# CSSRI

# वार्षिक प्रतिवेदन
# Annual Report
## 2014-15


**ICAR-CENTRAL SOIL SALINITY RESEARCH INSTITUTE**

KARNAL-132001 (INDIA)

भाकृअनुप
ICAR

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# ANNUAL REPORT

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## ICAR- CENTRAL SOIL SALINITY RESEARCH INSTITUTE

### KARNAL - 132 001 (HARYANA)

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# PREFACE

Excessive amounts of salts in soils and ground water is a characteristic feature in many parts of the world including India especially in the arid, semi-arid and coastal regions. The quality of land and potentiality of the water for irrigation purposes determine the productivity potential of these resources and the livelihood of the people depending upon them. Although primary salinity was in vogue, the appearance of water logging and salinity in irrigation commands accentuated the gravity and urgency of the problem and lead to worldwide investigational attention. These investigations addressed several facets of these problem i.e. assessment and characterization of salt affected soils and waters, identification of causative factors and development of preventive, reclamation and managerial interventions to increase productivity of these resources. I am happy to state that several technologies developed by the institute have spread widely and are quite popular amongst the farming community. Our current endeavor is to modify these technologies for cost reduction, develop new technologies and address many new challenges that are emerging over the years. The annual report for the period 2014-15 covers some significant activities and achievements of research, development and capacity building. Some of the significant research achievements are: identifying the potential polyembryonic mango rootstocks for salt affected soils, labile carbon fractions build-up and dynamics under agro forestry systems, bio–harderning protocol using salt tolerent bacteria, integrated farming system for management of waterlogged salt affected soils, mini sprinklers for efficent use of water and energy, remunerative rice based cropping systems for coastal saline soil and out scaling CSR-bio technology. Interesting results were obtained on assessing impacts and sustainability of brackish water aquaculture in coastal environment, ground water resource management to mitigate the impact of climate change in Haryana and resource conservation and crop productivity on partially reclaimed sodic soils. Institute produced about 8.1 tonnes of breeder seed of salt tolerant varieties of rice, wheat and mustard. A number of scientific, professional and partnership programmes were organized during the year. It was also a year when greater emphasis was given to strengthening facilities at Regional Research stations.

To disseminate institute technologies to the farming community, *rabi* and *kharif kisan melas* were organized during the year. While Dr. A.K. Singh DDG (Agric. Extension), ICAR, addressed the farmers in the *rabi kisan mela* at CSSRI, Karnal; Dr. Rameshwar Singh, Project Director, DKMA, was the chief guest in *kharif kisan mela* at Village Siwanamal. On March 1, 2015 the institute celebrated its foundation day and lecture was delivered by Dr. A.K. Sikka, DDG (NRM), ICAR, New Delhi. He also distributed the CSSRI excellence awards to the awardees on this occasion. The Research Advisory Committee (RAC) met during November 21-22, 2014 under the chairmanship of Dr. S.B. Kadrekar, Former Vice-Chancellor, Konkan *Krishi Vidhyapeeth*, Dapoli and reviewed the research programmes of the institute and offered very valuable suggestions for incorporation in the future research agenda. The Institute Research Council (IRC) meeting was organized during January 28-31, 2015 which reviewed the progress of each on-going project and approved various new research programmes formulated after taking into account the suggestions made by the RAC. The perspective plan of the institute "Vision 2050" was prepared.

The meeting of the Regional Committee V was organized by CSSRI at PAU, Ludhiana during 14-15 November, 2014 under the Chairmanship of Dr. S. Ayyappan, Secretary DARE and DG, ICAR, New Delhi. The event was successfully organized under the guidance of Hon'ble DG, Dr. K.M.L. Pathak, DDG (AS) and with the wholehearted support of the Vice-Chancellor, PAU and active cooperation of the staff of CSSRI and PAU.

A National Seminar was organized by Indian Society of Soil Salinity and Water Quality on 'Innovative Saline Agriculture in Changing Environment at Gwalior in collaboration with Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya (RVSKVV), Gwalior from 12 to 14 Dec., 2014. The flagged agenda was to discuss the soil degradation and pollution, water quality and its ever increasing pollution and crop productivity and quality under marginal land and water resources so as to devise strategies to overcome them for maximizing productivity. The seminar was inaugurated by Dr. A.K. Singh, Vice-chancellor, RVSKVV Gwalior. Human resource and capacity building activities undertaken during this period included Short Course on Advanced Technologies in Land and Water Remediation and Management, Training Programme on Conservation Agriculture (CA): Developing Resilient Systems, Hindi Week, Winter school on Diagnosis, Assessment and Management of Salt Affected Soils and Poor Quality Waters to Improve Productivity and Livelihood Security, and Short Course on Management of Frost and Prolonged Foggy Weather.

We had an opportunity to receive large number of dignitaries and experts at the institute that provided us opportunities to discuss with them our research experiments and plans. The notable visitors were Dr. R.S. Paroda, Chairman, Haryana Kisan Ayog, Dr. J.S. Chauhan, ADG (Seeds) and Dr. S.K. Chaudhari, ADG (SWM), ICAR New Delhi; Dr. Rameshwar Singh, Project Director, DKMA, Dr. B. Mishra, Former Vice Chancellor, SKUAST, Jammu, Dr. K.K. Katoch, Vice Chancellor, HPKV, Palampur, Dr. A.McDonald, a delegation from Tanjania which included Dr. Jackson Madulu Nkuba, Mr. Johan Linus Banzi, Ms. Ruth Kokuganyilwa Kamala, Dr. Geophrey Jasper Kajitu, Mr. El Matungwa Balongo, Ms. Justa Mtasingwa Katunzi, Dr. Mohamed Msigara Bahari and Mr. Mganga Joshua Kitilu; Mr. Michinari Kawano, Mr. Mitsuki Goto and Mr. Isamu Yamanaka of Japan, Mr. Watchara Suiadee, Mr. Sirode Prakunhungsit, Mr. Theeraphol Tungsomboun of Thailand, Mr. Mohd Yazid Bin Abdullah of Malaysia and Mr. Upali Wickramarane and Dr. Raj Mohan Natrajan of Sri Lanka and Dr. A.K. Singh, Vice Chancellor, RVSKV, Gwalior.

During the period, Dr. T. Damodaran and his team received Biotech Product & Process Development and Commercialization Award for the year 2014 by the Department of Biotechnology, Govt. of India. The Institute published 94 research papers in peer reviewed journals, 28 book chapters, 3 books/manuals, 9 bulletins/ folders, 23 popular articles, 3 technical reports and 115 papers were presented in seminar/ symposia and conferences. To upgrade the knowledge and skills, 9 scientists of the institute visited different countries *viz.* Bangladesh, Nepal, Philippines, Thailand, Korea, Japan and Vietnam. Three scientists joined the institute and Dr. P.C.Sharma joined as Head, Crop Improvement Division and Dr. Anil Chinchmaltpure, joined as Head, RRS, Bharuch during the period under report. We congratulate them and wish them all the best for their future professional life. A number of colleagues retired from services after rendering meritorious services to the institute. We wish them a very healthy and happy retired life.

The guidance and support received from Dr. S. Ayyappan, Secretary, DARE and DG, ICAR, Dr. A.K. Sikka, DDG (NRM) and Dr. S.K. Chaudhari, ADG (SWM) is gratefully acknowledged. Dr. A.K. Bhardwaj, Dr. Anshuman Singh, Dr. Randhir Singh shared the major responsibility of synthesizing, editing and getting the annual report printed. Dr. S.K. Tyagi helped in Hindi translation of the executive summary. I appreciate the efforts made by them and other colleagues who provided the material for timely publication of the report.

I believe that the information cited in this report would provide readers some glimpses of the CSSRI achievements during the year. I would be happy to receive any suggestions/ comments from readers for its improvement in future.

May 30, 2015

D.K. Sharma
Director

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# सारांश

वर्ष 1969 में स्थापित केन्द्रीय मृदा लवणता अनुसंधान संस्थान, करनाल हरियाणा 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 एक विश्व विख्यात केन्द्र है। मुख्यालय में बहुविषयक अनुसंधान कार्यक्रम चार विभागों–मृदा एवं फसल प्रबंध प्रभाग, सिंचाई एवं जलनिकास अभियांत्रिकी प्रभाग, फसल सुधार प्रभाग और प्रौद्योगिकी मूल्यांकन एवं प्रसार प्रभाग द्वारा संचालित किये जाते हैं। विभिन्न कृषि जलवायु क्षेत्रों की अनुसंधान आवश्यकताओं को पूरा करने के लिए संस्थान के तीन क्षेत्रीय अनुसंधान केन्द्र–कैनिंग टाउन (प. बंगाल), भरूच (गुजरात) और लखनऊ (उत्तर प्रदेश) क्रमशः समुद्र तटीय लवणता, लवणग्रस्त वर्टीसोल मृदाओं और सतही जल स्तर वाली मध्य एवं पूर्वी सिंधु–गंगा के मैदानों की क्षारीय मृदाओं संबंधी समस्याओं के समग्र वैज्ञानिक निदान हेतु कार्यरत हैं। संस्थान में 'लवणग्रस्त भूमियों के प्रबंधन और खारे पानी के कृषि में प्रयोग हेतु' अखिल भारतीय समन्वित परियोजना भी विभिन्न पारिस्थितिकी क्षेत्रों–आगरा, कानपुर, हिसार, इंदौर, बीकानेर, वापटला, गंगावटी, त्रिचुरापल्ली, बठिंडा, पनबैल, वाईटिला और पोर्ट ब्लेयर में स्थित केन्द्रों के सहयोग से इस दिशा में अनुसंधान कार्य में महत्वपूर्ण भूमिका निभा रही है। संदर्भित अवधि के लिए विभिन्न महत्वपूर्ण क्षेत्रों में संस्थान की कुछ प्रमुख अनुसंधान उपलब्धियाँ निम्नलिखित हैं।

## केन्द्रीय हरियाणा में लवण प्रभावित मृदा का मानचित्रीकरण और लक्षण

हरियाणा के फतेहाबाद जिले की लवण प्रभावित मृदा के मानचित्रीकरण और लक्षण वर्णन के लिए सुदूर संवेदन और भौगोलिक सूचना तंत्र तकनीकियों का उपयोग किया गया। लवणग्रस्त मृदाओं के अंतर्गत 11614 हैक्टेयर (4.6 प्रतिशत) क्षेत्र पांच खंडों फतेहाबाद (1.1 प्रतिशत), टोहाना (1.1 प्रतिशत), भूना (1.3 प्रतिशत) भट्टू कला (0.8 प्रतिशत) और रतिया (0.3 प्रतिशत) में फैला हुआ है। क्षारीय और लवणीय मृदा का क्षेत्रफल क्रमशः 62 और 38 प्रतिशत है। निम्न गुणवत्ता (क्षारीय) भूजल का प्रमुख क्षेत्र टोहाना खंड में है जबकि जलाक्रांत एवं लवणग्रस्त मृदाओं का बाहुल्य भाखड़ा नहर के सिंचित क्षेत्रों में पाया गया जो अवरूद्ध जल निकास को दर्शाता है।

## सीएसआर–जैव प्रौद्योगिकी का प्रभाव

एक गतिशील मीडिया में बेसिलस पुमिलास, बेसिलस थरयूजैन्सिस और ट्राइकाडर्मा इरजियानम के माक्रोबियल संघ का उपयोग कर सीएसआर जैव उत्पादन प्रौद्योगिकी का एनएआईपी द्वारा 7.11.2012 को पेटैंट वाणिज्यीकरण करवाया गया और बाद में भा.कृ.अनु.प. द्वारा 20 जुलाई 2013 को पेटैंट करवाया गया। कुल तीन फ्रर्मों ने सामग्री के उत्पादन के लिए लाइसैंस प्राप्त किया है। फर्मों के अतिरिक्त इस जैव सामग्री को केन्द्रीय मृदा लवणता अनुसंधान संस्थान के क्षेत्रीय अनुसंधान केन्द्र पर भी उत्पादित किया जा रहा है। फसलों में 19.75 प्रतिशत औसत उत्पादन में वृद्धि के साथ यह प्रौद्योगिकी सात राज्यों के 10800 किसानों तक पहुच चुकी है इस प्रौद्योगिकी को बड़े पैमाने पर दक्षिण तमिलनाडू, कर्नाटक और आंध्र प्रदेश के 18400 केले और फूलों को उगाने वाले किसानों द्वारा अपनाया जा रहा है। उत्तर प्रदेश, उत्तराखंड, बिहार और मध्य प्रदेश क्षेत्र के आलू, मिर्च, टमाटर और ग्रेडिओलस उत्पादन करने वाले किसानों द्वारा इसे व्यापक रूप से अपनाया जा रहा है। इस जैव संरचना ने रासायनिक कीटनाशक और कवकनाशी के प्रयोग में 3000 लीटर की कमी की है जिससे खाद्य श्रृंखला के माध्यम से पर्यावरण और मानवों तक पहुंच रहे विभिन्न प्रकार के विषाक्त पदार्थों के जोखित से उन्हें बचाया है। उत्तर प्रदेश के आलू उत्पादन करने वाले किसान 450 हेक्टेयर क्षेत्रफल में रासायनिक कवकनाशी की जगह 3 प्रतिशत सीएसआर–जैव से बीज कंद को उपचारित कर रहे हैं और उसके बाद दिसम्बर और जनवरी के महीने में दवा का प्रयोग कर रहे हैं। इन किसानों ने तकनीक न प्रयोग करने वाले किसानों की तुलना में 12 प्रतिशत अधिक उपज प्राप्त की और अंगमारी की घटनाओं में 65 प्रतिशत की कमी हुई। क्षेत्र पर मूल्यांकन उपरांत इस प्रौद्योगिकी को कई अनुसंधान संख्याओं जैसे महत्वपूर्ण सूक्ष्म–जीव राष्ट्रीय ब्यूरो, मऊ,: बीज अनुसंधान निदेशालय मऊ और वाई एसआर कृषि विश्वविद्यालय आंध्र प्रदेश जैसे कई शोध संस्थानों द्वारा आगे बढ़ाया जा रहा है। इस जैव–संरचना द्वारा Ixora., केला, टमाटन मिर्च, धनिया और धान के फाल्सस्मट जैसी गंभीर बीमारियों के नियंत्रण के लिए प्रभावी पाया गया। तमिलनाडू के त्रिचिरापल्ली जिले की फार्म उत्पादों को बनाने वाली एक फर्म ने इससे अपनी मानसून धान फसल के फाल्स स्मट के 90 प्रतिशत सफल नियंत्रण की सूचना दी।

## धान व गेहूँ की लवण सहिष्णु प्रजातियों के लिए अनुकूलित सिंचाई और रोपण समय–सारणी

लवण सहिष्णु बासमती धान की सीएसआर 30 प्रजाति लम्बी अवधि (155 दिन) में पकती है जिससे गेहूँ की बिजाई देर से हो पाती है और उत्पादकता प्रभावित होती है। सुधारी गई क्षारीय मृदाओं में धान व गेहूँ की लवण सहिष्णु प्रजातियों की विभिन्न तिथियों में बुआई और अनुकूलतम सिंचाई जल आवश्यकताओं के मानकीकरण लिए प्रयास किए जा रहे हैं। परिणामों ने दर्शाया कि 1 जुलाई को रोपित बासमती प्रजाति (सीएसआर 30) के खेत में जब रोपण के एक महीने बाद भरा हुआ पानी दिखाई देना बंद हो गया उस के 5 दिन बाद जब सिंचाई की गई तो इस प्रजाति ने अधिक दाना उपज (3.63 टन प्रति हे.) व अधिक जल उत्पादकता (0.591 कि. ग्रा प्रति घन मी.) प्रदर्शित की। गेहूँ की लवण सहिष्णु प्रजाति केआरएल 213 को तीन सिंचाई अनुसूचियों के अंतर्गत (आई डब्ल्यू प्रति सीपीई = 1.0, 0.8 और 0.6) व चार विभिन्न बुआई तिथियों (10 नवम्बर, 20 नवम्बर, 30 नवम्बर व 10 दिसम्बर) में बोया गया। परिणामों ने दर्शाया कि केआरएल 213 प्रजाति

की दाना उपज में 8 प्रतिशत की वृद्धि आई डब्ल्यू प्रति सीपीई 1.0 पर सिंचाई करने पर हुई। यह निष्कर्ष निकला कि आई डब्ल्यू प्रति सीपीई 1.0 सिंचाई अनुसूची के साथ 20 नवम्बर तक गेहूँ की बिजाई करके इसकी अधिकतम उपज (6.24 टन प्रति हेक्टेयर) प्राप्त की जा सकती है।

## सुधारी गई क्षारीय भूमि पर कृषि में विविधता लाने में ग्रीन हाउस गैस उत्सर्जन

बदलते हुए जलवायु परिदृश्य में सुधारी गई क्षारीय भूमियों से सतत आय एवं आर्थिक सुरक्षा सुनिश्चित करते हुये प्राकृतिक संसाधनों के समगतिशील संरक्षण एवं प्रबंधन हेतु लघु कृषकों के लिए कृषि विविधिकरण एक प्रभावी विकल्प सिद्ध हो सकता है। कृषि विविधिकरण माडल में ग्रीन हाउस गैसों का उत्सर्जन अनुमानित करने के लिए कूल फार्म टूल मॉडल (जो विश्व के कई जीएचजी मात्रा निर्धारित करने वाले अनुभवजनय माडलों को एकीकृत करता है) का प्रयोग किया गया। अनुमानित कुल जीएचजी उत्सर्जन (अर्थात $CO_2$ समतुल्य) के आंकड़ों से यह ज्ञात हुआ कि विभिन्न प्रकार की फसलों/उत्पादन प्रणालियों की प्रति हेक्टेयर ग्लोबल वार्मिंग क्षमता अलग–अलग थी। धान–गेहूँ प्रणाली ने औसतन 1.82 टन $CO_2$ समतुल्य उत्सर्जित किया जबकि मक्का–गेहूँ, हरा चारा, सब्जियों और बागवानी फसल प्रणालियों से क्रमशः 0.41, 0.25, 0.19 और 0.12 टन $CO_2$ समतुल्य उत्सर्जित हुआ। उसी क्षेत्र में धान–गेहूँ प्रणाली से 5.15 टन $CO_2$ समतुल्य की तुलना में विविध फसल प्रणाली के 1.8 हेक्टेयर क्षेत्र से कुल उत्सर्जन 2.78 टन $CO_2$ समतुल्य था। प्रति हेक्टेयर आधार पर विविध कृषि प्रणाली से 1.55 टन प्रति हे. $CO_2$ समतुल्य उत्सर्जन था जबकि धान–गेहूँ प्रणाली में यह मात्रा उत्सर्जन 2.86 टन थी। अतः विविध कृषि प्रणाली की ग्लोबल वार्मिंग क्षमता धान गेहूँ की अपेक्षा 46% कम पायी गई।

## लवणीय मृदा के तहत वर्षा जल संचयन प्रणाली के जल–भौतिक मूल्यांकन

क्षेत्रीय पैमाने पर मृदा लवणता के प्रबंधन के लिए इसकी भयावहता और स्थानिक–कालिक परिवर्तनशीलता के ज्ञान की आवश्यकता है। ऐसी मृदाओं के शीघ्र, विश्वसनीय एवं लागत प्रभावी सुधार हेतु संरचित क्षेत्रीय प्रस्तुति के निर्धारण के लिए भू–सांख्यिकीय तकनीक और मॉडलिंग की आवश्यकता है। नैन प्रायोगिक प्रक्षेत्र, पानीपत में 2013 में मानसून प्रारंभ से पहले 280 स्थानों पर 20 मी. x 20 मी. ग्रिड पर विद्युत चुंबकीय जांच संचालित की गई। इनमें से 40 स्थानों से 90 से. मी. गहराई तक मृदा नमूने एकत्र किए गए। मृदा नमूनों के संतृप्त अर्क की विद्युत चालकता, पीएच मान, धनायनों (कैल्शियम, मैग्नीशियम और सोडियम), ऋणायनों (कार्बोनेट, बाईकार्बोनेट, क्लोराइड) और सोडियम अधिशोषण अनुपात का विश्लेषण किया गया। विद्युत चालकता नमूना आकलन एवं पूर्वानुमान कार्यक्रम (ईएसएपी) पैकेज में सम्मिलित मल्टीपल लीनियर रीग्रेशन (एमएलआर) मॉडल के प्रयोग द्वारा विद्युत चालकता और सोडियम अधिशोषण अनुपात को परिवर्तित करने के लिए समायोजन समीकरणों को व्युत्पन्न किया गया। 0–15, 15–30, 30–60, 60–90 और 0–90 से.मी. परतों में मापी गई विद्युत चालकता और मॉडल द्वारा पूर्वानुमानित विद्युत चालकता में क्रमशः 0.75, 0.82, 0.82, 0.85 और 0.89 उच्च सहसंबंध गुणांक (आर$^2$) पाया गया। फार्म की औसत मृदा लवणता 17.4 डेसी सीमन प्रति मी. थी। मृदा की ऊपरी परत (0.15 से. मी.) में मृदा लवणता अधिकतम (21 डेसी सीमन प्रति मी.) थी, जो इंगित करती है कि वातावरण की प्रबल वाष्पीकरण मांग के कारण घुलनशील लवण निचली सतहों से ऊपरी सतह तक पहुंच जाते हैं।

## सूक्ष्म भूखंडों में लवण सहिष्णुता के लिए गेहूँ की प्रजातियों का मूल्यांकन

विभिन्न लवण तनावों [(सामान्य लवणीय (ईसी 5.9 डे.सी. सीमन प्रति मी.) और क्षारीयता (पीएच$_2$ 9.3)] के अंतर्गत सूक्ष्म भूखंडों में गेहूँ की 23 प्रजातियों का मूल्यांकन तीन प्रतिकृतियों में किया गया। केआरएल 3–4, केआरएल 99 और खर्चिया 65 सबसे सहिष्णु प्रजातियां पाई गईं जबकि डीडब्ल्यू 1, एचडी 4530, एचडी 2851, डीडब्ल्यू 3, बोक्टोन और एचडी 2009 के संवेदनशील प्रजातियों के रूप में चिन्हित किया गया। इसके अतिरिक्त केआरएल 330, केआरएल 345, केआरएल 346, केआरएल 213, केआरएल 240, केआरएल 210, केआरएल 19, एन डब्ल्यू 1014, एन डब्ल्यू 4018 और बी एच 1146 प्रजातियों में मध्यम लवण सहिष्णुता देखी गई।

## भारतीय सरसों (*ब्रैसिका जुनसिया*) का उदीयमान लवण सहनशील उपभेदों के रूप में अनुक्षवण और मूल्यांकन

सरसों की आठ प्रजातियों की लवणीय दशाओं (ईसी 10.7 डेसी प्रति सीमन मीटर) में नैन प्रयोगात्मक फार्म, पानीपत में और क्षारीय दशाओं (पीएच 9.3) में करनाल में मूल्यांकन किया गया। लवणीय व क्षारीय तनाव दशाओं में प्रजातियों में महत्वपूर्ण भिन्नता पाई गई। नैन फार्म में लवणता प्रतिबलों में बीज उपज 1.78 से 2.38 टन प्रति हेक्टेयर के मध्य (औसत 2.04 टन प्रति हे.) रही और करनाल की उच्च क्षारीय दशाओं (9.3 पीएच) में यह 1.47 से 0.06 टन प्रति हे. के मध्य रही (औसत 1.72 टन प्रति हे.)। दोनों ही दशाओं (लवणीय व क्षारीय) में प्रजाति सीएसीएन–18 ने सर्वाधिक बीज उपज दी और दूसरे स्थान पर सीएसीएन–13–7 प्रजाति रही।

## क्षारीय मृदा पर फ्लाई ऐश का प्रभाव

बंजर क्षारीय मृदा में भिन्न फ्लाई ऐश आधारित उपचारों ने नियंत्रण उपचार की तुलना में मृदा पीएच में घटते हुए रूझान को दिखाया। 50 जीआर द्वारा उपचारित मृदा ने पीएच (9.45) में अधिकतम कमी प्रदर्शित की जबकि 25 जीआर और ढैंचा के साथ 2.5 और 5.0 प्रतिशत फ्लाई ऐश उपचारित मृदा ने सभी भूखंडों में मृदा पीएच में अधिकतम (0.45 यूनिट) कमी प्रदर्शित की और जीआर 25 के साथ समतुल्य परिणाम दर्शाया। विद्युत चालकता ने भी कमी की इसी प्रवृति को दिखाया और यह 5 प्रतिशत फ्लाई ऐश + ढैंचा उपचार में सबसे कम पायी गई। अधिकतम गेहूँ उपज (1.32 टन प्रति हेक्टेयर) 50 जीआर उपचार में देखी गई। केवल 25 जीआर

से प्राप्त 0.93 टन प्रति हेक्टेयर उपज की तुलना में 25 जीआर के साथ 2.5 और 5 प्रतिशत फ्लाई ऐश + ढैंचा ने क्रमशः 1.12 और 1.25 टन प्रति हेक्टेयर उपज प्रदान की। 50 जीआर के बाद जांच वजन 25 जीआर + 2.5 प्रतिशत फ्लाई ऐश + ढैंचा में अधिकतम पाया गया।

## क्षारीय मृदा में विभिन्न सुधारकों के साथ कार्बन का खनिजीकरण

जिप्सम और जैविक सुधारकों के प्रयोग द्वारा प्रभावित कार्बन और नत्रजन के खनिजीकरण का क्षारीय मृदा में अध्ययन किया गया। यह पाया गया कि क्षेत्र क्षमता नमी में ऊष्मायन के 14 दिनों में कार्बन का खनिजीकरण हो गया जबकि नत्रजन का खनिजीकरण जैविक संसाधनों से ऊष्मायन के 21 दिन बाद हुआ। 50 प्रतिशत जीआर की दर से जिप्सम की मौजूदगी में प्रेस मड और वर्मी कम्पोस्ट द्वारा सुधारी गई क्षारीय मृदा में 21 दिन में संचयी आक्सीजन फलक्स में क्रमशः 28.3 व 69.8 प्रतिशत की वृद्धि हुई। केवल जिप्सम द्वारा सुधारी गई क्षारीय मृदा की तुलना में जिप्सम + प्रेस मड द्वारा सुधारी गई क्षारीय मृदा में ऊष्मायन के 56 दिनों में नाईट्रेट और एमोनिकल नत्रजन क्रमशः 36.7 और 23.5 प्रतिशत अधिक थे।

## क्षारीय मृदा सुधार और फसल उत्पादन

शिवरी फार्म, लखनऊ पर चावल–गेहूँ उपज और क्षारीय मृदा (पीएच 10.1) में भौतिक–रासायनिक परिवर्तनों पर कार्बनिक और अकार्बनिक सुधारकों के प्रभाव का अध्ययन किया गया। खरीफ मौसम में धान की उपज 25 जीआर जिप्सम + प्रेस मड + जैव–निवेश द्रव्य उपचार में अधिकतम थी जो कि 50 जीआर की दर से किये गये जिप्सम प्रयोग व 25 जीआर की दर से जिप्सम प्रयोग + प्रेसमड की तुलना में क्रमशः 25.83 और 56.89 प्रतिशत अधिक थी। हालांकि जिन भू–खंड़ों में 12.5 जीआर की दर से जिप्सम प्रयोग किया गया था उनकी तुलना में उपज 12.5 जी आर की दर से प्रयोग में लाए गये जिप्सम + प्रेस मड में 52.9 प्रतिशत अधिक थी। भूसा उपज 50 जीआर जिप्सम (चेक) की तुलना में 25 जीआर जिप्सम प्रयोग + प्रेसमड + जैव–निवेश द्रव्य उपचार में यह 8.4 प्रतिशत अधिक थी। धान की फसल के बाद संबंधित भूखंडों से मृदा के नमूने एकत्र किए गये और यह पाया गया कि नियंत्रण भूखंडों में औसत 9.88 पीएच की तुलना में सभी उपचारित भूखंडों का पीएच मान 9.16 से 10.42 के बीच था। मृदा पीएच में सबसे अधिक कमी 9.16 पीजी 25 जीआर + प्रेसमड उपचार में पाई गई। गहराई के अनुसार सतह से उपसतही परतों में पीएच मान में वृद्धि की प्रवृत्ति देखी गई।

## भू–आकार देने वाली तकनीकीयों का मृदा एवं जल की गुणवत्ता और तटीय भूमि की उत्पादकता पर प्रभाव

भू–आकार की विभिन्न तकनीकियाँ खरीफ में जल भराव की समस्या को दूर कर रबी में अच्छे गुणवत्तायुक्त सिंचाई जल की उपलब्धता सुनिश्चित करते हुए मृदा लवणता में गिरावट के माध्यम से तटीय क्षेत्रों में कृषकों की आजीविका बढ़ाने के लिए प्रभावी पाई गई हैं। विभिन्न भू–आकार देने वाली तकनीकीयों जैसे प्रक्षेत्र तालाब, गहरी खूंड, ऊँचीं मेड़ व धान सह मत्स्यपालन का मृदा और जल गुणवत्ता पर प्रभाव व इनके लाभः लागत अनुपात को जानने के लिये अध्ययन किया गया। प्रक्षेत्र तालाब तकनीकी के अंतर्गत बनाई गई निम्न भूमि स्थितियों जैसे उच्च, मध्यम और मूल निम्न भूमि की मृदा परिच्छेदिका में लवणता ने दर्शाया कि नियंत्रण (भू–आकार दिये बिना) की तुलना में सभी भूमि स्थितियों में लवण संचय कम था। इसी तरह की प्रवृत्ति गहरे खूड़–ऊँची मेड़ और धान–सह मत्स्यपालन भू आकार तकनीकीयां में भी पाई गई। भू–आकार देने वाली तकनीकीयों के विभिन्न वर्षों में कार्यान्वयन के बीच नव भू आकार दिए गये भूखंडों की तुलना में पुराने भू–आकारों में जैविक कार्बन और उपलब्ध पोषक तत्वों की मात्रा अधिक थी। यही प्रवृत्ति गहरे खूड़ ऊँची मेड़ और धान–सह मत्स्यपालन भू आकार तकनीकीयों में भी देखी गई। सर्वाधिक लाभ–लागत अनुपात प्रक्षेत्र तालाब तकनीकी में पाया गया।

## लवण तनाव दशाओं में जूट की किस्मों का मूल्यांकन

यद्यपि जूट (*सी कैप्सूलेरिस और सी ओलीटोरियस*) एक प्रमुख नकदी फसल है, फिर भी जूट की खेती विगत कुछ वर्षों से कम उत्पादक भूमियों में की जा रही है जबकि अच्छी भूमियों में खाद्य फसलें उगाई जा रही हैं। जूट की लवण सहिष्णु किस्मों को चिन्हित करने के लिए, जो सीमांत तटीय क्षेत्रों के तनावयुक्त पर्यावरण में उच्च उपज प्रदान कर सकें, के.प. एवं स.रे.अ.सं., बैरकपुर के साथ अंतर संस्थागत सहयोग में एक परियोजना शुरू की गई। क्षेत्रीय अनुसंधान केन्द्र, कैनिंग टाउन में बीज उत्पादन के लिए सितम्बर 2014 के तीसरे सप्ताह में जूट की आठ किस्मों (*5 कैप्सूलेरिस व 3 ओलीटोरियस*) को बोया गया। बोने के समय प्रयोगात्मक क्षेत्र की मृदा में जैविक कार्बन और उपलब्ध नत्रजन की मात्रा कम थी, उपलब्ध फास्फोरस की मात्रा मध्यम व विनिमेय पोटाश की मात्रा अधिक थी और यह अल्प क्षारीय थी (पीएच 7.98 और ईसी 0.51 से 2.83 डे.सी प्रति मीटर)। फसल को फरवरी 2015 के प्रथम सप्ताह में काटा गया। हालांकि, *कैप्सूलेरिस* अधिक लवण सहिष्णु पाई गई परन्तु *ओलीटोरियस* प्रजाति का जैवभार व उपज *कैप्सूलेरिस* से अधिक था। जेआओ 524 प्रजातियों में अधिकतम जैवभार व बीज उपज दर्ज की गई।

## नम व शुष्क मौसम के लिए आशाजनक धान की प्रजातियां

पश्चिम बंगाल के तटीय क्षेत्र में दक्षिणी और उत्तरी 24 परगना जिलों के विभिन्न प्रतिनिधि स्थलों पर बोरो और अमन मौसम के दौरान धान की उपयुक्त प्रजातियों का पता लगाने के लिए प्रयोग संचालित किये गये। जिन किसानों ने केन्द्रीय मृदा लवणता अनुसंधान संस्थान के क्षेत्रीय अनुसंधान केन्द्र से धान की भिन्न किस्मों के बीज खरीदे उनमें से 23 प्रतिशत बीज अमलमाना प्रजाति के थे और उन किसानों के धान के क्षेत्र के कुल 21 प्रतिशत भाग में लगाये गये। बाद के वर्षों में 43 प्रतिशत किसानों ने अपने कुल धान क्षेत्र के 31 प्रतिशत क्षेत्र में अमलमाना प्रजाति को उगाया जिससे उन्हें 34 प्रतिशत

अधिक उपज व 22 प्रतिशत अधिक शुद्ध लाभ प्राप्त हुआ। लवणीय वातावरण में उपज की अस्थिरता काफी अधिक है और किसानों का तर्कसंगत आता है इसलिए परिवर्तन करने के लिए किसान उपज में 15 प्रतिशत वृद्धि तक उदासीन बने हुए हैं। अन्य प्रेरक कारकों में उच्च लवण सहिष्णुता (95 प्रतिशत), उचित समय और समुचित मात्रा में उपलब्धता (80 प्रतिशत), अधिक बाजार मूल्य और गुणवत्ता पाने की उम्मीद (72 प्रतिशत) और कम अवधि (विशेष रूप से रबी के मौसम में) शामिल थे।

## कृषक समुदाय की आजीविका सुरक्षा को बढ़ाने के लिए तटीय भूमि और पानी का प्रबंधन

सुंदरबन और अंडमान द्वीप समूह में प्रयोजित तकनीकी हस्तक्षेप/नवाचारों में जल निकासी की सुविधा को सुधारने के लिए भू आकार देना, वर्षा जल संग्रहण और नीची निम्नीकृत भूमि की उत्पादकता को बढ़ाना सम्मिलित था। निम्नीकृत मृदाओं के स्वास्थ्य और उर्वरकता को बढ़ाने के लिए ढैंचे के साथ हरी खाद, मृदा परीक्षण के आधार पर उर्वरकों का प्रयोग और वर्मी खाद जैसे तकनीकी हस्तक्षेप प्रारंभ किए गये थे। विभिन्न भू–आकृति प्रदान करने वाली तकनीकीयों जैसे प्रक्षेत्र तालाब, गहरे खूड़–ऊँची मेड़, धान–सह–मत्स्यपालन, बड़ी क्यारी, तीन पंक्ति प्रणाली, युगल क्यारी प्रणाली और जल निकास सुधार जलतंत्र के कार्यान्वयन द्वारा 370 हेक्टेयर कम उत्पादक (एक फसली लवणग्रस्त भूमि) को बहु–फसली समेकित फसल और मछली उत्पादन में परिवर्तित कर दिया गया था। विभिन्न भू–आकार देने वाली तकनीकीयों के तहत प्रति वर्ष 13,04,600 घन मीटर वर्षा जल का संग्रहण किया गया। अध्ययन क्षेत्र में भू–आकृति देने वाली तकनीकीयों के चार साल के कार्यान्वयन के बाद कृषि गतिविधियों से लगभग 511600 मानव दिवस का सृजन हुआ। तटीय क्षेत्रों, विशेषकर लवणीय जल के स्रोतों या समुद्र तट के नजदीकी क्षेत्रों, को छिछले गहरे तालाब की आकृति दे कर करीब 21 हेक्टेयर भूमि को लवणीय जल कृषि हेतु प्रयोग किया गया।

## पुरस्कार और मान्यता

- डा. टी दामोदरन, वरिष्ठ वैज्ञानिक और सह वैज्ञानिकों को वर्ष 2014 के लिए 'जैव प्रौद्योगिकी उत्पाद और प्रक्रिया विकास और व्यवसायीकरण पुरस्कार' से जैव प्रौद्योगिकी विभाग, भारत सरकार द्वारा सम्मानित किया गया।
- डा. रंजय कुमार सिंह, वरिष्ठ वैज्ञानिक को परिषद के 86वें स्थापना दिवस के अवसर पर 'लाल बहादुर शास्त्री प्रतिभाशाली युवा वैज्ञानिक पुरस्कार' से सम्मानित किया गया।
- डा. कृष्णामूर्ति, एस. एल. को भारतीय आनुवांशिक एवं पादप प्रजनन समिति का 'श्रीनिवास रामानुजम मेमोरियल पुरस्कार' और 'यूरेशियन पर्यावरण विज्ञान अकादमी का फेलो' पुरस्कार प्राप्त हुआ।
- डा. दिनेश कुमार शर्मा, निदेशक ने दिनांक 1 मार्च 2015 को सीएसएसआरआई उत्कृष्ट पुरस्कार प्राप्त किया।
- डा. दिनेश कुमार शर्मा, निदेशक को भारतीय मृदा लवणता एवं जल गुणवत्ता समिति का फेलो निर्वाचित किया गया।
- डा. जोगेन्द्र सिंह को एसोसिऐशन आर दि एडवान्समैंट आफ बायोडाईवर्ससिटि साइन्सिस का फेलो पुरस्कार प्राप्त हुआ।
- डा. पी. सी. शर्मा, प्रधान वैज्ञानिक व फसल सुधार प्रभाग के अध्यक्ष को भारतीय पादप कार्यिकी समिति और भारतीय मृदा लवणता एवं जल गुणवत्ता समिति का फेलो निर्वाचित किया गया।
- डा. अजय भारद्वाज, वरिष्ठ वैज्ञानिक को 8 से 13 जून 2014 को जाजू, कोरिया में आयोजित मृदा विज्ञान की 20वीं विश्व कांग्रेस में 'आंशिक रूप से सुधारी गई लवणग्रस्त भूमि की कार्बन अधिग्रहण और नत्रजन की उपलब्धता पर चावल–गेहूँ फसल प्रणालियों के लिए संसाधन संरक्षण रणनीतियों का प्रभाव' विषय पर विख्यात वार्ता के लिए सम्मानित किया गया।
- डा. अजय भारद्वाज वरिष्ठ वैज्ञानिक ने जाजू, कोरिया में 8 से 13 जून 2014 को आयोजित मृदा विज्ञान को 20वीं विश्व कांग्रेस में यात्रा पुरस्कार प्राप्त किया।
- डा. अजय भारद्वाज, वरिष्ठ वैज्ञानिक को पर्यावरण विज्ञान एवं अभियांत्रिकी केन्द्र भारतीय प्रौद्योगिकी संस्थान कानपुर, से सहयोगात्मक अनुसंधान के लिए भारतीय राष्ट्रीय विज्ञान अकादमी का अतिथि वैज्ञानिक फेलोशिप पुरस्कार प्राप्त हुआ।
- डा. अजय भारद्वाज, वरिष्ठ वैज्ञानिक का पर्यावरण और सामाजिक विज्ञान के जरनल के 'संपादकीय बोर्ड के' सदस्य के रूप में चयन हुआ।
- डा. अजय भारद्वाज, वरिष्ठ वैज्ञानिक को सैद्यांतिक एवं एप्लाइड भौतिक रसायन विज्ञान अनुसंधान संस्थान, ला प्लाटा, अर्जनटीना में 2015 से 2017 में सहयोगात्मक अनुसंधान के लिए रासायन शास्त्र में 'कोनीसेट–यूनेस्को एसोसिएटशिप पुरस्कार' से सम्मानित किया गया।
- डा. जोगेन्द्र सिंह और डा. पी. सी0 शर्मा को राजमाता विजयराजे सिंधिया कृषि विश्वविद्यालय, ग्वालियर (मध्य प्रदेश), भारत में दिनांक 12 से 14, दिसम्बर 2014 में मध्य आयोजित राष्ट्रीय संगोष्ठी में सर्वश्रेष्ठ पोस्टर पुरस्कार (तृतीय) प्राप्त हुआ।
- डा. अश्वनी कुमार को बि.च.कृ.वि, कल्याणी, पश्चिमी बंगाल में नवम्बर 13 से 14, 2014 के मध्य 'जलवायु अनुरूप चारा उत्पादन और इसके उपयोग' विषय पर आयोजित राष्ट्रीय संगोष्ठी में लवण सहिष्णु घास प्रजातियों के चिन्हिकरण हेतु सर्वश्रेष्ठ पोस्टर पुरस्कार से सम्मानित किया गया।
- डा. प्रवीण कुमार, प्रधान वैज्ञानिक को राजमाता विजयराजे सिंधिया कृषि विश्वविद्यालय, ग्वालियर (मध्य प्रदेश) में 12 से 14 दिसम्बर 2014 के मध्य आयोजित राष्ट्रीय संगोष्ठी में सर्वश्रेष्ठ पोस्टर पुरस्कार (द्वितीय) प्राप्त हुआ।
- डा. अनिल आर चिंचमलातपुरे, अध्यक्ष क्षेत्रीय अनुसंधान केन्द्र, भरूच को 'लघु किसानों के लिए सतत आजीविका

सुरक्षा 2015' पर भा. कृ. अनु. प.–रा. डे. अ. सं. 3 से 6 फरवरी, 2015 के मध्य आयोजित 12वीं कृषि विज्ञान कांग्रेस में 'गुजरात के सरदार सरोवर नहर कमांड क्षेत्र में सिंचाई से प्रभावित लवणीय वर्टीसोल और फसल उपज' अनुसंधान पत्र पर सर्वश्रेष्ठ पोस्टर पुरस्कार प्राप्त हुआ।

- डा. जोगेन्द्र सिंह व डा. पी. सी. शर्मा को 19 से 21 फरवरी, 2015 के दौरान रेपसीड–सरसों अनुसंधान संस्थान, भरतपुर में 'भारत में तिलहन उत्पादन बढ़ाने के लिए रणनीतिक हस्तक्षेप पर आयोजित राष्ट्रीय संगोष्ठी में सर्वश्रेष्ठ पोस्टर पुरस्कार (प्रथम) प्राप्त हुआ।

निम्नलिखित तकनीकी, प्रशासनिक एवं कुशल कर्मचारियों को वर्ष 2014 के लिए सर्वश्रेष्ठ कर्मी सम्मान से सम्मानित किया गया :

- श्री विनोद कुमार, तकनीकी अधिकारी
- डा. चन्द्र शेखर सिंह, मुख्य तकनीकी अधिकारी
- श्री अवतार सिंह, वरिष्ठ लिपिक
- श्री रूपक घोष, वरिष्ठ लिपिक
- श्री सुभाष चन्द्र, एसएसएस
- श्री रामाभाई दीराभाई वलन्द, एसएसएस

## कार्यशाला, सेमीनार, प्रशिक्षण, स्थापना दिवस और किसान मेले का आयोजन

- किसानों के ज्ञान और उनकी रचनात्मकता के माध्यम से जलवायु परिवर्तन के अनुकूलन हेतु प्रभावी विकल्प चिन्हित करने हेतु 2 से 22 अप्रैल 2014 के मध्य एक 21 दिवसीय गांव कार्यशाला–सह प्रशिक्षण कार्यक्रम आयोजित किया गया जिसमें 200 किसानों व 20 तृणमूल अनुभवियों ने भाग लिया।
- आईपीवी 6 प्रौद्योगिकी पर विचार विमर्श हेतु संस्थान के वैज्ञानिक, तकनीकी, प्रशासनिक व वित्त अधिकारियो के लिए 16 मई 2014 को एक दिवसीय कार्यशाला का आयोजन किया गया।
- उपसतही जलनिकास प्रौद्योगिकी पर डा. आर.एस. परोदा, अध्यक्ष, हरियाणा किसान आयोग की अध्यक्षता में 26 मई, 2014 को हितधारकों की एक बैठक आयोजित की गई जिसमें 80 किसानों और करनाल, झज्जर, रोहतक, सोनीपत, जींद, भिवानी, सिरसा और हिसार के कृषि विभाग/एचओपीपी के अधिकारियों ने भाग लिया।
- भूमि एवं जल उपचार और प्रबंधन में उन्नत प्रौद्योगिकियों पर सितम्बर 15 से 24, 2014 के मध्य दस दिवसीय संक्षिप्त पाठ्यक्रम आयोजित किया गया जिसमें हरियाणा, उत्तर प्रदेश, राजस्थान, गुजरात, कर्नाटक, महाराष्ट्र और तेलंगाना के 23 प्रतिनिधियों ने भाग लिया।
- भारतीय एनएआरईएस और सीजीआईएआर संस्थानों के शोधकर्ताओं की क्षमता विकास के लिए संरक्षण कृषि पर एक प्रशिक्षण कार्यक्रम यूएसएड और बिल एंड मेलिंडा गेट्स फाउंडेशन (बीएनजीएफ) द्वारा वित्त पोषित सीएसआईएसए परियोजना के तहत 27 दिसम्बर से 4 अक्तूबर 2014 के बीच आयोजित किया गया।
- दिनांक 22 अक्तूबर, 2014 को लवणता प्रभावित ग्राम सिवानामाल (जींद) में खरीफ किसान मेले व 9 मार्च, 2015 को संस्थान परिसर (करनाल) में रबी किसान मेले का आयोजन किया गया। प्रत्येक मेले में हरियाणा, पंजाब व उत्तर प्रदेश के लगभग 800 किसानों ने भाग लिया और संस्थान की तकनीकीयों से लाभान्वित हुए।
- संस्थान के सक्रिय सहयोग से भारतीय कृषि अनुसंधान परिषद की क्षेत्रीय समिति 5 की 23वीं बैठक (जिसमें पंजाब, हरियाणा, दिल्ली सम्मिलित है), डा. एस अय्यप्पन, सचिव डेयर एवं महानिदेशक भा. कृ. अनु. प., नई दिल्ली की अध्यक्षता में 14 से 15 नवम्बर, 2014 को पंजाब कृषि विश्वविद्यालय, लुधियाना में आयोजित की गई।
- उत्पादकता और आजीविका सुरक्षा को बेहतर बनाने के लिए लवणग्रस्त मृदा एवं निम्न गुणवत्ता जल की पहचान, आकलन और प्रबंधन पर 11 नवम्बर से 1 दिसम्बर, 2014 के मध्य 21 दिवसीय शीतकालीन पाठ्यक्रम का आयोजन किया गया। इस स्कूल में 10 राज्यों के 24 प्रतिनिधियों ने भाग लिया।
- हरियाणा के नहरी कमांड क्षेत्रों की फसल जल उत्पादकता में सुधार लाने के लिए कुशल सिंचाई प्रौद्योगिकियों पर कमांड क्षेत्र विकास प्राधिकरण के अधिकारियों के लिए 2 से 6 दिसम्बर, 2014 के दौरान 5 दिवसीय प्रशिक्षण कार्यक्रम आयोजित किया गया। इस कार्यक्रम में कैथल, रोहतक और हिसार सर्किल के अधीन 12 प्रभागों के 24 अधिकारियों ने भाग लिया।
- राजमाता विजयराजे सिंधिया कृषि विश्वविद्यालय, ग्वालियर (मध्य प्रदेश) व भारतीय मृदा लवणता और जल गुणवत्ता समिति की सहभागिता से 12 से 14 दिसम्बर के बीच 'बदलते पर्यावरण में अभिनव लवणीय कृषि' पर तीन दिवसीय राष्ट्रीय संगोष्ठी आयोजित की गई। संगोष्ठी में विभिन्न संस्थाओं और संगठनों के 150 प्रतिनिधियों ने भाग लिया।
- कोहरे और दीर्घकालिक धुंध के फसलोत्पादन पर दुष्प्रभाव के प्रबंधन हेतु दिसम्बर 17 से 23, 2014 के बीच सात दिवसीय संक्षिप्त पाठ्यक्रम का आयोजन किया गया जिसमें हरियाणा, पंजाब, उत्तर प्रदेश और बिहार के 23 वैज्ञानिकों/अधिकारियों ने भाग लिया।
- एफ्रो–एशियाई ग्रामीण विकास संगठन के सदस्य देशों के लिए कृषि क्षेत्र में निम्न गुणवत्ता जल के उपयोग पर फरवरी 11 से 24, 2015 के दौरान दो सप्ताह के अंतर्राष्ट्रीय प्रशिक्षण कार्यक्रम का आयोजन किया गया। कार्यक्रम में इराक, नाईजीरिया, ताईवान, घाना, मिश्र, श्रीलंका और सूडान के 10 प्रतिनिधियों ने भाग लिया।
- 1 मार्च, 2015 को संस्थान का 46वां स्थापना दिवस आयोजित किया गया। इस अवसर पर डा. आलोक कुमार सिक्का, उपमहानिदेशक (प्रा. सं. प्र.) भा. कृ. अनु. प., नई दिल्ली ने स्थापना दिवस व्याख्यान प्रस्तुत किया।
- जल के महत्व और उसके सतत प्रयोग के बारे में किसानों को जागरूक करने के लिए संस्थान में 21 मार्च, 2015 को विश्व जल दिवस मनाया गया। इस कार्यक्रम में लगभग

200 किसानों, वैज्ञानिकों और प्रसार कार्यकर्ताओं ने भाग लिया।

## क्षेत्र प्रदर्शनी व भ्रमण

वर्ष 2014–15 के दौरान लवणग्रस्त मृदाओं के सुधार और प्रबंधन व निम्न गुणवत्ता जल के उपयोग पर विभिन्न अनुसंधान संस्थानों और विकास अभिकरणों में 15 प्रदर्शनियां लगाई गई। 105 समूहों में आये 4156 हितधारकों ने संस्थान के सूचना प्रौद्योगिकी केन्द्र व प्रायोगिक प्रक्षेत्र का भ्रमण किया। 4156 हितधारकों में 47 समूहों में आये 2200 किसान, 38 समूहों में आए 481 प्रसारकर्मी, 12 समूहों में आए 1136 विद्यार्थी, 21 समूहों में आए 180 भारतीय व विदेशी 180 वैज्ञानिक और वस्तु विषय विशेषज्ञ सम्मिलित थे।

## किसान सलाहकार सेवा

किसानों की मृदा लवणता, क्षारीयता व जल गुणवत्ता संबंधित समस्याओं के त्वरित और समुचित समाधान हेतु संस्थान ने 18001801014 नम्बर पर निःशुल्क फोन सेवा शुरू की है। वर्ष 2014–15 के दौरान देश के विभिन्न क्षेत्रों से कृषि समस्याओं संबंधित 208 कॉल प्राप्त हुई और संस्थान के वैज्ञानिकों द्वारा इन समस्याओं के निदान हेतु वैज्ञानिक उपाय सुझाए गए।

## अंतर्राष्ट्रीय सहयोग

- अफ्रीका और दक्षिण एशिया के गरीब किसानों के लिए तनाव सहिष्णु चावल (आईआरआरआई व वीएमजीएफ द्वारा प्रायोजित)
- दक्षिण–एशिया के लिए अन्न प्रणाली प्रयास (सीएसआईएसए) (आईआरआरआई फिलीपिन्स एवं सीआईएमएमवाई टी मैक्सिको द्वारा प्रायोजित)।
- सूखे, जल भराव व लवण सहिष्णुता प्रमुख क्यू टीएल के साथ अजैविक तनाव सहिष्णु चावल प्रजातियों का चिन्हक सहायक प्रजनन (डीबीटी भारत–आईआरआरआई, द्वारा प्रायोजित)
- तटीय लवणता (आईआरएसएसटीएन) के लिए चावल जननद्रव्य की जांच पर आईआरआरआई अंतर्राष्ट्रीय सहयोगात्मक कार्यक्रम।
- छिछले एवं गहरे जल परिस्थितियों में चावल के अग्रिम संवर्धन के लिए आईआरआरआई के साथ संबंध।
- पूर्वी भारत में वर्षा आधारित नीची भूमि के लिए चावल प्रणाली : चावल में फसल और पोषक तत्व के प्रबंधन के तरीकों का विकास (आईसीएआर–डब्ल्यू 3) (आईआरआरआई द्वारा पोषित)

## नये अंतर्राष्ट्रीय एवं राष्ट्रीय 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 माडलिंग में सार्क कृषि केन्द्र, ढाका और सीएसआईआरओ, आस्ट्रेलिया के साथ।
- वानिकी के माध्यम से अपशिष्ट जल के सतत प्रबंधन में वेधशाला बोर्ड, मेलबोर्न विश्वविद्यालय एवं सीएसआईआरओ, आस्ट्रेलिया के साथ।
- लवणग्रस्त क्षेत्रों के मानचित्र बनाने व इनके लक्षणों की सटीक जानकारी प्राप्त करने हेतु उपलब्ध अंतरिक्ष प्रौद्योगिकियों के प्रयोग के लिए राष्ट्रीय सुदूर संवेदी केन्द्र, हैदराबाद एवं राजकीय सुदूर संवेदी उपयोग केन्द्रों (आरएसएसी) और एनबीएसएस एंड एलयूपी, नागपुर (आईसीएआर) से संबंध।
- पर्यावरण अध्ययन संस्थान, कुरूक्षेत्र विश्वविद्यालय, कुरूक्षेत्र के साथ शैक्षिक संबंध।
- जैव–प्रौद्योगिकी विभाग महाऋषि मारकन्डेश्वर विश्वद्यिालय, मुलाना व दीनबन्धु छोटूराम विश्वविद्यालय, मुरथल (हरियाणा) से शैक्षिक संबंध।
- स्नातकोत्तर कार्यक्रम के लिए राष्ट्रीय डेरी अनुसंधान संस्थान, करनाल से शैक्षिक संबंध।
- राष्ट्रीय बीज मसाला अनुसंधान केन्द्र, अजमेर, राजस्थान के साथ सहयोगात्मक अनुसंधान हेतु।
- परियोजना निदेशालय, एनसीपी, आईजीबीपी, आईआईआरएस, (एनआरएसए), अंतरिक्ष विभाग, देहरादून से सहयोगात्मक अनुसंधान हेतु।
- जयपुर राष्ट्रीय विश्वविद्यालय, जयपुर राजस्थान से।
- सरदार वल्लभ भाई पटेल कृषि एवं प्रौद्योगिकी मेरठ (उत्तर प्रदेश)।
- पंजाब विश्वविद्यालय, पटियाला, पंजाब से।
- सैद्धांतिक और एप्लाइड भौतिक रसायन विज्ञान संस्थान (आईएनआईएफटीए), ला प्लाटा अर्जेनटीना (यूनेस्कोटी डब्ल्यू एएस–कोनीसटेस द्वारा वित्त पोषित) से सहयोगात्मक अनुसंधान हेतु।
- भारतीय प्रौद्योगिकी संस्थान, कानपुर उत्तर प्रदेश, भारत के पर्यावरण विज्ञान और अभियांत्रिकी (सीईएसई), केन्द्र में लवण उपचार हेतु कुशल और लागत प्रभावी सामग्री के विकास पर सहयोगात्मक अनुसंधान के लिए।

## प्रकाशन

संस्थान द्वारा प्रमुख जरनलों में 94 अनुसंधान पत्र, 28 पुस्तक अध्याय, 3 पुस्तक/मैनुअल, 9 बुलेटिन/फोल्डर, 23 लोकप्रिय आलेख, 3 तकनीकी प्रतिवेदन छपवाये गये और 115 आलेख सेमिनार/सिमपोसिया और कानफ्रेन्सों में प्रस्तुत किये गये।

## वैज्ञानिकों का विदेश भ्रमण कार्यग्रहण व सेवानिवृत्ति

ज्ञान व कुशलता को बढ़ाने हेतु संस्थान के 9 वैज्ञानिकों ने विभिन्न देशों जैसे बांग्लादेश, नेपाल, फिलीपीन्स, थाईलैंड, कोरिया, जापान और वियतनाम का दौरा किया। इस अवधि में 3 नए वैज्ञानिकों ने संस्थान में कार्यभार संभाला।

# EXECUTIVE SUMMARY

ICAR-Central Soil Salinity Research Institute (CSSRI), Karnal, Haryana is an internationally recognized premier research organization dedicated to multi-disciplinary research 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: 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 also established 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, respectively. The Coordinating Unit of All India Coordinated Research Project 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), Tiruchirapalli (Tamil Nadu), Bathinda (Punjab), Panvel (Maharashtra), Port Blair (A&N islands) and Vyttila (Kerala) 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 using RS and GIS

The mapping and characterization of salt affected soils of Fatehabad district of Haryana was conducted using Remote Sensing and Geographic Information System. Salt-affected soils covered 11614 ha area in the district (4.6%) and are distributed in five blocks viz, Fatehabad (1.1%), Tohana (1.1%), Bhuna (1.3%), Bhattu kalan (0.8%) and Ratia (0.3%). Sodic and saline soils covered 62% and 38% area, respectively. The areas having poor quality (sodic) ground water were mainly located in Tohana block while waterlogging and salinization were predominant in the irrigated areas (Bhakra canal) with restricted drainage.

## Impact of 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 ICAR. Three firms had obtained the license for producing the material. Apart from the firms licensed, the bio-formulation was also being produced at CSSRI Regional Research Station, Lucknow. The technology had reached to 10,800 ha in the country covering 7 states with an average yield increase of 19.75 per cent over the crops. Extensively, the technology is being adopted by 18,400 farmers of banana, flower growers of Southern Tamil Nadu, Karnataka and Andhra Pradesh. In Uttar Pradesh, Uttrakhand, Bihar, and Madhya Pradesh region, it has been widely used by the growers of potato, chillies, tomato and gladiolus. The bio-formulation had resulted in reducing the use of chemical pesticides and fungicides to a level of 3000 L, thereby saving the environment and people from exposure to different types of toxins through their food chain. In potato, the farmers are treating the seed tubers with 3 % CSR-BIO (450 ha area) instead of chemical fungicide followed by drenching during December and January. They had harnessed a yield increase of 12 per cent with 65 per cent reduction in blight incidence when compared with the non-adopters.

## Optimizing irrigation and planting schedules of salt tolerant rice and wheat varieties

The long duration, salt tolerant basmati rice variety CSR 30 requires 155 days to mature which often results in delayed sowing of wheat and adversely affects its productivity. Efforts were made to optimize irrigation water requirement of salt tolerant rice and wheat varieties in relation to different dates of planting in a reclaimed sodic soil. The results indicated that CSR 30 transplanted on 1$^{st}$ July gave the highest grain yield (3.63 t ha$^{-1}$) and irrgiation water productivity (0.591 kg/m$^3$) when irrigation was applied 5 days after disappearance of ponded water (DAD) imposed after one month of transplanting. Salt tolerant wheat variety KRL-213 was grown under three irrigation schedules (IW/CPE =1.0, 0.8 and 0.6) and four sowing dates (10 Nov., 20 Nov., 30 Nov. and 10 Dec.). The results indicated that the grain yield KRL 213 increased by

8 per cent when irrigation was applied at IW/CPE 1.0 over IW/CPE 0.6. The maximum grain yield was obtained when sowing was done on 20th Nov. It was concluded that sowing of KRL-213 wheat on 20th November with irrigation schedule of IW/CPE=1.0 gives the maximum yield (6.24 t ha$^{-1}$).

## Green house gas (GHG) emission in diversified agriculture model in reclaimed sodic land

Diversified agriculture may be an efficient alternative to rice-wheat cropping system for small land holders for higher and regular incomes, higher resource use efficiency and sustained soil health in changing climate scenario in reclaimed sodic soils. An attempt was made to estimate the green house gas emissions from the diversified model using the 'Cool Farm Tool Model' which integrates several globally recognized empirical GHG quantification models. Estimated total GHG emission i.e. global warming potential per hectare in terms of $CO_2$ equivalent ($CO_2$-eq) was different amongst different crop production systems. On an average, rice-wheat system emitted 1.82 t $CO_2$-eq, whereas maize-wheat, fodder, vegetables and horticulture components emitted 0.41, 0.24, 0.19 and 0.12 t $CO_2$-eq from the respective areas under these cropping systems. The total emission from 1.8 ha area under diversified cropping system was 2.78 t $CO_2$-eq as compared to 5.15 t $CO_2$-eq from the rice–wheat system in the same area. On hectare area basis, diversified agriculture system emitted 1.55 t $CO_2$-eq ha$^{-1}$ as compared to 2.86 t $CO_2$-eq ha$^{-1}$ in rice-wheat system. The global warming potential under diversified agriculture system was 46 per cent (1.32 t $CO_2$-eq ha$^{-1}$) lesser than that of rice-wheat system.

## Hydro-physical evaluation of a rainwater harvesting system in a highly saline environment

The effective control of soil salinity on a regional scale requires the knowledge of its magnitude and spatio-temporal variability. The cost-effective, rapid, and reliable methodologies are required for determining soil salinity *in-situ* and its structured regional presentation using modeling and geo-statistical techniques. The EM surveys were conducted at 20 m x 20 m grids at 280 locations during post-monsoon season at Nain farm, Panipat, out of which 40 locations were selected for collecting soil samples up to 90 cm depth. The soil samples were analyzed for electrical conductivity of saturated extract ($EC_e$), pH, cations ($Ca^{2+}$, $Mg^{2+}$and $Na^{+1}$), anions ($CO_3^{-2}$, $HCO_3^{-1}$, $Cl^{-1}$) and sodium adsorption ratio (SAR) using wet chemistry procedures. Calibration equations for converting EC and SAR were derived using the multiple linear regression (MLR) model included in the EC Sampling Assessment and Prediction program (ESAP) package. High correlation coefficients ($R^2$) of 0.75, 0.82, 0.82, 0.85 and 0.89 were observed between the measured $EC_e$ and model predicted $EC_e$ in 0-15, 15-30, 30-60, 60-90 and 0-90 cm soil layers, respectively. Average soil salinity in the farm was 17.4 dS m$^{-1}$. Soil salinity was the highest in 0-15 cm soil layer (EC 21 dS m$^{-1}$) as due to strong evaporative demand salts accumulate on the soil surface through capillary rises.

## Evaluation of wheat varieties for salt stress in microplots

Twenty three wheat varieties were evaluated for their performances under different salt stresses [normal, saline (EC 5.9 dS m$^{-1}$) and sodic ($pH_2$ 9.3)] in the microplots. Each genotype was replicated three times. Genotypes KRL 3-4, KRL 99 and Kh 65 were found to be highly tolerant whereas DW 1, HD 4530, HD 2851, DW 3, Brookton and HD 2009 were the salt sensitive genotypes. Genotypes KRL 330, KRL 345, KRL 346, KRL 213, KRL 240, KRL 210, KRL 19, NW 1014, NW 4018 and BH 1146 were ranked as moderately tolerant.

## Monitoring and evaluation of promising salt tolerant strains of Indian mustard (*Brassica juncea*)

Eight mustard genotypes were evaluated in IVT under saline conditions ($EC_e$ 10.7 dS m$^{-1}$) at Nain Experimental Farm, Panipat and under alkaline conditions (pH 9.3) at Karnal. Significant differences were observed in seed yield amongst the genotypes evaluated under both salinity and alkalinity stresses. Seed yield ranged from 1.78 to 2.38 t ha$^{-1}$ (mean 2.04 t ha$^{-1}$) at under salinity stress at Nain and from 1.47 to 2.06 t ha$^{-1}$ (mean 1.72 t ha$^{-1}$) under alkalinity stress (pH 9.3) at Karnal. Genotypes CSCN-13-8 (2.38 t ha$^{-1}$) followed by CSCN-13-7 (2.33 t ha$^{-1}$) at Nain and CSCN-13-8 (2.06 t ha$^{-1}$) followed by CSCN-13-7 (1.98 t ha$^{-1}$) at Karnal gave the highest seed yield.

### Effect of fly ash application on physico-chemical properties of sodic soils

In a barren sodic soil, different treatments of fly ash showed a decreasing trend for soil pH as compared to control. Soils treated with 50 GR showed the maximum decrease in pH. Soils treated with 2.5 and 5 per cent fly ash along with 25 GR and *dhaincha* showed the maximum decrease (0.45 units) in soil pH among all fly ash treated plots and gave at par results with 25 GR. The EC in treated plots also showed the decreasing trend with the lowest EC recorded in 5 per cent fly ash + *dhaincha* treatment. The highest wheat yield (1.32 t $ha^{-1}$) was observed under 50 GR treatment. 25 GR with 2.5 and 5 % fly ash + *dhaincha* gave the higher yields of 1.12 and 1.25 t $ha^{-1}$, respectively over 0.93 t $ha^{-1}$ from 25 GR alone. The test weight was highest in 25 GR+ 2.5 per cent fly ash+ *dhaincha* after 50 GR.

#### Mineralization of carbon with application of different amendments in sodic soils

The mineralization of carbon and nitrogen in sodic soils was studied as influenced by the application of gypsum and organic amendments. It was observed that carbon was mineralized in 14 days of incubation at field capacity while N was mineralized from organic sources in 21 days of incubation. There was cumulative increase in $CO_2$ flux by 28.3 per cent in pressmud and 69.8 per cent in vermicompost amended sodic soils in presence of gypsum @ 50 per cent GR at 21 days. Nitrate and ammonical N was 36.7 and 23.5 per cent higher when sodic soil was amended with gypsum + pressmud at 56 days of incubation over only gypsum amended soil.

#### Sodic soil reclamation and crop production

The effects of organic and inorganic amendments on rice-wheat production and chemical changes in sodic soil (pH 10.1) were studied at Shivri Farm, Lucknow. During *kharif* season, the maximum grain yield of paddy was observed in gypsum @ 25GR + pressmud + bio-inoculant treatment which was significantly higher- 25.83 per cent and 56.89 per cent- as compared to gypsum application @ 50 GR and gypsum @25 GR + pressmud, respectively. However, grain yield in plots amended with gypsum @12.5 GR + pressmud was higher by 52.9 per cent over gypsum @ 12.5 GR. The maximum straw was obtained with the application of gypsum @25 GR + pressmud + bio-inoculant treatment where it was 8.4 per cent higher than gypsum @ 50 GR (check). After harvest of paddy, soil pH in soil samples collected from different tretments ranged from 9.16 to 10.42 in all the treated plots as compared to 9.88 in control plots. The lowest soil pH (9.16) was noted in gypsum @ 25 GR + pressmud treatment. The soil pH showed increasing trend with increasing soil depth.

### Impact of land shaping techniques on soil and water quality and productivity of coastal degraded lands

Different land shaping techniques have been found suitable for augmenting the farmers' livelihoods in coastal areas as they effectively address the problems like waterlogging and soil salinity and ensure availability of good quality irrigation water. The effects of different land shaping techniques- farm pond, deep furrow & high ridge and paddy-cum- fish culture was studied on soil and water quality parameters and benefit : cost ratio. Farm pond technique significantly reduced soil salinity in all the land situations (high, medium and low-lands) as compared to control (without land shaping). A similar trend was observed for deep furrow & high ridge, and paddy-cum-fish culture techniques. The organic C and available nutrient status was significantly higher in old plots as compared to the newly shaped ones. The B:C ratio was the highest for farm pond technique followed by deep furrow & high ridge and paddy-cum-fish culture techniques.

### Evaluation of jute varieties under salinity stress

Although jute (*C. capsularis & C. olitorius*) is a remunerative cash crop, its cultivation is being increasingly pushed to the marginal environments. To identify salt tolerant jute varieties able to produce higher yields in such marginal coastal regions, a project was initiated under inter-institutional collaboration with CRIJAF, Barrackpore. Eight jute varieties (five *capsularies* and three *olitorious*) were sown in RRS, Canning research farm during third week of September 2014 for seed production. The soil of the experiment area was low in organic carbon and available N, medium in available P and high in exchangeable K and slightly alkaline in reaction (pH 7.98 and EC was 0.51-2.83 dS $m^{-1}$) at the time of sowing. The crop was harvested during first week of February, 2015. Though *capsularis* exhibited higher salt tolerance, biomass and seed yields were higher in *olitorious* varieties than *capsularis*. The highest biomass and seed yield was recorded for the variety JRO 524.

### Promising rice genotypes for wet and dry seasons

In order to find out suitable rice varieties, experiments were conducted during *boro* and *aman* seasons at different locations of South and North 24 Parganas districts in the coastal region of West Bengal. About 23 per cent of the farmers' purchased seeds of *Amal-Mana* variety from CSSRI RRS Canning, which accounted for 21 per cent of total rice area at their farms. During subsequent year, nearly 43 per cent farmers cultivated *Amal-Mana* variety that accounted for 31 per cent of total rice area. These farmers obtained 34 per cent incremental yield and 22 per cent incremental net return. Under saline conditions, instability of yield is quite high and the farmers have rational expectation, therefore, farmers' willingness to change remained indifferent up to incremental yield by 15 per cent. The motivational factors which accounted for higher adoption of *Amal-Mana* variety included its salt tolerance (95%), timely availability in desired quantity (80%), better market price and quality (72%) and short duration in *rabi* season (83%).

## Management of degraded coastal land and water for enhancing livelihood security of farming communities

The major technological interventions/innovations implemented in Sundarbans and Andaman islands were land shaping for improving drainage, rainwater harvesting and enhancing productivity of low lying degraded lands through green manuring with *Sesbania*, fertilizer application on soil test basis and use of vermi-compost. About 370 ha of low productive salt-affected degraded lands were converted from mono-cropped to multi-cropped with integrated crop and fish cultivation through implementation of different land shaping techniques like farm pond, deep furrow & high ridge, paddy-cum-fish, broad bed & furrow, three tire system, paired bed system and drainage improvement network. About 13,04,600 $m^3$ rain water was harvested annually under various land shaping techniques. About 5,11,600 person-days of employment was created from the farming activities after 4 years of implementation of land shaping techniques in the study area. About 21 ha area has been brought under brackish water aquaculture by creating shallow depth ponds in the coastal areas particularly near the rivers and sea coast.

### Awards and recognition

- Dr. T. Damodaran, Sr. Scientist and his team bagged the 'Biotech Product & Process Development and Commercialization Award' by Department of Bio-Technology Govt. of India for the year 2014.
- Dr. Ranjay Kumar Singh, Senior Scientist bagged 'Lal Bhadur Shastri Outstanding Young Scientist Award-2013' on the occasion of 86$^{th}$ Foundation Day of the Council.
- Dr. Krishnamurthy, S.L. was given 'Srinivasa Ramanujam Memorial Award' of the Indian Society of Genetics and Plant Breeding and was elected 'Fellow' of Eurasian Academy of Environmental Sciences, India.
- Dr. Jogendra Singh, Scientist was elected the 'Fellow' of Association for the Advancement of Biodiversity Science.
- Dr. P.C. Sharma, Principal Scientist and Head, Division of Crop Improvement was elected the 'Fellow' of the Indian Society for Plant Physiology and the Indian Society of Soil Salinity and Water Quality.
- Dr. D.K. Sharma, Director was given CSSRI Excellent Award on 1$^{st}$ March, 2015.
- Dr D.K. Sharma, Director was elected the 'Fellow' of the Indian Society of Soil Salinity and Water Quality.
- Dr. Ajay Bhardwaj, Sr. Scientist was invited as distinguished speaker to deliver a talk on "Resource conservation strategies for rice-wheat cropping systems in partially reclaimed salt affected soils and their effects on carbon sequestration and nitrogen availability" in the 20$^{th}$ World Congress of Soil Science, Jeju, Korea held from June 8-13, 2014.
- Dr. Ajay Bhardwaj, Sr. Scientist received the 20$^{th}$ World Congress of Soil Science Travel Award at Jeju, Korea held from June 8-13, 2014.
- Dr. Ajay Bhardwaj, Sr. Scientist was awarded 'Indian National Science Academy (INSA) Visiting Scientist Fellowship' for collaborative research at Centre for Environmental Science and Engineering (CESE), Indian Institute of Technology (IIT-K), Kanpur, Uttar Pradesh, India.

- Dr. Ajay Bhardwaj, Sr. Scientist was selected as the member of editorial board of Journal of Environmental and Social Sciences, (2015, http://www.open science publications.com).
- Dr Ajay Kumar Bhardwaj, Sr. Scientist was awarded the 'CONICET-UNESCO Associateship in Chemistry' for collaborative research at Research Institute of Theoretical & Applied Physical Chemistry, La Plata, Argentina from 2015-2017.
- Drs. Jogendra Singh and P.C. Sharma were bestowed with the 'Best Poster Award' (3rd Prize) in 4th National Seminar on "Innovative Saline Agriculture in Changing Environment" held at Rajmata Vijayaraje Scindia Krishi Vishwavidayalaya, Gwalior (M.P.), India from December 12-14, 2014.
- Dr. Ashwani Kumar bagged the 'Best Poster Award' for "Physiological studies on halophyte grasses *Sporobolus marginatus* and *Urochondra setulosa* under salt affected environments" in National symposium on "Climate Resilient Forage Production and its Utilization" held at BCKV, Kalyani during Nov. 13-14, 2014.
- Dr. Parveen Kumar, Principal Scientist was bestowed with 'Best Poster Award' (2nd prize) in National Seminar on "Innovative Saline Agriculture in Changing Environment" organized by Indian Society of Soil Salinity & Water Quality, ICAR-CSSRI at Rajmata Vijayaraje Scindia Krishi Vishavvidhyalya at Gwalior from 12-14 December 2014.
- Dr Anil R. Chinchmalatpure, Head, ICAR-CSSRI RRS Bharuch received the 'Best Poster Award' for the research paper entitled "Properties of saline Vertisol and crop yield as influenced by irrigation in Sardar Sarovar canal command area of Gujarat" during XII Agricultural Science Congress "Sustainable livelihood security for smallholder farmers" at ICAR-NDRI Karnal during 3-6 Feb. 2015
- Drs. Jogendra Singh and P.C. Sharma were bestowed with Best Poster Award (1st Prize) in National Seminar on Strategic Interventions to Enhance Oilseeds Production in India held at Directorate of Rapeseed-Mustard Research, Bharatpur during February 19-21, 2015.

The following technical, administrative and skilled supporting staff was awarded with the CSSRI Best Worker Award for year 2014.

Sh. Vinod Kumar, Technical Officer

Dr. C.S. Singh, Chief Technical Officer

Sh. Avtar Singh, Sr. Clerk

Sh. Rupak Ghosh, Sr. Clerk

Sh. Subhash Chand, SSS

Sh. Ramabhai Heerabhai Valand, SSS

## Workshops, Seminars, Trainings, Foundation Day and Kisan Mela organized

- A 21-days village workshop-cum-training programme on 'Farmers' Knowledge and their Creativity Leads to Sustainable Climate Change Adaptation' was organized from April 2-22, 2014 in which about 200 farmers and 20 grassroots knowledge holders participated.
- A one day workshop on IPv6 technology for Scientists, Technical, Administrative and Finance Officer was organised on 16th May 2014.
- A stakeholders' meeting on Sub-surface Drainage Technology was organized under the chairmanship of Dr. R.S.Paroda, Chairman, Haryana Kisan Ayog on 26th May, 2014. About 80 farmers and officers of Deptt. of Agriculture/ HOPP of Karnal, Jajjar, Rohtak, Sonipat, Jind, Bhiwani, Sirsa and Hisar districts participated in this meeting.
- A 10 days short course on 'Advanced Technologies in Land and Water Remediation and Management' was organized during September 15-24, 2014. Twenty three delegates from Haryana, Uttar Pradesh, Rajasthan, Gujarat, Karnataka, Maharashtra and Telengana participated in this training programme.
- A training programme on conservation agriculture for capacity development of researchers of Indian NARES and CGIAR institutes was organized during 27 September to 4 October, 2014 under the Flagship of CSISA project funded by USAID and Bill & Melinda Gates Foundation (BMGF).
- The *Kharif Kisan Mela* was organized on 22nd October, 2014 at salt-affected Siwanamal village of Jind district and *Rabi Kisan Mela* was organized on 9th March, 2015 at Karnal. About

800 farmers participated in each of the *melas* and benefitted from the CSSRI technologies.

- The 23rd meeting of the ICAR Regional Committee V, comprising of the states of Punjab, Haryana and Delhi, was organized at Punjab Agricultural University, Ludhiana during November 14-15, 2014 under the Chairmanship of Dr. S. Ayyappan, Secretary, DARE and Director General, ICAR, New Delhi.
- A 21 days winter school on 'Diagnosis, assessment and management of salt- affected soils and poor quality waters to improve productivity and livelihood security' was organized during 11th November to 1st December, 2014. Twenty four delegates from 10 states participated in this winter school.
- A 5 days training programme for CADA Officers on 'Efficient irrigation technologies for improving crop water productivity in canal commands of Haryana' was organized during December 2-6, 2014. Twenty officers from 12 Divisions under Kaithal, Rohtak and Hisar Circles participated in this programme.
- A 3 days 'National Seminar on Innovative Saline Agriculture In Changing Environment' was organized in collaboration with Indian Society of Soil Salinity and Water Quality and RVSKV, Gwalior (MP) during December 12-14, 2014. About 150 delegates from different institutes and organizations participated in this event.
- A 7 days short course on 'Management of frost and prolonged foggy weather' was organized during December 17-23, 2014 in which 23 Scientists/Officers from Haryana, Punjab, Utter Pradesh and Bihar participated in this training course.
- Two weeks international training programme on 'Use of poor quality water in agriculture' for Afro-Asian Rural Development Organisation member countries was organized during February11-24, 2015. Ten delegates from Iraq, Nigeria, R.O. China (Taiwan), Gana, Egypt, Sri Lanka and Sudan participated in this capacity development programme.
- CSSRI celebrated its '46th Foundation Day' on 1st March 2015 by organizing a Foundation Day lecture delivered by Dr. Alok Kumar Sikka, DDG (NRM) ICAR, New Delhi.
- The institute celebrated 'World Water Day' on 21st March, 2015 with a view to aware the farmers about the importance of water and its sustainable use. About 200 farmers, scientists and extension workers participated in this important event.

## Field Exhibition and Visits

During 2014-15, a total of 15 exhibitions were organized at different research institutions and developmental agencies which portrayed the technological achievements of CSSRI in reclamation and productive management of salt-affected soils and poor quality waters in agriculture. A total of 3997 stakeholders in 118 groups visited the Information Technology Centre and Experimental Farm. Out of 4156 stakeholders, 2200 farmers in 47 groups, 481 extension personnel in 38 groups, 1136 students in 12 groups, 180 scientists and subject matter specialists in 21 groups from India and abroad visited the institute.

## Farmers' Advisory Services

The institute has established facility of toll free phone number 18001801014 to receive the farmers' calls related to the problems of soil salinity, sodicity and water quality. During 2014-15, 208 calls pertaining to different aspects were received from various parts of the country and the appropriate remedial measures were suggested.

## International Collaboration

- Stress tolerant rice for poor farmers of Africa and South Asia (Sponsored by IRRI-BMGF)
- 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
- Future rainfed lowland rice systems in eastern India : Development of crop and nutrient management practices in rice (ICAR –W3) (IRRI funded).

## New International and National Linkages initiated/developed

- Singapore National University (SNU) in the area of wastewater remediation.
- SAARC Agriculture Centre (SAC), Dhaka 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.
- Research Institute of Theoretical & Applied Physical Chemistry (INIFTA), La Plata, Argentina (funding from UNESCO-TWAS-CONICETS) for collaborative research.
- National Remote Sensing Centre (NRSC), Hyderabad, State Remote Sensing Application Centres (RSAC), and NBSS&LUP, Nagpur (ICAR) on use of recent space technologies and image interpretations techniques for mapping and characterizing salinity affected areas with higher accuracies.
- Academic linkages with Institute of Environmental Studies, Kurukshetra University, Kurukshetra, (Haryana); Department of Biotechnology, Maharishi Markandeshwer University, Mullana (Haryana); ICAR-NDRI, Karnal and Deenbandhu Chhotu Ram University of Science & Technology, Murthal (Haryana).
- National Research Centre on Seed Spices, Ajmer, Rajasthan for collaborative research.
- Project Directore, NCP, IGBP, IIRS, NRSA and Department of Space, Dehradun, Uttrakhand for collaboration research project.
- Jaipur National University, Jaipur, Rajasthan.
- Sardar Vallahbhai Patel University of Agriculture & Technology, Meerut (UP) for collaborative research.
- CCS HAU, Hisar, Haryana and Punjabi University Patiala, Punjab for collaborative research.

## Publications

The Institute published 94 research papers in peer reviewed journals, 28 book chapters, 3 books/ manuals, 9 bulletins/folders, 23 popular articles and 3 technical reports. Besides, 115 papers were presented in different National and International seminar/symposia and conferences.

## Scientists' visits abroad and new scientists joined

To upgrade their knowledge and skills, 9 scientists of the institute visited different countries *viz.* Bangladesh, Nepal, Philippines, Thailand, Korea, Japan and Vietnam. Three scientists joined the institute during period under report.

# 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, CSSRI 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). For new centres viz; Panvel, Bathinda, Vytilla and Port Blair are also working in the above project.

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 water logging 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.

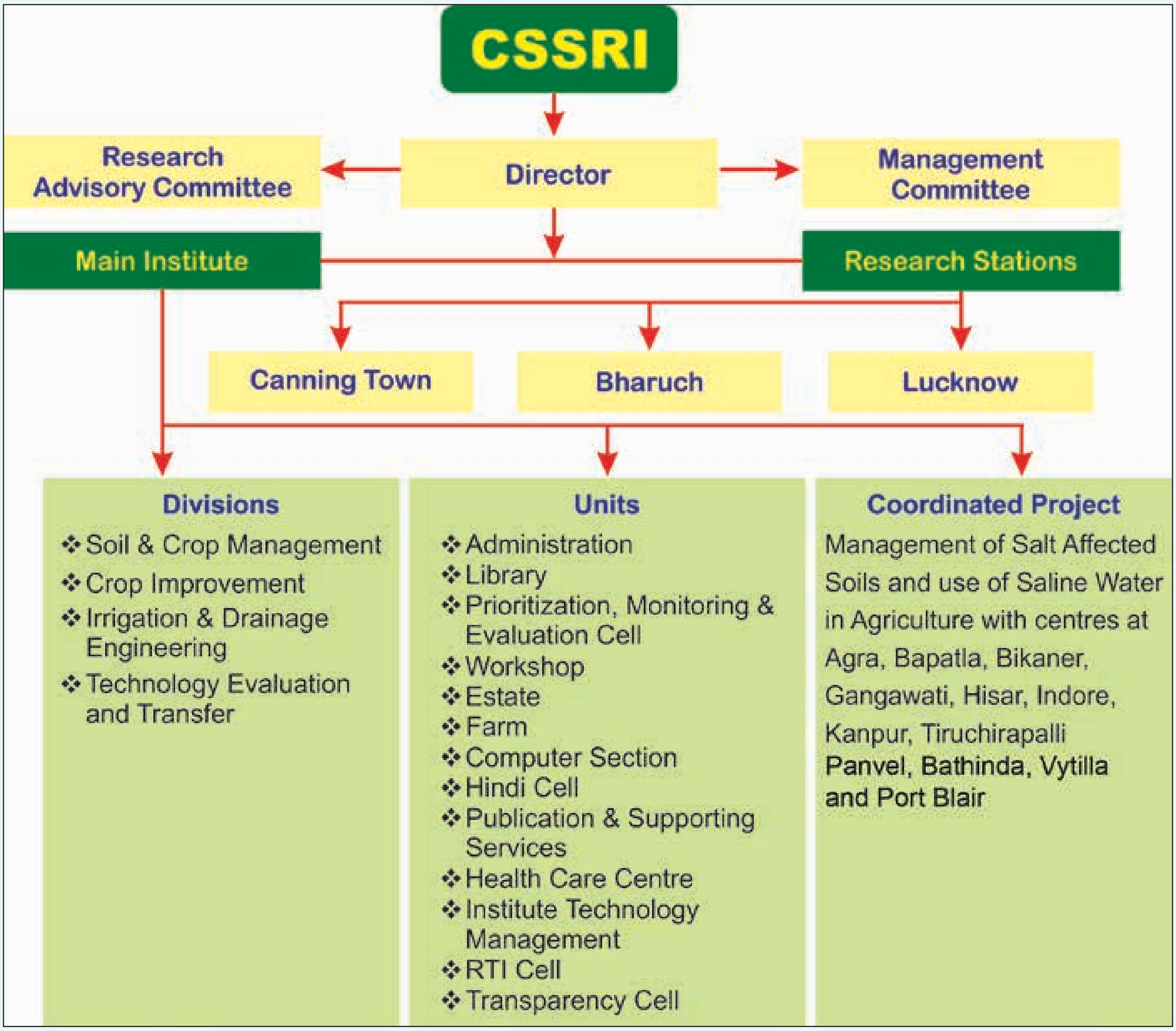
The Institute has developed technologies for the reclamation of alkali soils in the country with the addition of chemical amendments, reclamation of saline soils through subsurface drainage, development and release of salt tolerant crop varieties of rice, wheat and mustard and the reclamation of salt 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.



## 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 environment 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. During the period under report, the farm unit produced 28.5 and 26.5 tonnes of the quality seed of wheat and rice, respectively. 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 | Av. yield (t $ha^{-1}$) |
|---|---|---|
| | ***Rabi*** **2013 - 14** | |
| **Wheat** | KRL 19 | 4.55 |
| | KRL 210 | 5.38 |
| | KRL 213 | 5.63 |
| | HD 2967 | 4.66 |
| | ***Kharif*** **2014** | |
| **Paddy** | CSR 30 | 3.00 |
| | CSR 36 | 5.40 |
| | Pusa 44 | 6.93 |
| | Pusa 1121 | 4.38 |

## CSSRI, Research Farm, Nain

The Nain experimental farm is located at Nain village, west of Panipat- Gohana road, 25 km from Panipat town (District Panipat) and is about 65 kms from Karnal. This farm covers an area of 10.8 ha. The site also had some salt tolerant grasses and herbs as *sporobolus marginatus*, *Saccharum* *spontanium* (Kans), *Cynodon dactylon* (Dub grass), *Suaeda fruticosa* (Noon khari), *Kochia indica* (Bui) and *Calotropis procera* (Aak) etc. A wide range of soil salinity (<4 to >30 dS $m^{-1}$) was found at surface and sub-suface. The soil reaction showed sodic nature ranging from <8.2 to 8.9. The tube well water showed neutral pH (7.7) and higher EC (13 dS $m^{-1}$) indicating high salinity with dominance of $Na^+$, $Ca^{2+}$,$+Mg^{2+}$, $Cl^-$, $SO_4^{2-}$ and HCO3-. Higher SAR (19.3 $mmol^{1/2}L^{-1/2}$) showed limitations for use during seed germination. Such water may be used in cyclic mode with good quality water preferably for salt tolerant crops and forestry/ fruit plantations.

## Finances

Summary of allocation and expenditure during the year 2014-15 under Plan and Non-Plan budget is presented below:

*(Rs. in lakhs)*

| Budget | Sanctioned amount/receipts | Actual expenditure |
|---|---|---|
| Non-plan | 2431.63 | 2416.52 |
| Plan | 230.00 | 229.93 |
| AICRP (Non-plan) | 35.00 | 32.88 |
| AICRP (Plan) | 480.00 | 479.87 |
| Total | 3176.63 | 3159.20 |

## Staff

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

| Category of post | Sactioned | In position |
|---|---|---|
| Scientific | 81 | 54 |
| Technical | 117 | 99 |
| Administrative | 58 | 45 |
| Skilled Supporting Staff | 95 | 62 |
| Total | 351 | 260 |

## Library

Library is a self-education platform, a means of acquiring the knowledge and factual information while serving as a centre of intellectual recreation organized collection of sources of information. A collection can include books, periodicals, newspapers, manuscripts, maps, prints, documents, CDs, cassettes, DVDs, databases, and other formats. CSSRI library is well furnished, fully air-conditioned and equipped with 6 computers, I server and 2UPS.. 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 15383 books including Hindi books. A separate section is maintained for Hindi books. Hindi Newspapers, Employment News and Hindi Magazines are being subscribed to serve the readers. There are 8451 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 and 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 various 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 3000 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 and Soil CD.

**Online Public Access Catalogue (OPAC):** Library book catalogue is available in online form which is a systematic record of the 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 http//egranth.ac.in

**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 various Indian Council Agricultural Research Institutes, Agricultural Universities , NAAS members, QRT members, RAC members etc. and also distributed amongst the distinguished visitors, farmers, etc. We have a collection of 12 priced publications also which are supplied on cash payment or D.D. in advance.

## 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

ISO 9001:2008

Certificate No. 14RQ11AW

# 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)

Based on the interpretation of IRS LISS III (2009-10) data, coupled with soil profile studies and laboratory characterization of soil samples, salt affected soils in Fatehabad district were mapped. Soils were characterized for chemical characteristics such as pHs, $EC_e$, ESP, CEC, ionic (cation and anion) composition, $CaCO_3$ (<2mm size) content and soil texture. The nature, degree and extent of salinity/sodicity were evaluated for reclamation and management. The blocks/sub-divisions boundaries were superimposed to assess the distribution of salt affected soils (Table 1).

Physico-chemical characteristics of soil profiles are presented in Table 2. Pedon 1 located in the Ghaggar plain, showed moderately alkaline pHs (8.9 to 9.2). The soluble salt composition showed the dominance of carbonates and bicarbonates (7 to 11 me $l^{-1}$) and sodium (6.01 to 30.1 me $l^{-1}$). The presence of calcium, magnesium, chloride and sulfates were also noted. The ESP values were high to very high (49 to 70), indicating saturation with sodium. The CEC were low due to coarse texture ranging from sandy loam to loam.

Pedon 2 irrigated by the Bhakra canal is severely saline soil with $EC_e$ ranging from 10.5 to 46.5 dS $m^{-1}$. The salt composition showed the dominance of sodium (69.7 to 472.0 me $l^{-1}$), calcium + magnesium (80 to 200 me $l^{-1}$), chloride (268 to 1210 me $l^{-1}$) and sulfate (121 to 739 me $l^{-1}$). The depth wise $CaCO_3$ content (1.1 to 4.9%) showed an increasing trend of stratification in the soil profile. Soil texture ranged from loamy sand to sandy loam, CEC and ESP values were very low to low.

Pedon 3 was alkaline in nature (pHs 9.0 to 9.5) and is irrigated by sodic ground water showing poor productivity. Sodium and carbonates were dominant ions and the range of ESP values (21 to 37%), indicated slight to moderately sodic soil. The soil texture ranged from sandy clay loam to sandy loam. Pedon 4 showed slightly alkaline in nature (pHs 8.7 to 8.8) and salt composition was dominated by sodium (13.3 to 22.2 me $l^{-1}$), carbonates and bicarbonates (2 to 10 me $l^{-1}$). The high CEC values (24 to 29 cmol ($p^+$) $kg^{-1}$) appeared due to fine soil texture (sandy loam to sandy clay loam). For reclamation and management, P1 needs treatment with gypsum, P2 requires interventions with sub-surface drainage; P3 and P4 should be irrigated with ground water with gypsum application.

The chemical properties of water samples showed that the water was slight to moderately sodic ($pH_{iw}$ 8.4 to 9.7) in nature with a dominance of sodium (7 to 36 me $l^{-1}$), carbonates and bicarbonates (3 to 12 me $l^{-1}$) and the presence of calcium, magnesium (8 to 14 me $l^{-1}$) and chlorides (10 to 18 me $l^{-1}$) was also noted. The SAR values were above 10 in Tohana block. The prominent areas of salt affected soils (11614 ha, 4.6%) were noted in Fatehabad (1.1%), Tohana (1.1%) and Bhuna (1.3%) blocks. Sodic and saline soils occupied 7200 ha (62%) and 4414 ha (38%), respectively. Sodic soils covered 2689 ha (23%) in Tohana, 2460 ha (21%) in Fatehabad and 1216 ha (11%) in Bhuna blocks, respectively. Saline soils were located prominently in Bhattu Kalan (1976 ha, 17%) block (Table 2).

