CSSRI

वार्षिक प्रतिवेदन
Annual Report
2015-16

ICAR-Central Soil Salinity Research Institute
Karnal - 132001 (India)

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ANNUAL REPORT
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केन्द्रीय मृदा लवणता अनुसंधान संस्थान
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ICAR-CENTRAL SOIL SALINITY RESEARCH INSTITUTE
KARNAL - 132 001 (HARYANA)

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PREFACE

Food and nutritional security of the burgeoning global population has emerged as a challenge in the face of massive land degradation, fresh water scarcity and climate change necessitating concerted focus on technology-driven productivity enhancement in degraded lands. Available evidences show that prime lands have shrunk considerably due to fierce competition between different sectors of economy for land use, inappropriate anthropogenic modifications and secondary salinization leaving little scope for agricultural expansion in productive tracts. Similarly, overextraction and irrigation mismanagement have dealt a serious blow to fresh water resources which face huge risks of depletion, pollution and salinization. Efficient utilization of available fresh water and the sustainable use of saline water in soil and crop management have become urgent issues. Since the beginning, it has been our constant endeavour to develop farmer friendly technologies for the best productive utilization of salt-affected soils and poor quality water with greater focus on fragile agro-ecosystems in arid, semi-arid and coastal regions. The Institute has developed a number of doable, critically acclaimed technologies for assured returns even from difficult to reclaim salt-affected lands across the country. It is worth mentioning that about 2 million hectare salt-affected area has been ameliorated using such technologies. Nonetheless, the emerging constraints have necessitated a paradigm shift from the business-as-usual approach to ensure consistent dividends from soil reclamation projects. In near future, precise digital mapping in salinity affected regions will be given due priority to expedite the soil reclamation projects. An equal emphasis will be placed on identifying alternative approaches and strategies to hasten the reclamation efforts so as to bring additional salt-affected lands under vegetation cover. As in past, we will continue to develop strong research and academic collaborations with national and international institutions/organizations of repute to enhance the practical knowledge and skills of scientists, farmers and other stakeholders for cost-effective and environmental-friendly salinity management in agriculture.

The Annual Report for the period 2015-16 covers significant achievements in the areas of research, technology transfer and farmers' skill development. Major research achievements during the period under report are: identification of resource conserving technologies for sustaining yields and natural resources in rice-wheat cropping system in partially reclaimed sodic soils, use of municipal solid waste enriched compost for sustaining crop yields in saline soils, development of stress tolerant rice for poor farmers of Africa and South Asia, alternative management practices to mitigate climate change effects in salt affected soils of Indo-Gangetic plains, land shaping techniques for improving soil and water quality in degraded coastal lands and evaluation of vegetable crops under protected cultivation in saline environments. Many of these investigations have shown encouraging results and are being fine tuned for dissemination to farmers' fields. During the year, Institute produced about 9 tonnes of wheat, rice, mustard and gram breeder seeds for distribution among various agencies. A number of professional and skill development programmes were also organized during the year.

A pre-Rabi Kisan Mela was organized on 21st October, 2015 in village Gyong of Kaithal district with participation of over 250 farmers, scientists and extension workers. This was followed by a series of pre-Rabi Kisan Goshthis in villages adopted under 'Mera Gaon Mera Gaurav' programme in the states of Haryana, Punjab, Uttar Pradesh, Gujarat and West Bengal. In these Goshthis, over 2000 farmers participated and discussed their agricultural problems with the scientists. A Rabi Kisan Mela was organized on 5th March 2016 at Karnal, where more than 2000 farmers and students took active part and benefitted from the latest technologies showcased by the government organizations and private companies. Consistent with the Prime Minister's emphasis on sustainable soil health, soil samples were collected from 346 farmers' fields representing 78 villages from five states, namely, Haryana, Punjab, Uttar Pradesh, Gujarat and West Bengal. These samples were analysed for 12 parameters subsequently summarized in the form of soil health cards distributed during the 'Soil Health Day' on 5th December, 2015 among the target farmers for promoting balanced fertilizer use to enhance farm profitability. As a part of United Nations declaration of 2015 as the International Year of Soils, various programmes were organized for increasing the awareness about soil health. These included painting and declamation contest among school students, organization of Kisan Goshthi cum Brainstorming Session on 'Healthy Soil for Healthy Life' was organised. for increasing awareness among the farmers about soil health related issues. Shri O. P. Dhankar, Hon'ble Minister of Agriculture, Govt. of Haryana inaugurated the goshthi and advised the farmers to get their soil and water tested to ensure balanced fertilizer use.

To commemorate International Year of Soils 2015, Institute organized a brainstorming session on "Knowledge gaps and empowering reclamation of saline soils in changing climatic conditions". This session was chaired by Dr. Gurbachan Singh, Chairman, ASRB, New Delhi. Dr. I. P. Abrol, Director, CASA, New Delhi was the Chief Guest which was also attended by distinguished scientists such as Dr. J. S. Samra, Ex. CEO NRAA, New Delhi; Dr. P. K. Joshi, Director IFPRI; Dr. C. L. Acharya, Ex. Director, ISSS, Bhopal and Dr. S. K. Chaudhari, ADG (SWM) NRM, ICAR. The 66th vanmahatsava was organized on 21st August 2015 on the theme 'Greening Every Home for Happiness'. On this occasion, saplings of different horticultural species were planted. International Training Workshop on 'Approaches for integrated analysis of agricultural systems in South Asia: field, to farm, to landscape scale' was jointly organized by ICAR-CSSRI and CIMMYT at ICAR-CSSRI, Karnal, Haryana, India from 18-23 May, 2015. A total of 30 participants from different research institutions/universities of India, Nepal, and Bangladesh attended this training programme. Another International Training Programme on 'Conservation agriculture for capacity development of researchers of Indian NARES (ICAR, SAUs) and CGIAR institutes' was also organized from 02-11 September, 2015. A 5-days training of state agricultural extension officers, students and young professionals was organized at Karnal from 15-19 February, 2016 on subject "Participatory irrigation management for regional food and water security in northern India" in collaboration with IAFD, Australia and CIMMYT CCAF.

The Institute celebrated Hindi Pakhwara during 14-28 September, 2015. One-day workshop was organized for 'Developing a Road Map for Technological Support, Extension and Demonstration Services to the Farmers in Trans-Gangetic Plains Region (Agro-Climatic Zone-VI)' at ICAR-CSSRI, Karnal on 5th October, 2015, Karnal. Dr. K.M.L. Pathak, Deputy Director General (Animal Science), ICAR chaired the workshop and highlighted the need to make agriculture more sustainable and profitable by providing location specific solutions to the problems being faced by the farmers. About 30 farmers from various districts of the region participated in the Workshop. 'Jai Kisan Jai Vigyan' programme was organized on 26th December, 2015 in Beer Narayana village of Karnal district. About 100 farmers participated in this programme which aimed to showcase the latest technologies for sustainable agriculture in salt-affected lands. 'Swachh Bharat Abhiyan' was organized in Dabri village of district Karnal on 20th January, 2016 to sensitize the villagers and school students for ensuring cleanliness in homes and surroundings. The Institute celebrated its 47th Foundation Day on 1st March, 2016 by organizing a Foundation Day lecture 'Sustainable approaches for crop production technology in salt-affected soils' delivered by Dr. Arvind Kumar, Vice Chancellor, Rani Laxmi Bai Central Agricultural University, Jhansi.

During this period, notable visitors to the Institute included Hon'ble Prof. Kaptan Singh Solanki, Governor of Haryana; Hon'ble Shri Manohar Lal Khattar, Chief Minister of Haryana; Shri Om Prakash Dhankar, Minister of Agriculture, Govt. of Haryana; Shri Harvinder Kalyan, Chairman, HAFED, Govt. of Haryana, S. Bakhsish Singh, Chief Parliamentary Secretary, Govt. of Haryana; Dr. Gurbachan Singh, Chairman, ASRB, New Delhi; Dr. B. S. Dhillon, Vice-Chancellor, PAU, Ludhiana; Dr. K. S. Khokhar, Vice-Chancellor, CCSHAU, Hisar; Dr. I. P. Abrol, Director, CASA, New Delhi; Dr. J. S. Samra, Ex. CEO NRAA, New Delhi; Dr. P. K. Joshi, Director IFPRI and Dr. K.M.L. Pathak, Deputy Director General (Animal Science), ICAR.

The guidance and overwhelming support received from Dr. S. Ayyappan, Ex. Secretary DARE and Director General, ICAR, Dr. Trilochan Mohapatra, Secretary, DARE and Director General, ICAR, Dr. A. K. Sikka, Ex. DDG (NRM) and Dr. S.K. Chaudhari, ADG (Soil and Water Management), ICAR in the publication of Annual Report is gratefully acknowledged. Dr. Anshuman Singh and Shri Madan Singh shared the major responsibility of synthesizing, editing and printing the Annual Report. I appreciate the efforts made by my colleagues in providing the material for timely publication of the report.

I firmly believe that information presented in this report will provide a valuable understanding of recent trends in agricultural salinity research to the readers. I will be happy to receive suggestions/feedbacks from the readers to bring out desirable improvements in the Annual Report in future.

(Parbodh Chander Sharma)
Director (A)

June 27, 2016

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सारांश

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

अर्द्ध–सुधरी क्षारीय मृदाओं में संसाधन संरक्षण प्रौद्योगिकियां

वर्ष 2012 से संचालित एक प्रयोग ने अर्द्ध–सुधरी क्षारीय मृदाओं में धान–गेहूँ फसल चक्र में संवहनीय फसलोत्पादन एवं प्राकृतिक संसाधन संरक्षण हेतु परम्परागत कृषि पद्धतियों की तुलना में विभिन्न संसाधन संरक्षण प्रौद्योगिकियां की दक्षता इंगित की। गेहूँ अवशिष्ट के समावेश द्वारा परम्परागत पद्धति में धान की उपज (7.58 टन/हे.) और फसल अवशिष्ट के बिना रोपण में प्राप्त उपज (7.18 टन/हे.) में प्रभावी अंतर देखा गया। फसल अवशिष्ट के समावेश द्वारा रोपित धान की उपज में लगभग 5.5% की वृद्धि देखी गई। फसल अवशिष्ट समावेश के साथ धान की सीधी बिजाई में प्राप्त उपज (6.95 टन/हे.) बिना अवशिष्ट के सीधी बिजाई से प्राप्त उपज की तुलना में 4.65% अधिक थी। 50: न्यून जुताई के साथ धान की सीधी बिजाई में परम्परागत रोपण की तुलना में सतही सिंचाई में 27% सिंचाई जल की बचत हुई। परम्परागत पडलिंग रोपण सिंचित पद्धति की तुलना में लघु–बौछारी फर्टिगेशन द्वारा 27% नत्रजन की बचत हुई और अधिकतम (लगभग 60%) नत्रजन प्रयोग दक्षता दर्ज की गई। परम्परागत पद्धति की तुलना में फसल अवशिष्ट समावेश द्वारा गेहूँ में भी लगभग 16.43% अधिक दाना उपज प्राप्त हुई। गेहूँ में लघु–बौछारी सिंचाई करने पर सतही सिंचाई की तुलना में 60% जल व 36% उर्जा की बचत हुई।

लवण प्रभावित मृदाओं में धनायन विनियम संतुलन एवं विलेय अपवाहन

इस तथ्य को ध्यान में रखते हुए कि निम्न गुणवत्ता जल से सिंचाई मृदा गुणों एवं फसल उपज पर दुष्प्रभाव डालती है, संगरूर (पंजाब) एवं कालक (भरूच) से एकत्रित चूनेदार क्षारीय इन्सेप्टिसाल एवं वर्टिसाल सतही (0–30 सेमी) मृदाओं में मृदा स्तम्भ अध्ययन किया गया। अधिक क्षारीय जल ने पूर्ण छिद्र आयतन के निक्षालक का पीएच एवं विद्युत चालकता मान बढ़ा दिया। निम्न क्षारीय जल के प्रयोग से दोनों मृदाओं से प्राप्त निक्षालकों में आवक जल की तुलना में अधिक सोडियम अधिशोषण अनुपात देखा गया। जब आवक जल का सोडियम अधिशोषण अनुपात 30 एवं 20 था तब दोनों मृदाओं (क्रमशः इन्सेप्टिसाल एवं वर्टिसाल) से प्राप्त निक्षालकों में अर्द्ध–संतुलन प्राप्त करने की प्रवृत्ति देखी गई। आवक जल की बढ़ती क्षारीयता के साथ मृदा से सोडियम की तुलना में कैल्शियम एवं मैग्निशियम का अधिक निक्षालन हुआ। दोनों प्रकार की मृदाओं में 10 एवं 20 सोडियम अधिशोषण अनुपात वाले जल से निक्षालन करने पर विभिन्न मृदा परतों के पीएच मान में गिरावट देखी गई। निम्न सोडियम अधिशोषण अनुपात (10 एवं 20) वाले जल का प्रयोग करने पर कैल्शियम कार्बोनेट का कम विघटन देखा गया। इसके विपरीत, अधिक क्षारीय जल के प्रयोग से कैल्शियम कार्बोनेट की मात्रा अप्रभावित रही।

गन्ना आधारित कृषि प्रणालियों में कार्यदक्ष भूजल प्रबंधन

पश्चिमी उत्तर प्रदेश की गन्ना–आधारित सघन कृषि प्रणालियों में तेजी से गिरते भूजल स्तर को रोकने हेतु संस्थान द्वारा विकसित भूजल भरण तकनीकियों का मुजफ्फरनगर जिले में परीक्षण किया जा रहा है जिससे भूजल का संवहनीय प्रयोग सुनिश्चित करते हुए जलवायु परिवर्तन प्रभावित गन्ना कृषकों की अनुकूलन क्षमता में वृद्धि की जा सके। अध्ययन क्षेत्र की मृदाओं के भौतिक लक्षाण कुछ इस प्रकार के हैं कि शीर्ष चिकनी सतह के नीचे अधिक छिद्रयुक्त, मोटी एवं दानेदार परत मौजूद है जिससे सतही जलीय निकायों में उपलब्ध जल सुगमता से नीचे नहीं जा पाता है। जलवायु परिवर्तन जनित वर्षा जल की मात्रा में घटोत्तरी भी भूजल भरण में बाधा उत्पन्न कर रही है। इन

परिस्थितियों में चार चयनित स्थानों पर उपसतही भूजल भरण संरचनाओं (रिचार्ज शैफ्ट एवं रिचार्ज कैविटी) एवं चेक डैम का संयुक्त प्रयोग प्रस्तावित है। तालाबों एवं सतही नालियों में उपलब्ध अतिरिक्त जल का छन्नी कोष्ठ के सन्निकट निर्मित भरण गुहिका (रिचार्ज कैविटी) के माध्यम से भूजल भरण के लिए प्रयोग किया जाएगा। भूजल भरण हेतु प्रयुक्त किए जाने वाले तालाब जल का गुणवत्ता मानकों हेतु सामयिक अंतराल पर विश्लेषण किया जा रहा है।

अफ्रीका एवं दक्षिण एशिया के गरीब कृषकों हेतु लवण सहिष्णु धान

विभिन्न राष्ट्रीय एवं अंतर्राष्ट्रीय संस्थानों से एकत्रित धान के 30 जीन प्रारूपों का लवणीय (प्राकृतिक लवणता, नैन प्रक्षेत्र), अधिक लवणीय (10 डेसी/मी. लवणीय जल) एवं क्षारीय (पीएच 2 9.9, करनाल) दशाओं में परीक्षण किया जा रहा है। नमतल पौधशाला में तैयार किए गए 35 दिन पुराने पौधों का रोपण प्रति हिल में 2 की दर से 15 x 20 सेमी. की दूरी पर किया गया। स्वस्थ फसल तैयार करने हेतु संस्तुत सस्य क्रियाओं का अनुसरण किया गया। अधिक क्षारीय दशा (पीएच मान 9.9) में बल्क 216 (2.6 टन/हे.), आइ आर 87948–6–1–1–1–3–B (2.58 टन/हे.) एवं सीएस आर 2 के–228 (2.55 टन/हे.) ने सर्वोत्तम प्रदर्शन किया। अधिक लवणीय दशा (सिंचाई जल लवणता 10 डेसी/मी.) में बल्क 216 (3.03 टन/हे.), आइआर 87938–1–2–2–2–1–बी (3.01 टन/हे.) एवं टीआर 13–083 (2.99 टन/हे.) सर्वोत्तम पायी गईं। नैन प्रक्षेत्र पर, आइआर 87938–1–1–2–1–3–बी (2.25 टन/हे), बल्क 216 (2.179 टन/हे.) एवं आइआर 87938–1–2–2–1–3–बी (2.18 टन/हे.) ने बेहतर प्रदर्शन किया।

आणविक उपागमों द्वारा गेहूं में लवण सहिष्णुता में सुधार

खर्चिया 65 (लवण सहिष्णु) एवं एचडी 2009 (लवण संवदेनशील) के संकरण से प्राप्त 120 पुनः संयोजक अंतःप्रजात अभिजातियों का प्रयोग प्रतिचित्रण हेतु किया गया। इन अभिजातियों का विकास एकल–बीज विधि द्वारा आठवीं पीढ़ी तक किया गया। इन अभिजातिययों की फीनोटाइपिंग क्षारीय (पीएच मान 9.1) सूक्ष्म भूखंडों में चार नियंत्रण प्रजातियों (खर्चिया 65, एचडी 2009, केआरएल 19 एवं एचडी 2851) के साथ किया गया। सभी रूपात्मक एवं कार्यिकी मानकों ने ऐसे परिमाण प्रदर्शित किए जिन्होंने पैतृक परिणामों के औसत के समष्टि माध्य के इर्द–गिर्द अपेक्षाकृत सामान्य वितरण प्रदर्शित किया। कुछ अभिजातियों ने पैतृक वंशों की तुलना में अत्यधिक मान प्रदर्शित किए जो उत्क्रामी पृथक्करण इंगित करते हैं। मापित लक्षणों के मध्य संभावी सहसंबंधों में से 13 प्रभावी थे जिनमें से 12, सहसंबंध तनाव दशाओं में सकारात्मक पाये गए। सहिष्णुता सूचकांक, दाना उपज, जैवभार एवं कल्लों के मध्य प्रबल सकारात्मक सहसंबंध देखा गया। इसी प्रकार पोटेशियम : सोडियम अनुपात एवं सोडियम मात्रा के मध्य नकारात्मक सहसंबंध देखा गया। अन्वेशित अभिजातियों में पर्ण सोडियम एवं पोटेशियम सांद्रता का सहिष्णुता सूचकांक एवं उपज घटकों के साथ कोई सहसंबंध नहीं था।

लवणीय वर्टिसाल मृदाओं में देशी कपास एवं गेहूँ की खेती की संभाव्यता

गुजरात के भरूच जिले के काली कपास मृदा क्षेत्र, जो उपसतही लवणता एवं लवणीय भूजल की समस्या से प्रभावित है, में कपास एवं गेहूँ किसानों के मध्य एक अध्ययन किया गया। इस अध्ययन में 15 कपास खेतिहरों (जो कि प्रजाति जी.काट–23 उगाते हैं) एवं 25 गेहूँ खेतिहारों (जो केआरएल 19 एवं केआरएल 210 प्रजातियां उगाते हैं) का चयन किया गया। कृषक प्रक्षेत्रों पर देशी कपास की औसत उपज 8.1 कु/हे. थी जिससे प्रति हैक्टेयर 16073 रूपये का शुद्ध लाभ प्राप्त हुआ। अधिकांश किसानों ने बताया कि संकरों एवं बीटी कपास की तुलना में देशी कपास वर्षा–सिंचित एवं मध्यम लवणीय दशाओं के लिए अधिक उपयुक्त है। देशी कपास में सिंचाई जल की कम मात्रा के साथ लवणीय दशाओं में बीजकोश गिरने की समस्या भी कम होती है। लगभग 50 प्रतिशत किसानों ने बताया कि देशी कपास बाजार में अधिक कीमत पर बिकती है। कपास की भांति, गेहूं की लवण सहिष्णु प्रजातियों में भी सिंचाई की कम आवश्यकता होती है। इन प्रजातियों में पौधे गिरने एवं दाने झड़ने की समस्या भी कम होती है। कृषक प्रक्षेत्रों पर औसत गेहूँ उपज 30.4 कु/है. थी जिससे प्रति हैक्टेयर 31643 रूपये का शुद्ध लाभ एवं 2.37 का लाभ:लागत अनुपात प्राप्त हुआ। गुणवत्तायुक्त बीजों की अनुपलब्धता एवं ज्ञान का अभाव दोनों ही फसलों की व्यावसायिक खेती में मुख्य बाधाएं थीं।

अवक्रमित तटीय भूमियों में मृदा एवं जल गुणवत्ता संवर्द्धन हेतु भू–आकार तकनीकियां

भू–आकार तकनीकियों जैसे प्रक्षेत्र तालाब, गहरी कूँड़ एवं ऊंची मेड़, व धान–सह–मत्स्यपालन के मृदा एवं जल गुणवत्ता पर पड़ने वाले दीर्घकालिक प्रभावों का अध्ययन किया गया। प्रक्षेत्र तालाब तकनीकी के अंतर्गत निर्मित विभिन्न भू–परिस्थितियों जैसे उच्च भूमि, मध्यम भूमि एवं मूल निम्न भूमि, जो कि 5 वर्षों से कम व 15 वर्षों से अधिक समय के लिए क्रियान्वित की गई थी, में नियंत्रण उपचार की तुलना में मृदा लवणता कम थी। इसी प्रकार इन

भू–परिस्थितियों में नियंत्रण भूखंडों की तुलना में जैविक कार्बन एवं उपलब्ध नत्रजन व फास्फोरस अधिक थे। यदि क्रियान्वयन अवधि की तुलना की जाए तो यह स्पष्ट है कि जैविक कार्बन, उपलब्ध नत्रजन एवं उपलब्ध फास्फोरस की मात्रा नए भूखंडों की तुलना में पुराने भूखंडों में अधिक थी। गहरी कूँड़ एवं ऊंची मेड़ व धान–सह–मत्स्यपालन भूपरिस्थितियों में भी समरूप प्रवृत्ति देखी गई। लाभ–लागत अनुपात प्रक्षेत्र तालाब तकनीकी में अधिकतम था जिसके बाद गहरी कूँड़ एवं ऊंची मेड़ तथा धान–सह–मत्स्यपालन तकनीकियों का स्थान रहा।

संरक्षित खेती में लवणीय दशाओं में सब्जियों का मूल्यांकन

यह प्रयोग प्राकृतिक वायु–संचार युक्त पालीहाऊस में उगाई गई सब्जियों (शिमला मिर्च प्रजाति इन्द्रा, मिर्च प्रजाति क्रान्ति एवं टमाटर प्रजाति सिबेलिया) में अगस्त, 2015 में प्रारंभ किया गया। गुरूत्वाकर्षण प्रवाह चालित टपकदार सिंचाई विधि द्वारा लवणीय सिंचाई की गई। जल घुलनशील उर्वरकों की संस्तुत मात्रा टपकदार सिंचाई के साथ की गई। शिमला मिर्च की अधिकतम उपज (47.5 टन/है.) 6 डेसी/मी. लवणीय जल उपचार में प्राप्त हुई जिसके बाद 8 डेसी/मी. लवणीय जल का स्थान रहा (42 टन/है.)। इसी प्रकार मिर्च में अधिकतम उपज (34.75 टन/है.) 10 डेसी/मी. उपचार में देखी गई जिसके बाद (34.5 टन/है.) 6 डेसी/मी. उपचार का स्थान रहा। टमाटर की अधिकतम उपज (66.75 टन/है.) 10 डेसी/मी. वाले लवणीय जल में देखी गई जिसके बाद (60. 25 टन/है.) 4 डेसी/मी. लवणीय उपचार का स्थान रहा। इन परिणामों ने प्रयुक्त सब्जी फसलों में प्राकृतिक वायु–संचार युक्त संरक्षित खेती संरचना में टपकदार सिंचाई द्वारा अत्यधिक लवणीय जल के प्रयोग की संभावना प्रदर्शित की।

पुरस्कार एवं मान्यता

- डा. रंजय कुमार सिंह ने 'सामुदायिक ज्ञान नीत जलवायु परितर्वन अनुकूलन' विषय पर चार्ल्स डार्विन विश्वविद्यालय, आस्ट्रेलिया में 1 मई से 30 सितम्बर, 2015 के मध्य अनुसंधान करने हेतु 'इन्डेवर फेलोशिप' प्राप्त की।
- डा. अजय कुमार भारद्वाज ने 2015–17 की अवधि में सैद्धान्तिक एवं व्यावहारिक भौतिक रसायन अनुसंधान संस्थान, ला प्लाटा, अर्जेन्टीना के साथ सहयोगात्मक अनुसंधान हेतु 'रसायन विज्ञान में येनेस्को–ट्वास एसोसिएटशिप' प्राप्त की।
- डा. गजेन्द्र यादव एवं डा. निर्मलेन्दु बसक ने 02–26 नवम्बर, 2015 के मध्य 'लवण तनाव में फसलोत्पादन' विषय पर यरूशलम विश्वविद्यालय, इजरायल के राबर्ट एच.स्मिथ कृषि संकाय में प्रशिक्षण हेतु 'माशाव–इजरायल फेलोशिप' प्राप्त की।
- डा. रणधीर सिंह, मुख्य तकनीकी अधिकारी ने तकनीकी कर्मचारी श्रेणी में वर्ष 2014 हेतु 'भा.कृ.अनु.प. का नकद पुरस्कार' प्राप्त किया।
- डा. एस. के. दूबे, अध्यक्ष, भारतीय मृदा एवं जल संरक्षण संस्थान, क्षेत्रीय केन्द्र आगरा एवं डा. एस. के. कामरा, प्रधान वैज्ञानिक, भा.कृ.अनु.प.–के.मृ.ल.अनु.सं., करनाल ने वर्ष 2014 के लिए 'भा.कृ.अनु.प.–के.मृ.ल.अनु.सं. का उत्कृष्टता पुरस्कार' प्राप्त किया।
- डा. प्रबोध चन्द्र शर्मा, अध्यक्ष, फसल सुधार प्रभाग, भा.कृ.अनु.प.–के.मृ.ल.अनु.सं., करनाल एवं डा. विनय कुमार मिश्रा, अध्यक्ष, भा.कृ.अनु.प.–के.मृ.ल.अनु.सं. क्षेत्रीय केन्द्र लखनऊ ने वर्ष 2015 के लिए ' भा.कृ.अनु.प.–के.मृ.ल.अनु.सं. का उत्कृष्टता पुरस्कार' प्राप्त किया।
- डा. रणधीर सिंह ने 09–11 फरवरी , 2016 के मध्य दुबई, संयुक्त अरब अमीरात में आयोजित 'ग्लोबल वार्मिंग एवं जैवविविधता संरक्षण' के अंतर्राष्ट्रीय सम्मेलन में 'सर्वोत्तम अनुसंधान पत्र पुरस्कार' प्राप्त किया।
- डा. अजय कुमार भारद्वाज ने 17–19 फरवरी , 2016 के मध्य स्वामी केशवानंद राजस्थान कृषि विश्वविद्यालय, बीकानेर में 'जलवायु लचनशील कृषि एवं ग्रामीण विकास हेतु शुष्क व अर्द्ध–शुष्क परिस्थितिकी तंत्र में प्राकृतिक संसाधन प्रबंधन' विषय पर आयोजित 25वें राष्ट्रीय सम्मेलन में 'सर्वोत्तम पोस्टर पुरस्कार' प्राप्त किया।
- डा. रणधीर सिंह ने सोसाइटी फार रिसेंट डेवलपमेंट इन एग्रीकल्चर, मेरठ द्वारा प्रदत्त 'कृषि में उत्कृष्ट उपलब्धि पुरस्कार 2015' प्राप्त किया।
- डा. टी. दामोदरन ने समग्र विकास कल्याणकारी समिति, लखनऊ द्वारा जैविक बागवानी में उत्कृष्ट अनुसंधान हेतु 'अनुसंधान उत्कृष्टता पुरस्कार 2016' प्राप्त किया।
- डा. अंशुमान सिह ने 12–13 मार्च, 2016 के मध्य पटना में आयोजित 'नवप्रवर्तनशील कृषि उद्यमों के

माध्यम से ग्रामीण आजीविका सुरक्षा' विषय पर आयोजित राष्ट्रीय सम्मेलन मे 'सोसायटी फार अपलिफ्टमेंट आफ रूरल इकोनामी, वाराणासी द्वारा प्रदत्त 'युवा वैज्ञानिक पुरस्कार 2014' प्राप्त किया।

- भा.कृ.अनु.प.–के.मृ.ल.अनु.सं., करनाल द्वारा तकनीकी, प्रशासनिक एवं कुशल सहायक कर्मचारी वर्गों में वर्ष 2015 के लिए दिए गए 'उत्कृष्ट कर्मचारी पुरस्कार' इस प्रकार हैः
  - श्री एच. एस. तोमर, सहायक मुख्य तकनीकी अधिकारी
  - श्री राजपाल, तकनीकी सहायक
  - श्रीमती जसबीर कौर, सहायक
  - श्री सत्यनारायण शर्मा, सहायक
  - श्री राजकुमार, कुशल सहायक कर्मचारी
  - श्री देशराज, कुशल सहायक कर्मचारी

कार्यशाला, सेमिनार, प्रशिक्षण कार्यक्रम, स्थापना दिवस एवं किसान मेला का आयोजन

- 'दक्षिण एशिय में कृषि प्रणालियों के एकीकृत विश्लेषण हेतु उपागमः प्रेक्षेत्र से भूदृश्य स्तर' विषय पर 18–23 मई, 2015 के मध्य भा.कृ.अनु.प.–के.मृ.ल. अनु.सं., एवं सिमिट के संयुक्त तत्वाधान में करनाल में एक 6 दिवसीय प्रशिक्षण कार्यशाला का आयोजन किया गया जिसमें भारत, नेपाल एवं बांग्लादेश के विभिन्न अनुसंधानों संस्थानों/विश्वविद्यालयों से आए 30 प्रतिभागियों ने भाग लिया।
- संस्थान ने 'स्वस्थ जीवन के लिए स्वस्थ मृदाएं' विषय पर 14 अगस्त, 2015 को एक कार्यक्रम का आयोजन किया जिसका उद्देश्य किसानों एवं स्कूली छात्रों को मृदा स्वास्थ्य एवं सतत कृषि के महत्व के संबंध में जागरूक करना था।
- अंतर्राष्ट्रीय मृदा वर्ष 2015 के उपलक्ष्य में 19 अगस्त, 2015 को एक विचार–मंथन सत्र का आयोजन किया गया। इस कार्यक्रम के मुख्य अतिथि डा. आई. पी. अबरोल, पूर्व उपमहानिदेशक (प्रा.सं.प्रं.), भा.कृ.अनु.प., नई दिल्ली थे। इस कार्यक्रम में डा. गुरबचन सिंह, अध्यक्ष, कृ.वै.च.म., नई दिल्ली भी उपस्थित थे।
- संस्थान ने 21 अगस्त, 2015 को 'वन महोत्सव' का आयोजन किया।
- संस्थान में 14–28 सितम्बर, 2015 के मध्य 'हिन्दी पखवाड़ा' का आयोजन किया गया जिसका उद्देश्य संस्थान कर्मचारियों को हिन्दी में अधिकाधिक कार्य करने हेतु प्रेरित करना था।
- भा.कृ.अनु.प., नई दिल्ली द्वारा 'ट्रांस–गंगा मैदानी क्षेत्रों (कृषि जलवायु क्षेत्र VI) में किसानों को प्रौद्योगिकी सहयोग, प्रसार एवं प्रदर्शन सेवाएं प्रदान करने हेतु दिशानिर्देश का विकास' विषय पर संस्थान में 5 अक्तूबर, 2015 को एक दिवसीय कार्यशाला का आयोजन किया गया।
- संरक्षित कृषि विषय पर 2–11 नवम्बर, 2015 के मध्य भा.कृ.अनु.प.–के.मृ.ल.अनु.सं., करनाल एवं सीसा–सीमिट के संयुक्त तत्वाधान में एक 10 दिवसीय अंतर्राष्ट्रीय प्रशिक्षण कार्यक्रम का आयोजन किया गया जिसका उद्देश्य भारतीय राश्ट्रीय कृशि अनुसंधान तंत्र एवं सीजीआइएआर संस्थानों के अनुसंधानकर्ताओं का क्षमता विकास करना था।
- कैथल जिले के ग्योंग में 21 अक्तूबर, 2015 को एक प्री–रबी किसान मेले का आयोजन किया गया। इस मेले में लगभग 250 किसानों एवं प्रसार कार्यकर्ताओं ने भाग लिया। वैज्ञानिकों/विशेषज्ञों द्वारा किसानों की समस्याओं के निस्तारण हेतु उचित उपाय बताए गए।
- 'मेरा गांव, मेरा गौरव' कार्यक्रम के अंतर्गत हरियाणा, पंजाब, उत्तर प्रदेश, पश्चिम बंगाल एवं गुजरात प्रदेशों के अंगीकृत गांवों में प्री–रबी किसान गोष्ठियों का आयोजन भी किया गया। इन गोष्ठियों के दौरान 2000 से अधिक किसानों ने वैज्ञानिकों/विशेषज्ञों के साथ विचार–विमर्श किया।
- संस्थान में 5 दिसम्बर, 2015 को 'मृदा स्वास्थ्य दिवस' का आयोजन किया गया। इस कार्यक्रम में 200 से अधिक किसानों व 60 वैज्ञानिकों ने भाग लिया। इस अवसर पर श्री अमरेन्द्र सिंह, विशेष कार्याधिकारी, माननीय मुख्यमंत्री हरियाणा द्वारा किसानों में 254 मृदा स्वास्थ्य कार्ड बांटे गए।
- संस्थान ने 23–29 दिसम्बर, 2015 के मध्य 'जय किसान जय विज्ञान' सप्ताह का आयोजन किया जिसका मुख्य उद्देश्य किसानों को लवण प्रभावित मृदाओं की उत्पादकता बढ़ाने हेतु उपलब्ध नवीन तकनीकियों के बारे में जागरूक करना था।

