was installed in an area of 0.4 ha having a discharge rate of 12960 l h^{-1} $acre^{-1}$ at 2 kg cm^{-2} pressure having a high cent uniformity coefficient of 90 per cent. The irrigation scheduling in wheat crop was made on the basis of cumulative pan evaporation of 7 days. Sprinkler irrigation system saved 38.85 per cent water over surface irrigation. Zero tillage with rice straw mulch produced highest wheat yield (5.38 t ha^{-1}) under surface irrigation method followed by zero tillage with rice straw mulch (5.13 t ha^{-1}) under mini sprinkler irrigation system. A saving in consumption of electric energy to the tune of 2.16 per cent was recorded in mini sprinkler in comparison to conventional irrigation in wheat. Grain yield of rice under DSR with sprinkler and residue management was at par with CRT (conventional rice transplanting) with surface irrigation. This saved 57.9 % of applied water. The water productivity (0.95 kgm^{-3}) under CRT with surface irrigation was increased to 2.18 kgm^{-3} under DSR with sprinkler irrigation.

Performance of multi-enterprise agriculture model on reclaimed sodic land in farmer's participatory mode

Multienterprise agriculture model with multiple enterprises/components may pave the way to realize higher productivity and profitability through integrated use of water, nutrient and energy at small farms. The model was evaluated at CSSRI farm in the farmer's participatory mode to judge its acceptability, viability and sustainability. It was found that multienterprise agriculture has the potential to decrease cultivation cost by synergetic recycling of bi-products/residues of various components within the system and is a regular source of income and employment. The total mean revenue of Rs. 5,29,317 was generated from 2.0 hectares of land with a mean expenditure of Rs. 3,03,486 giving a net income of Rs. 2,25,83. Crop components generated a total gross income of Rs. 2,15,127 whereas subsidiary components generated Rs. 3,14,191 during July, 2011 to June, 2013. The fish component was found quite profitable (B:C ratio 4.80). The fish productivity was recorded to be 3.8 t ha^{-1} $year^{-1}$. The species recovery from the aqua ponds were in the order of Common carp > Grass carp > Catla > Rohu > Mrigal. The fish weight was in the range of 750-1000 g.

Evaluation of subsurface drainage projects in Haryana

The impact of newly installed subsurface drainage systems at Siwana Mal (Distt. Jind) and Mokhra Kheri (Distt. Rohtak) was evaluated. Despite the fact that regular pumping facilities have not been implemented in a number of blocks at these sites, there has been visible improvement in selected pockets. The results relating to ground water depth and different parameters of drainage water quality in selected blocks of Mokhra Kheri project area during May 2013 indicated shallow water table conditions and high salinity (1.66-21.1 dS m^{-1}) levels due to inadequate pumping. Highly saline drained waters (EC> 20 dS m^{-1}) also had very high SAR (8.3 to 62.2).

Groundwater resource management to mitigate the impact of climate change in Haryana

The project was initiated with the aim to study the impact of innovative agronomic interventions to reduce ground water withdrawal in Haryana and their impact on natural recharging of ground water aquifer through detailed water and salt balance analysis. Two study sites namely CSSRI farm in fresh and Nain farm in shallow saline ground water region have been selected to study the impact of precipitation and irrigation on ground water recharge under different cropping systems. A constant rise in water table was recorded in all observation wells from August- October, 2013 due to natural recharge of excess rain and irrigation during monsoon period. Uniformly distributed rain during July and August also contributed in arresting declining ground water table by meeting out a major part of water requirement of paddy leading to reduction in pumping of ground water. Direct seeded rice (DSR) was adopted in two agro-techniques i.e. tilled and zero tilled condition. The irrigation scheduling was based at 15, 30 and 45 kPa suction measured continuously by irrometers. Irrigation was applied whenever soil matric potential of 15 cm depth reached the predefine values. The frequent irrigations did not provide much beneficial use of rainwater in crop production. Higher water productivity (0.28 kg m^{-3}) was recorded in zero tilled rice crops as compared to other plots.

Wastewater use in non food crops

Eucalyptus tereticornis and lemon grass (*Cymbopogon fluxuosus)* were continuously assessed for their water use potential to evolve safe alternative to dispose wastewaters. Wastewater irrigation improved the tree growth in comparison to tube well irrigation and rainfed conditions. However, significant increase in growth was recorded with increasing frequency of wastewater irrigation only up to IW/CPE ratio 2.0. Fresh and dry biomass of lemon grass increased significantly from 3.03 to 4.13 and 3.53 to 4.76 kg m^{-3}, with increasing frequency of tube well water and wastewater irrigation from 0.6 to 1.2 IW/CPE, respectively. The essential oil yield of lemon grass also increased with increasing wastewater application regimes up to IW/CPE ratio of 1.2 followed by the tube well and sewage in the cyclic mode.

Wheat improvement for waterlogging, salinity and element toxicities in Australia and India

Waterlogging reduced the grain yield in both normal and sodic soils with differential response of various genotypes. The genotype KRL 210 was obtained highest yielder in normal microplots followed by DBW 17, KRL 238, KRL 3-4 and KRL 240. Maximum reduction in grain yield due to waterlogging was obtained in NW 4018 (42%) whereas minimum reduction was obtained in KRL 210 (13%) and Kharchia 65 (15%). With respect to grain yield, the performance of KRL 210 followed by KRL 3-4, Kharchia 65 and DBW 17 was the best in waterlogged soils. In sodic soils, KRL 3-4, KRL 210, KRL 99 and Kharchia 65 were the best performing varieties. Minimum reduction in grain yield was obtained in KRL 210 (3%), BH 1146 (4%) and KRL 3-4 (9%). The varieties Krichauff (48%) and Ducula 4 (46%) showed maximum reduction under waterlogging in sodic soils.

Carbon sequestration potential in agricultural land uses for mitigating climate change and increasing crop productivity in Gangetic basin

Climate change evokes serious threats to food security and livelihood in developing countries.

Carbon sequestration is one of the viable options to mitigate the repercussions of climate change. In an experiment, nitrogen, tillage and residue management were used as drivers to enhance the C sequestration in wheat-green gram-maize and rice–wheat cropping systems. The results indicated that addition of organic source with recommended dose of nitrogen increased the total biomass, whereas substitution of organic source for N or use of FYM alone resulted in significant decrease in carbon sequestered and biomass. Carbon sequestered by wheat crop in above ground and total biomass was highest where conventional tillage was done with one-third residue incorporation and lowest in zero tillage with one-third residue retention. Carbon sequestered by rice crop in above ground and total biomass was highest in farmers practice (CT with wheat residue removed + transplanted rice under puddled conditions) followed by zero tillage + full residue retention, where direct seeded rice was sown with conventional tillage.

Impact of CSR-BIO-an eco-friendly bio-growth enhancer for increasing profitability in horticultural crops

A cost effective bio-growth enhancer CSR BIO was introduced in horticultural crops grown by small and marginal land holders in Barabanki district of Uttar Pradesh. The profitability of the formulation in commercial crops like tomato and banana with its impact on reducing use of chemical fungicides toxic to environment was assessed with adopters and non adopters of CSR-BIO in two major banana and tomato growing areas of during 2011-13. The data were collected from 100 adopters and 100 non-adopters of CSR BIO technology in tomato var. Himsona and banana var. G-9. Results showed an overall increase in yield up to 22.4 and 15.6 per cent in the adopters of tomato and banana. It increased the gross profitability by 20.1 and 17.4 per cent in banana and tomato, respectively. The use of plant protection chemicals was 47.3 and 33.4 per cent lower than the non-adopters in tomato and banana, respectively. The mean banana bunch yield of 31.53 kg of the adopters was 15 per cent more than the non-adopters. The mean expenditure incurred by the adopters was Rs. 1.60 lakhs ha^{-1} which is 8.5 per cent less than non-adopters.

Impact of technological interventions in coastal saline soils of Saurashtra, Gujarat

Continued efforts have helped to spread the cultivation of salt tolerant herbaceum cotton varieties in coastal areas of Bharuch, Anand, Ahmedabad and Jamnagar districts. After receiving feedback from the farmers through CSPC, an NGO from Ahmedabad, field demonstrations and impact studies were conducted during *kharif* 2013 with two lines of G Cot 23 and G Cot 25. The studies indicated that on saline soils of Bara tract and Bhal area (Rajpura), herbaceum cottons showed better adaptability and good yields under rainfed conditions thus indicating their suitability for this region. The yield obtained at the farmers' fields was at par with that of yield at the experimental farm of CSSRI, RRS Bharuch at Samni.

Performance of wheat and cumin in coastal saline soils during *rabi* season

CSSRI wheat selections/varieties (KRL 210) and cumin (Gujarat Cumin–GC 4) were taken up in the coastal saline Bhal area. Cumin gave an average yield of 0.94 t ha^{-1} and wheat 3.62 t ha^{-1} at soil salinity of 7.8 dS m^{-1}. Because of the better performance of these crops under saline conditions, these interventions had significant impact in increasing the response of farmers to these crops. Performance of wheat (cv KRL 210) in coastal Gujarat in three blocks of Junagadh district yielded 3.4 to 4.0 t ha^{-1} in salinity range of 7.5 to 7.8 dS m^{-1} whereas the performance of cumin (cv GC 4) on saline tracks of Bhal area yielded 0.90 to 0.94 t ha^{-1} in the salinity range of 5.4 to 6.24 dS m^{-1}.

Breeding and evaluation of field crops for salt tolerance in saline vertisols

Bara tract is a water deficit area (with saline ground water) with inadequate irrigation facilities. Thus, any attempt to identify low water requiring and salt tolerant crops would pave a way for the farmers to obtain good economic returns. Two cotton lines G Cot 23 (Herbaceum) and G Bav 120 (Arboreum) showed good response to salinity even up to 12 dS m^{-1} in respect of growth, biomass production, higher monopodia, sympodia and number of bolls. Low shoot sodium and chloride coupled with better maintenance of potassium content enabled these accessions to maintain low Na/K ratio (a better indicator for salinity tolerance). The low Na/K ratio along with higher proline content in leaf tissue helped these lines in maintaining better water status and hence growth and productivity. Higher amount of osmotic substances like sugar and proline along with reduced uptake of ions like sodium and chloride and high chlorophyll content enabled G Bav 120 and G Cot 23 in better osmotic regulation leading to better plant water status resulting in higher seed cotton yield. On the basis of these parameters, four cotton accessions can be placed in order of G.Cot 23 > G Bav 120> G Bav 109> G Shv 99/307 for salt tolerance.

Assessing impacts and sustainability of brackish water aquaculture in coastal environment

The project was implemented in North 24 Parganas district in coastal areas of West Bengal with the objectives to assess the impacts of brackish water aquaculture on physical environment and to develop strategies to mitigate the adverse impact of brackish water aquaculture. Impact of brackish water aquaculture in terms of changes in soil and water salinity was studied in the adjoining agricultural fields and fresh pond water. It was observed that soil salinity was high in rice field adjoining to fish farms compared to fields away from the fish farm. Fresh water ponds used for fish cultivation in the area were also affected due to brackish water aquaculture. The higher salinity in water and soil was recorded in the fish pond which was located in the adjoining areas of brackish water fish farm compared to ponds away from the brackish water ponds. The increase in salinity of soil and water in adjoining agricultural land and freshwater fish pond may be due to seepage of brackish water from brackish water aquaculture farms. Built up of soil and water salinity in adjoining agricultural lands and fresh water reservoirs can be minimized by controlling seepage loss by making deep trenches at outer side of the embankment of brackish water bodies or making deep trenches at outer side of the embankment + lining with polythene sheet at the inner side of brackish water bodies.

Impact of saline water on solar powered drip irrigated *rabi* crops in coastal soils of West Bengal

To assess the suitability of *rabi* crop with drip irrigation using saline water, crops viz; cowpea, beet, okra, and basella were sown in the first week of February. There was flash flood three times towards the end of cropping season during May 2013. The cowpea suffered heavily from insects (ants) as well as water stagnation. The growth of beets and basella crops suffered from stagnant water. Okra was the only crop that coped up well under soil salinity, water deficit, and water stagnation condition. The yield of all the crops was converted into okra equivalent yield (OEY) by taking the prevalent market price. Highest equivalent yield was obtained in okra (0.42 kg plant^{-1}) followed by basella (0.19 kg plant^{-1}) and beet (0.07 kg plant $^{-1}$). Therefore, okra seems to be the most suitable *rabi* crop under drip irrigation in coastal saline soils amongst the four test crops.

Impact of conservation tillage on utilization of residual moisture, soil health and crop yield under rice-cotton cropping system in coastal agro-ecosystem

The impact of conservation tillage on utilization of residual moisture, soil health and crop yield under rice-cotton cropping system in coastal agro-ecosystem showed that there was 10-23% yield reduction in case of zero tillage than conventional and reduced tillage treatments. Increase in bulk density was observed in zero tillage than other treatments. More than 80% energy was used as application of inorganic fertilizer. Rice-rice system was more efficient in energy utilization than rice-cotton system. Since the yield reduction was more in rice-cotton system than rice-rice system, reduced tillage under rice-rice system was most efficient than other treatments.

Evaluation of crop establishment methods for rice-based cropping system in coastal salt affected soils

The experiment consisting of three methods of *kharif* rice crop establishment viz. dry direct sowing (DSR), unpuddled transplanting (UNPT) and puddled transplanting (PT) in main plot, three *rabi* crop establishment methods in sub-plot (direct sowing/dibbling, normal sowing and ridge sowing) and two *rabi* crops in sub-sub plot (rapeseed and maize). Direct sowing of *kharif* rice (var. Amal-Mana) was done on 28th May 2013 at a soil salinity of 15.27 dS m^{-1} , which reduced to 4.84 dSm^{-1} in the month of June due to monsoon rains. Dry direct sowing of paddy during last week of May can escape fresh flood situation in the 3rd week of August to 1st week of September 2013. Highest grain yield (5.08 t ha^{-1}) was recorded in puddled transplanting (PT) followed by DSR (4.93 t ha^{-1})

and unpuddled transplanting (UNPT) (4.55 t ha^{-1}), net returns and benefit cost ratio (2.74) was highest in DSR due to reduction in cost of cultivation.

Awards and recognition

- Drs. D.K. Sharma, V.K. Mishra, A.K. Nayak and Y.P. Singh bestowed with the prestigious Hari Om Ashram Trust Award 2010-11 by the Indian Council of Agricultural Research, New Delhi on 16th July, 2013 on 85th Foundation Day Function of the Council for addressing the specific issue of "Harnessing the production potential of sodic soils in Uttar Pradesh for livelihood security of the farmers".
- Drs. Anil R. Chinchmalatpure, A.K. Nayak and G. Gururaja has been bestowed with the prestigious ISSS-Dr JSP Yadav Memorial Award -2013 for Excellence in Soil Science by Indian Society of Soil Science, New Delhi in 78th Annual Convention of the Indian Society of Soil Science held at CAZRI, Jodhpur on 22-26th October, 2013 for their contribution in "Characterization of soil and water resources and development of reclamation and management options for providing sustainable livelihood to the resource poor farmers inhabiting the salt-affected soils".
- Dr. S.K. Chaudhari, Head, Soil and Crop Management Division has been awarded as Fellow of Indian Society of Soil Science- 2013 during the 78th Annual Convention of the Indian Society of Soil Science held at CAZRI, Jodhpur on 22-26th October, 2013.
- Dr. S.K. Jha, Asstt. Chief Technical Officer has been awarded as with Fellowship Award-2013 by Bioved Research Institute of Agriculture and Technology for his outstanding contribution in the field of Environment Science of Soil Chemistry.
- Dr. S.L. Krishnamurthi, Scientist, Crop Improvement Division has been awarded as Fellow of Association for the Advancement of Biodiversity Science (FABSc).
- Dr. Ranjay K. Singh has been awarded the Fulbright Alumni Award 2013-14 by the United States India Education Foundation (USIEF), New Delhi.
- Dr. D.K. Sharma, Director and Dr. B. Maji, Head, CSSRI, RRS, Canning Town have been awarded as Fellow of The Indian Society of Coastal Agricultural Research during 10th National Symposium of ISCAR held at CSSRI, RRS, Bharuch (Gujarat) during December 11-14, 2013.
- Dr. Satynder Kumar, Senior Scientist has been awarded the Distinguish Service Certificate by the Indian Society of Agricultural Engineers (ISAE) in the Annual Convention of Indian Society of Agricultural Engineers during March 2014.

Workshop, Seminar, Training, Foundation Day and *Kisan Mela* organized

- One week international training on land drainage for the Iraq Engineers was organized from April 15- 21, 2013. Eighteen senior engineers from the Department of Irrigation and Reclamation, Government of Iraq led by Mr. Nabeel Jassim Mohammed, Senior Chief Engineer, participated in the training.
- A team of sixteen stakeholders from four African countries *viz;* Tanzania, Kenya, Ethopia and Zimbabwe visited the Institute on 09.05.2013. The visit was organized under the auspices of ACIAR. The team was traveled in India for farm mechanization training cum study tour.
- A stakeholders meeting on promoting resilient diversification option through maize and climate smart practices was organized under the auspicious of CGIAR Research Programme on Climate Change, Agriculture and Food Security (CCAFS) and WHEAT (CRP 3.1) on 20th May, 2013. The meeting was inaugurated by Hon'ble Dr. R.S. Paroda, Chairman, Haryana Kisan Ayog, Govt. of Haryana. About 250 farmers, scientists, extension officers and policy makers participated in this meeting.
- A brainstorming session on climate change impact on salt affected soils and their crop productivity to commemorate Earthday-2013 sponsored by the Ministry of Earth Sciences, Govt of India was organised on 31.05.2013. About 60 scientists, progressive farmers and students participated in this session.
- Twenty one days summer school on technological innovation for shaping future agriculture in salt affected areas was organized during June 4-24, 2013. Dr. Gurbachan Singh, Chairman, Agricultural Scientists Recruitment Board, New Delhi inaugurated the Summer

School. In this summer school, 21 participants from ten states participated.

- XXIII biennial workshop of AICRP on Management of Salt Affected Soils and Use of Saline Water in Agriculture was held at UAS, Raichur during June 20-22, 2013. Prof. S.S. Khanna, Ex-Vice Chancellor and Ex-Advisor, Planning Commission inaugurated the workshop.
- A *Kisan Gosthi* for sugarcane officers and farmers on management of salt affected soils was organized on July 27, 2013. A total of 70 farmers participated in this training.
- A five days' training programme for CADA Officers on Use of Modern Tools in Water Management with Special Emphasis on GPS and GIS for Evaluating Water Use Efficiency and Crop Yield was organised during August 19-23, 2013. Nineteen Officers/ Engineers participated in this training. Dr. Rameshwar Singh Project Director, Directorate of Knowledge Management in Agriculture (DKMA), New Delhi inaugurated the training.
- The Institute celebrated the Hindi Week from September 13-27, 2013. Dr. D.K. sharma, Director of the Institute inaugurated the function on 13th September, 2013.
- Two field days were organised at Shivri and Patwakhera on 15.10.2013 and 19.10.2013 respectively. About 200 farmers participated in these events.
- *Kharif kisan mela* was organized at Nain Village (Panipat district) on 15th October 2012. The *mela* was inaugurated by Dr. A.K. Sikka, Deputy Director General (NRM), ICAR, New Delhi.
- A three days Regional Expert Consultation Meeting on Best Practices and Procedures of Saline Soil Reclamation System in SAARC Region was organized jointly by SAARC Agriculture Centre, Dhaka and CSSRI, Karnal during November 27-29, 2013. The meeting was inaugurated by Dr. I.P. Abrol, Director, Centre for Advancement of Sustainable Agriculture, New Delhi.
- A National Symposium was organized by the Indian Society of Coastal Agricultural Research, Canning Town (West Bengal) at the Regional Research Station, Bharuch during December 11-14, 2013. The symposium was inaugurated by Dr. N.K. Tyagi, former Member, ASRB, New Delhi.
- A media meet through an on-going NAIP Project (Sub-Project: Mobilizing Mass Media support for Sharing Agro-Information) was organized on January 30, 2014 at CSSRI, RRS, Bharuch in collaboration with Directorate of Medicinal and Aromatic Plants Research (DMAPR), Boriavi, Anand.
- A two weeks international training programme on Use of Poor Quality Water in Agriculture for Afro-Asian Rural Development Organisation (AARDO) member countries was organized during December 11-24, 2013. Eight delegates from Bangladesh, Iraq, Nigeria, Oman, Jordan, R.O. China (Taiwan), Sri Lanka and Sudan participated in the training programme. Dr. Alok. K. Sikka, Deputy Director General (NRM), New Delhi inaugurated the training programme.
- 45th Foundation Day of CSSRI, Karnal was organized on 1st March 2014, a Foundation Day Lecture by Dr. V.N. Sharda, Member, Agricultural Scientists Recruitment Board, New Delhi was delivered on "Combating land degradation to minimize production losses and ensure sustained productivity in India" on the occasion.
- The institute organized *Rabi Kisan Mela* on 10th March, 2014 which was inaugurated by Padma Bhushan Dr. R.S. Paroda, Former Director General, Indian Council of Agricultural Research, New Delhi and Chaiman, Haryana Kisan Ayog, Govt. of Haryana. About 3000 farmers from Haryana, Punjab and Uttar Pradesh and school students benefited from this important function.

Field Exhibition and Visits

During 2013-14, 9 field exhibitions were organized at various venues of research institutions and developmental agencies in problematic areas in reclamation and management of salt affected soils and use of poor quality waters in agriculture. Large number of farmers and extension personnel visited the stalls and acquainted themselves with the technologies developed by the institute. A total of 2729 stakeholders in 86 groups have been visited the Information Technology Centre and Institute Research Experimental farm. They have made aware about the research works going on in the institute and provided technical know-how for reclamation and management of salt affected soil and poor quality water. Out of 2729 stakeholders, 1948 farmers in 22 groups, 537 students in 12 groups, 177 extension personnel in 35 groups, 67 scientists and Subject Matter Specialists in 17 groups from India and abroad visited the institute. Six farmers' day was organized at the farmers' field. These farmers' days were concerned with managing the saline and sodic soils and waters management and also provoking reciprocal learning on management of overall natural resources.

Farmers' Advisory Services

The institute has established facility of toll free phone number 18001801014 to receive calls from the farmers related to the problems of soil salinity, sodicity and water quality. During 2013-14, 242 calls from various fields of agriculture were received from various parts of the country and provided them appropriate solutions of the problems.

International Collaborative Projects

- Stress tolerant rice for poor farmers of Africa and South Asia (Sponsored by IRRI-BMGF)
- Wheat improvement for waterlogging, salinity and element toxicities in Australia and India (sponsored by ACIAR, Australia)
- Cereal systems initiative for South Asia (CSISA) (sponsored by IRRI Philippines and CIMMYT Mexico)
- Marker assisted breeding of abiotic stress tolerant rice varieties with major QTL for drought, submergence and salt tolerance (Sponsored by DBT-India-IRRI)
- IRRI International collaborative programme on testing rice germplasm for coastal salinity (IRSSTN)
- Advanced cultures on rice for shallow and deep water situations with IRRI, Philippines

New Linkages of the Institute

- Singapore National University (SNU) in the area of wastewater remediation.
- SAARC Agriculture Centre (SAC) and CSIRO in cropping systems modeling to promote food security and the sustainable use of water resources in South Asia.
- University of Melbourne, Board of Meteorology and CSIRO Australia in sustainable management of wastewater through forestry.
- National Remote Sensing Centre (NRSC) Hyderabad and State Remote Sensing Application Centres (RSAC) and NBSS&LUP Nagpur (ICAR) on recent space technologies and image interpretations for mapping and characterizing salinity affected areas with higher accuracies
- Academic linkage with Institute of Environmental Studies, Kurukshetra University, Kurukshetra, Haryana.
- Academic linkages with Department of Bio-technology at Maharishi Markandeshwer University, Mullana (Haryana), Deenbandhu Chhotu Ram University of Science & Technology, Murthal (Haryana) and NDRI, Karnal.

Publications

The Institute published 86 research papers in peer reviewed journals, 63 book chapters, 7 books/ manuals, 15 bulletins/folders, 6 popular articles and 56 papers were presented in seminar/ symposia and conferences.

Scientists visits abroad, retired and joined

To upgrade their knowledge and skills, 12 scientists of the institute visited different countries *viz.* Bangladesh, Isreal, Austria, The Netherlands, Malaysia, France, Jordan, Philippines, Thailand, Egypt and Nepal. Six scientists joined during the period under report.

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INTRODUCTION

Historical Perspective

Central Soil Salinity Research Institute (CSSRI) is a premier research institute dedicated to pursue interdisciplinary researches on salinity/alkalinity management and use of poor quality irrigation waters in different agro-ecological zones of the country. The Govt. of India constituted an Indo-American team to assist the Indian Council of Agricultural Research to develop a comprehensive water management programme for the country. As a follow up of these recommendations, Central Soil Salinity Research Institute was established under Fourth Five Year Plan period. The Institute started functioning at Hisar (Haryana) on 1st March, 1969. Later on, in October, 1969, it was shifted to Karnal. In February 1970, the Central Rice Research Station, Canning Town, West Bengal was transferred to CSSRI, Karnal to conduct research on problems of coastal salinity. Another Regional Research Station for carrying out research on problems of inland salinity prevailing in the black soil region of western parts of the country started functioning at Anand (Gujarat) from February, 1989. As per recommendations of the QRT, the station was shifted from Anand to Bharuch in April 2003. Keeping in view the need of undertaking research to manage alkali soils of Central and Eastern Gangetic Plains under surface drainage congestion, high water table conditions, relatively heavy textured soils, and indurated pan below, another Regional Station was established during October, 1999 at Lucknow. The Coordinating Unit of AICRP on Management of Salt Affected Soils and Use of Saline Water in Agriculture is located at the Institute with a network of eight research centres located in different agro-ecological regions of the country (Agra, Bapatala, Bikaner, Gangawati, Hisar, Indore, Kanpur and Tiruchirapalli).

The Institute has grown into an internationally recognized esteemed centre of excellence in salinity research. Multidisciplinary research activities at the main institute are being strengthened through four research divisions. The major research activities in the Division of Soil and Crop Management include preparation and digitization of database on salt affected soils besides periodic assessment of state of soil resources, developing technologies for the optimal management of gypsum amended alkali soils and the use of high RSC and saline waters for crop production. In the post reclamation phase, focus is on developing resource conservation technologies and development of farming system models for resource poor farmers. Agro-forestry on salt affected soils is another area of focus besides the production and evaluation of bio-fuel and bio-energy efficient plants from salt affected soils. Development and propagation of individual farmer based groundwater recharge technologies, subsurface drainage for amelioration of waterlogged saline soils and decision support systems for ground water contaminations with fluoride and climate change are some of the major issues being addressed in the Division of Irrigation and Drainage Engineering. Development of high yielding genotypes tolerant to salinity, alkalinity and waterlogging stresses in rice, wheat and mustard through conventional breeding and modern molecular and physiological approaches are the major concerns of the Division of Crop Improvement. The Division of Technology Evaluation and Transfer is studying constraints in the adoption of land reclamation technologies and their impact on rural development.

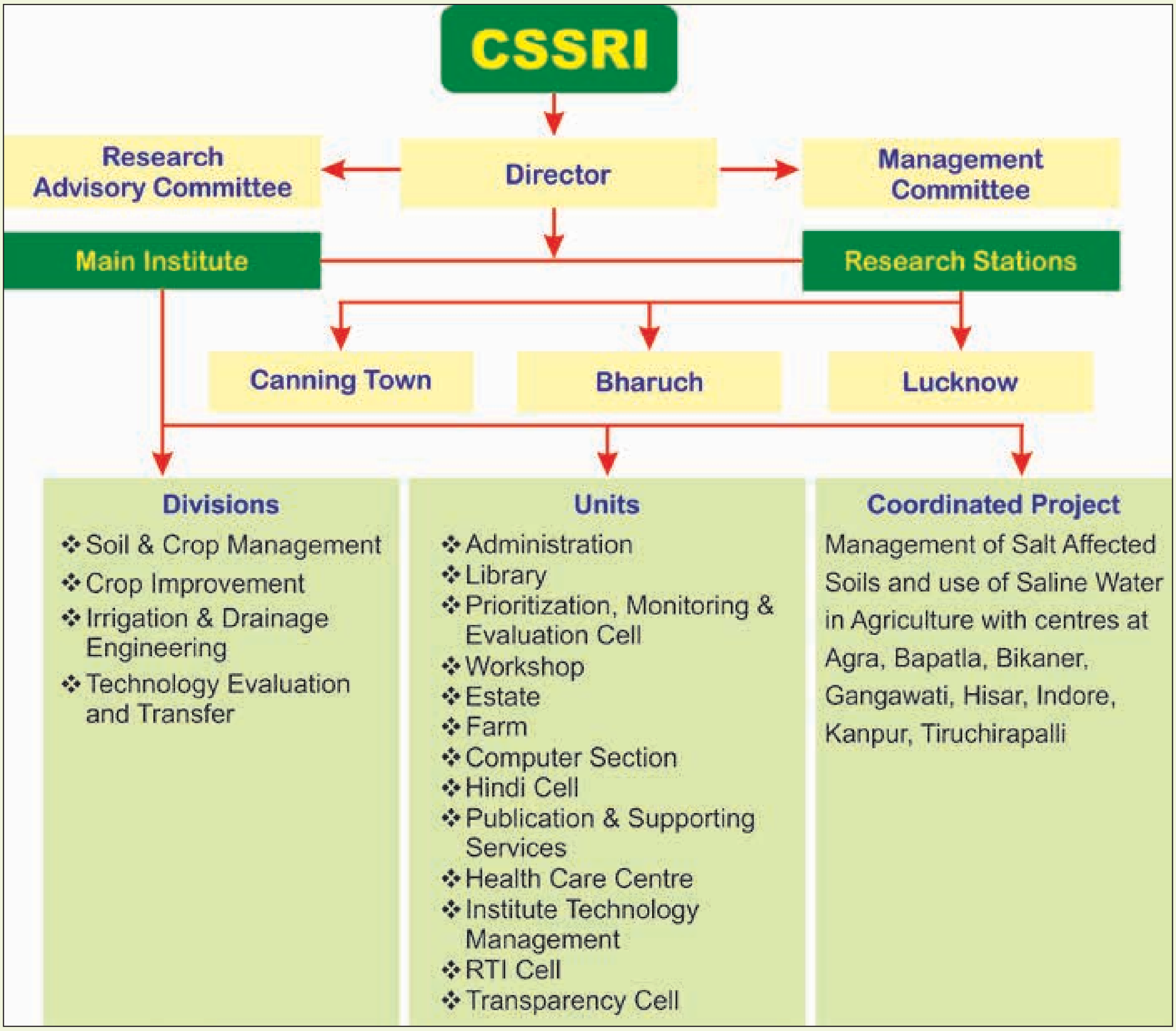
The Institute has developed technologies for the reclamation of alkali soils in the country with the addition of chemical amendments, reclamation of saline soils through subsurface drainage, development and release of salt tolerant crop varieties of rice, wheat and mustard and the reclamation of salt affected soils through salt tolerant trees. Nearly 2.0 million ha salt affected lands have been reclaimed using these technologies and put to productive use. It has been estimated that reclaimed area is contributing about 17 to 18 million tonnes food grains to the national pool. For waterlogged saline soils, subsurface drainage technology developed by the Institute initially for Haryana has been widely adopted and replicated in Rajasthan, Gujarat, Andhra Pradesh, Maharashtra and Karnataka. So far, about 70,000 ha waterlogged saline areas have been reclaimed. Artificial groundwater recharge is another area of interest for region with depleting water table. Besides, the technologies are also being developed for the salt affected areas of Vertisols and coastal regions of the country.

An International Training Centre to impart training at national and international level was established during 2001 under Indo-Dutch collaborative research programme. The Institute has developed Post Graduate Education programme in association with State Agricultural Universities (SAUs), Indian Institute of Technology (IIT) and other Universities, which has contributed to the growth of the Institute substantially. The Institute has several national and international projects to fund its research and development activities. The notable amongst them are: IRRI sponsored rice improvement programme, ACIAR sponsored programme for wheat improvement and IRRI, Philippines and CIMMYT, Mexico sponsored programme on the improvement of cereal based systems.

The institute has created state of the art facilities of sodic and saline micro-plots. Depending upon the objectives, desired stress levels of sodicity and salinity can be created in this facility for screening and better genotypic comparisons. Similarly, an environmentally controlled glass house facility is in place for growing crops and screening genetic resources during off-season. This allows precise screening under saline hydroponics and advancement of breeding generation. Transgenic green house facility has been created at CSSRI in the year 2008 under Indo-US program. A central laboratory with modern equipments has been established at the institute.

Organogram

The current organizational set up for implementing its research programmes is shown below.



Organisational Set up of CSSRI

Mandate

The mandate of the Institute, as approved by the ICAR, is as follows:

- To undertake basic and applied research for generating appropriate agrochemical/ biological/ hydraulic technologies for reclamation and management of salt affected soils and use of poor quality irrigation waters and related environmental issues for sustainable production in different agro-ecological zones
- To evolve, evaluate and recommend strategies that promote adoption of preventive/ ameliorative technology
- To be a nucleus of research on salinity management and coordinate/ support the network of research with universities, institutions and agencies in the country for generating and testing location specific technologies
- To act as a centre for training in salinity researches in the country and region and provide consultancy
- To act as repository of information on resource inventories and management of salt affected soils and waters
- To collaborate with relevant national and international agencies in achieving the above goals

Research Farm, Karnal

Agricultural farm at CSSRI, Karnal has total area of 82 ha. A motorable road has been laid all along the boundary of this farm, for regular monitoring, upkeep and proper watch and ward. Whole of the farm area under cultivation has been divided and laid out in standard plot size of 1.0 ha and each plot is connected with road for easy accessibility, underground water conveyance and lined channels for irrigation. Eight tube wells are installed in the farm to meet irrigation requirement of general agriculture, research experiments and water supply in the campus and laboratories. All essential farm machinery and implements *viz.*, laser leveler, multi-crop thresher, turbo seeder, zero till machines, laser leveler, tractors, hydraulic trolley, cleaner, shrub master, maize thresher, ride on lawn mower etc. are available; most of farm operations are mechanized. To achieve the optimization of water and other inputs, all the plots are precisely leveled with laser leveler at regular intervals. Combination of different cropping system is being practiced to optimize the land use in the farm. Experimental crops are grown on 19.6 ha area, while general crops are grown in 16.9 ha, which also includes 9 ha area under seed production mainly of salt tolerant varieties of rice and wheat. To reduce the emission of green house gases, most of area has been put under minimum tillage and no burning of residue is done in the farm. Agro-forestry system is practiced on 6.5 ha area of the farm, where multipurpose tree species have been planted in combination with arable crops of the region. The area under fruit crops such as ber (*Ziziphus mauritiana* Lam.), aonla (*Emblica officinalis* L.), jamun (*Syzygium cumini* L.), guava (*Psidium guajava* L.), litchi (*Litchi chinensis* Sonn.) and mango (*Mangifera indica*) is 7.8 ha. An herbal garden consisting of 85 species of medicinal/ aromatic herbs, shrubs and trees has also been established and maintained in an area of 1.4 ha, besides fish are reared in ponds covering about 2.5 ha area. The 27.3 ha area of the farm is permanently covered under glass house, net houses, micro-plots, laboratories, offices, residences, oxidation pond, roads and landscape.

Productivity of crops at CSSRI farm

Crop	Variety	Average yield (t ha^{-1})
	***Rabi* 2012 - 13**	
Wheat	KRL 19	4.06
	KRL 210	5.10
	KRL 213	4.27
	DPW 621-50	4.29
	HD 2967	4.56
Mustard	CS 54	0.77
	CS 56	0.65
	***Kharif* 2013**	
Paddy	CSR 30	2.90
	CSR 36	5.40
	Pusa 44	6.35
	Pusa 1121	3.88

CSSRI, Research Farm, Hisar

Hisar experimental farm is located on National Highway No. 10 near air strip of the town. This farm covers an area of 8.0 ha. The experiments on alternate cropping systems for development of suitable land use plans for rainfed saline ground water regions are being conducted here. For meeting the saline water requirement, two shallow tube wells have been installed. One of the tube well has low salinity (EC_{iw} 4-5 dS m^{-1}) water while the second has water of high salinity (EC_{iw} 9-10 dS m^{-1}). Performance evaluation of fruit and forestry trees, medicinal and aromatic plants and different types of cactus, *Prosopis*, grasses, castor and Indian mustard with saline irrigation are being carried out.

Finances

Summary of allocation and expenditure during the year 2013-14 under Plan and Non-Plan budget is presented below:

(Rs. in lakhs)

Budget	Sanctioned amount/ receipts	Actual expenditure
Non-plan	2158.00	2157.14
Plan	220.00	219.88
AICRP (Non-plan)	31.50	29.86
AICRP (Plan)	475.00	474.99
Total	**2885.18**	**2881.87**

Staff

The total staff strength of the institute is 351. The category wise details are:

Category of post	Sactioned	In position
Scientific	81	55
Technical	117	101
Administrative	58	46
Skilled Supporting Staff	95	64
Total	**351**	**266**

Library

Library is an instrument of self-education, a means of acquiring the knowledge and factual information while serving as a centre of intellectual recreation. CSSRI library is well furnished, fully air-conditioned and equipped with 6 computers, I server and 2 UPS. The Institute library has rare and large collection of Technical, Scientific books, Journals, Reports and other publications. The CSSRI Library possesses Indian and Foreign publications related to the fields of Water Management, Soil salinity, Drainage, Alkalinity, Water Resources, etc. The library has total collection of 15213 books including Hindi books. A separate section is maintained for Hindi books. There are 8000 bound volumes of the Journals. It has a rich collection of special publications of FAO, IRRI, UNESCO, ILRI, ICID, IFPRI, ASA, ASAE which fulfill the needs of scientists, researchers, teachers and students. It subscribes 44 National Journals.15 Journals are being received on gratis. About 160 theses on subjects relating to Soil Science, Agric. Engg., Water Management , etc. are available in the library. Annual Reports from the different Institutes, Agricultural Universities are being received from time to time.

e-Services

Internet connectivity: Whole Library is facilitating through LAN using ernet (dedicated lease line)

Online Journals: More than 2800 scientific research journals are available online through Consortium for e-Resources in Agriculture (CeRA) on request.

CD-ROM Data Bases: World wide agricultural information retrieval services of published agricultural researches are available on CD-ROM data base where abstracts of the researches can be consulted. The research databases are available since 1972 of AGRIS, Plant Gene CD , Soil CD**.**

Online Public Access Catalogue (OPAC): Library book catalogue is available online which is a systematic record of holding of a collection to find the physical location of information for easier to search using LIBSYS software version 6.0. Now "KOHA" software has also been implemented and all the data of books,journals, theses, etc. has been migrated to "KOHA"to strengthen the digital resources of all Libraries under NARS (e-Granth). The web OPAC of Library in "KOHA"may be accessed through the link or http//egranth.ac.in with username: adminuser and Password: admin@iari

Institutional Digital Repository: Institute Library has a digital repository i.e. "Krishikosh "which has been created through the digitized CSSRI documents including institutional publications, annual reports, foundation day lecture notes, tech. bulletins, rare and important books (150) by IARI, New Delhi centre. The digitized documents uploaded in "Krishi Kosh" may be accessed online through the link http://krishikosh.egranth.ac.in

Bar-code based circulation: Library provides Bar-coded Electronic Membership Cards to its readers for easy circulation and to know the borrower status.

Documentation services: Under Documentation Services, Current Awareness Services (CAS) and Selective Dissemination of Information (SDI) are provided to users with the help of Fresh Arrivals display on board and in training, advertisement files, etc.

The library also works as a repository center where institute's Publications such as Salinity News, Technical Bulletins, Annual Reports, Brochures, etc. are stocked and sent to Research Institutes, Agricultural Universities, NAAS members, QRT members, RAC members etc. and also distributed amongst the distinguished visitors, farmers, etc. Eleven priced publications are also available for sale.

Laboratories

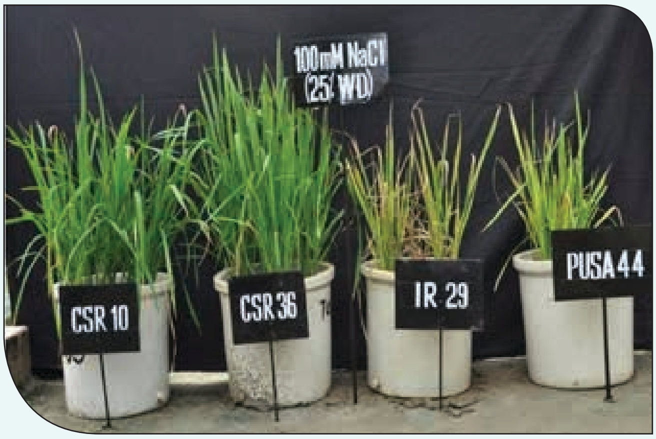
Well equipped laboratories for undertaking researches on various aspects of salinity management are in place with some of the advanced facilities like Atomic Absorption Spectrophotometer, Inductively Coupled Plasma (ICP), Carbon- Nitrogen- Hydrogen- Sulphur analyzer (CNHS), Ion Chromograph, UV VIS Spectro Photometer, Ultra pure water system, HPLC, Radio meter, Kjeltek N-analyser, EM Salinity Probe, Neutron Moisture meter, Scintillation Counter, Growth Chamber, Modulated flurometer, Dilutor, Hydraulic conductivity measurement apparatus, Pressure plate apparatus, etc. Large number of screen houses and micro-plots are also available for precision experimental works. The facilities of image processing and interpreting satellite imageries and geographical information system are also available. Recently, a multimedia laboratory has also been established to cater to the need of photographic and image processing and power point presentation etc.

Allied Facilities

A conference hall, seminar room and an auditorium with modern facilities are available for scientific meetings and group discussions. The institute has a museum with exhibits depicting salient research findings and the latest technologies developed at the institute. The museum is being upgraded with addition of new exhibits and state of art display infrastructure/ material. An international guesthouse and scientists hostel with boarding facilities caters to the need of scientists and other visitors. Besides, there is an extension hostel for students and trainees. A dispensary with physiotherapy unit is also available in the institute. A sports complex consisting of playgrounds for football, hockey, cricket, volley ball, lawn tennis court etc. besides indoor facilities for table tennis, chess, carom and badminton are available. The staff recreation club functions to meet the recreational requirements of the staff. Besides this, a Staff Welfare Club is also functioning actively for the welfare of the CSSRI staff.

☆☆☆☆☆

Research Achievements



DATABASE ON SALT AFFECTED SOILS

Mapping and Characterization of Salt Affected Soils in Central Haryana using Remote Sensing and GIS (A.K. Mandal, Ranbir Singh, P.K. Joshi and D.K. Sharma)

The assessment of the extent of salt affected soils of Kaithal district of Haryana was accomplished based on the interpretation of IRS LISS III (2009-10) data, integrated with ground truth by studing soil profiles to a depth of 1.5 m below surface, and laboratory characterization of soil samples for such characteristics as pHs, ECe, ESP, CEC, ionic (cation and anion) composition, $CaCO_3$ (<2 mm size) content and soil texture. Soils were characterized based on the nature, degree and extent of salinity/sodicity.

The mapping methodology included geo-referencing and digitization of thematic layers for preparation of basemap comprising of administrative and political boundaries, infrastructure, irrigation/ drainage, and settlements. It also included demarcation of boundaries of the interpreted units from IRS data, registration of the map units using soil characteristics and superimposition of soil salinity data on basemap. The georeferenced boundaries of the blocks/sub-divisions in Kaithal district (HARSAC, Hisar) were superimposed with the soils database to generate the block-wise distribution of salt affected soils.

The area under different categories of salt affected soils was computed based on the statistics prepared in the GIS (Table 1). Six categories of salt affected soils were identified in four blocks of Kaithal sub-division. In Kaithal block, slight (4313 ha) and moderately (1809 ha) sodic soils were dominating (6122 ha (2.6%) in areas irrigated with ground water of sodic nature, while slightly, moderately and strongly saline soils covered 804 ha (0.3%) located in lower topographic zone. In Kalayat block, salinity was dominant (4620 ha, 2%) in canal irrigated areas, while sodic soils (1452 ha, 0.6%) were also found in patches adjacent to Kaithal block. Salt affected soils covered 4891 ha (2.1%) in Pundri block of which dominantly sodic (4723 ha, 2%) were located in Chautang plain (paleo-channel) and saline soils (168 ha, 0.07%) were found in low-lying flats. In Rajound block, saline soils (3063 ha, 1.3%) were dominant in irrigated areas underlain by saline ground water. In total salt affected soils covered 21002 ha (9.0%) in Kaithal sub-division, of which sodic and saline soils covered 5.3% and 3.7%, respectively.

In Guhla block, slightly saline (1415 ha, 0.61%) and slightly sodic (1015 ha, 0.44%) soils were commonly distributed in tubewell irrigated areas and strongly (143 ha, 0.06%) and moderately sodic soils (73 ha, 0.03%) were found in Ghaggar plain. Salt affected soils covered 2653 ha (1.1%) in Siwan block, of which strongly sodic soil (2255 ha, 0.97%) were distributed in Saraswati plain (paleo-channel), while slightly saline (255 ha, 0.1%) and slightly sodic (143 ha, 0.06%) soils were found in the irrigated areas. A total area of 5299 ha (2.28%)

Table 1 : Distribution (ha) of salt affected soils in Kaithal district

Name of the blocks	Categories of salt affected soils						Total area (ha)	% of TGA
	Moderately saline	Moderately sodic	Slightly saline	Slightly sodic	Strongly saline	Strongly sodic		
Kaithal sub-division								
Kaithal	148	1809	50	4313	606	tr	6926	3.0
Kalayat	935	1306	1335	146	2350	tr	6072	2.6
Pundri	tr	1682	168	3041	tr	tr	4891	2.1
Rajound	tr	09	2028	51	1026	tr	3114	1.3
Sub-total	1083	4806	3581	7551	3982	tr	21002	9.0
Guhla and Siwan blocks								
Guhla	tr	73	1415	1015	tr	143	2646	1.1
Siwan	tr	tr	255	143	tr	2255	2653	1.1
Sub-total	tr	73	1670	1158	tr	2398	5299	2.3
Grand total	1083	4879	5251	8709	3982	2398	26301	11.3

TGA=Total Geographical Area of Kaithal district was salt affected in Guhla and Siwan blocks, of which sodic and saline soils covered 1.5% and 0.7%, respectively. Thus, salt affected soils covered 26301 ha (11.3%) in Kaithal district, of which the sodic and saline soils occupied 6.8% (15986 ha) and 4.4% (10315 ha), respectively.

The quality of ground and surface water samples was assessed based on the chemical analysis of water samples (13 Nos) collected from different sources in the study area (Table 2). The depth of ground water table ranged from 250-270 ft in Kaithal block, 60-70 ft in Kalayat, 250-300 ft in Guhla and Siwan blocks. The water samples of Kaithal block were neutral to sodic in nature (pH 7.6 to 8.3) showing dominance of carbonate and bicarbonate salts of sodium, calcium and magnesium. The water sample in Bhaini Majra village showed significant RSC (6.5 me l^{-1}) indicating need for reclamation with suitable amendments such as gypsum. The surface water samples collected from accumulated seepage water showed the presence of carbonate, bicarbonate salts of sodium, calcium, magnesium and chloride and sulfate ions. The samples from Kalayat block were saline in nature due to high EC (12.7 dS m^{-1}) and were dominated by the presence of chloride (80.0 me l^{-1}) and sulfate (54.8 me l^{-1}) of sodium (164.8 me l^{-1}), calcium and magnesium (48.0 me l^{-1}). These waters can be used for arable crops either mixing or cyclic mode with good quality canal water. In Guhla block, pH of water samples showed slight to moderately sodic (pH 9.3 to 9.6) and dominated by carbonates and bicarbonates of sodium, calcium and magnesium. The presence of chloride and sulfates were also noticed. Due to lower calcium and magnesium contents, SAR values were also higher (12.1 to 23.4). Due to high salt load, this water can be used in combination with good quality water. In Siwan block, the water sample showed sodic in nature (pH 8.8), with high RSC (12.7 me l^{-1}), and salt

Table 2 : Quality of water in Kaithal district

S. No	Location, source and depth of groundwater	pH	EC (dS m^{-1})	Na^+	K^+	Ca^{2+}+ Mg^{2+}	CO_3^- + HCO_3^-	Cl^-	SO_4^{2-}	RSC	SAR
				---(me l^{-1})---							
Water samples from Kaithal sub-division											
1	Vill.Mundri Block Kaithal (250ft)	8.3	1.1	10.3	0.06	10.0	9.0	10.0	tr	tr	4.8
2	Vill. Mundri Block Kaithal (270ft)	8.3	1.1	10.3	0.05	10.0	9.5	15.0	tr	tr	4.7
3	Vill.Sampli Kheri Block Kaithal (250ft)	7.6	1.1	9.9	0.08	8.0	10.5	12.0	tr	tr	4.9
4	Devigarh farm (KVK HAU) Seppage water	7.2	2.3	17.7	0.01	10.0	8.5	16.0	7.1	tr	7.9
5	Vill.Kolekha Block Kalayat (60-70 ft)	7.6	12.7	164.8	0.05	48.0	5.0	80.0	54.8	tr	33.6
6.	Village Bhaini Majra Block Kaithal (270 ft)	9.3	1.2	9.9	0.07	2.0	8.5	3.0	tr	6.5	9.9
Water samples from Guhla and Siwan block											
7	Vill. Sehun Majra, Block Guhla, 250 ft	8.6	1.3	10.6	0.1	3.0	2.5	10.0	8.8	tr	8.6
8	Vill. Kheri Daban, Block Guhla, 250 ft	9.1	1.3	12.6	0.1	1.5	2.5	10.0	6.4	1.0	14.5
9	Vill. Hansu Majra, Block Guhla, 250 ft	9.3	1.4	14.1	0.1	1.0	3.0	6.0	4.7	2.0	19.9
10	Vill. Majri, Block Guhla, 300 ft	9.1	1.2	12.1	0.1	2.0	4.0	20.0	2.9	2.0	12.1
11	Vill. Tatiana, Block Guhla, 300 ft	9.1	1.6	16.6	0.1	1.0	3.0	5.0	7.7	2.0	23.4
12.	Vill. Kamheri Block Guhla, 300 ft	8.8	0.8	6.8	0.1	3.0	2.5	3.0	0.4	tr	5.5
13	Vill. Bichian, Block Siwan, 270 ft	8.8	1.1	13.9	0.1	2.9	15.7	1.7	tr	12.7	11.5

composition showed the dominance of sodium, carbonate and bicarbonates. It needs reclamation by gypsum application or passage through gypsum beds for amelioration.

Development of Spectral Reflectance Methods and Low Cost Sensors for Real-Time Application of Variable Rate Inputs in Precision Farming (Madhurama Sethi, Rajeev Srivastava, D.S. Bundela and R.K. Yadav)

Information on NDVI and LAI were collected from five locations from each field in Village Waiser of Panipat District. Some sites of Waiser were reclaimed and had pH ranging from 6.8 to 9.8 and ECe ranged from 0.60 to 4.30 (Fig.1).

Greenseeker determined NDVI and Plant Canopy Analyser determined LAI showed an increasing trend in correlation from 75 DAS towards 120 DAS, R^2 increasing from 0.56 at 75 DAS to 0.61 at 120 DAS. Overall, NDVI and LAI exhibited a good correlation. LAI had a fluctuating trend in response to the varying salinity while NDVI being an average showed a more even trend. Where EC_e and Na were present at elevated levels, NDVI and LAI have lowered values indicating impact of stress from salinity. The interpolation (IDW) algorithm was applied to generate maps that grouped NDVI and LAI. The thematic maps showed the status of variability of NDVI and LAI in agricultural fields at Waiser in both NDVI and LAI from 75 DAS to 100 days. However, thereafter there is little variation in NDVI and LAI at 120 days (Fig. 2).

ASD spectro radiometer data was collected at 75 and 120 DAS using algorithms of Growth index (GI), Leaf Chlorophyll Index (LCI), Chlorophyll Absorption Index (CARI) and Soil Adjusted Vegetation Index (SAVI), it was found that the hyper spectral data showed good correlation with NDVI (Fig 3). However, there was a marginal drop in correlation between NDVI and plant indices as the crop begins to mature (120 DAS). NDVI and LCI had greater correlation than other indices (Table 3).

Trend lines of different indices showed that CARI has least variation of all the indices and therefore it seems to least affected by the variability of salinity in the field. Greeniness Index on the other hand exhibited the most variation while LCI and SAVI both show a very similar trend in response to the

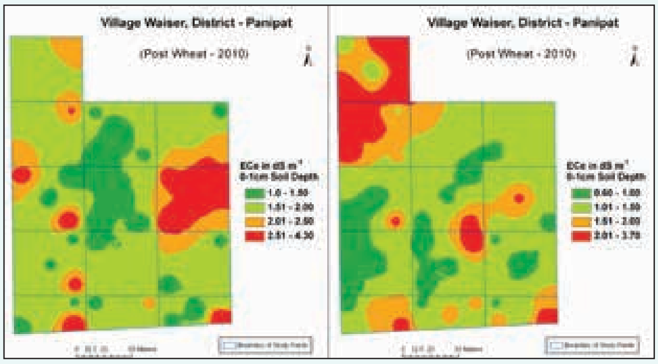


Fig 1 : Delineated ECe in soils at Village Waiser

Table 3 : Correlation coefficient between NDVI and other four vegetation indices at different days after sowing

Vegetation indices	Correlation coefficient (R^2) values in different DAS	
	75	120
NDVI and GI	0.713	0.643
NDVI and LCI	0.750	0.734
NDVI and CARI	0.613	0.591
NDVI and SAVI	0.725	0.643

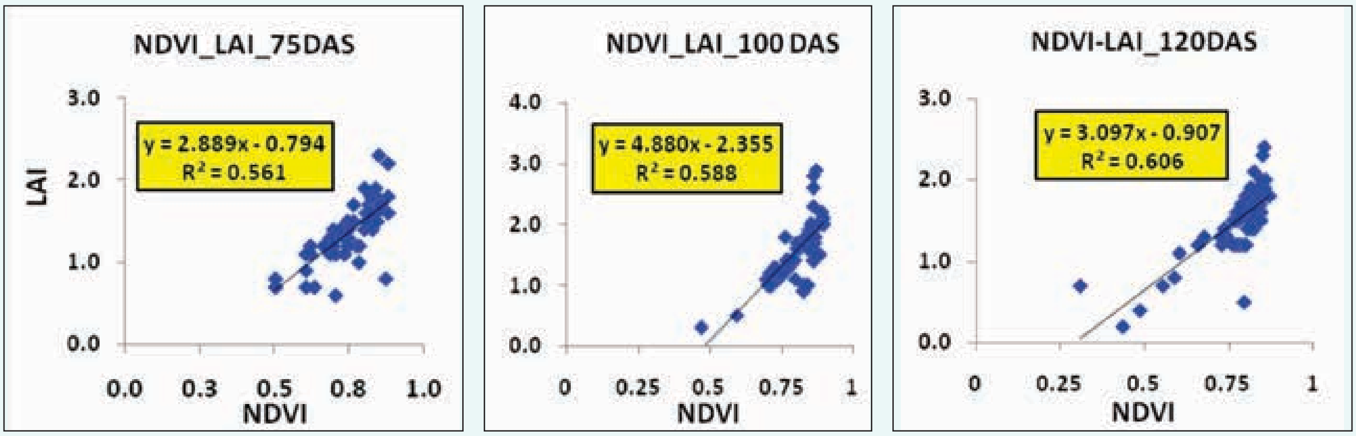


Fig 2 : Correlation between NDVI and LAI of wheat crop for district Waiser in three different dates after sowing

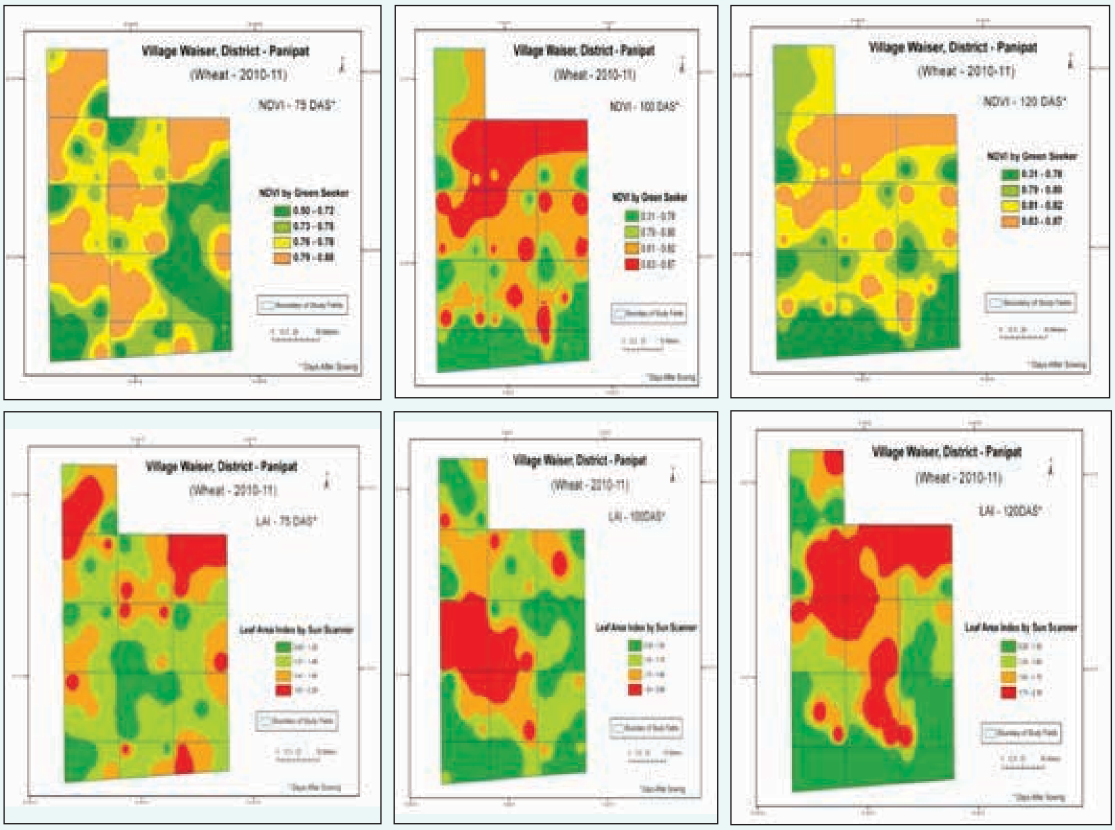


Fig 3 : IDW of NDVI and LAI data on different dates after sowing for the entire field of Waiser

variation of salinity at 75 DAS. The same trends were observed at 120 DAS except LCI subdues and SAVI index mainly due to crop has gained height with increased canopy. The correlation co-efficient values increased from 75 to 120 DAS, but the level of chlorophyll decreased due to onset of senescence in wheat. Alongside the values of GI and LCI also decreased at 120 DAS. SAVI also showed a decreasing trend from 75 to 120 DAS (Fig. 4).

Correlations between NDVI, LAI and EC_e and Na were also studied. Where EC_e and Na were present in higher quantities, NDVI and LAI were much lower in response to salinity stress. Correlations between soil EC_e and all plant properties showed negative relationship.

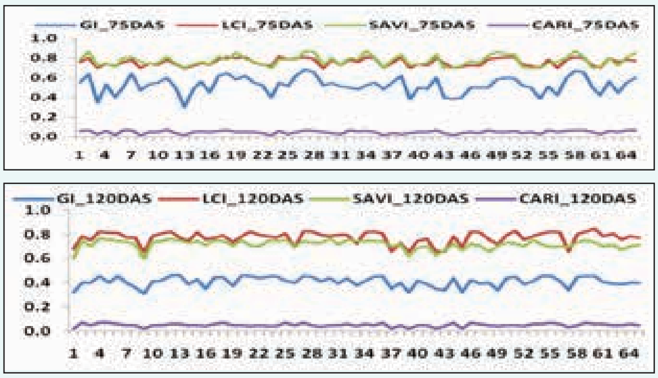


Fig 4 : Trend lines showing the rate of change of vegetation indices of wheat crop for village Waiser at 75 and 120 DAS

Assessment and Mapping of Salt Affected Soils using Remote Sensing and GIS in Southern districts of Haryana State (Anil R. Chinchmalatpure, Madhurama Sethi, Parveen Kumar, M.D. Meena, G.S. Sidhu, Jaya N. Surya and M.L. Khurana)

Interpretation of satellite images of IRS P-6 LISS-III was done to identify salt affected soils of Palwal district of Southern Haryana. Salt encrustation/efflorescence and waterlogging was higher in post-*rabi* (March) season apparently due to intensive agriculture. Prominent areas infested with salt affected soils and associated waterlogging were identified in Soundh, Madnaka, Riber, Akbarpur Natol, Bhigawali and Matepur and adjoining villages located in the alluvial plain. IRS imageries also showed high reflectance by barren salt affected soils and higher water absorption in cropped areas irrigated with saline ground water. Ground truth was conducted to characterize interpreted units for land uses, topography, drainage, irrigation, waterlogging, salt affected soils and the presence of sub-surface salinity/alkalinity, concretions and textural grades etc.

Depth-wise soil samples were collected from soil profiles (90 cm) for determination of physico-chemical properties. Analytical data showed that these soils are saline in nature with EC_e ranging from 0.26 to 59.9 dS m^{-1}. Among soluble cations sodium was dominant followed by magnesium and calcium. Soluble sodium and chloride ions were significantly correlated with electrical conductivity (EC_e). The mean concentration of soluble sodium was 2.0 times more than the concentration of calcium + magnesium in these soils. Similarly, chloride content was as high as 500 me l^{-1} and sulphate as high as 74.5 me l^{-1}. Soil of Mandkaul and Devali villages were highly sodic with pH_s ranged from 9.2 to 10.0 with presence of carbonate and bicarbonate ions (Table 4). The soils of the study area were sandy loam to loamy sand in texture. These soils were low in available nitrogen content (35 to 129 kg ha^{-1}) and poor in soil organic carbon content (0.04 to 0.65%). Satellite imageries were interpreted and subjected to supervised classification for estimation of area under different categories. Laboratory analysis of ground water samples from Palwal district revealed that pH ranged from 6.8 to 7.8 and EC ranged from 1.3 to 15.4 dS m^{-1}. The predominant cation and anion in the ground water was sodium and chloride, respectively. The groundwater was also affected by the fluoride content which ranged from 3.0 to 9.0 ppm (Table 5).

Table 4 : Physico-chemical properties of salt affected soils in Palwal district of Haryana

Sample depth	ECe (dS m^{-1})	pHs	Na (me l^{-1})	K (me l^{-1})	Ca+Mg (me l^{-1})	Cl (me l^{-1})	CO_3 (me l^{-1})	HCO_3 (me l^{-1})	OC (%)	Av. N (Kg ha^{-1})
Village: Bahin; Tehsil Hathin, District Palwal										
0-5	35.90	8.00	150.04	1.31	25.0	336.00	0	3.00	0.42	91.00
0-15	9.71	8.12	14.34	0.54	2.72	146.00	0	2.50	0.38	87.50
15-30	6.60	8.32	13.66	0.45	2.70	81.00	0	2.50	0.28	87.50
30-60	5.40	8.52	9.42	0.35	2.60	62.00	0	2.00	0.24	70.00
60-90	3.99	7.95	0.75	0.21	1.82	39.00	0	2.00	0.19	66.50
Village: Devali, Tehsil and district Palwal										
0-5	59.90	9.80	600.16	1.903	30.10	500.00	48.50	150.00	0.31	87.50
0-15	25.70	10.00	160.16	0.546	17.00	92.00	13.80	43.75	0.33	87.50
15-30	2.70	9.90	35.51	0.553	4.20	14.00	1.00	3.50	0.33	73.50
30-60	0.93	9.80	0.58	0.367	1.80	10.00	0.40	3.00	0.31	70.00
60-90	3.21	9.70	0.79	0.347	3.40	9.00	0.40	2.00	0.30	59.50

Table 5 : Composition of groundwater samples from Palwal district in Haryana

Name of village	EC (dS m^{-1})	pH	Na (me l^{-1})	K (me l^{-1})	Ca+Mg (me l^{-1})	Cl (me l^{-1})	HCO_3 (me l^{-1})	NO_3 (mg kg^{-1})	F (mg kg^{-1})
Yakubpur	1.42	7.20	1.93	0.09	15.00	19.00	0.60	198.60	0.30
Malai	1.89	7.21	8.34	0.08	12.00	17.00	0.70	4.00	0.30
Kot	15.43	6.88	129.50	0.35	49.00	159.00	0.80	0.50	8.50
Sundarnagar	3.90	7.24	48.24	0.37	14.00	31.00	1.10	114.10	3.89
Nimka	3.40	7.34	31.16	0.08	12.00	25.00	1.00	327.10	3.47
Madnaka	3.09	7.05	12.37	0.23	22.00	32.00	0.50	129.30	2.45
Akbarpur Natol	1.62	7.89	15.75	0.05	2.00	15.00	0.60	20.730	4.47
Bhigawali	1.31	7.20	7.31	0.02	9.00	18.00	0.50	24.11	0.00
Mathepur	4.48	7.53	37.70	0.71	10.00	45.00	0.90	0.50	4.10
Devali	8.55	7.25	60.16	0.45	23.00	85.00	1.00	9.00	7.98
Devali	5.79	7.10	44.59	0.89	14.00	57.00	0.80	29.31	9.00
Janauli	2.81	7.54	31.29	0.19	4.00	26.00	1.30	3.03	8.85
Maheshpur	2.57	7.02	18.05	0.03	9.00	24.00	0.80	56.13	0.30

☆☆☆☆☆

RECLAMATION AND MANAGEMENT OF ALKALI SOILS

Strategies of Resource Conservation and Mini-sprinkler on Crop Productivity under Rice-Wheat Cropping System on Semi-reclaimed Sodic Soils (Ranbir Singh, D.K. Sharma, S.K. Chaudhari, P.K. Joshi, R.S. Tripathi and Satyendra Kumar)

The irrigated rice-wheat cropping system in India spread over an area of 10 mha in Indo-Gangetic Plain (IGP) and together contributes 85% of cereal production in the country. An appreciable amount of water, labour and energy are required for good harvest of cereals. These inputs are becoming scarse and costly due to escalating demand. Keeping these constraints in view, a field experiment has been continuing from 2011, to evaluate the effect of resource conservation strategies viz., reduced tillage, residue and water management for enhancing crop productivity and sustaining soil health in semi-reclaimed sodic soils. Conventional practices (CV) *vis-à-vis* eight adopted resource conservation techniques were imposed to evaluate its long-term effect on water use, water productivity and nitrogen use efficiency. High yielding varieties of rice (Ariz-6129) and wheat (HD 2967) were used as test crops. The results indicated that highest yield of rice (7.4 t ha^{-1}) was recorded in CV with wheat residue incorporation followed by direct seeded rice (DSR) (6.9 t ha^{-1}) with wheat residue incorporation, and DSR in zero tillage without residue. An additional grain yield of rice (4.6%) was harvested under crop residue incorporation in DSR. A marginally higher grain yield of wheat was recorded in wheat sowing in conventional with wheat residue incorporation (5.47 t ha^{-1}) compared to CV (5.08 t ha^{-1}) and reduced tillage (5.07 t ha^{-1}), respectively. Overall, crop residue incorporation recorded 7.7 and 3.1 per cent higher wheat and rice yield, respectively over CV practice. Preponderance of weeds, *Cyperous rotundus* (motha), *Echinochloa crusgali* (Barta), *Echinochloa colonum* (Sanmak), Kallar grass, Makra etc. caused a significant yield reduction under zero tillage, CV and reduced tillage system. Optimum soil moisture and favourable temperature regulation under residue incorporation facilitated better seed germination and crop growth as compared to no-residue treatments.

A mini-sprinkler irrigation system was installed in an area of 0.4 ha with 12960 l h^{-1} acre^{-1} discharge rates at 2 kg cm^{-2} pressure and with 90 per cent uniformity coefficient. The criteria for irrigation

Table 6 : Effect of surface and mini sprinkler on wheat yields, irrigation water requirement, water productivity, and saving of water and energy during 2012-2013

Resource conservation techniques	Conventional wheat sowing	Wheat sowing in zero tillage with100% rice mulch / DSR without rice residue	Wheat sowing in zero tillage with 100 % rice mulch/ DSR without rice residue	Wheat sowing in zero tillage with 100% rice mulch / DSR with rice residue incorporation
Mode of irrigation	Surface	Surface	Mini-sprinkler	Mini-sprinkler
Irrigation criteria	Growth stages	Growth stages	(7 days CPE)	(7 days CPE)
Grain yields (t ha^{-1})	5.08	5.38	4.88	5.13
Straw yield (t ha^{-1})	8.47	10.04	10.12	9.90
Total crop productivity (t ha^{-1})	13.55	15.42	15.00	15.03
Total irrigation water (m^{3}ha^{-1})	2400	1800	1467.7	1467.7
Crop water productivity (kg m^{-3})	5.65	8.57	10.22	10.24
Grain water productivity (kg m^{-3})	2.12	2.98	3.32	3.49
Irrigation water saving (%)	-	25.00	38.85	38.85
Energy saving (%)	-	-	2.16	2.16
Physiological observation	Yellowness –water stagnated	Greenness-water not stagnated	Greenness water not stagnated	Greenness-water not stagnated

Rainfall received = 277.4 mm, CPE= cumulative pan evaporation of 7 days used for irrigation through mini sprinkler system during 2012-13.
CD (0.05) = 0.26 (grain)

Table 7 : Effect of surface and mini sprinkler on rice yields, irrigation water requirement, water productivity, and saving of water and energy during 2013

Resource conservation Techniques	Conventional rice transplanting	DSR without rice residue / wheat sowing in zero tillage with100% rice mulch	DSR without wheat residue / wheat sowing in zero tillage with 100% rice mulch	DSR with rice residue incorporation / wheat sowing in zero tillage with 100 % rice mulch
Mode of irrigation	Surface	Surface	Mini-sprinkler	Mini-sprinkler
Irrigation criteria	1DADPW	Small soil cracks with surface dryness	(CPE)	(CPE)
Grain yields (t ha^{-1})	7.19	7.20	6.90	6.70
Straw yield (t ha^{-1})	9.79	8.72	9.80	9.65
Total crop productivity (t ha^{-1})	16.98	15.92	16.70	16.35
Total irrigation water ($m^3 ha^{-1}$)	7500	5000	3159	3159
Crop water productivity (kgm^{-3})	2.26	3.18	5.29	5.18
Grain water productivity (kgm^{-3})	0.959	1.44	2.18	2.12
Irrigation water saving (%)	-	33.30	57.88	57.88
Electricity saving (%)	-	33.32	32.60	32.60

Rainfall received = 532.9 mm (June, 2013 to September 2013); CPE= cumulative pan evaporation criteria used for irrigation through mini sprinkler system during *kharif* 2013. CD (0.05) =0.31 grain yield.

scheduling for wheat was chosen to be the cumulative pan evaporation of 7 days. Sprinkler irrigation system saved 38.85 per cent over surface irrigation (Table 6). Zero tillage with rice straw mulch produced highest wheat yield (5.38 t ha^{-1}) under surface irrigation method followed by zero tillage with rice straw mulch (5.13 t ha^{-1}) under mini sprinkler irrigation system. Problem of crop lodging was noticed at the stage of grain filling and dough stages under sprinkler irrigation system. The electric energy of 2.2 per cent was saved in mini sprinkler irrigation in comparison to conventional irrigation in wheat. The highest grain yield of rice (6.90 t ha^{-1}) was recorded in DSR with minimum tillage without wheat residue incorporation in mini sprinkler irrigation. This saved 57.9 per cent of applied irrigation water (Table 7) and increased water productivity of 2.2 kg m^{-3}. DSR with minimum tillage saved irrigation water upto 33.3 per cent as compared to conventional tillage. Application of nitrogen through sprinkler saved 50 and 33 per cent of recommended N when mulching was done with 100 per cent rice crop residue, and zero tillage wheat sowing with 33 per cent rice residue retention, respectively.

DSR combined with zero tillage in wheat along with residue retention had the highest organic carbon in surface (11.57 g kg^{-1} soil aggregates) and the highest stratification ratio of 1.5. A considerable proportion of total SOC was found to be stored in macro aggregates (>2- 0.25 mm) in both surface (67.1%) and sub-surface layers (66.7%) leaving

Wheat in Zero Tillage

Mini sprinkler in wheat

Mini sprinkler in rice

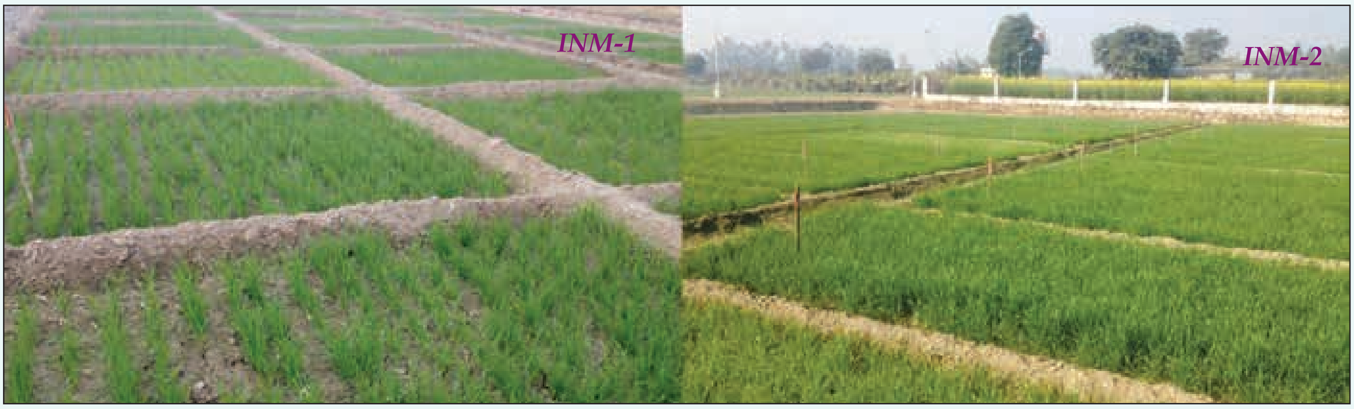
rest of the amount in micro aggregates and silt + clay particles. From this study, it has been proved that DSR with zero tillage in wheat (with residue) followed by DSR with reduced tillage in wheat (with residue) treatment has the best potential to sustain soil health by improving SOC sequestration in reclaimed sodic soil of sandy loam texture.

Nutrient Management Strategies for Sustainable Rice and Wheat Production in Reclaimed Alkali Soils (A.K. Bhardwaj, Nirmalendu Basak, S.K. Chaudhari and D.K. Sharma)

Proper nutrient and soil health management in partially reclaimed sodic soils is a key to sustainable productivity. To know basic nutrient flow mechanism, plant availability and how carbon sequestration mechanisms are affected by nutrient management from organic and inorganic sources is important for developing successful real world technology. This project was initiated in 1994 (treatments further modified in 2005) to assess the influence of chemical fertilizer and organic amendment on soil health and productivity under rice-wheat cropping system in a gypsum amended alkali soil (pH-8.7 and ESP- 18%) (INM-1). Another experiment was initiated in 2013 (INM-2) with different treatments of only organic amendment (FYM, paddy compost and green manure) along with NPK Fertilizer with three replications.

The INM-1 experiment consisted of ten treatments replicated four times in RBD. The treatments were- T_1-Control (without organic and inorganic fertilizer), T_2- $N_{180}P_{22}K_0Zn_5$ (Farmer's practice; FP), T_3- $N_{180}P_{39}K_{63}Zn_5$, T_4- $N_{100}P_{16}K_{26}$+Moong, T_5- $N_{100}P_{16}K_{26}$+GM (*Sesbania aculeate*) before rice transplanting, T_6- $N_{100}P_{16}K_{26}$+FYM before rice transplanting, T_7-$N_{100}P_{16}K_{26}$+wheat straw before rice transplanting, T_8- $N_{100}P_{16}K_{26}$+ rice straw before wheat sowing, T_9- $N_{150}P_{26}K_{42}S_{30}Zn_7Mn_7$ and T_{10}- $N_{150}P_{26}K_{42}S_{30}Zn_7Mn_0$. At the time of harvesting, 33 per cent of the total rice stalk length was kept untouched and incorporated into the soil by power tiller before wheat (cvDBW-17) sowing only in T_8 treatment. Before rice transplanting, greengram seeds (SML 668) were sown in first fortnight of May in the specified plots and incorporated *in situ* after two pickings of pods. Similarly, dhaincha (*Sesbania aculeate*) as green manure was sown in May in the plots of T_5 treatment. At the age of 45 days, it was harvested, weighed and incorporated *in situ* in the specified plots before rice transplanting. Farm yard manure (FYM) and wheat straw (WS) were added in soil 15 and 30 days before rice transplanting, respectively. Rice (cvPusa-44) seedlings (30 days old) were transplanted in first week of July at 20 cm × 15 cm spacing. One third of N and full doses of other macro and micro nutrients were applied at the time of sowing (in wheat)/transplanting (in rice) according to the treatment specifications. Remaining N was applied in two equal splits after 3 and 6 weeks of sowing (in wheat)/transplanting (in rice). Nutrient availability (Fig. 2) with changes in soil moisture regimes and treatments were monitored to work out sustainable strategies. Nutrient availability is also related to soil carbon and nutrient pools and, therefore, these pools are being determined at regular intervals.

All organic sources (along with recommended NPK) including *Moong* in rotation, green manuring (GM), farmyard manure (FYM), wheat straw (WS) and rice straw (RS) resulted in 0.4-1.6 g kg^{-1} increase in organic carbon (TOC) over farmers' practice (N,P,Zn). Farmer's practice had TOC values of



A general view of the field experiments (INM 1 and 2)

Polymer resin strips buried on soil surface

Soil moisture monitoring being done by the field staff

4.0 g kg^{-1}. Integrated nutrient management with organic sources also resulted in significant increase in microbial biomass carbon (Fig. 5).

Farmyard manure (FYM), green manuring (GM) and *moong* in rotation along with recommended NPK, also resulted in 20.7, 21.4 and 23.1per cent, respectively higher mineralizable carbon (at 3^{rd} days; 21.7, 22.4 and 24.1 µg C g $soil^{-1}day^{-1}$, respectively, compared to 19.8 µg C g $soil^{-1}day^{-1}$ for farmer's practice, FP) (Fig. 6). The differences in mineralizable carbon, decreased to 8.8, 7.7 and 8.2 per cent, respectively at 23^{rd} day (9.8, 8.7 and 9.2 µg C g $soil^{-1}day^{-1}$) for these treatments compared to FP (5.4 µg C g $soil^{-1}day^{-1}$).