**Table 1 : Distribution of salt affected soils in Fatehabad district**

| Name of the blocks | Area under different categories of salt affected soils (ha) | | | | | | Total area (ha) | % of TGA |
|---|---|---|---|---|---|---|---|---|
| | Moderately saline | Moderately sodic | Slightly saline | Slightly sodic | Strongly saline | Strongly sodic | | |
| Ratia | tr | 577 | tr | 238 | tr | 20 | 835 | 0.3 |
| Fatehabad | 244 | 879 | 120 | 1334 | 81 | 247 | 2905 | 1.1 |
| Bhattu Kalan | 1099 | tr | tr | tr | 877 | tr | 1976 | 0.8 |
| Bhuna | 954 | 45 | 664 | 1171 | 349 | tr | 3183 | 1.3 |
| Tohana | tr | 882 | 26 | 1807 | tr | tr | 2715 | 1.1 |
| Grand total | 2297 | 2383 | 810 | 4550 | 1307 | 267 | 11614 | 4.6 |

TGA=Total Geographical Area of Fatehabad district

**Table 2 : Physico-chemical properties of soils from Fatehabad district Haryana**

| Depth (cm) | $pH_s$ | ECe (dS $m^{-1}$) | $Na^+$ | $Ca^{2+}$+ $Mg^{2+}$ | $CO_3^{2-}$+ $HCO_3^-$ | $Cl^-$ | $SO_4^{2-}$ | ESP | $CaCO_3$ | CEC (cmol ($p^+$) $kg^{-1}$) | C S | FS | Silt | Clay | Texture |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (me $L^{-1}$) | | | | | (%) | | | (%) | | | | |
| **P1: Vill. Dhani Khanpur Block Fatehabad moderately alkali soil supporting R/W in Ghaggar plain** | | | | | | | | | | | | | | | |
| 0-30 | 9.2 | 2.7 | 30.1 | 4 + 6 | 3 + 4 | 10 | 23.5 | 70 | 2.3 | 4.5 | 24 | 29 | 36 | 11 | sl |
| 30-60 | 8.9 | 1.6 | 28.8 | 3 + 5 | 2 + 9 | 18 | 7.9 | 62 | 1.0 | 4.1 | 18 | 25 | 37 | 20 | l |
| 60-90 | 8.9 | 1.6 | 6.01 | 5 + 1 | 4 + 5 | 20 | 3.1 | 49 | 2.1 | 5.9 | 26 | 25 | 32 | 17 | l |
| 90-120 | 9.0 | 1.1 | 8.87 | 6 + 6 | 2 + 8 | 20 | 0.9 | 70 | 1.2 | 4.5 | 26 | 19 | 36 | 20 | l |
| **P2: Vill Banmandauri Block Bhattu kalan waterlogged (WT 1.5m), severely saline soil under irrigation** | | | | | | | | | | | | | | | |
| 0-30 | 8.7 | 46.5 | 472 | 80+120 | 0 + 20 | 1210 | 550 | 17 | 1.1 | 9.2 | 71 | 9 | 7 | 13 | ls |
| 30-60 | 8.7 | 11.3 | 69.7 | 40 + 60 | 0 + 40 | 510 | 312 | 19 | 2.4 | 7.3 | 66 | 10 | 8 | 16 | sl |
| 60-90 | 8.7 | 11.4 | 78.4 | 40 + 40 | 0 + 14 | 268 | 121 | 13 | 3.0 | 9.9 | 67 | 8 | 8 | 17 | sl |
| 90-120 | 8.7 | 10.5 | 94.0 | 42 + 44 | 0 + 20 | 900 | 739 | 12 | 4.9 | 12.1 | 64 | 10 | 8 | 18 | sl |
| **P3: Vill Kanhri, block Tohana sodic soil, sodic GW, partial waterlogging, R/W with low productivity** | | | | | | | | | | | | | | | |
| 0-30 | 9.0 | 1.3 | 18.4 | 3 + 3 | tr + tr | 7 | 10.0 | 28.15 | 1.8 | 12.4 | 53 | 17 | 0.8 | 29 | scl |
| 30-60 | 9.2 | 1.0 | 15.8 | 3 + 3 | 2 + tr | 4 | 0.7 | 25.48 | 1.9 | 16.9 | 53 | 18 | 7.8 | 21 | scl |
| 60-90 | 9.5 | 1.6 | 23.9 | 2 + 2 | 10 + tr | 4 | 0.7 | 36.85 | 0.6 | 13.8 | 58 | 17 | 8.5 | 16 | sl |
| 90-120 | 9.4 | 0.9 | 13.7 | 2 + 2 | tr + 2 | 4 | 0.5 | 20.55 | 0.5 | 20.7 | 61 | 19 | 1.3 | 18 | sl |
| **P4: Vill. Hindalwala Block Tohana slightly sodic soil, low productivity of R/W, sodic GW, waterlogging** | | | | | | | | | | | | | | | |
| 0-30 | 8.8 | 0.9 | 13.9 | 3 + 7 | tr + 5 | 4 | 0.6 | 13.32 | 1.9 | 24.2 | 27 | 41 | 16 | 16 | sl |
| 30-60 | 8.7 | 0.9 | 13.3 | tr + 2 | tr + 2 | 3 | 0.6 | 14.81 | 0.8 | 26.9 | 14 | 38 | 27 | 21 | scl |
| 60-90 | 8.7 | 1.6 | 22.2 | tr + 3 | tr + 2 | 4 | 2.1 | 16.49 | 0.9 | 25.8 | 8 | 39 | 33 | 19 | sl |
| 90-120 | 8.8 | 1.5 | 21.9 | tr + 5 | tr + 2 | 4 | 1.2 | 14.05 | 1.4 | 29.4 | 5 | 43 | 27 | 25 | scl |

**Assessment and Mapping of Salt Affected Soils using Remote Sensing and GIS in Southern Districts of Haryana** (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 over Faridabad district of Southern Haryana. IRS imageries showed strong reflectance of barren salt affected soils and higher water absorption in cropped areas irrigated with saline ground water. Analytical data showed that soil salinity was found to be as high as 54.7 dS $m^{-1}$ with mean of 7.8 dS $m^{-1}$ and standard deviation (SD) 11.8. Soil pH ranged from 7.1 to 10.0 with mean 8.6 and SD of 0.57. The mean concentration of soluble sodium is 3.0 times more than the concentration of calcium + magnesium in these soils. Similarly chloride content was as high as 492.0 me $L^{-1}$. Soils at Machghar, Sotai, Sagarpur and Harphalli villages were highly sodic soils with pHs ranged from 9.2 to 10.0 (Table 3). Soils of the study area are sandy loam to loamy sand in texture. These soils are low in available nitrogen content and soil organic carbon content ranged from 0.21 to 0.62%. Laboratory analysis of ground water samples from Faridabad district revealed that $pH_w$ ranged from 6.8 to 9.2 and $EC_w$ ranged from 0.8 to 4.5 dS $m^{-1}$ with SAR ranged from 1.9 to 17.1. Satellite imageries were interpreted and subjected to supervised classification (Fig 1) for estimation of area under different categories. Mapping of salt affected soils of four districts of southern Haryana using topomap of 1:50000 completed and extent of salt affected area in districts of Mewat, Palwal, Gurgaon and Faridabad was found to be 399.6, 336.83, 161.67 and 91.15 sq km, respectively (Table 4).

**Table 3: Physico-chemical properties of selected salt affected soils in Faridabad district, Haryana**

| Depth (cm) | $pH_2$ | ECe (dS $m^{-1}$) | OC (%) | $CaCO_3$ (%) | Na (me $l^{-1}$) | K (me $l^{-1}$) | Ca+Mg (me $l^{-1}$) | Cl (me $l^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| **Village Machgar, District Faridabad** | | | | | | | | |
| 0-15 | 9.98 | 7.23 | 0.42 | 7.4 | 63.7 | 0.08 | 7.0 | 27.0 |
| 15-30 | 10.03 | 8.77 | 0.39 | 5.0 | 101.8 | 0.10 | 5.0 | 29.0 |
| 30-60 | 10.10 | 11.98 | 0.38 | 2.0 | 128.4 | 0.07 | 5.0 | 36.0 |
| 60-90 | 10.02 | 11.69 | 0.35 | 2.0 | 120.2 | 0.07 | 5.0 | 38.0 |
| **Village Kabulpur bangar, District Faridabad** | | | | | | | | |
| 0-15 | 7.71 | 54.7 | 0.38 | 0.4 | 345.7 | 0.32 | 220.0 | 492.0 |
| 15-30 | 7.80 | 32.1 | 0.36 | 0.4 | 137.1 | 0.28 | 125.0 | 245.0 |
| 30-60 | 7.86 | 21.5 | 0.36 | 0.5 | 141.8 | 0.16 | 86.0 | 156.0 |
| 60-90 | 7.87 | 18.57 | 0.27 | 0.5 | 172.1 | 0.15 | 80.0 | 132.0 |

**Table 4 : Extent of salt affected area (Sq. Km) in four districts of Southern Haryana**

| Class Name | Faridabad | Palwal | Gurgaon | Mewat |
|---|---|---|---|---|
| Built-up Land/Settlements | 161.41 | 119.71 | 281.71 | 215.42 |
| Hill Area | 132.32 | 28.61 | 282.55 | 257.35 |
| Normal Soils | 344.67 | 843.04 | 502.30 | 636.91 |
| Moderate Saline Soils | 44.22 | 105.89 | 53.19 | 142.07 |
| Severely Saline Soils | 22.11 | 40.12 | 23.16 | 157.28 |
| Waterlogged Saline Soil | 24.82 | 190.82 | 85.32 | 100.25 |
| Waterbody | 9.59 | 26.38 | 6.93 | 9.03 |
| **Total** | **739.14** | **1354.58** | **1235.16** | **1518.31** |

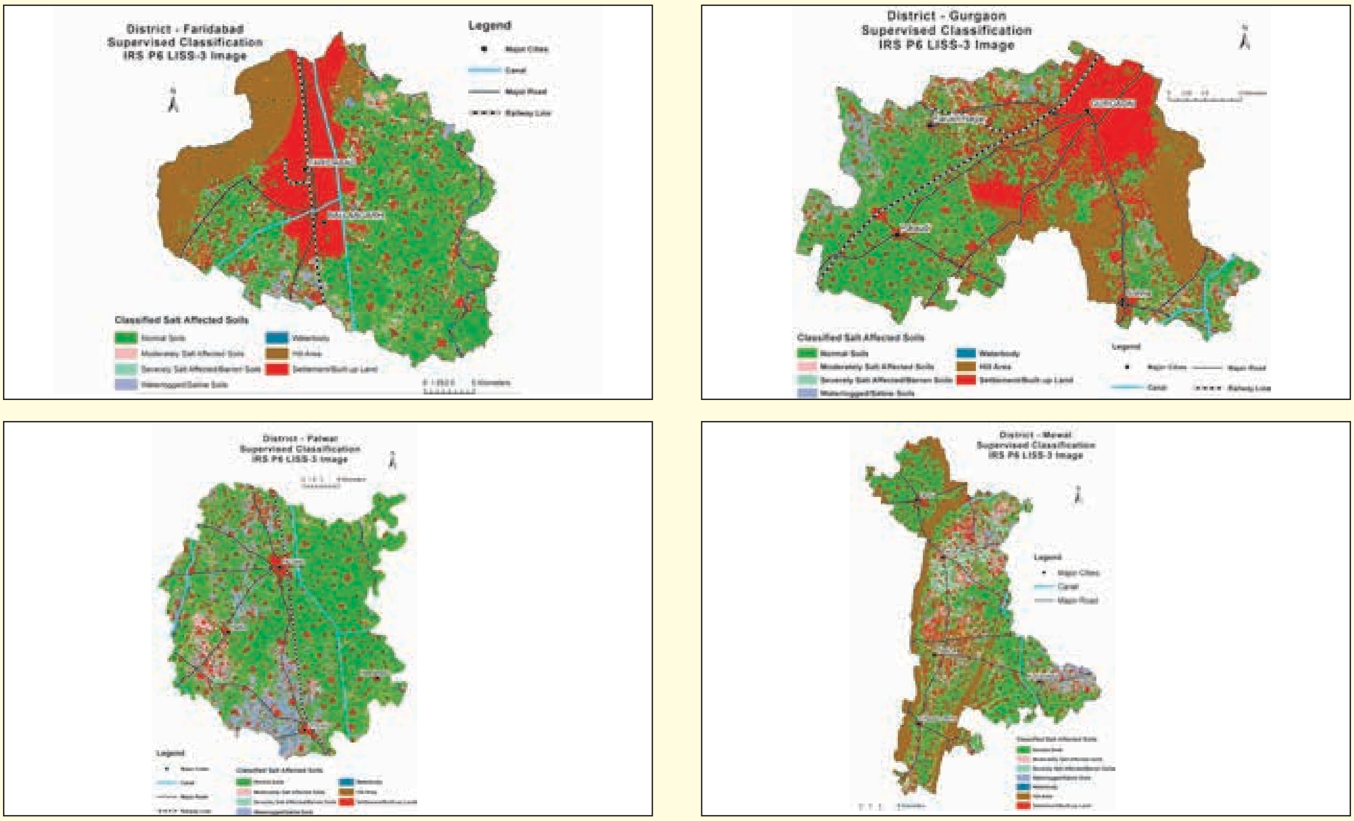



*Fig. 1 : Supervised classification of IRS P6 LISS-III satellite image of four districts of Haryana*

## Assessment and Mapping of SAS Using Remote Sensing and GIS in Rewari and Mahendragarh Districts, Haryana

(Madhurama Sethi, A.R. Chinchmalatpure, Ashim Datta, Anil Yadav, M.L. Khurana, Nirmalendu Basak)

GPS based soil samples were collected from salt affected areas of Rewari district from a depth of 90 cm (0-15, 15-30, 30-60 and 60-90 cm) with auger. A KML file was prepared using Google earth to indicate salt affected areas and soil sampling points. IRS LISS III, P-6 imageries were further interpreted using ERDAS IMAGINE for delineation (Fig.2 & 3).


*Fig 2 :.KML file showing soil sample points in Rewari District*

Analysis of the soil samples indicated that with increase in depth pHs and ECe increased at all sampling points. Soil pHs ranged from 7.5 to 9.0. and ECe ranged from 0.46 to 8.34 dS $m^{-1}$. Surface soil contained higher Na content and ranged from 1.46 to 91 me $l^{-1}$. Ca+Mg content of the soil ranged from 2.0 to 45 me $l^{-1}$. Potassium content was found to be very low ranging from trace to 8.3 me $l^{-1}$ whereas bicarbonate and chloride content varied from 1.0-4.0 and 4.0 to 46 me $l^{-1}$. Carbonate was undetectable in the soil. The soils contained appreciable quantities of calcium carbonate which ranged from 0.3 to 9.8 per cent. Oxidizable organic carbon content was low ranged from 0.12 to 0.54 per cent. These soils are slight to moderately saline in nature, however alkalinity existed at many places in the district. These soils are very low in organic carbon ranged from 0.12 to 0.54 and calcium carbonate content ranged from 0.30 to 9.8 per cent.

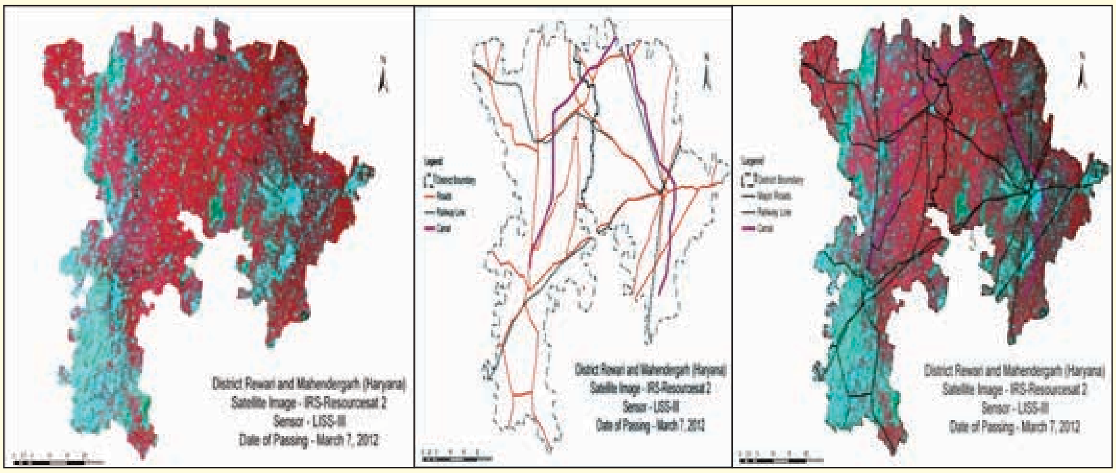



*Fig 3 : Image and GIS database of Rewari & Mahendragarh Districts (Haryana)*

# RECLAMATION AND MANAGEMENT OF ALKALI SOILS

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

Rice–wheat cropping system is labour, water and energy intensive and is becoming less profitable as these resources are scarce and costly. A field experiment has been continuing from 2011 to evaluate the effect of resource conservation strategies viz., tillage, residue and irrigation methods for enhancing crop productivity and sustaining the health of semi-reclaimed sodic soils. Eight resource conservation techniques were imposed and conventional cultivation. High yielding varieties of rice (Ariz-6129) and wheat (HD 2967) were used. The results indicated that highest grain yield of rice (7.8 t $ha^{-1}$) was recorded in CV with wheat residue incorporation followed by conventional tillage (7.3 t $ha^{-1}$) and DSR with reduced tillage and surface irrigation (Fig. 4). The highest grain yield of wheat (6.5 t $ha^{-1}$) was recorded in reduced tillage with rice residue incorporation as compared to conventional tillage (5.7 t $ha^{-1}$) (Fig. 5). Crop residue incorporation increased the grain yield of wheat by 10.2 per cent over CV practice. However, 50 per cent tillage with crop residue incorporation yielded 5.0 per cent additional wheat grain. Optimum soil moisture and favourable temperature regulation under residue incorporation treatments facilitated better seed germination and crop growth as compared to no- residue treatments.

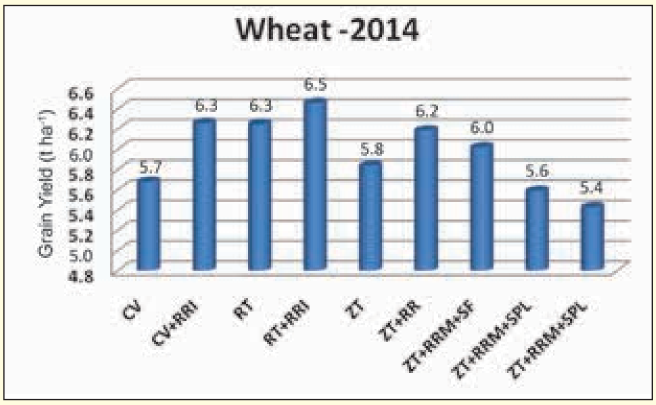



*Fig.5 : Effects of different resource conservation techniques on wheat grain yield.*

Note: CV=conventional tillage; RRI=Rice residue incorporation; RT=Reduced tillage; ZT=Zero tillage; RRM=rice residue mulch and SPL= sprinkler irrigation

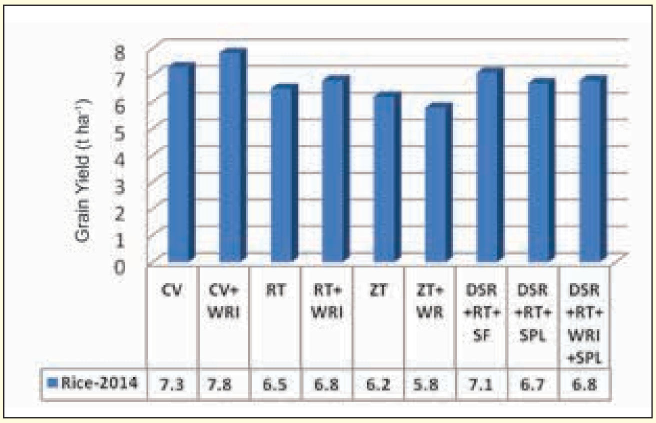



*Fig.4 : Effects of different resource conservation techniques on rice grain yield*

Note: CV=conventional tillage; WRI= Wheat residue incorporation; RT=Reduced tillage; ZT=Zero tillage; WR=Wheat residue retention and SPL= sprinkler irrigation; DSR= Direct seeded rice and SPL= sprinkler irrigation

A mini-sprinkler irrigation system has been installed in 0.4 acre area with 12960 $Lh^{-1}$ $acre^{-1}$ discharge rates at 2 kg $cm^{-2}$ pressure along with 90 per cent uniformity coefficient. The criteria for irrigation scheduling for wheat was considered to be the cumulative pan evaporation of 7 days. Sprinkler irrigation system saved 48.3 per cent water over the surface irrigation (Table 5). Zero tillage with 100 per cent rice straw mulch produced the highest wheat yield (6.41 t $ha^{-1}$) under surface irrigation system followed by 5.72 t $ha^{-1}$ in zero tillage with 100 per cent rice straw mulch under mini sprinkler irrigation system. About 1.94 times higher additional wheat grain water productivity was in mini sprinkler irrigation method with ZT and 100 per cent rice residue mulch as compared to conventional wheat sowing with surface irrigation.

*Mini Sprinkler in wheat*

**Table 5 : Effect of surface and mini sprinkler on wheat (cv HD 2967) yield, irrigation water requirement, water productivity, saving of water and energy during 2013-14.**

| Particulars | Resource Conservation Technologies | | | |
|---|---|---|---|---|
| | Conventional wheat sowing | Wheat sowing in Zero tillage with100 % rice mulch /DSR without wheat residue | Wheat sowing in Zero tillage with 100 % rice mulch/DSR without wheat residue | Wheat sowing in Zero tillage with 100 % rice mulch /DSR with wheat residue incorporation |
| Mode of irrigation | Surface | Surface | Mini–Sprinkler | Mini–Sprinkler |
| Irrigation criteria | Growth stages | Growth stages | (7 days CPE) | ( 7 days CPE) |
| Grain yield (t $ha^{-1}$) | 5.68 | 6.41 | 5.72 | 5.43 |
| Total crop productivity (t $ha^{-1}$) | 14.26 | 15.87 | 13.73 | 13.79 |
| Total irrigation water (ha-cm) | 18.0 | 12.0 | 9.3 | 9.3 |
| Crop water productivity (kg $m^{-3}$) | 7.92 | 13.23 | 14.73 | 14.79 |
| Grain water productivity (kg $m^{-3}$) | 3.16 | 5.34 | 6.14 | 5.82 |
| Irrigation water saving (%) | - | 33.33 | 48.33 | 48.33 |
| Energy saving (%) | - | | 17.12 | 17.12 |
| NUE(kg $kg^{-1}$ nitrogen) | 37.87 | 40.13 | 76.3 | 72.4 |
| Physiological observation | Greenness-water not stagnated | Greenness-water not stagnated | Greenness-water not stagnated | Greenness-water not stagnated |

Rainfall received =168.4 mm and Pan evaporation=255.3 mm during November 2013 to March 2014 , CPE= cumulative pan evaporation of 7 days used for irrigation through mini sprinkler system , CD (0.05) = 0.34 and NUE= nitrogen use efficiency

**Table 6 : Effect of surface and mini sprinkler on hybrid rice (Arize 6129) yield, irrigation water requirement, water productivity, saving of water and energy**

| Particulars | Resource Conservation Technologies | | | |
|---|---|---|---|---|
| | Conventional rice transplanting | DSR without wheat residue/wheat sowing in Zero tillage with 100 % rice mulch | DSR without wheat residue/wheat sowing in Zero tillage with 100 % rice mulch | DSR with wheat 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) Alternate day | ( CPE) Alternate day |
| Grain yield (t $ha^{-1}$) | 7.30 | 7.10 | 6.70 | 6.80 |
| Total crop productivity (t $ha^{-1}$) | 14.58 | 13.99 | 13.45 | 13.67 |
| Total irrigation water ( ha-cm) | 112.5 | 80.0 | 62.1 | 62.1 |
| Crop water productivity (kg $m^{-3}$) | 1.296 | 1.749 | 2.166 | 2.202 |
| Grain water productivity (kg $m^{-3}$) | 0.649 | 0.888 | 1.0790 | 1.095 |
| Irrigation water saving (%) | - | 29.2 | 45.13 | 45.13 |
| Electricity saving (%) | - | 28.89 | 11.69 | 11.69 |
| NUE (kg $kg^{-1}$ nitrogen) | 48.67 | 47.33 | 60.91 | 61.82 |

Rainfall received =389.7 mm and Pan evaporation =565.2 mm during June, 2014 to September 2014, CPE= cumulative pan evaporation criteria used for irrigation through mini sprinkler system, CD (0.05) = 0.36 (grain yield) and NUE= nitrogen use efficiency.

*Mini Sprinkler in Rice*

Considerable electric energy (17.12 %) was saved in mini sprinkler irrigation in comparison to conventional wheat sowing method. The highest nitrogen use efficiency (76.3 kg $kg^{-1}$ nitrogen) was observed in mini sprinkler fertigation method and it saved 50 per cent of the recommended nitrogen (75 kg) in wheat crop as compared to conventional surface irrigation method. The lowest nitrogen use efficiency (37.87 kg $kg^{-1}$ nitrogen) was recorded in conventional wheat cultivation method with 50 per cent tillage and 33 per cent rice residue incorporation, nitrogen use efficiency was recorded 43.07 kg $kg^{-1}$. The maximum yield (6.8 t $ha^{-1}$) was recorded in DSR with 50 per cent reduce tillage in mini sprinkler irrigation method. This saved 45.1 per cent of irrigation water and 11.7 per cent electrical energy (Table 6). DSR with 50 per cent reduce tillage under surface irrigation method saved 28.9 per cent irrigation as compared to conventional transplanting. Mini sprinkler fertigation method in rice saved 27 per cent of recommended nitrogen (40 kg) and increased the nitrogen use efficiency (up to 61.82 kg $kg^{-1}$ nitrogen) as compared to conventional rice transplanting.

### Conjunctive Water Use Strategies with Conservation Tillage and Mulching for Improving Productivity of Salt Affected Soils under Limited Fresh Water Irrigation

(Arvind Kumar Rai, R.K. Yadav, Anil R. Chinchmalatpure, Nirmalendu Basak, Satyendra Kumar, Bhaskar Narjary, Gajender Yadav, A.K. Bhardwaj and D.K. Sharma)

Soil salinity has emerged as the most significant problem constraining agricultural productivity in semi arid and arid region. In these areas, low rainfall and high temperature are always conducive for accumulation of salts in surface layers. Saline soil and groundwater coexist in nature, leaving very limited scope for reclamation using fresh water either from rain water harvesting and/or use of canal water. In the absence of proper soil-water-crop management practices, use of saline waters also increases the risk of soil salinization and deterioration of soil and environmental health. Developing appropriate soil and water management strategies for sustaining crop production seems promising in productive utilization of salt affected lands and use of poor quality water. Therefore, this experiment was initiated to utilize the conservation tillage and crop residue mulching for managing intra/inter seasonal root zone salinity, osmotic and matrix stress and increased water productivity of low water requiring cropping system under limited water supply. Soil salinity in saturation paste of the surface soil varied from 4-36 dS $m^{-1}$ as measured using EM-38 (Fig. 6). The ECe and OC (%) decreased with increase in soil depth (Table 7). A similar trend was also observed for cationic and anionic composition of soil saturation extract. There was not much variation in pHs, CEC and ESP of the soil with change in soil depth.

The experiment was laid out in *kharif* 2014 at Nain experimental farm, Panipat with three tillage treatment in main plot and six treatments comprising irrigation (three) and mulch (two) combination in subplots. Fodder sorghum (*cv.* HSSG-5000) was sown in August 2014 after monsoon rains with uniform tillage and irrigation. There was no significant difference in the green and dry forage yield under different treatments (Table 2). Large variability was observed in green and dry forage production due to variation in soil salinity in different plots. Surface soil salinity in different plots during the cropping season fluctuated under the influence of irrigation and rainfall. Reduction in soil salinity in block 1 was associated with increase in soil $pH_2$ measured on 15th September and 1st October, 2014 after irrigation and rainfall.

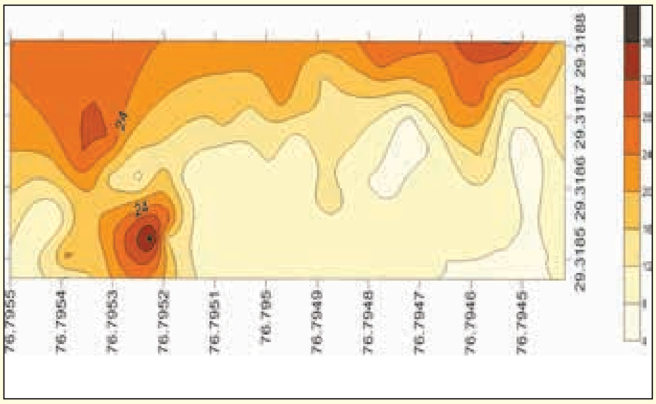



*Fig. 6 : Spatial variability in ECe of the experimental site at CSSRI Nain Experimental Farm, Panipat*

### Table 7 : Depth wise variability in initial soil properties

| Soil Depth (cm) | ECe (dS m$^{-1}$) | pHs | Organic C (%) | CEC cmol (P+) kg$^{-1}$ | ESP (%) | Composition of saturation extract (me l$^{-1}$) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | $Ca^{2+} + Mg^{2+}$ | $HCO_3^-$ | $Cl^-$ | $Na^+$ | $K^+$ |
| 0-15 | 16.2±9.6 | 8.2±0.2 | 0.46±0.1 | 13.36±3.25 | 39.32±12.47 | 37.88±10.89 | 3.56±2.47 | 108.38±70.14 | 3.66±1.81 | 0.95±0.14 |
| 15-30 | 12.4±5.9 | 8.2±0.2 | 0.44±0.1 | 10.70±2.73 | 37.42±14.18 | 34.63±11.49 | 3.13±2.25 | 86.88±61.28 | 3.54±1.79 | 0.93±0.15 |
| 30-45 | 11.2±5.5 | 8.3±0.3 | 0.37±0.1 | 12.10±5.32 | 41.20±17.65 | 30.50±13.41 | 2.38±1.81 | 61.88±37.56 | 3.37±1.54 | 0.86±0.13 |
| 45-60 | 9.7±5.9 | 8.4±0.3 | 0.34±0.1 | 11.64±3.44 | 42.24±18.15 | 25.75±14.57 | 2.63±2.15 | 44.75±20.27 | 3.02±1.49 | 0.78±0.10 |
| 60-90 | 8.0±3.6 | 8.2±0.3 | 0.24±0.1 | 14.39±4.31 | 32.62±18.23 | 24.63±12.51 | 2.14±2.10 | 38.88±20.98 | 2.88±1.71 | 0.72±0.11 |

± Standard deviation , n=8

### Table 8 : Green and dry forage yield of hybrid sorghum under different treatments

| Treatment no. | Treatment details | | Green forage yield (t ha$^{-1}$)* | Dry forage yield (t ha$^{-1}$) |
|---|---|---|---|---|
| | Tillage | Irrigation and mulching | | |
| T1 | Rt-Zt | 100 WR-no mulch | 31.7±21.3 | 6.4±4.0 |
| T2 | | 80 WR- no mulch\ | 13.7±5.0 | 2.5±1.1 |
| T3 | | 60 WR - no mulch | 19.3±25.0 | 3.7±4.7 |
| T4 | | 100 WR - mulch | 22.0±24.4 | 3.6±3.5 |
| T5 | | 80 WR - mulch | 29.2±11.8 | 6.6±3.2 |
| T6 | | 60 WR - mulch | 15.2±11.2 | 3.1±2.6 |
| T7 | Ct-Ct | 100 WR-no mulch | 30.8±18.1 | 6.8±4.2 |
| T8 | | 80 WR- no mulch | 30.0±17.5 | 5.0±3.2 |
| T9 | | 60 WR - no mulch | 30.2±24.3 | 5.1±4.0 |
| T10 | | 100 WR - mulch | 31.0±24.4 | 5.9±4.9 |
| T11 | | 80 WR - mulch | 34.2±23.1 | 7.1±4.9 |
| T12 | | 60 WR - mulch | 25.0±18.9 | 4.3±3.8 |
| T13 | Zt-Zt | 100 WR-no mulch | 22.7±21.5 | 4.3±4.1 |
| T14 | | 80 WR- no mulch | 29.3±21.0 | 5.3±3.9 |
| T15 | | 60 WR - no mulch | 20.8±3.8 | 3.9±0.9 |
| T16 | | 100 WR - mulch | 33.5±26.4 | 7.5±6.2 |
| T17 | | 80 WR - mulch | 35.0±19.8 | 6.9±4.5 |
| T18 | | 60 WR - mulch | 38.3±5.2 | 6.9±1.9 |
| T19 | Ct-Ct | 100% WR (good quality water) | 28.3±11.3 | 5.6±2.5 |
| T20 | | 100% WR (good quality water for pre and first irrigation | 35.2±32.6 | 6.4±6.1 |
| LSD (p=0.05) | | | NS | NS |

Tillage, WR- percent of total water requirement in *rabi* season (*kharif* season rainfed/life saving irrigation with good quality water), mulch- 5 t ha$^{-1}$ rice straw mulch in *rabi* season


*Sorghum crop grown in saline soils in kharif-2014*

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

Integrated nutrient management experiments were initiated with ten treatments replicated four times in RBD. The treatments were : $T_1$-Control (without organic and inorganic fertilizer, O), $T_2$-$N_{180}P_{22}K_0Zn_5$ (Farmer's practice; FP), $T_3$-$N_{180}P_{39}K_{63}Zn_5$ (O), $T_4$-$N_{100}P_{16}K_{26}$ + Moong LEG), $T_5$-$N_{100}P_{16}K_{26}$+GM (*Sesbania aculeate*) before rice transplanting (GM), $T_6$-$N_{100}P_{16}K_{26}$+FYM before rice transplanting (FYM), $T_7$-$N_{100}P_{16}K_{26}$+ wheat straw before rice transplanting (WS),$T_8$-$N_{100}P_{16}K_{26}$+paddy compost before wheat sowing (PC), $T_9$-$N_{150}P_{26}K_{42}S_{30}Zn_7Mn_7$ (SMN) and $T_{10}$-$N_{150}P_{26}K_{42}S_{30}Zn_7Mn_0$ (S). 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 (DBW-17) sowing only in $T_8$ treatment. Before rice transplanting, green gram (cv SML 668) was sown in first fortnight of May in the specified plots and incorporated *in situ* after two pickings of pods. Similarly, *dhaincha* as green manure crop 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 the soil 15 and 30 days before rice transplanting, respectively. Rice (Pusa-44) seedlings of 30 days old were transplanted in first week of July at 20 cm ×15 cm spacing and recommended agronomoic practices were followed during the season. Nutrient availability 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. Another experiment was initiated in 2013 with different treatments of only organic amendment (FYM, Paddy Compost and Green Manure) along with NPK fertilizer, with three replications.

Effects on mineralizable carbon were analysed under different treatments. Mineralizable carbon varied in the order of LEG > FYM > GM > WS > PC = I and O, with 298, 279, 263, 232, 217, 217 and 182 µg C $g^{-1}$ soil, respectively, over 23 days period. Nitrogen availability at different growth stages

*Polymer resin strips buried in the surface soil to monitor the nutrient availability to plants due to imposed treatments*

was determined using ion exchange resin (IER) membranes. Total amount of available N ($NH_4^+$ + $NO_3^-$) recorded in the full season was in the order: PC (186 µg $cm^{-2}$) > I (181 µg $cm^{-2}$) > WS (177 µg $cm^{-2}$) > FYM (176 µg $cm^{-2}$) > GM (176 µg $cm^{-2}$) > LEG (174 µg $cm^{-2}$) > O (90 µg $cm^{-2}$). The N-availability status over full season in rice indicated an inverse relationship with mineralizable carbon. Total amount of available N ($NH_4$+ + $NO_3$-) recorded in the full season in wheat was in the order: I (799 µg $cm^{-2}$) > GM (695 µg $cm^{-2}$) > LEG (686 µg $cm^{-2}$) > FYM (585 µg $cm^{-2}$) > PC (516 µg $cm^{-2}$) > WS (495 µg $cm^{-2}$) > O (419 µg $cm^{-2}$). The N-availability status in wheat indicated a direct relationship with mineralizable carbon (Fig 7).

There were no significant long term differences (4 year pooled data) in average yields recorded in inorganic and organic treatments indicating that recommended fertilizer doses can be reduced to half (50%) and compensated with organic sources, without any significant loss in yield, and with improved soil carbon (Fig. 8 & 9). The residual effects of organic sources did not have significant advantage in wheat season.

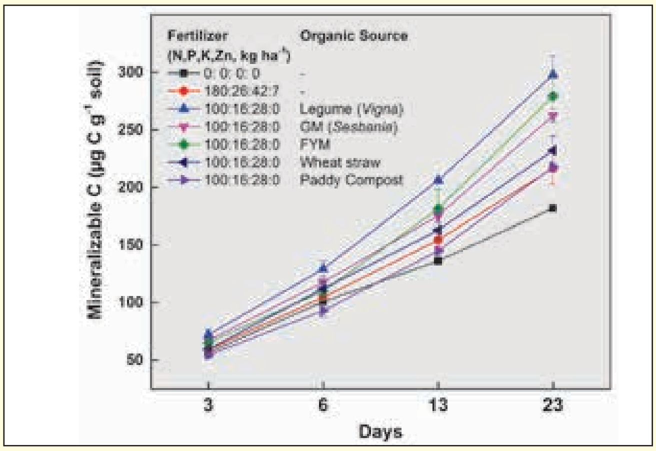



*Fig. 7 : Nitrogen availability in wheat under different treatments*

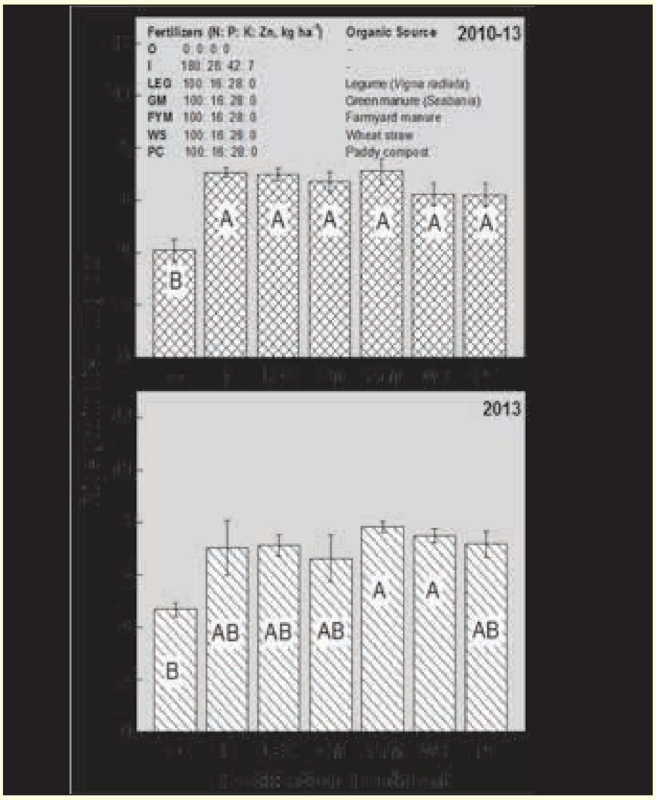



Fig. 8 : Rice yield over four years period (2010-13) and last cropping cycle (2013)

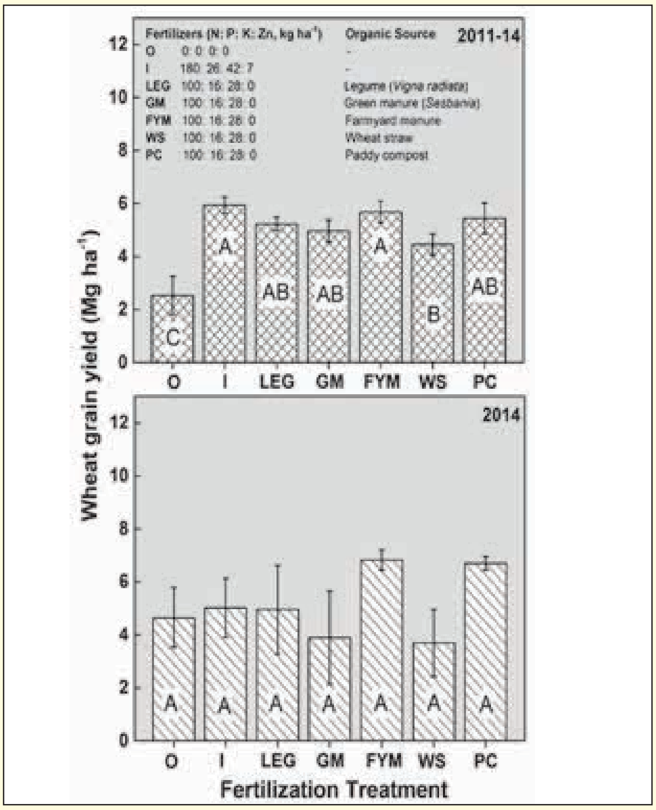


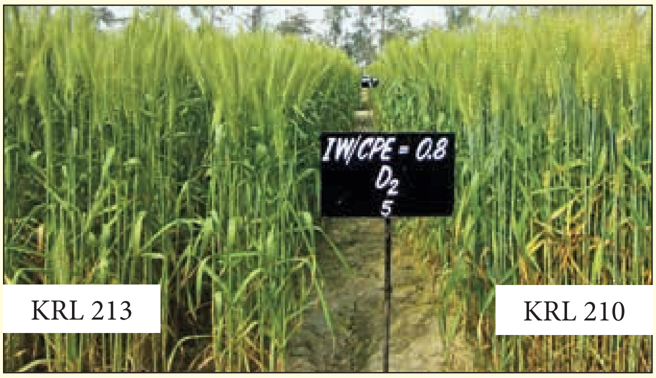

Fig.9 : Wheat yield over 4 years period (2010-13) and last cropping cycle (2013) alone.

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

Salt tolerant basmati rice variety CSR 30 is long duration and requires 155 days to mature. Due to this, wheat sowing is generally delayed which affects the productivity of wheat. Therefore, efforts are being made to optimize irrigation water requirement of salt tolerant rice and wheat varieties in relation to different dates of planting in 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 the grain yield of wheat varieties KRL 210 and KRL 213 was increased by 2 and 8 per cent when irrigation was applied at IW/CPE=1.0 over 0.8 and 0.6, respectively. Maximum grain yield of wheat varieties KRL 210 and KRL 213 was observed when crop was sown on 10 Nov. Further delay in sowing of wheat by 20 Nov., 30 Nov. and 10 Dec. resulted in reduction in grain yield by 4.7, 9.6 and 34.7 per cent (Table 9), respectively. It was further observed that wheat variety KRL 213 gave 4.7 per cent higher grain yield over KRL 210. Maximum IWP was recorded when irrigation was applied at

**Table 9: Grain yield (t $ha^{-1}$) of salt tolerant wheat varieties grown at different dates of sowing 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 | 5.04 | 5.64 | 5.21 | 5.30 | 5.69 | 6.25 | 5.18 | 5.71 |
| 20 November | 5.68 | 5.28 | 4.34 | 5.10 | 6.24 | 5.55 | 4.34 | 5.38 |
| 30 November | 5.00 | 4.89 | 4.98 | 4.96 | 5.24 | 4.04 | 5.66 | 4.98 |
| 10 December | 3.59 | 3.44 | 3.42 | 3.48 | 3.49 | 4.03 | 3.59 | 3.70 |
| Mean | 4.83 | 4.81 | 4.49 | 4.71 | 5.17 | 4.97 | 4.69 | 4.94 |
| $CD_{(0.05)}$ | IS=NS; DoS=0.94; Variety: 0.21; IS×DoS×Variety=0.72 | | | | | | | |




*Salt tolerant wheat varieties sown on 20 November with IW/CPE=0.8*

IW/CPE 0.8 and sowing was done on 20 Nov. (2.91 kg/m$^3$) with wheat variety KRL-213 (2.67 kg/m$^3$).

The three years data indicated that basmati rice may be transplanted on 1$^{st}$ July for getting higher grain yield (3.6 t ha$^{-1}$) and the highest irrgiation water productivity (0.591 kg/m$^3$) was recorded when irrigation was applied 5 days after disappearance of ponded water (DAD) imposed after one month of transplanting. It was further concluded that wheat can be sown on 20 November with irrigation schedule of IW/CPE=1.0 to obtain the maximum yield (6.2 t ha$^{-1}$).

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

Application of municipal solid waste compost (MSWC) is recommended to enhance the productivity of saline soils and rebuild the fertility. Their application could be a promising alternative to alleviate the adverse effects of salinity. Low rainfall and high potential evapotranspiration in these regions promote the upward movement of salts in the soil solution which adversely affects soils physical, chemical and biological properties. The field experiment was initiated in November, 2012 in RBD with mustard - pearl millet cropping system.

The treatments comprised of municipal solid waste compost (MSWC), rice straw compost (RSC) and gypsum enriched compost (GEC) along with 25 per cent recommended dose of fertilizers (RDF) and resulted in 22 and 24 per cent higher grain yield of mustard and pearl millet respectively, over use of 100% RDF alone. Soil treated with organic amendments along with 25% RDF ($T_9$) resulted in significantly higher grain yield (2.57 and 2.91 t ha$^{-1}$) of mustard and pearl millet over control, respectively. However, there was no significant difference among the treatments except control with respect to straw yield of mustard (Table 10).

Soil organic carbon (SOC) ranged from 1.5 to 5.2 and 1.4 to 5.5 g kg$^{-1}$ after the harvest of mustard and pearl millet respectively, whereas significant amount of SOC was maintained under $T_9$ (MSWC @ 8 t ha$^{-1}$ + 25% RDF) as compared to use of chemical fertilizers alone after harvest of both the crops (Fig. 9). Application of 100% RDF ($T_2$) was superior in terms of available $KMnO_4$-N and Olsen-P over the use of rice straw alone and gypsum enriched compost after mustard harvest. 100 % RDF ($T_2$) increased available $KMnO_4$-N by

**Table 10 : Effect of municipal solid waste compost *vis-à-vis* gypsum enriched compost and chemical fertilizers on mustard and pearl millet yield**

| Treatments | Yield of mustard (t ha$^{-1}$) | | Yield of pearlmillet (t ha$^{-1}$) | |
|---|---|---|---|---|
| | Grain | Straw | Grain | Straw |
| $T_1$-Control | 1.83$^{d*}$ | 7.80$^{b}$ | 2.11$^{b}$ | 4.83$^{c}$ |
| $T_2$-Recommended dose of NPK fertilizers (100% RDF) | 2.10$^{bcd}$ | 7.67$^{ab}$ | 2.34$^{ab}$ | 5.60$^{bc}$ |
| $T_3$-Rice straw compost @ 14 t ha$^{-1}$ | 2.03$^{cd}$ | 7.73$^{ab}$ | 2.35$^{ab}$ | 5.77$^{bc}$ |
| $T_4$-Gypsum enriched compost @ 14 t ha$^{-1}$ | 2.10$^{bcd}$ | 7.70$^{ab}$ | 2.48$^{ab}$ | 6.19$^{abc}$ |
| $T_5$-Municipal solid waste compost @ 16 t ha$^{-1}$ | 2.20$^{bc}$ | 7.90$^{ab}$ | 2.53$^{ab}$ | 6.37$^{ab}$ |
| $T_6$-50% RDF + Rice straw compost @ 7 t ha$^{-1}$ | 2.27$^{abc}$ | 8.07$^{ab}$ | 2.59$^{ab}$ | 6.54$^{ab}$ |
| $T_7$-50% RDF + Gypsum enriched compost @ 7 t ha$^{-1}$ | 2.33$^{abc}$ | 8.07$^{ab}$ | 2.58$^{ab}$ | 6.52$^{ab}$ |
| $T_8$-50% RDF+Municipal solid wastecompost @ 8 t ha$^{-1}$ | 2.43$^{ab}$ | 8.23$^{ab}$ | 2.70$^{ab}$ | 6.89$^{ab}$ |
| $T_9$-25% RDF+RSC@ 3.5+GEC @ 3.5+MSWC @ 4 t ha$^{-1}$ | 2.57$^{a}$ | 8.70$^{a}$ | 2.91$^{a}$ | 7.48$^{a}$ |
| LSD (P=0.05) | 0.30 | 1.4 | 0.6 | 1.4 |

*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.

**Table 11 : 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 pearlmillet 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 |
| $T_1$ | 84[e] | 11[d] | 176[f] | 85[d] | 11[c] | 171[f] |
| $T_2$ | 141[cd] | 32[bc] | 251[e] | 145[c] | 33[b] | 255[e] |
| $T_3$ | 138[d] | 31[c] | 255[de] | 152[bc] | 35[b] | 258[e] |
| $T_4$ | 140[cd] | 31[c] | 261[cde] | 157[bc] | 34[b] | 265[de] |
| $T_5$ | 146[bcd] | 33[abc] | 266[bcd] | 161[bc] | 35[b] | 269[cd] |
| $T_6$ | 155[bcd] | 36[abc] | 273[abc] | 165[ab] | 37[ab] | 277[bc] |
| $T_7$ | 157[bc] | 35[abc] | 274[abc] | 167[ab] | 37[ab] | 279[bc] |
| $T_8$ | 163[ab] | 38[ab] | 280[ab] | 169[ab] | 39[ab] | 286[ab] |
| $T_9$ | 175[a] | 40[a] | 285[a] | 181[a] | 41[a] | 292[a] |
| LSD (P=0.05) | 16 | 6.2 | 13.7 | 18.0 | 5.0 | 10.6 |

*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

67 and 70 per cent over control ($T_1$) after harvest of mustard. However, integrated use of organic amendment along with 25 % RDF was significantly higher in available $KMnO_4$-N, Olsen-P and $NH_4OAc$- K as compared to 100 % RDF after harvest of both the crops (Table 11).

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

Based on the last years observations on salinity tolerance of fennel (*Foeniculum vulgare*), coriander (*Coriandrum sativum*), celery (*Apium graveolens*) and fenugreek (*Trigonella foenum-graecum L.*); an

**Table 12 : Biomass and seed yields (t $ha^{-1}$) of coriander, fennel, fenugreek and celery under saline water irrigation regimes at different growth stages**

| Irrigation regime (DAS) | Fennel | | Celery | | Coriander | | Fenugreek | | Mean* | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Biomass | Seed | Biomass | Seed | Biomass | Seed | Biomass | Seed | Biomass | Seed |
| | Direct Seeding | | | | | | | | | |
| Control | 2.14 | 1.40 | 1.88 | 0.44 | 1.94 | 1.28 | 1.62 | 0.65 | 1.99 | 1.04 |
| 0-30 | 1.84 | 1.30 | 1.79 | 0.37 | 1.68 | 1.03 | 1.23 | 0.46 | 1.77 | 0.90 |
| 31-60 | 2.01 | 1.38 | 1.84 | 0.38 | 1.82 | 1.16 | 1.32 | 0.52 | 1.89 | 0.97 |
| 61-90 | 2.10 | 1.41 | 1.97 | 0.41 | 1.91 | 1.23 | 1.28 | 0.48 | 1.99 | 1.02 |
| 91-harvest | 1.96 | 1.33 | 1.89 | 0.39 | 1.95 | 1.21 | 1.46 | 0.50 | 1.93 | 0.98 |
| Cont.saline | 1.78 | 1.19 | 1.58 | 0.30 | 1.64 | 0.94 | 1.12 | 0.36 | 1.67 | 0.81 |
| Mean | 1.97 | 1.34 | 1.83 | 0.38 | 1.82 | 1.14 | 1.34 | 0.50 | 1.87 | 0.95 |
| | Transplanting | | | | | | | | | |
| Control | 1.97 | 1.26 | 1.71 | 0.42 | 1.80 | 1.19 | -- | -- | 1.83 | 0.96 |
| 0-30 | 1.78 | 1.24 | 1.84 | 0.39 | 1.71 | 1.05 | -- | -- | 1.78 | 0.89 |
| 31-60 | 1.96 | 1.35 | 1.80 | 0.40 | 1.87 | 1.13 | -- | -- | 1.88 | 0.96 |
| 61-90 | 2.15 | 1.43 | 1.94 | 0.43 | 2.03 | 1.28 | -- | -- | 2.04 | 1.05 |
| 91-harvest | 1.88 | 1.35 | 1.83 | 0.37 | 1.99 | 1.20 | -- | -- | 1.90 | 0.97 |
| Cont.saline | 1.69 | 1.14 | 1.47 | 0.27 | 1.56 | 0.83 | -- | -- | 1.57 | 0.75 |
| Mean | 1.91 | 1.30 | 1.77 | 0.38 | 1.83 | 1.11 | -- | -- | 1.83 | 0.93 |
| CD (p-0.05) | Crop biomass (CB): Seeding methods (SM) - NS; Irrigation regimes (IR) - 0.18; Crops-0.11; SM x IR = NS; SM x IR x Crop = 0.21<br>Seed yield (SY): Seeding methods- NS; Irrigation regimes - 0.13; Crops -0.21; SM x IR- 0.17; SM x IR x Crop - 0.14 | | | | | | | | | |

inter-institutional project with NRCSS, Ajmer was continued to ascertain the overall and stage dependant irrigation water salinity tolerance of direct seed sown and transplanted crops. Fenugreek was sown with seed only. Fennel, coriander and celery, and fenugreek were irrigated with saline water of EC 6.0 and 4.0 dS $m^{-1}$ at IW/CPE ratio 1.2 during 0-30, 31-60, 61-90 and 91-120 days after sowing.

Overall decrease in yield of fennel, coriander, celery and fenugreek under continuous saline water irrigation throughout growth period was 15, 27, 32 and 44 per cent, respectively. However, salinity stress imposed during 0-30 days after sowing (DAS), reduced biomass and seed production of all the crops as compared to stress imposed during later stages. Osmotic stress during initial 0-30 DAS period of these crops was most sensitive to salinity as the seed yield decreased by 8, 17, 20 and 29 per cent in fennel, celery, coriander and fenugreek, respectively in comparison to normal water irrigation. When methods of establishment were compared, it was observed that transplanting of fennel, coriander and celery under saline conditions proved better. The yields of all the three crops (1.34, 1.14 and 0.38 t $ha^{-1}$) were comparable to yields of the crops grown under direct seeding (Table 12).

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

Sodic soil can be reclaimed extraneous chemical amendments of Ca source or dissolution of native amendments in sodic calcareous soils. For this assumption, an attempt has been made in this project on sodic calcareous soil reclamation under laboratory conditions by mineral dissolution of native $CaCO_3$. A laboratory soil column experiments were set up with surface soil of 0-30 cm depth of Sodic Inceptisols (Munak, Haryana), Calareous Sodic Inceptisols (Sangrur, Punjab) and Calcareous Sodic Vertisols (Kalak, Bharuch). The soil columns were slowly wetted from the bottom by capillary action with water quality 10.0 dS $m^{-1}$ EC and 10 $mmol^{1/2} L^{-1/2}$ SAR (Na 50.0; Ca 33.3 and Mg 16.7 me-$L^{-1}$) and 20 pore volumes were passed and leachate at the end of each pore volume was collected. After the leaching process ended, the soils in the columns were drained under gravity

*Soil leachate of 20th pore volume*

for 24 h, and then were evenly sectioned into five slices, ~3.0 cm each, and air dried. The ESP, $pH_2$, $EC_2$ and $CaCO_3$ contents in soil slices were determined. Application of saline water decreased pH and increased the EC of the soil leachates following the entire pore volume: Sodic Inceptisols > Calcareous sodic Inceptisols > Calcareous sodic Vertisols. Entire soil leachates detected higher values of SAR than incoming solution. A drastic decrease in soil pH was detected at all the soil depth for all soils (Fig. 10). The calculated saturation index (SI) of leachates $HCO_3^-$ and $Ca^{2+}$ compared to SI in soil saturation extract indicates $CaCO_3$ dissolution with leaching with incoming quality water. Dissolution of $CaCO_3$ varied on soil type and depth of soil column at particular applied water quality. Among the studied soils, maximum quantity of $CaCO_3$ dissolution appeared in Sodic Inceptisols > Calcareous Soil Inceptisols> Sodic Vertisols (Fig. 11). ESP development in soils across soil depth was highest for Sodic Vertisols > Sodic Inceptisols > Calcareous Sodic Inceptisols compared to inherent soil ESP values of respective soils under the influenced for applied quality water (Fig. 12).

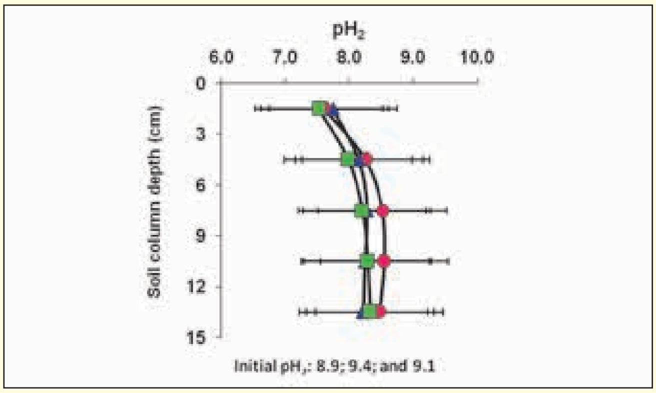



*Fig 10: The measured soil pH2 after leaching versus the soil depth after soils were leached with quality water*

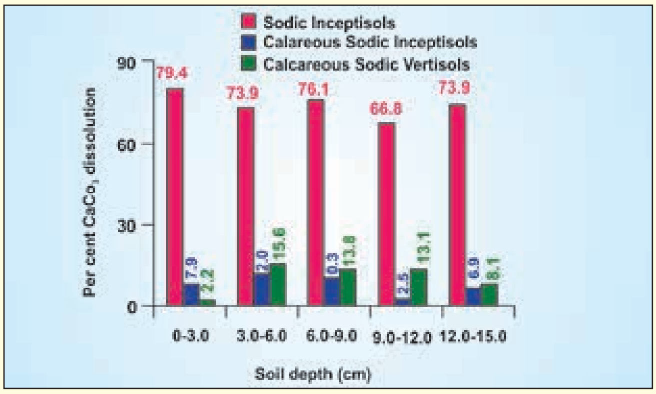



*Fig 11 : Per cent $CaCO_3$ dissolution in soils across soil column as function of 20 pore volume of quality water leaching*

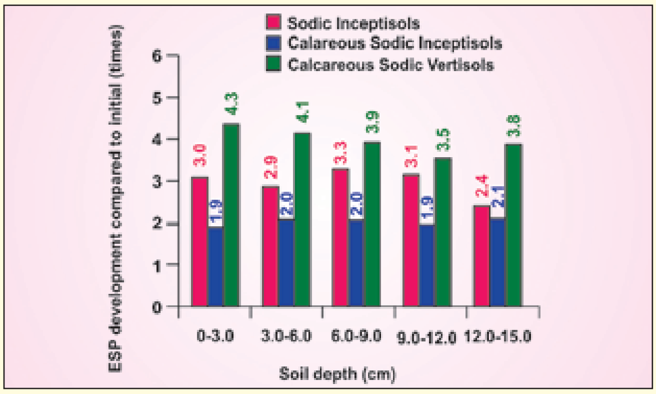



*Fig 12 : The measured soil ESP in across soil depth after leaching with 20-pore volume quality water*

## Diversifying Agriculture on Reclaimed Sodic Land in Farmer's Participatory Appraisal

(Gajender, R.S. Pandey, R. Raju, S.K. Ambast, K.S. Kadian, D.K. Sharma)

The benefits of technologies developed during green revolution were confined to large and resourceful farmers in India, because the majority of small and marginal farmers face different types of problems than large farmers. The sustainability of rice-wheat system in Indo-Gangetic plains is a serious concern due to degrading soil health and shrinking water resources in rapidly changing climatic scenario. Therefore, one alternative is to integrate more than one farm enterprise on the same piece of land to meet out the daily expenditure of a farmer. In Indo-Gangetic plains, integrating diversified agriculture may be an efficient alternative to rice-wheat cropping system for small land holders with the changing climatic scenario in reclaimed sodic soils. Keeping these in view, this research project was initiated with farmers' participatory mode from *kharif* 2013. The data presented here are from January to December 2014.

The profitability of different crops worked out on the basis of minimum support price of marketable produce for the year 2013-14 is presented in Table 1. The highest net income of Rs. 73669 $ha^{-1}$ was recorded in rice–wheat crop production system with a B:C ratio of 4.31, followed by rice-oat (Rs.40865 $ha^{-1}$). The lowest return was recorded from horticulture production system (Rs. 4885 $ha^{-1}$) with a B:C ratio of 1.39, that was expected to improve drastically after harvest of winter bearing in January 2015. The net return from fodder production system was Rs. 9299 with a B:C ratio of 1.34.

### Subsidiary components

The variation in milk production was governed by the lactation period of the animals. Highest milk (1023 ltrs.) was produced in the month of April, whereas lowest milk production (167 ltrs.) was recorded in the month of November 2014. The highest net income (Rs 105415) was recorded in dairy component with a B:C ratio of 1.57. Fish production and horticulture based system in which the vegetable crops were grown with the fruit plants on pond dikes generated income of Rs 90627 and Rs 18092 with B:C ratios of 8.04 and 3.40, respectively (Table 13) and proved highly beneficial to the farmers.

The greatest advantage of adopting diversified agriculture system is round the year income and employment for the farm family. The month wise income from diversified agriculture system as compared to rice-wheat system where farmer get income twice in a year is shown in Fig. 13.

*Performance of rice, maize, wheat, potato and berseem crops under diversified agriculture system*

**Table 13 : Income generated from multi-enterprise agriculture model during Jan. to Dec. 2014**

| Sl. No. | Agri. components | Area (ha) | Gross income (Rs.) | Total cost (Rs.) | Net income (Rs.) | B:C ratio |
|---|---|---|---|---|---|---|
| 1 | Rice-wheat-moong | 0.4 | 95900 | 22231 | 73669 | 4.31 |
| 2 | Rice - oats | 0.2 | 61900 | 21035 | 40865 | 2.94 |
| 3 | Maize-wheat-moong | 0.4 | 65000 | 30879 | 34121 | 2.10 |
| 4 | Horticulture | 0.2 | 17385 | 12500 | 4885 | 1.39 |
| 5 | Vegetables | 0.2 | 57075 | 32629 | 24446 | 1.75 |
| 6 | Fodder | 0.4 | 36550 | 27251 | 9299 | 1.34 |
| | **Sub Total-1** | | **333810** | **146526** | **187284** | **2.28** |
| 7 | Subsidiary Components | 0.2 | | | | |
| | Milk, compost, biogas | | 288768 | 183353 | 105415 | 1.57 |
| | Fish production | | 103500 | 12873 | 90627 | 8.04 |
| | Fruits/Veg. (Pond area) | | 25620 | 7528 | 18092 | 3.40 |
| | Poultry | | 43878 | 39167 | 4711 | 1.12 |
| | **Sub Total-2** | | **461766** | **242921** | **218845** | **1.90** |
| | **Total** | **2** | **795576** | **389447** | **406129** | **2.04** |

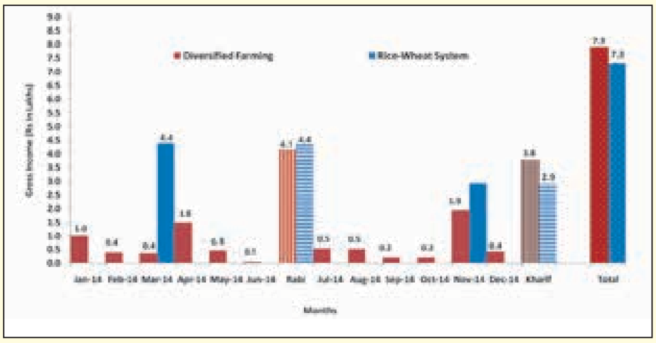



*Fig. 13 : Trend of monthly income generated from diversified farming Vs rice –wheat system*

The gross annual income from diversified agriculture system was Rs. 7.9 Lakhs, whereas income from rice-wheat system was Rs. 7.3 lakhs. The annual employment generated from diversified agriculture system was 745 mandays in 2014.

Seepage is a major component of water balance in the pond, affecting quality of pond water and water table around the pond. For this purpose, water table around the pond was monitored (Table 14). Observation wells are within 100 m around the pond.

It is evident from the table that in few cases water table has reached near the soil surface. Study revealed that these rising water table may result in perched water table depending upon formation of geological strata, and needs consideration while constructing a pond in a particular area.

**Table 14 : Observation well data during 2014 around the pond for seepage study**

| Sr No. | Date | Depth of water table in observation well no.1 (ft) | Depth of water table in observation well no.4 (ft) |
|---|---|---|---|
| 1 | 28.05.14 | 2.0 | 13.17 |
| 2 | 27.06.14 | 1.23 | 15.18 |
| 3 | 03.09.14 | 1.26 | 17.08 |
| 4 | 09.11.14 | 1.28 | 19.15 |

## Green house gas (GHG) estimation

The Cool Farm Tool (CFT) model used to estimate GHGs emission integrates several globally determined empirical GHG quantification models in one tool. It considers soil and climatic characteristics, plot area and total production, crop management such as fertilizer and pesticide applications; land-use and management such as tillage system and use of cover crops, compost, manure and residue. Similarly, total energy consumed per plot during entire crop cycle was also included to calculate GHGs emission from machinery use and fuel consumption.

Estimated GHG emission per unit area was influenced by the crop diversification and management strategies (Fig. 13). Estimated total GHG emission i.e. global warming potential (GWP) per hectare in terms of $CO_2$ equivalent ($CO_2$-eq) was different amongst different crop production systems. On average, rice-wheat system emitted 1.82 t $CO_2$-eq, whereas, maize- wheat, fodder, vegetables and horticulture emitted 0.41, 0.25, 0.19 and 0.12 t $CO_2$-eq from the respective allocated area of these cropping systems (Fig. 14). The total emission from 1.8 ha area under diversified cropping system was 2.78 t $CO_2$-eq as compared to 5.15 t $CO_2$-eq from the rice–wheat system in the same area. On hectare basis, diversified agriculture system emitted 1.55 t $CO_2$-eq $ha^{-1}$ as compared to 2.86 t $CO_2$-eq $ha^{-1}$ in rice- wheat system. The global warming potential under diversified agriculture system was 46 per cent (1.32 t $CO_2$-eq $ha^{-1}$) lesser than that of rice-wheat.

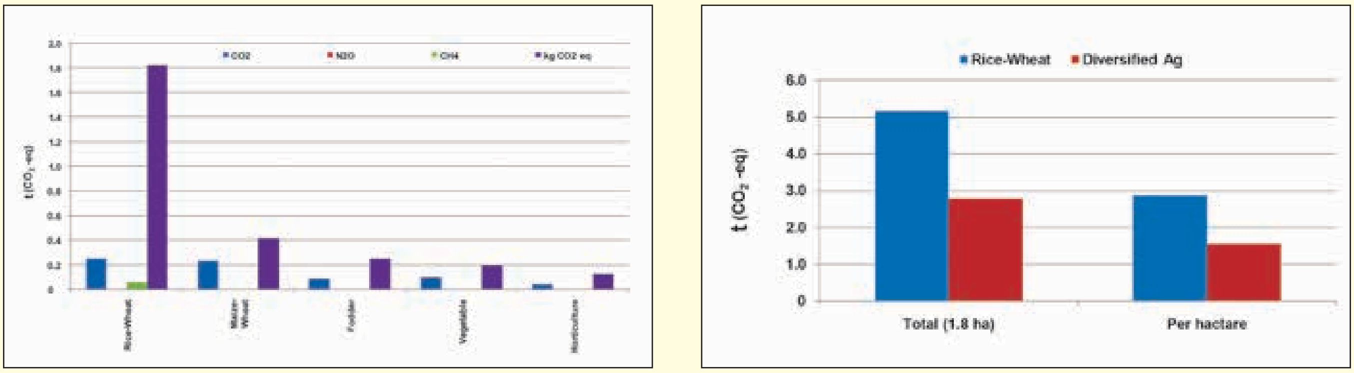



*Fig. 14 : Estimated $CO_2$ emissions under various components of diversified farming*

# 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)

Haryana is a forefront state in implementation of subsurface drainage (SSD) projects for amelioration of waterlogged saline lands. Out of 9461 ha area provided with SSD by Haryana Operational Pilot Project (HOPP) with technical collaboration with CSSRI till July 2014 over last 2 decades, 6300 ha has been covered under SSD in past 10 years with funding under Ministry of Rural Development (MORD, GOI) and RKVY schemes.

### Selection of SSD project Sites

During 2014-15, CSSRI team undertook 6 visits to 18 new sites identified by HOPP for possible execution of SSD projects. Based on extent and severity of waterlogging and salinity problem, analysis of collected soil and water samples and outfall conditions as well as interaction with farmers, CSSRI-HOPP team identified and recommended the installation of subsurface drainage in 4800 ha water logged saline area in 5 districts to Haryana Govt., including 1300 ha in Sirsa, 200 ha in Sonipat, 1200 ha in Jhajjar, 600 ha in Fatehabad and 1500 ha in Rohtak district (Table 15). All sites were characterizes by shallow (Watertable < 2m) groundwater and marginal to highly saline soil (threshold $EC_e$: 4 dS $m^{-1}$) and groundwater (threshold $EC_{gw}$: 2 dS $m^{-1}$). Further, at almost all sites, a main or link surface drain is available for discharge of drainage water and surface water supplies are reasonably good for cropping. At these sites, HOPP will conduct field surveys and investigations and propose detailed SSD designs for CSSRI approval / revision and final funding and execution.

**Table 15: Soil and groundwater conditions in proposed SSD sites during 2014**

| Distt./ date of visit | Villages | Area covered (ha) | Soil sample ECe (0-30 cm) | Water table depth (m) | Water EC | Drain availability |
|---|---|---|---|---|---|---|
| Sirsa 02-06-2014 | Lohgarh | 200 | 1.76-12.52 | < 1.0 | 0.27-25.50 | Main Drain |
| | Jottawali | | 9.33-9.54 | | 1.41-4.16 | No Drain |
| Sonipat 30-06-2014 | Ahulana | 200 | 7.84-10.68 | 1.0 to 1.3 | 0.63 - 5.87 | Main drain |
| Jhajjar 30-06-2014 | Palda | 300 | 12.71-16.85 | < 1.0 m | | Link drain |
| | Mangawas | 400 | 3.53-4.79 | < 1.0 m | 5.78 | Main drain |
| | Bisan | 500 | 1.06 -31.38 | 1.39-2.11 m | 10 & 40 | Main drain |
| | Kheri Khumbar | | 10.84-37.31 | < 1.0 m | 39.70 | Main drain |
| | Jahajgarh | | 6.33-12.3 | < 1.0 m | | Link drain |
| Fatehabad Aug., 2014 | Pili Mandori | 600 | | < 2 m | 8.7 | Link drain |
| | Thuian | | | | 7.5 | Link drain |
| | Mehuwala | | | | 4.6 | Link drain |
| Rohtak 15-09-2014 | Kahni | 500 | 20.2-39.6 | < 1.0 m | 3 to 11.4 | Main Drain |
| | Shanghi | | 6.0-26.9 | | 5.1 to 5.6 | Link Drain |
| | Rithal Narwal | | 2.4-18 | | 2 to 3.4 | Main Drain |
| Rohtak 08-12-2014 | Baniyani | 1000 | 6.0-56.7 | 1.4 m | 3.8 to 19.5 | Link Drain |
| Sirsa 16-02-2015 | Gudia Kheda | 100 | 2.68-11.36 | < 1.5 m | 0.3-07.5 | Main Drain |
| | Shakkar Manduri | 1000 | 4.36-39.5 | < 1.5 m | 4.2-11.5 | No Drain |

## Evaluation of existing SSD projects

During 2014-15, the impact of SSD systems was evaluated for Siwana Mal (Distt. Jind), Mokhra Kheri (Distt. Rohtak) and Ban Mandori (Distt. Fatehabad) project sites. Due to less concrete progress on construction of pump houses, formation of farmers' drainage societies (FDS) and distribution of pump sets to farmers, summarized from input of HOPP in Table16, the improvements in crop yields and economic return have remained non- satisfactory at a number of locations leading to discontentment among farmers.

However, visible improvements were observed in selected blocks where pumping was initiated either due to HOPP or individual farmers' efforts. In Mokhra Kheri, shallow watertable conditions existed in all blocks due to insufficient pumping in different months. Higher salinity (1.5- 24.4 dS $m^{-1}$) of drainage water in blocks 1,2,3,5,6 and moderate salinity (0.6- 4.0 dS $m^{-1}$) levels in block 4,7,9,10 reflect the differences in the extent of leaching and pumping efforts in different blocks with virtually no pumping in first group of six blocks. Highly saline drainage waters (EC> 10 dS $m^{-1}$) in blocks 1,2,3 were also characterized by high SAR (> 15).

In Siwanamal, notable increase in crop yields (30- 110 % in rice; 20- 120 % in wheat) over pre- drainage levels were observed in SSD blocks (Fig.15) with sporadic pumping efforts of HOPP and individual farmers. Despite the fact that absolute values of rice and wheat yields in different SSD blocks have been well below the potential yields in normal soils, economic analysis based on gross income, operational and input cost in selected SSD blocks indicated a benefit cost ratio of 1.56 and 1.13 for rice and wheat respectively.

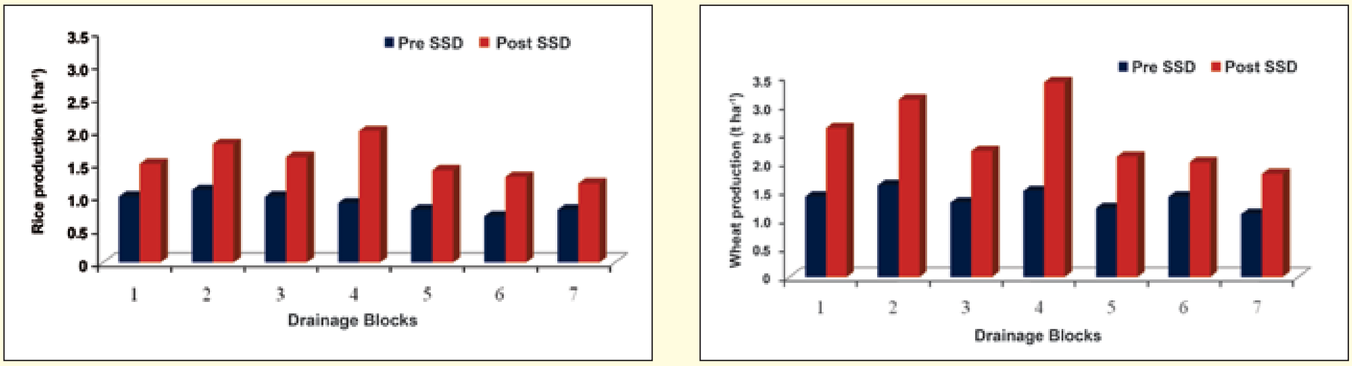



*Fig. 15: Rice and Wheat productivity before and after SSD installation at Siwanamal*

**Table 16: Summary statement on construction of pump houses, formation of FDS and distribution of pump sets to farmers in SSD projects in Haryana (March 2014)**

| Scheme (Districts) | Year of operation | Area (ha)# | No. of blocks | Pump houses | | FDS | | Pump sets | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | C* | P** | C* | P** | C* | P** |
| **MORD** (Jhajjar I, Bhiwani, Sonepat I, Sirsa) | 2003- 2010 | 3325/ 4600 | 65 | 55 | 10 | 65 | - | 37 | 28 |
| **RKVY** (Fatehabad, Jhajjar II, Palwal, Rohtak I, Jind, Sonepat II) | 2009- continuing | 3012/ 4900 | 87 | 22 | 65 | 75 | 12 | 23 | 64 |

# Actual completed/ Total sanctioned; C*: Completed, P**: Pending

Based on field visits to evaluate the performance of existing SSD projects, it can be stated that SSD projects in the past resulted in expected and timely enhancements in crop yields and farmers' income. However, exponential increase in SSD project areas and workload of HOPP with the available infrastructure and manpower are leading to certain inherent constraints in the operation of new SSD projects. This is substantiated by the fact that against an annual target of reclaiming 1000 ha area using 3 trenchers. HOPP could implement SSD in only 681 and 721 ha area only due to early rain and break down of machinery during 2013 and 2014, respectively.

## Study on Backpressure in Subsurface Drip Irrigation Prioritizing Field Study Utilizing Sewage Water (R.S. Pandey and Anshuman Singh)

The study on backpressure was started during 2006. At present, the results of the new research project on the study of backpressure prioritizing field study are reported. The experimental set up consisting of subsurface drip irrigation system involved 2 treatments for using sewage water and tube well water in plots covering 9 plants each of Guava and *Amla*. Each plant was irrigated by a 12 mm PE pipe, connected on other side to the 40 mm diameter PVC sub-main which was further connected to screen filter of the control head through a main line.

Each plant was provided with an emitter coil of 4 m length in a circle form of about 1.2 m diameter around the plant. 20 turbo type emitters having nominal discharge of 8 lph were equally spaced on each coil. The depth of the emitter coil was kept at 50 cm. The control head consisted of a mono block centrifugal 3 hp pump which was placed in a pit at around 50 cm depth for proper functioning of foot valve, particularly in sewage water use plots. A sand and another screen filter for removing the sediments and 2 water tanks of 2000 l capacity for storing of water were used in the experiment. Both Guava and *Amla* plants are at present 8 years old having the shading in almost entire area of the field. The shaded area was used to determine the crop water requirement.

In the beginning the system was tested by operating the flush valve. There was flow from the flush valves ranging from 24 l/minute to 30 l/minute at 0.5 kg cm$^{-2}$ pressure. The features of pump, water flow and computed backpressure for different sets of studies are presented in Table 17.

**Table 17 : Testing of installed drip system for its performance**

| Sr. No. | Duration of pump operated (minute) | Pressure (kg cm$^{-2}$) | Water flow from the set up (liter) | Back-pressure (kg cm$^{-2}$) |
|---|---|---|---|---|
| 1 | 15 | 1 | 137.70 | 0.85 |
| 2 | 20 | 1 | 229.50 | 0.77 |

**Table 18 : Estimated backpressure in subsurface drip system using water flow approach**

| Treatment | Pumping duration (minute) | Pressure (Kg/cm$^2$ | Flow of water (liter) | Back pressure (Kgcm$^{-2}$) |
|---|---|---|---|---|
| Tube well water for *Amla* | 10 | 5 | 214.2 | 4.20 |
| | 10 | 1 | 8.0 | 0.99 |
| | 10 | 1 | 8.0 | 0.99 |
| | 10 | 1 | 46.0 | 0.96 |
| Sewage water for *Amla* | 10 | 1 | 61.2 | 0.94 |
| | 10 | 1 | 153.6 | 0.59 |
| | 10 | 1 | 183.6 | 0.42 |
| Sewage water for Guava | 10 | 1 | 107.1 | 0.80 |
| | 10 | 1 | 183.6 | 0.42 |
| | 10 | 1 | 176.0 | 0.46 |
| Tube well water for Guava | 10 | 1 | 130.1 | 0.71 |
| | 10 | 1 | 23.0 | 0.99 |
| | 10 | 1 | 53.6 | 0.95 |

From earlier experiments, the backpressure estimated from a soil parameter based approach for same site did not exceed 0.331 kg cm$^{-2}$ much less than the estimated values derived in these studies (Table 18).

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

Climate of Haryana is arid to semi arid with the average rainfall of 35.5 cm. About 85 per cent of total rainfall is received during monsoon period of June to September. Hydro-geological situations of Haryana can be described as the regions comprising high yielding fresh water aquifers where rice-wheat cropping is practiced and saline ground water regions where aquifers of relatively poor transmission characteristics. The ground water table, particularly in fresh groundwater zone, is declining at alarming rate about 30-100 cm per year. The objective of the project is to study the role of innovative agronomic interventions for reducing ground water withdrawal in Haryana

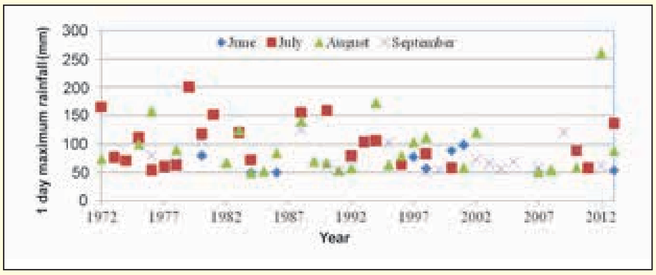



*Fig 16 : Frequency of one day maximum rainfall in monsoon months at Karnal*

and their impact on natural groundwater recharge under changing climate scenarios.

The variability in historical climate data of Karnal was studied and future climate scenarios were generated to study its impact on crop water requirement. The historical 41 years (1972-2013) climatic data of Karnal was analyzed to study the rainfall pattern of the area. The analysis shows that mean annual rainfall of 753 mm of Karnal district is characterized by high variability (CV=33.8%) with observed rainfall ranging from 340.7 mm during 2006 (driest year) to 1339.9 mm in 1988 (wettest year). Monsoon rainfall contributed 79% of the total annual rainfall with high coefficient of variation (CV= 39%). Monsoon rainfall categorization based on long period average (LPA) and coefficient of variation (CV) of the corresponding monsoon season in Karnal observed that in the last ten years (2003-13), 6 year received deficit rainfall (18-57 % lower than long term average), 2 year normal rainfall and only 2 year excess rainfall event (9-70% higher than long term average). In early two decades (1981-90 and 1991-2000), one day maximum rainfall (≥ 50 mm) was confined mainly in June and July months, but in the last 13 years (2001-2013) it was shifted to August and September months (Fig. 16).

## Haryana

The future daily climate data was generated by using ClimGen model and then used in CROPWAT computer program for estimating future crop water requirement. The CLimGen model was parameterized first by using daily rainfall, maximum (Tmax) and minimum (Tmin) temperature for 1980- 2005 climate data of Karnal. The daily series data of temperature and rainfall for 2006-10 was generated and agreement between observed and generated climate data was evaluated. The performance indicators used for validation of ClimGen model are given in Table 19. Fairly high index of agreement between (0.9 and above) for temperature indicates that model can be used for generating future daily temperature with good agreement. However, poor agreement between observed and generated daily rainfall data was recorded. The daily temperature and rainfall data were generated for coming years.

The average daily climate data of the period 2006-25, 2026-50, 2051-75 and 2076-99 was used as input parameter for CROPWAT model and future crop water requirement was estimated. The estimated evapo- transpiration, effective rainfall and net irrigation requirement for different crops are presented in Table 20.

It was found that crop water demand of rice and maize will decrease in coming future, while in wheat more water would be required to get

**Table 19: Performance indices for validation of ClimGen model**

| Parameters | RMSE | Model efficiency | Index of agreement |
|---|---|---|---|
| Temperature (max) | 4.24 | 0.62 | 0.90 |
| Temperature (min) | 3.58 | 0.79 | 0.94 |
| Rain | 11.30 | -0.89 | 0.15 |

**Table 20 : Modeling futuristic crop water demand of different crops**

| Year | ETc (mm) | Effective rain (mm) | Net irrigation requirement (mm) |
|---|---|---|---|
| Transplanted rice | | | |
| 2006-25 | 658.1 | 395.6 | 289.4 |
| 2026-50 | 637.0 | 375.5 | 294.3 |
| 2051-75 | 651.7 | 395.0 | 284.3 |
| 2076-99 | 657.1 | 430.0 | 242.7 |
| Wheat | | | |
| 2006-25 | 339.8 | 122.5 | 216.5 |
| 2026-50 | 340.0 | 114.6 | 229.9 |
| 2051-75 | 345.4 | 106.4 | 238.2 |
| 2076-99 | 336.6 | 113.5 | 223.2 |
| Maize | | | |
| 2006-25 | 399.0 | 379.4 | 113.9 |
| 2026-50 | 382.6 | 362.1 | 95.7 |
| 2051-75 | 395.4 | 378.1 | 97.5 |
| 2076-99 | 397.0 | 407.9 | 95.3 |

potential yield due to variation in predicted temperature and rainfall during different scenarios from 2006 to 2099 period.

Field studies on wheat crop were undertaken to develop a schedule of deficit irrigation based on evapo-transpiration and crop stages. The treatments imposed were -$T_1$- 50 % deficit irrigation at all stages, $T_2$-25 % deficit irrigation at all stages, $T_3$-no deficit irrigation at all stages, $T_4$ -no deficit irrigation at all stages with mulch, $T_5$-25 % surplus irrigation at all stages, $T_6$- farmer's practice (7cm), $T_7$-50 % deficit irrigation except CRI and milking stages, $T_8$-25 % deficit irrigation except CRI and milking stages, $T_9$-50 % deficit irrigation except at CRI stage, $T_{10}$-25 % deficit irrigation except at milking stage , $T_{11}$-50 % deficit irrigation except at milking stage, $T_{12}$-25 % deficit irrigation except at CRI stage. The deficit irrigation trial was initiated under two agro-techniques i.e. tilled and zero tiled condition. No tillage operation was conducted in zero tilled plots for last 3 years. Modified Penman-Monteith equation was used to calculate potential evapo- transpiration. The irrigation was applied precisely through water meter and plastic delivery pipe. Horizon wise soil samples upto 90 cm depth were collected to determine soil water content (SWC). Leaf area and transpiration during respective growth stages were monitored by leaf area meter (LICOR) and ERGA respectively while dry matter accumulation was determined from average biomass of 5 plant samples collected at different stages.

A total rainfall of 170.8 mm received during the season and mostly in the month of January, February and March at 6-7 days interval. Because of adequate and uniformly distributed rainfall, treatment on tillering stage could not be imposed. The treatments 50, 75 and 100% PET saved water by 150, 101, and 61 per cent, respectively as compared to farmer's practice of applying irrigation of 7 cm depth. There was no significant difference in yield among different treatments, probably due to fact that crop did not experience water stress in presence of uniformly distributed 17.8 cm of winter rain. However, variable irrigation water applied at crown initiation stage did not show any detrimental effect on crop yield.

### 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)

The effective characterization and control of regional soil salinity requires the knowledge of its magnitude and spatio-temporal variability. This requires cost-effective, rapid, and reliable methodologies for determining soil salinity


*Experimental set up to apply precise amount of water to the field*


*Using ERGA to determine physiological parameters of wheat* *in-situ* and its structured presentation using modeling and geo-statistical techniques. The EM surveys were conducted at 20 m x 20 m grid at 280 locations during post-monsoon season 2013, out of which 40 point locations were selected for collecting soils samples upto 90 cm depth at 15 cm depth increment (i.e., 0–15, 15–30, 30–60 and 60–90 cm). The soil samples were analyzed for electrical conductivity of saturated extract ($EC_e$), pH, cations ($Ca^{2+}$, $Mg^{2+}$and $Na^{+1}$), anions ($CO_3^{-2}$, $HCO_3^{-1}$, $Cl^{-1}$) and sodium adsorption ratio (SAR) using wet chemistry procedures. Calibration equations for converting EC and SAR were derived using the multiple linear regression (MLR) model included in the EC Sampling Assessment and Prediction Program (ESAP) package developed by the US Salinity Laboratory. High correlation coefficient ($R^2$) 0.75, 0.82, 0.82, 0.85 and 0.89 were observed between measured $EC_e$ and model predicted ECe in 0-15, 15-30, 30-60, 60-90 and 0-90 cm layer, respectively (Table 21). Average soil salinity in the farm was 17.4 dS $m^{-1}$ and ranged between 3-35 dS $m^{-1}$ (Table 22 and Fig.17) Soil salinity was highest in 0-15 cm soil layer (average 21 dS $m^{-1}$) and ranged between 5- 46 dS $m^{-1}$ due to strong evaporative demand of the atmosphere which brings salt to the soil surface through capillary rise.

In the summer season of both 2013 and 2014, mean groundwater table exists between 3.3-3.4 m below the ground surface (2013 and 2014) and corresponding groundwater salinity was 10.5-12.6 dS $m^{-1}$ (Table 23). A constant rise in water table was recorded in all observation wells during monsoon

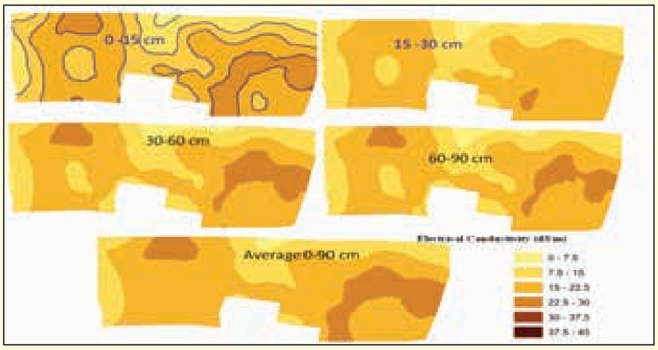



*Fig 17 : Spatial distribution of ESAP model estimated soil salinity at Nain*

months which raised the groundwater table to within 1-1.5 meter from soil surface and reduced the ground water salinity to 2.3-4.2 dS $m^{-1}$.

## 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, R.S. Tripathi, and D.K. Sharma)

The *Irri-agro Informatics Spatial Database* of WYC command on ArcGIS 10 platform was updated for daily inflow data of distributaries and minors for the *rabi* season 2013-14. During 2013-14, four canal irrigations were supplied to wheat and other *rabi* crops at 52 per cent intensity in the Butana distributary command where groundwater is of relatively saline-sodic and saline quality in mid and tail reaches. Two groundwater irrigations in these reaches during February end and mid-March and normal winter rainfall (30.3 mm) resulted in

**Table 21 : Multiple linear regression (MLR) models for estimating saturated paste electrical conductivity (based from electromagnetic induction (EMI) readings at different soil depths (2014)**

| Parameter | Model details | 0-15 cm | 15-30 cm | 30-60 cm | 60-90 cm | Average 0-90cm |
|---|---|---|---|---|---|---|
| $EC_e$ | Model selected | ECe = b0 + b1(z1) + b2(z2), Z1-EMh ; Z2- EMv | | | | |
| | Model $R^2$ | 0.7493 | 0.8159 | 0.8177 | 0.8457 | 0.8869 |
| | RMSE | 7.3936 | 5.2566 | 4.8366 | 4.2555 | 3.8853 |
| | P | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |

**Table 22 : Descriptive statistics of soil salinity (ECe-dS $m^{-1}$) of Nain farm in different soil layers**

| | 0-15cm | 15-30 cm | 30-60 cm | 60-90 cm | 0-90 cm |
|---|---|---|---|---|---|
| Mean | 21.0 | 15.7 | 16.6 | 16.4 | 17.4 |
| Standard Error | 0.6 | 0.5 | 0.5 | 0.5 | 0.5 |
| Median | 20.7 | 15.5 | 16.4 | 16.4 | 17.7 |
| Standard Deviation | 8.9 | 7.8 | 8.0 | 7.6 | 8.0 |
| Minimum | 5.9 | 1.9 | 0.3 | 1.0 | 2.3 |
| Maximum | 46.8 | 37.0 | 33.0 | 31.9 | 35.9 |

**Table 23 : Temporal changes in ground water depth and salinity in different observation wells at Nain farm**

| Observation wells | 10th July, 2013 | | Sep , 2013 | | July, 2014 | | Oct, 2014 | | Change (2013-14) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | WTD (m) | EC (dS $m^{-1}$) | 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 | 3.0 | 3.8 | | | 0.2 | 0.4 |
| PZM 2 | 2.7 | 11.32 | 1.1 | 12.0 | 2.9 | 13.0 | 1.9 | 13.2 | 0.2 | 1.7 |
| PZM 3 | 2.9 | 4.7 | 1.5 | 4.8 | 3.1 | 13.1 | 2.1 | 13.0 | 0.2 | 8.4 |
| PZM 4 | 3.4 | 13.26 | 0.8 | 2.5 | 4.0 | 2.8 | 1.8 | 1.2 | 0.6 | -10.5 |
| PZM 5 | 3.4 | 14.79 | 0.8 | 2.3 | 3.9 | 13.0 | 2.0 | 7.8 | 0.5 | -1.8 |
| PZM 6 | 3.8 | 23.10 | 1.2 | 23.0 | 3.9 | 15.4 | 1.5 | | 0.1 | -7.7 |
| PZM 7 | 3.5 | 16.98 | 2.3 | 16.4 | 3.5 | 15.8 | 3.1 | 16.4 | 0.0 | -1.2 |
| PZM 8 | 3.6 | 17.82 | 1.2 | 10.2 | 3.7 | 10.6 | 1.9 | 10.6 | 0.0 | -7.2 |
| PZM 9 | 2.9 | 13.61 | 1.9 | 13.8 | 3.3 | 15.4 | 3.2 | 15.5 | 0.4 | 1.8 |
| PZM 10 | 3.5 | 12.3 | 1.1 | 6.6 | 3.9 | 12.9 | 1.7 | 0.8 | 0.3 | 0.6 |
| PZM 11 | 3.4 | 11.79 | 0.8 | 3.6 | 3.2 | 10.4 | 1.6 | 0.7 | -0.2 | -1.4 |
| PZM 12 | 3.3 | 3.23 | 1.0 | 9.7 | 3.0 | 14.0 | 1.6 | 13.3 | -0.4 | 10.7 |
| PZM 13 | 3.2 | 3.27 | 0.9 | 3.5 | 3.4 | 15.2 | 1.5 | 14.7 | 0.1 | 11.9 |
| PZM 14 | 3.3 | 14.15 | 0.9 | 10.9 | 3.4 | 10.5 | 1.5 | 9.8 | 0.1 | -3.7 |
| PZM 15 | 3.9 | 20.6 | 0.6 | 2.4 | 2.3 | 11.7 | 0.9 | 3.4 | -1.5 | -8.9 |
| PZM 16 | 3.7 | 20.7 | 1.5 | 5.8 | 3.4 | 1.3 | 2.0 | 0.8 | -0.3 | -19.4 |
| PZM 17 | 3.3 | 13.81 | 1.1 | 13.9 | 3.5 | 14.4 | 1.6 | 14.2 | 0.2 | 0.5 |
| PZM 18 | 2.32 | 2.15 | 1.0 | 2.1 | 3.7 | 2.6 | 1.6 | 2.3 | 1.4 | 0.5 |
| Av | 3.3 | 12.3 | 1.1 | 8.1 | 3.4 | 10.9 | 1.8 | 8.6 | 0.1 | -1.4 |
| STD | 0.40 | 6.54 | 0.45 | 6.00 | 0.43 | 4.86 | 0.57 | 6.06 | | |

bumper wheat yield (3.92-4.75 t $ha^{-1}$). The water supply to demand ratio in Butana Gangesar and Kahnaur distributary during the *rabi* season was 78, 48 and 42 per cent, respectively. It was also observed that canal water has met 46 per cent of the irrigation demand.