- करनाल के डबरी गांव में 'स्वच्छ भारत अभियान' के अंतर्गत 20 जनवरी, 2016 को एक जागरूकता कार्यक्रम का आयोजन किया गया जिसका उद्देश्य स्कूली छात्रों का उनके घरों, आस–पास के स्थानों एवं गांव में सफाई को बढ़ावा देने हेतु जागरूक करना था।

- 'उत्तरी भारत में क्षेत्रीय खाद्य एवं जल सुरक्षा हेतु सहभागी सिंचाई प्रबंधन' विशय पर 15–19 फरवरी, 2016 के मध्य एक पांच दिवसीय प्रशिक्षण कार्यक्रम आयोजित किया गया जिसमें 31 राज्य कृषि प्रसार अधिकारियों, विद्यार्थियों एवं वैज्ञानिकों ने भाग लिया। इस प्रशिक्षण कार्यक्रम का आयोजन आइएएफडी, आस्ट्रेलिया एवं सीमिट सीसीएएफएस के सहयोग से किया गया।

- संस्थान ने 1 मार्च, 2016 को अपना 47वां स्थापना दिवस समारोह आयोजित किया जिसमें डा. अरविन्द कुमार, कुलपति, रानी लक्ष्मीबाई केन्द्रीय कृषि विश्वविद्यालय, झांसी द्वारा स्थापना दिवस व्याख्यान प्रस्तुत किया गया।

- संस्थान परिसर में 5 मार्च, 2016 को रबी किसान मेले का आयोजन किया गया जिसका उद्घाटन श्री हरविन्दर कल्याण, अध्यक्ष, हैफेड, हरियाणा सरकार ने किया। इस मेले में 2000 से अधिक किसानों एवं स्कूली छात्रों ने भाग लिय व 53 सरकारी संस्थानों एवं निजी कम्पनियों द्वारा प्रदर्शित की गई कृषि प्रौद्योगिकियों से लाभान्वित हुए। इस अवसर पर एक किसान गोष्ठी का आयोजन भी किया गया।

क्षेत्र प्रदर्शनी व भ्रमण

वर्श 2015–16 के दौरान लवणग्रस्त मृदाओं के सुधार और प्रबंधन व निम्न गुणवत्ता जल के उपयोग विषय पर विभिन्न अनुसंधान संस्थानों और विकास अभिकरणों में 15 प्रदर्शनियां लगाई गई। 80 समूहों में आये 2215 हितधारकों ने संस्थान के सूचना प्रौद्योगिकी केन्द्र व प्रायोगिक प्रक्षेत्र का भ्रमण किया। 4156 हितधारकों में 47 समूहों में आये 2200 किसान, 56 समूहों में आए 1051 प्रसारकर्मी, 55 समूहों में आए 2567 विद्यार्थी, 67 समूहों में आए 161 भारतीय व विदेशी वैज्ञानिक और विशय वस्तु विशेषज्ञ सम्मिलित थे।

किसान सलाहकार सेवा

किसानों की मृदा लवणता, क्षारीयता व निम्न गुणवत्ता जल संबंधित समस्याओं के त्वरित और समुचित समाधान हेतु संस्थान 18001801014 नम्बर पर निःशुल्क फोन सेवा शुरू की है। वर्ष 2015–16 के दौरान देश के विभिन्न क्षेत्रों से कृषि संबंधित समस्याओं संबंधित 208 फोन 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 सीआईएमएमवाईटी मैक्सिको द्वारा प्रायोजित)।

- सूखे, जल भराव व लवण सहिष्णुता प्रमुख क्यू टीएल के साथ अजैविक तनाव सहिष्णु चावल प्रजातियों की चिन्हक सहायक प्रजनन (डीबीटी भारत – आईआरआरआई, फिलीपिन्स द्वारा प्रायोजित)।

- तटीय लवणता (आईआरएसएसटीएन) के लिए चावल जननद्रव्य की जांच पर आईआरआरआई अंतर्राष्ट्रीय सहयोगात्मक कार्यक्रम।

- छिछलर एवं गहरी जल परिस्थितियों में चावल के अग्रिम संवर्धन के लिए आईआरआरआई के साथ संबंध।

- बांग्लादेश एवं पश्चिम बंगाल, भारत के लवण प्रभावित तटीय क्षेत्रों में फसल प्रणाली सघनीकरण (सीएसआरआरआई एवं मुडोर्क विश्वविद्यालय आस्ट्रेलिया द्वारा वित्तपोशित)

- पूर्वी भारत में वर्षा आधारित निचली भूमि में के लिए चावल प्रणाली : चावल में फसल और पोषक तत्व के प्रबंधन क्रियाओं का विकास (आईसीएआर–डब्ल्यू 3) (आईआरआई द्वारा पोशित)।

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।

- सैद्धांतिक एवं व्यावहारिक भौतिक रसायन अनुसंधान संस्थान, ला प्लाटा अर्जेनटीना (यूनेस्की–ट्वास द्वारा वित्त पोषित) से सहयोगात्मक अनुसंधान हेतु।

- वानिकी के माध्यम से अपशिश्ट 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 एनीबएसएसएलयूपी, नागपुर से संबंध।
- पर्यावरण अध्ययन संस्थान, कुरूक्षेत्र विश्वविद्यालय, कुरूक्षेत्र जैव–प्रौद्योगिकी विभाग, महाऋषि मारकन्डेश्वर विश्वद्यिालय, मुलाना, दीनबन्धु छोटूराम विश्वविद्यालय, मुरथल (हरियाणा) व राष्ट्रीय डेरी अनुसंधान संस्थान, करनाल के साथ 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।
- सरदार वल्लभ भाई पटेल कृषि एवं प्रौद्योगिकी विश्वविद्यालय मेरठ (उत्तर प्रदेश)।
- पंजाब विश्वविद्यालय, पटियाला, पंजाब।
- भारतीय प्रौद्योगिकी संस्थान, कानपुर उत्तर प्रदेश के पर्यावरण विज्ञान और अभियांत्रिकी केन्द्र में लवण उपचार हेतु दक्ष व लागत प्रभावी सामग्री के विकास पर सहयोगात्मक अनुसंधान हेतु।

प्रकाशन

संस्थान द्वारा प्रमुख जरनलों में 108 अनुसंधान आलेख, 35 पुस्तक अध्याय, 4 पुस्तक/मैनुअल, 8 बुलेटिन/फोल्डर, 23 प्रचलित आलेख, 3 तकनीकी प्रतिवेदन छपवाये गये और 53 आलेख सेमीनार / 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 आस्ट्रेलिया, फिलीपिन्स, ताईवान, अर्जेन्टीना, संयुक्त अरब अमीरात, दुबई, इजरायल का दौरा किया। इस अवधि में 12 वैज्ञानिकों ने 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 12 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 of the major research achievements of the institute in different thrust areas are as under:

Resource conservation strategies in semi-reclaimed sodic soils

An experiment being carried out since 2011 revealed the efficacy of resource conservation technologies (RCTs) in sustaining crop yields and natural resources in rice-wheat cropping system (RWCS) in comparison to conventional cultivation (CC) practices. Grain yield of rice (7.58 t ha^{-1}) recorded in CC with wheat residue incorporation was significantly higher than yield (7.18 t ha^{-1}) obtained in conventional transplanting (CT) without crop residue. Residue incorporation resulted in ~5.5 % higher grain yield of transplanted rice. Direct seeded rice (DSR) with crop residue gave grain yield of 6.95 t ha^{-1}, which was 4.67% higher in comparison to DSR without crop residue. DSR with 50% reduced tillage under surface irrigation saved 27% irrigation water as compared to CT. Similarly, mini-sprinkler fertigation saved 27% N giving the maximum (~60 kg kg^{-1} N) nitrogen use efficiency as compared to conventionally irrigated puddled transplanted rice. Crop residue incorporation resulted in ~16.43% additional grain yield of wheat under CC practice ascribed to prolonged residue incorporation. In wheat, mini-sprinkler irrigation saved ~60 and ~36% water and electricity, respectively, over surface irrigation in conventional cultivation.

Cation exchange equilibrium and solute transport in salt affected soils

Considering the fact that irrigation with poor quality water adversely affects soil properties and crop yields, a soil column study was carried out with surface (0-30 cm) soils representing calareous sodic Inceptisols (Sangrur, Punjab) and calcareous sodic Vertisols (Kalak, Bharuch). High sodicity (SAR) waters increased the pH and EC in leachate from entire pore volumes. With low SAR (10) water, entire soil leachates collected from both the soils showed higher SAR than that of incoming solution. However, the leaching solution tended to reach quasi-equilibrium with incoming water SAR levels of 30 and 20 in calcareous sodic Inceptisols and calcareous sodic Vertisols, respectively. Increasing sodicity of incoming water caused more leaching of Ca and Mg than Na. Decrease in pH was detected at all depths of both the soils when leached with water of SAR 10 and 20. Lesser $CaCO_3$ dissolution was noticed when low SAR (10 and 20) waters were applied. In contrast, $CaCO_3$ content remained unaffected when high SAR water was applied.

Efficient groundwater management in sugarcane-based farming systems

With a view to arrest the diminishing groundwater levels in intensively cultivated sugarcane growing areas of western Uttar Pradesh, groundwater recharge techniques developed by ICAR-CSSRI, Karnal are being tested in Muzaffarnagar district of Uttar Pradesh to ensure the sustainable use of groundwater for enhancing the adaptive capacity of sugarcane farmers to climate change. The lithology of study region, where groundwater has been over-exploited for irrigation, is characterized by the presence of a top clay layer underlain by a more porous and thicker granular zone. Top clay layer hinders downward flow of water from the surface water bodies which seems to have been accentuated by climate change induced decrease in rainfall. Under these conditions, subsurface groundwater recharge structures (recharge shaft and recharge cavities) are proposed in conjunction with check dams to be installed at selected 4 locations. Excess water from ponds and surface drain will be recharged through a recharge cavity constructed close by in a filter chamber. Water samples are being collected and analyzed to monitor the pond water quality to be recharged through recharge cavity.

Stress tolerant rice for poor farmers of Africa and South Asia

Thirty rice genotypes collected from different national and international institutes were evaluated under saline and sodic stress conditions in randomized complete block design under three environments viz., natural salinity (Nain Farm), high salinity (ECiw ~10 dSm^{-1}) and high sodicity (pH_2~9.9) in microplots at ICAR-CSSRI, Karnal. The 35 day old seedlings from wet bed nurseries were transplanted @ two seedlings per hill with a spacing of 15 × 20 cm. The recommended agronomic practices were followed to raise a healthy crop. Under high sodicity (pH_2 ~ 9.9), BULK 216 (2.60 t ha^{-1}) followed by IR 87948-6-1-1-1-3-B (2.58 t ha^{-1}) and CSR-2K-228 (2.55 t ha^{-1}) were the best entries. Under high salinity (EC_{iw} ~ 10 dS m^{-1}), the entries that performed well were BULK 216 (3.03 t ha^{-1}), IR 87938-1-2-2-2-1-B (3.01 t ha^{-1}) and TR 13-083 (2.99 t ha^{-1}. At Nain Farm, IR 87938-1-1-2-1-3-B (2.25 t ha^{-1}), BULK 216 (2.179 t ha^{-1}) and IR 87938-1-2-2-1-3-B (2.18 t ha^{-1}) recorded the highest yields.

Improvement of salt tolerance in wheat using molecular approach

A fixed population of 120 Recombinant Inbred Lines (RILs) of *Triticum aestivum* derived from a cross between Kharchia 65 (salt tolerant) x HD 2009 (salt sensitive) was used. RILs were developed by single-seed descent until the F8 generation. The phenotyping of these RILs was conducted in sodic microplots at pH_2 9.1 with four checks (Kharchia 65, HD 2009, KRL 19 and HD 2851). All the morphological and physiological values in the whole population showed a relatively normal distribution around a population mean that lies between the parental values. Some RILs had more extreme values than the parental lines showing a transgressive segregation; this is obvious for all traits under salt-stressed conditions. Correlations between measured traits showed 13 significant out of 32 possible correlations under stress condition with 12 positive correlations. A strong positive correlation was observed between tolerance index, grain yield, biomass and tillers. Negative association was observed between K/Na ratios with Na^+ contents. On the other hand, Na^+ and K^+ concentrations in leaves were not correlated with tolerance index and yield components in the studied mapping population.

Prospects of desi cotton and wheat cultivation in saline Vertisols

A study was conducted with cotton and wheat farmers in black cotton soils region of Bharuch district of Gujarat characterized by sub-surface salinity and saline groundwater. A total of 15 farmers cultivating desi cotton (var. G Cot- 23) and 25 farmers cultivating salt tolerant wheat (KRL 19 & KRL 210) were selected. Average yield of desi cotton at farmers' fields was 8.1 q ha^{-1} giving net income of Rs. 16073 ha^{-1}. Majority of the farmers opined that desi cotton was better suited to rainfed and moderate salinity conditions as compared to hybrids and Bt cotton. Desi cotton also required less irrigation and showed significantly less boll drop under saline conditions. About 50% of the farmers said that desi cotton fetched better market price than both hybrids and Bt cotton. As with cotton, salt tolerant wheat cultivars required less irrigation, had less lodging and shattering problems resulting in higher yields than traditionally grown varieties. Average wheat yield at farmers field was 3.04 t ha^{-1} giving net income of Rs. 31643 ha^{-1} with B:C ratio of 2.37. Non-availability of quality seeds and lack of knowledge were the major factors hindering cultivation of these crops.

Land shaping techniques for improving soil and water quality in degraded coastal lands

Long term impact of land shaping techniques, viz., farm pond, deep furrow and high ridge, and paddy-cum-fish culture was studied. Soil salinity under different land situations like high land, medium land and original low land created under farm pond technique implemented, since <5 years and > 15 years was less as compared to control. Organic carbon and available N and P were higher under different land situations created under farm pond technique than control. Among the different years of implementation, organic carbon and available N and P were higher under old land shaped plots compared to the newer plots. A similar trend was observed for deep furrow & high ridge and paddy-cum-fish land shaping techniques. The B: C ratio was higher for farm pond followed by deep furrow & high ridge and paddy-cum-fish land shaping techniques.

Evaluation of vegetable crops under protected cultivation in saline environments

This experiment was initiated during August 2015 with three vegetable crops; capsicum (var. Indra), chilli (var. Kranti) and tomato (var. Cibelia) grown in a naturally ventilated polyhouse. Saline irrigation was done using drip system under gravity flow. The recommended dose of water soluble fertilizers was given with drip irrigation. The highest fruit yield (47.5 t ha^{-1}) of capsicum was obtained with application of 6 dS m^{-1} saline water followed by 8 dS m^{-1} (42 t ha^{-1}). Similarly, the highest fruit yield of chilli was obtained when salinity in irrigation water was 10 dS m^{-1} (34.75 t ha^{-1}) followed by irrigation at 6 dS m^{-1} (34.5 ha^{-1}). The highest fruit yield (66.75 t ha^{-1}) of tomato was obtained with 10 dS m^{-1} saline water followed by 4 dS m^{-1} (60.25 t ha^{-1}) and 6 dS m^{-1} (55 t ha^{-1}). These results showed the possibility of using even high salinity water for irrigating these vegetable crops with drip system under naturally ventilated protected cultivation structure.

AWARDS AND RECOGNITIONS

- Dr. R.K. Singh was awarded the 'Endeavour Fellowship' to work on community knowledge led climate change adaptations at CDU, Australia from 1st May to 30th September, 2015.
- Dr. A. K. Bhardwaj was awarded the 'UNESCO-TWAS (The World Academy of Sciences) Associateship in Chemistry' for

collaborative research at Research Institute of Theoretical & Applied Physical Chemistry, La Plata, Argentina from 2015-2017.

- Dr. Gajender Yadav and Dr. Nirmalemdu Basak were awarded the 'MASHAV- Israel Fellowship' on "Crop production under saline stress" at The Hebrew University of Jerusalem's Robert H. Smith Faculty of Agriculture, Food & Environment, Israel.
- Dr. Randhir Singh, Chief Technical Officer was conferred the 'ICAR Cash Award' in the Technical Employee category.
- Dr. S.K. Dubey, Head, ICAR-IIS&WC, RRS Chhalesar, Agra and Dr. S.K. Kamra, Principal Scientist, ICAR-CSSRI, Karnal were conferred the 'ICAR-CSSRI Excellence Award' for the Year 2014.
- Dr. P.C. Sharma, Head, Crop Improvement Division, ICAR-CSSRI, Karnal & Dr. V.K. Mishra, Head, ICAR-CSSRI, RRS Lucknow were conferred the 'ICAR-CSSRI Excellence Award' for the Year 2015.
- Dr Randhir Singh was conferred the 'Best Paper Award' during the International Conference on Global Warming and Biodiversity Conservation (ICGB-2015) held at Dubai, UAE during 09-11 February, 2016.
- Dr. A.K. Bhardwaj was bestowed the 'Best Poster Award' during the 25th National Conference on Natural Resource Management in Arid and Semi arid Ecosystems for Climate Resilient Agriculture and Rural Development held at SKRAU, Bikaner during 17-19 February, 2016.
- Dr. Randhir Singh was conferred the 'Outstanding Achievement in Agriculture Award 2015' by the Society for Recent Development in Agriculture, Meerut, India.
- Dr. T. Damodran was conferred the 'Excellence of Research Award 2016' by Samagra Vikas Welfare Society, Lucknow, India for outstanding research in organic horticulture.
- Dr. Anshuman Singh was conferred the 'Young Scientist Award' by the Society for Upliftment of Rural Economy, Varanasi during the National Conference on Rural Livelihood Security through Innovative Agri-enterpreneurship held at Patna, India during 12-13 March, 2016.
- ICAR-CSSRI best worker awards for Technical, Administrative and Skilled Supporting Staff for the year 2015:
  - Sh. H.S. Tomar, ACTO
  - Sh. Raj Pal, TA
  - Smt. Jasbir Kaur, Assistant
  - Sh. Satya Narain Sharma, Assistant
  - Sh. Rajkumar, SSS
  - Sh. Desh Raj, SSS

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

- A six-days International Training Workshop on "Approaches for integrated analysis of agricultural systems in South Asia: field, to farm, to landscape scale" was jointly organized by ICAR-CSSRI and CIMMYT at ICAR-CSSRI, Karnal, Haryana, India from 18-23 May, 2015. A total of 30 participants from different research institutions/universities of India, Nepal, and Bangladesh attended this training programme.
- ICAR-CSSRI, Karnal organized the 'Healthy Soil for Healthy Life' programme on 14th August 2015 to sensitize the farmers and school children about importance of soil

health and sustainable agriculture.

- A brainstorming session was organized on the occasion of 'International Year of Soils-2015' on 19th August 2015. Dr. I.P. Abrol, Former DDG (NRM), ICAR, New Delhi was the Chief Guest of the programme. Dr. Gurbachan Singh, Chairman, ASRB, New Delhi.
- Institute celebrated Van Mahotsav on 21st August, 2015.
- A 10-days International Training Programme on 'Conservation Agriculture was organized by ICAR-CSSRI and CSISA-CIMMYT for capacity development of researchers of Indian NARS (ICAR, SAUs) and CGIAR institutes during September, 02-11 2015 at ICAR-CSSRI, Karnal.
- Hindi Pakhwara' was celebrated during 14-28 September, 2015 with a view to encourage the Institute staff to use Hindi in day to day work.
- A one-day workshop was organized by Indian Council of Agricultural Research for 'Developing a Road Map for Technological Support, Extension and Demonstration Services to the Farmers in Trans-Gangetic Plains Region (Agro-Climatic Zone-VI)' at ICAR-CSSRI, Karnal on 5th October, 2015.
- Pre-Rabi Kisan Mela was organized on 21st October, 2015 in Gyong village of Kaithal district. About 250 farmers and extension workers participated in the Mela. Scientists/experts suggested appropriate solutions to the problems being faced by the farmers.
- Pre-Rabi Kisan Goshthis were also organized in different villages adopted under Mera Gaon Mera Gaurav (MGMG) programme in the states of Haryana, Punjab, Uttar Pradesh, West Bengal and Gujarat. More than 2000 farmers interacted with Scientists/Experts during these Goshthis.
- Soil Health Day' was organized on 5th December, 2015 at ICAR-CSSRI, Karnal. More than 200 farmers and 60 scientists participated in this prgramme. A total of 254 soil health cards were distributed to the farmers on this occasion. OSD to Hon'ble Chief Minister of Haryana Sh. Amarendra Singh was the Chief Guest of the programme presided over by Sh. Bakhshish Singh Virk, Chief Parliamentary Secretary, Govt. of Haryana.
- ICAR-CSSRI, Karnal organized 'Jai Kisan Jai Vigyan' week from 23-29 December, 2015 to sensitize the farmers about recent technologies for harnessing the productivity of salt-affected lands to maximize the farm profitability.
- An awareness programme on 'Swachh Bharat Abhiyan' was organized on 20th January, 2016 in Dabri village of Karnal to motivate the school children for promoting cleanliness in their homes, surroundings and village.
- A 5-days training of state agricultural extension officers, students and young professionals from ICAR-CSSRI & ICAR-IIWBR, Karnal was organized at ICAR-CSSRI, Karnal from 15-19 February, 2016 on "Participatory irrigation management for regional food and water security in northern India" in collaboration with IAFD, Australia, and CIMMYT CCAFS. A total of 31 trainees participated in this training.
- ICAR-CSSRI, Karnal celebrated its 47^{th} Foundation Day on 1^{st} March 2016 by organizing a Foundation Day lecture delivered by Dr. Arvind Kumar, Vice Chancellor, Rani Laxmi Bai Central

Agricultural University Jhansi.

- Rabi Kisan Mela was organized on 5th March, 2016 at Main Campus, Karnal that was inaugurated by Sh. Harvinder Kalyan, Chairman, HAFED, Govt. of Haryana. More than 2000 farmers and students participated in which 53 different institutions and private companies showcased their agricultural technologies and products. A Kisan Goshthi was also organized on the occasion.

Field Exhibitions 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 2215 farmers in 80 groups, 2567 students in 55 groups, 1051 extension workers in 56 groups and 161 scientists in 46 groups and 21 groups from India and abroad have visited CSSRI technology information centers and research farmers to learn about the technologies being developed.

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 2015-16, 682 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 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
- IRRI: Development of crop and nutrient management practices in rice
- CSIRO and Murdoch University, Australia – Cropping system intensification in the salt affected coastal zones of Bangladesh and West Bengal, India
- Future rainfed lowland rice systems in Eastern India 15 (T3) (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) and CSIRO, Australia in cropping systems modelling 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 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 Director, NCP,IGBP,IIRS, (NRSA), Department of Space, Dehradun, Uttrakhand
- CCS HAU, Hisar, Haryana for collaborative research
- Punjabi University Patiala, Punjab
- 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

Publications

The Institute published 108 research papers in peer reviewed journals, 35 book chapters, 4 books/manuals, 8 bulletins / folders / leaflets / technical reports, 23 popular articles and 3 technical reports. Besides, 53 papers were presented in different National and International seminar/symposia and conferences.

Scientists' visits abroad and new Joinings

To upgrade their knowledge and skills, 9 scientists of the institute visited different countries viz. Philippines, Taiwan, Argentina, Australia, Israel and Dubai. 12 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, Central Soil Salinity Research Institute was established under Fourth Five Year Plan period. The Institute started functioning at Hisar (Haryana) on 1st March, 1969. Later on, in October, 1969, it was shifted to Karnal. In February 1970, the Central Rice Research Station, Canning Town, West Bengal was transferred to CSSRI, Karnal to conduct research on problems of coastal salinity. Another Regional Research Station for carrying out research on problems of inland salinity prevailing in the black soil region of western parts of the country started functioning at Anand (Gujarat) from February, 1989. As per recommendations of the QRT, the station was shifted from Anand to Bharuch in April 2003. Keeping in view the need of undertaking research to manage alkali soils of Central and Eastern Gangetic Plains under surface drainage congestion, high water table conditions, relatively heavy textured soils, and indurated pan below, another Regional Station was established during October, 1999 at Lucknow. The Coordinating Unit of AICRP on Management of Salt Affected Soils and Use of Saline Water in Agriculture is located at the Institute with a network of eight research centres located in different agro-ecological regions of the country (Agra, Bapatala, Bikaner, Gangawati, Hisar, Indore, Kanpur and Tiruchirapalli). Recently in 2014, four new centres have started functing at Bathinda (Punjab), Panvel (Maharastra), Vytilla (Kerela) and Port Blair (Andaman & Nicobar Islands).

Over the year 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, mustard and cheekpea 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, mustard and cheekpea 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

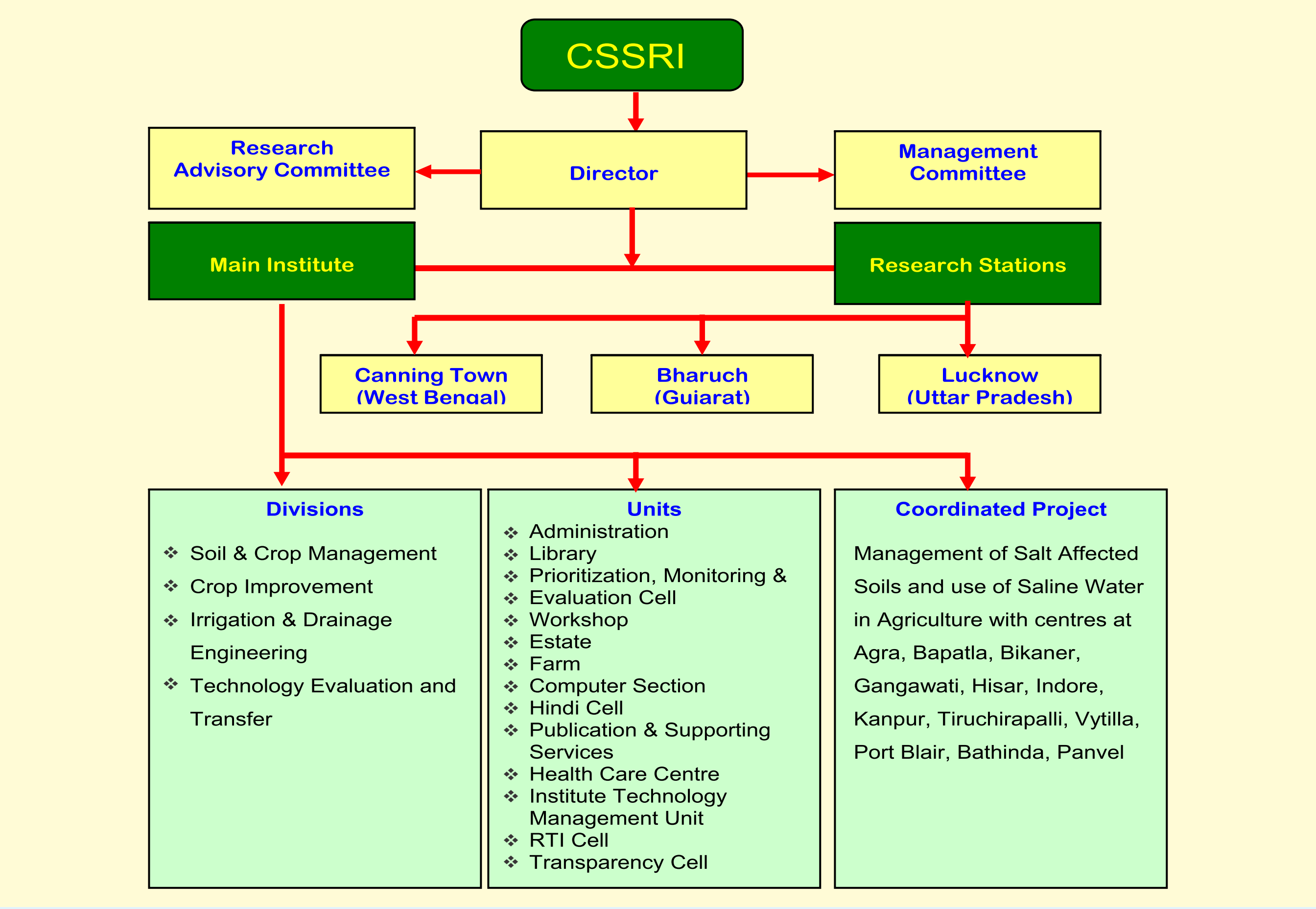
Institute initially for Haryana has been widely adopted and replicated in Rajasthan, Gujarat, Andhra Pradesh, Maharashtra and Karnataka. So far, about 70,000 ha waterlogged saline areas have been reclaimed, through institutional and private modes. Artificial groundwater recharge is another area of interest 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 salinity mapping 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:

- Developing technologies for reclamation and management of salt affected soils and use of poor quality irrigation waters in different agro-ecological regions of India.
- Evaluate and recommend strategies that promote adoption of preventive / ameliorative technology.
- Coordinate/support the network of research for generating and testing location specific technologies.
- Centre for training in salinity researches in the country.

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 size 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 the 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 residue burning is not practiced in the farm. Agro-forestry system is practiced on 6.5 ha area of the farm, where multipurpose tree species have been planted in combination with arable crops of the region. The area under fruit crops such as ber (Ziziphus mauritiana Lam.), aonla (Emblica officinalis L.), jamun (Syzygium cumini L.), guava (Psidium guajava L.), litchi (Litchi chinensis Sonn.) and mango (Mangifera indica) is 7.8 ha. An herbal garden consisting of 85 species of medicinal/ aromatic herbs, shrubs and trees has also been established and maintained in an area of 1.4 ha, besides fish are reared in ponds covering about 2.5 ha area. The 27.3 ha area of the farm is permanently covered under glass house, net houses, micro-plots, laboratories, offices, residences, oxidation pond, roads and landscape.