In integrated nutrient management (INM), inorganic nutrients (N,P,K) supplemented with *Moong* in rotation, green manuring (GM), farmyard manure (FYM), wheat straw (WS) and rice straw (RS) resulted in equivalent wheat yields (EWY) of 15.1, 13.0, 14.4, 10.5 and 10.9 t ha^{-1}, respectively. Inclusion of these organic sources of nutrients resulted in increase of 3.5, 1.4 and 2.8 t ha^{-1} EWY

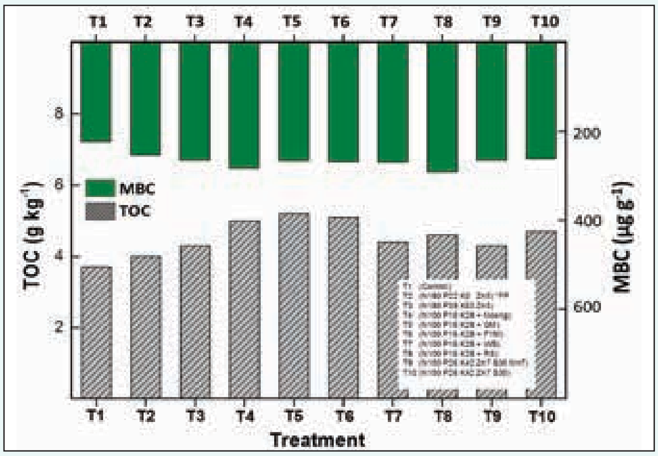


Fig. 5 : Effect of different treatments on total organic carbon (TOC) and microbial biomass carbon (MBC)

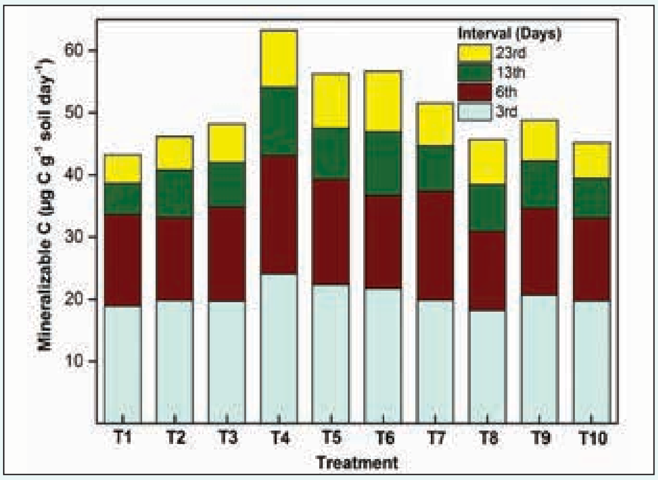


Fig. 6 : Soil mineralizable carbon pools under different treatments

over farmers' practice (N,P,Zn) which yielded 11.6 t ha^{-1} EWY. In 2013, EWY were obtained only in case of nutrients supplemented with *Moong* and with inclusion of S and Mn fertilizers and increased to 0.3, 0.15 and 0.32 t ha^{-1}, respectively over farmer's practice (Table 8)

Table 8 : Effect of nutrients on grain yield of wheat and rice crop

Treatment	2011-12 Equivalent wheat yield	2012-13 Equivalent wheat yield
T_1 (Control)	4.77	6.19
T_2 (N_{180} P_{22} K_0 Zn_5) FP	11.59	13.51
T_3 (N_{180} P_{39} $K_{63}Zn_5$)	13.84	13.42
T_4 (N_{100} P_{16} K_{28} + Moong)	15.05	13.85
T_5 (N_{100} P_{16} K_{28} + GM)	12.99	12.51
T_6 (N_{100} P_{16} K_{28} + FYM)	14.39	13.50
T_7 (N_{100} P_{16} K_{28} + WS)	10.51	12.99
T_8 (N_{100} P_{16} K_{28} + RS)	10.92	13.30
T_9 ($N_{150}P_{26}$ K_{42} S_{30} Zn_7 Mn_7)	13.84	13.65
T_{10}($N_{150}P_{26}$ K_{42} S_{30} Zn_7 Mn_0)	13.42	13.87
LSD (P=0.05)	0.86	0.52

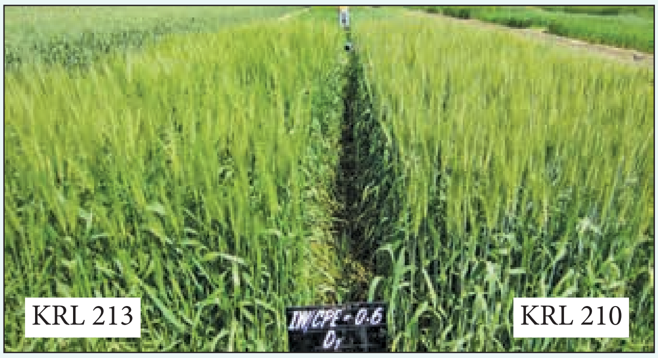
Optimizing Irrigation and Planting Schedules of Salt Tolerant Rice and Wheat Varieties (Parveen Kumar, D.K. Sharma, S.K. Chaudhari and P.C. Sharma)

Water is the most precious resource for successful crop production and its judicious use is the need of hour especially in areas where ground water is declining at faster rate. Rice-wheat cropping system requires more than 170 cm water, therefore, research efforts are being made to optimize irrigation water requirement of salt tolerant rice and wheat varieties in relation to different dates of planting on a reclaimed sodic soil.

Salt tolerant wheat varieties KRL-210 and KRL-213 were grown under three irrigation schedules (IW/CPE =1.0, 0.8 and 0.6) with four sowing dates (10 Nov., 20 Nov., 30 Nov. and 10 Dec.). The results indicated that across sowing dates and variety, grain yield of wheat was statistically similar under different irrigation schedules [IW/CPE - 1.0 (5.64 t ha^{-1}); 0.8 (5.89 t ha^{-1}) and 0.6 (5.84 t ha^{-1}) ratio]. Varieties KRL-210 (6.41 t ha^{-1}) and KRL-213 (6.28 t ha^{-1}) yielded higher when sowing was done on 10 November (Table 9). Across sowing dates and varieties, irrigation water productivity (IWP) increased with decreased irrigation frequency, IW/CPE - 1.0 (2.55 kg m^{-3}), 0.8 (2.90 kg m^{-3}) and 0.6 (3.25 kg m^{-3}). However, IWP decreased with delay in date of sowing from 10 November to 30 November (3.52-2.58 kg m^{-3}). IWP was slightly higher in KRL-210 (2.91 kg m^{-3}) than KRL-213 (2.89 kg m^{-3}) (Fig.7).

During *kharif* 2013, an experiment was conducted on rice with three irrigation schedules [continuous submergence (CS)/Farmers practice (FP), 3 days after disappearance of ponded water (DAD) and 5 DAD] and four dates of transplanting (21 June, 1 July, 11 July and 21 July) in strip plot design with three replications. One month old seedlings were transplanted in all the treatments. Irrigation schedules were imposed after one month of transplanting.

Different irrigation schedules, CS/FP (3.16 t ha^{-1}), 3 DAD (2.99 t ha^{-1}) and 5 DAD (3.07 t ha^{-1}) as well as dates of transplanting did not significantly influence the grain yield (Table 10). Across irrigation schedules, minimum and maximum grain yield was recorded when transplanting was done on 21 June (2.84 t ha^{-1}) and 21 July (3.22 t ha^{-1}), respectively. The yield of rice was low when rice was transplanted on 21 June, this was due to lodging (69.4%) because of plant height followed



Salt tolerant wheat varieties sown on 10 November with IW/CPE=0.6

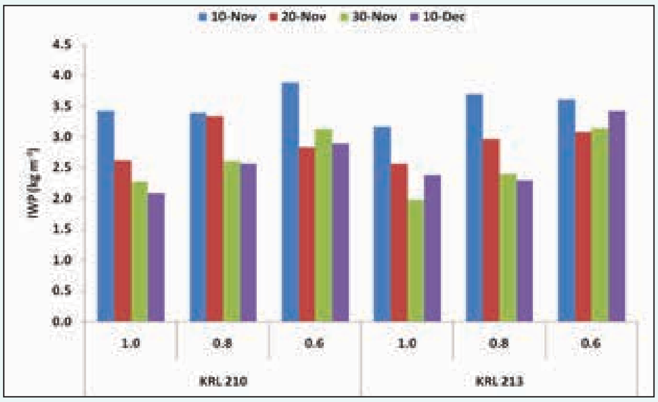


Fig 7: Irrigation water productivity of salt tolerant wheat varieties

Table 9 : Grain yield (t ha^{-1}) of salt tolerant wheat varieties grown at different sowing dates and irrigation schedules

Date of sowing	Irrigation schedule (IW/CPE)							
	KRL 210				KRL 213			
	1.0	0.80	0.60	Mean	1.0	0.80	0.60	Mean
10 November	6.15	6.09	6.98	6.41	5.68	6.67	6.48	6.28
20 November	6.25	5.99	5.09	5.78	6.14	5.32	5.55	5.67
30 November	5.44	5.72	5.64	5.60	4.73	5.73	5.65	5.37
10 December	5.01	6.14	5.21	5.46	5.69	5.50	6.15	5.78
Mean	5.71	5.98	5.73	5.81	5.56	5.80	5.96	5.77
$CD_{(0.05)}$	IS : NS; Date of sowing: 0.67; Interaction: NS							

with rainfall during 2nd week of October 2013. Mean irrigation water used varied from 54.7 to 63.2 cm for different irrigation schedules and 48.6 to 73.0 cm for different dates of transplanting. Irrigation scheduling at 5 and 3 DAD saved 13.5 and 7.0 per cent of irrigation water compared to CS. Higher irrigation water productivity was observed in 3 and 5 DAD schedules than continuous submergence/FP across the dates of transplanting. The mean irrigation water productivity was 0.576, 0.522 and 0.516 kg m^{-3} in 5, 3 DAD and continuous submergence schedules, respectively.

It was observed that 3 and 5 DAD schedules could only be imposed after one month of transplanting and some hair cracks were noticed in 5 DAD schedules which were filled with the help of adjoining soil to avoid leaching of water. Observation on panicle initiation and maturity indicated that both were hastened by 23 and 24 days, respectively by transplanting rice seedlings on 21 July than 21 June. Rice equivalent yield of rice (CSR 30)-wheat (KRL 210) system (Fig. 8 and Fig. 9) was higher under optimum irrigation schedule (CS/IW/CPE-1.0) with 2nd date of planting (1 July/20 Nov.); however, with rice (CSR 30)-wheat (KRL 213) system it was higher under irrigation

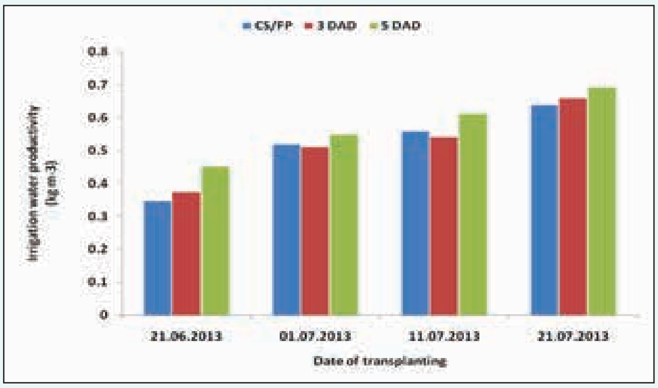
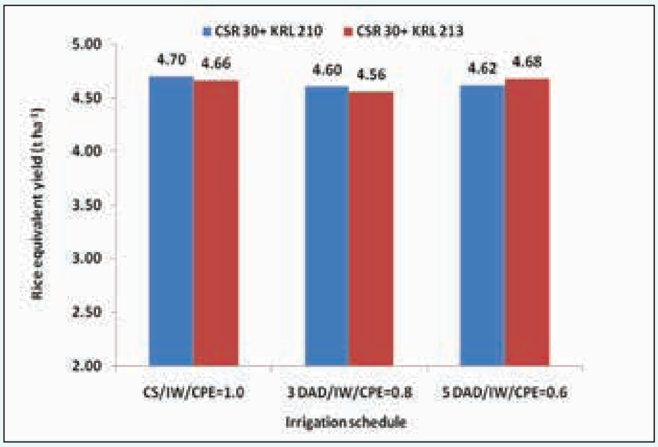


Fig. 8 : Irrigation water productivity of rice (CSR-30) transplanted on different dates and irrigation schedules

schedule (5 DAD/IW/CPE=0.6) with date of planting (21 July/10 Dec.).

Improving Productivity of Salt-affected Soils using Biodegradable Municipal Solid Waste and Gypsum Enriched Composts in a Mustard-Pearlmillet Cropping System (M.D. Meena, H.S. Jat, Parvender Sheoran, P.K. Joshi, Anil R. Chinchmalatpure and B. Narjary)

Use of municipal solid waste compost (MSWC) as soil organic amendment in normal as well as saline soil is economically and environmentally sustainable. Low rainfall and high potential evapotranspiration in these regions promote the



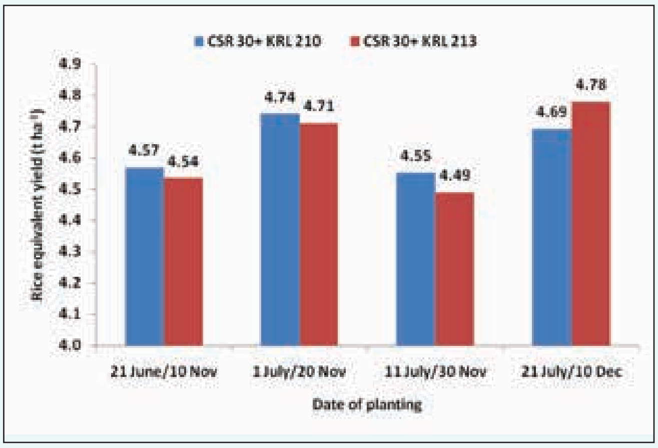


Fig.9 : Rice-wheat system productivity under different irrigation schedules and planting dates

Table 10 : Effect of irrigation schedules and dates of transplanting on the grain yield of rice (CSR-30)

Date of transplanting/ Irrigation schedules	Grain yield (t ha^{-1})			
	Cont. Subm./FP	3 DAD	5 DAD	Mean
21 June	2.70	2.69	3.13	2.84
01 July	3.35	3.12	3.08	3.18
11 July	3.25	2.94	2.95	3.04
21 July	3.34	3.19	3.13	3.22
Mean	3.16	2.99	3.07	-
$CD_{(0.05)}$	IS : NS; Date of transplanting: NS; Interaction: NS			

upward movement of salts in the soil solution which adversely affects soils physical, chemical and biological properties. Alternatively, growing salt tolerant plant species and use of organic amendments could be the only cost effective option in place of costly amendments. A field experiment was initiated in November, 2012 in randomized block design with mustard-pearl millet cropping system. Mustard was grown as the first crop and pearl millet was grown as the succeeding crop.

Soil treated with organic amendments namely, MSWC @ 4 t ha^{-1}, rice straw compost (RSC) @ 3.5 t ha^{-1} and gypsum enriched compost (GEC) @ 3.5 t ha^{-1} with 25% RDF resulted significantly higher grain yield (2.47 and 2.41 t ha^{-1}) of mustard and pearl millet, respectively followed by treatments receiving RSC @ 7 t ha^{-1}+ 50% RDF (T_6) over unfertilized control plot (T_1). Application of 100% RDF did not significantly affect the grain yield of both crops as compared to unfertilized control plot (Table 11). However, integrated use of organic amendments along with mineral fertilizers (25% RDF) led to further increase in the grain as well as total biomass yield of mustard and pearl millet over use of mineral fertilizers. Application of MSWC (16 t ha^{-1}) was more responsive with respect to soil EC_e as compared to RSC and GEC after harvest of both crops. However, organic amendments along with 25% RDF were more effective in respect of reducing the negative impact of pH and EC_e as compared to unfertilized control plot.

Integrated use of organic amendments and mineral fertilizers showed significant increase in organic carbon (OC) content over unfertilized control plot after harvest of both crops. WBC was ranged from 1.8 to 4.0 and 1.6 to 4.4 g kg^{-1} after mustard and pearl millet harvest, respectively, whereas highest amount of OC was maintained under treatments receiving organic amendments along with 25% RDF followed by MSWC (8 t ha^{-1}) + 50% RDF as compared to other treatments after harvest of both crops.

Table 11 : Effect of MSC and GEC *vis-à-vis* chemical fertilizers on mustard and pearl millet yield

Treatments	Yield of mustard (t ha^{-1})			Yield of pearl millet (t ha^{-1})		
	Grain	Straw	Total	Grain	Straw	Total
T1	1.96^{b*}	7.4^{b}	9.3^{c}	1.63^{d}	19.1^{a}	20.9^{b}
T2	2.01^{b}	7.6^{b}	9.6^{bc}	1.72^{cd}	24.2^{a}	22.2^{ab}
T3	2.17^{b}	7.7^{b}	9.9^{abc}	1.89^{bcd}	20.9^{a}	22.9^{ab}
T4	2.03^{b}	7.7^{b}	9.7^{bc}	1.87^{bcd}	22.4^{a}	23.9^{ab}
T5	2.16^{b}	7.6^{b}	9.8^{abc}	19.1^{bcd}	23.8^{a}	24.5^{ab}
T6	2.36^{a}	7.9^{b}	10.3^{ab}	2.33^{ab}	26.7^{a}	28.2^{a}
T7	2.13^{b}	7.9^{b}	10.0^{abc}	2.13^{abcd}	25.3^{a}	25.4^{ab}
T8	2.25^{b}	8.0^{b}	10.2^{abc}	2.18^{abc}	26.0^{a}	25.7^{ab}
T9	2.47^{a}	8.7^{a}	11.2^{a}	2.41^{a}	27.6^{a}	28.9^{a}
LSD (P=0.05)	0.35	0.8	1.0	0.46	8.4	6.2

Table 12 : Effect of municipal solid waste *vis-à-vis* gypsum enriched compost and chemical fertilizers on available $KMnO_4$-N, Olsen- P and NH_4OAc- K (kg ha^{-1}) after mustard and pearl millet harvest

Treatments	After mustard harvest			After pearl millet harvest		
	$KMnO_4$-N	Olsen-P	NH_4OAc- K	$KMnO_4$-N	Olsen-P	NH_4OAc- K
T1	104^{c*}	14^{d}	198^{b}	88^{c}	13^{e}	184^{c}
T2	130^{ab}	26^{bc}	223^{ab}	134^{ab}	25^{cd}	247^{ab}
T3	116^{bc}	24^{c}	226^{ab}	123^{b}	22^{d}	230^{b}
T4	122^{b}	25^{bc}	229^{ab}	125^{b}	23^{d}	231^{b}
T5	125^{ab}	27^{bc}	234^{ab}	127^{b}	25^{cd}	241^{ab}
T6	126^{ab}	28^{bc}	240^{ab}	137^{ab}	29^{bc}	250^{ab}
T7	126^{ab}	30^{abc}	248^{ab}	137^{ab}	30^{b}	257^{ab}
T8	133^{ab}	34^{ab}	257^{ab}	141^{ab}	35^{a}	265^{ab}
T9	141^{a}	37^{a}	269^{ab}	148^{a}	38^{a}	278^{a}
LSD (P=0.05)	16	9	59	17	4	43
Initial	108	18	203	-	-	-

T_1: Control, T_2: Recommended dose of NP fertilizers (100% RDF),T_3: Rice straw compost @ 14 t ha^{-1} ,T_4: Gypsum enriched compost @ 14 t ha^{-1} ,T_5: Municipal solid waste compost @ 16 t ha^{-1} , T_6: 50% RDF + Rice straw compost @ 7 t ha^{-1} ,T_7: 50% RDF + Gypsum enriched compost @ 7 t ha^{-1},T_8: 50% RDF + Municipal solid waste compost @ 8 t ha^{-1} ,T_9: 25% RDF + RSC @ 3.5 + GEC @ 3.5 + MSWC @ 4 t ha^{-1}.*For each parameter different letters within the same column indicate that treatment means are significantly different at P<0.05 according to Duncan's Multiple Range Test for separation of means.

Application of 100% RDF (T_2) significantly improved in available alkaline $KMnO_4$-N (130 and 134 kg ha^{-1}) as compared to unfertilized control plot after harvest of mustard and pearl millet, respectively. Plots receiving organic amendments along with recommended dose of fertilizers resulted in higher amount of available Olsen-P in soil as compared to unfertilized control plot after harvest of the crops (Table 12). After harvest of mustard, the available NH_4OAc-K did not significantly change with application of organic amendments either alone or in combination of mineral fertilizers.

Evaluation of Salinity Tolerance of Coriander, Fennel, Fenugreek and Celery Seed Spices (R.K. Yadav and R.L. Meena)

Overall and stage dependant irrigation water salinity tolerance of seed spices (cv GF-1 of fennel- *Foeniculum vulgare*, RCR-446 of coriander (*Coriandrum sativum*), local cultivars of celery (*Apium graveolens*) and fenugreek (*Trigonella foenum-graecum L.*) crops was assessed at CSSRI, Karnal (Haryana) and NRCSS, Ajmer (Rajasthan) as a inter-institutional project. The irrigations of saline water (4.0 dS m^{-1} in fenugreek and 6.0 dS m^{-1} in fennel, coriander and celery) were applied at 1.2 IW/CPE ratio during 0-30, 31-60, 61-90, 91-120 DAS harvest, 0-60, 0-90 DAS, and >91 DAS/harvest. The growth, development and yield recorded with above mentioned saline water irrigation treatments were compared with normal water irrigation as control during the crop season.

The osmotic stress imposed through saline water irrigation at successive growth stages did not delay the germination in fennel and celery but delayed it by 1 and 2 days in fenugreek and coriander, respectively. Saline water irrigation reduced germination in fenugreek, celery, coriander and fennel by 23, 12, 10 and 5 per cent, respectively. Growth of all the crops reduced during the period of osmotic stress, however, the reduction was maximum in fenugreek followed by coriander > celery > fennel (Fig 10; Table 13).

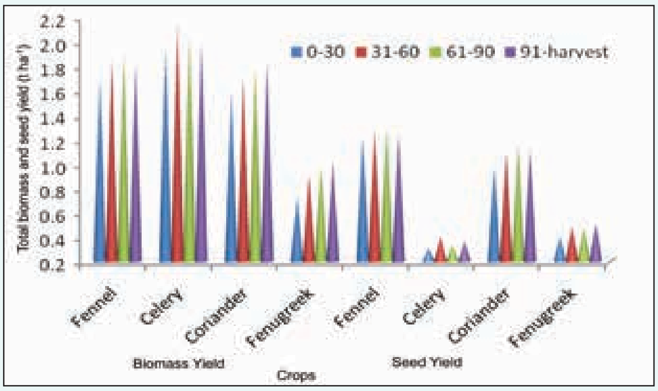


Fig. 10 : Total biomass and seed yields (t ha^{-1}) of coriander, fennel, fenugreek and celery under different saline water irrigation regimes

The stress at 0-30 days reduced the biomass and seed production of all the crops than at other stages, where it did not show any distinct pattern, particularly in seed yield of the crops. The observations on growth and seed yield of fennel, celery and coriander and fenugreek suggest that if proper crop stand is maintained by avoiding salinity stress at germination, these crops can tolerate irrigation water salinity of 6 and 4 dS m^{-1}, respectively.

Cation Exchange Equilibrium and Solute Transport through Different Textured Salt Affected Soils (N. Basak, S.K. Chaudhari and D.K. Sharma)

Salinity and sodicity are inherent problems in soils of arid and semi-arid regions of the world. Groundwater is the only source for irrigation to satisfy food-fiber-feed demand in these regions since rainfall is scanty and erratically distributed, and there is non accessibility of fresh canal water for farming. The ionic composition of available groundwater has not only a deleterious impact for raising salinity/sodicity but also cation exchange in the soil system.

Table 13 : Total biomass and seed yield (t ha^{-1}) of coriander, fennel, fenugreek and celery under different saline water irrigation regimes

Saline irrigation regime	Fennel		Celery		Coriander		Fenugreek	
	Biomass	Seed	Biomass	Seed	Biomass	Seed	Biomass	Seed
0-30	1.69	1.23	1.95	0.31	1.61	0.98	0.73	0.40
31-60	1.86	1.27	2.15	0.41	1.72	1.10	0.91	0.49
61-90	1.92	1.30	2.03	0.34	1.79	1.17	0.99	0.48
91-harvest	1.83	1.25	1.99	0.37	1.84	1.12	1.03	0.51
CD (p=0.05)	0.20	NS	0.18	0.06	0.19	0.08	0.21	0.08

Many theoretical exchange equations have been developed and reported in the literature to describe the equilibrium distribution between exchangeable and soluble cations. Divalent cation supplementation from exchange phase and native mineral dissolution has a great impact for building up high SAR even at low salinity water imposition in varied textured soils. Positive interaction of salinity (electrolyte concentration) and SAR influenced the ESP built-up. Additionally, inherent buffering capacity of soil *viz*., percent clay content, cation exchange capacity play a major role for further sodification of soils. With this context, this experiment was initiated to describe exchange phase to solution phase behavior of three Inceptisols from semi-arid region of North-West India under different quality waters.

Bulk soil samples were collected from surface 0-30 cm depth of clay loam (Berpura, Ambala, Haryana), silt loam (Beri, Jhajjar, Haryana) and loam soils (Sangrur, Punjab). Ionic consumption of each quality waters encompressing four levels of sodium adsorption ratio (SAR) *viz*., 5, 10, 20 and 30 mmol$^{1/2}$ l$^{-1/2}$ and three TEC levels *viz*; 25, 50 and 100 me l^{-1} was synthesized by using pure chloride salts of calcium, magnesium and sodium at Ca: Mg = 2:1. Normal clay loam, saline silty loam and calcareous sodic loamy soils had soil pHs (7.9, 7.3 and 9.4), EC_e (1.3, 13.3 and 1.4 dS m^{-1}), ESP (10.6, 9.6 and 43.5%), CEC (17.2, 26.1 and 7.0 cmol$_{(P+)}$ kg^{-1}), organic C (1.0, 1.1 and 0.34%, $CaCO_3$ (0.2, 1.0 and 16.4%), clay (25.1, 23.4 and17.6%), respectively (Table 14). At all electrolyte concentration (combination of TEC 25, 50 and 100 me l^{-1}; SAR 5, 10, 20 and 30 mmol$^{1/2}$ l$^{-1/2}$), SAR values were not attained to the equilibrium solution because of addition of Ca and Mg from the mineral dissolution from the exchange sites (Table 15). At higher TEC levels (100 me l^{-1}), a

Table 14 : Physico- chemical properties of the experimental soils

Soil	Texture	pH_s	EC_2	EC_e	ESP	CEC	OC	Sand	Silt	Clay	$CaCO_3$
			(dS m^{-1})		(%)	cmol$_{(P+)}$ kg^{-1}	(%)				
Normal (Soil I)	Clay loam	7.9	0.51	1.3	10.6	17.2	1.00	57.0	17.9	25.1	0.2
Saline (Soil II)	Silt loam	7.3	4.72	13.3	9.6	26.1	1.10	40.0	36.6	23.4	1.0
Calcareous sodic (Soil III)	Loam	9.4	0.56	1.4	43.5	7.0	0.34	72.3	10.1	17.6	16.4

Table 15 : Effect of water quality on sodium adsorption ratio (SAR), exchangeable sodium percentage (ESP) at equilibrium and Gapon's co-efficient of different soils

SAR_{iw}	Normal clay loam			Saline silt loam			Calcareous sodic soil		
	SAR_{eq}	ESP′	K_G	SAR_{eq}	ESP	K_G	SAR_{eq}	ESP′	K_G
25 me l^{-1}									
5	0.79	6.69	0.09	0.78	10.23	0.15	0.49	15.27	0.38
10	1.34	7.84	0.07	1.22	16.49	0.17	1.33	26.83	0.29
20	2.67	15.86	0.08	2.02	27.06	0.19	1.72	34.73	0.31
30	2.12	20.72	0.13	3.52	33.18	0.23	1.6	39.74	0.44
50 me l^{-1}									
5	0.8	8.11	0.11	2.08	11.89	0.07	0.62	23.71	0.51
10	1.66	13.76	0.1	1.6	36.39	0.36	1.05	33.05	0.49
20	3.12	28.34	0.14	2.53	38.29	0.41	1.94	40.51	0.43
30	3.39	41.81	0.24	4.6	42.78	0.31	2.11	49.31	0.78
100 me l^{-1}									
5	0.8	9.39	0.13	2.42	13.85	0.07	0.9	26.03	0.4
10	1.48	12.47	0.1	1.49	36.31	0.4	1.04	43.23	0.76
20	4.18	34	0.14	3.01	38.04	0.21	2.01	52.95	0.57
30	4.38	53.51	0.29	4.91	51.42	0.24	2.28	54.99	0.59

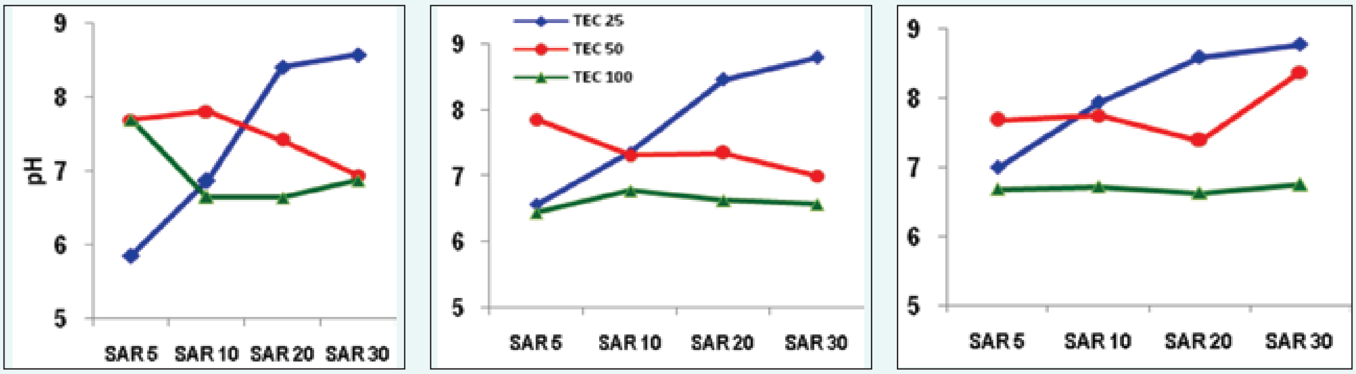


Fig 11 : Effect of water quality on pH of equilibrium solution in normal clay loam, saline silt loam and calcareous sodic loamy soil

considerable increase in ESP was observed in sodic loam (55.0%) followed by saline silty loam (51.4%) and normal clay loam soils (50.0%). With the increase in TEC and SAR at all levels, it was observed that there was a substantial increase in ESP of more than 2.1 to 3.8 times and 1.1 to 2.1 times, respectively. Gapon's selectivity coefficient values were perceptible in the following order: calcareous sodic loam> saline silt loam> normal clay loam. This indicates that normal clay loam soil has an affinity for Ca^{2+} + Mg^{2} rather than Na^{+} on the exchange complex. But loamy soil exhibits a considerable affinity for Na^{+} on the exchange complex. High ESP appeared in calcareous sodic loamy soil followed by saline silty loam and normal clay loam. This may be because of wash out of Ca^{2+} from the exchange sites in saline silty loam soil and dissolution of Ca bearing minerals in clay loam soil. The pH of equilibrium solution increased with increasing SAR for all the studied soils when equilibrating solution was lower salinity level (25 me l^{-1}) (Fig 11). Such variation was higher in normal clay loam and saline silt loam soils. However, this trend of increasing pH with increasing SAR at a particular salinity levels was not depicted in concentred saline water of 50 and 100 mel^{-1}.

Productive Utilization of Inland Sodic/ Saline Soil and Water through Aquaculture in relation to Farming System Approach (S.K. Singh and Anshuman Singh)

Field experiment

Rearing of carp in small pond at Institute farm was undertaken during the period under report. The fish growth based on supplementary feed (down size farm grain @ 1-5% of body weight of fish) in the small pond (0.1ha) was 600-1000g from the initial stocking size(10g) of different type of carp fish fingerling i.e.*Catla catla* (Catla), *Labeo rohita* (Rohu), *Cirrhinus mrigala* (Mrigal), *Ctenopharyngodon idella* (Grass carp), *Cyprinus carpio* (Common carp) @ 10,000/ha stocking density after ten month of culture of the species. Repeated bottom racking of pond was done as one of the tool for sediment nutrient mineralization. The standard method of pond management practices were followed with permissible modification for fish culture. The physico-chemical and hydro-biological parameters of pond soil and water were studied during report period (Table 16 and 17). RSC of pond water was found to be 0.8-1.2 me l^{-1} after using ground tubewell water.

Table 16 : Soil characteristics of small ponds

Parameter	Marginal area of new pond	Bottom of new pond
Soil pH	7.60-8.80	7.55-7.75
EC (dS m^{-1})	0.20-0.36	0.60-1.00
Organic carbon (%)	0.25-0.60	0.65-0.90

Table 17 : Physico-chemical and biological parameter of small pond water

Parameter	New Pond
Pond water area (ha)	0.1
Mean water depth (m)	1.0
Water transparency (cm)	12.0-21.1
Water temperature (°C)	7-40
Water pH	7.2-9.3
D.O.(mg l^{-1})	1.0-6.8
Free CO_2 (mg l^{-1})	0.0-10.0
Alkalinity (mg l^{-1})	160-240
Hardness (mg l^{-1})	116-150
DOM (mg l^{-1})	2.8-4.8
EC(dS m^{-1})	0.60-0.80
Planktonic productivity (ml/100 l water)	1.5-2.0
Bottom biota (Nos m^{-2})	8-12

Table 18 : Soil characteristics of nursery and large ponds

Parameter	Marginal area of nursery pond	Bottom of the nursery pond	Marginal area of dyke of large pond	Bottom of the large pond
Soil pH	7.2-8.02	7.15-7.50	7.0-7.42	7.0-7.44
EC (dS m^{-1})	0.8-1.2	1.30-1.80	1.2-1.70	2.54-3.02
Organic carbon (%)	0.10-0.12	0.20-0.28	0.10-0.20	0.20-0.30

Mortality of fishes was observed due to cloudy weather and suddenly occurrence of rain during summer months. The fish production was 5.0 t ha^{-1} $year^{-1}$. Water and nutrient management studies were carried-out through various treatments including pond irrigation water on guava at small pond dyke. The bund of new pond was used for growing pigeon pea, potato, cauliflower, garlic, broad bean, cucurbits, methi, palak, banana, guava etc in relation to farming system practices along with fish culture activity in the pond. The EC_2 of different plots where cultivation of crop was done found to be 0.36-1.90 dS m^{-1}. Pigeon pea has shown third year retuning behavior due to continuance of crop from second and first year. The B:C ratio was 4.38 for fish.

Old pond (0.4 ha) was renovated and nursery pond (0.05 ha) was made through soil laden embankment partitioning. After renovation of large pond, Indian major carp fingerling of 72-190 mm (11-50g) size was produced. The physico-chemical and biological details are presented in Tables 18, 19 and 20.

Table 19 : Physico-chemical and biological nursery and large renovated pond water

Parameter	Nursery pond	Large renovated pond
Pond water area (ha)	0.05	0.4
Mean water depth (m)	1.0	1.25
Water transparency (cm)	12.0-15.6	14.0-18.2
Water temperature (^{0}C)	7-40	30-34
Water pH	7.2-9.3	7.1-8.8
D.O. (mg l^{-1})	1.0-6.8	3.0-6.6
Free CO_2 (mg l^{-1})	0.0-10.0	0.0-8.0
Alkalinity (mg l^{-1})	160-240	120-160
Hardness (mg l^{-1})	116-150	80-110
DOM (mg l^{-1})	2.8-4.8	3.0-4.4
EC (dS m^{-1})	0.60-0.80	0.30-0.40
Planktonic productivity (ml/100-l water)	2.0-2.5	2.0-2.25

In addition to above cultivation, water spinach (*Ipomoea aquatica*) alongwith fish fingerling rearing was done during rainy season in the large pond. The coverage of plant in marginal area of pond

Table 20 : Details of spawn to fry and fry to fingerling rearing in nursery and large renovated pond

Parameter	Nursery pond	Large renovated pond
Spawn to fry rearing		
Stocking size (mm/mg)	6-10mm/0.5-1.0mg	6-10mm/0.5-1.0mg
Species ratio (%)	Catla(20), Rohu(35), Mrigal(45)	Catla(20), Rohu(35), Mrigal(45)
Stocking density (million /ha)	2.0	0.5
Actual number stocked	50,000	2,00000
Survival (%)	65	85
Number recovered	32,500	1,70,000
Final size (mm/g)	30mm/40mg	45mm/100mg
Culture period (month)	One month	One month
Fry to fingerling rearing		
Stocking size	30mm(40mg)	30-45mm(40-100mg)
Species ratio	Catla(20), Rohu(35), Mrigal(45)	Catla(20), Rohu(35), Mrigal(45)
Stocking density (lakh /ha)	0.5	2.0
Actual number stocked	2,500	
Survival (%)	80	85
Number recovered	2000	1,70,000
Final size	72-96 mm(11-20g)	120-190 mm(15-50g)
Culture period (month)	Two month	Two month

Table 21 : Physico-chemical and biological properties of tube well and Nain pond water

Parameter	Tube well	Nain Pond
Water area (ha)	-	0.2
Water depth (m)	24m (80ft)	0.3-1.25
Water transparency (cm)	-	12.0-47.1
Water temperature (^{0}C)	27.1-30.5	6.5-40
Water pH	7.4-9.24	8.43-11.6
D.O. (mg l^{-1})	-	1.0-7.8
Free CO_2 (mg l^{-1})	-	0.0-12.0
DOM (mg l^{-1})		2.8-4.8
EC(dS m^{-1})	0.60-20.3	1.1-25.8
Planktonic productivity (ml/100-l water)	-	1.5-2.0

was (10%) level. Yield of plant was recorded at the tune of 3.0 kg/m^2 biomass in three months time.

Rearing of carp in Nain Farm pond has shown 400-600g growth in six month at about 25 dS m^{-1} pond water and subsequent month cases of mass mortality of fishes was observed due to multiple factor (low water level, high evaporation, high temprature and high water pH). Harvesting of 600-800 gm size carp fishes was done after one year. Bottom salinity of pind soil was found in increasing order in one year of experimentation (Table 21).

Adopted farmer's field activities

1. Integrated farming system was adopted by a farmer of village Lotani of Kurukshetra District with common carp breeding by Indian method. He has produced and sold 2.0 lakh seed during February/March 2013.
2. During rainy season, 4.0 lakh Indian major carp fingerlings were produced from the nursery and large pond from 1.4-2.7 me l^{-1} RSC water.

Multi-enterprise Agriculture Studies on Reclaimed Sodic Land in Farmer's Participatory Mode (S.K. Singh, H.S. Jat, R.S. Pandey, S.K. Chaudhari, R. Raju, D.K. Sharma and N.S. Sirohi)

Multienterprise agriculture model with multiple enterprises/components may pave the way for realizing increased productivity and profitability through integrated use of water, nutrient and energy at small farms. The evaluation of model was continued at CSSRI farm in the farmer's participatory mode to judge its acceptability, viability and sustainability. Nearly 80 per cent of the farmers in India cultivate less than two ha land. Rice-wheat cropping system provides income to farmers only twice a year but a farmer needs regular income to meet out his day-to-day expenditure. Multienterprise agriculture has the potential to decrease cultivation cost by synergetic recycling of bi-products/ residues of various components within the system and also a regular source of income and employment.

Economics of multienterprise model

In multienterprise agriculture model, various components were broadly categorized into two i.e. crop components and subsidiary components. In subsidiary components, dairy is the backbone of this system wherein maximum returns were obtained. The animal dung and poultry droppings were used for composting, nutrient enrichment in fish pond and biogas generation. The compost prepared from dung and biogas slurry was used for fruits and vegetables cultivated on pond dykes which is a way forward towards organic farming. Total revenue generated expenditure and net income from the crop components and subsidiary components during July, 2012 to June, 2013 are given in Table 22. The total revenue of Rs. 6,12,479 was generated in the multienterprise model after expenditure of Rs. 3,31,563. The total net income of Rs 2,80,916 was achieved in this model. Crop components generated a total gross income of Rs. 2,30,590, whereas subsidiary components generated Rs. 3,81,889.

The total revenue generated, expenditure and net income from the crop and subsidiary components during July, 2011 to June, 2013 are given in Table 23. The total means revenue of Rs. 5,29,317 was generated in the multienterprise model after expending of Rs. 3,03,486. The total net income of Rs. 2, 25,831 was achieved in this model. Crop components generated a total gross income of Rs. 2, 15,127 whereas subsidiary components generated Rs. 3, 14,191.

Soil health

Vegetable system of multi-enterprise agriculture model showed more availability of Ca, Mg and S in soil than the other cropping systems. Higher amount of Fe was available in soil in maize-wheat-green gram cropping system, whereas higher Mn was noticed in sorghum-berseem fodder system than the

Table 22 : Economics of multienterprise agriculture under farmer's participatory mode (July 2012-June 2013)

Sl. No.	Agricultural components	Gross income (Rs.)	Total cost (Rs.)	Net income (Rs.)	B:C ratio
Crop components					
1	Rice-wheat-moong	71,200	16,205	54,996	4.39
2	Maize-wheat-moong	33,200	14,180	19,020	2.34
3	Rice-oats/wheat	59,520	16,146	43,374	3.69
4	Horticulture	23,000	1,710	21,290	13.45
5	Vegetables	12,470	33,275	-20,805	0.37
6	Fodder	31,200	21,765	9,435	1.43
	Sub Total-1	**2,30,590**	**1,03,280**	**1,27,310**	**2.23**
Subsidiary components					
1	Milk, compost, biogas	2,66,627	1,79,772	86,855	1.48
2	Fish production area	46,370	6,386	39,984	7.26
3	Poultry	67,792	41,925	25,867	1.62
4	Bee keeping	1,100	200	900	5.50
	Sub Total-2	**3,81,889**	**2,28,283**	**1,53,606**	**1.67**
	Total	**6,12,479**	**3,31,563**	**2,80,916**	**1.85**

Table 23 : Economics of the multienterprise agriculture under farmer's participatory mode (Mean July 2011-June 2012 and July 2012-June 2013)

Sl. No.	Agricultural components	Gross income (Rs.)	Total cost (Rs.)	Net income (Rs.)	B:C ratio
Crop Components					
1	Rice-Wheat-Moong	63,975	17,024	46,951	3.76
2	Maize-Wheat-Moong	46,763	19,974	26,789	2.34
3	Rice-Oats/Wheat	38,360	11,614	26,746	3.30
4	Horticulture	17,083	4,237	12,845	4.03
5	Vegetables	17,900	24,764	-6,864	0.72
6	Fodder	31,047	20,683	10,363	1.50
	Sub Total-1	**2,15,127**	**98,296**	**1,16,831**	**2.19**
Subsidiary Components					
1	Milk, Compost, Biogas	2,30,060	1,73,752	56,308	1.32
2	Fish Production Area	48,186	10,246	37,940	4.70
3	Poultry	33,896	20,963	12,934	1.62
4	Bee Keeping	2,050	230	1,820	8.91
	Sub Total-2	**3,14,191**	**2,05,190**	**1,09,001**	**1.53**
	Total	**5,29,317**	**3,03,486**	**2,25,831**	**1.74**

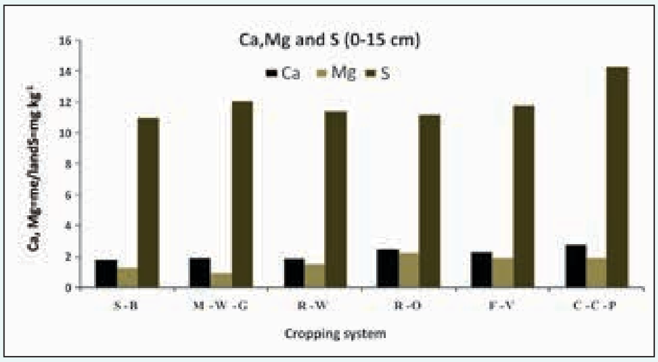


Fig. 12 : Nutrient status under different production systems

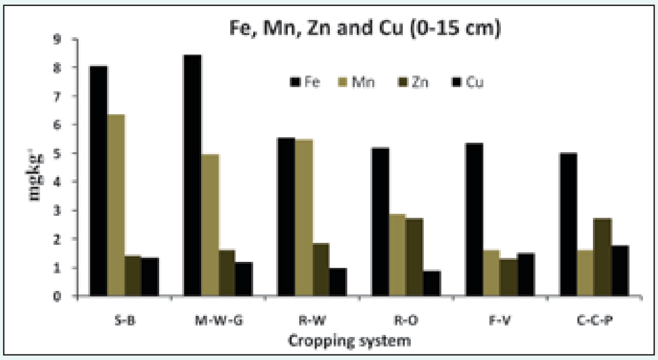


Fig 13 : Nutrient status under different production systems

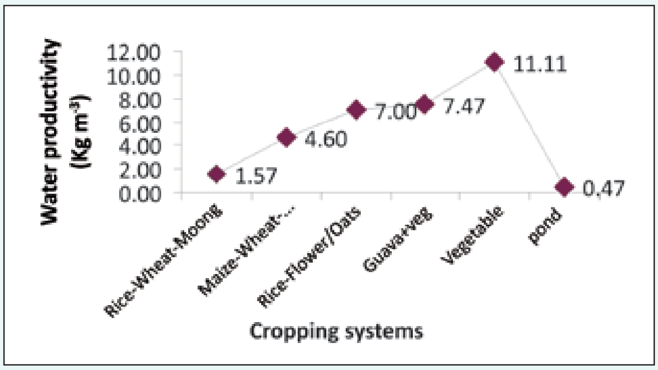


Fig 14 : Water productivity of different cropping and production systems

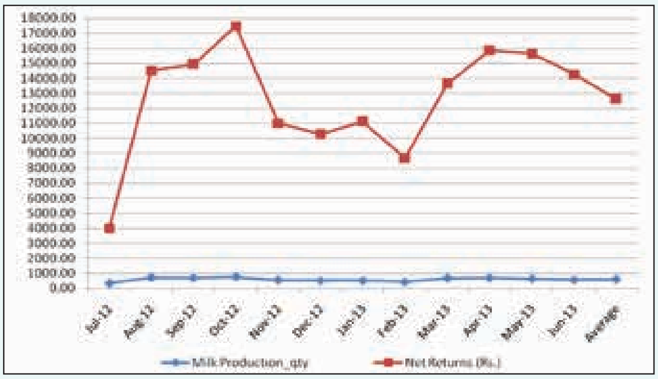


Fig. 15 : Month wise milk production and net returns generated from multienterprise agriculture (July 2013 to June 2014)

other cropping system. Zn and Cu availability was relatively higher in vegetable system (Fig. 12 and 13). Vegetable system and fruits + vegetable were more or less similar in the availability of nutrients.

Water productivity / Water use efficiency

The water productivity of different systems is presented in Fig. 14. The highest water productivity was recorded under vegetable production systems (11.11 kg m^{-3}), however lowest WP was observed with fish production (0.47 kg m^{-3}). Water productivity of 1.57 and 4.60 kg m^{-3} were observed with rice-wheat-moong and maize-wheat-moong cropping system, respectively.

Recycling of animal dung

About 50.57 t dung was obtained from five animals during the study period. Out of which, 17.47 t was used for generating biogas and 33.10 t for composting, whereas, animal shed washing was added in the fish pond to improve the growth phytoplankton. The dung used in biogas plant, after production of biogas it was also decomposed into the compost pits. A major part of urine of animals and some amount of biogas slurry was added directly into the fish pond. The cooking gas was available throughout the year that may meet energy needs of farmer's family. The compost prepared from dung and biogas slurry was used for fruits and vegetables cultivated on the pond dykes.

Dairy

In this model, milk production unit could be considered as 'core unit' of multienterprise model because it produced 585 liter of milk every month and generated a regular income of Rs. 12,615 per month and also regulated the employment to the farmer's family. Average monthly milk production and income statistics from cow and buffalo are presented in Fig 15. The variation in milk production was governed by the lactation period of the animals. The cow and buffalo milk was sold at the mean rate of Rs. 31 and Rs. 37 per litre, respectively on first cum first serve basis to the CSSRI employees.

Fishery/Aquaculture

In multienterprise agriculture pond, the fish productivity was recorded to be 3.8 t ha^{-1} $year^{-1}$. The fish growth was found to be 750-1000g. The species recovery from the ponds after harvest were found in the order of Common carp > Grass carp > Catla > Rohu > Mrigal. The physico-chemical and biological parameters of the pond soil and water were studied and found within the prescribed limit

Aquaculture activities in the salt affected environments (a,b,c)

Table 24 : Soil parameter of pond area

Parameter	Marginal area of pond	Bottom area of pond
Soil pH	7.5-9.15	7.30-7.65
EC (dS m^{-1})	0.20-0.90	0.54-0.90
Organic carbon (%)	0.22-0.40	0.78-1.46

(Table 24 and 25). The application of biogas slurry @ 8-12 litre day^{-1} along with urine of dairy animal led to increased phytoplankton productivity. Repeated bottom racking of reclaimed sodic land pond enhanced the fish food organism.

Water balance studies of the pond

Seepage is major component of water balance in the pond affecting quality of pond water and water table around the pond. For this purpose data on water table around the pond (within 100 m) was monitored. Well no.2 showed a variation in water table of around 7 feet during the year under report.

Table 25 : Physico-chemical and biological parameters of water

Parameters	Values
Pond water area (ha)	0.20
Mean water depth (m)	1.25 (1.0-1.5)
Water transparency (cm)	8.0 - 12.0
Water temperature (^{0}C)	8.0 - 39.0
Water pH	7.1 – 9.0
D.O. (mg l^{-1})	2.8 – 8.6
Fresh CO_2 (mg l^{-1})	0.0 - 12.0
Alkalinity (mg l^{-1})	182 - 260
Hardness (mg l^{-1})	136 - 210
DOM (mg l^{-1})	4.5 - 8.3
EC (dS m^{-1})	0.52 - 0.84
Planktonic productivity(ml/100 l water)	2.0 - 2.5
Bottom biota (No/m^2)	10 - 12

☆☆☆☆☆

MANAGEMENT OF WATERLOGGED/SALINE SOILS

Guidance in Identification of Problem Areas and Design and Evaluation of Subsurface Drainage Projects in Haryana (S.K. Kamra, R.S. Tripathi, Satyendra Kumar, Anil R. Chinchmalatpure, R.L.Meena, Bhaskar Narjary, Parveen Kumar, R. Raju, K. Thimmappa and D.K. Sharma)

Since 2009-10, Govt. of Haryana is providing liberal funds under RKVY for installing subsurface drainage (SSD) systems in about 1000 ha area annually using 3 trenchers available with HOPP. While SSD was installed in 1060 ha affected area in Jind, Rohtak, Jhajjar and Palwal districts of Haryana during 2012-13, early rains during June and breakdown of a trencher machine restricted installation to only 681 ha during 2013-14, more than 87 per cent (586 ha) in Mokhra Kheri and Madina villages in Rohtak district.

Selection of New Sites for SSD

During 2013-14, CSSRI team visited 11 new sites identified by HOPP for possible execution of SSD projects. Of the visited villages, 9 sites (4 in Rohtak district, 2 in Sonipat and 3 in Jhajjar districts) covering 3300 ha waterlogged saline area were recommended for conducting detailed surveys to HOPP based on close interaction with farmers, extent and severity of waterlogging and salinity problem, analysis of collected soil and water samples and outfall conditions (Table 26). At all suggested sites, a surface drain is available nearby for discharge of drainage water and surface water supplies are reasonably good for cropping.

Of these, HOPP proposed SSD designs and layout plans for 12 blocks (RKII-1 to RKII- 12) covering an area of 610 ha in villages Kharkhara, Basana and Madina of Rohtak district, based on detailed contour and socio-economic survey, were approved by CSSRI with respect to flow directions, slope, discharge capacities and permissible length of laterals and drainable area of collectors in February 2014 for possible funding by state govt. under RKVY scheme.

Evaluation of existing SSD projects

During 2013-14, the impact of newly installed SSD systems was evaluated for Siwana Mal (Distt. Jind) and Mokhra Kheri (Distt. Rohtak) project sites. Despite the fact that regular pump house and pumping facilities have not been implemented in a number of blocks of these sites, there has been visible improvement in selected pockets. The results relating to groundwater depth and different parameters of drainage water quality in selected blocks of Mokhra Kheri project area during May 2013 (Table 27) indicate shallow water table conditions and high salinity (1.66-21.1) levels in studied blocks due to inadequate pumping. Highly saline drainage waters (EC> 20 dS m^{-1}) also have very high SAR and need more investigations.

Besides water samples, estimation of soil salinity over large areas in project sites was attempted during 2013 using non-destructive EM-38 technique. Considering the highly dynamic nature of soil salinity, this technique seems effective in quick diagnosis of soil salinity of 1 m depth over large areas. For

Table 26 : Soil and groundwater conditions (April 2013) in proposed sites for SSD

Distt.	Villages	Total area (ha)	Water table depth (m)	Soil salinity (ECe; dS m^{-1})	Groundwater salinity (dS m^{-1})
Rohtak	Katwara, Kharkhara, Mokhrarose Basana	1400	0.7-1.2	4.1-32.2	2.9-20.2
Sonipat	Kohla, Kathura	900	0.5-1.5	12.0-12.5	5.0- 6.0
Jhajjar	Mangawas, MP Majra, Palda	1000	1.2	4.6-6.3	5.5-6.3



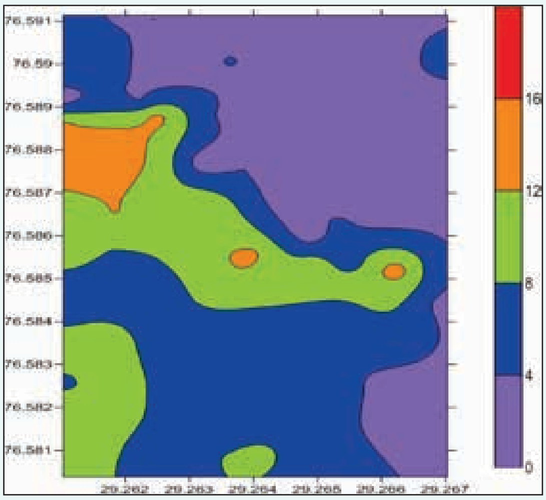

Visit of CSSRI-HOPP team for identification of new SSD sites

Table 27 : Watertable depth and quality of drainage water in selected blocks of Mokhra Kheri (May 2013)

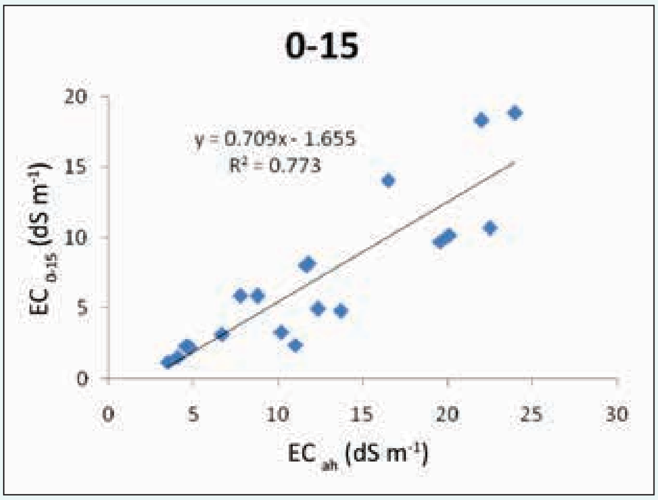
Block/ location	WTD (m)	pH	EC_w (dS m^{-1})	Ca+Mg (meq l^{-1})	CO^{-2} (meq l^{-1})	HCO^- (meq l^{-1})	Cl^- (meq l^{-1})	Na (meq l^{-1})	K (meq l^{-1})	SAR
B-1 sump	1.28	7.31	2.73	23.04	0.00	2.18	17.28	28.22	0.08	8.31
B-1 mainhole-1	1.51	7.16	2.53	21.12	0.00	2.39	16.80	26.98	0.05	8.30
B-1 mainhole-2	1.23	7.09	2.54	19.20	0.87	2.61	16.32	26.37	0.04	8.51
B-2 sump	1.46	7.68	21.10	66.24	0.87	2.18	172.80	358.35	0.41	62.27
B-2 mainhole-1	1.25	7.52	21.10	67.20	0.44	2.18	159.36	308.20	0.48	53.17
B-2 mainhole-2	2.11	7.24	4.49	30.72	0.87	2.61	37.44	61.64	0.07	15.73
B-2 mainhole-3	0.79	7.49	10.34	44.16	2.18	4.57	91.20	137.35	0.25	29.23
B-5 sump	1.05	7.68	1.66	9.60	1.31	3.92	9.60	29.50	0.12	13.46
B-5 mainhole-1	1.04	8.08	1.91	6.72	1.31	2.61	21.12	32.19	0.06	17.56
B-5 mainhole-2	1.20	7.65	2.90	14.40	0.87	1.96	16.80	35.08	0.05	13.07
B-5 mainhole-3	1.27	7.40	3.30	16.32	0.87	2.39	21.12	50.40	0.07	17.64
B-6 sump	1.20	7.32	7.95	25.92	0.44	2.83	65.76	123.28	0.27	34.24
B-6 mainhole-1	1.11	7.57	3.69	16.32	0.44	2.83	23.04	58.99	0.10	20.65
B-6 mainhole-2	1.14	7.68	2.90	14.40	0.44	3.05	16.80	52.75	0.11	19.66
B-6 mainhole-3	1.18	7.40	2.15	10.56	0.44	2.83	10.56	29.50	0.07	12.84

100 ha area, covering 2 SSD blocks of Siwana Mal, 112 observations of apparent conductivity using EM-38 in two positions (horizontal and vertical) at geo-referenced locations could be recorded in 2 days including collection of auger hole soil samples at 21 locations for calibration with soil electrical conductivity. Representative maps of soil salinity derived from the results of EM-38 and calibration curve for 0-15 cm depth are presented in Fig. 16. Though the results were influenced by soil moisture, texture, range of observed salinity, the technique seems promising for regional scale representation of soil salinity.

Field visits of CSSRI team to different SSD project sites and interaction with farmers indicated SSD technology to be quite robust. The major work on mechanical installation of drainage pipes and construction of sump and manholes was completed effectively at all sites. However, improvement in crop yields remained non-satisfactory at certain sites due to failure in construction of pump houses and formation of coherent farmers' societies for distribution of pump sets and sharing of pumping cost amongst farmers after initial leaching by HOPP. Further, without regular cleaning and de-silting of outfall surface drains, the disposal of drainage water and consequently, the performance of SSD system is getting adversely affected. The surface drains come in the preview of Irrigation



(a)



(b)

Fig. 16 : (a) Calibration curve of apparent conductivity (horizontal) and electrical conductivity (b) spatial distribution of soil salinity (ECe, dS m^{-1}) derived from EM 38 technique for SSD block I in Siwana Mal

Performance evaluation of SSD projects and demonstration of field tests to international trainees

Department whose involvement in these activities is mandatory and highly desirable.

Study on Backpressure for Irrigation Uniformity in Subsurface Drip and its Application in Wastewater Reuse (R.S. Pandey and Anshuman Singh)

The project was initiated to prioritize backpressure component along with construction of equipment to measure backpressure and field studies so that applicability of backpressure under practical problem of sewage water utilization could be understood. When the project was started, there was some preliminary knowledge on backpressure, which was attained in previous project.

At the initiation of project, the age of guava and *aonla* plants were 3.5 years, and the drip system was unable to meet the need of irrigation requirement to plants. The present design was improved (Table 28). The redesigned system was installed during the period under report. The diameter of the emitter coil was 1.2 m having 20 emitters at equal distance along 12 mm LDPE pipe. The emitters were turbo, having discharge rate of 8 lph. The depths of drippers were 50 cm. The installation was done manually. A trench was excavated digging and removing the soil in between the diameters of 1.2 m to 1.9 m, and placing the lateral in within the trench. The depth of drippers was 50 cm.

During the period under report, the root distribution study of a Guava plant was also conducted. The age of Guava plant was around 6 years. The soil was excavated up to the depth of 80 cm. The important observation, differentiating *aonla* plant root distribution was that, there was no main root in vertical direction. The excavation

Table 28 : Redesign values of field experimental set up for guava and *aonla* plants along with previous experimental set up values for both crops and other possibility for backpressure

Sr. No.	Particulars	Discharge rate of the emitters (lt h^{-1})	No. of emitters per plant	Depth of emitters (cm)	Diameter of emitter coil around the plant (cm)
1	Previous designed set up	8	4	40	40
2	Proposed present design set up	8	20	50	100
3	Change in design considering root study	8	20	50	120
4	Alternate design focused backpressure	40	4	--	--

Root study of a guava plant

Manual installation of lateral coil drippers around an aonla plant

Table 29 : Distribution of the main root and its major branching in a Guava plant

Sr. No.	Direction	No. of branches	Depth, (cm)	Root diameter in beginning (cm)	Root diameter at end (cm)	Maximum horizontal distance covered (m)
1	Vertical downwards	Nil	--	--	--	--
2	Horizontal expansion in South, 60^0 from West	3, One in beginning and branching at 20 cm. 2 in horizontal direction and one in vertical up to 45 cm depth	28	4.50	1.50	1.00
3	Horizontal expansion in South, 90^0 from West	1	46	6.00	4.50	1.30
4	Horizontal expansion in South, 100^0 from West	1	46	4.50	2.50	1.30
5	Horizontal expansion in South, 160^0 from West	1	18	3.50	1.50	0.88

was done by exposing the soil in south direction only, leaving the north direction soil intact to avoid plant mortality. There were four branching in south direction (Table 29), and the roots were mainly distributed in the radius of 60 cm.

Hydro-physical Evaluation of a Rainwater Harvesting System under Saline Soil and Groundwater Environment (Bhaskar Narjary, Satyendra Kumar, M.D. Meena, S.K. Kamra and D.K. Sharma)

Electromagnetic (EM 38) technique is a rapid and easy method to study the spatial variability and distribution of soil salinity over large areas. This technique was applied at experimental farm, Nain (Panipat) for characterizing soil salinity. The farm gets waterlogged during rainy season raising the water table to shallow depth which also has high salinity. For monitoring water table fluctuation in the farm, 18 observation wells were installed in a grid including a few near to the working tube well to study the influence of groundwater pumping (Fig 17). Eight observation wells were installed

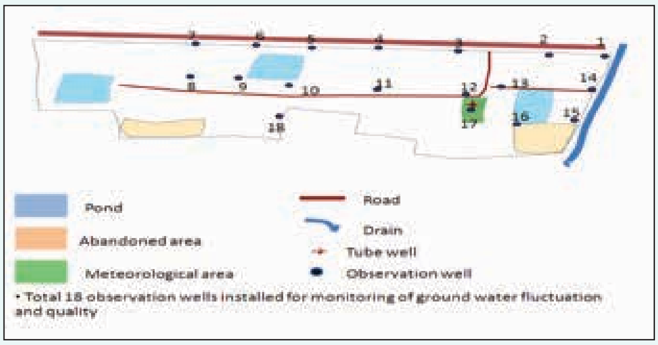


Fig 17: Location map of observation wells installed at Nain Farm

near to pond while remaining was installed in the area between pond and drain for seepage analysis. A drain is passing about 3-4 m away from the installed observation well in the west side. In pre-monsoon season, ground water table exists between 3-4 m below the ground surface. The ground water table depth during the month of July-August ranged from 0.5-1 m. Temporal changes in water table depth at different locations are presented in Table 30. An almost constant rise in water table was recorded in all observation wells during each of monsoon months i.e. August-October, 2013, due to rain and seepage from ponds and drain. About 30 cm rainfall occurred during August and September, 2013. Water was flowing in adjoining drain throughout the monsoon season and contributed through seepage to groundwater of the study area. There was little withdrawal of groundwater by pumping due to high salinity. Maximum groundwater rise was recorded during September, 2013. Observation wells (1, 4, and 15) installed near the pond and drain area recorded the maximum rise in groundwater table of 2-3.2 m and corresponding reduction in electrical conductivity was 1.0-18 dS m^{-1}. Although water table rose to 1.5-2 m near the tube well (pzm17) but there was no change in electrical conductivity. The lowest groundwater table rise (0.5-1.5 m) and least improvement in ground water salinity were recorded in observation wells away from the pond and drain (pzm 2, 7, 8, 17, 18). It indicated that seepage from water bodies (pond and drain) had dilution effect and floating layer of good quality water was present in nearby area. Increase in

Table 30 : Periodical ground water table depth and EC of different observation wells installed at Nain farm

Observation Wells	10th July		September		October		December	
	WTD (m)	EC (dS m^{-1})	WTD (m)	EC (dS m^{-1})	WTD (m)	EC (dS m^{-1})	WTD (m)	EC (dS m^{-1})
PZM 1	2.8	3.42	0.5	2.5	0.7	2.8	1.0	3.7
PZM 2	2.7	11.32	1.1	12.0	1.2	12.3	1.2	12.9
PZM 3	2.9	4.70	1.5	4.8	1.4	5.4	1.4	10.6
PZM 4	3.4	13.26	0.8	2.5	1.2	1.0	1.5	1.2
PZM 5	3.4	14.79	0.8	2.3	1.1	2.5	1.5	5.6
PZM 6	3.8	23.10	1.2	23.0	1.4	23.0	1.9	23.4
PZM 7	3.5	16.98	2.3	16.4	2.3	16.9	1.9	17.0
PZM 8	3.6	17.82	1.2	10.2	1.2	10.4	1.9	10.5
PZM 9	2.9	13.61	1.9	13.8	2.0	14.0	2.0	14.6
PZM 10	3.5	12.3	1.1	6.6	1.3	8.2	1.7	12.5
PZM 11	3.4	11.79	0.8	3.6	1.1	5.5	1.6	10.1
PZM 12	3.3	3.23	1.0	9.7	1.1	10.8	1.5	13.0
PZM 13	3.2	3.27	0.9	3.5	1.0	5.6	1.4	17.2
PZM 14	3.3	14.15	0.9	10.9	1.1	11.7	1.5	12.2
PZM 15	3.9	20.60	0.6	2.4	1.0	2.4	1.2	4.3
PZM 16	3.7	20.70	1.5	5.8	1.6	5.9	2.3	6.2
PZM 17	3.3	13.81	1.1	13.9	1.3	14.3	1.8	14.5
PZM 18	2.3	2.15	1.0	2.1	1.2	2.3	1.8	2.2

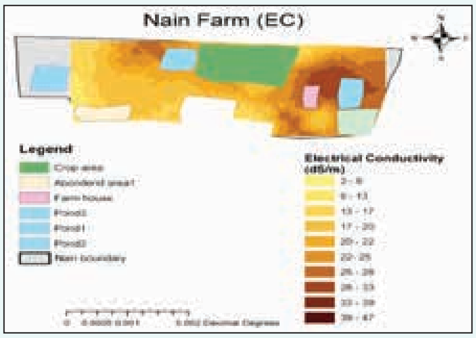


Fig 18 : Post monsoon soil salinity map of Nain farm

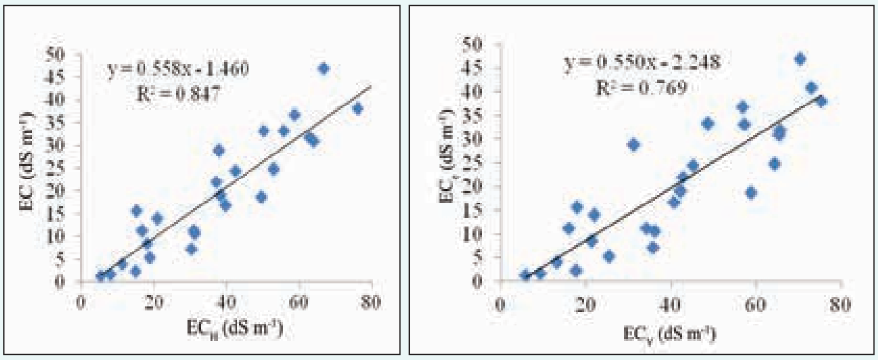


Fig 19 : Salinity level of Nain farm in horizontal & vertical modes

ground water salinity in the later stages indicated that rainwater contribution has little effect on improvement in ground water salinity.

EM-38 horizontal and vertical survey at 15 m x 15 m grid was conducted over 12 ha area (Fig 18 and 19). Soil samples upto 90 cm depth at 15 cm increment (i.e., 0–15, 15–30, 30–60 and 60–90 cm) were collected from 30 representative sites keeping in view the locations of EM observations. The soil samples were analyzed for electrical conductivity of saturated extract (EC_e), pH, cations (Ca^{2+}, $Mg^{2+}$and Na^{1+}), anions ($CO3^{2-}$, HCO^{2-}, Cl^{-1}) and sodium adsorption ratio (SAR) using standard analytical procedure. Geo-statistical based krigging approach was applied using Arc GIS 9.3 software to study spatial variability of apparent conductivity derived from EM-38 observations in horizontal and vertical modes. The correlation coefficients (r^2) of EC_a (V) and EC_a (H) were 0.77 and 0.85 with EC_e indicating higher correlations for horizontal EM observations. Soil salinity in the farm ranged from 3-50 dS m^{-1} with median EC of 17 dS m^{-1}. The results of the study suggest good reliability of EM approach for characterizing regional scale soil salinity.

Groundwater Resource Management to Mitigate the Impact of Climate Change in Punjab and Haryana (Satyendra Kumar, S.K. Kamra, Bhaskar Nargary and R.K. Yadav)

This project was initiated with the aim to study the impact of innovative agronomic interventions for reducing groundwater withdrawl in Haryana and their impact on natural recharging of groundwater aquifer. The other objective was to study the impact of land use changes and cropping pattern on natural recharge in fresh groundwater regions of Haryana. Two study sites have been selected (CSSRI farm in fresh and Nain farm in shallow saline groundwater regions) in Haryana to study the impact of precipitation and irrigation on groundwater recharge under different cropping systems through water and salt balance analysis.

At each location, soil samples upto 3m depth @ 30 cm interval were collected to characterize the lithology of sub soil stratum. The soil texture of different layers to 3 m depth is presented in Fig. 20 for different locations in Karnal site. Grain size distribution indicated domination of finer particles (silt + clay) in upper soil layer and a calcareous hard layer of about 30 cm thickness at 1.1-1.5 m depth. Fig. 20 also indicates that pH of soil increases with depth at all locations of Karnal being more than 8.5 below 60 cm depth.

Observation wells were installed in the study area to measure periodically depth and fluctuation of groundwater table. Temporal change in water table depth in different observation wells from 8th July, 2013 onwards is presented in Table 31. A constant rise in water table was recorded in all observation wells from August- October, 2013 due to natural recharge of excess rain and irrigation during monsoon period. Uniformly distributed rain during July and August also contributed in arresting declining groundwater table by meeting out a major part of paddy water requirement leading to reduction in pumping of groundwater.

Moisture content of soil at different depths was also measured in time to estimate natural recharge. The volume to a moisture profiles for tilled and zero tilled plots and DSR and transplanted plots is presented in Fig. 21. In surface (0-15 cm) layer, there was slight difference in moisture content between zero tillage and tillage treatments. Higher moisture content (2-3%) upto 1m was observed in tillage plots, thereafter upto 2 m zero tilled plots recorded higher moisture content (3-4%) as compared to tilled plots. The lower moisture content at lower depths in tilled plots may be due to the breaking of capillary pathways due to continuous tillage operations. In zero tilled plots continuity of pores was maintained which may have resulted in better movement of water through soil profile.

The trial on direct seeded rice (DSR) was conducted with the aim to develop irrigation schedule on the basis of soil moisture suction. DSR was adopted in two agro-techniques i.e. tilled and zero tiled condition. No tillage operation was conducted in zero tilled plots for last 3 years. The irrigation

Table 31 : Fluctuation in groundwater table of different observation wells installed at various location in the study area of Karnal

Observation wells	July	Aug	Sep	Oct
PZM 1	-0.84	-0.045	-0.72	-1.02
PZM 2	-0.23	-0.52	-0.63	-1.07
PZM 3	-0.60	-0.84	-0.96	-1.09
PZM 4	-0.33	-0.99	-1.11	-1.18
PZM 5	-0.79	-1.31	-1.71	-2.06
PZM 7	1.43	-0.11	-0.64	-1.07
PZM 9	1.49	-0.10	-0.34	-0.65
PZM 11	-0.18	-1.31	-1.69	-2.03
PZM 13	-0.13	-1.37	-1.54	-2.06

-(ve) sign indicates rise and +(ve) sign indicates decline in ground water table, with respect to ground water table depth of 08.07.2013 (pre-monsoon)

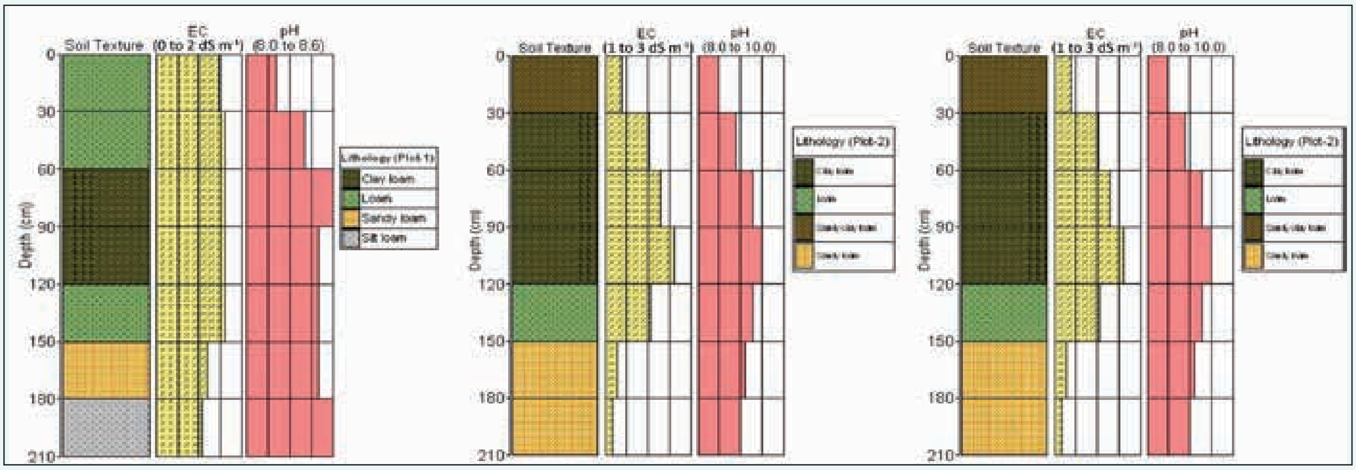


Fig. 20 : Layer wise soil texture (0-300 cm) of different location points in Karnal

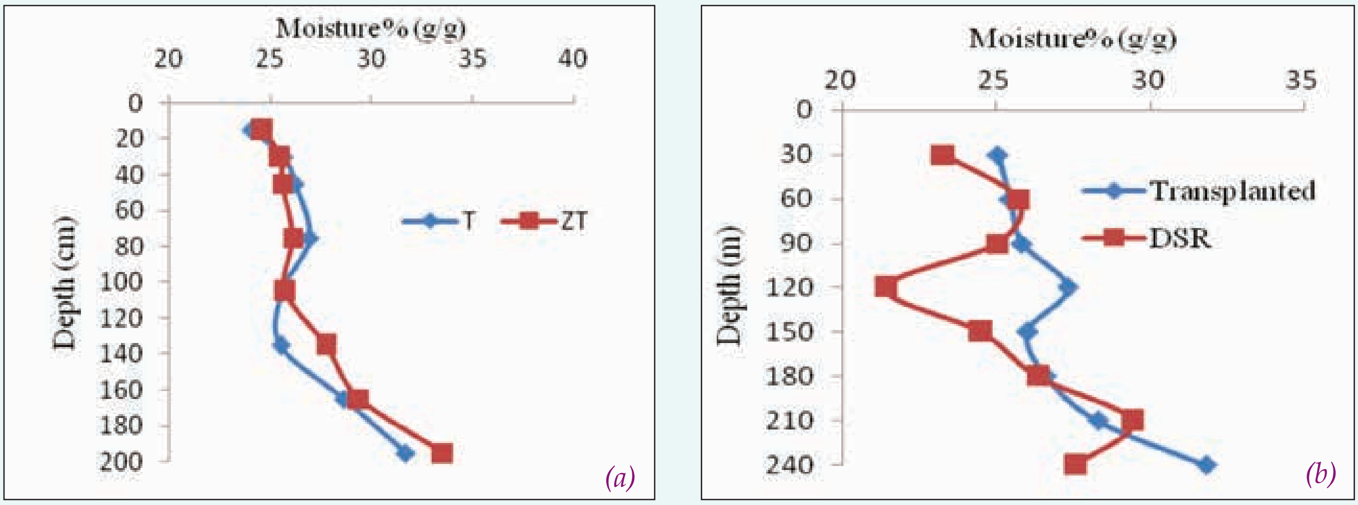


Fig. 21 : The average soil moisture measured in zero tilled and tilled plots (a) and transplanted and DSR (b)

scheduling was based at 15, 30 and 45 kPa suction measured continuously by irrometeres. A set of two irrometers was installed in each plot to determine matric potential at 15 and 30 cm depth. However, irrigation was applied on the basis of soil matric potential of 15 cm depth. Soil moisture suction was recorded daily and irrigation was applied when it reached the predefine values. The frequent irrigation did not provide much beneficial use of rainwater in crop production. The number of irrigations in schedules based on 30 and 45 kPa were 17 and 10, respectively compared to 30 in 15 kPa treatment.

The phonological parameters were found better in transplanted rice followed by DSR plots where irrigation was scheduled at 15 kPa followed by 30 and 45 kPa, respectively. Similarly, grain yield was maximum in transplanted rice followed by DSR irrigated at 15 kPa, DSR irrigated at 30 kPa and 45 kPa (Table 32). Slightly higher water productivity (0.28 kg m^{-3}) was recorded in zero tilled rice crop as compared to other plots. It was also found that water productivity was almost similar in 30 kPa and 45 kPa and slightly lower from 15 kPa. It indicated that decrease in production per unit volume of water was not proportionate to yield reduction. These are the preliminary observations which will be confirmed in next season.

Decision Support System for Enhancing Productivity in Irrigated Saline Environment using Remote Sensing, Modelling and GIS

(D.S. Bundela, S.K. Gupta, Madhurama Sethi, R.L. Meena, Anil Chinchmalatpure and R.S. Tripathi)

During 2013, the Western Yamuna Canal (WYC) command received 74 per cent of the long period average (LPA) monsoonal (June-September) rainfall classifying it a deficient rainfall year. This will likely influence the canal supply during *rabi* season and also partially desalinize the salt-affected soils particularly in lower reaches of WYC command. During the past five years (2009-13), monsoonal rainfall was deficient in four years while the year 2010 was surplus with 119 per cent of monsoonal rainfall (Fig. 22). The monsoonal rainfall received in 2012, 2011 and 2009 were 59, 73, and 69 per cent against its long period average.

Table 32 : Irrigation water, rainfall and yield and water productivity under different irrigation scheduling and agro techniques

Agro- technique	Irrigation schedule	Irrigation (cm)	Rainfall (cm)	Yield (t ha^{-1})	Irrigation water productivity (kg m^{-3})
Tilled	15 kPa	171.7	30.8	4.39	0.26
	30 kPa	87.6	30.8	1.83	0.21
	45 kPa	69.6	30.8	1.58	0.23
Zero tilled	15 kPa	163.2	30.8	4.57	0.28
	30 kPa	93.1	30.8	2.12	0.23
	45 kPa	68.9	30.8	1.45	0.21

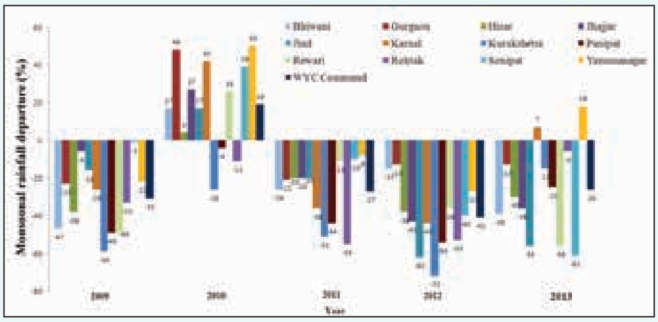


Fig. 22 : District-wise departure of monsoonal rainfall in WYC Command from 2009 to 2013

The Irri-agro Informatics Spatial Database of the WYC command developed using ArcGIS 10 was updated for daily inflow data of distributaries and minors for *rabi* 2012-13 and district-wise characteristics in terms of supplies in canal network from main canal to watercourses; rainfall departure from 2006 to 2013; rainfall distribution at every 100 mm rainfall; groundwater quality; salt affected soils; soil texture and three major cropping systems (rice-wheat, cotton-wheat and bajra-wheat). The database also identified and delineated the area of low productivity (7.24%) in the WYC command.

Demands of canal water from non-irrigation sectors are rapidly rising in the WYC System with 2012-13 share of irrigation being 73.8-75.2 per cent of the available supplies and the remaining used for drinking, domestic, industries and service sectors. During *rabi* 2012-13, three canal irrigations were supplied to wheat and other crops at nearly 50 per cent intensity in the Butana distributary command where groundwater is of relatively saline-sodic or saline nature in mid and tail reaches. A single marginally saline groundwater irrigation at mid and tail reaches was applied in March while adequate winter rainfall (128-181 mm) supplemented two additional irrigations leading to bumper crop yield (3.91-5.16 t ha^{-1}).