An improved version of 1.1 DSS program (Fig. 18) was developed in MS Visual C#.NET programming language by integrating database,

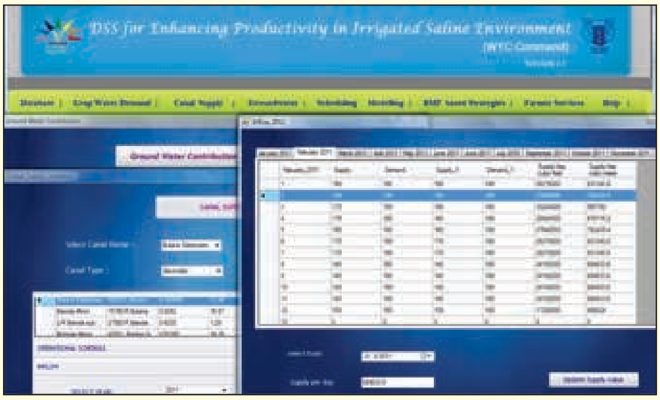



*Fig. 18 : Screen capture of improved user interface of DSS displaying canal supply module.*

five modules and crop-water-salinity-yield functions, AquaCrop and SWAP models to assess the resource constraints and to generate and evaluate the BMPs for enhancing productivity under saline environment One of a modules *database* module displays eight thematic data sets for assessing the prevailing six or more saline environments/constraints. The *Crop Water Demand* module computes the crop ET from daily weather data for 2001-14 using Penman-Monteith method and weekly Kc. The irrigation demand at watercourse outlet is then computed from aggregation of water demand of various crops after subtracting effective rainfall and capillary water, and adding conveyance and application losses. The *Canal Supply* module computes the canal supply and irrigation gap to meet full crop water demand whereas the *Groundwater* module computes the groundwater share and quality. In *Irrigation Scheduling* module, irrigation schedules to maximize/optimize yield are generated for wheat and other crops under one of the four options-canal or fresh groundwater supplies, deficit irrigation, conjunctive use with poor quality waters and both water and salinity stresses.

In Modelling, crop-water-salinity-yield functions along with AquaCrop and SWAP models were integrated. The crop yield response sub-module for six saline environments in the WYC command *viz,* surface water stagnation, waterlogging, soil salinity, soil sodicity, saline/sodic water irrigation, and deficit irrigation was developed to predict crop yield reduction and to recommend BMPs for minimizing the yield loss. The relative yield loss for five major crops (wheat, barley, mustard, pearlmillet and pigeon pea) under water stagnation and waterlogging condition could be predicted and BMPs were recommended for minimizing crop yield. The relative yield loss in soil salinity and sodicity could be predicted for root zone salinity (ECe) and sodicity (ESP) values at sowing, mid and harvest time for five crops. The BMPs for four salinity ranges (ECe < 4, 4-8, 8-12 and >12 dSm$^{-1}$) and three ESP ranges (< 20, 20-50 and >50%) were recommended for minimizing yield loss (Fig. 19). The gypsum requirement (GR) could be computed using Schoonover's formula or standard GR graph.

Water quality in saline/sodic water irrigation and its permissible range under different agro-climatic zones were assessed. The relative yield loss can be predicted for any water salinity values for five crops and BMPs are suggested for minimizing yield loss. In deficit irrigation, phenological growth stages for five crops were assessed and a deficit irrigation strategy based on number of expected irrigations is suggested. SWAP and AquaCrop models could be applied to simulate rootzone salinity build-up and crop productivity wherever adequate input data are available as these models. Information on soil and water testing facilities, salt tolerant and high yielding wheat varieties, and link to project website and state line departments are also provided for use by stakeholders. The Hindi support to DSS program was also developed.


*Fig. 19 : Screen captured window of crop-water-salinity-yield module for six prevailing saline conditions*

The crop-water-salinity-yield functions for soil salinity and sodicity were validated from six field data sets. The relative crop yield loss was predicted for various rootzone salinities (ECe) at different growth stages for wheat (Fig. 20). 121 officers/engineers from CADA, Agriculture and Irrigation Departments, KVKs, Research Stations and NGOs were imparted skills on use of database and DSS program. Similarly, 1194 members from canal WUA and farmers were imparted knowledge on DSS generated BMPs interventions in six saline environments including deficit irrigation.

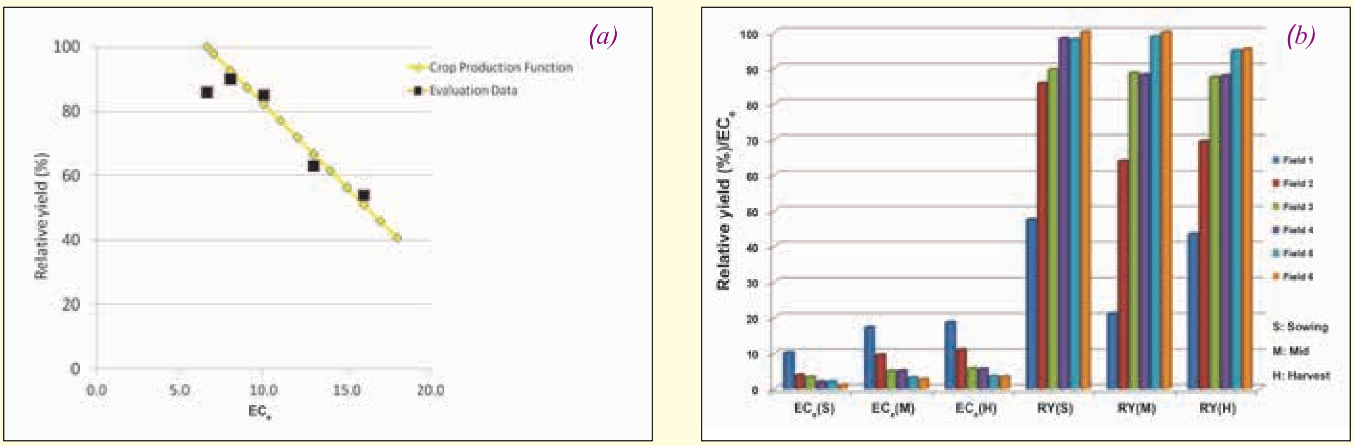



*Fig. 20 : Evaluation of crop production functions with field data for wheat (a) and yield prediction of six fields with sowing, mid and harvest time ECe (b)*

# MANAGEMENT OF MARGINAL QUALITY WATER

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

Temporal changes in growth, transpiration and evapo-transpiration of wastewater irrigated Bhadrachalam clone Eucalyptus (*Eucalyptus tereticornis*) plantation was measured during 10th year of growth. Water use, transpiration rate, plant height, diameter at stump height (DSH) and breast height (DBH) of *Eucalyptus* plantation were measured under irrigation regimes of 1.0, 2.0, 2.5 and 3.0 IW/CPE. Heavy metals accumulation and water use potential of lemongrass (*Cymbopogon fluxuosus*) was also measured under variable irrigation regimes (0.6, 0.8, 1.0, 1.2 and 1.5 IW/CPE ratio) of either wastewater alone or in cyclic use mode with tube well water.

During 10th year of growth height, DSH and DBH of *Eucalyptus* increased from 17.3 to 21.4 m, 18.1 to 26.8 cm and 16.4 to 22.5 cm, respectively under rainfed to wastewater irrigation at 2.0 IW/CPE. However, there was no significant increase with further increase in irrigation frequency to 2.5 and 3.0 IW/CPE. Average daily transpiration rate varied from 2.4 to 6.4 mm/day under rainfed to irrigation at 2.5 IW/CPE ratio. Total annual consumptive use of water increased from 897–2175 mm under rainfed to wastewater irrigation scheduled at 3.0 IW/CPE. Observations recorded during this year have confirmed that transpiration rate of differentially wastewater irrigated *Eucalyptus* plantations peaked during 6th year of growth when irrigated at 2.0 IW/CPE. Similarly, the consumptive use of water also did not increase much after 8th year of growth (Fig. 21).

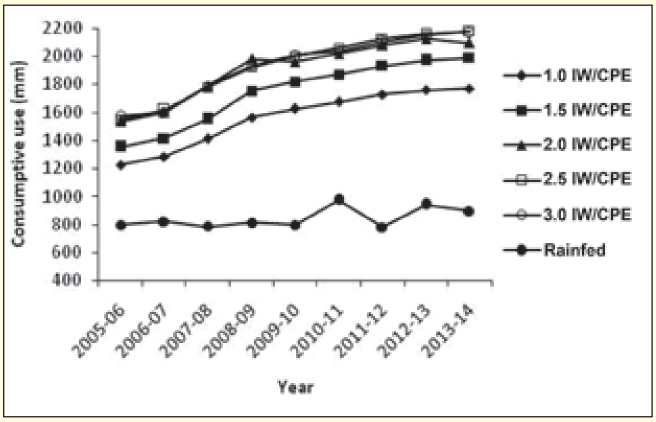



*Fig. 21 : Changes in consumptive use (mm) of Eucalyptus during different years of growth*

Fresh and dry biomass of lemongrass increased significantly from 3.24 to 4.39 and 0.91 to 1.18 kg $m^{-3}$, respectively with increasing frequency wastewater irrigation from 0.6 to 1.2 IW/CPE. Similar trend in fresh and dry biomass with lower magnitude was observed under increasing combined use of wastewater groundwater and groundwater alone. Though essential oil yield also increased from 13.8, 15.1, 17.5, 17.3 and 17.8 ml $m^{-2}$ with increasing wastewater application regimes up to 1.5 IW/CPE ratio but significant increase was recorded only up to 1.0 IW/CPE. Contents of metals in lemongrass oil increased with increasing application of wastewater but remained within the safe limits. Increasing loads of wastewater consistently increased soil salinity, organic carbon, and available status of N, P, K, Zn, Fe and Cu.

**Development of Effective Salt Tolerant Microorganisms to Mitigate Salt Stress for Higher Crop Production in Salt Affected Soils** (P.K. Joshi)

High concentration of salts in soil has a detrimental effect on crops and micro-organisms. Salt tolerant microbes help plants in overcoming the effect of salt stress by different mechanisms. They can alter the availability of nutrients so as to maintain Na, K ratio in plants. They are also involved in production of anti-oxidants to prevent injury to the plants because of salt stress. They can alleviate salt stress by production of plant growth promoting (PGP) substances like indole acetic acid (IAA), phosphorus solubilization, siderophore and ammonia production. This ability of microbes to alleviate salt stress in crops varies greatly among microorganisms in salt affected soils. Hence, there is need to develop effective salt tolerant microorganisms for higher crop productivity in salt affected soils.

**Isolation of salt tolerant micro-organisms from salt affected soils:** Collected 68 different soil samples from salt affected areas. The $pH_2$ and $EC_2$ of these samples varied from 7.9 to 10.9 and 0.987 to 15.75 dS $m^{-1}$, respectively. 211 bacterial isolates and 11 actinomycetes isolates were isolated from these soil samples on nutrient and Ken knight medium containing 5 per cent sodium chloride. These micro-organisms were purified by streaking methods and maintained on slants for

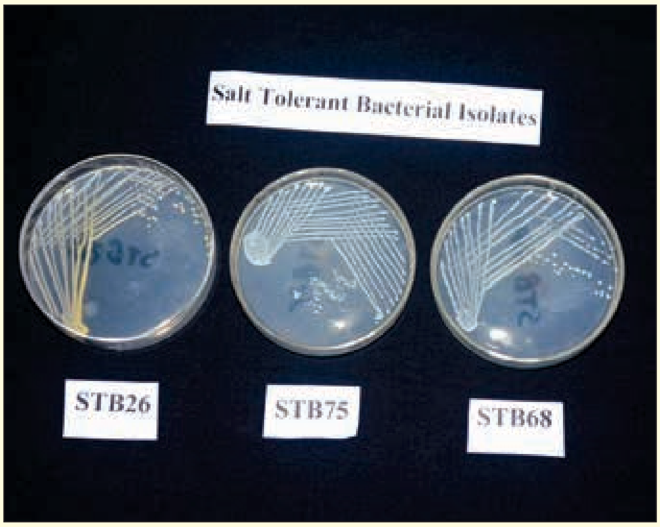



*Fig. 22 : Salt tolerant bacterial isolates on nutrient Agar at 5% NaCl concentration*

further use (Fig. 22). These bacterial isolates were further screened for tolerance to sodium chloride at 10, 15 and 20 % NaCl in nutrient broth and observing optical density after 48 hours. Similarly, actinomycetes isolates were screened for tolerance to NaCl on solid Ken knight medium containing 10, 15 and 20 per cent NaCl. Forty three bacterial isolates and 4 actinomycetes isolates were found tolerant up to 20 per cent of sodium chloride. Highly salt tolerant bacterial and actinomycetes were further screened for phosphate solubilizing activity on Pikovskaya solid medium. Twenty bacterial and a few actinomycetes salt tolerant isolates showed phosphate solublizing activity on solid medium (Fig.23). These microbial isolates will be screened for other plant growth promoting (PGP) traits like indole acetic acid, siderophore production and ammonia production.

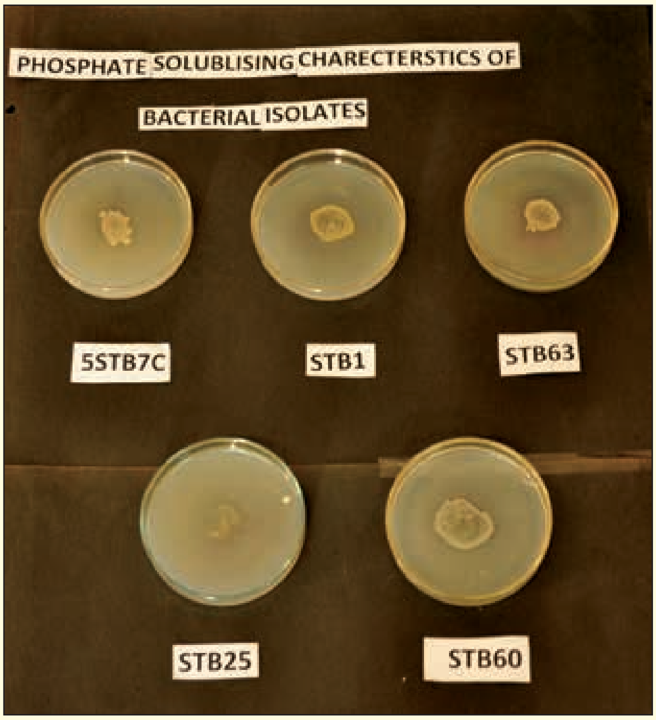



*Fig.23 : Phosphate solubilizing activity of salt tolerant bacterial isolates on Pikovskaya agar medium*

# CROP IMPROVEMENT FOR SALINITY, ALKALINITY AND WATER LOGGING STRESSES

**Genetic Improvement of Rice for Salt Tolerance** (S.L. Krishnamurthy, P.C. Sharma, 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* 2014.

## A. National trials:

### Alkaline and Inland Saline Tolerant Varietals Trial

The Alkaline and Inland Saline Tolerant Varietals Trial (AL&ISTVT) comprising of 44 entries including check varieties (CSR 36, CSR 27 and yield check - Jaya), was conducted across eight salt stress locations (Table 24) in RBD with three replications.

Under normal conditions, entry CSR 36 showed highest grain yield (8.16 t $ha^{-1}$) followed by Jaya (8.12 t $ha^{-1}$), 2312 (8.08 t $ha^{-1}$), 2318 and 2320 each (8.06 t $ha^{-1}$) and 2313 (8.05 t $ha^{-1}$).

Under salinity stress at Karnal, 19 entries outperformed the national salinity check CSR 27. Entry 2309 showed highest grain yield (3.71 t $ha^{-1}$) followed by 2315 (3.45 t $ha^{-1}$), 2302 (3.42 t $ha^{-1}$), 2305 (3.38 t $ha^{-1}$), 2325 (3.38 t $ha^{-1}$), 2336 (3.38 t $ha^{-1}$), 2316 (3.30 t $ha^{-1}$), 2318 (3.30 t $ha^{-1}$), 2321(3.29 t $ha^{-1}$), 2327 (3.29 t $ha^{-1}$), 2317 (3.21 t $ha^{-1}$), 2322 (3.15 t $ha^{-1}$), 2328 (3.14 t $ha^{-1}$), 2338 (3.14 t $ha^{-1}$), 3119 (3.21 t $ha^{-1}$), 2326 and 2334 (3.10 t $ha^{-1}$), 2333 and 2331(3.08 t $ha^{-1}$).

At Israna (Panipat), 13 entries outperformed the best check. Grain yield ranged from 1.34 (2342) to 3.94 t $ha^{-1}$ (2302). Entry 2302 showed the highest grain yield (3.94 t $ha^{-1}$) followed by 2315 (3.81 t $ha^{-1}$), 2325 (3.77 t $ha^{-1}$), 2316 (3.77 t $ha^{-1}$), 2317 (3.74 t $ha^{-1}$), 2321 (3.73 t $ha^{-1}$), 2305 and 2336 (3.71 t $ha^{-1}$), 2327 (3.68 t $ha^{-1}$), 2318 (3.66 t $ha^{-1}$), 2309 (3.61 t $ha^{-1}$), 2310 (3.60 t $ha^{-1}$) and 2311 (3.53 t $ha^{-1}$).

Under sodic stress at Karnal, 12 entries outperformed the national alkaline check CSR 36. Entry 2302 showed highest grain yield (3.78 t $ha^{-1}$) followed by 2317 (3.78 t $ha^{-1}$), 2316 and 2318 (3.72 t $ha^{-1}$), 2315 (3.69 t $ha^{-1}$), 2336 (3.69 t $ha^{-1}$), 2305 (3.67 t $ha^{-1}$), 2325 (3.63 t $ha^{-1}$), 2327 (3.59 t $ha^{-1}$), 2309 (3.50 t $ha^{-1}$), 2321 (3.50 t $ha^{-1}$) and 2328 (3.34 t $ha^{-1}$).

At Jind, 18 entries outperformed the national alkaline check CSR 36. Entry 2305 showed highest grain yield (3.80 t $ha^{-1}$) followed by 2302 (3.77 t $ha^{-1}$), 2321 (3.73 t $ha^{-1}$), 2336 (3.73 t $ha^{-1}$), 2338 (3.72 t $ha^{-1}$), 2315 (3.71 t $ha^{-1}$), 2309 (3.70 t $ha^{-1}$), 2318 (3.66 t $ha^{-1}$), 2325 (3.59 t $ha^{-1}$), 2326 (3.56 t $ha^{-1}$), 2327 (3.55 t $ha^{-1}$), 2316 (3.50 t $ha^{-1}$), 2317 (3.48 t $ha^{-1}$), 2333 and

**Table 24: Location wise soil status under AL&ISTVT Trial-2014**

| S.No. | Locations | Local check Name | Gross Plot Size ($m^2$) | Net Plot size ($m^2$) | Date of Sowing | Date of Planting | $pH_2$ | EC (dS $m^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| 1 | Israna | CSR 23 | 8.8 | 5.0 | 21.06.2014 | 22.07.2014 | 8.82 | 8.5 |
| 2 | Jind | CSR 36 | 8.8 | 5.0 | 13.06.2014 | 18.07.2014 | 9.73 | 2.72 |
| 3 | Normal field - Karnal | CSR 36 | 8.8 | 5.0 | 2.06.2014 | 1.07.2014 | 8.8 | 1.04 |
| 4 | High Salinity - Karnal | CSR 23 | 0.60 | 0.52 | 2.06.2014 | 1.07.2014 | 7.83 | 7.5 |
| 5 | Moderate Sodicity - Karnal | CSR 36 | 0.60 | 0.52 | 2.06.2014 | 1.07.2014 | 9.5 | 1.04 |
| 6 | Lucknow | Usar 3 | 15.6 | 10.0 | 11.06.2014 | 22.07.2014 | 9.0-10.2 | 2.72 |
| 7 | Aligarh | PB1 | 14.1 | 9.0 | 23.06.2014 | 29.07.2014 | 9.7 | 1.72 |
| 8 | Gautam Budha Nagar | Sharbhati | 15.6 | 10.0 | 5.06.2014 | 26.07.2014 | 9.5 | 1.72 |

2303 (3.46 t $ha^{-1}$), 2307 and 2335 (3.33 t $ha^{-1}$) and 2323 (3.31 t $ha^{-1}$).

At Lucknow, 21 entries outperformed the national alkaline check CSR 36. Entry 2334 showed highest grain yield (3.86 t $ha^{-1}$) followed by 2336 (3.82 t $ha^{-1}$), 2338 (3.66 t $ha^{-1}$), 2335 (3.56 t $ha^{-1}$), 2309 (3.47 t $ha^{-1}$), 2316 (3.37 t $ha^{-1}$), 2305 (3.31 t $ha^{-1}$), 2327 (3.16 t $ha^{-1}$), 2302 and 2330 (3.11 t $ha^{-1}$). At Aligarh, 20 entries out performed the national alkaline check CSR 36. The entry 2307 showed highest grain yield (4.77 t $ha^{-1}$) followed by 2304 (4.62 t $ha^{-1}$), 2325 (4.55 t $ha^{-1}$), 2316 (4.51 t $ha^{-1}$), 2336 (4.49 t $ha^{-1}$), 2309 (4.48 t $ha^{-1}$), 2313 (4.46 t $ha^{-1}$), 2315 (4.42 t $ha^{-1}$), 2327 (4.42 t $ha^{-1}$), 2303 (4.41 t $ha^{-1}$), 2302 (4.38 t $ha^{-1}$), 2332 (4.36 t $ha^{-1}$), 2333 (4.33 t $ha^{-1}$), 2326 (4.33 t $ha^{-1}$), 2330 (4.29 t $ha^{-1}$), 2344 (4.26 t $ha^{-1}$), 2331 (4.25 t $ha^{-1}$), 2305 (4.22 t $ha^{-1}$), 2321 (4.14 t $ha^{-1}$) and 2335 (4.09 t $ha^{-1}$).

At Gautam Budh Nagar, 18 entries outperformed the national alkaline check CSR 36. Entry 2305 showed highest grain yield (3.84 t $ha^{-1}$) followed by 2302 (3.80 t $ha^{-1}$), 2321 (3.77 t $ha^{-1}$), 2336 (3.76 t $ha^{-1}$), 2338 (3.76 t $ha^{-1}$), 2315 (3.75 t $ha^{-1}$) and 2309 (3.74 t $ha^{-1}$).

Genotype-environment interaction and stability performance were studied for grain yield across seven locations viz. (salinity-Karnal, and sodicity-Karnal), at farmers' fields of Jind, Israna, Lucknow, Gautam Budh Nagar and Aligarh. On the basis of grain yield, nine entries namely, 2305, 2316, 2327, 2317, 2344, 2335, 2319, 2340 and 2304 were found to be highly stable.

## B. Station Trials

### Monitoring, maintenance and development of breeding materials

#### a) Development of new $F_1$'s during *kharif* 2014

Different cross combinations were made to combine the yield and salt tolerance traits. These cross combinations were: MTU 1010 x CSR 27, MTU 1010 x CSR 11, MTU 1001 x CSR 27, MTU 1001 x CSR 11, BPT 5204 x Kalanamal, CSR 30 x Kalanamal, PB 1 x Kalanamak, CSR 30 x Vandana, CSR 30 x CSR 11, CSR 30 x CSR 27, CSR 30 x PB 3, CSR 30 x Jaya, CSR 30 x HUBR 10-9, CSR 30 x CSR 8, Pusa 44 x CSR 27 and MAUB 13 x CSR 30 (Table 25).

#### c) Screening and selection of $F_5$ populations

A total of 24 segregating populations (Table 26) were screened under high salinity (EC ~ 10.0 dS $m^{-1}$) in saline microplots. The top 10 progenies were selected from each segregating population by considering the yield, quality, tolerance and other traits to further screening/evaluation in the next cropping season

**Table 25 : List of $F_3$ populations advanced for the next generation under salt stress**

| S.No. | $F_3$ population | S.No. | $F_3$ population | S.No | $F_3$ population |
|---|---|---|---|---|---|
| 1 | IR 64 X CSR36 | 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 | PS5 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 | PS5 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 CSR 27 | 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 FL4 78 | | |

**Table 26 : 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 | PB6 X CSR 2K-262 | 18 | PR115 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 |

## International Rice Soil Stress Tolerance Nursery (IRRSTON Trial) 2014

The 34th International Rice Soil Stress Tolerance Nursery (Modules-2), consisting of 40 rice genotypes, was evaluated under high salinity (EC ~ 10.0 dS $m^{-1}$) and sodicity ($pH_2$ ~ 9.9) stress in microplots with two replications in *kharif* 2014. The genotypes CSR 28 (2.29 t $ha^{-1}$), IR 58443-6B-10-3 (2.02 t $ha^{-1}$), IR 13T145 (2.00 t $ha^{-1}$), IR 55179-3B-11-3 (1.98 t $ha^{-1}$), CSR 90 IR-2 (1.95 t $ha^{-1}$), A 69-1 (1.71 t $ha^{-1}$), IR 13T134 (1.69 t $ha^{-1}$), IR 11T219 (1.55 t $ha^{-1}$), IR 11T230 (1.47 t $ha^{-1}$) and IR 11T184 (1.42 t $ha^{-1}$) performed better (Fig. 24) under high salinity. Under high sodicity, genotypes, IR 11T129 (3.51 t $ha^{-1}$), IR 13T148 (3.24 t $ha^{-1}$), IR 55179-3B-11-3 (3.02 t $ha^{-1}$), IR 12T253 (2.97 t $ha^{-1}$), CSR 90 IR-2 (2.66 t $ha^{-1}$), IR 11T219 (2.64 t $ha^{-1}$), IRRI 147 (2.58 t $ha^{-1}$), IR 11T230 (2.49 t $ha^{-1}$), IR 13T134 (2.44 t $ha^{-1}$) and IR 12T260 (2.26 t $ha^{-1}$) performed better (Fig 25).

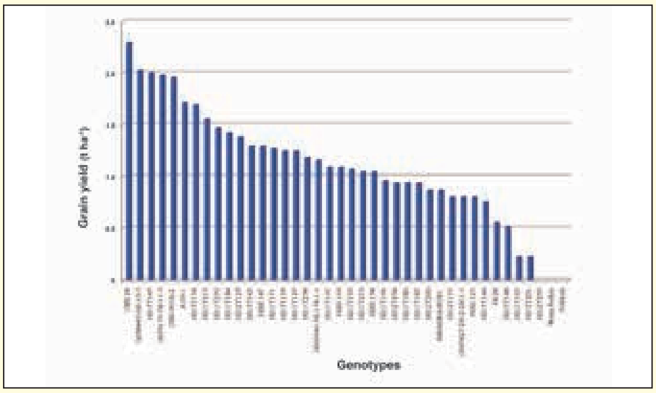



*Fig. 24 : Performance of IRSSTN entries under high salinity stress*

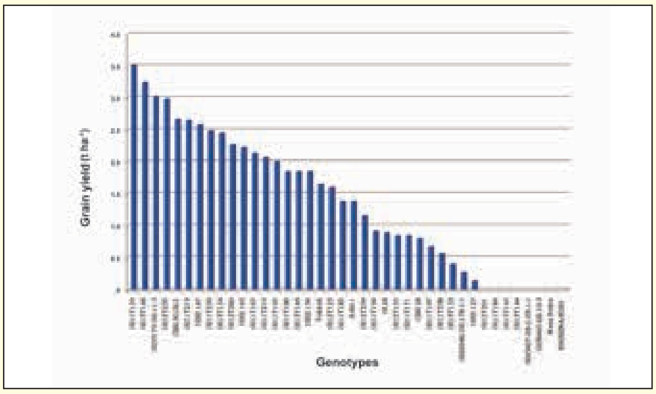



*Fig. 25 : Performance of IRSSTN entries under high sodicity stress*

The experiment was carried out with 6 rice genotypes, namely, Bulk 23 (E), Bulk 23 (L), CSR 36, CSR 43, VSR 56 and IR 29 to validate the performance of Bulk 23 (E) and Bulk 23 (L) along with two salt tolerant and two salt sensitive varieties (Fig 26). The experiment was laid out in randomized complete block design with three replications in 3 environments {normal, moderately sodic ($pH_2$ ~ 9.5) and highly sodic ($pH_2$ ~ 9.9) during *kharif* 2014. The variety CSR 36 performed better than other genotypes under normal and moderate sodic stress whereas Bulk 23 (E) and Bulk 23 (L) performed better were high sodic stress conditions. The genotypes, Bulk 23 (E) and Bulk 23 (L) showed yield reduction of 12 and 31 per cent under moderate stress and 42 and 57 per cent in high sodicity conditions, respectively over control among all the genotypes. The genotypes

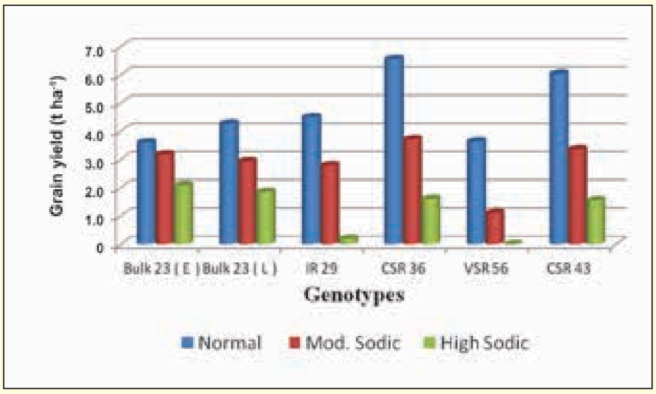



*Fig 26 : Mean performance of rice genotypes for grain yield under normal, moderate sodic and high sodic environments*

**Table 27 : Summary of mean grain yield (t $ha^{-1}$) of Bulk 212 (IET 22017) in co-ordinated varietal trials in sodic areas of Haryana and Pondicherry (AL&ISTVT: 2011 to 2013).**

| Details | Year of testing | No. of locations | Bulk 212 (IET 22017) | National check (CSR 36) | Local check | Yield check (Jaya) |
|---|---|---|---|---|---|---|
| Mean yield (t $ha^{-1}$) | I Year (2011) | 4 | 2.16 | 1.79 | 2.00 | 1.82 |
| | II Year (2012) | 3 | 3.99 | 2.91 | 3.52 | 1.85 |
| | III Year (2013) | 4 | 3.26 | 2.73 | 2.61 | 1.45 |
| | Mean | | 3.13 | 2.47 | 2.74 | 1.71 |
| Increase over checks (%) | I Year (2011) | | | 20.31 | 3.17 | 18.54 |
| | II Year (2012) | | | 37.28 | 13.60 | 115.78 |
| | III year (2013) | | | 19.34 | 24.79 | 124.59 |
| | Pooled Mean (% increase) | | | 25.64 | 13.85 | 86.30 |

Bulk 23 (E) and Bulk 23 (L) also showed 29 and 15 per cent yield advantage over best check CSR 36 (National check for alkaline/sodic stress).

The performance of Bulk 212 (IET 22017) was consistently high under alkalinity for three successive years (Table 27). It showed yield superiority in alkaline locations of Pondicherry for two years (2011: 8% over CSR 36, 2012: 40.5 % over local check) and in alkaline locations of Haryana for two years (2012: 4.2 % over CSR 36 and 2013: 24.3% over CSR 36). Therefore, IET 22017 was promising under sodicity stress in Pondicherry and Haryana States.

The performance of CSR 2K 232 (IET 20328) was consistently high under sodicity for three successive years (Table 28). It showed yield superiority in sodic locations of Haryana for three years (2011: 35.2%, 2012: 4.62 % and 2013: 19.04 % over the best check). Therefore, IET 20328 was promising in the states of Haryana under sodicity stress.

**Table 28 : Summary of mean grain yield (t $ha^{-1}$) of CSR 2K 232 (IET 20328) in co-ordinated varietal trials of sodic areas of Haryana (AL&ISTVT: 2011 to 2013)**

| Year | 20328 | CSR 36 | Local Check | Yield advantage (%) | |
|---|---|---|---|---|---|
| 2011 | 1.92 | 1.42 | 1.40 | 35.21 | 37.14 |
| 2012 | 4.87 | 4.65 | 4.60 | 4.62 | 5.80 |
| 2013 | 4.12 | 3.46 | 3.55 | 19.04 | 16.12 |
| Mean | 3.64 | 3.18 | 3.18 | 20.00 | 20.00 |

## Evaluation of salt tolerant rice variety Surjeet Basmati 1

The experimental material comprised of 5 rice genotypes namely, Surjeet Basmati 1, Basmati CSR 30, Pusa Basmati 1509, Pusa Basmati 1121 and Pusa Basmati 1. The experiment was laid out in randomized complete block design with three replications in 4 environments {normal, moderate sodic (pH ~ 9.5), salinity (EC ~ 8.5 dS ($m^{-1}$) at farmer's field of Israna, Panipat and salinity (EC ~ 10 dS/ ($m^{-1}$)} during *kharif* 2014. Ten plants were selected randomly from each entry in each replication to record the data on 9 morphological traits *viz.*, days to 50 % flowering, plant height, number of total tillers per plant, number of productive tillers per plant, panicle length, panicles $m^{-2}$, number of filled grains per panicle, spikelet fertility percentage and grain yield. Location wise soil status under Surjeet Basmati Trial-2014 is given in table 29.

Under non stress condition, the variety Pusa 1121 was showed the highest grain yield (5.06 t/ha) followed by Surjeet Basmati 1 (4.95 t/ha), While under salt stress condition, the entry CSR 30 showed the highest grain yield under moderate sodicity (2.87 t/ha), moderate salinity (2.31 t/ha) and high salinity (2.11 t/ ha). Genotype Pusa Basmati 1121 was most sensitive to sodicity and showed the maximum yield reduction of about 61.89 per cent followed by Pusa Basmati 1509 (54.92 %) and Surjeet Basmati 1 (54.46 %) under moderate sodicity stress as compared to normal. Under moderate salinity stress, Pusa Basmati 1 showed the maximum yield reduction of about 70.33 per cent followed by Pusa Basmati 1121 (68.79 %)

**Table 29 : Location wise soil stress status under Surjeet Basmati 1 Trial - 2014.**

| S.N | Locations | Plot Size ($m^{-2}$) | Date of Sowing | Date of Planting | pH | EC (dS/ ($m^{-1}$) |
|---|---|---|---|---|---|---|
| 1 | Normal | 1.8 | 29.05.2014 | 5.07.2014 | 8.5 | 0.14 |
| 2 | Moderate Sodicity | 1.8 | 29.05.2014 | 5.07.2014 | 9.5 | 0.48 |
| 3 | Moderate Salinity (Farmers field, Israna) | 8.8 | 29.05.2014 | 5.07.2014 | 8.82 | 8.50 |
| 4 | High Salinity | 1.8 | 29.05.2014 | 5.07.2014 | 8.54 | 10.0 |

**Table 30 : Grain yield and reduction in yield under moderately sodicity and high salinity**

| S. No | Name of genotype | Grains yield (t $ha^{-1}$) | | | | % Reduction over normal | | |
|---|---|---|---|---|---|---|---|---|
| | | Normal | Mod. Sodic ($pH_2$ ~ 9.5) | High Saline (EC ~ 10 dS $m^{-1}$) | Mod. Saline (EC ~ 8.5 dS $m^{-1}$) | MS | High Saline | Mod. Saline |
| 1 | PUSA 1509 | 4.22 | 1.90 | 0.95 | 1.47 | 54.92 | 77.36 | 65.12 |
| 2 | PUSA 1121 | 5.06 | 1.93 | 0.77 | 1.58 | 61.89 | 84.65 | 68.79 |
| 3 | Surjeet Basmati - 1 | 4.95 | 2.25 | 0.99 | 1.60 | 54.46 | 79.79 | 67.55 |
| 4 | Basmati CSR 30 | 4.17 | 2.87 | 2.11 | 2.31 | 31.16 | 49.41 | 44.67 |
| 5 | PB 1 | 4.67 | 2.13 | 1.19 | 1.39 | 54.35 | 74.56 | 70.33 |

and Surjeet Basmati 1 (67.55 %) as compared to normal. Under high salinity stress, Pusa Basmati 1121 showed the maximum yield reduction of about 84.65 per cent followed by Surjeet Basmati 1 (79.79 %) as compared to normal (Table 30).

## Production and maintenance of advanced bulks, segregating lines and germplasm

A total of 176 segregating lines derived from different crosses and 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. The 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 field for multiplication and maintenance.

## **National Project on Transgenics in Crops-Salinity Tolerance in Rice: Functional Genomics Component (ICAR funded)** (S. L. Krishnamurthy, P.C. Sharma and S.K. Sharma)

The main 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 fine mapping population (CSR27/MI48) for spikelet fertility

A total of 225 genotypes including 220 RILs along with parents were phenotyped in RBD with two replications under 3 environments {normal, moderate salinity (EC ~ 6.0 dS $m^{-1}$) and high salinity (EC ~ 10 dS $m^{-1}$) microplots} during *kharif* 2014. The range, mean and per cent reduction of different traits for RIL population recorded during 2014 are presented in Table 31. The grain yield (g) ranged from 4.10 (RIL 174) to 17.40 (RIL 7), 0.96 (RIL 208) to 8.20 (RIL 104) and 0.02 (RIL 163) to 5.70 (RIL 104) under normal, moderate salinity and high salinity, respectively. The spikelet fertility ranged from 50.88 (RIL 167) to 86.45 (CSR 27), 18.37 (RIL 41) to 66.74 (RIL 97) and 1.06 (RIL 121) to 64.03 (RIL 113) under normal, moderate salinity and high salinity, respectively. The RIL 121 registered lowest spikelet fertility of 1.06 per cent under high salinity stress. Top 10 RILs with high spikelet fertility (%) under normal, moderate salinity and high salinity stresses are presented in Table 32. The top 10 lines based on grain yield (g per plant) under normal, moderate salinity and high salinity stress are presented in Table 33.

**Table 31 : Mean, range and per cent reduction for different traits of homozygous recombinants derived from RIL 41 and RIL 44 of CSR 27 / MI 48 RIL under normal (N), moderate (MS) and high salinity (HS) stress.**

| Traits | Range | | | Mean | | | Reduction (%) | |
|---|---|---|---|---|---|---|---|---|
| | N | MS | HS | N | MS | HS | MS | HS |
| Grains per panicle | 45 - 134 | 9 - 71 | 1 - 48 | 74.82 | 40.41 | 18.82 | 45.99 | 74.84 |
| Spikelet fertility (%) | 50.88 – 86.45 | 18.37 – 66.74 | 1.06 – 64.03 | 67.65 | 48.95 | 27.54 | 27.64 | 59.29 |
| Biological yield/plant (g) | 16.80-46.20 | 6.20-33.60 | 0.60-21.0 | 26.44 | 16.90 | 10.31 | 36.07 | 61.00 |
| Grain yield/plant (g) | 4.10-17.40 | 0.96-8.20 | 0.02-5.70 | 8.84 | 3.86 | 1.59 | 56.29 | 82.00 |
| Harvest index (%) | 14.24-42.31 | 10.10-33.08 | 1.42-33.65 | 33.18 | 22.92 | 14.91 | 30.92 | 55.06 |

**Table 32 : Top 10 recombinants with high spikelet fertility (%) derived from RIL 41 and RIL 44 of CSR 27 x MI 48 RIL under normal, moderate and high salinity stress.**

| S. No. | Normal | | Moderate Salinity ($EC_{iw}$ ~ 6.0 dS $m^{-1}$) | | High Salinity ($EC_{iw}$ ~ 10.0 dS $m^{-1}$) | |
|---|---|---|---|---|---|---|
| 1 | RIL 4 | 80.92 | RIL 215 | 64.03 | RIL 138 | 47.22 |
| 2 | RIL 17 | 80.98 | RIL 100 | 64.25 | RIL 104 | 47.27 |
| 3 | RIL 118 | 81.28 | RIL 124 | 64.27 | RIL 12 | 48.15 |
| 4 | RIL 92 | 81.80 | RIL 92 | 64.39 | RIL 36 | 49.58 |
| 5 | RIL 2 | 81.95 | RIL 102 | 64.49 | RIL 111 | 50.85 |
| 6 | RIL 57 | 83.09 | RIL 27 | 64.53 | RIL 117 | 51.74 |
| 7 | RIL 196 | 83.09 | RIL 81 | 64.83 | RIL 115 | 54.18 |
| 8 | RIL 102 | 84.82 | RIL 113 | 65.38 | RIL 15 | 56.32 |
| 9 | RIL 108 | 86.03 | RIL 17 | 66.06 | RIL 85 | 59.62 |
| 10 | CSR 27 | 86.45 | RIL 97 | 66.74 | RIL 113 | 64.03 |

**Table 33 : Top 10 genotypes with high grain yield (g $plant^{-1}$) under normal, moderate and high salinity stress.**

| S. No. | Normal | | Moderate Salinity ($EC_{iw}$ ~ 6.0 dS $m^{-1}$) | | High Salinity ($EC_{iw}$ ~ 10.0 dS $m^{-1}$) | |
|---|---|---|---|---|---|---|
| 1 | RIL 7 | 17.40 | RIL 104 | 8.20 | RIL 104 | 5.70 |
| 2 | RIL 10 | 16.80 | RIL 90 | 7.95 | RIL 74 | 5.20 |
| 3 | RIL 14 | 16.50 | RIL 15 | 7.40 | CSR 27 | 4.96 |
| 4 | RIL 65 | 16.40 | RIL 118 | 7.20 | RIL 193 | 4.80 |
| 5 | RIL 46 | 15.80 | RIL 22 | 7.15 | RIL 72 | 4.40 |
| 6 | RIL 17 | 15.60 | RIL 103 | 7.00 | RIL 15 | 4.30 |
| 7 | RIL 23 | 15.40 | RIL 133 | 7.00 | RIL 66 | 4.10 |
| 8 | RIL 44 | 15.40 | CSR 27 | 6.96 | RIL 107 | 4.10 |
| 9 | RIL 3 | 15.20 | RIL 46 | 6.80 | RIL 111 | 4.00 |
| 10 | RIL 25 | 14.80 | RIL 98 | 6.60 | RIL 115 | 3.80 |

### 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 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 the 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 the first set, the experiment was conducted in glass house, while in second set, field experiment was conducted to produce $BC_1F_1$ population. $F_1$s 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 the advancement of generation to $BC_1F_1$, the experiment was conducted in glass house during off-season to produce $BC_2F_1$ population. Seven staggered sowing (23 October 2012 to 30 November 2012) and transplanting (14 October 2012 to 21 December 2012) were done to produce $BC_2F_1$ seeds. 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. 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. For the advancement of generation from $BC_2F_1$ to $BC_3F_1$, the experiment was initiated in field during *kharif* 2013. Seven staggered sowing (1 June 2013 to 12 July 2013) and transplanting (1 July 2013 to 12 August 2013) were done to produce $BC_3F_1$ seeds 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 for further maintainance. True $BC_2F_1$ plants were selected using *Saltol* markers RM 3412 (foreground selection) and RM 493 and G11A (recombinant selection) for their further use in crossing programme to 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, advanced to $BC_3F_2$ in June 2014 and harvesting of the seeds of BC3F3 in November 2014 (Table 34).

A total of 400 seeds of $BC_3F_1$ population along with parents were sown in hydroponics in glass house during February 2014 and used for further foreground and recombinant selection. The marker RM 3412 was used for foreground selection and markers RM 493 and G11a are being used for recombinant selection in Sarjoo52/FL478 populations. In Pusa 44/FL478 population, out of 240 plants only two desirable plants were found after foreground and recombinant selection (Fig. 27). These plants were selfed to produce $BC_3F_2$ seeds.

Seeds of selected $BC_3F_2$ plants along with parents were sown in field during *kharif 2014*. Almost 700 plants of each population were screened for foreground and recombinant selection using RM


*$BC_3F_1$ plants in glass house*

**Table 34 : Number of seeds harvested in $BC_2F_1$, $BC_3F_1$ and $BC_3F_2$ generations**

| Population | $BC_2F_1$ seeds harvested in March 2013 | $BC_3F_1$ seeds harvested in October 2013 | $BC_3F_2$ seeds harvested in June 2014 | $BC_3F_3$ seeds harvested in Nov. 2014 |
|---|---|---|---|---|
| Pusa 44/ FL 478 | 465 (Out of 26 lines) | 725 (Out of 24 lines) | >1000 (Out of 2 lines) | 20 lines (Out of 282 lines) |
| PR 114/ FL 478 | 422 (Out of 29 lines) | 828 (Out of 26 lines) | - | - |
| Sarjoo 52/ FL478 | 424 (Out of 24 lines) | 850 (Out of 23lines) | >1000 (Out of 2 lines) | 32 lines (Out of 180 lines) |

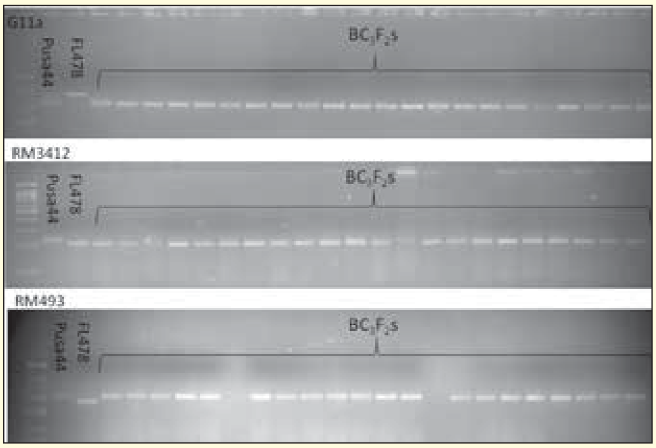



*Fig. 27 : Gel image of $BC_3F_2$s (Pusa44/FL478) with markers G11a, RM3412, RM493*

3412, RM 493 and G11a markers (Fig 27) and 50-60 plants progenies were found desirable. Finally, 20-25 $BC_3F_2$ plant progenies were selected after stringent phenotypic and genotypic selection. Selected plants were selfed to produce $BC_3F_3$ seeds.

## Development and maintenance of mapping populations and germplasm

Different mapping populations were developed and maintained (Table 35). New mapping populations viz; BPT 5204 x Kalanamak, CSR 30 x Kalanamak and PB 1 x Kalanamak were also developed during 2014.

**Table 35 : Maintenance of mapping populations and germplasm**

| S. No. | Mapping populations | Generation | Population size |
|---|---|---|---|
| 1 | Taraori Basmati / CSR 36 | $F_6$ | 400 |
| 2 | Taraori Basmati / CSR-2K-262 | $F_6$ | 400 |
| 3 | VSR 156 / CSR 20 | $F_6$ | 400 |
| 4 | VSR 156 / CSR 10 | $F_5$ | 400 |
| 5 | VSR 156 / CSR 36 | $F_5$ | 400 |
| 6 | CSR 11 x MI 48 | $F_{12}$ | 216 |
| 7 | CSR 27 x MI 48 | $F_{12}$ | 218 |
| 8 | CSR 27 x CSR 11 | $F_{12}$ | 215 |

## Stress Tolerant Rice for Poor Farmers of Africa and South Asia' (STRASA phase 3) (S.L. Krishnamurthy, P.C. Sharma and S.K. Sharma)

The experimental material comprising of 30 rice genotypes was collected from various national and international institutes to assess the performance

**Table 36 : List of genotypes and their geographical location**

| S. No. | Source | Genotypes |
|---|---|---|
| 1 | IRRI, Philippines | IR 87830-B-SDO1-2-3-B |
| 2 | | IR 87830-B-SDO1-2-2-B |
| 3 | | IR 87938-1-1-3-2-1-B |
| 4 | | IR 87830-B-SDO2-1-3-B |
| 5 | | IR 87916-4-1-2-1-1-B |
| 6 | | IR 87938-1-2-2-1-3-B |
| 7 | | IR 87831-3-1-1-2-2-BAY B |
| 8 | | IR 87938-1-1-2-1-3-B |
| 9 | | IR 87870-6-1-1-1-1-B |
| 10 | | IR 87872-7-1-1-2-1-B |
| 11 | | IR 87938-1-1-2-3-3-B |
| 12 | | IR 87938-1-2-2-2-1-B |
| 13 | | IR 87937-6-1-3-2-2-B |
| 14 | | IR86359-302-1-1-2-3-B |
| 15 | | IR 87952-1-1-1-2-3-B |
| 16 | | IR 84645-305-6-1-1-1 |
| 17 | | IR87848-301-2-1-3-B |
| 18 | | IR 87948-6-1-1-1-3-B |
| 19 | | IR87848-301-2-1-1-B |
| 20 | | IR 87938-1-2-2-3-2-B |
| 21 | PANJANCOA, Karaikal | KR 09009 |
| 22 | NDUAT, Faizabad | NDRK 11-4 |
| 23 | DRR, Hyderabad | RP 4353-MSC -38- 43-6-2-4-3 |
| 24 | CSSRI, Karnal | CSR - 2K- 262 |
| 25 | | CSR - 2K- 242 |
| 26 | | CSR 12-B 23 |
| 27 | Check (Coastal Saline) | CST 7-1 |
| 28 | Check (Inland Saline) | CSR 27 |
| 29 | Check (Alkaline) | CSR 36 |
| 30 | Local Check | Local Check |

of these genotypes under salinity and sodicity stresses conditions (Table 36). The genotypes were evaluated in randomize complete block design with three replications during *kharif* 2014 under high salinity ($EC_{iw}$ ~ 10 dS m$^{-1}$) and high sodicity ($pH_2$ ~ 9.9) stresses in micro plots at CSSRI, Karnal. Thirty five days old seedlings from wet bed nurseries with two seedlings per hill were transplanted at a spacing of 15 × 20 cm. Basal fertilizers for the main crop was 120-60-60 kg of NPK ha$^{-1}$. Recommended package of practices were followed. Twenty one days after transplanting, saline conditions were accomplished by using 7 NaCl: 1 $Na_2SO_4$: 2 $CaCl_2$ on equivalent basis. Randomly 5 plants were tagged from each genotype in each replication and yield data were recorded for different traits.

The mean and range for all the studied traits were recorded. Top 5 entries with respect to grain yield under high sodicity ($pH_2$ ~ 9.9) were CSR 12-B 23 (2.89 t ha$^{-1}$), CSR-2K-262 (2.67 t ha$^{-1}$), Local Check (2.44 t ha$^{-1}$), IR 87948-6-1-1-1-3-B (2.22 t ha$^{-1}$) and CSR 36 (2.19 t ha$^{-1}$). Under high salinity ($EC_{iw}$ ~ 10 dSm$^{-1}$), CSR-2K-242 (3.14 t ha$^{-1}$), IR 87948-6-1-1-1-3-B (2.80 t ha$^{-1}$), IR 87938-1-1-3-2-1-B (2.75 t ha$^{-1}$), IR87848-301-2-1-3-B (2.55 t ha$^{-1}$) and CSR 27 (2.05 t ha$^{-1}$) performed better as compared to other entries.

Under high salinity, association analysis revealed that grain yield had positive and significant association with total tillers per plant and productive tillers per plant. Grain yield also had negative significant association with stress score at vegetative and reproductive stages. Under high sodicity, grain yield had positive significant association with days to 50 % flowering, plant height, total tillers/plant, productive tillers/plant and panicle length. Grain yield also had negative but significant association with stress score at vegetative and reproductive stages.

In another experiment, 11 rice entries were evaluated across 5 saline and 6 sodic locations of India for three seasons in 2011, 2012 and 2013 (Fig. 28). Genotype CSR 2K 262 ranked first amongst the genotypes evaluated and showed yield advantage of 8.8 per cent over best check under sodicity stress locations. Further, CSR 2K 262 exhibited 7.4 per cent yield advantage over the best check across all the stress (saline and alkaline) locations.

During 2011, CSR-2K-262 ranked first and showed yield advantage of 6.4, 5.8 and 8.5 per cent over the best check in coastal saline (5), alkaline (6) and

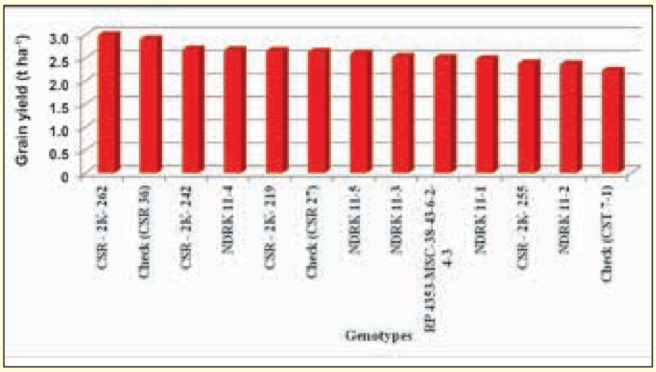



*Fig. 28 : Performance of 11 rice genotypes across 5 saline and 6 sodic locations of India for three seasons (2011, 2012 and 2013)*

both stress locations (11), respectively. In 2012, this genotype again ranked first and showed yield advantage of 8.6, 14.0 and 12.0 per cent over the best check in coastal saline (7), alkaline (7) and both stress locations (14), respectively. Further, in 2013, the same genotype again demonstrated yield advantage of 11.7 per cent over the best check in alkaline locations (9), whereas no genotypes showed any yield advantage over the checks in coastal saline (8) and both alkaline and saline locations (17).

## Genetic Enhancement of Wheat with respect to Salt and Waterlogging Tolerance (Neeraj Kulshreshtha, Arvind Kumar, P.C. Sharma, S.K. Sharma and G. Gururaja Rao)

### A. Summary of the experiments

- KRL 283 followed by KRL 330 and KRL 327 ranked first, second and third in UP State Alkalinity/Salinity Tolerance Varietal Trial for 2012-13 and were promoted to the second year of testing.
- Genotypes KRS 1301 (KRL 350) and KRS 1303 (KRL 351) performed better as compared to all the checks under saline/alkaline conditions and were promoted to the AICW&BIP: Special trail- salinity alkalinity trial 2014-15.
- KRL 304 ($Sr_{11+2+8a+9b+}$ $Lr_{23+}$ $Yr_{2+}$) was included in National Genetic Stock Nursery 2013-14 as a source of disease resistance in addition to salt tolerance.
- Twenty KRS genotypes (KRS 1401 - KRS 1420) were developed and included for their evaluation under Salinity/Alkalinity Nursery 2014-15.

## All India Salinity/Alkalinity Tolerance Varietal Trial

During *rabi* 2013-14, All India Salinity/Alkalinity Tolerance Varietal Trial was conducted at 9 centres (Table 37).

The trial consisted of 4 test entries and 3 checks. The trial mean ranged from 2.59 (Vanasthali) to 3.78 t $ha^{-1}$ (Bharuch). The zonal mean yield of genotypes varied from 3.17 (Kharchia 65) to 4.03 t $ha^{-1}$ (KRL 210). The check variety KRL 210 was the highest yielding and ranked first among all the entries and was in the first significant group on zonal mean basis as well as in UP. It produced statistically at par grain yield with three other entries namely DBW 154 (3.92 t $ha^{-1}$), KRL 349 (3.92 t $ha^{-1}$) and WH 1301 (3.87 t $ha^{-1}$). These entries together formed the first non-significant group.

In NWPZ, days to heading of different genotypes ranged from 90 (KRL 19) to 102 days (DBW 155). Plant height ranged from 87 cm (DBW 155) to 116 cm (Kharchia 65) and 1000 grain weight ranged from 34 g (KRL 19) to 42 g (KRL 210 and KRL 349). Similarly, in NEPZ, days to heading of different genotypes ranged from 83 (KRL 210 AND WH 1301) to 87 days (DBW 155). Plant height ranged from 74 cm (KRL 19) to 102 cm (Kharchia 65) and 1000 grain weight ranged from 31 g (DBW 155) to 39 g (KRL 210).

In NWPZ, most of the entries were either free from brown rust or exhibited very low diseases incidence except Kharchia 65 (5S). Again, most of the entries were either free or affected by moderately yellow rust incidence except Kharchia 65 (70S) and WH 1301 (40S) at Karnal. High incidence of these diseases in Kharchia 65 (80S) and KRL 19 (80S) and low in WH 1301 (5S) and KRL 349 (5S) were observed at Hisar.

In CZ, days to heading of different genotypes ranged from 79 (Kharchia 65) to 85 days (KRL 19 and WH 1301). Plant height ranged from 78 cm (WH 1301) to 102 cm (Kharchia 65) and 1000 grain weight ranged from 38 g (KRL 349, DBW 155, DBW 154, WH 1301 and Kharchia 65) to 41g (KRL 210). The test genotypes KRL 349, DBW 154, DBW 155 and WH 1301 were similar to the check varieties (KRL 19, KRL 210) for most of the agronomic traits in all the three zones. The Entry KRL 349 and check variety KRL 210 recorded the highest 1000- Grain weight.

## Salinity/Alkalinity Tolerance Screening Nursery

The salinity/alkalinity tolerance screening nursery was constituted with the aim to identify wheat lines that can perform better in salt affected soils. This nursery also serves as the source of test entries for Special Variety Evaluation Trial for salt stress conditions under AICW&BIP. During 2013-14, the nursery comprising of 65 test entries and four checks (Kharchia 65, HD 4530, KRL 19 and KRL 210) was evaluated at 10 locations in 4 states. Nine entries- WH 1309, WH 1301, LBP 2013-14, KRS 1301, KRS 1303, KLP 1221, RWP 2013-18, WA 1304 and WS 1305- were identified as high yielding along with resistance for all the three rusts (stem, leaf and yellow rust). These genotypes would be tested under special trail for salinity/alkalinity in 2014-15. Superior lines at Karnal centre 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 genotypes

**Table 37 : Soil status of different Coordinating centers of All India Coordinated Salinity /Alkalinity Trial. *rabi* 2013-14**

| S.N. | Name of centre | Gross plot size ($m^2$) | Net plot size ($m^2$) | Date of sowing | pH/EC ($dS\ m^{-1}$) | Nature of Soil |
|---|---|---|---|---|---|---|
| 1. | Bawal | 9.6 | 8.0 | 19.11.13 | $pH_2$ 9.2 | Sodic |
| 2. | Hisar* | 9.6 | 8.0 | 16.11.13 | $EC_{iw}$ 4.2 | Saline |
| 3. | Karnal* | 9.6 | 8.0 | 14.11.13 | $pH_2$ 9.2 | Sodic |
| 4. | Bharuch* | 9.6 | 8.0 | 13.11.13 | $EC_{iw}$ 9.3 | Saline Vertisol |
| 5. | Dalipnagar | 9.6 | 8.0 | 21.11.13 | $pH_2$ 9.2-9.4 | Sodic |
| 6. | Kanpur | 9.6 | 8.0 | 24.11.13 | $pH_2$ 8.5-8.9 | Sodic |
| 7. | Vanasthali | 9.6 | 8.0 | 17.11.13 | $EC_{iw}$ 5.9-6.7 | Saline |

* ECiw (EC of irrigation water)

KRS 1301 (KRL 350) and KRS 1303 (KRL 351) were found to perform better than all the checks under saline/alkaline conditions and were promoted to the salinity/alkalinity trial for 2014-15.

### Development of new $F_1$ crosses

Fifty two 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 like Kharchia 65, KRL 35, KRL 99, KRL 210, KRL 213, KRL 283, KRL 3-4, KRL 330, BH 1146, Camm, Ducula 4, DPW 621-50, HD 2967, HD 2009, HD 2851, Krichauff and Westonia. The hybridization programme was also strengthened by incorporating disease resistance in salt tolerant background of KRL 99, KRL 3-4, Kharchia 65, KRL 330, KRL 283, KRL 345, KRL 346, KRL 347, KRL 348, KRL 349, KRL 350 and KRL 351 from diverse sources viz. NW 4091 ($Lr_{23+1}$ $Yr_{9+}$), 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

Fifty two $F_2$ and 350 advanced generation material/lines from the crosses of the following varieties/germplasm lines were evaluated and selected for their suitability under different salt stresses :

- PBW 498, PBW 343, PBW 502, PBW 610, PBW 509, PBW 524, PBW 525, PBW 530, PBW 550, PBW 563, PBW 582, PBW 573, PBW 585, PBW 593, PBW 611, DPW 621-50
- HD 2160, HD 2189, HD 2285, HD 2851, HD 2962, HD 5204, HD 2937, HD 2997, HD 3086
- WH 1021, WH 5102
- HW 5021, HW 2045, HW 2062, HW 5102, HW 5210
- VL 824, VL 892, VL 852, VL 867, VL 868, VL 486
- UAS 295, DBW 17, DBW 37, DBW 233
- NW 1076, NW 1014
- UP 2338, UP 2584
- CSW 18
- Maringa, Camm, D2-9, 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 289, KRL 298, KRL 302, KRL 304, KRL 307, KRL 339, KRL 335, KRL 336, KRL 340, KRL 341, KRL 342, KRL 343, KRL 344, KRL 345, KRL 346, KRL 347, KRL 348, KRL 349, KRL 350, KRL 351
- FLW 2, FLW 3, FLW 5, FLW 8, FLW 11, FLW 12, FLW 20, FLW 24
- Raj 4120, Raj 3070
- HI 1552, HI 1516, MACS 6272

### Germplasm collection and maintenance

About 600 entries of working germplasm based on plant type, salt tolerance and productivity were maintained besides 400 doubled haploid lines of three different crosses (Ducula 4/*2 Brookton, HD2329/Camm and D4-13/Tammarin Rock) for further use in the breeding programme.

### Evaluation of wheat varieties for salt stress in Microplots

Twenty three wheat varieties were evaluated for their performances under different salt stresses (normal-control), saline (EC 5.9 dS $m^{-1}$) and sodic ($pH_2$ 9.3) in the microplots. Each genotype was replicated three times. Genotypes KRL 3-4, KRL 99 and Kh 65 were found to be highly tolerant whereas DW 1, HD 4530, HD 2851, DW 3, Brookton and HD 2009 were the sensitive genotypes. Further, genotypes KRL 330, KRL 345, KRL 346, KRL 213, KRL 240, KRL 210, KRL 19, NW 1014, NW 4018 and BH 1146 were established as moderately tolerant.

## **Multilocation Evaluation of Bread Wheat Germplasm** (Neeraj Kulshreshtha, P.C. Sharma and Arvind Kumar)

Eight hundred bread wheat germplasm lines were screened under moderate sodicity stress (pH 9.1) and high salinity stress (EC 10 dS $m^{-1}$) at Nain Farm, Panipat. Considerable genetic variability was observed amongst germplasm lines as evident from range and variance shown for yield attributes under sodicity (Fig 29). The range of grain yield per 30 cm row length was 0-283 with mean of 67g and variance of 2825. Days to heading ranged from 63-113 days with mean 90 and variance 86. Tillers per meter row length ranged from 3-285 plants with mean 106 and variance 4471. Variability recorded for different yield attributes suggested the great scope of improving yield attributes simultaneously to arrive at an ideal plant type for stress tolerance and high yield. Thirty seven genotypes were found

**Table 38 : Top 10 sodicity tolerant genotypes selected on the basis of grain yield per 30 cm row length from 800 germplasm lines**

| S.N. | Genotype/IC No. | Grain yield (g/0.30m²) | Days to heading | Days to maturity | Tiller/No. |
|---|---|---|---|---|---|
| 1 | 145831 | 283.0 | 93 | 115 | 285 |
| 2 | 534265 | 275.1 | 83 | 133 | 277 |
| 3 | 533546 | 266.6 | 99 | 131 | 224 |
| 4 | 335753 | 258.4 | 94 | 136 | 260 |
| 5 | 534274 | 247.6 | 79 | 133 | 250 |
| 6 | 252936 | 238.2 | 91 | 124 | 219 |
| 7 | 535435-A | 226.2 | 81 | 124 | 158 |
| 8 | 534643 | 225.2 | 81 | 121 | 170 |
| 9 | 290278 | 224.9 | 83 | 126 | 254 |
| 10 | 532515 | 224.8 | 78 | 131 | 218 |
| CH 1 | Kharchia 65 | 180.2 | 83 | 131 | 212 |
| CH 2 | C-306 | 109.5 | 89 | 131 | 182 |
| CH 3 | DBW 17 | 89.2 | 79 | 127 | 161 |
| CH 4 | PBW 343 | 75.3 | 85 | 127 | 137 |
| CH 5 | RAJ 3765 | 122.2 | 83 | 128 | 174 |
| | Mean | 66.8 | 90 | 126 | 106 |
| | Variance | 2825 | 86 | 28 | 4471 |
| | Range | 0-283 | 63-113 | 111-142 | 3-285 |

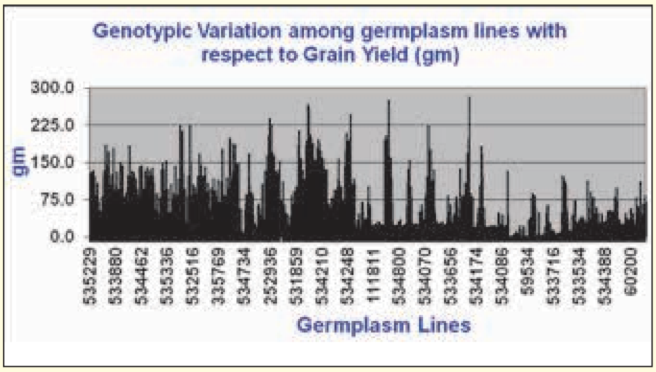



*Fig. 29 : Distribtion of the germplasm lines for grain yield (gm)*

better than checks (Kharchia 65, C-306, DBW 17, PBW 343 and RAJ 3765) (Table 38). However, these genotypes will be studied further for their potential to become a good source of salt tolerance.

## Improvement of Salt Tolerance in Wheat using Molecular Approach (Neeraj Kulshreshtha, P.C. Sharma and Arvind Kumar)

One hundred twenty fixed Recombinant Inbred Lines (RILs) of the cross Kharchia 65 (salt tolerant) and HD 2009 (salt sensitive) were screened and evaluated for phenotyping in the CSSRI sodic microplots ($pH_2$ 9.1) in an augmented design with four checks. Kharchia 65 performed best amongst the checks followed by KRL 19, HD 2009, and HD 2851 with respect to grain yield/plant (Table 39). The RILs displayed considerable variability with respect to grain yield, sodium and potassium uptake. The grain yield/plant amongst the RILs ranged from 0.6 to 8.2g (Fig. 30) whereas the K/Na ratio ranged from 0.3 to 2.5. During 2013-14, a number of RILs such as MP 1-119, MP 1-73, MP 1-109, MP 1-102, MP 1-116, MP 1-81, MP 1-107, MP 1-122, MP 1-46 and MP 1-49 were characterized as tolerant and MP 1-97, MP 1-18, MP 1-3, MP 1-99, MP 1-77, MP 1-112, MP 1-61, MP 1-93, MP 1-86 and MP 1-14 as sensitive on the basis of tolerance index (Table 17). Further, the RILs such as MP 1-26, MP 1-106, MP 1-20, MP 1-24, MP 1-21, MP 1-25, MP 1-102, MP 1-8, MP 1-43 and MP 1-9 were found to be associated with high K/Na ratio whereas the RILs such as MP 1-35, MP 1-88, MP 1-60, MP 1-41, MP 1-83, MP 1-48, MP 1-65, MP 1-47, MP 1-116 and MP 1-64 were associated with low K/Na ratio. The RILs MP 1-102 and MP 1-43 displayed high sodicity tolerance based on high grain yield (>6.0 g), high tolerance index (>0.7) and high K/

Na ratio (>1.6). Based on 5 years pooled data, 10 RILs (MP 1-119, MP 1-73, MP 1-69, MP 1-57, MP 1-111, MP 1-81, MP 1-16, MP 1-59, MP 1-105 and MP 1-43) recorded very high grain yield in sodic soils with high tolerance index (>0.7).

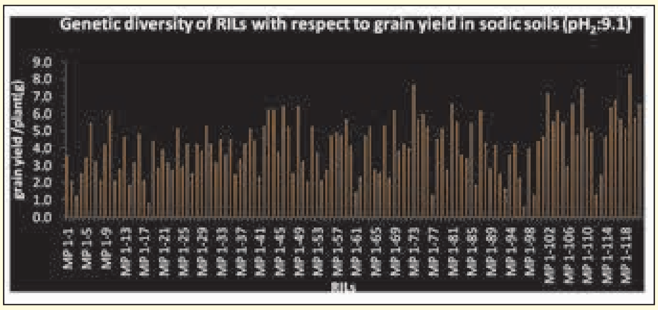



*Fig. 30 : Genotypic variation in RILs with respect to grain yield per plant (during 2013-14)*

**Table 39 : Performance of Checks and RILs under sodic condition ($pH_2$ 9.1)**

| Checks | Grain yield/ plant (g) | TI | Na% | K% | K/Na |
|---|---|---|---|---|---|
| Kharchia 65 | 6.0 | 0.7 | 1.9 | 2.7 | 1.4 |
| HD 2009 | 4.2 | 0.5 | 2 | 2.1 | 1.1 |
| KRL 19 | 6.1 | 0.8 | 1.8 | 2.4 | 1.4 |
| HD 2851 | 4.0 | 0.5 | 2.3 | 1.7 | 0.8 |
| RILs | | | | | |
| Mean | 4.1 | 0.5 | 1.9 | 1.62 | 0.92 |
| SD | 1.62 | 0.18 | 0.48 | 0.54 | 0.4 |
| Range | 8.2-0.6 | 1.1-0.1 | 3.3-1.0 | 3.5-0.7 | 2.5-0.3 |

**Table 40 : Top tolerant and sensitive RILs on the basis of grain yield, tolerance index and K/Na ratio (Pooled data of five years)**

| Genotype | Grain yield/plant (g) | Tolerance index | Na (%) | K (%) | K/Na |
|---|---|---|---|---|---|
| **Tolerant RILs** | | | | | |
| MP 1-119 | 6.6 ± 0.6 | 0.7 ± 0.0 | 1.5 ± 0.3 | 1.7 ± 0.3 | 1.8 ± 1.1 |
| MP 1-73 | 6.3 ± 0.6 | 0.8 ± 0.0 | 2.5 ± 0.3 | 2.5 ± 0.5 | 1.1 ± 0.3 |
| MP 1-69 | 6.0 ± 1.0 | 0.8 ± 0.1 | 2.0 ± 0.1 | 1.1 ± 0.2 | 0.5 ± 0.1 |
| MP 1-57 | 5.9 ± 0.6 | 0.7 ± 0.1 | 1.4 ± 0.3 | 2.2 ± 0.6 | 2.3 ± 1.3 |
| MP 1-111 | 5.8 ± 0.6 | 0.8 ± 0.1 | 1.5 ± 0.3 | 1.5 ± 0.2 | 1.6 ± 0.9 |
| MP 1-81 | 5.8 ± 0.4 | 0.8 ± 0.1 | 2.7 ± 0.2 | 1.8 ± 0.4 | 0.7 ± 0.2 |
| MP 1-16 | 5.7 ± 0.5 | 0.6 ± 0.1 | 2.1 ± 0.2 | 2.4 ± 0.4 | 1.2 ± 0.3 |
| MP 1-59 | 5.6 ± 0.5 | 0.7 ± 0.0 | 1.5 ± 0.1 | 2.2 ± 0.4 | 1.5 ± 0.4 |
| MP 1-105 | 5.6 ± 0.6 | 0.8 ± 0.0 | 1.2 ± 0.2 | 1.1 ± 0.3 | 1.5 ± 1.0 |
| MP 1-43 | 5.5 ± 0.6 | 0.7 ± 0.1 | 1.3 ± 0.1 | 2.1 ± 0.2 | 1.6 ± 0.4 |
| **Sensitive RILs** | | | | | |
| MP 1-97 | 1.1 ± 0.3 | 0.2 ± 0.1 | 2.2 ± 0.2 | 1.1 ± 0.2 | 0.6 ± 0.2 |
| MP 1-3 | 1.2 ± 0.2 | 0.3 ± 0.1 | 2.3 ± 0.1 | 1.8 ± 0.2 | 0.8 ± 0.1 |
| MP 1-18 | 1.2 ± 0.2 | 0.2 ± 0.1 | 1.9 ± 1.3 | 1.4 ± 0.2 | 0.8 ± 0.0 |
| MP 1-112 | 1.3 ± 0.6 | 0.3 ± 0.1 | 2.0 ± 0.2 | 1.2 ± 0.3 | 0.7 ± 0.2 |
| MP 1-14 | 1.4 ± 0.4 | 0.4 ± 0.1 | 2.8 ± 0.2 | 1.9 ± 0.3 | 0.7 ± 0.1 |
| **Checks** | | | | | |
| Kharchia 65 | 6.4 ± 0.5 | 0.9 ± 0.0 | 1.7 ± 0.2 | 2.8 ± 0.3 | 1.8 ± 0.4 |
| HD 2009 | 3.9 ± 0.9 | 0.5 ± 0.1 | 2.0 ± 0.1 | 2.4 ± 0.3 | 1.2 ± 0.2 |
| KRL 19 | 5.0 ± 0.7 | 0.7 ± 0.1 | 1.8 ± 0.1 | 2.6 ± 0.3 | 1.5 ± 0.2 |
| HD 2851 | 3.4 ± 0.6 | 0.4 ± 0.1 | 2.3 ± 0.1 | 1.9 ± 0.4 | 0.9 ± 0.1 |

Out of these RILs, MP 1-57, MP 1-119, MP 1-111, MP 1-43, MP 1-105 and MP 1-59 were also associated with high K/Na ratio. In addition to tolerant RILs, sensitive RILs were also found to be associated with low tolerance index, low grain yield 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)

### Development and evaluation of advanced breeding lines (IVT and AVT) in semi-reclaimed alkali soils

Thirty seven breeding lines including seven checks (CS 52, CS 54, CS 56, Kranti, Krishna, Pusa Bold and Varuna) were evaluated in IVT for seed yield in screening trial in reclaimed alkali soils (pH 8.1 to 9.5) at Karnal in 5x 0.60m plot (5m long two rows with 30 cm apart). Seed yield ranged from 356.67 to 633.33 g/plot (Mean 490.00 g/plot, CD $_{(0.05\%)}$ 110.00g). Three lines gave significantly higher yield over the best check CS 54 (563.33 g/plot) with CS 7003-3-2-6 (633.33 g/plot) followed by CS 700-2-1-4 (596.97 g/plot) recording maximum seed yield (Table 41).

**Table 41. Development and evaluation of advanced breeding lines (IVT) -2014**

| Sr. No. | Entries | IVT Nain-2014 Saline | IVT Karnal-2014 Alkali |
|---|---|---|---|
| | | Yield/plot (g) | Yield/plot (g) |
| 1 | CS 7003-3-2-6 | 633.33 | 633.33 |
| 2 | CS 1000-1-3-3-4 | 490.00 | 463.33 |
| 3 | CS 5000-1-3-1-8 | 550.00 | 516.67 |
| 4 | CS 6003-1-1-5 | 603.33 | 520.00 |
| 5 | CS 3000-1-3-2-4-3 | 340.00 | 463.33 |
| 6 | CS 1100-1-3-3-1-3 | 373.33 | 453.33 |
| 7 | CS 219-1 | 613.33 | 423.33 |
| 8 | CS 15000-1-1-1-4-5 | 616.67 | 500.00 |
| 9 | 15000-1-3-2-4-2 | 590.00 | 516.67 |
| 10 | CS 2900-3-3-2-4 | 660.00 | 443.33 |
| 11 | Kranti | 510.00 | 523.33 |
| 12 | CS 7003-1-2-5-1 | 733.33 | 520.00 |
| 13 | CS 13000-3-2-3-7 | 670.00 | 423.33 |
| 14 | CS 2800-1-2-3-5-1 | 1010.00 | 486.67 |
| 15 | CS 5001-3-2-7 | 630.00 | 523.33 |
| 16 | CS 900-1-1-2-4-1 | 830.00 | 523.33 |
| 17 | CS 700-2-1-4 | 703.33 | 596.67 |
| 18 | CS 508-4-2p1 | 670.00 | 506.67 |
| 19 | CS 3000-1-3-2-3 | 633.33 | 520.00 |
| 20 | CS 5000-1-2-4-5 | 783.33 | 550.00 |
| 21 | CS 3001-2-2-3-1 | 766.67 | 443.33 |
| 22 | Varuna | 586.67 | 483.33 |
| 23 | CS 15000-1-1-1-4-2 | 606.67 | 410.00 |
| 24 | CS 13000-3-3-7-2 | 696.67 | 526.67 |
| 25 | CS 2900-3-1-2-1 | 676.67 | 553.33 |
| 26 | CS 9000-1-2-2-1-1 | 703.33 | 586.67 |
| 27 | CS 1100-1-1-3-4-2 | 760.00 | 370.00 |
| 28 | CS 15000-1-3-1-7-2 | 746.67 | 356.67 |
| 29 | CS 900-1-1-4-4-1 | 643.33 | 360.00 |
| 30 | CS 8000-1-3-3-5-1 | 623.33 | 480.00 |
| 31 | CS 611-1-6-pd | 816.67 | 466.67 |
| 32 | CS 508-1-p2 | 683.33 | 536.67 |
| 33 | CS 52 | 510.00 | 473.33 |
| 34 | Krishna | 533.33 | 470.00 |
| 35 | Pusa Bold | 470.00 | 496.67 |
| 36 | CS 56 | 560.00 | 523.33 |
| 37 | CS 54 | 376.67 | 563.33 |
| Mean | | 633.33 | 490.00 |
| CD $_{5\%}$ | | 253.33 | 110.00 |
| Range | | 340.00-1010.00 | 356.67-633.33 |
| Best check | | Varuna (586.67)* | CS 54 (563.33)* |
| No. of Superior lines over best check | | 26 | 3 |
| Top two lines | | CS 2800-1-2-3-5-1 (1010.00)* | CS 7003-3-2-6 (633.33)* |
| | | CS 900-1-1-2-4-1 (830.00)* | CS 700-2-1-4 (596.97)* |

*Figures in parentheses are yield (g)

Further, thirty six 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 in 5x0.60 m plot (5 m long two rows with 30 cm apart). Seed yield ranged from 436.67 to 693.33 g/plot (Mean 530.00 g/plot, CD $_{(0.05\%)}$ 140.00g). Nine lines gave significantly higher yield over the best check CS 56 (550.00 g/plot) with CS 13000-3-2-2-5-2 (693.33 g/plot) followed by CS 700-3-3-1-5 (616.67 g/plot) recording maximum seed yield (Table 42).

## Development and evaluation of advanced breeding lines (IVT and AVT) in saline soils

Thirty seven breeding lines including seven checks (CS 52, CS 54, CS 56, Kranti, Krishna, Pusa Bold and Varuna) were evaluated in IVT for seed yield in screening trial in saline soils (ECe 9.2-15.4 dS ($m^{-1}$) at Nain Farm (Distt. Panipat) in 5x0.60m plot (5m long two rows with 30 cm apart).

**Table 42 : Development and evaluation of advanced breeding lines (AVT) -2014**

| Sr. No. | Genotypes | AVT Nain-2014 Saline | AVT Karnal-2014 Alkali |
|---|---|---|---|
| | | Yield/plot (g) | Yield/plot (g) |
| 1 | CS 8000-1-2-8 | 943.33 | 536.67 |
| 2 | CS 1100-1-2-1-4 | 740.00 | 486.67 |
| 3 | CS 8000-1-1-1-6 | 766.67 | 550.00 |
| 4 | CS 2200-3-4 | 713.33 | 483.33 |
| 5 | CS 900-1-2-2-1-2 | 783.33 | 513.33 |
| 6 | CS 13000-3-1-1-4-2 | 730.00 | 483.33 |
| 7 | CS 101-4 | 516.67 | 540.00 |
| 8 | CS 54 | 456.67 | 516.67 |
| 9 | CS 900-1-2-1-2-2 | 683.33 | 526.67 |
| 10 | CS 1500-1-1-3-2-1 | 753.33 | 546.67 |
| 11 | CS 13000-3-1-1-2-1 | 683.33 | 570.00 |
| 12 | CS 2200-5-5 | 546.67 | 490.00 |
| 13 | CS 513-2 | 753.33 | 440.00 |
| 14 | Kranti | 546.67 | 520.00 |
| 15 | CS 7003-3-2-1 | 446.67 | 550.00 |
| 16 | CS 700-2-1-6 | 740.00 | 523.33 |
| 17 | CS 900-1-2-2-1-3 | 510.00 | 566.67 |
| 18 | CS 700-2-1-1 | 750.00 | 486.67 |
| 19 | CS 900-1-2-4-5 | 613.33 | 606.67 |
| 20 | CS 1300-3-3-2-7-1 | 530.00 | 570.00 |
| 21 | CS 700-3-3-1-5 | 373.33 | 616.67 |
| 22 | CS 13000-1-3-2-4-3 | 290.00 | 523.33 |
| 23 | CS 1600-1-3-3-2 | 376.67 | 593.33 |
| 24 | CS 234-2p2 | 410.00 | 546.67 |
| 25 | CS 15000-1-3-2-1 | 756.67 | 436.67 |
| 26 | CS 3000-1-2-1-3-2 | 966.67 | 506.67 |
| 27 | CS 3000-1-2-1-3-1 | 680.00 | 456.67 |
| 28 | CS 56 | 530.00 | 550.00 |
| 29 | CS 1100-1-1-1 | 996.67 | 533.33 |
| 30 | CS 13000-3-3-2-2-1 | 840.00 | 440.00 |
| 31 | CS 15000-1-2-2-2-1 | 816.67 | 560.00 |
| 32 | CS 1600-1-1-1-1-1 | 800.00 | 506.67 |
| 33 | CS 13000-3-2-2-5-2 | 820.00 | 693.33 |
| 34 | CS 52-SPS-1-2012 | 583.33 | 530.00 |
| 35 | Varuna | 433.33 | 510.00 |
| 36 | CS 52 | 490.00 | 546.67 |
| Mean | | 646.67 | 530.00 |
| CD at 5% | | 266.67 | 140.00 |
| Range | | 290.00-996.67 | 436.67-693.33 |
| Best check | | Kranti (546.67)* | CS 56 (550.00)* |
| No. of superior lines over best check | | 23 | 9 |
| Top two lines | | CS 1100-1-1-1 (996.67)* | CS 13000-3-2-2-5-2 (693.33)* |
| | | CS 3000-1-2-1-3-2 (966.67)* | CS 700-3-3-1-5 (616.67)* |

*Figures in parentheses are yield (g)

Seed yield ranged from 340 to 1010 g/plot (Mean 633.33 g/plot, CD $_{(0.05\%)}$ 253.33g). Twenty six lines gave significantly higher yield over the best check Varuna (586.67 g/plot) with CS 2800-1-2-3-5-1 (1010 g/plot) followed by CS 900-1-1-2-4-1 (830 g/plot) recording maximum seed yield (Table 41).

Further, in AVT, thirty six 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 ($EC_e$ 9.2-15.4 dS ($m^{-1}$) at Nain Farm (Distt. Panipat) in 5x0.60 m plot (5 m long two rows with 30 cm apart). Seed yield ranged from 290.00 to 996.67 g/plot (Mean 646.67 g/plot, CD $_{(0.05\%)}$ 266.67g). Twenty three lines gave significantly higher seed yield over best check Kranti (546.67 g/plot) with CS 1100-1-1-1 (996.67 g/plot) followed by CS 3000-1-2-1-3-2 (966.67 g/plot) (Table 42).

## Development and evaluation of segregating material ($F_5$ and $F_7$) of mustard in semi – reclaimed alkali soils

Seventy two breeding lines including 5 checks (CS 54, Pusa Bold, Pusa Jagannath, CS 2007-6 and Kranti) were evaluated in $F_5$ generation for seed yield in reclaimed alkali soils (pH 8.1 to 9.5) at Karnal in 5x0.60 m plot (5 m long two rows with 30 cm apart). Seed yield ranged from 286.67 to 616.67 g/plot (Mean 433.33 g/plot, CD $_{(0.05\%)}$ 130.00 g). Thirty eight lines gave significantly higher seed yield over the best check CS 54 (430.00 g/plot) with CS 2013-56 (616.67 g/plot) followed by CS 2013-48 (546.67 g/plot) (Table 43) .

Sixty six breeding lines including four checks (CS 52, CS 54, Krishna and Kranti) were evaluated in $F_7$ generation for seed yield in reclaimed alkali soils (pH 8.1 to 9.5) at Karnal in 5x0.60m plot (5 m long two rows with 30 cm apart). Seed yield ranged from 113.33 to 633.33 g/plot (Mean 466.82, CD $_{(0.05\%)}$ 176.67g). Thirty five lines gave significantly higher seed yield over the best check CS 54 (470 g/plot) with CS 2009-144 (633.33 g/plot) followed by CS 2009-345 (623.33 g/plot) (Table 44).

**Table 43 : Development and Evaluation of segregating material ($F_5$)-2014**

| Sr. No. | Genotype | $F_5$ Karnal Yield (g/plot.) | $F_5$ Nain Yield (g/plot.) | Sr. No. | Genotype | $F_5$ Karnal Yield (g/plot.) | $F_5$ Nain Yield (g/plot.) |
|---|---|---|---|---|---|---|---|
| 1 | CS 2013-1 | 453.33 | 666.67 | 37 | CS 2013-37 | 426.67 | 497.00 |
| 2 | CS 2013-2 | 410.00 | 633.33 | 38 | CS 2013-38 | 460.00 | 569.33 |
| 3 | CS 2013-3 | 370.00 | 562.33 | 39 | CS 2013-39 | 446.67 | 625.33 |
| 4 | CS 2013-4 | 380.00 | 618.33 | 40 | CS 2013-40 | 456.67 | 534.33 |
| 5 | CS 2013-5 | 423.33 | 653.33 | 41 | CS 2013-41 | 483.33 | 613.33 |
| 6 | CS 2013-6 | 370.00 | 520.00 | 42 | CS 2013-42 | 506.67 | 550.67 |
| 7 | CS 2013-7 | 403.33 | 639.33 | 43 | CS 2013-43 | 500.00 | 676.67 |
| 8 | CS 2013-8 | 440.00 | 556.67 | 44 | CS 2013-44 | 403.33 | 525.00 |
| 9 | CS 2013-9 | 286.67 | 338.67 | 45 | CS 2013-45 | 396.67 | 532.00 |
| 10 | CS 2013-10 | 353.33 | 835.33 | 46 | CS 2013-46 | 450.00 | 604.33 |
| 11 | CS 2013-11 | 360.00 | 541.33 | 47 | CS 2013-47 | 503.33 | 576.33 |
| 12 | CS 2013-12 | 440.00 | 599.67 | 48 | CS 2013-48 | 546.67 | 539.00 |
| 13 | CS 2013-13 | 463.33 | 539.00 | 49 | CS 2013-49 | 336.67 | 588.00 |
| 14 | CS 2013-14 | 483.33 | 648.67 | 50 | CS 2013-50 | 496.67 | 667.33 |
| 15 | CS 2013-15 | 430.00 | 382.67 | 51 | CS 2013-51 | 450.00 | 641.67 |
| 16 | CS 2013-16 | 446.67 | 457.33 | 52 | CS 2013-52 | 466.67 | 588.00 |
| 17 | CS 2013-17 | 466.67 | 389.67 | 53 | CS 2013-53 | 350.00 | 553.00 |
| 18 | CS 2013-18 | 473.33 | 382.67 | 54 | CS 2013-54 | 473.33 | 812.00 |
| 19 | CS 2013-19 | 426.67 | 539.00 | 55 | CS 2013-55 | 440.00 | 543.67 |
| 20 | CS 2013-20 | 463.33 | 562.33 | 56 | CS 2013-56 | 616.67 | 448.00 |
| 21 | CS 2013-21 | 426.67 | 525.00 | 57 | CS 2013-57 | 533.33 | 585.67 |
| 22 | CS 2013-22 | 403.33 | 546.00 | 58 | CS 2013-58 | 473.33 | 541.33 |
| 23 | CS 2013-23 | 396.67 | 515.67 | 59 | CS 2013-59 | 503.33 | 660.33 |
| 24 | CS 2013-24 | 403.33 | 515.67 | 60 | CS 2013-60 | 323.33 | 415.33 |
| 25 | CS 2013-25 | 450.00 | 546.00 | 61 | CS 2013-61 | 333.33 | 434.00 |
| 26 | CS 2013-26 | 353.33 | 469.00 | 62 | CS 2013-62 | 390.00 | 543.67 |
| 27 | CS 2013-27 | 480.00 | 630.00 | 63 | CS 2013-63 | 410.00 | 609.00 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 28 | CS 2013-28 | 473.33 | 480.67 | 64 | CS 2013-64 | 523.33 | 427.00 |
| 29 | CS 2013-29 | 500.00 | 492.33 | 65 | CS 2013-65 | 460.00 | 515.67 |
| 30 | CS 2013-30 | 460.00 | 536.67 | 66 | CS 2013-66 | 396.67 | 448.00 |
| 31 | CS 2013-31 | 533.33 | 511.00 | 67 | CS 2013-67 | 393.33 | 492.33 |
| 32 | CS 2013-32 | 500.00 | 511.00 | 68 | Pusa Bold | 383.33 | 471.33 |
| 33 | CS 2013-33 | 406.67 | 534.33 | 69 | Pusa Jagannath | 400.00 | 471.33 |
| 34 | CS 2013-34 | 446.67 | 441.00 | 70 | CS 2007-6 | 350.00 | 487.67 |
| 35 | CS 2013-35 | 320.00 | 581.00 | 71 | CS-54 | 430.00 | 497.00 |
| 36 | CS 2013-36 | 393.33 | 529.67 | 72 | Kranti | 416.67 | 506.33 |
| Mean | | | | | | 433.33 | 543.33 |
| $CD_{5\%}$ | | | | | | 130.00 | 256.67 |
| Range | | | | | | 286.67-616.67 | 340.00-836.67 |
| Best check | | | | | | CS 54 (430.00)* | Kranti (506.67)* |
| No. of Superior lines over best check | | | | | | 38 | 51 |
| Top two lines | | | | | | CS 2013-56 (616.67)* | CS 2013-10 (836.67)* |
| | | | | | | CS 2013-48 (546.67)* | CS 2013-54 (813.33)* |

*Figures in parentheses are yield (g/plot.)

**Table 44 : Development and Evaluation of segregating material ($F_7$)-2014**

| Sr. No. | Name of Genotype | Yield (g/plot.) | Sr. No. | Name of Genotype | Yield (g/plot.) |
|---|---|---|---|---|---|
| 1 | CS 2009-103 | 500.00 | 34 | CS 2009-259 | 536.67 |
| 2 | CS 2009-112 | 473.33 | 35 | CS 2009-260 | 550.00 |
| 3 | CS 2009-118 | 483.33 | 36 | CS 2009-261 | 416.67 |
| 4 | CS 2009-130 | 470.00 | 37 | CS 2009-263 | 540.00 |
| 5 | CS 2009-138 | 390.00 | 38 | CS 2009-264 | 493.33 |
| 6 | CS 2009-140 | 463.33 | 39 | CS 2009-265 | 396.67 |
| 7 | CS 2009-144 | 633.33 | 40 | CS 2009-301 | 553.33 |
| 8 | CS 2009-151 | 456.67 | 41 | CS 2009-302 | 483.33 |
| 9 | CS 2009-154 | 343.33 | 42 | CS 2009-313 | 473.33 |
| 10 | CS 2009-156 | 410.00 | 43 | CS 2009-315 | 453.33 |
| 11 | CS 2009-201 | 516.67 | 44 | CS 2009-316 | 410.00 |
| 12 | CS 2009-204 | 396.67 | 45 | CS 2009-318 | 356.67 |
| 13 | CS 2009-208 | 380.00 | 46 | CS 2009-330 | 566.67 |
| 14 | CS 2009-215 | 513.33 | 47 | CS 2009-332 | 493.33 |
| 15 | CS 2009-216 | 500.00 | 48 | CS 2009-333 | 590.00 |
| 16 | CS 2009-219 | 366.67 | 49 | CS 2009-334 | 403.33 |
| 17 | CS 2009-224 | 543.33 | 50 | CS 2009-335 | 463.33 |
| 18 | CS 2009-227 | 506.67 | 51 | CS 2009-336 | 533.33 |
| 19 | CS 2009-229 | 456.67 | 52 | CS 2009-344 | 430.00 |
| 20 | CS 2009-241 | 556.67 | 53 | CS 2009-345 | 623.33 |

| | | | | | |
|---|---|---|---|---|---|
| 21 | CS 2009-243 | 556.67 | 54 | CS 2009-346 | 346.67 |
| 22 | CS 2009-244 | 426.67 | 55 | CS 2009-347 | 556.67 |
| 23 | CS 2009-245 | 516.67 | 56 | CS 2009-401 | 513.33 |
| 24 | CS 2009-246 | 356.67 | 57 | CS 2009-413 | 350.00 |
| 25 | CS 2009-247 | 443.33 | 58 | CS 2009-414 | 470.00 |
| 26 | CS 2009-248 | 526.67 | 59 | CS 2009-418 | 483.33 |
| 27 | CS 2009-250 | 113.33 | 60 | CS 2009-422 | 403.33 |
| 28 | CS 2009-251 | 450.00 | 61 | CS 2009-437 | 430.00 |
| 29 | CS 2009-253 | 546.67 | 62 | CS 2009-440 | 393.33 |
| 30 | CS 2009-255 | 576.67 | 63 | CS-52 | 330.00 |
| 31 | CS 2009-256 | 526.67 | 64 | Krishna | 390.00 |
| 32 | CS 2009-257 | 516.67 | 65 | CS-54 | 470.00 |
| 33 | CS 2009-258 | 576.67 | 66 | Kranti | 413.33 |
| Mean | | | | | 466.82 |
| CD at 5% | | | | | 176.67 |
| Range | | | | | 113.33-633.33 |
| Best check | | | | | CS 54 (470.00)* |
| No. of superior lines over best check | | | | | 35 |
| Top two lines | | | | | CS 2009-144 (633.33)* CS 2009-345 (623.33)* |

*Figures in parentheses are yield (g)

## Development and evaluation of segregating material ($F_5$) of mustard in saline soils

Seventy two breeding lines including 5 checks (CS 54, Pusa Bold, Pusa Jagannath, CS 2007-6 and Kranti) were evaluated in $F_4$ generation for seed yield in saline soils ($EC_e$ 9.2-15.4 dS(m$^{-1}$) at Nain Farm (Distt. Panipat) in 5x0.60 m plot (5 m long two rows with 30 cm apart). Seed yield ranged from 340.00 to 836.67 g/plot (Mean 543.33 g/plot, CD $_{(0.05\%)}$ 256.67g). Fifty one lines gave significantly higher seed yield over the best check Kranti (506.67 g/plot) with CS 2013-10 (836.67 g/plot) followed by CS 2013-54 (813.33 g/plot) (Table 3).