Productivity of crops at CSSRI farm

Crop	Variety	Average yield (t ha^{-1})
	***Rabi* 2014 – 15**	
Wheat	KRL 19	3.49
	KRL 210	4.32
	KRL 213	3.95
Mustard	CS 52	2.0
	CS54	2.2
	CS56	2.4
	***Kharif* 2015**	
Paddy	CSR 30	3.33
	CSR 36	4.49
	Pusa 44	6.74

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-, SO42- and HCO_3-. Higher SAR (19.3 mmol1/2^{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 2015-16 under Plan and Non-Plan budget is presented below:

(Rs. in lakhs)

Budget	Sanctioned amount/receipts	Actual expenditure
Non-plan	2746.63	2665.83
Plan	340.00	336.33
AICRP (Non-plan)	24.00	21.59
AICRP (Plan)	560.00	559.99
Total	**3670.63**	**3583.74**

Staff

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

Category of post	Sanctioned	In position
Scientific	81	67
Technical	117	99
Administrative	58	45
Skilled Supporting Staff	95	62
Total	**351**	**273**

Library

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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

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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


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DATABASE ON SALT AFFECTED SOILS

Mapping and characterization of salt affected soils in central Haryana using remote sensing and GIS (A. K. Mandal, Ranbir Singh, P. K. Joshi and D. K. Sharma)

The IRS LISS III data of March, June and October 2009-10 were used for identification and characterization of waterlogging and salt affected soils in Narnaud and Hansi II blocks of district Hisar in Haryana. In October imagery; scattered, discontinuous and mottled red to dark red; irregular shaped dark blue to blue-black, and white tones revealed poor crop growth, prominent waterlogging and barren surface with patchy salt inflictions, respectively along the Bhakra canal command. The area has saline groundwater at an average depth of <100 ft with over-exploitation and semi-critical development status in Narnaud and Hansi II (Bass) blocks, respectively. Ground truth studies revealed shallow water table depth (<1.5 m) causing waterlogging, secondary salinization and crop damage. Soils were characterized for texture, pHs, EC_e, ESP, CEC, ionic (cation and anion) composition and $CaCO_3$ (< 2mm size) content (Table 1). P1 and P2, being irrigated by the Fatehabad branch of Bhakra canal, showed the incidence of waterlogging and shallow watertable at ~1.5 m depth. It was associated with high soil salinity ranging from 9.8 to 16.9 dS m^{-1} with neutral reaction (6.4 to 7.8) in P1 and 2.44 to 12.7 dS m^{-1} with slight to moderate alkaline reaction (8.1 to 9.2) in P2. Due to high soil salinity, Ca^{2+} and Mg^{2+} contents of P1 (82 to 127 me L^{-1}) and P2 (7 to 70 me L^{-1}) exceeded that of Na^+ contents (45.5 to 103.0 me L^{-1}, 12.52 to 41.63 me L^{-1}). High Cl- (70-100 me L^{-1}) and SO_4^{2-} (67.1 to 86.2 me L^{-1}) contents indicated the presence of neutral salts in P1. While in P2, high Na^+ content found at higher pHs level with a concomitant decrease of Ca^{2+} and Mg^{2+} indicated possibility of their precipitation. High SO_4^{2-} contents (141.1 to 156.9 me L^{-1}) at surface of P2 may be ascribed to gypsum used in reclamation. Soil pHs varies from 8.8 to 9.0 in P3 and 8.7 to 10.1 in P4 that indicated slight to strong sodicity. The $CaCO_3$ contents increased from 0.4-8.96, 1.4-3.6, 0.4-24 and 0.3-2.7% in P1, P2, P3 and

Table 1 : Physico-chemical properties of soils from Hisar district Haryana

Depth (m)	pHs	ECe (dSm^{-1})	Na^+	K^+	Ca^{2+}+ Mg^{2+}	Ca^{2+}	Mg^{2+}	Cl^-	SO_4^{2-}	OM	$CaCO_3$*	ESP	CEC (c mol p^+ kg^{-1})
			me L^{-1}							(%)			
P1: Vil. Ghatoli Block Narnaud Dist Hisar 29° 10'20.5"N 76° 22'28.1"E Barren, Waterlogged (WTD 1.5m) irrigated by Bhakra canal													
0.0-0.3	7.8	16.9	103.0	0.14	127	72	55	200	74.3	0.3	0.4	15.8	15.5
0.3-0.6	6.4	9.8	47.6	0.13	82	40	42	80	86.2	0.2	0.3	10.5	16.2
0.6-0.9	6.5	9.8	45.5	0.09	96	41	55	70	67.1	0.2	0.7	12.8	13.5
0.9-0.12	7.1	10.8	49.1	0.05	98	42	56	100	80.5	0.2	8.96	12.1	9.9
P2:: Vil. Badchapar Block Narnaud Dist Hisar 29° 06'58.8"N 76° 17'55.0"E Waterlogged, WTD 1.5 m, Rice crop damaged, irrigated													
0.0-0.3	8.1	12.7	15.9	0.45	70	30	40	62	141.1	0.65	2.2	52.8	7.3
0.3-0.6	8.2	11.6	12.5	0.25	60	25	35	55	156.9	0.09	1.4	44.1	9.5
0.6-0.9	8.8	4.19	41.6	0.05	12	7	5	16	83.9	0.52	3.6	30.9	10.4
0.9-0.12	9.2	2.44	31.1	0.02	7	5	2	10	32.5	0.14	3.3	29.7	12.4
P3: Vil. Sangwa Khas Block Hansi II Dist Hisar 29° 03'32.92"N76° 14'32.6"E Waterlogged, rice crop damaged, $CaCO_3$ layer at 1.2 m													
0.0-0.3	8.8	5.5	27.8	tr	8	5	3	33	84.9	0.26	0.4	49.7	10.5
0.3-0.6	9.2	2.7	29.4	tr	5	4	1	13	28.9	0.22	1.9	54.8	8.3
0.6-0.9	9.1	1.7	20.0	tr	5	5	0	11	31.2	0.26	18.8	31.3	6.9
0.9-0.12	9.0	1.9	19.4	tr	6	6	0	10	19.3	0.22	24.0	38.5	9.1
P4: Vil. Mardanheri Block Hansi II Dist Hisar 29° 03'43.9"N 76° 14'15.1"E Barren for last 10 years, thick $CaCO_3$ layer at 1.2 m depth													
0.0-0.3	8.7	25.7	303.0	0.9	38	25	13	180	123.0	0.28	0.3	29.3	8.7
0.3-0.6	9.5	17.0	251.0	0.1	8	4	4	115	49.2	0.21	1.3	57.2	11.3
0.6-0.9	10.1	10.4	156.0	0.0	10	5	5	75	76.5	0.22	2.7	51.5	10.4
0.9-0.12	10.1	7.2	91.7	0.0	7	4	3	50	66.6	0.27	2.7	58.7	14.7

Table 2 : Soil physical properties from Hisar district Haryana

Depth (m)	Sand	Silt	Clay	Texture	Silt + Clay (< 50 u) (%)		$CaCO_3$ (< 2mm*) (%) in WDSS			
	----------------% ------------------				MC	WDSS	CS	FS	Silt	Clay
P1: Vil. Ghatoli Block Narnaud Dist Hisar 29°10'20.5"N 76° 22'28.1"E Barren, Waterlogged (WTD 1.5m) irrigated										
0.0-0.3	49	28	23	scl	51	42	0.1	0.1	0.1	tr
0.3-0.6	50	28	22	scl	50	35	0.1	0.1	0.2	tr
0.6-0.9	51	26	23	scl	49	41	0.2	0.1	0.3	tr
0.9-0.12	56	29	25	scl	54	41	2.8	1.7	0.5	tr
P2: Vil. Badchapar Block Narnaud Dist Hisar 29°06'58.8"N 76°17'55.0"E Waterlogged, WTD 1.5 m, Rice crop										
0.0-0.3	28	44	22	l	66	48	0.4	0.3	0.2	tr
0.3-0.6	52	33	14	l	47	56	0.6	0.2	0.2	tr
0.6-0.9	50	32	18	l	50	77	1.7	0.3	0.4	tr
0.9-0.12	36	39	24	l	63	80	1.1	0.3	0.7	tr
P3: Vil. Sangwa Khas Block Hansi II Dist Hisar 29°3'32.92"N76°14'32.6"E Waterlogged, rice crop damaged, $CaCO_3$										
0.0-0.3	54	31	14	sl	45	44	0.7	0.1	0.4	tr
0.3-0.6	57	25	19	sl	44	49	2.7	0.3	0.5	0.3
0.6-0.9	56	20	24	scl	44	65	2.6	1.3	2.4	1.7
0.9-0.12	47	27	27	scl	54	62	1.9	3.2	3.6	1.8
P4: Vil. Mardanheri Block Hansi II Dist Hisar 29° 03'43.9"N 76° 14'15.1"E Barren for last 10 years, thick $CaCO_3$ layer										
0.0-0.3	49	36	15	l	51	50	0.2	0.1	0.4	0.06
0.3-0.6	45	41	15	l	66	54	0.7	0.4	0.4	0.05
0.6-0.9	34	51	16	sil	77	73	1.6	0.6	6.4	0.17
0.9-0.12	32	40	28	cl	68	74	0.8	0.5	5.3	0.03

CS= Coarse sand, FS = Fine sand, MC = Mechanical composition, WDSS = Water Dispersible Soil Separates

P4, respectively indicating calcareous nature, indurations, low permeability and susceptibility to waterlogging. Coarse to medium texture of soil with non-expanding clay minerals and sodicity resulted in low CEC and higher ESP, respectively in P2, P3 and P4. Textural composition showed fine texture strata in P1 (sandy clay loam) and P2 (loam). However, textural changes in P3 (sandy loam to sandy clay loam) and P4 (silty clay loam to clay loam) occurred due to clay illuviation (14 to 27% in P3, 15 to 28% in P4). Water dispersible un-aggregated silt plus clay particles (< 50 μ) and $CaCO_3$ contents were studied to assess nature and distribution of natural aggregates and cementation due to carbonates (Table 2). The silt plus clay content abruptly varied (35 to 42%) in P1 and increased in sodic and calcareous soils (P2, P3 and P4). $CaCO_3$ content was higher in coarse sand (2.8 and 1.1%), fine sand (1.7 and 0.3%) and silt (0.5 and 0.7%) particles in neutral to alkaline soils (P1 and P2). Significant contents were noted in silt (0.4 to 3.6 and 0.4 to 6.4%), fine sand (0.14 to 3.2 and 0.1 to 0.6%), coarse sand (0.7 to 2.7 and 0.2 to 1.6%) and clay (0.3 to 1.8 and 0.03 to 0.17%) particle in moderate to highly sodic soils (P3 and P4). The study revealed that the silt and clay particles (<50 μ) and $CaCO_3$ concretion formed stable structures in sodic soils that restricted water movement and caused waterlogging and soil salinization in irrigated areas. Image interpretation of IRS LISS III 2009-10 data revealed prominent areas of waterlogging and soil salinization in irrigated areas (Bhakra canal) of Narnaud and Hansi II blocks of Hisar district. Restricted drainage, sandy texture of soil and arid climate favored capillary rise of salts within the root zone causing secondary salinization. About 30-40% of the area is affected with waterlogging and soil salinization. The soils are saline in general but at places saline-sodic in nature.

Assessment and mapping of SAS using remote sensing and GIS in Rewari and Mahendergarh districts of Haryana

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

Rewari district covers an area of 1590 km^2 and has a vast road and irrigation network (Fig. 1). Increasing use of poor quality water from tube wells with varying degree of salinity and sodicity in Nahar, Bawal, Rewari and Jatusana blocks has added to the increase in soil salinity. In Khol and Jatusana, the water quality is comparatively better and thus lesser problem of soil salinity.

In the district, texture of the soils ranges from sand to loamy sand with surface soil texture varying from sand to fine loamy sand. However, in fluvial low lands the soils are heavier in texture varying from sandy loam to loam. Mostly, these soils are calcareous, saline-alkaline in nature with $CaCO_3$ content ranging from 0.15 to 9.8%. pHs and EC_e of these soils ranged from 6.3 to 9.1 and 0.27 to 6.7 dS m^{-1}, respectively. The soils are excessively drained with slight to moderate soil erosion and have a high percolation rate. Overall, the soils have poor water and nutrient retention capacity and low organic carbon content (0.02 – 0.95%).

Analysis of satellite images and Map 1b based GPS coordinated soil samples indicated that pHs and EC_e increased with increasing depth at all sampling points. pHs and EC_e ranged from 7.5-9.1 and 0.27-6.7 dS m^{-1}, respectively. In surface soil, contents of cations viz., Na, Ca+Mg and K ranged from 0.81-91, 2.0-45 and 0.0-29.8 me L^{-1}, respectively; whereas, respective anions HCO_3, and Cl^- varied from 1.0-8.0 and 2.8 to 64 me L^{-1} with CO_3 generally being undetectable. As such, salt affected soils (SAS) covered 441.22 km^2 in the district (Table 3, Map). Supervised classification estimate suggested that severe, moderate and water logged/saline SAS are present over 29.06, 295.21 and 116.95 km^2, respectively. A Kappa coefficient of accuracy for mapping salt affected soils in the district was at a high 78%.

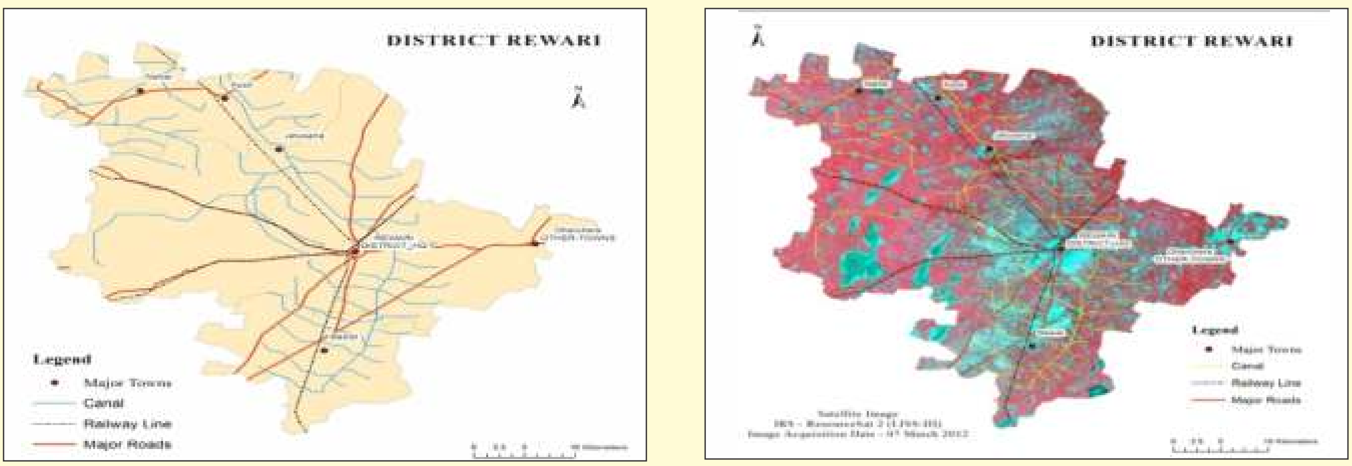
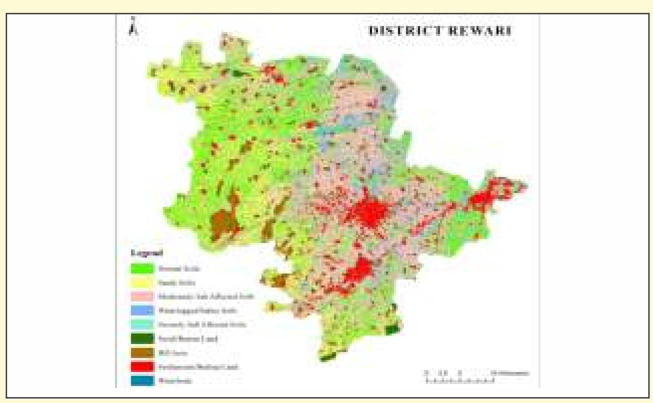


Fig. 1 : (a) Map of Rewari district and (b) its satellite image.

Table 3 : SAS and different land uses Area under and supervised classification (Map 2) in Rewari district

Class Name	Area in km^2
Moderately Salt Affected Soils	295.21
Normal Soils	543.62
Sandy Soils	208.40
Settlements/Built-up Land	237.56
Waterlogged/Saline Soils	116.95
Scrub/Barren Land	43.70
Hill Area	33.30
Severely Salt Affected Soils	29.06
Water bodies	11.38
Others (Railway Line, Roads, Canal etc.)	74.82
Total	1594



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, A.K. Rai, Satyendra Kumar and Thimmappa K)

In the Indo-Gangetic plains, continuous rice-wheat cropping sequence in light textured soils has weakened the natural resource base. Intensive tillage and residue burning, declining ground water levels, deteriorating soil and water qualities, increased cost of cultivation and reduced factor productivity are the emerging concerns for agricultural sustainability. Different resource conserving technologies offer newer opportunities for sustained yields and better livelihoods to the small and marginal farmers of the region. Keeping these constraints in view, a field experiment, on assessment of resource conservation strategies viz., tillage, residue and irrigation methods for enhancing crop productivity and sustaining health of semi-reclaimed sodic soils, has been continuing since 2011. Conventional cultivation practice (Cv) of rice-wheat cropping system was assessed vis-à-vis eight adopted resource conservation techniques. High yielding variety of rice (Arize-6129) and wheat (HD 2967) were used as test crops. The results indicated that in kharif season the highest grain yield of rice (7.58 t ha^{-1}) was recorded in Cv with wheat residue incorporation followed by conventional transplanting (7.18 t ha^{-1}) without crop residue. Crop residue incorporation resulted in ~5.57 % higher additional grain yield of transplanted rice. DSR with crop residue produced 6.95 t grain yield ha^{-1}, which was 4.67% higher in comparison to DSR without crop residue. Weed infestation has been found in DSR. Preponderance of *Cyperous rotundus* (motha), *Echinochloa crusgali* (Barta), *Echinochloa colonum* (Sanmak), *Dactyetenium aegyptium* (Makra) and Kallar grass, etc. caused a significant yield reduction under zero tillage and reduced tillage techniques.

The highest grain yield of wheat (5.67 t ha^{-1}) was recorded in conventional sowing with rice residue incorporation as compared to 5.65 and 4.87 t ha^{-1} with reduced tillage and Cv without rice residue incorporation, respectively. Crop residue incorporation resulted in ~16.43% additional grain

Table 4: Effect of surface and mini sprinkler methods of irrigation on wheat yield (Cv.HD 2967), irrigation water requirement, water productivity, saving of water and electricity during 2014-2015

RCTs	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 T1	Surface T7	Mini – Sprinkler T8	Mini –Sprinkler T9
Irrigation criteria	Growth stages	Growth stages	(7 days CPE)	(7 days CPE)
Grain yield (t ha^{-1})	4.87	5.07	4.95	5.07
Total crop productivity (t ha^{-1})	11.89	11.82	12.48	10.83
Total irrigation water (ha-cm)	28.00	24.5	11.23	11.23
Total irrigation water (m^3 ha^{-1})	2800	2450	1123	1123
Crop water productivity (kg m^{-3})	4.25	4.82	11.11	9.64
Grain water productivity (kgm^{-3})	1.74	2.07	4.41	4.51
Irrigation water saving (%)	-	12.50%	59.89%	59.89%
Electricity saving (%)	-	-	-	-
NUE (kg kg^{-1}N)	32.47	33.80	66.0	67.6
Physiological observation	Greenness-water not stagnated	Greenness-water not stagnated	Greenness-water not stagnated	Greenness-water not stagnated

Rainfall received = 196.7 mm and Pan evaporation=265.8 mm during November 2014 to March 2015 , CPE= cumulative pan evaporation of 7 days used for irrigation through mini sprinkler system , CD (0.05) =0.32 and NUE= nitrogen use efficiency

Wheat germination under mini sprinkler irrigation

Mini sprinkler in rice crop

yield of wheat under Cv practices because of long term rice and wheat residue incorporation. However, wheat in 50% tillage with crop residue incorporation yielded 5.84% higher grain yield in comparison to 50% tillage without crop residue. Optimum soil moisture and favourable temperature regulation under residue incorporation treatments facilitated better seed germination and crop growth as compared to no-residue treatments.

A mini-sprinkler irrigation system with discharge rate of 12960 lh^{-1} at 2 kg cm^{-2} pressure and 90% uniformity coefficient has been installed in 0.25 ha area. In wheat, irrigation was scheduled based on cumulative pan evaporation at 7 days interval. Sprinkler irrigation system saved ~60 and 36% water and electricity, respectively, over surface irrigation in conventional cultivation (Table 4). Under zero tillage with 100% rice straw mulch, the highest wheat grain yield (5.07 t ha^{-1}) was recorded under surface irrigation followed by 5.01 t ha^{-1} with mini sprinkler irrigation method. But ~2.53 times higher wheat grain water productivity was recorded in mini sprinkler irrigation method as compared to surface irrigation. In spite of crop lodging near sprinkler risers at grain filling and dough stages; the highest nitrogen use efficiency of 66.8 kg grain kg^{-1} N with 50% saving was observed in mini sprinkler fertigation as crop compared to conventional surface irrigation method. In case of DSR, the maximum grain yield 6.59 t ha^{-1} was recorded with mini sprinkler in 50% reduce tillage. Sprinkler irrigation also saved ~58 and 33% of irrigation and electricity consumption, respectively (Table 5). DSR on 50% reduce tillage under surface irrigation saved 27% irrigation as compared to conventional transplanting. In rice, fertigation using mini sprinkler saved 27% N with the maximum nitrogen use efficiency ~60 kg kg^{-1} N compared to conventionally irrigated, puddled transplant rice.

Table 5 : Irrigation water requirement, water productivity, saving of water and electricity in hybrid rice (Arize 6129) under surface and mini sprinkler irrigation methods

RCTs	Conventional rice transplanting	DSR without wheat residue /wheat in Zero tillage with100 % rice mulch	DSR without wheat residue /wheat in Zero tillage with 100 % rice mulch	DSR with wheat residue incorporation /wheat in Zero tillage with 100 % rice mulch
Mode of irrigation	Surface T1	Surface T7	Mini –Sprinkler T8	Mini –Sprinkler T9
Irrigation criteria	1DADPW	Small soil cracks with surface dryness	(CPE) Alternate day	(CPE) Alternate day
Grain yields (t ha^{-1})	7.18	6.97	6.48	6.59
Total crop productivity (t ha^{-1})	13.08	11.75	12.45	11.95
Total irrigation water (ha-cm)	77.50	56.30	32.76	32.76
Total irrigation water (m^3 ha^{-1})	7750	5630	3276	3276
Crop water productivity (kg m^{-3})	1.69	2.09	3.80	3.65
Grain water productivity (kg m^{-3})	0.926	1.24	1.98	2.01
Irrigation water saving (%)	-	27.35	57.73	57.73
Electricity saving (%)	-	27.36	32.49	32.49
NUE (kg kg^{-1} N)	47.87	46.47	58.81	59.91

Rainfall received = 379.3 mm and Pan evaporation = 519.6 mm during June, 2015 to September 2015, CPE= cumulative pan evaporation criteria used for irrigation through mini sprinkler system, CD (0.05) = 0.35 (grain yield) and NUE= Nitrogen use efficiency.

Nutrient management strategies for sustainable rice and wheat production in reclaimed alkali soils (A.K. Bhardwaj, N. Basak, S.K. Chaudhari and D. K. Sharma)

Integrated nutrient management experiments were started with ten quadruplicated treatments in RBD. Treatments are-$T_{1=}$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}= $N_{150}P_{26}K4_2S_{30}Zn_7Mn_0$ (S). At the time of harvesting, 33% of the total rice stalk length was kept in the field and incorporated in soil using power tiller before wheat (DBW 17) sowing only in T_8 treatment. Before rice transplanting, green gram seeds (SML 668) were sown in the first fortnight of May in the specified plots and incorporated *in situ* after two pickings of pods. Similarly, dhaincha (*Sesbania aculeate*) 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 soil 15 and 30 days before rice transplanting, respectively. Rice (Pusa-44) seedlings (30 days old) were transplanted in first week of July at 20×15 cm spacing. One third of N and full doses of other macro and micro nutrients were applied at the time of sowing (in wheat)/transplanting (in rice) according to the treatments. Remaining N was applied in two equal splits after 3 and 6 weeks of sowing (in wheat)/transplanting (in rice). Three field experiments are being run to answer different scientific questions. To work out sustainable strategies, nutrient availability under changing soil moisture regimes in different treatments was monitored using ion exchange resin strips.

Observations suggested that total amount of available N (NH_4^+ + NO_3^-) recorded in the full season of wheat (2014-15) was in the order: I (1780 µg cm^{-2}) > GM (1523 µg cm^{-2}) > LEG (1457 µg cm^{-2}) > FYM (1357 µg cm^{-2}) > PC (943 µg cm^{-2}) > WS (918 µg cm-2) > O (102 µg cm^{-2}) (Fig. 2). Total amount of available N (NH_4^+ + NO_3^-) recorded in the full rice season (2014-15) was in the order: PC (187 µg cm^{-2}) > I (180 µg cm^{-2}) > WS (176 µg cm^{-2}) > FYM (175 µg cm^{-2}) > GM (176 µg cm^{-2}) > LEG (174 µg cm^{-2}) > O (90 µg cm^{-2}) (Fig. 3). Majority of available nitrogen was in the form of NH_4^+-N in rice and in form of NO_3^--N in wheat.

There were significant differences in bulk density of soils due to different treatments. The maximum differences in the bulk density were found in the 0-15 cm depth. The mean bulk density for 0-60 cm depth (averaged for 1-15 cm, 15-30 cm, and 30-60 cm below surface) was in the order: T_1(1.71 g cm^{-3}) > T_3 (1.69 g cm^{-3}) >T_8 (1.69 g cm^{-3}) >T_6 (1.68 g cm^{-3}) >T_7 (1.68 g cm^{-3}) >T_5 (1.44 g cm^{-3}) >T_4 (1.42 g cm^{-3}).

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

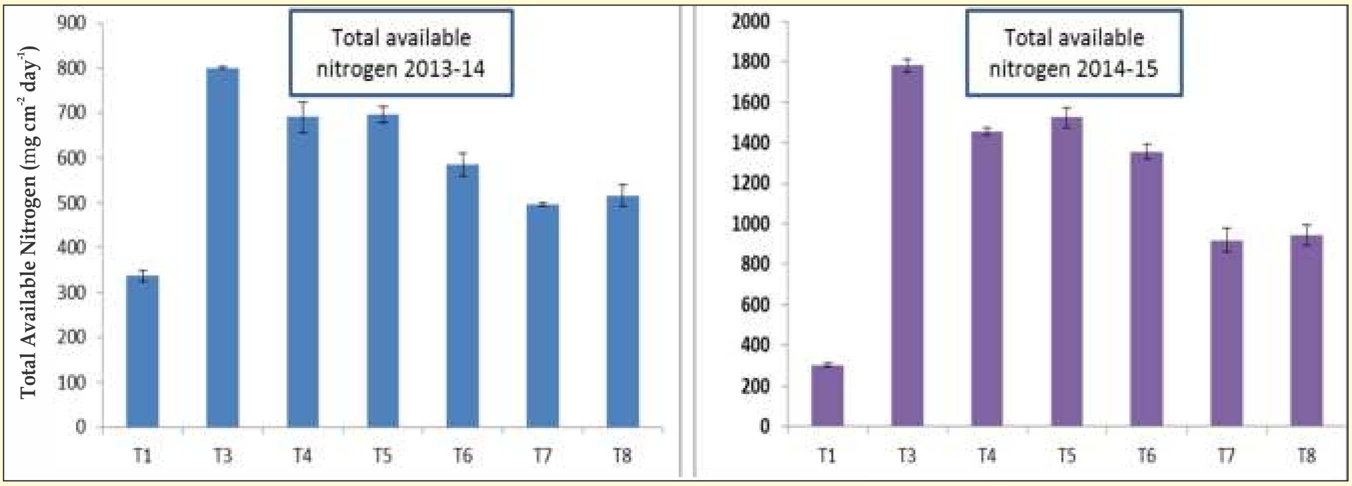


Fig. 2 : Effects of different treatments total (NH_4^+ and NO_3^-) available nitrogen in wheat

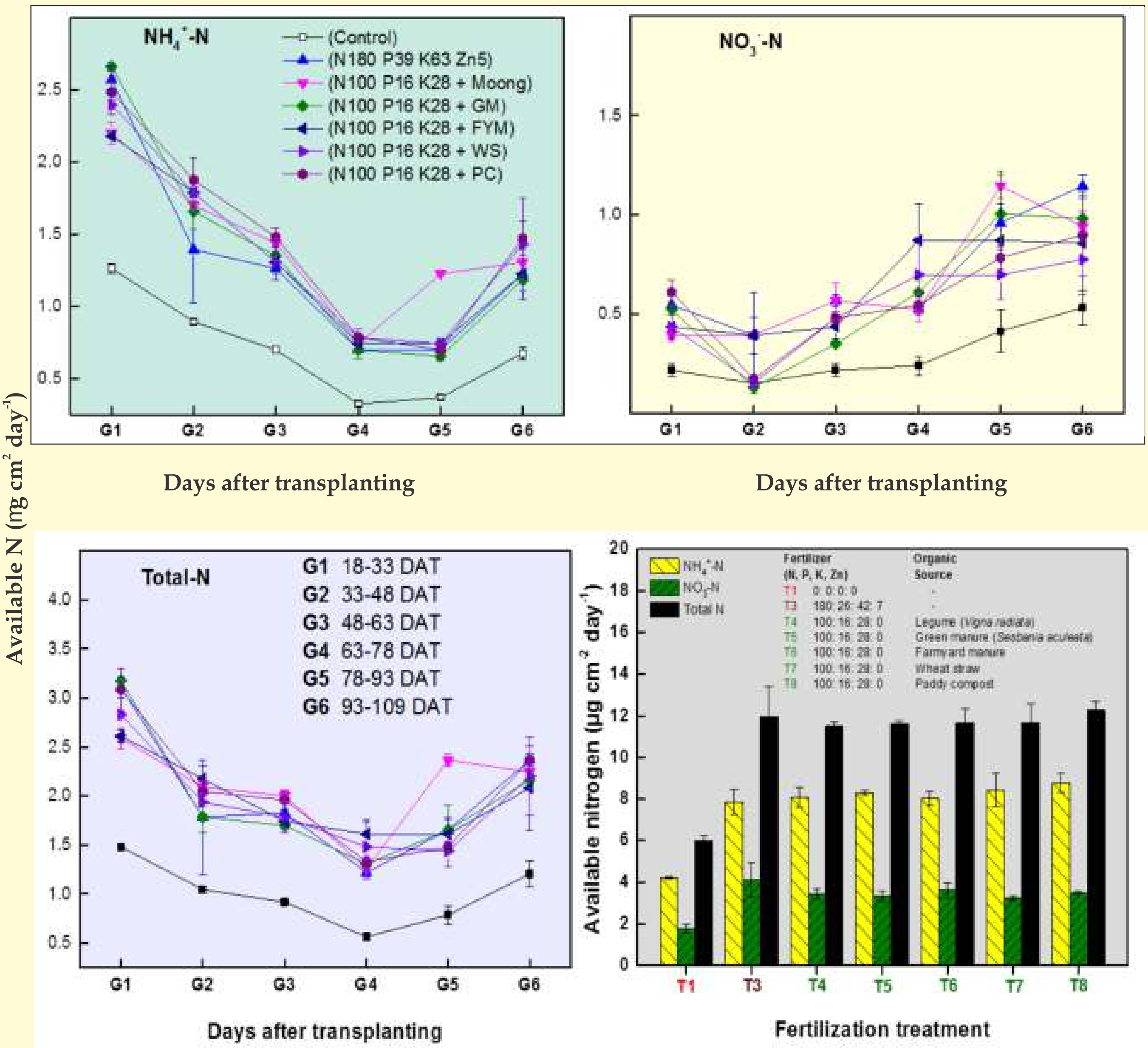


Fig . 3 : Nitrogen availability in rice under different treatments at different growth stages and full season

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)

Till now, very limited work has been done on direct seeded rice (DSR), especially on zero tillage (ZT)-DSR. Due to aerobic conditions under DSR, availability of N, Zn and Fe gets reduced. Higher loss of N with denitrification (N_2O, NO), leaching (NO_3) and volatilization etc. induce higher N requirements; necessitating more efficient N, Zn and Fe management in DSR. In this background, direct seeding of salt tolerant rice cultivar CSR 30 was done on 17 June 2015 under ZT with 16 treatment combinations of residue and nutrient management. After harvest of rice, salt tolerant wheat cultivar KRL 210 was sown in November, 2015 under ZT with recommended package of practices. During first year of investigation, results indicated that physiological traits (RWC, SPAD), yield attributes and yield of DSR basmati rice were not affected due to application of rice residues as mulch @ 5 t ha^{-1} (Table 6). Effective tillers/hill, grains/panicle and 1000-grain weight were statistically similar in all the nutrient management treatments. However, the maximum values of panicle length (23.0 cm), relative water content (RWC, 76.0) and chlorophyll content (SPAD reading, 33.7) were recorded with the recommended dose of fertilizers (RDF) supplemented with CSR-BIO (seed treatment + soil application); and these were significantly higher than treatment T_1 (RDF alone) and some other treatments (Fig. 4). The highest grain yield of ZT-DSR basmati was observed in treatment RDF+20% higher N with top cutting (T_4), closely followed by T_2(RDF+10% higher N) and T_8 (RDF+CSR-BIO), respectively. The significantly lower grain yield was observed in treatments T_1 and T_5(RDF+30% higher N with top cutting) than other treatments in the study. Data on lodging indicated that addition of higher N increased the lodging while top cutting at 70 days after sowing reduced it numerically.

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 and B. Narjary)

Municipal solid waste (MSW) is recently gaining importance for improving microbial and

Table 6 : Effect of residue and nutrient management on yield attributes and yield of ZT-DSR(Basmati)

Treatment	Effective tillers/hill	Panicle length (cm)	Grains/ panicle	1000-GW (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Lodging (%)
Residue management							
Rice mulch (5 t ha^{-1})	8.53	21.5	58.1	22.98	2.91	3.94	4.38
Control	8.77	22.2	60.5	23.28	2.93	3.83	4.33
$LSD_{0.05}$	NS	NS	NS	NS	NS	NS	NS
Nutrient management							
T_1	8.80	21.8	60.8	22.85	26.7	45.6	5.00
T_2	8.20	22.3	58.0	23.54	30.8	39.6	6.66
T_3	8.73	21.9	58.9	23.25	28.2	48.4	10.0
T_4	8.27	21.7	57.3	23.04	31.1	31.4*	4.16
T_5	8.50	19.9	57.3	22.71	27.6	31.7*	0.00
T_6	8.50	22.0	59.7	24.00	30.2	40.0	1.66
T_7	9.30	22.0	59.8	22.27	28.2	36.9	4.00
T_8	8.87	23.0	62.2	23.38	30.8	36.9	3.33
$LSD_{0.05}$	NS	1.85	NS	NS	3.1	-	-

T_1: RDF (60 kg N+30 kg P_2O_5+30 kg K_2O+25 kg $ZnSO_4$ ha^{-1}) + 5q ha^{-1} FYM (30 d); T_2: RDF+10% higher N; T_3: RDF+20% higher N: T_4: RDF+20% higher N with top cutting; T_5: RDF+30% higher with top cutting; T_6: RDF+25 kg ha^{-1} $ZnSO_4$; T_7: RDF+foliar spray of $FeSO_4$@ 3% (40 and 60 DAS); T_8: RDF + CSR-BIOPLUS (Seed treatment with 3% liquid formulation + soil application @ 25 kg ha^{-1} with FYM @ 5 q ha^{-1} at 30 DAS)

* Top cutting biomass not included

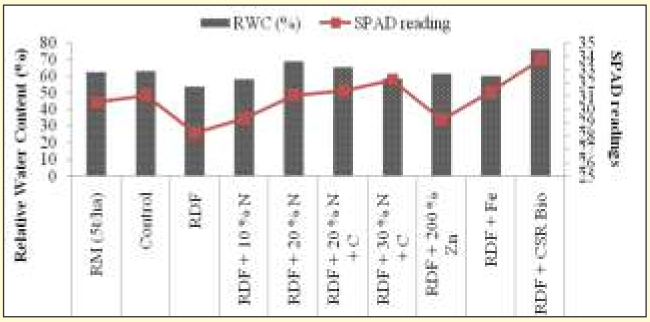


Fig. 4 : Effect of residue and nutrient management on physiological efficiency of ZT- DSR(CSR 30)

chemical properties of salt affected soils. In India, poor collection and inadequate management are the main reasons for accumulation of huge heaps of MSW which have become environmental hazards. In order to take advantage of nutritional and organic carbon constituents and to protect environment, sustainable management of MSW has become imperative. MSW compost reduces environmental pollution and provides an alternative organic amendment for salt affected soils. Therefore, a study was carried out to assess the biodegradable MSW and gypsum enriched composts for improving the productivity of mustard - pearl millet cropping system and health of salt affected soils.