Six thematic layers of the database of WYC Command were converted to open source GIS software using Quantum GIS v 1.8 and were distributed to 52 CADA officers and KVK specialists. A web map service of the Irri-agro Informatics database was developed and disseminated over the internet to the stakeholders/users for online querying through the project website (Fig. 23). The canal network and groundwater quality thematic layers were displayed as overlay on Google earth for use by stakeholders for identifying resource

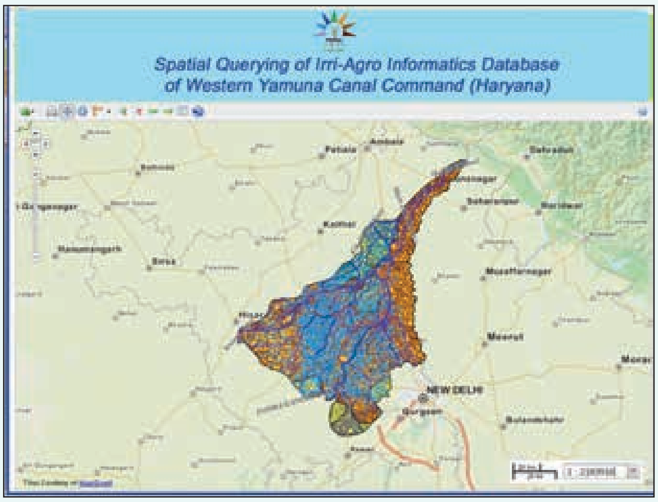


Fig. 23 : Web map service of Irri-Agro Informatics Geodatabase of the WYC Command

constraints for crop production at farm level-low canal supply, saline/sodic soils and poor quality groundwater classes. The database can be queried with multiple attributes- rainfall, groundwater quality, soil quality, soil texture and canal supply status for locating saline/low productivity areas (Fig. 24). All the nine modules of DSS viz. *Database, Crop Water Demand, Canal Supply, Groundwater, Irrigation Scheduling, Modelling, BMPs, Farmer's Services* and *Help* were integrated to assess the resource constraints and to generate and evaluate the BMP alternatives for different resource scenarios in irrigated saline environment for enhancing crop productivity. It was also seen through querying that these conditions prevailed in the south-west part of the WYC command (Jind, Sonipat, Rohtak and Jhajjar districts).

The first *module 'Database'* displays the six thematic layers and their attributes pertaining to the *Irri-agro Informatics database* for understanding the farm scenarios/constraints in saline environment. The second module *'Crop Water Demand'* computes crop

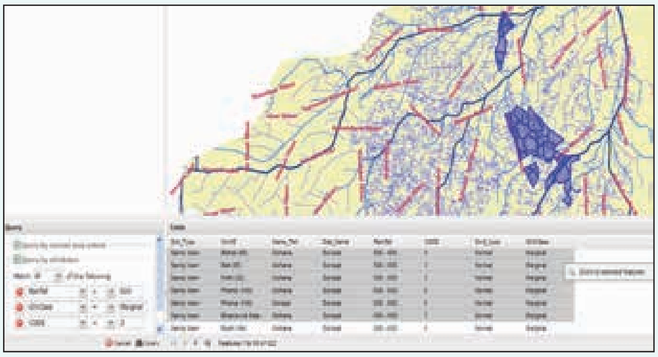


Fig. 24 : Online querying based on multiple layer attributes for identifying constraints in WYC Command

evapotranspiration (ET_c) from daily weather data archived from 2001 to 2013 using Penman-Monteith method for reference crop ET multiplied by crop coefficient. The irrigation demand at watercourse outlet/turn out level is computed from water demand of various crops after subtracting effective rainfall and capillary water and adding conveyance and application losses. The third module *'Canal Supply'* computes the canal contribution to meet irrigation demand and consequent groundwater needs. The fourth module '*Groundwater*' computes its contribution to meet full irrigation demand, if required, with water quality considerations.

The fifth module '*Irrigation Scheduling*' generates irrigation schedules to maximize or optimize wheat and mustard yield for following irrigation options: (i) single source or conjunctive use of canal and good quality ground water, (ii) deficit irrigation or critical phenological growth stage irrigation, (iii) effective conjunctive use of canal and marginal to poor quality saline/sodic waters, and (iv) both water and salinity stresses.

The sixth module '*Modelling*' predicts the relative crop yield for major *rabi* crops in six saline environments: surface water ponding or stagnation, waterlogging, soil salinity, soil sodicity, use of saline/sodic water irrigation, and deficit irrigation to recommend best management practices (BMPs). A crop-water-salinity yield response module for six saline environments was developed for predicting the relative crop yield loss (Fig. 25). Another modelling module developed at WTC, New Delhi for scenarios based on published data, experimental data and deficit irrigation has been integrated in the DSS program for enhancing crop yield under varying soil and water salinity conditions. AquaCrop and SWAP models in Modelling module were also integrated for predicting wheat yield in complex scenarios of saline soils and poor quality irrigation water.

Fig. 25 : Screen captured window of crop-water-salinity-yield module for six prevailing saline conditions

The seventh module '*BMP based Strategies*' can generate several strategies for controlling water stagnation, waterlogging, soil salinity and sodicity, sodic/saline water irrigation and deficit irrigation. The useful information on each BMP was provided for understanding its quantitative impact on crop yield and root zone salinity/sodicty build-up. The eighth module '*Farmer' Services*' enlists essential requirement of farmers viz. soil and water sample testing facilities available in each district, high yielding and salt tolerant varieties and their package of practices, input supplies, information of state line departments and a toll free number. The ninth module '*Help*' provides supports to users on how to run and make best use of DSS program for generating BMPs and their interpretation.

The DSS application program can run on any normal computer having windows operating systems- MS Windows XP, Vista and 7 and hardware with Intel® P4 CPU @ 2.53 GHz processor or better, 1GB RAM or better and minimum 500 MB disk space. This application also requires .NET Runtime 3.5 Service Pack 1, Access Database Engine (32 bit or 64 bit), and third party softwares, Dev Express (Dx Experience 11.1.8) and Telerik 2012 Q1. The bilingual support in Hindi to DSS application program was extended.

A feasibility assessment for deployment of DSS program was conducted at 7 KVKs (Panipat, Sonipat, Rohtak, Jhajjar, Rewari, Jind and Kaithal) and 6 CADA Divisional Offices (Karnal, Sonipat, Panipat, Rohtak, Jind and Kaithal). Problems were observed in KVKs on non-availability of suitable persons at Rohtak and irregular power supply during working hours at Panipat, Sonipat, and Jind. Internet connectivity was observed in all KVKs. The DSS program was successfully tested with existing computers at 3 KVKs (Panipat, Rohtak and Rewari) alongwith provision of backstopping services. Six CAD Division offices at Karnal, Sonipat, Panipat, Rohtak, Jind and Kaithal met all the requirements for software deployment and the program was deployed for their use.

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MANAGEMENT OF MARGINAL QUALITY WATER

Wastewater Use in Non Food Crops (R.K. Yadav, D.S. Bundela, S.K. Chaudhari and B.L. Meena)

Bhadrachalam clone plantations of *Eucalyptus tereticornis* and lemon grass (*Cymbopogon fluxuosus)* were continuously assessed for their water use potential to evolve safer alternative for wastewater disposal. Water use, transpiration rate, plant height, diameter at stump height (DSH) and breast height (DBH) and mean annual increase (MAI) in wood volume of *eucalyptus* plantation were monitored in field studies comprising of variable irrigation regimes 1.0, 2.0, 2.5 and 3.0 IW/CPE ratio, and no irrigation. While fresh and dry biomass, essential oil yield and heavy metals accumulation were measured in lemon grass irrigated with wastewater at 0.6, 0.8, 1.0, 1.2 and 1.5 IW/CPE ratio either alone or in cyclic conjunctive mode with tube well water.

Eucalyptus plantation growth, height, DSH, DBH, and MAI increased from 7.0 to 20.4 m, 17.4 to 24.1cm, 15.2 to 19.8 cm and 1.8 to 4.9 m^3 ha^{-1}, respectively when no irrigation to wastewater irrigation was applied up to 2.5 IW/CPE; but these growth parameters did not increase further with increasing irrigation frequency to 3.0 IW/CPE. Wastewater irrigation improved the tree growth relatively more in comparison to tube well irrigation and rainfed control, however, significant increase in growth was recorded with increasing frequency of wastewater irrigation only up to 2.0 IW/CPE. Average daily transpiration rate increased from 2.4 mm under rainfed to 4.8 mm/day in irrigations at 1.0 and further to 6.3 mm/day under wastewater application at 2.5 IW/CPE ratio. While the total annual water increased from 962–2168 mm with rainfed to 3.0 IW/CPE ratio wastewater irrigation frequencies. Observations on temporal changes in transpiration capacity of differentially wastewater irrigated *eucalyptus* plantations suggest that peak in transpiration reached during 6th year of growth at 2.0 IW/CPE irrigation frequency and the trend continued even in later years of plantation growth (Table 33).

The maximum transpiration capacity of *eucalyptus* plantation irrigated with wastewater at 2.0 IW/CPE increased temporally from ~0.57- 1.0 and 0.59 to 1.10 times of Ep and PET, respectively during 3rd to 8th year of growth and followed a logarithmic function "Y+506.6 ln(x) + 757.9 with R2 = 0.96" (Fig. 26).

Fresh biomass of lemon grass increased significantly from 3.03 to 4.13 and 3.53 to 4.76 kg m^{-3}, respectively with increasing frequency of tube well water and wastewater irrigation from 0.6 to 1.2 IW/CPE. Dry biomass also followed similar increasing trend from tube well to increasing frequency of wastewater irrigation up to 1.2 IW/CPE ratio. The essential oil yield of lemon grass also increased with increasing wastewater application regimes up to 1.2 IW/CPE ratio followed by the tube well and sewage in the cyclic mode. Though, the heavy metals contents in essential oil of lemongrass increased with increasing application

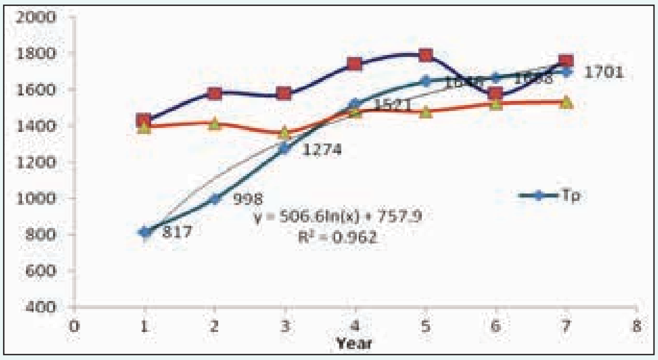

Fig. 26 : Temporal changes in Eucalyptus transpiration (max; Tp) in relation to potential ET (PET) and Pan Evaporation (Ep

Table 33 : Temporal changes in differentially wastewater irrigated *Eucalyptus* plantation

Irrig Reg IW/CPE	1.0	1.5	2,0	2.5	3.0	Rainfed
2006-07	665	757	817	830	822	584
2007-08	822	928	998	987	995	656
2008-09	1056	1185	1274	1281	1277	732
2009-10	1284	1433	1521	1526	1508	756
2010-11	1405	1514	1646	1665	1657	682
2011-12	1431	1539	1668	1648	1669	893
2012-13	1464	1578	1701	1694	1688	764

Table 34 : Cr content in essential oil of differentially wastewater irrigated lemon grass

Water quality / Irrigation schedules (IW/CPE)	Cr content (µg l^{-1})					
	0.6	0.8	1.0	1.2	1.5	Mean
Ground water	48.3	57.7	64.2	63.2	59.2	58.6
Waste water	56.5	67.5	73.0	73.6	70.0	68.1
Ground water : waste water	55.8	68.0	72.9	72.7	68.1	67.5
Mean	53.6	64.6	70.1	69.8	65.7	64.7
LSD 5%	WQ-3.3		IS-4.1		WQ x IS-7.3	

of wastewater under different regimes and modes of tube-well water and wastewater irrigation but these were within permissible levels, however, Cr being the maximum as presented in Table 34.

Microbial Bioremediation of Wastewater for Heavy Metals (P.K. Joshi)

Wastewater from industries contains high concentration of metals like Pb, Cd, Cr, Cu, Ni, etc which are toxic to living organisms even at low concentration. Biomass of microbes acts as an adsorbent to remove heavy metals from wastewater at low cost and in eco-friendly way. The ability to remove heavy metals from wastewater varies greatly among microbes. This needs to be exploited for removal of heavy metals from wastewater through efficient microbes.

Removal of heavy metals from wastewater by agrowastes along with microbial consortium: Laboratory experiment was conducted to see removal of heavy metals from aqueous solution by sterilized and unsterilized pressmud individually and in combination with rice husk along with a microbial consortium of six fungi and one bacterium. Microbial consortium was allowed to grow on pressmud and pressmud plus rice husk in both sterilized and unsterilized conditions. There was substantial growth of both fungi and bacteria on sterilized and unsterilized pressmud and pressmud plus rice husk up to three weeks. Maximum removal and uptake of heavy metals (Zn, Ni, Cu, Cd, Pb) was with sterilized and unsterilized pressmud and pressmud plus rice husk along with microbial consortium and results of removal Ni are given in Table 35. This indicated efficiency of inoculated micro-organism in removing heavy metals from aqueous solution containing heavy metals.

Table 35 : Removal of Ni by pressmud and pressmud and rice husk along with microbial consortium from aqueous solution containing 25 ppm of Ni

Treatment	Uptake (mg g^{-1})	Removal (%)
US PM+C	1.16	23.2
US PM	0.59	11.8
S PM+C	0.03	34.2
S PM	0.97	19.4
US PM+RH+C	0.19	03.8
US PM+RH	0.18	03.4
S PM+RH+C	0.30	06.0
S PM+RH	0.24	04.8

US-Unsterilized; S-Sterilized; RH-Rice husk; PM- Press mud; C-Microbial consortium

Optimization of conditions for removal of heavy metals by agrowastes along with microbial consortium: Experiments were conducted to find out optimum conditions like pH, dose of agro-wastes (algae, pressmud and rice straw individually and in combination with rice husk) and concentration of heavy metals along with microbial consortium of six fungi and one bacterium for maximum removal of heavy metals from aqueous solution. Data indicated pH 5-7, agro-waste dose of 0.4 to 1 per cent and concentration from 50 to 200 ppm of heavy metal as optimum conditions for maximum removal of heavy metals (Cu, Zn, Pb, Ni, Cd) from aqueous solution containing heavy metals. Maximum removal of heavy metals was observed by algae and pressmud agrowaste at optimum conditions. These optimum conditions can be used for removal of heavy metals from industrial wastewater

Isolation of Arsenic Tolerant Micro-organisms (P.K. Joshi)

Arsenic is present in higher concentration in groundwater and in industrial effluents in West Bengal, Bihar and in many other states of India. It is entering into human beings and living organisms through the food chain. Physio-chemical methods to remove As from groundwater and wastewater are very costly. Hence, there is a need to develop other alternative low cost methods to remove As from water. Recently microbes have been reported to remove As from water at low cost and in eco-friendly way. However, the efficiency of microbes vary greatly in terms of removal of arsenic. This need to be exploited for removal of As from water by isolating efficient microbes to remove As.

Tolerance and removal of As by fungi from liquid medium under laboratory conditions

Earlier fungi were isolated from samples of groundwater containing As. These fungi were tested for their tolerance As up to 320 ppb. Most of the fungal isolates were able to tolerate As up to 320 ppb. Subsequently, forty fungal isolates were tested for tolerance and removal of As from potato dextrose broth containing 1248 ppb of As(III). All the fungal isolates were able to tolerate As up to 1248 ppb. However, ten fugal isolates were found more tolerant to As at 1248 ppb and removed substantial amount of As from liquid medium. Maximum removal of As was observed by *A. niger* (58.50 ug/g fungal dry wt.) followed by *Trichoderma asperellum* (48.60 ug/g fungal dry wt.). These ten fungi were subsequently identified based upon morphological characteristics from Division of Mycology and Plant Pathology, IARI, New Delhi. These fungal cultures are being maintained and can be used for removal of As from water and wastewater at low cost and in eco-friendly way and data on removal of As by these fungi are presented in Table 36.

Table 36 : Removal of arsenic (III) from potato dextrose broth containing 1248 ppb of As by fungi

Fungal culture	Uptake of As (ug/g)
FS 2 *Trichoderma sp.*	17.24
FS 4 *Trichoderma sp.*	34.40
FS 7 *Aspergillus flavus*	11.40
FS 8 *A.flavus*	25.50
FS 23 *A.niger*	23.90
FS 26 *Penicillium purpurogenum*	21.95
FS 33 *P.funiculosum*	08.75
FS 34 *Trichoderma asperellum*	48.60
FS 36 *A.niger*	58.50
FS 38 *Trichoderma sp.*	22.59

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CROP IMPROVEMENT FOR SALINITY, ALKALINITY AND WATERLOGGING STRESSES

Genetic Improvement of Rice for Salt Tolerance (S.L. Krishnamurthy, S.K. Sharma and Y.P. Singh)

This project aims at the development, evaluation and dissemination of better salt tolerant rice genotypes. To achieve the objectives, following trials were conducted during *kharif* 2013.

National trials

Alkaline and Inland Saline Tolerant Varietal Trial

The Alkaline and Inland Saline Tolerant Varietal Trial (AL&ISTVT) comprising of 29 entries including check varieties (CSR 36, CSR 27 and yield check Jaya) was conducted on eight salt stress locations (Table 37) in Randomized Block Design with three replications.

Under normal (micro plot and field) conditions, twelve entries out performed the best check (Fig 27). The entry 2101 showed the highest grain yield (6.42 and 5.86 t ha^{-1}) followed by 2102 (6.23 and 5.72 t ha^{-1}), 2020 (6.20 and 5.61 t ha^{-1}), 2126 (6.19 and 5.70 t ha^{-1}), 2118 (6.19 and 5.58 t ha^{-1}), 2106 (6.13 and 5.84 t ha^{-1}), 2117 (6.11 and 5.52 t ha^{-1}), 2014 (6.11 and 5.75 t ha^{-1}), 2109 (6.10 and 5.53 t ha^{-1}), 2111(6.10 and 5.49 t ha^{-1}), 2115 (6.08 and 5.43 t ha^{-1}) and 2012 (5.86 and 5.65 t ha^{-1}).

Under salinity stress at Karnal, fourteen entries outperformed the national salinity check CSR 27 (Fig 28). The entry 2014 showed the highest grain yield (3.06 t ha^{-1}) followed by 2101(2.98 t ha^{-1}), 2109 (2.93 t ha^{-1}), 2102 (2.83 t ha^{-1}), 2115 (2.83 t ha^{-1}), 2126 (2.81 t ha^{-1}), 2117 (2.79 t ha^{-1}), 2111(2.78 t ha^{-1}), 2118 (2.78 t ha^{-1}), 2125 (2.76 t ha^{-1}), 2020 (2.75 t ha^{-1}), 2124(2.61 t ha^{-1}) and 2012 (2.56 t ha^{-1}).

At Nain Farm, Panipat fifteen entries outperformed the national salinity check CSR 27. The grain yield ranged from 0.81 t ha^{-1} (2110) to 1.95 t ha^{-1} (2111). The entry 2111 showed the highest grain yield (1.95 t ha^{-1}) followed by 2101 (1.90 t ha^{-1}), 2102 (1.80 t ha^{-1}), 2019 (1.75 t ha^{-1}), 2014 (1.61 t ha^{-1}), 2017, 2015 and 2018 (1.60 t ha^{-1}).

At Farmer's field in Rohtak, sixteen entries outperformed the national salinity check CSR 27. The

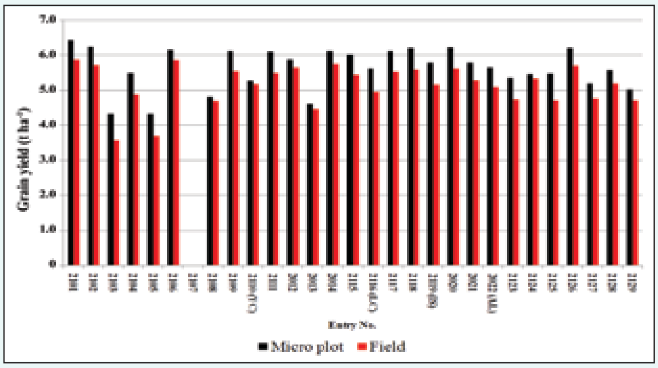


Fig 27 : Performance of AL&ISTVT entries under normal (micro plot and field) soil condition

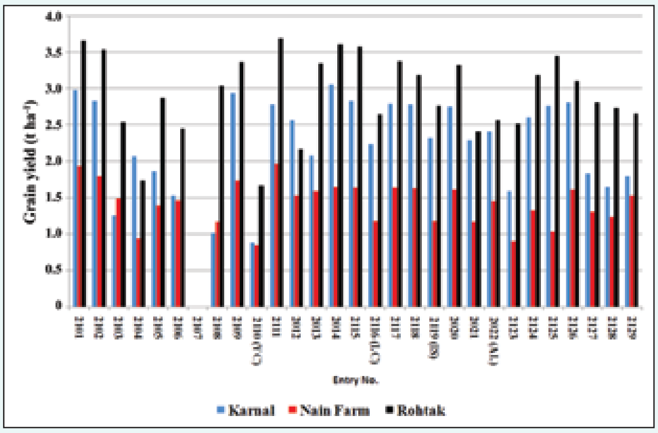


Fig 28 : Performance of AL&ISTVT entries under high salinity at Karnal, Nain Farm and Farmer's field Rohtak

Table 37 : Location wise soil status under AL&ISTVT Trial-2013

S. N.	Locations	Gross plot size	Net plot size	Date of sowing	Date of planting	pH_2	EC (dS m^{-1})
1	Normal field - Karnal	8.8 m^2	5.0 m^2	13.06.2013	22.07.2013	7.7	0.4
2	Normal micro plot - Karnal	0.60 m^2	0.52 m^2	13.06.2013	10.07.2013	7.5	0.4
3	High Salinity - Karnal	0.60 m^2	0.52 m^2	13.06.2013	10.07.2013	7.8	7.5
4	Moderate Sodicity - Karnal	0.60 m^2	0.52 m^2	13.06.2013	10.07.2013	9.5	0.4
5	Farmer's field, Kurukshetra	8.8 m^2	5.0 m^2	13.06.2013	26.07.2013	9.3	0.4
6	Nain Farm, Panipat	8.8 m^2	5.0 m^2	21.06.2013	22.07.2013	8.8	16
7	Farmer's field - Rohtak	8.8 m^2	5.0 m^2	13.06.2013	16.07.2013	7.3	6.5
8	Farmer's field - Jind	8.8 m^2	5.0 m^2	13.06.2013	18.07.2013	9.5	0.4

entry 2111 showed the highest grain yield (3.69 t ha^{-1}) followed by 2101 (3.66 t ha^{-1}), 2014 (3.60 t ha^{-1}), 2115 (3.57 t ha^{-1}), 2102 (3.53 t ha^{-1}), 2125 (3.45 t ha^{-1}), 2117 (3.38 t ha^{-1}), 2109 (3.37 t ha^{-1}), 2013 (3.34 t ha^{-1}), 2020 (3.32 t ha^{-1}), 2124 (3.18 t ha^{-1}), 2118 (3.18 t ha^{-1}), 2126 (3.10 t ha^{-1}), 2108 (3.04 t ha^{-1}), 2105 (2.87 t ha^{-1}) and 2127 (2.81 t ha^{-1}).

Under sodic stress at Karnal, twelve entries out performed the national alkaline check CSR 36. The entry 2101 showed highest grain yield (3.95 t ha^{-1}) followed by 2102 (3.79 t ha^{-1}), 2014 (3.76 t ha^{-1}), 2109 (3.76 t ha^{-1}), 2126 (3.68 t ha^{-1}), 2115 (3.64 t ha^{-1}), 2111 (3.61 t ha^{-1}), 2117 (3.57 t ha^{-1}), 2020 (3.56 t ha^{-1}), 2012 (3.47 t ha^{-1}), 2118 (3.47 ha^{-1}) and 2128 (3.30 t ha^{-1}).

At Kurukshetra, sixteen entries out performed the national alkaline check CSR 36 (Fig. 29). The entry 2101 showed highest grain yield (4.41 t ha^{-1}) followed by 2115 (4.30 t ha^{-1}), 2118 (4.19 t ha^{-1}), 2126 (4.17 t ha^{-1}), 2014 (4.15 t ha^{-1}), 2102 (4.12 t ha^{-1}), 2111 (4.09 t ha^{-1}), 2012 (4.05 t ha^{-1}), 2109 (4.021 t ha^{-1}), 2104 (3.97 t ha^{-1}), 2020 (3.97 t ha^{-1}), 2117 (3.92 t ha^{-1}), 2013 (3.85 t ha^{-1}), 2021 (3.72 t ha^{-1}), 2129 (3.55 t ha^{-1}) and 2116 (3.55 t ha^{-1}).

At Jind, twelve entries out performed the national alkaline check CSR 36. The entry 2109 showed highest grain yield (3.97 t ha^{-1}) followed by 2101 (3.95 t ha^{-1}), 2102 (3.92 t ha^{-1}), 2014 (3.81 t ha^{-1}), 2126 (3.78 t ha^{-1}), 2111 (3.78 t ha^{-1}), 2115 (3.77 t ha^{-1}), 2012 (3.74 t ha^{-1}), 2118 (3.72 t ha^{-1}), 2117 (3.71 t ha^{-1}), 2020 (3.65 t ha^{-1}) and 2021 (3.41 t ha^{-1}).

Genotype x environment interaction and stability performance were explored for grain yield at six locations viz.; salinity-Karnal, and sodicity-Karnal), Farmer's fields Jind, Rohtak, Kurukshetra and Nain Farm-Panipat. On the basis of grain yield, four entries namely 2111, 2012, 2017 and 2020 were found to be highly stable.

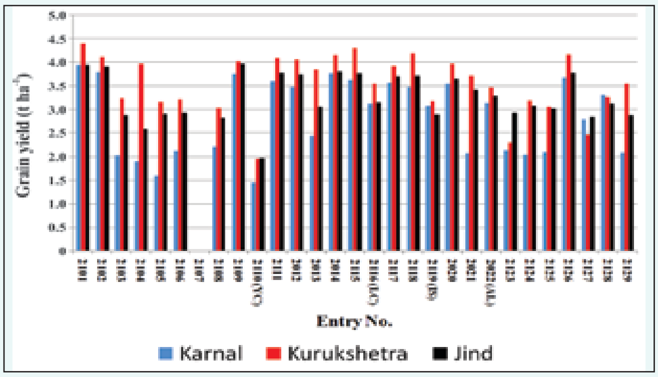


Fig 29 : Performance of AL&ISTVT entries under alkaline soil condition at Karnal, Kurukshetra and Farmer's field at Jind

Bio-fortification trial

Bio-fortification Trial (BT) comprising of 29 entries including three check varieties was conducted at 5 locations in RBD with three replications. Under high salinity stress (EC ~ 7.5 dS m^{-1}) at Karnal, five entries outperformed the national salinity check Kalanamak (1.73 t ha^{-1}). The entry 4002 showed highest grain yield (2.15 t ha^{-1}) followed by 4020 (1.96 t ha^{-1}), 4001 (1.88 t ha^{-1}), 4006 (1.85 t ha^{-1}) and 4027 (1.74 t ha^{-1}).

At very high salinity (EC ~ 16 dS m^{-1}) at Nain Farm Panipat, eleven entries outperformed the national salinity check Samba Masuri (0.98 t ha^{-1}). The entry 4025 showed highest grain yield (1.41 t ha^{-1}) followed by 4002 (1.39 t ha^{-1}), 4029 (1.38 t ha^{-1}), 4026 (1.36 t ha^{-1}), 4001 (1.34 t ha^{-1}), 4004 (1.14 t ha^{-1}), 4018 (1.13 t ha^{-1}), 4005 (1.09 t ha^{-1}), 4024 (1.07 t ha^{-1}), 4003 (0.99 t ha^{-1}), 4019 (0.99 t ha^{-1}) and 4007 (0.98 t ha^{-1}).

At farmer's field, Rohtak (EC ~ 6.5 dS m^{-1}), twelve entries outperformed the national salinity check Samba Masuri (2.63 t ha^{-1}). The entry 4001 showed highest grain yield (3.32 t ha^{-1}) followed by 4025 (2.99 t ha^{-1}), 4026 (2.89 t ha^{-1}), 4002 (2.86 t ha^{-1}), 4018 (2.84 t ha^{-1}), 4020 (2.79 t ha^{-1}), 4027 (2.78 t ha^{-1}), 4003 (2.74 t ha^{-1}), 4022 (2.69 t ha^{-1}), 4023 (2.68 t ha^{-1}), 4005 (2.68 t ha^{-1}), 4019 (2.68 t ha^{-1}) and 4007 (0.98 t ha^{-1}).

At farmer's field, Jind (pH_2 ~ 9.5), entry 4028 showed highest grain yield (2.55 t ha^{-1}) followed by 4023 (2.08 t ha^{-1}), 4022 (2.04 t ha^{-1}), 4003 (1.82 t ha^{-1}) and 4020 (1.73 t ha^{-1}). Under normal field condition at Karnal (Fig.30), entry 4001 showed highest grain yield (5.39 t ha^{-1}) followed by 4025 (5.32 t ha^{-1}), 4023 (5.24 t ha^{-1}), 4026 (5.23 t ha^{-1}), 4002 (5.06 t ha^{-1}) and 4027 (4.98 t ha^{-1}).

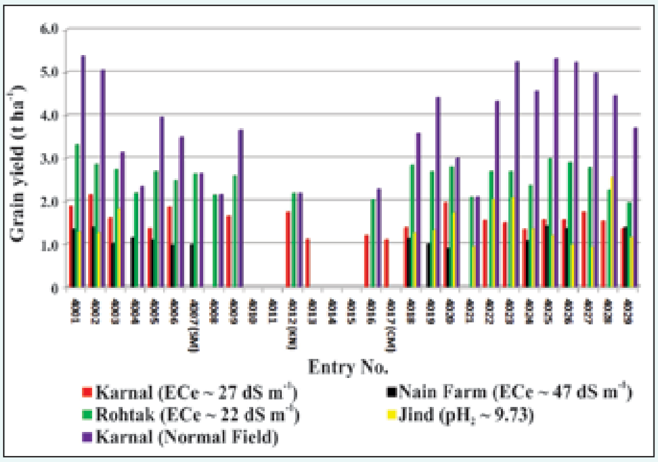


Fig. 30 : Performance of bio-fortification entries at Karnal, Panipat, Jind and Rohtak

Station Trials

Monitoring, maintenance and development of breeding materials

Screening and selection of F_2 populations

A total of 43 segregating populations (Table 38) were screened under high salinity (EC_e ~ 17 dS m^{-1}) at Nain Farm. The top 10 progenies were selected from each segregating population for further screening/evaluation in the next cropping season.

Screening and selection of F_4 populations

A total of 24 segregating populations (Table 39) were screened under high salinity (EC ~ 7.0 dS m^{-1}) in saline micro plot and Nain farm (EC ~ 16 dS m^{-1}). The top 10 progenies were selected from each segregating population by considering the yield, quality, tolerance and other traits for further screening/evaluation in the next cropping season.

International Rice Soil Stress Tolerance Nursery (IRSTON Trial) 2013

Two modules (M-1 and M-2) consisting of 32 and 34 rice genotypes were evaluated under high saline stress (EC ~ 7.0 dS m^{-1}) in micro plots with two replications in *kharif* 2013. The genotypes IR 86341-B-AJY1-B, IR 87938-1-1-1-2-B and IR 45427-2B-2-2B-1-1 performed better in module 1. Similarly, the genotypes IR 84107-2-B-AJY1-1-3-AJY1-2-B, IR 86337-B-AJYI-B, IR 87915-5-2-2-B, IR 86385-48-1-1-B, IR 55179-3B-11-3, YET 2, CSR 1148-143 and CSR 1148-10 performed better in module 2.

Both modules (M-1 and M-2) were also evaluated under highly saline stress (EC ~ 16 dS m^{-1}) at Nain farm, Panipat. The genotypes IR 85897-B-B-AJY1-B, IR 87856-7-AJY1-B, IR 87856-10-AJY1-B, IR 86341-B-AJY1-B and IR 86376-47-3-1-B were performed better in module 1. Similarly, the genotypes IR 83417-6-B-10-1-1-1-AJY1-B, IR 84645-311-58-1-B-AJY1-1-B, IR 87915-5-2-2-B, IR

Table 38 : List of F_2 populations advanced for the next generation under stress

S.No.	F_2S	S.No.	F_2S	S.No.	F_2S
1	IR 64 X CSR 36	16	IR 64 X CSR 30	31	PS 2 X CSR 27
2	HKR 126 X CSR 27	17	VANDNA X CSR 36	32	PS 5 X CSR 36
3	SAHABHAGI DHAN X CSR 36	18	PS 5 X CSR 30	33	BAS 370 X CSR 10
4	PS 3 X CSR 30	19	IR 64 X CSR 10	34	HAZARIDHAN X CSR 27
5	PUSA 1121 X CSR 10	20	SAHABHAGI DHAN X CSR 27	35	PUSA 1121 X CSR 10
6	PS 5 X CSR 10	21	PR 114 X CSR 27	36	CSR 36 X FL 478
7	SAHABHAGI DHAN	22	PS 5 X CSR 27	37	HAZARIDHAN X CSR 10
8	ANJALI X CSR 10	23	PUSA 1121 X CSR 30	38	TRICHY X CSR 27
9	PS 2 X CSR 36	24	BAS 370 X CSR 30	39	VANDNA X CSR 27
10	PUSA 1121 X CS R27	25	HKR 126 X CSR 10	40	NDR 359 X FL 478
11	PS 2 X CSR 30	26	PUSA 44 X CSR 36	41	ANJALI X CSR 27
12	PUSA 44 X CSR 10	27	TRICHY X CSR 10	42	Sarjoo 52 X CSR 36
13	ANJALI X CSR 36	28	HAZARIDHAN X CSR 36	43	PR 115 X CSR 27
14	PS 3 X CSR 36	29	PUSA 44 X CSR 27		-
15	PAU 201 X CSR 10	30	HKR 126 X FL 478		-

Table 39 : List of F_4 populations advanced for the next generation under stress

S. No.	Crosses	S. No.	Crosses	S. No.	Crosses
1	NDR 359 X FL 478	9	NDR 356 X CSR 27	17	Tar Bas X CSR 2K 262
2	FL 478 X PR 115	10	PB 6 X CSR 2K-262	18	PR 115 X FL 478
3	PR 115 X CSR 27	11	CSR 86-IR-8 X FL 478	19	PB 6 X CSR 27
4	Sarjoo 52 X PB 6	12	Sarjoo 52 X CSR 27	20	BCW 56 X CSR 36
5	Tar Bas X CSR 27	13	Sarjoo 52 X CSR 36	21	Tar Bas X PB 6
6	Bas 370 X CSR 2K 262	14	Tar Bas X CSR 36	22	PR 115 X CSR 10
7	Pusa 44 X CSR 27	15	IR-60997A X FL 478	23	PR 115 X CSR 2K 262
8	IR 60997 XCSR 36	16	CSR 27 X Indrasan	24	IR 60997 X FL 478

86376-27-1-1-B, IR 86385-116-1-1-B, IR 86385-165-1-1-B and IR 86385-48-1-1-B performed better in module 2.

Evaluation of lines collected from IRRI, Philippines

Two sets (SET A and SET B) received from IRRI each consisting of 28 and 41 rice genotypes, were screened under high sodic (pH_2 ~ 9.9) micro plots with two replications in *kharif* 2013. The genotypes IR 83440-4-B-11-2-1-1-AJY1-B, IR87832-303-1-B, IR 87859-9-AJY1-B, IR 83439-4-B-11-3-2-1-AJY1-3-B, IR86385-48-1-1-B and IR86385-117-1-1-B performed better in Set A. Similarly, the genotypes IR 87952-1-1-1-2-3-B, IR 87830-B-SDO1-2-2-B, IR 87830-B-SDO2-1-3-B, IR 87880-B-SDO1-2-3-B, IR 87829-3-1-2-1-3-BAY B and IR 87831-3-1-1-2-2-BAY B performed better in Set B.

Basmati trial

Five basmati rice genotypes, namely CSR Basmati 60, Pusa 1121, Pusa 1509 and CSR basmati 30 were evaluated across 5 salt stress locations (Table 40).

The genotype CSR Basmati 60 performed better than the national check PUSA 1121 and CSR Basmati 30 at all locations. CSR Basmati 60 registered 5.30 t ha^{-1} of grain yield at Karnal (non-stress conditions), 1.20 t ha^{-1} at Nain farm, Panipat, 3.50 t ha^{-1} at farmer's field, Rohtak and 1.30 t ha^{-1} at farmer's field, Jind (Fig. 31).

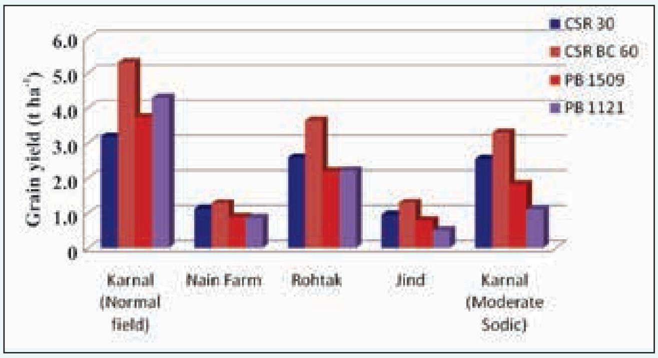


Fig. 31 : Performance of CSR Basmati 60 across different locations

A total of 15 F_2 progenies produced from basmati and salt tolerant lines were also evaluated at Nain farm, Panipat. The top 10 progenies were selected from each segregating population.

Production and maintenance of advanced bulks, segregating lines and germplasm

A total of 176 segregating lines derived from different crosses were grown in the field for maintenance. A total of 655 genetic stocks including 276 IRRI lines were grown in the field for maintenance. Besides, 104 advance stabilized lines were maintained. A total of 100 different elite breeding lines were grown and maintained in the field. A demonstration trial was conducted with 43 elite rice breeding lines. Nucleus seed of rice varieties was produced for next year breeder seed production and 87 promising lines were also grown in the field for multiplication and maintenance.

Breeder seed production

Breeder seeds of salt tolerant rice varieties i.e CSR 10 (0.2 t), CSR 13 (0.2 t), CSR 23 (0.2 t), CSR 27 (0.2 t), CSR 30 (4.5 t) CSR36 (3.5 t) and CSR 43 (5.0 t) were produced to meet the demand of seed producing agencies as per DAC (Department of Agriculture and Cooperation) guidelines.

National Project on Transgenics in Crops-Salinity Tolerance in Rice : Functional Genomics Component (ICAR funded) (S.L. Krishnamurthy, S.K. Sharma, Vinod Kumar and Vipul Batra)

The aim of this project is to map the important genomic regions/QTLs controlling salt tolerance traits in rice. This involves collaborative work between CSSRI (for phenotyping) and NRC on Plant Biotechnology, New Delhi (for genotyping).

Phenotyping of CSR 27 x CSR 11 RIL population

The salient findings of the systematic phenotyping of 215 recombinant inbred lines (RILs) derived from CSR 27 x CSR 11 cross are presented in

Table 40 : Location wise soil status under basmati trial - 2013

S.N.	Locations	Gross plot size	Net plot size	Date of sowing	Date of planting	pH_2	EC (dS m^{-1})
1	Normal field - Karnal	8.8 m^2	5.0 m^2	13.06.13	22.07.13	7.7	0.40
2	Moderate sodicity - Karnal	0.60 m^2	0.52 m^2	13.06.13	10.07.13	9.5	0.40
3	Nain Farm, Panipat	8.8 m^2	5.0 m^2	21.06.13	22.07.13	8.8	16.0
4	Farmer's field - Rohtak	8.8 m^2	5.0 m^2	13.06.13	16.07.13	7.3	6.50
5	Farmer's field - Jind	8.8 m^2	5.0 m^2	13.06.13	18.07.13	9.5	0.40

Table 41 : Mean, range and % reduction for different traits of CSR 27 x CSR 11 RILs at normal, moderately sodic (pH_2 ~ 9.5), highly sodic (pH_2 ~ 9.9), moderate saline (EC ~ 4 dS m^{-1}) and high salinity (EC ~ 8 dS m^{-1}) stress environments

Characters	Mean					Range					% Reduction over control			
	Normal	Moderate sodic	High sodic	Moderate saline	High Saline	Normal	Moderate sodic	High sodic	Moderate saline	High Saline	Moderate sodic	High sodic	Moderate saline	High Saline
Plant height (cm)	112.51	71.78	49.59	90.39	74.21	86.9 - 172.2	41.66 - 133.60	31.0 - 75.20	63.0 - 157.4	42.80- 152.3	36.2	55.9	19.7	34.0
Panicle length (cm)	24.18	20.02	15.83	21.84	17.87	20.9 - 31.0	12.67 - 30.20	8.50 - 21.25	17.0 - 30.0	9.9 - 29.5	17.2	34.5	9.7	26.1
Total tillers per plant	10.48	8.28	7.03	6.72	6.93	5.5 - 16.70	2.5 - 18.0	3.0 - 12.0	4.1 - 15.9	2.67 - 16.9	21.0	32.9	35.9	33.9
Productive tillers	9.50	7.29	5.82	5.97	5.15	4.5 - 15.7	3.67 - 20.0	1.0 - 12.2	3.4 - 13.2	1.2 - 14.6	23.3	38.7	37.2	45.8
Spikelet fertility	85.07	74.30	49.56	81.02	57.15	58.0 - 96.91	19.11 - 94.73	0.70 - 90.03	32.2 - 97.13	2.49 - 90.98	12.7	41.7	4.8	32.8
Grains per panicle	112.08	65.46	33.73	73.96	40.66	37.9 - 166.5	10.33 - 165.33	0.20 - 95.10	32.6 - 140.9	1.6 - 83.0	41.6	69.9	34.0	63.7
1000-grain weight (g)	25.70	20.77	15.36	21.97	17.75	8.38 - 33.65	12.97 - 19.05	5.14 - 23.03	10.1 - 22.28	9.54 - 25.77	19.2	40.3	14.5	30.9
Grain yield (g/plant)	13.03	4.97	1.12	5.78	2.39	5.0 - 29.80	0.40 - 14.60	0.02 - 5.44	1.34 - 12.36	0.10 - 8.80	61.9	91.4	55.6	81.7
Biological yield (g/plant)	44.04	17.59	6.77	20.29	14.81	18.90 - 110.10	1.2 - 87.90	0.20 - 19.70	7.70 - 52.80	1.20 - 29.40	60.1	84.6	53.9	66.4
Harvest Index (%)	30.08	27.22	14.70	28.41	15.03	16.83 - 43.22	5.26 - 41.78	0.29 - 39.0	34.97 - 61.84	0.71 - 34.83	9.5	51.1	5.5	50.0

Table 41. A total of 225 genotypes including 215 RILs along with parents were evaluated in Simple Lattice Design and replicated in 5 environments {normal, moderate sodic (pH_2 ~ 9.5), highly sodic (pH_2 ~ 9.9), low salinity (EC ~ 4 dS m^{-1}) and high salinity (EC ~ 8 dS m^{-1}) soil conditions} during *kharif* 2012. High mean grain yield and other related traits performance was noticed at normal soil as compared to moderatly sodic, highly sodic, moderatly saline and highly saline stresses. The grain yield and biomass were the most sensitive traits and reduced by 56 and 54 per cent under moderate salinity, 62 and 60 per cent under moderate sodicity, 82 and 66 per cent under high salinity and 91 and 85 per cent under high sodicity stress, respectively and followed by grains per panicle, plant height, productive tillers per plant, total tillers per plant, 1000-grain weight, panicle length, spikelet fertility and harvest index.

Based on the grain yield (Table 42), RILs namely, RIL 97, RIL 140, RIL 47, RIL 87, RIL 197, RIL 103, RIL 101, RIL 16, RIL 214 and RIL 54 performed better under moderate sodicity, RIL 83, RIL 123, RIL 81, RIL 15, RIL 214, RIL 179, RIL 60, RIL 182, RIL 34 and RIL 86 under high sodicity, RIL 27, RIL 177, RIL 135, RIL 180, RIL 65, RIL 31, RIL 9, RIL 63, RIL 59 and RIL 49 under low salinity and RIL 101, RIL 50, RIL 87, RIL 215, RIL 211, RIL 126, RIL 159, RIL 100, RIL 203 and RIL 99 under high salinity.

The rice genotype, RILs 59 was common in normal and moderate salinity, 97 was common in normal and moderate sodic, 215 was common in normal and high saline, 101 was common in moderate sodic and high saline, 214 was common in moderate and high sodic. RILs 59, 97, 215, 101 and 214 were more useful for across the normal and salt stress conditions (Table 42).

Genotyping of CSR11/MI48 RIL population

The genotyping of CSR 11/MI 48 was carried out through bulk segregant analysis (BSA) using ten extreme tolerant and sensitive RILs (identified based on 3 years phenotyping of CSR 11/MI 48) along with parents and randomly selected RILs. Bulk segregation analysis was performed which indicated that 8 markers were located on 5 regions which were located on Chromosome 1, 2, 8, 9 and 10 and exhibited tight linkage with SSI for grain yield. The locations at chromosome 1 and 8 were matched with two previously mapped QTLs. The genetic map was prepared and identification of precise location and effect of the novel QTLs i.e. on chromosome 2, 9 and 10 would be ascertained. Moreover, the genetic map will be saturated for fine mapping of chromosomes 2, 9 and 10 so that the exact location of the QTLs could be ascertained. The 93 SSR markers were designed using SSR Primer III and 38 were found to be polymorphic in RIL population. Furthermore, 3 prospective gene specific markers were also found. The saturation of chromosome 10 was pin pointed the QTL for SSI grain yield in sodicity.

Table 42 : Top and bottom 10 RILs based on grain yield under normal, moderately sodic (pH_2 ~ 9.5), highly sodic (pH2 ~ 9.9), moderately saline (EC ~ 4 dS m^{-1}), highly saline (EC ~ 8 dS m^{-1}) stress environments

Normal		Moderately sodic (pH_2 ~ 9.5)		Highly sodic (pH_2 ~ 9.9)		Moderately saline (EC ~ 4 dS m^{-1})		Highly saline (EC ~ 8 dS m^{-1})	
Top 10 RILs	Bottom 10 RILs	Top 10 RILs	Bottom 10 RILs	Top 10 RILs	Bottom 10 RILs	Top 10 RILs	Bottom 10 RILs	Top 10 RILs	Bottom 10 RILs
RIL 187	RIL 106	RIL 97	RIL 183	RIL 83	RIL 95	RIL 27	RIL 91	RIL 101	RIL 1
RIL 59	RIL 115	RIL 140	RIL 37	RIL 123	RIL 100	RIL 177	RIL 173	RIL 50	RIL 2
RIL 188	RIL 89	RIL 47	RIL 88	RIL 81	RIL 126	RIL 135	RIL 139	RIL 87	RIL 9
RIL 102	RIL 96	RIL 87	RIL 95	RIL 15	RIL 128	RIL 180	RIL 150	RIL 215	RIL 10
RIL 130	RIL 98	RIL 197	RIL 126	RIL 214	RIL 130	RIL 65	RIL 194	RIL 211	RIL 11
RIL 97	RIL 51	RIL 103	RIL 127	RIL 179	RIL 139	RIL 31	RIL 156	RIL 126	RIL 12
RIL 86	RIL 108	RIL 101	RIL 128	RIL 60	RIL 140	RIL 9	RIL 213	RIL 159	RIL 13
RIL 215	RIL 53	RIL 16	RIL 171	RIL 182	RIL 142	RIL 63	RIL 147	RIL 100	RIL 32
RIL 16	RIL 200	RIL 214	RIL 196	RIL 34	RIL 196	RIL 59	RIL 209	RIL 203	RIL 35
RIL 145	RIL 50	RIL 54	RIL 199	RIL 86	RIL 199	RIL 49	RIL 129	RIL 99	RIL 37

Phenotyping of fine mapping population (CSR27/MI48) for spikelet fertility

A total of 64 genotypes including 60 RILs along with parents were phenotyped in randomized block design with two replications under high salinity (EC ~ 8 dS m^{-1}) in microplots during *kharif* 2013. The range and mean of different traits for RIL population were recorded during 2013 (Table 43). The grain yield $plant^{-1}$ ranged from 0.04 (MI 48) to 3.22 gm (RIL 36).

The MI 48 registered the lowest spikelet fertility (2%) under salinity stress. RILs were categorized based on spikelet fertility (%) under high salinity stress (Table 44). The 10 lines based on grain yield, the RILs viz; RIL 36, RIL 57, RIL 33, RIL 34 and RIL 21 performed better under high salinity stress.

Development and maintenance of mapping populations and germpalsm

Different mapping populations were developed and maintained (Table 45). The first step in developing a mapping population is to select two divergent parents for obtaining sufficient polymorphism. At the same time, they should not be too genetically distant. In self-pollinating species, mapping populations originate from parents were found highly homozygous (inbred). Selection of populations is critical to successful linkage mapping. Two mapping populations are in F_4 generation which were developed by crossing two contrasting parents viz., 1. CSR 10 (salt tolerant) and VSR 156 (salt sensitive) and 2. CSR 36 (salt tolerant) and VSR 156 (salt sensitive).

Table 45 : Development and maintenance of mapping populations during 2013

Mapping populations	Generation	Population size
Taraori Basmati / CSR 27	F_5	400
Basmati 370 / CSR-2K-262	F_5	400
Taraori Basmati / CSR 36	F_5	400
Taraori Basmati / CSR-2K-262	F_5	400
VSR 156 / CSR 20	F_5	400
VSR 156 / CSR 10	F_4	400
VSR 156 / CSR 36	F_4	400

Genetic Enhancement of Wheat with respect to Salt and Waterlogging (Neeraj Kulshreshtha and S.K Sharma)

All India Salinity/Alkalinity Tolerance Varietal Trial

During *rabi* 2012-13, All India Alkalinity/Salinity Tolerance Varietal Trial was conducted at 9 centres. The trial consisted of 9 test entries and two checks. The trial mean ranged from 2.18 t ha^{-1} (Faizabad)

Table 43 : Mean and range for different traits of homozygous recombinants

S. No.	Traits	Mean	Range
1	Plant height (cm)	57.02	46.50 (RIL 2) – 68.10 (RIL 34)
2	Panicle length (cm)	18.09	13.86 (MI 48) – 20.20 (RIL 26)
3	Total tillers/plant	8.32	5.60 (RIL 46) – 12.10 (RIL 26)
4	Productive tillers/plant	5.18	2.18 (MI 48) – 7.10 (RIL 35)
5	1000-grain weight (g)	17.04	8.33 (MI 48) – 24.45 (RIL 20)
6	Grains/panicle	23.55	2.10 (RIL 22) – 39.60 (RIL 3)
7	Spikelet Fertility (%)	24.58	2.04 (RIL 22) – 67.46 (RIL 3)
8	Biological yield per plant (g)	10.80	6.13 (RIL 4) – 14.65 (RIL 59)
9	Grain yield per plant (g)	1.01	0.04 (MI 48) – 2.33 (RIL 36)
10	Harvest Index (%)	9.10	0.55 (MI 48) – 20.46 (RIL 36)

Table 44 : Grouping of recombinant inbred lines on the basis of spikelet fertility (%) under high salinity stress (EC ~ 8 dS m^{-1})

Spikelet fertility (%)		
Low (< 20 %)	Medium (20 – 30 %)	High (> 40 %)
RIL 22, RIL 15, MI 48, RIL 4, RIL 2, RIL 20, RIL 13, RIL 25, RIL 51 and RIL 1 (10 Lines)	RIL 28, RIL 11, RIL 5, RIL 40, RIL 49, RIL 29, RIL 38, RIL 39, RIL 54, RIL 7, (P1) RIL 41, RIL 8, RIL 10, RIL 47, RIL 41, RIL 36, RIL 52, RIL 18, RIL 27, RIL 6, RIL 44, RIL 26, (P3) CSR 27, RIL 58, RIL 12, RIL 9, RIL 37, RIL 31, RIL 33, RIL 48, RIL 16, RIL 30, RIL 23, RIL 35, RIL 34, RIL 14, RIL 50, RIL 59, RIL 45 and RIL 24 (40 Lines)	RIL 46, RIL 57, RIL 53, RIL 43, RIL 17, (P2) RIL 44, RIL 19, RIL 55, RIL 60, RIL 32, RIL 56, RIL 21, RIL 42 and RIL 3 (14 Lines)

to 4.39 t ha^{-1} (Bawal). The check variety KRL 210 was ranked 1st among all the entries and was in the first significant group on zonal mean basis in UP. In Haryana, KRL 345 ranked first followed by KRL 210, KRL 330 and KRL 346. These entries were in the first significant group.

In NWPZ, days to heading of different genotypes ranged from 93 (KRL 330) to 101 days (RAJ 4324). Plant height of the genotypes ranged from 83 cm (Raj 4324) to 120 cm (Kharchia 65(C)). Thousand grain weights of the varieties ranged from 34 gm (KRL 347 and Kharchia 65 (C) to 38 gm (KRL 345).

In NEPZ, days to heading of different genotypes ranged from 87 (RAJ 4324) to 92 days (KLP 1006, KRL 348, and DBW 131). Plant height of genotypes ranged from 66 cm (KRL 283) to 108 cm (Kharchia 65(C). Thousand grain weights of the varieties ranged from 31 gm (KRL 283) to 39 gm (Raj 4270).

In NWPZ most of the entries except Kharchia 65 (60S) were either free from brown rust or exhibited very low incidence. Regarding yellow rust, most of the entries except DBW 111 (40S), NW 5055 (60S) and Kharchia 65 (40S) were either free or exhibited very low level of incidence.

In NEPZ most of the entries except NW 5055 (80S) were either free from yellow rust or exhibited very low level of incidence. With respect to brown rust, all the test entries were either free or exhibited very low level of incidence.

(Neeraj Kulshreshtha, Indivar Prasad)

Salinity/Alkalinity Tolerance Screening Nursery

The Salinity/Alkalinity Tolerance Screening Nursery was grown with the aim to identify wheat lines that can perform better in salt affected soils. This nursery also serves as the source of test entry for Special Variety Evaluation Trial for salt stress conditions under AICW&BIP. During 2012-13, nurseries were proposed at 10 centres. The data of Faizabad, Lucknow, Hisar, Kanpur, Agra, Vanasthali and Dalipnagar were pooled to obtain the mean values.

The nursery consisted of 54 entries and five checks: Kharchia 65, HD 4530, KRL 19, KRL 3-4 and KRL 210 with 6 blocks in augmented design. Each block comprised of 9 test entries and 5 checks. Superior lines were identified on the basis of the analysis of grain yield and comparison with the pooled value (repeated 6 times at one centre) of the checks. The genotype KRS 1216 (KRL349) was found to perform better than other checks under saline/alkaline conditions and was promoted to the salinity/ alkalinity trial 2013-14.

(Neeraj Kulshreshtha, Indivar Prasad)

Development of new F_1 crosses

Twenty five crosses and back crosses were attempted to widen the genetic variability for salt and waterlogging tolerance and to incorporate salt tolerance in the widely adapted and disease resistant wheat lines/varieties involving varieties like Kharchia 65, KRL 35, KRL 99, KRL 210, KRL 213, KRL 283, KRL 3-4, KRL 99, KRL 330, BH 1146, Camm, Ducula 4, DPW 621-50, HD 2009, HD 2851, Krichauff and Westonia. The hybridization programme was also strengthened by incorporating disease resistance from diverse sources in salt tolerant back ground of KRL 99, KRL 3-4, Kharchia 65, KRL 330, KRL 283, KRL 345 and KRL 346. Some of these sources were NW 4091 (Lr_{23+1} $Yr9_{+}$), HD 3002 (Lr_{23+}), HPW 347 (Lr_{13+10} Yr_{9+}), VL 930 (Lr_{26+} Yr_{9+}), NW 4081 (R to KB), PBW 635 and DBW 62.

Screening of segregating and advanced generation crosses

Twenty five F_2 and about four hundred advanced generations material/lines from the crosses of the following varieties/germplasm lines were evaluated and selected for their suitability under different salt stress conditions.

- PBW 343, PBW 509, PBW 524, PBW 525, PBW 550, PBW 582, PBW 573, PBW 593, PBW 611, DPW 621
- HD 2189, HD 2851, HD 2962, HD 5204, HD 2937, HD 2997
- WH 1021, WH 5102
- HW 5021, HW 2045, HW 2062, HW 5102, HW 5210
- VL 892, VL 852, VL 867, VL 486
- UAS 295, DBW 17, DBW 37
- NW 1076, NW 1014
- UP 2338, UP 2584
- Maringa, Camm, D 2-9, Perenjori, BT Schomburgk, BH 1146, Krichauff and Westonia
- Kharchia 65, KRL 19, KRL 1-4, KRL 210, KRL 213, KRL 99, KRL 3-4, KRL 35, KRL 119, KRL

251, KRL 273, KRL 238, KRL 240, KRL 249, KRL 302, KRL 304, KRL 307, KRL 339, KRL 335, KRL 336, KRL 340, KRL 341, KRL 342, KRL 343, KRL 344

- FLW 2, FLW 5, FLW 8, FLW 11, FLW 12, FLW 20, FLW 24
- Raj 4120
- HI 1552, MACS 6272

Germplasm collection and maintenance

Nearly 600 entries of working germplasm based on plant type, salt tolerance and productivity were maintained besides 400 doubled haploid lines of three different crosses (Ducula4/*2 Brookton, HD 2329/Camm and D 4-13/Tammarin Rock) for further use in the breeding programme.

Breeder and nucleus seed production

Breeder seed of CSSRI varieties KRL 210 (0.75 t) and KRL 213 (0.75 t) was produced at CSSRI Karnal farm for distribution to various seed producing agencies and farmers. Nucleus seed of 40 lines (KRL entries) and of four of the released varieties (KRL 1-4, KRL19, KRL 210 and KRL 213) was produced at CSSRI experimental farm for use in the next season.

Evaluation of wheat varieties for salt stress in Microplots

Twenty three wheat varieties were evaluated for their performance under different salt stresses i.e. normal (control), saline (EC 5.9 dS m^{-1}) and sodic (pH_2 9.3) in the microplots. Each genotype was replicated thrice. The genotypes KRL 3-4, KRL 99 and Kh 65 were found to be highly tolerant whereas DW1, HD 4530, HD 2851, DW 3, Brookton and HD 2009 were the sensitive genotypes. The genotypes KRL 330, KRL 345, KRL 346, KRL 213, KRL 238, KRL 210, KRL 19, NW 1014, NW 4018 and BH 1146 were found to be moderately tolerant.

Multilocation Evaluation of Breadwheat Germplasm funded by NBPGR (ICAR) (Neeraj Kulshreshtha)

Nine hundred bread wheat germplasm lines were screened under sodic conditions (pH 9.1). Considerable genetic variability was observed among these lines as evident from range and variance shown for yield attributes (Table 46). The range of grain yield $plot^{-1}$ was from 4-206 with mean 94g and variance of 1237. Days to heading ranged from 86-138 days with mean 107 and variance 110. Tillers/m of plants ranged from 19-279 with mean 112 and variance 1261. Most of the lines were tall as evident from plant height mean of 101 cm; however, it ranged from 61-151 cm. Variability for different yield attributes also suggests that there is great scope of improving different yield attributes simultaneously to arrive at an ideal plant type for stress tolerance and high yield. Twenty genotypes were found to yield better than KRL 3-4.

Wheat Improvement for Waterlogging, Salinity and Element Toxicities in Australia and India (CIM/2006/177) ACIAR funded (Neeraj Kulshreshtha, S.K Sharma, N.P.S. Yaduvanshi and N. Basak)

Waterlogging tolerance and ICP/microelement analyses of key Indian and Australian wheat varieties was carried out in sodic soil (pH 9.3) microplots at CSSRI, Karnal. These experiments were conducted to demonstrate the genetic diversity for waterlogging tolerance in sodic soil among Indian and Australian wheat varieties. A number of salt tolerant and sensitive wheat varieties (KRL 3-4, KRL 99, Kharchia 65, Krichauff, KRL 19, KRL 210, NW 1014, Brookton, Ducula 4, DBW 17, HD 2851, HD 2009, BH 1146, NW 4018, KRL 238 and KRL 240) were grown in the sodic microplots where salt stress levels were much uniform relative to field conditions in three replications with 1m row length of each plot during 2009-10, 2010-11, 2011-12 and 2012-13.

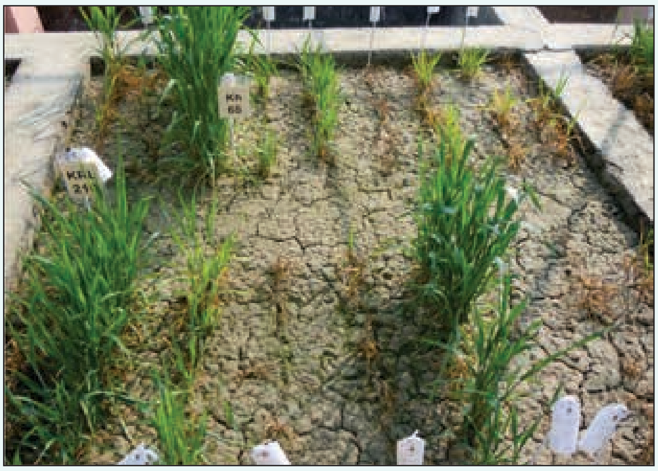
Waterlogging reduced the grain yield in both normal and sodic soils. Different varieties differed

Genetic diversity for waterlogging tolerance in sodic microplots as shown by the performance of KRL 99 in comparison to Brookton

Table 46 : Sodicity tolerant genotypes selected on the basis of grain yield/ plot from 900 germplasm lines

S.N.	Genotype/ IC No.	Grain yield ($g/0.30m^2$)	Days to heading	Days to maturity	Plant height (cm)	Tillers/m
1	664280	206	97	141	106	129
2	635853	194	99	145	114	129
3	598045	194	129	153	113	234
4	597939	192	129	153	114	114
5	663902	188	98	145	98	179
6	635733	186	99	145	97	189
7	693299	183	104	143	100	139
8	633909	179	99	144	96	160
9	693295	177	104	144	110	174
10	663920	176	96	143	98	160
11	664259	175	96	144	100	169
12	635545	169	104	144	117	164
13	664325	167	108	147	113	196
14	635780	166	96	141	98	146
15	598038	164	109	153	142	146
16	597943	164	106	145	103	133
17	603898	164	102	143	116	138
18	635570	160	97	143	100	121
19	664204	160	104	149	109	133
20	636243	160	108	149	131	111
CH 1	C 306	130	102	146	101	172
CH 2	RAJ 3765	126	96	146	95	167
CH 3	DBW 17	119	99	142	86	159
CH 4	PBW 343	99	101	144	100	143
CH 5	KRL 3-4	158	100	145	127	186
	Mean	**94**	**107**	**147**	**101**	**112**
	Variance	1237	110	19	174	1261
	Range	4-206	86-138	138-162	61-151	19-279

with respect to reduction in grain yield. KRL 210 was found to be the highest yielding in normal microplots followed by DBW 17, KRL 238, KRL 3-4 and KRL 240. Maximum reduction in grain yield due to waterlogging was obtained in NW 4018 (42%) whereas minimum reduction was recorded for KRL 210 (13%) and Kharchia 65 (15%). With respect to grain yield, the performance of KRL 210 followed by KRL 3-4, Kharchia 65 and DBW 17 was the best in waterlogged soils. In sodic soils, KRL 3-4, KRL 210, KRL 99 and Kharchia 65 were the best performing varieties. Minimum reduction in grain yield was obtained for KRL 210 (3%), BH 1146 (4%) and KRL 3-4 (9%). The varieties Krichauff (48%)



Genetic diversity for waterlogging tolerance from CSSRI microplots (pH 9.3) and Ducula 4 (46%) showed maximum reduction under waterlogging in these soils.

In normal soils, the performance of KRL 3-4 was the best under waterlogging followed by Kharchia 65 and KRL 240. Minimum reduction in biomass/plant was obtained from KRL 238 (7%) followed by KRL 240 (11%) and KRL 99 (12%) whereas the maximum reduction was obtained from Krichauff and DBW 17. In sodic soils, KRL 3-4 was the best performer under waterlogging followed by Kharchia 65, KRL 210 and KRL 99. Minimum reduction in biomass/plant under waterlogging was observed for Kharchia 65 (2%) whereas maximum reduction was observed for Ducula 4 (38%) and Brookton (31%).

Single Seed Descent (SSD) approach at CSSRI to increase waterlogging tolerance using waterlogging tolerant x disease resistant donors grown in sodic soils at Karnal

This is the main breeding program at CSSRI where suitable parents material were crossed and selected cross was chosen for further work according to the SSD schedule. This cross was developed throughout the project duration with major emphasis along with other crosses.

This unique experiment was initiated in 2009-10. The performance of PBW 525/KRL 99 populations was the best with respect to phenotypic performance under waterlogging and resistance to rusts. This was followed by FLW 4/KRL 99//FLW 4. The population of KRL 99/FLW 8//PBW 550 was the least performing. The population of PBW 525/ KRL 99 was advanced as per the protocol. The F_3 seeds were sent to Dalang Maidan and Wellington for generation advancement. During 2010-11, F_4 population of the cross PBW 525/KRL 99 obtained from Dalang Maidan were sown in the sodic field (pH 9.1) along with parents. The population was waterlogged for 15 days after 22 days of sowing. This population was selected for salt and waterlogging tolerance, disease resistance and other agronomical traits and data were generated for grain yield plant^{-1}. The population mean increased from 5.3 to 6.5 g plant^{-1} due to selection. The population was further sent to Dalang Maidan for generation advancement during off season in 2011 and was again sown during 2011-12 as F_6 as well as F_5 (obtained from seed not sent to Dalang) for further selection. A number of salt and waterlogging tolerant selections were made which were also resistant to rusts in the field conditions. The population mean increased to 7.18 in F_6.

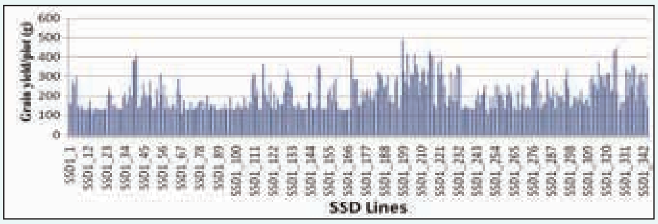


Fig 32 : Performance of SSD lines with respect to grain yield plot^{-1} in sodic soils waterlogged for 15 days after 22 days of sowing

During 2011-12, three hundred forty five F_6 SSD lines were selected from this population. These F_7 lines were evaluated in 2012-13 under sodic waterlogged soils (pH 9.1) in an augmented design. There were 23 blocks and each block comprised of 15 test entries and five checks (KRL99, PBW 525, KD2009, Kharchia 65 and KRL 3-4). The row length was kept 2.5 m and row to row distance was 30 cm. The experiment was waterlogged for 15 days after 22 days of sowing. A number of salt and waterlogging tolerant lines were selected from this population. These lines were fixed. These lines exhibited a wide range with respect to grain yield plot^{-1} (Fig. 32). Out of 345 lines, 19 lines outperformed KRL 99 with respect to grain yield under waterlogged conditions in sodic soils (pH 9.2). SSD1_199 was the topmost line followed by SSD_326, SSD_325, SSD_215, SSD_206, SSD_41, SSD_202 and SSD_169. However this population needs to be screened for a couple of years for getting the information about stable salt and waterlogging tolerant genotypes.

In addition to F_7 population, two F_6 populations (FLW2/KRL99//PBW 550 and FLW8/KRL99// PBW) and three F_4 populations (KRS 9382/PBW 621, KRS 9301/PBW 509 and KRS 9373/KRL 273) were sown and selected for waterlogging tolerance in sodic soils. These materials will further be selected as per the SSD protocol.

Waterlogging treatment of SSD population in sodic soils (pH 9.2)

Bi-plot/cluster analyses of 104 Indian and Australian wheat varieties/germplasm lines grown in waterlogged alkaline sodic soil at CSSRI to determine genotype x environment interactions

The bi-plot analysis/cluster analysis was carried out to identify parental material for future programmes under different conditions. This study will be very useful in evaluation of genetic variability in Indian/Australian material and will also help in identifying contrasting parents for different types of soil/production conditions in India. The study was conducted for the second year with little modification in the experimental design.

In this experiment, one hundred four promising genotypes/released varieties of wheat were pooled from CSSRI, Karnal (material for salinity tolerance/intolerance), DWR, Karnal (material for yield attributes, rusts, leaf blight and Karnal bunt) and NDUA&T, Faizabad (material for waterlogging conditions and element deficiency, if any) and evaluated in waterlogged as well as drained, reclaimed sodic soils (pH 8.5) in augmented design with 4 blocks (each block comprised of 24 test entries and the checks). The checks were KRL 3-4, HD 2009, DBW 17 and DBW 14. Each test plot consisted of 4 rows of 2.5 m long spaced at 23 cm. A lot of variability was observed among the checks and testing varieties with respect to waterlogging tolerance and *per se* performance under waterlogging. Waterlogging treatment of 25 days was given after 22 days of sowing.

Amongst check varieties, DBW 14 showed maximum reduction in grain yield (75%) under waterlogging followed by DBW 17 (73%), HD 2009 (72%) and KRL 3-4 (55%) (Table 47). The varieties differed with respect to grain yield plant^{-1} under

Table 47 : Top 20 and bottom 20 genotypes based on percent reduction in waterlogged treatments in comparison to drained ones in reclaimed sodic soils (pH 8.5) with respect to grain yield plot^{-1} (g)

Top 20 genotype	Drained	WL	Reduction (%)	Bottom 20 genotype	Drained	WL	Reduction (%)
KRL 105	303	194	36	HUW 638	683	45	93
NW-2036	517	311	40	DBW 58	790	55	93
Kharchia 65	376	226	40	RSP 561	800	56	93
KRL 283	605	317	48	CHARA	633	47	93
NW-4099	502	255	49	K 0807	688	52	92
NW-1014	636	313	51	DBW 51	842	64	92
KRL 236	584	287	51	GAMENYA	567	48	92
KRL 99	614	297	52	HD 2967	828	70	91
HD 3027	620	298	52	NW-3069	584	51	91
PBW 343	562	264	53	PBW 635	646	59	91
NW (S)-2-4	614	288	53	NW-3087	639	59	91
KRL 259	483	223	54	NWL-7-4	614	58	91
KRL 238	693	319	54	SPEAR	671	65	90
KRL 268	542	244	55	PBW 590	677	67	90
HD 2733	621	278	55	HI 1563	625	62	90
CAMM	410	181	56	CHIRYA 7	684	70	90
KRL 1-4	618	269	56	DBW 50	686	73	89
NW-1076	638	274	57	DUCULA 4	731	78	89
DBW 60	705	302	57	NW-4083	624	68	89
NW-4081	683	292	57	DBW 55	644	72	89

Checks

Variety/ Genotypes	Drained	WL	Reduction (%)
DBW 14	656	164	75
DBW 17	691	188	73
HD 2009	607	169	72
KRL 3-4	551	250	55

both the environments. This is evident from the list of top twenty and bottom twenty genotypes in drained as well as waterlogged reclaimed sodic soils. The genotypes KRL 105 followed by NW 2036, Kharchia 65, KRL 283, NW 4099, NW 1014, KRL 236, KRL 99, HD 3027 and PBW 343 were the top 10 genotypes based on per cent reduction under waterlogging. Similarly, HUW 638 followed by DBW 58, RSP 561, Chara, K 0807, DBW 51, Gamneya, HD 2967, NW 3069 and PBW 635 were found to be the bottom 10 genotypes. Two years data on yield and yield contributing characters under waterlogging was used to draw a dendogram to find out different clusters and relative genetic distance among genotypes. This cluster analysis can be used to design breeding programmes for waterlogging tolerance in future.

Evaluation of DHLs differing in waterlogging tolerance in sodic soils at CSSRI field (pH 9.1-9.2)

In this experiment, 138 entries (134 Doubled haploids of Ducula4/2*Brookton), 2 parents (Ducula 4 and Brookton) and two checks (HD 2009 and KRl 19) were sown in a row column design at CSSRI in sodic soils (pH 9.3) in two sets (Fig. 33). The objective of the experiment was to provide phenotypic data with respect to waterlogging tolerance. One set was waterlogged for 15 days after 22 days of sowing.

The range in tolerance indices among DH lines was from 0.35 to 0.97 on the basis of grain yield plot^{-1}. Top 20 doubled haploids were selected on the basis of tolerance indices. The doubled haploids viz; D 6W639 D 2-1, D 5-8, D 5-42, D 3-18 and D 5-21 had very good tolerance index. Similarly, bottom 20 doubled haploids were also selected based on tolerance indices. The doubled haploids viz; D 6W639 D 1-60, D 5-18, D 5-26, D 1-2 and D 6-38 had very poor tolerance indices. The doubled haploid D 3-19 and D 5-43 were categorized under both drained and waterlogged soils as top lines.

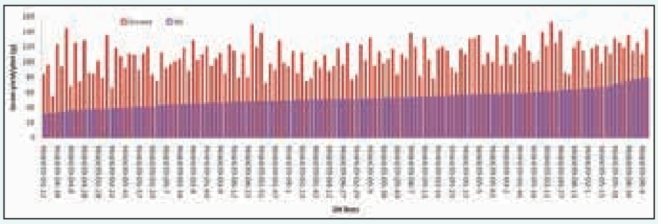


Fig. 33 : Diversity of DH population of cross Ducula 4/2 Brookton under waterlogged and drained conditions in sodic soils (pH 9.3)*

Similarly, D 2-22 was poor performer under both the treatments.

During 2012-13, a doubled haploid population of 100 genotypes (98 doubled haploids of D 6W639 D 4-13/Tammarin Rock and parents) were also included in the study. A set of 244 entries including 134 DH lines of Ducula-4/2*Brookton, 98 DH lines of D 6W639 D4 -13/Tammarin Rock, 4 parents and 8 varieties (KRL 99, KRL 19, KRL 1-4, HD 2851, HD 2009, DBW 17, PBW 343 and BH 1146) were sown in a row column design with two replications under drained as well as waterlogged soils of pH 9.3. A great genetic diversity was observed among the genotypes. One important observation was very good performance of an imported variety BH 1146 in sodic waterlogged soils. This variety is known for its aluminium tolerance in acidic soils. It is evident from the data that there was a great diversity among both the populations with respect to waterlogging tolerance. Some of the lines in the Ducula4/2*Brookton population were having high level of waterlogging tolerance (96W 639-D 3-18, D 2-1, D 4-26) and D 6-4 whereas 96W639-D 6-18, D 6-38, D 6-5 and D 4-28 showed very low level of waterlogging tolerance. Similarly, among D 6W639 D 4-13/Tammarin Rock population, 05Y207-D11-H091, 07Y236-D07-H246, 05Y207-D06-H031 and 05Y207-D08-H047 doubled haploids had high level of waterlogging tolerance whereas 07Y236-D07-H249, 05Y207-D08-H051, 07Y236-D08-H288 and 07Y236-D10-H101 showed low level of waterlogging tolerance (Fig. 34).

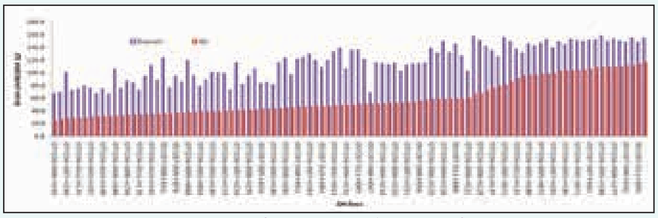


Fig. 34 : Diversity of DH population of cross 96W639 D4-13/Temmarin Rock under waterlogged and drained conditions in sodic soils (pH 9.3)

Performance of BH 1146 in sodic waterlogged soils at CSSRI Karnal (pH 9.3)

Among checks, KRL 99 had maximum tolerance index followed by KRL 19, BH 1146 and KRL 1-4. The checks Tammarin Rock, HD 2851 and HD 2009 had low level of waterlogging tolerance.

Germplasm exchange

Hundred wheat lines of the doubled haploid population of the cross D6W639 D4-13/Tammarin Rock (98 numbers) and parents (2 numbers) were imported from DAFWA through NBPGR New Delhi after getting all the formalities cleared.

Improvement of Salt Tolerance in Wheat using Molecular Approach ICAR-DWR funded Network Project (Neeraj Kulshreshtha and P.C Sharma)

One hundred twenty fixed Recombinant Inbred Lines (RILs) of the cross Kharchia 65 (salt tolerant) x HD 2009 (salt sensitive) were screened and evaluated for phenotyping in the CSSRI sodic microplots at pH_2 9.1 in an augmented design with four checks. Kharchia 65 performed better among the checks followed by HD 2009, KRL 19 and HD 2851 with respect to grain yield $plant^{-1}$ (Table 48). The RILs displayed a lot of variability with respect to grain yield, sodium and potassium uptake. The grain yield $plant^{-1}$ among the RILs ranged from 8.2-0.3 whereas the K/Na ratio among the RILs ranged from 2.1-0.3. During 2012-13, a number of RILs such as MP 1-87, MP 1-73, MP 1-43, MP 1-119, MP 1-16, MP 1-109, MP 1-102, MP 1-69, MP 1-105 and MP 1-57 were found to be tolerant whereas the RILs MP 1-86, MP 1-112, MP 1-11, MP 1-3, MP 1-97, MP 1-48, MP 1-32, MP 1-18, MP 1-41 and MP 1-14 were found to be sensitive on the basis of tolerance index. The RILs such as MP 1-20, MP

Table 48 : Performance of checks and RILs under sodic condition (pH_2 9.1)

Varieties	Grain yield/ plant (g)	Tolerance index	Na (%)	K (%)	K/Na
Checks					
Kharchia 65	5.5	0.7	2.0	2.5	1.3
HD 2009	4.5	0.5	2.0	2.1	1.1
KRL 19	6.6	0.9	1.5	2.3	1.5
HD 2851	4.7	0.5	2.4	1.5	0.7
RILS					
Mean	4.40	0.60	1.99	1.46	0.79
SD	1.63	0.20	0.52	0.50	0.37
Range	8.2-0.3	0.97-0.06	3.4-1.0	3.2-0.8	2.1-0.3

Table 49 : Top tolerant and sensitive RILs on the basis of grain yield, tolerance index and K/Na ratio (Pooled data of four years)

RILs/Checks	Grain yield/ plant (g)		Tolerance index		Na (%)		K (%)		K/ Na	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Tolerant RILs										
MP 1-57	6.1	0.6	0.7	0.1	1.4	0.3	2.3	0.6	2.5	1.5
MP 1-111	6.1	0.6	0.8	0.1	1.5	0.4	1.5	0.3	1.7	1.0
MP 1-73	6.0	0.6	0.7	0.0	2.4	0.3	2.6	0.6	1.1	0.4
MP 1-69	6.0	1.1	0.8	0.1	2.0	0.1	1.2	0.2	0.6	0.1
MP 1-81	5.7	0.3	0.8	0.1	2.7	0.2	1.9	0.5	0.7	0.2
MP 1-105	5.6	0.7	0.8	0.0	1.2	0.3	1.1	0.4	1.6	1.1
MP 1-59	5.6	0.6	0.8	0.0	1.5	0.1	2.2	0.5	1.5	0.4
MP 1-74	5.5	0.3	0.8	0.1	2.3	0.4	1.8	0.6	0.9	0.5
MP 1-28	5.4	0.3	0.8	0.0	2.0	0.3	1.5	0.5	0.7	0.2
MP 1-90	5.4	0.4	0.8	0.0	2.6	0.1	1.3	0.3	0.5	0.1
Sensitive RILs										
MP 1-48	1.2	0.1	0.4	0.1	2.3	0.1	1.1	0.2	0.5	0.1
MP 1-32	1.2	0.4	0.4	0.2	2.3	0.3	1.2	0.3	0.5	0.1
MP 1-3	1.2	0.3	0.4	0.2	2.3	0.1	1.8	0.2	0.8	0.1
MP 1-97	1.3	0.3	0.2	0.1	2.2	0.3	1.1	0.2	0.6	0.2
MP 1-11	1.3	0.5	0.3	0.2	2.6	0.1	1.8	0.2	0.7	0.1
Checks										
Kharchia 65	6.5	0.6	0.9	0.1	1.7	0.2	2.9	0.3	1.9	0.4
HD 2009	3.8	1.0	0.5	0.1	2.0	0.2	2.4	0.4	1.3	0.2
KRL 19	4.7	0.7	0.6	0.1	1.8	0.2	2.7	0.4	1.6	0.3
HD 2851	3.3	0.7	0.4	0.1	2.3	0.2	2.0	0.5	0.9	0.1

1-26, MP 1-24, MP 1-25, MP 1-21, MP 1-106, MP 1-102, MP 1-59, MP 1-34 and MP 1-57 were found to be associated with high K/Na ratio whereas the RILs such as MP 1-88, MP 1-60, MP 1-83, MP 1-35, MP 1-53, MP 1-65, MP 1-90, MP 1-47, MP 1-116 and MP 1-112 were found to be associated with low K/Na ratio. Based upon four years pooled data, 10 RILs were found to have very high grain yield in sodic soils with high tolerance index (>0.7). Out of these, 10 RILs, MP1-57, MP 1-111, 73, 105 and 59 were found to be associated with high K/Na ratio (Table 49). In addition to tolerant RILs, sensitive RILs were also found associated with low tolerance index, low grain yield in sodic soils and low K/Na ratio.