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

Eight genotypes were evaluated in IVT under saline conditions (ECe 10.7 dS m$^{-1}$) at experimental farm Nain (Distt. Panipat) and in 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 1.78 to 2.38 t ha$^{-1}$ (Mean 2.04 t ha$^{-1}$, CD$_{(0.05\%)}$ 0.24 t) at Nain and 1.47 to 2.06 t ha$^{-1}$ (Mean 1.72 t ha$^{-1}$, CD $_{(0.05\%)}$ 0.20 t) under high alkaline conditions (pH 9.3) at Karnal. Genotypes CSCN-13-8 (2.38 t ha$^{-1}$) followed by CSCN-13-7 (2.33 t ha$^{-1}$) at Nain and CSCN-13-8 (2.06 t ha$^{-1}$) followed by CSCN-13-7 (1.98 t ha$^{-1}$) at Karnal showed highest seed yield (Table 45).

Similarly, six genotypes were evaluated in AVT-1 under saline conditions ($EC_e$ 10.7 dS m$^{-1}$) at experimental farm Nain (Distt. Panipat) and under alkaline conditions (*p*H 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 1.80 to 2.45 t ha$^{-1}$ (Mean 1.98 t ha$^{-1}$, CD$_{(0.05\%)}$ 0.24 t) at Nain and 1.50 to 2.00 t ha$^{-1}$ (Mean 1.62 t ha$^{-1}$, CD $_{(0.05\%)}$ 0.18 t) under high alkaline conditions (pH 9.3) at Karnal. Genotypes CSCN-13-11 (2.45 t ha$^{-1}$) followed by CSCN-13-9 (1.94 t ha$^{-1}$) at Nain and CSCN-13-11(2.00 t ha$^{-1}$) followed by CSCN-13-14 (1.60 t ha$^{-1}$) at Karnal showed highest seed yield (Table 46).

**Table 45: Performance of mustard strains in IVT (saline/alkaline conditions)-2013-14**

| S. No. | Code | Strain | Seed yield (t ha$^{-1}$) | | | 1000-seed wt. (g) | | Oil content (%) | |
|---|---|---|---|---|---|---|---|---|---|
| | | | KAR 1 | KAR 2 | Mean | KAR 1 | KAR 2 | KAR 1 | KAR 2 |
| 1 | CSCN-13-1 | CS 2200-2-6 | 2.03 | 1.71 | 1.87 | 5.4 | 5.3 | 38.6 | 38.4 |
| 2 | CSCN-13-2 | RH 1006 | 1.86 | 1.47 | 1.67 | 4.7 | 4.0 | 39.1 | 38.4 |
| 3 | CSCN-13-3 | CS 8000-1-2-8 | 2.29 | 1.86 | 2.07* | 5.5 | 5.3 | 38.5 | 38.6 |
| 4 | CSCN-13-4 | CS-54 (Check) | 1.80 | 1.57 | 1.69 | 5.4 | 5.3 | 38.8 | 38.4 |
| 5 | CSCN-13-5 | RH 1003 | 1.87 | 1.56 | 1.72 | 4.3 | 3.7 | 39.0 | 38.5 |
| 6 | CSCN-13-6 | Kranti (NC) | 1.78 | 1.55 | 1.67 | 4.3 | 3.6 | 39.2 | 38.5 |
| 7 | CSCN-13-7 | CS 15000-1-2-2-2-1 | 2.33 | 1.98 | 2.16* | 5.6 | 5.3 | 39.2 | 38.4 |
| 8 | CSCN-13-8 | CS 13000-3-1-1-4-2 | 2.38 | 2.06 | 2.22* | 5.7 | 5.4 | 39.4 | 38.6 |
| | | GM | 2.04 | 1.72 | | | | | |
| | | CD (5%) | 0.24 | 0.20 | | | | | |
| | | DOS | 18.10.13 | 20.10.13 | | | | | |
| | | C.V. | 11.8 | 11.9 | | | | | |
| | | ECe | 10.7 | | | | | | |
| | | pH | | 9.3 | | | | | |

* Strain outyielding the best check by margin of >10 % seed yield

**Table 46 : Performance of mustard strains in AVT (saline/alkaline conditions)-2013-14**

| S. No. | Code | Strain | Seed yield (t ha$^{-1}$) | | | 1000-seed wt. (g) | | Oil content (%) | |
|---|---|---|---|---|---|---|---|---|---|
| | | | KAR 1 | KAR 2 | Mean | KAR 1 | KAR 2 | KAR 1 | KAR 2 |
| 1 | CSCN-13-9 | Kranti (Filler) | 1.94 | 1.51 | 1.72 | 4.4 | 4.1 | 39.9 | 38.7 |
| 2 | CSCN-13-10 | NRCHB101 (Filler) | 1.89 | 1.51 | 1.70 | 4.6 | 4.2 | 38.9 | 39.0 |
| **3** | CSCN-13-11 | CS 1100-1-2-2-3 | 2.45 | 2.00 | **2.22*** | **5.6** | **5.6** | **38.5** | **38.4** |
| **4** | CSCN-13-12 | Kranti (NC) | 1.80 | 1.50 | **1.65** | **4.4** | **3.8** | **38.6** | **38.6** |
| **5** | CSCN-13-13 | CS 54 (Check) | 1.89 | 1.59 | **1.74** | **5.5** | **5.4** | **38.8** | **38.7** |
| 6 | CSCN-13-14 | CS-54 (Filler) | 1.90 | 1.60 | 1.75 | 5.6 | 5.5 | 38.8 | 38.7 |
| | | GM | 1.98 | 1.62 | | | | | |
| | | CD (5%) | 0.24 | 0.18 | | | | | |
| | | DOS | 18.10.13 | 20.10.13 | | | | | |
| | | C.V. | 11.8 | 11.0 | | | | | |
| | | ECe | 10.7 | | | | | | |
| | | pH | | 9.3 | | | | | |

* Strain outyielding the best check by margin of >10 % seed yield

## Special attainment

Identified a 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 47: Comparison of yield and quality parameters of mutant with checks at $EC_e$ 10 dS $m^{-1}$ and pH 9.2**

| Name of genotype | 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 |

| Name of genotype | 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 |

- Developed and submitted four genotypes (CS 13000-3-2-2-5-2, CS 2800-1-2-3-5-1, CS 7003-3-2-6 and CS 2009-105) to AICRP on rapeseed & mustard for IVT Salinity/Alkalinity trial-2014-15.
- Developed and submitted three genotypes (CS 15000-1-2-2-2-1, CS 8000-1-2-8 and CS 13000-3-1-1-4-2) to AICRP on rapeseed & mustard for AVT-1 Salinity/Alkalinity trial-2014-15.
- Developed and submitted one genotype (CS 1100-1-2-2-3) to AICRP on rapeseed & mustard for AVT-2 Salinity/Alkalinity trial-2014-15.
- Developed 22 crosses/ back crosses and 4 RILs population (250 lines of each in $F_4$ generation) according to objectives of project.

## 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)

### Wheat

Growth and performance of Kharchia 65, KRL 210 and HD 2851 was good up to 25 per cent water deficit coupled with 50 mM NaCl, but increased concentration and water deficit reduced the growth in KRL 210, HD 2851 and HD 2009 genotypes.

### Physiological parameters

Kharchia 65 showed the highest GI (7.25) followed by HD 2851 (5.63), KRL 210 (4.26) and HD 2009 (3.75) under control conditions. The highest rate of electrolyte leakage (an indicator of membrane damage) was observed in HD 2009 (61.47%) at 100 mM NaCl + 50% WD while the minimum leakage occurred in Kharchia 65 (49.22%). The maximum (66.85 %) reduction in RWC was recorded in HD 2009 followed by HD 2851 (64.32%), KRL 210 (53.42%) and the minimum in Kharchia 65 (51.37%). Increasing salt and water deficit stresses significantly reduced chlorophyll content in all the varieties as compared to control. Kharchia 65 had the maximum (26.29 µg/ml) chlorophyll whereas the minimum (23.62 µg/ml) chlorophyll content was recorded in HD 2009. Kharchia 65 showed better gas exchange properties over the other varieties studied. The maximum photosynthetic rate (18.33 µmol/$m^2$/Sec) was observed in Kharchia 65 and minimum in HD 2009 (13.24 µmol/$m^2$/Sec). Stomatal conductance was maximum in Kharchia 65 and KRL 210 (0.26 mmol/$m^2$/Sec) and minimum in HD 2009 (0.20 mmol/$m^2$/Sec). The minimum transpiration rate (1.50 µmol/$m^2$/Sec) was recorded in HD 2009 while the maximum was noted in Kharchia 65 (2.12 µmol/$m^2$/Sec).

### Biochemical parameters, ionic relations and yield attributes

The leaves of wheat variety HD 2851 (43.88 mg/g dw) exhibited comparatively higher total soluble sugars over other tested varieties. The highest proline content was recorded in HD 2851 and minimum in Kharchia 65 under control conditions. Wheat variety HD 2009 showed the highest (9.81 mg/g fw) while Kharchia 65 showed the lowest (7.46 mg/g fw) mean value for proline content. The sensitive varieties HD 2851 and HD 2009 accumulated the highest mean $Na^+$ (0.63 and 0.68

%, respectively), whereas the tolerant Kharchia 65 accumulated the lowest (0.4 %) $Na^+$. Kharchia 65 and KRL 210 maintained significantly lower (4.54 and 4.55 % dw, respectively) $Cl^-$ content under all the treatments. At highest levels of salt and water deficit stress, HD 2009 had the lowest (5.5 % dw) $Cl^-$ content while KRL 210 accumulated highest (6.72 % dw). At the highest stresses conditions, $K^+$ concentration decreased from 1.09 to 0.39% in Kharchia 65, from 1.32 to 0.34% in KRL 210, from 1.29 to 0.34% in HD 2851 and from 1.14 to 0.28% in HD 2009 in comparison to control. Kharchia 65 showed the highest (25.0 g/plant) biomass followed by variety HD 2851 (24.6 g/plant), KRL 210 (24.5 g/plant) while the least biomass was noted in variety HD 2009 (24.2 g/plant) under non-stress conditions. Mean 1000 seed weight of wheat varieties followed the trend: 34.51 g in Kharchia 65, 28.52 g in KRL 210, 24.89 g in HD 2009 and 24.55 g in HD 2851.

## Rice

### Physiological parameters

Growth performance of CSR10 was the best amongst all the varieties under all the treatments. The mean chlorophyll concentration was the highest in CSR 10 while IR 29 showed lowest concentration. Membrane leakage was lowest in CSR 10 (36.07%) followed by CSR 36 (37.68%), IR 29 (45.45%) and Pusa 44 (46.11%). Relative Water Control was highest in CSR 10 and lowest in Pusa 44.

Amongst gas exchange parameters, the maximum photosynthetic rate was observed in CSR 10 (21.27 µmol/$m^2$/sec) and minimum in IR 29 (14.24 µmol/$m^2$/sec). Stomatal conductance was maximum in CSR 10 (6.05 mmol/$m^2$/sec) and minimum in IR 29 (3.82 mmol/$m^2$/sec). The lowest transpiration rate (8.68 µmol/$m^2$/Sec) was recorded in Pusa 44 while the highest in CSR 10 (10.61 µmol/$m^2$/Sec). Further, the maximal photochemical efficiency (Fv/Fm) and quantum photochemical yield [*Y (II)*] were noted in CSR 10 and the minimum in Pusa 44. Regarding total soluble sugars, maximum accumulation was observed in CSR 10 (33.19 mg/g dry wt) and minimum in Pusa 44 (28.37 mg/g dry wt). Reverse trend of increase was observed with respect to proline content with the highest proline (9.24 mg/g fresh wt) recorded in proline and lowest accumulation noted in CSR 10 (7.23 mg/g fresh wt).

## Understanding the Adaptation Mechanism of Wild Forage Halophytes in the Extreme Saline-Sodic Kachchh Plains for Enhancing Feed Resources (Ashwani Kumar)

Seeds as well as rootslips of 6 halophytes collected from extreme saline sodic Kachchh plains, Bhuj, Gujarat were established in microplots of different (two alkalinity and three salinity levels ($pH_2$ 9.5 and 10.0 and ECe 15, 25, 35 dS $m^{-1}$) separately and in combination ($pH_2$ 9.0 with $EC_e$ 10, 15, 20 $dSm^{-1}$) stresses.

The highest photosynthetic rate was recorded by *Dicanthium annulatum* (36.05 µmol $CO_2$ $m^{-2}$ $s^{-1}$) under control followed by *Suaeda nudiflora* (33.48), *Sporobolus marginatus* (30.45), *Urochondra setulosa* (28.65), *Aleuropus lagopoides* (34.55) and *Salvadora* (31.62). Under high stress ($pH_2$ 9.0 + $EC_e$ 20 $dSm^{-1}$) conditions, the photosynthetic rate declined and minimum was recorded in *D. annulatum* (17.16 µmol $CO_2$ $m^{-2}$ $s^{-1}$) followed by *S. nudiflora* (16.95), *S. marginatus* (11.2), *U. setulosa* (17.83) and *A. lagopoides* (18.05), while *Salvadora* plants did not survive under this stress treatment.

The highest Fv/Fm ratio was recorded in control plants (0.745 in *D. annulatum*, 0.715 in *S. nudiflora*, 0.701 in *S. marginatus*, 0.714 in *U. setulosa* , 0.708 in *A. lagopoides* and 0.768 in *Salvadora*) while plants in sodic soils ($pH_2$ 10.0) showed lower Fv/Fm ratio (0.703 in *D. annulatum*, 0.693 in *S. nudiflora*, 0.675 in *S. marginatus*, 0.657 in *U. setulosa* and 0.662 in *A. lagopoides*). Further, salinity stressed ($EC_e$ 35 dS $m^{-1}$) plants exhibited Fv/Fm ratio of 0.695 in *D. annulatum*, 0.731 in *S. nudiflora*, 0.643 in *S. marginatus*, 0.657 in *U. setulosa* and 0.692 in *A. lagopoides.* Plants under combined saline sodic stress ($pH_2$ 9.0 + $EC_e$ 20 dS $m^{-1}$) showed fv/fm ratio as 0.682 in *D. annulatum*, 0.677 in *S. nudiflora*, 0.614 in *S. marginatus*, 0.612 in *U. setulosa* and 0.631 in *A. lagopoides*.

Under stress conditions both grass and non grass halophytes accumulated higher of $Na^+$ in leaves as compared to roots (9.40% in *Dicanthium annulatum*, 22.25% in *Suaeda nudiflora*, 4.35% in *Sporobolus marginatus*, 4.33% in *Urochondra setulosa* and, 5.80% in *Aleuropus lagopoides).* These halophytes restricted $Na^+$ accumulation in roots (0.38% in *D. annulatum*, 2.25% in *S. nudiflora*, 1.04% in *S. marginatus*, 0.92% in *U. setulosa* and, 0.88% in *A. lagopoides).*

*Wild forage halophytes being evaluated under two alkalinity and three salinity levels ($pH_2$ 9.5 and 10.0 and $EC_e$ 15, 25, 35 dS $m^{-1}$) separately and in combination ($pH_2$ 9.0 with $EC_e$ 10, 15, 20 dS $m^{-1}$) in microplots*

Approximately 10 times higher proline accumulation was observed in these halophytes with increasing stress conditions (4.86 mg/g in *D. annulatum*, 7.44 mg/g in *S. nudiflora*, 5.1 mg/g in *S. marginatus*, 7.2 mg/g in *U. setulosa*, 7.75 mg/g in *A. lagopoides* at $EC_e$ 35 dS $m^{-1}$) which showed higher osmotic adaptations.

## Production of breeder seeds

In rice, breeder seeds of seven salt tolerant varieties CSR 10 (2 q), CSR 13 (2 q), CSR 23 (2 q), CSR 27 (2 q), CSR 30 (25 q) CSR36 (22 q) and CSR 43 (22 q) were produced to meet the demand of seed producing agencies as per DAC (Department of Agriculture and Cooperation) guidelines during *kharif* 2014. Similarly, about 85 Q seed of these varieties was also produced during 2013 and distributed during 2014. In wheat, breeder seed of two salt tolerant varieties KRL 210 (11.6 q) and KRL 213 (19.4 q) was produced at CSSRI Karnal farm for distribution to various seed producing agencies and also for farm section of CSSRI, Karnal for producing seeds for further distribution to different agencies and farmers. Further, in Indian mustard, breeder seed (graded) of three salt tolerant Indian mustard varieties CS 52 (1.5 q), CS 54 (3 q) and CS 56 (3 q) was produced for distribution to central and state government. agencies.

# AGROFORESTRY IN SALT AFFECTED SOILS

## 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)

A sustainable approach for productive utilization of salt-affected soils (SAS), relates to the use of salt tolerant crop genotypes. Keeping this fact in view, four cultivars of bael (*Aegle marmelos* Correa)- an indigenous fruit valued for its nutritive, medicinal and processing values were evaluated under soil and water salinity stresses to understand the physiological basis of salt tolerance as well as to identify the salt tolerant cultivar (s) for commercial cultivation in salt affected environments.

### Soil salinity

Grafted plants of four bael cultivars (Narendra Bael-5, Narendra Bael-9, CISH Bael-1 and CISH Bael-2) were grown in saline soils and irrigated with normal water. There were three salinity treatments: control (soil $EC_e$ 1.3 dS $m^{-1}$), medium (6.5 dS $m^{-1}$) and high (10.7 dS $m^{-1}$). Different growth and physio-biochemical parameters were recorded in salt stressed plants. Data on plant growth, survival (%) and number of fruits per plant were recorded to arrive at conclusion regarding suitability of tested cultivars in saline soils.

Data on growth parameters (Fig. 31a and 31b) indicated that salinity caused significant decrease in plant height and stem girth with the minimum (9.5%) decrease in plant height observed in NB-5 and the maximum (58%) in CB-2 plants at 6.5 dS $m^{-1}$ salinity. Similarly, salt stressed plants (6.5 dS $m^{-1}$) recorded significant reductions in stem girth with the lowest (19%) and the highest (62%) reductions observed in NB-5 and NB-9 cultivars, respectively.

Data on plant survival (%) after two years of experimentation (Fig. 31a) revealed significantly better performance of NB-5 cultivar at medium salinity (6.5 dS $m^{-1}$) as about 66 per cent of NB-5 plants exhibited satisfactory growth and produced fruits in saline soils. Survival was significantly lower in other cultivars and it ranged from 11 per cent in CB-2 to 44 per cent in NB-9 cultivars. At

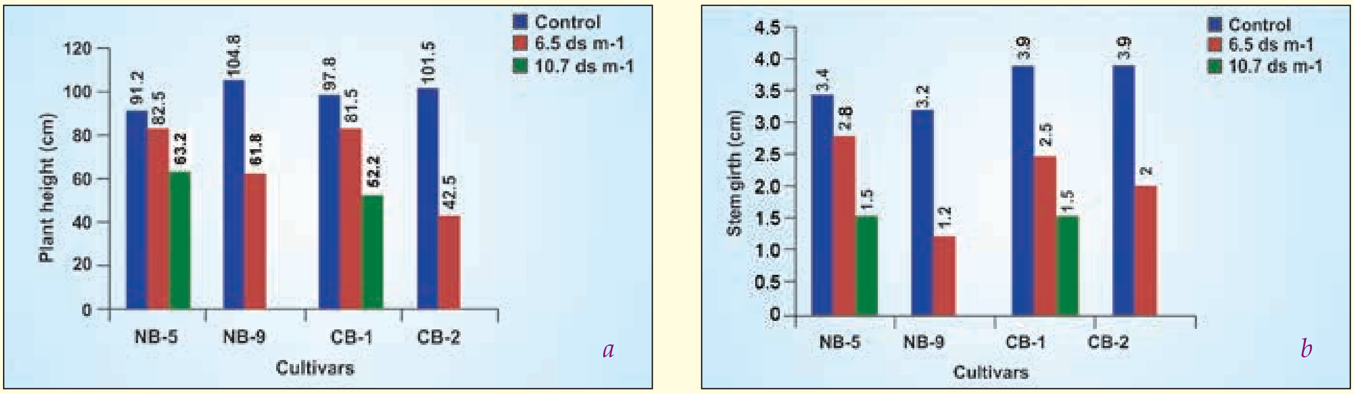



*Fig.31: Effect of soil salinity on (a) plant height (cm) and (b) stem girth (cm) in bael cultivars after two years.*

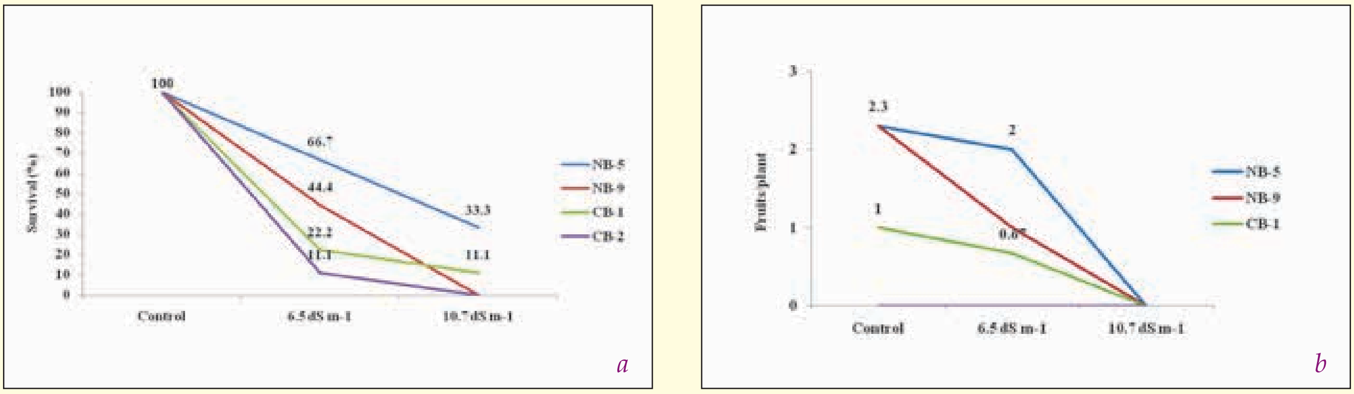



*Fig. 31 : Effect of soil salinity on (a) plant survival (%) and (b) fruits per plant in bael cultivars after two years.*

high salinity (10.7 dS $m^{-1}$), all the cultivars showed very poor performance with mean survival ranging from 11 (CB-1) to 33 per cent (NB-5). Regarding fruiting under salinity (Fig. 31b), it was observed that at 6.5 dS $m^{-1}$ salinity, average no. of fruits in NB-5 was 2 while it was 0.67 in both NB-9 and CB-1. None of the tested cultivars produced fruits under high salinity (10.7 dS $m^{-1}$). CB-2 plants did not flower and fruit even in normal soils indicating a relatively longer juvenile phase in this cultivar. Based on the performance, it may be concluded that cultivar NB-5 tolerates salinity and can be grown in salt-affected soils ($EC_e$ ~ 6-7) with application of good quality water.

## Water salinity

An experiment was conducted to evaluate the feasibility of saline water application in bael cultivars (Narendra Bael-5, Narendra Bael-9, CISH Bael-1 and CISH Bael-2) grown in normal soils. The experiment was laid out in RBD with three replications. The plants were irrigated with different salinity waters (normal, 3 dS $m^{-1}$ and 6 dS $m^{-1}$) at weekly intervals for a period of 6 months. The toxicity 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 necrosis and abscission of leaves. Data on membrane injury and relative water content (RWC) in leaves (Table 48) pointed to better tolerance of NB-5 plants as they showed comparatively lesser damage while other cultivars exhibited severe injury, particularly with the use of 6 dS $m^{-1}$ water. The minimum (21.19%) and the maximum (53.45%) membrane injury index (MII) values were recorded in NB-5 and CB-2 plants. Data on leaf $Na^+$ and $K^+$ concentrations (Table 49) also indicated tolerant nature of NB-5 cultivar as it maintained cultivars favourable ionic balance when irrigated with saline water. Observations on chlorophyll pigments and leaf proline also established superiority of cultivar NB-5 as compared to others. Irrigation with low $EC_w$ 3 dS $m^{-1}$ saline water caused yellowing, scorching and abscission of leaves in all except NB-5 and CB-1. Continuous application of saline water of $EC_w$ 6 dS $m^{-1}$ caused severe injury in all the cultivars except NB-5. Irrigation with moderately saline water seems feasible in cultivar NB-5 grown in normal soils. In future, use of high saline water in NB-5 cultivar in blended/alternate mode will be explored at Nain Experimental Farm, Panipat.

**Table 48 : Effect of saline irrigation on membrane injury index (MII) and relative water content (RWC) in bael cultivars**

| Cultivar/ Salinity | Membrane Injury Index | | | | Relative Water Content (%) | | | |
|---|---|---|---|---|---|---|---|---|
| | Control | 3 dS $m^{-1}$ | 6 dS $m^{-1}$ | Mean | Control | 3 dS $m^{-1}$ | 6 dS $m^{-1}$ | Mean |
| NB-5 | 11.29 | 14.68 | 21.19 | 15.72 | 79.87 | 75.43 | 68.55 | 74.95 |
| NB-9 | 12.95 | 28.71 | 50.42 | 30.69 | 80.88 | 61.03 | 48.65 | 68.35 |
| CB-1 | 11.68 | 24.26 | 43.13 | 26.36 | 81.21 | 65.5 | 52.12 | 66.28 |
| CB-2 | 13.56 | 38.35 | 53.45 | 35.12 | 80.92 | 53.35 | 42.43 | 58.9 |
| Mean | 12.37 | 26.5 | 42.05 | | 81.22 | 63.83 | 52.94 | |
| $LSD_{0.05}$ | | | | | | | | |
| Cultivar | 1.22 | | | | 2.13 | | | |
| Salinity | 1.06 | | | | 1.84 | | | |
| C x S | 2.11 | | | | 3.69 | | | |

*Comparative performance of bael plants (NB-5, NB-9, CB1 and CB-2 cultivars) under high salinity ($EC_{IW}$ 6 dS $m^{-1}$) treatment.*

**Table 49 : Leaf sodium and potassium concentrations in bael cultivars under saline irrigation**

| Cultivar/ Salinity | Na (% DW) | | | | K (% DW) | | | | Na/K ratio | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | C | M | H | Mean | C | M | H | Mean | C | M | H | Mean |
| NB-5 | 0.08 | 0.09 | 0.12 | 0.10 | 0.69 | 0.65 | 0.57 | 0.64 | 0.13 | 0.15 | 0.22 | 0.16 |
| NB-9 | 0.11 | 0.14 | 0.2 | 0.15 | 0.63 | 0.51 | 0.46 | 0.54 | 0.17 | 0.27 | 0.43 | 0.29 |
| CB-1 | 0.09 | 0.11 | 0.16 | 0.12 | 0.65 | 0.52 | 0.46 | 0.54 | 0.14 | 0.22 | 0.34 | 0.23 |
| CB-2 | 0.11 | 0.19 | 0.25 | 0.19 | 0.68 | 0.48 | 0.42 | 0.52 | 0.16 | 0.41 | 0.59 | 0.39 |
| Mean | 0.09 | 0.14 | 0.18 | | 0.66 | 0.54 | 0.48 | | 0.15 | 0.26 | 0.39 | |
| $LSD_{0.05}$ | | | | | | | | | | | | |
| Cultivar | 0.009 | | | | 0.02 | | | | 0.019 | | | |
| Salinity | 0.008 | | | | 0.02 | | | | 0.016 | | | |
| C x S | 0.016 | | | | 0.04 | | | | 0.032 | | | |

C - Control; M - Medium; H - High

## Growth and Physiology of Guava (*Psidium guajava* L. cv. Allahabad Safeda) and Bael (*Aegle marmelos* Correa cv. NB-5) under Salinity Stress (Anshuman Singh, R.K. Yadav, Ashwani Kumar and Ashim Datta)

Salt-affected soils (SAS) are widespread in arid and semi-arid regions of the world where irrigation is essential to sustain food production. Productive utilization of saline environments through the use of salt tolerant crop genotypes is seen as a cost effective and environment-friendly measure. Although most of the fruit species are categorized sensitive to salinity, some of them perform well under salt stress.

**Table 50 : Soil reaction (pH) and salinity ($EC_2$) of the experimental soil**

| Row/ Plant | Bael soil | | | | | | | | Guava soil | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | | 2 | | 3 | | 4 | | 1 | | 2 | | 3 | | 4 | |
| | pH | $EC_2$ | pH | $EC_2$ | pH | $EC_2$ | pH | $EC_2$ | pH | $EC_2$ | pH | $EC_2$ | pH | $EC_2$ | pH | $EC_2$ |
| 1 | 8.5 | 1.5 | 8.5 | 0.6 | 8.5 | 0.8 | 8.5 | 2.0 | 8.7 | 1.3 | 8.0 | 2.7 | 8.0 | 0.5 | 8.5 | 0.9 |
| 2 | 8.4 | 1.3 | 8.2 | 0.8 | 8.7 | 0.6 | 8.6 | 0.5 | 8.7 | 1.5 | 8.0 | 3.9 | 7.8 | 0.6 | 8.4 | 0.6 |
| 3 | 8.9 | 1.6 | 9.0 | 0.4 | 8.2 | 0.7 | 8.4 | 0.9 | 8.5 | 2.5 | 7.9 | 2.5 | 8.3 | 0.5 | 8.4 | 2.3 |
| 4 | 8.6 | 1.5 | 8.9 | 0.5 | 8.7 | 0.8 | 8.3 | 1.0 | 8.3 | 1.5 | 7.9 | 1.7 | 8.1 | 0.4 | 8.3 | 1.7 |
| 5 | 8.4 | 2.6 | 8.4 | 1.6 | 8.3 | 2.4 | 9.0 | 0.4 | 8.8 | 0.8 | 7.8 | 1.6 | 8.3 | 0.8 | 8.0 | 1.9 |
| 6 | 8.3 | 2.9 | 8.2 | 3.0 | 8.5 | 1.1 | 8.6 | 2.1 | 8.6 | 0.6 | 8.8 | 0.8 | 8.4 | 0.4 | 8.3 | 0.5 |
| 7 | 8.5 | 1.3 | 8.4 | 2.0 | 8.1 | 2.0 | 8.2 | 2.1 | 8.6 | 1.7 | 8.1 | 1.3 | 8.8 | 0.6 | 8.2 | 1.8 |
| 8 | 8.3 | 1.0 | 8.2 | 2.3 | 8.3 | 2.1 | 8.1 | 2.5 | 8.5 | 1.1 | 8.0 | 1.7 | 8.2 | 0.9 | 7.9 | 1.2 |
| 9 | 8.2 | 5.7 | 8.4 | 1.9 | 8.5 | 1.4 | 8.1 | 1.3 | 8.6 | 1.6 | 8.0 | 1.5 | 8.0 | 0.8 | 7.8 | 1.4 |
| 10 | 8.0 | 1.5 | 8.4 | 4.1 | 8.2 | 1.8 | 8.5 | 0.8 | 8.1 | 2.5 | 8.1 | 1.8 | 8.3 | 0.6 | 8.0 | 1.4 |
| 11 | 8.6 | 1.7 | 8.7 | 1.0 | 8.4 | 2.0 | 8.3 | 0.6 | 8.6 | 0.7 | 7.8 | 1.2 | 7.9 | 1.0 | 7.7 | 1.8 |
| 12 | 8.7 | 1.3 | 8.3 | 2.5 | 8.6 | 1.9 | 8.0 | 1.8 | 8.2 | 1.2 | 8.0 | 1.5 | 8.3 | 0.7 | 8.0 | 1.3 |
| 13 | 8.4 | 1.0 | 8.6 | 1.5 | 7.9 | 1.9 | 8.2 | 0.7 | 8.7 | 0.8 | 8.0 | 0.9 | 7.8 | 1.3 | 8.8 | 0.5 |
| 14 | 8.6 | 2.3 | 8.8 | 0.8 | 8.3 | 2.1 | 9.0 | 0.9 | 8.3 | 1.3 | 7.9 | 1.9 | 7.8 | 2.0 | 8.4 | 0.9 |
| 15 | 8.5 | 1.4 | 8.5 | 1.9 | 7.9 | 1.7 | 8.2 | 0.9 | 8.3 | 1.0 | 7.7 | 1.6 | 8.0 | 0.8 | 8.4 | 0.6 |
| 16 | 9.1 | 0.9 | 8.2 | 1.5 | 8.6 | 2.0 | 7.5 | 0.6 | 8.4 | 0.8 | 8.0 | 0.9 | 8.1 | 1.1 | 8.4 | 0.8 |
| Mean | 8.5 | 1.8 | 8.5 | 1.7 | 8.4 | 1.6 | 8.3 | 1.2 | 8.5 | 1.3 | 8.0 | 1.7 | 8.1 | 0.8 | 8.2 | 1.2 |
| SD | 0.26 | 1.17 | 0.26 | 1.00 | 0.25 | 0.59 | 0.37 | 0.68 | 0.20 | 0.57 | 0.24 | 0.78 | 0.27 | 0.4 | 0.3 | 0.6 |

Guava (*Psidium guajava* L.) is an important fruit crop of India and widely grown in arid and semi-arid climates. It is rich in Vitamin-C, minerals and pectin and has immense scope for value addition. Although bael (*Aegle marmelos* Correa) fruit has huge medicinal, therapeutic and processing values, there is no organized cultivation of this fruit in India. Bael fruits possess excellent medicinal properties; ripe fruits are digestive, restorative and good for heart and brain.

As these fruit crops are suitable for arid and semi-arid climates, it is pertinent to test their response to salinity to arrive at practical recommendations. In this back drop, a research project has been initiated in natural saline environment of Nain Experimental Farm, Panipat with following objectives: to evaluate the growth and development of guava and bael plants under salinity stress; to study the salinity induced physiological and biochemical changes in guava and bael plants, and to assess the changes in the properties of saline soil irrigated with saline waters.

The initial physico-chemical properties of the experimental soil are given in Table 50. The $EC_2$ values indicated moderate to high salinity in the experimental soils. The soil pH values were mostly below 8.5, but occasionally above 8.5. The organic carbon content of surface (0-15 cm) and sub-surface (15-30 cm) layers was in the range of 0.4-0.6 per cent. At 0-15 cm depth, available N, P and K contents ranged from 263.4 to 445.3, 15.54 to 24.4 and 344 to 489 kg $ha^{-1}$ while at 15-30 cm depth from 250.9 to 401.4, 14.23 to 24.4 and 313-491 kg $ha^{-1}$. Subsequent to transplanting, the plants were irrigated with best available water to enable good establishment.

## 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 very important for soil and environmental health. The project was initiated in June 2011 with financial support of Department of Science and Technology, New Delhi. The salient finding of the project area as follows.

### Carbon sequestration in plantation forestry

Carbon sequestered by 4-year old *Populus deltoides* plantation was 59.38 t $ha^{-1}$ (12.9% by roots), whereas it was 100.9 t $ha^{-1}$ (15.2% by roots) in 8-year old *Eucalyptus tereticornis* plantation. Carbon sequestration rate was 10.0 t C/ha/year for *Populus deltoides* and 12.2 t C/ha/year for *Eucalyptus tereticornis* block plantation.

Soil organic carbon (SOC) and carbon stock under 7-year old *Populus deltoides* plantation were 0.68% and 17.6 t $ha^{-1}$, respectively and showed an increase of 54.5 and 49.2 per cent as compared to 1-year old block plantation. Under *Populus deltoides* and *Prosopis juliflora*, SOC during January 2014 increased by 33.5 and 25.1 per cent from the benchmark (Sept. 2011) values, respectively. It appeared that increase in canopy cover with tree age reduced the oxidation of organic carbon which resulted in stabilised carbon under these plantations. Total carbon in soil increased by 32 per cent from one to four year under *Populus* (0.78-1.03 %) and *Eucalyptus* plantation (0.75-0.99 %) at Hara and Raina Farms, respectively.

In *Populus* as well as *Eucalyptus* plantation total carbon, total organic carbon and oxidizable organic carbon decreased with increasing soil depth but no such trend was found in case of total inorganic carbon. Macro-aggregated carbon in 4-year old *Populus* and *Eucalyptus* plantation was highest upto the root interference zone as compared to silt and clay associated and fine micro-aggregated carbon. Both photosynthetic rate and soil respiration reduced with increase in age of *Populus deltoides* and *Eucalyptus tereticornis* plantations.

### Carbon sequestration in agroforestry systems

Different *Populus deltoides* and *Eucalyptus tereticornis* based agroforestry systems [*Populus* (1-year) + turmeric, *Populus* (2-year) + mango, *Populus* (3-year) + pear, *Populus* (4-year) + wheat and *Eucalyptus* (1-year) + sugarcane, *Eucalyptus* (2-year) + sugarcane, *Eucalyptus* (3-year) + wheat, *Eucalyptus* (4-year) + sorghum] were studied at Hara Farm, Yamunanagar and Raina Farm, Kurukshetra to find out the best land use system and their management strategies for the maximum sequestration of atmospheric carbon in vegetation and soils, and conservation of sequestered carbon in the soils.

In *Populus*-based agroforestry system, turmeric grown during 1st and 2nd years of plantation added 22.2 and 59.3 per cent organic carbon in soil as compared to sole *Populus* (1-year) plantation. In 3rd and 4th years, pear/mango and turmeric/wheat/pear should be preferred as component crops in

*Populus*-based agroforestry system as these systems sequester higher organic carbon as compared to sole *Populus* based plantation. *Populus* + wheat had higher organic carbon content (0.68%) followed by *Populus* + pear (0.63%) in the top 15 cm soil layer.

In *Eucalyptus* based agroforestry system, sugarcane could be grown for 1st and 2nd year of plantation followed by wheat and sorghum in 3rd and 4th year of plantation. These systems showed higher active pools of carbon (MBC and POXC). The reduction in photosynthetic rate of maize and sugarcane under 2-years of *Populus deltoides* and *Eucalyptus tereticornis* was 13.3 and 34.6 per cent, respectively as compared to their sole crops.

## Carbon sequestration in agricultural systems

Two field experiments were conducted with different N management options and tillage and residue management practices to enhance the carbon sequestration in popular cropping systems of the region (maize-wheat-greengram and rice-wheat). In wheat-greengram-maize cropping system, addition of FYM @ 10 t $ha^{-1}$ with recommended dose of N (14.0 t $ha^{-1}$) increased the carbon sequestration by 41.4 per cent as compared to control treatment (9.9 t $ha^{-1}$).

Carbon sequestered by wheat crop was highest where conventional tillage (CT) was done without residue incorporation (5.97 t $ha^{-1}$) and it was the lowest in zero tillage with one-third residue retention (4.13 t $ha^{-1}$). Both the wheat varieties (KRL 213 and HD 2894) sequestered statistically similar carbon in the above ground and below ground biomass.

Carbon sequestered by rice crop was highest when rice transplanting was done in puddled conditions with 1/3rd wheat residue incorporation (6.33 t $ha^{-1}$) and lowest (5.87 t $ha^{-1}$) when tillage and residue management were done as per prevailing farmers' practices of the region (CT with wheat residue removed + transplanted rice under puddled conditions). Rice variety CSR 36 sequestered statistically higher carbon (6.62 t $ha^{-1}$) than CSR 30 (5.80 t $ha^{-1}$). However, carbon sequestered by below ground biomass of CSR 30 (0.97 t $ha^{-1}$) was statistically higher than CSR 36 (0.81 t $ha^{-1}$).

The soil health, assessed after 2-years crop rotation in wheat-green gram-maize system under different N management options indicated that SOC in 0-15 and 15-30 cm soil depths was the highest under $N_4$ (0.57 and 0.51 %) treatment, where 50 per cent of N was supplemented through organic source and rest 50 per cent through inorganic source and lowest under $N_7$ (0.43 and 0.29 %) treatment where N was not used. Total water stable aggregates (WSA) in 0-15 cm soil depth were highest under $N_3$ (59.3 %), where one-fourth N was substituted by organic source.

In tillage and residue management, OC in 0-15 and 15-30 cm soil depths was highest under zero tillage with full residue retention. Coarse macro-aggregated carbon was higher with residue retention/incorporation. Total WSA in 0-15 cm soil depth was highest under zero tillage with full residue retention followed by zero tillage with one-third residue retention. After three years of wheat-rice cropping system, SOC under different treatments of tillage and residue management in 0-15 and 15-30 cm soil depths were highest under conventional tillage + Direct Seeded Rice (DSR) and zero tillage +DSR, respectively.

**Enhancing Productivity Potential of Saline Soil through Agroforestry System using Saline Irrigation** (Rakesh K. Garg, R.K. Yadav, Bhaskar Narjary, Parvender Sheoran, M.D. Meena, Ashwani Kumar and D.K. Sharma)

Establishing tree plantations on saline soils irrigated with saline waters may provide an opportunity for the best economic use of such lands. But a knowledge gap exists on potential of growing commercially important fast growing tree species in salt affected soils with saline irrigation and their impact on soil physico-chemical properties. The present study was initiated to optimize the strategies for sustaining use of saline water for establishing *Melia composita* and *Eucalyptus tereticornis* based agroforestry models and evaluate the performance of field crops under trees and *vice versa*. The experiment was initiated in August, 2014 at CSSRI Experimental Farm, Nain, Distt. Panipat. The treatments comprised of five tree and crop combinations viz., *Eucalyptus tereticornis* + crops, *Melia composita* + crops, Sole *Eucalyptus tereticornis*, Sole *Melia composita* and sole crops i.e. pearl millet and mustard under open conditions. Irrigation treatments comprised of i) best available water combined with need-based saline water irrigation and ii) saline and normal water irrigation in cyclic mode. Soil sampling at different soil depths (0-15, 15-30, 30-60, 60-90 and 90-120cm) was done to know the initial EC and pH of the experimental soil.

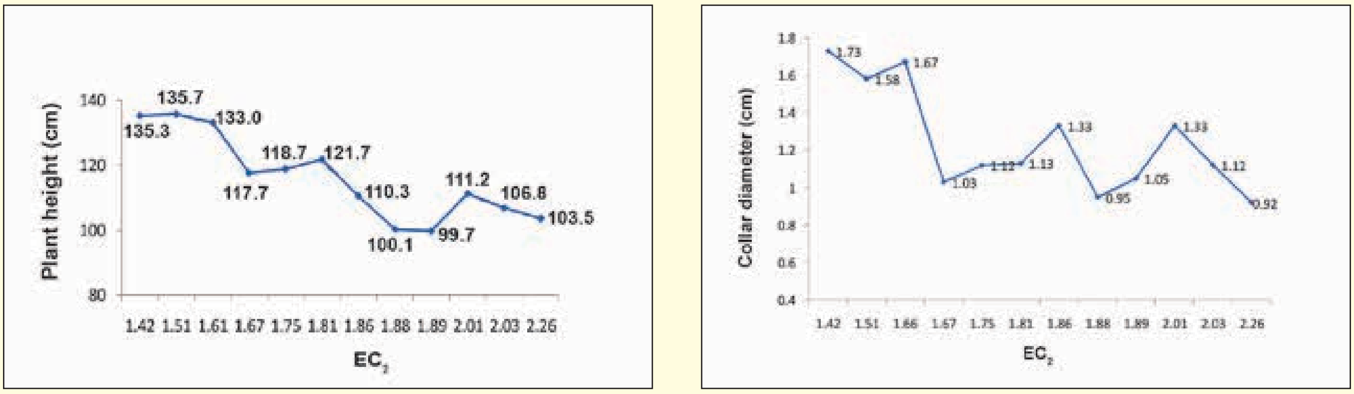



*Fig. 32 : Effect of soil salinity (dS $m^{-1}$) on plant height and collar diameter of Eucalyptus tereticornis four months after transplanting*

$EC_2$ ranged from 2.40-7.90 dS $m^{-1}$ (0-15 cm), 1.90-5.90 dS $m^{-1}$ (15-30 cm), 1.60-6.10 dS $m^{-1}$ (30-60 cm), 1.20-5.60 dS $m^{-1}$ (60-90 cm) and 1.20-5.90 dS $m^{-1}$ (90-120 cm). Soil pH ranged from 7.91-8.96 (0-15 cm ), 6.65-8.99 (15-30 cm), 7.94-8.95 (30-60 cm), 7.88-9.25 (60-90 cm) and 7.74-9.42 (90-120 cm). *Eucalyptus* and *Melia* tree species recorded 78 and 70 per cent survival, respectively. Growth performance of the two tree species was recorded four months after transplanting. In general, declining growth trend was observed with increase in soil salinity (Fig. 32). Maximum plant height (135.3 cm) in *Eucalyptus* was recorded at 1.42 dS $m^{-1}$ whereas minimum plant height (103.5 cm) was recorded under 2.26 dS $m^{-1}$ salinity. Similar trend was observed for plant collar diameter (PCD). The higher PCD (1.73 cm) was recorded at 1.42 dS $m^{-1}$ and the lowest (0.92 cm) at salinity level of 2.26 dS $m^{-1}$. Mustard was sown as intercrop in between *Melia* and *Eucalyptus* rows. Germination of mustard crop showed variable response depending upon level of salinity. Germination percentage varied from zero ($EC_2$ : 7.28 $dSm^{-1}$) to 85.0 ($EC_2$ : 2.40 $dSm^{-1}$) under *Eucalyptus* trees whereas it ranged from zero ($EC_2$ : 7.29 $dSm^{-1}$) to 70.0 ($EC_2$ : 2.40 $dSm^{-1}$) under *Melia* trees. The average germination under *Eucalyptus* and *Melia* plantation was 27.91 and 30.42 per cent, respectively. Germination of mustard decreased with increase in soil salinity (Fig. 33).

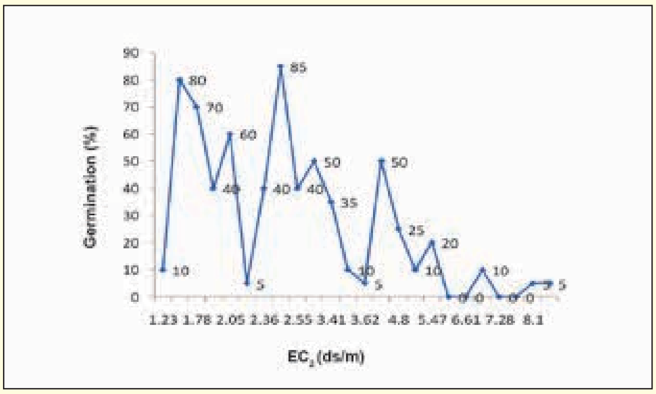



*Fig. 33 : Effect of soil salinity on germination*

*Mustard intercropped with Eucalyptus*

## Effect of Land Uses on Salt Distribution and Properties of Salt-affected Soils (Ashim Datta, Nirmalendu Basak, Anil. R. Chinchmalatpure and R. K. Garg)

Six land-uses namely Frass (*Tamarix articulate*), Desi kikkar (*Acacia nilotica*), Kainth (*Feronia limonia*), *Prosopis alba*-Aloevera, *Prosopis alba*-Mustard and *Karonda* (*Carissa carandas*)-Mustard, situated at Bir forest, Hisar were studied to evaluate the changes in soil $pH_s$, $EC_e$, cations and anions content. For this purpose soil samples were collected up to a depth of 200 cm with an interval of 20 cm. Results showed that surface soils (0-20 cm depth) under *Prosopis*-Aloevera system recorded highest $pH_s$ (8.5) and $EC_e$ (7.8 dS $m^{-1}$); whereas lowest $pH_s$ (7.8) and $EC_e$ (1.1 dS $m^{-1}$) were associated in soils under *Acacia nilotica* and *Feronia limonia* land uses (Table 51). With increase in depth, $EC_e$ of the soil increased significantly except a few exceptions for soils under *Prosopis alba*-Aloevera. At 80-100 and 100-120 cm depth, highest $EC_e$ (~13.0 dS $m^{-1}$) were associated in soils under *Desi kikkar* and *Karonda* plantation. When measuring soil $pH_2$ and

$EC_2$, it showed that soils under *Prosopis*-Aloevera system recorded highest $pH_2$ (9.0) and $EC_2$ (2.0 dS $m^{-1}$) at 0-20 cm depth; whereas lowest $pH_2$ (8.1) and $EC_2$ (1.0 dS $m^{-1}$) were associated in soils under *Tamarix articulate* and *Acacia nilotica* land uses. At 60-80 cm depth, highest $EC_2$ (3.1 dS $m^{-1}$) were associated with *Prosopis alba*-Aloevera and *Karonda* land uses, respectively. Higher salinity level (ECe >4.0 dS $m^{-1}$) reflected in almost all soils irrespective of soil depth and land-uses. Soils below 1.0 m depth contain more salt than upper layers except soils under *Prosopis*-Aloevera. Overall soil data suggest that ECe is 4.1 times higher than $EC_2$ ($R^2$ =0.63; $n$=120). Higher amount of calcium and magnesium throughout the soil depth were observed under *Prosopis*-mustard and *Tamarix articulate* plantations than other land uses. At 0-20 cm depth, highest Ca (20.0 me $L^{-1}$) and Mg (31.0 me $L^{-1}$) content were observed under *Tamarix* plantation followed by *Prosopis*-mustard (4.0 and 8.5 me $L^{-1}$), *Acacia nilotica* (1.0 and 1.85 me $L^{-1}$), *Karonda, Carrisa carandas* (0.6 and 2.1 me $L^{-1}$), Kainth (0.6 and 1.35 me $L^{-1}$), and Aloevera (0.3 and 0.55 me $L^{-1}$). In most of the land uses, calcium and magnesium content increased with depth. Significantly higher sodium content throughout the profile were observed under Aloevera-*prosopis* (1717.0 me $L^{-1}$ at 0-20 cm) and *Karonda, Carrisa carandas* (1370 me $L^{-1}$ at 0-20 cm) plantations than other land uses. Bicarbonate and chloride content in soils under all the land uses as well as along soil depth varied significantly. All soils irrespective of depth and land-uses carried a less quantity of bicarbonate; whereas carbonate was almost nil in all the land uses except soils under *Prosopis* and *Karonda* based systems. Soils along depth under *Kainth* and *Prosopis* based system contained the highest and lowest amount of calcium carbonate.

**Table 51 : Depth wise variation of pHs in soil saturation paste and electrical conductivity of saturation extract, ECe (dS $m^{-1}$) in soils under different land uses**

| Depth (cm) | Frass (*Tamarix articulata*) | | *Desi Kikkar* (*Acacia nilotica*) | | *Kainth* (*Feronia limonia*) | | *Prosopis alba*-mustard | | *Prosopis alba*-Aloevera | | Karonda (*Carrisa carandas*)-Mustard | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Soil parameter | pHs | ECe | pHs | ECe | pHs | ECe | pHs | ECe | pHs | ECe | pHs | ECe |
| 0-20 | 8.1 | 5.5 | 7.8 | 1.7 | 8.0 | 1.1 | 8.5 | 7.6 | 8.5 | 7.8 | 8.0 | 6.9 |
| 20-40 | 8.3 | 2.2 | 8.2 | 1.1 | 8.1 | 0.6 | 8.6 | 6.3 | 8.3 | 8.9 | 8.4 | 8.3 |
| 40-60 | 8.1 | 5.1 | 7.9 | 2.1 | 8.2 | 0.8 | 8.4 | 8.7 | 8.2 | 7.5 | 8.0 | 12.4 |
| 60-80 | 8.1 | 7.8 | 7.5 | 10.4 | 8.3 | 2.1 | 8.2 | 7.9 | 8.0 | 7.9 | 8.1 | 13.2 |
| 80-100 | 8.1 | 9.2 | 7.4 | 14.1 | 7.8 | 8.5 | 8.1 | 6.9 | 8.1 | 7.3 | 8.0 | 13.0 |
| 100-120 | 8.2 | 7.8 | 7.4 | 13.3 | 7.8 | 9.7 | 8.2 | 7.0 | 7.9 | 7.1 | 7.8 | 11.8 |
| 120-140 | 8.2 | 8.5 | 7.4 | 11.6 | 8.1 | 9.2 | 8.2 | 8.9 | 7.9 | 5.9 | 7.6 | 10.1 |
| 140-160 | 8.2 | 7.9 | 7.7 | 10.0 | 7.7 | 10.9 | 8.0 | 11.1 | 7.9 | 4.5 | 7.7 | 11.1 |
| 160-180 | 8.2 | 7.6 | 7.8 | 10.5 | 7.8 | 9.9 | 8.0 | 11.3 | 7.8 | 4.0 | 7.7 | 10.2 |
| 180-200 | 8.1 | 8.1 | 8.0 | 10.9 | 7.7 | 8.8 | 8.3 | 9.8 | 7.9 | 4.9 | 7.7 | 9.2 |




*Different land uses at bir forest, Hisar*

# 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)

To avoid secondary salinization, lowering of water table prior to the gypsum application is an essential requirement for successful reclamation and management of waterlogged sodic soils. Excessive seepage from unlined large canals is the main reason for waterlogging and secondary salinization in canal command. Salt accumulation due to secondary salinization is coupled with waterlogging in the areas where annual precipitation is less than the annual evaporation. Salt accumulation is prominent on soil surface where continuous seepage in the deeper soil profile keeps salts moving. Thus, by upward movement, salts are carried away along with seepage water from the deeper soil profiles. Rate of seepage increases with the increasing soil depths. Consequently, the soil pH is very high at the surface and low towards deeper soil profiles. Land modification by elevating field beds will enhance internal drainage of the soil and keep water table much below to suppress secondary salinization and salt built up load in the upper soil profile. Therefore, a study on raised and sunken bed is going on in Sharda Sahayak Canal Command in village Kashrawawn, district Raebareli with the objective to bring waterlogged sodic soils under cultivation for farmers having small land holdings.

The initial soil pH was high at the soil surface with a decreasing trend with increase in soil depths. Initial soil $pH_{1:2}$ of top 0-15 cm layer ranged from 9.31 to 10.47 and $EC_2$ ranged from 0.433 to 1.778 dS $m^{-1}$. Two raised beds of 60 m lengths were constructed during June 2009. Top width of raised beds was kept as 2 m and bottom width as 4 m. Length of sunken bed was 60 m and bed width was 7 m. Boundary embankment width was 2 m except for the boundary bunds towards south which was only one meter wide on the top. Side slopes of raised and boundary beds were kept as 1:1. Total area under raised beds, sunken beds and boundary beds is 0.36 ha (3560 $m^2$). Out of total area, raised beds are of 1266 $m^2$, sunken beds of 2293 $m^2$. Area under boundary beds is 786 $m^2$. After construction of the raised and sunken beds, the average $pH_2$ of first raised bed was observed to be 9.36 and $EC_2$ 0.43 dS $m^{-1}$ and that of second raised bed average $pH_2$ was 8.65 and EC 0.14 dS $m^{-1}$. 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 three metre.

## Crop performance

Yield data of vegetables grown on raised beds during *kharif* 2014 and *rabi* 2013-14 are presented in Table 52. During *kharif* 2014, sponge gourd, bottle gourd, bitter gourd, okra, brinjal, colocasia, suran (jimikand), karemuan, cluster bean, cow pea, chilly and spinach were grown as vegetables. Lemon planted three years back started giving fruits. Maize was also grown. Fourth banana ratoon was also taken on raised bed giving satisfactory yields under partial shade conditions. Guava and papaya also performed reasonably well. Aquatic and upland grass was prevalent over the entire model. In *kharif* season, the yield of sponge gourd, colocasia tubers, suran were obtained to be 135.8, 38.4 and 12.5 kg, respectively under complete shade conditions. Okra damaged by blue bull repeatedly yielded 15.0 kg. Spinach yield obtained was 37.3 kg. Damage to the crop by blue bull was significant this year hence yield declined. Rain was also delayed caused appreciable yield loss due to delayed planting. During *rabi* season, the yields of cabbage, tomato, radish, spinach, coriander, methi, dill, bakla, sem, cauliflower, chilly and peas were observed to be 310.00, 103.90, 593.40, 117.50, 18.60, 9.25, 31.50, 53.15, 18.50, 28.60, 6.90 and 16.30 kg, respectively. Mustard seed yield was obtained as 25 kg.

Banana, guava and papaya also gave reasonably good yields. Highest yield of banana was recorded as 484 kg followed by papaya 141 kg during *kharif* season. Guava yield was recorded as 38.5 kg during *kharif*. About 2294 kg of aquatic and upland grass was harvested while clearing the boundary bunds, raised beds and sunken beds. During *rabi* 2013-14, garlic, onion and coriander yielded 25.80, 67.00 and 2.00 kg, respectively. *Dhaincha* stalk used as fuel wood was recorded as 170 kg with seed yield of 6.30 kg.

**Table 52 : Crop performance of *kharif* 2014 on raised and sunken bed system**

| *Kharif* 2014 | | | *Rabi* 2013-14 | | |
|---|---|---|---|---|---|
| **S.N** | **Crops** | **Yield (kg)** | **S.N** | **Crop** | **Yield (kg)** |
| **Vegetables** | | | **Vegetables** | | |
| 1. | Sponge gourd | 135.8 | 1. | Cabbage | 310.0 |
| 2. | Bottle gourd | 16.0 | 2. | Tomato | 103.9 |
| 3. | Bitter gourd | 5.0 | 3. | Radish | 593.4 |
| 4. | Okra | 15.0 | 4. | Spinach | 117.5 |
| 5. | Brinjal | 0.6 | 5. | Coriander | 18.6 |
| 6. | Colocasia leaf | 7.0 | 6. | Dill | 31.5 |
| 7. | Colocasia tubers | 38.4 | 7. | Bakla | 53.2 |
| 8. | Suran (jimikand) | 12.5 | 8. | Sem | 18.5 |
| 9. | Karemua | 14.2 | 9. | Cauliflower | 28.6 |
| 10. | Cluster bean | 8.4 | 10. | Peas | 16.3 |
| 11. | Cowpea | 3.5 | 11. | Mustard | 25.0 |
| 12. | Spinach | 37.3 | **Other** | | |
| 13. | Lemon | 25 (No.) | 1. | Sesbania stalk | 353.0 |
| **Fruit** | | | **Spice** | | |
| 1. | Banana | 484.0 | 1. | Garlic | 25.8 |
| 2. | Guava | 38.5 | 2. | Onion | 67.0 |
| 3. | Papaya | 141.0 | **Fruits** | | |
| **Grass** | | | 1. | Banana | 49.0 |
| 1. | Aquatic + upland | 2294.0 | 2. | Papaya | 303.0 |
| | | | **Grass** | | |
| | | | 1. | Aquatic + upland | 1010.0 |

Vegetables namely cabbage, tomato, radish, spinach, dill, menthi, sem, bakla and coriander; garlic and onion as spice crops were grown during *rabi* 2013. and marigold and gladulus were tried as flower crops. Banana and papaya were fruit crops. Banana was taken as second ratoon crop giving satisfactory yield under partial *eucalyptus* shade. Farmers preferred banana ratoon under partial shading. The radish recorded highest yield of 593.4 kg followed by cabbage of 241.5 kg. Tomato recorded the yield of 178.6 kg and spinach of 72.0 kg. The yield of coriander, mentha, dill, bakla and sem were recorded to be 9.3, 1.0, 22.0, 4.5 and 13.0 kg, respectively. Mustard seed yield of 19.0 kg and gram of 10.5 kg was obtained. Garlic and onion also gave good yields of 111 kg and 108 kg, respectively. Banana yield was recorded as 276 kg and papaya 353 kg.

## Economics

The economics of raised and sunken bed system for 2013-14 is presented in Table 53. It may be seen from the table that the net return of the raised and sunken bed system during *rabi* 2013-14 was Rs. 11235 and *kharif* 2014 was Rs. 7943. The benefit cost ratio (B:C) for *rabi* 2013-14 and *kharif* 2014 were calculated as 2.76 and 1.72, respectively. The overall benefit cost ratio for the year 2013-14 was worked out to be 2.21.

**Table 53 : Economics of raised and sunken bed system.**

| Season | Gross return (Rs) | Labour component (Rs) | Inputs component (Rs) | Expenditure (Rs) | Net return (Rs) | B:C |
|---|---|---|---|---|---|---|
| *Rabi* 2013-14 | 15310 | 2500 | 1575 | 4075 | 11235 | 2.76 |
| *Kharif* 2013 | 12568 | 3200 | 1425 | 4625 | 7943 | 1.72 |
| Total | 27878 | 5700 | 3000 | 8700 | 19178 | 2.21 |

## Performance on raised beds

There are 339 *eucalyptus*, 22 guava, 10 *acasia* (broad leaf), 8 lemon, 6 neem, 4 teak, 3 mango, 1 *kachnar* and 1 *acasia* tree standing on peripheral bunds of raised and sunken bed systems. *Eucalyptus* is having good economic return value at present. These trees were planted at different times, hence their girth and height are varying.

The economic value of any tree depends on its type, trunk diameter and its heights. *Eucalyptus* trees were classified on the basis of trunk diameter and corresponding economic values as given in table 54. There exist a linear relationship between diameter at shoot height (DSH) and diameter at breast height (DBH) of *eucalyptus*. The present economic return from 339 *eucalyptus* trees is Rs. 150425 which will increase with the passage of time. *Eucalyptus* plantation is also useful in controlling water table due to excessive evapo-transpirative demand.

**Table 54 : Expected economic return from standing eucalyptus trees**

| Girth range (m) | Economic value (Rs./tree) | Expected return (Rs.) |
|---|---|---|
| 00-0.09 | 50 | 2800 |
| 0.09-0.18 | 125 | 5875 |
| 0.18-0.27 | 250 | 12750 |
| 0.27-0.36 | 400 | 22400 |
| 0.36-0.45 | 550 | 19800 |
| 0.45-0.54 | 700 | 18900 |
| 0.54-0.63 | 900 | 36000 |
| 0.63-0.72 | 1150 | 17250 |
| 0.72-0.81 | 1300 | 9100 |
| 0.81-0.90 | 1350 | 1350 |
| 0.90-0.99 | 1400 | 4200 |
| **Total** | | 150425 |

## Water balance

Daily water level fluctuations in canal, drain, sunken bed-1, 2 and 3 are shown in Fig. 34. The monthly average water depths in canal were observed to be 1.25, 0.888, 0.581, 0.416, 1.011, 0.838, 0.752, 1.577, 1.986, 1.991, 1.417 and 0.00 m, respectively above canal bed during Dec. 2013 to Nov. 2014. Similarly, the average depth of water in surface drain was observed to be 0.202, 0.187, 0.150, 0.146, 0.057, 0.048, 0.00, 0.541, 0.669, 0.975,

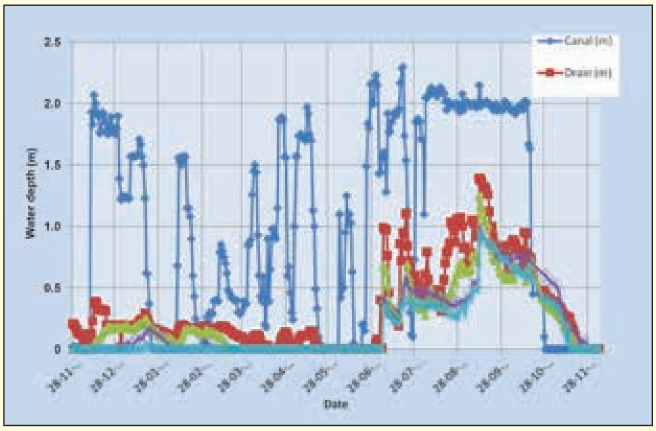



*Fig. 34 : Water depth fluctuations*

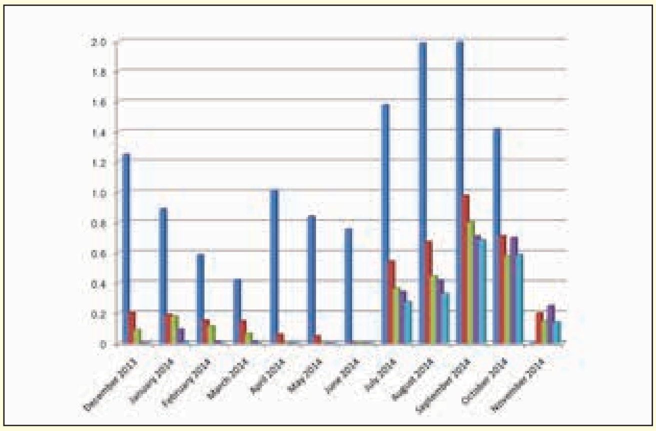



*Fig. 35 : Average water depth in sunken beds*

0.709 and 0.197 m, respectively for the month of Dec. 2013 to Nov. 2014. Corresponding average depths of water in sunken bed-1 were observed to be 0.086, 0.177, 0.115, 0.063, 0.00, 0.00, 0.00, 0.364, 0.444, 0.802, 0.578 and 0.147 m; in sunken bed-2 were 0.00, 0.090, 0.008, 0.009, 0.00, 0.00, 0.00, 0.338, 0.415, 0.708, 0.698 and 0.246 m and in sunken bed-3 were 0.00, 0.006, 0.00, 0.00, 0.00, 0.00, 0.00, 0.272, 0.326, 0.684, 0.582 and 0.137 m; respectively. It may be seen from Fig. 35 that sunken bed-3 remained dried for six months, sunken bed-2 for four months and sunken bed-1 for three months only. Fully grown *eucalyptus* trees might have controlled canal seepage.

Volumes of water stored in sunken bed-1 were 124.958, 257.181, 167.095, 91.539, 0.00, 0.00, 0.00, 528.892, 645.132, 1165.306, 839.834 and 213.591 $m^3$ during respective months from Dec. 2012 to Dec. 2013, respectively (Fig. 36). Volumes of water stored in sunken bed-2 were 0.00, 37.8, 3.36, 3.78, 0.00, 0.00, 0.00, 141.96, 174.3, 297.36, 293.16 and 103.32 m3 and in sunken bed-3 were 0.00, 2.52, 0.00, 0.00, 0.00, 0.00, 0.00, 114.24, 136.92, 287.28, 244.44 and 57.54 $m^3$ during the respective months from Dec. 2013 to Nov. 2014.

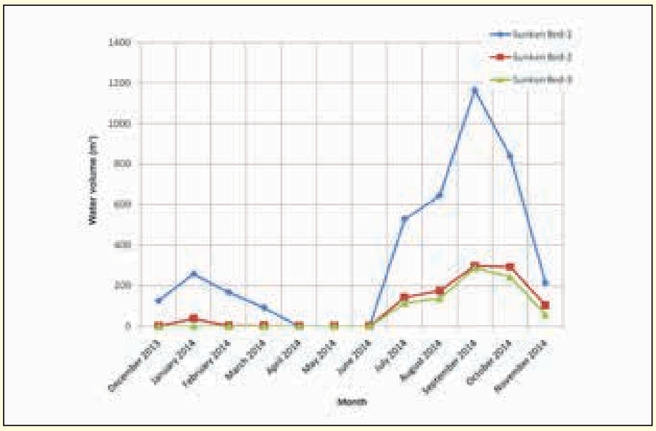



*Fig.36 : Volume of water stored in sunken beds*

## Salt dynamics

Salt loads at raised beds and in sunken beds decreased continuously with depth. Electrical conductivity was 6.75 dS $m^{-1}$ at 0-15 cm depth but always lower than 4 dS $m^{-1}$ for all the soil depths (Fig. 37 and 39). The electrical conductivity was on an average < 1.0 dS $m^{-1}$. Initial pH of the soil over raised bed was highest 10.14 at 0-15 cm depth and minimum of 9.01 at 90-120 cm depth. The pH of soil surface decreased to 8.50, 8.14 and 8.28 after third, fourth and fifth years of raised bed construction. The soil pH of soil layers below 0-15 cm with comparatively slow rate. The soil pH in raised bed was observed to be 8.28, 8.40, 9.00, 9.15, 8.96 and 8.68 at corresponding depth of 0-15, 15-30, 30-45, 45-60, 60-90 and 90-120 cm, respectively during 2014 (Fig. 38). The soil pH of sunken bed reduced at a faster rate due to continuous submergence. The soil pH in sunken bed were observed to be 7.17, 6.88, 6.95, 7.02, 7.35 and 7.50 at corresponding depth of 0-15, 15-30, 30-45, 45-60, 60-90 and 90-120 cm (Fig.40), respectively during 2014.

Organic matter is of prime importance to assess the overall soil health. Initial organic content of experimental area was 0.19, 0.15, 0.11, 0.11, 0.08 and 0.06 per cent at soil depths of 0-15, 15-30, 30-45, 45-60, 60-90 and 90-120 cm, respectively. The organic matter content was 0.64, 0.22, 0.41, 0.39, 0.58 and 0.15 over raised bed and 0.66, 0.50, 0.23, 0.42, 0.24 and 0.55 per cent in sunken bed against soil depths of 0-15, 15-30, 30-45, 45-60, 60-90 and 90-120 cm, respectively during 2014. Raised and

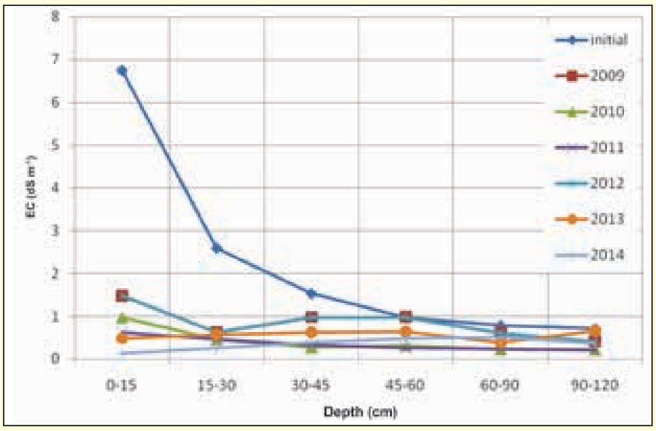



*Fig. 37 : Variation of EC with depth and time in raised bed*

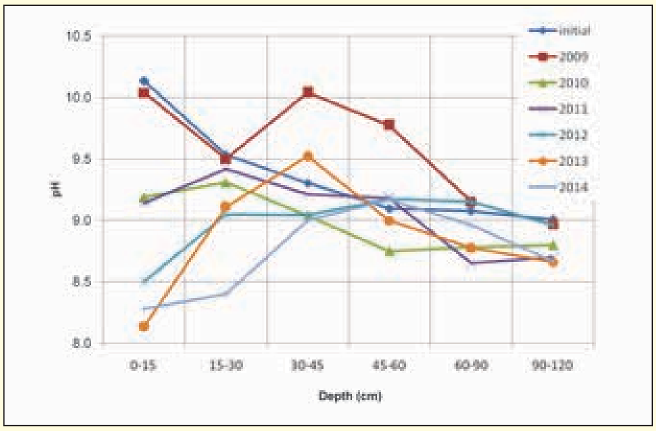



*Fig. 38 : Variation of pH with depth and time in raised bed*

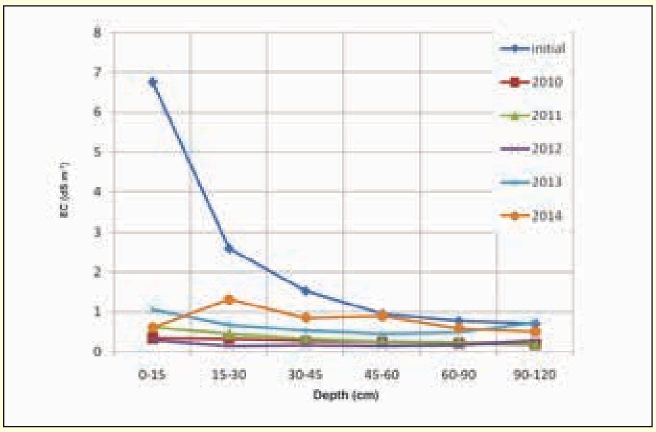



*Fig. 39 : Variation of EC with depth and time in sunken bed*

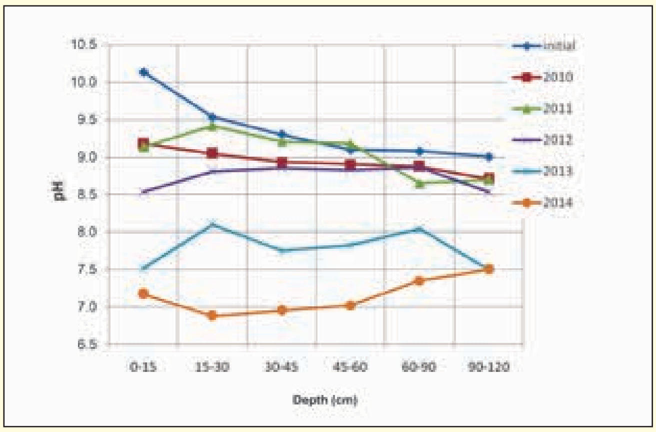



*Fig.40 : Variation of pH with depth and time in sunken bed.*

sunken bed based integrated farming system model performed well under waterlogged sodic soils and quite suitable for small land holding.

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

Sharda Sahayak Canal is one of the major canal commands which provide irrigation to 17.8 lakh ha in 16 districts of U.P., which have similar problems. About 0.12 to 0.18 M ha sodic land suffers from shallow water table conditions in Sharda Sahayak Canal Command. To address these problems, pond based farming system module based on harvesting and management of canal seepage water for multipurpose use, possible cropping system, suitable plantation crop for harnessing the proactive potential of unproductive water logged sodic soil have been initiated under farmers participatory mode at Patawakhera (Sameshi), Lucknow (Fig. 41). The total area of model was 0.80 ha, out of which rice–wheat (993.31m$^2$), rice-mustard (1439.15m$^2$), tomato (337.3m$^2$) fodder Napier CO-4 (343.06 m$^2$) and Fish ( 3137.58m$^2$) were taken. In rice-wheat and rice- mustard plots, *dhaincha* crop was grown as first green manure crop. FYM was applied @ 15 t ha$^{-1}$ in each system. The fodder was also planted on the slope of the pond. The depth of pond was 2.0m from surface. About 6000 fish fingerlings (Rohu, catla and Naini) were stocked in pond during month of July 14. Rice bran and mustard cake (2:1) ration at 1 per cent fish weight and 30 kg fresh cow dung/day were applied in pond.

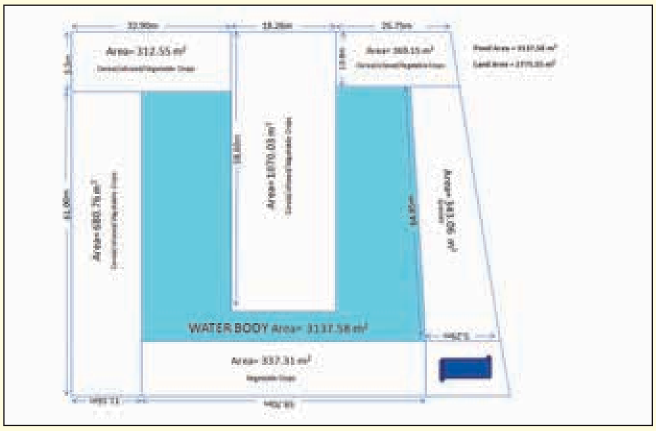



*Fig. 41 : Lay out of the land modification model*

### Soil characteristics

The surface (0-15 cm) and sub surface (15-30 cm) soil properties of raised bed indicated that the soil pH of all the system was < 9.0 and EC <1.0dS m$^{-1}$(Table 4). The organic carbon varied from 0.20-0.40 and 0.15-0.40 per cent in surface and subsurface soil, respectively. The soil NPK concentration showed that the addition of FYM and green manure considerably increased their content in surface soil.

### Water seepage from the pond

Seepage water moving in or out of the newly constructed pond is very important for initial years due to its high rate. High rate of seepage loss from pond will be detrimental parameters for fish stocking during the year when canal is closed. Seepage loss from pond reaches the highest rate when water supply is closed. The depth of pond water declined exponentially with depth of canal water (Fig. 42).

**Table 55 : Soil properties of raised bed at the time of planting of crops**

| Land use | Soil depth (cm) | pH | EC (dS m$^{-1}$) | Organic carbon (%) | Av. N (kg ha$^{-1}$) | Av. P (kg ha$^{-1}$) | Av. K (kg ha$^{-1}$) |
|---|---|---|---|---|---|---|---|
| Tomato | 0-15 | 8.62 | 0.25 | 0.20 | 56.5 | 8.82 | 116.48 |
| | 15-30 | 8.31 | 0.17 | 0.15 | 50.2 | 7.51 | 127.68 |
| Mustard | 0-15 | 8.71 | 0.20 | 0.38 | 119.2 | 12.33 | 279.44 |
| | 15-30 | 8.31 | 0.34 | 0.20 | 59.6 | 7.92 | 193.2 |
| Fodder grass | 0-15 | 8.98 | 0.19 | 0.34 | 147.4 | 8.33 | 262.08 |
| | 15-30 | 9.08 | 0.17 | 0.30 | 94.1 | 8.20 | 204.96 |
| Wheat | 0-15 | 8.25 | 0.34 | 0.40 | 124.3 | 11.41 | 262.32 |
| | 15-30 | 8.71 | 0.21 | 0.20 | 84.7 | 9.02 | 188.72 |

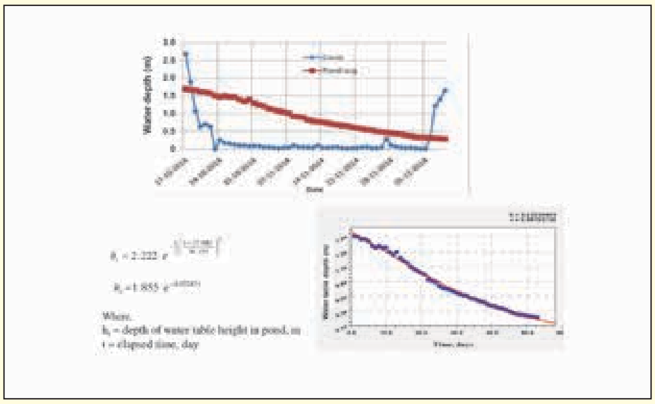


*Fig. 42 : Seepage loss from pond*

## Water seepage in pond

Periodical measurement of depth of water in canal and pond showed that when canal supply is restored, the canal seepage starts recovering pond storage. The recovering of seepage coming to the pond is initially high and recedes thereafter. The pond water raised exponentially with depth of canal water Fig. 43.

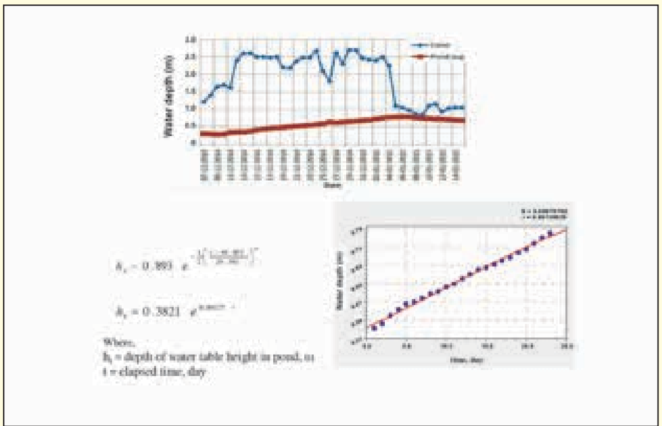


*Fig. 43 : Seepage in pond from canal*

## Crop production

Salt tolerant rice cultivars CSR 36 (long duration) and CSR 43 (short duration) were transplanted during July on raised bed. Normal practices were followed for cultivation of rice. The irrigation water of 70 cm in CSR 36 and 50 cm in CSR 43 were applied. The grain yield of 5.83 and 5.57 t $ha^{-1}$ was obtained from CSR 36 and CSR 43, respectively. After harvesting of CSR 36 and CSR 43, wheat and mustard was sown. The napier hybrid fodder (CO4) was planted using stem cuttings in month of July on raised bed with common spacing of 60x50 cm. Hybrid nappier grass is high yielding perennial grass. The grass has very high yield potential and maintained its productivity for 4-5 years. Hybrid napier grass has gained considerable importance in dairy industry because of its quick sprouting

*Visit of Dr Panjab Singh at Patwakhera*

and rejuvenating capacity. First harvesting was done in the last week of August. Subsequently, second and third harvests were made in the month of September and November. Average number of tillers (46/clump) was recorded. The growth of plant was stunted during month of December to February due to low temperature. Total 28.4 t $ha^{-1}$ green fodder was harvested during five months.

## 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. Damodaran and S.K. Jha)

Thermal power plants are the main source of power generation in India. There are around 83 major coal fired thermal power plants that generates about 120 m tons of fly ash. The current annual production of fly ash in India is approximately up to $90x10^6$ Mg which is believed to increase with the high demand of energy supply. Fly ash is an important portion of combustion and its properties depends on various other factors like type of coal, combustion method etc. Fly ash is characterized with coarse texture, low bulk density (around 0.98g/$cm^3$) and contain about 0.20% 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 the first crop of rice at Shivri Research farm, Lucknow. The experimental plan consists of two experiments: one on barren sodic soils and the other is on partially reclaimed sodic soils.

### Effect of fly ash on sodic soil

In barren sodic soil, different treatments of fly ash showed a decreasing trend for soil pH (Table 56) as compared to control. Soil treated with 50 GR showed maximum decrease in pH 9.45 however,

**Table 56 : Effect of Fly Ash and Gypsum on soil pH in Barren Sodic Soil**

| Treatment | pH | EC (dS $m^{-1}$) |
|---|---|---|
| $T_1$-Gypsum -50 % GR | 9.45 | 0.88 |
| $T_2$-Gypsum - 25 % GR | 9.54 | 0.80 |
| $T_3$-Fly ash 2.5 % of soil mass | 9.71 | 0.96 |
| $T_4$-Fly ash 5% of soil mass | 9.66 | 0.88 |
| $T_5$-25% GR + Fly ash 2.5% of soil mass | 9.54 | 0.98 |
| $T_6$-25% GR + Fly ash 2.5% of soil mass + *dhaincha* | 9.53 | 0.97 |
| $T_7$-Fly ash 5% of soil mass + *dhaincha* | 9.53 | 0.77 |
| $T_8$-Control | 9.98 | 1.86 |

soils with 2.5 and 5 per cent fly ash along with 25 GR and *dhaincha* showed maximum decrease (0.45 units) in soil pH among all fly ash treated plots and gave at par results with 25 GR i.e. 9.54. EC also showed the same trend of decrease with being lowest in 5 per cent fly ash + *dhaincha* treatment. Highest wheat yield of 1.32 t $ha^{-1}$ was observed under 50 GR treatment. 25 GR with 2.5 and 5 per cent fly ash+*dhaincha* gave higher yield of 1.12 and 1.25 t $ha^{-1}$ respectively over 0.93 t $ha^{-1}$ from 25 GR alone (Fig. 44). Test weight was observed highest in 25 GR+ 2.5 per cent fly ash+ dhaincha after 50 GR.

Rice yield was also improved in fly ash treated plants. 50 GR gave the highest yield of 3.12 t $ha^{-1}$ after that 25 GR along with 2.5 per cent fly ash (with or without *dhaincha*) gave similar yield of 2.40 t $ha^{-1}$ where as control treatment yielded zero. Grain weight was also affected and was found highest under 50 GR and gypsum+ fly ash treatments (Fig. 45).

## 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 57) however, EC showed an increase in soils treated with 3 per cent fly ash with *dhaincha*. The wheat grain yield considerably increased with application of fly ash (Fig. 46) and it was highest for 3 per cent fly ash treated with/ without *dhaincha* (~34% high). Two per cent fly ash application alone also significantly increased grain yield (3.47 t $ha^{-1}$) which was 30 per cent high over control (2.65 t $ha^{-1}$). Test weight was highest from 2 per cent v/v+ *dhaincha* treated plots and in control plots.

Rice yield in fly ash treated reclaimed sodic soils was also improved. Maximum yield was observed in 1, 2 and 3 per cent v/v fly ash + *dhaincha* treated

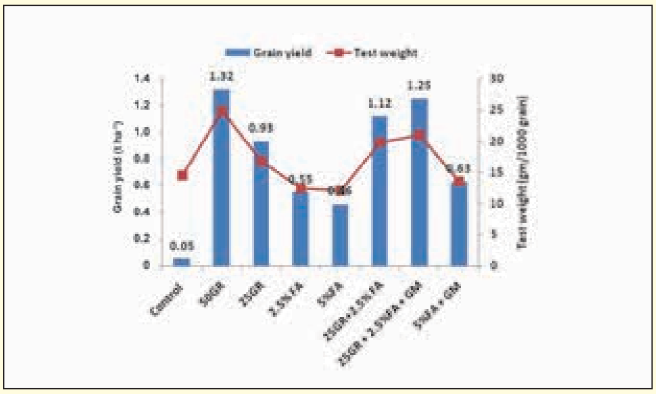



*Fig. 44 : Effect of Fly ash on wheat yield (2013-14) under barren sodic soil*

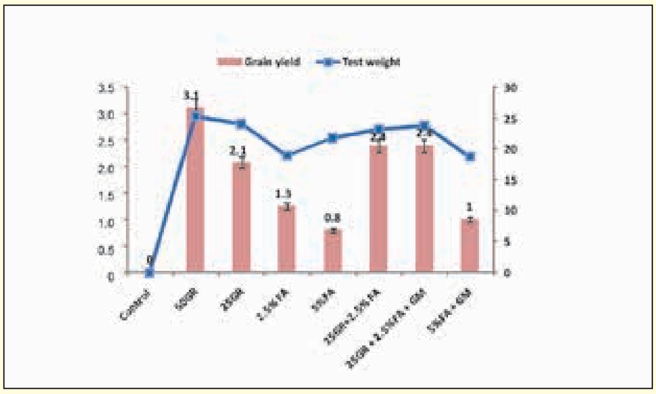



*Fig.45 : Effect of Fly ash on rice yield (2014) under barren sodic soil*

**Table 57 : Effect of Fly Ash on properties of partial reclaimed Sodic Soil**

| Treatment | pH | EC (dS $m^{-1}$) |
|---|---|---|
| Control | 8.74 | 0.440 |
| Fly ash 1.0% v/v of soil | 8.70 | 0.342 |
| Fly ash 1.0% v/v of soil + *dhaincha* | 8.83 | 0.399 |
| Fly ash 2.0% v/v of soil | 8.63 | 0.456 |
| Fly ash 2.0% v/v of soil + *dhaincha* | 8.65 | 0.444 |
| Fly ash 3.0% v/v of soil | 8.79 | 0..470 |
| Fly ash 3.0% v/v of soil + *dhaincha* | 8.50 | 0.578 |

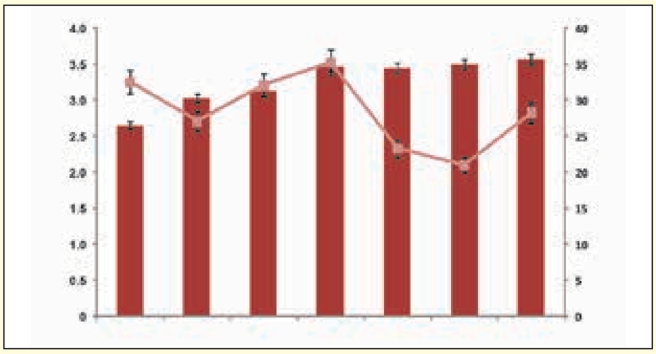
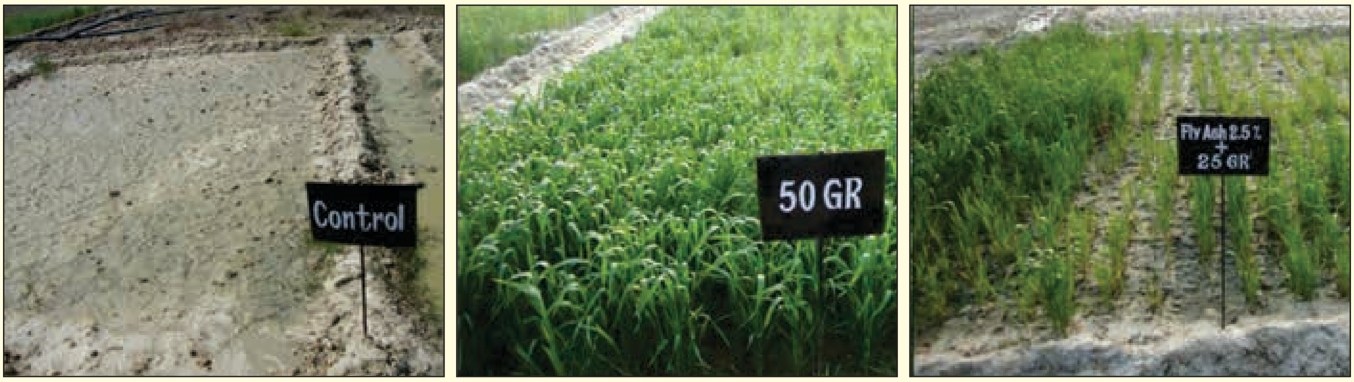


*Fig. 46 : Effect of fly ash on wheat grain yield (2013-14) in partial reclaimed sodic soil*




*Effect of fly ash on wheat crop in sodic soil*

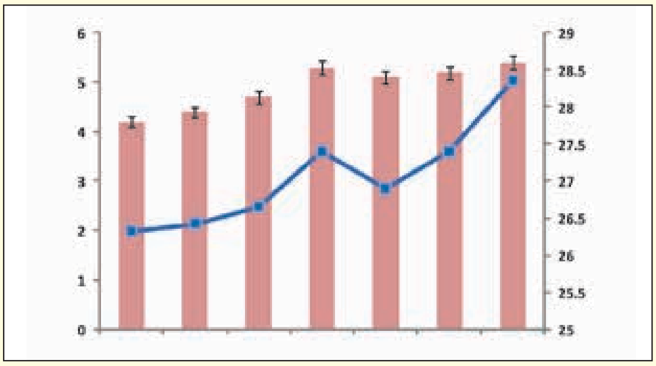



*Fig. 47 : Effect of fly ash on rice grain yield (2014) in partial reclaimed sodic soil*

plots that gave 11.9, 21.4 and 28.6 per cent higher yield over control (Fig. 47), respectively. Grain weight was highest in 3 per cent fly ash+ *dhaincha* treated plots.

### **Assessment of Municipal Solid Waste in Conjunction with Chemical Amendments for Harnessing Productivity Potential of Salt Affected Soils** (Y.P. Singh, Sanjay Arora and V.K. Mishra)

Various inorganic and organic amendments based technologies were developed to reclaim these lands. Chemical amendments alone do not add organic matter or stimulate microbial respiration or enzymatic activity in the soil.

In India about 90 million tons of municipal solid waste is generated annually and dumped in dump yards. The place where it is dumped are an environmental hazard – emanating methane causing greenhouse effect, smell & dirt causing health problems, and leachate contaminating the ground water, etc. Management of Municipal Solid Waste (MSW) is a major challenge faced by the governments. According to CPCB report Uttar Pradesh is producing 5515 tons of municipal solid waste per day. Various governments have developed municipal solid waste plants to convert municipal solid waste in to municipal solid waste compost but the cost of processed municipal solid waste compost available in the market is very high and beyond the reach of small and marginal farmers therefore, it is utmost important to develop low cost technology for composting of MSW through standardizing the methods of on-farm composting of raw municipal solid waste. Therefore, the present study was planned to 1) standardize the methods of on-farm composting of municipal solid waste and evaluate potential effectiveness of organic Municipal Solid Waste Compost (MSWC) in amelioration of sodic soils; 2) monitor the combined effect of organic MSWC and inorganic amendments on soil quality and biochemical changes; 3) find out the efficacy of inorganic amendments used in conjunction with MSWC on soil productivity, crop yield and quality in sodic soils; 4) to adjudge the economic feasibility of MSWC in respect of nutrient/fertilizer savings. Using of MSWC as source of organic amendment will reduce the gypsum requirement resulting in cost of reclamation and will also improve the soil physical and bio-chemical properties which ultimately will increase the crop yield. In addition to that, use of compost will also reduce the quantity of using mineral fertilizer in crops. Therefore, the project was conceptualized and initiated during July 2014.

To standardize the on-farm composting method, MSW was collected from the municipal authorities, segregated into degradable and non-degradable materials and analyzed for its physico–chemical properties. The data given in table 58 revealed that there was 37.5% degradable material including organic matter, garbage (30.5%), wood (2%) and paper (5%) and the remaining 62.5 per cent was non-degradable material consisting of metal (6%), stone (36.5%), plastic (15%) and glass (5%). The

*Standardization of protocol for decomposition of municipal solid waste*

**Table 58 : Physico-chemical properties of municipal solid waste**

| Physical properties | | Chemical properties | |
|---|---|---|---|
| **Composition** | **%** | **pH** | **6.97** |
| Paper/card board | 5.0 | Nitrogen (%) | 0.52 |
| Plastics | 15.0 | Phosphorus (%) | 0.053 |
| Metal | 6.0 | Potassium (%) | 0.28 |
| Glass | 5.0 | Calcium (%) | 0.36 |
| Stones/bricks/ pebbles | 36.5 | Magnesium (%) | 0.10 |
| Organic matter, garbage | 30.5 | Sulphate (%) | 0.106 |
| Wood/twigs | 2.0 | Total Carbon (%) | 28.35 |

biodegradable material alone and in combination with agricultural waste was filled in 12x4x2 feet beds inoculated with agriculturally useful microbes and earthworms with the treatments $T_1$: 100% Municipal Solid Waste + Microbes,$T_2$: 50% Municipal Solid Waste + 50% Agricultural Waste + Microbes,$T_3$: 100% Municipal Solid Waste + Earthworms, $T_4$: 50% Municipal Solid Waste + 50% Agricultural Waste + Earthworm,$T_5$: 100% Municipal Solid Waste + Microbes+Earthworm,$T_6$: 50% Municipal Solid Waste + 50% Agricultural Waste + Microbes+Earthworm. *Aspergillus*, *Trichoderma* and *Bacillus* were used as culture however, *Eisenia foetida* was used as species of earthworm. Chemical composition of agricultural wastes like paddy straw, mustard straw, *pongamia* and *casuarina* leaves used as agricultural waste was analyzed and it was observed that *Pongamia* and *Casuarina* leaves were rich in nutrient content.