Integrated use of organic amendments i.e. municipal solid waste compost (MSWC), rice straw compost (RSC) and gypsum enriched compost (GEC) along with 25% recommended dose of fertilizers (RDF) produced 23 and 25 % additional grain yield of mustard and pearl millet respectively, over use of 100% RDF alone. Use of organic amendments alone and MSWC performed better in terms of three year mean of grain yield of mustard and pearl millet than RSC and GEC. Combined use of organic amendments along with 25% RDF (T9) resulted in significantly higher mean grain yield (2.51 and 2.67 t ha^{-1}) of mustard and pearl millet respectively, over use of organic amendments alone. Application of 100% RDF produced 11 and 15% higher grain yield of mustard and pearl millet, respectively over unfertilized (control) plots after three year of crop cycle. Combined use of organic amendments along with chemical fertilizers showed significant improvement in three year mean of soil organic carbon (SOC) than other treatments but it was statistically at par with treatment receiving MSWC @ 8 t ha^{-1} + 50% RDF (Fig. 6). Application of MSWC @16 t ha^{-1} significantly increased of SOC (4.3 g kg^{-1}) than use of 100% RDF alone after completion of three years cropping cycle. SOC ranged from 1.5 to 5.1 g kg^{-1} after three years of mustard and pearl millet cropping cycle. SOC was more influenced by organic amendments than use of chemical fertilizers alone; however, it was significantly

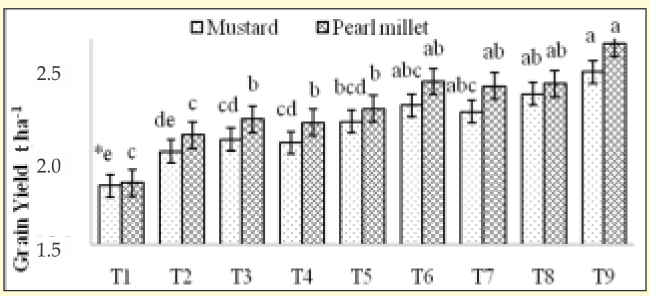


Fig. 5 : Effect of municipal solid waste compost vis-à-vis gypsum enriched compost and chemical fertilizers on three years mean grain yield of mustard and pearl-millet

T_1: Control, T_2: Recommended dose of NPK fertilizers (100% RDF),T_3: Rice straw compost @ 14 t ha^{-1} ,T_4: Gypsum enriched compost @ 14 t ha^{-1} ,T_5: Municipal solid waste compost @ 16 t ha^{-1} , T_6 50% RDF + Rice straw compost @ 7 t ha^{-1} ,T_7: 50% RDF + Gypsum enriched compost @ 7 t ha^{-1},T_8 50% RDF + Municipal solid waste compost @ 8 t ha^{-1} ,T_9: 25% RDF + RSC@ 3.5 + GEC @ 3.5 + MSWC @ 4 t ha^{-1}

*For each parameter, different letters within the same column indicate that treatment means are significantly different at P<0.05 according to Duncan's Multiple Range Test for separation of means.

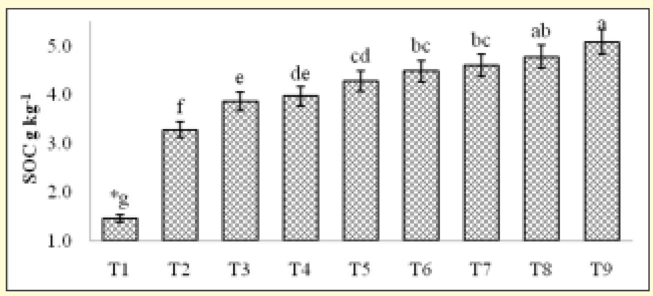


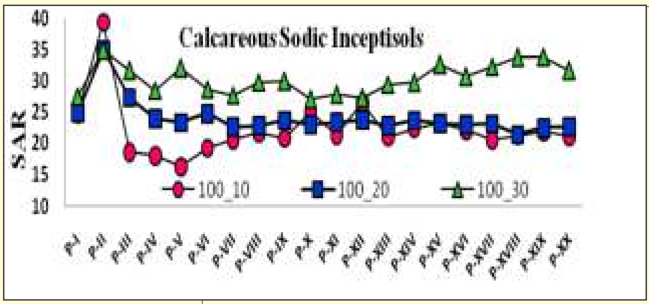
Fig. 6 : Effect of municipal solid waste, gypsum enriched compost and chemical fertilizers on 3 years mean soil organic carbon (g kg^{-1}) after mustard and pearl-millet harvest

T_1 Control, T_2: Recommended dose of NPK fertilizers (100% RDF),T_3 Rice straw compost @ 14 t ha^{-1} ,T4: Gypsum enriched compost @ 14 t ha^{-1} ,T_5: Municipal solid waste compost @ 16 t ha^{-1} , T_6: 50% RDF + Rice straw compost @ 7 t ha-1 ,T7: 50% RDF + Gypsum enriched compost @ 7 t ha^{-1},T_8: 50% RDF + Municipal solid waste compost @ 8 t ha^{-1} ,T_9: 25% RDF + RSC@ 3.5 + GEC @ 3.5 + MSWC @ 4 t ha^{-1}

*For each parameter, different letters within the same column indicate that treatment means are significantly different at P<0.05 according to Duncan's Multiple Range Test for separation of means higher with 100% RDF application than unfertilized plots.

Cation exchange equilibrium and solute transport through different textured salt affected soils (Nirmalendu Basak, S. K. Chaudhari and D.K. Sharma)

In arid and semi-arid regions with scanty rainfall, agriculture largely depends on saline groundwater and canal water. Generally groundwater in these regions is saline are sodic. Continuous use, fully or partly, of such poor quality water adversely affects the physical and chemical properties of the soils, water and nutrient uptake and ultimately the crop productivity. Such deteriorations are more on fine textured soils, which deserve special attention for management. Therefore, a soil column study was carried out with surface (0-30 cm) soil of calareous sodic Inceptisols (Sangrur, Punjab) and calcareous sodic Vertisols (Kalak, Bharuch). The soil columns were slowly wetted from the bottom by capillary action using saline-sodic water 100.0 me L^{-1} TEC and 10, 20 and 30 $mmol^{1/2}$ $L^{-1/2}$SAR. After wetting, 20 pore volumes of every quality water were passed through individual columns of respective soils and leachate was collected at the end of each pore volume. At the end of leaching process after passage of 20 pore volumes, soil columns were drained under gravity for 24 h, evenly sectioned into five slices of ~3.0 cm each, and air dried. The pH_2, EC_2 and $CaCO_3$ contents were determined in each soil slice. Increasing sodicity (SAR) of incoming water having same electrolyte concentration increased pH and EC in leachate from entire pore volumes. Under lower SAR (10) water use, entire soil leachates collected from both the soils detected higher SAR than that of incoming solution (Fig. 7). However, the leaching solution tended to reach quasi-equilibrium with incoming water SAR levels of 30 and 20 in calcareous sodic Inceptisols and calcareous sodic Vertisols, respectively. Increasing sodicity of incoming water increased relatively more leaching



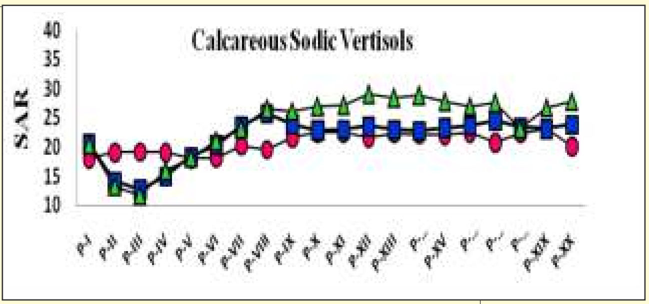


Fig. 7 : Changes in soil leachates SAR along varied pore volume when soils were leached with saline-sodic water of 100.0 me L^{-1} TEC and 10, 20 and 30 $mmol^{1/2}$ $L^{-1/2}$ SAR

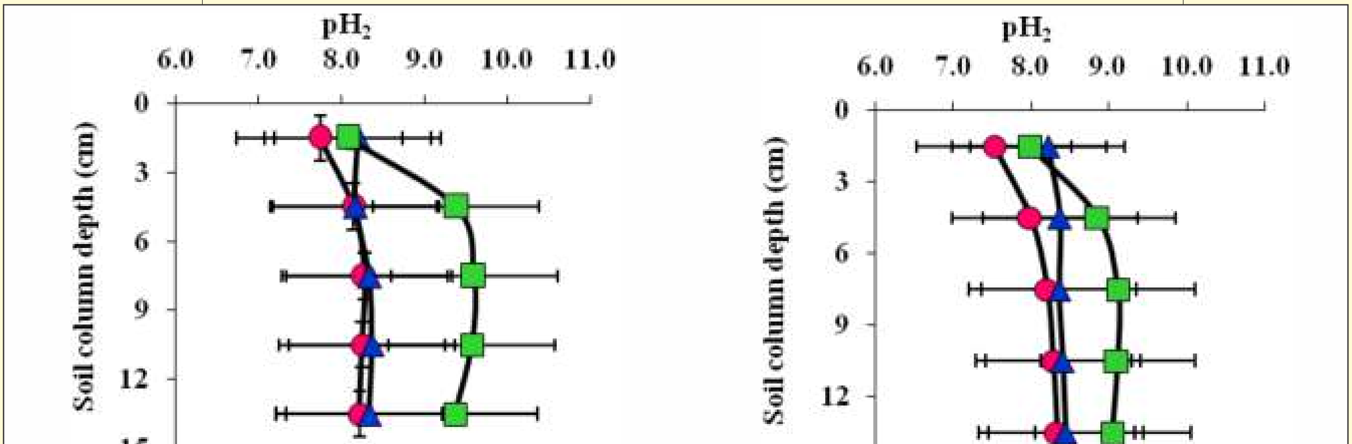


Fig 8 : Soil pH_2 in different depths values after leaching versus the soil depth when soils were leached with quality water of 100.0 me L^{-1} TEC and 10, 20 and 30 $mmol^{1/2}$ $L^{-1/2}$ SAR for calcareous sodic Inceptisols and calcareous sodic Vertisols of Ca and Mg than Na, from soil. Decrease in pH was detected at all depths of both the soils when leached with water of SAR 10 and 20 (Fig. 8). However, leaching of calcareous sodic Inceptisols with high SAR (30) water increased its pH at all depths but had no effect in calcareous sodic Vertisols. Lesser $CaCO_3$ dissolution was noticed when low SAR (10 and 20) waters were applied. Whereas, $CaCO_3$ content unaffected when a higher sodicity of saline-sodic incoming water were applied.

Effect of land uses on salt distribution and properties of salt affected soils

(N. Basak, Ashim Datta, A.R. Chinchmalatpure and Rakesh Banyal)

Five land-uses viz. mesquite (*Prosopis juliflora*), jamun (*Syzygium cumini*), kikar (*Acacia nilotica*) and Pasture (Grass land) on alkaline 9.36, 8.84, 8.49, 8.49 pH, respectively and Eucalyptus (*Syzygium cumini*) on 6.61 pH soils were studied at Saraswati Range in Kurukshetra. Both, soil pH_2 and pHs increased with increasing soil depth. For surface soil, the highest electrical conductivity of saturation extract (EC_e) was recorded under kikar followed by eucalyptus, mesquite, pasture and jamun with values being 9.54, 7.52, 7.11, 5.55 and 5.4 dS m^{-1}, respectively. Irrespective of soil depth and land uses, EC_e was 2.5 times higher than mean EC_2. All soils irrespective of land uses and soil depth showed higher values of exchangeable sodium percentage (ESP) >15%. In surface soil, the highest ESP of 74.3% was found under mesquite followed by jamun, kikar, eucalyptus and pasture with 62.6, 51.9, 45.5 and 37.1%, respectively; however, ESP increased with increasing soil depth. Overall, a significant positive correlation existed between pHs and ESP (R^2 =0.70). The ratio of exchangeable Ca to exchangeable Mg varied for soil under different land uses. Oxidizable organic C (OC) decreased with depth in all the land uses. Increment of ESP with soil depth decreased the amount of OC (R^2 =0.62) in all the land uses. Eight soil pedons were studied under different land uses namely frass (*Tamarix articulata*), kainth (*Feronia limonia*), eucalyptus (*Eucalyptus tereticornis*), pasture, karonda (*Carrisa carandas*)-mustard, aonla (*Emblica officinalis*), bael (*Aegle sp*) and prosopis (*Prosopis alba*)-mustard growing at Bir Researve Forest Farm Hisar. Surface soil pHs was slight alkaline i.e. under anola (8.58) > karonda-mustard (8.32) > bael (8.17), while neutral under prosopis - mustard (7.87) > grassland (7.83) > frass (7.57) > kainth (7.63) > eucalyptus (7.46). Overall soil data suggested a good correlation between pHs and

Table 7: Depth wise (meter) salinity (EC_e dS m^{-1}) in soil pedon under saline land use systems in Bir-forest, Hisar

Horizon	Frass	Horizon	Kainth	Horizon	Eucalyptus	Horizon	Grassland
0-0.08	2.75	0-0.24	5.53	0-0.24	3.16	0-0.2	2.31
0.08-0.3	3.43	0.24-0.46	5.04	0.24-0.56	9.49	0.2-0.54	2.11
1.48-1.68	3.84	0.46-0.84	9.95	0.56-0.94	23.885	0.54-0.88	2.17
0.53-0.87	5.04	0.84-1.20	17.5	0.94-1.18	22.82	0.88-1.14	4.08
0.87-1.10	8.62	1.20-1.80	17.3	1.19-1.67	22.865	1.14-1.55	5.63
1.10-1.40	10.92					1.55-1.70	9.43
1.40-1.70	10.29						
Horizon	**Karonda Mustard**	**Horizon**	**Anola**	**Horizon**	**Bael**	**Horizon**	**Prosopis - Mustard**
0-0.3	4.20	0-0.08	3.75	0-0.24	6.42	0-0.17	4.20
0.30-0.68	6.68	0.08-0.35	3.52	0.24-0.46	9.05	0.17-0.37	7.67
0.68-1.03	9.81	0.35-0.69	6.43	0.46-0.83	11.95	0.37-0.55	8.78
1.03-1.32	11.52	0.69-0.96	7.00	0.83-1.12	11.62	0.55-1.00	10.72
1.32-1.48	12.11	0.96-1.26	5.65	1.12-1.36	9.50	1.00-1.35	9.91
1.48-1.68	10.98	1.26-1.49	5.64	1.36-1.69	4.10	1.00-1.58	7.66
		1.49-1.90	4.90				

Soil pedon under different land uses

pH_2 (R^2=0.61).

Higher salinity level (ECe > 4 dS m^{-1}) was noted in almost all soil pedons irrespective of soil depth and land-uses (Table 7). However, surface horizons in few pedons indicated a lower EC_e viz., grassland (2.31 dS m^{-1} for 0-0.2m); frass (2.75 and 3.43 dS m^{-1} for 0-0.08 and 0.08-0.3m); eucalyptus (3.75 dS m^{-1} for 0-0.24m) and anola (3.75 dS $m^{-1}$for 0-0.08m). Overall ECe was 4.5 times higher than EC_2 (R^2=0.85). Higher $CaCO_3$ content was observed in ~0.5 m soil layer than deeper depths in pedon from kainth (8.84-11.69%), eucalyptus (6.63-11.64%) and bael (6.91-16.34%) with exception of 6.03% in deep layer (1.4-1.7m) of pedon under frass and no concretion in pasture pedon. Oxidizable OC for all cases was lower than 0.5% except the 0.0-0.8m soil depth of pedon for Anola (0.88%). Surface soil horizon of frass and prosopis -mustard contained 0.43 and 0.47% of oxidizable OC, respectively. Increment of soil depth decreased OC.

Diversifying agriculture on reclaimed sodic land in farmer's participatory appraisal (Gajender, R.S. Pandey, R. Raju, A. K. Rai, K.S. Kadian and D.K. Sharma)

Nearly half of the total land area of Indo-Gangetic Plains of South Asia is devoted to agriculture and provides livelihood and employment to 1.8 billion people. Rapid population growth in this densely populated region is exerting pressure on small and fragmented farms. The region is characterized by lowest per capita availability of land, inequitable agrarian structure and resource poor farmers. Continuity of rice-wheat system in this region has raised serious concerns on deteriorating natural resources in the face of diminishing water supplies and degrading soils. Integration of various farm enterprises and farming system diversification may offer solutions to these problems. Concerns of livelihood security of these farmers with increased demand for food, especially under frequent occurrences of droughts and floods, heat and cold waves in the changing climatic scenario, are other compelling reasons for need of a paradigm shift in approach from single crop/enterprise based farming to diversified agriculture. Diversification is treated as a sustainable, strategy for generating regular income and employment, better recycling of farm wastes and mitigation of multiple sources of short term economic risk to agricultural enterprises. A diversified mix of agricultural enterprises like crop husbandry, horticulture, fodder, dairy, poultry, fishery etc. suited to given agro-climatic conditions and socioeconomic status of the farmers would bring prosperity to the farmers and such systems could lift small-scale and marginal farmers out of poverty. Keeping these insights in mind, this research project was started in kharif 2013. The data presented here are from January to December 2015.

The profitability of different crops, worked out on the basis of minimum support price of marketable produce for the year 2014-15, is presented in Table 8. The highest net income of Rs. 54890 ha^{-1} was recorded in rice–wheat cropping system with a B:C ratio of 2.29, followed by rice-wheat-moong (Rs. 47853) with a B:C ratio of 2.71. The lowest return (Rs. 15010 ha^{-1}) with second highest B:C ratio of 4.13 was recorded from horticulture production system. The net return from fodder production system was Rs. 18131 with a B:C ratio of 1.98.

Table 8: Income generated from multienterprise agriculture model during 2015 (Jan. to Dec. 2015)

Sl. No.	Components	Area (ha)	Gross Income (Rs.)	Total Cost (Rs.)	Net Income (Rs.)	B:C Ratio
1	Rice -Wheat -Moong	0.4	97425	42527	54890	2.29
2	Rice - Oats	0.2	70375	25931	44444	2.71
3	Maize -Wheat -Moong	0.4	78050	30197	47853	2.58
4	Horticulture	0.2	19800	4790	15010	4.13
5	Vegetables	0.2	46966	24574	22392	1.91
6	Fodder	0.4	36600	18469	18131	1.98
	Sub Total-1		349216	146488	202728	2.38
7	Subsidiary Components	0.2				
	Milk, Compost, Biogas		95508	141066	-45558	-0.68
	Fish Production		40000	8673	31327	4.61
	Fruits/Veg. (Pond Area)		46443	12325	34118	3.77
	Poultry		10000	3485	6515	2.87
	Sub Total-2		191951	165550	26401	1.16
	Total	2	541167	268217	272950	2.02

Among subsidiary components, fish production and horticulture based system plus fruit plants on pond dykes and understory vegetable crops generated income of Rs 31327 and Rs 34118 with B:C ratios of 4.61 and 3.77, respectively (Table 8) and proved highly beneficial to the farmers. Performance of dairy component was poor due to problems with dairy animals during latter half of year.

Soil fertility of different components was determined during 2015 and provided in Table 9. Soil organic carbon (OC %) in surface (0-15 cm) soil in maize-wheat, fodder and horticulture was 0.57, 0.58 and 0.60%, respectively. Available N, P and K in various components varied from 141.1 to 120.2 and 18.9 to 49 and 173.5 to 324 kg ha-1, respectively.

Observations revealed that diversification can be an efficient alternative to rice-wheat cropping system for small land holdings in terms of revenue generation, soil health and resource use in reclaimed sodic soils. Conservation and judicious use of farm resources in this system can help restore the ecosystem for sustainability. This system may help to gain small and marginal farmers confidence in agriculture by increasing productivity, profitability and sustainability.

Table 9 : Soil fertility in various production systems of diversified agriculture during 2015

Components	OC (%)		N (kg ha^{-1})		P (kg ha^{-1})		K (kg ha^{-1})	
	0-15 cm	15 -30 cm	0-15 cm	15 -30 cm	0-15 cm	15 -30 cm	0-15 cm	15 -30 cm
Rice - Wheat - Moong	0.35	0.18	138.51	130.67	36.376	29.18	188.1	194.1
Maize -Wheat - Moong	0.57	0.41	130.67	135.89	27.84	14.28	173.5	181.4
Rice -Oat	0.27	0.23	141.12	130.67	29.864	18.37	189.3	219.1
Fodder	0.58	0.38	133.28	146.35	20.848	13.27	214.3	233.3
Vegetable	0.23	0.21	135.89	125.44	49.072	39.91	324.0	398.2
Horticulture	0.60	0.35	128.05	109.76	39.816	23.15	253.1	267.2
Pond	0.35	0.28	120.21	86.24	18.92	19.93	294.8	304.9

MANAGEMENT OF WATERLOGGED/SALINE SOILS

Guidance in identification of problem areas and design and evaluation of subsurface drainage projects in Haryana

(S.K. Kamra, Satyendra Kumar, R.L. Meena, Bhaskar Narjary, Parveen Kumar, R. Raju, K. Thimmappa, D.K. Sharma)

Subsurface drainage (SSD) is a foremost CSSRI technology propagated extensively for amelioration of waterlogged saline irrigated lands in different states of India. Out of 9831 ha waterlogged saline area provided with SSD in Haryana till June 2015 over a period of 2 decades (Table 10), it has been implemented in about two third area (6700 ha) in the past 10 years.

In Haryana, 3 fleets of laser controlled trenchers and bucket excavators/backhoes type machines are used to install SSD in about 1,000 ha area per year depending upon breakdowns or unexpected rains during summer working months (mid April-end June). At current price levels, the cost of installation of SSD in Haryana is Rs. 70,000/ ha (excluding staff salaries), covering almost equally on drainage materials (PVC pipes, filter, manholes, sump well and accessories) and installation process. CSSRI provides technical and scientific guidance to the implementing agency, i.e Haryana Operational Pilot Project (HOPP) in selection of new SSD project sites, approval/ revision of proposed engineering designs (spacing, depth, slope and size of lateral and collector drainage pipes and synthetic filters) and layouts of SSD in new areas and monitoring and impact evaluation of the completed projects.

Selection of SSD project sites

During the period of June 2014 to December 2015, CSSRI team undertook visits to 23 new sites covering 5,650 ha area in 7 districts identified by HOPP for possible execution of SSD projects. Based on extent and severity of the problem, analysis of collected soil and water samples and interaction with farmers, CSSRI- HOPP team has recommended installation of SSD in 3,800 ha waterlogged saline area in 5 districts including 300 ha in Sirsa, 200 ha in Sonipat, 1,200 ha in Jhajjar, 600 ha in Fatehabad and 1,500 ha in Rohtak district. All sites were characterized by shallow groundwater table(< 2 m) and marginal to highly saline soil and groundwater. Further, almost at all sites, a main or link surface drain is available for discharge of drainage water and surface water supplies are reasonably good for crop production. At these sites, HOPP further conducts field surveys and investigations and propose detailed SSD designs for approval/ revision by CSSRI and final funding and execution

Approval of design and layout of SSD projects

During 2015- 2016, CSSRI approved designs (drain spacing, depth, slope and size of lateral and collectors) and layout plans, submitted by HOPP for 1,331 ha area in Banwasa, Kohla, Kathura and Katwada villages of Sonipat district after field

Table 10 : SSD projects implemented by HOPP in Haryana (June 2015 status)

S.N.	Project /Funding and period	Districts covered	Area (ha)
1.	Indo- Dutch (1999- 2002)	Gohana (Sonipat) and Kalayat I and II (Kaithal) No. of beneficiaries: 1597	2406
2.	Ministry of Rural Development (MORD), GOI (2003- 2009)	Jhajjar, Bhiwani, Sonipat, Sirsa No. of beneficiaries: 2852	3325
3.	RKVY (2009-2015, contd)	Fatehabad, Jhajjar, Palwal, Rohtak, Jind, Sonipat No. of beneficiaries: 2721	4100
	Total	**No. of beneficiaries:** 7170	**9831 ha**

Table 11 : Mean values of water table depth (WTD) and quality parameters of groundwater inpumped (P) and non- pumping (NP) blocks of Mokhra Kheri

Year	WTD (m)		EC (dS m^{-1})		pH	
	NP*	P*	NP	P	NP	P
2013	1.25	-	14.50	-	7.50	-
2014	1.09	1.23	8.83	1.98	7.75	7.57
2015	1.04	1.28	8.75	1.79	7.69	7.49

*NP – Non pumping blocks; P – Full or partial pumping blocks

investigations on soil and groundwater salinity, weather parameters, contour and socio- economic surveys.

Evaluation of existing SSD projects

During 2015- 2016, the impact of SSD systems was evaluated for Siwana Mal (Jind), Mokhra Kheri (Rohtak) and Garhwal (Sonipat) project sites. As discussed in earlier reports, inadequate progress on the construction of pump houses, formation of farmers' drainage societies and distribution of pump sets has resulted in only marginal improvements in crop yields and economic returns in a number of blocks at each site. Again notable improvements in soil and groundwater salinity and crop yields were observed in blocks where pumping was done by efforts of HOPP or individual farmers.

For partial or full pumping in 4 blocks (B4,B7, B9 and B10) at Mokhra kheri resulted in notable reduction in soil salinity throughout 0- 90 cm soil profile and mean values of groundwater salinity monitored twice during summer months (Table 11) in comparison to non- pumping blocks (B1, B2, B3, B5, B6). This occurred despite consistent occurrence of shallow groundwater conditions in all blocks due to irregular pumping.

The improvement in soil salinity in 38 ha area of block B4 at Siwanamal site, where adequate pumping in being done by a farmer, is presented in Table 12. EM38 salinity survey results (contours) conducted during May 2012 (before) and May 2015 (after) installation of SSD and correlated with salinity analysis of collected soil samples were utilized to evaluate the impact of SSD on salinity distribution in 60 cm soil profiles. It can be seen that 98.7 and 97.1% area having more than 4 dS m^{-1} salinity in 0- 15 cm and 0- 30 cm layer during 2012 reduced respectively to 79.5 and 82.4 % area during 2015 due to SSD activities. Similarly the area having more than 8 dS m^{-1} salinity in 0- 60 cm zone reduced from 58.8 to 35.3% during the same period.

Based on field observations on evaluation of SSD projects in Haryana, it can be clearly stated that despite timely installation of subsurface drains utilizing about 90 % of project cost, deficient/poor arrangement of the required pumping facilities and operation by farmers are rendering these projects at below par performance and socio-economic impact.

Table 12 : Improvement in percent area under different soil salinity levels in Block-4 (38 ha area) at Siwanamal SSD site

Depth	Year	EC_e <4 dS m^{-1}	EC_e 4-8 dS m^{-1}	EC_e 8-16 dS m^{-1}	EC_e >16 dS m^{-1}
		Area %	Area %	Area %	Area %
0-15 cm	2012	01.3	21.8	66.2	10.7
	2015	20.5	54.3	23.2	2.0
0-30 cm	2012	02.9	25.4	63.9	7.7
	2015	17.6	37.2	35.6	9.6
0-60 cm	2012	06.6	34.6	56.4	2.4
	2015	18.7	46.0	30.0	5.3

Efficient groundwater management for enhancing adaptive capacity to climate change in sugarcane based farming system in Muzaffarnagar district

(S.K. Kamra, Satyendra Kumar, Aslam Latif Pathan and D.K. Sharma)

This research project relates to the evaluation of technological interventions on a pilot basis for sustainable use of groundwater for enhancing adaptive capacity to climate change. Of different interventions proposed under this objective, design and construction of groundwater recharging techniques have been entrusted to CSSRI.

The lithology of over-exploited blocks of Muzaffarnagar district, viz; Budhana, Baghara and Shahpur is characterized by the presence of a

Table 13 : Selected locations for installing recharge structures in different blocks of Muzaffarnagar district

Sl. No.	Village	Blocks	Longitude/ latitude	Recharge structure
1	RasoolpurJatan	Shahpur	N 29.364728°	Village pond and recharge cavity
2	Harsaulli Drain	Shahpur	N 29.364735° E 77.579704°	Check dam in drain and recharge cavity
3	Nirmana	Baghra	29º23’07.6’’N	Village pond and recharge cavity
4	Kutba	Baghra	N 29.39984° E 077.54208°	Canal distributary, village pond and recharge cavity

Table 14: Design features and features of a recharge cavity

S. N.	Items	Volume of work
1.	Machine drilling (Boki) for bore hole (10") and fitting of 9” PVC pipe of 10 kg/cm^2 pressure and ISI mark for recharge cavity at 20 – 40 m	60– 120 ft depth* at different locations
2.	Cavity development charges per location	Per location
3.	Construction of recharge chamber (inner size 1.5 m x1.5 m x 2.1 m) i) Earth work in excavation at location near pond/ drain around installed bore hole, size 3.3 m x 3.3 m x 3.8 m for construction of recharge chamber. ii) Brick work of specified class for construction of recharge chamber, size 3 m x 3 m x 3.5 m iii) Refilling with excavated earth in trench around pipe iv) First class cementing of recharge chamber at the bottom, inside walls and exposed portion on outside	Per location
4.	i) Joining of 9" PVC well pipe through socket with 12" PVC pipe of 10 kg/ cm2 pressure (leaving 1m blind from bottom of recharge chamber, perforated and wrapped with synthetic filter from 1.0-2.2 m from bottom. Also fitting another 0.3 m long 12" PVC inlet pipe with a synthetic filter in portion above the perforated area ii) Fitting of inlet pipe of 9" and 3- 10 m length through walls of pond/ drain and recharge chamber, wrapped with synthetic filter around 1 m perforated portion at the end in the submerged portion of pond or drain water	Per location
5.	**Accessories complete** i.e. Tee, Cross, Socket, End Plug, bail plug, Slotting charges & Synthetic filter etc	Per location

* Actual depth will depend on availability of required conditions of first cavity below water table (thick clay layer above sufficient depth of coarse sand)

top clay layer, underlain by a more porous and thicker granular zone in most of the area. The top clay layer hinders downward flow of water from the surface water bodies, compounded further by reduction in number of rainy days due to climate change. Under such conditions, pilot studies on subsurface groundwater recharge structures (recharge shaft and recharge cavities) have been proposed in conjunction with check dams to be installed in surface drains or at locations close to farm/village for augmenting groundwater at selected locations in Muzaffarnagar district of UP Table 13.

Based on intensive field surveys 4 locations have been shortlisted in the project area for installation of recharge cavity type groundwater recharge structures. Out of 4 sites, two are adjoining to village ponds (village Nirmana and Rasoolpur Jatan), one is close to Harsouli drain in village Shahpur where Dehradun institute has constructed a check dam to retain flood water during rainy season and one close to a farm pond receiving excess water from adjoining canal distributary (village Kutba) during rainy season. The excess water from ponds and surface drains will be recharged through a recharge cavity constructed close by in a filter chamber.

The specifications and design of a typical groundwater recharge cavity to be installed at selected locations is presented in Table 14. It is constructed by drilling a bore hole until a sandy layer (> 10 m) is found below a clay layer. A high pressure (10 Kg/ m^2) blind PVC pipe of 9 " (22.5 cm) is drilled into the clay layer and sand is pumped out until a stable semi- spherical cavity is developed below the clay layer. A recharge cavity can also be used for occasional pumping with a 7.5-10 HP submersible motors which automatically also cleans the clogging sediments deposited over the sand surface of the cavity. Water samples have been periodically collected and analyzed to monitor the quality of pond water to be recharged through recharge cavity.

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)

The water tables in fresh groundwater regions of north-western states India, particularly in Haryana and Punjab, are falling at an annual rate of 25-70 cm over the past 2-3 decades. There is growing evidence that climate is changing. The increase in mean maximum and minimum temperature has been projected which may influence crop water demand. Further, more intense rain is expected in coming future that will affect the aquifer recharge. Hence, the sustainable management of available fresh groundwater zone is threatened by climate change. There is a great need of studying possible change in local climate and its impact on crop water requirement and groundwater resources. Keeping these facts in mind, the future climate data for Karnal was derived from GCM projection and its impact on crop water requirement was worked out. The role of innovative agronomic interventions for reducing ground water withdrawal in Haryana was also studied.

Climate change projection of coupled model inter-comparison project 5 (CMIP5) was derived for Karnal region using Hybrid-Delta (HD) ensemble method. Daily temperature and precipitation were derived for historical (1981-2010, base period) and future time periods of 2040-2069 (2050s, mid century), 2070-2099 (2080s, end century). To quantify change in future climate under representative concentration pathway (RCP) 4.5, monthly projected maximum (Tmax) and minimum (Tmin) temperature and precipitation of mid and end of century and base period are presented in Fig 9. The monthly data for base period (1981-2010) and future time periods of 2040-2069 (2050s, mid century), 2070-2099 (2080s, end century) are average monthly data of 30 years. The change in mean annual temperature (T_{max}), (T_{min}) and precipitation of Karnal is projected to be 1.2-2.3 ^{0}C, 1.4-2.5 ^{0}C and 80=117mm, respectively, in mid and end century under RCP 4.5. However, the maximum change in monthly maximum and minimum temperature was found in the period of January to May.