Development of Indian Mustard (*Brassica juncea*) Genotypes with Improved Salinity Tolerance and Higher Seed Yield (Jogendra Singh and P.C. Sharma)

Evaluation of advanced breeding lines (IVT and AVT) in semi–reclaimed alkali soils

Fifty seven breeding lines including five checks (CS 52, CS 54, CS 56, Kranti and Varuna) were evaluated in IVT for seed yield in screening trial in reclaimed alkali soils (pH 8.1 to 9.5) at Karnal. Seed yield ranged from 0.49 to 2.52 t ha^{-1} (Mean 1.81 t ha^{-1}, CD $_{(0.05\%)}$ 0.52). Forty four lines gave significantly higher yield over best check CS 56 with CS 3001-2-2-3-1 (2.52 t ha^{-1}) followed by CS 508-1P2 (2.03 t ha^{-1}) recording maximum seed yield.

Further, thirty nine breeding lines including five checks (CS 52, CS 54, CS 56, Varuna and Kranti) were evaluated in AVT for seed yield in screening trial in reclaimed alkali soils (pH 8.1 to 9.5) at Karnal. Seed yield ranged from 1.62 to 2.45 t ha^{-1} (Mean 1.93 t ha^{-1}, CD $_{(0.05\%)}$ 0.59). Sixteen lines gave significantly higher yield over best check CS 52 with CS 15000-1-2-2-2-1 (2.45 t ha^{-1}) followed by CS 1300-3-2-2-5-2 (2.28 t ha^{-1}) recording the maximum seed yield.

Evaluation of advanced breeding lines (IVT and AVT) in saline soils

Similarly, fifty seven breeding lines including five checks (CS 52, CS 54, CS 56, Kranti and Varuna) were evaluated in IVT for seed yield in screening trial in saline soils (ECe 4.5 to 22.0 dS m^{-1}) at Nain Farm (Distt. Panipat). Seed yield ranged from 0.10 to 2.68 t ha^{-1} (Mean 1.02 t ha^{-1}, CD $_{(0.05\%)}$ 2.28 t). Thirty eight lines gave significantly higher seed yield over best check CS 52 with CS 2900-3-1-2-1 (2.57 t ha^{-1}) followed by CS 9000-1-2-2-2-1-1 (2.51 t ha^{-1}). Further, in AVT, thirty nine breeding lines including five checks (CS 52, CS 54, CS 56, Kranti and Varuna) were evaluated for seed yield in screening trial in saline soils at Nain Farm (Distt. Panipat). Seed yield ranged from 0.26 to 1.85 t ha^{-1} (Mean 0.86 t ha^{-1}, CD $_{(0.05\%)}$ 1.79). Twenty lines gave significantly higher seed yield over best check Kranti with CS 15000-1-2-2-2-1 (1.85 t ha^{-1}) followed by CS 13000-3-1-1-4-2 (1.41 t ha^{-1}).

Evaluation of segregating material (F_4 and F_6) in mustard in semi–reclaimed alkali soils

Sixty six breeding lines including 6 checks (CS 54, CS 56, Pusa Bold, Pusa Jagannath, CS 2007-6 and CS 2007-25) were evaluated in F_4 generation for seed yield in reclaimed alkali soils (pH 8.1 to 9.5) at Karnal. Seed yield ranged from 1.07 to 3.38 t ha^{-1}. Nineteen lines gave significantly higher seed yield over best check CS 54 (1.64 t ha^{-1}) with CS 2013-63 (3.38 t ha^{-1}) followed by CS 2013-62 (2.51 t ha^{-1}).

Four mustard populations (CS 52 x Krishna, Krishna x CS 52, CS 54 x Krishna and Krishna x CS 54) were evaluated in F_6 generation for seed yield in reclaimed alkali soils (pH 8.1 to 9.5) at Karnal. Forty lines (including four checks CS 52, CS 54, Kranti and Krishna) were evaluated under the cross CS 52 x Krishna. Seed yield ranged from 1.03 to 1.94 t ha^{-1} (Mean 1.46 t ha^{-1}, CD $_{(0.05\%)}$ 1.18). Three lines gave significantly higher seed yield over best check Kranti (1.70 t ha^{-1}) with CS 2009-401 (1.94 t ha^{-1}) followed by CS 2009-418 (1.87 t ha^{-1}). In second population of Krishna x CS 52, forty seven lines (including six checks CS 52, CS 54, Varuna, Kranti and Krishna) were evaluated. Seed yield ranged from 0.63 to 2.32 t ha^{-1} (Mean 1.65 t ha^{-1}, CD $_{(0.05\%)}$ 0.91). Twenty six lines gave significantly higher seed yield over best check Kranti (1.50 t ha^{-1}) with CS 2009-335 (2.32 t ha^{-1}) followed by CS 2009-346 (2.28 t ha^{-1}).

Further, sixty three lines (including six checks CS 52, CS 54, CS 56, Krishna, Varuna and Kranti) were evaluated under the cross CS 54 x Krishna. Seed yield ranged from 0.89 to 2.15 t ha^{-1} (Mean 1.51 t ha^{-1}, CD $_{(0.05\%)}$ 0.79 t). Fourteen lines gave significantly higher seed yield over best check CS 54 (1.67 t ha^{-1}) with CS 2009-156 (2.15 t ha^{-1}) followed by CS 2009-154 (2.14 t ha^{-1}). In fourth population of Krishna x CS 54, sixty five lines (including five checks CS 52, CS 54, CS 56, Krishna and Kranti) were evaluated.

Seed yield ranged from 1.13 to 2.52 t ha^{-1} (Mean 1.77 t ha^{-1}, CD $_{(0.05\%)}$ 0.60). Twenty seven lines gave significantly higher seed yield over best check CS 56 (1.72 t ha^{-1}) with CS 2009-263 (2.52 t ha^{-1}) followed by CS 2009-261 (2.45 t ha^{-1}).

Evaluation of segregating material (F_4 and F_6) of mustard in saline soils

Sixty six breeding lines including 6 checks (CS 54, CS 56, Pusa Bold, Pusa Jagannath, CS 2007-6 and CS 2007-25) were evaluated in F_4 generation for seed yield in saline soils (ECe 4.5 to 22.0 dS m^{-1}) at Nain Farm (Distt. Panipat). Seed yield ranged from 1.09 to 3.86 t ha^{-1}. Eleven lines gave significantly higher seed yield over best check CS 54 (2.80 t ha^{-1}) with CS 2013-59 (3.86 t ha^{-1}) followed by CS 2013-64 and CS 2013-33 (3.78 t ha^{-1}).

Four mustard populations (CS 52 x Krishna, Krishna x CS 52, CS 54 x Krishna and Krishna x CS 54) were evaluated in F_6 generation for seed yield in saline soils (ECe 4.5 to 22.0 dS m^{-1}) at Nain Farm (Distt. Panipat). Forty lines (including four checks CS 52, CS 54, Kranti and Krishna) were evaluated under the cross CS 52 x Krishna. Seed yield ranged from 0.17 to 1.21 t ha^{-1} (Mean 0.52 t ha^{-1}, CD $_{(0.05\%)}$ 0.58). Eight lines gave significantly higher seed yield over best check Kranti (0.60 t ha^{-1}) with CS 2009-431 (1.21 t ha^{-1}) followed by CS 2009-410 (1.09 t ha^{-1}). In second population of Krishna x CS 52, forty seven lines (including four checks CS 52, CS 54, Kranti and Krishna) were evaluated. Seed yield ranged from 0.03 to 2.54 t ha^{-1} (Mean 0.89 t ha^{-1}, CD $_{(0.05\%)}$ 0.62). Eight lines gave significantly higher seed yield over best check Kranti (1.40 t ha^{-1}) with CS 2009-323 (2.54 t ha^{-1}) followed by CS 2009-330 (2.20 t ha^{-1}).

Further, sixty three lines (including three checks CS 54, Krishna and Kranti) were evaluated under the cross CS 54 x Krishna. Seed yield ranged from 0.15 to 2.43 t ha^{-1} (Mean 1.26 t ha^{-1}, CD $_{(0.05\%)}$ 1.98). Eleven lines gave significantly higher seed yield over best check CS 54 (1.60 t ha^{-1}) with CS 2009-160 (2.43 t ha^{-1}) followed by CS 2009-149 (2.28 t ha^{-1}). In fourth population of Krishna x CS 54, sixty five lines (including four checks CS 52, CS 54, Krishna and Kranti) were evaluated. Seed yield ranged from 1.43 to 4.39 t ha^{-1} (Mean 2.64 t ha^{-1}, CD $_{(0.05\%)}$ 1.22). Twelve lines gave significantly higher seed yield over the best check CS 52 (2.7 t ha^{-1}) with CS 2009-265 (4.39 t ha^{-1}) followed by CS 2009-208 (3.71 t ha^{-1}).

Special attainment: Identified mutant CS 52-SPS-1-2012 having higher 1000 seed weight (9-10g), salt tolerance (up to 14 dS m^{-1} and pH 9.5), better oil quality parameters and short stature than the national check CS 54 and Kranti (Table 50).

Development of promising crosses and recombinant inbred lines (RIL) population

Developed 22 crosses and 4 RILs population according to objective of the project.

Evaluation of promising salt tolerant strains of Indian mustard (*Brassica juncea*) in All India Coordinated Trial on Rapeseed and Mustard

Six genotypes were evaluated in IVT under saline conditions (ECe 10 dS m^{-1}) at Nain experimental farm (Distt. Panipat) and under alkaline conditions (pH 9.3) at Karnal. Significant differences were observed in seed yield amongst the genotypes evaluated, both under salinity and alkalinity stresses. Under salinity stress, seed yield ranged from 1.66 to 2.15 t ha^{-1} (Mean 1.86 t ha^{-1}, CD$_{(0.05\%)}$ 0.32) at Nain and 1.07 to 2.09 t ha^{-1} (Mean 1.66 t ha^{-1}, CD $_{(0.05\%)}$ 0.22) under

Table 50 : Comparison of yield and quality parameters of mutant with checks at ECe 10 dS m^{-1} and pH 9.2

Genotypes	Plant height	Primary branch	Sec. branch	Main shoot length (cm)	Pods on MSL	Pods length (cm)	No. of seed / pod	1000 seed wt (gm)	Yield (t ha^{-1})
Kranti	199	5	13	84	55	5	15	5.0	1.4
CS 54	180	5	12	85	50	6	14	5.4	1.7
CS 52-SPS -1-2012	164	5	10	76	48	5	14	9.0	2.1

Genotypes	Oil (%)	Protein (%)	Erucic acid (%)	Crude fibre (%)
Kranti	39.0	19.8	45.6	10.5
CS 54	37.6	19.9	48.3	10.1
CS 52-SPS-1-2012	39.9	20.1	35.7	9.9

high alkaline conditions (pH 9.3) at Karnal. Genotypes CSCN-12-8 (2.15 t ha^{-1}) followed by CSCN-12-1 (2.12 t ha^{-1}) at Nain and CSCN-12-8 (2.09 t ha^{-1}) followed by CSCN-12-1 (2.01 t ha^{-1}) at Karnal showed highest seed yield.

Production of nucleus and breeder seeds of three salt tolerant varieties developed at CSSRI Karnal and released by CVRC

During 2012-13, breeder seed (graded) of Indian mustard varieties CS 52 (0.18 t), CS 54 (0.27 t) and CS 56 (0.28 t) was produced for distribution to central and state govt. agencies. Similarly, nucleus seed of CS 52 (50 kg), CS 54 (25 kg) and CS 56 (55 kg) was also produced.

Comparative performance of nine promising genotypes of Indian mustard (*Brassica juncea* L.) under saline water irrigation (P.C. Sharma and Jogendra Singh)

Performance of nine promising genotypes of Indian mustard viz. CS 204-2-2-1, CS 1100-1-2-2-3, CS 1600-1-1-1-1, CS 2009-2-9-2-2, CS 3001-1-1-1-1, CS 13000-3-3-2-2-1, CS 15000-1-2-2-2-1 alongwith one salinity check variety CS 54 and one high yielding check Pusa Bold were evaluated under different salinity waters of EC 2, 12, 15 and 18 dS m^{-1} in four replications. Salinity stress was applied at sowing time and maintained throughout the experiment. Maximum mean seedling emergence was recorded in genotype CS 2009-2-9-2-2 (88%) amongst different genotypes, whereas minimum seedling emergence was observed in CS 1100-1-2-2-3 (71%). Maximum mean shoot dry weight at seedling stage was recorded by CS 2009-2-9-2-2 (3 g $plant^{-1}$) and CS 54 (2.88 g $plant^{-1}$) and minimum by CS 15000-1-2-2-2-1 (1.77 g $plant^{-1}$). Further, CS 2009-2-9-2-2 and CS 13000-3-3-2-2-1 (0.42 g $plant^{-1}$) recorded maximum root dry weight under similar conditions and minimum by CS 15000-1-2-2-2-1 (0.23 g $plant^{-1}$). At 30 DAS, minimum accumulation of Na/K in shoot was observed in CS 2009-2-9-2-2 (0.24) and CS 3001-1-1-1-1 (0.29) and maximum in CS 1100-1-2-2-3 (0.51) and CS 1600-1-1-1-1 (0.47), whereas in root, CS 2009-2-9-2-2 (2.31) and Pusa Bold (5.05) recorded minimum and maximum mean Na/K, respectively amongst different genotypes evaluated (Table 51).

Maximum mean seed yield under different salinity levels was recorded by CS 3001-1-1-1-1 (65 g pot^{-1}), followed by CS 2009-2-9-2-2 (63 g pot^{-1}). Genotypes CS 13000-3-3-2-2-1 and CS 1100-1-2-2-3 recorded minimum mean seed yield of 47 g pot^{-1} under salinity stress. Further, minimum percentage reduction in seed yield at 15 dS m^{-1}, compared to control was recorded in CS 3001-1-1-1-1 (57%) followed by CS 204-2-2-1 (60%) and CS 13000-3-3-2-2-1 (61%), whereas high yielding check Pusa Bold recorded maximum percentage reduction (70%) at this level. At harvest stage, minimum accumulation of Na/K in shoot was observed in CS 1600-1-1-1-1 (1.53) followed by CS 3001-1-1-1-1 (2.18) and maximum

Table 51 : Performance of mustard genotypes under different salinity levels at vegetative growth stage

Genotypes	Mean across 5 salinity levels (2-18 dS m^{-1})						
	Seedling stage			Harvest stage			
	Shoot Na*	Root Na*	Shoot Na/K	Shoot Na*	Shoot Na/K	Root Na/K	Seed yield (g pot^{-1})
CS 54	24.68	26.10	0.29	36.67	2.25	9.44	55.31
Pusa Bold	28.00	28.03	0.40	50.16	2.72	9.69	57.96
CS 204-2-2-1	41.05	26.24	0.40	49.93	2.88	8.53	49.45
CS 1100-1-2-2-3	45.70	26.58	0.51	45.66	2.46	6.41	47.94
CS 1600-1-1-1-1	44.42	28.84	0.47	27.33	1.53	4.60	58.16
CS 2009-2-9-2-2	25.01	25.10	0.24	35.31	2.33	6.21	63.12
CS 3001-1-1-1-1	30.69	26.38	0.29	37.59	2.18	6.37	65.22
CS 13000-3-3-2-2-1	31.07	26.61	0.30	35.4	2.54	6.54	47.39
CS 15000-1-2-2-2-1	33.33	31.27	0.41	35.35	2.30	9.27	55.33
CD (P=0.05)							
Genotypes (G)	3.87	1.36	0.07	3.54	0.53	0.97	1.83
Salinity (S)	2.61	0.95	0.04	2.13	0.43	0.63	1.11
G x S	7.84	2.86	0.13	6.40	1.30	1.91	3.32

* mg/g dry wt.

in CS 204-2-2-1 (2.88) followed by Pusa Bold (2.72). Further in root, CS 1600-1-1-1-1 (4.60) and CS 2009-2-9-2-2 (6.21) recorded minimum mean Na/K whereas high yielding check Pusa Bold (9.69) and salinity check CS 54 (9.44) recorded maximum mean Na/K, respectively amongst different genotypes evaluated.

Better performing genotypes CS 3001-1-1-1-1 and CS 2009-2-9-2-2 recorded highest seed yield along with minimum accumulation of Na in shoots at seedling stage and also minimum Na/K ratio in seedling shoots. Further, the minimum seed yield in genotype CS 1100-1-2-2-3 was also associated with minimum germination percentage along with maximum Na/K ratio in shoot at seedling stage amongst different genotypes evaluated.

Genetic variation in salt tolerance on seedling emergence in Indian mustard (*Brassica juncea* L.) genotypes

Sixty four genotypes (phy 12-1 to phy 12-64) as provided by the Directorate on Rapeseed and Mustard Research for the physiology experiment on 'Screening of genotypes for seed germination under salinity stress' were evaluated for their seedling emergence under salinity stress (Control, 15 and 18 dS m^{-1}) in sand culture conditions. Thirty three genotypes recorded 100 per cent seedling emergence under control conditions whereas only four genotypes (phy 12-4, phy 12-33, phy 12-37 and phy 12-46) recorded 100 per cent seedling emergence at EC 15 dS m^{-1} salinity level. Further, phy 12-23 and phy 12-18 recorded minimum seedling emergence of 20 and 25 per cent, respectively at EC 15 dS m^{-1}. Genotypes phy 12-45 and phy 12-57 recorded maximum seedling emergence (45%) at EC 18 dS m^{-1} and eleven genotypes didn't show any seedling emergence at the highest salinity level of EC 18 dS m^{-1}. Significant differences were recorded amongst different genotypes for their performance in seedling emergence under salinity stress conditions.

From QTL to Variety: Marker Assisted Breeding of Abiotic Stress Tolerant Rice Varieties with Major QTLs for Drought, Submergence and Salt Tolerance (P.C. Sharma, S.L. Krishnamurthy and Preeti Rana)

This project is aimed to transfer major quantitative trait loci (QTL) for salinity tolerance into locally adapted high yielding varieties of rice through molecular marker-assisted backcross breeding. Genotype FL 478 was used as donor parent, whereas Sarjoo 52, PR 114 and Pusa 44 were used as recipient parents for the transfer of salinity tolerance genes. After crossing recipient parents with donor parent, F_1 seeds were obtained for Sarjoo 52 x FL 478, PR 114 x FL 478 and Pusa 44 x FL 478 during October 2011. Ten to fifteen per cent of F_1 seeds were obtained from each cross. A total of 250, 100 and 150 F_1 seeds were obtained from PUSA 44 X FL 478, PR 114 X FL 478 and SARJOO 52 X FL 48, respectively. The available F_1 seeds were divided into two sets for advancing the generation to BC_1F_1 during early (March to August 2012) and normal *kharif* season 2012. In first set, experiment was conducted in glass house, while in second set, field experimentation was conducted to produce BC_1F_1 population. F_1s were used as male parent and recipient parent of last year was used as female parent in cross. True F_1 plants were selected using *Saltol* markers for their further use in crossing programme. BC_1F_1 seeds were harvested at the end of August 2012.

For advancement of generation to BC_1F_1, experiment was conducted in glass house during off-season to produce BC_2F_1 population. Seven staggered sowing (23rd October 2012 to 30th November 2012) and transplanting (14th October 2012 to 21st December 2012) were done to produce BC_2F_1 seeds. The seeds of parents and BC_1F_1 were sown on floating grids under hydroponics in Yoshida Culture Solution. After twenty one days, two plants were transplanted in each pot and maintained carefully. For identification of true BC_1F_1 plants, leaf samples were collected for DNA isolation. True BC_1F_1 plants were selected using *Saltol* markers, through foreground and recombinant marker selection, for their further use in crossing programme. RM 3412 was used as marker for foreground selection. For recombinant selection, RM 493, RM 10748 and RM 10893 were used as markers. Gel image of BC_1 F_1s of FL 478, Pusa 44, PR 114 and Sarjoo 52 with foreground marker RM 3412 presented in Fig 35.

The selected true BC_1F_1 plants were backcrossed with their respective parents (Pusa 44, PR 114 and Sarjoo 52) and BC_2F_1 seeds were harvested in March 2013 (Table 52).

For the advancement of generation from BC_2F_1 to BC_3F_1, experiment was initiated in field during *kharif* 2013. Seven staggered sowing (1st June 2013 to 12th July 2013) and transplanting (1st July

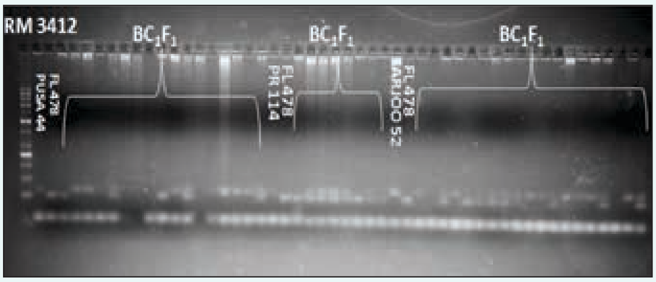


Fig. 35 : Gel image of BC_1 F_1s of FL 478, Pusa 44, PR 114 and Sarjoo 52 with foreground marker RM 3412

Table 52 : Sowing of BC_2F_1 seeds to produce BC_3F_1 seeds in *kharif* 2013

Date of sowing	Date of transplanting	Parents/F_1s + parents
1/6/2013	1/7/2013	Parents
7/6/2013	7/7/2013	Parents
14/6/2013	14/7/2013	Parents + BC_2F_1
21/6/2013	21/7/2013	Parents + BC_2F_1
28/6/2013	28/7/2013	Parents + BC_2F_1
5/7/2013	5/8/2013	Parents
12/7/2013	12/8/2013	Parents

2013 to 12th August 2013) were done to produce BC_3F_1 seeds (Table 53). The seeds of parents and BC_2F_1 were sown on floating grids under hydroponics in Yoshida Culture Solution. After thirty days, seedlings were transplanted in field and maintained carefully.

True BC_2F_1 plants were selected using *Saltol* markers RM 3412 (foreground selection), and RM 493, AP 3206 and GIIA (recombinant selection) for their further use in crossing programme to

Table 53 : Number of seeds harvested in BC_2F_1 and BC_3F_1 generations

Cross	No. of BC_2F_1 seeds harvested in March 2013	No. of BC_3F_1 seeds harvested in October 2013
F_1 (Pusa 44 X FL 478) X Pusa 44 X Pusa 44	465	725
F_1 (PR 114 X FL 478) X PR 114 X PR 114	422	828
F_1 (Sarjoo 52 X FL 478) X Sarjoo 52 X Sarjoo 52	424	850

produce BC_3F_1 population. The selected true BC_2F_1 plants were backcrossed with their respective parents (Pusa 44, PR 114 and Sarjoo 52) and BC_3F_1 seeds were harvested in October 2013 (Table 53). Separately, true BC_2F_1 plants were also selfed to produce BC_2F_2 plants.

Physiological and Biochemical Basis of Salinity and Drought Stresses Tolerance in Rice and Wheat Cropping System (Ashwani Kumar, S.K. Sharma, Neeraj Kulshreshtha and S.L. Krishnamurthy)

An experiment was conducted to evaluate drought stress in relation to salinity in four rice varieties differing in their salt tolerance [CSR 10, CSR 36) and IR 29, Pusa 44 (salt sensitive)]. Growth performance of CSR 10 was best amongst all the varieties under different treatments. IR 29 showed maximum reduction in growth at 25 and 50 per cent water deficit. Rather, at 50 and 100 mM NaCl along with 50 per cent water deficit, 80 per cent of plants died. Chlorophyll content was highest in CSR 10 while IR 29 showed lowest content. Membrane leakage was lowest in CSR 36 (46.67%) followed by CSR 10 (47.15%), IR 29 (50.95%) and Pusa 44 (51.59%). RWC and WUE were highest in CSR 10 and lowest in Pusa 44. Among gas exchange parameters, maximum photosynthetic rate (14.88 µµmol/m²/sec) was observed in CSR 10 and minimum in Pusa 44 (10.25 µµmol/m²/sec). Stomatal conductance was maximum in CSR 10 (5.075 mmol/m²/sec) and minimum in IR 29 (3.315 mmole/m²/sec). Minimum transpiration rate was recorded in Pusa 44 (9.304 µmol/m²/sec) while maximum in CSR 10 (11.237 µmol/m²/sec). Under increasing stress, CO_2 assimilation decreased with maximum assimilation observed in CSR 10 and minimum in Pusa 44. Maximal Photochemical Efficiency (Fv/Fm) and Quantum photochemical yield [*Y (II)*] was maximum in CSR 36 and minimum in Pusa 44.

Among biochemical parameters, protein content (mg g^{-1} DW), proline content (µg g^{-1} FW) and total soluble sugars content (mg g^{-1} DW) increased in all the treatment among all the varieties. Maximum protein accumulation was observed in CSR 36 (5.79 mg g^{-1} DW) while minimum in IR 29 (4.89 mg g^{-1} DW). In case of total soluble sugars, maximum accumulation was found in

Performance of rice varieties under salinity and drought stresses conditions

CSR 10 (42.95 mg g^{-1} DW) and minimum in IR 29 (37.19 mg g^{-1} DW). Reverse trend of increase was observed in proline content with highest accumulation in Pusa 44 (9.46 µg g^{-1} FW) and lowest CSR 36 (7.67 µg g^{-1} FW). Na^+ and, Cl^- contents increased while K^+ content decreased. Maximum increase in Na^+ and Cl^- content was observed in IR 29. Maximum K^+ content was found in CSR 36 (15.26 ppm) and minimum in IR 29 (11.51 ppm).

Stress-tolerant rice for Africa and South Asia (STRASA) Phase 2 (S.K. Sharma and S.L. Krishnamurthy)

This project funded by Bill and Melinda Gates Foundation through IRRI, its second phase (STRASA Phase II) has completed three years. The salient activities of this project in the last season were:

Salt Tolerant Breeding Nursery (STBN)

Based on the performance in the second year trial conducted at 14 different stress locations, fourteen rice genotypes were promoted to third year. STBN Trial comprising 32 rice genotypes including 4 checks (14 promoted from 2nd year and 14 new entries received from different stations). Seed material was sent to 14 locations for multilocation testing/screening under different stresses.

At Karnal, genotypes were sown on raised seed beds on 29.05.2013. Thirty five days old seedlings were transplanted with 2 seedlings per hill in high saline and high sodic micro plots, respectively. The plot size comprised of 1 row of 3m, plant to plant and row to row spacing was 15 cm. Thirty one genotypes were screened under 2 environments viz. high sodic (pH_2 9.9) and high saline (EC_{iw} ~ 10 dS m^{-1}) in micro plots in RBD with three replications.

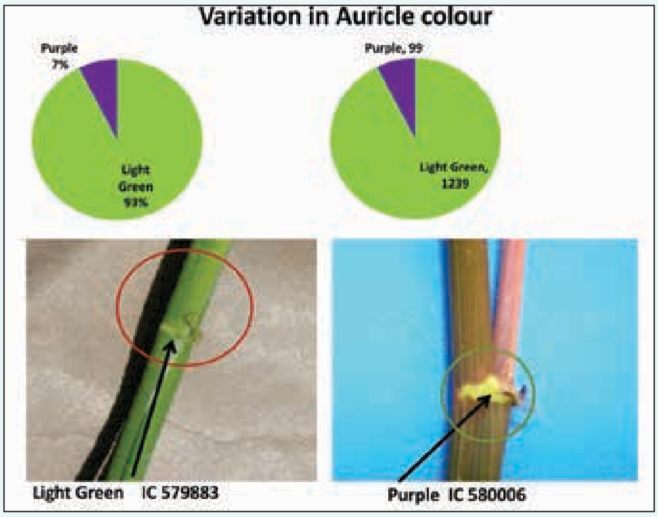
Based on the first and second year trials, following entries were ranked as top five entries in different stress environments (Table 54) and majority of the top ranked entries were from CSSRI, Karnal.

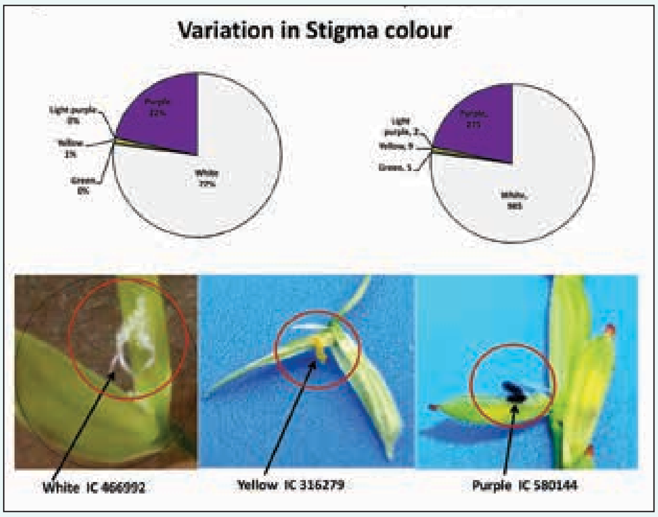
Table 54 : Grain yield (t ha^{-1}) of top 5 entries in alkaline, salinity stress and Nain farm

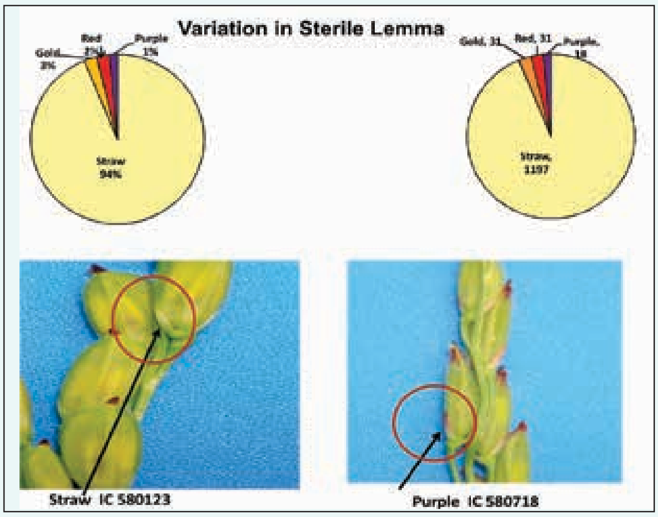
Entries	Alkaline stress	Salinity stress	Nain farm
CSR-2K-262	2.61	3.01	2.52
CSR-2K-242	-	2.85	1.74
CSR-2K-219	2.60	2.69	1.73
NDRK 11-4	2.55	2.55	-
CSR 10-M2-27	2.54	2.79	1.99
CSR 12-B 23	-	-	1.78
Local check (CSR 36)	2.41	-	-

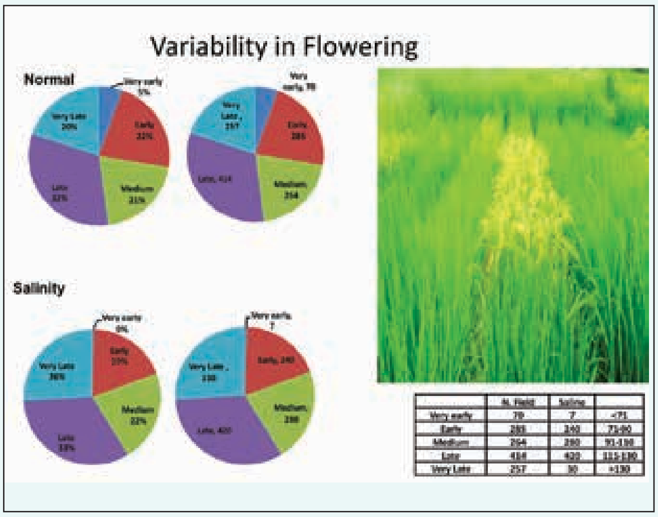
Establishment of National Rice Resource Database

Based on the evaluation of about nine thousand accessions of rice for 30 DUS characters during the last three years, a mini-core of one thousand five hundred three (1503) accessions was selected for evaluation under normal and saline condition in 2013 in an augmented design at Karnal. Data were recorded for 17 DUS traits specified in the protocol as per schedule.

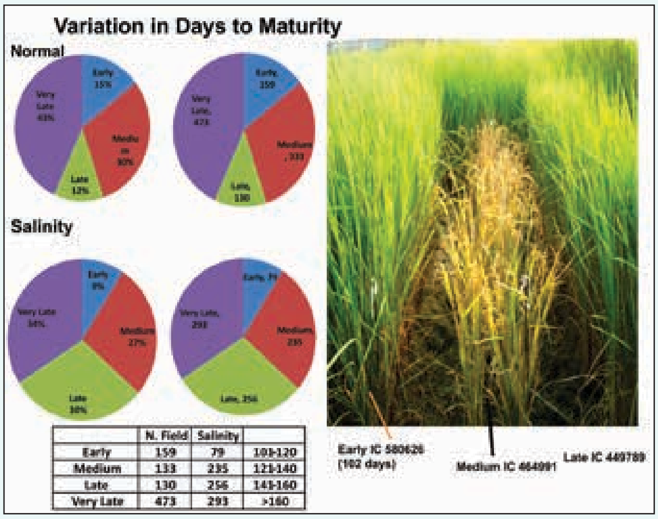




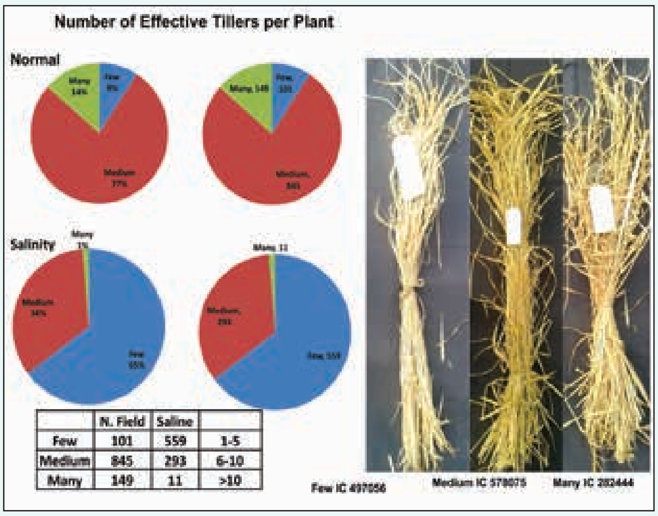




	N. Field	Saline	
Very early	70	7	<71
Early	285	240	71-90
Medium	264	280	91-110
Late	414	420	111-130
Very Late	257	30	>130



	N. Field	Salinity	
Early	159	79	101-120
Medium	133	235	121-140
Late	130	256	141-160
Very Late	473	293	>160



	N. Field	Saline	
Few	101	559	1-5
Medium	845	293	6-10
Many	149	11	>10

Table 55 : Top ten best performing accessions out of the mini-core population

Top ten performer rice accessions *Kharif*-2013-14											
Normal		Saline		Normal		Saline		Normal		Saline	
IC No.	Days to 50% flowering	IC No.	Days to 50% flowering	IC No.	Leaf length (cm)	IC No.	Leaf length (cm)	IC No.	Leaf width (cm)	IC No.	Leaf width (cm)
559056	58	466824	68	463562	84	466629	80	299465	2.4	377423	2.2
559053	59	559056	68	376968	84	450071	81	301126	2.4	256551	2.2
580344	60	580760	68	450071	84	450104	82	310017	2.5	463634	2.3
580290	62	559053	69	447342	85	451346	82	301119	2.5	545503	2.3
466824	62	580344	70	326126	85	447342	82	301123	2.5	299991	2.3
580760	65	466795	70	466511	86	466511	82	299544	2.5	252242	2.3
578935	65	580626	70	544981	86	326126	82	300202	2.5	301093	2.4
580255	66	580290	72	426012	88	426012	85	377569	2.7	300948	2.4
580423	66	467368	72	450892	89	450892	85	301116	2.7	451321	2.4
578303	66	466905	72	413609	93	413609	90	301543	2.7	282400	2.4
GM - 63		70		86		83		2.5		2.3	
Min. - 58		68		18.5		15.1		0.9		0.6	
Max. - 155		161		93.1		90.3		2.7		2.4	
Normal		Saline		Normal		Saline		Normal		Saline	
IC No.	Days to maturity	IC No.	Days to maturity	IC No.	Plant height (cm)	IC No.	Plant height (cm)	IC No.	Panicle length (cm)	IC No.	Panicle length (cm)
497050	98	580626	102	577905	53	577905	41	556512	30	577490	29
580626	100	580416	106	578113	54	578113	42	577780	30	459959	29
466905	103	466905	106	311017	59	578132	47	470442	30	377238	29
578303	103	578937	107	513841	60	578998	48	467213	30	577803	29
578272	103	578303	107	578303	60	577003	49	300147	30	450251	29
580416	104	578272	107	580399	62	578303	49	464144	31	466848	30
580627	104	578975	107	578998	62	578119	51	466511	31	580667	30
580726	104	578944	107	577003	62	346880	53	326126	31	381759	30
578975	104	579040	107	578952	62	578927	55	496957	31	497036	30
578944	104	578927	109	578119	63	578982	55	466386	31	545393	30
GM - 102.7		106.5		60		49		31		30	
Min. - 98		102		53		41		15		10	
Max. - 194		187		219		215		31		30	

Normal		Saline	
IC No.	Effective tillers / plant	IC No.	Effective tillers / plant
256731	18	578430	11
578342	19	466865	11
465081	19	580627	11
282504	19	578734	11
438550	19	464950	11
292265	20	578478	12
282408	20	578278	12
406404	20	310436	14
392255	20	282444	14
310436	20	578342	15
GM - 19		12	
Min. - 3		1	
Max. - 20		15	

Experiment was conducted in an augmented design for evaluating three thousand one hundred fifty two accessions. Each accession was planted in three rows. In each row, 20 hills were planted in 3.0 m long rows. Spacing of 20 x 15 cm was followed. Six checks were included (Swarna, Pusa Basmati 1, NDR 97, Annada, IR 64 and Jaya). Date of sowing was June 20, 2013 and transplanting was done after one month of sowing.

Out of 1503 core accessions, 1338 germinated but only 1277 flowered. Days to flowering and maturity were increased in saline conditions (70 and 103 days, respectively) as compared to normal (63 and 108 days, respectively). Leaf length and width, plant height, panicle length and number of effective tillers decreased in saline environment (90 cm, 2.4 cm, 49 cm, 30 cm and 12 cm, respectively) as compared to normal (93 cm, 2.7cm, 60 cm, 31 cm and 19 cm, respectively). List of Top 10 performer accessions is given in Table 55.

Cereal Systems Initiative for South Asia (CSISA) – Objective 2 (Strategic Experimental Platforms for Future Cereal Systems)

(NARES team: P.C. Sharma, Ashim Datta and D.K. Sharma; CGIAR team: H.S. Jat, Virender Kumar and A. McDonald)

Developing crop and resource management practices for sustainable future cereal based systems

The project aims to devise strategies to reorient the rice-wheat cropping system in Indo-Gangetic Plains keeping into consideration the declining yields, declining natural resources, climatic changes besides water, labour and energy shortages being faced by the present day agriculture. Further objective is to design next generation of cereal systems that are highly productive, resource efficient, sustainable, and adapted to the expected changes in environmental and socio-economic drivers. At research experimental platform, near-production scale long-term experiments were designed to assess the performance of different agricultural systems, using a wide range of indicators. Four scenarios were planned at research platform at CSSRI, Karnal.

Four scenarios in the experiment pertains to rice (puddled)-wheat (conventional) cropping system as in farmers' practice (Scenario I) and achieving higher yield in same cropping system adding moongbean i.e. rice (puddled)-wheat (ZT)-mungbean (ZT) in Scenario II. Scenario III addresses present day problems in agriculture by direct seeded rice (ZT)-wheat (ZT)- moongbean (ZT) cropping system, whereas scenario IV is futuristic by replacing rice with maize in maize (ZT)-wheat (ZT)-mungbean (ZT) cropping system.

During three years of experimentation, around 34, 44 and 50 tonnes of crop residue were added in scenarios II, III and IV, as per the plan outlined. Averaging three years data, significant differences were recorded in rice and maize yields in different scenarios, whereas scenarios I (farmers' practice) and III (DSR) did not differ significantly amongst themselves with respect to rice yield. However, significant differences in system yield in a year were observed on rice equivalent basis. On system basis, three years average data recorded 14 per cent increase in yield in scenario III (DSR-ZT wheat-ZT mung) compared to farmers' practice (scenario I). Similarly, the futuristic system (ZT maize-ZT wheat-ZT mung) in scenario IV showed 11 per cent increase in yield as compared to scenario I.

Irrigation water applied was measured in all the four scenarios and water productivity was also computed accordingly. Three years average data showed substantial reduction of about 33 per cent in water applied in scenario III (DSR- ZT wheat-ZT mung) on system basis compared to scenario I (rice-wheat) whereas, in scenario IV (ZT maize- ZT wheat- ZT mung), water applied was only 29 per cent of that in scenario I.

During *rabi* 2012-13, wheat cv. HD 2967 was sown in all the four scenarios. Seed yield differed significantly amongst different scenarios. In scenario I, fields were kept fallow during summer 2013, whereas mungbean (cv. SML 668) was relay sown about 15 days prior to wheat harvesting in other three scenarios. Whole biomass of moongbean was retained in the field itself. During *kharif* 2013, rice (cv. Pusa 44) seedlings were transplanted in scenario I as per farmers' practice, while in scenario II, rice (cv. Arize 6444) seedlings were transplanted. In scenario III, rice (cv. Arize 6129) was directly sown using turbo seeder and maize (cv. NK 6240) was directly sown using multi-crop planter in scenario IV.

Significant differences were recorded in rice and maize yields in different scenarios (Table 56). Further, significant differences in system yield during the year were observed on rice equivalent basis amongst different scenarios with scenario I and III recording statistically at par.

Irrigation water applied was measured in all the four scenarios and water productivity was also computed accordingly. During wheat season 2012-13, water applied ranged from 277 to 367 mm in different scenarios. Further, during *kharif* 2013, substantial reduction (more than 50%) in water applied was recorded in scenarios III compared to scenario I, whereas, in scenario IV (maize), water applied was only 11 per cent of that in scenario I.

Table 56 : Crop productivity in different scenarios

Scenario	Crop yield (t ha^{-1})		
	Wheat *rabi* 2012-13	Rice *kharif* 2013	System (rice equivalent)
1	4.58^{c}	6.79^{c}	11.51^{c}
2	4.94^{bc}	7.91^{b}	13.00^{b}
3	5.57^{a}	5.56^{d}	11.49^{c}
4	5.23^{ab}	9.36^{a}	14.97^{a}

☆☆☆☆☆

AGROFORESTRY IN SALT AFFECTED SOILS

Evaluation of Biosaline Agro-forestry Systems for Dry Regions (R.K. Yadav and Gajender)

The agro-horticulture (cluster bean–mustard cropping system in *karonda*, *aonla* and *bael*) and agro-forestry systems (pearlmillet–mustard and *Aloe vera* in *Prosopis alba*) were established with furrow irrigation using low (3.6 dS m^{-1}, T_2), alternate use of low and high (T_3), and high saline (8.9 dS m^{-1}, T_4) groundwater at Bir forest research farm of CSSRI at Hisar. These systems were continuously assessed for their suitability on sandy loam soils of semi-arid region with availability of saline groundwater as source for irrigation.

Among horticultural species, *bael* produced highest fruit yield of 4.12, 3.68 and 3.31 t ha^{-1} in T_2, T_3 and T_4 treatments, respectively while saline water irrigation treatments produced 1.48, 1.42 and 1.36 t ha^{-1} yields of *karonda*, and 0.57, 0.42 and 0.44 t ha^{-1} in *aonla* respectively. Both crops i.e. mustard as well as cluster-bean produced relatively more yield in *aonla* followed by *karonda* and *bael*. However, there was no conspicuous effect of saline water irrigation treatments on grain and straw yields of the two companion crops (Table 57). Cluster-bean yield levels were again low because of occurrence of rainfall during the crop establishment stage resulting in less germination and poor stand establishment.

In *Prosopis alba* agro-forestry system with pearlmillet–mustard and *Aloe vera*, pearlmillet and mustard produced 1.56 to 1.28 and 1.22, and 1.63, 1.41 and 1.30 t ha^{-1}, respectively when irrigated with low salinity, alternate use of low and high salinity, and high salinity groundwater. *Aloe vera* produced fresh leaf biomass of 29.8, 27.5 and 26.2 t ha^{-1}, respectively with low, alternate and high saline water irrigation. *Prosopis alba* with *Aloe vera* agro-forestry system proved very successful on sandy loam calcareous soils of semi-arid region with availability of only saline groundwater as source for irrigation. Grain and straw yield of mustard (CS 56) and cluster-bean (HG 365) with different tree species and saline ground water irrigation

Evaluation of *Cactus* and *Prosopis* for Arid Biosaline Agro-forestry (R.K. Yadav)

Pot studies for standardizing cactus cultivation agro-practices were continued to, and field studies to assess the effect of pollarding and pruning on biomass production in *Prosopis* species were carried out during the report period. Though increasing salinity in irrigation water from 4.0 to 6.0 dS m^{-1} reduced the height and number of cladodes in clone 1270 (fodder type) by 7 and 11, and 9 and14 per cent, respectively during this year, but under adverse conditions of salinity and alkalinity, this clone produced the highest number of cladode

Table 57 : Grain and straw yield of mustard and cluster bean with different tree species and saline ground water irrigation

Tree sp.	Irrigation Method	Cluster bean yield ($t\ ha^{-1}$)		Mustard yield ($t\ ha^{-1}$)	
		Grain	Straw	Grain	Straw
Karonda	Low salinity (T_2)	0.76	1.34	1.62	3.18
	Alternate low & high salinity(T_3)	0.73	1.29	1.48	3.02
	High salinity (T_4)	0.66	1.23	1.34	2.92
	Mean	**0.72**	**1.28**	**1.48**	**3.04**
Aonla	Low salinity (T_2)	0.81	1.42	1.81	3.82
	Alternate low & high salinity(T_3)	0.79	1.38	1.76	3.71
	High salinity (T_4)	0.67	1.25	1.60	3.53
	Mean	**0.76**	**1.35**	**1.72**	**3.69**
Bael	Low salinity (T_2)	0.62	1.13	1.43	2.79
	Alternate low & high salinity(T_3)	0.59	1.10	1.34	2.81
	High salinity (T_4)	0.54	1.04	1.27	2.34
	Mean	**0.58**	**1.09**	**1.35**	**2.64**

Table 58 : ***Prosopis*** **sp growth and biomass with different cutting management**

Species/cutting		Height (m)	Basal dia (cm)	Basal area (m^2 ha^{-1})	Wood vol (m^3 ha^{-1})	Pruned dry biomass (t ha^{-1})
No cutting						
P. alba		3.55	5.36	1.34	5.02	-
P. juliflora		3.96	7.10	1.61	6.42	-
P. glandulosa		3.28	6.16	1.45	5.41	-
Polarding						
P. alba		2.43	9.86	1.82	6.48	9.43
P. juliflora		2.82	10.34	2.01	7.84	9.75
P. glandulosa		2.21	9.92	1.84	5.72	7.20
Pruning						
P. alba		3.79	5.42	1.37	5.12	7.65
P. juliflora		4.45	7.48	1.67	7.24	6.74
P. glandulosa		3.82	6.24	1.46	6.17	5.17
LSD 5%	Species	0.56	1.32	0.34	1.17	1.46
	Cutting	0.24	0.57	0.15	0.49	0.62

and biomass among all the clones (1270, 1271, 1280 and 1287) tested. Application of N, P, K (40: 20: 20 kg ha^{-1}) fertilizer and FYM (6 t ha^{-1}) helped to overcome the adverse effect of saline soils up to EC_2 4 dS m^{-1}.

Effect of pollarding and pruning on the biomass production of different species of *Prosopis* (*P. alba*, *P. juliflora*, *P. glandulosa*) was continuously assessed on sodic soils (pH: 9 to 9.5) at CSSRI Research Farm, Karnal. All the species of *Prosopis* produced more prunned biomass and bole growth under pollarding than pruning treatment (Table 58).

Effect of Salinity on Growth and Physio-biochemical Changes in Bael (*Aegle marmelos* Correa) Genotypes (Anshuman Singh, M.D. Meena, P.C. Sharma and D.K. Sharma)

Bael (*Aegle marmelos* Corr.) is a hardy tree and performs well in wide range of soils. *Bael* cultivation is a promising alternative land use in salty environments. *Bael* is characterized as moderately tolerant to soil salinity. Therefore, it was proposed to estimate the effect of soil and water salinity on different growth, physiological and biochemical indices of commercial *bael* genotypes to deduce the conclusive evidence on their salt tolerance. One year old, budded plants of four improved *bael* genotypes, *viz*. Narendra Bael-5, Narendra Bael-9, CISH Bael-1 and CISH Bael-2 were exposed to three soil salinity levels; normal (Soil ECe 1.28 dS m^{-1}), medium (ECe 6.49 dS m^{-1}) and high (ECe 10.7 dS m^{-1}). Plants were irrigated with normal water. The plant samples were analyzed for different physiological and biochemical parameters to assess the relative salt tolerance of the studied genotypes.

The symptoms of salt stress were initially manifested as yellowing, scorching and chlorosis of the leaf edges. These symptoms gradually progressed to the entire leaf. It was followed by the necrosis and abscission of leaves. At high salinity (10.7 dS m^{-1}), the plants of NB-9 and CB-2 genotypes did not survive. Salinity stress increased membrane injury in all the genotypes. There were significant differences between control and salinized plants at moderate salinity (6.49 dS m^{-1}) with exception of NB-5 which exhibited lesser degree of membrane injury. At high salinity, both NB-5 and CB-1 genotypes recorded significant differences in membrane injury as compared to the control values. There was also a significant reduction in relative water content with increased salinity (Table 59). The effects of salt stress on chlorophyll degradation, presumably due to increased activity of the enzyme chlorophyllase, were characterized as the yellowing of leaves which failed to produce the optimum amounts of photosynthates leading to reduced plant growth and vigour.

Accumulation of higher amounts of proline and soluble sugars under salt stress in NB-5 indicated its high salinity tolerance as compared to other genotypes (Table 60). At moderate and high salinity levels, there was a significant increase in leaf Na^+ accumulation, irrespective

Comparative plant performance of four bael varieties; a- NB-5, b-NB-9, c-CB1 and d-CB-2 at high salinity (10.7 dSm^{-1}) treatment

Table 59 : Effect of salinity on membrane injury index (MII), relative water content (RWC), proline, total soluble sugars (TSS) and total soluble proteins (TSP) in *bael* varieties one year after planting

Treatment	MII (%)	RWC (%)	Proline (mg g^{-1} DW)	TSC (mg g^{-1} DW)	TSP (mg g^{-1} DW)
V_1T_1	14.46g	77.78a	1.51g	13.36f	94.42a
V_1T_2	21.66e	71.08b	2.66c	22.4c	87.07c
V_1T_3	37.03b	59.89d	5.28a	31.43a	81.23e
V_2T_1	16.3fg	78.37a	1.52g	13.1f	92.21b
V_2T_2	28.35c	64.04c	2.08e	21.69cd	80.41e
V_2T_3	PNS	PNS	PNS	PNS	PNS
V_3T_1	14.52g	79.53a	1.47gh	14.08f	92.92ab
V_3T_2	24.46d	73.34b	2.32d	18.4e	83.33d
V_3T_3	42.71a	55.25e	2.95b	28b	72.18f
V_4T_1	17.44f	79.96a	1.34h	13.39f	92.66ab
V_4T_2	24.08d	60.94cd	1.88f	20.26d	79.48e
V_4T_3	PNS	PNS	PNS	PNS	PNS
Mean	24.1	70.02	2.3	19.61	85.59
CV (5%)	6.56	4.04	4.64	5.53	1.69

V_1, V_2, V_3 and V_4 represent *bael* varieties NB-5, NB-9, CB-1 and CB-2, respectively. T_1, T_2 and T_3 denote control (1.28 dS m^{-1}), modertae (6.49 dS m^{-1}) and high salinity (10.7 dS m^{-1}) treatments, respectively. Means with at least one letter common are not statistically significant using Duncan's Test at 5% level of significance. PNS - The plants of NB-9 and CB-1 did not survive at high salinity (10.7 dS m^{-1}).

Table 60 : Effect of salinity on Na, K and Na/K ratio in *bael* varieties one year after planting

Treatments	Na (%)	K (%)	Na/K ratio
V_1T_1	0.06e	0.27g	0.22ab
V_1T_2	0.18d	1e	0.18d
V_1T_3	0.29b	1.46b	0.2c
V_2T_1	0.06e	0.45f	0.13e
V_2T_2	0.3b	1.35c	0.22ab
V_2T_3	PNS	PNS	PNS
V_3T_1	0.06e	0.42f	0.14e
V_3T_2	0.24c	1.07d	0.23a
V_3T_3	0.35a	1.65a	0.21bc
V_4T_1	0.06e	0.46f	0.12e
V_4T_2	0.24c	1.41bc	0.17d
V_4T_3	PNS	PNS	PNS
Mean	0.18	0.95	0.15
CV (5%)	6.36	4.75	6.64

PNS-Plants did not survive at high salinity

of the genotypes. Nevertheless, this effect was less pronounced in variety NB-5, which not only prevented the accumulation of Na^+ to toxic levels but also exhibited higher K^+ accumulation. The net result was a favourable ionic balance in terms of Na^+/K^+ ratio resulting in good plant performance under salinity stress. The plants of NB-9 and CB-2 varieties could not sustain Na^+ toxicity at high salinity.

Carbon Sequestration Potential in Plantation Forestry and Agricultural Land Uses for Mitigating Climate Change and Increasing Crop Productivity on Gangetic Basin (Parveen Kumar, S.K. Chaudhari and D.K. Sharma)

Carbon sequestration is one of the viable options for mitigation of repercussions due to climate change. Climate change evokes serious threats to food security and livelihood in developing countries. In this study, three different land uses were selected for identifying the drivers of carbon sequestration and viable options for manipulation of present management practices.

Plantation forestry

During 2013-14, an attempt has been made to calculate different carbon fractions of 4 years *Populus deltoids* and *Eucalyptus tereticornis* plantation. In both systems, particulate carbon decreased with soil depth and soil particle size. In *Populus* and *Eucalyptus*, coarse macro aggregated

Table 61 : Soil organic carbon retained under various particles size of water stable aggregates under four year *Populus* and *Eucalyptus* plantation

Soil depth (cm)	Particulate carbon (g kg^{-1})		
	(Silt+Clay) AC (0.05mm)	FMicAC (0.05-0.25 mm)	CMacAC (0.25-2.0 mm)
Populus plantation (Hara Farm, Yamunanagar)			
0-15	4.01	0.74	14.41
15-30	0.45	0.74	9.65
30-45	0.15	0.30	1.93
45-60	0.30	0.45	2.67
Mean	1.23	0.56	7.17
Eucalyptus plantation (Raina Farm, Kurukshetra)			
0-15	2.52	3.56	13.37
15-30	1.34	6.68	5.94
30-45	0.30	0.59	2.82
45-60	0.00	0.15	1.04
Mean	1.04	2.75	5.79

Where, (silt+clay) AC- Silt and clay associate carbon; FMicAC- Fine micro aggregated carbon; CMacAC- Coarse macro aggregated carbon

carbon was almost 4 and 5 times higher than silts and clay associated carbon, respectively (Table 61). Coarse macro aggregated carbon (0.25-2.0 mm) which is a indicator of long-term carbon stabilization was higher by 23.8 per cent in *Populus* as compared to *Eucalyptus* over the soil depths studied. To know the mechanism of carbon stabilization studies are underway for characterizing active and passive pools of carbon in different soil depths. Soil carbon stock increased with the increasing age of *Populus* plantation, whereas it decreased with the soil depth (Fig. 36).

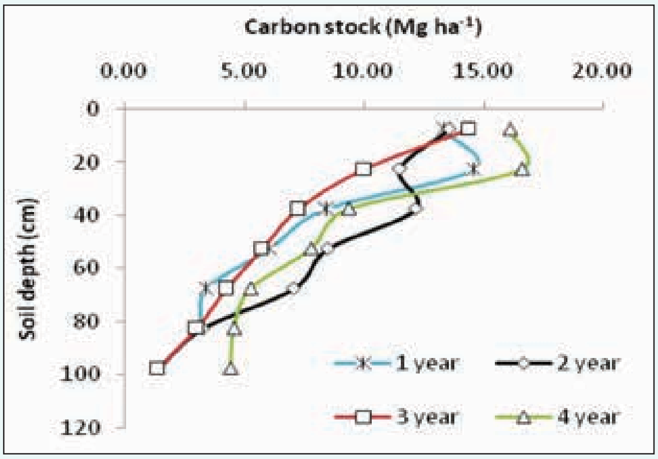


Fig 36 : Soil carbon stock under different age of Populus

Agroforestry system

The data indicated that soil organic carbon (SOC) decreased with increasing soil depth, irrespective of the crop grown of *Eucalyptus* plantation (Table 62). There was no much difference in SOC under sugarcane alone and *Eucalyptus* (1year) + sugarcane plantation. Soil samples collected under *Eucalyptus* (3 year) + sorghum plantation had 14.3 per cent higher SOC than sole sorghum crop. Similarly, *Eucalyptus* (4 year) + wheat had 26.3 per cent higher SOC as compared to sole wheat at upper depth (0-15 cm). Increment in canopy cover of *Eucalyptus* plantation reduced the productivity of the crop. When plantation age increased from 2 to 4 years, the increase in SOC was 23.1 per cent in upper depth (0-15 cm) and 75.0 per cent in lower depth (90-105 cm). Soil carbon stock under *Eucalyptus* coppice was higher up to 0-60 cm at 4 years of age compared to 2 years coppice (Fig. 37).

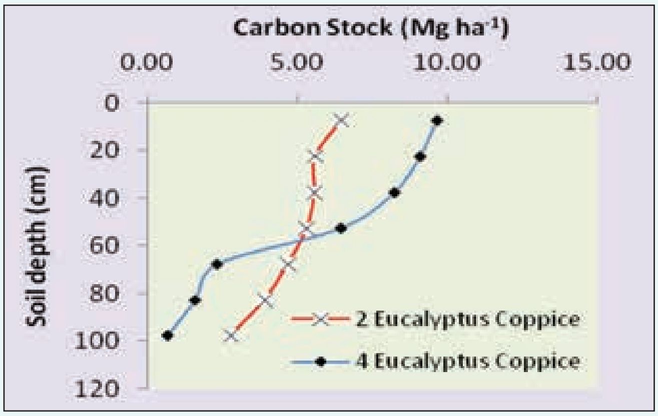


Fig. 37 : SOC stock in 2 and 4 yr of Eucalyptus coppice

Sample collection in Eucalyptus +sorghum system

Agricultural systems

In an experiment, nitrogen was used as a driver to enhance the C sequestration in wheat-greengram-maize cropping system (Table 63). The results indicated that addition of organic source with recommended dose of N (N_1) increased the total biomass, whereas substitution of organic source for N or use of FYM alone resulted in significant decrease in carbon sequestered and biomass.

In another experiment, tillage and residue management was used as a driver to enhance C sequestration in wheat-rice cropping system. The results indicated that C sequestered by wheat crop in above ground and total biomass was highest where conventional tillage was done with one-third residue incorporation and lowest in zero tillage with one-third residue retention. Root biomass remained unaffected due to different treatments of tillage and residue management. Both the wheat varieties (KRL 213 and HD 2894) sequestered statistically similar carbon in above and below ground biomass (Table 64).

Carbon sequestered by rice crop in above ground and total biomass was highest in T_2, where tillage and residue management was done as per prevailing farmers' practice of the region (CT with wheat residue removed + transplanted rice under puddled conditions) followed by T_4, where direct seeded rice was sown with conventional tillage (Table 65). Rice variety CSR 36 sequestered statistically higher carbon than CSR 30; however, C sequestered in below ground biomass of CSR 30 was statistically higher than CSR 36.

Table 62 : Comparative increment in SOC (%) under *Eucalyptus* based agroforestry systems at Raina Farm, Kurukshetra

Agroforestry system	Soil depth (cm)						
	0-15	15-30	30-45	45-60	60-75	75-90	90-105
Sole sugarcane	0.36	0.32	0.30	0.26	0.20	0.14	0.10
Eucalyptus (1yr)+sugarcane	0.37	0.30	0.26	0.22	0.18	0.13	0.09
Sole wheat	0.38	0.28	0.21	0.18	0.16	0.12	0.08
Eucalyptus (2 yr)+wheat	0.39	0.23	0.16	0.12	0.09	0.07	0.04
Eucalyptus (4 yr)+wheat	0.48	0.42	0.34	0.19	0.18	0.12	0.07
Sole sorghum	0.35	0.31	0.27	0.22	0.14	0.13	0.05
Eucalyptus (3yr)+sorghum	0.40	0.34	0.28	0.21	0.16	0.11	0.08

Table 63 : Carbon sequestered by wheat-green gram-maize system at harvest under different N management options

Nitrogen management	Biomass yield (t ha^{-1})			Carbon sequestered (t ha^{-1})		
	Above ground	Below ground	Total	Above ground	Below ground	Total
N_1 - 100% RDN [a] +10 t ha^{-1} FYM	33.99	3.09	37.08	13.19	1.26	14.45
N_2 - 100% RDN	31.87	3.67	35.54	12.03	1.33	13.36
N_3 - 75% RDN + 25 % N through FYM	36.75	3.73	40.48	12.02	1.55	13.57
N_4 - 50 % RDN + 50% N through FYM	32.46	3.04	35.50	12.33	1.26	13.59
N_5 - 50% N through FYM	22.03	2.82	24.85	10.10	1.16	11.26
N_6 - 25% N through FYM	24.22	3.01	27.23	10.07	1.24	11.31
N_7 - No Nitrogen	19.11	2.16	21.27	9.39	0.90	10.29

RDN[a]- recommended dose of N-150, P_2O_5- 60; K_2O - 30 and 60 kg ha^{-1} for wheat and maize, respectively

Table 64 : Biomass and carbon sequestered by wheat crop in wheat-rice system under different tillage and residue management during April 2013

Tillage and residue management	Biomass yield (t ha^{-1})			Carbon sequestered (t ha^{-1})		
	Above ground	Below ground	Total	Above ground	Below ground	Total
Tillage and residue management						
T_1 (CT+1/3 RI)	14.0	0.85	14.9	5.64	0.29	5.93
T_2 (FP+R Removed)	13.1	0.79	13.9	5.46	0.28	5.74
T_3 (ZT+1/3 R Retention)	11.1	0.79	11.9	4.61	0.29	4.90
T_4 (ZT +FR Retention)	12.9	0.85	13.8	5.33	0.30	5.63
CD (P=0.05)	0.9	NS	0.9	0.44	0.02	0.46
Variety						
KRL 213	13.1	0.82	13.9	5.36	0.29	5.65
HD 2894	12.5	0.82	13.3	5.16	0.29	5.45
CD (P=0.05)	NS	NS	NS	NS	NS	NS

T_1 = Conventional tillage with one-third residue incorporation; T_2= Farmers practice full residue removal; T_3=Zero tillage with one-third residue retention; T_4=Zero tillage with full residue retention (turbo seeding)

Table 65 : Biomass and carbon sequestered by rice crop in rice-wheat system under different tillage and residue management during October 2013

Tillage and residue management	Biomass yield (t ha^{-1})			Carbon sequestered (t ha^{-1})		
	Above ground	Below ground	Total	Above ground	Below ground	Total
Tillage and residue management						
T_1 (CT with 1/3 RI +TPR+Puddling)	14.9	3.28	18.2	6.25	1.38	7.63
T_2 (CT with RR+TPR+Puddling)	17.6	3.61	21.2	7.39	1.52	8.91
T_3 (ZT+DSR)	12.1	2.76	14.9	5.10	1.16	6.26
T_4 (CT+DSR)	16.8	2.72	19.5	7.05	1.14	8.19
CD (P-0.05)	1.8	0.35	1.9	0.76	0.15	0.84
Variety						
CSR 30	13.3	3.34	16.6	5.58	1.40	6.98
CSR 36	17.4	2.84	20.2	7.31	1.19	8.50
CD (P-0.05)	1.3	0.25	1.4	0.54	0.10	0.63

CT - Conventional tillage, RI - Wheat residue incorporation; TPR - transplanted rice, RR- Full wheat residue removed, ZT - Zero Tillage, DSR - direct seeded rice

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RECLAMATION AND MANAGEMENT OF ALKALI SOILS OF CENTRAL AND EASTERN GANGETIC PLAINS

Study on Salt and Water Dynamics and Crop Performance in Waterlogged Sodic Soils under Raised and Sunken Beds (C.L. Verma, Y.P. Singh and T. Damodaran)

Raised and sunken bed system for small and marginal farmers, with limited economic resources, was planned in Sharda Sahayak Canal Command in village Kashrawan, district Raebareli with the objective to bring waterlogged sodic soils under cultivation. Most suitable crops and crop combinations were studied.

Initial soil pH_2 of 0-15 cm soil depth ranged from 9.31 to 10.47 and EC_2 from 0.43 to 1.78. Two raised beds of 60 m lengths and 7 m width were constructed during the month of June 2009. Top width of raised beds was kept as 2.0 m and bottom width as 4 m. Boundary embankment width was also kept 2.0 m wide except for the boundary bunds towards south which was only 1 meter wide on the top. Side slopes of raised beds and boundary bunds were kept as 1:1. Total area under raised beds, sunken beds and boundary beds was 0.36 ha (3560 m^2). Out of this area, raised beds were over an area of 1266 m^2, sunken beds of 2293 m^2. Area under boundary beds is 786 m^2. After construction of raised and sunken beds, the average pH_2 of first raised bed was observed to be 9.4 and EC_2 0.4, and second raised bed average pH_2 was 8.7 and EC_2 0.14. First raised bed width was increased by one meter at the end of third year. Thus, the average width of first raised bed increased to 3 meters.

Crop performance

Vegetables such as bottle gourd, bitter gourd, sponge gourd, pumpkin, brinjal, tomato, coriander, spinach, okra, cabbage, garlic, onion, chilly, cowpea, colocasia, radish, mustard, dill and soya etc. were grown throughout the year. Water chestnut was grown in sunken beds. Third banana ratoon was taken on boundary bunds giving satisfactory yields under partial shade conditions. Colocasia as vegetable and turmeric as spice crop gave good yields under complete shade conditions. Elephant foot yam grew well under shade condition. Crop performance during *kharif* 2013-14 was quite good. Sponge gourd was raised over a vertical bamboo frame with significant increase in yield. Yield data of vegetables grown on raised beds during *kharif* 2013-14 and *rabi* 2013 is presented in Table 66.

Early rain during June 2013 damaged the vegetable crops but they were replanted later. Sponge gourd supported on vertical bamboo frame gave the highest yield of 623.5 kg followed by bottle gourd (228.1 kg). The yield of okra was recorded as 35.4 kg and bitter gourd only 7 kg. The colocasia tuber yield was obtained as 78.4 kg along the surface drain under the shade of *eucalyptus*, banana, mango, guava and *kachnar*. Green leaves of colocasia are also favoured by

Table 66 : Crop performance under raised and sunken bed

Kharif 2013-14	Yield (kg)	*Rabi* 2012-13	Yield (kg)
Vegetables			
Sponge gourd	623.5	Cabbage	241.5
Bottle gourd	228.1	Bottle gourd	29.5
Bitter gourd	7.0	Tomato	178.5
Pointed gourd	8.6	Radish	593.4
Okra	35.4	Spinach	72.0
Brinjal	7.7	Coriander	9.3
Colocasia leaf	35.6	Methi	1.0
Colocasia tubers	78.4	Dill	22.0
Karemua (Ipomea)	53.8	Bakla	4.5
Spinach	37.3	Sem	13.0
Fruits			
Banana	111.0	Banana	276.0
Guava	78.2	Papaya	147.1
Papaya	351.5	-	-
Spices			
Turmeric	19.6	Garlic	111.0
Chilli	8.8	Onion	108.0
Cucurbits			
Water chest nut	64.5	Water chestnut	37.0
Sunhemp flower	25.5	-	-
Crops			
Maize cob	130	Mustard	19.0
-	-	Gram	10.5
Flowers			
-	-	Gladiolus (No)	135
-	-	Marigold	8.4

the local mass and fetches good market price, it was reported to be harvested to the tune of 35.55 kg. Karemua (ipomea) and spinach leafy vegetables yields were 53.82 and 37.3 kg. Water chest nut yield was 64.5 kg only during *kharif*. Sunhemp flower as vegetable yielded 25.5 kg. About 130 maize cobs were also harvested. Turmeric a spice crop, grown under complete shade of *eucalyptus, acacia, neem,* and black berry gave a yield of 19.6 kg. Green chilies yield was recorded as 8.8 kg. Banana, guava and papaya gave reasonably good yields. Highest yield of papaya was recorded as 351.45 kg followed by banana (111.0 kg). Guava gave an average yield of 78.20 kg. About 2460 kg of green grass was harvested from the boundary bunds and raised beds as fodder. The biomass from sunken bed as water chestnut residues, algae, banana residues and aquatic weeds is not included in this. Dhaincha stalk yield as fuel was recorded as 110 kg with grain yield of about 6.30 kg.

Vegetables namely cabbage, tomato, radish, spinach, dill, methi, sem, bakla and coriander were grown during *rabi* 2013. Garlic and onion were grown as spice crops and marigold and gladiolus were tried as cash flower crops. Farmers preferred banana ratoon under partial shade on one side. The radish recorded the highest yield of 593.4 kg followed by cabbage (241.5 kg). The yields of tomato and spinach were 178.6 and 72.0 kg, respectively. The yield of coriander, methi, dill, bakla and sem was recorded to be 9.25, 1.0, 22.0, 4.5 and 13.0 kg, respectively. The seed yield of mustard and gram was found to be 19.0 kg and 10.5 kg, respectively. Garlic and onion also gave good yields of 111.0 and 108.0 kg, respectively. The yield recorded of banana (276.0 kg) and papaya (147.1 kg). 8.4 kg marigold and 135 gladiolas were also obtained during *rabi* 2013.

Economics

The results given in Table 67 indicated that gross return from raised and sunken bed system during *rabi 2012-13* and extended *zaid* was Rs. 25,973 and during *kharif* 2013-14 was Rs. 36,909. Cost of inputs for *rabi* 2012-13 was Rs. 3281 and for *kharif* 2013-14 was Rs. 2,861 Similarly cost of labour was Rs. 3,210 and Rs. 3,838 during *rabi* 2012-13 and *kharif* 2013-14. Net annual gross return from the system was Rs. 62,882. Annual expenditure on account of labour charges was Rs. 7,048 and inputs were Rs. 6,142. Thus, total annual expenditure on crop production was worked out to be Rs. 13,190. The net return of the raised and sunken bed system


Sponge gourd on frame *Okra*

Performance of kharif 2013 vegetables on raised beds




Cabbage *Garlic* *Spinach* *Radish*

Performance of rabi vegetables on raised beds

Table 67 : Economics of raised and sunken bed system

S.N.	Season	Gross return	Labour component (Rs)	Inputs component (Rs)	Expenditure (Rs)	Net return (Rs)
1.	*Rabi* 2012-13	25973	3210	3281	6491	19482
2.	*Kharif* 2013	36909	3838	2861	6699	30210
	Total	**62882**	**7048**	**6142**	**13190**	**49693**
Benefit : Cost						**3.63**

during 2012-13 was calculated as Rs. 49,693. The benefit cost ratio (B:C) was worked out to be 3.63.

Water balance

The average water depths in canal declines continuously after rainy season due to increasing demand of water for crop irrigation water. The average water depths in canal were observed to be 1.10, 1.42, 0.92, 1.11, 0.73, 0.00, 0.64, 1.25, 1.71, 1.80, 1.35, 0.00 and 1.12 m during December 2012 to December 2013 (Fig. 38 & 39). Similarly, the average depth of water in surface drain were observed to be 0.49, 0.58, 0.38, 0.22, 0.27, 0.00, 0.33, 0.67, 0.56, 0.58, 0.57, 0.28 and 0.20 m for 12 months from December 2012 to December 2013. Average depths of water in sunken bed-1 were observed to be 0.06, 0.21, 0.18, 0.04, 0.00, 0.00, 0.16, 0.47, 0.39, 0.49, 0.42, 0.08 and 0.09 m; in sunken bed-2 0.00, 0.03, 0.12, 0.03, 0.00, 0.10, 0.13, 0.45, 0.43, 0.53, 0.40, 0.03 and 0.00 m and in sunken bed-3 0.15, 0.04, 0.12, 0.00, 0.00, 0.00, 0.10, 0.43, 0.44, 0.51, 0.40, 0.04 and 0.00 m, respectively.

Volume of water stored in sunken bed-1 was 87.18, 309.49, 260.09, 53.76, 0.000, 0.00, 235.39, 687.27, 569.58, 707.61, 611.71, 113.33 and 26.41 m^3 during 12 months from December 2012 to December 2013, respectively (Fig. 40). Volumes of water stored in sunken bed-2 were 0.42, 14.28, 51.24, 13.02, 0.00, 43.26, 55.44, 187.74, 181.02, 221.34, 167.16, 13.02 and 0.00 m^3 and in sunken bed-3 64.68, 18.06, 50.40, 0.42, 0.00, 0.00, 39.90, 178.50, 185.22, 213.36, 169.68, 17.64 and 0.00 m^3 during the respective months from December 2012 to December 2013.

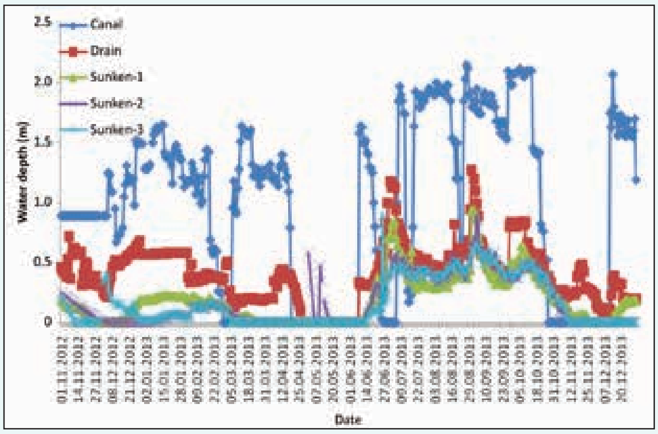


Fig.38 : Water depth fluctuations

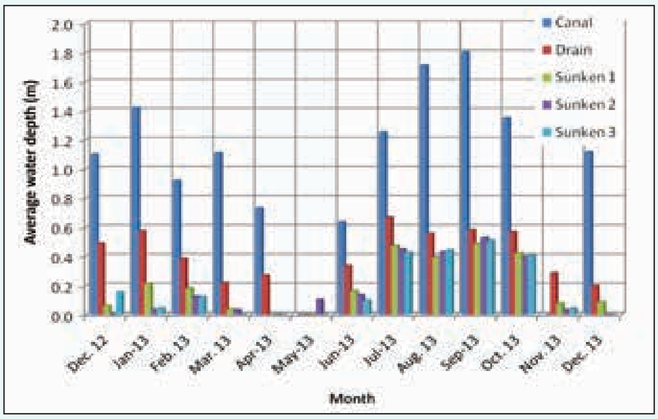


Fig. 39 : Average water depth in sunken beds

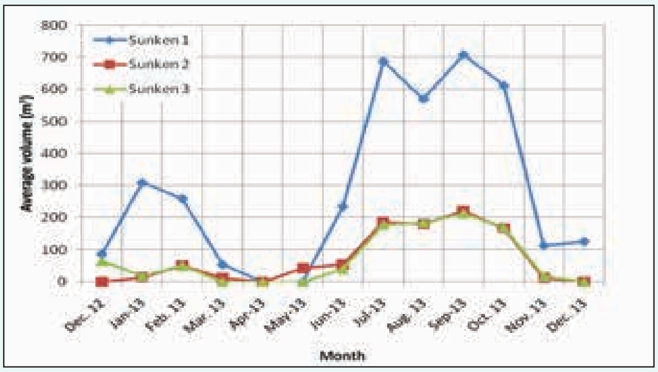


Fig. 40 : Volume of water stored in sunken beds

Salt dynamics

Salt loads at the end of *kharif* 2012 and *rabi* 2013 are presented in Table 68. Total salt load in raised beds during October 2012 was 856.25 kg and May 2013 was 433.22 kg. Similarly, total salt load in sunken beds during October 2012 was 664.52 kg and during May 2013 was 1708.53 kg. Thus, there was substantial reduction in salt loads of raised bed soil profiles with the passage of time due to continuous crop production and irrigation. There was increase in salt content of sunken bed profiles indicating insufficient leaching due to shallow water table conditions and accumulation of salts drained out of the raised beds. The increase in EC_2 was always much below the threshold limit of 4 dS m^{-1}.

Table 68 : Salt status (kg) in raised and sunken beds

Soil depth cm	Raised beds (480 m^2)		Sunken beds (2293 m^2)	
	October 12	May 13	October 12	May 13
0-15	75.42	51.20	118.18	499.63
15-30	53.98	42.94	83.09	237.22
30-45	53.81	51.65	76.74	162.71
45-60	47.22	52.34	78.86	159.05
60-90	110.10	110.85	147.27	338.88
90-120	515.70	124.24	160.38	311.08
Total	**856.25**	**433.22**	**664.52**	**1708.53**

Harnessing Productivity Potential of Waterlogged Sodic Soil through Intervention of Farming System Module in Sarda Canal Command for Livelihood Generation (V.K. Mishra, C.L. Verma, Y.P. Singh, T. Damodarn, S.K. Jha, Sanjay Arora, A.K. Singh, P.K. Varsney and D.K. Sharma)

Uttar Pradesh has good network of canals (21 % of the net irrigated area) and plays major role in increasing the food grain production of Uttar Pradesh as well as India. Sharda Sahayak Canal is one of the major canal commands in U.P., which provides irrigation to 17.80 lakh ha in 16 districts. About 0.12 to 0.18 million ha sodic land in Sharda Sahayak Canal Command suffer from shallow water table conditions. To address this problem, harvesting and management of canal seepage water for multipurpose use and harnessing potential of unproductive waterlogged sodic soil was initiated under farmers participation mode at Patwakhera (Sameshi), Lucknow. The total selected area is 0.8 ha, out of that 0.26 ha and 0.54 ha area are under pond and raised bed, respectively. The depth of pond is 1.8 m from surface.

Arial view of Project Site (Patwakhera, Lucknow)

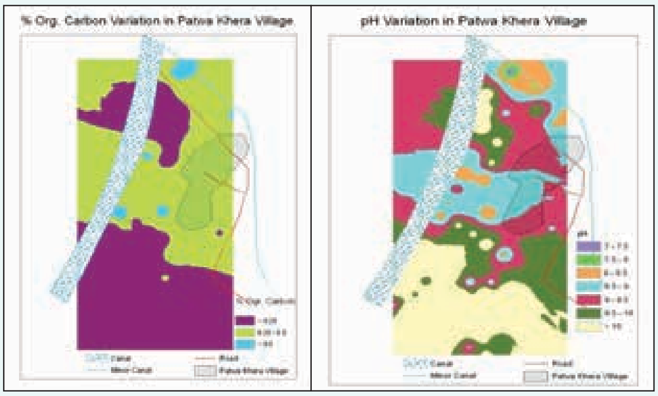


Fig. 41 : Spatial extent of the soil carbon and pH of study site

Soil Characteristics

Before inception of the project, surface soils samples were collected from 68 different locations of 25 ha waterlogged sodic soil affected area falling within 500 m near the canal for analysis of physico-chemical properties. The surface soil pH (1:2) ranged from 7.3 to 10.7, EC ranged from 0.02 to 0.7 dS m^{-1}. Organic carbon content ranged from 0.05 to 0.84 per cent, ESP ranged from 10.8 to 78.1 (Fig. 41). In upper part of the soil (surface to 45 cm), pH varied from 10.4- 9.0 and EC varied from 0.46-0.14 dS m^{-1}and below 45 to 205 cm depth, the soil pH was recorded < 9.0 and EC 0.11-0.04.

Socio-economic status of village

Patwakhera (Sameshi) village is located adjoining to the Sharda main canal in Lucknow district. One hundred five families are residing in Patwakhera village. Out of the total families, 82.2 per cent were under category of below poverty line(BPL). The female and male illiteracy was 76.4 and 53.7 per cent, respectively. Farmers of the village were mostly (94.1%) under marginal land holding capacity.