During the composting process, samples were collected at 30 days interval and analyzed for estimation of rate of decomposition, nutrient mineralization and heavy metal load in municipal solid waste compost. Periodical observations like temperature, moisture etc during decomposition of municipal solid waste was taken at regular interval.

**Table 59 : Chemical properties of soil used for pot experiment**

| | |
|---|---|
| $pH_2$ | 9.22 |
| EC (dS $m^{-1}$) | 0.68 |
| Na (meq $l^{-1}$) | 3.50 |
| K (meq $l^{-1}$) | 0.34 |
| Ca (meq $l^{-1}$) | 3.50 |
| Mg (meq $l^{-1}$) | 3.55 |
| Available N(kg $ha^{-1}$) | 214.19 |
| Total N (%) | 0.15 |
| $CO_3$ (meq $l^{-1}$) | 1.20 |
| $HCO_3$(meq $l^{-1}$) | 0.80 |
| Cl (meq $l^{-1}$) | 2.20 |

To optimize the quantity of municipal solid waste compost and it effect on crop growth and soil properties, pot experiments on mustard and wheat crop was conducted. The chemical propeties of soil used for pot experiment is given in Table 59.

## 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 2K 232, Bulk 22, CSR 2K 219, RIL 178, CSR 10 M2 27, CSR 12 B 23, Bulk 18, BMZ 20, CSR-89IR-15, CPWF 05-15, Bulk 19, CSR 2K 262, CSR 2K 242, CSR-89IR-14 and CSR 2K 255 were conducted to find out a salt tolerant high yielding genotype. The trials were conducted at CSSRI, Research


Mother trial at Shivri


Baby trials at Patwakhera

Mother trial at Samesi

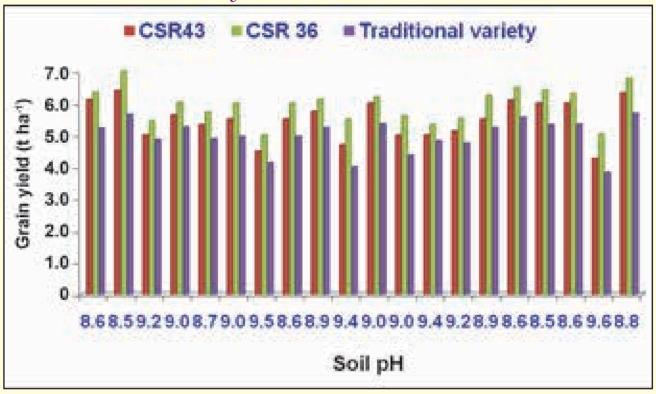



*Fig. 49 : Grain yield of salt tolerant and traditional varieties under farmers managed baby trials*

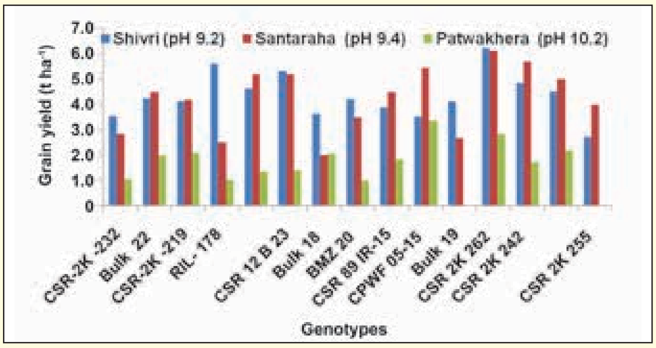



*Fig. 48 : Grain yield of different genotypes under farmers participatory varietal selection trials*

farm, Shivri, Village Santaraha and Patwakhera in Sitapur and Lucknow districts respectively in *kharif* 2014. The pH of the experimental site was 9.2, 9.4 and 10.2, respectively. Three times replicated trials with 30-35 days old nursery were transplanted on 4$^{th}$, 16$^{th}$ and 15$^{th}$ July 2014 at Shivri, Santaraha and Patwakhera, respectively. Recommended dose of fertilizer (120:60:40 kg NPK ha$^{-1}$) and Zinc sulphate @ 25kg ha$^{-1}$ was applied at all the three locations. Among the genotypes, CSR 2K 262 gave highest grain yield under medium sodicity level (pH 9.2-9.4). However, under high sodicity level (pH 10.2) genotype CPWF 05-15 found highly promising (Fig.48).

## Baby trials

To scale out the high yielding salt tolerant varieties CSR 36 and CSR 43, farmers managed baby trials were conducted on 20 farmer's field in Patwakhera village of Lucknow district. These varieties were planted at pH ranging from 8.5 to 9.6 and compared with the traditional variety (Ganga Kaveri, Sonam and Narendra 359). On the basis of crop cutting, yield data collected from 20 farmers fields, CSR 36 and CSR 43 yielded 20.23 and 10.47 per cent higher over the traditional varieties grown by the farmers. Short duration variety CSR 43 matured about 20-25 days earlier than the traditional variety Ganga Kaveri, Sonam and Narendra 359 and saved about 2-3 irrigations (Fig. 49).

## Stress Tolerant Breeding Network Trial (STBN)

The experiment consisted of 30 rice genotypes/ cultures, including 4 checks was conducted at CSSRI Regional Research station, Shivri farm, Lucknow in RBD with three replications. The soil $pH_2$ of the experimental field ranged from 9.5-10.2. Five rows of 30 days old seedlings were transplanted on 24.07.2014 at 20 x 15cm spacing. The recommended dose of fertilizer (150:60:40 kg NPK/ha ) was applied in three splits. Among the genotypes evaluated, 3 genotypes viz. CSR-12B-23, CSR 2K 262 and IR 87938-1-1-3-2-1-B found highly promising and 5 genotypes IR 87830-B-SDO1-2-3-B, IR 87830-B-SDO1-2-2-B, IR 87830-B-SDO2-1-


*STBN trial under highly sodic soil at Shivri Research farm*

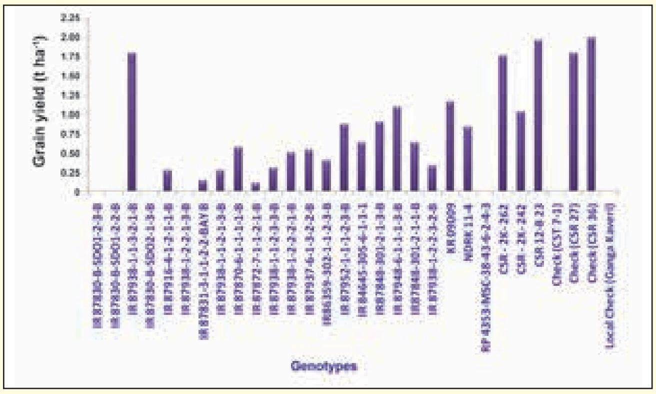



*Fig. 50 :Grain yield of STBN entries under highly sodic soils*

3-B, IR 87938-1-2-2-1-3-B and RP 4353-MSC-38-43-6-2-4-3 did not start flowering (Fig. 50).

## Front line demonstration

Forty front line demonstrations on salt tolerant varieties along with management practices were conducted at farmers' field in collaboration with KVK Etawa, Mainpuri, Raebareli, Sant Ravidas Nagar, Hardoi and Kannauj. The grain yields of salt tolerant varieties CSR 36 and CSR 43 were significantly higher over the traditional varieties at all the locations (Fig. 51).

## Cluster demonstration

A cluster demonstration (25 ha) of salt tolerant varieties of wheat KRL 19 and KRL 213 were conducted in *rabi* 2014 on 63 farmers field in 7 blocks of Raebareli district of U.P.in collaboration with IRRI and KVK Raebareli. Salt tolerant varieties were compared with highly preferred traditional variety PBW 343. Before initiating the demonstration, soil samples were collected from all the fields and analyzed for soil pH. The pH ranged from 8.6 to 9.4. Based on crop cutting data, the grain yield of salt tolerant varieties ranged from 2.8 to 4.7 t $ha^{-1}$ whereas traditional variety yielded 2.3 to 4.3 t $ha^{-1}$. The increase in yield of variety KRL 19 over PBW 343 ranged from 4.6 to 21.7 per cent where as KRL 213 yielded 10.46 to 34.78 per cent higher yield over PBW 343. The yield increase from STVs was higher in high sodicity conditions. Therefore, KRL 213 was highly preferred over KRL 19 (Table 60).

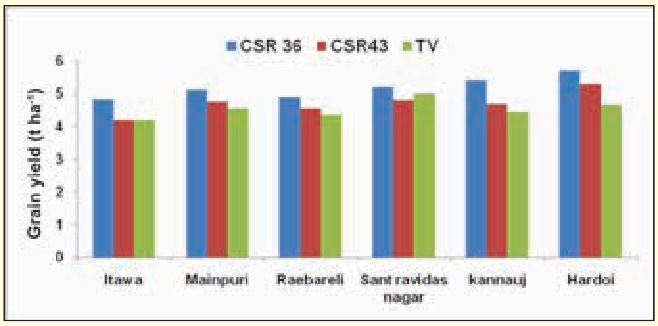



*Fig. 51 : Performance of salt tolerant and traditional varieties under front line demonstrations*

## Crop and Resource Management Practices for Rainfed Lowland Systems in Eastern India (ICAR-W3) (Y.P. Singh and V.K. Mishra)

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

To identify a suitable cropping system that can be fitted with short duration salt tolerant variety CSR 43, an experiment consisting of four sodicity levels i.e. pH 8.8, 9.0, 9.2 and 9.4 and three crop rotations viz. rice-wheat, rice-spinach-wheat and rice-toria-

**Table 60 : Grain yield of salt tolerant and traditional varieties of wheat under cluster demonstrations conducted on farmers fields.**

| No. of farmers | pH range | Average grain yield (t $ha^{-1}$) | | | Yield increase over traditional varieties (%) | |
|---|---|---|---|---|---|---|
| | | KRL 19 | KRL 213 | Traditional varieties | KRL 19 | KRL 213 |
| 20 | 8.6-8.8 | 4.5 | 4.7 | 4.3 | 4.65 | 10.46 |
| 18 | 8.8-9.0 | 4.0 | 4.5 | 3.4 | 17.64 | 32.35 |
| 17 | 9.0-9.2 | 3.7 | 4.0 | 3.2 | 15.65 | 25.00 |
| 8 | 9.2-9.4 | 2.8 | 3.1 | 2.3 | 21.73 | 34.78 |

wheat was conducted at CSSRI, Research Farm Shivri during 2013-14. The cropping schedule of all the three cropping systems is given in Table 61. Wheat grain yield reduced significantly with increasing levels of sodicity. Maximum wheat yield (2.64t $ha^{-1}$) was obtained at pH 8.8 in all three cropping systems. Similar trend was observed in rice, spinach and toria yield. System productivity calculated on the basis of rice equivalent yield was higher in rice-spinach-wheat cropping system as compare to rice-wheat and rice-toria- wheat (Fig. 52). Cost economics of all three cropping systems was calculated on the basis of support price of rice, wheat and toria and the market price of spinach. Maximum income was recorded with rice-spinach-wheat cropping system as compare to rice-wheat and rice-toria-wheat cropping systems. With the introduction of short duration variety CSR 43 can fit an additional short duration crop in between traditional rice-wheat cropping system and fetched an additional income. With the introduction of short duration variety, the cropping intensity of partially reclaimed sodic soils has increased up to 300 per cent. Variety CSR 43 is earlier maturing which is helpful in saving approximately two irrigations per season. Moreover, such water saving approach could extremely be useful in helping conserve depleting water tables. In addition, economic benefits of its early maturity, Rs. 2400 $ha^{-1}$ savings was observed through irrigation water reduction.

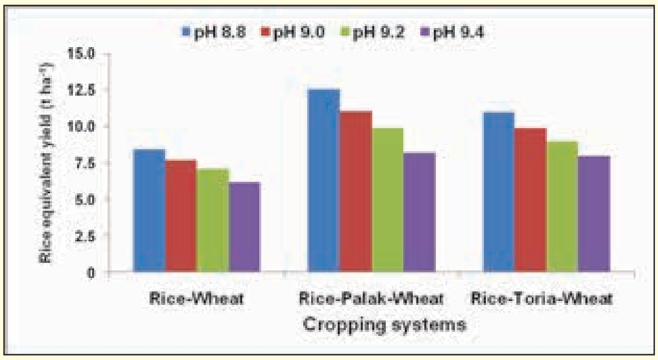



*Fig. 52 : Rice equivalent yield of different cropping systems with CSR 43*

## Screening and Evaluation of Wheat, Mustard and Rice Genotypes for Sodic Soils (Y.P. Singh and V.K. Mishra)

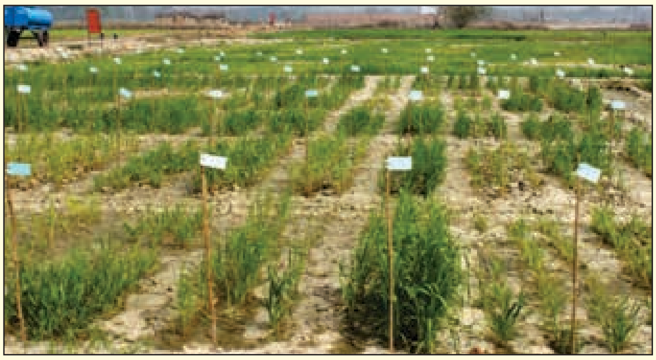
### Wheat

#### *All India Coordinated Wheat Improvement Trial*

During *rabi* 2013-14, all India coordinated wheat improvement trial was conducted at CSSRI RRS, Research farm, Shivri, Lucknow. The initial soil pH of the experimental field was 9.2. The trial consisted of 7 entries. The experiment was laid in RBD with six replications having row spacing 23 cm and 2 m row length with a net plot size of 4 mx2 m. Wheat crop was sown on 29.11.2013 and harvested on 9.04.2014. Among the genotypes/ varieties screened, genotype SPL-AST-07 produced maximum grain yield (2.75 t $ha^{-1}$) followed by genotypes SPL-AST-2 (1.96 t $ha^{-1}$) and minimum (1.22 t $ha^{-1}$) in SPL-AST-01.

#### *All India Salinity/Alkalinity Tolerance Nursery Trial*

All India Salinity/ Alkalinity Tolerant Nursery Trial on wheat consisted of 65 entries including 4 checks (Kharchia 65, HD 4530, KRL 19, and KRL 210) with a plot size 1.8 $m^2$ was conducted at CSSRI, Research Farm Shivri, Lucknow. The experiment was laid at $pH_2$ 9.2. Two rows of 3 m length of each line were sown on 29.11.2013 and harvested on 17.04.2014. Genotype WH 1309, HI 1602, LBP 2013-25, LBP-2013-23 found promising and yielded 500, 350 and 300 g $plot^{-1}$ respectively.



*All India salinity /alkalinity tolerance nursery trial*

**Table 61 : Cropping schedule of different cropping systems with CSR 43**

| Treatments | Ist crop | | IInd crop | | IIIrd crop | |
|---|---|---|---|---|---|---|
| | DOS | DOH | DOS | DOH | DOS | DOH |
| Wheat-rice | 15.11.13 | 15.04.14 | 1.07.14 | 29.09.14 | - | - |
| Wheat-rice-spinach | 10.12.13 | 20.04.14 | 1.07.14 | 29.09.14 | 09.10.14 | 3.12.14 |
| Wheat-rice-toria | 05.01.14 | 25.04.14 | 1.07.14 | 29.09.14 | 01.10.14 | 25.12.14 |

## Mustard

### *All India coordinated Trial on Rapeseed Mustard*

Eight lines were evaluated in IVT under alkaline condition ($pH_2$ 9.4) at CSSRI, Research farm Shivri, Lucknow. Each genotype was sown in 7.5$m^2$ area and replicated three times. Significant differences were observed in seed yield amongst the genotypes evaluated. Seed yield ranged from 0.23 to 0.73 t $ha^{-1}$. Genotype CSCN13-14-3 (0.73 t $ha^{-1}$) followed by CSCN13-14-8 (0.73 t $ha^{-1}$) and CSCN13-14-5 (0.60 t $ha^{-1}$) produced highest seed yield.

Another AVT trial consisted of six genotypes was also conducted during *rabi* 2014 at Research farm Shivri, Lucknow at the same site. Significant differences were observed in seed yield amongst the genotypes evaluated. Seed yield ranged from 0.63 t $ha^{-1}$ to 0.79 t $ha^{-1}$. Genotype CSCN13-14-13 produced maximum grain yield (0.79 t $ha^{-1}$) followed by CSCN13-14-10 (0.71 t $ha^{-1}$) and CSCN13-14-12 (0.69 t $ha^{-1}$) whereas minimum (0.63 t $ha^{-1}$) with CSCN13-14-9.

## Rice

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

To evaluate comparative performance of promising elite cultures for alkalinity and inland salinity, a field experiment consisting of 44 entries with four alkaline and one local check was conducted at Research Farm, Shivri, Lucknow (U.P.). The pH of experimental field was 10.1. The experiment was conducted in a RBD with four replications. Each genotype was planted with five rows of 10 m length having gross plot size of 10.0 $m^2$. The experiment was transplanted on 22.07.2014. Genotype 2339, 2336 and 2334 found promising under highly sodic soils.


*Alkaline and Inland Saline Tolerant Variety Trial*

### *All India Coordinated Agronomy Trial*

AVT-AL&ISTVT trial

Nitrogen response trials on selected AVT-2 rice cultures under high and low input management environments was conducted at CSSRI, Regional Research Station, Lucknow during *kharif* 2014 with the objectives 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 four nitrogen levels ($N_1$-50% of recommended dose, $N_2$-100% of recommended dose and $N_3$-150% of recommended dose) in main plot and rice cultures/varieties (one AVT lines viz. IET 23210 and four checks viz. CSR 23, CSR 36, Jaya and local (Ganga Kaveri) in sub–plot. Three times replicated experiment was laid in split plot design with a plot size of 10.4$m^2$. The experiment was conducted at soil pH 9.2. Grain yield of all the entries increased with increasing levels of N. Maximum grain yield (6.10 t $ha^{-1}$) was recorded with IET 23210 at 150% of recommended dose of N. Genotype IET 23210 produced higher yield over the checks at all the nitrogen levels.

## 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. Mishra, D.K. Sharma and C.L.Verma)

### Development and screening of wilt and salt tolerant rootstock of guava

A hybrid *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. The rootstock was screened in sodic soils of CSSRI, RRS, Lucknow where the soil pH was 9.65 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 (Table 62). It exhibited a plant height of 112 cm and exhibited lower Na/K ratio (0.109) at the end of one year compared to the control Lalit rootstock (0.721).

**Table 62 : Performance of guava rootstocks in sodic soils**

| Variety | Month | Height (cm) | No.of branches | Na/K |
|---|---|---|---|---|
| Lalit | 0 | 44 | 1 | 0.679 |
| | 3 | 49.5 | 1 | 0.776 |
| | 6 | 56.5 | 3 | 0.826 |
| | 9 | 67 | 5.75 | 0.721 |
| | 12 | 72 | 8.25 | 0.652 |
| P. Molle | 0 | 49 | 1 | 0.121 |
| | 3 | 64 | 2 | 0.115 |
| | 6 | 74.7 | 7.25 | 0.114 |
| | 9 | 95.33 | 11.66 | 0.118 |
| | 12 | 122 | 18.55 | 0.109 |

## 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 and V.K. Mishra)

### Success of CSR-BIO Technology in India through Public-Private Partnership

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 7.11.2012 and by ICAR on 20th July 2013. Three firms had obtained the license for producing the material. Apart from the firms licensed, the bio-formulation was also being produced at CSSRI Regional Research Station, Lucknow. The technology had reached to 10,800 ha in the country covering 7 states with an average yield increase of 19.75 per cent over the crops. Extensively, the technology is being adopted by 18,400 farmers of banana, flower growers of Southern Tamil Nadu, Karnataka and Andhra Pradesh. In Uttar Pradesh, Uttrakhand, Bihar, and Madhya Pradesh region, it has been widely used by the growers of potato, chillies, tomato and gladiolus (Table 63). The bio-formulation had resulted in reducing the use of chemical pesticides and fungicides to a level of 3000 L, thereby saving the environment and people from exposure to different types of toxins through their food chain. In potato, the farmers are treating the seed tubers with 3 % CSR-BIO (450 ha area) instead of chemical fungicide followed by drenching during December and January. They had harnessed a yield increase of 12 per cent with 65 per cent reduction in blight incidence when compared with the non-adopters.

Based on the on-field evaluation, the technology is also being promoted by many research institutes like National Bureau of Agriculturally Important Micro-oganisms, Mau, Directorate of Seed Research, Mau and YSR Agricultural University, Andhra Pradesh. The bio-formulation has been found to control major diseases like wilt in Ixora, banana, tomato, chillies, coriander and false smut of paddy. The Farmer Producer

**Table 63 : Impact of CSR-BIO on the production of commercial horticultural crops**

| Firms producing | Quantity produced (2012-14) | Area benefitted (ha) | % yield increase | Crops | Disease controlled |
|---|---|---|---|---|---|
| CSSRI, RRS, ICAR Lucknow | 22 tonnes (solid)<br>3000 L (liquid) | 1200 | 15 | Paddy, wheat, potato, banana, tomato, capsicum, okra, gladiolus, mango and guava (both salt affected and normal soils) | Wilt of tomato, banana, Fe+ availability, Blight of potato and Paddy smut |
| M/S Krishicare Bioinputs, Tamil Nadu | 140 tonnes (solid)<br>1200 L (liquid) | 2200 | 24 | Ixora, banana, jasmine and Green house tomato | Wilt of Ixora, Fe+ availability and Blight of potato |
| M/S Alwin Industries, Madhya Pradesh | 164 tonnes (solid)<br>6000 L (liquid) | 7000 | 22 | Chilies and garlic etc., | Wilt and blight |
| M/S Jai Visions Agri-Tech, Ghaziabad, U.P | 3 tonnes (solid) | 400 | 18 | Gladiolus and Potato | Blight of potato |


*Impact of CSR-BIO in potato*

Company of Trichirapalli district in Tamil Nadu has successfully reported the control of paddy false smut to about 90 per cent in their monsoon crop.

## Identification of Salt Tolerant Microbes and Development of Dynamic Substrate for Cultivation of Commercial Crops in Sodic Soils (AMAAS Funded) (T. Damodaran, S.K. Jha, V.K. Mishra, D.K. Sharma, Y.P. Singh)

### Isolation and identification of rhizospheric bacteria/fungi from plants/salt tolerant crop varieties grown in sodic soils of pH > 9.5.

Survey for natural selection of rhizospheric and endophytic diversity in wheat, rice and mango was carried out in salt affected districts of Raebarely, Sitapur, Kanput, Unnao etc. Sixty five samples were collected and processed using serial dilution technique for isolation. About 56 isolates were obtained and on purification and further characterization about 28 strains were taken as pure cultures. Among them, 27 were bacterial isolates and one was fungal *Trichoderma* isolate (Table 64).

### Screening of isolates for NaCl tolerance

For determining salt tolerance of the isolated bacteria, they were streaked on nutrient agar supplemented with 0.5, 10 and 15% NaCl which acts as a selective medium. Eight isolates (CSR1, CSR10, CSR11, CSR13, CSR16, CSR17, CSR18 and CSR19) were found to grow luxuriantly in 15% NaCl concentration exhibiting the OD value of more than 1.000 (Fig. 53) in the pellet. These isolates were further screened for the sodium absorption rate where it was observed that they also exhibited higher absorption of sodium to about 30 per cent ranging from 6585 ppm/g fresh weight in isolate CSR-9 to 12365 ppm/g fresh weight in CSR-20.

### Screening for PGPR properties

A total of eleven isolates exhibited PGPR properties like IAA production, siderophore production and phosphate solubilization (Table 65).

**Table 64 :Enumeration of isolates collected from salt affected rhizospheres of Uttar Pradesh**

| Sl. No | Place of collection | Source | GPS data | Plant part | Bacterial population (CFU $g^{-1}$ FW) | No. of phenotypes selected |
|---|---|---|---|---|---|---|
| | | | Raebareli district | | | |
| 1. | Hardoi | Plant | 26.2338° N, 81.2336° E | Stem<br>Leaves<br>Root | $7.0 \times 10^{-3}$<br>$8.0 \times 10^{-3}$<br>$7.6 \times 10^{-3}$ | 4<br>3<br>2 |
| 2. | Lalganj | Soil | | Soil | $8.6 \times 10^{-3}$ | 4 |
| | | | **Sitapur district** | | | |
| 1. | | Plant | 27.5000° N, 80.9167° E | Stem<br>Leaves<br>Root | $4.4 \times 10^{-3}$<br>$6.0 \times 10^{-3}$<br>$6.0 \times 10^{-3}$ | 5<br>2<br>3 |
| 2. | | Soil | | Soil | $6.6 \times 10^{-3}$ | 8 |
| | | | **Kanpur district** | | | |
| 1. | Meitha | Soil | 26.4607° N, 80.3334° E | Soil | $7.8 \times 10^{-3}$ | 2 |
| 2. | Vinoba Nagar | Plant | | Stem | $4.0 \times 10^{-3}$ | 4 |
| | | | | Leaves | $4.6 \times 10^{-3}$ | 8 |
| | | | | Root | $7.2 \times 10^{-3}$ | 7 |
| | | | **Lucknow district** | | | |
| 1. | Shivri | Plant | | Root | $5.2 \times 10^{-3}$ | 2 |
| | | **Total no of isolates** | | | | 56 |

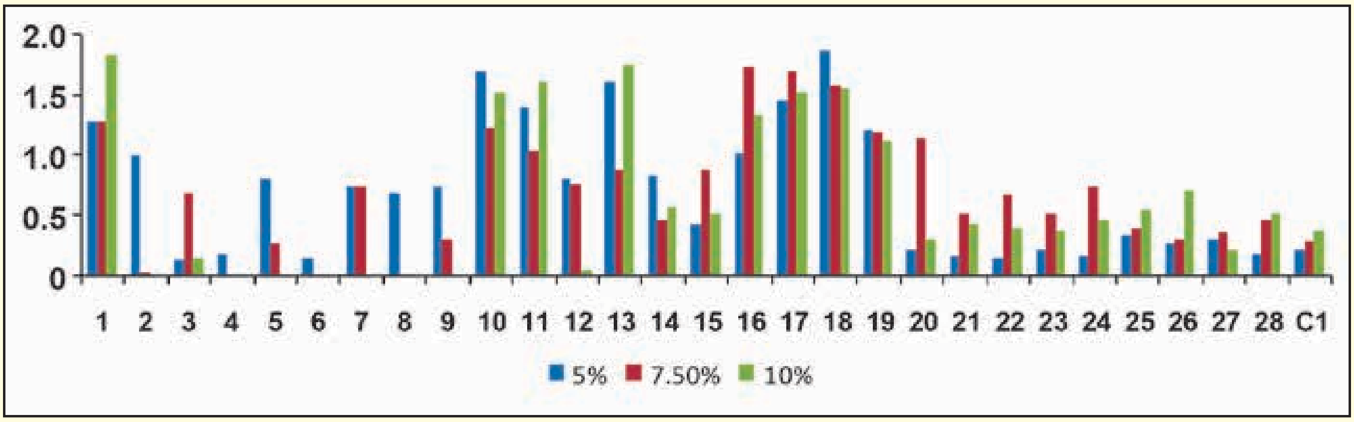



*Fig. 53: Growth of isolates under different NaCl concentrations*

**Table 65 : Screening of isolates for PGP characters**

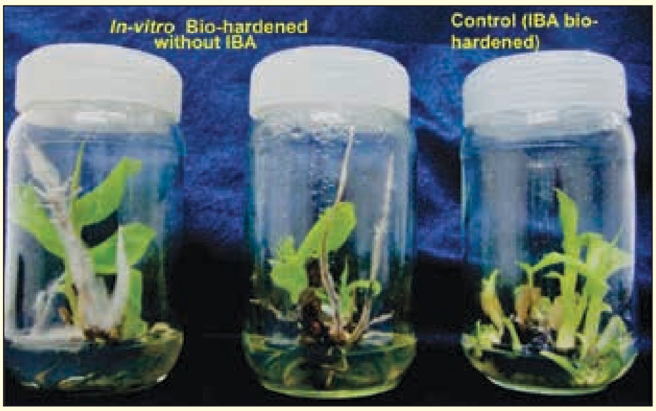
| S. No | Isolate name | Plant growth promoting properties | | | |
|---|---|---|---|---|---|
| | | IAA production (μg/ml) | Siderophore production | HCN prodcution | $PO_4$ solubilization |
| 1 | CSR-A-01 | 49.7 | ++ | - | +++ |
| 2 | CSR-A-09 | 45.2 | +++ | - | ++ |
| 3 | CSR-A-11 | 58.2 | ++ | - | ++ |
| 4 | CSR-A-13 | 71.23 | +++ | - | ++ |
| 5 | CSR-A-16 | 66.34 | +++ | - | ++ |
| 6 | CSR-A-17 | 40.71 | +++ | - | ++ |
| 7 | CSR-A-18 | 47.88 | +++ | - | +++ |
| 8 | CSR-A-20 | 36.42 | +++ | - | +++ |
| 9 | CSR-A-24 | 25.50 | ++ | - | +++ |
| 10 | CSR-A-26 | 54.00 | ++ | - | ++ |
| 11 | CSR-A-27 | 22.00 | +++ | - | +++ |

## Assessment of vigour index in sodic soils

Among 9 strains tested for their efficacy to improve the vigour index of wheat seedlings under sodic soils of pH 9.45, 4 showed plant growth enhancing activity and interestingly CSR 1, CSR 9, CSR 11 and CSR 17 showed higher germination percentage ranging from 72.3 to 81.5 per cent with a vigour index of 1829.05 to 2060.89.

## Bio-hardening of banana plantlets for inducing salt tolerance

*In vitro* bio-hardening protocol using salt tolerant bacteria CSR-B-1 and CSR-B-2 was standardized to induce rooting in the multiple shoots of the banana tissue culture plantlets without the use of any hormone like IAA and IBA. Technology for bio-hardening in the rooting media was standardized




*Bio-priming of the tissue cultured banana with salt tolerant endophytes*

**Table 66 : Growth parameters at 45 days after inoculation**

| Phenotypical parameters | Bio-primed | Control (IBA) |
|---|---|---|
| Plant height (cm) | 8.0a | 6.2b |
| No. of leaves / plant | 5.0a | 4.0a |
| Root length (cm) | 9.5a | 4.2b |
| No. of roots | 14.0a | 8.0b |

and is under evaluation. There was a significant difference in the root length and number of roots among the bio-primed and control where rooting was induced with the use of IBA (Table 66).

## 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)

The field experiment was initiated in *kharif* 2013 using various tillage practices with and without crop residue. During *rabi* 2014, the grain yield of wheat was found to be maximum (3.6 t ha$^{-1}$) in direct seeded rice + *Sesbania* as brown manuring + zero tillage in wheat + crop residue (DSR+SES+ZTW+CR) which was on par with direct seeded aerobic rice + zero tillage in wheat + addition of crop residue (DSR+Aero+ZTW+CR) followed by dry ploughing and rice transplanting +zero tillage in wheat + crop residue addition (DP$_{trans}$+ZTW+CR) and puddling in rice +zero tillage in wheat + crop residue (PudR+ZTW+CR). The rice yield on the other hand recorded maximum (4.6 t ha$^{-1}$) both in ZTR+ZTW+CR and DSR+SES+ZTW+CR (Fig. 54). The data revealed that zero tillage practices have contributed in enhancing the yield parameter. The nutrient fractionation in soil samples collected after wheat crop was carried out for phosphorous and zinc using sequential analysis.

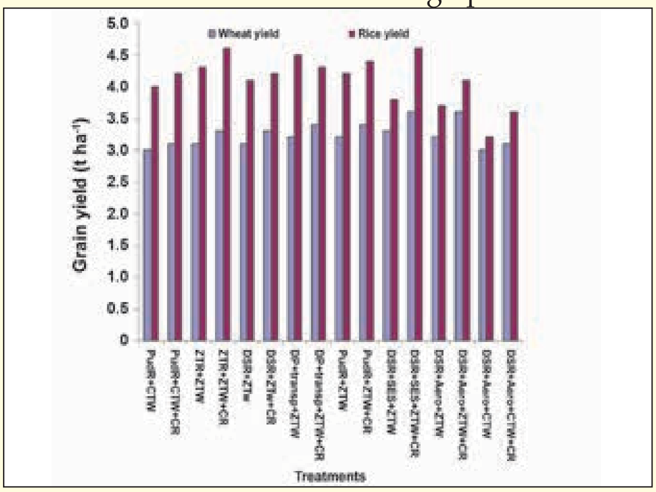



*Fig. 54 : Yield of rice and wheat*

## P-fractionation

The inorganic phosphorous fractionations have been widely used to interpret native inorganic P status and applied P to the soil. The phosphorous in soil is considered to be distributed among several geochemical forms including soil solution, exchangeable Ca-bound, Al- & Fe- bound P. So far, Olsen P extraction technique has been regarded to be the best indicator of plant available P in soil, but this fraction is not able to differentiate between various P fractions that exists in the soil. Therefore, phosphorous fractionation is essentially needed to identify P-pools that are sources and sinks of plant available P during cropping and also to know replenishing ability of the soil. Looking into the above, the effect of crop residues and different tillage practices on inorganic P-fractions in soil was studied. Various P fractions such as soluble and loosely bound P, aluminium phosphate bound P, iron phosphate bound P, reductant soluble P and calcium phosphate bound P were estimated using sequential analysis of soil. It was found that soluble and loosely bound P which is regarded as the easily available P was maximum (138.3 mg P kg$^{-1}$) in puddling in rice followed by conventional tillage in wheat (PudR-CTW) followed by zero tillage practices (ZTR-ZTW) with 130.4 mg P kg$^{-1}$ soil. The Al-phosphate bound P was maximum (85 mg kg$^{-1}$) in (ZT$_R$-ZT$_W$+CR) followed by DSR-SES-ZT+CR whereas maximum Fe-phosphate bound P (121.5 mg kg$^{-1}$) was observed in puddling in rice + conventional tillage in wheat with the addition

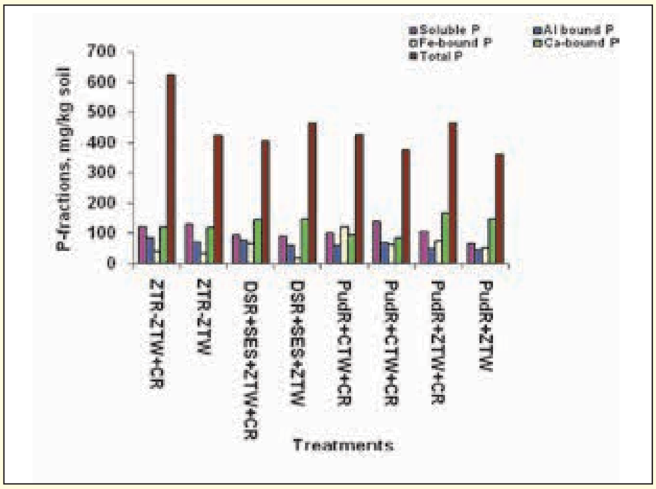



*Fig. 55 : Phosphorous fractions in soil*

of 30per cent crop residue (PudR-CTW+CR). No traces of reductant soluble P (extracted with solution comprising sodium citrate, sodium dithionate and sodium bicarbonate) was found in any of the tillage practices whereas puddling in rice–zero tillage in wheat + crop residue addition (PudR-ZTW+CR) was having highest with respect to $H_2SO_4$ soluble P (calcium phosphate bound P). The total P was found to be maximum (623 mgP $kg^{-1}$) in zero tillage with crop residue addition (ZT-ZT+CR). The olsen P however, was found to be maximum (10.97 mgP $kg^{-1}$) in DSR-SES-ZT+CR (Fig. 55).

## Zn-fractionation

The soil solution concentration and plant available Zn was governed predominantly by solution pH and Zn adsorbed on clay and organic surfaces in soil. The non specifically adsorbed Zn (soluble+exchangeable) was found maximum (0.336 mg Zn $kg^{-1}$) in ZTR-ZTW whereas organically bound was maximum (2.492 mg Zn $kg^{-1}$) in ZTR-ZTW+CR. Between Al & Fe bound, Mn-oxide bound Zn, Al & Fe bound Zn was found to be maximum (5.94 mg Zn $kg^{-1}$) in ZTW-ZTW+ CR followed by DSR-SES-ZTW+CR (Fig. 56). A good correlation (r=0.81) was found between organically bound Zn and non specifically adsorbed Zn. Between specifically adsorbed and non-specifically adsorbed Zn coefficient of correlation was 0.80.

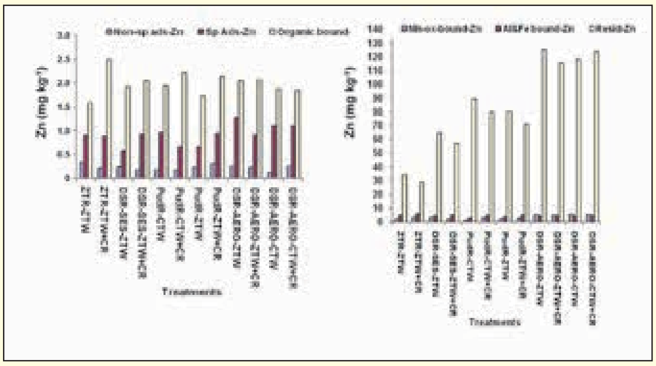



*Fig. 56 : Various zinc fractions in soil*

## B-fractionation

About 33 per cent of Indian soils are deficient in Boron. It is the only micronutrient taken by plants not as an ion but as an uncharged molecule $B(OH)_3$ or $H_3BO_3$. In aqua environment: $B(OH_3) + H_2O \leftrightarrow B(OH)_4^- + H^+$ $K_a = 6 \times 10^{-10}$. The level of soil solution B is controlled by adsorbed pool of B and equilibrium exists between soil solution B and adsorbed pool of B. In sequential fractionation,

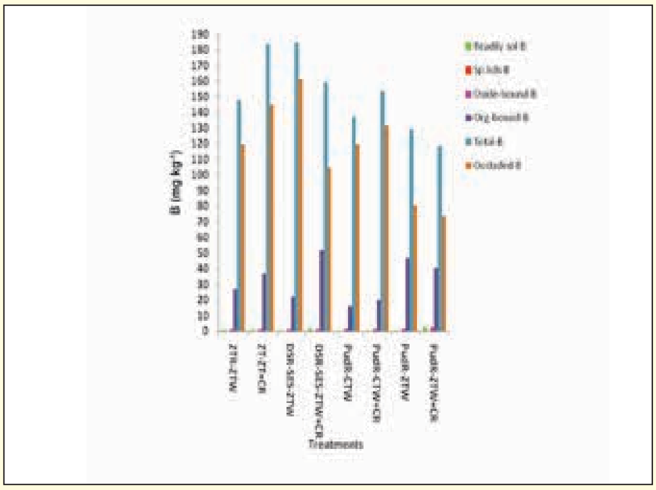



*Fig. 57 : Boron fractions in soil*

readily soluble boron was maximum (2.38 mgB $kg^{-1}$) in PudR-ZTW+CR followed by DSR-SES-ZTW+CR (1.33 mgB $kg^{-1}$) whereas organically bound boron was maximum (52.09 mgB $kg^{-1}$) in DSR-SES-ZTW+CR (Fig 57). This is because organic matter represents a large potential source of plant available B.

## 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, A.K. Bhardwaj, V.K. Mishra, Y.P. Singh, T. Damodaran and D.K. Sharma)

In soils and sediments, carbon is present in the various forms such as elemental, organic and inorganic forms. Inorganic forms include carbonate minerals viz calcite, dolomite siderites etc. The organic carbon on the other hand derives from the decomposition of plants and animals, humus, carbohydrates, humic acid, fulvic acid and many other organic acids. The soil samples collected from the experimental plots of the project which was continuing since 2012 and were subjected to analysis of total organic carbon (TOC) and total inorganic carbon (TIC) fractions by loss on ignition (LOI) method. The TOC was found to be maximum in zero tillage plots where crop residue was added (ZTR-ZTW+CR) followed by Puddling in rice-conventional tillage in wheat + crop residue (PudR-CTW+CR) whereas in aerobic conditions, maximum was found in direct seeded rice-zero tillage in wheat where crop residue was added (DSR-ZTW+CR). The total inorganic carbon was found to be highest (17.7 g $kg^{-1}$) in zero tillage practices (ZTR-ZTW) (Fig. 58).

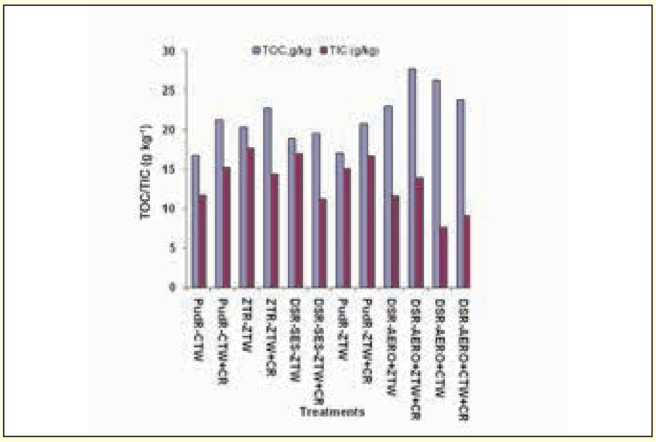



*Fig. 58 : Distribution of TOC and TIC in soils of different tillage practices*

Under the labile pool of carbons, hot water soluble (HWS-C), acid hydrolysable (carbohydrate) carbon (AHC) and permanganate oxidisable carbon (POxC) were determined in the soils. The HWS-C was found to be highest (1.64 g kg$^{-1}$) in ZTR-ZTW+CR. A very good correlation was found between TOC and HWS-C with coefficient of correlation of 0.983. It is known that HWC pool also tends to relate well with microbial biomass carbon (MBC) and strongly correlate with $CO_2$ evolution. The acid hydrolysable carbon acts as an indicator of mineralisable SOM was found to be maximum (642.1 ppm in PudR-CTW+CR followed by PudR-ZTW+CR (573.9 ppm). The POxC on the other hand was found to be maximum (386 mg kg$^{-1}$) in ZTR-ZTW+CR followed by ZTR-ZTW. This pool of carbon is very sensitive to tillage intensity and the level of carbon input that quantify labile soil carbon rapidly. Under the direct seeded aerobic rice condition (DSR-AERO-ZTW+CR), the POxC was maximum (370 mg kg$^{-1}$) (Fig. 59).

The carbon management index was also determined which measure the rate of change of soil carbon dynamics of a given system relative to more stable reference soil. The reference soil was taken as conventional treatment. The carbon pool index (CPI) was calculated as :

$$CPI = \frac{Sample\ Total\ Organic\ C\,(g/kg)}{reference\ sample Total\ C\,(g/kg)}$$

Lability index (LI) was calculated as :

$$LI = \frac{Lability\ of\ C\ in\ each\ sampled\ soil}{Lability\ of\ C\ in\ reference\ soil}$$

Where

$$Lability\ of\ C = \frac{KMnO_4\ C}{TOC - KMnO_4\ C}$$

Finally CMI was estimated as:

$$CMI = CPI\ x\ LI\ x\ 100$$

The CMI was found to be highest (119.3) in ZTR-ZTW+CR followed by ZTR-ZTW (103.8) whereas under the direct seeded aerobic rice condition (DSR-AERO-ZTW+CR) the CMI was maximum (118.7) as shown in fig. 60.

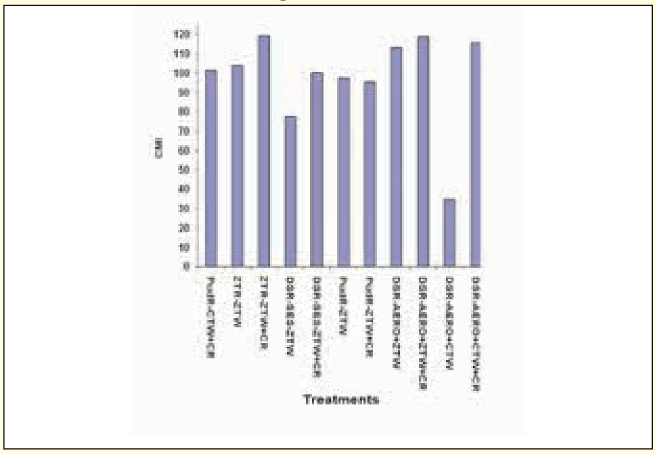



*Fig. 60: Carbon Management Index (CMI) under different tillage practices*

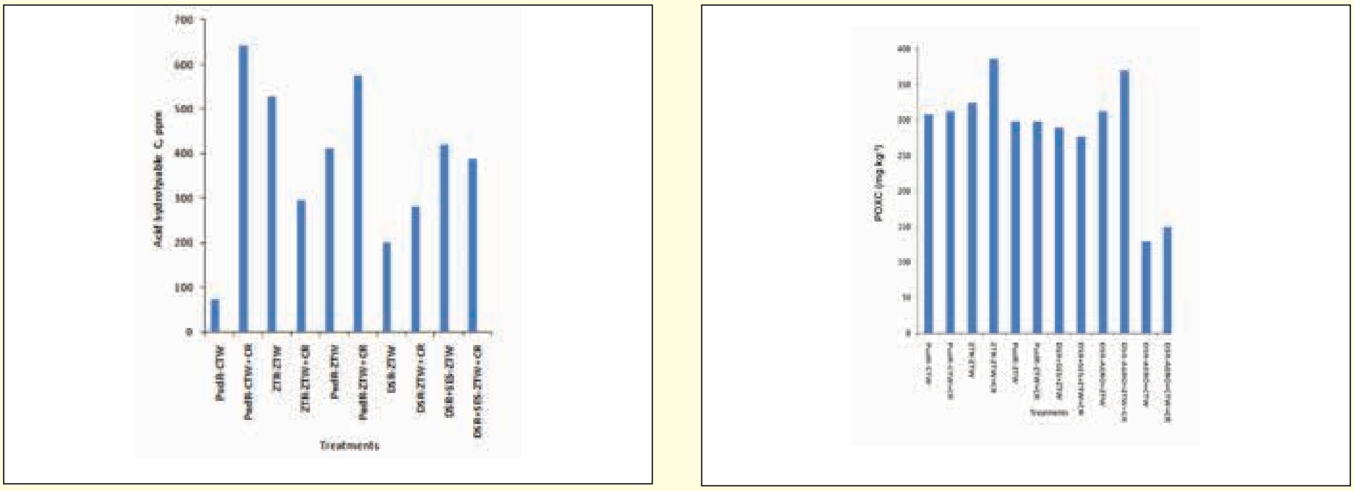



*Fig. 59 : Acid hydrolysable carbon (AHC) and Permanganate Oxidisable carbon (POxC)*

## 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. Singh, V.K. Mishra, Y.P. Singh and D.K. Sharma)

### Gypsum and native $CaCO_3$ dissolution

The release of Ca+Mg ions was studied from calcareous sodic soils of Samastipur and Muzaffarpur districts of Bihar having varying content of native $CaCO_3$. The soil samples were amended with pressmud @ 10 t $ha^{-1}$ at field capacity moisture and incubated at 30±1°C for 60 days. The release of Ca+Mg increased due to dissolution of $CaCO_3$. It was higher in soils having higher content of free $CaCO_3$ and the effect was more pronounced in the presence of pressmud. After 60 days of incubation, 15.2 to 22.8 per cent higher release of Ca+Mg was observed in pressmud amended soils as compared to no pressmud application (Fig 61). The study indicates that native $CaCO_3$ dissolution can help in ameliorating sodic effect when pressmud was applied to sodic calcareous soils.

Different kinetic models were used to fit the release of Ca+Mg with respect to time period from the mineral gypsum amended with pressmud. This suggested that release of Ca+Mg was more precisely predicted by first order rate equation followed by Elovich equation keeping in view the high $R^2$ value and low SE values. The higher 'a' constant value for pressmud addition in all models suggested instantaneous rate of release of Ca+Mg when pressmud was added (Table 67).

Mineralization of carbon and nitrogen in sodic soil was studied as influenced by application of gypsum and organic amendments. It was observed that C was mineralized in 14 days of incubation at field capacity moisture while N was mineralized from organic sources in 21 days of incubation. There was cumulative increase in $CO_2$ flux by 28.3 per cent in pressmud and 69.8 per cent in vermicompost amended sodic soil in presence of gypsum @ 50% GR at 21 days (Fig 62). Nitrate and ammonical N was 36.7 and 23.5 per cent higher when sodic soil was amended with gypsum + pressmud at 56 days of incubation over only gypsum amended soil (Fig 63).

A laboratory study was conducted to evaluate the effect of flushing soil with good quality water and thereafter estimating gypsum requirement of sodic and saline-sodic soils as per Schoonover's method. It was observed that flushing reduced the gypsum requirement to the tune of 17.4 to 31.25 per cent and 40.4 to 75.4 per cent in sodic and saline sodic soils, respectively (Table 68).

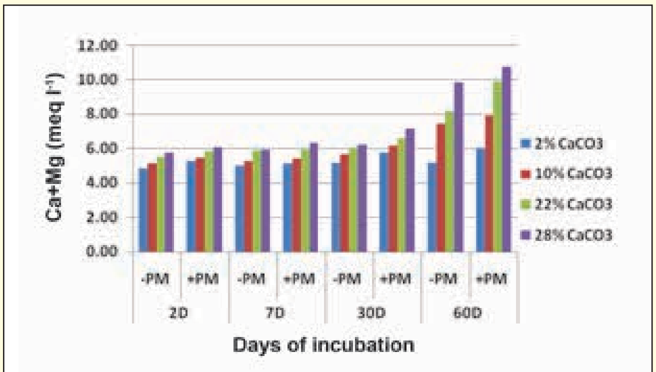



*Fig. 61 : Native $CaCO_3$ dissolution in calcareous sodic soils of Bihar*

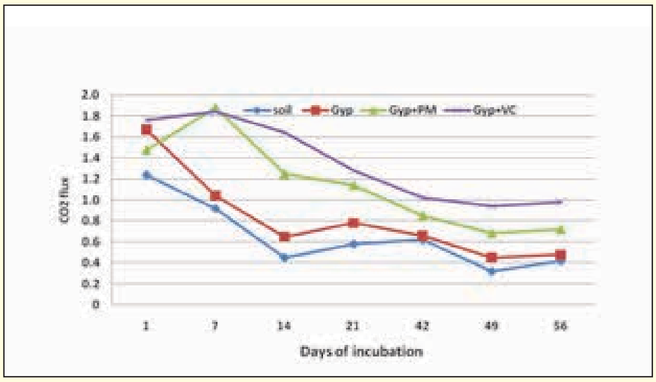
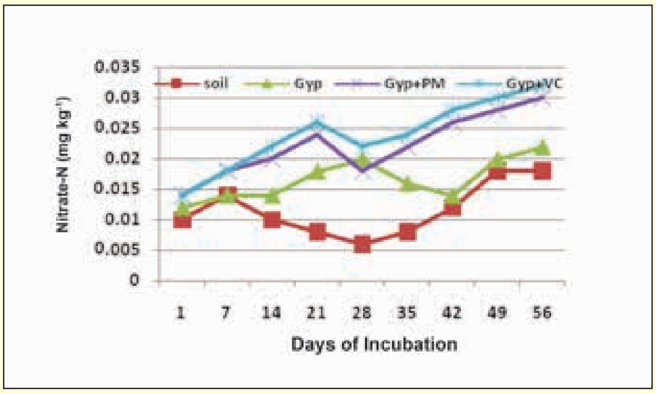



*Fig. 62 : Mineralization of Carbon from different amendments in sodic soil*

**Table 67 : Kinetics of mineral gyspum in absence and presence of PM**

| Kinetic equation | a | | b | | $R^2$ | | S.E. | |
|---|---|---|---|---|---|---|---|---|
| | -PM | +PM | -PM | +PM | -PM | +PM | -PM | +PM |
| First order<br>-ln(1-Ct/Cs) = a+bt | 0.51 | 0.72 | 1.78 | 1.92 | 0.81 | 0.92 | 1.92 | 1.17 |
| Power function<br>lnY=lna+b*lnt | 3.60 | 5.75 | 0.82 | 1.14 | 0.76 | 0.88 | 2.84 | 2.39 |
| Elovich<br>Y=a+b*lnt | 4.14 | 7.88 | 0.76 | 0.92 | 0.82 | 0.95 | 2.46 | 2.12 |



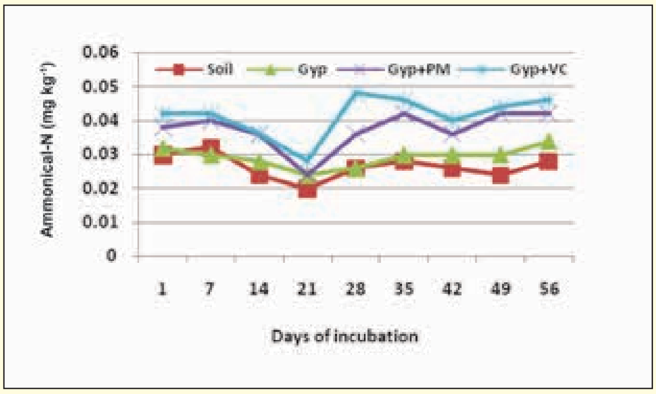
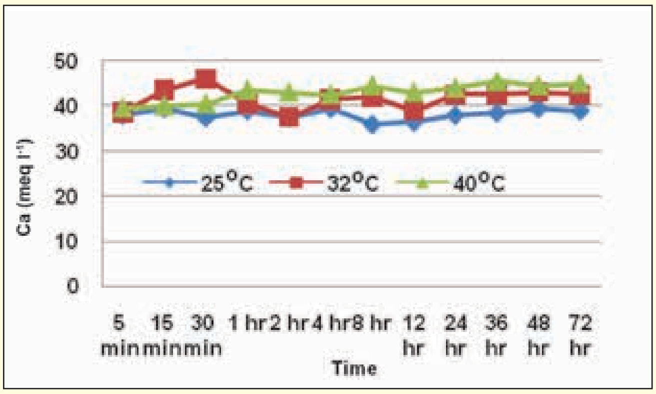




*Fig. 63 : Nitrogen mineralization as influenced by organic and inorganic amendments*

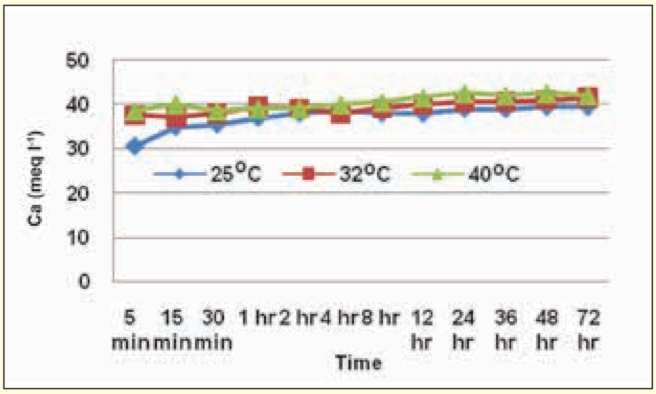
**Table 68 : Effect of flushing on gypsum requirement**

| Soil location | $pH_2$ | $EC_2$ (dS $m^{-1}$) | Gypsum requirement (meq/100g) by Schoonover's method | Gypsum requirement (meq/100g) after washing |
|---|---|---|---|---|
| Koithar | 10.1 | 8.18 | 5.70 | 1.40 |
| Kausambhi | 9.2 | 0.74 | 3.70 | 2.90 |
| Rasoolpur | 8.9 | 2.43 | 1.60 | 1.10 |
| Baratikhera | 10.1 | 9.81 | 5.20 | 3.10 |
| Lalganj | 10.0 | 1.28 | 5.80 | 3.40 |
| Sandila | 10.3 | 2.50 | 5.30 | 3.70 |
| Dhaura | 10.1 | 4.04 | 4.50 | 2.20 |
| Vishnupur | 9.8 | 2.25 | 5.80 | 4.80 |

Incubation study was conducted to ascertain the effect of temperature on dissolution kinetics of mineral gypsum and phosphogypsum. It was observed that there was instant dissolution of both the chemical amendments in terms of Ca release in distilled water during first 30 minutes and thereafter gradual increase was noted upto 24 hours at all temperatures and thereafter stabilized. However, there was 15.3 and 7.5 per cent higher release of Ca from gypsum and phosphogypsum at 40°C as compared to 25°C (Fig 64). Mineral gypsum and phsphogypsum dissolution was higher at 40°C as compared to 25°C at all time periods. In canal water (EC 0.3 dS $m^{-1}$) and tubewell water (EC 2.1 dS $m^{-1}$), the dissolution of gypsum as well as phosphogypsum was higher by 12 to 17 per cent compared to distilled water at 25°C at 16 hours (Table 69 & 70). Decomposition rate of pressmud was higher in soil of pH 9.6 as compared to 10.2 both in presence and absence of gypsum or phosphogypsum.




*(a)*




*(b)*

*Fig 64 : (a) Mineral gypsum and (b) phosphogypsum dissolution in DW as influenced by temperature*

**Table 69 : Kinetics of mineral gyspum as influenced by water quality**

| Kinetic equation | Distilled water (DW) | | Canal water (CW) | | Tube well water (TW) | |
|---|---|---|---|---|---|---|
| | a | b | a | b | a | b |
| First order | 1.84 | 0.061 | 1.36 | 0.065 | 1.42 | 0.077 |
| Power function | 3.58 | 0.052 | 3.65 | 0.085 | 3.74 | 0.060 |
| Elovich | 23.22 | 0.044 | 30.43 | 1.881 | 33.64 | 1.732 |

b= coefficient of dissolution; a=constant

**Table 70 : Kinetics of mineral gyspum as influenced by water quality**

| Kinetic equation | DW | | CW | | TW | |
|---|---|---|---|---|---|---|
| | $R^2$ | S.E. | $R^2$ | S.E. | $R^2$ | S.E. |
| First order | 0.886 | 0.009 | 0.972 | 0.004 | 0.984 | 0.003 |
| Power function | 0.918 | 0.106 | 0.929 | 0.042 | 0.916 | 0.038 |
| Elovich | 0.907 | 0.032 | 0.897 | 0.160 | 0.902 | 0.172 |

## Sodic soil reclamation and crop production

The field experiment was continued on sodic soil (initial pH 10.1) at Shivri Farm to ascertain the effect of organic and inorganic amendments on rice-wheat production and effect of amendments on chemical changes in sodic soil during reclamation. The treatments were imposed during *kharif* 2013 in plot size of 30m². The treatments imposed were : $T_1$: Gypsum@50 GR; $T_2$: Gypsum@25 GR; $T_3$: Gypsum @12.5 GR; $T_4$: Phospho-gypsum @ 25 GR; $T_5$: Gypsum@ 25 GR+pressmud; $T_6$: Phospho-gypsum@ 25 GR+ pressmud; $T_7$: Gypsum@ 25 GR+ pressmud +bio-inoculant; $T_8$: Gypsum@ 12.5 GR+ pressmud; $T_9$: Phosphogypsum @12.5 GR +pressmud; $T_{10}$: Gypsum @12.5 GR + pressmud + bio-inoculant. Rice-wheat crops were grown continuously in RBD with 3 replications where fresh halophilic plant growth promoting bio-inoculant was inoculated as per the treatments.

During *kharif* 2014, maximum grain yield of paddy was observed in gypsum @ 25 GR + pressmud+bio-inoculant treatment which was superior by 25.8 and 56.9 per cent compared to gypsum @ 50GR and gypsum@25 GR+pressmud, respectively. However, grain yield in plots amended with gypsum @12.5 GR+pressmud was higher by 52.9 per cent over gypsum @12.5 GR. Straw yield was found to be influenced by the application of organic and inorganic amendments in combination with bio-inoculant. It was found maximum with the application of gypsum @25 GR+pressmud+bio-inoculant treatment where it was 8.4 per cent higher than gypsum @ 50 GR (check). After harvest of paddy, depth wise soil samples were collected from respective plots. It was noted that soil pH ranged from 9.16 to 10.42 (mean of 3 replications) in all the treated plots as compared to 9.88 in control plots. Maximum reduction in soil pH was noted in treatment $T_6$ ($PG_{25GR}$+Pressmud) where pH was 9.16. Depth wise soil pH showed increasing trend from surface to sub-surface layers. It was observed to be in the range of 9.16 to 9.72 in 0-15 cm depth as compared to 9.84 to 10.20 in 15-30 cm, 9.94 to 10.05 in 30-45 cm and 9.90 to 10.42 in 45-60 cm soil layers in all the imposed treatments.

During *rabi* 2013-14, maximum wheat yield was obtained in treatment where phosphogypsum @25% GR+ 10 t pressmud were applied which was at par with the treatment where Gypsum @ 25% GR + Pressmud + bio-inoculants were applied. Grain as well as straw yield was 63.19 and 40.84 per cent higher in combined use of phosphogypsum and pressmud as compared to only gypsum @ 25% GR.

## GypCal- A decision support system

The GypCal, a desktop based software application was developed on visual basic platform. This is based on soil pH (1:2), ESP and gypsum requirement (GR) determined in sodic soil samples collected from 7 districts of Indo-Gangetic plains and the relationship was developed between soil $pH_2$ and GR. Further, the average crop yield from each sampled site was equated to predict the yield based on the soil pH for traditional as well as tolerant varieties.

This software is user friendly and can be useful for optimizing crop production in Indo-Gangetic plains by calculating the gypsum requirement


GypCal- A desktop based decision support system

in bags (50 kg), total depth of water required for leaching, expected yield of salt tolerant as well as traditional varieties of rice-wheat after chemical reclamation. It also estimates ESP of the sodic soil. The software calculates the gypsum requirement on the basis of the mathematical equations obtained through curve fitting.

In input parameter, the requirement is only soil $pH_2$, depth of soil to be leached and dimension of the field to be reclaimed. The output generated shall provide the gypsum quantity required in bags for heavy, medium and light textured soil. Also the output information includes the depth of water required for leaching soluble salts in cm and expected yield of crops (rice and wheat) both for salt tolerant as well as traditional cultivars. This software application will allow straight forward decision support for reclamation of sodic soil following standard protocols and optimize crop yields in Indo-Gangetic plains of North India.

## Soil quality and production efficiency of sodic soils

In order to find out the contribution of various soil and climatic indicator parameters towards production efficiency, influence intensity of these parameters in sodic soils of Indo-Gangetic plains was determined (Fig. 65). It was observed that soil ESP have greatest influence (17%) followed by organic carbon and pH both of which were having influence intensity to the tune of 15 per cent. Thereafter, influence intensity followed the trend as cation exchange capacity (12%) > EC (10%) > available N (8%). Cropping season rainfall, temperature and soil potassium content were having influence intensity of around 6 per cent. Least influence intensity was noticed in case of available phosphorus content of soil which was around 5 per cent.

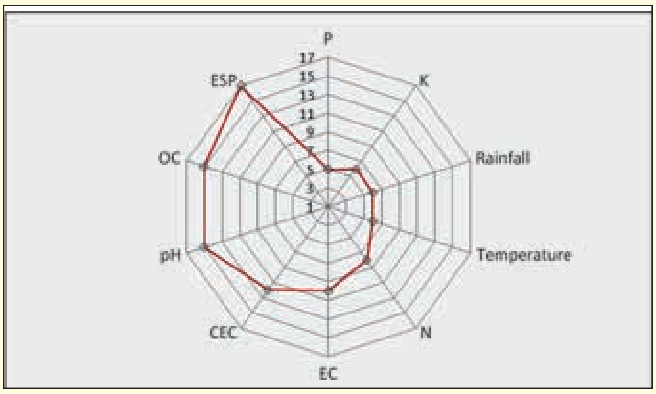



*Fig. 65 : Influence intensity (%) of indicator parameters on production efficiency*

Relative soil quality (RSQI) and production efficiency indices (RPEI) for soils having different levels of sodicity were worked out. It was observed that soil quality wise, strongly sodic soils were not suitable for both wheat (RPEI=39) and rice (RPEI=47). Relative soil quality index (RSQI) was 53 and RPEI was 56 in case of moderately sodic soils revealed that these soils were least suitable for wheat crop but these values for rice were 64 and 67, respectively indicating suitability of moderately sodic soils for rice crop. In case of slightly sodic soils, both RSQI as well as RPEI values for wheat was in class I, thus showing suitability of these soils for wheat crop. In these soils, RSQI value for rice was in class II (79) where as its RPEI value was in class I (80) reflecting its suitability for rice crop as influenced by the climatic parameters that are included to determine relative production efficiency index.

Average grain yield and corresponding RPEI values of salt tolerant and non salt tolerant (traditional) varieties of wheat and rice in soils having varying levels of sodicity are presented in Table 71. In strongly sodic soils, which were having RPEI value of 43, no yield in both salt tolerant and non tolerant varieties was observed. Where as in case of moderately sodic soils, having RPEI value of 56, an average yield of about 13 t $ha^{-1}$and 19 t

**Table 71 : Relative production efficiency index and average yield of salt and non salt tolerant varieties of wheat and rice in sodic soils**

| Soils | Wheat | | | Rice | | |
|---|---|---|---|---|---|---|
| | $RPEI_w$ | Yield (traditional) (t ha$^{-1}$) | Yield (salt tolerant) (t ha$^{-1}$) | $RPEI_w$ | Yield ) (traditional) (t ha$^{-1}$) | Yield (salt tolerant) (t ha$^{-1}$) |
| Strongly Sodic | 43 | - | - | 51 | 1.2 | 2.6 |
| Moderately sodic | 56 | 1.3 | 1.9 | 67 | 3.6 | 4.3 |
| Slightly Sodic | 86 | 2.4 | 3.2 | 80 | 4.5 | 5.7 |

ha$^{-1}$ in non salt tolerant and tolerant variety was observed. In slightly sodic soils, having RPEI 86 and suitability class I, salt tolerant variety having average yield of around 32 t ha$^{-1}$ which was about 8 t ha$^{-1}$ higher than the non salt tolerant traditional variety of wheat. In case of rice, average grain yield of 12 t ha$^{-1}$ for non tolerant and 26 t ha$^{-1}$ for salt tolerant varieties was observed in strongly sodic soils which were having RPEI value of 51 and was in least suitable class. In moderate sodic soils, which were in class III (slightly suitable) observed that non salt and salt tolerant rice varieties yielded 3.6 and 4.3 t ha$^{-1}$, respectively. In slightly sodic soils, which were having RPEI value of 80 and in class I, grain yield of 4.5 and 5.7 t ha$^{-1}$ in case of non salt tolerant and tolerant rice varieties were observed. Salt tolerant varieties in all the cases were superior in comparison to non tolerant varieties in sodic soils of Indo-Gangetic plains.

A linear and positive relationship amongst RPEI and yield was observed in wheat as well as rice (Fig. 66). It was observed that salt tolerant varieties have more crop yields than non-salt tolerant varieties. The extent of increase with every one unit increase in RPEI was more in salt tolerant (0.41 t ha$^{-1}$) than non-tolerant varieties (0.35 t ha$^{-1}$) in case of wheat. Similarly, in case of rice higher yield at various RPEI values was observed in salt tolerant than non tolerant varieties but the extent of increase with per unit increase in RPEI was more in non-salt tolerant (1.13 t ha$^{-1}$) than the salt tolerant (1.00 t ha$^{-1}$) varieties.

Variation in relative production efficiency based suitability class in soils having different levels of sodicity was also worked out for both wheat and rice (Fig. 67). It was observed that in strongly sodic soils RPEI values of salt tolerant and non

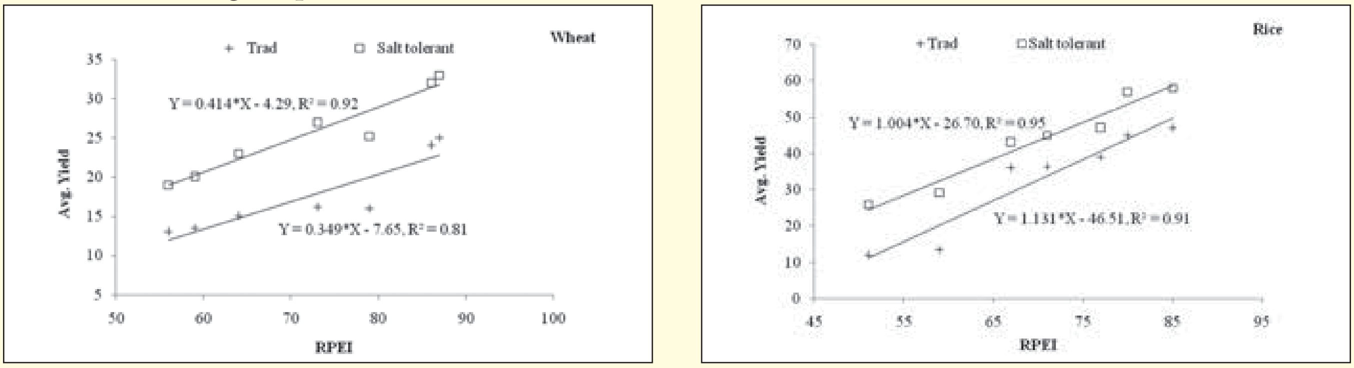
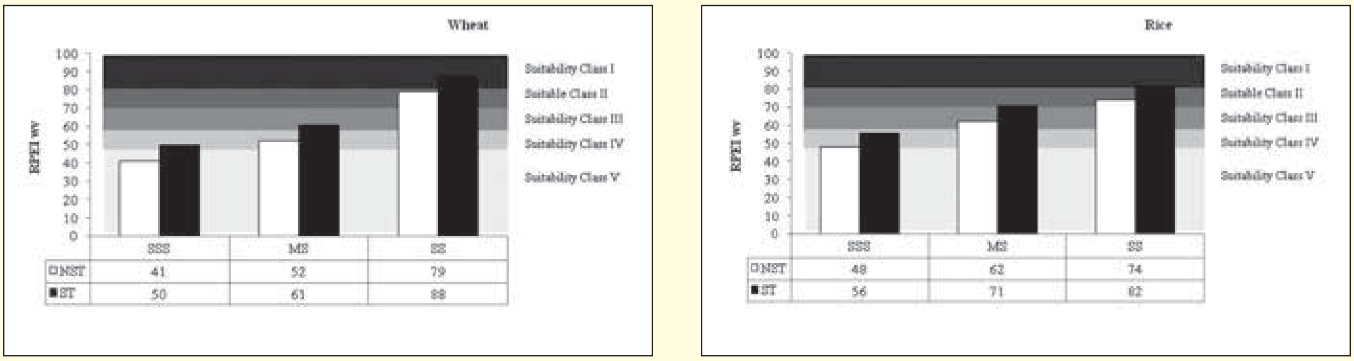



*Fig 66 : Relationship between relative production efficiency index and yield of wheat and rice in sodic soils of UP*




*RPEIwv: Varietal parameter also included in relative production efficiency evaluation*

*Fig. 67 : Production efficiency variation in sodic soils of UP*

tolerant wheat varieties were in suitability class IV and V, respectively. Similarly, in moderately sodic soils these were in suitability class of III and IV, respectively. It was further observed that in slightly sodic soils, the RPEI values of salt tolerant varieties was in class I i.e. most suitable for wheat but RPEI value for non-salt tolerant variety was in class II. In case of rice also the RPEI values showed a difference of one suitability class between salt and non salt tolerant varieties. In strongly sodic soils, the RPEI values of salt tolerant varieties were in class III where as these values were in class IV for non-salt tolerant varieties. In moderately and slightly sodic soils, the RPEI values for salt tolerant varieties were in class II and I, respectively where as these values for non salt tolerant varieties were in class III and II, respectively.

### Bioremediation of Salt Affected Soils of Uttar Pradesh through Halophilic Microbes to Promote Organic Farming (Sanjay Arora and Y.P. Singh)

Surface soil samples were collected from agricultural fields from sodic areas of Hardoi, Sandila, Shivri and Samesi for isolation of halophilic bacterial and fungal isolates. Isolated 22 bacterial and 4 fungal isolates which were having salt tolerance of more than 15 per cent NaCl from sodic soils of Indo-Gangetic plains.

The isolates were tested for tolerance to different combination of salts as well as pH and temperature. Plant growth promotion traits and bio-chemical characterization of the isolates is also initiated to screen the potential halophiles for remediation of sodic soils (Table 72). It was found that out of the 22 halophilic bacterial isolates, two were having potential plant growth promoting traits.

These isolates were tested for plant growth promotion in sodic soil (pH 9.9) in pot experiment. It was observed that the combination of two compatible halophilic plant growth promoting bacteria when applied to paddy seed along with vermicompost, increased plant height, grain yield, and straw yield by 8.43, 22.3 and 25.5 per cent, respectively in sodic soil (Table 73).

*Pot experiment with bio-inoculation in paddy*

**Table 72: Bio-chemical tests for halophilic bacterial isolates**

| Bio-chemical Test | Halophilic bacterial isolates | | | |
|---|---|---|---|---|
| | H-3 | H-4 | H-9 | H-10 |
| Malonase | -ve | -ve | -ve | -ve |
| Voges-Prousker | -ve | -ve | -ve | -ve |
| Citrate utilization | -ve | -ve | -ve | -ve |
| ONPG | +ve | -ve | +ve | +ve |
| Nitrate reduction | -ve | -ve | -ve | +ve |
| Catalase | -ve | -ve | -ve | -ve |
| Arginine | +ve | +ve | +ve | +ve |
| Sucrose | +ve | -ve | +ve | +ve |
| Mannitol | +ve | -ve | +ve | +ve |
| Glucose | +ve | -ve | +ve | +ve |
| Arabinose | -ve | -ve | -ve | -ve |
| Trehalose | +ve | -ve | +ve | +ve |

**Table 73 : Effect of bio-inoculation of halophilic PGP bacteria on paddy**

| Treatment | Plant height (cm) | Grain yield (g/ plant) | Straw yield (g/plant) |
|---|---|---|---|
| K $T_1$ (Control) | 67.12 | 1.95 | 3.64 |
| K $T_2$ (VC) | 76.24 | 2.42 | 4.08 |
| K $T_3$ (VC+HB1) | 82.07 | 2.85 | 4.74 |
| K $T_4$ (VC+HB2) | 83.45 | 2.68 | 4.85 |
| K $T_5$ (VC+HB1+HB2) | 82.67 | 2.96 | 5.12 |

**Table 74 : Effect of bio-inoculation of halophilic PGP bacteria on wheat**

| Treatment | Plant height (cm) | Root length (cm) | Number of tillers | Ear length (cm) |
|---|---|---|---|---|
| $T_1$- Control (NPK) | 68.5 | 7.00 | 2 | 12.5 |
| $T_2$- NPK+FYM | 74.2 | 8.25 | 3 | 13.0 |
| $T_3$- NPK+ FYM+HB1 | 78.5 | 8.75 | 3 | 14.0 |
| $T_4$- NPK+ FYM+HB2 | 80.5 | 9.75 | 4 | 14.5 |
| $T_5$- NPK+FYM+ HB1+HB2 | 80.5 | 10.5 | 4 | 14.0 |

The potential isolates are being tested in the field with wheat as test crop. The Field experiment was initiated at Shivri farm to ascertain the effect of plant growth promoting (PGP) halophilic microbes on wheat in sodic soils. The observations recorded for plant growth at 60 DAS are presented in Table 74. It was observed that liquid media formulation of two halophilic PGP bacteria showed increase of 8.5 per cent in plant height and 27.3 per cent in root length of wheat.

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

Performance of different irrigation methods namely Surface, Sprinkler and LEWA observed at different scheduling in rice and wheat under partially reclaimed sodic soil to evolve appropriate irrigation scheduling plans to water and energy saving was undertaken. The different irrigation schedules followed incase of surface method in rice were 2, 3 & 4 DAD and incase of sprinkler and low energy water application (LEWA), the irrigation schedules were daily, at 1 day and 2 days interval (when there is no ponding in the field). Similarly, during wheat crop, the irrigation schedules incase of surface, sprinkler, and LEWA were 0.6, 0.8 and 1.0 IW/CPE ratio. The depth of irrigation in rice and wheat through surface method applied was 6.0 cm and 4.0 cm at each irrigation by LEWA and sprinkler.

#### *Rabi* (2013–14)

The irrigation scheduling in wheat crop was planned on the basis of IW/CPE ratios (1.0, 0.8 and 0.6) with irrigation depth of 6.0 cm incase of Surface and 4.0 cm in sprinkler and LEWA. The experiment initiated with wheat sowing on 22nd November 2013.

#### Rainfall during *rabi* season

The total rainfall received during wheat growing period was 72.6 mm from 13 rainfall events. Maximum rainfall of 32 mm was received on 17th Jan, 2014. The daily evaporation rate trend reflects that upto December the average evaporation rate was 1.55 mm per day, which declined below 1 mm per day during January. Further, the rate of pan evaporation increased. During February, the average evaporation rate was 1.62 mm, in March 3.84 mm and in April 6.81 mm per day.

#### Application of irrigation

It was observed that the maximum of three irrigations were applied through sprinkler and LEWA when irrigation was scheduled at IW/CPE ratio of 1.0 resulting in 12 cm depth followed by two irrigations (8 cm depth) incase of each Sprinkler and LEWA when scheduled at IW/CPE ratio of 0.8 and one irrigation (4 cm) when sprinkler and LEWA was scheduled at IW/CPE ratio of 0.6. In contrast under surface irrigatied plots maximum of two irrigations of 6 cm depth each was applied when irrigation was scheduled at IW/CPE ratio of 1.0 & 0.8 (12 cm of irrigation depth). In surface irrigated plots when irrigation was scheduled at IW/CPE ratio of 0.6 only one irrigation of 6 cm depth was applied.

#### Effect of treatments on wheat yield

The highest grain yield of wheat (2.9 t $ha^{-1}$) was observed when irrigation was applied through sprinkler at IW/CPE 0.8 followed by irrigation applied through sprinkler at IW/CPE 1.0 (2.8 t $ha^{-1}$) and LEWA at IW/CPE 0.8 (2.6 t $ha^{-1}$). Irrigation applied through surface method at IW/CPE 0.8 gave the wheat yield of 2.5 t $ha^{-1}$, whereas irrigation applied through surface at IW/CPE 0.6 gave 2.4 t $ha^{-1}$. LEWA method of irrigation at IW/CPE 0.6 gave 2.1 t $ha^{-1}$ whereas sprinkler irrigated plots at IW/CPE 0.6 gave 2.0 t $ha^{-1}$

#### Water and energy productivity

The benefits of irrigation schedules were reflected in terms of water and energy productivity (Fig-68). It is observed that under surface irrigated plots, the highest water and energy productivity recorded when irrigation was scheduled at IW/CPE ratio of 0.6 but considering the yield trend it is observed that nearly 5-10 per cent of yield was declined with respect to irrigation schedule of 1.0 & 0.8 amongst surface irrigated plots. Hence, under surface irrigation schedule at IW/CPE ratio of 1.0 considered to be best on account of higher yield, water and energy productivity of Rs. 21.67 per cubic metre of water used and Rs. 5.42 per unit cost of diesel used, respectively.

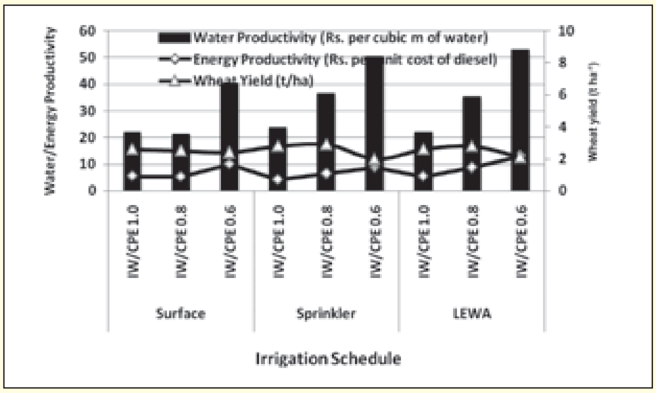



*Fig. 68: Water and Energy productivity and yield trend*

The best performing irrigation schedule under Sprinkler and LEWA was IW/CPE ratio of 0.8 resulting in water productivity in the range of Rs. 35-36 per cubic metre of water used and energy productivity in the range of Rs. 6-8 per unit cost of diesel used.

## *Kharif* (2014)

### *Rainfall during kharif*

The total rainfall recorded during rice growing season was 455.4 mm in 39 rainy days. Maximum rainfall (47.2 mm) was received on 14th October. 2014. This year rainfall was comparatively low than the previous year.

### *Effect of treatments on rice yield*

The maximum yield of rice (4.9 t $ha^{-1}$) was recorded under surface irrigation method when irrigation was scheduled at 2 DAD followed by irrigation applied through sprinkler at 2 days interval (4.7 t $ha^{-1}$). Irrigations applied at 1-day & 2-day interval through LEWA and at 1-day interval through sprinkler gave 4.6 t $ha^{-1}$ grain yield of rice. Surface irrigation scheduled at 3 DAD gave 4.3 t $ha^{-1}$ and LEWA irrigation scheduled at daily produced 4.1 t $ha^{-1}$ grain yield of rice. It was observed from the data that surface method of irrigation scheduled at 2 DAD gave the highest grain yield of rice whereas, under sprinkler and LEWA irrigation method scheduled at 2 days interval resulted in highest yield.

### *Application of irrigation*

It was observed that 18 irrigations (at 2 DAD), 15 irrigations (at 3 DAD) and 10 irrigations (at 4 DAD) of 6 cm depth was applied through surface irrigation method and 45 irrigations (daily), 27 irrigations (at one day interval) and 16 irrigations (at two days interval) of 4 cm depth each was applied through sprinkler and LEWA in rice. Total irrigation depth applied under surface method were 108, 90 and 60 cm when irrigation was scheduled at 2, 3 and 4 DAD, respectively. Under sprinkler and LEWA method, depth of irrigation applied was 180, 108 and 64 cm when irrigation was scheduled at daily, 1day and 2 days interval,

*Irrigation through sprinkler in rice*

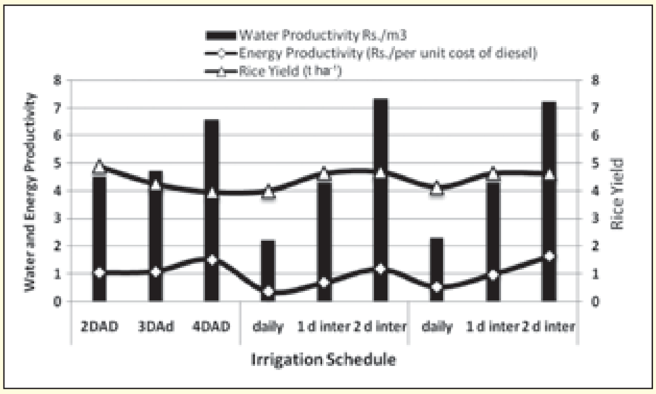



*Fig. 69: Water and energy productivity and yield trends*

respectively. This indicates that depth of irrigation increased at shorter irrigation interval leading to higher consumption of pumping energy.

### *Water and energy productivity*

Based on the volume of water applied, fuel consumed and yield obtained under various treatments, the water and energy productivity was estimated and depiced through Fig. 69.

It was observed that application of irrigation at 2 days interval through sprinkler and LEWA resulted in highest water productivity in the range of Rs. 7.3 per cubic m of water applied, whereas, irrigation schedule at daily and 1 day interval under sprinkler and LEWA resulted in low water productivity ranging between Rs. 2.2 to 4.2 per cubic m of water applied. Amongst surface irrigated plots, the highest water productivity of Rs. 6.58 per cubic m of water applied was achieved when irrigation was scheduled at 4 DAD, but considering the yield trends it was observed that there is sharp decline of yield in the range of 15 to 20 per cent under 4 DAD with respect to 2 and 3 DAD. The productivity under 2 and 3 DAD was Rs. 4.51 and Rs. 4.72 per cubic m of water applied. Similar trends incase of energy productivity was also observed.

## **Assessment and Refinement of Existing Irrigation Practices of Major Crops Grown under Sodic Environment** (Atul Kumar Singh, C.L. Verma, Y. P. Singh, Sanjay Arora)

Keeping in view the efficient water management practices, the project aims to apply low depth of irrigation in partially reclaimed sodic soils at varying interval than normal soils to save irrigation water and pumping energy to facilitate favourable soil moisture regime to achieve optimum production of rice (CSR 36) in *kharif* and wheat (KRL 210) and sugar beet (LS 6) in *rabi* with surface irrigation method with different irrigation schedules. During *kharif* season, two depths of irrigation i.e. 5 cm and 7 cm was applied at 2, 3 & 5 days after disappearance of water and when soil moisture tension reached at 7.5 kPa and 10 kPa and control where 7.5 cm of water was applied when cracking in top layer starts. During *rabi* season, wheat and sugarbeet were taken. Two irrigation depth of 3 and 5 cm was applied at 30, 50 and 70% depletion of soil moisture from field capacity and at IW/CPE ratio of 0.8 and 1.0 and control where irrigation was applied at different crop stages of wheat.

## Application of irrigation in *kharif* season

The number and depth of irrigation water was applied in rice is shown in Fig. 70.

It was observed that maximum 10 irrigations were applied in control amounting to a total irrigation depth of 75 cm.

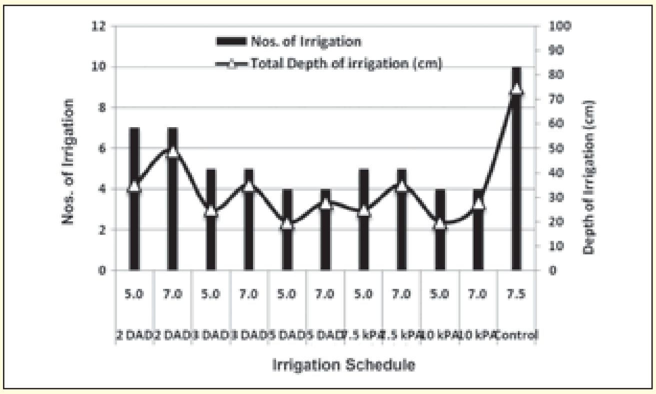



*Fig . 70: Number and depth of irrigation practiced in rice*

## Effect of irrigation schedules on rice yield

The yield obtained at various irrigation schedules are presented in Table-75.

**Table 75: Yield of rice under varying irrigation schedule**

| Irrigation depth (cm) | Irrigation schedule | Grain yield ($t\ ha^{-1}$) |
|---|---|---|
| 5 | 2 DAD | 5.5 |
| 7 | 2 DAD | 5.8 |
| 5 | 3 DAD | 5.4 |
| 7 | 3 DAD | 5.5 |
| 5 | 5 DAD | 5.6 |
| 7 | 5 DAD | 5.1 |
| 5 | 7.5 kPa | 4.9 |
| 7 | 7.5 kPa | 4.6 |
| 5 | 10 kPa | 4.8 |
| 7 | 10 kPa | 5.4 |
| 7.5 | Control | 5.1 |

*Tensiometer form*

The highest grain yield of 5.8 t $ha^{-1}$ was obtained when 7 cm of irrigation water was applied at 2 DAD followed by 5.6 t $ha^{-1}$ when 5 cm irrigation water at 5 DAD, 5.5 t $ha^{-1}$ when 7 cm irrigation water at 3 DAD and 5 cm irrigation water was applied at 2 DAD.

## Water and energy productivity

The benefits of irrigation schedules are reflected in terms of water and energy productivity and depicted in Fig. 71. It was observed that highest water productivity of Rs. 28.17 per cubic meter of water recorded when irrigation was scheduled by applying of 5 cm depth at 5 DAD, it also resulted in highest energy productivity of Rs. 5.91 per unit cost of diesel. The highest grain yield of rice (5.8 t $ha^{-1}$) was recorded when irrigation was scheduled by applying 7 cm of water at 2 DAD followed by 5.63 t $ha^{-1}$ when irrigation was scheduled by applying 5 cm depth at 5 DAD. This indicates that irrirrigation schedule of 5 cm of water at 5 DAD may facilitate substantial saving of water as well as pumping energy over other schedules without any major loss in yield under sodic environment.

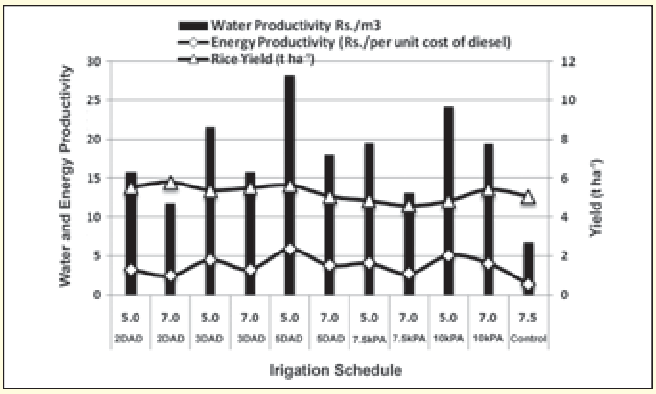



*Fig. 71: Water and Energy productivity and yield of rice*

# RECLAMATION AND MANAGEMENT OF SALT AFFECTED VERTISOLS

## Breeding and Evaluation of Field Crops for Salt Tolerance in Saline Vertisols (G. Gururaja Rao and D.K. Sharma)

Major crops of the region are cotton, wheat and maize in the inland and coastal saline tracks. Earlier studies indicated that cotton species, *herbaceums* and *arboreums* performed better under saline conditions over *hirsutums* and Bt cotton. The 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 the farmers to obtain good economic returns. During *rabi* season, saline water irrigation has proved beneficial for certain wheat accessions. Wheat varieties like KRL 210, KRL 19, KRL 238 and KRL 99 yielded 3.7-3.9 t $ha^{-1}$ with saline water irrigations (9.4 dS $m^{-1}$). Due to lack of assured canal water irrigation, the saline ground water can effectively be used for wheat production in Bara tract either as such or in conjunctive mode. Keeping this in view, experiments were continued to identify salt tolerant lines of field crops like cotton (*G. herbaceum* and *G. arboreum*) in *kharif* and, wheat and maize in *rabi* season. Additional objectives were: to study the mechanism and physiological basis of salt tolerance on identified lines as well as to assess their utility in breeding programme and to develop new breeding populations through hybridization and subsequent generation advancement for saline Vertisols.

### Cotton

Experiments with cotton were conducted in microplots with two *herbaceum* (G Cot 23 and G Cot 25) and two *arboreum* (GBav 109 and GBav 120) lines with saline water irrigations (4, 8 and 12 dS $m^{-1}$) and use of tube well water as control. A total of 50 new germplasm lines of desi cotton (*Gossypium arboreum* and *Gossypium herbaceum*) were collected and evaluated for salinity tolerance. Ten breeding populations of *Gossypium herbaceum* were advanced to $F_4$ generation for varietal development. Apart from this, 16 new crosses of *Gossypium arboreum* were developed and advanced to $F_2$ generation. In addition, Line X Tester programme was taken at Samni farm to study genetics of salt tolerance as well as to develop superior salt tolerant hybrids.

*Performance of desi cotton*

In another study, two lines each of *herbaceum* (G. Cot 23 and G Cot 25) and *arboreum* (GBav 109 and GBav 120) were sown in microplots and irrigated with saline water having $EC_{1:2}$ : BAW, 4, 8 and 12 dS $m^{-1}$ and the plant samples were analysed for biochemical constituents. Data indicated that higher Na/K ratio in roots followed by shoots and leaves suggested the role of roots as potential sinks for Na in these lines. Of all the accessions, G Cot 23 *herbaceum* and GBav 109 *arboreum* maintained low Na/K ratio. Similarly, G Cot 23 showed higher proline, sugar and chlorophyll content (Tables 76 & 77) indicating its superiority over other lines. Negative correlation (Fig. 72) was also seen between sodium ion content and leaf chlorophyll. The decline, however, was not so sharp with increase in salinity.