In order to assess the impact of climate change on crop water demand, projected daily Tmax, Tmin and precipitation of RCP 4.5 were used as input data in CROPWAT computer program and future crop water requirement was estimated. The model was run with different date of transplanting of rice to find out the appropriate time for transplanting to utilize maximum precipitation and require minimum groundwater for irrigation. Data on

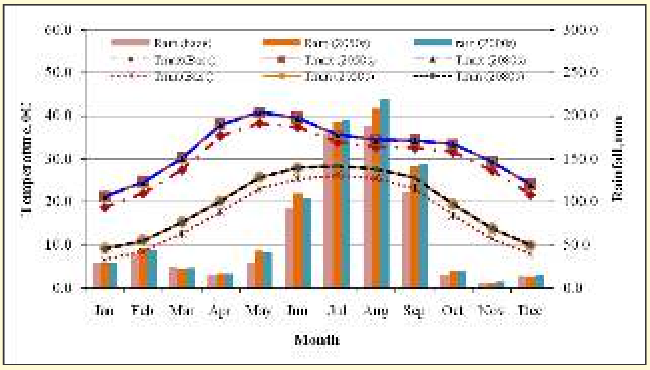


Fig. 9: Projected mean monthly minimum (T_{min}) and maximum (T_{max}) temperature and precipitation of Karnal

estimated crop evapotranspiration, effective rainfall and irrigation requirement are given in (Table 15) show that shifting of date of transplanting of rice from 15th June onward to 5th July would help in reducing irrigation demand by 70-75 mm and subsequently groundwater draft in the future.

Trial on direct seeded rice (DSR) was conducted with the aim to maximize on farm rain water utilization and reduce groundwater withdrawal for irrigation. The DSR was adopted under two agro-techniques i.e. tilled and zero tilled condition. In zero-tilled plots, no tillage operation was conducted for the last 5 years. In zero-tilled agro-technique, mulch with wheat straw as soil cover as well as without mulch treatments were adopted. The basmati rice var. CSR 30 was taken for the study. Irrigation was scheduled on the basis of soil moisture suction. These DSR treatments were compared with improved method of irrigation of transplanted rice i.e. subsequent irrigation was applied after 2 days of disappearance of water from the surface. The plant growth, irrigation water requirement and yield were considered for comparing the different treatments. Visual view of crop revealed healthy growth of plants in all treatments. However, measured leaf area index (LAI) of rice showed that initially. LAI in transplanted rice was lower than DSR was treatments. It was probably due to the fact that DSR sown 15 days earlier than transplanted rice. Transplanted plants might have felt stress during establishment phase and attained a healthy LAI value of 4.72 at the peak. The highest LAI was recorded in tilled condition when water was applied at 15 kPa throughout the crop growing season. It might be due to higher density of plants. In DSR, plant to plant spacing was 7-8 cm instead of 15 cm of transplanted rice. Hence, two seedlings of DSR resulted in slightly higher number of tillers/unit area and subsequently LAI also as compared to transplanted rice shifting from nursery to the field. But, once seedling got established, they grew at faster rate.

Irrigation water applied, yield and irrigation water productivity of rice under different agro-techniques are given in Table 16. It is clear that transplanted rice required the highest irrigation (198.1 cm) amongst all treatments and produced maximum yield too. The yield level recorded under tilled condition with 15 kPa irrigation schedule was found to be statistically at par with the transplanted rice. The irrigation water productivity was highest (0.21 kg/m^3) when

Table 15: Crop evapotranspiration (ET_c), effective rainfall (ER) and irrigation requirement (IR) of transplanted rice as affected by date of transplanting under changing climatic scenario (RCP 4.5)

Period	Date of transplanting								
	15-Jun			25-Jun			05-Jul		
	ET_c (mm)	ER (mm)	IR (mm)	ET_c (mm)	ER (mm)	IR (mm)	ET_c (mm)	ER (mm)	IR (mm)
Base	591.7	516.4	800.4	560.8	420.3	840.2	559.4	461.6	797.3
2020	590.1	526.4	800.6	567.3	498.2	770.3	558.6	507.3	726.9
2050	599.7	537.1	800.8	577	542.2	700.5	568.3	517.6	727.1
2080	600.4	570.6	800.8	577.1	495.0	770.6	568.1	518.4	727.2

View of rice crop under different treatments

Table 16 : Irrigation, water saving, yield and irrigation water productivity of rice under different treatments

Treatment	Irrigation Water applied (cm)	% irrigation water saving	Yield (t ha^{-1})	Irrigation water productivity (kg/m^3)
Transplanted rice	198.1	-	3.44^{A}	0.17
15-15-15-15 kPa (NT)	166.8	15.8	2.98^{B}	0.18
15-15-15-15 kPa (NT+M)	147.3	25.6	3.04^{B}	0.21
15-15-15-15 kPa (T)	174.5	11.9	3.19^{AB}	0.18

- NT- No till, T- till; Values with same letter indicate statistically non-significant differences with DMRT

irrigation was given at 15 kPa soil moisture and soil was covered with wheat residue. It was due to application of less water for irrigation under soil cover.

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)

Waterlogging and poor water quality are serious environmental problems adversely affecting the crop yield, soil health and socio-economic conditions of the farmers. Monitoring the water table fluctuation and water quality both spatially and temporarily is important to assess adverse effect of water logging and salinity on crop production and environmental degradation.

Spatial and temporal behavior of groundwater level and salinity in the waterlogged saline area (Nain Farm, Panipat) was studied using geostatistical approaches. The variograms and krigged spatial maps were generated for pre and post-monsoon seasons of 2013 and 2015. It was observed that in temporal scale, there was no significant change in groundwater level. In the summer season, mean groundwater table existed 3.3-3.4 m below the ground surface (2013 and 2015). A constant rise in water table was recorded in all observation wells during monsoon months and raises the groundwater table 1-1.5 meter below the surface (Fig. 10). Overall, there was a reduction in groundwater salinity 2.2-2.4 dS m^{-1} in summer and post-monsoon seasons (Fig. 11). Seepage from water bodies (pond) had dilution effect and floating layer of good quality water was present in nearby area. Near the pond area reduction of salinity ranged between 6.5-7.5 dS m^{-1} in post monsoon and summer season respectively, as compared to initial salinity level 12-13 dS m^{-1} in 2013.

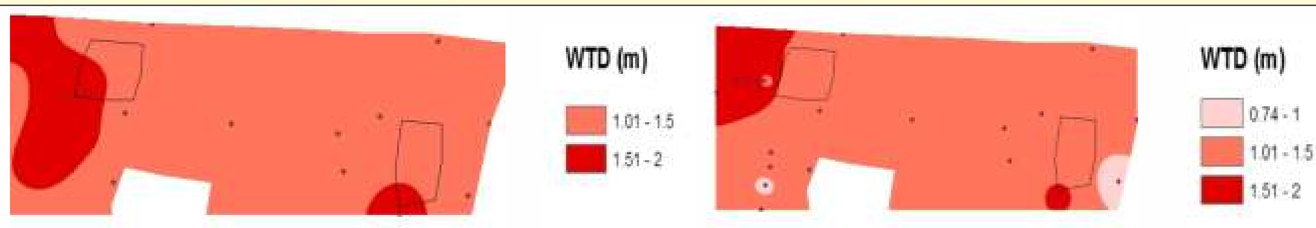
Cost-effective, rapid, easy and less labour intensive electromagnetic induction based geophysical method using EM-38 instrument was used for characterizing and quantifying soil salinity at Nain farm. Dominant cations and

Table 17 : Correlation analysis of apparent soil conductivity (EM-38) and soil salinity variables for average soil (0-90 cm) profile

Pri/Sec Soil Variable	Prd EC_a Corr	Obs EC_a Corr	Correlation among soil properties									
				EC_e	SP	MC	BD	SAR	Na	Cl	Ca+ Mg	CO_3 +H CO_3
EC_e	0.815*	0.827	EC_e	1								
SP	0.164	-0.001	SP	0.161	1							
MC	-0.002	-0.235	GWC	- 0.044	0.287	1						
BD	-0.164	0.001	BD	- 0.161	-1	-0.287	1					
SAR	0.596*	0.548	SAR	0.721*	0.299	0.054	-0.299	1				
Na	0.793*	0.774	Na	0.968*	0.285	0.002	-0.285	0.793*	1			
Cl	0.716*	0.735	Cl	0.874*	0.196	-0.027	-0.196	0.46	0.798*	1		
Ca+Mg	0.338	0.378	Ca+Mg	0.424	-0.106	-0.033	0.106	-0.172	0.264	0.691	1	
CO_3+ HCO_3	-0.269	-0.344	CO_3+ HCO_3	- 0.337	0.028	0.206	-0.028	-0.012	-0.267	- 0.520	-0.51	1

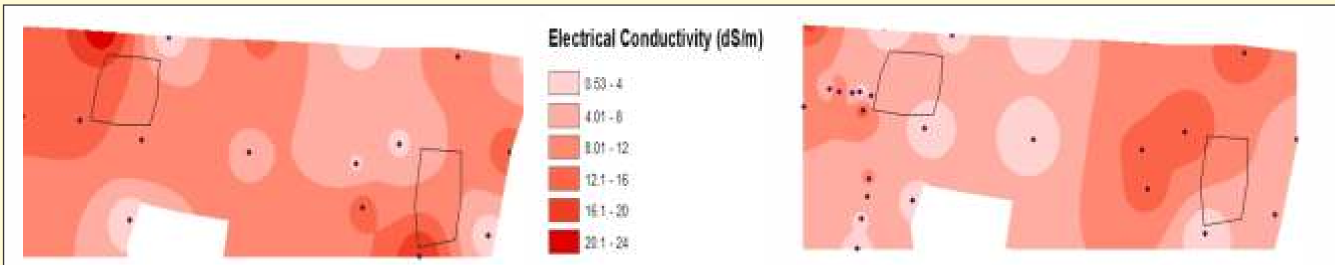
* Significant at $p< 0.05$

anions responsible for soil salinity were identified using correlation analysis and it was observed that Na^+ and Cl^- ions were mainly responsible for salinity and sodicity (Table 17). By using MLR model employed in electrical conductivity sampling assessment and prediction (ESAP) software, salinity, sodicity (SAR), dominant cation's (Na^{+1}) and anion's (Cl^{-1}) were predicted



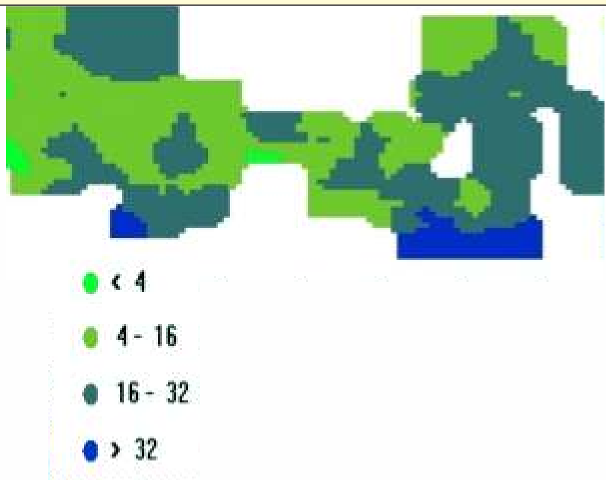
Water table depth in Nov, 2013 Water table depth in Nov, 2015

Fig. 10 : Spatio-temporal change in ground water depth in post monsoon season

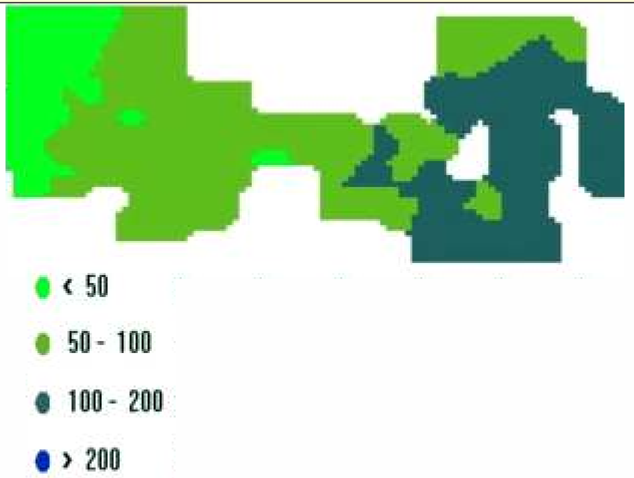


Groundwater salinity in July, 2013 Groundwater salinity in July, 2013

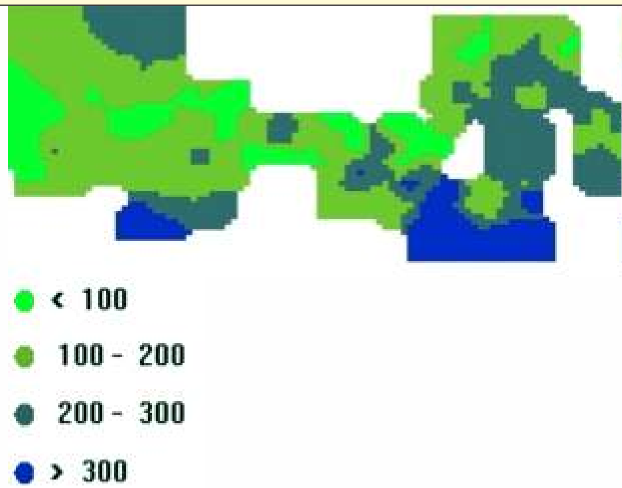
Fig. 11: Spatio-temporal changes in ground water salinity in summer season



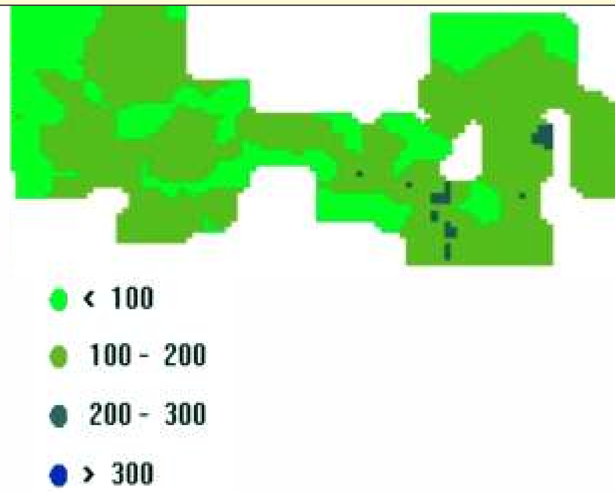
a : Bulk average (0-90 cm) soil salinity (EC_e) map of Nain farm



b : Bulk average (0-90 cm) soil sodicity (SAR) map of Nain farm



c : Bulk average (0-90 cm) Na^{+1} map of Nain farm



d : Bulk average (0-90 cm) CI^{-1} map of Nain farm

Fig. 12: (a-d). Spatial distribution soil salinity, SAR, Dominant cation (Na^{+1}) and Anion (Cl^{-1}) at Nain Farm

and compared with the conventional wet chemistry methods. Analysis of results indicated that apparent electrical conductivity (EC_a) based MLR model strongly predicts soil salinity at all depths. However, in case of SAR, observed and predicted SAR values were strongly correlated only for upper soil layer of 0-15 cm. Quantitative evaluation of the field revealed that about 90% of the field area was affected by salinity (EC_e> 4 dSm^{-1}) (Fig.). Due to the presence of higher Na^{+1} areas of greater sodicity (SAR) coincided with the areas of higher salinity (EC_e). Presence of shallow and saline ground water table salts might have moved upward through capillarise and accumulated in the root zone during the dry season and resulted in high salinity and sodicity.

Performance evaluation of subsurface drainage systems in Haryana and to implement interventions for improving operational performance and impact (D.S. Bundela, Bhaskar Narjary, Aslam Latif Pathan, R. Raju, Parvender Sheoran, R.K Singh, S.K. Kamra and D.K. Sharma)

Seven sites of subsurface drainage (SSD) systems out of 13 sites installed in Haryana were identified

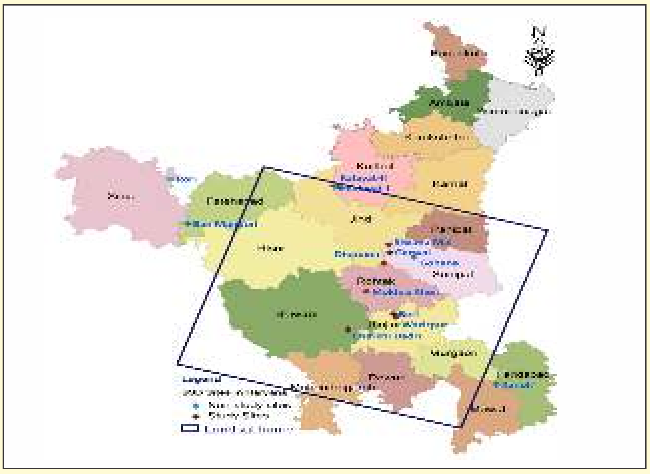


Fig. 13 : Location map of seven selected sites of SSD systems in Haryana under study

from a single scene Landsat imagery frame, field survey and farmers' feedback. The developmental history, drainage network layout and implementation period of the seven selected SSD sites viz. Beri and Wazirpur in Jhajjar district, Charkhi Dadri in Bhiwani, Dhanana and Garwal in Sonipat, Mokhra Kheri in Rohtak, and Siwana Mal in Jind district (Fig. 13) covering a total area of 6,700 ha and 4,400 beneficiaries were collected from HOPP and other project authorities. The conditions of sump, pump set, pump house, and link drain of each SSD block were surveyed and assessed and the feedback from farmers/beneficiaries on low/non-pumping of SSD systems and drainage societies were analyzed. It was found that on an average, 3-4 blocks of SSD project were operational in the post project period due to major efforts of farmers.

The performance of these SSD projects was assessed and it was found that in three older sites (Beri, Charkhi Dadri, and Dhanana), 100% farmers societies at drainage block level were formed at the time of implementation, which were not functional during the post project period; 85% pump houses were constructed and 57% pump sets were installed/operational whereas in four newer sites, 86% drainage societies were formed, 26% pump houses were constructed and 25% pump sets were installed. The conditions of all pump sets and pump houses were dilapidated except where some farmers have maintained/ installed their own electric pump sets such as in Dhanana and other project sites. Part of SSD site was monitored for reduction/build-up of soil salinity status using multi-date Landsat ETM+ and OLI imageries for 10 years (2007 to 2016) including pre and post project periods for assessing temporal operational performance. It showed that in pre-project period (before 2009), large patches of soil salinity and water logging could be seen on satellite imageries (12 Feb 2007). After installation of the SSD project during 2009-10, the large patches of salinity were reduced to smaller patches as visible on 4 April 2011 satellite imagery (Fig. 14). These patches of soil salinity disappeared completely from satellite imagery on 28 May 2014 & 22 Feb 2016) due to individual farmer's effort on water pumping at their own expenses in order to get the benefits from SSD system. Out of seven sites, three sites viz. Dhanana (Sonipat), Mokhra Kheri (Rohtak) and Siwana Mal (Jind) were further selected for intensive studies and interventions including solar pump set for improving operational performance and impact.

Australia-India Council collaborative project on salinity and sodicity mapping in 3D-seeing is believing (D.S. Bundela, D.K. Sharma, Bhaskar Narjary and Aslam Latif Pathan)

Fig. 14 : Monitoring of soil salinity at Jagsi (Dhanana) using Landsat data (2007-14) during pre and post project period

Manual and cart surveys with DUALEM-21 and GPS instruments at three sites

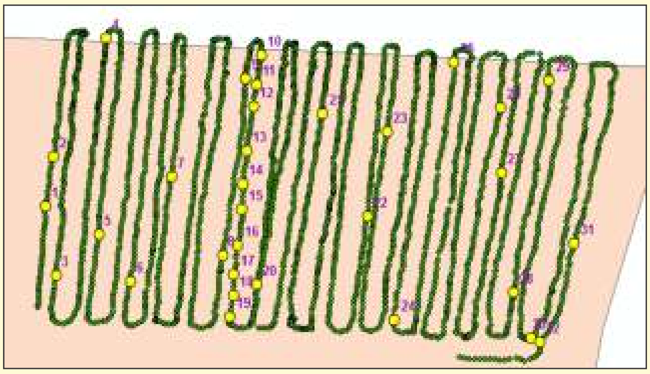


Fig. 15 : Transect map of Nain Field with location of 32 soil sampling points

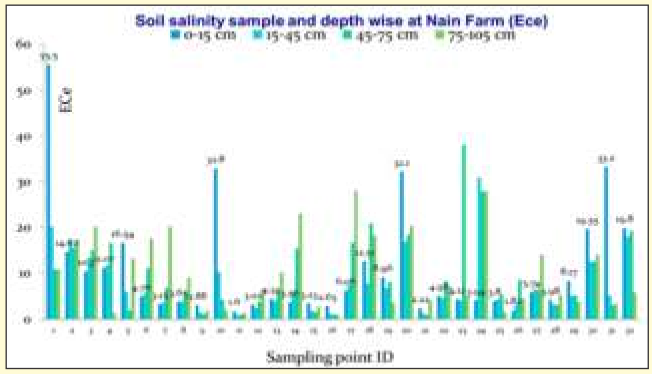


Fig. 16 : Variation of soil salinity (ECe) at four depths at 32 sampling points at Nain field

The aim of this project was to assess and map salinity and sodicity in 3D using the state-of-the-art electromagnetic based geophysical technology. The EM (electromagnetic) data of three Indian sites (Nain in Panipat district and Mokhra Kheri in Rohtak district in Haryana, and Shivari in Lucknow district of UP) were collected by deploying the dual geometry array DUALEM-21 device. Manual survey with DUALEM-21 and NovAtel GPS instruments were carried out for EM data recording where crop (mustard/wheat) was standing at Nain field and Shivari field. The DUALEM-21 with GPS set mounted on a sled or cart was pulled by car in Mokhra Kheri field for EM data recording. The different kinds of transects for each survey were adopted. For the Nain field, the total distance in the transect was 1.92 km during the survey. For model calibration and validation, a total of 128 samples from 32 sampling points with four depths (0-15, 15-45, 45-75 and 75-105 cm) were collected from Nain field (Fig. 15). Similarly, a total of 96 soil samples were collected from 24 sampling points with four depths from Mokhra Kheri field and a total of 76 soil samples were collected from 38 sampling points with two depths (0-15 and 15-45 cm) at Shivari field. Soil samples of Nain field were analyzed for salinity for all depths. Twelve soil samples (37.5%) had EC_e less than 4.0 as m^{-1} for 0-15 cm depth whereas 20 samples (62.5%) had EC_e from 4.12 to 55.5 dS m^{-1} (Fig. 16).

The DUALEM-21 operates at a low frequency (9 kHz) and consists of two pairs of horizontal co-planar (HCP) and perpendicular (PRP) receiver arrays. The transmitter is located at one end and is shared by all receiver arrays with the distance between the transmitter to the centre of the HCP, being 1 and 2 m. The depth of EC_a resolved was 0-1.5 m (1 m PCon), 0-3.0 m (2m PCon), 0-0.5 m (1m HCon) and 0-1.0m (2m HCon), respectively. The DUALEM-21 survey involved carrying instrument at a height of 0.30 m by manually or mounted on a sled with a NovAtel SMART- V1 GPS receiver and GeoSCOUT datalogger (GLS-400) was used for georeferenced EM data recording. The data were collected in January 2016. Four 2D EM conductivity images (EMCI) for 1 and 2 m PCon and HCon, respectively (Fig. 17) were generated using EM4Soil software. The EM images were inverted using EM4Soil software and were compared 2-D model of true electrical conductivity with depth against the measured EC_e (dS m^{-1}) at four depths. The EM4Soil software (Q3D module) uses a non-linear regression model and by varying forward modelling algorithms

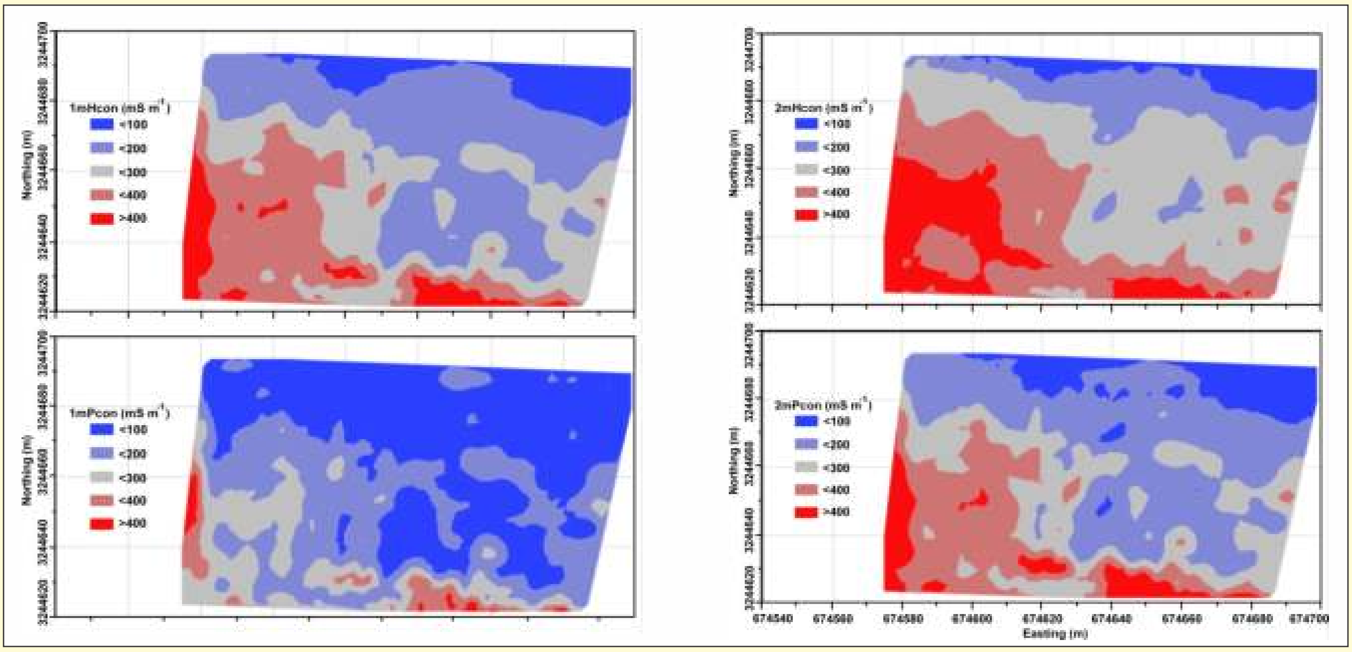


Fig. 17 : EM conductivity images (EMCI) of 1 and 2 m PCon and HCon for Nain Field

(cumulative function and full solution) to define the initial inversion algorithm and its parameters. Three inversion algorithms viz. S_1, S_2 and S_3 were attempted with different combinations of dampness factor and cumulative function (CF) parameters. The optimal results for a suitable EMCI image of Nain field were produced with algorithm S_2, dampness factor of 0.07 and CF parameters. The 2D predicted salinity maps of Nain field were then generated for four depths. These inverted EC_e values were correlated with field observed values of Nain site. It was found that R^2 was 0.78 which is quite acceptable for salinity mapping. The uncertainty analysis was also carried out to evaluate uncertainty of the inversion process. The best results of inverted salinity of Nain field were used and generated 3D cube with seven profile layers which can be displayed as 3-D cube or horizontal or vertical slices of 3-D salinity images.

ICAR Extramural Project entitled 'Spatio-temporal monitoring of secondary salinization in the Indira Gandhi Canal Command using geoinformatics

(D.S. Bundela, Bhaskar Narjary, R.L. Meena, A.K. Mandal, Madhurama Sethi and D.K. Sharma)

In order to assess and monitor the secondary salinization in space and time in the Indira Gandhi Nahar Pariyojana (IGNP), two study sites- Naurangdesar distributary in Hanumangarh district and Dattor distributary in Bikaner district in Stage-I and Stage-II, respectively, were selected. The IGNP, one of the largest irrigation project in arid region, has two stages in which the stage-I consists of 189 km long main canal between Masitawali head (RD 0) and Sattasar head (RD 620) with 3454 km long distribution system which irrigates 5.53 lakh hectares in Hanumangarh, Sriganganagar and Bikaner districts through Naurangdesar, Rawatsar, Suratgarh Anupgarh and Pugal distributaries. The stage-II consists of 231 km long main canal between Sattasar head (RD 620) and Sri Mohangarh head (RD 1458) with 5606 km long distribution system which irrigates 14.10 lakh ha in Bikaner, Jodhpur, Jaisalmer, Barmer, and Churu districts through Dattor, Birsalpur, Charanwala, Saheed Birbal, Sagarmal Gopa & Gadra road distributaries.

The site-1 (Naurangdesar distributary command in stage-I) has flat land suffering from seasonal waterlogging and high soil salinity problems as well as moderate crop yields whereas the site-2 (Dattor distributary command in stage-II) has undulating land that has suffered from low soil salinity, scarce and unreliable canal supply and, low crop yield. The outlet water allowance for gravity irrigation at the site-1 is 0.24 l s^{-1} ha^{-1} (3.50 cusecs/1000 acres) with 100% irrigation intensity (63% Rabi and 37% Kharif). In IGNP command, all canals were divided into three groups and six sub groups to run with full supply or remain closed with available water supplies from the Harike barrage. All the watercourses were lined and land holdings in the chak irrigated with a turn out. The canal water was supplied to distributaries after two week interval group rotation supply and warabandi system is used to deliver water to farms for a cycle of 7 days. Five crops in the study site-1 viz., wheat, mustard, chickpea, cotton and clusterbean were grown from mainly canal water with improved border irrigation. Five cropping systems viz., wheat-cotton, wheat-cluster bean, mustard-cotton, chickpea-cluster bean, and mustard-cluster bean are intensively practised.

The outlet water allowance for gravity irrigation at the study site-2 is 0.21 l s^{-1} ha^{-1} (3.0 cusecs/1000 acres) with 80% irrigation intensity (45% Rabi and 35% Kharif). Since the canal supply was low and unreliable, canal water was delivered in diggies (surface water storage/bank) of size (2,900 m^3) at farmers' fields to mitigate scarce and unreliable canal supply. Five crops (wheat, mustard, chickpea, groundnut and cluster bean) were grown in undulating inter-dunal plains irrigated through sprinkler irrigation system. Five cropping systems viz., wheat-groundnut, wheat-clusterbean chickpea-cluster bean, mustard-groundnut and mustard-cluster bean were adopted with sprinkler irrigation. Twelve scenes of Landsat-8 OLI & TIRS data (Nov, Feb , Mar and May of 2009-10 and 2015-16) were downloaded and were processed using multiscaling approach with multi-temporal multispectral Landsat data for locating hot spots of secondary salinization in Stage-I and II. The hot spots of soil salinity in the Stage-I and II were located using image enhancement and Gaussian classification. The ground verification of the hot spots is being carried out.

Impact of secondary salinization and other stressors on agricultural systems: constraint analysis in South-Western Punjab (Ranjay K. Singh, Satyender Kumar, Anshuman Singh, Nirmalendu Basak , Randhir Singh and D.K. Sharma)

Secondary salinization has emerged as a severe threat to agricultural production and farmers' livelihoods in many parts of south-western Punjab, India. Development of large tracts of waterlogged saline lands, climate variability and socio-economic changes have posed formidable constraint, to the livelihoods of majority of the farmers dependent on wheat, cotton and kinnow crops. In order to understand the impact of these stressors on agricultural systems of this region, a study has been started in selected five villages of Fazilka district of Punjab. Two developmental blocks (Abohar and Baluana) affected by secondary salinization were purposively selected for this study. Out of two blocks, a total of 5 villages were selected randomly. From each village, 5 farmers and thus a total of 25 farmers were randomly sampled for recording the observations. The villages were sampled in a manner that they were located near the canals with agricultural lands lying 0.5-2.0 km away from canal. Data pertaining to this study were collected using transect walk, key informant interviews, focus group discussion (FGD), event ecology, trend analysis and sampling of soil and water from different agricultural production systems. Soil and water samples were analyzed in laboratory to obtain salinity and pH status of the soil. Besides soil and water indicators, data relating to socioeconomic, institutional and policy constraints were also recorded of the sampled farmers. 85.0% of the sampled from farmers were small and marginal landholders having poor adaptive capacity to cope-up with salinity and waterlogging hazards. Three major cropping systems in the study area are kinnow (wheat/berseem as intercrops during initial few years), rice-wheat and cotton-wheat. Rising watertables (Dhani-Latkan- 5.0-6.0 feet below the surface; Alamgarh- 2.0-4.0 feet; Saidawali- 0-7.0

Transect walk in a salinity affected kinnow orchard in Dhani-Latkan village feet Bhawalwasi-1.0-1.5 feet and Kera Kheda- 3.0-4.0 feet, (Fig. 18) have gradually become a severe stressor and are threatening traditional kinnow orchards in the area. The drains made for draining salty water are against the slope, and thus do not permit seepage of salty water as reveled by over 90.0% of the farmers. The rising watertables have also adversely affected the cotton-wheat system. The salinity problem which started around 1986 from Datta-Kheda area, is now affecting extensive tracts of productive agricultural lands in the region.