Utilization of Fly Ash for Increasing Crop Productivity by Improving Hydro-physical Behaviour of Sodic Soils of Uttar Pradesh (DST Funded) (V.K. Mishra, T. Damodran and S.K. Jha)

Combustion of coal for power generation produces huge quantity of fly ash which is treated as a nuisance to the environment. The current annual production of fly ash in India is approximately up to 90 x10^6 Mg which is presumed to increase with the high demand of energy supply. Properties of fly ash depend on various other factors like type of coal, combustion method etc. Fly ash is characterized with coarse texture, low bulk density (around 0.98 g cm^{-3}) and contain about 0.20 per cent carbon content. To explore the potentiality of fly ash in sodic soil reclamation and improvement in partial reclaimed sodic soil, two experiments were initiated with rice crop at Shivri Research farm, Lucknow. The experimental plan consisted of two experiments: first on barren sodic soils and second on partially reclaimed sodic soils. The treatments were: T_1- Gypsum -50% GR – Conventional, T_2-Gypsum - 25% GR, T_3- Fly ash 2.5 % of soil mass, T_4- Fly ash 5% of soil mass, T_5- 25% GR + Fly ash 2.5% of soil mass, T_6 -25% GR + Fly ash 2.5% of soil mass + *Dhaincha*, T_7- Fly ash 5% of soil mass + *Dhaincha*,T_8-Control

Under barren sodic soil, soil pH showed a decreasing behaviour (Table 69) with fly ash incorporation over initial soil pH of 10.1, however, soil treated with 50% GR (T_1) and 25% GR+2.5 % fly ash with *Dhaincha* (T_5) showed maximum reduction in pH 9.5 and 9.6, respectively. Application of fly ash at 2.5 and 5 per cent alone also reduced the soil pH by 0.5 over initial value. EC_2 showed a decreasing trend over initial value of 1.75 dS m^{-1} in all treatment. Highest rice yield (3.7 t ha^{-1}) was harvested under 50% GR whereas 25% GR also gave grain yield of 2.6 t ha^{-1}. Application of fly ash 2.5 and 5 % produced 1.96 and 1.73 t ha grain yield of rice, respectively. In control plot, only 0.12 t ha^{-1} rice grain yields were recorded. Combined application of fly ash with gypsum did not show better response in comparison to gypsum alone.

Effect of fly ash on rice crop in sodic soil (a) and partially reclaimed sodic soil (b)

Table 69 : Effect of fly ash and gypsum on soil pH in barren sodic soil and grain yield of rice

Treatment	pH	EC (dS m^{-1})	Grain yield (t ha^{-1})
T_1-Gypsum -50 % GR	9.47	0.86	3.67
T_2-Gypsum - 25 % GR	9.61	0.81	2.55
T_3-Fly ash 2.5 % of soil mass	9.74	0.99	1.96
T_4-Fly ash 5% of soil mass	9.80	0.81	1.73
T_5-25% GR + Fly ash 2.5% of soil mass	9.54	1.00	1.70
T_6-25% GR + Fly ash 2.5% of soil mass + *Dhaincha*	9.60	1.35	2.00
T_7-Fly ash 5% of soil mass + *Dhaincha*	9.59	0.70	1.95
T_8-Control	10.05	1.75	0.12

Effect of fly ash on partial reclaimed sodic soil

In partially reclaimed sodic soils, application of fly ash did not show considerable effect on soil pH (Table 70). The EC value showed a reduction in all treatment over control except in Fly ash 3.0% v/v of soil (T_6) where an increase in EC was observed. The rice grain yield considerably increased with application of Fly ash. Grain yield of rice increased by 22.4 per cent under 3 per cent Fly ash treated with dhaincha as compared to control. Fly ash alone i.e 1, 2.and 3 per cent v/v of soil application increased the grain yield by 6.89, 14.04 and 15.52 per cent, respectively over control.

Table 70 : Effect of fly ash on properties of partially reclaimed sodic soil and grain yield of rice

Treatment	pH	EC (dS m^{-1})	Grain yield (t ha^{-1})
T_1 - Control	8.9	0.92	4.06
T_2 - Fly ash 1.0% v/v of soil	8.6	0.49	4.34
T_3 - Fly ash 1.0% v/v of soil + *Dhaincha*	8.7	0.64	4.67
T_4 - Fly ash 2.0% v/v of soil	8.5	0.51	4.63
T_5 - Fly ash 2.0% v/v of soil + *Dhaincha*	8.6	0.65	4.75
T_6 - Fly ash 3.0% v/v of soil	9.7	1.15	4.69
T_7 - Fly ash 3.0% v/v of soil + *Dhaincha*	8.5	0.60	4.97

Performance of *Prosopis* Species under Different Amendments on Sodic Soil (Y.P. Singh, Sanjay Arora and V.K. Mishra)

Salt affected soils are devoid of any vegetation and it restricts the choice of arable crops to be grown due to adverse edaphic environment. Various studies were conducted to evaluate the performance of this multipurpose tree species using inorganic sources of amendments like gypsum as a filling mixture. The availability of gypsum is becoming a problem in the days to come because of its high market price, mining and environmental concern. Present study was initiated during 2009 at CSSRI, Research farm, Shivri, Lucknow with five *Prosopis* species viz; *Prosopis juliflora, Prosopis chilensis, Prosopis alba, Prosopis glandulosa* and *Prosopis levingata* using 3 organic and inorganic amendments like gypsum, phosphogypsum and press mud in filling the augor holes. The experiment was laid in Randomized Block Design with 3 replications.

These species were planted in auger holes of 45 cm diameter at surface and 20 cm at the bottom and 120 cm deep at a spacing of 4 m x 3 m. The auger holes were filled with a mixture of original soil + 2.5 kg gypsum + 10 kg FYM, original soil + 2.5 kg phosphogypsum + 10 kg FYM, original soil + 10 kg press mud, and no FYM and control with original soil without any amendments. Karnal grass (*Leptochloa fusca*) was planted as intercrop through root slips at 30 cm intervals in rows 50 cm apart. After four years of plantation, highest survival (87.9%) was recorded with phosphogypsum treated plants as compared to gypsum and press mud. Among the species, *P. alba* treated with phosphogypsum recorded maximum survival (94.4%). In control treatment where no amendment was used, highest survival (81.6%) was recorded with *P. levingata* over rest of the species.

Prosopis species with under storey plantation of L. fusca

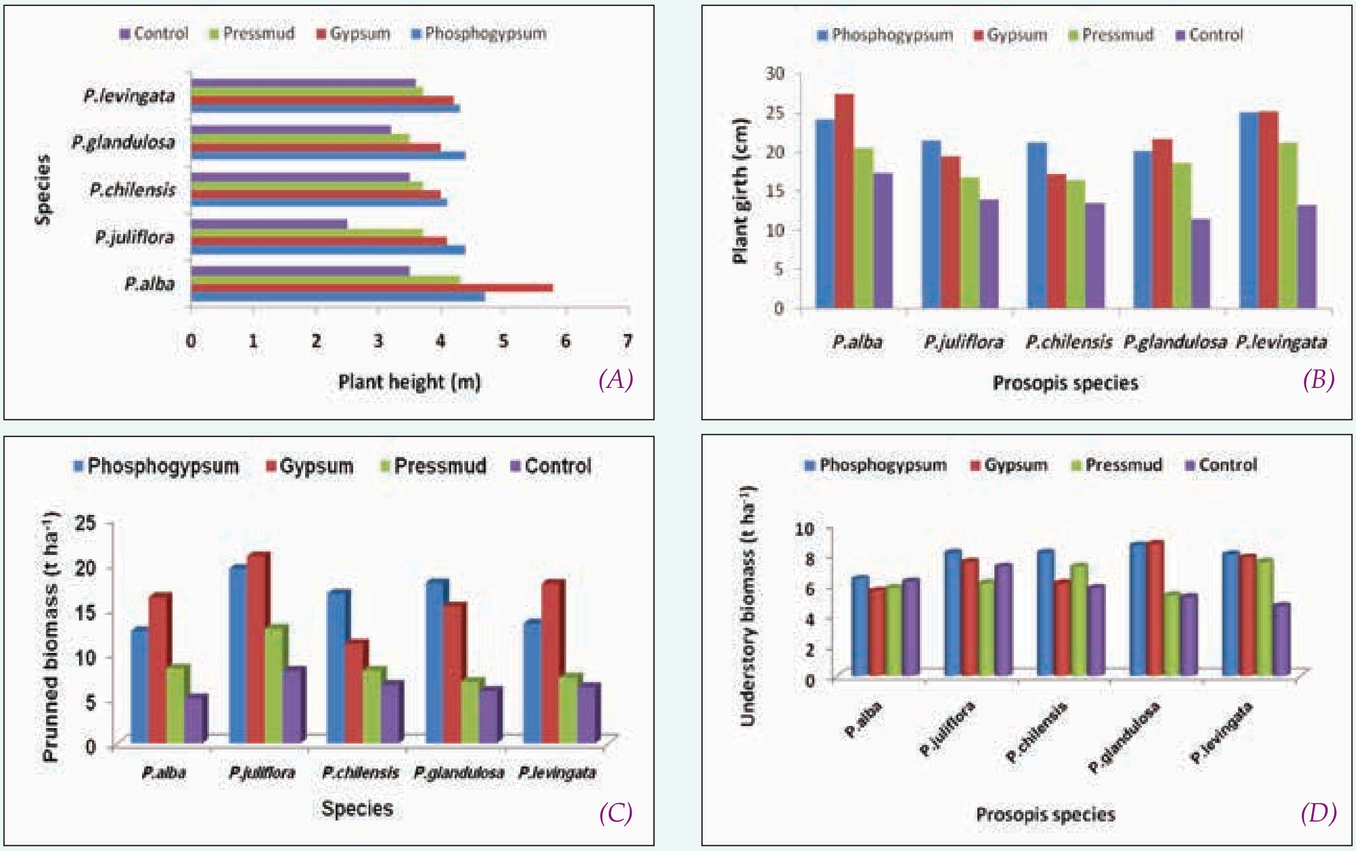


Fig. 42 : (A,B,C) Growth parameters of different Prosopis species planted with different amendments, (D) Understorey biomass yield of L. fusca

Maximum plant height (5.8 m) was attained by *P. alba* treated with gypsum followed by phosphogypsum treatment (4.7 m). Similar trend was recorded in plant girth. Maximum air dried pruned biomass (20.8 t ha^{-1}) was recorded with *P. juliflora* treated with gypsum followed by phosphogypsum and minimum with *P. glandulosa* (6.8 t ha^{-1}) under pressmud. *P. juliflora* also reported maximum pruned biomass (8.1t ha^{-1}) under control. Understorey dry biomass was maximum (8.7 t ha^{-1}) under *P. glandulosa* treated with gypsum but the difference between gypsum and phosphogypsum was not significant. *P. juliflora* reported maximum under storey biomass (7.2 t ha^{-1}) under control (Fig. 42). Maximum tree biomass yield (stem, root, branches, twigs and leaf) after four years of planting was recorded from phosphogypsum treated plants as compared to those treated with gypsum and press mud. In control treatment, where no amendment was added at the time of planting, *P. juliflora* produced maximum (10.1 t ha^{-1}) tree biomass yield whereas, minimum (8.3 t ha^{-1}) was attained with *P. chilensis* (Table 71).

Stress Tolerant Rice for Poor Farmers in Asia and South Africa (STRASA) (Y.P. Singh and V.K. Mishra)

Mother Trials

Under CSSRI-IRRI collaborative project 'Stress Tolerant Rice for Poor Farmers in Asia and South Africa' mother trials consisted of 15 rice genotypes viz; CSR 10 M_2 27, Bulk 18, CPWF 05-15, BMZ 20, RIL 178, Bulk 19, Bulk 22, CSR-89IR-14, CSR-89IR-15, CSR 2K 232, CSR 2K 219, CSR 2K 242, CSR 2K 255, CSR 2K 262 and CSR 12 B 23 (Table 72). The trials were conducted at CSSRI, Research farm, Shivri, Krishi Vigyan Kendra, Kaushambi, and village Patwakhera in *kharif* 2013 to identify a salt tolerant high yielding genotype through farmers participatory approach. The trials were conducted with 30-35 days old nursery transplanted on 8th, 12th and 17th July 2013 at pH 9.3, 10.0 and 9.8 with three replications. Recommended dose of fertilizers (120:60:40 NPK kg ha^{-1}) and zinc sulphate @ 25kg ha^{-1} were applied at all the locations. Due to continuous flooding for

Table 71 : Total tree biomass yield of *Prosopis species* planted with different amendments

Prosopis species	Total biomass (t ha^{-1}) after four years of plantation			
	Phosphogypsum	Gypsum	Pressmud	Control
P. alba	25.75	21.32	13.11	9.09
P. juliflora	23.60	21.23	16.10	10.14
P. chilensis	15.74	14.08	9.78	8.26
P. glandulosa	11.98	13.81	8.67	8.32
P. levingata	21.32	19.34	12.00	9.37

Table 72 : Grain yield and preference score of different genotypes evaluated through farmers participatory varietal selection

Name of genotypes	Shivri		Patwakhera	
	Grain yield (t ha^{-1})	Preference score	Grain yield (t ha^{-1})	Preference score
CSR 10 M_2 27	4.03	0.159	2.78	0.297
Bulk 18	3.62	0.080	2.64	0.029
CPWF 05-15	3.76	0.036	0.69	0.007
BMZ 20	3.01	-0.261	0.56	-0.203
RIL 178	2.08	-0.051	1.11	-0.145
Bulk 19	2.16	-0.051	1.39	-0.087
Bulk 22	2.31	-0.130	2.08	-0.058
CSR 89 IR 14	2.02	-0.029	2.36	-0.029
CSR 89 IR 15	2.38	-0.029	2.08	-0.181
CSR 2K 219	1.64	-0.058	3.89	0.181
CSR 2K 232	2.43	-0.065	2.22	-0.051
CSR 2K 242	2.20	0.145	3.23	-0.036
CSR 2K 255	1.90	0.007	2.25	-0.145
CSR 2K 262	4.46	0.283	3.75	0.420
CSR 12B 23	3.43	-0.036	3.30	0.000

Mother trial at Shivri

Mother trial at Samesi

more than 15 days at KVK, Kaushambi, the trial fields were completely submerged and damaged. To evaluate the performance of different varieties, farmers' participatory varietal selection (FPVS) was conducted at Shivri and Patwakhera. Based on the FPVS data, preference score was computed. On the basis of grain yield and preference score, genotype CSR 2K 262 was ranked 1st indicating that it is highly preferred by the farmers at both location.

Baby trials

To scale out the high yielding salt tolerant varieties CSR 36 and CSR 43, baby trials were conducted on 60 farmer fields covering 24 ha land in Patwakhera, Mohanpur, Maudipur gaus, Umarcha (Kaushambi) and Salehpur (Pratapgarh) villages of Lucknow, Kaushambi and Pratapgarh districts of Uttar Pradesh, respectively during *kharif* 2013. These varieties were planted at soil pH ranged from 8.9 to 10.2, and compared with farmers own varieties like Ganga kaveri and BPT 5204. On the basis of yield data collected from 60 farmer fields of three districts, CSR 36 yielded 4.55, 5.96 and 4.50 t ha^{-1} and CSR 43 yielded 3.65, 5.61 and 4.72 t ha^{-1} whereas farmers own varieties yielded 2.87, 4.95 and 3.84 t ha^{-1}. The yield enhancement of salt tolerant variety CSR 36 and CSR 43 was 28.5 and 13.7 per cent over the farmer's varieties. The yield enhancement of CSR 43 was comparatively less than CSR 36 over farmers varieties but it matured about 15-20 days earlier than CSR 36 and traditional varieties, which saved about 3 irrigations. Location wise average grain yield of CSR 36, CSR 43 and farmer's variety is given in Fig. 43.

Baby trial at Patwakhera

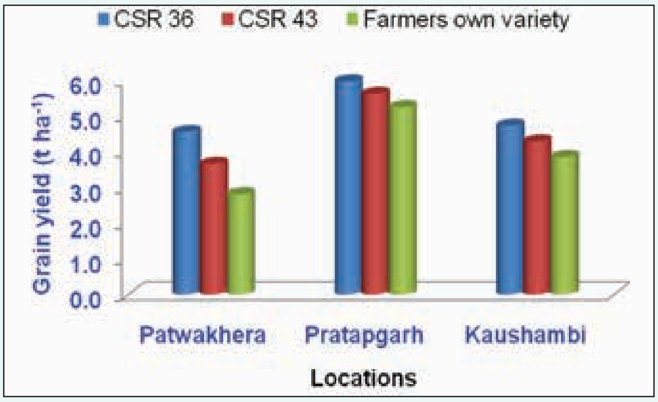


Fig. 43 : Average grain yield of CSR 36, CSR 43 and farmers own varieties under farmers managed baby trials

Salt Tolerant Breeding Network Trial (STBN)

The experiment consisted of 32 rice genotypes/ cultures, including four checks was conducted at Shivri Research farm, Lucknow in randomized block design (RBD) with three replications during *kharif* 2013. The soil pH_2 was 9.2 and EC_2 was 1.34 dS m^{-1}. Five rows of thirty days old seedlings were transplanted on 24th July, 2013 at 20 x 15 cm spacing. The recommended dose of fertilizers was applied in three equal splits. Among the genotypes evaluated, four genotypes viz. CSRC (D) 2-17-5, CSRC (D) 12-8-12, CSRC (D) 13-16-9 and CR2218-64-1-227-4-1 did not flower. The grain yield of top five genotypes was : 6.0 t ha^{-1} (CSR-2K-262), 5.47 t ha^{-1} (KR09003), 5.08 t ha^{-1} (CSR-2K-219), 4.99 t ha^{-1} (RP 4353-MSC-38-43-6-2-4-3) and 4.89 t ha^{-1} (NDRK 11-4). These genotypes were found promising as compared to all other genotypes tested (Fig. 44).

Trial of STBN entries under moderate sodic soil at Shivri farm

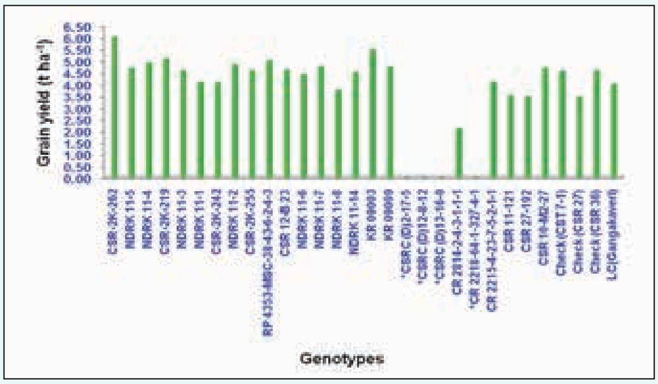


Fig. 44 : Grain yield of STBN entries under moderate sodic soil (pH 9.2)

Improved Rice Crop Management for Raising Productivity in Submergence Prone and Salt Affected Rainfed Low Lands in South Asia (IFAD funded) (Y.P. Singh and V.K. Mishra)

Optimizing nitrogen doses in conjunction with growth promoter to harness productivity potential of salt tolerant CSR 43 rice cultivar

To find out the optimum dose of N in nursery as well as in main field, nursery management trial consisting of two nitrogen levels (N_1-125 kg and N_2-150 kg ha^{-1}) with T_1-CSR Bio and T_2-without CSR-Bio was conducted with three replications at CSSRI, Research farm Shivri during *kharif* 2013. Seed treated with 10 % CSR- bio and also without treatment was sown in nursery. Half dose of N and full dose of P & K was applied at the time of sowing of nursery and remaining N was applied in two equal splits at 10 and 20 days after sowing. 30 days old seedling was transplanted in main field having soil pH 9.1 with five nitrogen doses (100, 125, 150, 175 and 200 kg ha^{-1}) and three replications. A uniform dose of P (60 kg ha^{-1}), K (40 kg ha^{-1}) and $ZnSO_4$ (25 kg ha^{-1}) was applied in all the treatments. Half dose of N, full dose of P, K and Zinc sulphate were applied at the time of transplanting and remaining half dose of N was applied in two equal splits at tillering and panicle initiation stages. Growth data collected from nursery revealed that maximum plant height, number of leaves per plant and root and shoot weight were recorded from the nursery treated with CSR-Bio and fertilized with 150 kg N ha^{-1}. The grain yield of CSR 43 was significantly higher from the nursery raised with N @ 150 kg ha^{-1} + CSR-Bio over 125 kg N ha^{-1} with CSR-Bio. Maximum grain yield (5.73 t ha^{-1}) of CSR 43 was recorded with 150 kg N ha^{-1} applied in the main field. As the level of N increased from 150 kg ha^{-1} to higher tested levels, the grain yield of CSR 43 did not increase significantly (Table 73).

Effect of short duration salt tolerant variety of rice on cropping intensity under different sodic environments

To identify tolerance level, date of transplanting and suitable cropping system that can be fitted with short duration CSR 43 salt tolerant variety, an experiment consisting of four sodicity levels (pH 8.8, 9.2, 9.6 and 9.8), three date of rice transplanting (1st July, 16th July and 1st August) and three crop rotations viz. rice-wheat, rice-spinach-wheat and rice-ladyfinger was initiated at CSSRI, Research Farm Shivri during 2012-13. The data of all the cropping system revealed that wheat grain yield reduced significantly with increasing levels of sodicity. Maximum wheat yield was obtained at pH 8.8 in both rice-spinach-wheat and rice-wheat cropping systems. Cost economics of all three

Table 73 : Effect of N levels in nursery and main field on grain yield of rice (cv CSR 43)

Nitrogen levels in main field (kg ha^{-1})	Nursery management				Mean
	125 kg N ha^{-1} + CSR Bio	125 kg N ha^{-1} + Control	150 kg N ha^{-1} + CSR-Bio	150 kg N ha^{-1} + Control	
N_1-100	4.96	4.77	5.10	4.99	4.96
N_2-125	5.23	4.93	5.30	5.13	5.15
N_3-150	5.39	5.42	5.73	5.48	5.51
N_4-175	5.28	5.10	5.47	5.27	5.28
N_5-200	5.22	4.82	5.54	5.46	5.26
Mean	5.22	5.01	5.43	5.27	-

cropping systems was calculated on the basis of support price of rice, wheat and toria and the sale price of spinach and lady finger. Maximum net income was recorded with rice-toria-ladyfinger cropping system as compared to rice-spinach-wheat and rice-wheat system (Table 74). System productivity calculated on the basis of rice equivalent yield was maximum from rice-toria-ladyfinger cropping system as compare to rice-wheat and rice-spinach-wheat (Fig 45).

To validate the above results, the experiment was repeated during 2013-14 with three rice based cropping systems viz. rice-wheat, rice- spinach-wheat and rice-toria-wheat. Thirty days old seedlings of CSR 43 was transplanted on 1st July 2013 and harvested on 29th September 2013 with total duration of 120 days. In rice–wheat cropping system, wheat (cv KRL 213) was sown on 20th November 2013. In rice-spinach-wheat crop rotation, spinach crop was sown on 15th October and harvested on 15th December and wheat was sown on 20th December 2013. In rice-toria–wheat cropping system, toria (*Brassica compestris*) was sown on 1st October and harvested on 31st December and late sown variety Halna of wheat was sown on 8th January 2014. The average grain yield of rice, spinach and toria was recorded 5.20, 12.40 and 0.78 t ha^{-1}, respectively. With the introduction of short duration variety, the cropping intensity of partially reclaimed sodic soils has increased to 300 per cent. Earlier maturation of variety CSR 43 is helpful in saving of about two irrigations per season which saves farmers costs. Moreover, such water saving could extremely be useful in conserving depletion of water tables. In addition, economic benefits of its early maturity saved Rs. 2400 ha^{-1} through irrigation water reduction. With the introduction of CSR 43, we can identify certain other rice based crop diversification options for partially reclaimed sodic soils to enhance the income of the farmers.

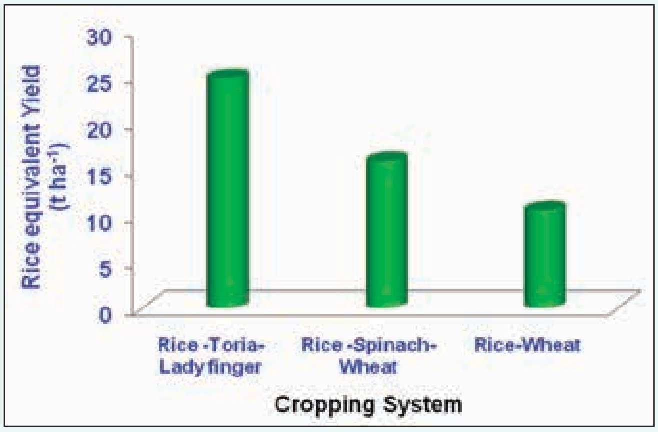


Fig. 45: System productivity of rice based cropping systems in reclaimed sodic soil (pH 8.8)

Cluster Demonstration of Salt Tolerant Varieties of Rice and Wheat (Y.P. Singh, V.K. Mishra and Sanjay Arora)

During *rabi* 2012-13, a cluster demonstration of salt tolerant variety of wheat KRL 19 was conducted at 16 ha salt affected land of village Santaraha in Hardoi district of Uttar Pradesh which was reclaimed during 2012 through integration of gypsum and pressmud. The work was done in a collaborative mode with the involvement of CSSRI, UPBSN and DSCL Sugar mill Hardoi. The

Table 74 : Cost economics of different rice based cropping systems evaluated at different pH levels.

Date of rice transplanting	Crop rotation	Soil pH_2	Yield (t ha^{-1})			Gross income (Rs ha^{-1})	Cost of production (Rs ha^{-1})	Net income (Rs ha^{-1})
			Ist crop	IInd crop	IIIrd crop			
01.07.2012	Rice-toria-lady finger	8.8	5.68	1.30	14.00	271353	79135	192218
		9.2	5.03	0.98	13.00	243221	79135	164086
		9.6	4.82	0.74	4.20	128117	79135	48982
		9.8	4.28	0.33	0.96	71338	79135	-7797
16.07.2012	Rice -spinich -wheat	8.8	4.73	1.40	3.90	184179	59387	124792
		9.2	4.18	9.85	3.03	157395	59387	98008
		9.6	4.10	7.82	0.94	116309	59387	56922
		9.8	3.93	4.51	0.45	78219	59387	18825
01.08.2012	Rice-wheat	8.8	4.15	-	3.60	113668	49779	63889
		9.2	4.03	-	2.81	99874	49779	50095
		9.6	3.87	-	1.13	70725	49779	20946
		9.8	3.64		0.44	49789	49779	10

soil of the site was highly alkaline having pH 9.0 to 10.6, EC 1.44-2.65 dS m^{-1} and gypsum requirement 6.40 to 13.60 t ha^{-1}. After reclamation of land and growing of salt tolerant variety of rice as first crop, the soil pH was reduced from 8.8 to 9.8. To monitor the performance of salt tolerant variety KRL 19 and traditional variety PBW 343 of wheat, a cluster demonstration on 20 farmer's fields covering 8 ha land was conducted during *rabi* 2012-13. The grain yield of salt tolerant variety KRL 19 ranged from 0.94 to 4.46 t ha^{-1} with an average of 3.57 t ha^{-1} whereas traditional variety PBW 343 yielded 2.60 t ha^{-1}. The yield enhancement of KRL 19 over PBW 343 was 37.3 per cent.

During *kharif* 2013, a cluster demonstration of salt tolerant variety of rice 'CSR 36' was conducted at 43 farmers' field covering 16 ha land on the same site. Salt tolerant variety CSR 36 was compared with traditional variety Ganga Kaveri. Before initiating the demonstration, soil samples were collected and analyzed for soil pH. The pH ranged from 8.8 to 9.6. Based on crop cutting data, the grain yield of CSR 36 ranged from 4.00–6.50 t ha^{-1} with an average of 5.4 t ha^{-1}. However, the grain yield of variety Ganga Kaveri ranged from 4.00 to 5.42 t ha^{-1} with an average of 4.8 t ha^{-1}. The yield enhancement in CSR 36 over Kanga Kaveri was 12.5 per cent. However, at high sodicity levels (pH 9.8), yield enhancement of CSR 36 was up to 43.2 per cent.

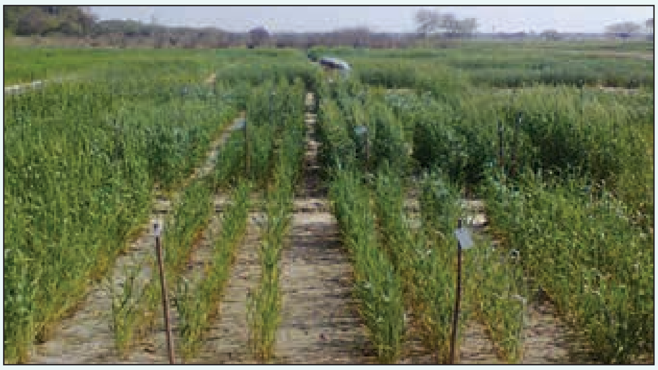
Performance of CSR 36 and farmers' variety in village Santaraha

Screening and Evaluation of Rice, Wheat and Mustard Genotypes for Sodic Soils (Y.P. Singh and Dhananjay Singh)

Wheat

All India Coordinated Wheat Improvement Trial

During *rabi* 2012-13, All India Coordinated Wheat Improvement trial was conducted at CSSRI, Regional Research Station, Shivri farm, Lucknow.



All India Salinity /Alkalinity Tolerance Nursery Trial

The trial consisted of 11 genotypes/varieties laid in randomized block design with six replications. The crop was sown on Nov. 24, 2012 at a row spacing of 23 cm and 2 m row length. Harvested was done on April 9, 2103. The trial was conducted in the field having pH_2 9.1-9.2. Among the genotypes/varieties screened, genotype SPL-AST-01 produced maximum grain yield (1.94 t ha^{-1}) followed by genotypes SPL-AST-7 (1.93 t ha^{-1}) and minimum (1.46 t ha^{-1}) in SPL-AST-10.

All India Salinity/Alkalinity Tolerance Nursery Trial

All India Salinity/Alkalinity Tolerant Nursery Trial on wheat consisted of 59 genotypes including 5 checks (Kharchia 65, HD 4530, KRL 19, KRL 3-4 and KRL 210) was conducted at CSSRI, Research Farm Shivri, Lucknow during *rabi* 2012-13. The trial was laid at soil pH_2 9.1-9.2. Two rows of 3 m length were sown on Nov. 24, 2012 and harvested on April 9, 2013 with plot size of 1.8 m^2. Genotype NW 6010, PS-1080, KRS 1213, KRS 1207, LBP 2012-25, WH 1303, LBP 2012-24, and KRS 1209 found promising and yielded 600, 590, 570, 560, 499, 462, 419 and 407 g $plot^{-1}$, respectively.

Mustard

All India Coordinated Trial on Rapeseed Mustard

Four genotypes were evaluated in IVT under alkaline condition (pH_2 9.3-9.5) at CSSRI, Research farm Shivri, Lucknow. Significant differences were observed in seed yield amongst the genotypes evaluated. Seed yield ranged from 1.39-2.01 t ha^{-1}. Genotype CSCN 2012-13-01 (2.01 t ha^{-1}) followed by CSCN-2012-13-04 (1.87 t ha^{-1}) and CSCN 2012-13-02 (1.45 t ha^{-1}) produced highest seed yield.

Another AVT trial consisting of four genotypes was evaluated at CSSRI, Research farm Shivri, Lucknow at pH_2 9.3-9.5. Significant differences were observed in seed yield amongst the genotypes evaluated. Seed yield ranged from 0.95-2.09 t ha^{-1}. Genotype CSCN2012-13-08 (2.09 t ha^{-1}) followed by CSCN-2012-13-05 (1.96 t ha^{-1}) and CSCN2012-13-07 (1.90 t ha^{-1}) produced highest seed yield.

Rice

Alkaline and Inland Saline Tolerant Variety Trial (AL& ISTVT)

Twenty nine rice genotypes including three alkaline check and one local check were evaluated under highly sodic soil (pH_2-9.7) at Research Farm, Shivri, Lucknow (U.P.) during *kharif* 2013. The trial was conducted in randomized block design with three replications. Each genotype was planted in five rows of 8.4 m length having gross plot size of 8.4 m^2. Thirty two days old nursery was transplanted on 29.07.2013. Genotype 2117 reported highest grain yield (4.55 t ha^{-1}) followed by genotype 2114 (4.28 t ha^{-1}), and 2118 (3.98 t ha^{-1}) (Fig. 46).

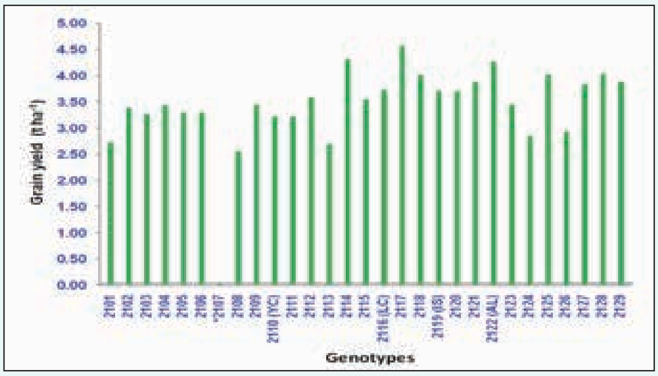


Fig. 46 : Grain yield of 29 genotypes screened under AL & ISTVT trial

Alkaline and Inland Saline Tolerant Variety Trial

Screening of Segregating Material

To monitor the performance of segregating material, a trial consisting of 30 lines including 3 checks was conducted at pH_2-9.2. Amongst the lines, highest grain yield (4.20 t ha^{-1}) was recorded with genotype 77-2 followed by genotype 83-1 (4.10 t ha^{-1}) whereas minimum (1.70 t ha^{-1}) with genotype 80-3.

Segregating line trials

All India Coordinated Agronomy Trial

AVT-AL&ISTVT trial

Nitrogen response trial on selected AVT-2 rice cultures under high and low input management environments was conducted at Lucknow during *kharif* 2013.The objective of the trial was to study the grain yield potential, nutrient response and nutrient use efficiency of promising AVT-2 cultures under high and low input management and to identify promising and stable genotypes based on the grain yield efficiency index. Treatments consisted of three nitrogen levels (N_1-50% of recommended dose, N_2-100% of recommended dose and 150% of recommended does) in main plot and rice cultures/varieties (Two AVT lines viz. IET 20328 and IET 22017 and four checks viz. CSR 23, CSR 36, Jaya and local Ganga Kaveri) in sub–plot. An experiment was laid in split plot design with three replications in a plot size of 15 m^2. The experiment was conducted at soil pH_2 - 9.2. Grain yield of all the entries increased with increasing levels of N. Maximum grain yield (5.59 t ha^{-1}) was recorded with CSR 36 at 150% of recommended dose. However at 100% recommended dose IET 22017 reported maximum (4.93 t ha^{-1}) grain yield.

Identification of Genotypes in Banana, Guava and *Aonla* for Tolerance to Sodicity and Standardization of Management Practices for Economic Livelihood in the Resource Poor Sodic Lands (T. Damodaran, V.K. Misra, D.K. Sharma and C.L.Verma)

Screening of guava for sodicity tolerance

Four varieties of guava (Shweta, Lalit, Sardar and Allahabad Safeda) were screened under three different planting systems (2 x 2 m), (3 x 3 m) and (3 x 1.5 m). The trees under the 2 x 2 m planting systems gave the highest yield (3.232

Table 75 : Morphological and yield characters of guava in high density system

Planting system	Variety	Yield (kg plant^{-1})	Plant girth (cm)	Plant height (cm)	Canopy (cm)
2 x 2 m	Shweta	2.82^{d}	23^{c}	140^{b}	450^{e}
	Lalit	3.23^{g}	28^{f}	145^{c}	466^{f}
	A. Safeda	2.50^{e}	26^{e}	142^{bc}	375^{c}
	Sardar	1.25^{c}	21^{c}	135^{a}	328^{a}
3 x 3 m	Shweta	6.40^{b}	21^{c}	156^{e}	350^{b}
	Lalit	5.48^{b}	26^{e}	163^{f}	390^{c}
	A. Safeda	4.12^{a}	18^{ab}	152^{c}	330^{a}
	Sardar	2.94^{a}	16^{a}	154^{ce}	335^{ab}
3 x 1.5 m	Shweta	5.23^{f}	27^{e}	148^{c}	345^{b}
	Lalit	4.40^{b}	24^{cc}	145^{c}	334^{a}
	A. Safeda	4.12^{b}	17^{ab}	140^{b}	325^{a}
	Sardar	2.74^{c}	20^{bc}	142^{bc}	330^{a}

Values are the means of three replications. Means in the columns followed by the same subscript letter are not significantly different according to Duncan's multiple range test at P=0.05.

kg plant^{-1}) with variety Lalit (Table 75). Due to higher responsive nature of variety Lalit, the yield increase was higher as compared with other varieties. However, under high density system (3 x 3 m) and (3 x 1.5 m), variety Shewta out yielded all other varieties and under high sodicity conditions, an average yield of 6.40 kg plant^{-1} was obtained. The analysis of the varieties for their yield revealed higher inter clonal variability due to differential response of non-descriptive rootstocks used for grafting. This problem was more where soil pH was higher than 9.35 at 15-30 cm depth.

Development and screening of wilt and salt tolerant rootstock of guava

A hybrid between *P. molle* x *P. guajava* was developed at CISH, Lucknow and found resistant to the wilt disease as well as it has produced significant growth at pH 9.6 and thus making guava cultivation possible in the areas where wilt and high pH are the main limiting factors for it successful cultivation. Since, clonal multiplication of inter specific wilt resistant rootstock is pre-requisite for it utilization at commercial scale, a two leaf cutting multiplication technique was developed at Central Institute of Sub-tropical Horticulture which is in process of patent protection.

The rootstock was screened in sodic soils of CSSRI, RRS, Lucknow where the soil pH was 9.7 without addition of any ameliorants and compared with normal Lalit on non-descriptive rootstock which is the current nursery practice. It was observed that the inter specific rootstock was more vigorous and exhibited lower Na/K ratio with higher activity of stress tolerant defense enzymes like SOD (super oxydismutase), PO (Peroxidase) and PPO (Poly Phenol oxidase) (Fig. 47).

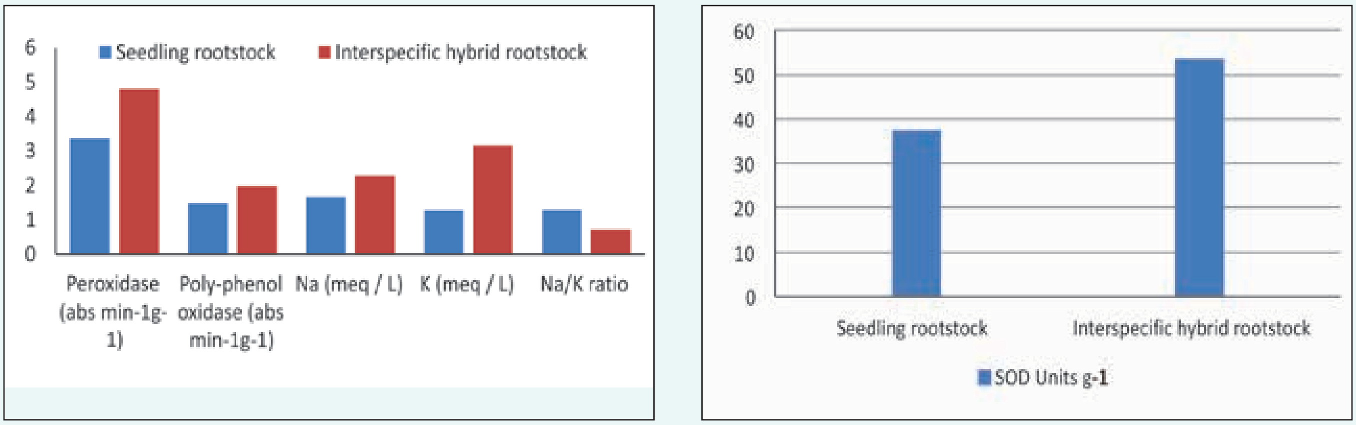
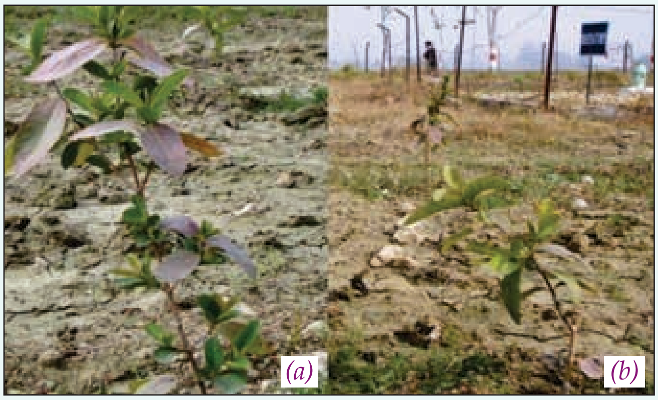


Fig. 47 : Effect of sodicity on Na/K contents in leaves and stress enzymes

Two leaf cutting multiplication technology for interspecific rootstock



Rootstock screening at Lucknow (a) Lalit guava graft on tolerant rootstock at pH 9.6 (b) Lalit graft on seedling at pH 9.6 rootstock

Holistic Approach for Improving Livelihood Security through Livestock Based Farming System in Barabanki and Raebareli districts of U.P. (NAIP-III Project) (T. Damodaran, D.K. Sharma, V.K. Mishra and S.K. Jha)

CSR-BIO – Bio-growth enhancer for commercial horticultural crops

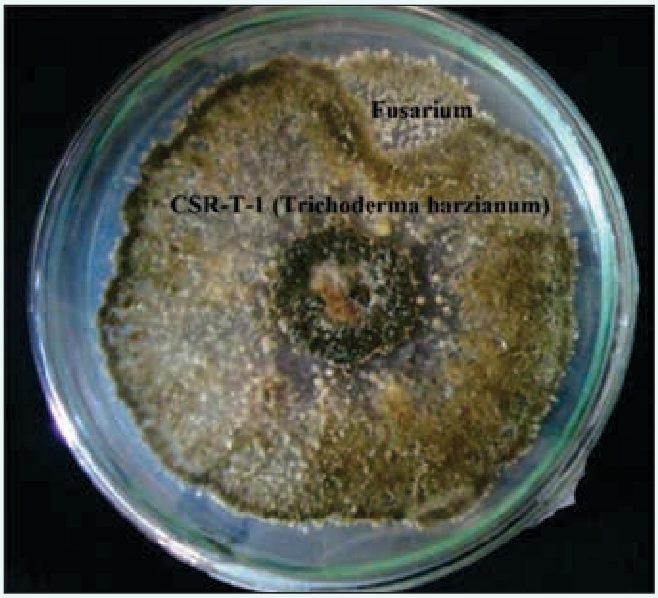
The productivity of commercial crops particularly high value horticultural crops in sodic soils even after the reclamation remains a challenge globally. The normal land is also witnessing decline in productivity due to fatigue of green revolution. Given the negative environmental impacts of chemical fertilizers and their increasing costs, the use of PGPR (Plant Growth Promoting Rhizobacteria) is considered as an alternative or a supplemental way to increase the productivity of sodic soils and thereby reducing the use of chemicals in agriculture. Currently, there are no efficient strains available to perform under sodic conditions where soil pH is more than 8.5. Though considerable number of microbial isolates are available in the country as biofertilizers and biocontrol agents, for soils of pH 7.0 to 8.5, they are highly location specific and are based on single potential isolate. Furthermore, the cost of commercial product ranges from Rs. 100-150/kg in the open market and public sector institutions. Due to high cost, location specific performance, the small and marginal farmers have reservation over its use and are inclined towards indiscriminate use of chemical fertilizers and fungicides which apart from reducing the sustainability in production also spreads concerns over eco-system contamination with residual toxicity effect. Addressing the above mentioned issues, the CSSRI, Regional Research Station, Lucknow and IVRI, Izatnagar under the world bank funded National Agricultural Innovation Project has developed a potential bio-growth enhancer based on integration of dynamic microbial consortia with dynamic patented culture media for increasing the productivity of crops grown in sodic soils as well as in normal soils.

Salient features

- The consortia of microbes enhance the growth, productivity, nutrient mobilization and support the establishment of plantlets.
- Promotes growth of crops grown in sodic as well as normal soils with increase in the quality of produce.
- Supports the growth of crops by increasing photosynthetic and bio-chemical activity of the leaves.
- Acts as soil conditioner and biocatalyst.
- Highly economical and also induces systemic disease resistance in treated plants against soil borne diseases apart from growth enhancement.
- Performs over a wide range of soils with pH varying from 6.5 to 9.3.

Efficacy of fungal and bacterial strains used in CSR-BIO against *F. solani in vitro* conditions

The strains CSR-B-2, CSR-B-3 and CSR-T-1 were evaluated for antagonistic effect against *Fusarium solani* on petri dishes containing PDA medium showed that all the three strains succeeded in eliciting antagonistic activity against *F. solani* pathogen. *T. harzianum* was more effective in reduction of pathogen growth by exhibiting 6.7 cm radial growth



Antagonistic effect of CSR-T-1 (Trichoderma harzianum on fusarium)

Table 76 : Effect of CSR-T-1, CSR-B-2 and CSR-B-3 against the radial growth of *F. solani*

Microbial strain	Mean radial growth (cm)	Reduction %
T. harzianum (CSR-T-1)	6.7	74.4
B. pumilus (CSR-B-2)	3.6	40.0
B. thuringensis (CSR-B-3)	3.9	43.3
Control	9.0	0.0

followed by *Bacillus thurigensis* (3.6) and *Bacillus pumilus* (3.9). Moreover, *T harzianum* reduced the growth percentage of *F. solani* (Table 76) by 74.4 per cent followed by *B thurigensis* (43.3 %).

Efficiency of antagonistic biocontrol agents under green house conditions

Pot culture experiment was undertaken to assess the efficacy of the three biocontrol agents to antagonize *F. solani* under green house conditions in tomato var. NS 507 of Namdhari Seeds, Ltd.. Data revealed

Table 77 : Influence of antagonistic strains applied against *F. solani* and their effect on seedling survival percentage under green house conditions

Treatment	Damping off (%)		Survival (%)
	Pre-emergence	Post emergence	
F solani + T. harzianum	16.6	0.0`	83.4
F. solani + B. pumilus + B. thuringensis	25.0	8.3	66.6
F. solani + CSR BIO	16.6	0.0	83.4
F. solani	66.6	16.6	16.6
CD (0.05%)	8.20	8.14	9.16

that soil infested with *F. solani* alone significantly increased the incidence of wilting of tomato seedlings which reduced the survival percentage to 16.6 when compared with soils treated with *F. solani* + CSR-BIO (*Trichoderma harzianum* + *Bacillus pumilus* + *Bacillus thurigensis*) and *Trichoderma harzianum* alone showed 83.4 per cent survival rate (Table 77).

It was observed that the plant height (Fig. 48a) and dry weight (Fig. 48b) were also significantly higher in plants treated with CSR-BIO and CSR-T-1, the strain of *Trichoderma harzianum* than the plants treated with *F. solani* (control). The treatments with CSR-BIO and CSR-T-1 of *Trichoderma harzianum* antagonised *F. solani* and protected the plant from the wilt disease.

Impact of CSR-BIO-an eco-friendly bio-growth enhancer on increasing profitability of horticultural crops to small and marginal land holders

A cost effective bio-growth enhancer CSR-BIO was tested in Barabanki district of Uttar Pradesh.

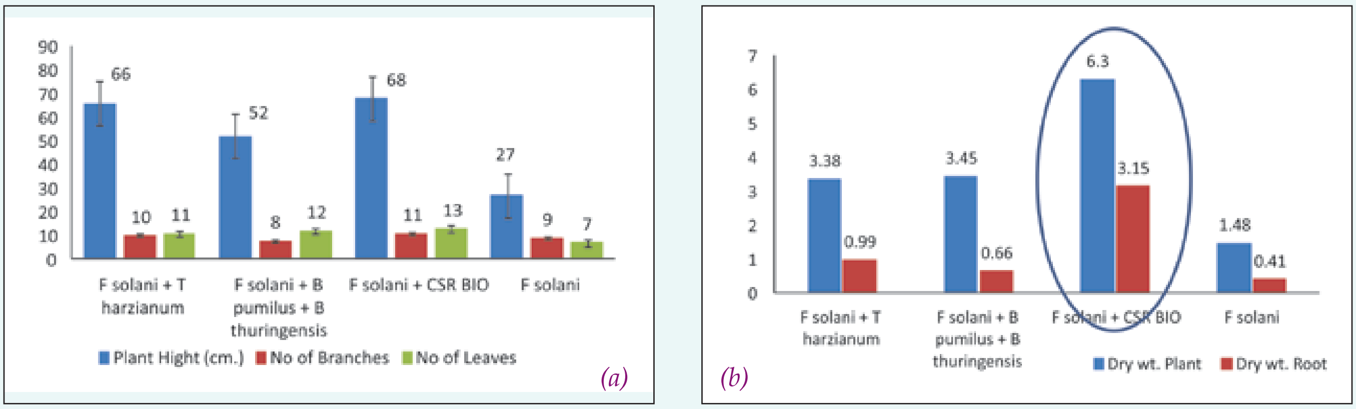


Fig. 48 : Effect of F. solani on green house tomato plant var. NS 507

The profitability of the formulation in commercial crops like tomato and banana with its impact on reducing use of chemical fungicides toxic to environment was assessed with adopters and non adopters of CSR-BIO in two major banana and tomato growing areas of the Barabanki district (Trivediganj and Haidergarh) during two growing seasons of 2011-12 and 2012-13. A structured questionnaire was designed and used in the collection of data from the respondents. Data were collected from 100 adopters and 100 non-adopters of CSR BIO technology in tomato var. Himsona (Syngenta Hybrid Seeds, India) and banana var. G-9 (Hindustan Bioenergy Ltd.). Survey was restricted to adopters and non-adopters who had similar land fertility status and market. Frequencies, means and standard deviation and independent T test were used for testing the significance at $P = 0.01$ between adopters and non adopters.

Results showed an overall increase in yield up to 22.43 and 15.62 per cent in the adopters of tomato and banana which simultaneously increased the gross profitability to 20.11 and 17.39 per cent in banana and tomato, respectively. The use of plant protection chemicals was 47.33 and 33.36 per cent lower than the non-adopters who didn't practice the technology in tomato and banana, respectively. The mean banana bunch yield of 31.53 kg was obtained with adopters while non-adopters obtained a mean bunch yield of 27.27 kg. The mean expenditure incurred in production was Rs. 1.60 lakhs among the adopters while it was Rs. 1.75 lakhs among non-adopters. Adopters gained an average gross income of Rs.6.95 lakhs from one hectare while the non adopters obtained a gross profit of Rs.5.90 lakhs from one hectare of crop. Adopters sprayed their crops with pesticide/ fungicide combination for 7.33 times while the non adopters used chemical sprays for 11.07 times (Table 78).

In case of tomato, adopters obtained a mean yield of 49.10 t ha^{-1} while non-adopters obtained 40.12 t ha^{-1} (Table 79). The mean expenditure incurred in production was Rs. 92,500/- among adopters while Rs. 1,02,500/- among non adopters. The gross return obtained was Rs. 5.53 and Rs. 4.60 lakhs by the adopters and non-adopters, respectively. An average of 6.5 sprays was done to the crop during its growing period by the adopters while the mean spray used by non adopters was 12.4 times.

Impact of social factors in adoption of CSR-BIO - A cost effective, eco-friendly bio- growth enhancer for sustainable crop production

The sampling population was divided into two groups, small (< 1 ha) and large farmers (> 1 ha),

Table 78 : Impact of CSR-BIO on profitability and environment among the adopters and non-adopters in banana (N=100)

Parameters	*Group	Mean	Standard deviation (SD)	Significance ($P = 0.05$)	Standard error difference (SED)
Yield (kg)	1	31.53	4.61	0.030	1.867
	2	27.27	5.57	0.030	1.867
Expenditure (Rs)	1	0.65	5.52	0.006	2.026
	2	0.71	5.57	0.006	2.026
Income (Rs)	1	2.78	0.39	0.013	0.157
	2	2.37	0.46	0.013	0.157
Pesticide	1	7.33	1.20	0.004	0.658
	2	11.07	2.25	0.005	0.658

*1= adopters; 2= non adopters



Commercial cultivation of bio-primed banana and tomato

Table 79 : Impact of CSR BIO on profitability and environment among adopters and non-adopters in tomato (N=100)

Parameters	*Group	Mean	Standard deviation	Significance (P = 0.05)	Standard error difference
Yield (t ha^{-1})	1	49.10	4.079	0.004	1.137
	2	40.12	1.663	0.005	1.137
Expenditure (lakhs ha^{-1})	1	0. 925	4.224	0.026	1.414
	2	1.025	3.489	0.026	1.414
Income (lakhs ha^{-1})	1	5.53	0.448	0.008	0.130
	2	4.60	0.229	0.010	0.130
Pesticide (Times)	1	6.533	1.567	0.001	0.569
	2	12.400	1.549	0.001	0.569

based on the average land holding data to assess the social factors that led to the acceptance and adoption of CSR-BIO technology. 344 respondents were interviewed among 582 beneficiaries of the technology. Respondents were restricted to farmers who had practiced the technology more than once. Training was imparted to farmers group of four clusters each in two blocks of the district during 2010-11, 2011-12 and 2012-13. A structured questionnaire was designed and used for data collection from the respondents' socio economic conditions, use of technologies and factors contributing towards the adoption of technology. The questions were based on the impact of training sessions attended, occupation, land holdings, age, sex etc. It was hypothesized that these variables influenced significantly the adoption process of the technology. They also had a strong relationship with the intensity of adoption (AI).

Adoption intensity (AI) = (Adoption score/highest score) x 100

The score details are :

Those adopted only seed treatment = 1
Those adopted seed treatment + soil application = 2
Those adopted seed + soil treatment + 2 foliar spray = 3
Those adopted seed + soil treatment + 1 foliar spray = 4

Data analysis was based on descriptive statistics such as percentages, frequencies and means. The assessment of adoption level was expressed in percent. Regression analyses based on logit regression model using dummy variables were used for assessing the level of factors contributing the adoption intensity (AI). According to results of the investigation, the important factors that influenced the adoption and adoption intensity of the technology included training level, engagement in agriculture as primary occupation and small landholding. Therefore, it can be concluded that small landholders form economically backward group with agriculture as primary occupation showed more interest in attending training program and adopting the technology intensively than the big landholders (Table 80).

CSR-BIO – Commercialization of technology

The technology of CSR-BIO production using microbial consortium of *Bacillus pumilus*, *Bacillus thurigensis* and *Trichoderma harzianum* in a dynamic media was patented and commercialized by NAIP on Nov. 7, 2012 and subsequently by ICAR on July 20, 2013. The technology was presented before private entrepreneurs for licensing under the chairmanship of Deputy Director General, Horticulture where

Table 80 : Logistics regression co-efficient of the factors affecting the adoption intensity (AI) of CSR-BIO technology (N=344)

Statistics variable	Parameter estimate	Standard error	Pr > |t|	Significance	Adjusted R-Square	Co-efficient of variation
Training	0.05008	0.22428	0.8243*	0.001	0.9504	23.63285
Land Holding	-0.11498	0.20017	0.5686*	0.000		
Occupation	0.17785	0.26978	0.5132*	0.015		
Marketing	0.31790	0.28126	0.1430	0.385		
Age	-0.87353	0.88521	0.3291	0.386		
Gender	-0.32889	0.22051	0.1250	0.385		

* Significance at P= 0.01 %

three firms have entered MoU with ICAR for licensing. The licence was transferred by Hon'ble member Planning Commission Dr.Kasturirangan to the producer companies. A number of germplasms were registered with NBAIM, Mau (Table 81) and salt tolerant microbes registered at MCBT, Maryland (Table 82).

Table 81 : Germplasms registered with National Bureau of Agricultural Important Micro-organism, Mau, Uttar Pradesh

S. No	Scientific name	Accession No.	NBAIM-Mau Accessions number
1	*Bacillus thuringiensis*	CSR B 3	TB- 1660
2	*Bacillus cereus*	CSR-B-1	TB- 1664
3	*Bacillus pumilus*	CSR-B-2	TB- 1663
4	*Bacillus sp*	CSR-B-4	TB- 1659
5	*Oceanobacillus*	CSR-O-1	TB- 1665
6	*Bacillus pumilus*	CSR-M-12	TB- 1653
7	*Bacillus megatarium*	CSR-M-8	TB- 1654
8	*Bacillus coagulans*	CSR-M-6	TB- 1655
9	*Bacillus subtilis*	CSR-M-16	TB- 1662
10	*Bacillus marisflavi*	CSR-G-4	TB- 1661
11	*Bacillus subtilis*	CSR-G-5	TB- 1657
12	*Bacillus subtilis*	CSR-G-1	TB- 1658
13	*Trichoderma harizanum*	CSR-T-1	TF- 1273

Table 82 : Salt tolerant microbes partial sequences registered with National Centre for Biological Information (NCBI), Maryland (USA)

S. No	Scientific name	Strain name	NCBI, ID.No.
1	*Bacillus thuringiensis*	CSR B 3	KF383226
2	*Bacillus cereus*	CSR-B-1	JQ768235
3	*Bacillus pumilus*	CSR-B-2	JQ768236
4	*Bacillus sp*	CSR-B-4	KC433665
5	*Oceanobacillus*	CSR-O-1	KC433666
6	*Bacillus pumilus*	CSR-M-12	KC433667
7	*Bacillus megatarium*	CSR-M-8	KF382761
8	*Bacillus coagulans*	CSR-M-6	JQ768242
9	*Bacillus subtilis*	CSR-M-16	KC768636
10	*Bacillus marisflavi*	CSR-G-4	KC433668
11	*Bacillus subtilis*	CSR-G-5	KC433669
12	*Bacillus subtilis*	CSR-G-1	JQ740645
13	*Trichoderma harizanum*	CSR-T-1	JQ764321

Kinetics of Gypsum and Native $CaCO_3$ Dissolution and Nutrient Transformations Mediated through Organic Amendments and Microbial Inoculants for Crop Production in Sodic Soils (Sanjay Arora, A.K. Bhardwaj, V.K. Mishra, Y.P. Singh and D.K. Sharma)

In order to assess the nature and extent of sodicity, soil samples were collected from 7 sodic soil dominant districts of Uttar Pradesh and 2 sodic and calcareous districts of Bihar from reclaimed fields as well as adjoining un-reclaimed field. In all, 93 soil samples were collected from U.P. and 56 samples from Bihar using GPS receiver.

It was revealed from the analysis that soil pH_2 ranged from 7.7 to 10.5 while EC_2 from 0.05 to 3.85 dS m^{-1}. It was further noted that soil samples from fields reclaimed by gypsum application within last three years had pH_2 range of 7.7 to 8.8, soil samples from fields where application of gypsum as amendment in last 3-8 years had pH_2 range 8.0-9.6 while those soils reclaimed more than 8 years had pH range of 8.8 to 9.9. The soil samples collected from unreclaimed sodic soils of 7 districts of U.P. ranged from 8.8 to 10.5.

In saturation extract, Na content in soil samples ranged from 2.8 to 392.5 meq l^{-1}. In soil samples from recently reclaimed sodic soil, Na content ranged from 2.8 to 118.6 meq l^{-1} while those were reclaimed more than 8 years had accumulated Na in the range of 14.0 to 361.9 meq l^{-1}. The Na content in unreclaimed sodic soils ranged from 24.5 to 392.5 meq l^{-1}. Overall, the CO_3 and HCO_3 content ranged from 1 to 190.5 and 2 to 115 meq l^{-1}, respectively. The chloride content ranged from 2 to 168.5 meq l^{-1}.

A field experiment was conducted on unreclaimed sodic soil (pH 10.1) at Shivri Farm to ascertain the effect of organic and inorganic amendments on rice production and effect of amendments on chemical changes in sodic soil during reclamation. The treatments were imposed including gypsum, phosphogypsum, pressmud and bioinoculant in RBD with 3 replications in plot size of 12 m^2. The amendments were thoroughly spread and mixed in surface soils manually. The plots were ponded with equal quantities of water to allow leaching for continuous 15 days maintaining the water level in each plot, after application of amendments. Paddy (cv CSR 36) was transplanted in each plot and crop growth and yield was recorded. The soil

Manual mixing of amendments after application in surface soil

sample from surface was drawn daily to monitor the reclamation effect of amendments applied. At periodic intervals, soil samples were collected and analyzed. After harvest, the soil samples were collected upto 60 cm depth to monitor gypsum dissolution and exchange as influenced by different amendments.

It was observed that soil pH_2 decreased from mean of 10.1 to minimum of 8.24 with the application of Phosphogypsum in combination with pressmud at 2 days after leaching. Similarly, soil pH declined in all the plots applied with different amendments till 5 days after initiation of leaching and thereafter there was slight increase in soil pH_2 values in all the imposed treatments. After 15 days of ponding water for leaching, soil pH_2 was decline by 0.7 to 1.1 units in all the treatments. Maximum decline of soil pH_2 from 10.1 to 8.98 at this time was noted in plots amended with PG_{25GR}+ Pressmud.

After harvest of paddy, depth wise soil samples were collected from respective plots. It was noted that soil pH ranged from 9.05 to 9.36 (mean of 3 replications) in all the treated plots as compared to 9.85 in unamended plots allowed for 15 days

Leaching of plots after application of amendments

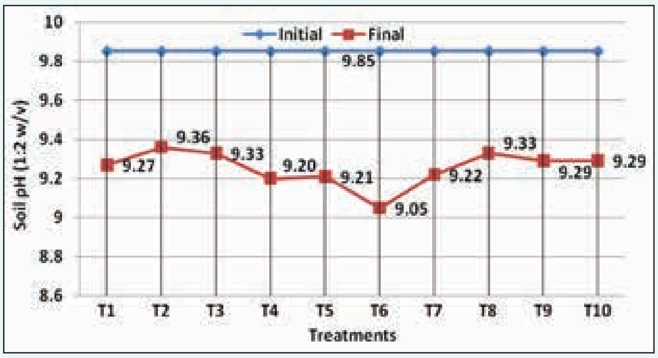


Fig. 49 : Changes in pH of soil amended with different amendments

continuous leaching. Maximum reduction in soil pH was noted in treatment T_6 (PG_{25GR}+ Pressmud) where pH_2 reduced from 9.85to 9.0 (Fig. 49).

It was also observed that pH ranged from 9.05 to 9.80 in 0-15 cm as compared to 9.91 to 10.26 in 15-30 cm, 10.14 to 10.45 in 30-45 cm and 10.00 to 10.52 in 45-60 cm soil layers in all the treatments. The soil pH increased with increasing soil depth.

Exchangeable Na content ranged from 589 to 876 mmol kg^{-1} which increased from 968.5 to 1335.8 mmol kg^{-1} in lower soil layers indicating leaching of ions from surface to sub-surface layers with the application of amendments (Fig. 50).

Sodium content in ponded water declined by 16 to 54 per cent where amendments was applied in paddy after 15 days of leaching in all the treatments. While, pH of ponded water ranged from 8.49 to 8.81 after 10 days of leaching and reduced from 7.49 to 8.52 after 15 days of leaching and 7.77 to 8.32 in all the treatment plots after 3 months of imposed amendments.

Maximum grain yield was observed in PG_{25GR} + Pressmud treatment which was superior by 18.1 and 18.9 per cent compared to G_{50GR} and G_{25GR} + Pressmud, respectively (Fig 51). However, grain yield in plots amended with gypsum @ 12.5 GR

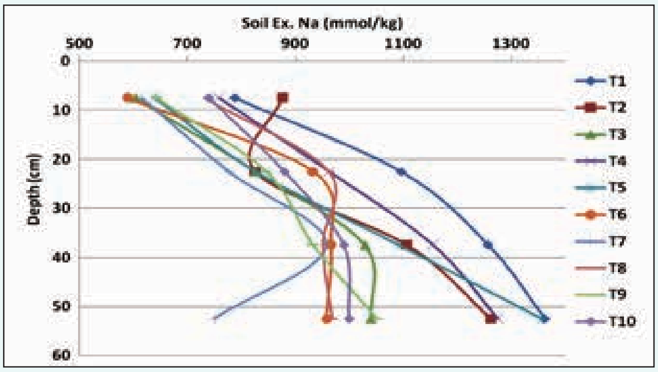


Fig. 50 : Depth of distribution of Na in soil as influenced by amendments

Field experiment with paddy (CSR 36) on sodic soil amendmend with different organic and inorganic amendments

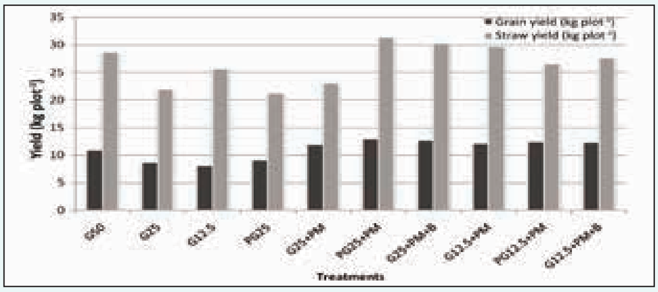


Fig. 51: Effect of amendments on grain and straw yield of paddy

+ pressmud and Phosphogypsum @ 12.5GR + pressmud was higher by 50.1 and 25.3 per cent to that of gypsum @ 12.5 GR and Phosphogypsum @ 25GR treatments, respectively. Straw yield was also affected by the application of organic and inorganic amendments in combination with bio-inoculant.

Evaluating Climate Change Mitigation Potential of Alternative Management Practices for Rice-Wheat Cropping Systems in Salt Affected Soils of Indo-gangetic plains (S.K. Jha, V.K. Mishra, Y.P. Singh, T. Damodaran, A.K. Bhardwaj and D.K. Sharma)

The agricultural activities accounts for 1/5th of the projected anthropogenic green house effects. The major green house gases (GHGs) emitted as a result of agricultural activities is methane (CH_4), carbon

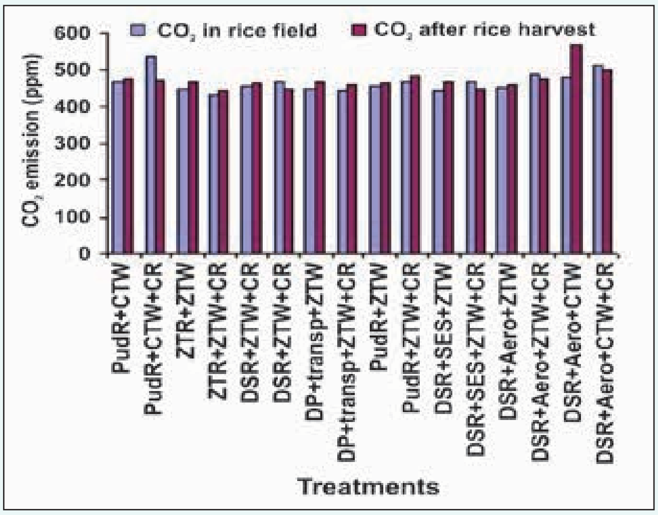


Fig. 52 : CO_2 emissions from the soils under different tillage practices

dioxide (CO_2) and nitrous oxide (N_2O). These GHGs are solely responsible for global warming and climate change. The present experiment dealt with the management practices involving conventional tillage practices, zero tillage or no tillage, minimum tillage, aerobic conditions with and without crop residues. Carbon dioxide emissions from soils were measured by using EGM-4 CO_2 gas analyzer, in the experimental plots where treatments were initiated in the year 2005 with different tillage practices with and without crop residues. The CO_2 emissions from the soil were recorded two times i.e. while the paddy crop was standing in the field and just after the rice harvest. It was found that CO_2 emission was maximum from the soil of direct seeded rice in aerobic condition (568 ppm) after rice harvest followed by puddling in rice with crop residue mixed (537 ppm) while paddy was standing on the field (Fig. 52).

Comparing conventional tillage (CT) and zero tillage practices (ZT), CO_2 emissions was recorded higher in CT than ZT practices during both the occasions. Similarly, conventional tillage with

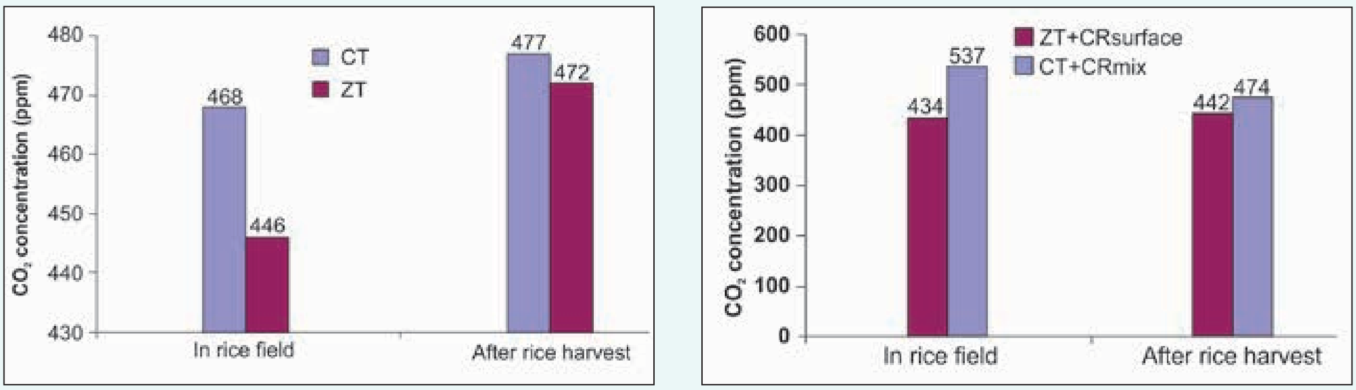


Fig. 53 : Effect of zero tillage and crop residue addition on CO_2 emission

crop residues incorporation was found to emit more CO_2 as compared to zero tillage with crop residue applied on surface (Fig. 53).

The data for soil microbial biomass carbon (MBC) which comes under labile pool of carbon and is vital for soil organic carbon dynamics and nutrient cycle revealed that soils with zero tillage practice both in rice and wheat with crop residue (ZTR+ZTW+CR) had maximum soil MBC (364.9 µg gm^{-1}) followed by puddling in rice and conventional tillage in wheat with crop residues (PudR+CTW+CR) (237.9 µg gm^{-1}). However, the MBC in PudR+CTW+CR was on par with DSR+SES+ZTW+CR.

Strategies for Stimulating Nutrient Dynamics in Resource and Energy Conservation Practices for Rice-Wheat Cropping Systems on Partially Reclaimed Sodic Soils (S.K. Jha, V.K. Mishra, A.K. Singh, Y.P. Singh and D.K. Sharma)

A field trial was conducted with rice as first crop on sodic soils which was reclaimed during 2005 and practiced various tillage practices taking rice–wheat cropping system. Sixteen treatments viz; T_1- Puddled rice+conventional tillage in wheat (PudR+CTW), T_2- Puddled rice+conventional tillage in wheat+crop residue (PudR+CTW+CR), T_3- Zero tillage in rice+ zero tillage in wheat (ZTR+ZTW), T_4- Zero tillage in rice+ zero tillage in wheat+ crop residue (ZTR+ ZTW+CR), T_5- Direct seeded rice + zero tillage wheat (DSR+ZTW), T_6- Direct seeded rice + zero tillage in wheat + crop residue (DSR+ZTW+CR), T_7- Dry ploughing + transplanting+ zero tillage wheat (DP+transp+ZTW), T_8- Dry ploughing + transplanting + zero tillage in wheat + crop residue (DP + transp + ZTW+CR), T_9- Puddled rice + zero tillage in wheat (PudR+ZTW), T_{10}- Puddled rice + zero tillage wheat + crop residue (PudR+ZTW+CR), T_{11}- Direct seeded rice+ *sesbania* + zero tillage in wheat (DSR+SES+ZTW), T_{12}- Direct seeded rice+ *sesbania* + zero tillage in wheat + crop residue (DSR+SES+ ZTW+CR), T_{13}- Direct seeded rice+ aerobic + zero tillage in wheat (DSR+Aero+ZTW), T_{14}- Direct seeded rice+ aerobic + zero tillage in wheat + crop residue (DSR+Aero+ZTW+CR), T_{15}- Direct seeded rice+ aerobic + conventional tillage in wheat (DSR+Aero+CTW) and T_{16}- Direct seeded rice+ aerobic + conventional tillage in wheat + crop residue (DSR+Aero+CTW+CR) were laid down for the experiment.

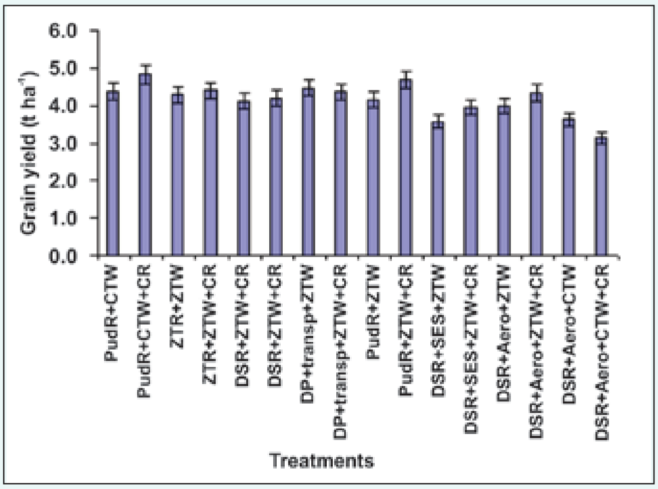


Fig. 54 : Rice grain yield obtained under various tillage practices

Maximum rice grain yield was obtained in the treatment PudR+CTW+CR followed by PudR+ZTW+CR (Fig.54). PudR+CTW, ZTR+ZTW+CR and DP+transp+ZTW+CR recorded the same grain yield of 4.4 t ha^{-1}. In aerobic condition, DSR with CR in wheat recorded highest yield of 4.3 t ha^{-1}. Soil samples collected after the harvest of rice crop revealed that in 0-15 cm soil depth C-sequestration potential was found to be maximum in ZTR+ZTW+CR followed by ZTR+ZTW. In aerobic condition, DSR+ZTW+CR found to have maximum C-sequestration followed by DSR+CTW+CR.

In 15-30 cm soil depth, C-sequestration potential of PudR+ZTW+CR was found at par with DSR+SES+ZTW+CR and in aerobic condition, DSR+ZTW+CR & DSR+CTW+CR have same carbon content (Fig. 55).

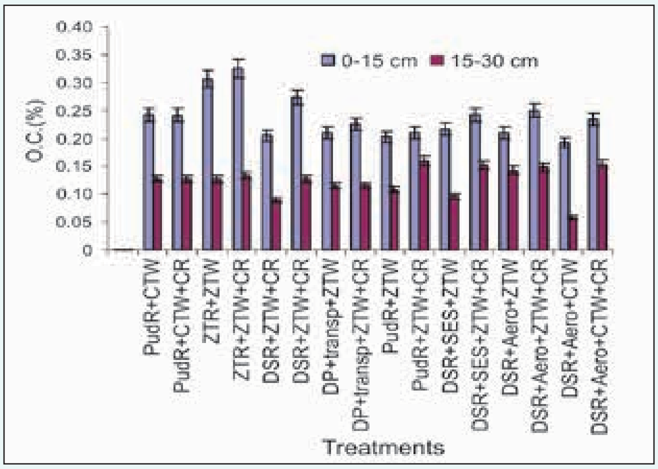


Fig. 55 : C-sequestration potential in different tillage practices at 0-15 cm and 15-30 cm soil depth

Managing Water and Energy Efficiency in RW (Rice-Wheat) Cropping Systems under Partially Reclaimed Sodic Soils through Controlled Irrigation Techniques (Atul Kumar Singh, C.L. Verma, Y.P. Singh and A.K. Bhardwaj)

The different irrigation schedules followed in surface method in rice were 2, 3 and 4 days after disappearance of ponded water (DAD) and in sprinkler and low energy water application (LEWA) methods were daily, one and two days interval (when no ponding in the field). In wheat crop, the irrigation schedules in surface, sprinkler and LEWA were 0.6, 0.8 and 1.0 IW/CPE ratio. The depth of irrigation applied in rice and wheat through surface method was 6.0 cm and 4.0 cm through LEWA and sprinkler.

The highest grain yield of wheat (2.3 t ha^{-1}) was obtained in T_8 (sprinkler irrigated plots at IW/CPE 0.8) followed by 2.19, 2.16 and 1.97 t ha^{-1} in T_5 (LEWA irrigated plots at IW/CPE 0.8), T_4 (LEWA irrigated plots at IW/CPE 1.0), T_1 (surface irrigated plots at IW/CPE 1.0), respectively. The water applied through surface irrigation system at IW/CPE ratio of 1.0, 0.8 and 0.6 was 45.6, 45.6 and 22.8 cum, repectively and by LEWA and sprinkler method at IW/CPE ratio of 1.0, 0.8 and 0.6 was 28.8, 19.2 and 9.6 cum, respectively. Considering all irrigation schedules, it was observed that irrigation applied through sprinkler and LEWA saved about 35 per cent water over surface method of irrigation. The pattern of cost of fuel spent to apply irrigation water, sprinkler system consumed highest energy as compared to surface and LEWA methods. Surface method of irrigation was observed most economical on account of energy consumption when irrigation was practiced at IW/CPE ratio of 1.0, whereas LEWA incurred lowest cost on energy as compared to surface and sprinkler when irrigation was applied at IW/CPE of 0.8 and 0.6.

The highest grain yield of rice (4.1 t ha^{-1}) was obtained from T_6 (sprinkler irrigated plots at 2 days interval), T_7 (LEWA irrigated plots at daily interval), and (LEWA irrigated plots at 2 days interval) treatments followed by T_1 (Surface irrigated plots at 2 DAD) 4.0 t ha^{-1} and T_4 (Sprinkler irrigated plots at daily interval) 3.9 t ha^{-1}. The result indicated that 14, 12 and 10 irrigations of 6 cm depth were applied at 2, 3 and 4 days after disappearance of poned water under surface irrigation method whereas 21, 17 and 14 irrigations of 4 cm depth were applied when irrigation was scheduled daily, at one and two days interval under sprikler and LEWA method of irrigation in rice crop. The volume of total water applied to rice under different treatments through surface, sprinkler and LEWA methods is presented in Fig.56. The lowest volume of water applied per unit area amounted to 0.56 m^3/m^2 through sprinkler (T_6) and LEWA (T_9) method when scheduled at 2 days interval as compared to all other treatments, whereas highest volume of water applied was 0.84 m^3/m^2 in Surface method at 2 DAD (T_1) and Sprinkler (T_4) and LEWA (T_7) when scheduled daily.

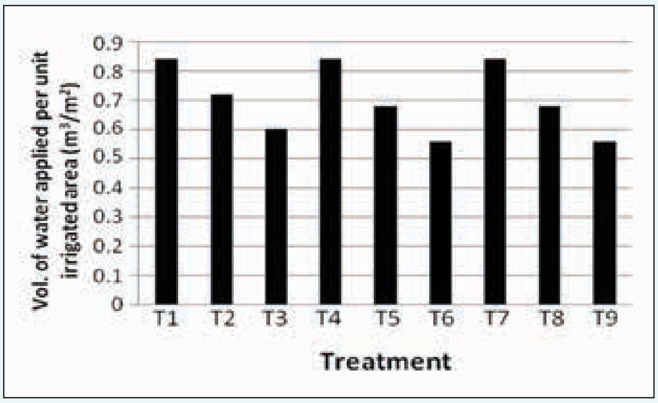


Fig. 56 : Volume of water applied per unit area

The cost per unit area was the lowest of Rs. 2.27/m^2 in LEWA (T_9) when scheduled at 2 days interval followed by Rs. 2.39/m^2 in surface method (T_3) when scheduled at 4 DAD (Fig. 57). Incase of sprinkler, the cost per unit area was higher as compared to other treatments of surface and LEWA. The highest cost @ Rs. 4.81/m^2 was incurred in sprinkler (T_4) when scheduled daily.

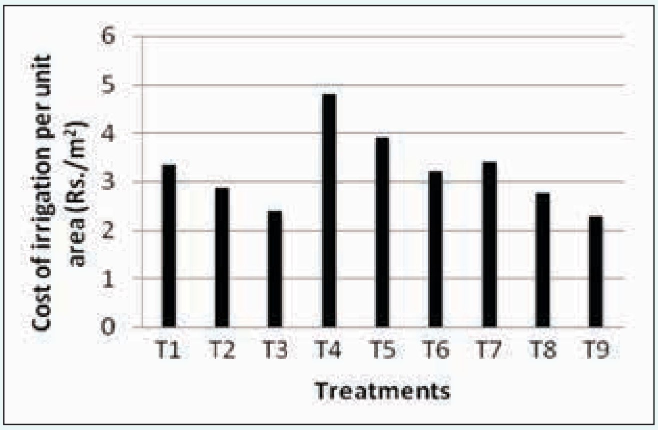


Fig. 57 : Cost incurred per unit area for irrigation

Based on the volume of water applied, fuel consumed and yield obtained under various treatments, the water and energy productivity was estimated. Applying irrigation at 2 days interval through sprinkler (T_6) and LEWA (T_9) resulted in highest water productivity of Rs. 7.32 per cubic m of water applied followed by Rs. 5.58 per cubic m of water applied and 5.29 per cubic m of water applied when sprinkler (T_5) and LEWA (T_8) scheduled at one day interval. The highest water productivity of Rs. 5 per cubic m of water applied amongst surface irrigated plots observed in T_2 (scheduled at 3 DAD) and T_3 (scheduled at 4 DAD). Applying irrigation through LEWA (T_9) at 2 days interval results into highest energy productivity of Rs. 1.80 per unit cost of diesel invested followed by Rs. 1.30 and Rs. 1.27 per unit cost of diesel invested of LEWA (T_8) scheduled at one day interval and sprinkler (T_6) scheduled at 2 days interval, respectively. The highest energy productivity Rs. 1.25 per unit cost of diesel was observed in surface method when scheduled at 3 DAD and 4 DAD.