**Table 76 : Proline content in cotton under saline water irrigation**

| Proline (µg/g dw) | | | | | |
|---|---|---|---|---|---|
| **Variety** | | | | | |
| $V_1$-GCot23 | 538.36 | $V_1T_1$ | 423.93 | $V_1T_3$ | 612.40 |
| $V_2$-G Cot 25 | 461.94 | $V_2T_1$ | 316.20 | $V_2T_3$ | 405.95 |
| $V_3$-GBav109 | 421.56 | $V_3T_1$ | 397.00 | $V_3T_3$ | 450.85 |
| $V_4$-GBav120 | 471.03 | $V_4T_1$ | 405.98 | $V_4T_3$ | 414.95 |
| **Irrigation water** | | | | | |
| $T_1$-BAW | 385.79 | $V_1T_2$ | 504.70 | $V_1T_4$ | 612.40 |
| $T_2$-4 EC. | 509.16 | $V_2T_2$ | 603.40 | $V_2T_4$ | 522.20 |
| $T_3$-8 EC. | 471.04 | $V_3T_2$ | 379.00 | $V_3T_4$ | 459.40 |
| $T_4$-12 EC. | 526.91 | $V_4T_2$ | 549.55 | $V_4T_4$ | 513.60 |

**Table 77 : Chlorophyll content in cotton under saline water irrigation**

| Total Chlorophyll in leaf (mg/g fw) | | | | | |
|---|---|---|---|---|---|
| **Variety** | | | | | |
| $V_1$-GCot23 | 1.471 | $V_1T_1$ | 1.588 | $V_1T_3$ | 1.633 |
| $V_2$-G Cot 25 | 0.979 | $V_2T_1$ | 0.975 | $V_2T_3$ | 0.890 |
| $V_3$-GBav109 | 1.067 | $V_3T_1$ | 0.950 | $V_3T_3$ | 1.330 |
| $V_4$-GBav120 | 1.080 | $V_4T_1$ | 1.135 | $V_4T_3$ | 0.973 |
| **Irrigation water** | | | | | |
| $T_1$-BAW | 1.162 | $V_1T_2$ | 1.173 | $V_1T_4$ | 1.490 |
| $T_2$-4 EC | 1.135 | $V_2T_2$ | 0.980 | $V_2T_4$ | 1.070 |
| $T_3$-8 EC | 1.206 | $V_3T_2$ | 1.023 | $V_3T_4$ | 0.965 |
| $T_4$-12 EC | 1.093 | $V_4T_2$ | 1.365 | $V_4T_4$ | 0.848 |

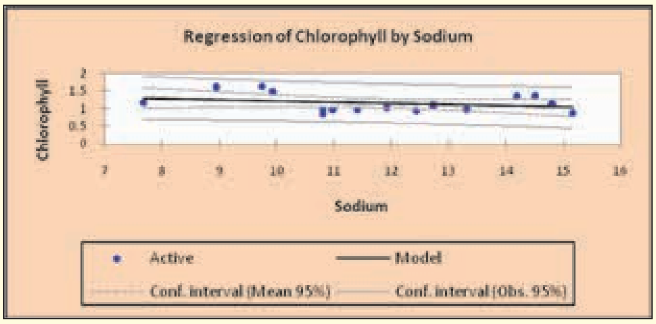



*Fig 72 : Correlation between Na content and leaf chlorophyll*

The studies indicated that

- Cotton variety G Cot 23 is superior in terms of salt tolerance and agronomic performance.
- Two years pooled microplot data indicated that salt tolerance of cotton varieties decreased in the order : G Cot 23>G Cot 25>G Bav 109> G Bav 120.
- Lower Na/K ratio in leaves, higher compatible solute content in leaves and maintenance of chlorophyll despite higher sodium concentration are the important attributes conferring salt tolerance.
- Chlorophyll content in leaf was negatively correlated with sodium ion content in less tolerant genotypes.

## Trials on cotton genotypes at Samni Farm ($EC_e$ 7.2 to 9.8 dS $m^{-1}$)

Out of total 52 entries (Table 78) of three species (*herabaceum, arboreum* and *hirsutum)* tested at Samni Farm, 11 entries better than check were selected based on agronomic performance. These entries are being utilized in making new crosses. Superior entries were planted in 2014-15 in larger plots for biochemical and physiological evaluation. Among three species, *Herbaceum* was found to be more suitable under saline water irrigation.

## Development of breeding populations/ generation advancement

Ten breeding populations of *Gossypium herbaceum* were advanced to $F_4$ generation for varietal

**Table 78 : Cotton genotypes used for screening studies**

| Herbaceum | | | | Arboreum | | Hirsutum | |
|---|---|---|---|---|---|---|---|
| Entry | Genotype | Entry | Genotype | Entry | Genotype | Entry | Genotype |
| 1 | IC 371100 | 15 | GShv 273107 | 1 | CNA 342 | 1 | CNH 14 |
| 2 | IC 371106 | 16 | GShv 274109 | 2 | CNA 343 | 2 | CNH 16 |
| 3 | IC 371127 | 17 | GShv 285107 | 3 | CNA 347 | 3 | CNH 15 |
| 4 | IC 371117 | 18 | GShv 233109 | 4 | CNA 375 | 4 | CNH 19 |
| 5 | IC 371109 | 19 | GShv 451108 | 5 | CNA 398 | 5 | DTS132 |
| 6 | IC 371119 | 20 | GShv 524108 | 6 | GBav 107 | 6 | DTS301 |
| 7 | IC 371108 | 21 | GCot 23 | 7 | GBav 109 | 7 | DTS121 |
| 8 | IC 371118 | 22 | GCot25 | 8 | GBav 111 | 8 | DTS95 |
| 9 | IC 371126 | 23 | RAHS 14 | 9 | GBav 120 | 9 | DTS123 |
| 10 | IC 371099 | 24 | Gheti | 10 | GBav 124 | 10 | 29-1 |
| 11 | GBhv 276 | 25 | GBhv 283 | 11 | GBav 131 | | |
| 12 | GBhv 287 | 26 | GBhv 287 | 12 | GBav 133 | | |
| 13 | GBhv 289 | 27 | GShv 378/05 | 13 | GBav 135 | | |
| 14 | GBhv 290 | | | 14 | GBav 136 | | |
| | | | | 15 | GBav 137 | | |

development. Out of 10 populations, eight were selected for advancement in 2014-15 (Table 79).

**Table 79 : Crosses developed using herbaceum lines and status of the progeny**

| S.No. | Code | Pedigree | Status |
|---|---|---|---|
| 1 | CSB-1 | GBhv 291 x GShv 297/07 | Good |
| 2 | CSB-2 | GCot 23 x GShv 378/05 | Good |
| 3 | CSB-3 | GBhv 287 x GShv 451/08 | Good |
| 4 | CSB-4 | GBhv 287 x GBhv 291 | Poor, rejected |
| 5 | CSB-5 | GBhv 451/08 x GShv 290 | Good |
| 6 | CSB-6 | GBhv 378/05 x GShv 433/08 | Good |
| 7 | CSB-7 | GBhv 291 x GBhv 283 | Good |
| 8 | CSB-8 | GBhv 297/07 x GBhv 290 | Good |
| 9 | CSB-9 | GBhv 297/07 x GBhv 451/08 | Poor, rejected |
| 10 | CSB-10 | Gshv 297/07 x GShv 273/07 | Good |

Sixteen new crosses of *Gossypium arboreum* were developed and they have been advanced to $F_2$ generation. Line x Tester programme was taken to study genetics of salt tolerance as well as to develop superior salt tolerant hybrids. These advanced materials showed good variability for agronomic traits and salt tolerance related attributes.

## Maize

A trial with twenty maize hybrids and 26 varieties collected from DMR, New Delhi, AAU, Anand and Monsanto were conducted for screening. The crop was irrigated five times with saline water (ECiw=3.2 dS $m^{-1}$). Analysis of variance (Table 80) indicated high variability for key traits like total ion content, yield and biomass among genotypes.

Ten entries from both the trials were selected in *rabi* 2014-15. DKC 8101 was found to be the highest yielder and most salt tolerant hybrid after two years of evaluation. It was also observed that in maize, salinity at flowering stage greatly impacted chlorophyll content in leaves and thus yield. Parameters like plant height, biomass, proline and total ion content in leaves were highly correlated with yield.

*Performance of hybrid maize*

**Table 80 : Analysis of variance for different traits in maize**

| | Plant height (cm) | Flag leaf | Leaf fresh wt (g) | Leaf dry wt (g) | Chl before flowering (mg/g fw) | Chl after flowering (mg/g fw) | $Na^+$ (ppm) | $K^+$ (ppm) | $Cl^-$ (ppm) | Total ions (ppm) | K/Na ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean | 237.41 | 524.02 | 9.84 | 3.04 | 2.65 | 2.89 | 8.38 | 365.99 | 590.57 | 964.94 | 44.77 |
| S D | 19.12 | 103.83 | 2.8 0 | 0.75 | 0.39 | 0.59 | 1.5 | 42.66 | 117.61 | 139.77 | 8.14 |
| MS | 994.87 | 24303.74 | 20.34 | 14.31 | 0.15 | 0.56 | 2.99 | 3423.57 | 26724.73 | 38515.06 | 109.67 |
| CV | 3.98 | 8.87 | 15.28 | 10.64 | 14.08 | 16.53 | 16.67 | 9.14 | 14.32 | 11.07 | 16.16 |
| SEm | 7.71 | 37.95 | 1.23 | 0.26 | 0.31 | 0.39 | 1.14 | 27.31 | 69.07 | 87.25 | 5.91 |
| CD 5% | 27.43 | 134.99 | 4.37 | 0.94 | NS | NS | NS | 97.14 | 245.71 | 310.39 | NS |

| | Proline (µg/g) | Protein (µg/g) | Biomass (kg) | HI | Cob length (cm) | Sugar (µg/g) | Total solute (µg/g) | Plot yield (kg) | Cob diameter | Kernel row, (no.) | Test wt (g) | Shelling (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean | 10.22 | 1110.18 | 11.79 | 52.91 | 18.66 | 550.86 | 1671.25 | 13.48 | 151.19 | 14.37 | 38.7 | 78.84 |
| S D | 3.27 | 256.4 | 2.5 | 4.79 | 1.47 | 206.47 | 337.97 | 3.52 | 11.84 | 1.57 | 3.08 | 3.31 |
| MS | 16.93 | 59115.99 | 5.91 | 38.35 | 4.21 | 35764.81 | 56437.74 | 23.77 | 263.51 | 4.7 | 24.33 | 28.53 |
| CV | 27.7 | 20.68 | 23.24 | 6.94 | 5.21 | 40.36 | 22.22 | 19.85 | 6.33 | 8.93 | 5.52 | 2.31 |
| SEm | 2.31 | 187.45 | 2.24 | 3 | 0.79 | 181.53 | 303.24 | 2.19 | 7.82 | 1.05 | 1.43 | 1.49 |
| CD 5% | NS | NS | NS | 10.67 | 2.82 | NS | NS | 7.78 | 27.81 | 3.72 | 5.09 | 5.29 |

### Wheat

During *rabi* 2012, 84 wheat accessions were selected from Salinity/Alkalinity nursery (AICRP) and tested in augmented design at Bharuch. The crop was irrigated with saline water (EC 9.3 dS $m^{-1}$) coupled with sub-surface salinity prevailing in the field which provided ideal condition for selection of salt tolerant lines. Data revealed that 16 accessions were superior to national checks KRL 210 and KRL 213 in terms of yield and other agronomic traits. These 16 accessions were again tested in *rabi* 2013 in larger plots and plethora of agronomic as well as biochemical traits were studied to validate previous results and to explore mechanism of salt tolerance in superior accessions. Analysis of variance revealed that plant height and biomass were statistically significant characters. It was also found that these traits were positively and significantly correlated with the yield (r=0.60; 0.32). Genotypic variability was of higher proportion in total phynotypic variability for some important traits like biomass, K content and plant height which clearly indicated that these characters can be improved through selection. High heritability was found to be associated with $K^+$ ion content and plant height ($h^2$=0.48, 0.30). RWP 2012-17 was found to be highest yielder (5.1 t $ha^{-1}$) followed by Raj 4372 and LDP 2012-24. Five entries performed well over check KRL-210 (20-35% superiority). In superior accessions like RWP 2012-17, Raj 4372 and LDP 2012-24, K/Na ratio, a salt tolerance indicator, was found to be high (2.5-3.0).

*Performance of wheat variety KRL 210*

### Soil Physical Characteristics and Nutrient Dynamics in Vertisols with Sub-Surface Salinity (G. Gururaja Rao)

Under Sayakha branch (Head and middle portion) and outside canal command areas, eighteen sites were selected from Amod, Vagra and Jambusar talukas (Bara tract) of Bharuch district, Gujarat, of which 6 sites were studied during summer and their physico-chemical properties and soluble ions were correlated.

The correlation matrix of physico-chemical properties and soluble ions of soils of profiles (II, IV & V) showed positive correlation between $Cl^-$ and both $Ca^{2+}$ and $Mg^{2+}$ (except profile V). The profile II (Head region, Sayakha branch) soils showed a highly positive correlation between electrical conductivity with soluble $Na^+$ and $Cl^-$ ions, while negative correlation between $CO_3^-$+$HCO_3^-$ with $Ca^{2+}$. In the profile IV (Middle portion of Sayakha branch), $CO_3^-$+$HCO_3^-$ showed a positive correlation with $Ca^{2+}$. Electrical conductivity was positively correlated with most dominant ions except SOC and $CaCO_3$. In the profile V (Outside canal command), electrical conductivity was positively correlated with most dominant ions except SOC and $Mg^{2+}$ .

In irrigated head region, water retained at field capacity (FC) ranged from 38.0- 43.6 per cent and permanent wilting point (PWP) ranged from 24.1 to 27.2 per cent at different depths. Depth-wise water retention increased with soil depth (up to 90 cm) at FC and PWP points. The available water ranged from 13.9-17.4 per cent and increased with soil depth (Table 81).

The available water was also higher under irrigated command i.e. head and middle portion of soil profile as compared to outside canal command soil profile and its higher values were noticed in the deeper layers. In irrigated soil profile (middle portion), the available water ranged from 14.3-18.7 per cent (Table 82) while outside canal command soil profile, these values ranged from 11.9-16.3 per cent. In irrigated condition, available water content was higher in middle as compared to head portion and increased with depth due to higher clay content present in deeper layers (Fig. 73).

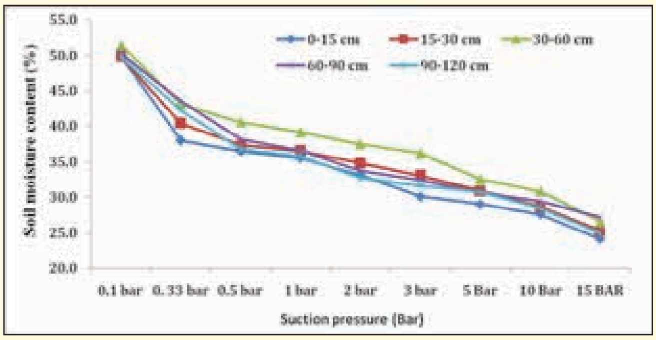



*Fig. 73 : Water retention curve of irrigated head portion*

**Table 81 : Water retained at different suction pressure (Bar) in irrigated head (canal) portion of soil profile (I+II)**

| Soil depth (cm) | Water retained (%) at different suction pressure (Bar) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.1 bar | 0. 33 bar | 0.5 bar | 1 bar | 2 bar | 3 bar | 5 bar | 10 bar | 15 bar | AW |
| 0-15 | 49.8 | 38.0 | 36.5 | 35.5 | 33.1 | 30.1 | 29.0 | 27.6 | 24.1 | 13.9 |
| 15-30 | 49.8 | 40.4 | 37.4 | 36.5 | 34.8 | 33.1 | 30.9 | 28.6 | 25.3 | 15.1 |
| 30-60 | 51.4 | 43.2 | 40.6 | 39.2 | 37.5 | 36.2 | 32.5 | 30.9 | 26.6 | 16.6 |
| 60-90 | 50.3 | 43.6 | 38.2 | 36.6 | 33.8 | 32.4 | 30.7 | 29.5 | 27.2 | 16.4 |
| 90-120 | 49.8 | 42.3 | 36.8 | 35.8 | 32.7 | 31.7 | 30.7 | 28.5 | 24.9 | 17.4 |

**Table 82 : Water retained at different suction pressure (Bar) in irrigated middle (canal) portion of soil profile (III+IV)**

| Soil depth (cm) | Water retained (%) at different suction pressure (Bar) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.1 bar | 0. 33 bar | 0.5 bar | 1 bar | 2 bar | 3 bar | 5 bar | 10 bar | 15 bar | AW |
| 0-15 | 51.1 | 40.3 | 35.6 | 34.6 | 33.5 | 32.2 | 29.2 | 28.3 | 26.0 | 14.3 |
| 15-30 | 52.3 | 43.4 | 38.6 | 35.8 | 35.0 | 33.0 | 31.7 | 30.3 | 26.6 | 16.8 |
| 30-60 | 53.1 | 41.2 | 38.0 | 34.9 | 34.2 | 31.7 | 29.5 | 27.8 | 24.7 | 16.5 |
| 60-90 | 54.0 | 44.0 | 39.7 | 38.8 | 36.3 | 34.3 | 32.3 | 29.8 | 26.8 | 17.2 |
| 90-120 | 53.0 | 45.5 | 41.3 | 40.6 | 38.1 | 36.4 | 34.2 | 30.3 | 26.8 | 18.7 |

Water retention decreased with increasing suction in irrigated (-head & -middle) canal command and outside canal command areas (Table 83). In these sites, water retention was higher in the irrigated middle portion. From soil water retention curve (Fig. 74), moisture content was found higher below 30 cm soil layer ($EC_e$ 1.28 dS $m^{-1}$) as compared to surface 30 cm soil layer (ECe 0.43 dS $m^{-1}$) for irrigated canal command (head portion). In middle portion of irrigated commands same results were found but its magnitude was higher than head portion. Soil moisture content was observed higher below 30 cm soil layer (ECe 3.22 dS $m^{-1}$) as compared to surface 30 cm soil layer (ECe 0.65 dS $m^{-1}$) for middle portion (Fig. 75).

**Table 83 : Soil water retained at 0-30 cm and below 30 cm soil layers with electrical conductivity (dS $m^{-1}$) in head and middle portions of canal command and outside command**

| Soil layer (cm) | Water retained (%) at different suction pressure (Bar) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.1 bar | 0. 33 bar | 0.5 bar | 1 bar | 2 bar | 3 bar | 5 bar | 10 bar | 15 bar | AW |
| **Irrigated canal command (Head)** | | | | | | | | | | |
| 0-30 cm (ECe 0.43 dS $m^{-1}$) | 49.8 | 39.2 | 36.9 | 36.0 | 33.9 | 31.6 | 30.0 | 28.1 | 24.7 | 14.5 |
| Below 30 cm (ECe 1.28 dS $m^{-1}$) | 50.5 | 43.0 | 38.5 | 37.2 | 34.7 | 33.4 | 31.3 | 29.6 | 26.2 | 16.8 |
| **Irrigated canal command ( Middle)** | | | | | | | | | | |
| 0-30 cm (ECe 0.65 dS $m^{-1}$) | 51.7 | 41.8 | 37.1 | 35.2 | 34.2 | 32.6 | 30.5 | 29.3 | 26.3 | 15.6 |
| Below 30 cm (ECe 3.22 dS $m^{-1}$) | 53.4 | 43.6 | 39.7 | 38.1 | 36.2 | 34.1 | 32.0 | 29.3 | 26.1 | 17.5 |
| **Outside canal command** | | | | | | | | | | |
| 0-30 cm (ECe 6.98 dS $m^{-1}$) | 51.1 | 39.8 | 37.7 | 37.0 | 36.0 | 34.7 | 32.8 | 30.4 | 26.7 | 13.1 |
| Below 30 cm (ECe 2.98 dS $m^{-1}$) | 53.7 | 42.8 | 41.4 | 40.1 | 37.0 | 36.3 | 34.7 | 31.7 | 27.0 | 15.8 |

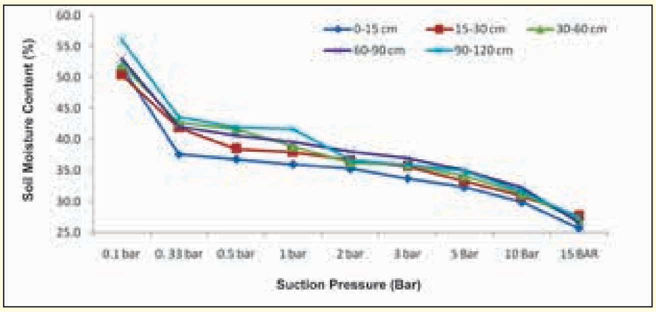



*Fig. 74 : Water retention curve of outside canal command soil profile*

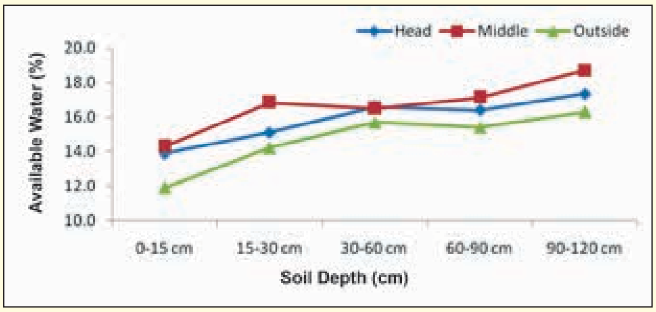
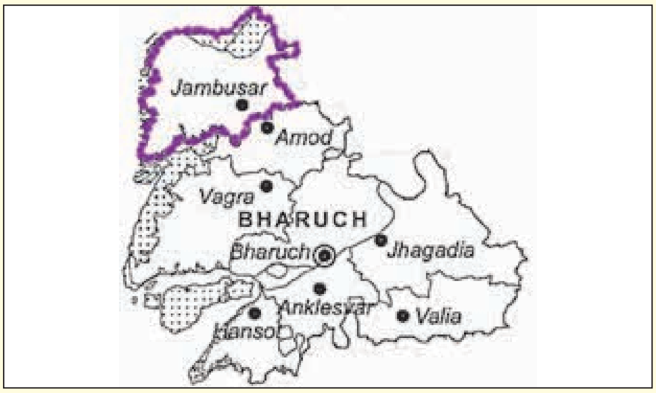



*Fig. 75 : Available water (%) in head, middle canal command and outside command profile at different depth*

## **Prospects of Cultivating Desi Cotton Genotypes and Salt Tolerant Wheat Varieties in Saline Vertisols** (Nikam Vinayak Ramesh, G. Gururaja Rao and D.K. Sharma)

This study was initiated with 15 wheat growing farmers of 9 villages of Jambusar taluka of Bharuch district from February, 2014. These farmers were growing salt tolerant varieties (STV). They were provided seeds of STV viz. KRL 210 and KRL 19. Jambusar taluka, in north of Bharuch has hot sub-tropical type of climate. Soil of the region is mixture of black cotton and sandy soil and area is characterized by presence of sub-surface salinity. Ground water is mostly saline, and most of the region is canal irrigated. Data pertaining to socio-economic, biophysical aspects, cost of cultivation, perception about salt tolerant varieties and constraints faced were collected by personally interviewing the farmers. Soil samples of the selected farmers were also collected to assess the salinity status.




**Map of Bharuch district showing Jambusar taluka**

### Soil salinity status of the selected area

The data given in Table 84 showed that salinity at surface was low and it increased with increasing

**Table 84 : Soil salinity status of the selected villages**

| Soil depth | Soil pH | Soil $EC_e$ (dS $m^{-1}$) |
|---|---|---|
| 0-15 | 8.54 | 1.28 |
| 15-30 | 8.78 | 1.70 |
| 30-60 | 8.91 | 2.66 |
| 60-90 | 8.93 | 4.15 |

**Table 85 : Economic analysis of STV cultivation**

| | Particulars | Cost (Rs./ha) |
|---|---|---|
| **A. Cost A1** | | |
| | Value of hired human labour | 1169 |
| | Value of owned bullock labour | 656 |
| | Value of hired bullock | 73 |
| | Value of owned machinery | 313 |
| | Value of hired machinery | 5406 |
| | Value of seed | 560 |
| | Value of manure (owned and purchased) | 733 |
| | Value of fertilizers | 3663 |
| | Irrigation charges | 6604 |
| | Misc. expenses (artisans etc.) | 375 |
| | Depreciation of implements and machinery | 158 |
| | Interest on working capital | 222 |
| | Land revenue | 100 |
| | Total | 20032 |
| **B. Cost A2** | | |
| | (Cost A1 + rent paid for leased-in land) | 23491 |
| **C. Cost B** | | |
| | (Cost A2 + rental value of owned land (net of land revenue) & interest on owned fixed capital excluding land) | 33974 |
| **D. Cost C** | | |
| | (Cost B + imputed value of family labour) | 35537 |
| **E. Production** | | |
| | Yield of main produce (t $ha^{-1}$) | 3.13 |
| | Value (Rs.17500 per ton) | 54775 |
| F. | **B:C ratio** | 1.54 |

soil depth. Average $EC_e$ at 60-90 cm layer was 4.15, indicating presence of sub surface salinity in the region. In case of soil pH, same trend was observed. At depth 60-90 cm, pH level was 8.93, indicating presence of sodicity in sub-surface soils in the region.

## Economic analysis of STV cultivation

Data on cost of cultivation were collected using recall method. Economic analysis of the same is given in Table 85. It was observed that cost A involving various operational costs was Rs.20032/ha for the farmers growing salt tolerant varieties. Salt tolerant variety (STV) required less number of irrigation than other varieties and therefore farmers growing STV could save cost of 1-2 irrigations. Cost B, involving rental value of owned land and interest on fixed capital, was Rs.33974/ha, while cost C, covering imputed value of family labour, was Rs. 35537/ha.

At farmers' field, salt tolerant wheat varieties gave an average yield of 3.13 t $ha^{-1}$. Farmers could earn gross income of Rs. 54775 per hectare and net income of Rs. 19238 per hectare. B:C ratio for salt tolerant varieties was 1.54.

**Table 86 : Perception of the farmers about salt tolerant varieties**

| Particulars | Disagree* | Neutral* | Agree* | Strongly Agree* |
|---|---|---|---|---|
| **Economic benefit** | | | | |
| Increase in grain yield | 0.00 | 8.33 | 50.00 | 41.67 |
| Increase in straw yield | 0.00 | 16.67 | 41.67 | 41.67 |
| Reduction in cost of cultivation | 8.33 | 41.67 | 25.00 | 25.00 |
| Increase in income | 8.33 | 25.00 | 41.67 | 25.00 |
| **Social benefits** | | | | |
| Increase in standard of living | 16.67 | 16.67 | 50.00 | 16.67 |
| Increase in social participation | 25.00 | 41.67 | 25.00 | 0.00 |
| Food security of the household | 8.33 | 16.67 | 41.67 | 33.33 |
| Upliftment of small and marginal farmers | 25.00 | 33.33 | 25.00 | 0.00 |
| **Agronomic practices** | | | | |
| Reduced use of fertilizers | 16.67 | 58.33 | 25.00 | 0.00 |
| Reduction in weed infestation | 0.00 | 100.00 | 0.00 | 0.00 |
| Reduction in number of irrigations | 0.00 | 25.00 | 58.33 | 16.67 |
| Reduction in no of labour days | 16.67 | 25.00 | 50.00 | 8.33 |
| **Crop characteristics** | | | | |
| More number of tillers | 0.00 | 16.67 | 33.33 | 50.00 |
| Less lodging | 8.33 | 25.00 | 50.00 | 16.67 |
| Less grain shattering | 16.67 | 25.00 | 33.33 | 25.00 |
| Decrease in incidence of pests and diseases | 16.67 | 41.67 | 41.67 | 0.00 |
| Early maturity | 0.00 | 66.67 | 16.67 | 16.67 |
| **Environmental benefit and improvement in quality of output** | | | | |
| Improvement of soil texture | 16.67 | 75.00 | 8.33 | 0.00 |
| Compatibility to changing climate | 0.00 | 41.67 | 50.00 | 8.33 |
| Grain quality | 0.00 | 8.33 | 50.00 | 41.67 |
| Straw quality | 16.67 | 33.33 | 25.00 | 25.00 |
| Complementary enterprise/ resource use | 8.33 | 66.67 | 16.67 | 8.33 |
| Eco-friendliness | 8.33 | 50.00 | 25.00 | 16.67 |

* figures show percentage of farmers response for given statement



*Perception of the farmers about salt tolerant varieties*

**Table 87 : Constraints faced by STV growing farmers**

| Constraints | Least severe* | Not so severe* | Severe* | Quite severe* |
|---|---|---|---|---|
| **Production constraints** | | | | |
| Non-availability of seed of salt tolerant varieties | 8.3 | 58.3 | 16.7 | 16.7 |
| Lack of knowledge about salt tolerant varieties | 0.0 | 50.0 | 25.0 | 25.0 |
| Non availability of manures/fertilizer in time | 8.3 | 75.0 | 16.7 | 0.0 |
| Non availability of insecticides and pesticide in time | 8.3 | 58.3 | 33.3 | 0.0 |
| **Labour constraints** | | | | |
| Non-availability of labour during peak period | 0.00 | 8.33 | 25.00 | 33.33 |
| Lack of technical skill to the labour | 0.00 | 16.67 | 33.33 | 41.67 |
| High cost of labour | 0.00 | 16.67 | 16.67 | 25.00 |
| **Economic constraints** | | | | |
| High cost of plant protection chemicals | 8.33 | 33.33 | 41.67 | 16.67 |
| High cost of fertilizers | 0.00 | 16.67 | 25.00 | 41.67 |
| High cost of seed material | 16.67 | 41.67 | 33.33 | 8.33 |
| Unawareness of credit facilities | 25.00 | 41.67 | 25.00 | 8.33 |
| **Marketing constraints** | | | | |
| Problems of transportation | 33.33 | 50.00 | 16.67 | 0.00 |
| Heavy fluctuation in prices every year | 0.00 | 16.67 | 16.67 | 25.00 |
| No produce procurement policy of government | 0.00 | 16.67 | 41.67 | 33.33 |
| Lower price at the harvesting stage | 0.00 | 8.33 | 33.33 | 58.33 |
| Inadequate physical facilities in market | 16.67 | 50.00 | 25.00 | 8.33 |
| **General constraints** | | | | |
| More incidence of pest and disease | 0.00 | 25.00 | 66.67 | 8.33 |
| Irregular supply of electricity | 58.33 | 33.33 | 8.33 | 0.00 |
| Lack of mechanization | 16.67 | 50.00 | 25.00 | 8.33 |
| Fragmentation of land holdings | 0.00 | 33.33 | 25.00 | 33.33 |
| Lack of irrigation facilities | 0.00 | 41.67 | 25.00 | 25.00 |
| Lack of soil and water testing facilities | 0.00 | 33.33 | 50.00 | 16.67 |

* Figures show percentage of farmers' response for a given constraint

Majority of the farmers perceived benefits of STV in terms of increasing yield of grains and straw. Half of the respondents agreed (Table 86) that adoption of salt tolerant varieties increased their standard of living. About 58 per cent farmers perceived that STVs have low irrigation requirement. Regarding crop characteristics, most of the farmers perceived that STVs have less lodging and grain shattering problem. About 50 per cent of the farmers perceived that STVs were more compatible to the changing climate in the region.

### Constraints faced by STV growing farmers

While analyzing different population constraints (Table 87) faced by the farmers, it was noted that non availability of improved seeds and lack of knowledge were the major constraints in adoption of STVs. Among labour constraint, high cost of labour was reported as very severe by the farmers. High cost of fertilizer was rated quite severe constraint by majority of the farmers in economic constraints (41%). Among marketing constraints, heavy fluctuation in price every year was ranked highest by majority of the farmers (41.67%). Among general constraints, 33.33 per cent farmers ranked fragmentation of land holdings as quite severe.

## Impact on Use of Treated Effluent from Aniline –TDI Plant of GNFC Unit II in Forage and Biomass Species Grown on Black Cotton Soils (G. Gururaja Rao and D.K. Sharma)

With the ever-growing population associated with urbanization and industrialization, the demand for water for domestic use, industrial purposes, agriculture, power generation and other uses would keep increasing. Therefore, recycling of effluents in agriculture is viewed as a solution to conserve water resources to meet out the future water shortages. Use of effluents for non-food crops which do not affect the food chain, such as woody biomass species, aromatic grasses, trees, flowers crops and non-edible oil seed crops etc., do form some viable alternatives. Cultivation of green fodder with effluents for meeting the requirements of dairy sector is another important land use. Water is becoming a scarce commodity for irrigation especially when its present share of 85 per cent of available water resources is likely to get reduced to 68 per cent by 2050. Consumptive use of effluents more effectively for biomass/ crop production thus provides an opportunity to conserve limited fresh water resources for other human needs.

The Aniline-TDI Complex (Unit-2 of GNFC Limited) located at Bharuch primarily deals with the manufacturing of Toluene disocyanate and Aniline. This has established a well developed effluent treatment plant which produces about 500 $M^3$ of treated effluent from their Aniline plant. The analytical report of the treated effluent indicated that the effluents produced are less toxic as their chemical constituents are within acceptable limits. The field trials were initiated to assess the suitability of the treated effluents for cultivation of different crops such as fodder maize and fodder sorghum, and woody biomass species like *Pongamia*, *Terminelia arjuna* and *Eucalyptus* with the objectives., (a) to study the effect of treated effluent application on soil physical and chemical properties; (b) to study the impact of the treated effluents on growth and productivity of forage and biomass species; (c) to study the quality of forages species, and (d) to suggest the modalities for using the treated effluents for irrigation purposes.

Initial soil characteristics indicated that the soils are almost neutral to slightly alkaline in reaction and soil salinity ranged from 0.7 to 1.75 dS $m^{-1}$ which increased with depth (Table 88). Organic carbon content of these soils also remained low and calcium carbonate content ranged from 3.6 to 5.9 per cent. Among the exchangeable cations, these soils are dominant in calcium followed by magnesium, while sodium and potassium were relatively low. The cation exchange capacity ranged from 41.2- 42.2 cmol/kg and exchangeable

**Table 88 : Physico-chemical characteristics of soils**

| Depth, cm | pH | $EC_e$ | OC (%) | $CaCO_3$ (%) | Exchangeable cations (cmol $kg^{-1}$) | | | | ESP (%) | CEC (cmol $kg^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Ca | Mg | Na | K | | |
| 0-30 | 7.6 | 0.7 | 0.4 | 3.6 | 22.5 | 16.0 | 1.05 | 0.362 | 2.1 | 42.2 |
| 30-60 | 7.7 | 1.05 | 0.3 | 4.4 | 23.0 | 14.5 | 1.17 | 0.28 | 3.0 | 41.5 |
| 60-90 | 7.6 | 1.75 | 0.3 | 5.9 | 24.5 | 16.0 | 1.75 | 0.30 | 3.7 | 41.8 |

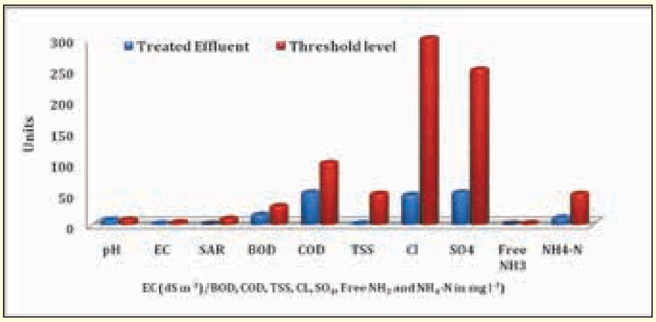



*Fig. 76 : Chemical composition of treated effluent*

sodium percentage (ESP) ranged from 2.1-3.7 which increased with depth. These soils are clayey with clay content up to 50 per cent and montmorillonite as the dominated clay mineral.

The treated effluent from the ETP Unit was analysed for different chemical properties. Data indicated that the chemical parameters viz., pH, electrical conductivity, BOD, COD, total soluble solids, chloride, sulphate, SAR, free ammonia and ammonical nitrogen are well within the threshold values (Fig. 76) meant for irrigating the field crops.

Field planting of *Pongamia*, *Terminelia* and *Eucalyptus* was done and forages crops (2 varieties of sorghum (CSV 21F and GFS-5) and fodder maize were sown. Soil samples were collected and analysed for their initial properties. Data on salinity, $pH_2$ and ionic content are given in Fig. 6 and 7, respectively. Observations indicated that there is no salinity development under the biomass species during the initial plant establishment. While sodium ion was found to be slightly more under BAW, potassium and Ca+Mg were found to be more under effluent treatment. Further observations during crop growth period are under study. As fodder maize stand was relatively poor due to pest infestation, it was replaced by Sudan grass cv GM-999. Plant observations on growth and yield will be studied.

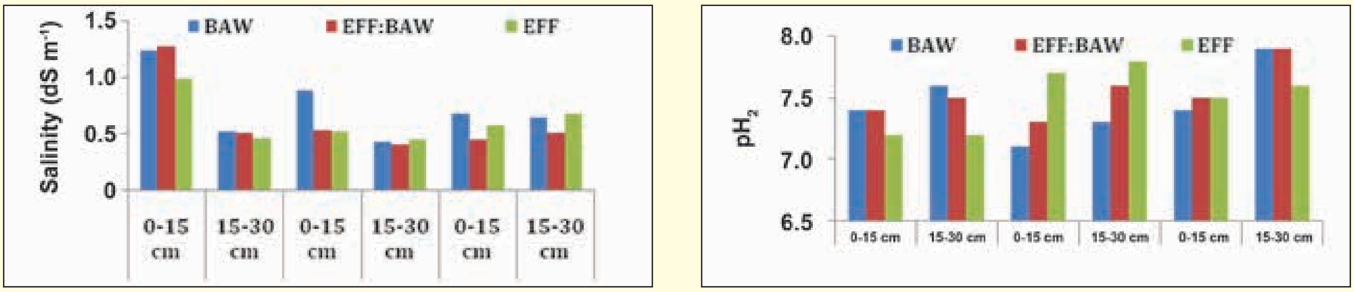



*Fig. 77 : Soil salinity and pH under biomass species under treated effluent irrigtion*

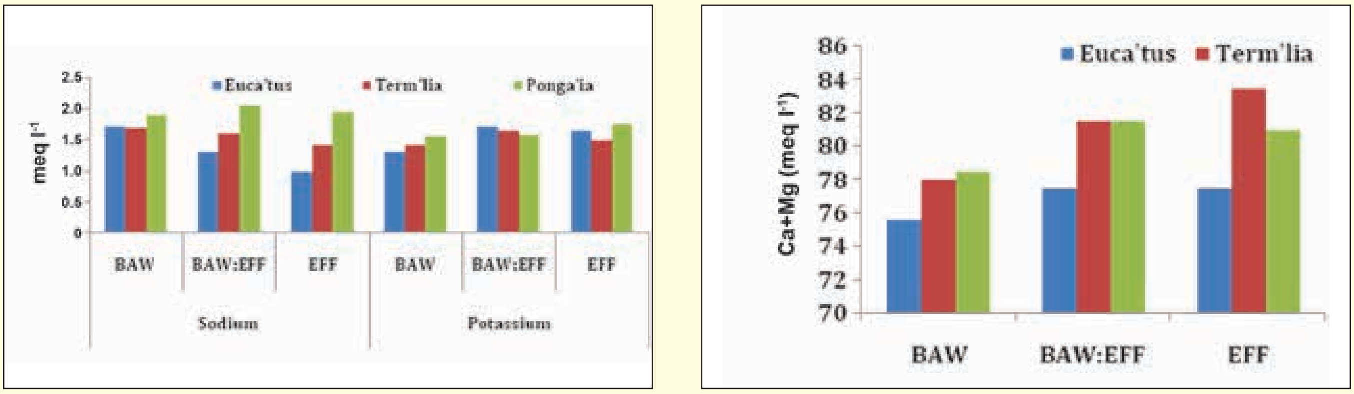



*Fig. 78 : Ionic content of soils under biomass species under treated effluent irrigation*

*Fodder sorghum and biomass species, Terminelia arjuna (Centre) and Eucalyptus (clone)*

# COASTAL SALINITY MANAGEMENT

## Assessment of Ground Water at 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 availability in the coastal areas adjoining to CSSRI, Canning research farm. IRSP6L3 satellite data (29th April, 2012) was purchased from NRSA, and linearly rectified using polyconic projection using ERDAS IMAGINE-2011 image analysis software with RMS error of 0.5. During rectification, 15 GCP's were selected. These points were found in SOI toposheets (1:50,000). The latitude-longitude values for the points calculated from SOI map and observed in satellite image were separately fed into the programme. The image was then linearly rectified. The rectified image was then subset for the area under study. The rectified image was analysed for NDVI and supervised maximum likelihood classification. *Acacia* sp. (Babul, *Acacia nilotica*; family: Mimosoideae) of plants with 3-5 m deep root system was chosen for geobotanical type for the area. A hand held GPS was used to find out latitude-longitude values of the bushes of the plants. In NDVI image, the *Acacia* sp. showed an NDVI value of 0.40-0.45. Then the whole area was made into ten classes by classifying the rectified image. The GPS based data were used for making AOI layer while doing classification. The classes are *Acacia* plantation, other plantation, rice, rice + vegetables, river, water body, bare soil, fallow, others, unclassified etc. (Fig. 79). The NDVI value of plantations other than *Acacia* was 0.45-0.5. The values for all other classes were around 4.0 or less.

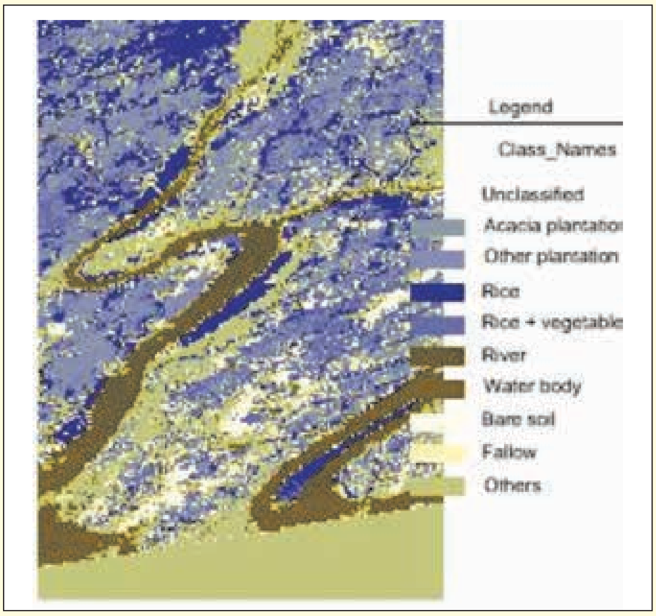



*Fig 79 : Maximum likelihood classified image of the study area*

Field survey was done to find out water depths in the nearby open wells, ponds and tube wells for analysis of the influence of ground water on geobotanical type. *Acacia* plantation can be found in most of the areas. Since, the water quality of the subsurface ground water is uniform throughout the area, the green vigour of *Acacia* sp. during different seasons represented availability of ground water in the area. Ground water was available at 2-3 m below the ground level which was confirmed by the water level of nearby open wells (15 no.).

## 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)

The study area comprises of Canning1, Basanti and Gosaba blocks which are mostly salt affected (Fig. 80). The area mainly covers four soil series namely, Gosaba, Tangrakhali, Sonakhali, and Nikarighata series (Table 89). Gosaba series consists mainly of silty clay to sandy clay, whereas texture of Sonakhali series is silty clay loam to clay. The texture of other two series is relatively coarser and mostly clay loam. Gosaba series covers most of the study area and is distributed mainly in the eastern part. The area under study is agricultural area.

**Table 89 : Different soil series covering the study area**

| Soil series | Description |
|---|---|
| Gosaba | Fine, mixed hyperthermic Fluvaquentic Endoaquepts, texture- silty clay to sandy clay |
| Tangrakhali | Fine loamy mixed hyperthermic Aeric Endoaquepts, texture: silty clay to silty clay loam |
| Sonakhali | Fine loamy mixed hyperthermic Typic Fluvaquents, texture: silty clay loam to clay |
| Nikarighata | Fine loamy mixed hyperthermic Aeric Endoaquepts, texture: silty clay loam to clay loam |

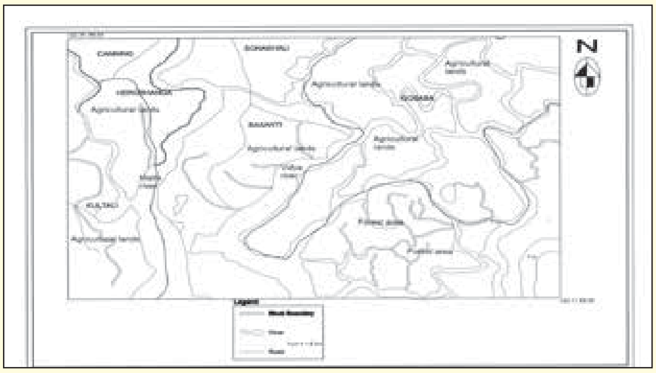


*Fig. 80 : Study area covering Canning 1, Basanti and Gosaba blocks*

NDVI and green vegetation index (GVI) was determined from IRSP6 L3 data. Soil series, land use and salinity maps were collected from related organizations and put into GIS. Soil samples were collected from cultivated and non-cultivated fields (30 no.) covering Canning1, Basanti and Gosaba blocks. The geo-reference points for the samples were recorded using a hand held GPS. IRSP6L3 data (April, 12, 2013) were classified based on supervised maximum likelihood classification. The GPS based data were used to make AOI layers of different features. The classes thus obtained were rice, vegetables, urban, bare soil, fallow land and water body (Table 90). The rice area in the image was 4,785 ha and vegetable area was 1,889 ha. Out of a total area of about 24,000 ha, cultivated area was about 7000 ha and non-cultivated area was 13000 ha. Non-cultivated area is fallow land or pasture. The EC values of soil were found to be increased from west to east direction of the study area.

Irrigation performance indices (IP1 and IP2) were also studied. IP1 is based on irrigated and non-irrigated area and IP2 is based on crop water demand in comparison to supply (Fig. 81). Irrigation performance indices revealed that Nikarighata and Tangrakhali soils were receiving

**Table 90 : Classes obtained in supervised classified image and their respective areas**

| Classes | Areas (ha) |
|---|---|
| Urban | 2449 |
| Bare soil | 3599 |
| Fallow land | 9468 |
| Rice | 4785 |
| Vegetables | 1889 |
| Water body | 2205 |
| Total | 24395 |

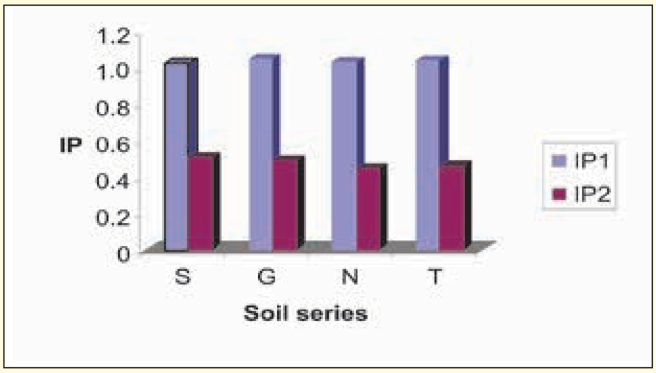



*Fig. 81 : Irrigation performance index (IP1 &IP2) obtained in different soils (S: Sonakhali, G: Gosaba, N: Nikarighata and T: Tangrakhali)*

relatively higher amount of water (> 1000 mm) compared to the other soil series (750 mm). The growth performance of rice under these soil series was high (av. NDVI 0.40) as compared to others (0.35 in Gosaba and 0.33 in Sonakhali).Water received by rice was little higher than supply to the crop (IP1 values > 1.0) and water demand was lower than supply (IP2 values < 1.0) in different soils.

Irrigation scheduling efficiencies for vegetables were also determined in CROPWAT 8.0 which was more for Gosaba series for all kinds of water applications. Sonakhali series performed 2nd to Gosaba, whereas Tangrakhali and Nikarighata series performed below the above two soils in terms of efficiency. Four irrigations with lower amount (40 mm) reduced irrigation loss as was observed in case of three (60 mm) and two irrigation (100 mm) applications resulting in higher scheduling efficiencies. While increase in temporal uniformity in irrigation resulted in higher irrigation scheduling efficiencies, any deviation in application from critical growth stages of vegetables resulted in lower efficiencies.

The relation between soil salinity and vegetation index were developed and is given below:

GVI = 148.04 + (-2.46)*EC ($r^2$-0.29);

EC= 2.2 + (-3.4) GVI ($r^2$-0.25, cultivated soil);

EC= 2.1 + (-4.0) GVI ($r^2$-0.36, uncultivated soil);

pH = 4.3 + 8.2 NDVI ($r^2$-0.25)

where GVI is green vegetation index and NDVI is normalized difference vegetation index.

## 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 carried out at Canning Town farm during *rabi* 2013-14 to evaluate the performance of vegetables under solar drip irrigation system. The dripper discharge rate was 2.4 lph at 1 kg/cm$^2$ pressure. The uniformity coefficient and the irrigation efficiency were evaluated to be 92.5 and 87.2 per cent, respectively. The upland created by land shaping technique adjacent to the farm pond was selected. The initial soil EC of 0-15, 15-30, 30-45 and 45-60 cm were 2.8, 2.5, 2.1 and 1.95 dS m$^{-1}$ and pH of respective depth were 6.5,6.3, 7.4 and 7.1.

Seven crops such as tomato (Roky), beet (Red globe), knol-khol (Green globe), cabbage (Maharani), cauliflower (F$_1$ Hybrid), chilli (Surya mukhi) and okra (Avantika) were taken during *rabi* season and sown/transplanted in the last week of November, 2013. Normal dose of fertilizers was applied in three splits through the fertigation tank during the crop growing period. The okra crop was taken in the plot after harvesting of the cauliflower, knol-khol and cabbage. The soil salinity in the root zone was <3 dS m$^{-1}$ at the start of the season (November, 2013). Later, the soil salinity decreased due to drip irrigation and increased at non-irrigated soil at the upper depths (Fig. 82).

All the crops except chilli performed well in terms of production, chilli crop was affected by leaf curl virus, which is a major problem in chilli cultivation in Sundarbans area. The net return was highest in tomato (Fig. 83) due to higher market demand as well as price. The cost of cultivation of *rabi* season vegetables was reduced due to introduction of solar drip irrigation system as there was savings of about 60 per cent of labour and 40~50 per cent of irrigation water.

*The crop field before rabi crop*

*The field crop at the production stage*

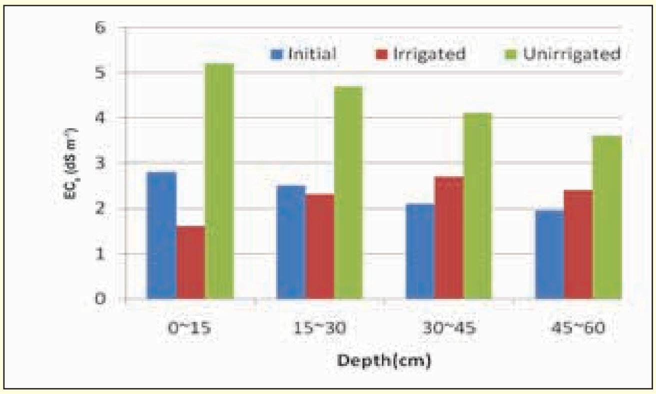



*Fig. 82 : The change in soil salinity in the rootzone*

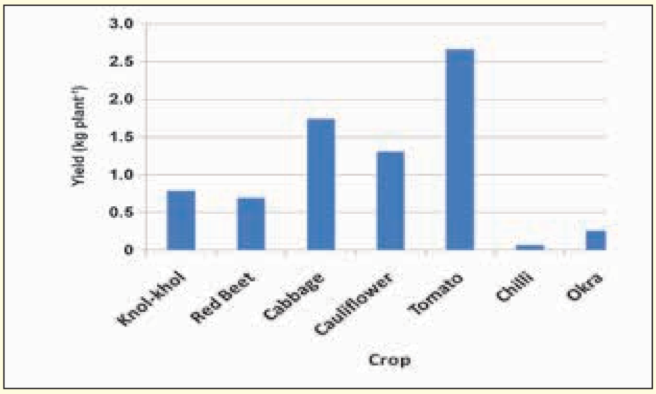



*Fig. 83 : The yield of rabi crops per plant*

## 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)

Based on preliminary survey data, impact of rice varieties on farmers' economy was assessed through gains in terms of profitability, cost of production, fetching better price in open market and incremental yield over existing rice varieties. Various motivation factors to adopt new varieties and constraints in large scale adoption were analysed. The information was collected from the two sets of sample farmers. One set included those, where CSSRI has conducted some rice varietal trials (60 farmers) and second set included those with no direct involvement of CSSRI (60 farmers). Among the farmers' who purchased different rice variety seeds from CSSRI RRS Canning, around 23 per cent were using Amal-Mana that accounted for 21 per cent of total rice area allocation in their farms. During subsequent year, nearly 43 per cent farmers have grown Amal-Mana that accounted for 31 per cent rice area and have obtained 34 per cent incremental yield and 22 per cent incremental net return. Major rice varieties other than Amal-Mana were Pankaj, Patnai, Prateeksha and Dudhewshar in *kharif* season and lal-minikit & sada-minikit during rabi season. This implied that farmers have very limited choice of rice varieties during *rabi* season and therefore, varietal preference is skewed to only few varieties.

There were some distinct differences in sourcing of paddy seed during *kharif* and *rabi* season. About 63 per cent farmers relied on their own seeds followed by purchasing from multiple sources (16%), Govt. farm (11%) and open market (10%). In contrast, over half of the farmers (56%) were dependent on open market for paddy seed followed by Govt. farm (20%), farm saved or own (16%) and multiple sources (8%). Similarly, there were some distinct differences between purpose of growing rice varieties during *kharif* and *rabi* season. *Kharif* rice was grown primarily for home consumption (90%) whereas *rabi* rice for selling (76%) in market. This indicated that there is a need to popularise CSSRI rice varieties through making them available in the open market and increasing awareness among farmers.

Various motivation factors that influence farmer's decision or willingness to change their varieties were analysed from the primary survey. Results indicated that farmer's decision (84%) to change a rice variety remains unchanged when the yield increase to the extent of 15 per cent. Under saline environment, instability of yield is quite high and the farmers have rational expectations, therefore, farmer's willingness to change remained indifferent up to incremental yield by 15 per cent. Other motivational factors were higher salt tolerance (95%), availability in time and quantity (80%), likely to fetch better market price and quality (72%) and short duration (83%) particularly in *rabi* season. CSSRI needs to develop more rice varieties for both *kharif* and *rabi* seasons and thereby increasing the options for choosing varieties according to farmers' need and preference. Farmers' are willing to adopt CSSRI varieties and it needed to make available in the seed market chain with formal release.

### 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)

Continuous waterlogging on soil with highly saline water under brackish water aquaculture (BWA) brings out several permanent/semi-permanent changes in soil including salt load, nutrient status, accumulation of toxic products, etc. It may release green house gases in the atmosphere. Practice of BWA after converting agricultural land may adversely affect socio-economic status of the people. This project was carried out in North 24 Parganas district in coastal areas of West Bengal with the objectives to assess the impacts of BWA on the physical and social environment of the coastal region and to develop strategies to mitigate the adverse impact of BWA in the coastal environment.

Impact of BWA in terms of changes in soil and water salinity was studied in adjoining agricultural fields and fresh water pond. The soil salinity was more in rice field adjoining to fish farms compared to rice field away from fish farm (Table 91). The higher salinity in water and soil was recorded in fish pond which was located in the adjoining areas of BWA farm compared to ponds away from it (Table 92). The increase in salinity of soil and water in adjoining agricultural land and freshwater fish

**Table 91: Effect of brackish water aquaculture (BWA) farm on rice field**

| Months | Adjoin to BWA farms | | | | Away from BWA farms | | | |
|---|---|---|---|---|---|---|---|---|
| | Water | | Soil | | Water | | Soil | |
| | pH | EC ($dSm^{-1}$) | pH | ECe ($dSm^{-1}$) | pH | EC ($dSm^{-1}$) | pH | ECe ($dSm^{-1}$) |
| April | - | - | 7.34 | 14.87 | - | - | 7.22 | 8.02 |
| June | - | - | 7.65 | 17.66 | - | - | 7.89 | 9.28 |
| October | 7.34 | 4.54 | 7.86 | 6.35 | 7.2 | 2.42 | 7.45 | 3.01 |
| November | 7.79 | 6.08 | 7.11 | 8.09 | 7.07 | 3.01 | 7.21 | 5.21 |

**Table 92 : Effect of brackish water aquaculture (BWA) farm on fresh water pond**

| Months | Adjoin to BWA farms | | | | Away from BWA farms | | | |
|---|---|---|---|---|---|---|---|---|
| | Water | | Soil | | Water | | Soil | |
| | pH | EC ($dSm^{-1}$) | pH | ECe ($dSm^{-1}$) | pH | EC ($dSm^{-1}$) | pH | ECe ($dSm^{-1}$) |
| April | 7.24 | 9.12 | 7.26 | 10.56 | 7.56 | 3.67 | 7.24 | 3.99 |
| June | 7.21 | 13.23 | 7.39 | 13.99 | 7.57 | 3.52 | 7.46 | 5.05 |
| October | 7.22 | 7.99 | 7.87 | 8.22 | 7.16 | 2.25 | 7.09 | 3.01 |
| November | 7.65 | 10.43 | 7.19 | 11.34 | 7.27 | 2.76 | 7.28 | 3.77 |

pond could be due to seepage of brackish water from adjoining BWA farms.

BWA 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 fish farms varied periodically. Water salinity was highest (26.3-30.0 dS $m^{-1}$) before onset of monsoon (June) and lowest (7.5-9.2 dS $m^{-1}$) in monsoon month like September. Soil salinity (ECe dS $m^{-1}$) on the surface layer (0-15 cm) was also highest (27.4-32.1 dS $m^{-1}$) before onset of monsoon (June) and lowest (8.9–11.1 dS $m^{-1}$) during monsoon (September). Higher salinity of soil and water was recorded in the old BWA farms compared to newly introduced farms. Green gas emission form BWA farms were measured. The fluxes of $CH_4$, $N_20$ and $C0_2$ during June from different ages of BWA farms are presented in Fig. 84. Higher green house gas emission was recorded in the old BWA farm (>25 yrs) compared to newly introduced farm (3 yrs).

Socio-economic study was conducted through primary survey as well as focus group discussion in different villages in North 24 Parganas District. It was observed that overall the area under brackish water aquaculture was increasing and more paddy area were being converted to such system. In the study area, the BA started during 30-35 years ago and all these areas was under paddy cultivation. Average area under BWA was quite high (1.78 ha) as compared to agriculture. In the study area, BWA accounted for 91 per cent area, freshwater aquaculture for 1.5 per cent area and agriculture for 7.5 per cent area. BWA becomes major occupation (10-12 months/year) for the households (HH). Average income per HH from BWA was around Rs. 1.68 lakh/year.

Field experiment was conducted for controlling seepage losses to restrict the salinity build up in adjoining areas of BWA farms. The treatments were : control, deep trench at outer side of the embankment of brackish water bodies and combination of both deep trench at outer side of the embankment + lining with polythene sheet at the inner side of brackish water bodies. Salinity build up in the adjoining fields of BWA farm was monitored periodically, up to 10 m distance, from the water body at an interval of 1 m. Salinity build up in surface soil (0-15 cm) was lower at treatment of trench + lining with polythene sheet followed by trench compared to control before onset of monsoon (May) (Fig. 85). However, no difference in salinity in soil was observed at different treatments after monsoon due to washing of salt with heavy monsoon shower. Similar trend was recorded at 15-30 and 30-45 cm soil layers.

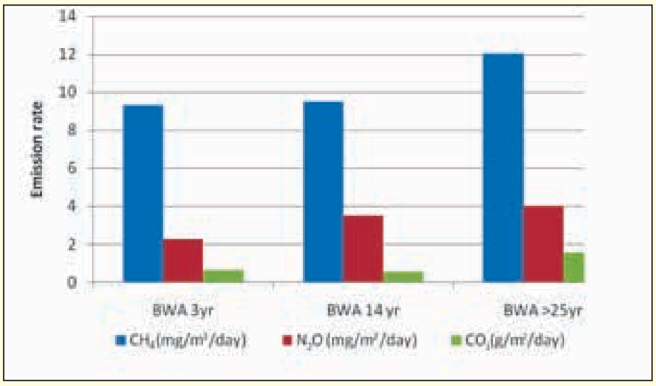



*Fig. 84 : Green house gas emission from brackish water aquaculture (BWA) farm*

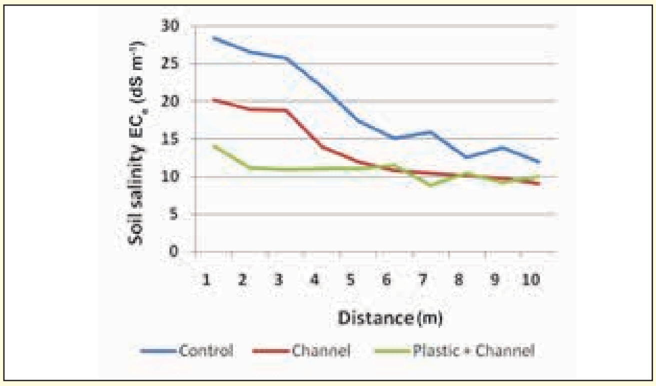



*Fig. 7 : Changes in soil salinity at surface (0-15cm) during May at various distances from BWA farm under different treatments*

## Long Term Impact of Land Shaping Techniques on Soil and Water Quality and Productivity of Coastal Degraded Land

(D.Burman, U.K. Mandal, S.K. Sarangi, S. Mandal, K.K. Mahanta, S. Raut and B. Maji)

The land shaping techniques are most problem solving and suitable approaches for augmenting livelihoods of the farming communities in coastal areas addressing the problems like waterlogging in *kharif* and scarcity of good quality irrigation water and reduction of soil salinity during *rabi*. Experiences indicated that such interventions were able to harness the benefits, at least in short period (3-4 years) and continue to be for few more years. Long term effect of such techniques, particularly on soil, water and other environmental parameters and overall sustainability in long term is not well understood. This research project was initiated with the objectives to study the long term impact of land shaping techniques and rain water harvesting on soil and water quality, to identify suitable crops under different land shaping techniques and to determine economics and long term sustainability of land shaping techniques in coastal region. The effect of different land shaping techniques viz. farm pond, deep furrow & high ridge, and paddy cum fish practicing from <3-5 years - >15 years on soil and water quality and also economics was studied. Soil salinity in the profile of the different land situations like high, medium and original low-land created under farm pond technique, implemented for <3 years and > 15 years indicated that soil salinity build up was less in all the land situations compared to control (without land shaping) (Fig. 86 & 87). Similar trend was observed for deep furrow & high ridge, and paddy cum fish land shaping techniques.

The salinity of harvested rain water in different land shaping techniques was monitored round the year. Salinity of water in the farm pond land shapng technique during post monsoon period in the newly implemented (<3 yr) farm pond land shaping technique compared to old (>15 yr) farm pond. However, during monsoon season, salinity of water in the pond was similar in both the cases. The organic C and available N, P and K was higher under different land situations created under farm pond land shaping technique implemented since <3 and > 15 years compared to control (Table 93). Amongst different years of implementation of land shaping technique organic C and available nutrient status was higher under old land shaped compared to newly land shaped plots. The similar trend was observed under deep furrow & high ridge and paddy-cum-fish land shaping techniques.

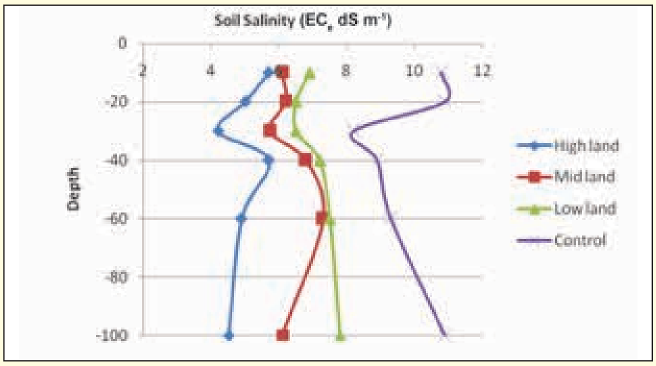



*Fig. 86 : Profile soil salinity under farm pond land shaping technique implemented <3 years and under control.*

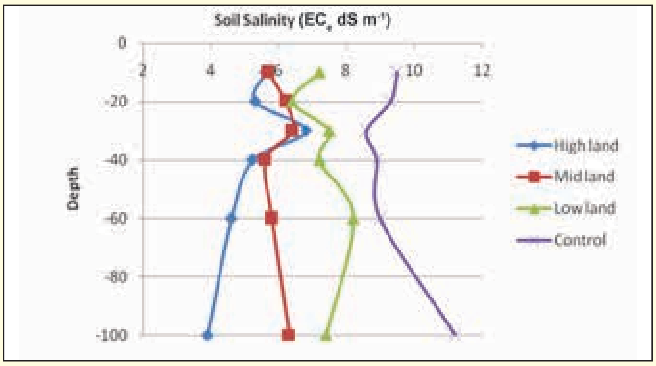



*Fig. 87 : Profile soil salinity under farm pond land shaping technique implemented >15 years and under control.*

The economics were worked out for farm pond, deep furrow & high ridge and paddy-cum-fish land shaping techniques implemented since <5 and > 15 years. The B:C ratio was higher for farm pond followed by deep furrow & high ridge and

**Table 93 : Nutrient status under farm pond land shaping technique**

| Land situations | Duration of implementation | OC (%) | Av. N (kg ha$^{-1}$) | Av. K (kg ha$^{-1}$) | Av. P (kg ha$^{-1}$) |
|---|---|---|---|---|---|
| High land | >15 | 0.89 | 398.5 | 379.8 | 26.9 |
| | <3 | 0.59 | 301.7 | 405.3 | 22.2 |
| Medium land | >15 | 0.78 | 365.0 | 376.8 | 25.8 |
| | <3 | 0.56 | 310.6 | 405.4 | 18.6 |
| Low land | >15 | 0.68 | 321.1 | 421.2 | 23.3 |
| | <3 | 0.55 | 254.7 | 418 | 19.2 |
| Control (without land shaping) | - | 0.53 | 213.8 | 418.5 | 18.2 |

**Table 94 : Economics (B:C ratio) of land shaping techniques**

| Duration of implementation | Land shaping technologies | | |
|---|---|---|---|
| | Farm pond (B:C ratio) | Deep furrow & high ridge (B:C ratio) | Paddy cum fish (B:C ratio) |
| >15 years | 2.41-3.76 | - | 2.14-2.63 |
| < 5 years | 2.40-3.67 | 2.32-2.87 | 2.09-2.73 |

paddy-cum-fish land shaping techniques (Table 94). The duration of implementation of land shaping techniques did not affect its economics.

## 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 initiated to evaluate the impact of conservation tillage on soil health under rice-cotton cropping system in coastal region of West Bengal during January 2012. 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 such as zero tillage (ZT), reduced tillage (RT) and conventional tillage (CT) as sub-plot treatments. The third year of the study showed that there was 10-13% yield reduction in case of zero tillage than other treatments (Table 95) Yield reduction was 10-23% in zero tillage than other treatments during 2013-14. There was reduction in bulk density (Table 96) and increase in organic C (Table 97) in zero tillage than other treatments in surface. Stratification ratio is defined as a soil property at the soil surface divided by the same soil property at a lower depth such as the bottom of the tillage layer. Stratification ratio of organic C (Fig. 88) was higher in zero tillage with residue than other treatments whereas for bulk density (Fig. 89), the trend was reverse. Though there was reduction in bulk density and increase in organic C in zero tillage in surface depth the beneficial effect was not noted in lower soil depth. The soil organic C stock was determined up to 45 cm soil depth and it was highest in reduced tillage with residue followed by conventional tillage with residue, reduced tillage without residue, zero tillage with residue, conventional tillage without residue and lowest in zero tillage without residue treatment. Soil salinity was marginally high in zero tillage than other treatments possibly due to higher capillary rise of salts in zero tillage than other treatments.

**Table 95 : Rice and cotton yield (t ha$^{-1}$) during *rabi* (2013-14) and *kharif* (2014) season under rice-rice and rice-cotton system**

| Treat-ment | *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 | Non - residue | Average |
| ZT | 2.25 | 2.02 | 2.13 | 4.40 | 4.02 | 4.21 | 10.02 | 9.08 | 9.55 |
| RT | 2.64 | 2.32 | 2.48 | 4.84 | 4.22 | 4.53 | 11.44 | 10.03 | 10.73 |
| CT | 2.54 | 2.41 | 2.47 | 4.91 | 4.10 | 4.50 | 11.24 | 10.13 | 10.69 |
| Mean | 2.47 | 2.25 | | 4.72 | 4.11 | | 10.90 | 9.74 | |
| | *Rabi* Rice in rice- cotton system | | | *Kharif* Rice in rice- Rice system | | | | | |
| ZT | 3.85 | 4.07 | 3.96 | 4.57 | 4.29 | 4.43 | 8.42 | 8.36 | 8.39 |
| RT | 4.42 | 4.15 | 4.29 | 5.13 | 4.90 | 5.02 | 9.55 | 9.05 | 9.30 |
| CT | 4.54 | 4.24 | 4.39 | 5.01 | 4.93 | 4.97 | 9.55 | 9.17 | 9.36 |
| Mean | 4.27 | 4.15 | | 4.90 | 4.71 | | 9.18 | 8.86 | |
| CD (0.05) Cropping System - 0.33; *Kharif* rice yield-NS; Total crops yield- CD (0.05) 0.63 | | | | | | | | | |
| CD (0.05) Tillage - 0.28 | | | | CD (0.05) - 0.42 | | | CD (0.05) - 0.44 | | |
| CD (0.05) Residue - 0.19 | | | | CD (0.05) - 0.29 | | | CD (0.05) - 0.32 | | |
| CD (0.05) Cropping system x tillage -0.44 | | | | NS | | | NS | | |
| CD (0.05) Cropping system x residue- 0.26 | | | | NS | | | NS | | |
| CD (0.05) Tillage x residue - 0.44 | | | | NS | | | NS | | |
| Cropping system x residue x tillage -NS | | | | NS | | | NS | | |

NS - non significant; cotton yield was multiplied with 2.5 considering cotton price 2.5 times of rice to get rice equivalent yield

**Table 96 : Depth-wise soil bulk density (Mg m$^{-3}$) after harvesting of *kharif* rice during December 2014**

| Treatment | Rice-rice | | | Rice-cotton | | |
|---|---|---|---|---|---|---|
| | Soil depth (cm) | | | Soil depth (cm) | | |
| | 0-6 | 15-30 | 30-45 | 0-6 | 15-30 | 30-45 |
| ZTNR | 1.542 | 1.572 | 1.663 | 1.530 | 1.552 | 1.610 |
| ZTR | 1.312 | 1.545 | 1.632 | 1.303 | 1.546 | 1.631 |
| RTNR | 1.481 | 1.531 | 1.542 | 1.498 | 1.518 | 1.531 |
| RTR | 1.395 | 1.486 | 1.537 | 1.352 | 1.492 | 1.544 |
| CTNR | 1.519 | 1.543 | 1.562 | 1.476 | 1.502 | 1.537 |
| CTR | 1.362 | 1.499 | 1.504 | 1.372 | 1.468 | 1.522 |
| Average | 1.435 | 1.529 | 1.573 | 1.422 | 1.513 | 1.563 |

ZTNR, zero tillage with no residue; ZTR, zero tillage with residue; RTNR, reduced tillage with no residue; RTR, reduced tillage with residue; CTNR, conventional tillage with no residue; CTR, conventional tillage with residue.

**Table 97 : Depth-wise organic carban (Mg m$^{-3}$) after harvesting of *kharif* rice during Dec. 2014**

| Treatment | Rice-rice | | | | Rice-cotton | | | |
|---|---|---|---|---|---|---|---|---|
| | Soil depth (cm) | | | | Soil depth (cm) | | | |
| | 0-5 | 5-15 | 15-30 | 30-45 | 0-5 | 5-15 | 15-30 | 30-45 |
| ZTNR | 0.543 | 0.501 | 0.270 | 0.245 | 0.596 | 0.442 | 0.270 | 0.211 |
| ZTR | 0.714 | 0.603 | 0.328 | 0.260 | 0.644 | 0.473 | 0.275 | 0.236 |
| RTNR | 0.669 | 0.539 | 0.324 | 0.263 | 0.581 | 0.479 | 0.280 | 0.231 |
| RTR | 0.699 | 0.603 | 0.324 | 0.279 | 0.623 | 0.582 | 0.270 | 0.236 |
| CTNR | 0.586 | 0.515 | 0.351 | 0.269 | 0.521 | 0.459 | 0.295 | 0.246 |
| CTR | 0.643 | 0.471 | 0.381 | 0.260 | 0.562 | 0.533 | 0.290 | 0.296 |
| **Average** | 0.642 | 0.539 | 0.330 | 0.263 | **0.588** | **0.495** | **0.280** | **0.243** |

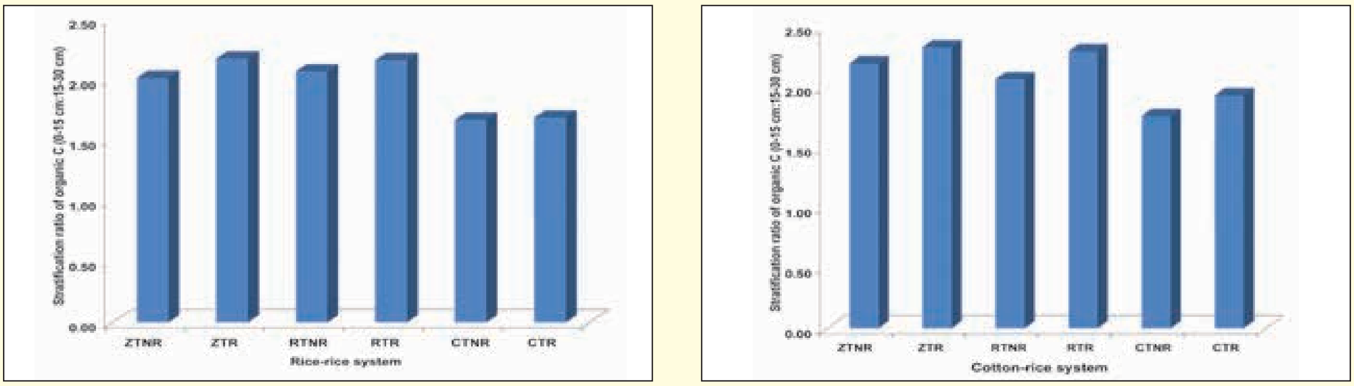



*Fig. 88 : Stratification ratio of soil organic C under different tillage treatments*

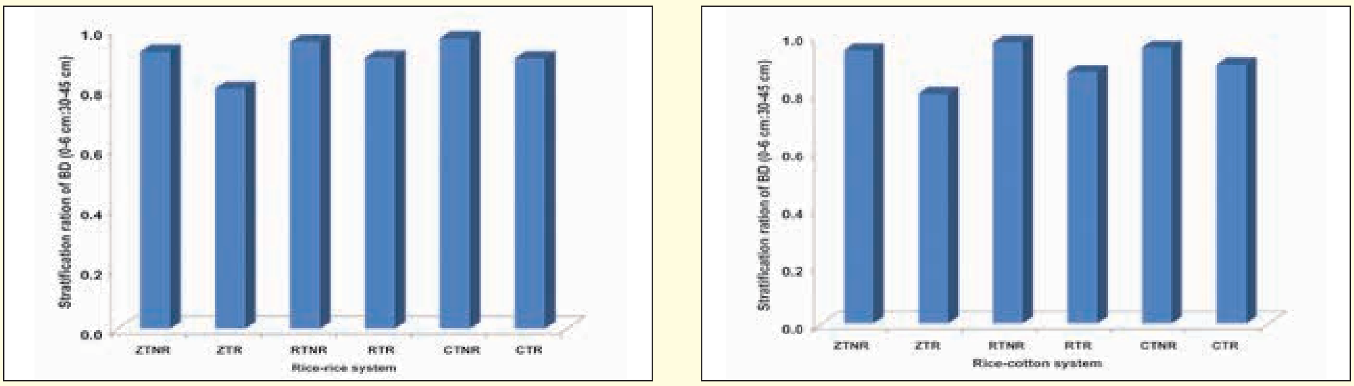



*Fig. 89 : Stratification ratio of soil bulk density under different tillage treatments*

### Effect of Salinity Stress on Jute (*C. capsularis & C. olitorius*) (M. Ramesh Naik, Dhananjay Barman, R.T. Maruthi and Uttam Kumar Mandal)

Though jute is a major cash crop, the area under jute is being pushed to the marginal low productive lands in order to make room for food crops. In order to find out salt tolerant jute varieties which can sustain stress environment and be able to produce higher yield in marginal coastal regions, a project was initiated under inter institutional collaboration with CRIJAF, Barrackpore. The objectives of the study were: to determine the salinity effect on the jute growth parameters and introducing the best variety for salinity tolerance. Eight jute varieties five *capsularies* and three *olitorious* were sown in RRS, Canning research farm during third week of September 2014 for seed production. The soil of the experiment area was low in organic C (0.414%) and available N (219.5 kg $ha^{-1}$), medium in available P (14.33 kg $ha^{-1}$) and high in exchangeable K (653.8 kg $ha^{-1}$). Soil was slightly alkaline in reaction (pH 7.98) and EC was 0.51-2.83 dS $m^{-1}$ at the time of sowing. The crop was harvested during first week of February, 2015. Though Capsularis was consider more salt tolerant, biomass and seed yield was higher in olitorious varieties than capsularis (Table 98). Highest biomass and seed yield was recorded for variety JRO 524.

**Table 98 : Biomass and jute seed yield**

| Variety | Seed yield (t $ha^{-1}$) | Dry biomass (t $ha^{-1}$) |
|---|---|---|
| JRO-524 | 1.01 | 2.34 |
| JRO-2407 | 0.77 | 1.67 |
| JRO-8432 | 0.80 | 2.25 |
| JRC-698 | 0.55 | 1.03 |
| JRC-532 | 0.49 | 1.27 |
| JBC-5 | 0.43 | 2.01 |
| JRC-321 | 0.53 | 2.07 |
| JRC-517 | 0.75 | 1.94 |

*Performance of jute varieties*

### Evaluation of Crop Establishment Methods for Rice-based Cropping System in Coastal Salt Affected Soils (S.K. Sarangi, U.K. Mandal and S. Mandal)

*Rabi* crops like maize and rapeseed were grown under three establishment methods viz. direct/ dibble sowing (DS), normal sowing (NS) and ridge sowing (RS) after harvest of *kharif* rice. DS was done on 3rd December 2013 after harvest of *kharif* rice to use the residual soil moisture, whereas normal and ridge sowing was delayed (18th December 2013) as tillage was done when soil moisture attained ploughable condition. These treatments were imposed on the same layout of *kharif* season which consisted of three methods of rice crop establishment viz. dry direct sowing (DSR), unpuddled transplanting (UNPT) and puddled transplanting (PT) in main plot. *Rabi* crop establishment methods were in sub-plot and two *rabi* crops in sub-sub plot (rapeseed and maize).

Soil salinity on surface (0-15 cm) during *rabi* increased with progress of season (Fig. 90). In the DS plots, the salinity was higher in comparison to NS and RS. Due to ploughing, there was creation of dust mulch on the soil surface and due to breakage of capillary pores, the upward movement of salts was restricted, as a result there was less deposition of salts on the soil surface. Therefore, ploughing of

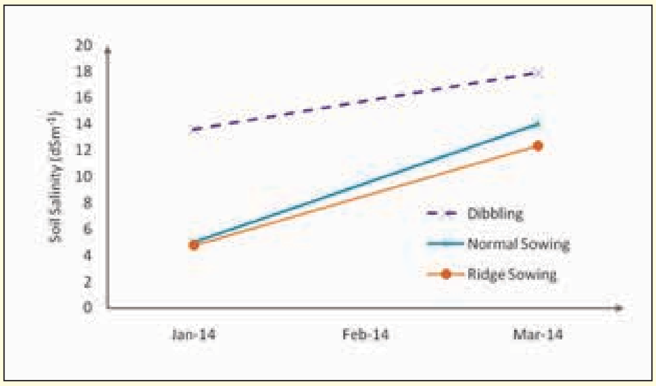



*Fig. 90: Soil salinity during rabi season at Canning Town*

**Table 99: Growth parameters of *rabi* crops under different establishment methods**

| Crop and Establishment methods* | CGR (g/plant/day) | | RGR (g/plant/day) | | NAR (g/plant/dm²/day) |
|---|---|---|---|---|---|
| | 30-60 DAS | 60 DAS – harvest | 30-60 DAS | 60 DAS – harvest | 30-60 DAS |
| Maize | | | | | |
| DS | 0.19 | 2.46 | 0.06 | 0.04 | 0.010 |
| NS | 0.54 | 3.78 | 0.14 | 0.05 | 0.012 |
| RS | 1.14 | 5.14 | 0.15 | 0.05 | 0.018 |
| CD (P=0.05) | 0.18 | 0.22 | 0.02 | 0.008 | 0.006 |
| **Rapeseed** | | | | | |
| DS | 0.16 | 0.14 | 0.21 | 0.020 | 0.032 |
| NS | 0.18 | 0.09 | 0.17 | 0.011 | 0.030 |
| RS | 0.20 | 0.06 | 0.18 | 0.009 | 0.031 |
| CD (P=0.05) | 0.18 | 0.22 | 0.02 | 0.008 | 0.006 |

*DS = Direct/dibbled sowing, NS = Normal sowing, RS = Ridge sowing

land at the start of *rabi* season helped in reducing salinity build up in the surface soil.

Crop growth rate (CGR), relative growth rate (RGR) and net assimilation rate (NAR) were studied by recording the dry matter (DM) weight and leaf area at 30, 60 days after sowing (DAS) and at harvest.

In case of maize, the CGR and NAR were significantly higher in ridge sowing over dibbling and normal sowing (Table 99). Though RGR was higher in ridge sowing over dibbling, it was at par with normal sowing. Whereas in rapeseed, the RGR was significantly higher in direct sowing than normal and ridge sowing at 30-60 DAS as well as 60 DAS to harvest.

Since the direct sown rapeseed was sown early, it got favourable carry over soil moisture, low temperature condition and matured earlier than normal and ridge sown crops. The NS and RS

*Direct sown rapeseed at maturity stage*

crop maturity was delayed and faced higher temperature condition during the month of March. The maximum, minimum and mean air temperatures during March 2014 were almost 5$^0$C higher over those of February 2014.

In case of maize, dibbling method of establishment was not favourable, as there was development of soil cracks during March-April, resulting in loss of

**Table 100: Depth of irrigation water applied to *rabi* crops under different establishment methods**

| Establishment methods | IW (ha-cm) | | | $IW_P$ (kg/ha-cm) | | |
|---|---|---|---|---|---|---|
| | Maize | Rapeseed | Mean | Maize | Rapeseed | Mean |
| Direct sowing | 63.2 | 32.5 | 47.8 | 60.9 | 34.7 | 47.8 |
| Normal sowing | 59.2 | 34.8 | 47.0 | 88.3 | 19.0 | 53.6 |
| Ridge sowing | 53.7 | 33.2 | 43.5 | 113.9 | 23.0 | 68.4 |
| Mean | 58.7 | 33.5 | | 87.7 | 25.5 | |
| Comparison | $LSD_{0.05}$ | | | $LSD_{0.05}$ | | |
| Interaction | 1.1 | | | 6.2 | | |
| Crop means | 0.6 | | | 3.6 | | |
| Establishment means | 0.9 | | | 6.1 | | |


*Effect of maize establishment methods on cob size (grains per cob)*

irrigation water through these cracks; whereas in ridge sowing, there was favourable soil moisture availability and less soil salinity builds up.

Depth of irrigation water (IW) applied (ha-cm) to *rabi* crops under different establishment methods were calculated by dividing the volume of water applied by the area to which irrigation water was applied. In maize, the amount of irrigation water applied to direct sown crop was significantly higher over ridge sown crop, however, in rapeseed normal sowing required higher amount of irrigation water in comparison to other methods of establishments (Table 100).

The irrigation water productivity (IWp) of different treatments was calculated by dividing the seed/grain yield of irrigation water applied. The mean IWp was significantly higher in maize over rapeseed. Among establishment methods, ridge sowing resulted in higher IWp than normal and direct sowing.

Among the yield contributing characters, the number of cobs per plant was in an increasing trend from direct to ridge sowing in maize. In case of ridge sown maize, the number of grains per cob was significantly higher over normal and dibbled sowing, whereas in rapeseed, the number of pods per plant was significantly higher in direct sowing over normal and ridge sowing.

Grain yield of maize was 3.78, 5.22 and 6.09 t ha$^{-1}$ under direct, normal and ridge sowing, respectively. Seed yield of rapeseed was significantly higher in direct sowing (1.1 t ha$^{-1}$) over normal (0.65 t ha$^{-1}$) and ridge sowing (0.75 t ha$^{-1}$). Similar trend was also observed for stover yield.

The REY of rice based cropping systems was computed (Table 101 & 102). In case of rice-maize cropping system, highest REY (12.81 t ha$^{-1}$) was observed in direct sown rice-ridge sown maize, whereas in rice-rapeseed cropping system REY was highest (8.81 t ha$^{-1}$) in direct sown rice-direct sown rapeseed.

**Table 101 : Yield of rice based cropping systems under different establishment methods**

| Treatments | Rice grain yield (t ha$^{-1}$) | Maize yield (t ha$^{-1}$) | | Rapeseed yield (t ha$^{-1}$) | | System REY (t ha$^{-1}$) | |
|---|---|---|---|---|---|---|---|
| | | Grain | REQ | Grain | REQ | Rice-maize | Rice-rapeseed |
| DSR-DS | 4.93 | 4.77 | 5.64 | 1.40 | 3.88 | 10.57 | 8.81 |
| DSR-NS | 4.93 | 5.17 | 6.11 | 1.01 | 2.80 | 11.04 | 7.73 |
| DSR-RS | 4.93 | 6.67 | 7.88 | 0.99 | 2.75 | 12.81 | 7.68 |
| UnPT-DS | 4.55 | 3.55 | 4.19 | 1.36 | 3.77 | 8.74 | 8.32 |
| UnPT-NS | 4.55 | 5.02 | 5.93 | 0.77 | 2.14 | 10.48 | 6.69 |
| UnPT-RS | 4.55 | 5.98 | 7.07 | 0.93 | 2.58 | 11.62 | 7.13 |
| PT-DS | 5.08 | 3.03 | 3.58 | 1.14 | 3.16 | 8.66 | 8.24 |
| PT-NS | 5.08 | 5.47 | 6.46 | 0.75 | 2.08 | 11.54 | 7.16 |
| PT-RS | 5.08 | 5.62 | 6.64 | 0.94 | 2.61 | 11.72 | 7.69 |
| $LSD_{0.05}$ | NS | 0.38 | - | 0.38 | - | - | - |

REQ = Rice equivalent yield, Price of rice = Rs.11000/t, Price of maize = Rs.13000/t, Price of rapeseed= Rs.30500/t, DSR= Dry direct sown rice, UnPT=Unpuddled transplanted, PT=Puddled transplanted, DS= Direct sowing, NS = Normal sowing, RS = Ridge sowing

**Table 102 : Economics ($10^3$ Rs. $ha^{-1}$) of rice based cropping systems under different establishment methods in coastal areas**

| Treatments | Rice-maize cropping system | | | | Rice-rapeseed cropping system | | | |
|---|---|---|---|---|---|---|---|---|
| | Cost of cultivation | Gross return | Net return | BCR | Cost of cultivation | Gross return | Net return | BCR |
| DSR-DS | 65.5 | 134.2 | 68.7 | 2.05 | 47.5 | 112.9 | 65.4 | 2.38 |
| DSR-NS | 65.1 | 141.4 | 76.3 | 2.17 | 48.4 | 100.9 | 52.5 | 2.08 |
| DSR-RS | 67.6 | 162.9 | 95.3 | 2.41 | 49.9 | 100.0 | 50.1 | 2.00 |
| UnPT-DS | 72.0 | 113.9 | 41.9 | 1.58 | 54.0 | 107.1 | 53.1 | 1.98 |
| UnPT-NS | 71.6 | 134.2 | 62.6 | 1.87 | 54.9 | 88.9 | 34.0 | 1.62 |
| UnPT-RS | 74.1 | 148.5 | 74.4 | 2.00 | 56.4 | 93.8 | 37.4 | 1.66 |
| PT-DS | 82.0 | 113.8 | 31.8 | 1.39 | 64.0 | 107.4 | 43.4 | 1.68 |
| PT-NS | 81.6 | 146.9 | 65.3 | 1.80 | 64.9 | 95.1 | 30.3 | 1.47 |
| PT-RS | 84.1 | 150.9 | 66.8 | 1.79 | 66.4 | 101.1 | 34.7 | 1.52 |

Price of rice = Rs.11000/t, Price of maize = Rs.13000/t, Price of rapeseed= Rs.30500/t, DSR= Dry direct sown rice, UnPT=Unpuddled transplanted, PT=Puddled transplanted, DS= Direct sowing, NS = Normal sowing, RS = Ridge sowing

In rice-maize cropping system, highest cost of cultivation was incurred in puddled transplanted rice-ridge sown maize, but the gross and net returns and BCR were highest in direct sown rice (DSR)-ridge sown maize (RS). The performance of rice-rapeseed cropping system was different from rice-maize system in terms of economics. Direct sown rice (DSR)-direct sown rapeseed (DS) resulted in lowest cost of cultivation but highest gross return, net return and BCR.

Energy output as well as output:input ratio were higher in DSR over unpuddled and puddled transplanting in *kharif* rice, however, output was increased from direct sowing to ridge sowing in case of maize. The system energy conversion was highest in DSR-RS (Fig 91).

In rice-rapeseed cropping system, the energy conversions are different than rice-maize system.

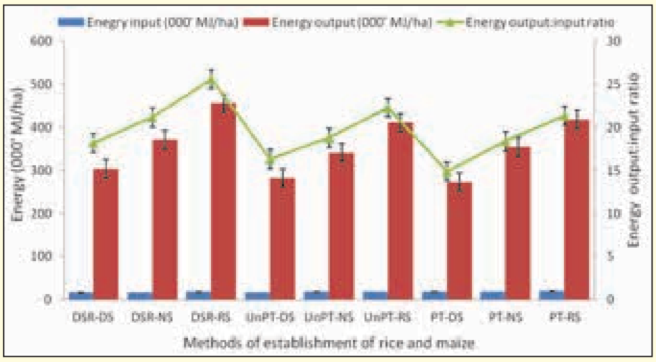



*Fig. 91 : Energy input, output and output : input ratio in rice-maize cropping system under different establishment methods*

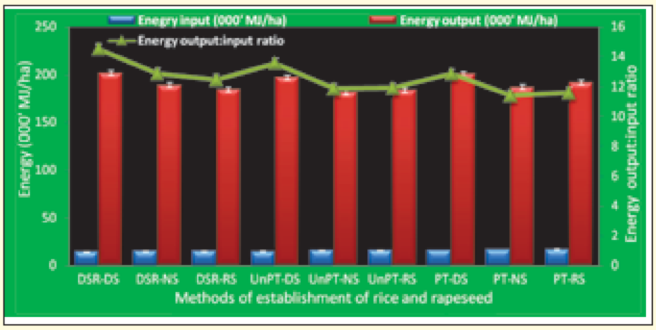



*Fig. 92 : Energy input, output and output:input ratio in rice-rapeseed cropping system under different establishment methods*

Energy parameters were favorable under direct sown rapeseed than normal and ridge sown (Fig. 92). Therefore, DSR-DS rapeseed recorded higher energy output and output:input ratio.

## Coastal Saline Tolerant Varietal Trial (CSTVT) (S.K. Sarangi and B. Maji)

During the *Kharif* 2014, thirty three entries (2401 to 2433) under CSTVT were evaluated at CSSRI, RRS, Canning Town. Out of these, 2 entries (2422 & 2226) did not survive in the nursery. Rest 31 lines were evaluated in the main field. These entries include 3 checks like coastal saline check (CST 7-1), yield check (Jaya) and local check (Canning 7). The entries were sown in the nursery on 03.07.14 and transplanting on 30.07.14 with a spacing of 15 cm x 15 cm. Net and gross plot size was 3.94 and 6.14 $m^2$ respectively. Days to flowering varied from 87 days (2414) to 133 days (2401 & 2402). Entries flowered close to local check (89 days) was

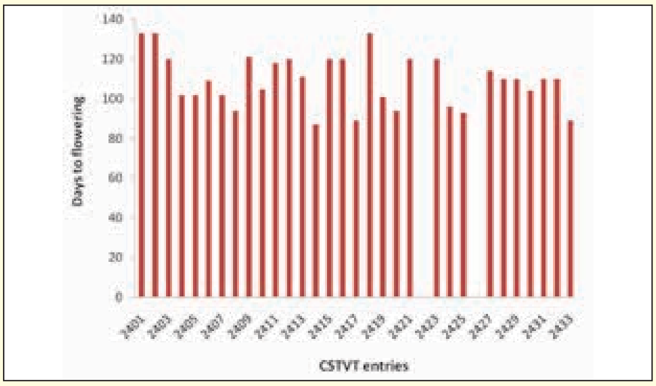



*Fig. 93 : Days to flowering in CSTVT entries during kharif 2014*

2408, 2020, 2425, and 2433. Twenty eight entries flowered after local check (Fig. 93). Mixtures were observed in 2409, 2415, 2418, 2421 & 2423. Highest grain yield of 4.65 t $ha^{-1}$ was recorded in entry 2404 followed by 2403 (4.40 t $ha^{-1}$) and 2431 (4.37 t $ha^{-1}$). Local check (Canning 7) produced grain yield of 2.77 t $ha^{-1}$.

**Seed Production, Maintenance and Evaluation of Rice Germplasm** (S.K. Sarangi and B. Maji)

Turthfully levelled (TL) seeds of Amal-Mana (6.10 t), Bhutnath (0.054 t), Canning 7 (0.087 t), Dadsal (0.072 t), Geetanjali (1.45 t), Sabita (1.17 t), SR 26 B (0.76 t), Swarna-Sub 1 (0.063 t) and WGL 20471 (0.074 t) were produced during *kharif* 2014.