In some of the villages, high salinity in groundwater (3.37 to 9.67 dS m^{-1}) and shallow water tables (~2 feet below surface) have wrecked havoc to kinnow orchards prompting over 60% of the farmers to replace kinnow plantations with rice and wheat crops. A strong majority of the farmers (89.75%) ranked salinity as the major stressor followed by diseases and climate variability leading to kinnow decline, severe losses in crop biodiversity and yield. Mostly, the soils were found to be saline-sodic nature (mean pH ranging from 8.02-10.12 and mean EC_2 from 0.28-2.68; Table 18). Shallow watertables and salt accumulation in soils are also responsible for the heavy yield losses in rice and wheat crops (Fig. 4). Due to relentless secondary salinization, cotton area has decreased by 40-60% as reported by the farmers. Results indicated that 30-40% small and

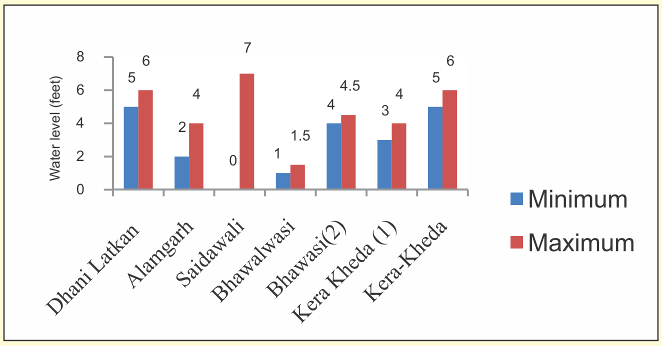


Fig. 18. Water table of studied villages

Table 18 : Soil pH and EC patterns in different production systems of studied villages

Villages	System	Soil pH range	Soil EC_2 range	Soil pH		Soil EC_2	
				Mean	SD	Mean	SD
Dhani Latkan (site-1)	Kinnow (declining)	8.17-8.65	0.21-0.38	8.49	0.20	0.28	0.06
	Kinnow based (healthy)	8.17-8.69	0.52-1.0	8.41	0.21	0.78	0.18
	Cotton-wheat	8.47-8.81	0.58-2.55	8.59	0.16	1.39	0.79
Site-2	Kinnow based (declining)	8.54-8.95	0.23-1.53	8.72	0.15	0.98	0.55
	Kinnow based (healthy)	7.88-8.70	0.30-1.58	8.58	0.20	1.29	0.39
	Kinnow based (declining)	8.31-8.87	0.74-1.07	8.60	0.21	0.95	0.13
	Rice-wheat	8.95-9.43	1.05-2.53	9.16	0.18	1.68	0.55
Site-3	Rice-wheat	7.96-9.19	0.55-1.70	8.82	0.48	0.80	0.44
	Cotton-wheat	8.31-9.00	0.91-2.52	8.68	030	1.91	0.51
Saidawali	Rice-wheat	8.13-9.03	0.48-1.43	8.61	0.37	0.72	0.35
	Kinnow-1	8.13-8.87	0.49-1.36	8.36	0.23	0.94	0.32
	Kinnow-1	8.15-8.78	0.50-1.86	8.41	0.20	1.05	0.54
	Cotton-wheat-1	8.25-8.72	0.40-3.20	8.51	0.18	1.51	0.99
	Cotton-wheat-2	8.53-9.75	1.66-3.00	8.97	0.59	2.27	0.56
Bhawalwasi	Barren land	8.98-9.90	1.14-5.09	9.51	0.40	2.68	1.86
	Kinnow (declining)	7.80-8.22	0.45-2.92	8.02	0.16	1.65	0.98
	Rice-wheat	9.99-10.28	2.10-3.24	10.12	0.12	2.63	0.51
Bhawalwasi	Cotton-wheat	8.83-8.55	0.72-1.77	8.44	0.09	1.16	0.45
Kera-Kheda	Kinnow (declining)	7.78-8.29	0.34-5.44	8.08	0.20	1.58	2.14
	Cotton-wheat	7.82-8.30	2.18-3.60	8.07	0.18	2.93	0.55

marginal farmers are facing severe problems due to secondary salinization and some of their most productive lands have turned into barren patches.

Such farmers are increasingly becoming beneficiaries of social security schemes such as MAGNREGA and PDS for livelihoods and enhanced adaptive capacity to cope up with an array of stressors. Those having joint family system (28.5%) have migrated to cities for regular earnings to minimize the livelihood risks.

Majority of the farmers experienced climate variability as another major stressor after high salt concentrations. They perceived that climate has changed from arid to semi-arid as evident by increase in annual rainfall from ~25 cm to ~35 cm in the last three decades. Frequency of rains has increased affecting crop management practices in wheat, rice, kinnow and cotton crops. Anomalies in seasonal cycles are such that onset of winter has been delayed by about 30 days with apparent reduction in the number of cool, winter days. While day temperature has significantly decreased, sudden decline in night temperature is increasingly becoming noticeable. Late onset of winter postpones flowering in kinnow and abrupt increase in temperature in April adversely affects the fruit set. These compounding impacts have caused huge yield losses in kinnow in the last few years. Due to erratic rainfall, the efficacy of insecticides has reduced leading to more protective sprays elevating the production costs. During 2015, for example, despite repeated insecticide sprays white fly infestation spoiled the

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cotton crop. Some farmers are likely to switch over to lentil in marginally salt-affected lands. These observations strengthen the argument that secondary salinization has gradually become a major threat to local cropping systems and farmers' livelihoods. Abrupt changes in seasonal cycle, erratic rainfall and increase in temperature coupled with socio-economic transition are likely to accentuate the adverse impacts of salinization in foreseeable future. While huge threats to kinnow orchards due to salinization and volatile market prices are beyond any doubt, rice and wheat crops are also reeling under severe salinity hazard and feeble institutional support. Non-availability of appropriate technologies, disintegration of joint families into the nuclear ones, fragmentation of landholdings and migration of farmers to cities for gainful livelihoods were observed to be the compounding factors.

Perceived climate variability and agricultural adaptations by material resource poor farmers in salt affected agroecosystems: Implications for food and livelihood security (Ranjay K. Singh, Anshuman Singh, Satyender Kumar, Parvender Sheoran, Thimmappa K, Dheeraj Singh and D.K. Sharma)

It is well recognized that climate change would adversely impact agro-ecosystem health, agricultural productivity and farmers' livelihood in India. Although extreme weather events are a historical phenomenon in India (e.g. severe droughts in 1918, 1972, 1987, 2002, 2009 and 2012), the cause for concern is that their frequency has significantly increased in the recent past. Sensitivity of resource-poor farmers to climate risks has compelled them to develop location specific adaptive practices for sustaining the livelihoods. The farmers living in such ecologically stressed areas not only suffer from poor agricultural productivity, but are also exposed to high vulnerability. This project is being carried out in arid and semi-arid parts of Rajasthan (RJ) and Haryana (HR) and sub-humid region of Uttar Pradesh (UP). The first criterion for selecting these three Indian states is that agricultural systems of the small and marginal farmers of these regions are identified as highly sensitive to climate change, and are particularly vulnerable to compounding impacts from other structural and environmental stressors. The study was started in December, 2015 in selected villages of Pali (RJ), Hisar (HR) and Jaunpur (UP) districts of where salinity and sodicity are the major constraints to agricultural production.

From each selected district of three states (RJ, HR and UP), 20 farmers each from two blocks and thus a total of 60 farmers from 12 villages were sampled based on the climate hazards, salinity/sodicity, size of land holding and farmers' adaptive capacity. The detailed sampling methodology is given in Table 19. Soil and water sampling from 40 farmers' fields from Hisar and Pali districts indicated high salinity induced risks in agricultural production. Data on farmers' perception about climate variability from Pali district indicated that climate variability in terms of reduced number of rainy days, erratic rainfall and increased atmospheric temperature (Table 20) are posing risks to crop production. The intensity and duration of rainfall have also reduced as reported by more than 85.0% of the farmers. In both Hisar and Pali districts, water salinity was found to be a major ecological stressor followed by land use change, market uncertainty, high input costs and policy flaws in the pricing of agricultural produce and crop insurance. Many of these factors are also responsible for gradually diminishing biodiversity in traditional cereal, pulse and oilseed crops .

It is evident from the soil and water salinity, soil pH and sodium adsorption ratio (SAR) that farmers of Pali district are facing huge salinity risks in agricultural production. Water salinity was observed to be minimum (2.15 dS m^{-1}) in Rampura-1 village of Pali block, while the maximum (13.2 dS m^{-1}) in Rampura-2 (Rohat block). Water pH was almost neutral in these villages. The lowest SAR value of 6.45 was

Table 19 : Sampling and selection of districts, villages and farmers

Districts	Types of climate and social system	Sampling methods for district & block[1]	No of blocks	No of villages per block	No of farmers per village	Sampling method for village & farmers	Types of participating farmers in competition	Other farmers/village[3]	Total No of farmers to be sampled from each village
Hisar (HR)	Arid & MRP[1] to moderately rich farmers	Stratified	2	2 (4)	5(20)	Random	MRPF[2,3]	10(40)	15 (60)
Pali (RS)	Arid & MRP[1] to moderately rich farmers	Stratified	2	2 (4)	5(20)	Random	MRPF	10(40)	15 (60)
Jaunpur (UP)	Sub-humid & MRP farmers	Stratified	2	2 (4)	5(20)	Random	MRPF	10(40)	15 (60)
Total	--		6	12	60 farmers	--	--	100 farmers	160 farmers

MRPF= Material resource-poor farmers; Note: 1 Developmental blocks in study districts having sodicity and/or salinity problems; 2The small and marginal farmers are named here as 'Material Resource-poor (MRP) farmers'; 3Preference was also given to prepare a list of followers of sampled farmers. Thus, we expect to have a total 160 farmers from 12 villages. Grand total = 60+100= 160 farmers.

Table 20 : Farmers' perception about climate variability and its impact on livelihood

Climatic variables	Types of changes	Effects		
		Soil, crop and water resources	Animal resources	Trees and local flora
Temperature	Increased (82%)	Increased insect pests and diseases (75%), early maturity (95%), rapid evaporation (87.5%), reduced yields (78%)	High incidence of FMD (6 6%), infertility (72%), forced birth (30%), and animal deaths (35 %); decrease in milk production (58%)	Stunted growth, gum formation and deformity in *Khejri* trees (68.5%).
Rainfall	Highly erratic (95%), reduced number of rainy days, drought at every third year (90%)	Reduced recharge of open-wells (83.0%), increased water salinity (95.0%), reduced seed germination and crop growth, reduction in yield, reduced land use system (70.0%)	Shrinkage of pastures and grazing lands compelling forced migration of pastoralists to long distances, reduced populations of cow, sheep, and goat	Stunted growth and sparse plant population in *Khejri* and indigenous babool trees.
Winter	Postponed from last week of October to first week of December (80%) virtually nil frost incidence (75%)	Reduced duration of winter crops, poor germination of seeds, increased	Stomach disorders increased, cough and cold in sheep increased	Growth of species affected
Summer	Preponed from March to February (90%), *Loo* reduced (68%)	Disease and pest attacks (e.g., *mole*-mustard aphid) increased leading to more pesticide sprays	Flatulence increased	Decrease in productivity

recorded from farmers' open-well of Hemnawas village and the maximum SAR (68.6) was noted in Muradiya village. Such extremely high SAR values indicate the possible heavy damage to crops particularly during winter months when farmers use open-well water in irrigation.

Soil salinity was nominal to marginal except in Rampura-1 where it was close to 6 dS m^{-1}. In this village, soils were also sodic with pH values ranging from 8.9-9.3. The water flowing through Badi tributary of Luni River is heavily polluted causing contamination of the open-wells. River water salinity was 10.35 dS m^{-1} while SAR was 101.7. Farmers were of opinion that before 1979, this tributary had normal and sweet water, but due to heavy effluent discharge from the textile industries in Pali city water has become highly polluted. Presently, almost all the village open-wells lying near this tributary are heavily polluted as reported by the villagers.

The problems of river and soil salinity often increase manifold during droughts or extended dry periods. Over the years, area under different agro-forestry systems such as Khejri has significantly decreased. On other hand, invasion of the alien species such as *Prosopis juliflora* has increased. Pervasive land use, degradation of community ponds and the disappearance of the local cropping systems (e.g., moth + bajra) were found to be other stressors compounding the

Focus group discussion in Rampura village of Rohat, Pali district.

livelihood risks in the studied villages of Pali district.

In Hisar district, salinity was the major stressor affecting crop yields and farmers' livelihoods. The maximum (33.2) and the minimum (1.51) SAR value was recorded in Payal and Bhatol-Jatan villages, respectively. High salinity adversely affects rice, wheat and mustards yields in these villages. As the district falls under semi-arid climate with sandy clay to sandy loam soils, drought or longer dry spells accentuate the vulnerability of farmers as rice crop often fails due to high temperature and excess salt load. Consequently, many farmers (35-45%) replant their rice crop two times. During rabi season, especially in low lying areas where watertables lie about 2.5 feet below the soil surface, soil salinity was very high (~15 dS m^{-1}). In Payal and Chidaud villages, extremely high water salinity (18-21.3 dS m^{-1}) causes heavy yield loss in wheat and mustard crops.

Polluted Badi river water passing from village Muradiya (Rphat block) and which pollute open-well water

Stunted cumin crop with reduced plant population due to salinity (EC_{IW} from 3.4-13.2).

Impact assessment of subsurface drainage technology in canal command areas of Karnataka (R. Raju, Thimmappa, K. and A.L. Pathan)

The impact assessment study was carried out in subsurface drainage project area located in village Ugar Budruk in Athani Taluk of Belgaum district in Karnataka. About 944 ha of waterlogged saline land in the village was either partially cultivated or barren for more than 20 years. The continuous efforts made by the farmers helped to reclaim affected land through the installation of subsurface drainage technology as suggested by ICAR-CSSRI, Karnal. The 925 ha area was reclaimed by spending Rs. 499.51 lakhs which costs about Rs. 52000 per ha. The waterlogged saline land was reclaimed with the fund contribution made by the Department of Land Resources, Govt. of India (60%), Department of Watershed Development, Govt. of Karnataka (20%) and Farmers' contribution (20%). The salient features of the SSD project is given in Table 21 & 22.

About 644 farmers have benefitted by the land reclamation through subsurface drainage

Table 21: Land holdings of SSD farmers in Ugar BK

Farmers Category	No. of Farmers	Area (ha)
Marginal (<1ha)	295 (45.8)	180.8 (19.5)
Small (1-2ha)	235 (36.5)	343.2 (37.1)
Semi-Medium (2-4ha)	96 (14.9)	240.4 (26.0)
Medium (4-10ha)	17 (2.6)	96.2 (10.4)
Large (>101ha)	1 (0.2)	64.8 (7.0)
Total	**644 (100.0)**	**925.4 (100.0)**

Table 22 : Salient Features of SSD Project in Ugar BK

Parameters	Description
Area under subsurface drainage (ha)	925
Total Farmers/beneficiaries covered (No.)	644
Type of drainage system	Pipe drainage with natural outlet
Size (mm) -diameter	80
Depth (m)	1 to 2 (Perforated PVC pipes)
Spacing (m)	30
Total No. of Outlets/Blocks (Closed drains)	22 (3)
Total No. of Manholes	35
Years of installation	2009 -10 to 2012 -13
Total co st of SSD Project (Rs. in Lakhs)	499.51
Approximate cost of installation (Rs. ha^{-1})	52000
Project Life (in years)	50

Size of land holdings

Table 23 : Major crops and their yield for Pre-SSD and Post-SSD in the Project Area

Sl. No.	Crop	Unit	Yield ($t\ ha^{-1}$)		% increase in yield
			Pre-SSD	Post-SSD	
1	Sugar cane				
	Planted	$t\ ha^{-1}$	42	119.0	183
	Ratoon-I	$t\ ha^{-1}$	26	82.0	215
	Ratoon-II	$t\ ha^{-1}$	0.0	57.0	-
2	Wheat	$t\ ha^{-1}$	0.80	2.74	243
3	Chick Pea	$t\ ha^{-1}$	0.35	1.43	309
4	Soybean	$t\ ha^{-1}$	0.73	2.15	195
5	Jowar	$t\ ha^{-1}$	0.45	1.64	264

technology in the village. The majority of the farmer beneficiaries (82.3%) are small and marginal farmers holding 56.6 % area.

The mean soil salinity was 2.46 and pH was 8.52. It showed that the 60 percent of the area was non-saline with EC of 0.55 dS m^{-1} and about 33 percent area was slight and moderately saline. The affected land in the village was hardly fetching Rs. 1.6 lakh per acre in pre-SSD period. But after the reclamation, the land value increased to Rs. 8.6 lakh per acre. It was observed that severely affected land which was having the value of Rs. 50000 per acre has jumped to Rs. 3 lakh per acre during post-reclamation period. The increase in land values was mainly attributed to the improvement in land quality after SSD installation.

Sugarcane is the major crop of the Ugar Budruk project area, which occupies more than 90 percent of the cultivated area, followed by oilseeds (5.7%), fruits and vegetables (1.2%), cereals and pulses (0.5%). Sugarcane farmers harvest planted crop and one ratoon crop. In the time gap between harvest of ratoon crop and the next planting season of sugarcane crop, they grow short duration crops like wheat, soybean, chick pea and jowar. The yield of major crops has increased upto 300 percent. The yield of planted and ratoon-I sugarcane was increased to 119 t ha^{-1} and 82 t ha^{-1} respectively, for post-SSD as compared to 42 t ha^{-1} and 26 t ha^{-1} respectively, in the pre-SSD. Majority of the farmers also (90-95%) harvest only two crops and few farmers harvest the second ratoon (Table 23). This has mainly occurred in the post-SSD period due to land reclamation. The farmers get more yield in the second ratoon than the yield which they harvest from planted crop in the pre-SSD period. Similarly, the yield of other short duration or off season crops has also shown a significant increase in the post-SSD as compare to pre-SSD period

MANAGEMENT OF MARGINAL QUALITY WATER

Conjunctive water use strategies with conservation tillage and mulching for improving productivity of salt affected soils under limited fresh water irrigation

(A.K. Rai, R.K. Yadav, A.R. Chinchmalatpure, N. Basak, S. Kumar, B. Narjari, Gajender Yadav, A.K. Bhardwaj, Madhu Chaudhary and D.K. Sharma)

In many of arid and semi-arid regions, limited availability of good quality water necessitates the conjunctive use of fresh and saline water to sustain the crop yields. To develop proper soil-water-crop management practices for such situations, a field experiment was initiated in 2014 at Nain Farm Panipat, Haryana. Conservation tillage, deficit irrigation and crop residue mulching approaches were employed for managing intra/inter seasonal root zone salinity for increased production of low water requiring crops under limited water supply. The experiment was laid out in kharif-2014 with three tillage treatments in main plot and six treatments comprising irrigation (three) and mulch (two) combination in subplots. Wheat grain yield and fodder sorghum yield obtained in 2014-15 are presented in Table 24. Tillage had non significant effect on wheat grain and fodder sorghum yield. Grain yield of wheat (cv. KRL-210) in saline soils (EC_2 3.1-3.4 dS m^{-1}) irrigated with saline water (8.0 dS m^{-1}) was 4.69 t ha^{-1}. Wheat yield obtained at 80% (4.6 t ha^{-1}) and 100% (4.69 t ha^{-1}) irrigation supply of crop water requirement were statistically at par.

Application of mulch (5 t ha^{-1}) under deficit irrigation (60% WR) showed 7.5% increase in wheat yield as compared to without mulching (4.0 mg ha^{-1}). Sorghum grown as rainfed crop produced significantly higher green forage yield in the plots irrigated with saline water at 60% water requirement (6.42 t ha^{-1}) in rabi season as compared to saline water irrigation at 100% WR. Tillage, irrigation and mulching had no effect on dry matter content of the fodder sorghum. Soil moisture content of the mulched plots in 0-10 cm and 40-50 cm soil layer was higher than non-mulched plots in entire *rabi* season (Fig. 19). Soil moisture content in February was 6-23% higher in mulched plot in comparison to non-mulched plots.

Table 24 : Sorghum and wheat yield (t ha^{-1}) with variable tillage, mulching and deficit irrigation

Treatment	Wheat (2014)	Sorghum GFY (2015)	Sorghum DFY	Dry matter (%)
Tillage*				
RT -ZT	4.41a	550.0a	137.0a	25.2a
CT -CT	4.52a	562.5 a	132.4a	23.6 a
ZT -ZT	4.51a	558.3a	135.0a	24.3 a
Irrigation and mulching				
100 WR #-no mulch	4.69a	505.6b	125.7b	25.2a
80 WR - no mulch	4.6ab	541.8b	130.7b	24.1a
60 WR - no mulch	4.0b	547.2 b	137.3ab	23.9a
100 WR – mulch**	4.67ab	563.2b	136.7ab	24.2a
80 WR - mulch	4.62ab	541.7b	125.7b	23.5a
60 WR - mulch	4.31ab	641.7a	152.7a	25.2a
100WR -G	4.90a	658.0a	158.4a	24.1a
100WRC	4.70ab	508.3b	126.1b	24.0a
Tillage × irrigation and mulch: NS				

*RT-reduced tillage, ZT-zero tillage, CT-conventional tillage; # WR-water requirement; ** Mulch- rice straw mulch (5 t ha^{-1})

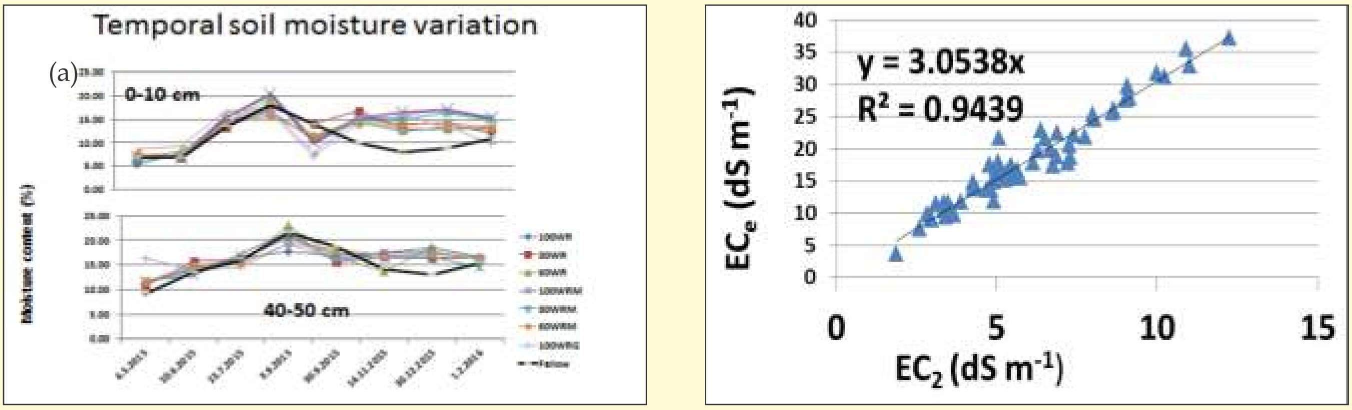


Fig. 19 : Relationship between EC_e and EC_2 under different treatments

Effects of mulching were more perceptible in surface as compared to subsurface layers. A similar trend was observed for soil salinity. Throughout the year EC_2 of the surface soil was lowest in the 60% WR + mulch (60W RM) treatment. The relationship between EC_e and EC_2 is shown.

Soil pH_2 was inversely related with change in soil EC_2. Decrease in soil salinity was associated with the increase in soil pH_2. Maximum increase in soil pH was observed in soils irrigated with good quality water (EC_{iw}<1 dS m^{-1}).

Soil solution in quasi-equilibrium with soil solid phase was extracted and correlation matrics between different cationic and anionic constituents and their indices were developed. Soil pH_2 was positively correlated ®> 0.3-0.6) with soil solution indices like sodium adsorption ratio (SAR), Na^+/K+ (SPR), Na^+/ (Cl^- +SO_4^{2-})(NCSR), Cl^- /SO_4^{2-}(CSR) and dissolved organic carbon (DOC). Ca^{2+}/Mg^{2+} (CMR) was negatively correlated with pH_2. These findings suggest that EC_2 and SAR play important roles in determining soil pH but at micro level cationic and anionic ratio could also modify the soil pH. Biomass production of the salt tolerant wheat variety KRL-210 was not affected much by different soil solution parameters due to its adoptive mechanisms in the tested range. Whereas, 85.6% variability in DOC content of soil solution was explained by Ca^+ Mg, pH_s, total nitrogen and Na/(Cl^- +SO_4^{2-}) ratio (Table 25).

Development of effective salt tolerant microorganisms to mitigate salt stress for higher crop production in salt affected soils (P.K. Joshi and Madhu Choudhary)

Salt tolerant bacterial and actinomycetes with higher PGR activities like production of indole acetic acid (IAA), ammonia excretion, phosphorus solubilization and Na^+ uptake were identified. 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, help to maintain Na/K ratio in plants and are also involved in production of anti-oxidants and thereby prevent salt stress induced injury to

Table 25 : Relationships of soil solution parameters with dissolved organic carbon in a saline soil under conjunctive water irrigation

Variable	Parameter Estimate	Standard Error	Partial R-square	Model R-square	Pr> F
Intercept	1105.63728	344.36718			0.0035
Ca+Mg	7.63971	0.91603	0.779	0.779	<.0001
pH_s	-135.62517	40.69961	0.027	0.807	0.0026
TN	1.22191	0.37316	0.027	0.834	0.0030
Na^+/Cl^-+SO_4	88.08817	34.66658	0.022	0.856	0.0174

plants. Ability of microbes to alleviate salt stress in crops varies greatly. Hence, salt tolerant fifty bacterial and fourteen actinomycetes isolates were screened for PGP traits like IAA production, ammonia excretion and phosphors solubilization. Uptake of sodium from liquid medium was also studied by salt tolerant bacterial and actinomycetes isolates. Salt tolerant bacterial isolates 10STB3C(2) and 15STB2C showed the maximum Na^+ uptake (513 and 323 mg g^{-1}) from nutrient broth containing 700 ppm of Na^+. The maximum ammonia excretion was observed by salt tolerant bacterial isolates 15STB1 (0.082µg ml^{-1}) and STB110 (0.078 µg ml^{-1}) in comparison to control (0.036 µg ml^{-1}). The highest production of IAA was observed by salt tolerant bacterial isolates STB38 (11.40 ppm) and STB105 (8.90 ppm); while the maximum P solubilization was recorded with bacterial isolates 5STB19 (17.41 ppm P_2O_5) and 10 STB 7B (16.93 ppm PP_2O_5). In case of salt tolerant actinomycetes, the highest sodium uptake was observed in isolates STAc8 (73.17 mg g^{-1}) and STAc3 (64.70 mg g^{-1}) but isolates STAc1 and STAc2 excreted the maximum (0.188 and 0.136 µg ml^{-1}, respectively) ammonia, and isolates STA8 and STAc8 produced the highest IAA contents of 9.67 and 5.77ppm, respectively. The maximum P solubilization was recorded in salt tolerant actinomycetes isolates STAc18 (31.13 ppm) and STAc17 (30.65 ppm). IAA production by salt tolerant actinomycetes isolates has been depicted in Fig. 20. Seven potential salt tolerant bacterial isolates with highest PGP activities were identified and 4 deposited to NBAIM, Mau with accession number.

Isolation, identification and evaluation of plant growth-promoting bacteria for mitigating salinity stress in crops (Madhu Choudhary, P.K. Joshi, Gajender, M.D. Meena and Vineeth T.V.)

Soil salinity affects the germination, establishment and different plant growth phases including reproductive development by imposing oxidative and osmotic stress, nutrient (N, Ca, K, P, Fe, Zn) deficiency and ion toxicity on plants. Production of plant growth promoting hormones by native microorganisms could play a significant role to mitigate the salt stresses under the targeted areas. Some specific types of bacteria, called plant growth promoting bacteria (PGPB) are found in the rhizosphere and in the roots of salt tolerant plants which may play an important role in plant growth and development under salt affected conditions, because of their positive effects on providing conducive soil physical conditions, ease in nutrient availability direct stimulation on plant growth by providing plants with fixed nitrogen, phyto-hormones, iron that has been sequestered by bacterial siderophores, and soluble phosphate. Others may do this indirectly by protecting the plant against soil-borne diseases, most of which are caused by pathogenic fungi. Therefore, this study was initiated in 2015 using PGPB with suitable carrier for improving the performance of rice - wheat with the following objectives:- (i) Isolation of bacteria from rhizosphere and roots of salt tolerant plants. (ii) Screening and identification of bacteria for plant growth promoting traits and salt tolerance. (iii) Screening of suitable carrier for bacterial isolates.

Fig. 20: Indole acid production by salt tolerant actinomycetes isolates

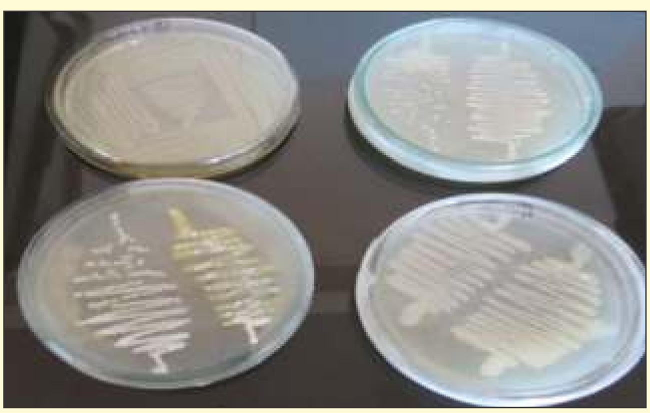


Fig 21 : Pure colonies of bacterial isolates

Table. 26 : Soil samples have been analysed for EC

Sample no.	EC 1:2	pH 1:2
1	12.31	8.84
2	3.83	8.62
3	7.65	8.28
4	6.36	8.14
5	3.51	8.10
6	4.47	8.11
7	7.21	8.72

(iv) Study of the effect of inoculated carrier on performance of different crops (Fig. 21).

Seven samples of rhizospheric soil and roots of plants were collected from Nain Farm for the isolation of bacteria. Soil samples have been analysed for EC and pH (Table 26). Bacteria were isolated on different types of media like Nutrient Agar, Jensen's media, Pikovaskaya media and Ashby's media. More than 80 rhizospheric bacteria have been isolated and purified on Nutrient agar.

Evaluation of salinity tolerance of seed spices (R. K. Yadav and R. L. Meena)

An inter-institutional (CSSRI, Karnal and NRCSS, Ajmer) project on evaluation of salinity tolerance of seed spices has been continued since 2013 at CSSRI, Karnal. Three sets comprising one pot and two lysimeter experiments were carried out during previous year to ascertain the overall and stage dependant tolerance of seed spice crops to salinity and RSC levels in irrigation water under direct seed sowing and transplanting conditions. One lysimeter experiment is continued to further verify overall and stage dependant tolerance of fennel *(Foeniculum vulgare)*, coriander *(Coriandrum sativum)*, celery *(Apium graveolens)* and fenugreek *(Trigonella foenum-graecum L.)* to irrigation water salinity imposed during period 0-30, 31-60, 61-90 and 91-120 days after sowing/harvest. Fenugreek was sown with seed only and irrigated with saline (4.0 dS m^{-1}) water; while fennel, coriander and celery were raised by seed and transplanting seedlings using 6.0 dS m^{-1} saline water. Another lysimeter experiment was conducted on assessment of tolerance of fennel and coriander to levels of RSC (0, 2.5, 5.0 and 5.0 meq l^{-1} + gypsum to neutralize to 2.5) in irrigation water and the 3rd experiment consisted of evaluating irrigation water salinity (3.0, 6.0, 9.0, 12.0 dS m^{-1}) tolerance in anise (Pimpinella anisum), ajwain *(Trachyspermum ammi)* and dil (*Anethum sowa*). The irrigations were scheduled at 1.2 ID/CPE ratio in all experiments. Growth, development, yield parameters and yield of all crops were recorded with above mentioned saline/RSC water irrigation treatments and compared with normal (~0.6) water irrigation throughout season (control) (Table 27.)

Under saline conditions, transplanting and direct seeding of fennel, coriander and celery produced similar seed yields. Fennel, coriander and celery produced 1.33, 1.13 and 0.39 t ha^{-1}, respectively of seed yield under direct seeding, which were comparable to yields of respective crops under transplanting. Overall decrease in yield of direct seeded fennel, celery, coriander and fenugreek under continuous saline water irrigation throughout growth period was 18, 27, 35 and 49%, respectively in comparison to 14, 16 and 38% in

Stage dependant saline irrigation in fennel, coriander, celery; Anise, ajwain and dil under variable salinity and fennel and coriander under RSC water irrigation (left to right).

Table 27: Coriander, fennel, fenugreek and celery Seed yields (t ha^{-1}) under saline water irrigation at different growth stages

IR (DAS)	Fennel	Celery	Coriander	Fenugreek	Mean*
	Direct Seeding				
Control	1.42	0.46	1.26	0.68	1.05 (0.96)
0-30	1.31	0.36	0.98	0.44	0.89 (0.78)
31-60	1.39	0.40	1.18	0.54	0.99 (0.88)
61-90	1.40	0.41	1.23	0.51	1.01 (0.89)
91-harvest	1.30	0.38	1.19	0.48	0.96 (0.87)
Continuous Saline	1.17	0.30	0.92	0.35	0.81 (0.80)
Mean	1.33	0.39	1.13	0.50	0.95 (0.84)
	Transplanting				
Control	1.36	0.44	1.28	--	1.03
Tr. -30	1.24	0.37	1.02	--	0.88
31-60	1.35	0.41	1.18	--	0.98
61-90	1.44	0.43	1.23	--	1.03
91-harvest	1.32	0.37	1.09	--	0.93
Continuous Saline	1.14	0.26	0.79	--	0.74
Mean	1.31	0.38	1.10	--	0.93
CD (*p=0.05*)	Seeding Methods (SM) = NS; Irrig. Regimes (IR) = 0.12; Crops = 0.17; SM*IR = NS; Crop*IR=0.21; SM *IR*Crop = 0.14				

celery, fennel and coriander under transplanting (Table 28). Salinity stress imposed during 0-30 days after seed sowing (DAS) stage reduced seed production by 8, 21, 22 and 35% in fennel, celery, coriander and fenugreek, respectively. Similar effects were recorded in biomass production also. Likewise osmotic stress inmposed during reproductive phase i.e. 91 – 120 DAS sowing had significant adverse effect on seed production of all the crops without any significant adverse effect on biomass production of all the crops.