Irrigation through sprinkler in rice at shivri farm

Irrigation through LEWA in rice at shivri farm

☆☆☆☆☆

RECLAMATION AND MANAGEMENT OF SALT AFFECTED VERTISOLS

Management of Coastal Saline Soils of Saurashtra, Gujarat – Impact Studies on Technological Interventions (G. Gururaja Rao, Sanjay Arora, M.K. Khandelwal and Anil R. Chinchmalatpure)

The coastal belt of Gujarat has problems of soil and water salinity with moderate to poor rainfall and thus necessitates proper water management strategies to enhance on-farm productivity. In order to bring such problematic soils under productive cultivation, the technologies evolved by this Station as well as crop cultivars selected/ identified by the Institute shall be tested and evaluated by taking on-farm trials.

On farm trials conducted at different places along the coastal Gujarat region in a cluster approach in collaboration with Coastal Salinity Prevention Cell (NGO) in public-private partnership mode indicated wider acceptability of the technological intervetions among the farmers. This is clearly evident from the increased trials conducted by the farmers with wheat, cotton, seed spices and water conservation measures. Wheat KRL 210 followed by KRL 19 and cotton G.Cot 23 have wider acceptability followed by seed spices such as cumin and dill. Multicut fodder such as sorghum and rajka bajra have also received wider acceptance among the farmers of Bhal region. Rice varieties CSR 23 and CSR 30 have also got good response.

Kharif 2013

On farm trials were conducted on cotton (herbaceums) and paddy (CSR 23, CSR 30, CSR 43 and NAUR 1) in Bharuch and Surat disrict of South Gujarat, Anand and Ahmedabad districts of Central Gujarat and Junagadh of Saurashtra region. The data on paddy indicated that CSR 23 gave higher yield than local NAUR 1 and these lines have received farmers' attention to a greater extent. Similarly herbaceum cotton, G.Cot 23 gave seed cotton yield of 1.78 to 1.89 t ha^{-1} (Table 83).

Locations of the study area in coastal Gujarat

Table 83 : Yield of cotton and paddy in saline tracks of Bara tract

District/ Taluka	Village	Crop	Mean yield (t ha^{-1})
Bharuch/ Jambusar	Kalak	G. Cot 23	1.78
	Kalak	Paddy- CSR 23 CSR 30	3.64 2.97
Bharuch/ Jambusar	Sigam	Paddy -CSR 23 CSR 30	3.96 3.02
	Magnad	Desi Cotton - G Cot 23 GBav 120	1.89 1.68
	Bojadra	Paddy -CSR 23 CSR 30	3.82 2.66
Surat/ Olpad	Olpad	Paddy -CSR 23 CSR 30 NAUR 1	4.84 3.14 3.04

Partners : SAVE, Jambusar and KVK Surat

Soil salinity (EC_2) at harvest : Cotton 10.8 dS m^{-1} and Paddy : 6.6 dS m^{-1}

The studies clearly indicated that on saline soils of Bara tract and Bhal area (Rajpura), the herbaceum cottons showed better adaptability and good yields under rainfed conditions thus indicating their suitability for this region. The yield obtained at the farmers' fields was at par with that of experimental yield obtained at RRS research farm at Samni. These accessions are performing well in Saurashtra also (Table 84).

Herbaceums and Arboreums in Bhal area (left) and Bart tract (right)

Table 84: Performance of cotton (G Cot 23) in Junagadh district

Name of Farmer	Soil salinity, (ECe, dS m^{-1})	Water salinity, (EC_{iw}, dS m^{-1})	Yield, (t ha^{-1})
Gordhanbhai Nathabhai Jambucha	6.2	6.8	1.78
Bhajirathbhai Mulubhai Gohil	6.7	5.6	1.66
Geetaben Ranchodbhai Dodiya	7.2	6.4	1.62
Kailasba Mangalsinh Gohil	6.8	6.6	1.78

NGO Partner: VRTI, Rajula

Physical impacts

Continued efforts have resulted spreading the cultivation of salt tolerant herbaceum cottons in coastal areas of Bharuch, Anand, Ahmedabad and Jamnagar districts. After receiving feedback from the farmers through CSPC, an NGO from Ahmedabad, field demonstrations and impact studies were planned for *kharif* 2014 with two lines, initially G Cot 23 and G Cot 25.

Economic impact

Saline lands having salinity up to 10-12 dS m^{-1} were profitably brought under cultivation with herbaceum cotton G Cot 23 in Jambusar taluka of Bharuch district. This has resulted in gross income in the range of Rs. 70,000 to 75,000 per hectare and net income of Rs. 45,000 to 50,000 per hectare in Bojadra and Kalak with B:C ratio of 1.8 to 2.0. Apart from this, an assured employment generation occurs by bringing the saline wastelands under production.

Performance of wheat and cumin in *rabi* season

CSSRI wheat selections/varieties like KRL 210 and cumin (Gujarat Cumin–GC 4) were taken up in the coastal saline Bhal area. Cumin gave an average yield of 0.94 t ha^{-1} and wheat 3.62 t ha^{-1} at salinity of 7.8 dS m^{-1} in Bhal area (Table 85). Because of the better performance of these crops under saline conditions, these interventions had significant impact in increasing the farmers for these crops on coastal saline soils. Performance of wheat (cv KRL 210 in coastal Gujarat along with different NGO partners are given in Fig. 58-60. In three blocks of Junagadh district, variety KRL 210 yielded 3.4 to 4.0 t ha^{-1} at 7.5 to 7.8 dS m^{-1} salinity (EC_e). The data indicated that KRL 210 at different locations gave the grain yield of 3.7-4.0 t ha^{-1} which was significantly higher than the local wheat cultivar Lok 1 even at 6-7.2 dS m^{-1} salinity (EC_e).

Table 85 : Performance of cumin and wheat in Bhal areas

Farmers' name	Crop	Yield (t ha^{-1})	EC_e (dS m^{-1})
M.R. Solanki	Cumin	0.98	5.40
B.D. Rathod	Cumin	0.93	5.95
D.A. Vaghela	Cumin	0.90	6.24
K.V. Chauhan	Wheat	3.44	5.92
D.A. Vaghela	Wheat	3.79	5.72

Wheat : KRL 210 /Cumin : GC 4, Cumin on saline tracks of Bhal area

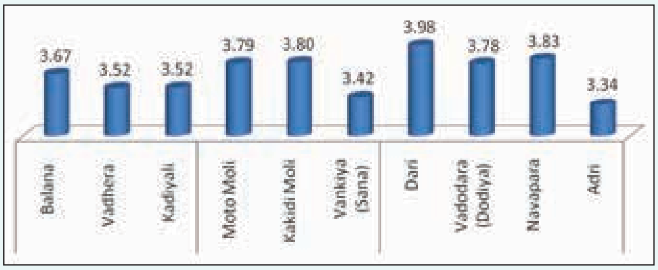


Fig. 58 : Wheat (KRL 210) yield (t ha^{-1}) in Junagarh district, (ECe 7.5 to 7.8 dS m^{-1})

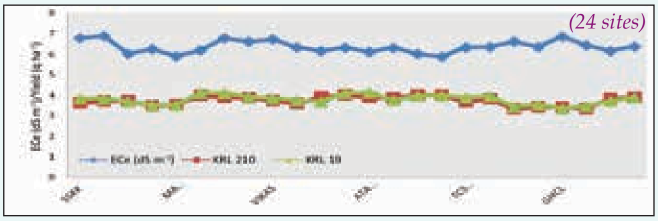


Fig. 59 : Performance of Wheat in coastal areas of Gujarat

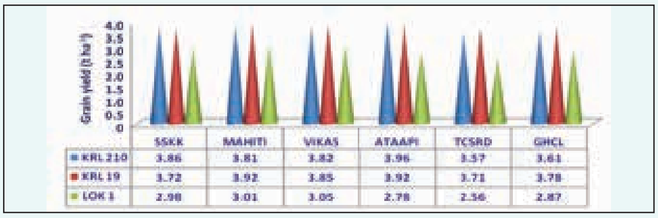


Fig. 60 : Comparative performance of CSSRI wheat varieties over Local (Lok 1) under saline soils of Coastal Gujarat

Performance of Cumin (GC 4) on saline tracks of Bhal area

Impact of salt tolerant accessions

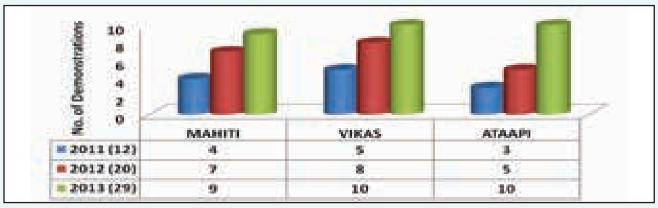
Data given in Fig. 61-62 indicated gradual increase in number of on farm studies from 2011 to 2013 in coastal Gujarat. While cotton showed an increase mainly in Bara tract, wheat has found good response in the entire NGO clusters in the coastal Gujarat indicating the wider acceptability of the technological interventions. Looking into the above, several organization have come forward to adopt this technology.

Impact of technological interventions

1. Farmers of coastal Gujarat are well aware of the technological interventions brought out by RRS and crop varieties developed by CSSRI and are eager to extend the cultivation.
2. Wheat varieties KRL 210 and KRL 19 are gaining more popularity among farmers.
3. To cater the need of seeds, seed production programme is undertaken at RRS, Bharuch.
4. Desi cotton, in view of their higher salt tolerance and better response to saline water, is getting an edge over Bt lines and hybrids which invariably need good quality water and their salt tolerance is low.

Soil Physical Characteristics and Nutrient Dynamics in Vertisols with Sub-surface Salinity (Shrvan Kumar, Indivar Prasad and G.G. Rao)

Salinity of soil and water are the major constraints in agricultural crop production particularly in Vertisol region. Vertisols with subsurface salinity problems are present in Bara tract comprising Amod, Jambusar and Vagra talukas of Bharuch district. The area was brought under irrigation by the Sardar Sarovar Narmada Irrigation Project since 2005-06. This area is characterized by Vertisols with clay content ranging from 55 to 65 per cent with subsurface salinity (2-14 dS m^{-1}) problems below 60 cm soil depth. The ground water in the region is saline (2.6 to 17 dS m^{-1}). The major crops in the region are cotton, jowar, pigeonpea, wheat and arid horticultural crops. The high clay content, low infiltration rate and low hydraulic conductivity and associated salinity problems are the major impediments to crop growth and productivity.



	MAHITI	VIKAS	ATAAPI
2011 (12)	4	5	3
2012 (20)	7	8	5
2013 (29)	9	10	10

Fig. 61: Farmer's adoption of Herbaceum Cotton, G Cot 23 in Bhal area and Bara Tract

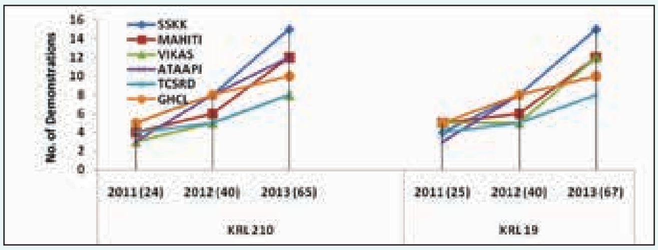


Fig. 62 : Adoption of interventions (cultivation of salt tolerant wheat varieties) in three years

The introduction of irrigation in the region and its impact on different cropping systems has already been studied by the station. However, the changes in soil physical characteristics and nutrient dynamics have not received adequate attention. Hence, the present programme was taken up to find out hydro-physical properties, nutrient dynamics and crop growth and productivity in the region both in rainfed and irrigated scenario. Eighteen sites were selected from Amod, Vagra and Jambusar talukas of Bharuch district, Guajrat, of which 6 sites (profiles) were completed during summer period under Sayakha branch and outside canal command areas and their physical and chemical properties were analyzed. Rest of sites will be completed in due course of time.

The selected sites, their geographical location and crops grown are given in Table 86. Soil samples (including core samples) were collected and their physical and chemical characteristics were determined (Tables 87 and 88). The major crops grown in the region are cotton, sorghum, wheat, pigeonpea, *moong* and *guar* along with horticultural crops. Due to very hard nature, *in situ* soil hydraulic conductivity could be measured in profile 3 only (Table 89).

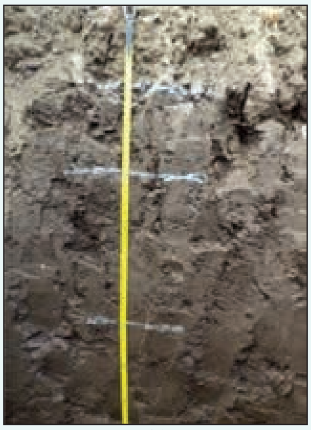
The results of the studies indicated that

- In soil profile-I, pH and ECe ranged from 7.43 to 8.50 and 0.31 to 0.45 dS m^{-1}, respectively which increased in deeper soil layers.
- These soils are neutral to moderately alkaline in nature and their pH increased with depth. $CaCO_3$ content ranged from 2.2 to 6.0 per cent in profile-I with tendency to increase with depth and similar trend was also found in other sites.



Study sites under SSNNL command

Profile II



Profile III

Profile IV

Profile VI

Soil profiles from the selected sites

Table 86 : Location of the study sites and crops cultivated under SSNNL command

S.N.	Farmer's name	Location	Crops
	Sayakha branch canal		
1	Thakoor Bhai (Profile I)	Head, Right side, CC (Canal command), Samni	Pigeonpea, Dill
2	Jayanti Bhai (Profile II)	Head, Left side, CC, Samni	*Guar*
3	P.S. Chauhan (Profile III)	Middle, Right side, CC, Vachnad	Sugarcane
4	Kamlesh Bhai (Profile IV)	Middle, Left side, CC, Samni	Wheat, *Moong*
5	Kamlesh bhai (Profile V)	Outside canal command (OCC), Samni	*Moong*
6	Ghambhir Singh (Profile VI)	OCC, Vachnad	Pigeonpea, *Moong*

Table 87 : Ionic composition of soil samples collected from Profiles I and II

Ionic compositions of saturation extracts of soils							
Soil depth (cm)	------------- Cations (meq l^{-1}) ---------				------Anions (meq l^{-1}) ---		
	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Cl^{-}	$CO_3^{2-}+HCO_3^{-}$	SAR
Profile I							
0-15	0.5	3.0	0.82	0.07	2.3	0.3	0.62
15-30	0.5	3.5	1.10	0.04	2.5	0.3	0.78
30-60	1.5	3.0	1.55	0.05	4.5	0.6	1.03
60-90	1.2	1.0	2.45	0.03	2.5	0.5	2.34
90-120	1.0	2.5	2.70	0.03	2.5	0.4	2.04
Profile II							
0-15	1.0	1.5	3.58	0.04	3.1	0.4	3.20
15-30	0.5	2.0	4.18	0.04	3.0	0.2	3.74
30-60	2.0	3.0	5.01	0.42	8.5	0.4	3.17
60-90	5.0	2.0	11.86	0.07	9.5	0.3	6.34
90-120	3.0	3.0	27.30	0.06	21	0.2	15.76

Table 88 : Physical and chemical characteristics of soil samples from Profiles I and II

Physical and chemical properties of soils														
Soil depth (cm)	pH	ECe (dS m^{-1})	SOC (%)	CaCO3 (%)	Db (Mg m^{-3})	Sand	Silt (%)	Clay	Exchangeable bases [cmol(p+) kg^{-1}] Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CEC	ESP
Profile I														
0-15	7.43	0.33	0.432	2.18	1.27	19.3	32.1	48.6	31.5	10.8	0.39	0.41	45.1	1.42
15-30	8.01	0.31	0.312	3.13	1.42	20.3	26.5	53.2	34.5	10.8	0.59	0.32	48.2	1.82
30-60	8.09	0.42	0.315	5.28	1.68	17.8	26.3	55.9	34.0	11.5	0.83	0.30	48.6	2.67
60-90	8.22	0.41	0.305	5.40	1.43	13.3	35.1	51.6	33.3	16.8	1.26	0.24	53.5	2.81
90-120	8.50	0.45	0.269	5.98	1.51	24.7	22.1	53.2	33.5	8.5	1.50	0.23	45.7	4.11
Profile II														
0-15	8.13	0.50	0.390	5.40	1.38	16.9	36.3	46.9	28.5	13.3	2.73	0.40	46.9	9.17
15-30	8.46	0.58	0.331	5.43	1.49	17.1	28.7	54.2	27.5	11.8	4.10	0.36	45.7	12.70
30-60	8.97	1.11	0.269	5.50	1.55	26.8	28.0	45.2	29.8	8.5	6.99	0.27	47.5	19.07
60-90	8.78	1.77	0.383	5.65	1.47	19.7	30.2	50.1	31.3	8.8	7.54	0.20	49.7	16.38
90-120	8.51	3.50	0.256	6.13	1.36	14.5	30.2	55.3	25.8	9.8	6.73	0.18	44.4	13.58

- Particle size of soil i.e. sand, silt and clay differed in all sites at different soil depths. The bulk density (Db) ranged from 1.27 to 1.68 Mg m^{-3}. For every site, Db increased with soil depth; but in some cases it slightly decreased with depth due to its clay content.
- The profile V has relatively high CEC ranging from 53.2 to 57.7 cmol (p+) kg^{-1} and dominance of Ca^{2+} on exchangeable complex followed by Mg^{2+}, Na^{+} and K^{+}. The other sites showed similar trend but their magnitudes were lower as compared to this one. The ESP ranged from 1.15 to 2.87.

Table 89 : Saturated hydraulic conductivity at Profile 3

Soil depth	Ks (cm hr^{-1})
Profile III	
0-15 cm	1.51×10^{-5}

Vertisols have very deep and wide cracks during summer season; use of Guleph permeameter becomes difficult

In-situ saturated hydraulic conductivity measured by using Guleph permemeter

- Soil organic carbon (SOC) content ranged from 0.27 to 0.43 per cent in profile-I and higher content in profile-III (0.24-0.65%) due to sugarcane crop. The SOC was the highest at surface (0-15 cm) layer and it decreased as lower layers in every site.
- The saturation extract showed the dominance of sodium followed by Ca^{2+} and Mg^{2+} with low concentration of CO_3^{2-} and HCO_3^{-} in profile-I and profile II at deeper depth i.e. 60-120 cm, this trend did not exist in other sites.
- The saturated hydraulic conductivity (Ks) of Profile-I ranged from 0.05 to 0.10 and 0.20 to 0.34 cm hr^{-1} under undisturbed and disturbed soil samples, respectively which decreased with increasing depth in the profile for each site.
- The decrease was related to higher clay content at lower depths of soils. The Profile V and VI (outside canal command) had high Ks values of 0.51 and 0.43 cm hr^{-1}, respectively on surface layer. Among the sites, Ks values were lower in profile-I and profile-II because of irrigated conditions.
- In profile-I, field capacity (FC, 0.33 bars) ranged from 38.1 to 46.5 per cent at different depths. Depth-wise water retention at FC point showed a greater retention with

increase in soil depth; and this trend was similar in every site. The available water in profile-I to VI were 13.7-17.6, 14.1-17.1, 15.9-20.2, 12.7-17.2, 12.4-16.4 and 11.4-17.5 per cent, respectively. The available water was also greater under profile I to IV (irrigated command) as compared to profile V and VI (outside canal command) and its higher values were noticed in the deeper layers (higher the clay content, higher FC and available water content).

- The higher N and K contents were found in 0-15 cm layer (407.7 kg N ha^{-1} and 359 kg K ha^{-1} respectively) and lower in deeper layer (263.4 kg N ha^{-1} and 197.7 kg K ha^{-1}, respectively) in profile-I. This trend was found in all sites, instead of available P. The available N and P content were found in medium range, while available K content was found in high range.

Breeding and Evaluation of Field Crops for Salt Tolerance in Saline Vertisols (Indivar Prasad, Shrvan Kumar, G. Gururaja Rao and D.K. Sharma)

In India, Vertisols and associated soils occupy about 72.9 M ha of which 1.87 M ha occur in Gujarat state. These soils have peculiar soil-water characteristics such as very low hydraulic conductivity, high swelling and shrinkage behaviour, formation of deep and wide cracks on the surface and narrow workable moisture range that pose very complex water management problems. Salt affected black soils due to the above complex problems pose severe threat to crop production even at low salinity.

The major crops of the region are cotton, wheat and maize in the inland and coastal saline tracks. Our earlier studies indicated herbaceum and arboreum cotton species performed better under saline conditions over hirsutums and Bt cottons. Some salt tolerant herbaceum lines like G.Cot 23, G. Cot DH 7, GShv 297/07, GShv 287 and arboreum like GBav 109, GBav 120 and G Bav 123 were identified as salt tolerant and can give seed cotton yields from 1.7 to 1.9 t ha^{-1} at 8.4 dS m^{-1} salinity. Bara tract is mainly a water deficit area (having saline ground water) with inadequate irrigation facilities and thus identifying low water requiring and salt tolerant crops would pave the way for farmers to obtain good economic returns (Table 90 a & 90 b).

During *rabi* season, saline water irrigation was proved beneficial for certain wheat accessions. Wheat varieties like KRL 210, KRL 19, KRL 238 and KRL 99 gave 3.7-3.9 t ha^{-1} grain yield with four saline water irrigations (9.4 dS m^{-1}). In the absence of canal water irrigation, the saline ground water can effectively be used for wheat production in Bara tract either as such or in conjunctive mode.

Cotton

Collection of germplasm: A total of 70, 80 and 50 lines of cotton, wheat and maize, respectively were collected. Experiments with cotton were conducted in microplots with hebaceums (G Cot 2e and GShv 99/307) and arboreums (GBav 109 an d GBav 120) varieties with saline water irrigations of 4, 8 and 12 dS m^{-1} and tube well water as control. Biomass and biochemical constituents are given in Tables 90a-90b and the analysis of variance is given in Table 91.

Studies on cotton have indicated that

- All the four cotton lines exhibited response to salinity even up to 12 dS m^{-1}.
- However, among the four lines; GBav 120 (Arboreum) and G.Cot 23(Herbaceum) were found superior in terms of growth and biomass production.
- GBav 120 and G.Cot 23 produced higher monopodia, sympodia and number of bolls (major yield components in cotton).
- Low shoot sodium and chloride coupled with better maintenance of potassium content enabled these accessions to maintain low Na/K ratio (a better indicator for salinity tolerance)
- The low Na/K ratio along with higher proline content in leaf tissue helped these lines in maintaining better water status and hence growth and productivity.

Experiments with cotton – Microplots

Table 90a. Effect of salinity on various traits in cotton – Monopodia and Sympodia

Variety	No. of Monopodia/plant					No. of Sympodia/plant				
	Treatments, ECiw (dS m^{-1})					Treatments, ECiw (dS m^{-1})				
	BAW	4	8	12	Mean	BAW	4	8	12	Mean
G Cot 23	35.00	7.50	14.50	13.00	11.88	12.50	36.00	35.00	30.00	34.00
GShv 99/307	26.50	15.50	15.00	12.00	14.63	16.00	28.50	28.50	25.50	27.25
GBav 109	28.50	11.00	17.50	13.00	14.50	16.50	22.50	31.50	26.00	27.13
GBav 120	23.00	14.50	17.00	18.00	16.25	15.50	25.50	24.50	26.50	24.88
Mean	28.25	12.13	16.00	14.00	14.31	15.13	28.13	29.88	27.00	28.31
S.D.	4.89	4.19	3.12	4.57	3.97	3.52	7.70	4.73	4.28	5.39
		V/S		V X S			V/S		V X S	
S.Em. ±		1.49		2.98			1.75		3.50	
S.Ed. ±		2.10		4.21			2.47		4.95	

Table 90b : Effect of salinity on various traits in cotton –Chlorophyll and Na/K ratio

Variety	Chlorophyll (mg g^{-1} fw)					Na/K ion ratio in leaf tissue				
	ECiw (dS m^{-1})					ECiw (dS m^{-1})				
	BAW	4	8	12	Mean	BAW	4	8	12	Mean
G Cot 23	1.59	0.044	0.047	0.046	0.044	0.041	1.17	1.63	1.49	1.47
GShv 99/307	.98	0.060	0.057	0.047	0.053	0.049	.98	.89	1.07	0.98
GBav 109	0.95	0.058	0.052	0.059	0.054	0.049	1.02	1.33	0.97	1.07
GBav 120	1.14	0.069	0.061	0.066	0.069	0.079	1.37	.97	0.85	1.08
Mean	1.16	0.058	0.054	0.054	0.055	0.054	1.14	1.21	1.09	1.15
S.D.	0.37	0.018	0.013	0.012	0.015	0.020	0.18	0.34	0.32	0.30
		V/S		V x S			V/S		Vx S	
S.Em. ±		0.005		0.011			0.08		0.16	
S.Ed. ±		0.008		0.017			0.11		0.23	

Table 91 : Effect of salinity on various traits in cotton - Analysis of Variance (ANOVA) of different traits

Variety	Proline content in leaf (µg/g f.w.)					Biomass plant^{-1} (kg)				
	ECe (dS m^{-1})					ECe (dS m^{-1})				
	BAW	4	8	12	Mean	BAW	4	8	12	Mean
G Cot 23	423.93	504.70	612.40	612.40	538.36	0.40	0.31	0.50	0.36	0.39
GShv 99/307	316.20	603.40	405.95	522.20	461.94	0.14	0.25	0.28	0.30	0.24
GBav 109	397.00	379.00	450.85	459.40	421.56	0.31	0.27	0.42	0.33	0.33
GBav 120	405.98	549.55	414.95	513.65	471.03	0.21	0.24	0.34	0.26	0.26
Mean	385.78	509.16	471.04	526.91	473.22	0.27	0.27	0.38	0.31	0.31
S.D.	59.11	114.64	113.71	70.60	104.18	0.12	0.07	0.12	0.11	0.11
		V/S		V X S			V/S		V X S	
S.Em. ±		26.72		53.45			0.036		0.072	
S.Ed. ±		37.80		75.60			0.051		0.102	

BAW - Best Available Water

- Higher amount of osmotic substances like sugar and proline along with reduced uptake of ions like sodium and chloride and high chlorophyll content enabled GBav 120 and G.Cot 23 in better osmoregulation leading to better plant water status resulting in higher seed cotton yield.
- Four cotton accessions according to their yield, yield attributes and biochemical constituents can be placed in order G.Cot 23 > GBav 120> GBav 109> GShv 99/307 for salt tolerance.
- Based on these findings, GCot 23 and GBav 120 will be used as parent for making new crosses.

Development of new breeding populations

Ten crosses were made from herbaceums lines in F_2 generation (Table 92). Further, the lines would be developed based on salt tolerance and yield attributes.

Table 92 : Crosses made using herbaceum cotton lines

S. No.	F_1 Pedigree		
1	GBhv 291	x	GShv 297/07
2	GCot 23	x	GShv 378/05
3	GBhv 287	x	GShv 451/08
4	GBhv 287	x	GBhv 291
5	GBhv 451/08	x	GShv 290
6	GBhv 378/05	x	GShv 433/08
7	GBhv 291	x	GBhv 283
8	GBhv 297/07	x	GBhv 290
9	GBhv 297/07	x	GBhv 451/08
10	GShv 297/07	x	GShv 273/07

Mechanism of salt tolerance in maize

Nine maize hybrids (Table 93) obtained from Monsanto were irrigated with saline water of 3.4 dS m^{-1} The data on growth, ionic composition, yield and yield attributes and biochemical constituents given in Tables 94 and 95 indicate that variety DKC 8101 is superior in maintaining high protein and chlorophyll levels under saline water as compared to other hybrids.

Table 93 : Maize hybrids used in the study

S. No.	Hybrids	Description
1	900 M GOLD	Released hybrid by CVRC
2	DKC 9117	High yielding yellow grain
3	DKC 8101	High yielding yellow grain
4	IL 8534	Experimental hybrid
5	JI 8212	Experimental hybrid
6	DKC 7074	Release hybrid with good cooking quality
7	IJ 8214	Experimental hybrid
8	IL 8537	Experimental hybrid
9	Local White	White grain

The studies indicated that

- All the maize hybrids responded well to saline water irrigation on vertisols.
- Hybrids DKC 8101, DKC 9117, IL 8534, IJ 8214 and JI 8212 were found to be superior. They maintained better growth, plant water status, biomass production and higher seed yield as compared to local check.

Table 94 : Growth and biochemical constituents of maize under saline water irrigation (3.2 dS m^{-1})

Hybrid	Na^+ (ppm)	K^+ (ppm)	Cl^- (ppm)	K/Na ratio	Proline (µg/g)	Protein (µg/g)	Carbo-hydrate (µg/g)	Chlorophyll during flowering (%)	Leaf area (cm^2)	Plant height (cm)
900 MGOLD	8.50	333.87	562.08	39.27	7.95	913.68	663.69	36.96	491.31	224.58
DKC 9117	7.65	360.99	433.89	47.16	11.73	1203.74	696.03	42.82	424.13	236.67
DKC 8101	7.99	342.88	522.64	42.91	10.28	1263.86	552.77	35.81	510.36	273.67
IL 8534	8.21	352.94	591.67	42.97	10.00	886.00	623.50	34.43	695.34	246.00
JI 8212	7.50	336.62	640.97	44.91	13.41	1000.85	578.77	32.50	644.21	241.86
DKC 7074	8.72	354.78	512.78	40.68	6.41	1132.35	375.67	14.32	481.59	206.67
IJ 8214	7.63	440.97	640.97	57.79	9.93	1186.21	548.85	28.22	485.54	243.00
IL 8537	10.79	384.96	660.69	35.69	11.53	1226.28	395.92	24.96	447.55	237.00
Local white	8.44	385.94	749.44	45.72	10.42	1178.69	522.55	25.22	502.85	227.25

- Based on their performance and yielding ability, out of 8 hybrids, five were ranked DKC 8101 > IJ 8214 > IL 8534 > JI 8212 > 900 MGOLD and rest was found better than local check but not at par with the above hybrids.
- Hybrids DKC 8101, IJ 8214, IL 8534, JI 8212 and 900 MGOLD showed better tissue tolerance (Na and chloride relationship), seed yield, harvesting index and shelling ability.
- The farmers, who earlier adopted the poor yielder local white check with low yield potential, now have better maize accessions which would enable them to obtain higher yields under moderate saline conditions.

Table 95 : Yield and yield attributes of maize under saline water irrigation (3.2 dS m^{-1})

Hybrid	Biomass (kg)	Cob yield (kg)	HI (%)	100 seed wt (g)	Shelling (%)	Yield increase over local variety (%)
900 MGOLD	12.90	13.93	51.54	33.1	74.75	55
DKC 9117	11.76	12.69	51.70	29.8	79.28	42
DKC 8101	13.51	17.99	57.24	31.7	78.56	101
IL 8534	12.62	15.37	55.21	32.2	78.84	71
JI 8212	12.34	14.84	54.64	32.4	80.19	65
DKC 7074	9.68	11.74	54.69	27.7	80.65	31
IJ 8214	12.45	15.43	55.75	38.7	82.65	72
IL 8537	10.23	10.38	49.61	37.2	74.71	16
Local white	10.61	8.97	45.86	26.6	77.55	-

☆☆☆☆☆

COASTAL SALINITY MANAGEMENT

Study of Soil Salinity in relation to Land Use and Land Cover in Coastal Areas of West Bengal using Remote Sensing and GIS (Shishir Raut, S.K. Sarangi and B. Maji)

In this study, assessment of soil salinity was done for the coastal West Bengal covering Canning1, Basanti and Gosaba Blocks for the year 2013 in South 24 Parganas. IRSP6L3 data for summer season was collected from NRSC on 12th April, 2013. Survey of India maps (SOI) were collected from SOI office, Kolkata. Land use, soil series and soil salinity maps were collected from NBSS & LUP Regional Centre, Kolkata. IRSP6L3 standard satellite data were analysed in ERDAS IMAGINE-2013 software. The data were rectified using polyconic map projection with RMS error of 0.5. During rectification, 15 GCP's were selected. These points were found in SOI toposheet (1: 50,000). The latitude–longitude values for the points calculated from SOI map and observed in satellite image were separately fed for the programme. The image was then linearly rectified. The rectified map was then subset making AOI layer covering three Blocks namely, Canning 1, Basanti and Gosaba. A normalized difference vegetation index (NDVI) map was prepared from the rectified map (Fig.63). From the map, NDVI values for different features like rice field, bare soil, uncultivated grasses, water bodies, forests etc. were obtained (Table 96). The NDVI values for cultivated rice was 0.40-0.46, and that of

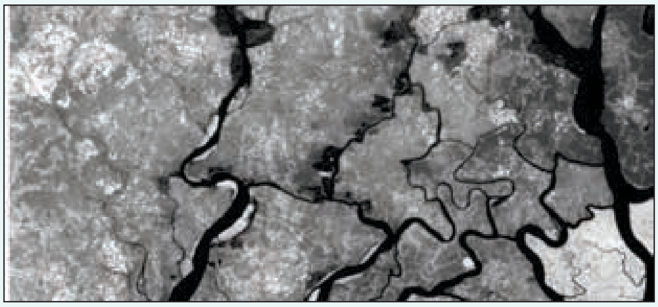


Fig. 63 : NDVI map of the study area

Table 96 : Normalized difference vegetation index (NDVI) values obtained from IRSP6L3 for different features

Feature type	EC (dS m^{-1})	NDVI
Rice	0.40-0.70	0.40-0.46
Bare soil	0.81-2.0	0.18-0.20
Water body	<1.0	<0
Forest	>5.0	0.46-0.55
Uncultivated grass	0.7-1.0	0.35-0.40

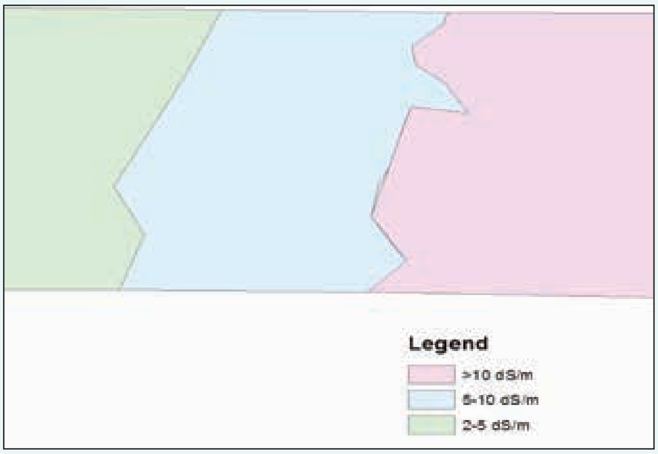


Fig.64 : Salinity map of the study area

bare soil, non-cultivated grass, forest, water bodies etc. were found to be 0.18-0.20, 0.35-0.40, 0.46-0.55, <0, respectively.

A salinity map of the study area was also collected. A composite map based on the conventional salinity and NDVI maps was prepared. It was found that soil salinity varied from 2-5 dS m^{-1}, 5-10 dS m^{-1} and > 10 dS m^{-1} from west to east of the study area (Fig. 64). The soil EC for rice crop was 0.40-0.70 dS m^{-1} and corresponding NDVI value was 0.40-0.46. The bare soils had low NDVI values (0.18-0.20) and relatively high EC (0.81-2.0 dS m^{-1}). NDVI of uncultivated grassland was 0.35-0.40 and that of forest, it was 0.46-0.55. In general, with an increase in soil EC there was a decrease in NDVI values for agricultural lands.

Assessment of Groundwater in the Research Farm of CSSRI Canning and Coastal Areas of W.B. using Geo-electrical Method, Remote Sensing and GIS (Shishir Raut, B. Maji and D. Burman)

Study was carried out to assess groundwater in terms of its potential and to understand the influence of soil particles on geo-physical parameters. Qualitative and quantitative interpretations of Vertical Electrical Sounding (VES) data along traverse 1-5-10-15 VES points indicated a thin layer of formation (0-6.5m) representing the soil cover with a resistivity of 58.5-227.0 Ohm-m. The high value of 226.5 and 241 Ohm-m at VES 5 and 15 may be due to hard clay layer below the rice soil. Below this layer, there is a thin layer of fine sand with low to moderate resistivity (>78.8 Ohm-m). A layer of fine sand and clay exists at a depth of 7-40 m

Table 97 : Correlation matrix generated for geo-chemical parameters and soil texture

Variables	S (30 m)	T (30 m)
Sand (0-0.15m)	-0.20	0.13
Silt (0-0.15m)	-0.24	0.31
Clay (0-0.15m)	0.30	-0.42
EC (1:2)	0.28	-

below the ground level with resistivity of 53.1-241.2 ohm-m throughout the traverse which along with the previous layer forms the potential aquifer for ground water in the study area. A distinct clay, hard sand and clay layer of variable thickness (15-40 m) exists below this zone.

The correlation matrix of soil texture and Dar-Zarrouk parameters (S and T) showed that S values were positively correlated (r=0.30) with clay and EC (r= 0.28) and negatively correlated with sand (r=-0.20) and silt (r =-0.24). Similarly, T values were negatively correlated with clay (r = -0.42) and positively correlated with sand and silt (r = 0.13 and 0.31) (Table 97).

Impact of Saline Water on Solar Powered Drip Irrigated *Rabi* Crops in Coastal Soils of West Bengal (K.K. Mahanta, S.K. Sarangi, U.K. Mandal, D. Burman and B. Maji)

A field experiment was conducted at CSSRI, RRS, Canning Town farm during 2013 for identifying a suitable *rabi* crop under drip irrigation system. The crops like cowpea, beet, okra, and basella were sown in the first week of February. The normal dose of fertilizers was applied in three splits during the cropgrowing period. There was flash flood three times towards the end of cropping season during May 2013. The cowpea suffered most from insects (ants) as well as water stagnation. The growth of beets in terms of biomass yield was good but affected by stagnant water. The leaves of basella crop became yellowish suffering from water stagnation. Overall, okra was the best crop and coped up well under soil salinity, water deficit, and water stagnation condition. The yield of all the crops was converted into okra equivalent yield (OEY) by taking the prevalent market price. Highest equivalent yield was obtained in okra (0.42 kg plant^{-1}) followed by basella (0.19 kg plant^{-1}) and the lowest OEY was observed in beet (0.07 kg plant $^{-1}$). Therefore, okra was the most suitable *rabi* crop under drip irrigation in coastal saline soils among the four crops.

Crops grown under drip irrigation system

Impact of Salt Tolerant Rice Varieties of CSSRI on Farmers' Economy in Coastal Salt Affected Areas (Subhasis Mandal, S.K. Sarangi, D. Burman, U.K. Mandal and B. Maji)

Rice was the main crop of *kharif* and *rabi* and will continue to be most dominant crop in the coastal areas of Sundarbans, West Bengal. Scope for expansion of area under rice was limited in *kharif* season because maximum area was already brought under cultivation and restricted in *rabi* as the good quality water was not plenty. Therefore, to increase the rice productivity, there was a need of technological intervention. One of the key options was to develop salt tolerant rice varieties for coastal areas. The study was focused on analyzing the impact of salt tolerant rice varieties on farmers' economy in coastal areas. Rice varietal adoption studies were quite challenging and sometimes might lead to either under valuation or tall claims. Once a rice variety is adopted by farmers, it was used to spread among farmers through own saving or exchanges among fellow farmers.

The study was initiated through primary survey in three states viz; West Bengal (coastal areas), Andaman and Nicobar Islands, and Goa. In these states, substantial coastal areas are salt affected. Primary survey on rice varietal adoption pattern is continuing and some observations indicated that farmers in this region need high yielding and salt tolerant rice varieties for *kharif* and *rabi* season. Farmers' adoption behaviour of new crop varieties depends on several attributes that includes characteristics of the varieties like yield, grain and straw quality, duration etc. as well as farmers' socio-economic conditions like farm situation, water availability, family income, off-farm and on-farm income, occupation, taste, preferences etc. Varietal preference during *kharif* and *rabi* are distinctly different. Maximising yield, better quality and ensuring better market price were the primary objective in *rabi* whereas low risk, stability of yield, tall and long duration of varieties were the deterministic factors for varietals adoption in *kharif*. Popularity of CSSRI rice varieties developed earlier (e.g., Canning 7) is gradually declining. Farmers' are more careful in choosing rice variety for *rabi* season and preferred high yielding rice varieties having good market demand (quality). However, Amalmana rice variety had gained popularity among the farmers in the region and it was estimated to provide 35-40 per cent higher yield as compared to the existing farmers' varieties such as Geetanjali, Dudheswar, Sabita etc. in *kharif* season.

Assessing Impacts of Brackish Water Aquaculture in Coastal Environment and Strategies for its Sustainable Use (D. Burman, U.K. Mandal, Subhasis Mandal, B. Maji and K.K. Mahanta)

The project was carried out in North 24 Parganas district in coastal areas of West Bengal with the objectives to assess the impacts of brackish water aquaculture on physical and social environment of the coastal region and to develop strategies to mitigate the adverse impact of brackish water aquaculture in coastal environment. Impact of brackish water aquaculture in terms of changes in soil and water salinity was studied in the adjoining agricultural fields and fresh pond water. It was observed that soil salinity was more in rice field adjoining the fish farms as compared to rice field away from fish farm. Fresh water ponds used for fresh water fish cultivation in the area were also affected due to brackish water aquaculture. The higher salinity in water and soil was recorded in the fish pond which was located in the adjoining areas of brackish water fish farm as compared to ponds away from it (Table 98). The increase in soil and water salinity in adjoining agricultural land and freshwater fish pond may be due to seepage of brackish water from brackish water aquaculture farms.

Brackish water aquaculture farms introduced in agricultural fields for <5, 5-10, 10-15 and > 25 years were selected for periodical monitoring of soil and water quality. Soil and water salinity of the fish farms varied periodically. Water salinity was the highest (29.5-31.2 dS m^{-1}) before onset of monsoon (June) and lowest (7.1-7.6 dS m^{-1}) in monsoon month like September. Soil salinity (ECe dS m^{-1}) of the surface layer (0-15 cm) was also highest (30.2-33.5 dSm^{-1}) before onset of monsoon (June) and lowest (9.74 – 10.71 dS m^{-1}) during monsoon (September). Higher salinity of soil and water was recorded in the old brackish water aquaculture farms compared to newly introduced farms.

Socio-economic study was conducted through primary survey as well as focus group discussion in several villages in North 24 Parganas District covering the details of age of brackish water aquaculture (BA) practices, leasing systems prevailing, stockings and costs/returns of the system. It was observed that the overall area under brackish water aquaculture was increasing and more and more paddy area converted to such system. In the study area, the BA started from 30-35 years and all these areas was under paddy cultivation. An individual farmer was managing about 1.3-2.0 ha of BA land and large area like 133.3-200 ha were managed by contractors through leasing system. The lands were leased out to the contractors for about 4-5 years with a rental value of Rs. 6650-7980 per ha. Management practices were very traditional. Free entry of river water without any purification, very often leads to virus attack and massive mortality of fishes.

Table 98 : Impact of brackish water aquaculture (BA) farm on rice field and fresh water pond

Months	Rice field								Fresh water pond							
	Adjoin to BA farms				Away from BA farms				Adjoin to BA farms				Away from BA farms			
	Water		Soil		Water		Soil		Water		Soil		Water		Soil	
	pH	EC	pH	ECe	pH	EC	pH	ECe	pH	EC	pH	ECe	pH	EC	pH	ECe
April	-	-	7.67	12.23	-	-	7.22	7.49	7.37	10.2	7.39	11.23	7.47	3.46	7.51	4.10
June	-	-	8.01	16.19	-	-	7.89	8.89	7.20	12.74	7.12	13.25	7.19	3.12	7.26	5.62
October	7.18	4.21	7.23	6.21	7.2	2.42	7.45	3.45	6.92	8.79	7.23	7.54	7.06	2.66	7.3	3.36
Nov.	7.13	5.76	7.13	8.24	7.07	3.01	7.21	4.10	6.89	10.12	7.45	10.32	7.20	2.62	7.61	3.93

ECe/EC: dSm^{-1}

Average costs of BA were Rs.10,640-13,300/ha including rent and return (Rs. 19,950-21,280/ha). Several externalities were being experienced due to expansion of such system in the study area. Most important externality was, once the land was converted to BA, land was no more suitable for growing other crops and the neighbouring lands were also affected by the saline water intrusion and it gradually becomes a compulsion to follow the BA. Therefore, many farmers were looking for the opportunities to practice freshwater aquaculture in *kharif* and *rabi*. However, growing crops in *rabi* become delayed and very difficult under such system. Major factors for expansion of BA in the study area were : 1) cultivation of paddy was becoming non-remunerative due to shortage of good quality irrigation water, but leasing out land for BA was easiest way to earn money. Farmers' families could look for other jobs in nearby cities or distance places for additional income, (2) Non-availability of family labourers for agriculture was the key factors for BA and farmers were likely to practice BA sooner or later and (3) Farmers in adjoining areas of BA were tempted to high return from fish cultivation. Trade-off between less remunerative paddy cultivation vs brackish water aquaculture were favouring the adoption of such system in the area.

Field experiment was conducted for controlling seepage losses to restrict the salinity build up in adjoining areas of brackish water aquaculture farms. Three treatments viz. control, deep trenches at outer side of the embankment of brackish water bodies and combination of both deep trenches + lining with polythene sheet at the inner side of brackish water bodies was taken in the experiment. Salt build up in the adjoining field was monitored periodically at a distance of 1 m interval from the water body. Salinity build up in surface soil (0-15 cm) was lower at treatment of trenches + lining with polythene sheet followed by trenches compared to control before onset of monsoon (June) (Fig. 65). However, no difference in soil salinity was observed at different treatments after monsoon (January) due to washing of salt with heavy monsoon shower. Similar trend was recorded at 15-30 cm soil layer.

Built up of soil and water salinity in adjoining agricultural land and fresh water reservoir was observed due to practicing brackish water aquaculture in the coastal areas and it can be

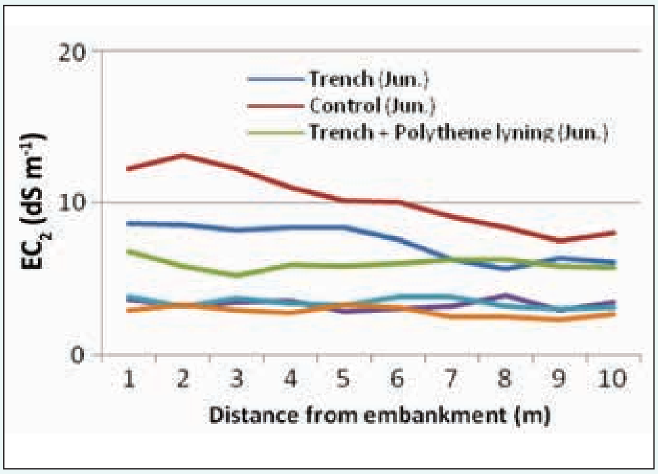


Fig. 65 : Soil salinity (0-15 cm) at different distances from brackishwater aquaculture farm

restricted by controlling seepage loss by making deep trenches at outer side of the embankment of brackish water bodies and making deep trenches at outer side of the embankment + lining with polythene sheet at the inner side of brackish water bodies.

Impact of Conservation Tillage on Utilization of Residual Moisture, Soil Health and Crop Yield under Rice-Cotton Cropping System in Coastal Agro-ecosystem (U.K. Mandal, D. Burman, S.K. Sarangi and B. Maji)

Considering the benefit of conservation tillage in rice based cropping system, a field experiment was continued to evaluate the impact of conservation tillage on soil health under rice-cotton cropping system in coastal region of West Bengal. The experimental site was under mono-cropped paddy cultivation for last eight years with low soil organic carbon and available nitrogen. The climate of the site is hot humid, the average annual rainfall is 1802 mm, out of which about 89 per cent occurs during monsoon season (June-October).

The design of experiment is split-split plot with cropping system (rice-rice and rice-cotton) (*kharif-rabi*) as main plot treatments and tillage type (Zero tillage (ZT), Reduced tillage (RT), and Conventional tillage (CT) as sub plot treatments. The second year of the study showed that there was 10-23 per cent yield reduction in zero tillage than other treatments and yield reduction was more in rice-cotton system than rice-rice system (Table 99). Soil physico- chemical properties (Table 100) and operation wise energy utilization pattern in each treatment was evaluated. Though, there

Table 99 : Rice and cotton yield (t ha^{-1}) during *rabi* (2012-13) and *kharif* (2013) under rice-rice and rice-cotton system

Treatment	*Rabi* cotton and rice yield			*Kharif* rice yield			Total *rabi* and *kharif* yield		
	Cotton in rice-cotton system			Rice in rice-cotton system			Rice equivalent yield		
	Residue	No residue	Average	Residue	No residue	Average	Residue	No residue	Average
ZT	1.71	1.18	1.45	3.44	3.39	3.42	8.58	6.93	7.75
RT	1.87	1.96	1.91	4.39	4.47	4.44	10.00	10.34	10.17
CT	1.89	2.11	2.00	4.43	4.33	4.38	10.10	10.67	10.38
Average	1.82	1.75		4.09	4.06		9.56	9.31	
	Rice in rice- rice system			Rice in rice- rice system					
ZT	4.46	4.26	4.36	4.22	4.15	4.18	8.68	8.41	8.55
RT	4.86	4.92	4.89	4.53	4.63	4.58	9.39	9.55	9.47
CT	4.84	4.73	4.79	4.77	4.66	4.71	9.61	9.40	9.50
Average	4.72	4.64		4.51	4.49		9.23	9.12	
Cropping System			S			NS			S

Tillage-S, Residue-NS, Cropping System x Tillage-NS, Cropping system x Residue-NS, Tillage x Residue-NS, Cropping system x residue x tillage-NS; NS- non significant; S-Significant ($P < 0.05$), Cotton yield was multiplied with three considering cotton price three times of rice to get rice equivalent yield

Table 100 : Soil physical and chemicals properties after *kharif* rice (December 2013)

Treatment	pH	EC (dS m^{-1})	OC (%)	Ex. K (kg ha^{-1})	BD (g/cc)	Av. P (kg ha^{-1})	Ex. Ca	Ex. Mg	Ex. Na
							Meq 100g soil^{-1}		
	Cotton – rice								
ZT	7.93	1.50	0.435	586	1.57	21.64	6.47	8.48	5.28
RT	7.72	2.13	0.451	577	1.55	21.47	7.85	5.05	6.39
CT	7.65	1.97	0.442	501	1.48	19.22	6.05	8.25	6.55
Residue	7.85	1.78	0.451	541	1.50	21.63	6.94	7.60	6.06
No residue	7.69	1.96	0.434	568	1.56	19.92	6.63	6.92	6.09
Average	7.77	1.87	0.443	554	1.53	20.78	6.79	7.26	6.08
	Rice – rice								
ZT	7.42	0.87	0.48	574	1.52	24.24	7.28	6.72	3.49
RT	7.49	0.94	0.46	477	1.47	26.31	7.07	8.37	3.73
CT	7.68	1.37	0.54	588	1.48	23.62	6.70	7.48	4.47
Residue	7.47	1.14	0.47	506	1.46	26.91	6.79	7.82	3.57
No residue	7.59	0.99	0.50	566	1.49	22.54	7.24	7.22	4.23
Average	7.58	1.06	0.491	546	1.48	24.73	7.02	7.52	3.90

was no significant difference in soil properties among treatments, bulk density increased in zero tillage than other treatments. More than 80 per cent of energy was used for indirect energy of application of inorganic fertilizer. Rice-rice system was more efficient in energy utilization than rice-cotton system and the results showed that reduced tillage under rice-rice system was most efficient than other treatments.

Evaluation of Crop Establishment Methods for Rice-based Cropping System in Coastal Salt Affected Soils (S.K. Sarangi, U.K. Mondal and S. Mandal)

The experiment consisted of three methods of *kharif* rice crop establishment viz. dry direct sowing (DSR), unpuddled transplanting (UNPT) and puddled transplanting (PT) in main plot, three *rabi* crop establishment methods in sub-

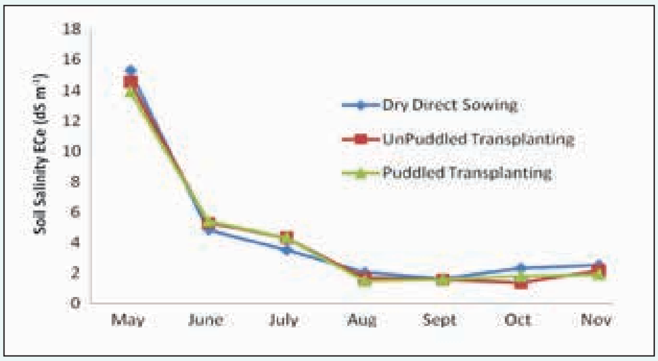


Fig. 66 : Variation of soil salinity during kharif season

plot (direct sowing/dibbling, normal sowing and ridge sowing) and two *rabi* crops in sub-sub plot (rapeseed and maize). Direct sowing for *kharif* rice (var. Amal-Mana) was done on 28th May 2013 when soil salinity was 15.27 dS m^{-1} and it was reduced to 4.84 dS m^{-1} in the month of June due to occurrence of monsoonal rain (Fig. 66).

On the same day, nursery sowing was done for other two treatments. The germination was 82.50, 82.98 and 82.44 per cent for DSR, UNPT and PT, respectively. In DSR treatment, there was 10.7 per cent mortality of seedlings in the month of June due to salinity, whereas other treatments were not affected as the salinity was low.

Tillers $hill^{-1}$ was 7, 7 and 6 in DSR, UNPT and PT treatments, respectively at 40 days after sowing (DAS), which increased to 11, 11 and 12, respectively at 60 DAS. Thereafter, it decreased in all the treatments due to mortality of secondary tillers. In the last week of August to first week of September 2013, there was heavy rain, which submerged and damaged the normal transplanted crop in the adjacent plots, whereas in DSR plot, the crop was not affected as the plants were above the standing water due to higher plant height.

Weed biomass in different treatments were studied at 80 DAS. The differences were statistically non-significant, which may be due to application of selective herbicide Pretilachlor 50 EC applied at 33 DAS to all the treatments. Root length was studied at different growth stages and found highest in the DSR treatment. Highest grain yield (5.08 t ha^{-1}) was recorded in PT followed by DSR (4.93 t ha^{-1}) and UNPT (4.55 t ha^{-1}). However, the differences were statistically non-significant. Similar trend was obtained for straw yield. Net return and benefit cost ratio was highest in DSR due to reduction in cost of cultivation (Table 101).

After *kharif* rice, bulk density (BD), soil moisture (SM) and soil organic carbon (SOC) were studied. The bulk density of soil was significantly higher in PT plot in comparison to DSR and UNPT. Soil moisture and SOC were higher in the DSR plots. After *kharif* rice, maize and rapeseed were directly sown on 3rd December, 2013. Maize was sown in holes at a spacing of 60 cm x 30 cm and rapeseed in continuous lines at a row spacing of 30 cm. After sowing, holes and rows for maize and rapeseed were covered by dry farm yard manure (FYM).

Direct/dibble sowing of rabi crops after harvest of kharif rice

Table 101 : Yield and economics of *kharif* rice as influenced by establishment methods

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Cost of cultivation (Rs ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C ratio
Dry direct sowing	4.93	9.87	25158	68996	43838	2.74
Unpuddled transplanting	4.55	10.43	31683	64637	32954	2.04
Puddled transplanting	5.08	10.83	41640	71591	29951	1.72
SEm±	0.46	1.04	-	-	-	-
LSD (0.05)	NS	NS	-	-	-	-

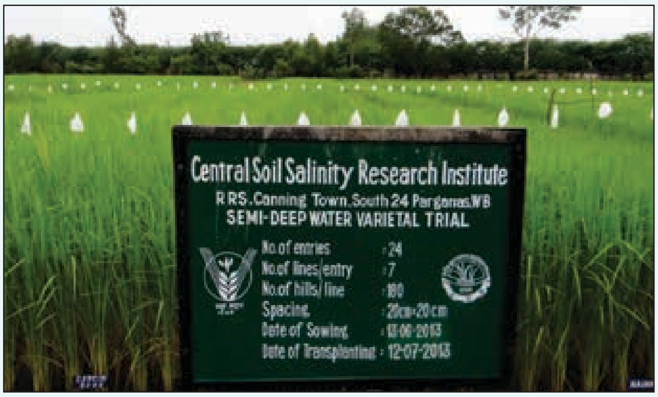
Coastal Saline Tolerant Variety Trial (CSTVT) (S.K. Sarangi and B. Maji)

During *kharif* 2013, twenty eight entries (2201 to 2228) were evaluated under CSTVT at CSSRI, RRS, Canning Town. These entries include 3 checks including coastal saline check (CST 7-1), yield check (Jaya) and local check (Canning 7). The entries were sown in the nursery on 11.7.2013 and transplanted on 16.08.2013 at a spacing of 15 cm x 15 cm in net and gross plot size of 4.20 and 5.94 m^2, respectively. Two entries viz. 2227 and 2228 did not germinate in the nursery. Lowest (77.75 cm) and highest (124.37 cm) plant height and panicles m^{-2} were observed in entry no. 2212 and 2218, and. 2218 and 2223, respectively. Highest grain yield of 4.15 t ha^{-1} was recorded in entry no. 2202 followed by 2201 (4.04 t ha^{-1}) and 2203 (3.64 t ha^{-1}). Local check (Canning 7) produced the grain yield of 3.35 t ha^{-1}.

CSTVT trial conducted during kharif 2013 at Canning Town

Maintenance and Evaluation of Rice Germplasm/Varieties for Semi-deep Water Ecosystem (S.K. Sarangi and B. Maji)

Under semi-deep water situation, 24 entries were evaluated during *kharif* 2013. Highest grain yield of 4.02 t ha^{-1} was produced by CSRC (D) 7-0-4 followed by CSRC (D) 12-8-12 (3.80 t ha^{-1}) and CSRC(D) 2-0-8 (3.78 t ha^{-1}), which were found statistically at par with each other (Table 102). Highest (176.33 cm) and lowest plant height (107.33 cm) were observed in NC 678 and Swarna *sub 1*, respectively. Highest tillers hill^{-1} and ear bearing tillers hill^{-1} was observed in line CSRC (D) 7-0-4.



Evaluation of semi-deep rice germplasm/lines/varieties during kharif 2013

Evaluation of Rice Germplasm/Varieties for Low Land Ecosystem (S.K. Sarangi and B. Maji)

Under low land situation, 51 entries were evaluated during *kharif* 2013. The highest grain yield of rice (5.15 t ha^{-1}) was obtained from Amal-

Table 102 : Rice germplasm/varieties/lines tested under semi-deep water ecosystem

Sl. No.	Entries	Plant height (cm)	Tillers/hill (no.)	EBT/hill (no.)	Grain yield (t ha^{-1})
1	Gavir Saru	134.00	9	9	3.13
2	C 300 BD-50-11	150.67	9	9	3.26
3	CSRC(D) 2-17-5	147.67	9	8	3.46
4	CSRC(D) 2-0-8	167.67	10	10	3.78
5	CSRC(D) 7-5-4	163.00	10	9	3.23
6	CSRC(D) 12-8-12	155.00	11	10	3.80
7	CSRC(D) 13-16-9	157.00	8	8	3.12
8	CSRC(D) 7-12-1	161.67	9	9	3.50
9	CSRC(D) 7-0-4	158.00	12	11	4.02
10	Nalini	142.33	7	7	3.07
11	Swarna sub 1	107.33	8	8	3.15
	SEm±	2.66	0.84	0.78	0.50
	CD (P=0.05)	7.58	2.39	2.23	1.43

mana, followed by CSR 40 (5.05 t ha^{-1}) and CSR 41 (4.95 t ha^{-1}). The lowest grain yield of rice was obtained from variety pokali (2.24 t ha^{-1}).

Strategies for Sustainable Management of Degraded Coastal Land and Water for Enhancing Livelihood Security of Farming Communities (D. Burman, S. Mandal, S.K. Sarangi, K.K. Mahanta, U.K. Mandal and B. Maji)

This GEF funded NAIP sub-project was implemented since September 2009 under consortium mode with the objectives of (i) sustainable enhancement of the productivity of degraded land and water resources of the coastal region through integrated approaches; (ii) enhancement of livelihood security and employment generation for the poor farming communities of the coastal region; and (iii) empowerment through capacity building and skill development of stakeholders including men and women farmers. CSSRI Regional Research Station, Canning Town is the lead center of the consortium and the partners are Ramkrishna Ashram Krishi Vigyan Kendra (RAKVK), Nimpith, Central Institute of Brackishwater Aquaculture, Kakdwip Research Centre (CIBA, KRC), Kakdwip, Bidhan Chandra Krishi Viswavidyalaya (BCKV), Mohanpur and Central Agricultural Research Institute (CARI), Port Blair. The project sites are disadvantaged areas in Sundarbans region of Ganges delta (West Bengal) and *Tsunami* affected Andaman and Nicobar Islands covering 32 villages in 12 Clusters of 4 districts (2 in West Bengal and 2 in Andaman & Nicobar Islands). The project was implemented in 8 Clusters representing 7 Blocks viz; Canning I, Basanti, Patharpratima, Mathurapur II, Kultali, Namkhana and Kakdwip in South 24 Parganas District and 1 Block viz., Sandeshkhali II in North 24 Parganas District in Sundarbans and in 4 Clusters viz; Chouldari in Port Blair and Shoal Bay in Ferrargunj of South Andaman District, and Dashrathpur in Rangat and Deshbandhugram in Diglipur of North and Middle Andaman District in Andaman and Nicobar Islands.

Major critical gaps identified in the project sites are degraded land and water with high salinity and waterlogging and drainage congestion; high scarcity of good quality irrigation water during dry season with poor cropping intensity (monocropped) and low productivity of land and water; and poor soil health and unscientific soil fertility management. Various technological interventions suiting to the prevailing land and water resources were implemented to bridge these gaps for higher land and water productivity in a sustainable manner. The major technological interventions/innovations implemented in the project sites were land shaping for improving drainage congestion, rainwater harvesting and enhancing productivity of low lying degraded lands including *Tsunami* affected land; cultivation of multiple and diversified crops including horticultural crops and their improved varieties for degraded saline and *Tsunami* affected lands, promotion of composting including vermi-composting, green manuring, INM, etc. for enhancing productivity of agriculture and aquaculture and improvement of soil health; skill and capacity building of farmers and other stakeholders and establishment of rural technology centers in villages at the project sites.

About 263.7 ha of land (180.4 ha and 83.3 ha in Sundarbans and Andaman & Nicobar Islands, respectively.) was converted from monocropped to multicropped with integrated crop and fish cultivation through implementation of different land shaping techniques like farm pond, deep furrow and high ridge, paddy-cum-fish, broad bed and furrow, three tier, pair bed and drainage improvement network. More than 1500 households were involved under land shaping techniques. About 8,48,530 m^3 rain water was harvested through various land shaping techniques adopted in 263.7 ha area and out of this, 178.9 ha area was brought under multiple cultivation of crops with harvested rainwater. The cropping intensity was increased up to 300 per cent from a base level value of 100 per cent due to implementation of land shaping techniques in the study area. Compared to base line value, the income of the farmers increased manifolds. Land raising and creating water harvesting facilities reduced the problem of drainage congestion and salinity build up in soil during dry months. Reduction of salinity and drainage congestion and increase in availability of fresh water for irrigation helped the farmers to grow multiple crops round the year instead of mono-cropping with rice in monsoon season (*kharif*). About 19.0 ha area was brought under brackish water aquaculture through shaping of land into shallow depth pond in the coastal areas particularly near the brackish water rivers or sea coast which remain highly saline throughout the year and not suitable for irrigation.

New crops and improved varieties of crops like rice, vegetables, pulses, oilseeds, plantation and spices, cotton, fruit crops, etc. were introduced in 374.3 ha area in monocropped and degraded land in disadvantaged region of Sundarbans and Andman and Nicober Islands for sustaining food security and economic growth. Introduction of improved varieties and crop diversification has increased productivity of degraded lands by 12-20 per cent. It has enhanced employment, reduced risk of crop failures, provided better nutritional security, improved soil health, crop nutritional imbalances and increased farm income.

Technological interventions like green manuring with *sesbania*, fertilizer application on soil test basis and vermi-composting were introduced to enhance the health and fertility status of the degraded soils of the study area. About 81 ha of degraded land were brought under improved nutrient management and 120 vermi-composting units were established in the study areas.

On-campus and off-campus training programmes and exposure visits of farmers were organized by all the partner institutions on various aspects for skill and capacity building of the farming communities of the study area. More than 6000 farmers participated in 133 trainings/ exposure visits. Four Rural Technology Centres (RTCs) were established in Canning I, Patharpratima, Kakdwip and Kultali Clusters of Sundarbans region.

About 6050 farmers are using different technological interventions in the study area under this project. For sustainability of the project, an amount of Rs. 72 lakhs as sustainability fund was generated up to January, 2014 at all the

Deep furrow and high ridge technique of land shaping

Pair bed technique of land shaping

cluster levels to ensure continued technological upgrading and land holding of the beneficiary farmers. Synergy was developed with different line departments and NGOs. During the year, Govt. of West Bengal has allocated Rs.16.48 crores through different schemes like ATMA; NREGA and BGREI to implement land shaping techniques in different parts of the Sundarbans region. Different workshops which were organized under this project were 'Review and planning workshop of NAIP sub-project' at RAKVK, Nimpith on 23rd March 2013, 'Up-scaling of agro-technologies for enhancing livelihoods in coastal regions of India' at NIRJAFT, Kolkata on 20.08.2013 and 'Review workshop: GEF funded NAIP sub-projects' held at Sundarbans from Oct. 26-28, 2013.

Stress-Tolerant Rice for Africa and South Asia (STRASA – Phase 2)

Stress Tolerant Rice for Coastal Soil (B. Maji, D.Burman, S.K. Sarangi and Subhasis Mandal)

Under the participatory research programme on Stress tolerant rice for poor farmers of Africa and South Africa (Phase 2) funded by Bill and Melinda Gates Foundation (BMGF), farmers were involved in selecting rice lines/varieties included in researcher-managed trials (Mother trials), sensory evaluation, and in farmer-managed trials (Baby trials). Trials were conducted during *rabi* and *kharif* seasons at different parts of Sundarbans with the major thrust to identify most suitable varieties/ new lines of rice along with their management practices through participatory varietal selection (PVS); thereby enabling the poor farmers of eastern coastal areas of the country to produce more food, generate more income and to reduce poverty and hunger.

Researcher-managed trials (Mother trials)

During *rabi* 2012-13, three on-farm mother trials were conducted at Bermajur village of Sandeshkhali-I Block and Daudpur village of Sandeshkhali-II Block in North 24 Parganas District and at Arampur Village of Gosaba Block in South 24 Parganas District. A set of 10 promising varieties/new lines viz. WGL20471 (Lalminikit), IET4786 (Sadaminikit), Annada, Boby, Parijat, N-Sankar, Super Sankar, Khitish, Bidhan-2 and CSR-22 was evaluated under Mother trials. The single–factor experiment in randomized complete block design (RCBD) was followed with 3 replications. Preference analysis (PA) was conducted during the pre-harvest period when most of the varieties were at 80 per cent maturity stage. A group of male and female (at least 30% female participants) farmer-co-operators for PVS and other stakeholders (breeders, extension workers and traders) were invited to select the 2 most preferred and 2 least preferred varieties/lines during the field day. In Preferential Analysis (PA) for the Mother trials, Bidhan 2 and Boby emerged as the most preferred rice varieties, while Khitish, CSR 22 and WGL20471 (Lalminikit) emerged as least preferred varieties. The least preferred varieties at different locations were not alike because of differences in farmers' opinion on selection traits which were dominated by salinity tolerance of the varieties, duration of varieties, grain quality and yield potentiality. The varieties preferred most by the farmers had traits like tolerance to salinity, tall plant type, long panicles with more grains, no/ minimum infestation of pest and diseases, more tillers, good grain types (medium long and medium bold), overall good performance of crop, more straw for fodder/thatching/fuel and expected high yield, etc. Farmers didn't prefer Khitish and CSR 22 because of their short plant height, small panicles with unfertile grains, poor tillering, and expected low yield. Rice variety WGL 20471 (Lalminikit) emerged as one of the most preferred during previous year but it was least preferred one this year because the crop was damaged as compared to other varieties/lines due to hail storm during milk grain stage. The grain yield of the crop revealed that highest grain yield of 4.78 t ha^{-1} was produced by Bidhan-2 and lowest of 3.88 t ha^{-1} by Khitish.

During *kharif*, two on-farm Mother trials were conducted at Simulhati village of Sandeshkhali-I Block in North 24 Parganas District and Joygopalpur village of Basanti Block in South 24 Parganas District. The entries were Amalmana, Geetanjali, SR 26B, Sabita, Swarna Sub-1, Namita Dipti (CSR21-2-5-B-1-1), Dinesh, Patnai 23, CST 7-1 and Bina-8. The preferential analysis was conducted at two locations. Rice entries viz; Amalmana, Sabita, Swarna sub-1 and CSRC (S) 21-2-5-B-1-1 emerged as farmers' most preferred ones. Farmer's preferences were linked to traits like heavy weight of panicles, long panicles, strong plants, less lodging, more no. of grains/ panicles, less shattering of grain, sustainability for the deep waterlogging conditions in these areas. Least preferred entries were Bina-8 and CST 7-1. Farmers did not prefer the attributes like early flowering causing rat damage, lesser tillers, less no. of grains and expected low yield. Among the different entries under trials, the highest grain yield of 4.16 t ha^{-1} was recorded for Swarna sub-1, while lowest yield of 3.52 t ha^{-1} for Bina-8.

Preferential Analysis at village Arampur

Farmer-managed trials (Baby trials)

Twenty baby trials were carried out during *rabi* at farmers fields at different villages of Canning I, Basanti, Gosaba Blocks in South 24 Parganas District and Sandeshkhali- I & II Blocks in North 24 Parganas District of Sundarbans region. Three varieties viz. WGL20471 (Lalminikit), IET4786 (Sadaminikit) and Annada were given to farmers for the trials. In Baby trials, farmers were given seed invigouration treatment practices with organic (neem leaf powder), inorganic (Bavistin) and control (no inputs). About 16 and 11 per cent improvement in yield of rice varieties as recorded at organic and inorganic seed invigoration treatments, respectively over farmers' practice.

Fifteen baby trials were conducted during *kharif* in different villages of Basanti Block in South 24 Parganas District and Sadeshkhali - I Block in North 24 Parganas District. Three promising

Baby trail at village Jaygopalpur in Basanti Block

varieties viz. Amalmana, Geetanjali and SR26B were included in the trials. The planting treatments like conventional transplanting and line spacing (20 cm x 15 cm) were followed as management practices. About 8-10 per cent improvement in yield was recorded under line spacing treatment over conventional transplanting method.

Sensory evaluation

During this period, sensory evaluation was conducted at village Korakathi, Canning I Block and village Arampur, Gosaba Block in South 24 Parganas District, and village Daudpur, Sandeshkhali II Block in North 24 Parganas District of West Bengal. The three samples evaluated by farmers were Sabita (local check and 1st preferred line during 2012 preference analysis), CSRC (D) 12-8-12 (2nd preferred line), and CSRC (D) 21-5-2-B-1-1 (3rd preferred line). The results of sensory evaluation revealed that all samples were acceptable to the farmers but they ranked CSRC (D) 12-8-12 as 1st, Sabita as 2nd and CSRC (D) 21-5-2-B-1-1 as 3rd in terms of eating and cooking quality (Table 103). Farmers preferred CSRC (D) 12-8-12 most because of its good taste and aroma, attractive colour, glossy appearance, soft but non-cohesive texture, digestibility, and good keeping quality. Male and female farmers' have preferred the same variety across sites based on eating and cooking qualities. Female farmers though gave higher preference ratings than males. Farmers, especially women, look for other eating and cooking qualities of rice such as: keeping quality (remains soft even when eaten the next day), more grain expansion, a feeling of satiety, suitability for various rice preparations, high prices, and lesser time to cook.

Sensory Analysis at village Korakathi

Table 103 : Sensory evaluation for test varieties

Code/Variety	Percent Acceptable		Relative weight: Ranking		Relative weight: Rating		Combined weight		Rank	
Village Daudpur (Female-17, Male-21)										
Variety	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
Sabita (LC*)	100	100	38.24	30.95	35.41	28.57	36.82	29.76	2	2
CSRC (D) 12-8-12	100	95	38.24	44.44	37.94	47.14	38.09	45.79	1	1
CSRC (D) 21-5-2-B-1-1	100	100	23.53	24.60	26.65	24.29	25.09	24.44	3	3
Village Gosaba (Female-18, Male-16)										
Sabita (LC)	100	100	28.70	29.17	28.06	28.35	28.38	28.76	3	2
CSRC (D) 12-8-12	100	94	42.59	45.83	43.33	44.82	42.96	45.33	1	1
CSRC (D) 21-5-2-B-1-1	100	100	28.70	25.00	28.61	26.83	28.66	25.91	2	3
Village Korakati (Female-13, Male-10)										
Sabita (LC)	100	100	38.46	31.67	37.92	28.86	38.19	30.26	1	2
CSRC (D) 12-8-12	100	100	33.33	40.00	33.38	39.80	33.36	39.90	2	1
CSRC (D) 21-5-2-B-1-1	100	100	28.21	28.33	28.69	31.34	28.45	29.84	3	3

*LC- Local check

Salinity Tolerant Breeding Network (STBN)

STBN trial was conducted at the experimental farm of CSSRI, RRS Canning Town during *kharif* 2013 with 33 rice genotypes including 5 check varieties in Randomized Block Design (RBD) with 3 replications. Days to 50 per cent flowering of the entries ranged from 70 days (CSR 12-B 19) to 142 days (PNL 4-35-20-4-1-4) with a mean of 110 days. It was 112, 120, 128, 118 and 121 days for CST 7-1 (check), CSR27 (check), CSR-36 (check), Canning-7 (local check), Geetanjali (local check), respectively. Plant height of the entries varied from 87 cm (NDRK 11-2) to 147 cm (KR09009) with a mean height of 115 cm. Stress score at vegetative stage varied from 1 (RP 4353-MSC-38-43-6-2-4-3, Geetanjali (local check), Canning-7 (local check), NDRK 11-17, KR 09003, KR09009, CSRC(D) 2-17-5, CR 2814-2-4-3-1-1-1), CR2815-4-23-7-5-2-1-1, CST 7-1 (check), CSR 27 (check), CSR36 (check), to 6 (CSR- 2K -255) with a mean value of 2. At reproductive stage, stress score also varied from 1 (RP 4353-MSC-38-43-6-2-4-3, Geetanjali (local check), Canning -7 (local check), NDRK 11-17 , KR 09003 , KR09009, CSRC(D) 2-17-5 , CR 2814-2-4-3-1-1-1, CR2815-4-23-7--5-2-1-1 , CST 7-1 (check) , CSR 27 (check) , CSR36 (check) to 6 (CSR- 2K -255) with a mean value of 3. Tillers per plant ranged from 8 (CSR 12-B 19) to 14 Geetanjali (local check) with a mean value of 11. Number of reproductive tillers varied from 7 (CSR 12-B-19, CSR36 (check), NDRK11-3) to 12 Gitanjali (cheek) with a mean of 9. Panicle length of the different entries under trial ranged from 17 cm (CSR 12-B 19) to 24 cm (CSR-2K-219, CSRC(D)13-16-9) with a mean of 21cm. Number of filled grains per panicle varied from 54 (NDRK 11-17) to 96 (NDRK 11-1, NDRK11-8) and mean of 81. Spikelet fertility of the entries under trial ranged from 75.7 per cent (NDRK 11-3) to 90 per cent (RP 4353-MSC-38-43-6-2-4-3, NDRK-11-1) with a mean of 85 per cent. In the trial, 1000 grain weight of the entries varied from 14.21 g (CSR- 2K -255) to 28.75 g (CSR 10-M2-27) with a mean of 24 g. Mean grain yield of different entries under trial are presented in Fig.67. Grain yield of the entries varied from 2.47 to 4.40 t ha^{-1} with mean yield of 3.46 t ha^{-1}. Out of all the entries higher grain yield was recoded from Geetanjali (4.40 t ha^{-1}), CSRC(D)12-8-12 (4.40 t ha^{-1}), RP 4353-MSC-38-43-6-2-4-3 (4.23 t ha^{-1}), CSR 27-192 (4.18 t ha^{-1}), NDRK-11-8 (4.13 t ha^{-1}), KR09009 (4.13 t ha^{-1}), Canning -7 (local check) (4.01 t ha^{-1}) and from other check varieties viz. CSR-36 (3.68 t ha^{-1}), CST7-1 (3.67 t ha^{-1}), CSR27(3.47 t ha^{-1}).

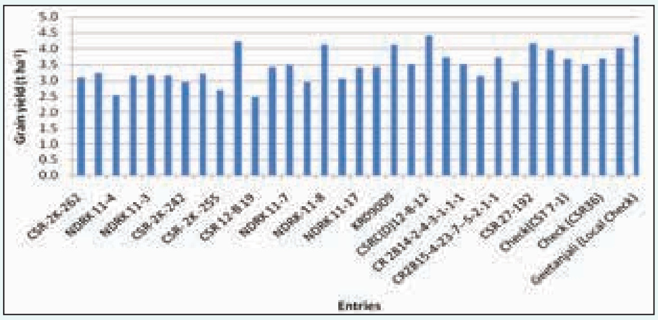


Fig. 67: Mean grain yield of entries under STBN trial

Productive, Profitable and Resilient Agriculture and Aquaculture Systems (CGIAR Challenge Programme on Water and Food, CPWF) (D. Burman, S. Mandal, S.K. Sarangi and B. Maji)

Research for Development Programme of the Ganges Basin Development Challenges (GBDC) under CGIAR Challenge Programme on Water and Food (CPWF) was operated in the coastal salt-affected areas with a goal to develop and introduce more productive, diversified, and resilient agriculture/aquaculture production systems in the fresh/brackish water coastal zones of the Ganges delta in Bangladesh and India. The objectives of the project were: Validate new germplasms of rice suitable for different areas of the Ganges delta and establish seed distribution networks in target zones; and enhance the productivity of homestead production systems. The project was implemented in India and Bangladesh in a consortium mode. IRRI is the lead organization, and WFC, BRRI, BFRI, BRAC, CSSRI and CIBA are consortium partners.

Participatory varietal evaluation and seed multiplication

During *rabi* (Boro) 2012-13, three varietal evaluation and 30 seed multiplication trials were conducted at village Kheria of Basanti Block in South 24 Parganas District, village Bermajur of Sandeshkhali-I Block and village Daudpur of Sandeshkhali-II in North 24 Parganas District. Ten varieties of rice were selected viz; WGL-20471 (Lalminikit), IET-4786 (Sadaminikit), Annada, Parijat, Bidhan-2, N.Sankar, Super Sankar, BRRI Dhan 47, BRRI Dhan 55 and BINA Dhan 8. The characteristics of the varieties taken in the trial conducted in Kheria village have been summarised in Table 104.