Rice germplasm including released varieties and lines from ICAR-CSSRI, IRRI, local landraces were maintained and evaluated under different land situations and seasons during 2014. Twenty nine ICAR-CSSRI varieties (CSR 1, CSR 2, CSR 4, CSR 8, CSR 10, CSR 12, CSR 13, CSR 14, CSR 16, CSR 20, CSR 21, CSR 22, CSR 23, CSR 25, CSR 26, CSR 27, CSR 28, CSR 29, CSR 31, CSR 32, CSR 33, CSR 34, CSR 35, CSR 36, CSR 37, CSR 38, CSR 39, CSR 40 and CSR 41) were evaluated during *kharif* 2014. CSR 2, CSR 14, CSR 22 and CSR 40 produced grain yield of more than 3.5 t $ha^{-1}$.

Under lowland with stagnant flooding situation, 26 entries (Amal-Mana, Gitanjali, Swarna-Sub 1, SR 26 – B, Sabita, Patnai – 23, Dinesh, Purnendu, Ambica, Nalini, Manas swarabar, Tilak kanchari, Najani, Sada Mota, CSRC(D)5-2-2-2, CSRC(D)7-0-4, CSRC(D)7-12-1, CSRC(D)13-16-19, CSRC(D)12-8-12, CSRC(D)7-5-4, CSRC(D)2-0-8, CSRC(D) 2-17-5, C 300 BD-50-11, Asfal, NC 678 and Gavir saru) were evaluated and highest grain yield of 4.4 $tha^{-1}$ was recorded from Amal-Mana,


*Rice seed production plots during Kharif 2014*

which was significantly superior over all other entries. Twenty entries were evaluated under medium land situation (Utpala, Sumati, SR 26B, Dadsal, CST 7-1, Bhutnath, Namita-Dipti, Chamar Mani, Dudheswar, Buck Tulsi, CSR 6, Talmugur, CAC 615 (Velki), Nona Bokra, Pankaj, CN 1233-33-9, CN 1231-11-7, CN 1039-9 and Swarna-Sub 1). Highest grain yield of 4.2 t $ha^{-1}$ was recorded by Swarna-Sub 1, followed by Namita-Dipti (3.4 t $ha^{-1}$) and Bhutnath (3.3 t $ha^{-1}$).

During *rabi*, forty entries were evaluated, out of these, CSRC(S) 50-2-1-1-4-B, CSRC(S) 49-B-5-2-B-1, CSRC(S) 47-7-B-B-1-1, CSR 22, CSR 34, Annada, WGL 20471, Bidhan 2, Boby, BRRIdhan 53, BRRIdhan 47 and BINAdhan 8 produced grain yield of more than 5 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 with the objective to curb the ill-effects of degraded land and water of the disadvantaged coastal regions of Sundarbans and Andaman islands for improving productivity, livelihood security and employment opportunities of rural men and women and their capacity building.

The project was implemented in disadvantaged areas in Sundarbans region of Ganges delta (West Bengal) and *Tsunami* affected Andaman & Nicobar Islands covering 32 villages in 12 clusters in 4 districts (2 in West Bengal and 2 in Andaman & Nicobar Islands). The project sites were 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 in South Andaman District, and Dashrathpur in Rangat and Deshbandhugram in Diglipur in North & Middle Andaman District in Andaman & Nicobar Islands. The major technological interventions/ innovations implemented in the study areas were land shaping for improving drainage facility, rainwater harvesting and enhancing productivity of low lying degraded land 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 (RTCs) in villages at the project sites.

About 370 ha of low productive salt affected degraded land in Sundarbans and Andaman & Nicobar Islands was converted from mono-cropped to multi-cropped with integrated crop and fish cultivation through implementation of different land shaping techniques like farm pond, deep furrow & high ridge, paddy-cum-fish, broad bed & furrow, three tire system, paired bed system and drainage improvement network. About 13,04,600 $m^3$ rain water was harvested annually under various land shaping techniques. Raising of land and creating water harvesting facilities reduced the problem of drainage congestion and salinity build up in soil thus, improved soil environment. Reduction of salinity and drainage congestion and increase in availability of fresh water for irrigation helped the farmers to grow multiple and diversified crops round the year instead of mono-cropping with rice in monsoon season (*kharif*). The productivity of extremely saline degraded land was brought back to the productive potential closer to normal non-saline land. The cropping intensity was increased up to 240 per cent from a base level value of 100. Income of the extremely poor small and marginal farming family has increased from Rs.10,000-20,000 to Rs,1,50,000-2,00,000 or even more. About 5,11,600 man-days were created from the farming activities after 4 years of implementation of land shaping techniques in the study area. Creating employment opportunity encouraged the farmers to come back to their farm land for cultivation, thus reduced migration. About 21 ha area has been brought under brackishwater aquaculture through shaping of land into shallow depth pond in the coastal areas particularly near the brackish water rivers or sea coast which remained highly saline throughout the year and not suitable for crop cultivation.

New crops and improved varieties of crops were introduced in 388 ha area in mono-cropped areas of degraded land in dis-advantaged region of Sundarbans and Andaman & Nicobar Islands for sustaining food security and economic growth. Introduction of improved varieties and diversified new crops have increased productivity of degraded land, enhanced employment, reduced risk for crop failure, provided better food and nutritional security, improved soil health, reduced 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. About 121.2 ha of degraded land were brought under improved nutrient management and 133 vermi-composting units were established in the study areas.

On 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 RTCs were established in Sundarbans region for dissemination of improved technologies in rural areas during the project period and post project period. About 6400 small and marginal farmers are using different technological interventions in the study area under this project. About 7,15,700

*Deep furrow & high ridge land shaping technique* man-days were generated under different activities of the project. Women felt proud in joining hand with their family members for well off their family. About 35-40 per cent women were involved in different activities of the project. For the post project sustainability village/cluster committees were set up, farmers club and SHGs were formed/involved, reputed NGOs as well as line departments were involved, RTCs were constructed and a sustainability fund of about Rs. 1 core has been generated to ensure continued technological upgrading and hand holding of the beneficiary farmers.

### Stress-Tolerant Rice for Africa and South Asia (STRASA – Phase 2) Stress Tolerant Rice for Coastal Soil (CSSRI, RRS, Canning Town) (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 Asia (Phase 3) funded by Bill and Melinda Gates Foundation (BMGF), farmers were involved in selecting rice lines/varieties included in researcher-managed trials (Mother trials) and in farmer-managed trials (Baby trials). Trials were conducted during *kharif* seasons at different parts of Sundarbans in the coastal region of West Bengal 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 the eastern part of coastal areas of the country to produce more food, generate more income, and to reduce poverty and hunger. Salinity Tolerant Breeding Network (STBN) trial was also conducted at the experimental farm of CSSRI, RRS canning Town during this season.

### Researcher-managed trials (Mother trials)

During *kharif* season, two on-farm mother trails were conducted at Pakhiralay village of Gosaba Block in South 24 Parganas District and Mondal Para village of Sandeshkhali-II Block in North 24 Parganas District. A set of 10 promising varieties/new lines viz. Amal-Mana, Geetanjali, SR 26 B, Sabita, Swarna Sub 1, CSR 21-2-5-B-1-1, Dinesh, Patnai 23, CST 7-1 and BINA dhan 8 was evaluated under mother trials in the single–factor experiment in RCBD with three replications. Preferential Analysis (PA) was conducted at Pakhiralay and Mondal Para villages. In PA for the mother trials Amal-Mana, Sabita and Swarna sub-1 were emerged as most preferred rice varieties. Dinesh and Patnai 2 were emerged as least preferred varieties. Those varieties were preferred most by the farmers due to their traits like tolerance to submergence, long panicles with more grains, no/minimum infestation of pest and diseases, more tillers, good grain types (medium long), overall good performance of crop, more straw for fodder/thatching/fuel and expected high yield, etc. Farmers didn't prefer Dinesh and Patnai 2 because of their traits like small panicles with unfertile grains, poor tillering, and expected low yield.

**Table 103 : Grain yield (t ha$^{-1}$) of different entries under mother trails**

| Entries | Pakhiralay village of Gosaba Block in South 24 Parganas | Mondal Para village of Sandeshkhali-II Block in North 24 Parganas District |
|---|---|---|
| Amal-Mana | 4.25 | 3.57 |
| BINA dhan 8 | 3.40 | 3.06 |
| CSR 21-2-5-B-1-1 | 3.95 | 3.58 |
| CST 7-1 | 3.93 | 3.31 |
| Dinesh | 3.45 | 3.02 |
| Geetanjali | 3.13 | 3.11 |
| Patnai 23 | 3.15 | 3.28 |
| Sabita | 4.05 | 3.85 |
| SR 26 B | 3.75 | 3.26 |
| Swarna Sub 1 | 4.33 | 3.28 |
| CD (0.05) | 0.35 | 0.43 |

It was revealed that highest grain yield was produced by Amal-mana while lowest grain yield was produced by Geetanjali (Table 103).

*Preferential Analysis at village Pakhiralay*

## Farmers-managed trials (Baby trials)

Five baby trials were conducted during *Kharif* 2014 on farmers' fields at different villages in South 24 Parganas District and in North 24 Parganas District of Sundarbans region. Three varieties viz. Amal-Mana, Geetanjali and SR 26 were given to farmers for trials. In baby trials, the plating treatments like conventional transplanting and line spacing (20 cm X 15 cm) were taken as management practices. The mean grain yield of rice varieties over the locations under management practices is presented in Table 104. About 16-23 per cent improvement in grain yield of rice varieties was recorded at line spacing over farmers' practice of conventional spacing of planting.

**Table 104 : Mean yield (t ha$^{-1}$) of improved varieties of rice with management practices at different locations of Sundarbans region**

| Entries | Line Spacing (20cmx15cm) | Conventional transplanting |
|---|---|---|
| Amal-Mana | 3.70 | 3.13 |
| Geetanjali | 2.92 | 2.52 |
| SR26B | 3.35 | 2.73 |
| CD (0.05) | Variety: 0.37; Management practices: 0.30 | |

## Salinity Tolerant Breeding Network (STBN)

The experiment consisted of 30 rice genotypes including 5 check varieties. The experiment was conducted in randomized block design (RBD) with three replications. Days to 50 per cent flowering of the entries in the trial ranged from 73 days (RP 4353-MSC-38-43-6-2-4-3) to 98 days (Amal-Mana (Local cheek)) with a mean of 86 days. Plant height of the entries varied from 65 cm (IR 87870-6-1-1-1-1-B) to 165 cm (Amal-Mana (Local cheek)) with a mean height of 102 cm. Out of all the entries, higher grain yield was recorded from Amal-mana (Local cheek) (2.53 t ha$^{-1}$), IR 87830-B-SDO1-2-2-B (2.54 t ha$^{-1}$), IR 87952-1-1-1-2-3-B (2.57 t ha$^{-1}$), IR 87830-B-SDO2-1-3-B (2.64 t ha$^{-1}$), CSR-2K-262 (2.68 t ha$^{-1}$) and IR 87830-B-SDO1-2-3-B (2.69 t ha$^{-1}$) (Fig. 94).

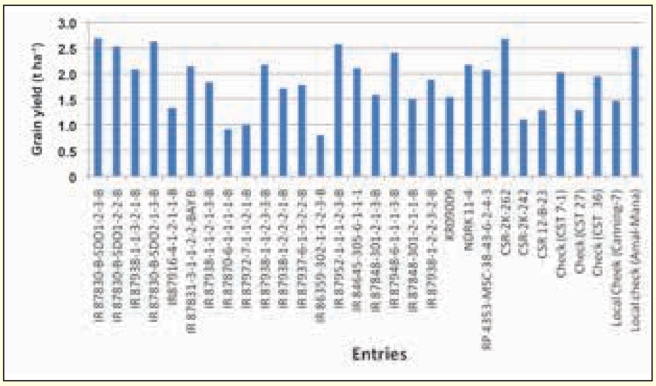



*Fig. 94 : Mean grain yield of the entries under STBN trial*

## G2 : 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)

The Research for Development Programme of the Ganges Basin Development Challenges (GBDC) under CGIAR Challenge Programme on Water & Food (CPWF) was set up with a goal to reduce poverty, improve food security, and strengthen livelihood resilience in coastal areas through improved water governance and management, and more productive and diversified farm systems. This project was implemented during 2011-14 in Sundarbans region in West Bengal with the specific objectives: validation of 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.

In order to find out suitable rice varieties, on-farm experiments were conducted both during boro and aman seasons of 2011-12 to 2013-14 at various representative locations of South and North 24 Parganas districts in the coastal region of West Bengal. Performance of elite lines and varieties from CSSRI, IRRI, government agencies of India, Bangladesh were evaluated and compared to the local cultivars. During the maturity stage of the rice varieties, the farmers and farm women (at least 30%) from different villages were invited to vote for two most and least preferred varieties out of the varieties tested. Participatory Varietal Selection (PVS) process was conducted following the standard protocol developed by IRRI. During dry seasons (boro), 17 entries were tested in saline soils having average $EC_e$ of < 4.0 (3-4) and >4.0(5-7) dS m$^{-1}$. On-farm trials were conducted at Sandeshkhali PS (Block Sandeshkhali II, village: Daudpur) in North 24 Pargana district and at Gosaba PS (Block Gosaba, Village: Pakhiralay South, Jatirampur, Dulki and Pakhiralay) in South 24 Parganas district. During 2011-12, eight entries were evaluated and in subsequent years ten entries were tested. Some of the entries (BRRI dhan 47, BRRI dhan 55 and BINA dhan 8) were obtained from Bangladesh Rice Research Institute (BRRI) and Bangladesh Institute of Nuclear Agriculture (BINA) through IRRI. Some entries were common over the years, however, depending upon the extreme performance and availability of new promising ones, the entries were added or deleted. However, with higher salinity stress (>4 dS $m^{-1}$), the yield of IET 7486 was affected much (8.0% reduction in grain yield) in comparison to other entries (mean yield reduction of 2.6%). Almost same result was observed at Gosaba, however, the yield level of different entries were less at this location due to higher initial soil and irrigation water salinity. During 2013, entries like N. Sankar and S. Sankar were included as local checks in the trial as these were found to be grown by many farmers in the study sites and new promising entries from BRRI (BRRI dhan 47 and BRRI dhan 55) and BINA (BINA dhan 8) were tested. Across salinity levels and locations BRRI dhan 47 and WGL 20471 were found promising. During 2014, trials were conducted only with less salinity stress and under this situation, WGL 20471 and BINA dhan 8 were promising. Based on the average preference analysis (PA) score of each entries over the three years of study, the most preferred entries were Bidhan 2, BINA dhan 8 and WGL 20471 with mean PA score of 18.25, 8.28 and 7.17, respectively. The lowest PA score was observed in IR 87938 (-22.00), NSIC RC 238 (-18.00) and N. Sankar (-17.50). It was observed that both male and female farmers given negative scores to these entries and they attributed these due to susceptibility to salinity, less grains/ panicle, and expected lower yield.

During wet seasons, 13 entries were evaluated in three field water depth (FWD) categories: <15 cm, 15 to 30 cm and >30 cm. All the entries were tall with height varying from 140-160 cm except Swarna Sub 1, BRRI dhan 47 and BINA dhan 8. The later three varieties were dwarf with height around 100 cm. During 2012, with FWD of <15 cm, significantly higher grain yield was observed in Swarna Sub1 (4.2 t $ha^{-1}$), however this was at par with Amal-Mana (3.8 t $ha^{-1}$). But with medium FWD, higher grain yield was observed in Amal-Mana (4.6 t $ha^{-1}$). With FWD of > 30 cm, significantly higher grain yield was observed in CSRC (D) 12-8-12 (4.8 t $ha^{-1}$). During 2013, some of the local cultivars (NC 678 and SR 26B) and entries from BRRI (BRRI dhan 47) and BINA (BINA dhan 8) were included in the trial. With FWD of 15-30 cm, highest grain yield was observed in Amal-Mana (4.96 t $ha^{-1}$) which was at par with CSRC (D) 7-0-4 (4.73 t $ha^{-1}$). Under higher FWD of > 30 cm though Sabita was at par with Amal-Mana, CSRC (D) 2-17-5 and CSRC (D) 7-0-4, the yield of Sabita was inconsistent over locations. Preference analysis at Sandeshkhali II, during 2012 with FWD of <15 cm revealed Swarna Sub 1 and Amal-Mana as the most preferred varieties of farmers because of traits like strong and taller plants, less lodging, less disease and pest incidence, more tillers, long panicle, and expected higher grain yield. Whereas CSRC(D)2-17-5 and Sabita were the least preferred varieties because of traits like susceptible to lodging, less compact panicle, and expected lower grain yield. At Gosaba with FWD of 15-30 cm, Amal-Mana and Swarna Sub 1 were the most preferred varieties of farmers due to traits like healthy plants, more number of tillers, long panicle, medium height, expected higher grain yield. The least preferred varieties were Sabita and SR 26B due to traits like less number of tillers, short panicle length, less number of panicles and expected lower grain yield. At Basanti, tall varieties like Amal-Mana and CSRC(D) 12-8-12 were the preferred varieties since the FWD was >30 cm, these varieties performed better in terms of grain yield and chosen by the farmers. During 2013 wet season, Amal-Mana was most preferred variety in FWD of 15-30 cm, whereas CSRC (D) 7-0-4 was most preferred one with FWD of >30 cm.

*Participatory varietal selection*

The entries BRRI dhan 47, BINA dhan 8 and WGL 20471 produced highest grain yields of 5.0, 4.8 and 4.5 t $ha^{-1}$ during boro season, compared to 3.20 t$ha^{-1}$ of local cultivars. During aman season, the improved varieties yielded (~ 4 t $ha^{-1}$) higher than those of the local cultivars (3.37 t $ha^{-1}$) in all three categories of FWD. The best performing entries were Swarna- *Sub 1* for FWD <15 cm, Amal-Mana for FWD 15-30 cm, and CSRC(D) 7-0-4 [also

CSRC(D) 12-8-12] for FWD >30 cm. The results demonstrate the great potential for increasing productivity of the coastal zone by adoption of improved rice varieties.

### Reducing irrigation water requirements of dry season rice

This study aimed at reducing irrigation water and increasing irrigation water productivity ($W_p$) in *boro* rice by optimizing the date of sowing and the use of suitable rice varieties. This experiment was conducted during *boro* seasons of 2012-13 and 2013-14. The experiment was conducted in two adjacent fields. Field 1 was grown with early seeded rice. Rice was seeded on 6 November, 2012 and 4 November, 2013. In Field 2: late seeded, rice was seeded on 28 November, and 24 November, 2013. The test varieties were BRRI dhan 47, BRRI dhan 53, BRRI dhan 55, BINA dhan 8 ,CSR 34, CSR 22, IR 10206-29-2-1-1and CSRC (S) 50-2-1-1-4-B.

For both cropping seasons, and under early sowing, yields of BINA dhan 8 (6.04 t $ha^{-1}$), BRRI dhan 47(5.89 t $ha^{-1}$), CSR 22 (5.95 t $ha^{-1}$), and IR 10206-29-2-1-1 (5.87 t $ha^{-1}$) did not differ significantly and were significantly higher than those of other varieties. Under late sowing, BINA dhan 8 produced significantly higher grain yield (5.86 t $ha^{-1}$). In both sowings, CSRC(S) 50-2-1-1-4-B produced significantly lower yield. Irrigation water input for different varieties increased with their growth durations. Depth of irrigation water was lowest (117 cm for early sowing; 145 cm for late sowing) in the variety BRRI dhan 47, followed by IR 10206-29-2-1-1. Varieties CSR 34 and CSR 22 had the highest irrigation water inputs. For all cultivars, early sowing consumed 17 per cent less irrigation water than late sown crop. The difference was due to higher water inputs for land soaking, land preparation and puddling in the late sown crop. Late sowing reduce grain yield of most varieties, more so in the case of longer duration varieties, by up to 24 per cent. Irrigation water productivity ($W_p$) under early sowing (41-45 kg grain/ha-cm) was about 30 per cent higher than that under late sowing (31-35 kg grain/ha-cm) during both the years of study. Amongst varieties, highest $W_P$ was recorded in BRRI dhan 47 under early sowing and in BINA dhan 8 in case of late sowing.

### Participatory seed multiplication

Good quality rice seed of improved salt tolerant variety WGL- 20471 for *rabi* and Amal-mana for

*Participatory seed production*

*kharif* season was produced under participatory mode. On-farm seed production was conducted at different locations in Blocks Basanti and Gosaba in South 24 Parganas Districts and Blocks Sandeshkhali I & II in North 24 Parganas Districts. About 18 t seed of WGL- 20471 and 23 t of Amal-mana were produced in the farmer’s field.

### Homestead Production Systems

A survey was conducted in South Bangladesh and two coastal districts of West Bengal (South and North 24 parganas) and database on homestead production system has been prepared. The ponds were mostly perennial but with limited water during non-monsoon months. On an average, 70-75 per cent of vegetables produced (340 kg/household) in the HPS were consumed by the households (HH), and this accounted for 30-40 per cent of their total requirement. Some part of the harvest (25-30%) was marketed every one to two days. Similarly, around 30-35 per cent of the fish produced (143 kg/household) in the HPS was consumed by the farm family, and this accounted for 50-60 per cent of their total household requirement of fish. Around 50-60 per cent of the total fish produced in the HPS were sold. In case of livestock, since the production quantity was very small, 80-85 per cent was consumed by the

*Homestead production system*

households, providing almost 50 per cent of their needs, while the remainder was sold to the local markets. Resource use of HPS can be made more productive and provide a greater contribution to the goal of regional food security.

### Future Rainfed Lowland Rice Systems in Eastern India (Development of crop and nutrient management practices in rice) ICAR W3 (B. Maji and S.K. Sarangi)

Under this project, activities were initiated from June 2014 at Canning Town, West Bengal. During *kharif* season, an experiment was conducted for increasing nitrogen use efficiency and economy in wet season lowland rice in coastal areas. The hypothesis for this study was that split application of slow release N fertilizer like neem coated urea along with foliar spray of prilled urea will increase nitrogen use efficiency in low land rice. During *rabi* season, experiment was undertaken to validate management options for drum seeding for dry season rice (*boro*) in coastal areas with hypothesis that improved boro rice variety with seed treatment sown with a drum seeder will increase *boro* rice yield.

During *kharif* season experiment was conducted with rice variety Amal-Mana in RBD with three replications and consisted of ten treatments. Highest grain yield of 4.6 t ha$^{-1}$ was recorded when 50 per cent N was applied to soil one week after transplanting with neem coated urea (NCU) + 25 per cent N applied to soil at tillering with NCU+ 25 per cent N in 3 foliar sprays with prilled urea (Table 105).

**Table 105 : Grain yield of *kharif* rice with different nitrogen management practices**

| Treatments | Grain yield (t ha$^{-1}$) |
|---|---|
| 50% N as basal with PU+ 50% N as foliar in 6 sprays with PU | 2.69 |
| 50% N as basal with NCU+ 50% N as foliar in 6 sprays with PU | 3.35 |
| 50% N applied to soil one WAT with PU+ 50% N as foliar in 6 sprays with PU | 3.53 |
| 50% N applied to soil one WAT with NCU+ 50% N as foliar in 6 sprays with PU | 3.62 |
| 50% N applied basal with PU+ 25% N applied to soil at tillering with PU+ 25% N as foliar spray in 3 sprays with PU | 3.54 |
| 50% N applied basal with NCU+ 25% N applied to soil at tillering with NCU+ 25% N as foliar spray in 3 sprays with PU | 3.66 |
| 50% N applied to soil one WAT with PU+ 25% N applied to soil at tillering with PU+ 25% N as foliar spray in 3 sprays with PU | 3.90 |
| 50% N applied to soil one WAT with NCU + 25% N applied to soil at tillering with NCU+ 25% N as foliar spray in 3 sprays with PU | 4.59 |
| Recommended existing practice by CSSRI for coastal areas with PU (50% basal, 25% at tillering and 25% at PI stage | 3.00 |
| Recommended existing practice by CSSRI for coastal areas with NCU(50% basal, 25% at tillering and 25% at PI stage | 3.54 |
| LSD 0.05 | 0.48 |

# 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)

In arid and semi arid regions, the availability of good quality water for irrigation is limited. Under these resource poor conditions, the farmers of these areas are forced to use poor quality water to irrigate these crops. Therefore, in order to ensure sustainable use of available saline/sodic waters in combination with organic inputs management, a field experiment was initiated during *kharif* 2008 at Bir Forest Experimental Farm, Hisar and continued upto 2014. Fennel crop was sown during *rabi* 2013-14 and was harvested during April-May, 2014 in 4 pluckings. After harvesting of the fennel, the yield data were recorded from different treatments and analyzed. The morphological characteristics were recorded. After completing the experiment, soil samples were collected from different depth of soil profile in 9 selected plots and analyzed for chemical parameters.

Under low saline irrigation water ($EC_{iw}$ <4), treatment, plant height (cm), umbels/plant, umbellets/umbel, seed weight (g)/umbel, 100 seed weight (g) and seed yield (t $ha^{-1}$) of fennel were recorded to be 136.4, 24.6, 20.2, 2.32, 0.82 and 1.46, respectively. Under high saline irrigation water ($EC_{iw}$ >7) treatment, the data on plant height (cm), umbels/plant, umbellets/umbel, seed weight (g)/umbel, 100 seed weight (g) and seed yield (t $ha^{-1}$) were recorded to be133.2, 24.3, 19.5, 2.32, 0.85 and 1.50, respectively. It was observed that low saline water affected 100 seed weight and seed weight/umbel and seed yield of fennel as compared to high saline water irrigation (Table 106).

Organic input application showed that plant height increased significantly upto 137.7 cm with FYM+vermicompost ($T_3$) application (50+50 ratio) as compared to $T_1$ and $T_2$ treatments though the highest plant height was observed in $T_7$ treatment. Similarly, highest umbels/plant were observed in $T_3$ treatment. Highest seed yield was observed in $T_2$ treatment (1.60 t $ha^{-1}$) with application of inorganic + organic inputs (50:50 ratio).

Analysis of soil samples collected after 6 years cropping system showed that $EC_e$ was 1.71 dS $m^{-1}$ under low saline water irrigation while it was 4.13 dS $m^{-1}$ under high saline water irrigation. The pH of soil was 8.94 and 8.62. Organic carbon (0.50 and 0.43%), available nitrogen (141.1 and 145.1 kg $ha^{-1}$), available phosphorus was higher under low saline irrigation.

**Table 106 : Growth, yield attributes and yields of fennel under different treatments (2013-14)**

| IW | $T_1$ | $T_2$ | $T_3$ | $T_4$ | $T_5$ | $T_6$ | $T_7$ | $T_8$ | Mean |
|---|---|---|---|---|---|---|---|---|---|
| **100 seed weight (gm)** | | | | | | | | | |
| $EC_{iw}$ <4 | 0.82 | 0.87 | 0.91 | 0.84 | 0.81 | 0.75 | 0.76 | 0.83 | 0.82 |
| $EC_{iw}$ >7 | 0.77 | 0.74 | 0.82 | 0.92 | 0.97 | 0.88 | 0.83 | 0.85 | 0.85 |
| Mean | 0.80 | 0.80 | 0.86 | 0.88 | 0.89 | 0.82 | 0.79 | 0.84 | |
| **Weight of seeds/umbel (gm)** | | | | | | | | | |
| $EC_{iw}$ <4 | 2.00 | 2.34 | 2.21 | 2.24 | 2.70 | 2.36 | 2.18 | 2.49 | 2.32a |
| $EC_{iw}$ >7 | 1.89 | 1.78 | 2.22 | 2.18 | 2.96 | 2.72 | 2.24 | 2.55 | 2.32a |
| Mean | 1.95a | 2.06ab | 2.21abc | 2.21abc | 2.83d | 2.54bcd | 2.21abc | 2.52bcd | |
| **Seed yield (t $ha^{-1}$)** | | | | | | | | | |
| $EC_{iw}$ <4 | 1.44 | 1.61 | 1.48 | 1.37 | 1.44 | 1.47 | 1.43 | 1.48 | 1.46 |
| $EC_{iw}$ >7 | 1.54 | 1.60 | 1.48 | 1.53 | 1.42 | 1.56 | 1.30 | 1.57 | 1.50 |
| Mean | 1.49 | 1.60 | 1.48 | 1.45 | 1.43 | 1.51 | 1.36 | 1.52 | |

Values denoted by same letters are non significant at p=0.05

$T_1$:100% Inorganic fertilizer $T_2$: Inorganic + organic inputs (50:50), $T_3$: 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).

**Optimizing Zinc and Iron Requirement of Pearlmillet-Mustard Cropping System in Salt Affected Soil** (B.L. Meena, Parveen Kumar, Ashwani Kumar and S.K. Ambast)

Pearl millet [*Pennisetum glaucum* (L.)]-mustard [*Brassica juncea* (L.)] is one of the predominant cropping systems in arid and semi-arid regions of Indo-Gangetic plains. In general, these soils are alkaline in reaction, coarse in texture, high in carbonates and low in organic matter. Soil salinity and sodicity are largely responsible for low productivity of pearl millet as well as mustard in these soils which are often deficient in micronutrients especially zinc (Zn) and iron (Fe). Hence, nutrient management has been identified as one of the critical constraints limiting productivity of pearl millet- mustard cropping system in sub soils. With this consideration, a field experiment was continued at Nain research farm in 2013-14 under pearl millet-mustard cropping system to optimize the Zn and Fe requirement. The experiment was conducted with 12 treatments replicated thrice in RBD. The details of the treatments are given in Table 107. Zinc and iron were applied by $ZnSO_4.7H_2O$ and $FeSO_4$ $7H_2O$, respectively at the time of sowing. Zn and Fe were applied through foliar sprays at 30 and 45 days after sowing. The results indicated that application of 5 kg Zn+10 kg Fe +10 t FYM ($T_9$) increased the seed yield of mustard and pearl millet by 44.3 and 58% as compared to control, whereas application of 5 kg Zn+10 kg Fe without FYM ($T_8$) increased the seed yield of mustard and grain yield pearl millet by 22.8 and 35.9 per cent, respectively over control.

**Table 107 : Effect on zinc and iron applications methods on yield of pearl millet and mustard**

| Treatment | Pearl millet | | Mustard | |
|---|---|---|---|---|
| | Grain yield (t $ha^{-1}$) | Stover yield (t $ha^{-1}$) | Seed yield (t $ha^{-1}$) | Stover yield (t $ha^{-1}$) |
| $T_1$ - Control | 2.36 | 5.44 | 1.57 | 5.51 |
| $T_2$ -5 kg Zn | 2.70 | 6.33 | 1.65 | 6.05 |
| $T_3$ -6.25 kg Zn | 2.91 | 7.26 | 1.81 | 6.61 |
| $T_4$ -7.5 kg Zn | 3.13 | 7.86 | 1.94 | 7.14 |
| $T_5$ -7.5 kg Fe | 2.63 | 6.49 | 1.71 | 5.96 |
| $T_6$ -10 kg Fe | 2.86 | 7.08 | 1.79 | 6.23 |
| $T_7$ -12.5 kg Fe | 3.03 | 7.76 | 1.84 | 7.07 |
| $T_8$ -5 kg Zn+10 kg Fe | 3.21 | 7.76 | 1.92 | 7.90 |
| $T_9$ -5 kg Zn+10 kg Fe + 10 t FYM | 3.73 | 9.26 | 2.26 | 8.50 |
| $T_{10}$ - Foliar sprays of 0.5% $ZnSO_4$ (twice) | 2.45 | 5.92 | 1.64 | 5.86 |
| $T_{11}$ - Foliar sprays of 1% $FeSO_4$ (twice at 30 and 45 days) | 2.73 | 6.46 | 1.67 | 6.00 |
| $T_{12}$ - Combined foliar sprays (0.5% $ZnSO_4$+ 1% $FeSO_4$; twice) | 2.81 | 6.82 | 1.70 | 6.16 |
| CD (P=0.05) | 0.06 | 0.08 | 0.24 | 0.61 |


*Performance of pearl millet and mustard grown at Nain farm*

## Performance of Groundnut under Saline Water through Drip Irrigation System (Bapatla)

The experiment was conducted on sandy loam soils of pH 7.5 and EC 0.5 dS $m^{-1}$ at Bapatla during *rabi* 2013-14. The results revealed that the maximum pod yield of groundnut (cv Kadiri 7) was recorded to be 1.52 t $ha^{-1}$ which was at par with Kadiri 6 (1.24 t $ha^{-1}$.) and lowest pod yield of 1.21 t $ha^{-1}$ was recorded with variety Anantha. Among salinity levels, the highest pod yield (1.73 t $ha^{-1}$) was recorded with BAW and it was significantly superior as compared to EC 6 and 8 dS $m^{-1}$ irrigation water. Groundnut produced the optimum pod yield of 1.41 t $ha^{-1}$ with $EC_{iw}$ 4 dS $m^{-1}$ (Table 108). Further increase in the salinity level reduced the pod yield of groundnut significantly.


*Micro drip saline water irrigation to Groundnut*

**Table 108 : Groundnut as influenced by saline irrigation water through drip system**

| | Plant height (cm) | Pod Yield (t $ha^{-1}$) | Stover Yield (t $ha^{-1}$) | Oil content (%) |
|---|---|---|---|---|
| **Varieties** | | | | |
| Anantha | 17.87 | 1.21 | 2.43 | 45.05 |
| Kadiri 6 | 23.42 | 1.24 | 2.56 | 46.14 |
| Kadiri 7 | 24.15 | 1.52 | 2.74 | 38.09 |
| CD (0.05) | 1.40 | 1.02 | 0.12 | 0.36 |
| **Salinity of water** | | | | |
| BAW | 26.54 | 1.73 | 3.23 | 47.38 |
| 2 dS $m^{-1}$ | 24.42 | 1.53 | 2.95 | 45.25 |
| 4 dS $m^{-1}$ | 23.13 | 1.41 | 2.77 | 43.85 |
| 6 dS $m^{-1}$ | 18.58 | 1.05 | 2.08 | 41.26 |
| 8 dS $m^{-1}$ | 16.42 | 0.89 | 1.86 | 37.75 |
| CD (0.05) | 1.65 | 0.02 | 0.19 | 0.36 |

## Evaluation of Controlled Drainage System (CDS) in Vertisols of TBP Command (Ganagawati)

Maintenance and performance of conventional sub-surface drainage system for reclamation of waterlogged saline soils especially at tail-end of the irrigation command was found difficult as the farmers are compelled to clog the drainage discharge outlets of SSD due to shortage of water at critical crop growth stages. Hence, evaluation of controlled drainage in comparison to conventional SSD system was initiated in an area of 1.4 ha at ARS Gangavathi for reclamation of saline soil, nutrient losses and crop yield. The soil salinity under conventional SSD was 4.27, 5.09, 5.9 and 5.19 dS $m^{-1}$ while in case of controlled drainage system, the average soil salinity was 6.2, 8.34, 11.98 and 13.8 dS $m^{-1}$ at 0-15, 15-30, 30-60 and 60-90 cm depths, respectively (Table 109).

The average drain discharge over the sampling period (84 times sampling during the crop growth) was 2.60 mm/d and 0.79 mm/d in conventional and controlled SSD systems, respectively. Thus, the drain discharge in conventional system was 3.30 times higher over the controlled system. With respect to the average salinity of drainage water, conventional system had higher salinity 3.61 dS $m^{-1}$ as compared to 3.21 dS $m^{-1}$ under controlled SSD system. The salt removal from the soil in conventional drainage system was 4.61 t $ha^{-1}$, this might be due to higher drainage discharge resulting in increased salt removed as compared to controlled drainage system.

Loss of nutrients through drainage discharge is also an important aspect of SSD system. Nutrient losses (nitrate nitrogen, phosphorus and potassium) through drainage water were 21.33, 0.35 and 6.56 kg $ha^{-1}$ under conventional while it was 7.50, 0.02 and 1.19 kg $ha^{-1}$ under controlled SSD system (Table 110). It was indicated that the losses of nutrients especially nitrogen could be higher in case of conventional system as compared to controlled drainage system. There was improvement in grain yields. Though not much difference were observed between conventional and controlled drainage systems, within the system the yield increase during *kharif* 2014 was from 3.84 (prior to SSD) to 4.68 t $ha^{-1}$ and 3.76 (prior to SSD) to 4.58 t $ha^{-1}$, respectively.

**Table 109 : Mean drainage discharge rate, discharge salinity and salt removal under different drainage systems**

| Period | Conventional drainage | | | Controlled drainage | | |
|---|---|---|---|---|---|---|
| | Drain discharge (mm/d) | EC dw (dS $m^{-1}$) | Salt removal (t $ha^{-1}$) | Drain discharge (mm/d) | EC dw (dS $m^{-1}$) | Salt removal (t $ha^{-1}$) |
| Sep.2013 | 2.23 | 3.66 | 1.43 | 0.80 | 3.04 | 0.43 |
| Oct.2013 | 3.26 | 3.43 | 1.93 | 0.77 | 3.05 | 0.39 |
| Nov.2013 | 2.31 | 3.74 | 1.24 | 0.81 | 3.55 | 0.40 |
| Average | 2.60 | 3.61 | 4.60 | 0.79 | 3.21 | 1.22 |

**Table 110 : Nutrient losses (kg $ha^{-1}$) under conventional and controlled drainage systems**

| Period | Nitrogen | | Phosphorous | | Potassium | |
|---|---|---|---|---|---|---|
| | Conventional | Controlled | Conventional | Controlled | Conventional | Controlled |
| Sep.2013 | 4.75 | 2.40 | 0.230 | 0.012 | 2.33 | 0.59 |
| Oct.2013 | 10.89 | 2.98 | 0.087 | 0.006 | 2.81 | 0.36 |
| Nov.2013 | 5.69 | 2.13 | 0.031 | 0.002 | 1.42 | 0.24 |
| Total | 21.33 | 7.50 | 0.35 | 0.02 | 6.56 | 1.19 |


*View of conventional (a) and controlled (b) Sub-Surface Drainage systems*

## Effect of Laser Land Leveling and Conservation Agriculture Practices in Direct Seeded Rice under Saline Vertisols of TBP Command Area (Gangawati)

In recent years, due to delay in canal water release with short supply of water, farmers especially at tail-end, find it difficult to take up second crop of paddy in *rabi*/summer. Hence, the concept of direct seeded rice (DSR) with the advantage of no land preparation, no nursery raising, no transplanting etc is gaining its importance. Due to limited water usage in DSR, waterlogging and soil salinization can be prevented

The experiment was initiated during *kharif* 2013 at Gangawati to know the effect of laser land leveling and conservation agriculture practices on direct seeded rice (DSR) under saline soils. The initial soil salinity ranged between 7.07-9.67 dS $m^{-1}$ and 6.95-9.97 dS $m^{-1}$ at 0-15 and 15-30 cm depth, respectively in DSR plot and 3.85-7.1 dS $m^{-1}$ and 4.5-7.5 dS $m^{-1}$ at 0-15 and 15-30 cm depth, respectively in transplanted rice plot. The salt tolerant variety *viz,* CSR-23 was used as a test crop. The soil salinity after harvest ranged from 4.03-7.25 dS $m^{-1}$ and 5.29-9.63 dS $m^{-1}$ at 0-15 and 15-30 cm depth, respectively in DSR plots and 4.37-7.45 dS $m^{-1}$ and 3.6-5.93 dS $m^{-1}$ at 0-15 and 15-30 cm in transplanted rice plots.

The results indicated that significantly higher grain yield was observed in transplanted rice (4.60

**Table 111 : Grain yield of paddy as influenced by irrigation levels and mulching**

| Irrigation level | Paddy yield (t ha$^{-1}$) | | | Mean |
|---|---|---|---|---|
| | Laser leveling + DSR without mulch | Laser leveling + DSR with mulch | Transplanting | |
| | $M_1$ | $M_2$ | $M_3$ | |
| $S_1$ : ET (1.0) | 1.43 | 1.37 | 4.24 | 2.35 |
| $S_2$: ET (1.5) | 2.69 | 2.56 | 4.74 | 3.33 |
| $S_3$: ET (2.0) | 4.11 | 4.40 | 4.81 | 4.44 |
| **Mean** | **2.74** | **2.78** | **4.60** | |
| CD (0.05) M- 0.94; S-0.72; M X S – 1.25 | | | | |

*Direct seeded rice in saline Vertisols at ARS Gangawati*

t ha$^{-1}$) followed by laser leveling + DSR with mulch (2.78 t ha$^{-1}$) and least in case of laser leveling + DSR without mulch (2.74 t ha$^{-1}$). Among ET levels, the yield was significantly higher in case of paddy irrigated with 2.0 ET (4.44 t ha$^{-1}$) followed by 1.5 ET (3.33 t ha$^{-1}$) and least in case of 1.0 ET (2.35 t ha$^{-1}$). Among $M_1S_1$, $M_1S_2$, $M_2S_1$, $M_2S_2$ and $M_3S_3$ treatments, $M_3S_3$ recorded significantly higher grain yield (4.81 t ha$^{-1}$). The lower grain yields under DSR might be due to slightly higher soil salinity under DSR plots as compared to transplanted rice plots (Table 111).

## Evaluation of Sewage Sludge as a Source of NPK for Pearlmillet-Wheat Rotation Irrigated with Saline Water (Hisar)

Investigations on possible use of sewage sludge and canal/saline water on growth and yield of wheat crop was initiated at Hisar during 2013-14. The treatments comprised of three qualities of irrigation water (canal water, EC 8 and 10 dS m$^{-1}$) in main plots, sewage sludge application (sewage sludge 5 t ha$^{-1}$, sewage sludge 5 t ha$^{-1}$ + 50% RDF, sewage sludge 5 t ha$^{-1}$ + 75% RDF and 100% RDF) in pearl millet-wheat rotation.

The grain yield of wheat (WH- 711) decreased by 4.0 and 8.1 per cent undersaline irrigation (8 and 10 dS m$^{-1}$) as compared to control (Table 112). Grain yield of wheat (WH-711) reduced by 15.6, 8.4 and 4.1 per cent in sewage sludge (5 t ha$^{-1}$), SS 5 t ha$^{-1}$ + 50% RDF and SS 5 t ha$^{-1}$ + 75% RDF as compared to 100% application of RDF.

**Table 112 : Grain yield of wheat irrigated with different saline water and sewage sludge**

| Treatments | Grain yield (t ha$^{-1}$) | | | Mean (t ha$^{-1}$) |
|---|---|---|---|---|
| | Canal | $EC_{iw}$ (8 dS m$^{-1}$) | $EC_{iw}$ (10 dS m$^{-1}$) | |
| Sewage sludge 5 t ha$^{-1}$ | 3.64 | 3.59 | 3.37 | 3.53 |
| Sewage sludge 5 t ha$^{-1}$ + 50% RDF | 4.04 | 3.72 | 3.72 | 3.83 |
| Sewage sludge 5 t ha$^{-1}$ + 75% RDF | 4.13 | 4.08 | 3.81 | 4.01 |
| No Sewage sludge + 100% RDF | 4.39 | 4.17 | 3.97 | 4.18 |
| Mean | 4.05 | 3.89 | 3.72 | |
| CD (0.05) Treatments (T) = 0.17, Salinity (S) = 0.15, T x S = NS | | | | |

# TECHNOLOGY ASSESSED AND TRANSFERRED

**Perceived Climate Variability and Agricultural Adaptations in Sodic Agro-ecosystems of Uttar Pradesh** (Ranjay K. Singh, Parvender Sheoran, Satyendra Kumar, R. Raju and D.K. Sharma

About 1.37 m ha cultivable area in the Uttar Pradesh is affected by sodicity. Again, seepage from canals and climate variability enhance the agricultural vulnerability. More than 84.0 per cent of farmers in UP belong to small and marginal categories. In the past 30 years, climate variability has caused many adverse impacts on agriculture and related activities. Although, the meteorological unit record observations on climate parameters and issue timely advisory to the farmers, farmers have their own perspectives and perception about the climate.

Keeping this fact in mind, the present study was carried out in the Raebareli district of UP with the following objectives: (i) to know the perceptions of farmers on climate variability under sodic social-ecological systems, (ii) to study the impact of climatic variables and socio-economic, and institutional factors that affect adaptive behaviour of farmers, (iii) to identify adaptive agriculture practices based on formal and informal knowledge/ technology employed by farmers, and (iv) to study institutional patterns of adaptive practices. Data were collected using personal interviews, focus group discussions and PRA techniques from 80 farmers of 10 villages in two blocks of Raebareli district. Soil and water samples of studied villages were taken and analyzed in the laboratory for estimating the degree of sodicity and its relation to climate variability and crop management.

*Group discussion with the farmers of village of Rae-Bareily district (UP)*

**Perception of farmers about climate variability**

The data indicated that more than 57 per cent of the farmers perceived that duration of winter has decreased and commencement of winter season has postponed (64.28% response). Similarly, about 57 per cent farmers were of the opinion that duration of summer has increased and summer season as a whole has been pre-ponned as compared to the 1980s. About 67 per cent of the studied farmers perceived that number of rainy days has decreased as compared to 1980s. About 29 per cent of them perceived that the frequency of drought has increased. The secondary data indicated that droughts in 2002 and 2004 were the most serious with heavy losses to crop and livestock assessed at Rs.7540 and Rs. 7292 crores, respectively (NIDM 2014).

The 18th July 2014 was recorded one of the heaviest rainy days (NDTV 18 July 2014). In the last 30 years, rainfall was highly variable as perceived by 58 per cent farmers (Table 113), and the similar observations were recorded for temperature also. The frequency of cyclone has increased as reported by 55 per cent farmers.

In general, weather in recent past has changed (53.0% response) considerably and the farmers are not able to predict it using indigenous bio-meteorological indicators. It was easily done in the past (perceived by 21.4%), while 35.7 per cent of the farmers perceived that bio-meteorological indicators (ant and termite movement, flowerings of mango and *neem*, abnormal behavior of some birds and animals, etc.) are still helpful in predicting weather. In drought years, bamboo flowering is an important local phenomenon as observed by the local farmers

**Table 113 : Perceived changes in climate patterns**

| Trends in past 30 years | Normal (%) | Less/ optimum (%) | High (%) | High variability (%) |
|---|---|---|---|---|
| Rainfall | 08.0 | 28.0 | 06.0 | 58.0 |
| Temperature | 11.0 | 16.50 | 18.50 | 54.0 |
| Cyclone | 27.50 | 17.50 | 55.0 | -- |

## Changes and risks in agriculture

About 35.71 per cent of the farmers said that climate variability did not significantly reduce the crop yield, while 21 per cent of them have refused this view. This might be due to increased irrigation facilities and time awareability of agricultural inputs such as improved varieties, agrochemicals, etc. They perceived that climate variability and interaction of sodicty affected the crop yield. About 64 per cent of the farmers informed that crop production has un-stabilized in recent past and 79 per cent of them reported that climate variability (together with other factors) has caused decline in agro-biodiversity. Frequent and extreme climatic events have reduced the soil fertility (71.43% response) and have adversely affected ground water level in fields away from the canal commands (42.86 % response). About 21 per cent farmers perceived that water quality has also deteriorated.

The climate variability has also caused increasing migration of farmers and labouers (42.86% response), has increased human vulnerability (50% response), cost of cultivation (64.28%) and as a result has increased livelihood risks (45% response).

*Cyclone Hudhud* increased the crop loss by about 30 per cent in low lying and waterlogged areas of eastern UP (The Economic Times Oct 14, 2014), while it saved the crop in upland, un-irrigated landscapes and late maturing rice varieties (yield increased by 15-20%). *Hud-hud* thus saved 2 irrigations (Rs.3000-3500) in study areas (The Business Standard, Oct 13 2014) and provided an opportunity to minimize the use of irrigation water, required energy and labour costs. High climate variability resulted in attack of rice *gundhi* bug (30.0% after the Hudhud in low laying areas in late variety of rice) and *bhund* insect attack by about 85 per cent in low lying and waterlogged areas. Thus, it decreased the market price to produce by 15-20 per cent. During 2014, black gram and sesamum crops failed due to drought stress.

## Adaptation by farmers

The results indicated that 86 per cent of the farmers are adapting the changes in the crop varieties at every 2-3 years. Out of total, 19 per cent farmers were growing CSR 30 in partial sodic soils (pH 7.8-8.8), while 43 per cent grow CSR 36 in the studied villages having relatively high soil pH (8.6-9.3). Rice varieties namely *Ganga Kaveri, Bauni Mansuri* in low lying areas and *Moti, Saryu 52, Dankal, Pakistani Basmati, Damini*, etc. in upland areas were predominately grown. Diversifying cropping/farming systems with animals and agro-forestry and business activities are seen to be new dimension of adaptation.

Lands located in low lying areas and affected by canal seepage are being leased out to the local *Kahar* community who generally grow water chestnut and rear fish. The land owners get Rs. 4000-6000/ha while *Kahar* do cultivate chestnut crop by pooling resources and by creating their knowledge networks and fetch Rs. 12000-14000/ha. From fish, they earn Rs. 15,000-20,000/ha. The low productivity of these waterlogged areas is due to lack of outlet filtering/monitoring structures for fish raring and casual adaptation of fish practice without any scientific management.

Some farmers have adopted multi-enterprise model in sodic soils which have seepage as major problem. For example, a farmer of village Kasrawan was assisted by the CSSRI RRS, Lucknow to adopt this model. The farmer, having 0.4 ha land, grew bottle guard, pumpkin, ladyfinger, banana, colocassia and foot-yam (6 species) in summer, while he cultivated water-chestnut (*Singhada)* in rainy season and thus

*Attack of Bhund insect on rice crop in low lying areas having high humidity*

*Mr Shivbaran Chaudhary of village Bahadur Nagar of Bachhrawan block with tomato crop*

*Kahar community managed water chestnut crop in village Kasrawan of Bachhrawan block*

maintained ecological and livelihood resilience. He earned Rs. 15000 from water chestnut and Rs. 40,000-50,000 from the multi-enterprise model. Those who do not have supportable land holding have become beneficiaries under MGNREGA (79.80%), have migrated as livelihood adaption strategy (72.18%) and have benefited from the PDS system (68.0%). Giving land on *Adhiya* (22.5%) and leasing out (36.0%) and leasing in (21.5%) were the main institutional strategies of adaptation among the farmers.

It was concluded that the problem of agricultural vulnerability caused by climate variability was further aggravated due to other stresses of ecological, socio-economic, institutional and policy dimensions. Adaptation was learned to be a highly location specific and behavioral affair. In majority, adaptations were casual and reactive in nature. Types of crop and related varieties were very much affected by sodicty and reclamation measures undertaken by state government. The agricultural adaptation in Raebareli district was learned to be very much influenced by the economic status of the farmers. The social systems, timely communication about extreme events

*Mr Prem Kumar Verma in Kasrawan village of Bachhrawan block with his multi-enterprise model*

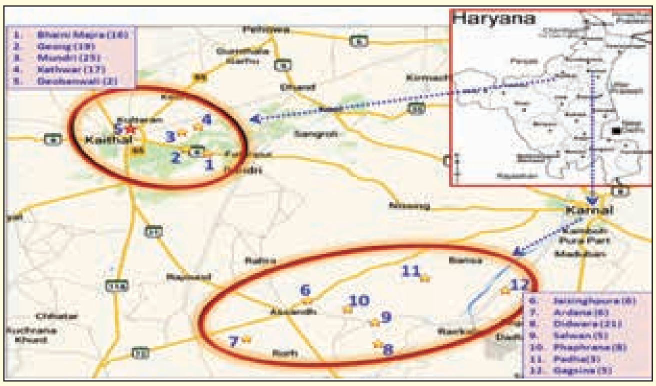
(e.g. sowing of early potato was delayed after getting the news of Nilofar cyclone), livelihood diversity and welfare schemes of central and state governments were observed to be determinant in adaptation processes.

## Improving Farm Productivity through Sustainable Use of Alkali Waters at Farmer's Field in Rice-Wheat Production System (Parvender Sheoran, R.K. Yadav, Nirmalendu Basak, Satyendra Kumar, K. Thimmappa and Ranjay K. Singh)

Continuous use of poor quality (sodic) ground water would result in build up of higher proportion of exchangeable sodium ions in the root zone and it would limit the land and crop productivity. Improved technological interventions through appropriate selection of crops and crop cultivars and irrigation water management could be the possible alternative options that might help to ameliorate the existing or predicted conditions of sodicity for harvesting satisfactory yields. The sodicity of the irrigation waters can be neutralized with chemical/organic amendments (gypsum, pressmud and FYM) for preventing the build up of salt load in soil-water system as well as to minimize their adverse effects on crop growth. With this consideration, a field experiment was initiated at farmers' fields to study the performance of management strategies for neutralization and sustained use of sodic waters in rice-wheat cropping system.

### Site selection

Field diagnostic surveys were conducted in May 2014. A total of 133 water samples from 12 villages in two districts (Karnal and Kaithal) were collected and analyzed for water quality parameters. About 83 per cent (76.7% of high RSC and 6.0% saline)




*Map showing the village sites for collection of water samples*

**Table 114 : Water quality analysis of experimental site (s)**

| Site | Motor capacity (HP) | Tubewell depth (feet) | $Ca^{2+} + Mg^{2+}$ (me $l^{-1}$) | $CO_3^{2-}$ (me $l^{-1}$) | $HCO_3^{2-}$ (me $l^{-1}$) | RSC (me $l^{-1}$) | pH | EC (dS $m^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| Site I | 12.5 | 325 | 3.80 | - | 10.73 | 6.93 | 7.48 | 1.32 |
| Site II | 15.0 | 370 | 0.93 | - | 6.10 | 5.13 | 7.56 | 1.12 |


*Actual ground position of the selected sites*

water samples were found to be of poor quality. Based on the survey reports, two sites at village Mundri, District Kaithal were selected for the experimental purpose. The water quality and initial soil analysis of the experimental sites are given in Table 114.

A field experiment was conducted with two replications having $RSC_{iw}$≈7.0 and 5.0 me $l^{-1}$. Two varieties of rice (CSR 30 Basmati/Pusa 1121) were grown with four sodic water neutralization treatments viz., $T_1$-RSC water; $T_2$- $T_1$ + gypsum @ 7.5 t $ha^{-1}$; $T_3$- $T_1$ + Pressmud @ 10 t $ha^{-1}$; $T_4$- $T_1$ $_+$ gypsum @ 3.75 t $ha^{-1}$ + pressmud @ 5 t $ha^{-1}$. The cultural practices were followed as per crop recommendations.

Irrespective of the dose and source of neutralization treatment for applied irrigation water, rice variety Pusa 1121 recorded 15.6 per cent (0.41 t $ha^{-1}$) higher yield over CSR 30 Basmati (Table 115). It was also observed that with the increase in $RSC_{iw}$ from 5.0 $l^{-1}$ (Site II) to 7.0 me $l^{-1}$ (Site I), the performance of basmati CSR 30 was relatively better than Pusa 1211. Secondly, higher tiller sterility (13.8%) was recorded in Pusa 1121 in comparison to CSR 30 Basmati (2.3%). Neutralization of RSC of irrigation water through different amendments (gypsum/pressmud) either individually or in combination recorded 8.5-10.6 per cent higher rice yield as compared to crop irrigated with available RSC waters. Application of amendments also helped in reduction of soil pH.

**Table 115 : Interactive effects of $RSC_{iw}$ neutralization treatments and genotypes on the rice yield at two locations**

| Treatments | Grain yield (t $ha^{-1}$) | | | |
|---|---|---|---|---|
| | Site I (RSC-7.0) | | Site II (RSC - 5.0) | |
| | CSR 30 | Pusa 1121 | CSR 30 | Pusa 1121 |
| RSC water | 2.25 | 2.51 | 2.56 | 3.09 |
| Gyp @ 7.5 t $ha^{-1}$ | 2.48 | 2.73 | 2.73 | 3.32 |
| PM @ 10 t $ha^{-1}$ | 2.49 | 2.77 | 2.80 | 3.38 |
| Gyp @ 3.75 t $ha^{-1}$ + PM @ 5 t $ha^{-1}$ | 2.54 | 2.79 | 2.82 | 3.37 |

## 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)

Sodicity is a serious problem in Uttar Pradesh and sodic soils occupy 1.37 m ha area, which is 5.68 per cent of the total geographical area of the state. Rice and wheat are the principal crops of the state. An intensive study was conducted in Santaraha village of Uttar Pradesh. Temperature in summer goes as high as 44 °C and in winter comes down to 4°C. Annual rainfall varied from 629 to 818 mm (June-September). The average land holding size was 0.62 ha and majority of the farmers were of marginal category. The crop production was an important activity contributing 68 per cent to the total household income. Many farmers (27%) supplemented their household income by engaging themselves or their family members as farm labourers. Transplanted rice (*Oryza sativa*) was most popular in *kharif* and wheat (*Triticum aestivum*) in *rabi* season. In moderately sodic soils, rice was grown in *kharif* season but land remained fallow in *rabi* season. No crop was grown in severe soil sodicity condition.

Soil samples were analyzed in pre and post reclamation periods to know the extent of reduction in soil pH and ESP. Soil pH varied from 8.9 to 10.3 and ESP from 31 to 85 in pre-reclamation period. Results indicated that amendments (25% GRV + 10 tones of press mud) improved the soil properties in two years of reclamation when compared with pre-reclamation period. The soil pH was reduced by 8.09, 8.82 and 11.75% under slight, moderate and severe sodicity conditions, respectively, in post-reclamation period. Similarly, as compared to pre-reclamation period, addition of amendments reduced the ESP by 67.6 to 82.7 per cent indicating remarkable reduction in sodicity level.

The average cropping intensity during 2009-2012 was 122.93 per cent. The cropping intensity in *rabi* season was low (47.95%) in pre-reclamation period as land under moderate and severe categories were left fallow due to high sodicity. In post-reclamation period, all degraded lands in pre-reclamation period were put under cultivation. Hence, the cropping intensity increased from 122.9 to 199.5 per cent in post-reclamation period.

The yield loss was detrimental at a local scale because salt-affected soils were not uniformly distributed. The degree of sodicity varied across the farms within the village. It was observed that the salt concentration in soil has significantly reduced the crop yield (Table 116). In normal soils, the rice yield was 4.87 t ha$^{-1}$ whereas in slightly sodic soils, it was 2.95 t ha$^{-1}$ (39.43% decline). The yield was drastically reduced (74.95%) in moderately sodic soil. Similarly, wheat yield decreased from 3.65 to 2.82 t ha$^{-1}$ in slightly sodic soil as compared to normal soil.

Rice-wheat rotation is most common in the Indo-Gangetic plains. Before reclamation, the productivity of rice was 2.95 t ha$^{-1}$ in slight sodic soils whereas 1.22 t ha$^{-1}$ in moderately sodic lands. The productivity of rice increased to 4.71 t ha$^{-1}$ in slightly sodic soils (60%) in post reclamation period. In moderately sodic soils, rice productivity increased to 4.40 t ha$^{-1}$ (261%). In severely sodic soils, rice productivity was 3.90 t ha$^{-1}$ in post reclamation period which was barren during pre-reclamation period.

Wheat productivity increased from 2.82 to 3.49 t ha$^{-1}$ in slightly sodic land in post-reclamation period. The wheat yield was 3.17 t ha$^{-1}$ in moderate and 2.75 t ha$^{-1}$in severely sodic land in post-reclamation period. The yield gain was highest (100%) in moderate and severely sodic soils and 24

**Table 116 : Average yield (t ha$^{-1}$) of rice and wheat in different sodicity classes**

| | Soil sodicity class | | | |
|---|---|---|---|---|
| | Normal | Slight | Moderate | Severe |
| **Rice crop** | | | | |
| **Pre -reclamation** | | | | |
| 2009 - 2010 | 4.85 | 2.96 | 1.21 | 0 |
| 2010 - 2011 | 4.89 | 2.97 | 1.25 | 0 |
| 2011 - 2012 | 4.88 | 2.93 | 1.20 | 0 |
| Average | 4.87 | 2.95 | 1.22 | 0 |
| Yield loss (%) | - | 39.43 | 74.95 | 100 |
| **Post -reclamation** | | | | |
| 2012-2013 | 4.96 | 4.66 | 4.35 | 3.88 |
| 2013-2014 | 4.97 | 4.75 | 4.44 | 3.92 |
| Average | 4.97 | 4.71 | 4.40 | 3.90 |
| Yield loss (%) | - | 5.24 | 11.48 | 21.45 |
| **Wheat crop** | | | | |
| **Pre -reclamation** | | | | |
| 2009 - 2010 | 3.65 | 2.82 | 0 | 0 |
| 2010 - 2011 | 3.66 | 2.86 | 0 | 0 |
| 2011 - 2012 | 3.65 | 2.79 | 0 | 0 |
| Average | 3.65 | 2.82 | 0 | 0 |
| Yield loss (%) | - | 22.74 | 100 | 100 |
| **Post -reclamation** | | | | |
| 2012-2013 | 3.67 | 3.43 | 3.02 | 2.63 |
| 2013-2014 | 3.81 | 3.54 | 3.32 | 2.86 |
| Average | 3.74 | 3.49 | 3.17 | 2.75 |
| Yield loss (%) | - | 6.82 | 15.24 | 26.60 |

Note: In pre-reclamation period, the severely sodic lands were left fallow in both the seasons and no wheat cultivation was done in moderately sodic lands in *rabi* season.

per cent in slightly sodic soils. The rice yield losses ranged from 39 to 100 per cent in pre-reclamation period as compared with normal lands. The yield losses were reduced from 5-21 per cent in post-reclamation period. Similarly, wheat yield losses varied from 23 to 100 per cent in pre-reclamation period. The losses were substantially reduced from 7 to 27 per cent after reclamation.

Rice (*kharif*) and wheat (*rabi*) production costs and returns were estimated for each sodicity class

**Table 117 : Costs and returns (Rs/ha) per season**

| Sodicity class | Gross return | | Total cost | | Net returns | | Total net returns |
|---|---|---|---|---|---|---|---|
| | *Kharif* | *Rabi* | *Kharif* | *Rabi* | *Kharif* | *Rabi* | |
| **Pre-reclamation period** | | | | | | | |
| Normal | 77290 | 58320 | 41715 | 34614 | 35575 | 23706 | 59281 |
| Slight | 47120 | 45032 | 40351 | 31707 | 6769 | 13324 | 20094 |
| Moderate | 19470 | - | 37597 | - | -18127 | - | -18127 |
| **Post-reclamation period** | | | | | | | |
| Normal | 79278 | 59740 | 44442 | 34396 | 34836 | 25344 | 60180 |
| Slight | 75143 | 55548 | 44366 | 33732 | 30777 | 21815 | 52592 |
| Moderate | 68958 | 50670 | 44214 | 33088 | 24743 | 17582 | 42325 |
| Severe | 62275 | 43558 | 42964 | 31342 | 19311 | 12216 | 31527 |

Note: Moderate sodicity category lands were kept fallow only in *rabi* season. Severe sodicity category lands were kept fallow in both the seasons.

(Table 117). The net income from slightly sodic land class was lower (Rs. 6769/ha) as compared to the normal land (Rs. 35575/ha) during *kharif* season (a loss of 81 %). The farmers incurred income loss of Rs. 18127/ha in moderately sodic soils class. In *rabi* season, decline in the net income was 44 per cent in slight soil sodicity class whereas the moderate sodicity affected lands were kept fallow.

The total net return was Rs.20094/ha in slight soil sodicity category in pre-reclamation period and increased to Rs. 52592/ha in post-reclamation period, indicating a gain of 162 per cent. Farmers incurred income loss in moderate soil sodicity category during pre-reclamation period and income increased to Rs. 42325/ha after reclamation. The increased crop productivity contributed to higher net income across the soil sodicity categories. In the severe soil sodicity category, net income was Rs. 31527/ha which was left fallow in pre-reclamation period. Hence, reclamation of degraded sodic land made a remarkable positive impact on crop productivity and farm income.

## Performance Evaluation of Subsurface Drainage Systems in Haryana (R. Raju, R.S. Tripathi, Parveen Kumar, Satyendra Kumar, K. Thimmappa)

Waterlogging and soil salinity are threatening the sustainability of agricultural production in approximately 0.5 m ha area in the state of Haryana. Subsurface drainage (SSD) technology helps lower down the water table and promotes the salt leaching process. Subsurface drainage systems were installed in different locations of Haryana about 9000 ha area especially in Western Yamuna and Bhakra command areas. To assess the socio-economic impact of SSD technology, the present study was carried out with the following objectives: 1) to study the characteristics of groundwater table and drainage outflow to assess the performance of subsurface drainage systems in Haryana; 2) to compare economic performance of crops grown and estimate input use efficiency for farm enterprises with and without drainage situations.

### Study area

The study was carried out in subsurface drainage area of village Banmandori located in Bhattu block of Fatehabad district in Haryana (Fig. 95). Bhakra and Western Yamuna are the two major canals which irrigate most part of the district. The average rainfall of the district is 400 mm. The extensive canal irrigation introduced by the Bhakra Nangal project has caused rapid changes

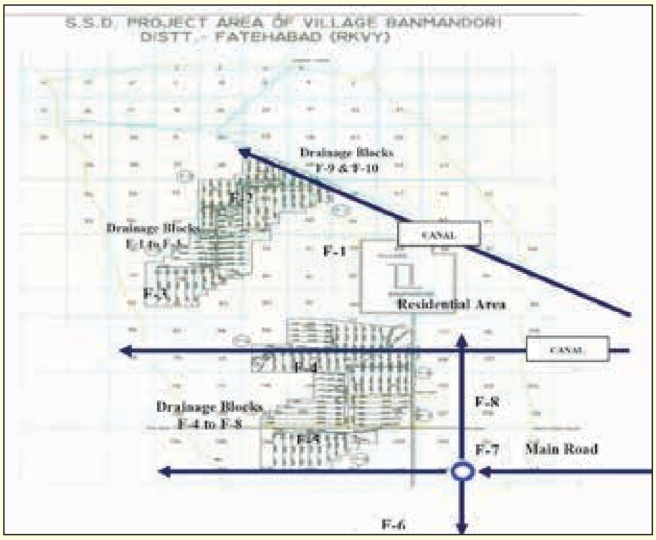



*Fig. 95: Layout of subsurface drainage area in Banmandori*

in water table configuration. The ground water is saline and unfit for domestic consumption as well as for agricultural use.

## Salient features of subsurface drainage area

The block wise area, number of farmers covered and other details are given in Table 118. The total area under subsurface drainage is 277 ha, which covers 152 farmers. The subsurface drainage area was divided into ten blocks, with each block covering 16.5 to 52 ha area. Each drainage block had one sump and 1 to 4 manholes, depending on the size and structure of the drainage area. At present, only six pump houses were constructed for six blocks. During the study period, only one drainage blocks (no. F-3) was functioning and other nine blocks were not functioning (other blocks functioned for only a week in September 2013, when HOPP provided initial 170 litre diesel as per the provision). The salient features of subsurface drainage system installed at Banmandori are presented in Table 119.

**Table 118 : Blockwise area under subsurface drainage in Banmandori project area**

<table>
<tr><th>Drainage blocks</th><th>Total area (ha)</th><th>No. of farmers covered</th><th>Sump</th><th>Manholes</th><th>Pump house constructed</th><th>Pumps provided</th><th>Remarks</th></tr>
<tr><td>F-1</td><td>28</td><td>8</td><td>1</td><td>2</td><td>No</td><td>1</td><td>NF</td></tr>
<tr><td>F-2</td><td>23</td><td>9</td><td>1</td><td>3</td><td>No</td><td>1</td><td>NF</td></tr>
<tr><td>F-3</td><td>49</td><td>23</td><td>1</td><td>4</td><td>1</td><td>1</td><td>Functioning</td></tr>
<tr><td>F-4</td><td>52</td><td>27</td><td>1</td><td>3</td><td>1</td><td>1</td><td>NF</td></tr>
<tr><td>F-5</td><td>26</td><td>14</td><td>1</td><td>2</td><td>1</td><td>1</td><td>NF</td></tr>
<tr><td>F-6</td><td>30</td><td>6</td><td>1</td><td>2</td><td>1</td><td>No</td><td>NF</td></tr>
<tr><td>F-7</td><td>16.5</td><td>18</td><td>1</td><td>1</td><td>1</td><td>1</td><td>NF</td></tr>
<tr><td>F-8</td><td>23</td><td>20</td><td>1</td><td>1</td><td>1</td><td>No</td><td>NF</td></tr>
<tr><td>F-9</td><td rowspan="2">29.5</td><td rowspan="2">27</td><td>1</td><td>2</td><td>No</td><td>No</td><td>NF</td></tr>
<tr><td>F-10</td><td>1</td><td>4</td><td>No</td><td>No</td><td>NF</td></tr>
<tr><td>Total</td><td>277</td><td>152</td><td>10</td><td>24</td><td>6</td><td>6</td><td></td></tr>
</table>

NF=Not functioning

**Table 119 : Salient features of subsurface drainage system**

| Parameters | Description |
|---|---|
| Area under subsurface drainage (ha) | 277 |
| Total farmers (beneficiaries) covered | 152 |
| Type of drainage system | Pipe drainage with pumped outlet |
| Design drainage discharge | 1 mm/day |
| Drain depth (m) | 1.3-1.5 |
| Drain spacing (m) | 60 or 67 |
| Size of laterals (mm) | 80 |
| Length of lateral pipes (m) | 16087 |
| Size of collector pipes (mm) | 160-200 |
| Length of collector pipes (m) | 4536 |
| Total blocks (Sumps) | 10 |
| Years of installation | 2009-10 (80ha), 2010-11 (117ha) & 2011-12 (80ha) |
| Approximate cost of installation (Rs./ha) | 58000 |

## Cropping pattern and cropping intensity

The cropping pattern and cropping intensity of village Banmandori were worked out based on average value of crop from 2006 to 2013. During *kharif* season, cotton was the major crop occuring 40 to 58 per cent area. Guar was the next major crop and it occupied 15 to 25 per cent area followed by rice which occupied 10 to 21 per cent area. Bajra, groundnut, fodder and moong were other prominent *kharif* crops. During *rabi* season, wheat was the major crop covering 68 to 76 per cent area and mustard was the next major crop with 13 to 16 per cent area. Barley, oat, berseem and castor were other *rabi* season crops.The cropping intensity of *kharif* and *rabi* season were 83-93 percent and 85-93 per cent, respectively. The overall cropping intensity was 171 to 185 per cent.

## Rainfall of Fatehabad District

The rainfall pattern of the district from 1997 to 2013 is presented in Fig. 96. The average annual rainfall of the district was 312 mm. The highest rainfall of 690 and 790 mm was received during 1997 and 1998, respectively. After 1999, there was a lot of variation in the annual rainfall, which caused variations in cropping patterns as well as cropping intensity in the region.

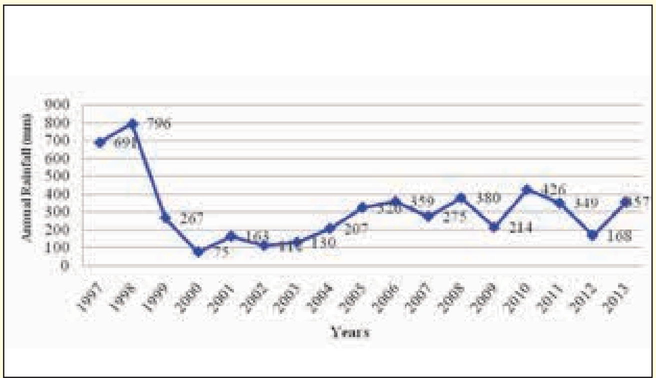



*Fig. 96: Annual rainfall of Fatehabad District (1997 to 2013)*

## Water table depth, salinity and pH of drained water

The water table depth was measured during the critical months of April/May, August/September and October/November for the years 2011 to 2014. Simultaneously, the drainage water samples were collected and analysed to know the quality of the ground water with respect to salinity and pH. The mean water table depths for 2011, 2012, 2013 and 2014 were recorded to be 0.53, 0.72, 0.58 and 0.86 m, respectively. The depth of the water table varies among the drainage blocks depending on the slope of the area. In general, the water table depth was dependent on the rainfall. It was observed that water table depth was very high during rainy season and very low during summer season.

Before installation of subsurface drainage, the water table was around 0.5 to 1.0 m below the ground level (as given by HOPP). It was noted that in some areas water table was less than 0.5 m which caused problems of waterlogging and salinity. The drainage water salinity ranged from 15 to 16 dS $m^{-1}$ during 2007 (before installation of subsurface drainage). After installation of subsurface drainage, the mean drain water salinity for the year 2011, 2012, 2013 and 2014 was 10.88, 10.52, 10.17 and 8.30, respectively. The overall salinity of drained water was decreased during the study period but there was no clear trend observed among the different drainage blocks. The pH of the drain water was in the normal range and has no negative impact on crop growth.

## Soil salinity (EC)

The soil samples were collected after the harvest of *kharif* (November) and *rabi* (May) crops and were analysed for estimating the salinity status. The block wise and season wise salinity were measured for the period 2011 to 2014. The lowest and highest soil salinities of 8.2 and 10.8 dS $m^{-1}$ was observed during November 2011 and May 2012, respectively. It was also observed that the salinity varied among different blocks in the study area. Some blocks had soil salinity as low as 1.3 dS $m^{-1}$ (Block F-9 in May 2014) while some had salinity as high as 27.56 dS $m^{-1}$ (Block F-5 in November 2014). In terms of salinity classes, block No. F-4 and F-5 were severely affected with salinity above 16 dS $m^{-1}$ and block No. F-6 and F-7 were highly affected by salinity of 8-16 dS $m^{-1}$. The block No. F-1, F-2, F-3 and F-10 were moderately affected by salinity (4-8 dS $m^{-1}$). Since, the subsurface drainage was functioning in block No. F-3, the soil salinity was stable around 4-5 dS $m^{-1}$.

**Table 119 : Comparison of soil salinity and pH with and without SSD in Block No. F-3**

| Particulars | ECe (dS $m^{-1}$) | | | pH | | |
|---|---|---|---|---|---|---|
| | With drainage | Without drainage | Percent difference | With drainage | Without drainage | Percent difference |
| Nov-11 | 4.60 | 7.69 | 67.17 | 8.49 | 8.59 | 1.18 |
| May-12 | 4.96 | 10.68 | 115.32 | 7.99 | 8.27 | 3.50 |
| Nov-12 | 4.63 | 8.91 | 92.44 | 8.24 | 8.28 | 0.49 |
| May-13 | 5.00 | 7.12 | 42.40 | 8.05 | 8.15 | 1.24 |
| Nov-13 | 4.86 | 8.23 | 69.34 | 8.22 | 8.42 | 2.43 |
| May-14 | 5.02 | 9.95 | 98.21 | 8.24 | 8.33 | 1.09 |

Note : $EC_e$ of soil before drainage was around 15 dS $m^{-1}$ (collected from HOPP office)

The subsurface drainage system was functioning only in block No. F-3. Therefore, soil salinity of this block was measured and compared with no drainage system in the adjacent area (Table 119). It was observed that in block No. F-3, soil salinity was stable (ECe 4-5 dS $m^{-1}$) whereas without subsurface drainage, soil salinity was high to very high (7-11 dS $m^{-1}$ ) during the study period.

## Yield of major crops before and after installation of subsurface drainage

Cotton and rice was the major *kharif* while wheat and mustard were the major *rabi* crops of the project area. The yield data was obtained through crop cutting experiments in the selected plots. Soil samples were also collected from these plots. The year wise crop performances were compared before and after the installation of subsurface drainage as well as with and without subsurface drainage.

The block wise yield performance of rice, wheat and cotton crop is presented in Table 120. Before installation of subsurface drainage, the average yield of rice, wheat and cotton were 1.06, 1.25 and 0.56 t $ha^{-1}$, respectively but after subsurface drainage, the yield was increased to 1.42 t $ha^{-1}$ for rice, 1.85 t $ha^{-1}$ for wheat and 7.76 t $ha^{-1}$ of cotton. Before installation of subsurface drainage, Block No. F-4 to F-7 were much affected by waterlogging and soil salinity and even after installation of subsurface drainage, the situation remained same as the system was not functioning in these blocks, and hence much improvement was not observed in the yield before and after subsurface drainage. These blocks came under low lying areas and due to non-functioning of the system, the area under these blocks was more affected than before. The block No. F-3 was the worst affected before subsurface drainage but after installation, more than two fold increase in yield was observed. Due to functioning of subsurface drainage, only this block has showed an increasing trend in yield over the years for all the crops. The block No. F-1, F-2, and F-8 to F-10 were although affected by waterlogging and soil salinity, significant improvement in crop yield was noted in these blocks after installation of subsurface drainage.

## Yield and B:C ratio of major crops with and without subsurface drainage in block No. F-3

The yield of major crops obtained in soil having subsurface drainage was compared with the yield obtained without subsurface drainage in block No. F-3 as this was the only block where the system was functioning. The average yields obtained with subsurface drainage were 2.24, 1.06, 3.39 and 0.81 t $ha^{-1}$, respectively for rice, cotton, wheat and mustard crops during the study period. In general, there was 12-20 per cent increase in yield with subsurface drainage as compared to fields without subsurface drainage. The benefit : cost ratio was estimated for major crops of the study area as shown in Table 121. The B:C ratio for rice in drainage and non-drainage area was 1.46 and 1.30, respectively. The least benefit cost ratio was obtained

**Table 120 : Yield of major crops before and after subsurface drainage**

| Block No. | Before SSD yield (t $ha^{-1}$) | | | *After SSD yield (t $ha^{-1}$) | | |
|---|---|---|---|---|---|---|
| | Rice | Wheat | Cotton | Rice | Wheat | Cotton |
| F-1 | 1.28 | 1.55 | 0.82 | 1.62 | 1.99 | 1.10 |
| F-2 | 1.16 | 1.60 | 0.92 | 1.75 | 2.16 | 1.36 |
| F-3 | 0.90 | 1.23 | 0.48 | 2.24 | 3.39 | 1.06 |
| F-4 | 0.92 | 1.16 | 0.36 | 1.08 | 1.32 | 0.55 |
| F-5 | 0.81 | 0.95 | 0.43 | 0.77 | 1.31 | 0.42 |
| F-6 | 0.88 | 1.00 | 0.48 | 0.90 | 1.19 | 0.50 |
| F-7 | 1.10 | 1.11 | 0.39 | 1.13 | 1.58 | 0.44 |
| F-8 | 1.26 | 1.20 | 0.67 | 1.81 | 2.29 | 0.85 |
| F-9 | 1.13 | 1.33 | 0.52 | 1.35 | 1.65 | 0.74 |
| F-10 | 1.20 | 1.43 | 0.55 | 1.56 | 1.63 | 0.73 |
| Mean | 1.06 | 1.26 | 0.56 | 1.42 | 1.85 | 0.78 |
| Minimum | 0.81 | 0.95 | 0.36 | 0.77 | 1.19 | 0.42 |
| Maximum | 1.28 | 1.60 | 0.90 | 2.24 | 3.39 | 1.36 |

*Mean value of three years 2011-12, 2012-13 and 2013-14*

**Table 121: Yield performance and B:C ratio of major crops with and without SSD (Block No. F-3)**

| Year | Yield (t $ha^{-1}$) | | | B:C ratio | | |
|---|---|---|---|---|---|---|
| | With SSD | Without SSD | % difference | With SSD | Without SSD | % difference |
| **Rice** | | | | | | |
| 2011 | 2.22 | 2.07 | 7.18 | 1.25 | 1.08 | 16.18 |
| 2012 | 2.16 | 1.96 | 10.38 | 1.33 | 1.12 | 17.99 |
| 2013 | 2.33 | 1.99 | 17.20 | 1.80 | 1.68 | 7.09 |
| Average | 2.24 | 2.01 | 11.59 | 1.46 | 1.30 | 12.58 |
| **Cotton** | | | | | | |
| 2011 | 0.79 | 0.72 | 10.74 | 1.06 | 0.99 | 7.24 |
| 2012 | 1.11 | 0.93 | 19.57 | 1.20 | 1.12 | 7.31 |
| 2013 | 1.29 | 1.04 | 24.15 | 1.23 | 1.12 | 9.66 |
| Average | 1.06 | 0.89 | 18.15 | 1.17 | 1.08 | 8.13 |
| **Wheat** | | | | | | |
| 2011-12 | 3.44 | 2.89 | 19.34 | 1.19 | 1.13 | 5.16 |
| 2012-13 | 3.34 | 2.90 | 15.04 | 1.16 | 1.05 | 10.69 |
| 2013-14 | 3.40 | 3.06 | 11.26 | 1.32 | 1.19 | 10.31 |
| Average | 3.39 | 2.95 | 15.21 | 1.22 | 1.12 | 8.77 |
| **Mustard** | | | | | | |
| 2011-12 | 0.70 | 0.62 | 12.08 | 0.90 | 0.84 | 7.36 |
| 2012-13 | 0.86 | 0.65 | 32.87 | 1.08 | 0.88 | 22.63 |
| 2013-14 | 0.87 | 0.75 | 15.01 | 1.13 | 1.02 | 11.00 |
| Average | 0.81 | 0.67 | 19.98 | 1.04 | 0.91 | 13.65 |

from mustard which was 1.04 and 0.91, respectively for with and without subsurface drainage area.

After installation of subsurface drainage, the water table depth has gone down by 35 per cent and drain water salinity has reduced by 98 per cent. The soil salinity with drainage showed over 50 per cent reduction as compared to soil salinity without drainage. The yield and net income obtained with drainage were 10-20 and 30-40 per cent more respectively to without drainage situation. The soil salinity control and waterlogging requires a community approach and collective action for proper functioning of the subsurface drainage system.

### Impact Assessment of Subsurface Drainage Technology in Canal Command Areas of Karnataka (R. Raju, K. Thimmappa and Satyendra Kumar)

Irrigation has played a major role in the development of civilizations. However, along with positive contribution to agricultural production, irrigation has also caused many negative externalities. Excessive and injudicious use of water has created the problems of waterlogging and soil salinity all over the world which severely limit the land productivity and pose threats to the sustainability of irrigated agriculture and livelihoods of the farmers in canal irrigated areas. Many major and medium irrigation projects in Karnataka state are witnessing the similar problems.

Karnataka has 313563 ha area under salt affected soils of which 184416 ha is waterlogged, 85617 ha is saline and 43530 ha is sodic (Table 122). The waterlogged, saline and alkali soils are 59, 27 and 14 per cent, respectively. In Karnataka, alarming levels of land degradation are seen in all canal commands. To overcome the problems of salinity and waterlogging, subsurface drainage technology is suggested as one of the best measures of reclamation, which lowers the water table along with reduction of soil salinity. But, large scale adoption of this technology has not materialized due to several constraints. Either farmers are not aware of its benefits or the technology is unaffordable to them. The overall focus of this research is to evaluate the financial viability of drainage option and its socio-economic impact on the farm families.

**Table 122: Area affected, reclaimed and to be reclaimed in Karnataka (Upto March 2014)**

| Particulars | Waterlogged | Saline | Alkali | Total | % to Total |
|---|---|---|---|---|---|
| Affected area | 184416 | 85617 | 43530 | 313563 | 100 |
| Area reclaimed | 42480 | 7803 | 17355 | 78807 | 25 |
| Balance area | 141936 | 77814 | 26175 | 234756 | 75 |

## Study area

The impact assessment study was carried out in subsurface drainage area of Ugar Budruk village in Athani Taluk of Belgaum district in Karnataka. This is the only subsurface drainage project where the government took an initiative to reclaim the waterlogged saline soils in the state. About 925 ha area was reclaimed through installation of subsurface drainage system with a cost of Rs. 499.51 lakhs. A total of 644 farmers (including small and marginal) benefited from this initiative (Table 123).


**Table 123 : Financial outlay and SSD installation cost (Rs. in lakhs)**

| Sl. No. | Activity | 1st Year 2007-08 | 2nd Year 2008-09 | 3rd Year 2009-10 | Total | % of total |
|---|---|---|---|---|---|---|
| | SSD installation area (ha) | 472 | 472 | - | 944 | |
| | **A. Project implementation cost** | | | | | |
| 1 | Project preparation, survey & designing | 11.10 | - | - | 11.10 | 2.22 |
| 2 | Laying of corrugated pipes for SSD system | 97.90 | 97.90 | - | 195.80 | 39.20 |
| 3 | Construction of pucca structure on SSD system | 5.94 | 5.94 | - | 11.88 | 2.38 |
| 4 | Supply of PVC pipes and fittings | 95.50 | 95.50 | - | 191.00 | 38.24 |
| 5 | Providing and fixing of envelope material | 40.55 | 40.55 | - | 81.10 | 16.24 |
| | Sub Total (A) | 250.99 | 239.89 | - | 490.88 | 98.27 |
| | **B. Overhead Cost** | | | | | |
| | Training to: | | | | | |
| 1 | 200 farmers @ Rs. 125/person/ day for 2 days | 0.50 | 0.50 | 0.50 | 1.50 | 0.30 |
| 2 | 5 Officials @ Rs.250/person/day for 10 days | 0.125 | - | - | 0.125 | 0.03 |
| 3 | Staff TA/DA/POL, contingencies, publicity etc | 2.00 | 1.00 | 1.00 | 4.00 | 0.80 |
| 4 | Meterological station | 3.00 | - | - | 3.00 | 0.60 |
| | Sub Total (B) | 5.625 | 1.500 | 1.500 | 8.625 | 1.73 |
| | Grand Total (A+B) | 256.62 | 241.39 | 1.50 | 499.51 | 100.00 |
| | Subsurface drainage installation cost (Rs./ha) | - | - | - | 52000 | - |
| | Project life of subsurface drainage (yrs) | - | - | - | 50 | - |
| | **Contribution of cost** | | | | | |
| | DoLR's share (Central Govt.) | 156.22 | 145.43 | 1.50 | 303.15 | 60 |
| | Beneficiaries share | 50.20 | 47.98 | - | 98.18 | 20 |
| | State Governments share | 50.20 | 47.98 | - | 98.18 | 20 |
| | Total | 256.62 | 241.39 | 1.5 | 499.51 | 100 |

The installation work was delayed and commenced from 2009-10, major work was done in 2010-11 & total work completed in 2012-13.

**SSD project work in Karnataka**

*Observation of Saline soils and subsurface drainage area*

*Fields with and without subsurface drainage*

*Collection of data from the farmers of the study area*

## Cropping Pattern

Sugarcane is the major crop of the Ugar Budruk subsurface drainage project area as it occupies 64.4% area followed by oilseeds (5.7%), fruits and vegetables (1.2%) and cereals and pulses (0.5%).

## Yield of major crops

The yield of sugarcane and wheat crop in the study area increased by 211 and 335 per cent, respectively after the installation of subsurface drainage. The sugarcane yield increased from 21 to 44.3 t $ha^{-1}$ and wheat yield increased from 0.77 to 2.31 t $ha^{-1}$ after the installation of subsurface drainage.

**Frontline Demonstrations of Salt Tolerant Crop Varieties at Farmers' Field** (Ranjay K. Singh, Parvender Sheoran and K. Thimmappa)

During *kharif* 2014 and *rabi* 2013-14, forty seven field demonstrations on salt tolerant rice (29), wheat (15) and mustard (3) varieties were conducted. The details of each are given below:

## Rice

A total of 29 frontline demonstrations on varietal component (CSR 30 Basmati) were conducted in 3 districts (Jind, Karnal and Kaithal) in 7 villages under saline/sodic soil and RSC water conditions. In Jind district, the selected sites had saline soils with soil $EC_2$ ranging from 3.62-5.20 dS $m^{-1}$ whereas sodic soils were predominent in Karnal district with soil pH ranging from 8.05-9.05. The problems of sodicity and high RSC water were prevalent in Kaithal district (Table 124). In Jind, 4 demonstrations failed due to waterlogging and high salinity stress. The yield potential of CSR 30 was relatively higher in Karnal district as compared to Jind and Kaithal districts. An average yield of 2.98 t $ha^{-1}$ was obtained (range of 1.70 to 4.00 t $ha^{-1}$) in the demonstration plots.

Long dry spells in the initial stages of crop establishment enforced the farmers to transplant the crop twice/thrice and the terminal rains with high wind velocity resulted in poor crop yields.

**Table 124 : Performance of basmati rice (CSR 30) under different soil and water quality at various location during 2014**

| District | Village | No. of FLDs | Mean yield (t $ha^{-1}$) | Soil | | Water | | |
|---|---|---|---|---|---|---|---|---|
| | | | | $EC_2$ | $pH_2$ | EC | pH | RSC |
| Jind | Siwanamal | 13* | 2.50 | 3.62-5.20 | 7.89-8.94 | *4.20-4.65 | *6.69-7.41 | - |
| Karnal | Kachhwa | 3 | 3.90 | 0.50-0.71 | 8.15-8.62 | 0.42 | 7.58 | - |
| | Dabri/ Gagsina/ Taraori/ Gudha | 5 | 3.40 | 0.33-1.34 | 8.05-8.80 | - | - | - |
| | Munak | 2 | 3.23 | 0.74-0.81 | 8.05-9.05 | - | - | - |
| Kaithal | Geong | 2 | 3.03 | 0.31-0.61 | 8.71-8.88 | 1.20-1.89 | 7.67-8.32 | 4.2-5.0 |
| | Mundri | 4 | 2.68 | 0.58-0.81 | 8.85-9.50 | 1.12-1.32 | 7.48-7.64 | 4.84-5.13 |
| **Total/Mean** | | **29** | **2.98** | **-** | **-** | **-** | **-** | **-** |

*4 FLDs failed due to waterlogged saline conditions

*Performance of CSR 30 in FLD on farmer' field in village Siwanamal (Jind)*

Adaptability of CSR 30 was better at soil pH of 8.53 and EC of 3.16 dS $m^{-1}$ in Siwanamal village. It also performed well in comparison to Pusa1121 at pH >9.1 with high RSC water (5.0 m eq $l^{-1}$) in mundri village (Kaithal).

## Wheat

In wheat, 15 front line demonstrations were conducted in Siwanamal (Jind), Gudha (Panipat) and Munnak (Karnal) villages. Ten demonstrations were conducted with zero tillage and five with conventional tillage. Eight FLDs were conducted on KRL 210 and 7 on KRL 213 under varying soil pH (7.84-8.88) and EC (0.38 to 6.28 dS $m^{-1}$) conditions. The average pH was 8.84, while average EC was 3.84 dS $m^{-1}$. The average yield of variety KRL 210 was 5.06 t $ha^{-1}$ and KRL 213 was 4.89 t $ha^{-1}$. Majority of the farmers observed that the performance of wheat variety KRL 210 was relatively better in terms of growth, phenotypic attributes, nutrient use efficiency and yield as compared to other varieties in waterlogged and salt affected soils of Siwanamal. This variety also performed better in those lands where sub-surface drainage technology was implemented. Farmers of Siwanamal village, where high salinity and high climate variability are serious constraints, have adapted zero tillage as a practice to optimize the germination percentage of wheat and enhance the crop yield. In case of high climate variability (high intensity rains during January to March, 2013 and 2014), 78.5 per cent farmers found this variety better as compared to others.

*CSSRI scientists observing the performance of salt tolerant wheat variety KRL210 on farmer's field in Siwanamal (Jind) during 2014*

The farmers of village Munak where soil is sodic (pH 9.0) were not aware about variety KRL 210 before 2011-12, but now it is grown in more than 8 ha of land. The similar situations prevailed in Sambhali, Sagga and Kachhwa villages of Karnal district and Gudha, Moi Majari and Nain villages of Panipat district where it is grown in more than 40 ha of land. During 2011-12, in Siwanamal where soil pH was 7.6-8.4 and soil EC ranged from1.5-11.2 dS $m^{-1}$, germination of wheat crop was as a challenge. During 2011-12, KRL 210 was grown for the first time on 4 ha of land but now in this area, KRL 210 is grown on more than 180 ha of salt affected lands due to its better adaptability under multiple stresses (ecology, climate and other socio-economic factors). It was observed that farmers are harvesting about 3.5-5.2 t $ha^{-1}$ (soil EC 0.5-4.5) from those lands where yield was about 0.4-1.5 t $ha^{-1}$ during 2011-12. Therefore, this variety covered more than 400 ha of salt affected lands in Jind, Karnal, Panipat and Sonepat districts within a short span of two years. It is concluded that salt tolerant wheat variety KRL 210 performed better in the lands having salt, poor quality water, waterlogging and climate variability problems.

## Mustard

Three demonstrations were conducted on mustard with salt tolerant varieties (CS 54 and CS 56) in Siwanamal, Kachhwa and Sambhali villages. The average soil pH and EC of Siwanamal were 8.57 and EC 2.5 dS $m^{-1}$, respectively while in the remaining two villages, pH ranged from 8.70-8.80 and EC ranged from 0.15-0.18 dS $m^{-1}$. It was observed that variety CS 54 produced the seed yield of 1.44 t $ha^{-1}$ whereas variety CS 56 produced 0.88 t $ha^{-1}$. The poor yield of CS 56 was due to hailstorm and waterlogging conditions caused by heavy rains (>100 mm) within three days.

## Field Exhibition and Visits

During 2014-15, 15 exhibitions were organized at various research institutions and developmental agencies covering reclamation and management aspects of salt affected soils and use of poor quality waters in agriculture. A total of 4156 stakeholders in 105 groups have been visited the Information Technology Centre and Institute Research Experimental farm. Out of 4156 stakeholders, 2200 farmers in 47 groups, 481 extension personnel in 38 groups, 1136 students in 12 groups, 180 scientists and subject matter specialists in 21 groups from India and abroad visited the institute.