Fennel and coriander proved sensitive to RSC in irrigation water. Germination of fennel and coriander reduced by 37/28 and 79/66% in silty loam soils under 2.5 and 5 meq/l RSC water

Table 28: Germination, biomass and seed yields (t ha^{-1}) of coriander and fennel under high RSC water irrigation

RSC levels (meq l^{-1})/ Crops	Germination (%)		Seed yield		Biomass yield	
	Fennel	Coriander	Fennel	Coriander	Fennel	Coriander
Nil	94	89	1.46	1.34	2.23	1.94
2.5	60	64	0.93	0.96	1.52	1.47
5.0	20	30	0.29	0.47	0.49	0.68
5.0 + gypsum	31	49	0.48	0.75	0.75	1.10
CD (*p=0.05*)	12	14	0.13	0.17	0.20	0.19

irrigation, respectively. However, neutralizing RSC (5 meq l^{-1}) to 2.5 using gypsum improved germination to 56 and 65%, respectively over use of 5 meq l^{-1} RSC water in the two crops. After germination crops sustained even high (5.0 meq l^{-1}) RSC levels in irrigation water.seed and biomass production of both fennel and coriander decreased significantly with increasing levels of RSC in irrigation water.

In case of anise, ajwain and dil, increasing salinity levels in irrigation water delayed germination by 2-3 days and data on growth and yield are in the process of analysis.

Assessing use of press mud/press mud compost in gypsum beds for neutralization of RSC in irrigation water (R. K. Yadav, M. D. Meena, Satyendra Kumar, Madhu Choudhary, Parul Sundha and D. K. Sharma)

This project was initiated with the objectives to assess the effectiveness of mixing of press mud in gypsum beds on neutralization of RSC in irrigation water, optimizing ratio of gypsum and press mud for maximum neutralization of RSC in groundwater and understanding the improvement in soil physico-chemical and microbial properties and crop productivity with use of neutralized water. Project comprised of conducting batch studies in columns with mixing of gypsum and press mud in different ratios (gypsum alone; 4:1; 3:1; 2:1; 1:1; press mud alone) for passage of different RSC (2.0, 4.0, 6.0, 8.0 meq l^{-1}) concentration water at variable discharge rates equivalent to 10, 12, 16 an 20 l/sec in 2x2x1.5 m^3 size gypsum bed. So far, we have collected and characterised press mud (for physic-chemical properties) from three sugar factories i.e. Panipat, Kaithal and Yamunanagar. pH, EC, Ca and S contents in the press mud of these varied from 4.82 – 5.13, 0.79 – 1.24 dS m^{-1}, 2.14- 2.40% and 1.18 – 1.26%, respectively. A set of 36 Columns (75 cm hieght and 12 cm dia) has been fabricated and column studies with different treatments initiated. Periodic sampling and analysis (2 hourly interval) of bed material and outlet (leachate) water for Ca and other nutrients has been started. Pot studies on use of leachates on crops (rice-wheat) growth and soil (pH, ESP, BD, aggregate stability and nutrient availability) properties will be initiated in coming season.

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, Satyender Kumar, K. Thimmappa and R.K. Singh)

Continuous use of poor quality sodic ground water would result in buildup of exchangeable Na^+ ions in the root zone severly limiting the 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 ameliorate the sodicity and harvest the satisfactory yields. The sodicity hazards of the irrigation water can be mitigated by neutralization of the RSC in irrigation water with chemical or organic materials while preventing salinity build up in soil-water system as well as minimizing their adverse effects on crop growth. With this view, a field experiment was initiated at farmers' field to evaluate the management strategies for neutralization and sustained use of sodic water in rice-wheat cropping system.

Two sites were selected for the experimental purpose in village Mundri, District Kaithal, having RSC_{iw}≈7.0 and 5.0 meq l^{-1} (Table 29). Two varieties of rice (CSR 30 Basmati/Pusa 1121) were grown with four sodic water neutralization treatments viz., RSC water (T_1); T_1 + t gypsum @ 7.5 t ha^{-1} (T_2); T1 + Pressmud @ 10 t ha^{-1} (T_3); T_1 + gypsum @ 3.75 t ha+ pressmud @ 5 t ha^{-1} (T_4). All other cultural practices were followed as per the recommendations.

All the treatments used for neutralizing the adverse effect of RSC waters used for irrigating wheat either individually or in combination proved to be better in comparison to the untreated water. Overall, the application of different amendments resulted in 10.2-16.5% higher yield compared with control (Table 30). Under the present situation, varietal intervention through inclusion of salt tolerant wheat variety KRL 210 resulted in 14.4 to 18.1% higher yield in comparison to HD 2967.

Table 29 : Water quality analysis of experimental site(s)

Site	Motor capacity (HP)	Tubewell depth (feet)	$Ca^{2+} + Mg^{2+}$ (meq l^{-1})	CO_3^{2-} (meq l^{-1})	HCO_3^{2-} (meq l^{-1})	RSC (meq l^{-1})	pH	EC (dS m^{-1})
Site I 29°46'52.9 N 76°29'41.6 E	12.5	325	3.80	-	10.73	6.93	7.48	1.32
Site II 29°46'57.2 N 76°29'23.6 E	15.0	370	0.93	-	6.10	5.13	7.56	1.12

Table 30 : Interactive effect of RSCiw neutralization treatments and genotypes on the wheat yield at two locations during rabi 2014-15

Neutralization treatments	Yield (t ha^{-1}) Site I (RSC≈ 7.0)			Yield (t ha^{-1}) Site II (RSC≈ 5.0)			Overall Mean (Kg ha^{-1})
	KRL 210	HD 2967	Mean	KRL 210	HD 2967	Mean	
RSC water (Control)	3.898	3.354	3.626	3.948	3.413	3.680	3.653
Gyp @ 7.5 t ha^{-1}	4.240	3.709	3.975	4.402	3.750	4.076	4.025
PM @ 10 t ha^{-1}	4.392	3.796	4.094	4.555	3.810	4.183	4.138
Gyp @ 3.75 t ha^{-1} + PM @ 5 t ha^{-1}	4.456	3.990	4.223	4.668	3.906	4.287	4.255
Mean (t ha^{-1})	4.246	3.712		4.393	3.720		

Table 31 : Interactive effect of RSC_{iw} neutralization treatments and genotypes on the rice yield at two locations during kharif 2015

Neutralization treatments	Yield (t ha^{-1}) Site I (RSC≈ 7.0)			Yield (t ha^{-1}) Site II (RSC≈ 5.0)			Overall Mean (t ha^{-1})
	CSR 30 Basmati	Pusa 1121	Mean	CSR 30 Basmati	Pusa 1121	Mean	
RSC water (Control)	2.333	2.590	2.462	2.728	3.136	2.932	2.697
Gyp @ 7.5 t ha^{-1}	2.804	3.043	2.924	3.177	3.577	3.377	3.150
PM @ 10 t ha^{-1}	2.967	3.106	3.037	3.375	3.742	3.559	3.297
Gyp @ 3.75 t ha^{-1} + PM @ 5 t ha^{-1}	2.982	3.208	3.095	3.327	3.823	3.575	3.335
Mean (t ha^{-1})	2.771	2.987		3.152	3.570		

Across two locations, irrespective of the dose and source of neutralization treatment for available RSC irrigation water, rice variety Pusa 1121 recorded overall 10.7% (0.317 t ha^{-1}) yield superiority over the CSR 30 Basmati (Table 31). With the increase in RSC_{iw} from 5.0 meq l^{-1} (Site II) to 7.0 meq l^{-1} (Site I), the performance of basmati CSR 30 was relatively better than Pusa 1211 owing to lesser pollen sterility, better relative water content, lower Na/K ratio in shoot and as root. Neutralization of RSC of applied irrigation water through different amendments (gypsum/pressmud) either individually or in combination recorded 16.8-23.7 higher rice yield as compared to crop irrigated with the available RSC waters.

The data also revealed that after completion of one and half year crop cycle (Rice 2014 & 2015 and Wheat 2014-15), neutralization of RSC water through amendments resulted in 14.5% higher system equivalent yield as compared to crops irrigated with available RSC waters. Improvement in soil pH and ESP has been observed with the application of neutralizing amendments at both the sites after one year crop cycle.

CROP IMPROVEMENT FOR SALINITY, ALKALINITY AND WATER LOGGING STRESSES

Development of salt tolerant genotypes in rice–Conventional and Molecular breeding approaches (S. L. Krishnamurthy, P.C. Sharma, Ravikiran, K.T., Vineeth, T. V., Y. P. Singh and S. K. Sarangi)

This project aims at the development, evaluation and dissemination of better salt tolerant rice genotypes. To achieve the objectives, following trials were conducted and the breeding material was advanced during Kharif, 2015.

A. National trials:

IVT-Alkaline and Inland Saline Tolerant Variety Trial-2015

The IVT-Alkaline and Inland Saline Tolerant Variety Trial (IVT-AL&ISTVT) comprised of 39 entries including the check varieties (CSR 36, CSR 27 and yield check-Jaya) which were evaluated across five salt stress locations (Table 32) in Random Block Design with three replications. Under salinity stress at Karnal, eight entries outperformed the national salinity check CSR 23. The entry 3922 showed the highest grain yield (3.46 t ha^{-1}) followed by 3911 (3.42 t ha^{-1}), 3932 (3.39 t ha^{-1}), 3929 (3.30 t ha^{-1}), 3927 (3.05 t ha^{-1}), 3915 (3044 t ha^{-1}), 3909 (3.01 t ha^{-1}), 3912 (3.0 t ha^{-1}) and local check (2.98 t ha^{-1}). At Nain, Panipat, ten entries outperformed the local check. The grain yield ranged from 0.89 t ha^{-1} (3910) to 2.83 t ha^{-1} (3922). Entry 3.9 showed the highest grain yield (2827 t ha^{-1}) followed by 3932 (2.82 t ha^{-1}), 3929 (2.76 t ha^{-1}), 3911 (2.71 t ha^{-1}), 3926 (2.59 t ha^{-1}), 3916 (2.59 t ha^{-1}), 3917 (2.50 t ha^{-1}), 3920 (2.47 t ha^{-1}), 3924 (2.45 t ha^{-1}), 3919 (2.44 t ha^{-1}) and 3936 (2.43 t ha^{-1}).

Under sodic stress at Karnal, six entries performed better than the national alkaline check CSR 36. The entry 3922 showed the highest grain yield (4.3 t ha-1) followed by 3932 (4.27 t ha^{-1}), 3911 (4.21 t ha^{-1}), 3929 (4.08 t ha^{-1}), 3901 (3.93 t ha^{-1}), 3912 (3.88 t ha^{-1}) and local check (3.81 t ha^{-1}). At Jind, thirteen entries outperformed the national alkaline check CSR 36. The entry 3913 showed the highest grain yield (3.94 t ha^{-1}) followed by 3922 (3.72 t ha^{-1}), 3932 (3.67 t ha^{-1}), 3929 (3.65 t ha^{-1}), 3911 (3.63 t ha^{-1}), 3916 (3.24 t ha^{-1}), 3909 (3.19 t ha^{-1}), 3927 (3.19 t ha^{-1}), 3902 (3.17 t ha^{-1}), 3920 (3.16 t ha^{-1}), 3914 (3.16 t ha^{-1}), 3910 (3.15 t ha^{-1}), 3912 (3.10 t ha^{-1}) and local check (3.00 t ha^{-1}). At Kurukshetra, five entries performed better than the local check CSR 36. Entry 3911 showed the highest grain yield (3.84 t ha^{-1}) followed by 3922 (3.67 t ha^{-1}), 3929 (3.56 t ha^{-1}), 3932 (3.54 t ha^{-1}), 3912 (3.32 t ha^{-1}) and local check (3.28 t ha^{-1}).

AVT-Alkaline and Inland Saline Tolerant Variety Trial-2015

The AVT-Alkaline and Inland Saline Tolerant Variety Trial (AVT-AL&ISTVT) comprising of 18 entries including check varieties (CSR 36, CSR 27 and yield check Jaya) were tested across five salt stress locations in Random Block Design with three replications. The entry 1701 didn't come to

Table 32 : Soil status at different locations under IVT-AL&ISTVT Trial-2015

S. No	Locations	Local Check	Gross Plot Size	Net Plot size	Date of Sowing	Date of Planting	pH_2	EC (dS m^{-1})
1	Nain	CSR 23	9.0 m^2	5.0 m^2	9.06.2015	15.07.2015	7.20	10.0
2	Jind	CSR 36	9.0 m^2	5.0 m^2	9.06.2015	8.07.2015	9.6	2.0
3	Kurukshetra	CSR 36	8.8 m^2	5.0 m^2	9.06.2015	8.07.2015	9.6	2.0
4	High Salinity-Karnal	CSR 23	0.45 m^2	0.39 m^2	9.06.2015	10.07.2015	7.5	8.0
5	Moderate Sodicity-Karnal	CSR 36	0.45 m^2	0.39 m^2	9.06.2015	10.07.2015	9.5	2

flowering at all the testing locations. Under salinity stress at Karnal, seven entries outperformed the local check CSR 23. Two entries 1702 and 1708 showed the highest grain yield (3.60 t ha^{-1}) followed by 1711 (3.54 t ha^{-1}), 1712 (3.39 t ha-1), 1715 (3.23 t ha^{-1}), 1703 (3.07 t ha^{-1}), 1705 (3.02 t ha^{-1}) and local check (2.98 t ha^{-1}). At Nain, Panipat, seven entries outperformed the local check. The grain yield ranged from 0.998 t ha^{-1} (1707) to 2.79 t ha^{-1} (1702). The entry 1702 showed the highest grain yield (2.77 ha^{-1}) followed by 1711 (2.67 t ha^{-1}), 1708 (2.64 t ha^{-1}), 1712 (2.62 t ha^{-1}), 1714 (2.38 t ha^{-1}), 1703 (2.35 t ha^{-1}), 1717 (2.33 t ha^{-1}) and local check (2.30 t ha^{-1}).

Under sodicity stress at Karnal, six entries performed better than local check. Entry 1702 showed the highest grain yield (4.21t ha^{-1}) followed by 1712 (4.14 t ha^{-1}), 1708 (4.11 t ha^{-1}), 1711 (4.03 t ha^{-1}), 1707 (3.73 t ha^{-1}), 1705 (3.79 t ha^{-1}) and local check (3.65 t ha^{-1}). At Jind, eight entries outperformed the local check. Entry 1702 showed the highest grain yield (3.86 t ha^{-1}) followed by 1713 (3.84 t ha^{-1}), 1711 (3.77 t ha^{-1}), 1708 (3.63 t ha^{-1}), 1712 (3.62 t ha^{-1}), 1705 (3.27 t ha^{-1}), 1704 (3.17 t ha^{-1}), 1703 (3.17 t ha^{-1}) and local check (2.96 t ha^{-1}). At Kurukshetra, five entries performed better than local check CSR 36. Entry 1702 showed the highest grain yield (3.99 t ha^{-1}) followed by 1711 (3.92 t ha^{-1}), 1708 (3.91t ha^{-1}), 1712 (3.86 t ha^{-1}), 1705 (3.44 t ha^{-1}), and local check (3.34 t ha^{-1}).

B. Station Trials

Monitoring, maintenance and development of breeding materials

Multiplication of F2's during Kharif 2015

Different combination of crosses made during Kharif 2014 to combine the yield and salt tolerance in rice were multiplied during 2015. These cross complication were MTU 1010 × CSR 27, MTU 1010 × CSR 11, MTU 1001 × CSR 27, MTU 1001 × CSR 11, CSR 30 × Vandana, CSR 30 × CSR 11, CSR 30 × CSR 27, CSR 30 × PB 3, CSR 30 × Jaya, CSR 30 × HUBR 10-9, CSR 30 × CSR 8, Pusa 44 × CSR 27 and MAUB 13 × CSR 30. The corresponding F_1 were sown during Kharif, 2015 to generate F_2 populations.

Screening and selection of F_4 populations

A total of 43 segregating populations (Table 33) were screened under high salinity (EC_{iw} ~ 12 dSM^{-1}) in microplots. The top 10 progenies were selected from each segregating population for further screening/evaluation in the next cropping season.

Table 33 : List of F3 populations advanced for next generation under stress conditions.

S.No.	F_4s	S.No.	F_4s	No.	F_4s
1	IR 64 × CSR36	16	IR 64 × CSR30	31	PS2 × CSR27
2	HKR126 × CSR 27	17	Vandna × CSR 36	32	PS5 × CSR36
3	Sahabhagi Dhan × CSR 36	18	PS5 × CSR30	33	BAS 370 × CSR 10
4	PS3 × CSR30	19	IR 64 × CSR10	34	Hazaridhan × CSR 27
5	PUSA1121 × CSR10	20	Sahabhagi Dhan × CSR 27	35	PUSA1121 × CSR10
6	PS5 × CSR10	21	PR 114 × CSR 27	36	CSR 36 × FL478
7	Sahabhagi Dhan	22	PS5 × CSR27	37	Hazaridhan × CSR 10
8	Anjali × CSR 10	23	PUSA1121 × CSR30	38	Trichy × CSR27
9	PS2 × CSR36	24	BAS 370 × CSR 30	39	Vandna × CSR 27
10	PUSA1121 × CSR27	25	HKR126 × CSR 10	40	NDR 359 × FL478
11	PS2 × CSR30	26	PUSA 44 × CSR 36	41	Anjali × CSR 27
12	PUSA 44 × CSR 10	27	Trichy × CSR10	42	Sarjoo 52 × CSR36
13	Anjali × CSR 36	28	Hazaridhan × CSR 36	43	PR 115 × CSR 27
14	PS3 × CSR36	29	PUSA 44 × CSR 27		
15	PAU 201 × CSR10	30	HKR126 × FL478		

Screening and selection of F6 populations

A total of 24 segregating populations 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, salt tolerance and other traits for further screening/evaluation in the next cropping season

International Rice Soil Stress Tolerance Nursery (IRSSTON Trial) 2015

The 35th International Rice Soil Stress Tolerance Nursery (Modules-2) consisting of 49 rice genotypes was evaluated at high saline stress (EC~10.0 dS m^{-1}) in micro plots with three replications in *Kharif*, 2015. The genotypes namely, IR 58443-6B-10-3 (3.30 t ha^{-1}), IRRI 147 (3.17 t ha^{-1}), IRRI 123 (3.13 t ha^{-1}), Local Check 2 (CSR 23) (2.22 t ha^{-1}), IR14T132 (2.3 t ha^{-1}), IR11T182 (2.12 t ha^{-1}), IR 45427-2B-2-2B-1-1 (2.04 t ha^{-1}), Local Check 1 (CSR 36) (2.0 t ha^{-1}), IR14T101 (1.82 t ha^{-1}) and IR12T133 (1.67 t ha^{-1}) performed better (Fig. 22) among the genotypes tested under high salinity stress.

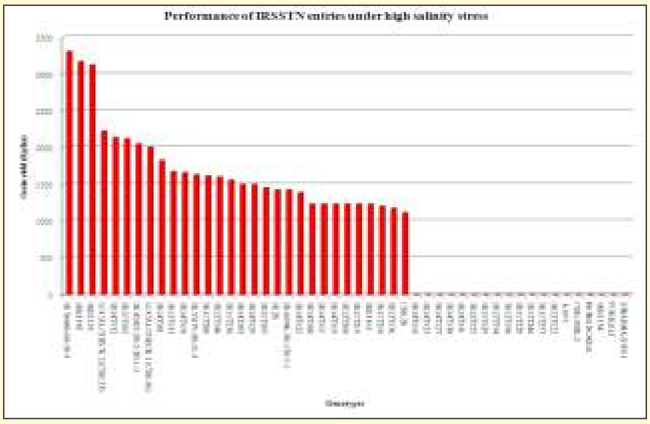


Fig. 22 : Performance of IRSSTON entries under high salinity stress

Performance of Bulk 18 (IET 23210) in AL & ISTVT Trial

The performance of Bulk 18 (IET 23210) was consistently high under inland salinity for three successive years (2012, 2013 and 2014) (Table 34). This entry registered ≥ 5% mean increase in yield over the best check for 3 years under inland saline conditions. It registered 17.4% yield advantage over the best check (CSR 23) in 2012; 25.6 % over local check in 2013 and 16.2 % over CSR 10 (best check) in 2014. Further, the entry IET 23210 out yielded the best check for 3 consecutive years (2012 to 2014) in Haryana. It showed yield gain of 17. 4% in 2012, 28.2 % in 2013 over CSR 23 and 13.3 % in 2014 over local check (Table 35). Therefore, IET 23210 can be considered promising under inland salinity situation.

Production and maintenance of advanced bulks, segregating lines and germplasm

A total of 176 segregating lines derived from different crosses and a total of 655 genetic stocks including 276 IRRI lines were grown in the field for

Table 34 : Summary performance of promising entry IET 23210 during 2012 - 2014 in AL & ISTVT

S. No.	IET No.	Year of testing	Yield improvement (%) over best check under Inland Salinity
1	23210 (Bulk 18)	I Year 2012	17.4 (CSR 23)
		II Year 2013	25.6 (Local Check)
		III Year 2014	16 (CSR 10)

Table 35 : Performance of promising entry IET 23210 during 2012-14 under AL & ISTVT in Haryana

S. No.	IET No.	Year of testing	Increased Yield (%) over best check in Haryana (Inland salinity)
1	23210 (Bulk 18)	I Year 2012	17.4 (CSR 23)
		II Year 2013	28.2 (CSR 23)
		III Year 2014	13.3 (Local Check)

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.

Breeder seed production

Breeder seed of the salt tolerant rice varieties i.e., CSR 10 (50 Kg), CSR 13 (1.0 Kg), CSR 23 (1.0 Kg), CSR 27 (1.0 Kg), CSR 30 (2700 Kg) CSR36 (1300 Kg) and CSR 43 (2000 Kg) was produced to meet the demand of seed producing agencies as per DAC (Department of Agriculture and Cooperation) requirement.

National project on transgenics in crops-salinity tolerance in rice: Functional genomics component (ICAR funded) (S.L. Krishnamurthy, P.C. Sharma, Ravi Kiran, K.T and V. Vinod)

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 ICAR-CSSRI (for phenotyping) and ICAR-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 randomized block design with two replications under 4 environments [normal, low salinity (EC_{iw} ~ 3.0 dS m^{-1}), moderate salinity (EC_{iw} ~ 6.0 dS m^{-1}) and high salinity (EC_{iw} ~12 dS m^{-1}) micro plots] during Kharif 2015.

The range, mean and percent reduction over normal of different traits for RIL population were recorded during 2015. The grain yield per plant ranged from 5.60g (RIL 1106) to 44.40g (RIL 31) in normal soil, 3.50g (RIL 62) to 26.90g (RIL 178) at low salinity, 0.002g (RIL 183) to 7.93g (RIL 163) at moderate salinity and 0.002g (RIL 22) to 3.92g (CSR 27) at high salinity. The spikelet fertility ranged from 49.12% (RIL 78) to 97.48% (RIL 150), 36.10% (RIL 78) to 90.32% (RIL 209), 1.92% (RIL 183) to 71.21% (RIL 163) and 1.59% (RIL 159) to 55.89% (RIL 173) under normal, low salinity, moderate salinity and high salinity, respectively. The highest spikelet fertility of 55.89 % under high salinity stress was observed in RIL 173. Top 10 RILs with high spikelet fertility (%) under normal, moderate

Table 36: Top 10 recombinants for spikelet fertility (%) derived from RIL 41 and RIL 44 of CSR 27x MI 48 RIL under normal, low, moderate and high salinity stress

S. No.	Normal		Low Salinity (EC_{iw} ~ 3.0 dS m^{-1})		Moderate Salinity (EC_{iw} ~ 6.0 dS m^{-1})		High Salinity (EC_{iw} ~ 12.0 dS m^{-1})	
1	RIL 150	97.48	RIL 209	90.32	RIL 163	71.21	RIL 173	55.89
2	RIL 134	97.19	RIL 221	89.64	RIL 173	69.63	RIL 196	55.20
3	RIL 92	96.97	RIL 36	89.29	RIL 170	65.61	RIL 75	48.84
4	RIL 35	96.77	RIL 29	89.13	RIL 111	63.37	RIL 199	45.17
5	RIL 27	96.65	RIL 42	88.43	RIL 204	61.65	CSR 27	44.84
6	RIL 209	96.34	RIL 179	88.35	RIL 196	61.08	RIL 200	41.18
7	RIL 23	96.24	RIL 94	88.05	RIL 75	59.35	RIL 42	38.82
8	RIL 36	96.22	RIL 44	87.76	RIL 160	56.76	RIL 43	38.82
9	RIL 29	96.21	RIL 134	86.25	CSR 27	55.34	RIL 194	37.83
10	RIL 182	96.00	RIL 163	84.11	RIL 193	54.12	RIL 44	37.60

Table 37: Top 10 genotypes for grain yield per plant under normal, low, moderate and high salinity stress

S. No.	Normal		Low Salinity (EC_{iw} ~ 3.0 dS m^{-1})		Moderate Salinity (EC_{iw} ~ 6.0 dS m^{-1})		High Salinity (EC_{iw} ~ 12.0 dS m^{-1})	
1	RIL 31	44.40	RIL 178	26.90	RIL 163	7.93	CSR 27	3.92
2	RIL 119	40.92	RIL 207	23.92	CSR 27	4.88	RIL 193	3.24
3	RIL 58	37.30	RIL 177	23.80	RIL 193	4.48	RIL 44	3.20
4	RIL 89	37.00	RIL 192	23.10	RIL 44	4.40	RIL 196	2.36
5	RIL 178	33.00	RIL 208	20.50	RIL 192	3.44	RIL 195	2.08
6	RIL 150	32.24	RIL 181	20.40	RIL 195	3.26	RIL 173	1.96
7	RIL 206	32.00	RIL 209	19.36	RIL 196	2.96	RIL 75	1.68
8	RIL 149	31.44	RIL 166	18.60	RIL 215	2.62	RIL 198	1.48
9	RIL 59	30.60	RIL 179	18.50	RIL 187	2.60	RIL 43	1.40
10	RIL 192	30.50	RIL 180	18.40	RIL 219	2.60	RIL 45	1.36

salinity and high salinity stresses are presented in Table 36. The top 10 lines based on grain yield under different salinity stress are presented in Table 37 .

Development and maintenance of mapping populations and germpalsm

Different combination of crosses made during Kharif 2014 to develop different mapping population in rice were multiplied during 2015.

Development and advancement of new mapping populations

1. BPT 5204 x Kalanamak (F_1 to F_2)
2. CSR 30 x Kalanamak (F_1 to F_2)
3. PB 1 x Kalanamak (F_1 to F_2)

Molecular genetic analysis of resistance / tolerance in rice, wheat, chickpea and mustard including sheath blight complex genomics - Rice (Sub-project 1) - CSSRI, Karnal (S.L. Krishnamurthy, P.C. Sharma and Ravi Kiran, K.T.)

The main aim of this project is to map the important genomic regions/QTLs controlling sodicity tolerance traits in rice. This is a network project involving various components with salinity / sodicity component being dealt by ICAR-CSSRI, Karnal.

Phenotyping of mapping population (Trichy / Pusa Basmati 1) for sodicity tolerance

A total of 225 genotypes including 215 RILs along with parents were evaluated in replicated Simple Lattice Design in three environments [normal, moderate sodic (pH2 ~ 9.5) and high sodic (pH2 ~ 9.9 soil conditions] during Kharif 2015. The range, mean and per cent reduction of different traits for RIL population were recorded during 2015 (Table 38 & 39.). In general, high mean for grain yield and other, related traits was recorded on normal soil as compared to moderate and high sodicity stresses. The grain yield per plant ranged from 3.50g (RIL 109) to 22.55g (RIL 31) under normal, 0.77g (RIL 150) to 8.40g (RIL 43) at moderate sodicity and 0.10g (RIL 81) to 5.80g (RIL 42) at high sodicity. Similarly, the spikelet fertility ranged from 25.93% (RIL 109) to 92.67% (RIL 107) under normal, 25.41% (RIL 109) to 79.79% (RIL 2) at moderate sodic and 1.06% (RIL 194) to 74.25% (RIL 93) under high sodicity. The grain yield and biomass were the most sensitive traits and were reduced by 61.16% and 47.12% respectively, followed by grains per panicle, harvest index, plant height,

Table 38: Mean, range and per cent reduction for different traits of Recombinant Inbred Lines derived from Trichy × Pusa Basmati 1 under normal, moderate and high sodicity stress

Traits	Mean			Range			% Reduction	
	Normal	Mod. Sodic	High Sodic	Normal	Mod. Sodic	High Sodic	Mod. Sodic	High Sodic
Grains per panicle	103.33	56.75	22.99	44.90 - 165.9	22.5 - 112.10	0.75 - 71.8	45.08	77.75
Spikelet fertility (%)	77.20	61.41	32.86	25.93 - 92.67	25.41 - 79.79	1.06- 74.25	20.45	57.44
Biological yield per plant (g)	37.99	20.09	11.84	21.80 - 73.80	9.35 - 33.60	3.80 -26.60	47.12	68.84
Grain yield per plant (g)	9.88	3.84	1.51	3.50 - 22.55	0.77 - 8.40	0.10 - 5.80	61.16	84.69
Harvest index (%)	25.91	18.56	12.69	12.95 - 39.72	6.13 - 30.37	1.56 - 25.36	28.36	51.02

total tillers per plant, productive tillers per plant, spikelet fertility and panicle length under moderate sodicity stress. The grain yield was reduced by 84.69% under high sodicity followed by grains per panicle, biomass, spikelet fertility, productive tillers per plant, harvest index, plant height, total tillers per plant and panicle length. The top 10 lines based on grain yield under normal, moderate sodicity and high sodicity stress are presented in Table 30. The top 10 lines showed less per cent reduction for grain yield under moderate and high sodicity stress are presented in Table 40.

Stress tolerant rice for poor farmers of Africa and South Asia (STRASA Phase 3)

(S.L. Krishnamurthy, P.C. Sharma and Ravi Kiran, K.T.)

The experimental material comprised of 30 rice genotypes which were collected from various national and international institutes to assess their performance under saline and sodic stress conditions (Table 41). The genotypes were evaluated in randomized complete block design with three replications during wet season of Kharif

Table 39: Top 10 RILs for high grain yield per plant under normal, moderate and high sodicity stress

S. No.	Normal		Moderate Sodic (pH_2 ~9.5)		High Sodic (pH_2 ~9.9)	
1	RIL 31	22.55	RIL 43	8.40	RIL 42	5.80
2	RIL 145	22.30	RIL 129	8.02	RIL 27	5.00
3	RIL 59	22.25	RIL 30	7.16	RIL 93	4.40
4	RIL 173	20.65	RIL 32	7.02	RIL 95	3.83
5	RIL 43	19.25	RIL 84	6.82	RIL 140	3.80
6	RIL 30	18.50	RIL 156	6.74	RIL 134	3.60
7	RIL 201	18.50	RIL 160	6.66	RIL 180	3.44
8	RIL 156	18.35	RIL 97	6.64	RIL 97	3.37
9	RIL 161	18.27	RIL 31	6.63	RIL 136	3.04
10	RIL 130	17.90	RIL 130	6.52	RIL 22	3.00

Table 40. Top 10 RILs showing less percent reduction for grain yield under moderate (pH_2~ 9.5) and high (pH_2~ 9.5) sodicity stress

S. No.	Moderate Sodicity (pH_2 9.5)		High Sodicity (pH_2 9.9)	
	Genotypes	% reduction	Genotypes	%reduction
1	RIL 32	20.23	RIL 27	35.23
2	RIL 127	22.40	RIL 93	47.93
3	RIL 100	29.47	RIL 42	51.05
4	RIL 8	29.56	RIL 140	51.41
5	RIL 82	29.57	RIL 22	58.90
6	RIL 97	30.11	RIL 97	64.58
7	RIL 109	30.86	RIL 13	66.86
8	RIL 140	33.76	RIL 67	66.98
9	RIL 27	34.46	RIL 95	67.58
10	RIL 93	34.67	RIL 135	67.89

Table 41 : List of genotypes with their geographical location

S. No.	Genotypes	Source
1	IR 87830-B-SDO1-2-3-B	IRRI, Philippines
2	IR 87938-1-1-3-2-1-B	IRRI, Philippines
3	IR 87830-B-SDO2-1-3-B	IRRI, Philippines
4	IR 87938-1-2-2-1-3-B	IRRI, Philippines
5	IR 87831-3-1-1-2-2-BAY B	IRRI, Philippines
6	IR 87938-1-1-2-1-3-B	IRRI, Philippines
7	IR 87938-1-1-2-3-3-B	IRRI, Philippines
8	IR 87938-1-2-2-2-1-B	IRRI, Philippines
9	IR 87937-6-1-3-2-2-B	IRRI, Philippines
10	IR 87952-1-1-1-2-3-B	IRRI, Philippines
11	IR 84645-305-6-1-1-1	IRRI, Philippines
12	IR87848-301-2-1-3-B	IRRI, Philippines
13	IR 87948-6-1-1-1-3-B	IRRI, Philippines
14	CSR-2K-232	CSSRI, Karnal
15	CSR-2K-228	CSSRI, Karnal
16	BULK 216	CSSRI, Karnal
17	RYT - 3207	PAU, Ludhiana
18	CSRC(D) 7-0-4	RRS CSSRI, Canning town
19	GMS 8-3-2-1-2	CSS, Kolkota
20	KR 09011	PANJANCOA, Karaikal
21	TR 05-031	Trichy
22	TR 13-083	Trichy
23	NDRK 11-13	NDUAT, Faizabad
24	CSAR 1209	CSA Kanpur
25	RAU-1478-5-4-3-2-2-2	RAU Pusa Bihar
26	PUSA 44	Check (Sensitive)
27	CST 7-1	Check (Coastal Saline)
28	CSR 27	Check (Inland Saline)
29	CSR 36	Check (Alkaline)
30	Local Check	Local Check

Table 42 : Mean and range of grain yield and yield attributing traits under high sodicity (pH_2 ~ 9.9), high salinity (EC_{iw} ~ 10 dS m^{-1}) and high salinity at Nain Farm (EC_{iw} ~ 11 dS m^{-1})

S. No.	Traits	Mean			Range		
		High Sodic (pH_2~ 9.9)	Saline (EC_{iw} ~ 10 dS m^{-1})	Nain Farm (EC ~ 11 dS m^{-1})	High Sodic (pH_2~ 9.9)	Saline (EC_{iw} ~ 10 dS m^{-1})	Nain Farm (EC ~ 11 dS m^{-1})
1	Productive tillers/plant	4.70	4.82	7.74	2.67 - 7.67	2.80 - 6.80	5.20 - 9.73
2	Spikelet fertility (%)	39.80	39.72	35.50	10.50 -64.97	11.25 -70.75	9.51 -60.37
3	Grain yield (Kg/ha)	1201.71	1690.45	1565.40	155 - 2604	289 - 3028	375 - 2235

2015 under three environments viz., natural salinity (Nain Farm), high salinity stress (ECiw ~10 dSm^{-1}) and high sodicity (pH_2~9.9) in microplots at CSSRI, Karnal. The 35-day old seedlings from wet bed nurseries were transplanted @ two seedlings per hill with a spacing of 15 × 20 cm. Basal fertilizer dose for the main crop was 120-60-60 kg of NPK ha^{-1}. The recommended agronomic practices were followed to raise a healthy crop. Twenty one days after the transplanting, salinity was imposed by using 7 NaCl: 1 Na_2SO_4: 2 $CaCl_2$ on equivalent basis. Five randomly selected plants were tagged from each genotype in each replication and data were recorded for the following traits: days to 50% flowering, plant height (cm), stress score at vegetative stage, total tillers/plant, productive tillers/plant, panicle length (cm), grains per panicle, spikelet fertility (%), 1000 seed weight, stress score at reproductive stage and grain yield (t ha^{-1}).