Table 104 : Varietal evaluation at village Kheria, Block Basanti, Dist. South 24 Parganas

Variety	Plant height (cm)	No. of tillers hill^{-1}	No. of panicles hill^{-1}	Panicle length (cm)	Grains panicle^{-1}	Unfiled grains panicle^{-1}	1000 seeds weight (gm)	Grain yield* (t ha^{-1})
WGL-20471 (Lalminikit)	98.2	16	15	22.4	70.7	26.9	17.0	5.8
IET-4786 (Sadaminikit)	95.1	26	23	21.91	65.7	23.6	16.0	5.2
Annada	95.1	18	16	21.58	69.0	27.5	20.6	4.6
Parijat	95.6	26	24	22.04	69.2	13.2	16.6	3.8
Bidhan-2	115.4	13	12	21.92	85.2	30.8	14.4	4.8
N. sankar	103.7	20	18	20.56	67.2	14.5	17.2	5.3
Super sankar	106.0	17	13	23.77	59.7	20.4	17.0	4.4
BRRI dhan 47	108.5	15	14	25.89	91.1	32.8	22.8	5.8
BRRI dhan 55	97.7	15	14	21.98	63.5	18.8	25.2	4.2
BINA dhan 8	116.0	15	15	22.44	71.0	27.6	22.6	5.2
CD (0.05)	8.0	4	6	1.6	5.0	3.8	10.5	0.5

Grain yield of WGL-20471 (Lalminikit) and BRRI Dhan 47 was higher at this experimental site. At village Daudpur, highest grain yield (4.80 t ha^{-1}) was recorded from BRRI Dhan 47 followed by WGL-20471 (Lalminikit) (4.80 t ha^{-1}). Grain yield of Bidhan-2 (4.92 t ha^{-1}) was highest followed by Bina 8 (4.89 t ha^{-1}) at village Bermajur. Preferential analysis under PVS indicated that IET 4786 (Sadaminikit), Annada, Bidhan-2, BINA Dhan 8 and BRRI Dhan 47 were farmers' most preferred while Super Sankar, BRRI Dhan 55 and N. Sankar were least preferred varieties of rice. The most preferred and least preferred varieties at different locations were not alike because of differences in farmers' opinion on selection traits which were dominated by salinity tolerance of the varieties, duration, grain quality and yield potentiality. The seed multiplication sites were at Block Canning-I, Gosaba, Basanti in South 24 Parganas District and Sandeshkhali-I, Sandeshkhali-II in North 24 Parganas District. The rice variety for seed multiplication was WGL-20471 (Lalminikit). 17.84 t seed was produced under participatory mode.

During *kharif,* three rice varietal evaluation trials were conducted at village Pakhiralay of Gosaba Block, village Mokamberia of Basanti Block in South 24 Parganas District and village Bermajur of Sandeshkhali I Block in North 24 Parganas District. Ten varieties/lines viz. Amalmana, Patnai 23, SR 26 B, CSRC(D) 7-0-4, CSRC(D) 2-17-5, NC 678, BRRI Dhan 47, Sabita, BRRI Dhan 55 and BINA Dhan 8 were tested in the trials. The results revealed that grain yield of Amalmana (4.96 t ha^{-1}) was highest followed by CSRC(D) 7-0-4 (4.86 t ha^{-1}) at Bermajur. At Mokamberia higher grain yield was recorded for Sabita (4.63 t ha^{-1}) followed by CSRC(D) 2-17-5 (4.57 t ha^{-1}). Grain yield of CSRC(D) 7-0-4 (4.79 t ha^{-1}) was more followed by Amalmana (4.50 t ha^{-1}) at Pakhiralay. CSRC (D) 7-0-4, Sabita, CSRC (D) 2-17-5 and Amalmana emerged as farmers' most preferred varieties under PVS. However, farmers' least preferred varieties/lines were NC 678, Patnai 23 and SR 26B. Participatory seed multiplication of Amalmana was conducted at 30 locations in Blocks Basanti and Gosaba in South 24 Parganas Districts and Blocks Sandeshkhali I & II in North 24 Parganas Districts. 11.69 t of seeds of variety Amalmana was produced under on-farm seed multiplication trials.

Homestead production systems (HPS): Survey of HPS was conducted in coastal Blocks of North 24 Parganas District from 240 households covering 12 villages in 2 blocks. HPS contribute significantly towards meeting the daily needs of food and nutrition (30-40% vegetables and 50-60 % fish required for household level), income and employment for the family, mitigating price or output shocks due to unforeseen events and the overall fight against poverty. Production of commodities from HPS was small in quantity, non-capital intensive, and the scope for increasing the area under HPS was also limited. In general, HPS in the study area could not be termed as market responsive i.e., supply-demand situation had very limited scope to alter the production level of these commodities. Kind of dichotomy between adoption of management techniques for vegetable production and aquaculture practices were observed. Aquaculture production management was very traditional, less capital intensive and devoid of any scientific management, like maintaining optimum stocking densities, suitable fish composition, feeding management, phased harvesting, de-silting of ponds or fertilization in ponds to increase the food availability for fishes. It seemed that mostly farmers were not keen to maximize the output from their ponds; rather it was their way of life. Whereas, vegetable production units were quite intensive, farmers tried to maximize their output with all out efforts from the small unit. It was observed that many of the farmers were changing the crop-mix and purchased quality seeds from the market to grow in their vegetable gardens depending on the market demand. Farmers were keen to gain knowledge particularly on crop protection and nutrient management. Farmers need assured supply of quality inputs and training on production management of all enterprises, fish, vegetables and livestock.

Improved Rice Crop Management for Raising Productivity in Submergence prone and Salt Affected Rainfed Lowlands in South Asia (IRRI-EC-IFAD Project) (B. Maji, S. K. Sarangi, D. Burman and Subhasis Mandal)

The productivity of rice during *kharif* was constrained with several biotic and abiotic stresses and poor agronomic practices followed by the farmers. Farmers usually grow low yielding traditional rice varieties especially in wet season with improper fertilizer and nutrient management in the nursery in main field. Development of suitable nursery management practices was important for increasing the productivity of rice in coastal region. Management of rice seedlings in the nursery was as important as in the main field under transplanted condition. Nursery management for healthy and robust seedlings under salinity stress was essential to improve the productivity of transplanted rice.

Eight on-farm trials on nursery management were conducted during *kharif* 2013 to enhance the productivity of rice in salt affected soils in four districts of South and four of North 24 Parganas with three treatments (T_1: farmer's method of nursery growing with farmer's varieties Prateekksha, Pankaj, Masuri and CR 1017; T_2: farmer's method of nursery growing with improved varieties Amalmana and Swarna-Sub1; T_3: improved method of nursery growing with improved variety) in randomized block design with six replications. The improved method of nursery growing was found to be the best in on-station trial during *kharif* 2011 and 2012. 40 g m^{-2} seed density with nutrient dose of N-P_2O_5-K_2O @ 75-30-15 kg ha^{-1} (25 kg N through 5 t FYM ha^{-1} and rest through chemical fertilizer) were applied in the nursery. Transplanting was done with 40 days old seedlings. Amalmana, a promising salt tolerant variety for *kharif* season was used for the salt affected areas, whereas Swarna sub-1 was used in submerged areas. The farmers were selected in the target area on the basis of land type suitable for improved varieties. For Amalmana variety, two farmers were selected in the district of South 24 Parganas and three in North 24 Parganas having low lands with water depth of 30-40 cm. For Swarna sub-1, two farmers in South 24 Parganas and one in North 24 Parganas were selected. Pure quality seeds of the improved varieties were given to the farmers before the on-set of monsoon for sowing in the nursery in right time. Details of farmers and initial soil salinity and pH status of the experimental soil are presented in Table 105. The seeds were sown in the nursery in the last week of June 2013 and transplanted in last week of July 2013. Transplanting was done with a row-to-row spacing of 15 cm and plant to plant spacing of 15 cm with 2 seedlings per hill.

The grain and straw yields of *kharif* rice increased by 9.8 and 7.3 per cent, respectively due to improved nursery management practices (Table 106). Similarly, due to introduction of improved rice variety suitable to the land type and ecology, the grain and straw yields increased by 23.9 and 24.1 per cent, respectively. In case of variety Amalmana, the grain and straw yields increased by 10.7 and 8.6 per cent, respectively, due to improved nursery management practices, whereas in case of Swarna sub-1 the increase was 9.7 and 4.9 per cent, with same management practices followed by the farmers. Introduction of rice variety Amalmana increased the grain and straw yields by 32.1 and 26.5 per cent, respectively, whereas in case of Swarna sub-1

Table 105 : Farmer name and initial soil salinity and pH of the experimental sites

	Name of the Farmer	Village	Experiment variety	Farmer's variety	EC (dS m^{-1})	pH	Plot size (m^2)
District: South 24 Parganas							
F1	Ratan Mondal	Dulki (5 No.)	Swarna-Sub1	Pratikhya	4.20	5.04	294.92
F2	ProbhudhanMondal	Pakhiralay	Amalmana	CR 1017	4.57	5.90	140.00
F3	ArunMondal	Pakhiralay	Swarna-Sub1	Pratikhya	4.38	5.80	237.50
F4	AchintaMondal	Pakhiralay	Amalmana	Pankaj	4.02	5.57	275.00
District: North 24 Parganas							
F5	BirbalSardar	Simulhati	Amalmana	Masuri	4.60	6.02	352.00
F6	GhanashyamPatra	Simulhati	Amalmana	Masuri	4.02	5.94	135.00
F7	Hazra Singh	Simulhati	Swarna-Sub1	Sabita	4.35	6.28	252.00
F8	NirapadaDayal	Simulhati	Amalmana	Pankaj	4.79	5.87	110.00

F1-F8: Participatory farmers (F1, F3 and F7 used Swarna-Sub1 as improved variety with Prateeksha (F1 and F2) and Sabita (F3) as local checks, whereas, F2, F4, F5, F6 and F8 used Amalmana as improved variety with CR 1017 (F2), Pankaj (F4 and F8), Masuri (F5 and F6).

Table 106 : Effect of improved nursery management practices and improved rice varieties on grain and straw yield (t ha^{-1})

Treatment	F1	F2	F3	F4	F5	F6	F7	F8	Mean
Grain yield									
T_1	4.43	4.03	4.23	4.40	3.42	4.18	3.56	3.13	3.92
T_2	4.09	3.52	3.81	3.98	3.18	3.85	3.33	2.79	3.57
T_3	3.59	1.83	3.38	3.39	2.52	3.21	3.00	2.13	2.88
SEm±	0.07	0.05	0.08	0.06	0.03	0.07	0.05	0.04	-
LSD (P=0.05)	0.22	0.17	0.25	0.18	0.10	0.23	0.16	0.14	-
Straw yield									
T_1	8.30	9.38	8.41	8.24	7.45	8.63	6.98	7.46	8.11
T_2	7.71	8.43	7.97	7.49	7.11	7.98	6.90	6.90	7.56
T_3	6.75	5.45	5.54	5.88	5.63	7.31	6.48	5.66	6.09
SEm±	0.08	0.04	0.08	0.18	0.04	0.05	0.05	0.04	-
LSD (P=0.05)	0.26	0.14	0.24	0.56	0.14	0.16	0.16	0.15	-

T_1: Improved nursery with improved rice variety; T_2: Farmer's nursery with improved rice variety; T_3: Farmer's nursery with farmer's variety

the corresponding values were 12.7 and 20.3 per cent, respectively. Improved varieties with best nursery management practices produced more yield in comparison to farmer's variety with farmer's practices. Thus helpful in harnessing the productivity potential of less utilized stress prone, unfavourable soil/environmental conditions and better livelihood conditions of the poor farmers.

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AICRP ON MANAGEMENT OF SALT AFFECTED SOILS AND USE OF SALINE WATER IN AGRICULTURE

Organic Input Management Options with Saline Water Irrigation for Sustaining Productivity of High Value Crops (R.L. Meena, Anil R. Chinchmalatpure and S.K. Ambast)

Due to shortage of good quality irrigation water in arid and semi arid regions of the country, the farmers are using saline and alkali ground water for irrigation. In order to ensure their sustainable use in combination with organic inputs management, an experiment was initiated in *kharif* 2008 at Bir Forest Experimental Farm, Hisar. During *kharif* 2012, sesame variety HT-1 was sown on 8 July and harvested on 25 October, 2012 and fennel variety Hisar Swarup (HF-33) was sown on 8 November, 2012 and harvested during April-May, 2013 with total 4 pluckings. The data on growth, yield and yield attributes of sesame during *kharif* 2013 showed significantly higher response under low saline water irrigation. The seed yield of 1.08 and 1.07 t ha^{-1} was obtained with both qualities of irrigation water and it was found that during 5 years period, the seed yield of fennel reduced considerably due to increased soil salinity by continuous application of high saline water as well as increased sodicity in low saline water irrigation treatment (Table 107). Analysis of soil samples collected after 5 years of cropping showed that EC_e under low saline water irrigation was 2.44 dS m^{-1} while it was 4.73 dS m^{-1} under high saline water irrigation during 2012-13. The pH of soil was 8.64 under low saline irrigation while it was 8.43 under high saline water irrigation and this might be due to increased RSC (Residual Sodium Carbonate) in low saline water irrigation. Organic carbon (0.38 and 0.43) differed significantly while available nitrogen (121.7 and 126.9 kg ha^{-1}) did not differ under low and high saline water irrigation.

Optimizing Zinc and Iron Requirement of Pearlmillet-Mustard Cropping System on Salt Affected Soil (B.L. Meena, Parveen Kumar, Ashwani Kumar and S.K. Ambast)

In saline-sodic soils, the deficiencies of Zn and Fe are commonly observed. Ameliorating the deficiencies of Zn and Fe in pearl millet and mustard under salt affected soils are required for

Table 107 : Growth, yield and yields attributes of fennel under different treatments

IW	Organic inputs								Mean
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	
	No. of umbellets /plant								
EC <4	14.7	15.7	19.3	20.3	20.3	17.7	18.3	18.0	18.0a
EC >7	18.0	17.3	16.7	18.0	19.7	19.7	18.0	16.3	18.0a
Mean	16.3a	16.5ab	18.0ab	19.2bc	20.0bc	18.7ab	18.2ab	17.2abd	
	100 seed weight (gm)								
EC <4	0.82	0.90	0.81	0.92	1.08	0.92	1.00	0.91	0.92a
EC >7	0.89	1.04	1.13	0.93	1.06	0.96	0.98	0.89	0.98a
Mean	0.85a	0.97a	0.97a	0.92a	1.07a	0.94a	0.99a	0.90a	
	Weight of seeds/umbel (gm)								
EC <4	1.18	1.83	3.26	3.18	3.02	2.51	2.84	2.70	2.56a
EC >7	2.82	2.80	2.66	2.75	3.40	3.18	2.43	3.08	2.89a
Mean	2.00a	2.32a	2.96b	2.97b	3.21bc	2.84bc	2.63b	2.89bc	
	Seed yield (t ha^{-1})								
EC <4	0.89	1.00	1.01	1.29	1.17	1.15	0.86	1.31	1.08a
EC >7	0.96	0.95	1.12	0.76	1.34	1.15	1.17	1.07	1.07a
Mean	0.92a	0.98a	1.06a	1.03a	1.25a	1.15a	1.02a	1.19a	

Values denoted by same letters are non significant at p=0.05

T_1:100% Inorganic fertilizer T_2: Inorganic + organic inputs (50:50)-fully organic after 3 years, T_3: FYM+ Vermicompost (50:50), T_4: FYM+ Non-edible Neemcake manure (50:50), T_5: FYM+ Vermicompost+Non-edible Neemcake manure (1/3rd each), T_6: FYM+Vermicompost (100: 100), T_7: FYM+Non-edible Neemcake manure (100:100), T_8: FYM+Vermicompost+Non-edible Neemcake manure (1/3rd each).

sustainable production of these crops. Adequate attempts have not yet been made to optimize the requirement in relation to their deficiencies in salt affected soils. To evaluate the Zn and Fe requirement and their relative efficacy of soil and foliar application in combating deficiency of these micronutrients, a field experiment was initiated on salt affected soil (pH 8.45 and EC_e 10.71 dS m^{-1}) at Nain Research Farm during 2013, in RBD in combination of 12 treatments with three replications. The treatments were : T_1- Control, T_2-5 kg Zn, T_3-6.25 kg Zn, T_4-7.5 kg Zn, T_5-7.5 kg Fe, T_6-10 kg Fe, T_7-12.5 kg Fe, T_8-5 kg Zn+10 kg Fe, T_9-5 kg Zn+10 kg Fe + 10 t FYM, T_{10}- Foliar sprays of 0.5% $ZnSO_4$ (twice), T_{11}-Foliar sprays of 1% $FeSO_4$ (twice at 30 and 45 DAS) and T_{12}-Combined foliar sprays (0.5% $ZnSO_4$+1% $FeSO_4$; twice). The results showed that application of FYM along with 5 kg Zn+10 kg Fe (T_9) improved the total numbers of tillers, effective tillers, ear length, test weight and yield significantly followed by 5 kg Zn+10 kg Fe

Performance of pearl millet grown at experimental site of Nain farm

(T_8) under the combined application of Zn and Fe. Basal application of 7.5 kg Zn and 12.5 kg Fe ha^{-1} increased the yield of pearl millet significantly over control (Table 108). Combined twice foliar application of 1% $FeSO_4$+ 0.5% (T_{12}) and 1% $FeSO_4$ (T_{11}) significantly increased the ear length, plant height of pearl millet at 60 DAS whereas effective tillers per plant, test weight and yield did not increase significantly over control.

Efficacy of Phosphogypsum as an Amendment for Alkali Soil (Kanpur)

Experiment was initiated on use of phosphogypsum as an amendment for alkali soils reclamation in rice-wheat cropping system at Crop Research Farm, Nawabganj, Kanpur during 2009. Treatments comprised of RSC water (untreated)- (T_1), BAW-(T_2), RSC water (15 cm phosphogypsum bed)-(T_3), soil application of phosphogypsum-(T_4), RSC water (15 cm gypsum bed)-(T_5), soil application of gypsum-(T_6). Rice (CSR-27) and wheat (KRL 213) varieties was sown on sandy clay loam soils in randomized block design with four replications. The soil pH was 9.10, ECe-2.60 dS m^{-1}, ESP was 46.70. Results of *kharif* 2012 and *rabi* 2012-13 showed that highest grain yield of rice (4.01 t ha^{-1}) was obtained with the T_3 (treating RSC water with phosphogypsum) followed by T_5 (treating RSC water with gypsum). Similarly, significant different was also obtained in wheat yield when RSC water was treated with phosphogypsum. Lowest grain yield of both the crops was recorded when the plot was treated with RSC water alone (Table 109).

Table 108 : Effect on zinc and iron applications on yield and yield attributes of pearl millet

Treatment	Effective tillers/ plant	Ear length (cm)	Test weight (g)	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})
T_1	1.07	19.99	6.45	2.15	5.13
T_2	1.27	22.62	7.07	2.50	5.95
T_3	1.27	25.00	7.18	2.69	6.81
T_4	1.47	26.50	7.35	2.94	7.40
T_5	1.20	22.50	6.95	2.46	6.16
T_6	1.27	24.06	7.10	2.67	6.66
T_7	1.33	25.97	7.16	2.85	7.45
T_8	1.53	26.54	7.37	2.98	7.32
T_9	1.80	29.29	8.06	3.63	8.81
T_{10}	1.07	22.03	6.66	2.28	5.59
T_{11}	1.13	22.75	6.72	2.60	6.12
T_{12}	1.13	24.28	6.74	2.66	6.46
CD at 5%	0.22	2.13	0.60	0.64	-

Table 109 : Effect of different treatments on grain yield (t ha^{-1}) of rice and wheat

Treatments	Rice (2012)	Wheat (2012-13)
T_1-RSC water (untreated)	29.1	25.5
T_2-BAW	35.3	30.2
T_3-RSC water (15cm phosphogypsum bed)	42.3	39.7
T_4-Soil application of phosphogypsum	38.2	34.2
T_5-RSC water (15cm gypsum bed)	40.1	36.5
T_6-Soil application of gypsum	36.2	31.3
CD (5%)	1.5	1.7

Evaluation of Different Cotton Hybrids for Sodicity Tolerance (Trichy)

The cotton hybrids (Surabhi and RCH-20) and variety (SVPR-2) were tested under different ESP levels during 2013. The main plot treatment comprised of four ESP levels, 9.8, 17, 30 and 41 and subplot treatments comprised of cotton hybrids (Surabhi and RCH-20) and variety (SVPR-2). The soil was clay loam in texture with initial pH of 8.9, EC 0.41 dS m^{-1}, CEC 18 cmol (p+)/kg and an ESP of 16. The water used for irrigation was highly alkaline in nature with pH 8.8, EC 1.42 dS m^{-1} and RSC 9.2. The results of the experiment revealed that number of bolls/plant (93) was also maximum in hybrid RCH-20 at ESP 9.2 which was reduced with each successive ESP level and lowest no. of bolls per plant (20) was obtained in variety SVPR-2 at ESP 39. Among the cotton hybrids and variety, the hybrid RCH-20 produced highest seed cotton yield (2.16 t ha^{-1}) at ESP 9.2 and variety SVPR-2 recorded the lowest seed cotton yield (0.55 t ha^{-1}) at ESP 39 (Table 110).

Relative Efficacy of Distillery and Sugar Industry Waste on Reclamation and Crop Production in Sodic Vertisols (Indore)

The gypsum is most commonly and widely used chemical amendment for reclamation of sodic soils. Considering the limited availability of mined gypsum in future, low cost organic based technique for reclaiming sodic soils will have to be explored. The experiment was conducted during *kharif* and *rabi* seasons at Salinity Research Station, Barwaha, district Khargone (MP) with rice (cv CSR 30) - wheat (cv HI 1077) cropping sequence in randomized block design. There was 7 treatments (T_1-Control, T_2-Gypsum @ 75 % GR, T_3-Raw Spent Wash (RSW) @ 5 lakh l ha^{-1}, T_4 -Lagoon Sludge (LS) @ 10 t ha^{-1}, T_5 -Press Mud (PM) @ 5 t ha^{-1}, T_6 -Lagoon Sludge (LS) 5 t ha^{-1} + Raw Spent Wash (RSW) @ 2.5 lakh l ha^{-1} and T_7-Press Mud (PM) @ 2.5 t ha^{-1} + Raw Spent Wash (RSW) @ 2.5 lakh l ha^{-1} replicated four times. The experimental soil belongs to fine smectitic hyperthermic family of typic heplusterts-sodic phase having ESP 38.4 cmol (p+) kg^{-1}. One time application of spent wash and other treatments (except gypsum) was done 30 days prior to transplanting of rice seedlings every year. Gypsum was applied once in three years. After harvesting rice, wheat crop was sown in the same plots. Recommended doses of nutrients were applied as per the recommendations for sodic soils.

Application of LS 5 t ha^{-1} + RSW @ 2.5 lakh l ha^{-1} significantly increased the number of tillers per hill, length of penicle, grain and straw yield of paddy as compared to gypsum @ 75 % GR as well as LS @ 10 t ha^{-1} and PM @ 5 t ha^{-1} application. Highest number of tillers per hill (29.2), plant height (127.5 cm), length of penicle (23.7 cm), grain (2.78 t ha^{-1}) and straw (8.47 t ha^{-1}) yield was recorded in case of LS 5 t ha^{-1} + RSW @ 2.5 lakh l ha^{-1} application. The data on yield of wheat indicated that grain and straw yield of wheat increased significantly with the application of amendments over control. Addition of LS 5 t ha^{-1} + RSW @ 2.5 lakh l ha^{-1} significantly increased the grain and straw yield as compared to gypsum @ 75 % GR as well as LS @ 10 t ha^{-1} and PM @ 5 t ha^{-1} application. Highest grain (3.65 t ha^{-1}) and straw (4.49 t ha^{-1}) yield was recorded in case of LS 5 t ha^{-1} + RSW @ 2.5 lakh liter ha^{-1} application (Table 111).

Table 110 : Growth and seed cotton yield under different ESP levels

ESP (E)	Plant height (cm)			Bolls plant^{-1}			Seed cotton yield (t ha^{-1})		
	Surabhi	RCH-20	SVPR-2	Surabhi	RCH-20	SVPR-2	Surabhi	RCH-20	SVPR-2
9.2	121	156	101	73	93	67	1.36	2.16	1.14
19	92	115	72	60	72	49	1.21	1.56	0.92
28	62	85	54	42	58	34	0.99	1.23	0.76
39	35	44	29	28	37	20	0.72	0.94	0.55
CD (5%)	E-3.02	V-2.50	ExV-5.09	E-1.96	V-0.52	ExV-3.16	E-0.08	V-0.07	ExV-0.14

Performance of paddy and wheat crop under different treatments under sodic condition

Table 111 : Effect of different treatments on grain and straw yield of rice and wheat (t ha^{-1})

Treatments	Rice		Wheat	
	Grain	Straw	Grain	Straw
T_1	1.40	4.26	1.94	2.26
T_2	2.37	7.50	3.23	4.07
T_3	2.63	7.87	3.28	3.83
T_4	2.30	7.16	2.69	3.13
T_5	2.18	6.86	2.41	2.83
T_6	2.78	8.47	3.65	4.49
T_7	2.50	7.80	3.25	3.80
S Em (±)	0.06	0.24	0.06	0.08
CD (5%)	0.16	0.72	0.18	0.22

Performance of Wheat Varieties under Saline Water through Drip Irrigation in Sandy Soil (Bikaner)

With continuous decrease in water resources in arid regions of western Rajasthan, farmers are forced to use low quality water for crop production. The drip irrigation system provides an advantage using saline water with more frequent irrigation to maintain high soil matric potential and low salt concentration in the root zone. The experiment was carried out during *rabi* 2012-13 with four levels of water quality (Canal water, 4, 8 and 12 dS m^{-1}) in main plot and four wheat varieties (Raj 3077, Raj 4188, KRL 210 and KRL 213) in sub plots replicated four times in split plot design. The grain yield

Performance of wheat crop with varying quality of saline water irrigation using drip irrigation system

(3.09 t ha^{-1}) obtained with canal water showed 7.8 per cent (2.87 t ha^{-1}), 13.5 per cent (2.72 t ha^{-1}) and 31.9 per cent (2.34 t ha^{-1}) yield reduction with 4, 8 and 12 dS m^{-1} saline water irrigation. Highest grain yield (3.26 t ha^{-1}) obtained by Raj 3077 followed by KRL 210 (2.92 t ha^{-1}), KRL 213 (2.72 t ha^{-1}) and Raj 4188 (2.12 t ha^{-1}) (Table 112).

Table 112 : Effect of saline irrigation water on wheat varieties under drip system

Treatments	Plant height (cm)	Ear length (cm)	Grains/ear	Test weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
ECiw levels (dS m^{-1})						
BAW	72.0	8.3	36.1	35.5	3.09	4.40
4	69.8	8.1	35.6	35.3	2.87	4.15
8	66.3	7.9	34.3	34.1	2.72	3.79
12	61.1	7.5	29.4	33.6	2.34	3.52
CD (5%)	7.4	0.3	4.1	NS	0.29	0.25
Varieties						
Raj 3077	65.3	7.8	35.1	35.0	3.26	3.85
Raj 4188	68.9	7.6	33.0	34.4	2.12	3.71
KRL 210	67.6	8.6	34.4	35.5	2.92	3.86
KRL 213	67.4	7.7	33.1	33.6	2.72	4.44
CD (5%)	NS	0.3	NS	NS	0.20	0.33

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TECHNOLOGY ASSESSED AND TRANSFERRED

Economic Evaluation of Resource Conservation Technologies at Farmer's Management Practices in Reclaimed Alkali Soils (R.S. Tripathi. R. Raju, K. Thimmappa and Ranbir Singh)

The study is based on Karnal and Kaithal districts of Haryana where resource conservation technologies (RCTs) are practiced extensively for rice-wheat cropping system. A sample of 80 farmers- 40 adapted resource conservation technology (RCT) and 40 practiced conventional method of crop cultivation were investigated for collection of input-output data and other parameters required for comparing the two methods during 2012-13 and 20013-14. Objective of the study was to find out saving of crucial farm resources and quantify economic benefits of RCT at farmers' management practices prevalent in reclaimed alkali soils. The main crop rotation followed in irrigated areas of Haryana is rice-wheat, therefore, rice and wheat crops considered for detail analysis.

Rice production

Results indicated that farmers saved 21.34 per cent human labour, 38.96 per cent machine power and 18.82 per cent irrigation water in direct sown rice (DSR) as compared to the transplanted practice of rice (TPR). The analysis of costs and returns structure for DSR and TPR method of rice cultivation revealed that the cost of cultivation was Rs. 51,837 per ha in conventional method which was 19 percent higher than the cost of DSR (Table 113). The low cost of cultivation in DSR was mainly due to lower expenses on human labour (21.34%), machine labour (38.96%) and irrigation (18.82%). The yield and gross return in DSR were at par to that of the TPR method. The net income was 20.30 percent higher in DSR due to lower cost of cultivation. The benefit-cost ratio 2.35 was observed in DSR as against 1.91 in TPR method. The findings proved that net income of rice crop in salty environment can be enhanced through DSR compared to transplanting method.

Table 113: Production of high yielding rice in conventional and direct sown methods

Particulars	Conventional method	Direct sown method	Saving (%)
Human labour (Rs ha^{-1})	13847.44	10892.70	21.34
Machine power (Rs ha^{-1})	10942.10	6678.88	38.96
Fertilizer (Rs ha^{-1})	6255.33	5824.26	6.89
Irrigation (Rs ha^{-1})	12750.00	10350.00	18.82
Cost of cultivation (Rs ha^{-1})	51836.76	41056.43	19.07
Yield (t ha^{-1})	7.18	7.16	-0.30
Gross income (Rs ha^{-1})	96978.38	96687.00	-0.30
Net income (Rs ha^{-1})	46241.61	55630.57	20.30
B:C ratio	1.91	2.35	23.88

Discriminate analysis

The results of discriminate function fitted with six variables are given in Table 114. The fertilizers (X_3)

Table 114 : Relative contribution of different variables to the total distance measured in DSR and TPR methods

Variables	Coefficients	Mean Difference	Coefficient x Mean difference	Relative contribution (%)
Charges paid to human labour (X_1)	0.380	847 (18.610)*	321.86	10.18
Charges paid to machine labour (X_2)	0.688	3133(26.556)*	2155.50	68.15
Cost of seeds (X_4)	-0.436	-614(20.528)*	267.70	8.46
Irrigation charges (X_5)	0.442	776 (22.271)*	342.99	10.84
Cost of pesticides (X_6)	0.009	526 (3.290)**	4.73	0.15
Cost of weedicides (X_7)	-0.140	-501(4.297)*	70.14	2.22
Total			**3162.93**	**100.00**

Values given in parentheses are t values of the particular factor.
D^2 value = 3162.93*; $F_{(6, 63)}$ value = 309.552
**Significant at 0.05 level of probabilities; *Significant at 0.01 level of probabilities
Z-score for TPR method (Z_1) = 11118; Z-score for DSR method (Z_2) = 7956; The critical mean discriminate score (Zc) = 9537

and net return (X_8) variables were not included in the analysis as mean differences of these were not statistically significant. The equation fitted with standardized coefficients was Z = 0.380 X_1 + 0.688 X_2 - 0.436 X_4 + 0.442 X_5 + 0.009 X_6 - 0.140 X_7. The values of D^2 and F ratio calculated were 3162.93 and 309.552, respectively. The D^2 value showed a significant discriminatory power at 0.01 level of probability. This indicates that all six variables included in the model were useful in discriminating two methods of rice production. A coefficient of variable with a positive value indicates that the variable was higher in TPR method. Similarly, a negative coefficient indicates that the variable was higher in DSR method. The charges paid to human labour (0.380), machine labour (0.688) and irrigation (0.442) were higher in TPR method. The negative coefficient values of cost of seeds (-0.436) and weedicides (-0.140) indicate that these variables were higher in DSR method of rice production.

The relative importance of variables based on their power to discriminate between DSR and TPR is shown by percentage contribution of each variables to the total distance measured. The results indicate that most important variables which discriminated TPR and DSR methods of rice production were machine labour charges (68.15%), irrigation charges (10.84%) and charges paid to human labour (10.18%). These three variables together contributed about 89.17 per cent to the total distance measured. It could be inferred that expenditure on machine labour, irrigation and human labour were major contributing variables which discriminated between two methods of rice production. The Z-score for DSR and TPR methods of rice production were RCT calculated. The Z score values were 7956 and 11118 for DSR and TPR methods, respectively. The critical mean value (Zc) was 9537. This means that if Z value is higher than critical mean value of Zc, that farmer belongs to TPR method of rice production. Similarly, if Z value is lower than critical mean value of Zc, such a farmer belongs to DSR method of rice production.

Wheat production

The farmers saved human labour, machine labour and irrigation water by 14.85, 40.03 and 23.12 percent, respectively, in zero tillage than that of the conventional method of wheat. The chemical fertilizers also saved 11.35 per cent in zero tillage than the conventional method of wheat production. The yield and gross returns were 3.18 per cent higher in zero tillage as compared to the conventional method of wheat production. The higher net return obtained in ZT was mainly due to reduction in the cost of cultivation by 16.88 per cent (Table 115). Thus, the ZT method of wheat production is associated with significant benefits such as saving of water, reductions in production cost, less requirements of labour and timely establishment of crops resulting in to better crop yield and significant higher net income. This suggests that by adopting zero tillage method, farmers can save substantial quantity of resources which helps to overcome the problems of human and machine (tractor) labour shortage at the time of land preparation and sowing operations.

Decomposition analysis

Total change in wheat yield (output) due to zero tillage technology was decomposed with the help of decomposition equation analysis using the values of production parameters of important input variables. The results, presented in Table 115, indicate that production of wheat with ZT technology was 1.88 per cent higher than that of the conventional method. The contribution of

Table 115 : Production of wheat in conventional and direct sown methods

Particulars	Conventional Method	Zero Tillage Method	Saving (%)
Human labour (Rs ha^{-1})	8794.74	7488.73	14.85
Machine power (Rs ha^{-1})	8521.50	5110.43	40.03
Fertilizer (Rs ha^{-1})	5848.00	5184.08	11.35
Irrigation (Rs ha^{-1})	1492.50	1147.50	23.12
Cost of cultivation (Rs ha^{-1})	35852.14	29808.36	16.88
Yield (t ha^{-1})	5.24	5.40	3.18
Gross income (Rs ha^{-1})	79069.64	81587.19	3.18
Net income (Rs ha^{-1})	43207.50	51778.83	19.84
B:C ratio	2.20	2.74	24.14

technical change (i.e. zero tillage) to total change in output estimated to be 0.84 per cent. Technical change affects the sources of output growth by shifting the values of scale and slope parameters of the production function. With the same level of inputs, 0.84 per cent more output could be obtained due to adaption of ZT technology. The change in the input use under ZT method has contributed about 1.04 per cent of the increased output. It is obvious from this analysis that the contribution made by ZT to the additional production is about 45 per cent, while 55 per cent contribution is due to change in the level of input variables.

It can be concluded that the traditional method of crop production in rice and wheat requires higher quantity of inputs as compared to resource conservation techniques. In the present scenario of rising inputs cost and labour shortage in agriculture, farmers need input saving alternative technologies to sustain crop production. The RCT has potential to increase farm income and save inputs cost in both rice and wheat crops. Hence, resource conservation technologies are a viable alternative to overcome the problems of rising cost of cultivation and shortages of labour and water to sustain rice and wheat production in the Indo-Gangetic Plains of India. The advantages of resource conservation technologies are as follows:

- Saving of labour (15- 20%).
- Saving in tractor use (38-40%).
- Saving of diesel (60 lt/ha).
- Saving of time in field preparation (30-40%).
- Saving of irrigation water (18- 23%).
- Saving of energy in pumping of water.
- Reducing cost of cultivation (16-20%).
- Higher wheat yield (1-2 q/ha).
- Increasing net income of crops (6–20%)

Perception of Farmers about Climatic Variability and Adaptations under Varying Socio-ecological Systems of India (Ranjay K. Singh, Satyendera Kumar, H.S. Jat, Parvendar Sheoran, R. Raju and D.K. Sharma)

The perception about climatic variability and related adaptations study was carried out in selected villages of three states Haryana, Uttar Pradesh and Rajasthan. Data were collected using personal interview and PRA techniques. A total of three social-ecological systems were identified in the study areas of Rajasthan, Haryana and Uttar Pradesh. The data for 16 selected indicators on climatic variability and their relation with farmers' perception revealed that the time of winter start is pre-poned as perceived by 82 per cent farmers in Uttar Pradesh, 60 per cent in Haryana, 50 per cent in Rajasthan. A similar trend about farmers' perception regarding expansion of summer duration was also recorded. In general, farmers were experiencing high variability in the climatic phenomenon. For example, majority of 90.6 per cent farmers from UP, 70 per cent in Rajasthan and 45.0 per cent in Haryana agreed that duration of rainy season has decreased over time.

Similarly, farmers reported (response of 92.6 % in UP, 80 % in Haryana and 70 per cent in Rajasthan farmers) that total rainy days have decreased whereas intensity of rainfall has increased. Further, in case of Haryana, the high intensity of rainfall during winter season 2013 (January and February, the rainfall was 116 mm) caused the severe losses of winter season crops including wheat and vegetables. The wheat crop was further more vulnerable due to high salinity, such as in the village Siwana Mal (Jind). Another climatic event of January 2014 with high intensity rainfall (65.8 mm in 3 days) caused waterlogging to many places of Haryana which affected the wheat crop. When the response of farmers about 100 years of climate data was compared, it was noticed that there was a variation of 9.72 per cent, while for only last 30 years the total variation was 21.60 per cent in case of Azamgarh district. The variation in rainfall was observed more in the arid climate of Rajasthan (eg.100 years CV of 40.67 and 38.25 per cent of Jodhpur and Pali districts, respectively indicate the high variability in annual rainfall) as compared to sub-humid climate of UP. In Pali district, there was an increase

High waterlogging and salinity caused severe damage to wheat crop in Siwana Mal (Jind) during Jan-Feb, 2013

Table 116 : Pattern of change in rainfall and temperature regimes across the districts in three studied social-ecological systems of India

Districts and period	Temperature (° C)				Rainfall		Remarks
	Maximum		Minimum				
	Mean	CV	Mean	CV	Mean	CV	
Azamgarh							
Last 100 years (1901-2002)	32.56	1.23	19.43	2.04	977.0	19.88	In last 30 years, the annual mean rainfall has come down to 878 mm from 100 years' average of 977.0 mm. Reduction of about 100 mm.
Last 30 years (1972-2002)	32.66	1.14	19.58	2.13	878.0	21.60	--
Hisar							
Last 40 years (1970-2011)	29.9	1.8	16.9	2.6	738.5	31.6	--
Jodhpur							
Last 100 years (1901-2002)	33.5	1.4	18.7	2.51	314.7	40.67	CV of 40.67 indicates the high variability in annual rainfall
Last 30 years (1972-2002)	33.7	1.4	18.9	2.47	330.0	38.55	--
Pali							
Last 100 years (1901-2002)	32.4	1.45	18.9	2.49	522.1	38.25	CV of 38.25 indicates the high variability in annual rainfall
Last 30 years (1972-2002)	32.6	1.44	19.1	2.42	534.7	38.32	In max and min temp, 0.2^0C increased

Source: IMD website and collection from concerned institute (except Rajasthan) of studied state through proper channel.

in maximum and minimum temperature of 0.2^0C (Table 116).

A list of adaptive practices followed by the farmers of Rajasthan is presented in Table 117. It was observed that in almost all the villages, the underground water used for irrigation was saline (pH from 7.29 to 7.90 with EC 2.09 to 9.20 and RSC 1.5 to 6.2), and farmers whose land and wells were located near the Luni river was of more saline (groundwater is found to be saline to highly saline as around Sanchore, with total dissolved salts ranging from 3000 to 7000 ppm). The erratic rainfall (total annual 320 mm with 97% during June-Sep) during last 30 years and increased number of check dams on Luni River have magnified vulnerability of social-ecological system of the region with decreased water availability and increased water salinity of wells. Due to these problems, few farmers have migrated from their native place to other place as the part of their overall livelihood adaptation. In order to adapt this situation, some of the farmers who belong to a same clan form group and with their shared resources they cultivate wheat with *Kharchia* variety using irrigation from saline underground tube well water. Other than this, a set of integrated adaptations where livestock play a crucial role is being practiced by the farmers of highly risky social-ecological systems of Rajasthan.

In Azamgarh (UP), about 85% of the farmers (large, small and marginal) have adapted the sanda method (double transplanting) of raising rice nursery and cultivating the crop. From May 8-20th, they prepared nursery beds and sown the seeds of desired rice varieties. After 20-25 days, the rice seedlings were transplanted into a second nursery field and left there for 20-22 days. When every seedling had 4-5 tillers, the plants were re-transplanted into the main field. Certain

Kharchia wheat variety on farmers' field cultivated using saline water from tube well

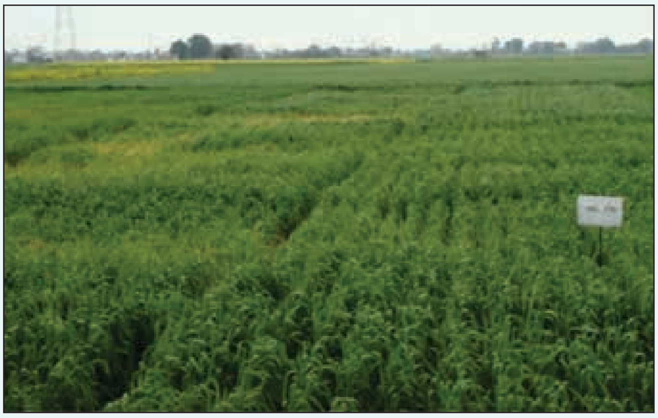
Table 117 : Adaptive practices by farmers of Jodhpur and Pali districts of Rajasthan

Adaptive measures needed	%	Types of knowledge	Types of farmers needed
Water harvesting in community ponds	35.6	TEK	Small and marginal farmers
Maintaining traditional water storage structures	25.7	TEK	All categories of farmers
Maintaining *Khejari* (*Prosopis cenararia*) groves to regulate micro-environment	32.4	TEK	All categories of farmers
Clan based agriculture (wheat crop using *Kharchia* variety)	08.1	Co-knowledge	Small and marginal farmers
Storage of fodder to ensure feeding during uncertainty	85.2	TEK	All categories of farmers
Storage of food grains for longer period	92.1	TEK	Small and marginal farmers and landless laborers
Fodder and fuel wood (women led role) from CPR resources	42.1	TEK	All categories of farmers
Economic adaptation of castor, Bt cotton and horticultural crops (onion, cumin, garlic) using good quality water by sprinkler technique	04.2	Co-knowledge	Large farmers
Castor for sand dune stabilization using good quality water and sprinkler method	03.5	Co-knowledge	Large farmers
Introducing wheat crop using modern irrigation techniques (pipes, sprinkler, etc.)	14.4	Co-knowledge	Large farmers
Rainwater harvesting in individual houses	78.5	TEK	All categories of farmers
Subsistence adaptation by pastoralists by selling animal based products	37.5	TEK and Co-knowledge	Pastoralists, small and marginal farmers

varieties such as Sambha, Mahasri, Moti gold and Saryu-52 were preferred for this adaptive practice. This method was found to be very useful for variable climate (erratic rainfall), disease and pest infestations. It also helped in meeting labour demands and contributed 25-30 per cent more yield than the conventional method of single transplanting of seedlings in a simpler nursery technique. With this practice, farmers can harvest their paddy crop in second week of October and the same plot was used for potato cultivation (high value crop) or early sown wheat.

Agricultural adaptations in Haryana

Majority of the farmers of Jind district were small and marginal, and they belong to social-ecological systems that has very high vulnerability. This vulnerability was observed to be governed by ecological stress (high salinity-pH 8.05, EC 3.5-11.5 (2012), and waterlogging), climate variability and socio-economic variables. For example, in village Siwana Mal, during 2012 many varieties including CSR-36 could not succeed at farmer's field. The reason was high saline water, saline soil and waterlogging. These problems were further magnified by the flood. Similar incidence happened during 2013 and only 3 farmers could save their CSR 36 rice variety. This was because of no rain and mismanagement with high saline water (EC 6.0-11) as well as the poor economic condition of farmers to afford good quality water from canal. The farmers who adapted salt tolerant wheat variety KRL 210 performed better in waterlogging due to high intensity of rainfall during winter seasons of 2013 and 2014 as compared to other varieties. During 2013, the farmers, who did not have KRL 210 variety of wheat, were bound to lift the water using tractor. It takes 4-5 hours to drain water from wheat field in sodic condition when the rain was 65.8 mm



Comparative performance of KRL-210 with other wheat varieties under high rainfall during winter in reclaimed sodic soil (pH 8.4 with EC 0.5) (within 3 days). This adaptation was not possible for small and marginal farmers and intervention of CSSRI to set-up the water recharge system become useful. The farmers who adapted zero till technique together with the salt tolerant wheat varieties (KRL 210), could harvest 4.0 to 5.2 t ha^{-1} of wheat under the saline conditions where water table was on 2-3 feet, soil pH 7.8-8.6 and EC 3.4 to 9.

The small and marginal farmers of Haryana were better than those of UP and Rajasthan. Most of the farmers of Haryana were adapting the practices governed by scientific knowledge as compared to UP and Rajasthan farmers. Livestock and pastoralism was a backbone of livelihood strategies of Rajasthan farmers. Farmers of Rajasthan were using short duration and salinity tolerant crops and varieties, whereas some of the farmers of UP and Haryana have manipulated agronomic practices, other than using number of other practices, to cope-up the vulnerability caused by climatic variability and other needs as well.

Study on Sodic Land Reclamation Progress and Constraints in Adoption of Technology in Uttar Pradesh (K. Thimmappa, R.S.Tripathi, R. Raju and Y.P. Singh)

Land degradation due to alkalinity is a serious problem in Uttar Pradesh. Land reclamation programmes have been implemented by the central and state governments to improve the income and livelihood security of resource-poor farmers. A study was conducted to explore the impact of land reclamation on income and food security in the salt affected regions of Raebareli and Unnao districts of Uttar Pradesh.

The food grain requirement was calculated as the difference between the total annual production of rice or wheat and total annual family consumption. All categories of farmers produced excess rice than the annual family consumption. In case of wheat, small farmers could not meet annual family consumption requirement from their own farm (Table 118). After reclamation, all categories of farmers produced excess rice and wheat in their farm due to significant increase in the farm productivity. Across the farm size groups, medium farmers produced highest quantities of excess rice and wheat due to higher size of land holdings and small family size as compared to marginal and small farmers. Hence, farmers benefited through ensured food security for sustaining livelihood even after a decade of land reclamation.

The households with annual consumption requirement are more than annual production is classified as food deficit households and assumed to have low food security status. The results indicated that 26.32 per cent of marginal and 16.67 per cent of small farmers were not producing sufficient

Table 118 : Foodgrain production status of different categories of farmers

Particulars		Marginal	Small	Medium
Family size (No)		7	7	6
Average farm size (ha)		0.66	1.31	3.09
Before reclamation period				
Rice	(a) Production (q/family/year)	8.26	13.30	38.22
	(b) Consumption (q/family/year)	3.60	3.60	3.08
	(c) Deficit/Excess (q/family/year)	4.67	9.71	35.14
Wheat	(a) Production (q/family/year)	5.92	12.06	29.53
	(b) Consumption (q/family/year)	7.47	7.47	6.40
	(c) Deficit/Excess (q/family/year)	-1.55	4.59	23.13
After reclamation period				
Rice	(a) Production (q/family/year)	15.09	28.18	72.02
	(b) Consumption (q/family/year)	3.56	4.36	3.05
	(c) Deficit/Excess (q/family/year)	11.53	23.81	68.96
Wheat	(a) Production (q/family/year)	16.91	35.16	91.80
	(b) Consumption (q/family/year)	6.33	7.14	5.91
	(c) Deficit/Excess (q/family/year)	10.58	28.02	85.89

Note: Figures in parentheses indicate percentage to the total quantities of rice for family consumption in pre-reclamation period (Table 119). Similarly, 68.42 per cent of marginal and 20.83 per cent of small farmers were not producing sufficient quantities of wheat required for family consumption. Farmers opined that the entire scenario has changed after reclamation due to increase in farm crop productivity as well as profitability. They have not only produced sufficient food grains for family consumption but also could sell excess rice in the market due to more marketable surplus. Even after reclamation, still 15.79 per cent marginal farmers could not produce sufficient wheat required for family consumption due to lower farm size. Irrespective of farm size, farmers acknowledged the role of land reclamation technology as the greatest contribution to bring improvement in their livelihood and standard of living.

The household expenditure pattern was also influenced by enhanced farm income. Majority of farmers (92%) were of the opinion that food grain purchase especially rice and wheat has declined. A few farmers opined that the expenditure on fruits and vegetables purchase has increased. About 65 per cent farmers thought that the purchase of non food items like clothing and household items has increased after reclamation. The farmers stated that there is a rise in the expenditure on house construction and children education after reclamation due to increase in farm income. This indicated that land reclamation made substantial improvement in the socio-economic well being of the farm families.

The indirect social benefits of land reclamation would include improvement in the income distribution among farm households. The total income included income from farm, labour, business and other services. The share of bottom 10 per cent farmers in total income was increased from 3.20 per cent to 5.06 per cent, registering a net increase of 58.17 per cent (Table 120). Similarly, the share of bottom 20 per cent farmers registered a net increase of 32.04 per cent. The Gini concentration ratio further suggests that the income inequality reduced over time. It indicated that the land reclamation helped to reduce income inequalities among the farm households.

Performance Evaluation of Subsurface Drainage Systems in Haryana (R. Raju, R.S.Tripathi, Parveen Kumar, Satyendra Kumar and K. Thimmappa)

The performance of subsurface drainage (SSD) system was evaluated at Banmandori village of Fatehabad district in Haryana where SSD was installed during 2009-10. The total area covered under SSD is 247.5 ha. The drainage area is divided in eight blocks and each block

Table 119 : Distribution of households by food security status

(Fig. in %)

Categories of farmers	Foodgrain	Before reclamation period		After reclamation period	
		Deficit	Excess	Deficit	Excess
Marginal	Rice	26.32	73.68	0.00	100.00
	Wheat	68.42	31.58	15.79	84.21
Small	Rice	16.67	83.33	0.00	100.00
	Wheat	20.83	79.17	0.00	100.00
Medium	Rice	0.00	100.00	0.00	100.00
	Wheat	0.00	100.00	0.00	100.00

Table 120 : Percentage share of farmers in total income in pre and post reclamation periods

Share of bottom farmers (%)	Pre-reclamation period (1999-2000)	Post reclamation period (2011-12)	Change over the initial year (%)
10	3.20	5.06	58.17
20	8.37	11.06	32.04
30	15.44	17.59	13.91
40	23.24	24.58	5.77
50	31.40	32.20	2.57
60	40.23	40.55	0.80
70	49.78	49.81	0.06
80	59.65	61.90	3.78
90	71.80	77.82	8.39
Gini ratio	0.2938	0.2589	-

covering an area of 16.5 ha to 52 ha. The SSD was designed with a discharge rate of 1 mm/ day. The depth of drain varies from 1 to 1.5 meter and spacing of lateral pipes is 66 meter, the size of lateral pipe is 80 mm and collector pipes 160-200 mm. The installation cost of the system was estimated to Rs. 55,000 per ha. The average family size of the selected farmers was 7 persons with literacy rate around 60%. Agriculture was the main occupation and average size of holding was 3.04 ha. Most of the area is either affected by salinity or acute waterlogging. The major irrigation source was canal (70% area irrigated). Agriculture (52%) was the major source of family income followed by dairy (22%). Other sources of family income included hiring out of labour.

The major *kharif* crops were cotton (50%) followed by guar (19%) and rice (10%). Bajra, groundnut and moong were the other prominent *kharif* crops of the area. Wheat was the major crop of the *rabi* season covering 71 per cent area followed by mustard (15%). Jowar, oat, berseem and castor were the other important crops of *rabi* season. The cropping intensity of *kharif* and *rabi* seasons was 87 and 88 per cent, respectively. The overall cropping intensity was 176 per cent.

The underground water table depth was measured during critical months of April/May, August/ September and October/November for the year 2011 to 2013. Water sample was analyzed to know the status of EC and pH. The mean water table depth was 0.57 m during the study period, which showed an increase in water table depth to 13.7 per cent compared to 0.49 m before installation of the drainage (Table 121). The EC showed a remarkable reduction of 98 per cent after the installation of the system.

Soil samples were collected twice in a year after the harvest of *kharif* and *rabi* crops. The drainage is functioning only in block number 3. The mean EC in the selected drainage area was 4.8 dS m^{-1}, whereas it was recorded 8.32 dS m^{-1} for without drainage situation. The EC of without drainage showed much variation (47.96%) than EC of with drainage situation (Table 122).The pH was in a normal range and showed much variation in both the situations.

The cost of cultivation and net returns for major crops under drainage and without drainage situation are given in Table 123. The yield obtained in drained situation was 2.24, 1.29 and 3.39 t ha^{-1} for rice, cotton and wheat, respectively. The drainage area has 6 to 10 per cent more yield compared to without drainage. The net income was 34 to 52 per cent more under drainage situation than those of

Table 121 : Water table depth, EC and pH of project area

Particular	Water table depth (m)			ECe (dS m^{-1})			pH		
	Before	After	Difference (%)	Before	After	Difference (%)	Before	After	Difference (%)
Mean	0.49	0.57	13.7	9.10	4.60	-97.90	7.66	7.77	1.3
Minimum	0.25	0.36	29.9	2.20	3.52	37.4	7.42	7.38	-0.5
Maximum	0.70	0.78	10.3	15.00	5.88	-155.0	8.02	7.94	-1.0
S.D.	0.32	19.22	98.3	6.25	1.04	-501.4	0.23	0.27	17.2
C.V. at 5%	64.94	38.11	-70.4	55.62	22.80	-144.0	2.97	3.54	16.3

Table 122 : EC and pH of soil samples of project area

Particulars	EC			pH		
	With drainage	Without drainage	% inc. (+)/ dec. (-)	With drainage	Without drainage	% inc. (+)/ dec. (-)
Mean	4.80	8.32	-73.49	8.19	8.32	-1.57
Minimum	3.07	4.74	-54.49	8.03	8.13	-1.15
Maximum	7.15	13.48	-88.70	8.30	8.50	-2.35
S.D.	2.02	3.98	-97.13	0.12	0.16	-27.94
C.V. (%)	42.11	47.96	-13.88	1.52	1.89	-24.52

Note: Base year EC was 3-15 dS m^{-1} (before installation of SSD)

Table 123: Performance of major crops with and without drainage situations in the area

Particulars	Rice			Cotton			Wheat		
	With drain	Without drain	% inc.(+)/dec. (-)	With drain	Without drain	% inc.(+)/dec. (-)	With drain	Without drain	% inc.(+)/dec. (-)
Yield (t ha^{-1})	2.24	2.03	0.94	1.29	1.21	0.61	3.39	3.06	0.98
Total cost (Rs ha^{-1})	37364	38257	-2.39	38180	38487	-0.80	37790	38400	-1.61
Gross income (Rs ha^{-1})	54596	49654	9.05	44592	41571	6.77	44295	41732	5.79
Net income (Rs ha^{-1})	17232	11397	33.86	6412	3085	51.89	6505	3332	48.78
B:C ratio	1.46	1.30	11.18	1.17	1.08	7.50	1.17	1.09	7.25

the without drainage. The benefit-cost ratio with drainage was 1.46, 1.17 and 1.17 for rice, cotton and wheat crops, respectively as against 1.30, 1.08 and 1.09 without drained situation. Hence, the SSD technology has a significant contribution in increasing yield and net income besides balancing water table depth and significant reduction in electrical conductivity.

Demonstration of Salt Tolerant Crop Varieties at Farmers' Field (Ranjay K. Singh, R.S Tripathi, R. Raju, K. Thimmappa and Parvendar Sheoran)

The institute has developed salt tolerant mustard and wheat varieties in the recent years. Under mustard, three varieties CS 52 (in 1997), CS 54 (in 2005) and CS 56 (in 2008) were released to grow at pH 9.3 and EC 6-9 dS m^{-1} and the recommended yields of these varieties are 1.5 to 1.9 t ha^{-1} under salt affected conditions. Similarly, four wheat varieties namely KRL 1-4 (in 1990 for pH 9.3 and EC 7.0), KRL 19 (in 2000 for pH 9.3 and EC 7.3), KRL 210 (in 2010 for pH 9.3 and EC 6.6) and KRL 213 (in 2010 for pH 9.3 and EC 6.4) were released for growing under various salt affected lands and the recommended yields of these varieties are 3.0, 3.0, 3.5 and 3.3 t ha^{-1}, respectively. Looking to the importance of these varieties, 25 field demonstrations on salt tolerant rice, wheat and mustard crops varieties were conducted during the report period.

Rice

Ten front line demonstrations of salt tolerant rice varieties CSR-30 (7) and CSR 36 (3) were conducted in Siwana Mal, Gagsina, Munnak, Kachhwa and Sambhali villages at 7 farmers fields. The variety CSR 36 was demonstrated on soil pH 7.63 to 9.02 and EC 1.21 to 8.40 dS m^{-1}. This variety demonstrated in Siwana Mal village (Jind) could not perform due to use of high salty water in initial stage of transplanting and heavy rain that caused floods. Some of the farmers who were having better adaptive capacity and could sustain their CSR 36, due to longer gap of rain, the crop matured. Those who could save their crop were able to harvest an average yield of 4.1 t ha^{-1}. Variety CSR 30 was demonstrated on the farmers' field with saline and sodic conditions of Siwana Mal, Munnak and Kachhwa village. This variety was demonstrated on soil pH 7.88 to 8.40 and EC 1.22 to 1.50 at village Munnak and Kachhwa . In Siwana Mal, this variety was demonstrated on soil pH from 7.63 to 8.02 and EC 1.54 to 8.40. On an average of 7 farmers, the grain yield of rice variety CSR 30 was recorded to be 2.77 t ha^{-1}.

Wheat

During 2013-14, a total of 12 demonstrations of salt tolerant wheat varieties (9 of KRL 210 and 3 of KRL 213) were conducted in village Siwana Mal (Jind) on soil pH range 7.81 to 8.64 with EC of 0.70 to 8.18.

Looking to the performance of these varieties during the last year, few farmers had adapted

Mr Praghat Singh, village Munnak with salt tolerant CSR-30 rice variety under sodic condition

Wheat (KRL 210) sown with ZT in Siwana Mal

Mustard (CS 56) demonstrated in Siwana Mal village

variety KRL 210 in 12-15 ha area using the previous years' seed. This year, farmers were advised to sow the seed with zero till method which might help good germination of seed as well as for better establishment of the crop as compared to conventional method. Therefore, these varieties were demonstrated with ZT and without ZT. It was observed that KRL-210 with ZT method has better germination and crop performance than the non-ZT. When variety KRL 210 was compared with other wheat variety such as HD 2369, farmers perceived that variety KRL 210 performed better in high salinity, waterlogging and heavy rains and reducing the nitrogen demand of the crop. The results are awaited.

Mustard

During *rabi* 2013-14, a total of 11 demonstrations were conducted on salt tolerant mustard varieties at saline soils of farmers' field in Siwana Mal (Jind) and salt affected environment of villages of Karnal district. Out of these, four demonstrations were conducted on variety CS 54 at pH 8.48 to 9.11 and EC 0.88 to 1.21 dS m^{-1} and seven on variety CS 56 at pH 7.54 to 8.34 and EC 0.72 to 9.03 dS m^{-1}. The results are awaited.

Field exhibition and visits

During 2013-14, 9 field exhibitions were organized on various events at different research institutions and developmental agencies covering reclamation and management of salt affected soils, and use of poor quality waters in agriculture. Large number of farmers and extension personnel visited the stalls and acquainted themselves with the technologies developed by the institute. A total number of 2729 stakeholders in 86 groups have visited the Information Technology Centre and Institute Research Experimental farm. They have been made aware of the research works going on in the institute and provided with technical know-how for reclamation and management of salt affected soil and poor quality waters. Out of 2729 stakeholders, 1948 farmers in 22 groups, 537 students in 12 groups, 177 extension personnel in 35 groups, 67 scientists and Subject Matter Specialists in 17 groups from India and abroad visited the institute. Six farmers' day was organized at the different farmers' fields. These farmers' days were concerning management of saline and sodic soils, waters management, and also instigating reciprocal learning on management of overall natural resources.

Farmers' advisory services

The institute established facility of toll free phone number (18001801014) to receive calls from the farmers related to the problems of soil salinity, sodicity and water quality. During 2013-14, 242 calls regarding various problems were received from different parts of the country, and were replied with appropriate solutions of those problems.

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Miscellaneous

TRAININGS IN INDIA AND ABROAD

Sr. No.	Name and Designation	Subject	Duration	Place
1	Dr. S.K. Sarangi Sr. Scientist	Training workshop on developing capacity in cropping system modeling to promote food security and sustainable use of water resourses in South Asia at SAARC Agriculture Centre	07.04.2013 - 12.04.2013	Bangladesh
2	Dr. S.K. Sarangi Sr. Scientist	Rice technology transfer systems for stress prone environments in South Asia	29.04.2013- 03.05.2013	Annamalai University, Tamilnadu
3.	Dr. Nirmalendu Basak Scientist Dr. M.D. Meena Scientist Dr. B.L. Meena Scientist Dr. Anshuman Singh Scientist Dr. Randhir Singh, CTO Sh. Naresh Kumar, ACTO	Summer school on innovative technologies for shaping future agriculture in salt affected areas	08.05.2013- 28.05.2013	CSSRI, Karnal
4	Sh. Avtar Singh,UDC Sh. Suresh Pal Rana,UDC	Condensed translation training course	15.07.2013- 19.07.2013	NDRI, Karnal
5	Dr. B. Maji Head, RRS, Canning Dr. S.K. Sarangi Sr. Scientist	Training workshop of IRRI-EC-IFAD Project	24.07.2013 - 27.07. 2013	Nepal
6.	Dr. Ranjay K Singh Sr. Scientist Dr. R.Raju Scientist	Priority setting, monitoring and evaluation, and policy communication	19.08.2013- 03.08.2013	IFPRI, New Delhi
7.	Dr. Nirmalendu Basak Scientist	Climate change, carbon sequestration and carbon trading in agriculture	23.08.2013- 05.09.2013	IISS, Bhopal
8.	Dr. U.K. Mandal Sr. Scientist	NAIP sponsored international training on geoinformatics (NRM) at ISRIC -World Soil Information, Wageningen	16.09.2013 14.12.2013	The Netherlands
9.	Sh. Maneesh Pandey Technical Assistant	3rd capacity building programme for technical assistant	23.09.2013- 04.10.2013	IIPA, New Delhi
10.	Dr. Thimmappa K. Sr. Scientist	Disposal of appeal under RTI	11.10.2013	ISTM, New Delhi
11.	Sh. Harish Vats Assistant	Special training programme for newly recruited Assistant of ICAR	21.10.2013- 01.11.2013	ISTM, New Delhi
12.	Dr. Parveen Kumar Principal Scientist	Climate change and carbon mitigation	21.10.2013- 25.10.2013	ICFRE, Dehradun
13.	Dr. D.S. Bundela Principal Scientist	International training of ICARDA	27.10.2013- 14.10. 2013	Amman, Jordan
14.	Sh. Suresh Pal Rana UDC	Training programme in microsoft office suite for officer & staff	18.11.2013- 22.11.2013	ISTM, New Delhi
15.	Sh. Satyanarain Sharma Assistant	Workshop on noting & drafting	21.11.2013- 22.11.2013	ISTM, New Delhi

16.	Dr. A.K. Bhardwaj Sr. Scientist	Eddy co-variance training course organised by Campbell Scientific, USA and Canada	28.11.2013- 30.11.2013	IARI, New Delhi
17.	Sh. Tarun Kumar Assistant	Training programme in administrative vigilence	02.12.2013 – 06.12.2013	ISTM, New Delhi
18.	Dr. S. Mandal Sr. Scientist	Participation in workshop on food value chain analysis: Tools and applications	04.12.2013 08.12.2013	Bangkok, Thailand
19.	Dr. S.L. Krishnamurty Sr. Scientist	Winter school on frontier technologies in the area of biotechnology, on gene isolation, characterization and breeding with reference to abiotic stress related genes	10.12.2013- 30.12.2013	NRCPB, New Delhi
20.	Sh. Dinesh Kumar Meena, Sr. Technician	4th capacity building programme for technical assistant	10.02.2014 – 21.02.2014	IIPA, New Delhi
21.	Dr. D.S. Bundela Principal Scientist Sh. M.P. Bhatia, TO	Sensitization cum training workshop for the Nodal Officer of IPv6	27.02. 2014	NASC Complex, New Delhi

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DEPUTATION OF SCIENTISTS ABROAD

S. N.	Name and designation	Subject	Period of deputation	Country
1	Dr. S.K. Sarangi Sr. Scientist	Training workshop on developing capacity in cropping system modeling to promote food security and sustainable use of water resources in South Asia at SAARC, Agriculture Centre	07.04.2013 - 12.04.2013	Bangladesh
2.	Dr. S.K. Chaudhari Head, SCM	Visiting fellowship on soil salinity and water management	26.4.2013- 24.5.2013	Isreal
3.	Dr. S.K. Chaudhari Head, SCM	First Research Coordination Meeting on landscape salinity and water management for improving agricultural productivity (FAO/IAEA)	15.07.2013- 19.07.2013	Austria
4.	Dr. B. Maji Head, RRS, Canning Dr. S .K. Sarangi Sr. Scientist	Training workshop of IRRI-EC-IFAD Project	24.07.2013 - 27.07. 2013	Nepal
5.	Dr. U.K. Mandal Sr. Scientist	NAIP International Training on geoinformatics (NRM) at ISRIC -World Soil Information	16 .09.2013- 14 .12.2013	The Netherlands
6.	Dr. S. Mondal Sr. Scientist	Write-shop on homestead production system under Project of CPWF-G2	17.9.2013- 20.9.2013	Malaysia
7.	Dr. P.C. Sharma Principal Scientist	Meeting on strategic experimental platforms for the cereal system	27.9.2013- 28.9.2013	Nepal
8.	Dr. U.K. Mandal Sr. Scientist	Global soil map conference-2013	07.10.2013- 09.10.2013	France
9.	Dr. D.S. Bundela Principal Scientist	International training, ICARDA	27.10.2013- 14.10.2013	Jordan
10.	Dr. S.L. Krishna Murty Scientist Dr. Y.P. Singh Principal Scientist	7th International rice genetics symposium organized by IRRI	5.11.2013- 8.11.2013	Philippines
11.	Dr. D. Burman Principal Scientist Dr. S. Mondal Sr. Scientist Dr. S.K. Sarangi Sr. Scientist	Review and planning workshop of CPWF G-2 Project	08.11.2013- 13.11.2013	Bangladesh
12.	Dr. S. Mondal Sr. Scientist	Food value chain analysis: Tools and application	4.12.2013- 8.12.2013	Thailand
13.	Dr. R.K. Yadav Principal Scientist	Study visit on controlling diversification	22.12.2013- 29.12.2013	Egypt
14.	Dr. V.K. Mishra Head, RRS, Lucknow	Training workshop on rice technology transfer systems for stress prone environment in South Asia	20.03.2014- 22.03.2014	Nepal
15.	Dr. B. Maji Head, RRS, Canning Town	Scientific writing workshop at IRRI	24.03.2014- 28.03.2014	Philippines

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AWARDS AND RECOGNITIONS

- Drs. D.K. Sharma, V.K. Mishra, A.K. Nayak and Y.P. Singh have been bestowed with the prestigious Hari Om Ashram Trust Award 2010-11 by the Indian Council of Agricultural Research, New Delhi on 16th July, 2013 on 85th Foundation Day Function of the Council for addressing the specific issue of "Harnessing the production potential of sodic soils in Uttar Pradesh for livelihood security of the farmers".

- Dr. S.K. Jha, Asstt. Chief Technical Officer has bestowed with Fellowship Award-2013 by Bioved Research Institute of Agriculture and Technology for his outstanding contribution in the field of "Environmental Science of Soil Chemistry".

- Drs. Anil R. Chinchmalatpure, A.K. Nayak and G. Gururaja Rao have been bestowed with the prestigious ISSS-Dr JSP Yadav Memorial Award-2013 for Excellence in Soil Science by Indian Society of Soil Science, New Delhi in 78th Annual Convention of the Indian Society of Soil Science held at CAZRI, Jodhpur on 22-26th October, 2013 for their contribution in "Characterization of soil and water resources and development of reclamation and management options for providing sustainable livelihood to the resource poor farmers inhabiting the salt-affected soils".

- Dr. S.K. Chaudhari, Head, Soil and Crop Management Division has been awarded as Fellow of Indian Society of Soil Science- 2013 during the 78th Annual Convention of the Indian Society of Soil Science held at CAZRI, Jodhpur on 22-26th October, 2013.

- Dr. S.L. Krishnamurthi, Scientist, Crop Improvement Division has been awarded as Fellow of Association for the Advancement of Biodiversity Science (FABSc).

- Dr. Ranjay K Singh has been awarded the Fulbright Alumni Award 2013-14 by the United States India Education Foundation (USIEF), New Delhi.

- Dr. B. Maji, Head, CSSRI, RRS, Canning Town has been awared as Fellow of The Indian Society of Coastal Agricultural Research (ISCAR) during 10th National Symposium of ISCAR held at CSSRI, RRS, Bharuch (Gujarat) during December 11-14, 2013.

- Dr. D.K. Sharma, Director has been awared as Fellow of The Indian Society of Coastal Agricultural Research during 10th National Symposium of ISCAR held at CSSRI, RRS, Bharuch (Gujarat) during December 11-14, 2013.

- Dr. Satynder Kumar, Senior Scientist has been awarded the Distinguish Service Certificate by the Indian Society of Agricultural Engineers (ISAE) in the Annual Convention of Indian Society of Agricultural Engineers during March 2014.

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LINKAGES AND COLLABORATIONS

Collaborative Programmes at Main Institute, Karnal

International Collaboration

- Stress tolerant rice for poor farmers of Africa and South Asia (Sponsored by IRRI-BMGF)
- Wheat improvement for waterlogging, salinity and element toxicities in Australia and India (sponsored by ACIAR, Australia)
- Cereal systems initiative for South Asia (CSISA) (sponsored by IRRI Philippines and CIMMYT Mexico)
- Marker assisted breeding of abiotic stress tolerant rice varieties with major QTL for drought, submergence and salt tolerance (Sponsored by DBT-India-IRRI)

National Collaborations

- Transgenics in crops-salinity tolerance in rice: functional genomics component (Funded by ICAR)
- Monitoring and evaluation of large-scale subsurface drainage projects in the state of Haryana (Funded by Haryana Operational Pilot Project, DOA, Haryana)
- Farmers' participatory research on enhancing groundwater recharge and water productivity in North-West India (Funded by Ministry of Water Resources, GOI)
- Control of waterlogging and salinity through agroforestry interventions (Funded by INCID)
- Multi-locational evaluation of bread wheat germplasm (Funded by NBPGR, New Delhi)
- AMAAS-Application of micro-organism in agriculture and allied sectors (Funded by ICAR)
- Intellectual property management and transfer/commercialization of agricultural technology system (Funded by ICAR)
- Development of spectral reflectance methods and low cost sensors for real time applications of variable rate inputs in precision farming (Funded by NAIP)
- Network project on improvement of salt tolerance in wheat using molecular approach (DWR-CSSRI)
- Decision support system for enhancing productivity in irrigated saline environment using remote sensing modelling and GIS (Funded by NAIP)
- An inter-institutional collaborative project on Evaluation of Salinity Tolerance of Coriander, Fennel and Fenugreek Seed Spices (Funded by NRC on Seed Spices, Ajmer, Rajasthan).

Collaborative Programmes at Regional Research Station, Canning Town

International Collaborations

- IRRI International collaborative programme on testing rice germplasm for coastal salinity (IRSSTN)
- Advanced cultures on rice for shallow and deep water situations with IRRI, Philippines
- IRRI-BMGF Project on stress tolerant rice for poor farmers in Africa and South Asia

National Collaborations

- Coastal salinity tolerant varietal trial (CSTVT) and national salinity and alkalinity screening nursery (NSASN) with DRR, Hyderabad
- Strategies for sustainable management of degraded coastal land and water for enhancing livelihood security of farming communities with RAKVK, West Bengal, CIBA, Chennai, CARI, Port Blair, BCKV, West Bengal.

Collaborative Programmes at Regional Research Station, Lucknow

National Collaborations

- Holistic approach for improved livelihood security through livestock based farming system in Barabanki and Rae bareli districts of U.P. (Funded by NAIP)
- Utilization of fly ash for increasing crop productivity by improving hydro-physical behaviour of sodic soils of Uttar Pradesh (DST Funded)

Collaborative programmes at Regional Research Station, Bharuch

National Collaboration

- Anand Agricaltrual University, Maize Breeding Station, Godhra, Gujaart
- Gujarat Narmada Fertilizers & Chemical Limited, Bharuch
- Coastal Salinity Prevention Cell, Ahmedabad
- Saline Area Vitalisation Enterprise (SAVE), Ahmedabad, Jambusar

NEW LINKAGES WITH NATIONAL AND INTERNATIONAL AGENCIES

- Singapore National University (SNU) in the area of wastewater remediation.
- SAARC Agriculture Centre (SAC) and CSIRO, Australia in cropping systems modeling to promote food security and the sustainable use of water resources in South Asia.
- University of Melbourne, Board of Meteorology and CSIRO, Australia in sustainable management of wastewater through forestry.
- National Remote Sensing Centre (NRSC), Hyderabad and State Remote Sensing Application Centres (RSAC) and NBSS&LUP, Nagpur (ICAR) on recent space technologies and image interpretations for mapping and characterizing salinity affected areas with higher accuracies
- Academic linkage with Institute of Environmental Studies, Kurukshetra University, Kurukshetra, Haryana.
- Academic linkages with Department of Biotechnology, Maharishi Markandeshwer University, Mullana (Haryana), Deenbandhu Chhotu Ram University of Science & Technology, Murthal (Haryana) and NDRI, Karnal.
- National Research Centre on Seed Spices, Ajmer, Rjasthan
- Project Directore, NCP,IGBP,IIRS, (NRSA), Department of Space, Dehradun, Uttrakhand
- Jaipur National University, Jaipur, Rjasthan
- Sardar Vallahbhai Patel University of Agriculture & Technology, Meerut(UP)
- CCS HAU, Hisar, Haryana
- Punjabi University Patiala, Punjab

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LIST OF PUBLICATIONS

Journal Paper

Ali, S., Gautam, R.K., Mahajan, R., Krishnamurthy, S.L. and Sarangi, S.K. 2013. Genetic variability and association analysis for grain yield components among SALTOL QTL introgressed rice genotypes under normal and saline environments. *Journal of the Indian Society of Coastal Agricultural Research,* 31(1): 34-40.

Ali, S., Gautam, R.K., Mahajan, R., Krishnamurthy, S.L., Sharma, S.K., Singh, R.K. and Ismail, A.M. 2013. Stress indices and selectable traits in *SALTOL* QTL introgressed rice genotypes for reproductive stage tolerance to sodicity and salinity stresses. *Field Crops Research*, 154 : 65–73.

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Damodaran, T., Mishra,V.K., Sharma, D.K., Jha, S.K., Verma, C.L., Rai, R.B., Kannan, R., Nayak, A.K. and Dhama, K. 2013. Management of sub-soil sodicity for sustainable banana production in sodic soil – An approach. *International Journal of Current Research,* 5(7):1930-1934.

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Kusuma, J.G., Sharma, K.L., Sumachandrika, D., Srinivas, K., Mandal, U.K., Raju, B.M.K., Korwar, G.R., Venkateswarlu, B., Kumar, S., Sankar, G.R.M., Munnalal, Kumar, T.S., Sammireddy, K., and Shinde, R. 2013. Effect of long-term use of tillage, residues and N levels in sorghum (*Sorghum vulgare* (L)-castor (*Ricinus communis*) cropping system under rainfed conditions-crop responses and economic performance-part I. *Experimental agriculture,* 49(3): 395-415.

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PARTICIPATION IN CONFERENCE/SEMINAR/SYMPOSIUM/ WORKSHOP

Name	Title	Period
Dr. Y.P. Singh Dr. S.L. Krishnamurthy	Annual Review and Planning Workshop (STRASA) organized by IRRI, Philippines at New Delhi	April 9-11, 2013
Dr. S.L. Krishnamurthy	48th All India Annual Rice Group Meetings at SKUAST, Srinagar J&K	April 14-16, 2012
Dr Y.P. Singh Dr. Sanjay Arora Dr. A.K. Singh Dr. A.K. Bhardwaj	24th National Conference on Sustainable Farming System and Bio-industrial Watershed Management for Food Security and Enhancing Income of the Farming Community organized by Soil Conservation Society of India at Lucknow	April 16-17, 2013
Dr. A.K. Bhardwaj	Brain Storming Session on Climate Change Impact on Salt Affected Soils and their Crop Productivity held at CSSRI, Karnal, Haryana	May 31, 2013
Dr. D.S. Bundela	G.B-cum-State Level Monitoring Committee Meeting of Command Area Development Authority, Haryana held at Chandigarh	June 3, 2013
Dr. Jogender Singh	Participated in MDP Workshop on PME of Agricultural Research Projects held at NAARM, Hyderabad	June 18 to 22, 2013
Dr. S.K. Ambast Dr. R.L. Meena	Biennial Workshop of AICRP on Management of Salt Affected Soils and Use of Saline Water in Agriculture, UAS, Raichur (Karnataka)	June 20-22., 2013
Dr. Sanjay Arora	National Seminar on Microbes and Human Welfare held at Bharathidasan University, Tiruchirappalli.	July 20-21, 2013
Dr. S.K. Ambast	Seminar on Geo-enabling State Governance using GIS	July 22, 2013
Dr. S.K. Ambast	USIEF Workshop on Water Quality Issues, Opportunities and Socio-cultural Concerns of Wastewater Use in Agriculture, DWM, Bhubaneswar	August 7-8, 2013
Dr. B. Maji Dr. D. Burman Dr. S.K. Sarangi Dr. K.K. Mahanta Dr. S. Mandal Dr. U.K. Mandal	Workshop on Up-scaling of Agro-technologies for Enhancing Livelihoods in Coastal Regions of India under NAIP sub-project on Strategies for Sustainable Management of Degraded Coastal Land and Water for Enhancing Livelihood Security of Farming Communities at NIRJAFT, Kolkata	August 20, 2013
Dr. Parveen Kumar	Sensitization Workshop on Enhancing Water Use Efficiency in Yamuna basin at NASC Complex, New Delhi	August 30, 2013
Dr. Neeraj Kulshreshtha	Report presented in 52nd All India Wheat Research Workers Meeting at CSAUA&T Kanpur	Sept. 1-4, 2013
Dr. Bhaskar Narjary	Special course on Principles and Application of Radar Remote Sensing with emphasis on RISAT-1 Data Utilization Dhehradun	Sept. 2-13, 2013
Dr. R.S. Tripathi Dr. K. Thimmappa Dr. R. Raju	Sustainable Agricultural Growth for Improving Rural Livelihood Security Sher-e-Kashmir University of Agricultural Sciences & Technology, Srinagar (J&K)	Sept. 10-12, 2013
Dr. Parveen Kumar	Travelling Seminar on Conservation Agriculture jointly organized by ICAR-CIMMYT	Sept. 16-25, 2013

Dr. B. Maji	Consultation Workshop on Development of Action Plan for Livelihood Options for Adivasipara, Hathkhola, Bali Island of Sundarban, under TSP held at Adivasipara, Hathkhola Village, Bali Island, Sundarban.	October 2, 2013
Dr. S.K. Chaudhari Dr. A.R. Chinchmalatpure Dr. N. Basak Dr. M.D Meena Dr. Sanjay Arora Dr. S. Raut Dr. B.L. Meena	78th Annual Convention of the Indian Society of Soil Science, held at CAZRI, Jodhpur (Rajasthan).	October 22-26, 2013
Dr. G.G. Rao Sh. Indivar Prasad Sh. Shrvan Kumar Sh. Nikam Vinayak Ramesh	National Seminar on Technology for Development and Production of Rainfed Cotton held at RCRS,NAU, Bharuch (Gujarat)	October 24-25, 2013
Dr. B. Maji Dr. D. Burman Dr. S.K. Sarangi Dr. K.K. Mahanta Dr. S. Mandal	Review Workshop: GEF Funded NAIP sub-projects held at Sundarbans	October 26-28, 2013
Dr. S.L. Krishnamurthy	7th International Symposium on Rice Genetics at IRRI, Los Banos, Manila, Philippines	Nov. 5-8, 2013
Dr. Parveen Kumar Dr. B.L. Meena	Attended Regional Expert Consultation Meeting of SAARC at CSSRI, Karnal	Nov. 27-29, 2013
Dr. D.S. Bundela	Cross Cutting Workshop of ICT Sub-projects of NAIP held at NASC Complex, New Delhi	Dec. 6-7, 2013
Dr. D.K. Sharma Dr. S.K. Chaudhari Dr. B. Maji Dr. G.G. Rao Dr. S.K. Ambast Dr. D. Burman Dr. S.K. Sarangi Dr. K.K. Mahanta Dr. S. Mandal Dr. Y.P. Singh Dr. Sanjay Arora & Other Scientists	10th National Symposium of Indian Society of Coastal Agricultural Research on Managing Natural Resources for Agricultural and Allied Productivity in Coastal Region under Changing Climate at CSSRI, RRS, Bharuch, Gujarat	Dec. 11-14, 2013
Dr. R.S. Tripathi	14th Rashtriya Sangosthi on Krishi ki Adunik Paryogiki Ki Uplabdhian evam Chunautian held at Indian Institute of Fishery Education, Mumbai	Dec. 14-16, 2013
Dr. S. Mandal	73rd Annual Conference of Indian Society of Agricultural Economics at NAARM, Hyderabad.	Dec. 19-21, 2013
Dr. S.L. Krishnamurthy	International Conference on Biodiversity, Bioresources and Biotechnology at Mysore, Karnataka	Jan. 30-31, 2014
Dr. S.K. Ambast	Indo-German Workshop on Water and Waste Water Management for Sustainable Development, IIT, Delhi	Jan. 30-31, 2014
Dr. S.K. Ambast Dr. R.L. Meena Dr. B.L. Meena Smt. Meena Luthra	Workshop on ‘KOHA’ LMS-OPAC under e-Granth Project	Feb. 6, 2014

Dr. D.K. Sharma Dr. S.K. Sharma Dr. Y.P. Singh Dr. R.K.Yadav Dr. B.L. Meena	World Congress on Agroforestry held at New Delhi	Feb. 10-14, 2014
Dr. S.K. Kamra	Governing Body-cum-State Level Monitoring Committee Meeting of CADA, Haryana held at Chandigarh	Feb. 12, 2014
Dr. Satyendra Kumar	47th Annual Convention of ISAE and National Symposium on Conservation Agriculture	Feb. 21-23, 2014
Dr. D.S. Bundela	Sensitization Workshop for Nodal Officers of IPv6 held at NASC Complex, New Delhi	Feb. 27, 2014
Dr. B. Maji	Seminar on Food Security and Sustainable Agriculture organised by RKM Vivekananda University, Belur Math at Ramkrishna Mission Ashram, Narendrapur, Kolkata.	March 2, 2014
Dr. D.S. Bundela	Final Review Workshop of NAIP Component-1 held at NASC Complex, New Delhi	March 7-8, 2014

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LIST OF ON GOING PROJECTS

Institute Funded

Priority area - Data Base on Salt Affected Soils and Poor Quality Waters

1. P1-2011/DBR3.1-ISR-F24./F20 Mapping and characterization of salt affected soils in Central Haryana using remote sensing and GIS (A.K. Mandal, Ranbir Singh and P.K. Joshi)
2. P1-2011/DBR3.2-ISR-IBS-F24. Assessment and mapping of salt affected soils using remote sensing and GIS in southern districts of Haryana state. (Anil R. Chinchmalatpure, Madhurama Sethi, Parveen Kumar, M.D. Meena, G.S. Sidhu, Jaya N. Surya and M.L. Khurana)

Priority Area - Reclamation and Management of Alkali Soils

3. P1-2011/ASM4.5-ISR-F00/P12/F27/0150/0180. Optimizing irrigation and planting schedules of salt tolerant rice and wheat varieties. (Parveen Kumar, S.K. Chaudhari and P.C. Sharma)
4. P1-2011/ASM4.6–ISR-A00/P00/ F27. Strategies of resource conservation in rice-wheat cropping system (Ranbir Singh, P.K. Joshi, R.S.Tripathi, S.K.Chaudhari, D.K.Sharma and Satyender Kumar)
5. P1-2011/ASM4.8-ISR-E10/P10. Economic evaluation of resource conservation technologies at farmer's management practices in reclaimed alkali soils. (R.S. Tripathi, R. Raju, Thimmappa K. and Ranbir Singh)
6. P1-2011/ASM4.9-ISR-C00. Perceived climatic variability and knowledge systems adaptation in agriculture under varying socio-ecological systems of India.(Ranjay K. Singh, Satyendra Kumar, Parvender Sheoran and R. Raju)
7. P1-2011/ASM5.0-ISR-E00-P20. Study on sodic land reclamation progress and constraints in the adoption of technology in Uttar Pradesh. (K. Thimmappa, R.S. Tripathi, R. Raju and Y.P. Singh)
8. P1-2011/ASM5.1-ISR-F25/F27/0150/0180. Nutrient management strategies for sustainable rice and wheat production in reclaimed alkali soils. (A.K. Bhardwaj, Nirmalendu Basak, S.K. Chaudhari and D.K. Sharma)
9. NRMACSSRISIL201200300844. Improving productivity of salt-affected soils using biodegradable municipal solid waste and gypsum enriched composts in a mustard-pearl millet cropping system.(M.D. Meena, Parvender Sheoran, P.K. Joshi, Anil R. Chinchmalatpure, and B. Narjary)
10. NRMACSSRISIL201300400849. Cation exchange equilibrium and solute transport through different textured salt affected soils. (Nirmalendu Basak, S.K. Chaudhari and D.K. Sharma)
11. NRMACSSRISIL201300700852. Optimizing zinc and iron requirement of pearl millet-mustard cropping system on a salt affected soil (B.L Meena, Parveen Kumar, Ashwani Kumar and S.K. Ambast)
12. Diversifying agriculture on reclaimed sodic land in farmer's participatory appraisal. (S.K Singh, S.K. Chaudhari, R.S Pandey, R Raju, DK Sharma and N.S. Sirohi).