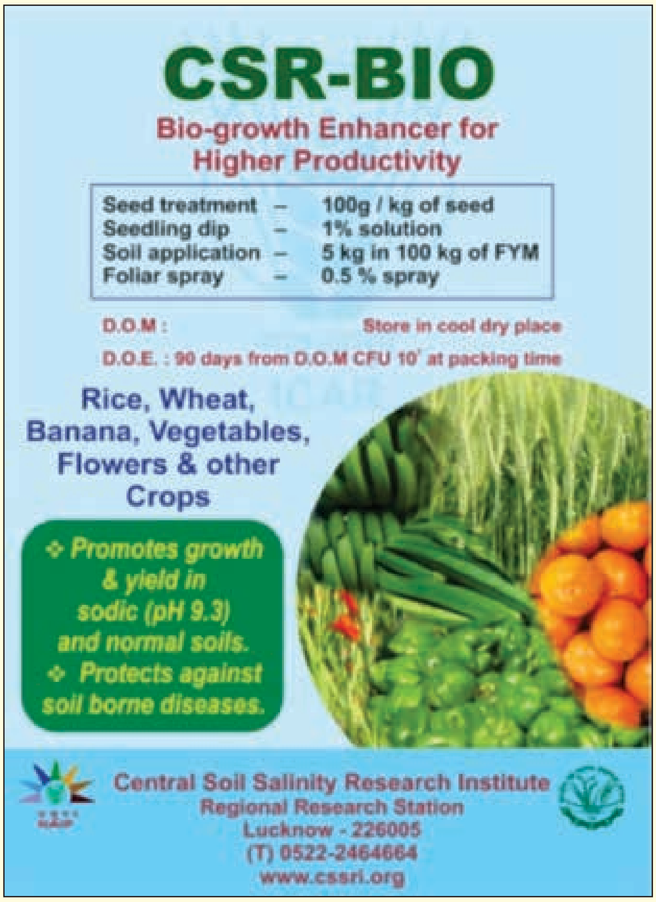
## Farmers' Advisory Services

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 2014-15, 208 calls from various fields of agriculture were received from various parts of the country and provided them appropriate solutions of the problems.

**Intellectual Property Management and Transfer/ commercialization of Agricultural Technology** (D.K Sharma, Parveen Kumar, D.S. Bundela, Ranjay K. Singh, Jogendra Singh and Anshuman Singh)

Intellectual property rights (IPR) are a major concern in Indian agriculture as they provide an avenue for royalties or other fees to be paid to the inventor for the use of a given technology. The objectives of the project '*Intellectual property management and transfer/commercialization of agricultural technology*' are: (i) to set up and place an institutional mechanism to protect/manage Intellectual Property (IP) generated within the ICAR system; (ii) to implement the incentive system; incorporated in the ICAR guidelines for IP management and technology transfer/ commercialization and to encourage greater creativity and rapid innovativeness in the systems; and (iii) to maximize technology transfer by ICAR institute and to generate income/resources through commercialization of IP.

ICAR-CSSRI, Karnal has developed and commercialized a total of 38 technologies such as gypsum based reclamation of sodic soils, subsurface drainage technology for ameliorating waterlogged saline soils, auger-hole technology for afforestation of salt-affected soils, salt tolerant varieties (rice, wheat, mustard and chick pea), groundwater recharge technology and management of poor quality water. To protect the varieties as per the Plant Varieties and Farmers Rights (PPV&FR) Act, 2001, seven salt tolerant rice varieties (Basmati-




CSR 30, CSR 36, CSR 43, CSR 23, CSR 27, CSR 13 and CSR 10), four salt tolerant wheat varieties (KRL 213, KRL 210, KRL 19 and KRL 1-4) and three salt tolerant mustard varieties (CS 52, CS 54 and CS 56) varieties have been registered. These salt tolerant varieties are being cultivated in about 16, 22,004 ha area and are significantly contributing to the national food basket. In the year 2013-14, total seed production of these varieties was about 542.7 q and the IP protected technologies through commercialization generated the revenue of Rs. 82.45 lakh. A patent has been filed for CSR-BIO, which is recently developed bio-growth enhancer for agri-horti crops in normal and sodic soils.


*KRL 213 registered with PPV&FR, reg. no. 6/4/2014 dated 15/10/2014*

*KRL 210 registered with PPV&FR, reg. no. 816/2014, dated 23/12/2014*

*CS 54 registered with PPV&FR, reg. no. 203/2014; dated 26/05/2014*

For the commercialization of CSR-BIO, public-private partnerships have been made through memorandum of understandings (MoUs) with M/s Krishicare Bioinput, Tiruchirapalli (TN); M/s Jayvisions Agri-Tech, Ghaziabad, (U.P.) and M/s Alwin Industries, Bhopal, (M.P.). These technologies are playing an important role in enhancing the productivity of salt affected soils and waters. Out of these technologies seventeen are available in the public domain and have been adopted by the farmers, NGOs and State Government Institutions across the country. Over the years, adoption of these technologies has improved the livelihoods of thousands of poor farmers in different parts of the country.


# *Miscellaneous*

ISO 9001:2008

Certificate No. 14RQ11AW

# TRAININGS IN INDIA AND ABROAD

| Sr. No. | Name and Designation | Subject | Duration | Place |
|---|---|---|---|---|
| 1. | Sh.Raj Kumar Madaan Asstt.<br>Sh. Randhir Singh, UDC | Special training Programme for ICAR employees (CSP for Asstt.(DR) | 19.05.2014-<br>30.05.2014 | ISTM,<br>New Delhi |
| 2. | Dr. Vinayak R. Nikam<br>Scientist | Forecast modeling analytics in crops | 30.05.2014-<br>19.06.2014 | IASRI, New Delhi. |
| 3 | Dr. Sanjay Arora<br>Sr. Scientist | Refresher course on agricultural research management | 14.07.2014-<br>26.7.2014 | NAARM,<br>Hyderabad. |
| 4. | Sh. Maneesh Pandey<br>Technical Assistant | Training on digital mapping and geographical information system (DMGIS) | 01.08.2014-<br>26.08.2014 | NATMO,<br>Kolkata |
| 5. | Sh. Tarun Kumar<br>Asstt. Admn. Officer | Training on organizational behaviour in Govt. | 04.08.2014-<br>08.08.2014 | ISTM,<br>New Delhi |
| 6. | Dr. Randhir Singh<br>Chief Technical Officer | Workshop on disposal of appeal under Right to Information | 14.08.2014 | ISTM,<br>New Delhi |
| 7. | Dr. S.L. Krishnamurthy<br>Scientist | ICAR winter school on "New Frontiers in Rice Breeding for Improving Yield, Quality and Stress Tolerance for Sustaining Future Production | 10.09.2014-<br>30.09.2014 | DRR,<br>Hyderabad |
| 8. | Dr. R.K.Garg , Principal Scientist<br>Dr.A.K.Rai, Principal Scientist<br>Dr. R.K. Singh, Sr. Scientist<br>Dr. Gajender, Scientist | Advanced techniques in Land & Water remediation and management | 15.09.2014-<br>24.09.2014 | CSSRI<br>Karnal |
| 9 | Mrs Madhu Choudhary<br>Scientist | Conservation agriculture: Developing resilient systems | 27.09.2014-<br>04.10.2014 | CSSRI,<br>Karnal |
| 10 | Mrs Madhu Choudhary<br>Scientist | Third short course on metagenomics-role of next generation sequencing and bioinformatics | 06.10.2014-<br>15.10.2014 | AAU,<br>Anand |
| 11. | Dr. Gajender<br>Scientist | Advance course on conservation agriculture: gateway for productive & sustainable cropping system | 08.10.2014-<br>21.10.2014 | PAU<br>Ludhiana |
| 12. | Dr. R. Raju<br>Scientist | CAFT training on recent advances in survey design and analysis of survey data using statistical software | 28.10.2014-<br>17.11.2014 | IASRI New Delhi |
| 13. | Dr. Nirmalendu Basak<br>Scientist | Winter School on soil-plant-water relations under conservation tillage practices for sustainable agriculture" | 05.11.2014-<br>25.11. 2014 | ICAR-IARI,<br>New Delhi |
| 14. | Dr. R.K. Singh<br>Sr. Scientist | Management of frost and prolonged foggy weather | 17.12.2014-<br>23.12.2014 | CSSRI,<br>Karnal |
| 15. | Sh. Raj Kumar<br>Technical Officer<br>Sh. Raj Pal<br>Technical Asstt. | 6$^{th}$ capacity building programme for technical personnel | 02.02.2015<br>13.02.2015 | ISTM,<br>New Delhi |
| 16 | Mrs Madhu Choudhary<br>Scientist | International training on experimental techniques and data analysis in agriculture | 12.02.2015-<br>14.02.2015 | NASC,<br>New Delhi |

# DEPUTATION OF SCIENTISTS ABROAD

| Sr. No. | Name and designation | Subject | Period of deputation | Country |
|---|---|---|---|---|
| 1 | Dr. B.Maji, Head, RRS, Canning Town, Dr. D. Barman Principal Scientist Dr. Subhasis Mandal Sr. Scientist Dr. S.K.Sarangi Sr. Scientist | Participated in CPWF G-2 Review and Planning Workshop | 30.04.2014–06.04.2014 | Bangladesh |
| 2 | Dr. D.K.Sharma Director Dr. P.C.Sharma Principal Scientist | An objective and planning meeting on strategic experiment plateforms for further cereal system | 22.05.2014-23.05. 2014 | Kathmandu, Nepal |
| 3. | Dr. A.K. Bhardwaj Sr. Scientist | 20th World Congress of Soil Science | 07.06.2014-13.06.2014 | Jeju, Korea |
| 4. | Dr. Neeraj Kulshreshtha, Principal Scientist, | Review and work plan meeting on BML & CSISA wheat breeding | 10.09.2014 14.09.2014 | Kathmandu, Nepal |
| 5. | Dr.B. Maji, Head, RRS, Canning, Dr. Subhasis Mandal, Sr. Scientist, Dr. D. Barman, Principal Scientist Dr. S.K.Sarangi, Sr. Scientist | Conference on revitalizing the Ganga coastal zone in Bangladesh | 17.10.2014-24.10.2014 | Dhakha, Bangladesh |
| 6. | Dr.B.Maji Head, RRS, Canning Dr. Krishna Murthy, Scientist | Climate-ready Rice Symposium of 4th international rice congress | 27.10.2014-01.11.2014 | Bangkok, Thialand |
| 7. | Dr. D.K.Sharma, Director | 12th Asian Maize Conference, expert consultant on maize for food, feed, nutrition and environment security. | 30.10.2014–01.11.2014 | Bangkok, Thialand |
| 8. | Dr. Krishna Murthy, Scientist | Workshop on rice breeder expert elicitation | 20.11.2014-21.11. 2014 | Laguna, Philippines |
| 9. | Dr. D.K.Sharma, Director | JIRCAS International symposium and 2014 Japan International Award for young Agricultural Researcher | 27.11.2014-28.11. 2014 | Tokyo, Japan |
| 10 | Dr. B.Maji, Head, RRS, Canning Town, Dr. D. Barman, Principal Scientist, Dr. Subhasis Mandal, Sr. Scientist, Dr. S.K.Sarangi, Sr. Scientist | Study tour across salinity regimes organized under CGIAR Challenge Programme on Water and Food (CPWF) funded project G-2 by IRRI | 20.12.2014-27.12. 2014 | Mekong delta, Vietnam |

# AWARDS AND RECOGNITIONS

- Dr. T. Damodaran, Sr. Scientist along with team of scientists have been awarded the Biotech Product & Process Development and Commercialization Awards by Department of Bio-Technology, Govt. of India for the year 2014.
- Dr. Ranjay Kumar Singh, Senior Scientist begged Lal Bhadur Shastri Outstanding Young Scientist Award-2013 on the occasion of 86$^{th}$ Foundation Day of the Council
- Dr. Krishnamurthy, S.L. awarded Srinivasa Ramanujam Memorial Award of Indian Society of Genetics and Plant Breeding and Fellow' of Eurasian Academy of Environmental Sciences, India.
- Dr. D.K. Sharma, Director was given CSSRI, Excellence Award on Ist March, 2015.
- Dr. D.K. Sharma, Director awarded as 'Fellow' of Indian Socety of Soil Salinity and Water Quality.
- Dr. Jogendra Singh, Scientist has been awarded as Fellow, Association for the Advancement of Biodiversity Science
- Dr P.C. Sharma, Head, Division of Crop Improvement awarded as 'Fellow' of Indian Society for Plant Physiology and Indian Society of Soil Salinity and Water Quality.
- Dr.Parvendar Sheoran (2014): Team Award, Best Performer, Main-Centre Category AICRP-Rapeseed Mustard Award for the year 2012-13 for outstanding contribution in research and development of rapeseed mustard.
- Dr. Ajay Bhardwaj, Sr. Scientist awarded as distinguished talk on "Resource conservation strategies for rice-wheat cropping systems in partially reclaimed salt affected soils and their effects on carbon sequestration and nitrogen availability" in 20$^{th}$ World Congress of Soil Science, Jeju, Korea from June 8-13, 2014.
- Dr. Ajay Bhardwaj, Sr. Scientist received 20th World Congress of Soil Science, Travel Award at Jeju, Korea from June 8-13, 2014.
- Dr. Ajay Bhardwaj, Sr. Scientist, Indian National Science Academy Visiting Scientist Fellowship awarded for collaborative research at Centre for Environmental Science and Engineering, Indian Institute of Technology, Kanpur, Uttar Pradesh, India, 2014.
- Dr Ajay Kumar Bhardwaj, Sr. Scientist has been awarded as CONICET-UNESCO Associateship in Chemistry' for collaborative research at Research Institute of Theoretical & Applied Physical Chemistry, La Plata, Argentina from 2015-2017.
- Dr.Parvender Sheoran bestowed with best presentation award (3$^{rd}$ Prize): International Conference on "New Dimensions in Agrometeorology for Sustainable Agriculture" held at GBPA&T, Pantnagar from October 16-18, 2014.
- Dr. Ashwani Kumar bestowed with Best Poster award for "Physiological studies on halophyte grasses *Sporobolus marginatus* and *Urochondra setulosa* under salt affected environments" in National symposium on "Climate Resilient Forage Production and its Utilization" held at BCKV, Kalyani during Nov. 13-14, 2014
- Drs. Jogendra Singh and P.C. Sharma bestowed with Best Poster Award (3$^{rd}$ Prize) in 4$^{th}$ National Seminar on "Innovative Saline Agriculture in Changing Environment" held at RVSKV, Gwalior (M.P.), India on December 12-14, 2014.
- Dr. Parveen Kumar, Principal Scientist bestowed with Best Poster Award (2$^{nd}$ prize) in National Seminar on "Innovative Saline Agriculture in Changing Environment" organized by Indian Society of Soil Salinity & Water Quality, ICAR-CSSRI at RVSKV, Gwalior from December 12-14, 2014.
- Dr. Parvender Sheoran bestowed with Best Poster Presentation Award (3$^{rd}$ Prize): 4$^{th}$ National Seminar on Innovative Saline Agriculture in Changing Environment held at RVSKV, Gwalior from December 12-14, 2014.
- Dr Anil R. Chinchmalatpure, Head, ICAR-CSSRI-RRS, Bharuch received the Best Poster Award for the research paper entitled "Properties of saline Vertisol and crop yield as influenced by irrigation in Sardar Sarovar canal command area of Gujarat" during XII Agricultural Science Congress "Sustainable

livelihood security for smallholder farmers" at ICAR-NDRI Karnal during Feb. 3-6, 2015

- Parvender Sheoran bestowed with Best Poster Award (3rd Prize): National Seminar on Strategies Interventions to Enhance Oilseeds Production in India held at ICAR-DRMR, Bharatpur during February 19-21, 2015.
- Drs. Jogendra Singh and P.C. Sharma bestowed with Best Poster Award (1st Prize) in National Seminar on "Strategic Interventions to Enhance Oilseeds Production in India" held at ICAR-DRMR, Bharatpur during February 19-21, 2015.

The following technical, administrative and skilled supporting staff was awarded Best Work Award for 2010-11, 2012-13 and 2014.

**For 2010-11 :**

- Sh. N.K. Vaid, Sr. Technical Officer
- Sh. Tarun Kumar, Assistant
- Sh. Ramesh Kumar, SSS
- Sh. Gopal Rai, SSS

**For 2012-13 :**

- Dr. Randhir Singh, Chief Technical Officer
- Smt Sunita Malhotra, PA,
- Sh. Dalip Singh, SSS

**For 2014 :**

- Sh. Vinod Kumar, Technical Officer
- Dr. Chander Shekhar Singh, Chief Technical Officer
- Sh. Avtar Singh, Sr. Clerk
- Sh. Rupak Ghosh, Sr. Clerk
- Sh. Subhash Chand, SSS
- Sh. Ramabhai Heerabhai Valand, SSS

# 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)
- 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)
- 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)
- Network project on improvement of salt tolerance in wheat using molecular approach (DWR-CSSRI)
- 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

### Intenational Collaborations

- Future rainfed lowland rice systems in Eastern India 15 (T3) (Development of crop and nutrient management practices in rice) (ICAR –W3) (IRRI funded).

### National Collaborations

- Utilization of Fly Ash for increasing crop productivity by improving hydro-physical behaviour of sodic soils of Uttar Pradesh (DST Funded)
- Assessment of municipal solid waste in conjunction with chemical amendments for harnessing productivity potential of salt affected soils (UPCAR funded).

## Collaborative programmes at Regional Research Station, Bharuch

### National Collaboration

- Anand Agricultural University, Maize Breeding Station, Godhra, Gujarat.
- 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) and Deenbandhu Chhotu Ram University of Science & Technology, Murthal (Haryana)
- Academic linkage with NDRI, Karnal, Haryana for Post Graduate programmee
- National Research Centre on Seed Spices, Ajmer, Rajasthan for collaborative research
- Project Directore, NCP,IGBP,IIRS, (NRSA), Department of Space, Dehradun, Uttrakhand
- Jaipur National University, Jaipur, Rajasthan
- Sardar Vallahbhai Patel University of Agriculture & Technology, Meerut (UP)
- CCS HAU, Hisar, Haryana for collaborative research
- Punjabi University Patiala, Punjab
- Research Institute of Theoretical & Applied Physical Chemistry (INIFTA), La Plata, Argentina (funding from UNESCO-TWAS-CONICETS) for collaborative research.
- Indian National Science Academy (INSA) Visiting Scientist Fellowship awarded for collaborative research for "Development of efficient and cost effective materials for remediation of salt at Centre for Environmental Science and Engineering (CESE), Indian Institute of Technology (IIT-K), Kanpur, Uttar Pradesh, India, 2014

# LIST OF PUBLICATIONS

## Journal Paper

Al-Wahaibi, N.S.S., Hussain, N., Al-Hashmi, H.S., Al-Zedjalli, M.S., Al-Habsi, S.S. and Meena, R.L. 2014. Comparative study of organic manure and mineral fertilizer application on performance of tomato in dryland conditions of Sultanate of Oman. *Journal of Soil Salinity and Water Quality*, 6(2): 79-85.

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Chinchmalatpure, Anil R., Bardhan, G., Nayak, A.K., Rao, G.G., Chaudhari, S.K. and Sharma, D.K. 2014. Effect of sodium adsorption ratio with different electrolyte concentrations on saturated hydraulic conductivity of salt affected soils of Gujarat, India. *J. Indian Soc. Soil Sci.*, 62 (1): 1-8.

Chinchmalatpure, Anil R., Rao, G.G., Arora, Sanjay, Khandelwal, M.K. and Sharma, D.K. 2014. Impact assessment of Aniline Plant Treated effluent irrigation in Vertisols surrounding Bharuch. *J. Indian Soc. Soil Sci.*, 62 (2) 168-173.

Choudhury, S.G., Srivastava, S., Singh, R., Chaudhari, S.K., Sharma, D.K., Joshi, P.K., Tripathi, R.S., Satyendra, K., Singh, S.K. and Sarkar, D. 2014. Tillage and residue management effects on soil aggregation, organic carbon dynamics and yield attributes in rice-wheat cropping system under reclaimed sodic soil. *Soil and Till.Res*.136:76-83.

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## Conference/Seminar/Symposia and Workshop papers

Ali, Sharik, Gautam, R.K., Mahajan, R., Krishnamurthy, S.L. and Sarangi, S.K. 2014. Genetic variability and association analysis for grain yield components among *SALTOL* QTL introgressed rice genotypes under normal and saline environments. In: *4th National Seminar on "Innovative Saline Agriculture in Changing Environment"* held at RVSKV, Gwalior during Dec. 12-14, p. 79 (Abstract).

Ambast, S.K. and Meena, R.L. 2014. Technological interventions for use of poor quality waters for sustainable crop production in diverse agro-climatic conditions of India. In: *National Seminar on Innovative Saline Agriculture in Changing Environment held at* RVSKV, Gwalior during 12-14 December.

Aishwath, O.P., Mehta, R.S., Dubey, P.N., Yadav, R.K., Meena, R.L., Jha, B.K. and Singh, Balraj. 2015. Influence of sodic irrigation water on performance of coriander and soil properties. In: *National Seminar on Sustainable Management of Land Resources for Livelihood Security* held at Nagpur during 28-30 January.

Ambast, S.K. 2014. Technological challenges for managing abiotic stresses in climate smart horticulture. In : *Global Conference on Technological Challenges and Human Resources for Climate Smart Horticulture* at NAU, Navsari during 28-31 May.

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# PARTICIPATION IN CONFERENCE/SEMINAR/SYMPOSIUM/ WORKSHOP

| Name | Title | Period |
|---|---|---|
| Dr. S.L. Krishnamurthy | 49th All India Annual Rice Group Meetings at Hyderabad | April, 13-16,2014 |
| Dr. A.R. Chinchmalatpure | NAIP Agribusiness Idol camp, ICAR-IARI, New Delhi. | May 9, 2014 |
| Dr. A.R. Chinchmalatpure | One day Sensitization Workshop on IPv6 Technology | May 16, 2014 |
| Dr. A.R. Chinchmalatpure | Workshop on Priority Setting, Monitoring and Evaluation in NARS: Status, Experience and Way forward at ICAR-IARI, Pusa New Delhi | May 27, 2014 |
| Dr. S.K. Sarangi<br>Dr. K.K. Mahanta | All India Seminar on Appropriate Technologies of Farm Mechanization for Marginal and Small Farmers held at Kolkata | Aug. 08-09, 2014 |
| Dr. P.C. Sharma | Participated in 21th AICRP on Rapeseed & Mustard Group Meeting held at Kalyani, W. Bengal | Aug. 20-22, 2014 |
| Dr. D.S. Bundela | Workshop on Conclusion of Phase-I and Inception of Phase-II of ICAR-ICARDA Collaborative Project on Improving Crop and Water Productivity in IGNP held at SKRAU, Bikaner | Aug. 21-22, 2014 |
| Dr. P. Sheoran | International Conference on New Dimensions in Agrometeorology for Sustainable Agriculture held at GBPA&T, Pantnagar. | Oct. 16-18, 2014 |
| Dr. D.S. Bundela<br>Dr. Ashwani Kumar<br>Dr. Jogindra Singh | Participated in Interface meeting of ICAR-SAU-Development department and Stakeholders held at NDRI, Karnal. | Oct. 18, 2014 |
| Dr. B. Maji<br>Dr. D. Burman<br>Dr. S.K. Sarangi<br>Dr. S. Mandal | International Conference on Revitalizing the Ganges Coastal Zone – Turning Science into Policy and Practices under CGIAR Challenge Program on Water & Food (CPWF), Ganges Basin Development Challenges (GBDC) and Water, Land & Ecosystems (WLE) held at Dhaka, Bangladesh | Oct. 21-23, 2014 |
| Dr. S. K. Sarangi | National Seminar on Management Options for Enhancing Farm Productivity and Livelihood Security under Changing Climate, Indian Society of Agronomy, held at OUAT, Bhubaneswar, Odisha | Oct. 29-31, 2014 |
| Dr.Parveen Kumar | National Seminar on Emerging Problems of Potato held at CPRI Shimla. | Nov.01-02, 2014 |
| Dr. S.L. Krishnamurthy, | National Symposium on Crop Improvement for Inclusive Sustainable Development at PAU, Ludhiana | Nov 7-9, 2014 |
| Dr. K. Thimmappa<br>Dr. R. Raju | Leveraging Institutional Innovations for Agricultural Development held at UAS, Raichur, Karnataka. | Nov.18–20, 2014 |
| Dr. S.L. Krishnamurthy | Rice Breeders Expert Elicitation Workshop held at IRRI, Los Banos, Manila, Philippines. | Nov. 20-21 2014 |
| Dr. P.C. Sharma | National Conference on Plant Physiology on Frontiers of Plant Physiology Research: Food Security and Environmental Challenges held at OUAT, Bhubaneshwar | Nov. 23-25, 2014 |
| Dr. S. Raut | 79th Annual Convention and National Seminar of Indian Society of Soil Science held at ANGRAU, Hyderabad | Nov., 2014 |
| Dr. D.K. Sharma<br>Director & other scientists | 4th National Seminar on Innovative Saline Agriculture Changing Environment held at Gwalior | Dec. 12-14, 2014. |

| | | |
|---|---|---|
| Dr. D.S. Bundela | National Knowledge Network (NKN) Workshop 2014: The $E^4$ (Encourage, Empower, Enable, Enrich) Next Generation Network held at IIT, Guwahati | Dec. 15-17, 2014 |
| Dr. U. K. Mandal | NAAS Silver Jubilee Symposium on Managing Natural Resources for Posterity: 25 Years of Achievements and Way Forward held at BCKV, Kalyani | Dec. 30, 2014 |
| Dr. U.K. Mandal | Soil and Water Networking National Workshop- jointly organized by IIT Kharagpur and the University of Sydney | Jan. 04-07, 2015 |
| Dr. Nikam Vinayak R. | 2nd International Conference on Bio-resource and stress management held at Hyderabad | Jan. 07-10, 2015 |
| Dr. Satyendra Kumar | 3rd India Water Week" – a seminar cum exhibition, Organised by Min. of Water Resources, Govt of India, held at Pragati maidan, New Delhi | Jan. 14-16, 2015 |
| Dr. D.K. Sharma Director & other scientists | 12th Agricultural Science Congress held at ICAR-NDRI, Karnal, Haryana | Feb. 03-06, 2015 |
| Anil R. Chinchmalatpure | National Seminar on "Climate smart Agriculture and water management" at Junagarh Agricultural University, Junagarh | Feb. 12-14, 2015 |
| Dr. Jogendra Singh | Participated in National Seminar on Strategic interventions to enhance oilseeds production in India held at ICAR-Directorate of Rapeseed-Mustard Research, Bharatpur, Rajasthan. | Feb. 19-21, 2015 |
| Dr. K.K. Mahanta | National Symposium on Food and Nutrition: Need for the future at Institute of Agricultural Science, Kolkata, | Feb. 25-27, 2015 |

# LIST OF ON GOING PROJECTS

## Institute Funded

### Priority area - Data Base on Salt Affected Soils & 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, Murli Dhar Meena, G.S. Sidhu, Jaya N. Surya and M.L. Khurana)
3. NRMACSSRISIL201400400862. Assessment and Mapping of Salt Affected Soils using Remote Sensing and GIS in Rewari and Mahendragarh districts of Haryana State (Madhurama Sethi, Anil R. Chinchmalatpure, Ashim Datta, and M.L. Khurana, Soil Testing Lab. Karnal)

### Priority Area - Reclamation and Management of Alkali Soils

4. 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)
5. P1-2011/ASM4.6–ISR-A00/P00/ F27 Strategies of resource conservation and mini sprinkler on productivity under rice-wheat cropping system (Ranbir Singh, P.K. Joshi, R.S.Tripathi, S.K.Chaudhari, D.K.Sharma and Satyender Kumar)
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. (Thimmappa K., 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 Bhaskar 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. NRMACSSRISIL201301300858. Diversifying agriculture on reclaimed sodic land in farmer's participatory appraisal. (Gajender, S.K. Singh, S.K. Chaudhari, R.S. Pandey, R Raju, S.K. Ambast, D.K. Sharma and N.S. Sirohi).
13. NRMACSSRISIL201400100859. Effect of land uses on salt distribution and properties of salt affected soils (Ashim Datta, Nirmalendu Basak, Anil R. Chinchmalatpure and R.K. Garg)
14. NRMACSSRISIL201400600864. Nutrient and residue management of ZT-DSR basmati rice-ZT wheat cropping system under partially reclaimed sodic soils. (Parveen Kumar, D.K. Sharma, R.K. Yadav, A.K. Rai and Ashwani Kumar)

### Priority Area - Drainage Investigations and Performance Studies

15. NRMACSSRISIL2014001000868. Impact assessment of subsurface drainage technology in canal command areas of Karnataka. (R. Raju, Thimmappa K. Satyendra Kumar, Soil scientists (1 or 2) study area)

### Priority Area - Management of Marginal Quality Waters

16. 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)

17. 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)
18. NRMACSSRISIL201400500863. Study on backpressure in subsurface drip irrigation prioritizing field study utilizing sewage water (R.S. Pandey and Anshuman Singh)
19. NRMACSSRISIL201400300861. Improving farm productivity through sustainable use of alkali waters at farmer's field in rice-wheat production system (Parvender Sheoran, R. K. Yadav, Nirmalendu Basak, Satyendra Kumar, K. Thimmappa and R.K. Singh)
20. NRMACSSRISIL201400700865. Conjunctive water use strategies with conservation tillage and mulching for improving productivity of salt affected soils under limited fresh water irrigation. (Arvind Kumar Rai, R.K. Yadav, Anil Chinchmalatpure, Nirmalendu Basak, Satyendra Kumar, Bhaskar Narjari, Gajender Yadav, A. K. Bhardwaj and D.K. Sharma)
21. Evaluation of commercial vegetable crops under protected cultivation structures in saline environment (R.L. Meena, B.L. Meena, Anshuman Singh and S.K. Ambast)

### Priority Area - Crop Improvement for Salinity, Alkalinity and Waterlogging Stresses

22. P1-2009/CIS4.6-ISR-30/0150. Genetic improvement of rice for salt tolerance (S.L. Krishnamurthi, S.K. Sharma and Y.P. Singh )
23. 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)
24. NRMACSSRISIL201200100842. Genetic enhancement of wheat with respect to salt and waterlogging tolerance. (Neeraj Kulshreshtha, S K Sharma and G. Gururaja Rao)
25. NRMACSSRISIL201200200843. Effect of salinity on growth and physio-biochemical changes in bael (*Aegle marmelos Correa*) genotypes. (Anshuman Singh, Murali Dhar Meena, P.C. Sharma and D.K. Sharma)
26. NRMACSSRISIL201300600851. Physiological and biochemical basis of salinity and draught stresses tolerance in rice and wheat cropping system. (Ashwani Kumar, S.K Sharma, Neeraj Kulshreshtha and Krishnamurthy, S.L)
27. NRMACSSRISIL201400900867. Growth and physiology of guava (*Psidium guajava* L. cv. Allahabad Safeda) and bael (*Aegle marmelos* Correa cv. Narendra Bael-5) under salinity stress. (Anshuman Singh, R.K. Yadav, Ashwani Kumar and Ashim Dutta)

### Priority Area - Agroforestry in Salt Affected Soils

28. NRMACSSRISIL201400800866. Enhancing productivity potential of saline soil through agroforestry system using saline irrigation. (Rakesh Garg, R K Yadav, Bhaskar Narjary, Parvender Sheoran, M.D Meena, Ashwani Kumar and D.K Sharma)

### Priority Area - Reclamation and Management of Coastal Saline Soils

29. 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 )
30. 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)
31. 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. Maji and K.K. Mahanta)
32. NRMACSSRISIL201300300848. Evaluation of crop establishment methods for rice based cropping system in coastal salt-affected soils. (S.K. Sarangi, U.K. Mandal and Subhasis Mandal)
33. 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)

34. NRMACSSRICIL201300900854. 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)
35. NRMACSSRISIL201300800853. 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)
36. Effect of land shaping techniques on soil and water quality and productivity of coastal degraded land with long term perspective (D. Burman, U.K. Mandal, S.K. Sarangi, S. Mandal, K.K. Mahanta S. Raut and B. Maji.)

## Priority Area - Reclamation and Management of Salt Affected Vertisols

37. NRMACSSRISIL201200400845. Breeding and evaluation of field crops for salt tolerance in saline Vertisols (G.Gururaja Rao and D.K. Sharma)
38. NRMACSSRISIL201300100846. Soil physical characteristics and nutrient dynamics in Vertisols with subsurface salinity (G. Gururaja Rao)
39. NRMACSSRISIL201400200860. Prospects of cultivating desi cotton genotypes and salt tolerant wheat varieties on saline vertisols (Nikam Vinayak Ramesh, G. Gururaja Rao and D.K. Sharma.)

## Priority Area - Reclamation and Management of Alkali Soils of Central and Eastern Gangetic Plains

40. 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)
41. 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)
42. 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. (S.K. Jha, A.K. Bhardwaj, V.K. Mishra, Y.P. Singh, T. Damodran and D.K. Sharma)
43. 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 Sanjay Arora)
44. NRMACSSRICIL201301000855. 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, S.K. Jha, A.K. Singh, Sanjay Arora, V.K. Varsney (NBFGR) and D.K. Sharma)
45. NRMACSSRISIL201301100856. 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)
46. NRMACSSRISIL201301200857. 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. Singh, V.K. Mishra,Y.P. Singh and D.K. Sharma)
47. Water flow simulation in field scale model for raised bed conditions under waterlogged conditions (Chhedi Lal Verma, V.K. Mistra, A.K. Singh and S.K. Jha)

## Externally Funded Research Projects

1. C2-2009/ASM4.1-ISR-A00/P00/ F27 (Phase-II).Cereal system initiative for South Asia – Objective 2 component (Team Leader D.K. Sharma, P.C. Sharma Asim Datta and Rajbir Singh (NRM Division)
2. Intellectual property management transfer/ commercialization of agricultural technologies. (Anil R. Chinchmalatpure, Neeraj Kulshrestha, D.S. Bundela and R.K. Singh)
3. Guidance on identification of problem areas and design and evaluation of subsurface drainage projects, 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.)

4. 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)
5. C2-2008/CIS4.1-ISR-F30/0180. Multilocation evaluation of bread wheat germplasm (Neeraj Kulshreshtha)
6. Improvement of wheat for salt tolerance using molecular approach. (Neeraj Kulshreshtha and P.C. Sharma)
7. Establishment of National Database on rice. (S.K. Sharma, S.L. Krishnamurthy and Jogendra Singh)
8. 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)
9. 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).
10. Stress tolerant rice for poor farmers in Africa and south Asia under BMGF project (STRASA Phase 2). (D.K. Sharma, S.K. Sharma, Krishnamurthy S.L, B. Maji, D. Burman, B.K. Bandyopadhyay, S.K. Sarangi, S. Mandal, Vinay Kumar Mishra and Y.P. Singh)
11. G2: Productive, profitable and resilient agriculture and aquaculture systems (D. Burman, S. Mandal, S.K. Sarangi and B. Maji)
12. 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)
13. Understanding the adaptation mechanism of wild forage halophytes in the extreme saline-sodic Kachchh plains for enhancing feed resources. (Ashwani Kumar (CPI), Devi Dayal, Arvind Kumar, Shamsudheen Mangalaseery and JP Singh)
14. ICAR-ICARDA Collaborative project on "Improving crop and water productivity in Indira Gandhi Canal Command Area" .(D.S Bundela (CPI)
15. Utilization of fly ash for increasing crop productivity by improving hydro-physical behaviour of sodic soils of Uttar Pradesh (V.K. Mishra, T. Damodaran, S.K. Jha and Shefali Srivastava)
16. Development of effective salt tolerant microbes to mitigate salt stress for higher crop production in salt affected soils. (P.K. Joshi)
17. UPCAR funded Project on Assessment of municipal solid waste in conjunction with chemical amendments of harnessing productivity potential of salt affected soils. (Y.P. Singh, Sanjay Arora and Vinay Kumar Mishra)
18. UPCAR funded Project on Bio-remediation of salt affected soils of UP through Halophilic microbes to promote organic farming (Sanjay Arora and Y.P. Singh)
19. UPCAR funded Project "Land modification based integrated farming system under waterlogged and waterlogged sodic conditions (C.L. Verma, Y.P. Singh, T. Damodaran, Atul Kumar Singh, S.K. Jha, V.K. Mishra and D.K. Sharma)
20. UPCAR funded project on "Assessment and refinement of existing irrigation practices of major crops grown under sodic environment (Atul Kumar Singh, Y.P. Singh, C.L. Verma and Sanjay Arora)
21. AMAAS project on Identification of salt tolerant microbes and development of dynamic substrate for cultivation of commercial crops in sodic soils (T. Damodaran, S.K. Jha, V.K. Mishra, D.K. Sharma and Y.P. Singh)
22. Future rained lowland rice systems in Eastern India 15 (T-3) (Development of crop and nutrient management practices in rice) (B. Maji and S.K. Sarangi (RRS Canning Town) and Y.P. Singh & V.K. Mishra (RRS Lucknow).

# CONSULTANCIES, PATENTS AND COMMERCIALISATION OF TECHNOLOGIES

- Subsurface drainage for heavy soils of Maharashtra, Karnataka and Gujarat (D.K. Sharma and S.K. Kamra)

  **(Funding: Rex-Poly Extrusion Pvt. Ltd., Sangli, Maharashtra)**

- Impact on the use of treated effluent from Aniline –TDI Plant of GNFC Unit II in forage and biomass species grown on black cotton soils. (G.G. Rao, A.R. Chinchmalatpure and Nikam Vinayak Ramesh)

  **(Funding: The Gujarat Narmada Valley Fertiliser Co. Ltd., Narmada Nagar, Bharuch, Gujarat)**

- CSR BIO technology commercialization (T. Damodaran, D.K. Sharma and V.K. Mishra)

  **(M/s Krishicare Bioinputs, Tamil Nadu, Alwin Industries, Madhya Pradesh, Jai Visions Agri-Tech, Ghaziabad, U.P)**

- Evaluation of salt tolerant rice variety Surjeet basmati (P.C. Sharma and S.L. Krishnamurthy)

- Assessing impact of agro-chemical on environment using EIQ tool on rice crop (Sanjay Arora)

# INSTITUTIONAL ACTIVITY

## Research Advisory Commmmittee Meeting

The XVIII meeting of the Research Advisory Committee (RAC) of the Institute was held during November 21-22, 2014 at ICAR-CSSRI, RRS, Canning Town (West Bengal) under the Chairmanship of Dr. S.B. Kadrekar, former Vice Chancellor, Konkan Krishi Vidyapeeth, Dapoli. The other members were: Dr. R.C. Gautam, Dr. R.P. Sharma, Dr. H.S. Lohan, Dr. R.P.S. Malik, Dr. J.P. Singh, Dr. D.K. Sharma, Director, ICAR-CSSRI and Dr. Anil R. Chinchmalatpure, Member Secretary. The member secretary presented the action taken report (ATR) on the issues raised in the last meeting of the RAC.

## Recommendations

1. Waterlogging with salinity in the command areas is the major issue. To reclaim these areas use of sub-surface drainage technology may be advocated on large scale with awareness and involvement of stakeholders.
2. Crop diversification, in addition to breeding salt tolerant varieties of different crops, managing the existing cropping systems on salt affected soils needs to be considered.
3. Explore the possibilities of co-cultivation of seaweeds and fisheries in coastal saline areas with high rainfall.
4. Alternative strategies like use of municipal and industrial waste for reclamation of salt affected soils needs to be considered. Role of microbes in reclamation of saline and sodic soils should be encouraged.
5. Ground water quality of various states is poor; use of poor quality water needs to be promoted through pressurized irrigation system.
6. Alternative to reclamation technology using gypsum needs to be explored. Cost effective technology is to be developed for reclamation of water logged sodic land in UP.
7. Due to limited availability of human resources, Institute is facing difficulties for in-depth study of the problems. The RAC feels that vacant positions may be filled on priority.
8. Targeting technologies for their large scale adoption based on the typology of technologies, socio-economic conditions of farmers' and institutional arrangements need to be considered.
9. At Panvel Centre work on rain water harvesting in shallow ponds to be strengthened for fish rearing as well as growing *rabi* vegetable crops.

## Institute Management Committee Meeting

During the report period, 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 17.05.2014. The following members were present.

| | | |
|---|---|---|
| 1. | Dr. D.K.Sharma | Chairman |
| 2. | Dr. Muneshwar Singh, PC (LTFE), IISS, Bhopal | Member |
| 3. | Rajeev Kumar Srivastava,PS& Head, NBSS&LUP, Nagpur | Member |
| 4. | Dr. R.K.Gupta, Principal Scientist, DWR, Karnal | Member |
| 5. | Dr. Madhurama Sethi, Principal Scientist, CSSRI, Karnal | Member |
| 6. | Sh. A.K. Srivastava, Admn. Officer, CSSRI, Karnal | Member Secretary |


*IMC meeting is in progress*

## Institute Joint Staff Council Meeting

The Institute Joint Staff Council Meeting was held at CSSRI Regional Research Station, Lucknow (UP) on June 27, 2014 and Nov. 03, 2014 held at Karnal. The meeting was chaired by Dr. D.K. Sharma, Director and attended by Sh. Abhishek Srivastava, Administrative Officer & Principal Scientist, Dr. R.K. Yadav and Sh. Ved Parkash, F&AO, Sh. Tarun Kumar, Sh Suresh Pal Rana, Sh. Dilbag Singh, Sh. Dharambir Singh, Sh. Dalip Kumar, Sh. Ramesh Kumar and Dr. V.K. Mishra, Head, RRS, Lucknow. 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.

# WORKSHOP, SEMINAR, TRAINING, FOUNDATION DAY AND KISAN MELA ORGANISED

## Farmers' Knowledge and their Creativity Leads to Sustainable Climate Change Adaptation

A 21 days village workshop cum training programme was organised with the financial assistance of United States India Educational Foundation, New Delhi from April 2-22, 2014. The objectives of this workshop were to learn and explore the farmers' knowledge and creativity on climate resilient food production systems in normal and salt affected environments of Haryana, Uttar Pradesh, Punjab and Rajasthan and to facilitate the scientific community and policy makers on integration of grassroots knowledge practices with climate change adaption policy. A total of 12 village workshops were organized in which more than 200 farmers and 20 grassroots knowledge holders actively participated. These workshops were organised in villages of Baras, Taraori, Sikandar-Kheri, Hajwana, Amritkalan, Gudha, Talakaur, Julaha-Majra, Lahariya, Alakhpura (Haryana) and Kheda-Afgan (UP). With the series of these workshops, climate resilient farmers' varieties, soil and water conservation practices, fertility and carbon management practices, crop and agriculture diversification, organic farming, biopesticides, network and informal institutions developed by male and female farmers to adapt changing social and climatic scenarios, and product diversification by rural women and men have been explored and learned. This workshop was concluded on 22nd April, 2014 on the occasion of Earth Day under the Chairmanship of Dr. A.K.Srivastava, Director and Vice Chancellor, Deemed University NDRI, Karnal. On 22nd April 2014, selected 25 farmers from studied areas participated in this workshop. This programme was organized by Dr. Ranjay K. Singh, Senior Scientist of the Institute.


*Village workshop on climate and salt resilient crop diversification with medicinal plants and horti crops in Lahariya village (Fatehabad district)*

## Workshop on IPv6 Technology

A workshop on IPv6 technology for Scientists, Technical, Administrative and Finance Officer was organised on 16th May 2014 to sensitize the staff members about new Internet Protocol version 6 (IPv6) and the need for migration from IPv4 to IPv6 in the institute. The workshop was inaugurated by Dr. D.K. Sharma, Director, CSSRI while Dr. A.K. Choubey, Head, Division of Computer Applications, IASRI, New Delhi was the Guest of Honour. About 60 staff members and Heads of RRS at Canning Town, Bharuch and Dr. Sudeep Marwah, Sr. Scientist, IASRI, New Delhi participated. Dr. D.S. Bundela, Principal Scientist presented the overview of the workshop and informed about the IPv6 Deployment Plan for CSSRI.

Dr. D.K. Sharma stressed over the use of this technology in research by presenting comparative study between India and USA for the use of Internet. Dr. S.K. Kamra explained the benefits of IPv6. Dr. A.K. Choubey emphasized the need for migration from IPv4 to IPv6 in phased and time bound manner in all ICAR institutes. He also briefed about initiatives taken by Department of Telecommunications, Govt. of India that released National IPv6 Deployment Plan version II in Government Institutions and for other stakeholders.

Sh. Rajeev Aggarwal introduced the IPv4 and IPv6 and its merits and demerits. Dr. Sudeep Marwah, Sr. Scientist (Computer Science), IASRI, New Delhi described about the migration from IPv4 to IPv6.

*IPv6 workshop is in progress*

He information about the development of proforma for auditing inventory of all existing network equipments, servers, computers, switches, routers, network printers, application software, website and mail service, which was sent to all ICAR institutes for obtaining the information about the existing equipment in compliance with IPv6.

## Stakeholders Meeting on Sub-surface Drainage Technology

A stakeholders meeting on Sub-surface Drainage Technology was organized under the chairmanship of Dr. R.S.Paroda, Chairman, Haryana Kisan Ayog on 26th May, 2014. In this meeting, 80 farmers and Ofiicers of Deptt of Agriculture/ Haryana Operational Pilot Project of Karnal, Jajjar, Rohtak, Sonipat, Jind, Bhiwani, Sirsa and Hisar participated. Sh. Vijay Jain, Chief Engineer (Haryana), Panchkula was also participated. Dr. D.K.Sharma, Director, CSSRI Karnal informed that this technology has been developed by this institute and spreading in other states like Rajasthan, Maharashtra, Karnataka. Dr. R.S. Paroda said that about 10 per cent areas in Haryana are affected by salinity and waterlogging. He suggested various solutions for its reclamation like mixing of 10-20 per cent saline water with fresh water can be used for irrigation.He also suggested that where sub surface drainage technology has been installed, we should make them functional with formation of a society, continuous draining of saline water, make aware about proper working of this technology etc. He also suggested that machinery for its installation of this technology should be made available and its proper maintenance is required so that this technology could be made functional at large areas. He further suggested that machinery should be made available through out sourcing and drained should make clean properly by the

*Dr. R.S. Paroda, Chairmen, Haryana Kisan Ayog discussing about sub surface drainage technology*

farmers. For proper use of saline water, he stressed for brackish water aquaculture, agroforestry and bio drainage by planting eucalyptus. He advised that this institute will help in imparting training, evaluation and keeping in view the problems of faced by the farmers for running this technology develop a white paper for its proper functioning. Dr. S.K. Kamra requested all the stakeholders to provide the information of the problems faced while running the technology. Sh. Vijay Jain, Chief Engineer (Haryana) assured for every help required from the Irrigation Deptt for proper functioning of this technology.

## Field days/Farmers' goshthi

Field days were organized on the farmer's field in Siwanamal village (Jind) with saline and sodic soils and waters management and also provoking reciprocal learning on management of overall natural resources including adaption to the extreme events. On 29th May 2014, a Farmer's Goshthi was also organized to sensitize the farmers about DSR technology for combating climate variability and mitigating yield penalty in the rice crop.

*Kisan Goshthi on DSR in salt affected lands in Siwanamal village (Jind)*

## Parthenium Grass : Awareness and Management

A goshthi on Parthenium eradication was organized under Chairwoman of Dr (Mrs) Indu Sharma, Director, Indian Institute of Wheat and Barley Research, Karnal on 6th September, 2014. About 200 scientists, farmers and Officers participated in this goshthi. Dr. D.K. Sharma, Director CSSRI explained this grass have various adverse effects like allergy in skin, ear, nose, eye, liver and respiration problems. It is poisonous for animals also. It is spreading like any thing which creating great problems to the living organism and crops. Dr. Samunder Singh, Sr. Scientist, CCS

*Scientists discussing on eradication of parthenium grass*

HAU, Hisar delivered a talk on its eradication. Dr. R.S. Chhokar, Sr. Scientist, IIW &BR, Karnal presented the spray techniques for its control. Dr. Indu Sharma suggested the integrated control of this weed and awareness programmes should be organized for removing this abnoxious weed.

## Hindi week

The Institute celebrated the Hindi Week during September 15-30, 2014. Dr. S.K. Chaudhari, ADG(SWM) inaugurated the function on 15$^{th}$ September, 2014. 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 function, Dr. R.K. Bhardwaj, Principal, Dayal Singh College, Karnal advised the scientists of the institute to make use of Hindi language in brining out the scientific and technical literature, it is beneficiary for farmers. Dr. D.K. Sharma told the institute staff to do more and more work in Hindi.

CSSRI RRS Bharuch celebrated the Hindi Saptah during 16-22-9-2014, events like quiz, letter, essay and precise writing and elocution were organized. Dr. Kalarathi, Professor and Head, Hindi Department, JP College, Bharuch was the Chief Guest. The prizes for different events were distributed to the winners by the Chief Guest.

## Short Course on Advanced Technologies in Land and Water Remediation and Management

Ten days short course on Advanced Technologies in Land and Water Remediation and Management was organized during September 15-24, 2014. Twenty three delegates from Haryana, Uttar Pradesh, Rajasthan, Gujarat, Karnataka, Maharashtra and Telengana participated. Dr. S.K.Chaudhari, Asstt. Director General (SWM), ICAR, New Delhi inaugurated the programme while Dr. D.K.Sharma, Director, CSSRI, Karnal presided over the function. Dr. Chaudhari emphasized on basic and applied research. With the reclamation of salt affected soils, the institute has contributed a lot toward the food security of the country. He expressed that the soil health card should be made available to every farmers and stressed upon the release of salt tolerant varieties of horticultural crops also. He said that soybean is the

*Dr. D.K. Sharma Director, CSSRI along with trainees of short course*


*Dr. S.K. Chaudhari, ADG(SWM) inaugurating the hindi week at the Institute* most important crop and salt tolerant varieties of this crop should be introduced. He further stressed about sub-surface drainage, biotechnology, neno technology, quality of irrigation water, molecular biology and agro-forestry.

During this training programme, extent of poor quality water, impact of long term usage of poor quality water comprising saline, amendments for sodic and waste water on crop yield and soil health and best management practices for mitigating the deleterious effects of poor quality water were discussed.

Dr. D.K. Sharma, Director said that with the proper use of waste land and poor quality waters can make a remarkable contribution to the production of food grains to sustain the livelihood.

## Training Programme on Conservation Agriculture (CA) : Developing Resilient Systems

A training programme on conservation agriculture for capacity development of researchers of Indian NARES (ICAR, SAUs) and CGIAR institutes was organized during 27 September to 4 October, 2014 under the Flagship of CSISA project funded by USAID and Bill & Melinda Gates Foundation (BMGF). The training programme was sponsored by CSISA, CIMMYT and organized jointly by CSSRI and CIMMYT.

Globally, the positive impact of CA-based techniques on natural resources, adaptation and mitigation of climate change effects has been widely acknowledged. In India, too, more strategic research on CA such as precise nutrient application, water, cultivars and weed management has been initiated in the recent past. CA remains relatively a new concept in the country. This training programme offered a unique opportunity for the scientific community working in the area of natural resource management.

*Training on conservation agriculture is in progress*

In the training programme, basic principles of CA and issues related to minimum disturbance of soil, rational surface cover and crop diversification/intensification were covered. Field experiences and modern technologies for efficient and sustainable management of natural resource for sustaining food security and profitability and productivity were also covered. Dr. J.S. Chauhan, ADG (Seeds), ICAR, New Delhi inaugurated the function and underlined the importance of CA for improving the productivity of crops and cropping system in different agro-ecological regions of India to sustain the livelihood of small holders.

Drs. D.K. Sharma and A. McDonald had opinion that continuous cultivation of rice-wheat cropping system for almost five decades in Indo-Gangetic alluvial plains has set in the processes of degradation in the natural resources of water, soil, climate and biodiversity. Apart from these, the labour charges continues to increase, high prices of inputs with low factor productivity making profits from rice-wheat crops to decrease and thus causing unsustainability and migration of farmers to urban areas and also selling of agriculture lands. This, therefore, calls for an urgent need to reorient the present ways of doing agriculture to those that can improve resource (water, labour and energy) efficiency by advanced crop management technologies. Conservation agriculture offers a key solution for enhancing crop productivity and safeguarding the environment through prudent and efficient resource use in Indian IGP.

## *Kharif* Kisan Mela

The *kharif kisan mela* was organized at the door steps of the farmers at Village Siwanamal (Jind) on 22$^{nd}$ October, 2014 in order to get first hand information about the problems of the farmers on soil salinity and water quality, and ensure maximum participation through reciprocal learning. The *kisan mela* was inaugurated by Dr. Rameshwar Singh, Project Director, Directorate of Knowledge Management in Agriculture, New Delhi while Dr. D.K. Sharma, Director CSSRI, Karnal presided over the function. A number of dignitaries including consultants, experts from Karnal based ICAR Institutes, KVK and State Deptt of Agriculture actively participated in the *kisan*


*Dr. Rameshwar Singh, Project Director, DKMA, ICAR, New Delhi addressing the farmes*

*mela.* Exhibition of seeds, fertilizers, pesticides and agriculture implements were also put up by various governments, cooperative and private agencies on the occasion.

A *kisan goshthi* and field visit were 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 800 farmers benefited from this important function. Seeds of salt tolerant wheat varieties KRL 19, KRL 210, KRL 213 and HD 2967 and mustard varieties CS 52, CS 54 and CS 56 were sold during the *mela*. Three hundred soil and water samples brought by the farmers were tested free of cost.

Dr. Singh 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 also appreciated the role of salt tolerant varieties developed by the Institute. He suggested about the problems faced by the farmers in operation of the Sub Surface drainage system that they should develop cooperative system for effective operation of the system. 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. The Sarpanches of two villages were awarded for their contributions made in adoption of CSSRI technologies.

## Farmers' Day Celebration

Farmers' Day was celebrated on 1st November, 2014 wherein farmers from Bara tract comprising Amod, Vagra and Jambusar talukas, Shri. A.D. Chouhan, Deputy Development Officer, Sh. J.S. Patel, District Agriculture Officer, officers from Taluka Agriculture office, KVK Chaswad, NABARD, NGOs like SAVE, Jambusar and ATAAPI, Gajera participated. Dr. K G Patel, Principal, Agriculture College, Bharuch was the Chief Guest. The farmers were appraised the beneficial aspects of cultivation of salt tolerant cultivars of cotton and wheat on saline tracts. Seeds of two salt tolerant varieties of wheat (KRL 210 and KRL 19) were distributed for on-farm trials.

## ICAR Regional Committee V Meeting

XXIII meeting of Indian Council of Agricultural Research (ICAR) Regional Committee V, comprising the States of Punjab, Haryana and Delhi held at Punjab Agricultural University, Ludhiana during November, 14-15, 2014 under the Chairmanship of Dr. S. Ayyappan, Secretary, DARE and Director General, ICAR, New Delhi. Dr. K.M.L. Pathak, Deputy Director General (Animal Science), ICAR was the Nodal Officer while Dr. D.K.Sharma, Director, CSSRI, Karnal was the Member Secretary of the meeting. This committee acts as an effective interface between research and development organizations of the region. About 125 Senior Officers including Agricultural Secretaries of the states, Vice Chancellors of Agricultural/Veterinary Universities, Deputy and Assistant Director Generals, Directors of different ICAR institutes, Heads of the Regional Stations of ICAR and progressive farmers participated. Dr. B.S.Dhillon, Vice Chancellor, PAU delivered the welcome address in the inaugural function. Dr. D.K. Sharma presented the action taken report of the recommendations of the last meeting held at IARI, New Delhi in December, 2012.

Dr. S. Ayyappan emphasized on moving from green revolution to evergreen revolution. The food


*XXIII meeting of ICAR Regional Committee V is in progress*

basket states of Punjab and Haryana with only 2.9 per cent of nation's geographical area, contribute more than one fifth of country's food grain production including 20% rice and 30% wheat. He said that focus should be on crop diversification, climate change, quality seed production of different crops and development of resource conservation technologies and innovative nutrient and water management practices. He expressed his concern on sub-surface drainage, biodrainage, food quality and safety, development of salt tolerant varieties and improvement in livestock and fishery sector, paddy straw burning, ground water issues, pesticide residue. He suggested that farmers should be provided with soil health cards. He called upon the farm experts to give a new paradigm shift to all the KVKs through cyber extension and lay special thrust on more farm productivity and profitability.

Dr. Pathak pointed out for meeting the food requirements of 2025 in view of the challenges of climate change and decreasing profits is going to be a tough task. Dr. Sharma said that recommendations emerging out of this meet will go a long way in improving the livelihood of the farmers. The progressive farmers of these states were also fecilitated in the meeting.

## Winter School on Diagnosis, Assessment and Management of Salt Affected Soils and Poor Quality Waters to improve Productivity and Livelihood Security

Twenty one days winter school on diagnosis, assessment and management of salt affected soils and poor quality waters to improve productivity and livelihood security was organized during 11th Nov. to 1st December, 2014. Twenty four delegates from 10 states participated in this winter school. The programme was inaugurated by Dr. B.Mishra, Former Vice Chancellor, Sher-e-Kashmir University of Agricultural Science and Technology, Jammu while Dr. S.K.Ambast, Director (A), CSSRI, Karnal presided over the function. Dr. B.Mishra

*Winter school is in progress*

told that about 260 million tonnes of foodgrain are produced from 40 percent irrigated areas. About 300 per cent more fertilizers are being used in Haryana. This Institute has developed various salt tolerant varieties of rice, wheat and mustard. CSR 30 variety of rice replaced the taraori basmati rice in this area because it gives about 20 per cent more yield than taraori basmati. He said that application of 20 per cent gypsum with salt tolerant varieties gave a good yield.

Dr. S.K. Ambast informed that this institute has established in 1969 with the objective to reclaim salt affected and water logged soils. The main purpose of this winter school was to share the knowledge with the participants. This institute has reclaimed the salt affected soil with gypsum and sub-surface drainage technology as well as developed salt tolerant varieties of rice, wheat, mustard and gram. He informed that Canning Town (West Bangal) Centre has been established for reclamation of salt affected areas of coastal region, Bharuch (Gujarat) centre for dry land salinity and Lukhnow (Uttar Pradesh) centre for sodic soil.

## Efficient Irrigation Technologies for Improving Crop Water Productivity in Canal Commands of Haryana

A five days training programme for CADA Officers on Efficient Irrigation Technologies for Improving Crop Water Productivity in Canal Commands of Haryana was held at ICAR-CSSRI, Karnal during December 2-6, 2014. Twenty officers including one Superintending Engineer, three Executive Engineers, six SDO, and ten JE from 12 Divisions (Karnal, Kurukshetra, Kaithal, Panipat, Rohtak, Jind, Jhajjar, Rewari, Bhiwani, Fatehabad and Sirsa) under Kaithal, Rohtak and Hisar Circles participated in the training programme which was inaugurated by Dr. S.K. Chaudhari, ADG (SWM) and Guest of Honour, Er. Rakesh Chauhan, Principal Director (HIRMI), Kurukshetra. Dr. D.S. Bundela welcomed the participants and presented the overview of the training programme.

*CADA Officers training on efficient irrigation technologies*

Dr. S.K. Chaudhari stressed on increasing water and input use efficiency in irrigated agriculture as both have direct and positive relationship to each other. Dr. Chaudhari drew the attention to the waterlogging and soil salinity problems in the canal commands of the country which have been developed due to inadequate drainage network and emphasised to address the problems by adopting efficient irrigation and effective subsurface drainage technologies for improving on-farm water productivity. Dr. Chaudhari also highlighted the importance of micro-irrigation and improved surface irrigation in RKVY programme for improving water productivity in normal and saline conditions. Er. Rakesh Chauhan highlighted the CADWM programme for managing canal and ground water efficiently and equitably for irrigation and stressed to increase water use efficiency by 20 per cent by 2017. Therefore, CADA must play an important role for efficient water delivery to farms by watercourse lining and micro-irrigation..

Dr. D.K. Sharma, Director, ICAR-CSSRI emphasised the use of efficient irrigation technologies for enhancing crop and water productivity in marginal groundwater quality areas as well as for preventing waterlogging and soil salinization problems. Dr. Sharma also explained the technologies of the institute for reclamation of waterlogging, saline and sodic soils, and use of poor quality water for enhancing crop and water productivity. Dr. S.K. Kamra, Head, Division of Irrigation and Drainage Engineering highlighted the role of efficient irrigation and drainage technologies and other innovative technologies including modern tools developed by the Division.

## National Seminar on Innovative Saline Agriculture in Changing Environment

A three days national seminar on Innovative Saline Agriculture in Changing Environment was organized in collaboration with Indian Society of Soil Salinity and Water Quality (ISSWQ) and Rajmata Vijayaraje Scindia Krishi Vishwavidalaya (RVSKV), Gwalior (MP) from 12-14$^{th}$ December 2014. The seminar was aimed at providing a platform to research scientist to discuss the emerging issues on salinity and poor quality waters. Dr. A.K.Singh, Vice-Chancellor, RVSKV,

*Dr. A.K. Singh, Vice Chancellor, RVSKV, Gwalior inaugurating the national seminar on innovation saline agriculture*

Gwalior (MP) inaugurated the national seminar. He informed the house that year 2015 has declared as world soil year. He said that in Madhya Pradesh 2.4 lakh ha area falls under salt affected soils. The area under irrigation is increasing in Madhya Pradesh but judicious use of water is a great challenge and water use efficiency should be increased. Good amount of land is utilized for industrial and urban development and good fertile land is used to form bricks. He emphasized that water quality is also an another issue of concern and stress that waste water has to be used very carefully by the farmers specially in vegetables and for aquaculture due to presence of heavy metals.

Dr. S.S.Khanna, Former Advisor (Agri.), Planning Commission, GOI, New Delhi stressed that Coastal area salinity ingress is highly detrimental aspect because 10.1 M ha is affected in the coastal areas; some proper thinking should be given for reclamation of saline areas and employment generation to the farming community. Degraded land should be converted to productive land. Dr. D.K.Sharma, Director, CSSRI, Karnal explained the achievements and future challenges of the Institute. He informed the house that the institute has reclaimed 2.0 M ha salt affected land in Haryana, Punjab, Uttar Pradesh, Maharashtra and Gujarat. The institute has developed 15 salt tolerant varieties of rice, wheat, mustard and gram. The variety basmati CSR 30 of this institute completely replaced traditional taraori basmati variety in the area of Haryana, Pubjab and Western Uttar Pradesh. The institute is also working on use of poor quality waters in agriculture and microbial bioremediation of waste water for heavy metals.

Dr. P.C. Sharma, Head, Crop Improvement Division and General Secretary of Indian Society of Soil Salinity and Water Quality emphasized about the productive use of poor quality water with proper management. He cautioned that reclamation of degraded land and climate change are the second generation problem and researchers, policy makers and administrators should give proper thinking on these aspects. Dr. Sudhir Bharagava, Member, GB, ICAR, New Delhi, Dr. Ravinder Kaur, Director (A), ICAR-IARI, New Delhi, Dr. S.K. Chaudhari, ADG (SWM), ICAR, New Delhi, Dr. A.K. Patra, Director, ICAR-IISR, Bhopal, Dr. H.S. Sen, Ex Director, ICAR-CRIJAF, Barrackpore, Dr. J.C. Dagar, Ex-ADG (AAF), ICAR, New Delhi, Dr. S.K. Gupta, Professor, INAE, ICAR-CSSRI, Karnal and Dr. Ashwani, Pareek, Professor, Biotechnology, JNU, New Delhi were also present on the occasion. About 150 delegates registered from different Institutes and Organizations in the country to discuss innovations on saline agriculture in changing climate for future research in India

## Short Course on Management of Frost and Prolonged Foggy Weather

Seven days Short Course on Management of Frost and Prolonged Foggy Weather was organized during 17-23 December, 2014. This training was organized under the aegis of National Disastrous Management Division, New Delhi and 23 Scientists/Officers from Haryana, Punjab, Utter Pradesh and Bihar participated. Dr. Indu Sharma, Director, ICAR-Indian Institute of Wheat and Barley Research, Karnal was the Chief Guest and Dr. D.K. Sharma, Director, ICAR-CSSRI, Karnal was the Chairman of the Inaugural Session of the training programme.

Dr. Indu Sharma stressed upon the management of disaster because the productivity of the crops reducing due to occurrence of floods, changing pattern of rainfall. She informed that when the temperature goes down to less than $5^0$C sometime

*Short course on frost management is in progress*

the panicles of wheat becomes white and no grain formation takes place specially in early sown crop and it is necessary to irrigate the crop. When heavy rain comes and waterlogging situation arises resulting in 50% reduction in wheat yield and in unleveled fields, the loss would be by about 15%. In case of foggy weather, the vegetables like tomato, potato, brinjal, chilly etc. would effects more as compared to cereal crops and there is a chance of black and yellow rust in wheat.

Dr. D.K. Sharma informed about the various disastrous events occurred during 1900 to 2009 like flood and climate change, geological, nuclear, incidental and biological. He said that some disasters are natural and some are man made which are harmful in the form of property, animal and human losses. He suggested that conservation agriculture is a very effective technology to maintain the temperature of the soils. Sprinkler irrigation is also an effective option to reduce the loss in crop productivity of wheat crop during the month of March when temperature becomes high.

## International Training Programme on Use of Poor Quality Water in Agriculture

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 February11-24, 2015. Dr. R.K.Yadav, Coarse Director gave the overview about the structure and participation in the training programme. Ten delegates from Iraq, Nigeria, R.O. China (Taiwan), Gana, Egypt, Sri Lanka and Sudan participated in the training programme. During this training programme, extent of poor quality water, impact of long term usage of poor quality water comprising saline, amendments for sodic and waste water on crop yield and soil health and best management practices for mitigating the deleterious effects of poor quality water will be discussed.

Dr. S.K.Chaudhari, Assistant Director General (SWM), New Delhi inaugurated the training programme. Dr. Chaudhari focused on scarcity of fresh water and underlined the importance and need of use of poor quality and waste water for irrigation. He explained the scenario of Egypt regarding the quality of water. The poor quality water can help in meeting out the demand of food grain for the growing population of the world. It can be used in conjunction with the good quality water. He stressed that there is a need to develop the best management practices for use of poor quality water in agriculture.

Dr. D.K. Sharma, Director emphasized that when agriculture is improved, the livelihood of the rural population automatically improved. The raw material for the industries is available from the agriculture sectors. Dr. Sharma also said that with the proper use of waste land and poor quality waters can make a remarkable contribution to the production of food grains to sustain the livelihood.

*Dr. S.K. Chaudhari, ADG (SWM), ICAR, New Delhi inaugurating the international training on use of poor quality water*

## Foundation Day

CSSRI, Karnal celebrated its 46th Foundation Day on 1st March 2015 by organizing a Foundation Day lecture delivered by Dr. Alok Kumar Sikka, DDG (NRM) ICAR, 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. Sikka addressed the gathering on subject 'Harnessing Synergies from Degraded Lands for Enhancing Food Production in the Country'. He explained that India has 2.3 % land, 4.2 % freshwater,16 % population, 17 % of world's cattle.

Net sown area increased from 119 to 140 M ha, and still about 141 M ha. untapped potential in rainfed areas, challenged to produce 345 Mt by 2030 from 141 M ha or less with less water, low input use efficiencies 80% small & marginal holder's posses 36% land. About 121 M ha land is suffering from different forms of land degradation, land use changes as well as faulty management practices responsible for land degradation. In India, about 39% area in the country is having erosion rates of more than 10 t $ha^{-1}yr^{-1}$ About 11% area have erosion rates of more than 40 t $ha^{-1}yr^{-1}$. Some of the states in the North-West and North-East Himalayas are severely affected - more than 1/3rd of their geographical area falling in very severe (40-80 t $ha^{-1}yr^{-1}$) category. Among different land resource regions, highest erosion rate occurs in the black soil, Siwalik, North-Eastern region with shifting cultivation (27-40 t $ha^{-1}$) and least in North Himalayan Forest region (2.1 t $ha^{-1}$). 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 Karnal based ICAR institutes participated in the function.

## *Rabi Kisan Mela*

*Rabi Kisan Mela* was organized on 9th March, 2015. Dr. A.K. Singh, Deputy Director General (Agril. Ext.), ICAR, New Delhi was the Chief Guest while Dr. D.K. Sharma, Director, CSSRI presided over the function. About 800 farmers from Haryana, Punjab and Uttar Pradesh and school students of Karnal participated in the *Mela*. A number of experts from Karnal-based ICAR Institutes and officials of the state agriculture department also participated in the *Mela* to suggest solutions to diverse challenges being faced by farming community in Haryana.

An impressive exhibition of ICAR Institutes, state department of agriculture and allied sectors, CCSHAU, RRS Karnal and other private agencies/ NGOs, testing of soil and water samples, field visits to experimental sites, sale of rice seed produced at CSSRI farm and a highly interactive *Kisan Goshthi* were other highlights of the Mela. There was high demand for CSSRI rice seed leading to the sale of 100 quintal seed of CSR 30, CSR 36, CSR 43 and Pusa 44 varieties within a few hours during the *Mela*. The visiting students were appraised about the Central Laboratory facility, meteorological unit, groundwater recharge system and the herbal garden of the institute.

In the *kisan goshthi*, the farmers were informed about CSSRI technologies for reclamation of salt-affected soils, resource conservation, groundwater recharge, use of poor quality water, crop diversification, and salt tolerant varieties. Dr. D.K. Sharma, Director, CSSRI highlighted the


*Dr. A.K. Sikka, DDG, (NRM), ICAR, New Delhi delivering the foundation day lecture*


*Dr. A.K. Singh, DDG, (AE), ICAR, New Delhi addressing the farmers on the occasion of rabi kisan mela*

major achievements of the Institute, including a multi-enterprise agriculture involving integration of crop, fishery, fodder and cattle components which provides remarkable regular income to the farmers.

Dr. A.K. Singh appreciated the efforts of CSSRI for providing solutions for sustainable management of salt-affected soils and poor quality waters as reflected by wide scale adoption of CSSRI varieties and technologies by the farmers in different parts of country. He emphasized on the adoption of resource conservation technologies such as zero-tillage and direct seeded rice and crop diversification to low water requiring pulses and oilseed crops. Referring to the recently launched *Pradhan Mantri Krishi Sinchai Yojna* and Soil Health Card programme of the Central government, he stressed the need for vigorous research and extension efforts to popularize drip and sprinkler irrigation and soil-test based fertilizer use to realize per drop more crop. Thirteen progressive farmers were felicitated during the *kisan mela.*

## World Water Day

The institute has celebrated a World Water Day on 21st March, 2015 with a view to aware the farmers about the importance of water and its sustainable use. About 200 farmers, scientists and extension workers participated in this important event. Sh. S.K. Jain, Regional Director, Central Ground Water Board, Chandigarh and Chief Guest of the function, informed the farmers about the aquifer mapping which will provide the information of availability of water and its quality up tp 1000 m depth in a particular area. Dr. D.K. Sharma Director, CSSRI, Karnal highlighted that under limited available resources and increasing cost of cultivation, the Institute has developed a multi-enterprise agriculture model which could help in multiple use of water. Dr. S.K. Kamra, Head, Division of Irrigation and Drainage Engineering informed that 40 per cent water is of good quality and 60 percent of brackish in Haryana. Therefore efficient use of good quality and brackish water by adopting management practices is the need of the day. He also explained about the ground water recharge technology which can help in increasing the availability of ground water in future. On this occasion, Nukar Natak on *Jal Hi Jivan Hai* was also played.

*Dr. D.K. Sharma, Director, CSSRI addressing the farmers, scientists and extension workers on world water day*

# LIST OF SCIENTIFIC, TECHNICAL AND ADMINISTRATIVE PERSONNEL

## Dinesh Kumar Sharma, Ph.D., Director

### Division of Soil and Crop Management

Madhurma Sethi, Ph.D., Head (A)
P.K. Joshi, Ph.D.
Anil R. Chinchmalatpure, Ph.D. (30.10.2014)[a]
A.K. Mandal, Ph.D.
R.K. Yadav, Ph.D.
Parveen Kumar, Ph.D.
R.G. Garg, Ph.D.
A.K. Rai, Ph.D.
Sharad Kumar Singh, Ph.D. (29.11.2014)[a]
Gajender Yadav, Ph.D.
Ranbir Singh, Ph.D.
A.K. Bhardwaj, Ph.D.
H.S. Jat, Ph.D.
Madhu Chaudhary, M.Sc.
Anshuman Singh, Ph.D.
Murli Dhar Meena, Ph.D.
Nirmalendu Basak, Ph.D.
Assim Dutta M.Sc.
David Cames D. M.Sc. ( 13.10.2014) [b]

### Technical Officers

T.N. Khurana, B.Sc. (31.3.2015) [c]
Naresh Kumar, M.Sc.

### Division of Crop Improvement

S.K. Sharma, Ph.D., Head (31.7.2014) [c]
Parbodh Chander Sharma, Ph.D., Head (1.11.2014) [b]
Neeraj Kulshreshtha, Ph.D. (3.11.2014)[a]
S.L.Krishna Murthy, Ph.D.
Joginder Singh, Ph.D.
Ashwani Kumar, Ph.D.
Arvind Kumar, Ph.D. (15.12.2014)[b]

### 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 (A)
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 ( 31.10.2014) [c]
Brij Mohan
Sat Pal

### Division of Technology Evaluation and Transfer

R.S. Tripathi, Ph.D., Head (31.7.2014) [c]
R.K. Singh, Ph.D., Head (A) (1.8.2014)[b]
K. Thimmappa, Ph.D.
R. Raju, Ph.D.
Parvender Sheoran, Ph.D.
Sanjay Vasant Kad, M.Sc. (09.04.2014)[b]

### Technical Officers

S.K. Tyagi, Ph.D.

### AICRP (Salt-Affected Soils & Use of Saline Water)

S.K. Ambast, Ph.D., Project Coordinator (21.1.2015)[a]
R.L. Meena, Ph.D.
Babu Lal Meena, Ph.D.

### Technical Officers

Anil Kumar Sharma, MA, (English)

### 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.) (30.04.2014)[c]
N.B. Mondal, ITI
Sivaji Roy , M.Sc.
P.K. Dhar, B.Sc.
Smt. S. Roy, B.Sc. (30.9.2014)[c]
S. Mandal, B.Sc.

A.K. Pramanik
L.K. Nayak, Driver
D. Mukherjee
D. Banerjee

### PS to the Head

A.K. Nandi, B.Sc.

### Regional Research Station, Bharuch

Anil R. Chinchmalatpure, Ph.D. Head (31.10.2014)[b]
G. Gururaja Rao, Ph.D. Head (A) (30.10.2014)[a]
Sarwan Kumar, M.Sc.
Indivar Parshad, M.Sc.
Nikam Vinayak Ramesh, M.Sc.

### Technical Officer

M.V.S. Rajeshwar Rao, M.Sc.
Akshay Kumar

### 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.

### Technical Officers

C.S. Singh, Ph.D.
Hari Mohan Verma, M.Tech.

### Administrative and Supporting Section

### Administration

R.K. Bhardwaj, Sr. Admn. Officer (22.11.2014)[b]
Abhishek Srivastava, Admn. Officer
Ved Parkash, Finance and Account Officer
A.K.Kathuria, Jr. Account Officer (10.8.2014)[a]
A.K.Kathuria, Jr. Account Officer (5.9.2014)[b]
Randhir Singh, Jr. Account Officer (6.9.2014)[b]
A.K.Mishra, Asstt. Admn. Officer
Tarun Kumar, Asstt. Admn. Officer
Ranjeet Singh, Asstt. Admn. Officer
Multan Singh, Asstt. Admn. Officer (04.05.2014)[b]

### RTI Cell

K. Thimmappa, Ph.D., CPIO
Randhir Singh, Ph.D., APIO

### Transparency Officer

Dr. R.S. Tripathi, Ph.D. (31.7.2014)[c]

### Priortizing, Monitoring and Evaluation (PME) and Institute Technology Management Unit (ITMU)

Anil R. Chinchmalatpure, Ph.D., CO (30.10.2014)[a]
Parveen Kumar, Ph.D., CO (31.10.2014)[b]

### Publication and Supporting Services Unit

Anil R. Chinchmalatpure, Ph.D., CO (30.10.2014)[a]
Parveen Kumar, Ph.D. (31.10.2014)[b]
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

Santra Devi, PS

### Public Relation Officer

Randhir Singh, Ph.D.

### PS to Heads

Dinesh Gugnani
Rita Ahuja
Sunita Malhotra
Shashi Pal

### Farm Section

H.S. Tomar, MA, Farm Manager
Chander Gupt
Seth Pal
Jaswant Singh

### Library

Meena Luthra, M.A., M. Lib. Sci., OIC,

### Medical Unit

Dr. (Mrs.) Mahathi Parkash, M.B.B.S.
Sunita Dhingra
Chanchal Rani
Geeta Rani

### Estate Section

Satyender Kumar, Ph.D., CO
S.K. Dahiya, OIC, Security
N.K. Vaid, M.Tech. OIC (Estate Civil)
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 31.3.2015

| 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 | - | 29 | 29 | 01 | 3.44 | 03 | 10.34 |
| Lowest rung of Class-1 | - | 44 | 44 | 01 | 2.27 | 01 | 2.27 |
| Class-II | - | 70 | 70 | 17 | 24.28 | 05 | 7.14 |
| Class-III | - | 56 | 56 | 10 | 17.85 | 05 | 8.92 |
| Class-IV (excluding sweepers) | - | 56 | 56 | 15 | 26.78 | 05 | 8.92 |
| Class-IV (only sweepers) | - | 06 | 06 | 06 | 100 | - | - |
| **Total** | **-** | **261** | **261** | **50** | **177.62** | **19** | **37.59** |

## 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 31.3.2015

| Classified posts | Total vacancies | | Scheduled Castes | | Scheduled Tribes | |
|---|---|---|---|---|---|---|
| | Notified | Filled | Notified | Filled | Notified | Filled |
| Direct Recruitment | | | | | | |
| Class-I | | | | | | |
| Class-II | | | | | | |
| Class-III | | | Nil | | | |
| Class-IV | | | | | | |
| **Promotions** | | | | | | |
| Class-I | | | | | | |
| Class-II | | | Nil | | | |
| Class-III | | | | | | |
| Class-IV | | | | | | |

# WEATHER REPORT 2014

## Main Institute, Karnal

During the year 2014, a total rainfall of 713.1 mm was recorded at Agro-met Observatory at Karnal as compared to the mean annual rainfall of 740.2 mm (for the last 43 years). The year was a normal year (96% of the long-term mean annual rainfall) whereas the year 2013 was also anormal rainfall year (117% of the mean annual rainfall). The maximum monthly rainfall of 256.3 mm was recorded in September. During the monsoon season, the highest rainstorm of 136.2 mm was recorded on 6$^{th}$ September. The winter rainfall (January and February) was 115.0 mm as compared to the last year winter rainfall (180.8 mm). The winter rainfall along with favourable weather condition prevailed during *rabi* season and supplemented two irrigations which substantially decreased the irrigation demand of *rabi* crops in January and February month resulting in application of two more irrigations either from canal orground water or both for wheat crop and yielded bumper *rabi* crop production. There were 43 rainy days as compared to 51during the last year.

The minimum and maximum air temperatures, 2.0° and 46.0°C were recorded on 6$^{th}$ January and 7$^{th}$June, respectively. The lowest air relative humidity was 6% on 30$^{th}$ April while the highest (100%) was recorded on several occasions during the year. The highest soil temperatures at 5,10 and 20 cm depths were 45.5, 44.0 and 42.5°C on 5$^{th}$ June, 8$^{th}$ June and 21$^{st}$ June, respectively. The lowest values at same depths were recorded as 6.0, 6.5 and 7.0°C on a single day (10$^{th}$ February). The total open pan evaporation during the year was 1465.3 mm, which is two times higher than the annual rainfall. The lowest evaporation of 0.6 mm was recorded on 17$^{th}$ and 31$^{st}$ January and the highest of 13.0 mm was on 13$^{th}$ June. The average sunshine hours per day were6.7. The highest and lowest vapour pressure values were 29.2 and 4.6 mm of mercury column on 17$^{th}$ June and10$^{th}$ December, respectively. The average wind speed was 3.8 km per hour. The monthly weather parameters recorded at agro-meteorological observatory, CSSRI, Karnal for the year 2014 are presented in Table I.

## RRS, Canning Town

The mean monthly weather parameters recorded at RRS, Canning, are presented in Table II. The southwest monsoon set in the last week of May. Total annual rainfall of 1368.3 mm was recorded at meteorological unit during 2014. The maximum of 337.8 mm rainfall was recorded in the month of September, but the maximum rainy days (17) were recorded in the month of July. This year total annual rainfall was less than the long time average annual rainfall of 1768 mm, which affected the smooth growth of rice in the middle of the *kharif* season. There were 73 rainy days in this year. The average daily sunshine hours were moderate. The minimum temperature reached its lowest (total mean monthly average 12.6$^{0}$C) in the month of January. The average mean monthly temperature of 18.3$^{0}$C in January rose very rapidly to 31.4$^{0}$C in the month of May. The relative humidity remained quite high throughout the year, which caused several problems of pest and disease infestations. Highest average wind velocity (10.5 km/h.) was recorded in May.

## RRS, Bharuch 2014

Agro-meteorological observations (Table III) recorded at Cotton Research Station, Bharuch (latitude 22$^{O}$N, longitude 73.5$^{O}$E, and altitude 16.50 m ASM) during 2014 revealed that this region received normal rainfall of 879.5 mm spread over 40 days. Season's highest rainfall 415.8 mm was received during July followed by 249.8 mm and 132.0 mm in August and September 2014, respectively. Maximum air temperature ranged from 40.0 $^{o}$C (May) to 28.3 $^{o}$C (Jan) and minimum air temperature varied 14.1 $^{o}$C (Jan) to 27.7 $^{o}$C (June). Pan evaporation varied from 2.4 mm day$^{-1}$ during August to 12.3 mm day$^{-1}$ during May. The average bright sunshine hours varied from 4.5 during August to 10.3 during May. Mean relative humidity varied from 46.3 per cent during December to 80.4 per cent in August. The average wind speed varied from 0.9 kmph during November to 11.4 kmph during June.

**Table 1: Mean monthly weather parameters for the year 2014 recorded at the 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 | | | | |
| January | 17.1 | 6.7 | 3.2 | 8.3 | 16.5 | 8.2 | 13.2 | 8.2 | 9.4 | 98 | 68 | 22.0/28 | 9.8/16 | 10.2/22 | 2.0/06 |
| February | 20.0 | 7.9 | 3.7 | 9.3 | 19.8 | 9.0 | 15.0 | 8.5 | 10.0 | 95 | 58 | 24.0/04 | 13.0/15 | 12.5/22 | 2.8/10 |
| March | 25.5 | 12.2 | 08.9 | 14.4 | 25.0 | 13.4 | 18.4 | 11.0 | 11.9 | 88 | 51 | 31.0/18 | 15.5/02 | 17.0/26 | 6.7/03 |
| April | 34.1 | 16.3 | 13.4 | 19.9 | 33.9 | 19.8 | 19.5 | 11.8 | 8.3 | 69 | 22 | 41.0/30 | 27.6/19 | 20.0/30 | 12.2/01 |
| May | 37.6 | 21.7 | 19.1 | 24.8 | 36.8 | 20.4 | 22.7 | 15.4 | 12.3 | 66 | 28 | 43.0/02 | 28.2/14 | 25.5/30 | 18.0/13 |
| June | 40.9 | 26.2 | 23.5 | 28.7 | 39.6 | 24.0 | 25.7 | 19.7 | 16.3 | 67 | 32 | 46.0/07 | 35.5/24 | 31.0/21 | 22.6/14 |
| July | 34.5 | 26.7 | 23.9 | 28.1 | 32.9 | 26.3 | 26.9 | 24.6 | 23.1 | 86 | 62 | 39.0/13 | 29.2/20 | 29.0/11 | 22.8/01 |
| August | 34.4 | 25.8 | 24.0 | 27.2 | 33.4 | 25.7 | 27.7 | 24.0 | 24.5 | 89 | 64 | 36.0/27 | 31.0/06 | 27.6/12 | 23.0/31 |
| September | 32.3 | 23.4 | 21.1 | 24.8 | 31.6 | 24.0 | 26.3 | 22.0 | 22.3 | 94 | 65 | 34.2/21 | 27.5/01 | 25.5/03 | 20.8/15 |
| October | 31.1 | 17.8 | 15.4 | 19.2 | 30.3 | 19.7 | 22.5 | 16.4 | 15.8 | 96 | 49 | 35.5/06 | 27.4/29 | 23.0/06 | 12.5/09 |
| November | 27.8 | 10.5 | 7.2 | 12.4 | 35.0 | 11.1 | 16.8 | 9.3 | 8.1 | 85 | 30 | 31.7/08 | 25.0/26 | 17.0/22 | 6.5/22 |
| December | 18.9 | 7.0 | 0.9 | 8.6 | 18.1 | 8.0 | 13.1 | 7.8 | 8.4 | 93 | 57 | 28.5/01 | 10.0/26 | 13.0/14 | 2.6/29 |
| **Average:** | **27.3** | **16.8** | **13.7** | **18.8** | **29.4** | **17.5** | **20.7** | **14.9** | **14.2** | **85.4** | **48.8** | -- | -- | -- | -- |

| 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 | | |
| January | 10.1 | 16.3 | 10.8 | 15.0 | 11.3 | 14.3 | 65.8 | 03 | 29.4/18 | 1.1 | 34.7 | 3.0 | 3.1 |
| February | 11.0 | 19.0 | 11.5 | 17.7 | 12.1 | 17.0 | 49.2 | 05 | 18.2/22 | 1.7 | 48.3 | 5.7 | 3.2 |
| March | 15.2 | 24.6 | 15.5 | 22.7 | 16.3 | 21.8 | 51.6 | 06 | 13.8/12 | 2.7 | 83.1 | 7.0 | 3.8 |
| April | 21.6 | 33.2 | 22.6 | 30.4 | 22.9 | 30.0 | 11.6 | 03 | 7.4/18 | 5.9 | 171.5 | 9.7 | 4.5 |
| May | 26.2 | 37.5 | 27.2 | 36.3 | 27.8 | 35.5 | 42.6 | 03 | 23.4/06 | 7.8 | 242.7 | 9.2 | 5.5 |
| June | 31.2 | 41.8 | 32.2 | 40.5 | 32.9 | 39.7 | 43.2 | 02 | 19.0/30 | 9.6 | 270.6 | 7.3 | 5.6 |
| July | 29.8 | 36.9 | 30.7 | 35.8 | 31.3 | 35.3 | 66.0 | 06 | 51.0/01 | 5.3 | 165.5 | 6.4 | 5.2 |
| August | 30.0 | 37.7 | 30.8 | 36.6 | 31.6 | 35.8 | 54.8 | 05 | 22.6/11 | 4.7 | 147.0 | 7.2 | 4.2 |
| September | 26.7 | 34.8 | 27.7 | 32.8 | 28.3 | 31.4 | 256.3 | 06 | 136.2/06 | 3.6 | 101.7 | 7.3 | 3.7 |
| October | 21.8 | 29.5 | 22.9 | 28.3 | 23.8 | 27.3 | 65.6 | 02 | 38.0/14 | 2.5 | 78.0 | 6.1 | 2.1 |
| November | 15.7 | 23.6 | 16.6 | 22.4 | 17.4 | 21.4 | 0.0 | 00 | 0.0 | 2.5 | 73.7 | 7.3 | 2.4 |
| December | 11.7 | 16.5 | 12.5 | 15.6 | 13.3 | 15.3 | 6.4 | 02 | 4.8/14 | 1.6 | 48.5 | 4.5 | 3.0 |
| Total: | -- | -- | -- | -- | -- | -- | 713.1 | 43.0 | -- | -- | 1465.3 | -- | -- |
| **Average:** | **20.9** | **29.3** | **21.8** | **27.8** | **22.4** | **27.1** | **59.4** | **--** | **--** | **5.1** | **122.1** | **6.7** | **3.8** |

* Rainfall < 2 mm is drizzle or trace.

**Table II :Mean Monthly Weather Parameters at Canning Town (Latitude 22$^{0}$15′ N, Longitude 88$^{0}$40′E, Altitude (AMSL)-3.0 M, during the year-2014**

| Month | Temperature ($^{0}$C) | | | RH (%) | | Rainfall ( mm) | Rainy days | Av. wind (kmph) | Max wind (kmph) | BSH/ days | Solar Radiation MJ/M$^{2}$/ DAY | EVP (mm/ day) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Max | Min | Mean | Max | Min | | | | | | | |
| Jan. | 24.2 | 12.6 | 18.3 | 100 | 48.2 | 0.0 | 0 | 3.2 | 18.5 | 6.3 | 11.6 | 2.8 |
| Feb. | 27.1 | 15.8 | 21.5 | 100 | 40.6 | 63.0 | 2 | 3.9 | 19.8 | 7.1 | 13.6 | 3.3 |
| March | 32.1 | 20.5 | 26.6 | 100 | 40.1 | 54.3 | 3 | 4.7 | 22.9 | 7.7 | 16.0 | 4.0 |
| April | 36.7 | 25.6 | 31.2 | 100 | 35.6 | 0.2 | 0 | 6.5 | 23.4 | 8.2 | 17.7 | 4.2 |
| May | 36.1 | 26.7 | 31.4 | 100 | 48.3 | 205.1 | 7 | 10.5 | 32.2 | 8.0 | 14.3 | 4.0 |
| June | 33.2 | 27.1 | 30.2 | 100 | 75.4 | 173.5 | 11 | 7.6 | 29.7 | 4.3 | 10.8 | 3.7 |
| July | 31.1 | 27.2 | 29.2 | 100 | 83.1 | 227.2 | 17 | 7.5 | 24.5 | 4.0 | 9.7 | 3.3 |
| Aug. | 32.4 | 26.8 | 29.5 | 100 | 73.4 | 255.9 | 12 | 7.9 | 27.2 | 4.5 | 11.4 | 3.9 |
| Sept. | 32.2 | 26.3 | 29.3 | 100 | 69.0 | 337.8 | 16 | 6.6 | 29.1 | 5.3 | 14.2 | 3.4 |
| Oct. | 31.7 | 24.0 | 27.8 | 100 | 57.8 | 51.3 | 5 | 3.1 | 20.3 | 6.6 | 13.9 | 2.8 |
| Nov. | 29.9 | 18.1 | 24.0 | 100 | 38.6 | 0.0 | 0 | 2.1 | 15.2 | 7.8 | 12.7 | 2.1 |
| Dec. | 25.7 | 13.4 | 19.6 | 100 | 40.8 | 0.0 | 0 | 2.5 | 16.0 | 6.0 | 10.2 | 2.3 |
| **Total** | **372.4** | **264.0** | **318.4** | **1200** | **650.8** | **1368.3** | **73** | **66.1** | **278.8** | **75.7** | **156.1** | **39.8** |
| **Mean** | **31** | **22** | **26.5** | **100** | **54** | | | **5.5** | **23.2** | **6.3** | **13** | **3.3** |

Max temperature=40.1$^{0}$C ON 26/4/14, 17/5/14 and 21/5/14 (three days), Minimum temp=9.6$^{0}$C ON 9/1/14 , Maximum Rainfall 111.4 mm on 21/9/14, Maximum wind velocity =73.0 km/h on 26/3/14 (first Kalbaisaki)

Note: RH% of maximum is not calibrated data.

**Table III : Monthly average agro-meteorological parameters at Bharuch during 2014**

| Month | Air Temperature ($^{0}$C) | | Rainfall (mm) | Total rainy days | Relative humidity (%) | Vapour pressure (mm) | Wind speed (km/hr) | Sunshine (hr/day) | EPan (mmpd) |
|---|---|---|---|---|---|---|---|---|---|
| | Max | Min | | | | | | | |
| January | 28.3 | 14.1 | 21.6 | 1 | 56.5 | 11.4 | 5.6 | 7.7 | 3.6 |
| February | 30.7 | 15.6 | 2.0 | 1 | 48.2 | 11.2 | 3.4 | 9.0 | 3.6 |
| March | 35.0 | 19.4 | 16.0 | 1 | 46.6 | 14.0 | 3.5 | 8.8 | 6.9 |
| April | 39.0 | 23.3 | 2.0 | 1 | 47.4 | 16.3 | 4.8 | 9.9 | 10.9 |
| May | 40.4 | 26.8 | 0.0 | 0 | 48.6 | 18.9 | 7.2 | 10.3 | 12.3 |
| June | 36.8 | 27.7 | 40.3 | 4 | 64.6 | 23.8 | 11.4 | 7.7 | 7.3 |
| July | 33.4 | 26.1 | 415.8 | 14 | 75.9 | 23.5 | 7.2 | 4.6 | 3.7 |
| August | 31.8 | 24.8 | 249.8 | 10 | 80.4 | 24.0 | 5.7 | 4.5 | 2.4 |
| September | 32.0 | 23.9 | 132.0 | 8 | 74.5 | 22.6 | 2.8 | 5.3 | 2.8 |
| October | 36.8 | 22.3 | 0.0 | 0 | 50.3 | 17.5 | 1.2 | 8.4 | 4.69 |
| November | 34.0 | 20.5 | 0.0 | 0 | 51.3 | 15.1 | 0.9 | 7.9 | 5.65 |
| December | 29.8 | 14.5 | 0.0 | 0 | 46.3 | 9.8 | 3.2 | 8.2 | 6.0 |
| **Total** | | | **879.5** | **40** | | | | | |

# AUTHOR INDEX





हर कदम, हर डगर
किसानों का हमसफर
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*Agrisearch with a human touch*

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