Priority Area - Drainage Investigations and Performance Studies

13. P1-2010/DIP2.8-ISR-E10/P10. Performance evaluation of subsurface drainage systems in Haryana. (R. Raju, Parveen Kumar, R.S. Tripathi, K.Thimmappa and Satyendra Kumar)

Priority Area - Management of Marginal Quality Waters

14. P1-2007/WQM4.4-ISR-A00/3850/ 0120/0180. Organic input management option with saline water irrigation for sustaining productivity of high value crops. (R.L. Meena, Anil R. Chinchmalatpure and S.K. Ambast)
15. P1-2008/WQM 4.7-ISR-M10. Productive utilization of inland sodic/saline soil and water for aquaculture. (Sharad Kumar Singh and Anshuman Singh)
16. P1-2009/WQM 4.9-ISR-P10/3860.Wastewater use in non-food crops. (R.K. Yadav, B.L. Meena, D.S. Bundela and S.K. Chaudhari)

17. P1-2010/WQM5.0-ISR-T00/3860. Isolation and characterization of arsenic tolerant microbes. (P.K. Joshi)
18. P1-2010/WQM5.1-ISR-P12/3860. Study on back pressure for irrigation uniformity in subsurface drip irrigation and its application in wastewater reuse. (R.S. Pandey and Anshuman Singh)
19. NRMACSSRISIL201300200847. Hydro-physical evaluation of a rain water harvesting system under saline soil and groundwater environment. (Bhaskar Narjary, Satyendra Kumar, M.D. Meena, S.K. Kamra and D.K. Sharma)

Priority Area - Crop Improvement for Salinity, Alkalinity and Waterlogging Stresses

20. P1-2009/CIS4.6-ISR-30/0150. Genetic improvement of rice for salt tolerance. (S.L. Krishnamurthi, S.K. Sharma and Y.P. Singh)
21. P1-2011/CIS4.7-ISR-F30/0338. Development of Indian mustard (*Brassica juncea*) genotypes with improved salinity tolerance and higher seed yield.(Jogendra Singh and P.C. Sharma)
22. NRMACSSRISIL201200100842. Genetic enhancement of wheat with respect to salt and waterlogging tolerance. (Neeraj Kulshreshtha, S.K. Sharma and Indivar Prasad)
23. NRMACSSRISIL201200200843. Effect of salinity on growth and physio-biochemical changes in bael (*Aegle marmelos* Correa) genotypes. (Anshuman Singh, M.D. Meena, P.C. Sharma and D.K. Sharma)
24. NRMACSSRISIL201300600851. Physiological and biochemical basis of salinity and drought stresses tolerance in rice and wheat cropping system. (Ashwani Kumar, S.K. Sharma, Neeraj Kulshreshtha and S.L. Krishnamurthy)

Priority Area - Agroforestry in Salt Affected Soils - Nil

Priority Area - Reclamation and Management of Coastal Saline Soils

25. P1/2011/CSM3.7-ISR-F22/F26/F27/0150/0430. Impact of conservation tillage on utilization of residual moisture, soil health and crop yield under rice-cotton cropping system in coastal agro-ecosystem.(U.K. Mandal, D. Burman, S.K. Sarangi, and B. Maji)
26. P1-2011/CSM3.8-ISR-P10/F22. Assessment of ground water in the research farm of CSSRI Canning and Coastal areas of W.B. using geo-electrical method, Remote Sensing and GIS. (Shishir Raut, D. Burman and B. Maji)
27. P1-2011/CSM3.9-ISR/P10/E50/8145. Assessing impacts of brackish water aquaculture in coastal environment and strategies for its sustainable use (D. Burman, U.K. Mandal, Subhasis Mandal, B.K. Bandyopadhyay, B. Maji and K.K. Mahanta)
28. NRMACSSRISIL201300300848. Evaluation of crop establishment methods for rice based cropping system in coastal salt-affected soils. (S.K. Sarangi, U.K. Mandal and S. Mandal)
29. NRMACSSRISIL201300500850. Impact of saline water on solar powered drip irrigated *rabi* crops in coastal soils of West Bengal. (K.K. Mahanta, S.K. Sarangi, U.K. Mandal, D. Burman and B. Maji)
30. Study of soil salinity in relation to land use and land cover in coastal areas of West Bengal using remote sensing and GIS. (Shishir Raut, S.K. Sarangi and B. Maji)
31. Impact of salt tolerant rice varieties of CSSRI on farmers' economy in costal salt affected areas. (Subhasis Mandal, S.K. Sarangi, D. Burman, U.K. Mandal and B. Maji)

Priority Area - Reclamation and Management of Salt Affected Vertisols

32. P1-2009/SMV3.7-ISR-C00/F20/P20. Management of coastal saline soils of Saurashtra, Gujarat-Impact studies on technological interventions (G. Gururaja Rao, Sanjay Arora and M.K. Khandelwal)
33. NRMACSSRISIL201200400845. Breeding and evaluation of field crops for salt tolerance in saline Vertisols (Indivar Prasad, Shrvan Kumar, G. Gururaja Rao and D.K. Sharma)
34. NRMACSSRISIL201300100846. Soil physical characteristics and nutrient dynamics in Vertisols with subsurface salinity (Shrvan Kumar, Indivar Prasad and G. Gururaja Rao)

Priority Area - Reclamation and Management of Alkali Soils of Central and Eastern Gangetic Plains

35. P1-2007/EGSM1.8-ISR-F26/P10/A00. Performance of *Prosopis* species under different amendments in sodic soils. (Y.P. Singh, V.K. Mishra and Sanjay Arora)
36. P1-2008/EGSM1.9-ISR-F30/1100/1112. Identification of genotypes in banana and aonla for tolerance to sodicity and standardization of management practices for economic livelihood in the resource poor sodic lands. (T. Damodaran, Chhedi Lal and V.K. Mishra)
37. P1-2008/EGSM2.0-ISR-F05/P10. Study on salt and water dynamics and crop performance in waterlogged sodic soils under raised and sunken beds. (Chhedi Lal, Y.P. Singh and T. Damodaran)
38. P1-2011/EGSM2.1-ISR-P10/P20. Evaluating climate change mitigation potential of alternative management practices for rice-wheat cropping systems in salt affected soils of Indo-Gangetic plains. (A.K. Bhardwaj, V.K. Mishra, Y.P. Singh, T. Damodran and D.K. Sharma)
39. P1-2011/EGSM2.2-ISR-F27/P10/P12. Managing water and energy efficiency in RW (Rice-Wheat) cropping systems under partially reclaimed sodic soils through controlled irrigation techniques. (A.K. Singh, C.L. Verma, Y.P. Singh and A.K. Bhardwaj)
40. Harnessing productivity potential of waterlogged sodic soil through intervention of farming system modules in Sarda Canal Command for livelihood generation (V.K. Mishra, C.L. Verma, Y.P. Singh, T. Damodran, A.K. Bhardwaj, A.K. Singh, Sanjay Arora and D.K. Sharma)
41. Strategies for stimulating nutrient dynamics in resource and energy conservation practices for rice-wheat cropping systems on partially reclaimed sodic soils (A.K. Bhardwaj, V.K. Mishra, A.K. Singh, Y.P. Singh and D.K. Sharma)
42. Kinetics of gypsum and native $CaCO_3$ dissolution and nutrient transformations mediated through organic amendments and microbial inoculants in sodic soils (Sanjay Arora, A.K. Bhardwaj, V.K. Mishra and Y.P. Singh)

Externally Funded Research Projects

1. Development of spectral reflectance methods and low cost sensors for real-time application of variable rate inputs in precision farming. (Madhurama Sethi)
2. Decision support system for enhancing productivity in irrigated saline environment using remote sensing, modelling and GIS (Consortium Leader D.K. Sharma, D.S. Bundela, Madhurama Sethi, R.L. Meena, R.S. Tripathi and Anil R. Chinchmalatpure)
3. C2-2009/ASM4.1-ISR-A00/P00/ F27.Cereal system initiative for South Asia – Objective 2 component (Team Leader D.K. Sharma, P.C. Sharma and Asim Datta)
4. Intellectual property management transfer/ commercialization of agricultural technologies. (Anil R. Chinchmalatpure, Neeraj Kulshrestha, D.S. Bundela and R.K. Singh)
5. Guidance on identification of problem areas and design and evaluation of subsurface drainage projects in Haryana. (Team leader D.K. Sharma, S.K. Kamra (PI), R.S. Tripathi, Anil R. Chinchmalatpure, Parveen Kumar, Satyendra Kumar, R.L. Meena, Raju R., Bhaskar Narjary and Thimmappa K.)
6. C2-2007/WQM4.6-ISR-P10/T00/3860/3930. Microbial bioremediation of wastewater for heavy metals. (P.K. Joshi)
7. C2-2006/CIS3.6-ISR-F30/F26/0150. National project on transgenics in crops (Functional Genomics component) : Salinity tolerance in rice. (S.L. Krishnamurthy and S.K. Sharma)
8. C2-2008/CIS4.1-ISR-F30/0180. Multilocation evaluation of bread wheat germplasm (Neeraj Kulshreshtha)
9. Improvement of wheat for salt tolerance using molecular approach. (Neeraj Kulshreshtha and P.C. Sharma)
10. Establishment of National Database on rice. (S.K. Sharma, S.L. Krishnamurthy and Jogendra Singh)
11. DBT India-IRRI Network project "From QTL to variety: Market assisted breeding of abiotic stress tolerant rice varieties with major QTLs

for drought, submergence and salt tolerance". (P.C. Sharma and S.L. Krishnamurthy)

12. Carbon sequestration potential in plantation forestry and agricultural land uses for mitigating climate change and increasing crop productivity on Gangetic basin. (S.K. Chaudhari, Parveen Kumar and D.K. Sharma).
13. Strategies for sustainable management of degraded coastal land and water for enhancing livelihood security of farming communities. (Consortium Leader D.K. Sharma, D. Burman, S.K. Sarangi, S. Mandal and K.K. Mahanta)
14. Holistic approach for improving livelihood security through livestock based farming system in Barabanki and Raebareli district of U.P. (T. Damodaran, D.K. Sharma and V.K. Mishra)
15. Improved rice crop management for raising productivity in submergence prone and salt affected rainfed lowlands in South Asia (IFAD Funded). (Project leader D.K. Sharma, B. Maji, D. Burman, B.K. Bandyopadhyay, S.K. Sarangi, S. Mandal, V.K.Mishra and Y.P. Singh).
16. Stress tolerant rice for poor farmers in Africa and South Asia under BMGF project (STRASA Phase 2). (D.K. Sharma, S.K. Sharma, S.L. Krishnamurthy, B. Maji, D. Burman, B.K. Bandyopadhyay, S.K. Sarangi, S. Mandal, V.K. Mishra and Y.P. Singh)
17. G2: Productive, profitable and resilient agriculture and aquaculture systems (D. Burman, S. Mandal, S.K. Sarangi and B. Maji)
18. Groundwater resource management to mitigate the impact of climate change in Punjab and Haryana (Satyendra Kumar, S.K. Kamra, Bhasker Narjary and R.K. Yadav)
19. Understanding the adaptation mechanism of wild forage halophytes in the extreme saline-sodic Kachchh plains for enhancing feed resources. (Ashwani Kumar, Devi Dayal, Arvind Kumar, Shamsudheen Mangalaseery and J.P. Singh)
20. ICAR-ICARDA Collaborative project on improving crop and water productivity in Indira Gandhi Canal Command Area. (D.S. Bundela)

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CONSULTANCIES, PATENTS AND COMMERCIALISATION OF TECHNOLOGIES

- Subsurface drainage for heavy soils of Maharashtra (D.K. Sharma and S.K. Gupta)

  (Funding : Rex-Poly Extrusion Pvt. Ltd., Sangli, Maharashtra)

- Feasiability study using biological sludge from Nitro-ETP Plant and treated effluent from environmental control unit 1 of GNFC for crop production on vertisols (G. Gururaja Rao, Sanjay Arora, Anil R. Chinchmalatpure, M.K. Khandelwal and D.K. Sharma)

  (Funding : The Gujarat Narmada Valley Fertiliser Co. Ltd., Narmada Nagar, Bharuch, Gujarat)

- Feasiability studies on the use of treated effluent from Aniline-TDI Plant of GNFC Unit-11 in diverse crop interventions on vertisols (G. Gururaja Rao, Sanjay Arora, Anil R. Chinchmalatpure, M.K. Khandelwal and D.K. Sharma)

  (Funding : The Gujarat Narmada Valley Fertiliser Co. Ltd., Narmada Nagar, Bharuch, Gujarat)

- **CSR-BIO technology**

  The technology of CSR-BIO production using microbial consortium of *Bacillus pumilus*, *Bacillus thurigensis* and *Trichoderma harzianum* in a dynamic media was patented and commercialized by NAIP on 7th Nov. 2012 and subsequently by ICAR on 20th July 2013. The technology was presented before private entrepreneurs for licensing under the chairmanship of Deputy Director General, Horticulture where three firms have entered MoU with ICAR for licensing. The licence was transferred by Hon'ble member Planning Commission Dr. Kasturirangan to the producer companies.

CSR-BIO commercialization by Member Planning Commission, Govt. of India and Director General, ICAR in New Delhi and germplasms registered with National Bureau of Agricultural Important Micro-organism, Mau, (Uttar Pradesh)

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INSTITUTIONAL ACTIVITY

Research Advisory Committee Meeting

The XVII meeting of the Research Advisory Committee (RAC) of the Institute was held during October 29-30, 2013 at CSSRI, Karnal under the Chairmanship of Dr. S.B. Kadrekar, former Vice Chancellor, Konkan Krishi Vidyapeeth, Dapoli. Other members including special invitees were: Dr. R.C. Gautam, Dr. R.P. Sharma, Dr. H.S. Lohan, Dr. R.P.S. Malik, Dr. B. Mohan Kumar, ADG (Agro & AF and S &WM), Dr. D.K. Sharma, Director, CSSRI, Dr. G. Gururaja Rao, Head, Regional Research Station (RRS), Bharuch, Dr. P.C. Sharma, Head (A), Crop Improvement Division, Dr. S.K. Kamra, Head, Irrigation and Drainage Engineering Division, Dr. R.S. Tripathi, Head, Technology Evaluation and Transfer Division, Dr. S.K. Chaudhari, Head, Soil and Crop Management Division, Dr. B. Maji, Head, RRS, Canning Town, Dr. V.K. Mishra, Head, RRS, Lucknow, and Dr. S.K. Ambast, Project Coordinator and and Dr. Anil R. Chinchmalatpure, Principal Scientist and Member Secretary (RAC). The Member-Secretary presented the Action Taken Report (ATR) on the issues raised in the last meeting of the RAC.

Following recommendations emanated from the meeting :

1. Since conjunctive use of saline ground water with fresh water for crop cultivation might reduce the burden on per capita fresh water availability, its extensive use may be explored.
2. Integrated drainage programme for reclamation and management of saline waterlogged soils needs to be developed.
3. Continuous rice-wheat cropping system in northern States has been a concern for depleting natural resources. Diversification in salt affected soils needs to be advocated.

RAC meeting is in progress

4. To minimize the imbalance created by excess use of inorganic fertilizers, integrated nutrient management needs to be advocated to the farmers.
5. Alternatives to reclamation technology using chemical amendments and more so with gypsum need to be developed. Use of green manuring through glyricidia, different cropping sequences and improvement in crop varieties for salt tolerance needs to be taken up.
6. Molecular work in the breeding programme of the institute needs to be strengthened.
7. Identifying constraints for adoption and assessing impact of improved technologies for their upscaling and mainstreaming into on-going Government missions and programmes may be taken up.

Institute Research Committee

The Institute Research Committee (IRC) meeting was held during August 26-27, 2013 under the chairmanship of Dr. D.K. Sharma, Director, CSSRI, Karnal to discuss the progress of externally funded projects, achievements of projects completed by June 2013 and changes in the ongoing projects at the main institute of CSSRI Karnal. In his opening remarks, Chairman welcomed the recently joined scientists and congratulated the award winners. He emphasized the main theme of CSSRI's research work mainly productive utilization of salt affected soils and poor quality water. He emphasized that the focus also be given to resource conservation technologies, climate change and carbon sequestration, coastal salinity and sea water ingress and nano-technology and possibility of microorganism from sea weed. Recently acquired Nain farm exhibits various stresses in terms of soil salinity, sodicity, and poor quality ground water. He appreciated the effort in development of salt tolerant varieties of different crops in the past. He also mentioned about the successful subsurface drainage technology but pointed out that the rate of adoption is slow and more work has to be taken up in this direction in collaboration with different state governments. There is a need to develop a user friendly and low cost technology for salt affected soils as our client is farmer. He informed that salt tolerant bio-growth enhancers (CSR-BIO) for increasing productivity of agri-horti crops in normal and sodic soils developed by CSSRI RRS, Lucknow has been commercialized

Member Secretary, Dr. Anil R Chinchmalatpure presented framework prepared by NCAP to estimate Performance Indicators (PIs) of the Institute in quantitative terms. The Chairman informed that performance indicators will also be implemented at divisional level. Each divisional head will present divisional performance indicators in the next IRC meeting. Dr. R.K. Singh presented a detailed report on the training program which he has recently attended on priority setting, monitoring, evaluation and policy communication at IFPRI office, New Delhi. Dr. S.K. Ambast presented a brief outline of multi-objective maximization programming model which will be used for fitting the available data from multi-enterprise system to suggest the optimum utilization of resources. Thereafter, the presentations of externally funded projects and the achievements of completed projects were made.

The second IRC meeting was held from 4-7 February and 28-29 March 2014. The Chairman stated that 25 to 30 per cent of resources are allocated to basic research and 70-75 per cent budget for applied research. He mentioned that while formulating new research proposal, QRT and RAC recommendations should be considered. While narrating the ten priority areas of the Institute, he urged that each division and station should identify one flagship programme. He also talked about the RFD (Result Framework Document) System, Performance Indicators (PIs) of the Institute and pointed out that weightage assigned for 10 different area like publications; technology/ technique/ variety/ breed and Knowledge Product: Vaccine, formulation, tools, machinery etc; Patents; Resource generation; Discovery; Recognitions; Capacity development; and other mandates like extension in the performance indicator. The scientists were advised to strictly follow the time schedule of various activities mentioned in the RPP-I and submit the RPP-II and RPP-III on time.

The Chairman informed the house about the CSSRI's Result Framework Document (RFD) and its objectives *viz.* management and reclamation of salt affected soil; utilizations of poor quality water and human resources development and impact assessment of technologies.

The presentations were made by the Heads of RRS and Heads of Divisions about the overview of the research projects undertaken and the research priorities for the coming year. The results of the on-going research projects were presented by the respective PIs of the projects and were reviewed critically. The progress of externally funded research projects was presented during the meeting for appraisal of the House. The presentation of new project proposal was taken up. Each proposal was critically reviewed keeping in view the recommendation of RAC, QRT, institute mandate and its relevance to client and technical suitability. Dr. S.K. Chaudhari, ADG (SWM), ICAR, New Delhi gave critical inputs for shaping the future research direction of the Institute.

Institute Management Committee Meeting

During the period under report, a meeting of the Institute Management Committee (IMC) was held at CSSRI, Karnal under the Chairmanship of Dr. D.K. Sharma, Director, CSSRI, Karnal on 15.6.2013. The following members were present:

1.	Dr. D.K. Sharma	Chairman
2.	Dr. Muneshwar Singh, PC (LTFE), IISS, Bhopal	Member
3.	Dr. R.K. Gupta, Principal Scientist, DWR, Karnal	Member
4.	Dr. Madhurama Sethi, Principal Scientist, CSSRI, Karnal	Member
5.	Sh. A.K. Manchandha, Admn. Officer, CSSRI, Karnal	Member Secretary

In addition to these members, all Heads of Divisions, Project Coordinator (SWS), Finance and Accounts Officer, Assistant Administrative officers, Controlling Officer (PME), Controlling Officer (Main and Nain Farms) and Estate Officer of the Institute attended the meeting.

Institute Joint Staff Council Meeting

The Institute Joint Staff Council Meeting was held at CSSRI Regional Research Station, Bharuch (Gujarat) on August 8, 2013. The meeting was chaired by Dr. D.K. Sharma, Director and attended by Sh. Anil Kumar Manchanda, Administrative Officer & Head of Office, Drs. S.K. Chaudhari and R.K. Yadav, Sh. Ved Parkash, F&AO, Sh. Roshan Lal, Sh. Tarun Kumar, Smt Jasbir Kaur, Sh. Narendra Sharma, Sh. Subhash Chand, Sh. Ramesh Kumar and Dr. G.G.Rao, Head, RRS, Bharuch. The members discussed the various agenda items and other related issues for the welfare of the staff of the Institute and Regional Research Stations at length and settled the issues systematically and amicably.

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WORKSHOP, SEMINAR, TRAINING, FOUNDATION DAY AND KISAN MELA ORGANISED

International Training for Iraq Engineers

One week international training on land drainage for the Iraq Engineers was organized from April 15-21, 2013. Eighteen senior engineers from the Department of Irrigation and Reclamation, Government of Iraq led by Mr. Nabeel Jassim Mohammed, Senior Chief Engineer, participated in the training. The training was organized under the aegis of India Iraq Economic Cooperation Council (IIECC), New Delhi which is involved in commissioning of a large number of developmental and rehabilitation projects in Iraq by interfacing Indian industry with the Govt. of Iraq.

The training was inaugurated by Dr. J.S. Samra, CEO, National Rainfed Area Authority (GOI) as the Chief Guest on April 15, 2013. S. Pripuran Singh Haer, Former Indian Ambassador to Iran and currently Secretary General (IIECC) was the Guest of Honour, while Dr. D.K Sharma, Director CSSRI chaired the session. The Course Director, Dr. S.K. Kamra, Head, Division of Irrigation and Drainage Engineering, CSSRI informed that the subsurface drainage is a foremost CSSRI technology developed and propagated extensively in about 50000 ha waterlogged saline area in different states of India. Besides CSSRI and guest faculty, a number of private companies dealing with drainage and related machinery were involved in this training. The training contributed further strengthening of Indo-Iraq cooperation in the area of salinity management in irrigated agriculture.

Visits of African Stakeholders

A team of sixteen stakeholders from four African countries *viz;* Tanzania, Kenya, Ethopia and Zimbabwe visited the Institute on 09.05.2013. The visit was organized under the auspices of Australian Council of International Agricultural Research (ACIAR). The team traveled to India for farm mechanization training cum study tour. They visited CIAE, Bhopal, PAU, Ludhiana and acquainted with the knowledge of farm/planting/harvesting/plant protection/spraying machinery, multicrop planters, precision planters, tractor operated machinery and conservation agriculture planters like zero till, happy seeder, raised bed etc,. They also visited manufacturers of various farm machineries in Punjab and others cities of India.

The team also interacted with the scientists of the institute. During the visit Dr. M.L. Jat from CIMMYT-India explained the purpose and programme of the team. Dr. D.K. Sharma, Director, CSSRI highlighted the institute technologies and their impact in farmers' perspective and national scenario. He informed that 2.00 m ha land was reclaimed by this institute and 12-15 m tonnes of additional foodgrain are being produced from this land. Dr. Sharma apprised the stakeholders

African stakeholders visiting the museum of the institute

S.Pripuran Singh Haer, addressing the Iraqi Engineers at the inaugural function of training programme about natural resources in view of climate change pattern; development of salt tolerant high yielding varieties of rice, wheat and mustard. Dr. S.K. Kamra, Head, Division of Irrigation and Drainage Engineering explained about the technologies on sub-surface drainage for reclamation of waterlogged saline soils and artificial groundwater recharge techniques for arresting groundwater decline/ dilution of poor quality groundwater.

Stakeholders' Consultation on Promoting Resilient Diversification Option through Maize and Climate Smart Practices

A stakeholders meeting on promoting resilient diversification option through maize and climate smart practices was organized at the Institute under the auspicious of CGIAR Research Programme on Climate Change, Agriculture and Food Security (CCAFS) and WHEAT (CRP 3.1) on 20th May, 2013. The meeting was inaugurated by Hon'ble Dr. R.S. Paroda, Chairman, Haryana Kisan Ayog, Govt. of Haryana. Dr. Alok Kumar Sikka, Deputy Director General (NRM), ICAR, New Delhi was the Chairman while Dr. J.S. Sandhu, Agriculture Commissioner, Govt. of India was the Guest of Honour of the meeting. About 250 farmers, scientists, extension officers and policy makers participated in this meeting. Dr. M.L. Jat, Senior Scientist, CIMMYT, New Delhi explained the purpose of the meeting and told that maize could be a profitable crop than rice by adopting proper package of practices. He also narrated that maize is the best option for diversification in *kharif* season which could be helpful in sustainability of agriculture production and food security of India. Dr. R.S. Paroda stressed upon the knowledge based agriculture. He said that India became self sufficient in foodgrains during green revolution period but degradation of natural resources were not kept in mind. He told that we have to be self sufficient in foodgrains with limited water availability; therefore we should adopt conservation agriculture. He said that we have to change our mind set and go for direct seeded rice, timely sowing, use of newly released varieties, use of nitrogen on the basis of soil test and leaf colour chart basis and adopt soybean/ maize as an alternative crop in place of rice. He also stressed on the self marketing. Dr. Sikka said that maize can be included in diversification and climate smart practices. He expressed that about 86 per cent of the area of maize has been reduced. He said that intensive agriculture has resulted in depeletion of groundwater and has affected crop sustainability. He told that coarse grained rice can be replaced by maize. He explained that water can be saved by adopting direct seeding, late planting, planting on raised bed and micro-irrigation system in rice. Dr. Sandhu said that about 259 m tonnes of foodgrain was produced in the country during 2011-12. Rice was not the main crop of Northern India but it has become a main crop now. He stressed upon proper management of rice residues instead of burning it. He said that maize can be grown in diverese climate and on different type of soils and a number of maize hybrids are available in the country.

Dr. R.S. Paroda, Chairman, Haryana Kisan Ayog, Govt. of Haryana addressing the farmers, scientists and policy makers

A Brainstorming Session on Climate Change Impact on Salt Affected Soils and their Crop Productivity to Commemorate the Earthday-2013

The Institute organized a brainstorming session on climate change impact on salt affected soils and their crop productivity to commemorate Earth Day-2013 on 31.05.2013. This event was sponsored by the Ministry of Earth Sciences, Govt of India. About 60 scientists working in the related area, progressive farmers with vast experience in improved farming and students from various Universities/ICAR institutes participated in this session. Sh. Paritosh Tyagi, Former Chairman, Central Pollution Control Board, GOI and Chairman IDC Foundation was the Chief Guest while Sh. Ajit Tyagi, Former Director General, Meteorology, Department of Earth Sciences, GOI presided over and Dr. N. K. Tyagi, Former Member, ASRB, New Delhi was the Guest of Honour at the inaugural function of the brainstorming session.

Dr. D.K. Sharma, Director while welcoming the dignitaries said that about 6.73 m ha land is affected by salinity, 52 m ha is frequently drought prone and 3.2 m ha. affected by waterlogging. He also said that the institute has reclaimed about 2.0 m ha of salt affected areas. Dr. S.K. Chaudhari explained the purpose of this session and said that climate is a primary

Brainstorming session is in progress

determinant of agricultural productivity; agriculture has been a major concern in the discussions on climate change. Climate change has manifold effects on agriculture and the changes in temperature, precipitation, green house gases, etc affect the crop productivity. Climate change included salinity and sodicity were found to be one of the most affecting factors reducing crop productivity.

Sh. Paritosh Tyagi stressed that why climate change happened, what was its effect on agriculture and what we are doing and what should be done to avoid its effect. He also said that the scientist should make aware the farmers about the effects of climate change on agriculture. Sh. Ajit Tyagi said that meteorologist-agricultural advisors-farmers should interact with each other before the start of the crop season so that the planning may be done keeping in view the weather assumptions. The weather forecasting should be reached to the farmers. Dr. N.K.Tyagi emphasized that climate change has created the problems of soil and water pollution. Brainstorming session resulted in practical recommendations helpful to the planners and policy makers in mitigating climate change impact on saline agriculture.

Summer School on Technological Innovation for Shaping Future Agriculture in Salt Affected Areas

A twenty one days ICAR sponsored summer school on technological innovation for shaping future agriculture in salt affected areas was organized during June 4-24, 2013. Dr. Gurbachan Singh, Chairman, Agricultural Scientists Recruitment Board, New Delhi inaugurated the Summer School on June 4, 2013, while Dr. B.K.Joshi, Director, National Bureau of Animal Genetic Resources, Karnal presided over the function. In this summer school, 21 participants from ten states participated. The knowledge gained during the summer school would enhance the capacity of the participants which would ultimately help in increasing the productivity of major crops in the salt affected areas.

In his inaugural address, Dr. Gurbachan Singh apprised that the country has made a record in production of foodgrains of about 259 million tonnes during 2011-12 but we have to produce 15 m tonnes of extra foodgrain every year to meet the demands of growing population of the country. He also said that the deficiency of nutrients in the soils appeared in different parts of the country and it has resulted in the reduction in crop yield. Dr. B.K. Joshi appreciated the efforts of this institute in reclamation of salt affected soils which immediately contributed in extra production of foodgrains for human and fodder for animals. In his valedictory address, Dr. C.L. Acharya, Former Director, Indian Institute of Soil Science, Bhopal focused on scarcity of fresh water and nutrient use efficiency. He said that mechanization and Hi-tech agriculture are the future areas for agricultural development. He also stressed upon protected agriculture, drip irrigation and fertigation.

Dr. Gurbachan Singh, Chairman ASRB, New Delhi inaugurating the summer school

Dr. D.K. Sharma, Director informed that this summer school was not just a training programme but a platform for reciprocal sharing of knowledge amongst the participants and the resource persons. He said that this such training programme is very useful for KVK scientists who are instrumented in transfer of technology to the farmers. He informed that low resource based technology should be generated for sustaining livelihoods of the poor resource farmers. Dr. S.K. Chaudhari, Course Director and Head, Soil and Crop Management Division briefed about the road map of this summer school.

Workshop of AICRP on Management of Salt Affected Soils and Use of Saline Water in Agriculture

XXIII biennial workshop of AICRP on Management of Salt Affected Soils and Use of Saline Water in Agriculture was held at University of Agricultural Sciences, Raichur during June 20-22, 2013. Prof. S.S. Khanna, Ex-Vice Chancellor and Ex-Advisor, Planning Commission was the Chief Guest while Prof. B.V. Patil, Vice-Chancellor, University of Agricultural Sciences, Raichur presided over the inaugural function. Dr. D.K. Sharma, Director, CSSRI, Karnal and Dr. B.S. Janagoudar, Director Research, UAS, Raichur were the guests of honour. In his inaugural address, Prof. S.S. Khanna appreciated the research achievements of AICRP for 2010-12. He laid emphasis on quality research work focussed to generate agro-ecological region based technologies in a clientele targeted approach. He emphasised for creating better opportunities for quality human resource development of scientists to meet the future challenges. Prof. B.V. Patil mentioned about the reclamation and management of saline areas in Tungabhadra canal command as one of the priority areas of the UAS, Raichur. Dr. D.K. Sharma, Director, CSSRI, Karnal and Dr. B.S. Janagoudar, Director Research, UAS, Raichur also addressed the gathering. Dr. S.K. Ambast, Project Coordinator, AICRP (SAS&USW) highlighted the research achievements of the project made during 2010-12.

Prof. B.V. Patil Vice-Chancellor, UAS, Raichur addressing the Biennial workshop of AICRP on management of salt affected soils and use of saline water in agriculture

During the technical sessions, cooperating centres presented their progress, achievements and new research proposals. During the workshop, significant achievements on reclamation of abandoned aqua ponds, use of distillery and sugar industry waste in alkali land reclamation and conjunctive use of canal water with saline/alkali water were made. New initiatives on controlled sub-surface drainage for higher water and nutrient use efficiency, crop tolerance to irrigation with salty waters using micro-irrigation system and monitoring sea water intrusion in coastal areas in the wake of climate change scenario were highly appreciated. The need of national level spatial database on salt affected land and water and its monitoring at regular interval by modern tools like remote sensing and geographical information system was observed.

Visits of Director General and Dy. Director General (NRM) ICAR at CSSRI, RRS Canning Town, West Bengal

Sunderland of West Bengal is one of the most underdeveloped areas in India where millions of people are living under abject poverty. Agriculture including fisheries is the main occupation of the people but prevalent coastal salinity is the biggest problem for getting higher productivity. As a result large-scale migration is common for people of this region in search of alternative livelihoods across the country. In view of these problems, CSSRI RRS, Canning Town is actively engaged in research to

Dr. S. Ayyappan, Secretary, DARE & DG, ICAR, visiting the Mokanberia village of Basanti Block

Dr. A.K. Sikka, DDG (NRM) visiting the experimental area of the station

Kisan Gosthi on Sugarcane Production

develop suitable technologies for increasing farm income. The land shaping models as designed by this station reached too many farmers field in this region and the farm income has increased by manifolds under demonstration plots.

Many collaborative farmers explained their experiences and benefits due to adoption of land shaping models to Dr S. Ayyappan, Secretary, DARE & DG, ICAR, during his visit at Mokanberia village of Basanti Block on 26th July, 2013. The land shaping models have created the opportunities to grow crops (paddy, vegetables, sunflower etc) along with fishes throughout the year which otherwise was characterised by monocropped with *kharif* rice. Farmers are earning around Rs. 1.50 lakh per hectare after land shaping as compared to Rs. 22,000 per ha earlier. After successful implementation of these technologies and realizing the benefits, some of the farmers have come back to their villages to take up agriculture as primary occupation, leaving the other alternative options in nearby cities.

Similar experiences were shared by the farmers with Dr Alok K. Sikka, DDG (NRM) also, when he visited the area on 1st October, 2013 along with Dr Dipak Sarkar, Director, NBSS&LUP, Nagpur and Dr D.K. Sharma, Director, CSSRI, Karnal. These technologies particularly farm pond and paddy-cum-fish are financially viable and attractive proposition for the coastal region. These technologies can be a viable option for other areas in Sundarbans and other coastal areas of India.

Kisan Gosthi on Sugarcane Production in Salt Affected Soils with Proper Water Management

A one day training programme for sugarcane officers and farmers on management of salt affected soils was organized on July 27, 2013. A total of 70 participants participated in this training. The major aspects covered during the training were about how to reclaim the sodic/saline soils and use of poor quality water. The farmers and officers were also exposed to the resource conservation and plant protection measures in the sugarcane based cropping systems.

Training on Use of Modern Tools in Water Management for Evaluating Water Use Efficiency and Crop Yield

A five days training programme for CADA Officers on Use of Modern Tools in Water Management with Special Emphasis on GPS and GIS for Evaluating Water Use Efficiency and Crop Yield was held during 19-23 August 2013. Nineteen Officers/ Engineers from Karnal, Kurukshetra, Kaithal, Panipat, Rohtak, Jind, Jhajjar, and Rewari Divisions under Kaithal and Rohtak Circles participated in the training programme which was inaugurated by Dr. Rameshwar Singh Project Director, Directorate of Knowledge Management in Agriculture (DKMA), New Delhi. Er. Atul Narang Executive Engineer, CAD Division, Panipat, and Er. P.K. Luthra, Executive Engineer, CAD Division, Karnal were the Guest of Honour and Special Guest, respectively. Dr. D.S. Bundela, Course Director and Principal Scientist welcomed the officers and presented the overview of the training programme. He emphasised that CADA and Irrigation departments of Haryana have not made significant progress in the use of modern tools and ICT in irrigation water management whereas Gujarat, Andhra Pradesh and Maharashtra have become leaders in use of modern tools/ICT in irrigation. This training course was designed to give a boost to the applications of ICT in irrigation sector of Haryana.

Training on use of modern tools in water management

In his inaugural address, Dr. Rameshwar Singh highlighted the importance of efficient use of water resources for irrigation in enhancing crop production in view of reduction of canal water to agriculture and looming dangers of climate change. Modern tools and ICT have played a pivotal role in monitoring of water delivery to farms in order to improve reliability and equitable distribution with enhanced water use efficiency. Dr. Singh cited the example of Israel which has demonstrated the use of technologies for efficient water conveyance, distribution, delivery and on-farm applications for improving water productivity with minimum use and maximum recycle of water resources. He also stressed upon the use of ICT in water management in Haryana along with involvement of CADA and canal water user associations/societies. Er. Atul Narang emphasised the use of canal water efficiently and equitably for irrigation as less canal water is available for agriculture due to stiff competition from other sectors. Therefore, CADA plays an important role for efficient water delivery to farms by lining of tertiary irrigation channels. He expressed the importance of such training for CADA officers for effective transfer and use of modern tools/ICT technologies for management of watercourse lining works.

Dr. D.K. Sharma, Director, CSSRI emphasised the need for efficient irrigation for enhancing water use efficiency and crop yield as well as to prevent waterlogging and secondary salinization problems. He also highlighted leading technologies developed by the institute for reclamation of waterlogged saline and sodic soils, and use of poor quality water in agriculture. He stressed on the use of modern tools in CADWM programme in planning, implementing and monitoring of water course lining and field drain linking. Dr. S.K. Kamra, Head, Division of Irrigation and Drainage Engineering highlighted the projects undertaken on development of modern tools for irrigation by the Division and underlined the importance of modern tools for efficient irrigation water management. He also appreciated the efforts made through such training for capacity building of state officers/farmers on use of modern tools.

Hindi Week Celebration

The Institute celebrated the Hindi Week from 13-27 September, 2013. Dr. D.K. sharma, Director of the Institute inaugurated the function on 13th September, 2013. On this occasion, he urged the staff to use Hindi in day to day work. During this week, different competitions such as *Tatkal Bhashan, Tippan Aalekhan, Aavedan Patra, Computer mein hindi typing, Tippani evam masauda lekhan, Prashanotri Pratiyogita* and *Takniki Poster Pradarshani* were organized. On the concluding fuction, Sh. Shivas Kaviraj, Assistant Inspector General of Police, Tranport and Highways, Karnal was the chief guest. He advised the staff of the institute to make more use of Hindi language in brining out the scientific and technical literature. Dr. D.K. Sharma told the institute staff to do more and more work in Hindi. On this occasion, two plays viz; Chauraha and Railway Phatak Gogripur

Dr. D.K. Sharma, Director inaugurating the Hindi week at the Institute were played to show the increasing raod incidents. A moving trophy was also given to the Audit and Account section of the Institute for doing laudable work in Hindi.

Mrs. Sonia Gandhi Distributed Seeds of Salt Tolerant Wheat Varieties

Out of 1.37 million hectare sodic lands in Uttar Pradesh, more than 50,000 hectares are severely affected by sodicity problem in Raebareli district. Currently 25,000 hectares of land have been reclaimed in the district by different government agencies using gypsum based technology developed by the Institute. This has increased the productivity of these lands to about 5 tones/ha/ year. However, there is a scope of further increase in productivity through use of salt tolerant varieties of rice and wheat by about 1-1.5 t ha^{-1} and 2 t ha^{-1}, respectively without using any additional inputs in the partially reclaimed sodic soil. In view of the importance of salt tolerant varieties, a programme was organised at KVK, Raebareli with the help of International Rice Research Institute (IRRI) for popularisation of these varieties among the farmers. Hon'ble Smt. Sonia Gandhi, M.P. Raebareli and Chairperson, UPA distributed the seeds of salt tolerant varieties of wheat viz; KRL-19 and KRL-213 developed by CSSRI among the farmers on 8th October, 2013. During this programme, Mrs. Sonia Gandhi appreciated the works of CSSRI and IRRI. Dr. V.K. Mishra, Head CSSRI-Regional Research Station, Lucknow and Dr. Sudhanshu Singh, Agronomist South Asia (IRRI) interacted with Mrs. Sonia Gandhi and farmers and highlighted the ongoing collaborative STRASA and NFSM programme in the district and the impact of salt tolerant rice and wheat varieties in enhancing sodic land productivity.

Smt. Sonia Gandhi M.P. Raebareli distributing the seeds of salt tolerant varieties of wheat to the farmers

Field Day

A field day was organised at Shivri and Patwakhera village son 15.10.2013 and 19.10.2013, respectively. About 200 farmers participated in these events. The scientists of the CSSRI RRS, Lucknow delivered the lectures on cultivation of salt tolerant varieties, soil sampling methodology and water management etc.

Field day at Patwakhera

Kharif Kisan Mela

Kharif kisan mela was organized at the door steps of the farmers at Nain Village (Panipat district) on 15th October 2013. The *mela* was inaugurated by Dr. A.K. Sikka, Deputy Director General (NRM), ICAR, New Delhi while Dr. D.K. Sharma, Director CSSRI, Karnal presided over the function.

A number of dignitaries including experts from Karnal based ICAR Institutes, Krishi Vigyan Kendras and Development Departments actively participated in the *Kisan Mela.* The private agencies displayed their exhibitions on seeds, pesticides and agricultural implements. On this occasion, a *Kisan goshthi* and field visit was organized in which scientists and Subject Matter Specialists (SMS) interacted with the farmers and suggested remedial measures for their current and emerging agricultural problems. About 1000 farmers benefited from this important function. In the *Kisan Mela*, the farmers were informed about the technologies developed by CSSRI for the reclamation of salt affected soils, use of poor quality water, crop diversification, and salt tolerant varieties etc. Seeds of wheat varieties KRL-210, KRL 213, KRL 19, HD 2967, DPW 621-50 and mustard varieties CS 52, CS 54 and CS 56 were sold during the *mela*. The soil and water samples brought by the farmers were tested free of cost. Large number of farmers availed these benefits.

Dr. A.K. Sikka, Deputy Director General (NRM), ICAR New Delhi addressing the farmers

In the inaugural address, Dr. A.K. Sikka highlighted the contribution of CSSRI in solving the problems of salinity and sodicty as well as sustainable use and management of natural resources. He also advocated the sustainable adaptations in the salty environments, especially against the variable climate. He gave remarks on various activities and projects being pursued by ICAR and Government of India for managing problematic natural resources. He also appreciated the role of salt tolerant varieties developed by the Institute. Dr. D.K. Sharma expressed the purpose for organization of the *kisan mela* and said that *kisan mela* was the best media for transfer of technology to the farmers. Fifteen progressive farmers were awarded for their contributions made in conservation agriculture and natural resources management.

Regional Expert Consultation Meeting on Best Practices and Procedures of Saline Soil Reclamation System in SAARC Region

A three days Regional Expert Consultation Meeting on Best Practices and Procedures of Saline Soil Reclamation System in SAARC Region was organized jointly by SAARC Agriculture Centre, Dhaka and CSSRI, Karnal during November 27-29, 2013. The meeting was inaugurated by Dr. I.P. Abrol, Director, Centre for Advancement of Sustainable Agriculture, New Delhi on 27th Nov., 2013. In this meeting, Dr. Jalal Uddin Md. Shoaib from Bangladesh, Dr. Arshad Ali from Pakistan, Dr. Nihal Sirisena Dinaratne from Sri Lanka and Dr. S.K. Chaudhari from India participated and shared their experiences on reclamation and management of salt affected soils in respective countries. Dr. Tayan Raj Gurung, SAARC Agriculture Centre was the coordinator from SAARC and Dr S.K. Chaudhari was the coordinator from India side. The meeting was organized to finalize a concept paper for SAARC Region by documenting and compiling the data on salt affected areas and existing reclamation systems in SAARC region. The most common and appropriate reclamation techniques were compared and identified to solve the regional problems. Some of the policy, researchable and extension issues were emerged from this meeting.

The policy issues were: Adopting a uniform methodology, assessment of salt affected soils and waters may be carried out in the region and clear cut land use policy be developed, sharing of

Regional Expert consultation meeting for efficient utilization of salt affected areas in the light of climate change in SAARC region technological innovations, research information and materials including germplasm be encouraged under the framework of IPR, preservation and conservation and sharing of biodiversity in SAARC region under the framework of IPR, adequate government support and funding for the land reclamation programmes in SAARC countries and capacity building for efficient utilization of salt affected areas in the light of climate change must be assigned a priority in SAARC region. The researchable issues were : Spatio-temporal data base of salt affected soils, breeding for abiotic stress tolerant varieties, alternate amendments to reclaim sodic soils, management of saline waterlogged soils, management of poor quality waters and climate change and salt affected soils. The extension issues were: Poor diffusion of recommended technologies at farm level, need based availability of technology, human resource development and information technology and financial support. Efforts will be made to document technologies which are highly relevant to solve the problems of salt affected areas and have the potential for dissemination in large areas.

National Symposium on Managing Natural Resources for Enhancing Agricultural and Allied Productivity in Coastal Region Under Changing Climate

A National Symposium was organized by the Indian Society of Coastal Agricultural Research, Canning Town (West Bengal) in collaboration with CSSRI, Karnal at the Regional Research Station, Bharuch during December 11-14, 2013 to deliberate the problems pertaining to the soil, water, crop and livestock and strategies to overcome them for maximizing production in the region under the changing climate.

The symposium was inaugurated by Dr. N.K. Tyagi, Former Member, ASRB, New Delhi and presided over by Dr. A.R. Pathak, Vice-Chancellor, Navsari Agricultural University (NAU) Gujarat while Dr. B. Mishra, former Vice Chancellor of SKUAST, Jammu was the Guest of Honour at the Inaugural Session. Dr. Tyagi in his address emphasized the climate smart agriculture with special reference to water, nutrients, land use, weather, risk and knowledge aspects that need to be given priority in the region.

Dr. A.R. Pathak in his presidential address gave special emphasis on the issues prevailing in the coastal Gujarat and the adaptable strategies evolved by the NAU giving special emphasis to salt tolerant cotton lines, rice, horticultural crops and aquaculture. He made a special mention of the salt tolerant herbaceum cotton lines identified by the Main Cotton Research Station, Surat in association with CSSRI Regional Research Station, Bharuch. Abstracts of the Symposium and a Technical Bulletin entitled Coastal Saline Soils of Gujarat – Problems and their Management were released in the Symposium.

The Symposium covered important themes viz.; Advance in soil, water and crop management; Advanced management of aquaculture, livestock and allied activities; Development in field, horticultural and plantation crops; Emerging ecological threats and coastal forestry management; Livelihood improvement and Coastal saline Vertisols with special reference to Gujarat. About 78 research papers and invited lectures were delivered by the guest speakers.

Media Meet

The Directorate of Medicinal and Aromatic Plants Research (DMAPR), Boriavi, Anand in collaboration

Dr. N.K. Tyagi, former Member, ASRB, New Delhi inaugurating the symposium

Media meet organised at RRS, Bharuch (Gujarat)

with CSSRI, RRS, Bharuch organized a media meet through an on-going NAIP Project (Sub-Project: Mobilizing Mass Media support for Sharing Agro-Information) on January 30, 2014. It was envisaged for taking stock of the technologies for salinity management and their dissemination to the farming community and other user agencies. The promising technologies briefed to the print and electronic media included (1) Cultivation of *Salvadora* on highly saline black soils; (2) Prospects of dill cultivation; (3) Cotton-pulse intercropping for saline Vertisols; (4) Conjunctive use of saline ground water for crop production; (5) Ground water recharging and its role in enhancing crop productivity; (6) Feasibility of desi cotton cultivation on saline Vertisols; (7) Cultivation of forage grasses on saline Vertisols; (8) Use of liquid and solid industrial wastes for crop production etc.

International Training Programme on Use of Poor Quality Water in Agriculture

A two weeks international training programme on Use of Poor Quality Water in Agriculture for Afro-Asian Rural Development Organisation (AARDO) member countries was organized during February 11-24, 2014. Dr. R.K.Yadav, Coarse Director gave the overview of the structure and objectives of the training programme. Eight delegates from Bangladesh, Iraq, Nigeria, Oman, Jordan, R.O. China (Taiwan), Sri Lanka and Sudan participated in this training programme. Dr. Alok. K. Sikka, Deputy Director General (NRM), New Delhi inaugurated the training programme. Dr. Sikka focused on scarcity of fresh water and underlined the importance and need for use of poor quality water and waste water in irrigation. He said that intensive agriculture resulted in declining groundwater and reduced the sustainability of crops. He apprised that 1.5 to 1.6 per cent area of the world is irrigated by waste water. The quality of treated water should be of certain standard. He stressed the need to get feed back from the participants to further improve the training programme in future.

His Excellency Er. Wassfi Hasan El Sreihin, Secretary General, AARDO, New Delhi said that AARDO is an autonomous mutual inter-governmental organisation comprising 30 countries (15 each from Asia and Africa). This organization was set up with a view to promote coordinated efforts, exchange of experiences and cooperative action for furthering the objective of development of the rural areas. He emphasized that there is a scarcity of fresh water and use of poor quality water in agriculture has a great importance. He stressed that there is a need to develop the best management practices for use of poor quality water in agriculture. The poor quality water can help in meeting out the demand of food grains for the growing world population. He said that climate change has an adverse impact on water use. There is a need to harvest rainwater in rural areas and make efficient use of this water for irrigation and other purposes.

Dr. D.K. Sharma, Director highlighted the achievements of the institute. He informed that the institute has reclaimed 2.00 m ha salt affected land which are producing about 15 m tons of food grains and generating employment to 240 million

Dr. Alok. K. Sikka, Deputy Director General (NRM), New Delhi inaugurating the AARDO training programme man days. He stressed upon the reclamation of coastal and dry land salinity. He said that this institute has developed 7 salt tolerant varieties of rice, 4 of wheat, 3 of mustard and 1 of gram. Dr. Sharma also said that with the proper use of waste land and poor quality waters, we can make a remarkable contribution to the food grains production to sustain the livelihoods.

During this training programme, extent and distribution of poor quality water, impact of long term usage of poor quality water (saline), amendments for sodic and waste water; and best management practices for mitigating the deleterious effects of poor quality water were discussed. The knowledge gained during the programme would enhance the capacity of the AARDO member countries for safe and sustainable use of poor quality water, which would ultimately help in increasing the productivity of major crops in the member countries.

Celebration of 45th Foundation Day

CSSRI, Karnal celebrated 45th Foundation Day on 1st March 2014, by organizing a Foundation Day Lecture by Dr. V.N. Sharda, Member, Agricultural Scientists Recruitment Board, New Delhi. On the occasion, Dr. D.K. Sharma, welcomed the Chief Guest and the other invited guests and also gave a glimpse of institute's achievements on the occasion. Recognition of the institute at various national and international fora can be gauged from various awards conferred on the institute and its scientists from time to time. Dr. Sharda addressed the gathering on subject 'Combating land degradation to minimize production losses and ensure sustained productivity in India'. He explained that as per the first global assessment of human-induced land degradation (GLASOD), out of the world's total land area of 13.5 billion ha, about 2 billion ha (15%) is degraded (13% light and moderate, 2% severe and very severe). It is estimated that if this trend continues, 1.4-2.8 per cent of the total agricultural, pasture, and forest land would be lost by 2020, and declining yields can be expected over a much larger area. In India, as per harmonized database on land degradation, 120.72 million ha area is subjected to various forms of land degradation. The main degradation processes operating on land are water and wind erosion; salinization and alkalization; chemical, physical and biological degradation; and waterlogging. Soil erosion by water is a global phenomenon as it occurs widely among all agro-climatic regions of the world. Out of 2 billion ha of degraded area in the world, water erosion alone contributes about 55 per cent (1.1 billion ha) followed by wind erosion (0.55 billion ha), chemical degradation (0.24 billion ha) and physical degradation (0.08 billion ha). As per the harmonized database of India, maximum area of about 82.57 million ha is degraded due to water erosion, followed by chemical degradation (24.68 million ha), wind erosion (12.40 million ha) and physical degradation (1.07 million ha). Nearly 29 per cent of the total eroded soil by water is permanently lost to sea, and nearly 10 per cent is deposited in reservoirs, resulting in reduction of their storage capacity by 1 to 2 per cent annually. The remaining 61 per cent of the eroded soil is displaced from one place to another. Various researchable and policy issues were emphasized to be addressed on high priority for checking land degradation and ensure food security by minimizing production losses. About 200 scientists and other officers from the ICAR institutes in Karnal participated in the function.

Dr. V.N. Sharda, Member, ASRB, New Delhi delivering the Foundation Day Lecture

Rabi Kisan Mela

The institute organized *Rabi Kisan Mela* on 10th March, 2014. The *Kisan Mela* was inaugurated by Padma Bhushan Dr. R.S. Paroda, Former Director General, ICAR, New Delhi and Chaiman, Haryana Kisan Ayog, Govt. of Haryana while Dr. D.K. Sharma, Director, CSSRI, Karnal presided over the function. A number of dignitaries including consultants, experts from Karnal based ICAR Institutes and Development Departments actively participated in the deliberations of the *Kisan Mela.* All ICAR Institutes located at Karnal**,** Department of Agriculture, CCS HAU, Regional Station, Karnal and other government/private agencies displayed their exhibitions. Besides these, some NGOs also displayed their exhibitions on seeds, pesticides and agricultural implements. On this occasion, a *kisan goshthi* and field visit was organized in which scientists and Subject Matter Specialists (SMS) interacted with the farmers and suggested remedial measures for their current and emerging agricultural problems. About 3000 farmers from Haryana, Punjab and Uttar Pradesh and school students benefited from this important function. In the *Kisan Mela*, the farmers were informed about the technologies developed by CSSRI for the reclamation of salt affected soils, use of poor quality water, crop diversification, and salt tolerant varieties etc. Seeds of rice varieties Pusa 44, Pusa 1121, CSR 30 and CSR 36 were sold during the *mela*. The soil and water samples brought by the farmers were tested free of cost.

In his inaugural address, the chief guest Dr. Dr. R.S. Paroda highlighted the remarkable contributions made by CSSRI to safeguard the interest of the farmers and advised the farmers to adopt integrated farming (Multi-enterprise agriculture model developed by CSSRI) in view of the shrinking land and water resources and the fragmentation of land holdings. Noting the fact that year 2014 is being celebrated as the International Year of Family Farming, he emphasized the need for ensuring equal participation of women and youth in agriculture and related activities. He also highlighted the importance of timely dissemination of scientific agricultural information to the farmer. He stressed that *Kisan Mela* was the best platform for the dissemination of latest technologies amongst the farmers. Keeping in view the declining water table, climate change and decreasing land holdings, he emphasized the need for adoption of sustainable agricultural practices namely, conservation agriculture, integrated pest management, direct seeded rice and residue management. He further stressed the need for developing varieties for water and heat stresses, particularly in wheat crop. He laid focus on crop diversification through horticultural crops, fisheries, bee keeping, dairy and poultry farming to make the agriculture climate resilient as well as for providing handsome income to the farmers on a regular basis. Dr. D.K. Sharma, Director of the Institute highlighted the major achievements of the Institute. He said that due to limited available resources and increasing cost of cultivation, the Institute has developed a multi-enterprise agriculture model. He stressed the need for integrated nutrient management and highlighted the role of micronutrients in sustainable agriculture.

Twenty five progressive farmers were felicitated during the *kisan mela.* Besides, prizes were awarded to the three best exhibition stalls. The students were apprised about the Central Laboratory facility, meteorological unit, groundwater recharge structures and the herbal garden.

Padma Bhushan Dr. R.S. Paroda, Former DG, ICAR, New Delhi and Chairman, Haryana Kisan Ayog addressing the farmers'

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LIST OF SCIENTIFIC, TECHNICAL AND ADMINISTRATIVE PERSONNEL

Dinesh Kumar Sharma, Ph.D., Director

Division of Soil and Crop Management

S.K. Chaudhari, Ph.D. Head (31.12.2013) [a]
Madhurma Sethi, Ph.D. Head (A)(01.01.2014) [b]
P.K. Joshi, Ph.D.
Anil R. Chinchmalatpure, Ph.D.
A.K. Mandal, Ph.D.
R.K. Yadav, Ph.D.
Parveen Kumar, Ph.D.
Sharad Kumar Singh, Ph.D.
Gajender Yadav, Ph.D.
Ranbir Singh, Ph.D.
A.K. Bhardwaj, Ph.D.
H.S. Jat, Ph.D.
Madhu Chaudhary, M.Sc.
Shreyasi Gupta Choudhury, Ph.D (18.05.2013)[a]
Anshuman Singh, Ph.D.
Murli Dhar Meena, Ph.D.
Nirmalendu Basak, Ph.D.
R.G. Garg, Ph.D. (28.01.2014) [b]
A.K. Rai, Ph.D. (17.02.2014)[b]
Assim Dutta, M.Sc. (11.04.2013) [b]

Technical Officers

T.N. Khurana, B.Sc.
Naresh Kumar, M.Sc.
Rati Ram (30.06.2013)[c]

Division of Crop Improvement

S.K. Sharma, Ph.D. Head
Parbodh Chander Sharma, Ph.D.
Neeraj Kulshreshtha, Ph.D.
S.L. Krishnamurthy, Ph.D.
Joginder Singh, Ph.D.
Ashwani Kumar, Ph.D.

Technical Officers

P.S.Tomar, B.Sc. (Ag.)
G.C. Purty
Roshan Lal

Division of Irrigation and Drainage Engineering

S.K. Kamra, Ph.D., Head
R.S. Pandey, Ph.D.
D.S. Bundela, Ph.D.
Satyender Kumar, Ph.D.
Baskar Narjary, Ph.D.

Technical Officers

Rajiv Kumar, M.Sc.
S.K. Srivastava, Dip. Auto. Engg.
Jai Parkash, M.Sc.
S.K. Dahiya
Mohinder Pal
Ram Pal
Mahabir Singh
Brij Mohan
Sat Pal

Division of Technology Evaluation and Transfer

R.S. Tripathi, Ph.D., Head
R.K. Singh, Ph.D.
K. Thimmappa, Ph.D.
M. Raju, Ph.D.
Parvender Sheoran, Ph.D. (14.08.2013)[b]

Technical Officers

S.K. Tyagi, Ph.D.

AICRP (Saline Water)

S.K. Ambast, Ph.D., Project Coordinator
R.L. Meena, Ph.D.
Babu Lal Meena, Ph.D.

Technical Officers

Brij Mohan, M.Sc. (31.01.2014)[c]
Anil Kumar Sharma, MA, Eng.

Regional Research Station, Canning Town

B. Maji, Ph.D., Head
D. Burman, Ph.D.
S.K. Sarangi, Ph.D.
Subhasis Mandal, Ph.D.
U.K. Mandal, Ph.D.
Shishir Raut, Ph.D.
K.K. Mahanta, Ph.D.

Technical Officers

D. Pal, Ph.D.
D.D. Majhi, B.Sc. (Ag.)
N.B. Mondal, ITI
Sivaji Roy, M.Sc.

P.K. Dhar, B.Sc.
Smt. S. Roy, B.Sc.
L.K. Nayak, Driver
D. Mukherjee
D. Banerjee

PS to the Head

A.K. Nandi, B.Sc.

Regional Research Station, Bharuch

G. Gururaja Rao, Ph.D., Head
M.K. Khandelwal, Ph.D. (19.09.2013)[d]
Sarwan Kumar, M.Sc.
Indivar Parshad, M.Sc.
Nikam Vinayak Ramesh, M.Sc. (11.04.2013)[b]

Technical Officer

M.V.S. Rajeshwar Rao, M.Sc.
Akshay Kumar
Balwan Singh (30.11.2013)[c]

Regional Research Station, Lucknow

V.K. Mishra, Ph.D. Head
Y.P. Singh, Ph.D.
Chhedi Lal Verma, Ph.D.
T. Damodaran, Ph.D.
Atul Kumar Singh, Ph.D.
Sanjay Arora, Ph.D.
S.K. Jha, Ph.D. (01.07.2013)[b]

Technical Officers

S.K. Jha, Ph.D. (30.06.2013)[b]
C.S. Singh, Ph.D.
Hari Mohan Verma, M.Tech.

Administrative and Supporting Section

Administration

Abhishek Srivastava, Admn. Officer (7.09.2013)[b]
A.K. Manchanda, Admn. Officer (30.09.2013)[a]
Ved Parkash, Finance and Account Officer
A.K. Kathuria, Jr. Account Officer (09.01.2014)[a]
A.K. Mishra, Asstt. Admn. Officer
Som Singh, Asstt. Admn. Officer (31.08.2013)[c]
Tarun Kumar, Asstt. Admn. Officer (11.09.2013)[b]
Jai Pal Sharma, Asstt. Admn. Officer (31.01.2014)[c]
Ranjeet Singh, Asstt. Admn. Officer(11.09.2013)[b]

RTI Cell

K. Thimmappa, Ph.D., CPIO
Randhir Singh, Ph.D., APIO

Vigilance Officer

P.C. Sharma, Ph.D.

Priortizing, Monitoring and Evaluation (PME) and Institute Technology Management Unit (ITMU)

Anil R. Chinchmalatpure, Ph.D., CO

Technical Officer

Vijay Kumar, B.Sc., M.A. (30.04.2013)[c]

Publication and Supporting Services Unit

Anil R. Chinchmalatpure, Ph.D., CO
Randhir Singh, Ph.D., OIC
Madan Singh, M.A. (Geography)

Hindi Cell

A.K. Srivastava, Admn. Officer, OIC

Technical Officer

S.K. Tyagi, Ph.D

Director Cell

Smt. Santra Devi, PS

Public Relation Officer

Randhir Singh, Ph.D.

PS to Heads

Smt. Dinesh Gugnani
Smt. Rita Ahuja
Smt. Sunita Malhotra
Shashi Pal (24.08.2013)[b]

Farm Section

H.S. Tomar, MA, Farm Manager
Chander Gupt
Seth Pal
Jaswant Singh

Library

Smt. Meena Luthra, M. Lib. Sci., OIC

Medical Unit

Dr. (Mrs.) Mahathi Parkash, M.B.B.S.
Smt. Sunita Dhingra
Smt. Chanchal Rani
Smt. Geeta Rani

Estate Section

Randhir Singh, Ph.D., CO
N.K. Vaid, M.Tech., OIC
S.K. Dahiya
Ashwani Kumar, Dip. in Machinist
Kulbir Singh, Dip. in Civil Engineering

* Superscripts a, b, c and d refer to date of relieving, joining superannuating and expired, respectively

CSSRI STAFF POSITION

Statement showing the total number of employees and the number of Scheduled Castes(SC)/Scheduled Tribes (ST) as on 31.3.2014

Group/class	Number of employees			Scheduled Castes		Scheduled Tribes	
	Temporary	Permanent	Total	No.	% of total	No.	% of total
Class-1 permanent other than lowest rung of Class-1	-	31	31	01	3.22	03	9.67
Lowest rung of Class-1	-	44	44	02	4.54	01	2.27
Class-II	-	67	67	18	26.86	05	7.46
Class-III	-	60	60	09	15.00	05	8.33
Class-IV (excluding sweepers)	-	58	58	16	27.58	05	8.62
Class-IV (only sweepers)	-	06	06	06	100	-	-
Total	**-**	**266**	**266**	**52**	**177.2**	**19**	**36.35**

Statement of Scheduled Castes (SC) and Scheduled Tribes (ST)

Statement showing the number of reserved vacancies filled by Scheduled Castes (SC)/ Scheduled Tribes (ST) as on 31.3.2014

Classified posts	Total vacancies		Scheduled Castes		Scheduled Tribes	
	Notified	Filled	Notified	Filled	Notified	Filled
Direct Recruitment						
Class-I						
Class-II			Nil			
Class-III						
Class-IV						
Promotions						
Class-I						
Class-II						
Class-III			Nil			
Class-IV						

☆☆☆☆☆

WEATHER REPORT 2013

Main Institute, Karnal

The monthly weather parameters recorded at agro-meteorological observatory, CSSRI, Karnal for the year 2013 are presented in Table I. A total rainfall of 875.9 mm was recorded at Agro-met Observatory as compared to the mean annual rainfall of 747.9 mm (for the last 40 years). The year was a normal rainfall year as the annual rainfall was 117 per cent of the long-term mean annual rainfall whereas the year 2012 was a deficient rainfall year (64% of the mean annual rainfall). The maximum monthly rainfall of 275.3 mm was recorded in August. During the monsoon season, the maximum rain (88.6 mm) with rainstorm was recorded on 1st August. The winter rainfall (January and February) was 180.8 mm as compared to the last year winter rainfall (23.4 mm). The heavy winter rainfall along with favourable weather conditions was conducive for *rabi* crops and substantially decreased the irrigation demand in January and February month resulting in only two withdrawal of water from canal/ground water for wheat and resulted in bumper *rabi* crop production. There were 51 rainy days as compared to 29 during the last year.

The minimum and maximum temperatures, -0.2 ° and 46.0 °C were recorded on 6th January and 24th May, respectively. The lowest relative humidity was 9 per cent on 8th May while the highest (100%) was recorded on several occasions during the year. The highest soil temperatures at 5, 10 and 20 cm soil depths were 48.0°C, 42.5°C and 39.5°C on 4th June, 5th June and 6th June, respectively. The lowest values at same depths were recorded as 6.0°C, 7.0°C and 9.0°C on a single day (6th January). The total open pan evaporation during the year was 1418.0 mm, which is 1.6 times higher than the annual rainfall. The lowest evaporation of 0.5 mm was recorded on 6th January and the highest of 12.6 mm was on 24th May. The average sunshine hours per day were 6.6. The highest and lowest vapour pressure values were 28.4 and 5.5 mm of mercury column on 19th July and 8th January, respectively. The average wind speed was 4.1 km per hour.

RRS, Canning Town-2013

The mean monthly weather parameters recorded at RRS, Canning are presented in Table II. The southwest monsoon set in on June 9. Total annual rainfall of 2164.2 mm was recorded at meteorological unit during 2013. The maximum of 672.3 mm rainfall was recorded in the month of August, but the maximum rainy days (16) were recorded in the month of July and August each. This year total annual rainfall was more than the long time average annual rainfall of 1768 mm, which affected the smooth growth of rice in the middle of the *kharif* season. Due to meagre/slight rain after the monsoon period supplementary irrigation is essential for cultivation of *rabi* crop. There were 83 rainy days in this year. The average daily sunshine hours was moderate. The minimum temperature reached its lowest (total mean monthly average 11.8^{0}C) in the month of January. The average mean monthly temperature of 18.0^{0}C in January rose very rapidly to 30.1^{0}C in the month of May. The relative humidity remained quite high throughout the year, which caused several problems of pest and disease infestations. In October month unoccasional heavy rainfall (70.0 mm) with high wind speed affected the milk stage of *kharif* rice. Highest average wind velocity (12.5 km/h.) was recorded in May.

RRS, Bharuch 2013

Agro-meteorological observations recorded at Cotton Research Station, Bharuch (latitude 22^{O}N, longitude 73.5^{O}E, and altitude 16.50 m) during 2013 revealed that this region received annual rainfall of 1443 mm spread over 66 days. Season's highest rainfall of 602 mm was received during September followed by 493.2 mm, 182.4 mm and 143.8 mm during July, August and June, respectively. Maximum and minimum air temperature varied from 29.4^{0}C (Jan) to 40.8^{0}C (May) and 12.7^{0}C (Jan) to 26.4^{0}C (May). Pan evaporation varied from 2.6 mm/day during July to 9.0 mm/day during May. The average bright sunshine hours varied from 1.3 hours during July to 10.4 hours during May. Mean relative humidity varied from 55.5 per cent during March to 89.1 per cent during July. The average wind velocity varied from 4.4 kmph during January to 11.6 kmph during May. Year 2013 was high rainfall year in this region (Table III).

Table I : Mean monthly weather parameters for 2013 recorded at Agro-meteorological Observatory, CSSRI, Karnal

Latitude: 29° 43′ N

Longitude: 76° 58′ E

Altitude : 245 metres above the Mean Sea Level

I Time : 0722/0830 hours IST

II Time : 1422 hours IST

Month	Temperature, °C							Vapour pressure (mm of Hg)		Relative humidity (%)		Max. Temp, °C		Min. Temp, °C	
	Max.	Min.	Grass Min.	Dry bulb		Wet bulb						High/ date	Low/ date	High/ date	Low/ date
				I	II	I	II	I	II	I	II				
Jan.	16.8	4.8	0.5	6.4	16.2	6.1	12.4	7.0	8.6	96	63	22.2/15	8.4/6	11.5/17	-0.2/6
Feb.	20.7	9.1	6.0	10.6	20.0	10.3	15.9	9.3	11.1	97	64	25.0/28	16.0/5	14.1/4	5.0/11
Mar.	27.5	12.7	9.4	15.1	27.1	14.2	19.9	11.7	13.1	90	49	31.5/24	22.5/5	16.0/19	8.5/5
Apr.	35.2	17.2	14.2	21.1	35.0	17.3	20.6	12.5	9.5	68	23	38.2/30	30.5/4	22.2/29	14.5/1
May	40.4	22.2	19.5	27.1	39.8	20.9	23.4	14.7	11.8	54	22	46.0/24	29.0/13	27.0/27	16.7/3
Jun.	35.6	26.0	24.6	28.0	34.7	25.5	27.1	22.9	22.2	80	54	42.0/6	26.4/18	29.0/11	19.9/17
Jul.	33.6	26.6	24.9	28.2	32.8	26.6	27.9	25.1	25.3	87	68	36.0/2	28.5/21	28.5/2	24.0/16
Aug.	32.2	25.4	23.7	26.9	31.3	25.8	27.6	24.3	25.6	91	75	35.0/1	29.0/10	27.2/26	23.6/9
Sept.	33.0	23.4	21.9	25.2	31.9	24.0	26.4	21.8	22.5	90	64	35.0/21	25.5/22	26.0/2	20.0/18
Oct.	31.5	19.4	17.9	21.2	31.1	20.4	23.7	17.8	17.6	92	52	32.5/16	27.0/12	25.0/9	13.2/29
Nov.	26.9	10.0	6.7	11.9	26.7	10.7	16.9	9.1	8.6	86	33	28.5/27	25.5/22	16.7/1	6.6/17
Dec.	21.1	7.6	3.3	9.2	20.3	8.6	14.7	8.2	9.3	93	54	26.0/1	14.6/19	12.0/22	0.2/30
Total	**354.5**	**204.4**	**172.6**	**230.9**	**346.9**	**210.4**	**256.5**	**184.4**	**185.2**	**1024**	**621**	--	--	--	--
Average	**29.5**	**17.0**	**14.4**	**19.2**	**28.9**	**17.5**	**21.4**	**15.4**	**15.4**	**85**	**52**	--	--	--	--

Month	Soil temperature, °C (depthwise)						Rainfall*			Evaporation		Sunshine (hr/day)	Wind speed (km/hr)
	5 cm		10 cm		20 cm								
	I	II	I	II	I	II	Monthly (mm)	No of rainy days	Heavy/ date	mm/ day	mm/ month		
Jan.	8.5	16.6	9.7	14.2	11.0	12.8	64.4	2	42.2/18	1.4	44.2	4.4	2.9
Feb.	11.6	19.0	12.5	16.5	13.6	15.0	116.4	10	39.2/6	1.9	52.1	5.7	5.2
Mar.	16.3	26.4	17.2	23.2	18.3	20.7	5.8	3	4.2/24	3.2	100.0	8.0	5.1
Apr.	23.1	37.3	24.4	33.2	26.4	28.9	5.2	1	5.2/22	6.7	194.6	8.8	4.9
May	29.3	43.7	30.7	39.5	31.8	36.2	2.0	1	2.0/27	9.2	284.2	9.5	4.5
June	29.4	37.4	30.1	36.2	31.6	33.8	156.6	5	52.6/16	6.2	172.9	7.3	7.5
July	28.3	35	29.1	34	29.7	32.9	215.9	7	72.6/16	4.6	132.9	5.4	4.8
Aug.	27.2	32	27.6	31.2	28.1	30.7	275.3	16	88.6/1	3.8	110.4	5.0	3.6
Sept.	26.7	36.1	27.6	34.6	28.5	33.9	13.0	2	7.6/22	3.9	113.1	7.3	3.1
Oct.	23.2	33.1	24.1	31.9	24.9	30.9	19.5	3	14.4/12	3.0	94.2	5.5	2.1
Nov.	14.6	25.5	15.6	24.1	16.4	23.2	0.0	0	---	2.5	72.5	7.3	2.4
Dec.	11.2	19.6	12.2	18.1	13.2	17.3	1.8	1	01.8/31	1.5	46.9	4.7	2.7
Total	**249.4**	**361.7**	**260.8**	**336.7**	**273.5**	**316.3**	**875.9**	**51**	**-**	**47.9**	**1418.0**	**78.9**	**48.8**
Average	**20.8**	**30.1**	**21.7**	**28.1**	**22.8**	**26.4**	**73.0**	**-**	**-**	**4.0**	**118.2**	**6.6**	**4.1**

Rainfall < 2 mm is drizzle or trace.

Table II : Mean monthly weather parameters at Canning Town (Latitude 22°15′ N, Longitude 88°40′E, Altitude (AMSL)-3.0 M, during 2013

Month	Temperature (°C)			RH%		Rainfall (mm)	Rainy days	Av. wind (kmph)	Wind Max (kmph)	BSH/ hour
	Max	Min	Mean	Max	Min					
January	24.2	11.8	18.0	100	38	2.0	0	3.1	16.9	6.0
February	28.1	15.1	21.6	100	34	5.1	1	3.8	19.7	7.5
March	34.0	21.1	27.6	100	31	6.1	0	5.3	21.7	7.9
April	35.7	24.2	29.9	100	37	16.3	1	8.4	31.0	7.8
May	34.0	26.1	30.1	99	64	198.6	11	12.5	37.8	5.3
June	33.3	26.6	29.9	100	68	241.5	12	8.5	31.0	4.5
July	32.2	26.5	29.3	100	77	312.7	16	7.9	28.4	4.8
August	31.4	26.2	28.8	100	91	672.3	16	7.0	28.2	4.1
September	32.2	26.3	29.2	100	73	435.3	11	4.9	24.0	4.4
October	30.2	24.5	27.3	100	72	274.3	15	5.3	22.6	3.5
November	29.2	18.4	23.8	100	44	0	0	2.6	17.0	7.9
December	26.9	14.5	20.7	100	42	0	0	2.7	16.7	6.9
Total	**371.4**	**261.3**	**316.2**	**1199**	**671**	**2164.2**	**83**	**72**	**295**	**70.6**
Mean	**30.9**	**21.8**	**26.3**	**100**	**56**	**-**	**-**	**6.0**	**24.6**	**5.9**

Max temperature = 39.4 °C on 09/04/2013; Min temperature = 7.0 °C on 09/01/2013; Max daily rainfall =125.6 mm on 19/08/2013; Cyclone on 14/06/2013 (Maximum wind speed 61.6 Km, Rain 49.4 mm)

Table III : Monthly average agrometeorological parameters at Bharuch during 2013

Month	Air temperature (°C)		Rainfall (mm)	Total rainy days	Relative humidity (%)	Vapour pressure (mm)	Wind velocity (kmph)	Bright sunshine hours	EPan (mmpd)
	Max	Min							
January	29.4	12.7	0.0		59.5	8.4	4.4	8.9	4.9
February	33.0	16.6	0.0		61.1	11.1	4.6	9.0	6.0
March	37.6	19.7	0.0		55.5	13.1	4.9	8.9	6.5
April	38.8	22.8	0.0		66.4	18.2	6.9	9.6	7.2
May	40.8	26.4	0.0		71.9	23.1	11.6	10.4	9.0
June	34.2	25.4	143.8		84.0	24.9	9.5	4.7	5.7
July	30.7	25.4	493.2		89.1	24.2	8.9	1.3	2.6
August	30.6	25.2	182.4		87.5	23.0	6.9	3.0	2.7
September	33.0	25.0	602.0		84.7	23.0	7.2	4.1	3.2
October	33.4	23.3	22.0		78.9	20.6	5.8	8.5	3.6
November	32.6	19.2	0.0		68.5	14.5	4.9	8.3	5.5
December	30.1	14.7	0.0		69.3	11.9	4.6	8.0	4.6
Total			**1443.4**	**66**					

☆☆☆☆☆

AUTHOR INDEX

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