Mean and range of grain yield and yield attributing traits under high sodicity (pH_2 ~ 9.9), high salinity (EC_{iw} ~ 10 dS m^{-1}) and high salinity (EC_{iw} ~ 11 dS m^{-1}) at Nain Farm are presented in Table 42. Top five entries with respect to grain yield under high sodicity (pH_2 ~ 9.9) were BULK 216 (2.60 t ha^{-1}), IR 87948-6-1-1-1-3-B (2.58 t ha^{-1}), CSR-2K-228 (2.55 t ha^{-1}), CSR-2K-232 (2519 t ha^{-1}) and Local Check (2.23 t ha^{-1}). Under high salinity (EC_{iw}~10 dS m^{-1}) the entries that performed well were BULK 216 (3.03 t ha^{-1}), IR 87938-1-2-2-2-1-B (3.01 t ha^{-1}), TR 13-083 (2.99 t ha^{-1}), CSR-2K-228 (2.95 t ha^{-1}) and KR 09011 (2.94 t ha^{-1}). At Nain farm IR 87938-1-1-2-1-3-B (2.25 t ha^{-1}), BULK 216 (2.179 t ha^{-1}), IR 87938-1-2-2-1-3-B (2.18 t ha^{-1}), CSR-2K-228 (2.15 t ha^{-1}) and CSR-2K-232 (2.15 t ha^{-1}) gave higher yields.

Novel Genetics Stocks: Multi-parent advanced generation inter-crosses (MAGIC) among diverse genotypes to facilitate gene discovery for various traits in rice (S.L. Krishnamurthy and P.C. Sharma)

The main aim of this project is to tag essential novel salinity, bacterial blight (BB) and brown spot QTLs using the MAGIC population through phenotyping and genotyping. It is collaborative project between IRRI, Philippines, ICAR-CSSRI, Karnal (for salinity screening), ICAR-IIRR, Hyderabad and ANGRAU, Rice Research Station, Maruteru. A total of 407 genotypes including five checks received from IRRI, Philippines in 2015 were phenotyped for seedling stage salinity and sodicity tolerance. Screening for salt tolerance at seedling stage was performed in hydroponics using Yoshida culture solution under controlled conditions in the CSSRI transgenic glasshouse with 29-35°C/21°C day/night temperature. Two treatments, ~2 dS m^{-1} (normal) and 10 dS m^{-1} (saline) were imposed. Standard Evaluation Score (SES), root and shoot lengths were measured on 21st day after sowing. Simultaneously, three representative plants were sampled for Na^+ and K^+ estimation. For seedling stage sodicity tolerance, the seedlings were grown in sodic trays with pH of the soil maintained around 9.7-9.9. Each genotype was sown in a single row of 30 cm and one week after germination seedlings were thinned to ten per row. On 30th day after sowing, SES scores and plant height/shoot length were taken and seedlings were sampled for Na^+ and K^+ estimation. The mean, range and per cent reduction of different traits recorded during 2015 are presented in Table 43 .

Table 43 : Mean, range and percent reduction of root and shoot lengths under saline and sodic environments

Trait	Mean			Range			% reduction (saline)
	Normal	Saline	Sodic	Normal	Saline	Sodic	
Root length	9.63	7.40	-	2.33-21.3	2.27-14.50	-	23.%
Shoot length	35.40	24.58	14.17	19.20 – 61.80	14.40-35.73	6.44-48.48	30.56%
SES	1.00	6.65	7.65	1-1	3-9	3-9	

In general, all the genotypes showed a decrease in their root and shoot lengths with the degree of reduction varying across the genotypes. The root length (cm) ranged from 2.33 (IR 93347:21-B-7-7-5-1RGA-2RGA-1-B-B) to 21.3 (IR 93337:28-B-9-3-20-1RGA-2RGA-1-B-B) and 2.27 (IR 93327:27-B-8-19-6-1RGA-2RGA-1-B-B) to 14.50 (IR 93353:15-B-3-22-7-1RGA-2RGA-1-B-B) under normal and saline conditions respectively. The shoot length (cm)/ranged from 19.20 (IR 93336:31-B-16-23-6-1RGA-2RGA-1-B-B) to 61.80 (IR 93350:45-B-23-16-15-1RGA-2RGA-1-B-B), 14.40 (IR 93343:14-B-12-5-20-1RGA-2RGA-1-B-B) to 35.73 (IR 93347:2-B-10-14-4-1RGA-2RGA-1-B-B) and 6.44 (IR 93346:35-B-23-2-7-1RGA-2RGA-1-B-B) to 25.34 (IR 93341:59-B-3-13-10-1RGA-2RGA-1-B-B) under normal, saline and sodic conditions, respectively. Under salinity, shoot length suffered more than root length. Almost all the genotypes germinated under sodic conditions. Regarding SES, maximum no. of genotypes scored 7 under salinity and 9 under sodicity. While 45 genotypes were found salinity tolerant at seedling stage, while only two genotypes were found sodicity tolerant. However, 52 genotypes were found moderately tolerant to sodicity. The genotype IR 93331:14-B-9-16-8-1RGA-2RGA-1-B-B was found sodicity tolerant and simultaneously moderately tolerant to salinity. However, these morphological traits has to be correlated with the physiological traits i.e., Na^+ and K^+ accumulation in the plants for valid conclusions.

CRP on Agrobiodiversity - Evaluation of rice germplasm for salinity / sodicity (S.L. Krishnamurthy, P.C. Sharma and Ravi Kiran, K.T.)

A total of 660 genotypes including two checks (IR 29- sensitive check and FL478- tolerant check) received from IIRI, Hyderabad were phenotyped for seedling stage salinity tolerance. Screening for salt tolerance at seedling stage was performed in hydroponics using Yoshida culture solution under controlled conditions in the CSSRI transgenic glasshouse with 29-35°C/21°C day/night temperature. Two treatments ~2 dS m^{-1} (normal) and 12 dS m^{-1} (saline) were imposed. The nutrient solution was salinized on 14th day after sowing by adding NaCl. Standard Evaluation Score (SES), root and shoot lengths and root and shoot dry matter were measured on 21st day after sowing. The mean, range and per cent reduction of different traits recorded during 2015 and presented in Table 44.

In general, shoot length, root length, dry shoot weight and dry root weight were lower under salinized condition compared to control plants. Vigour score ranged from 1 to 5 under normal conditions and from 3 to 9 under saline conditions. Seven genotypes were found tolerant (score-3), 30 genotypes were moderately tolerant (score-5), 256 were moderately sensitive (score-7) and 369 genotypes were highly sensitive (score-9). Soot length ranged from 12.5 to 80.3 cm and from 5.30 to 49.67 cm with a mean of 46.41 cm and 29.68 cm under normal and saline treatments, respectively. The range of root length was between 1.2 to 19.5 cm and 0.7 to 18.33 cm with a mean of 9.67 and 7.18 under normal and saline conditions, respectively. Shoot fresh weight ranged from 0.07 to 62.8 g with a mean of 1.89 g under normal treatment while it ranged from 0.02 to 1.34 g with a mean of 0.36 g under saline conditions. Root fresh weight ranged from 0.02 to 1.02 g with a mean of 0.28 gm and 0.02 to 0.93 with a mean of 0.17 g under normal and saline treatments, respectively. The dry shoot weight was the most sensitive trait which showed a reduction of 80.87% over the normal followed by dry root weight (38.10%), shoot length (36.04%) and root length (25.75%).

Table 44 : Mean, range and per cent reduction for different traits under normal and high salinity stress.

Traits	Mean		Range		% reduction over normal
	Normal	Saline	Normal	Saline	
Vigour Score	1.30	7.96	1–5	3.0 - 9.0	-
Shoot Length (cm)	46.41	29.68	12.5 - 80.3	5.30 - 49.67	36.04
Root Length (cm)	9.67	7.18	1.2 - 19.5	0.70 - 18.33	25.75
Shoot fresh weight	1.89	0.36	0.07 - 62.8	0.02 - 1.34	80.87
Root fresh weight	0.28	0.17	0.02 - 1.02	0.02 - 0.93	38.10
Root-Shoot length ratio	0.22	0.24	0.09 - 0.67	0.06 - 0.68	-
Root-Shoot weight ratio	0.22	0.55	0.001 - 1.63	0.10 - 3.10	-

Evaluation of BAYER rice hybrids under salinity stress (Consultancy project) (P.C. Sharma, S.L. Krishnamurthy and D. K. Sharma)

Two hybrids, ARIZE 6444GOLD and INH 15126 received from Bayer Crop Sciences, Hyderabad were tested under fives stress levels, normal, moderate saline, high saline, moderate sodic and high sodic conditions (Table 45) in the microplots at Karnal during Kharif, 2015. Under normal soil, CSR 36 showed the highest grain yield of 7.05 t ha^{1}. While under moderate and high salinity conditions, the entry CSR 27 topped among all the genotypes with a grain yield of 2.86 t ha^{-1} and 1.18 t ha^{-1}, respectively. Under moderate and high sodic conditions, CSR 36 performed best with mean grain yield of 3.39 t ha^{-1} and 2.39 t ha^{-1} respectively. VSR 156 was the most sensitive under all stress levels and showed highest yield reduction as compared to normal soil. The Bayer hybrids could give at par yield with the check only under moderate stress levels. But under higher stress levels, their performance was significantly lower than the respective checks (Fig. 23). Under high saline conditions, the yields of these two genotypes were similar to the sensitive check VSR 156.

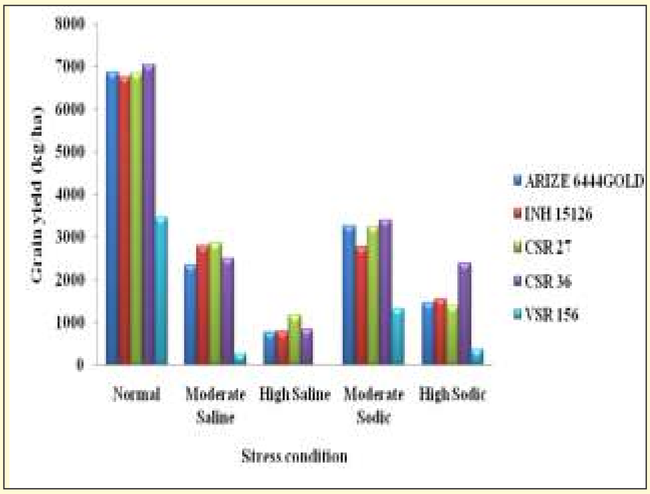


Fig. 23 : Mean grain yield (kg ha^{-1}) of rice genotypes under normal, moderate saline, high saline, moderate sodicity and highly sodic conditions.

Table 45 : Soil status and other experiment details of the different locations

S. N	Locations	Gross Plot Size	Net Plot size	Date of Sowing	Date of Planting	pH_2	EC (dS m^{-1})
1	Normal Sodic field	1.5 m^2	1.35 m^2	26-05-2015	30-06-2015	7.5	1.0
2	Moderate Sodicity	1.5 m^2	1.35 m^2	26-05-2015	30-06-2015	9.5	1.0
3	High Sodicity	1.5 m^2	1.35 m^2	26-05-2015	30-06-2015	9.9	1.0
4	Moderate salinity	1.5 m^2	1.35 m^2	26-05-2015	30-06-2015	7.5	6.0
5	High salinity	1.5 m^2	1.35 m^2	26-05-2015	30-06-2015	7.5	10.0

Genetic enhancement of wheat with respect to salt and waterlogging tolerance

(Arvind Kumar, P.C. Sharma and G. Gururaja Rao)

Salinity/Alkalinity Tolerance Varietal Trial 2014-15

During Rabi 2014-2015, the special trial on salinity/alkalinity comprising eight entries and three checks (KRL 19, KRL 210 and Kharchia 65) was conducted across three zones NWPZ, NEPZ and CZ at eight locations (Bawal, Hisar, Karnal, Dalipnagar, Faizabad, Lucknow, Vanasthali and Bharuch). The yield data from Lucknow was incomplete. Similarly, yield data from Vanasthali was incomplete and unrealistic. Therefore, these were not reported.

The trial mean ranged from 2.8 t ha^{-1} (Bharuch) to 3.82 t ha^{-1} (Bawal). The zonal mean yield of genotypes varied from 2.63 t ha^{-1} (Kharchia 65) to 3.59 t ha^{-1} (WH 1309). The variety WH 1309 was the highest yielding and ranked 1st among all the entries and was in the first significant group on zonal mean basis. It was statistically at par with three other entries namely DBW 182 (3.52 t ha^{-1}), KRL 210 (3.50 t ha^{-1}) and KRL 351 (3.37 t ha^{-1}). These entries together formed the first non-significant group.

In NEPZ, all the entries were affected by leaf blight with highest score of 67 recorded in DBW 184.With respect to brown rust, eight entries were either free or recorded very low of disease incidence except for Kharchia 65 (70S), WH 1301 (60 S) and KRL 210 (40S) at Hisar centre. Based on yield performance and disease reactions none of the entry was promoted for second year testing under salinity/alkalinity tolerance varietal trial 2015-16.

Salinity/Alkalinity Tolerance Screening Nursery (SATSN) trial 2014-15:

The nursery comprising of 60 test entries obtained from different wheat breeding centers of the country was evaluated along with three salt tolerant checks (Kharchia 65, KRL-19 and KRL 210) and one sensitive check (HD 2009) in an augmented randomized block design in 5 blocks (2 m plot with 3 rows spaced 20 cm apart). Each block comprised of 16 treatments (12 test entries + 4 checks interspersed within each block). The trials at DWR-Hisar and CSSRI-Lucknow failed. The yield data of six centers Karnal, Bawal, HAU-Hisar, Faizabad, Dilipnagar and Bharuch were considered for reporting. Out of 60 test entries in the nursery, 16 entries were out performing (in comparison to Kh. 65, KRL 19 and HD 2009) of which 7 entries (WH 1310, WS 1403, WS 1401, NW 6094, WS 1405, KA 1427 and RWP 2014-19) were found to be promising on basis of mean yield along with resistance to all the three rusts (stem, leaf and yellow rust) as evident from IPPSN 2014-15 data. These seven entries might be considered for testing in salinity/alkalinity trial to be conducted during 2015-16. Six lines of CSSRI, Karnal (KRS 1402, KRS 1404, KRS 1407, KRS 1412, KRS 1413 and KRS 1419) were found to perform better than the checks in which KRS 1402 KRS 1404 and KRS 1413 were placed in the top five group. However, unfortunately due to high rust reactions in IPPSN 2014-15 any of these entries might not be promoted in the salinity/alkalinity trial (Table 46).

Performance of the CSSRI, Lines under Uttar Pradesh State Varietal Trial

Uttar Pradesh State Varietal Trials were conducted at three locations i.e. Mathura (pH_2: 8.9) Hardoi (pH_2: 9.1) and Etawah (pH_2 : 9.3) during Kharif 2012-13 to Kharif 2014-15 with three salt tolerant checks (K-8334, NW 1067 and KRL 19). The variety KRL 283 performed better than other entries as well as all the checks across the location during 2012-13 to 2014-15. It showed yield superiority of 15.02% over K-8334, 13.68% over NW 1067 and 5.24% over KRL 19 (national check). KRL 330 and KRL 327 also showed 19 and 9.54 per cent yield advantage over the best check of Uttar Pradesh K-8334 (State check for alkaline/sodic stress). The performance of KRL 330 was consistently higher in terms of increasing per yield gain (5.25%, 9.24% and 12.99%) over the years (2012, 2013 and 2014) respectively, in comparison to KRL 19 as well other varieties. The performance of KRL 283, KRL 327 and KRL 330 was better for three successive years over the salt tolerant checks (K-8334, NW 1067 and KRL 19) under salt-affected locations of Uttar Pradesh (Table 47). Therefore, these promising entries were selected for promotion as new varieties for salt affected soils of Uttar Pradesh.

Table 46 : Mean performance of top 16 entries in SATSN across the locations

Entry	L1	L2	L3	L5	L4	L6	Mean	Over All Rank
WH 1310	317	492	719	558	386	396	478	1
KRS 1402	530	415	736	338	324	397	457	2
KRS 1413	330	655	584	373	449	335	454	3
LBP 2014 20	387	425	653	475	486	282	451	4
KRS 1404	517	415	574	261	486	387	440	5
WS 1403	347	455	611	480	336	390	437	6
WS 1401	357	505	690	320	286	460	436	7
WH 1311	375	825	475	208	318	395	433	8
NW 6094	342	442	589	488	361	326	425	9
WS 1405	287	555	377	485	486	354	424	10
KRS 1407	287	615	434	320	486	346	415	11
KRS 1419	450	615	495	308	293	309	412	12
KRS 1412	300	405	536	448	418	349	409	13
NW 6096	292	545	580	81	486	447	405	14
KA 1427	437	485	624	235	286	354	404	15
RWP 2014 -19	325	575	630	208	318	363	403	16
KRL 210 (C)	382	494	614	364	460	288	434	
HD 2009 (C)	170	496	271	264	230	238	278	
Kh. 65 (C)	280	456	457	221	335	382	355	
KRL 19 (C)	316	472	444	334	345	313	371	

L1- Bawal; L2- Dalipnagar; L3- CSSRI Karnal; L4- Faizabad; L5- Hisar (HAU); L6- Bharuch

In All India Coordinated Varietal Yield Trial (2009-10 to 2011-12), KRL 283 showed good yielding ability and salt tolerance with superiority in grain yield on two year's mean (35.94% 14.69% and 0.64%) over three salt tolerant checks i.e. Kharchia 65, KRL 19 and KRL 210 respectively. KRL 283 also possesses diverse genes (Sr_{2+31}+, $Lr_{26+23+,}$ Yr_{9+}) for rust resistance and is resistant to most of the prevalent rust pathotypes. KRL 283 is more resistant than available varieties (KRL 19, Kharchia 65 and KRL 210). Release proposal of the entry KRL 283 has been submitted to the UP State Varietal Release Committee.

Table : 47 Summary of the Uttar Pradesh State Varietal Trial (t ha^{-1}) conducted during 2012-13 to 2014-15

Year of testing	No. of Locations	KRL 283	KRL 330	KRL 327	Check 1 K-8334	Check 2 NW1067	Check 3 KRL 19
2012	3	2.37	2.33	2.08	1.97	2.11	2.21
2013	3	2.31	2.51	2.31	2.16	2.17	2.28
2014	2	1.33	1.39	1.33	1.12	1.05	1.23
Weighted Mean		**2.09**	**2.16**	**1.98**	**1.83**	**1.87**	**1.99**
% yield gain over the checks			KRL 283		15.02%	13.68%	5.24%
			KRL 330		18.98%	17.76%	8.68%
			KRL 327		9.54%	8.58%	0.09%

Introgression of desirable traits for improving yield, adaptation and resistance

During the crop season, a total of two hundred sixty crosses (160 Single Cross and 100 Three Way Cross) were attempted between 43 parents (18 salt tolerant lines developed at CSSRI and 25 higher yielding and disease resistant cultivars from different sources) made primarily for improving yield and adaptation to marginal lands (salt affected, waterlogged and elemental toxicities) and rust resistance. About 5-6 spikes were attempted for each combination. During this season, F_1 generations are being advanced. Shuttle breeding approach will be used to identify potential combinations for high yield and adaptation to marginal lands and also to make site specific selections.

Salt tolerant lines: Kharchia 65, KRL 1-4,KRL 3-4, KRL 35, KRL 99, KRL 210, KRL 213, KRL 283, KRL 325, KRL 326, KRL 327, KRL 329, KRL 330, KRL 332, KRL 336, KRL 346, KRL 349, KRL 350, KRL 351

High Yielding Varieties: WH 1105, WH 1146 ,NW 4018, NW 1014, PBW 65, PBW 58, PBW640, PBW 658, CSW 18, DBW 621-50, NK 14034, VL 941, RPS 560, HD 2009, HD 2160, HD 2851, HD 3086, HD 2967, UAS 320, UAS 321, UP 2338, UP 2763, HS 534, HS 545, HUW 640

Screening of segregating and advanced generation crosses

During this crop season, the breeding materials were evaluated with four checks namely KRL 210, KRL 213, KRL 283 and KRL 1-4 and selections were made on the basis of disease response and other desirable attributes (Table 48).

Table 48 : Selections made in different generations

Generation	Cross combination	Selections made
F_1	67	54
F_2	38	500 single spikes
F_3	50	300 single spikes
F_4	23	200 single spikes
F_5	12	180 single spikes
F_6	32	220 single spikes
F_8	48	Bulk seed
F_9	23	Bulk seed
F_{10}	29	Bulk seed

Germplasm collection and maintenance: Nearly 600 entries of working germplasm based on plant type, salt tolerance and productivity were maintained besides 400 doubled haploid lines of three different crosses (Ducula4/*2 Brookton, HD2329/Camm and D4-13/Tammarin Rock) for further use in the breeding programme.

Breeder and nucleus seed production: Breeder seed of CSSRI varieties KRL 210 (2.18 t) and KRL 213 (3.86 t) was produced at CSSRI Karnal farm for distribution to various seed producing agencies and also for farm sale to the growers. Nucleus seed of 20 lines (KRL entries) and of four released varieties KRL 1-4, KRL19, KRL 210 and KRL 213 were produced at CSSRI experimental farm for use in the next season.

Evaluation of advance generation bulks in CSSRI station Trial 2014-15: During the crop year 2014-15, 80 advance generation bulks were tested in Increased Block Design (Augmented Randomized Block Design) with five checks (KRL 210, KRL 99, KRL 3-4, KRL 19 and HD 4530) under normal (~pH_2 :8.2), and four salt stress environments, saline (5.1- 6.4 ds m^{-1}), and sodic high (pH_2 :9.4) in microplots and sodic high (pH_2 : 8.8 - 9.4) with waterlogged (WL) treatment under field conditions. The WL treatments were non – waterlogged (drained), and waterlogged for 15 days. The WL treatment was imposed at 21 days after sowing . Plants were watered weekly prior to WL treatment. When WL commenced, water was maintained 2-5 cm above the soil surface during waterlogging period. The material was artificially inoculated for different rust strains. Out of 80 advance bulks, 20 genotypes performed better than checks. On the basis of yield performance and other desirable traits, these 20 bulks were selected for further evaluation in the Salinity/Alkalinity Tolerance Screening Nursery (SATSN) and Initial Plant Pathological Screening Nursery.

Evaluation of wheat varieties for salt stress in microplots: Twenty three wheat varieties were evaluated for their performance under different grades of salt stresses i.e. normal (pH_2: ~8.2), normal (pH_2 ~8.2) + 20 days waterlogged, saline (EC_e: 5.9 dS m^{-1}), sodic (pH_2: 9.3) and sodic (pH_2 9.3)

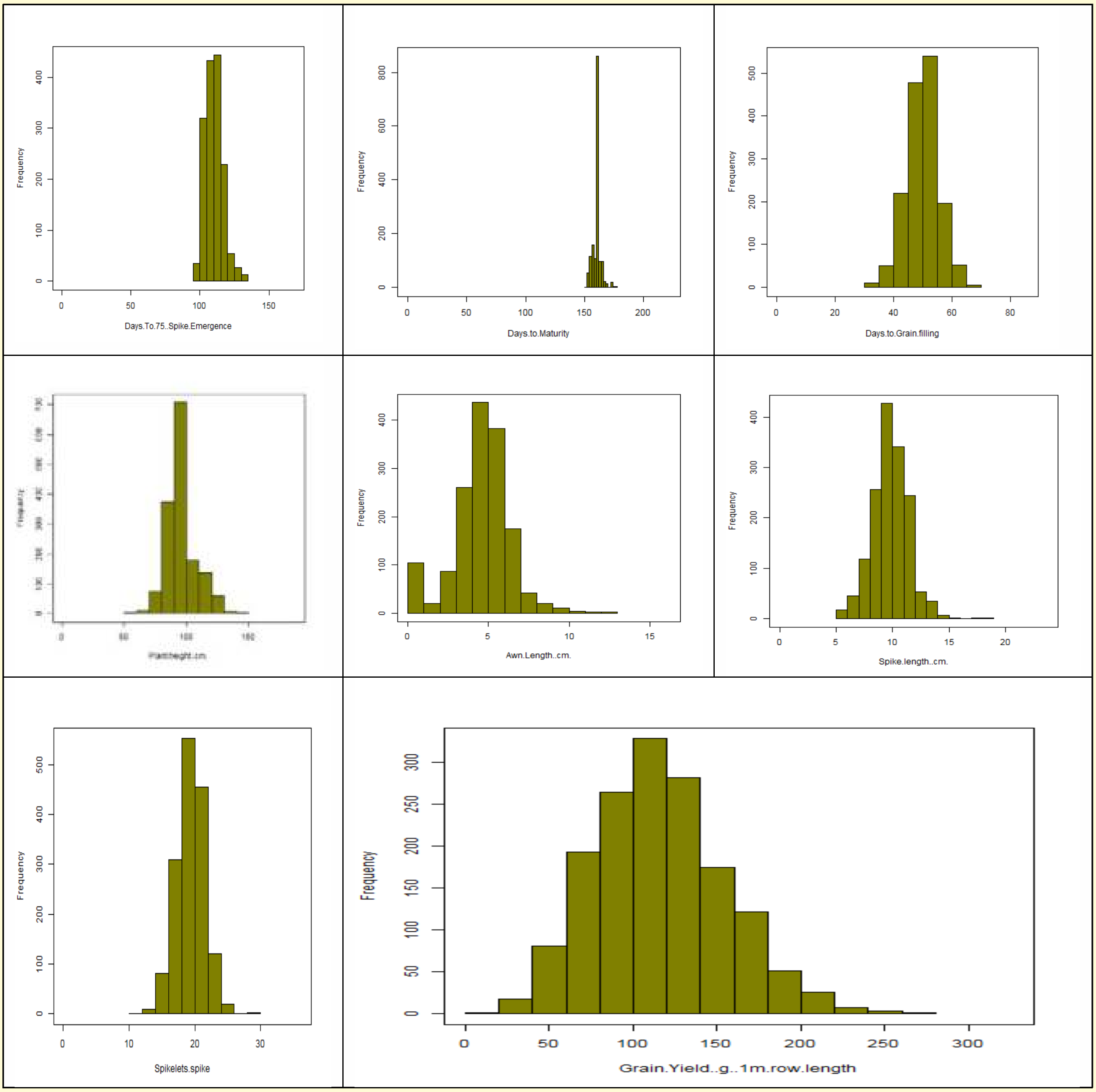


Fig. 24: Frequency distribution of average heading date (A), days to maturity (B), days to grain filing (C), plant height (D), awn length (E), spike length (F), spikelets per spike (G) and grain yield (H) of the germplasm accessions under sodicity (season 2014-15).

+ 20 days water logged in the microplots. Each genotype was replicated three times. The genotypes Kh. 65, KRL 3-4, KRL 99 and KRL 210 were found highly tolerant genotypes whereas KRL 19, KRL 350, KRL 351, KRL 213, KRL 240, KRL 330, and HD 2967 were found tolerant. While DW1, DW 3 and HD 4530 were the highly sensitive genotypes Ducula 4, Brookton, Krichauff, HD 2009, HD 2851, NW 1014, and NW 4018 were the sensitive genotypes.

Evaluation of bread wheat germplasm collection under sodic soil during Rabi 2014-15

Fourteen hundred and eighty three bread wheat germplasm lines (1309 Indigenous collections and 178 exotic collections) were evaluated under sodic conditions (pH 9.1) with five checks (HD 2967, RAJ 3765, C 306, HD 2009 and KRL 210) for their per se performance and salt tolerance through potential yield efficiency under mild salt stress. Germplasm lines were evaluated under Federer's Increased Block Design (Augmented Randomized Complete Block Design). Evaluation was based on eight quantitative (Days to 75% spike emergence, days to maturity, grain filling duration, plant height, awn length, spike length, No. spikelets per spike and grain yield/row length/m) and five qualitative characters (early growth vigour, growth habit, flag leaf angle glume colour and grain colour) recorded at different growth stages. Based on grain colour, 724 lines were amber in colour, 502 line white in colour and 324 lines were red in colour.

Considerable genetic variability was observed among germplasm lines as evident from range and coefficient of variation shown for yield attributes under sodicity (Fig. 24).Majority of the lines (69.19%) had erect growth habit of young plants; the lines with prostrate growth habit may be some landraces and old cultivars. Heading date was very variable, with a difference of 38 days between the earliest and the latest accessions. Plant height also showed a very high variation; ranging from 55 to 155cm, with an average of 97.4 cm. Maximum variability seems to be in awn length as 40% coefficient of variation was recorded for this particular trait. Grain yield/ g row length, on the contrary, was also extremely variable, from 19.8 to 260.8 g. The average number of spikelets per spike was 19, ranging from 11-29. The lines with short awns (10-40 cm) and with awns longer than 40 mm were the most represented (23.92% and 52.23%, respectively), while both longer awn (with > 60 mm long awns) and lines with very long awns (awns longer than spike) were much less frequent . Majority of the lines had poor early growth vigour (64.79%) and amber seeds (46.49 %).

Variability shown for different yield attributes suggest that there is great scope of improving yield attributes simultaneously to arrive at an ideal plant type for salt tolerance and high yield. Twenty eight genotypes were found better than checks (HD 2967, RAJ 3765, C 306, HD 2009 and KRL 210). These genotypes will be studied further for their yield potential and confirmation of the results for use as good source of salt tolerance.

Improvement of salt tolerance in wheat using molecular approach (P.C. Sharma and Arvind Kumar)

Phenotyping of the mapping population (Kharchia 65 x HD 2009)

A fixed population of Recombinant Inbred Lines (120 RILs) of T. *aestivum* derived from a cross between Kharchia 65 (Salt tolerant) x HD 2009 (Salt sensitive) was used. RILs were developed by single-seed descent until the F_8 generation at the CSSRI, Karnal. The phenotyping of these RILs was

Table 49: Trait means in parent and trait means, standard deviations (SD) and range in RILs of *Kharchia* 65 x HD 2009 population

Trait	Parental lines		Recombined Inbred Lines					
	Kharchia 65	HD 2009	Means	SD	Range	CV%	Skewness	Kurtosis
PH (cm)	123.9	95.43	102.25	13.21	67.20-137.40	12.92	-0.18	-0.04
GY (g)	139.02	69.1	73.34	29.92	3.20-166.60	40.80	0.34	0.64
BM(g)	397.5	180.53	203.30	81.28	14.40-418.0	39.98	0.36	-0.03
T	121.17	56.17	64.43	24.55	11.00-159.0	38.10	0.68	1.09
DM	158.17	154.67	156.50	5.51	149.00-175.0	3.52	1.04	0.91
Na^+%	1.88	1.78	1.90	0.48	1.03-3.29	25.29	0.28	-0.57
K^+%	2.66	2.4	1.62	0.54	0.73-3.48	33.06	1.12	1.85
K^+/Na^+	1.44	1.36	0.92	0.40	0.29-2.54	43.88	1.27	2.15
TI	-	-	0.6	0.2	0.10-1.00	37.1	-0.1	-0.7

PH – Plant height (cm), GY- Grain yield (g/ m row length) T- tillers /m row length, DM- days to maturity and TI- Tolerance index

Table 50 : Estimated correlations between measured traits for RILs population

	PH	GY	BM	T	DM	Na	K	K/Na
GY	0.171 ns							
BM	0.487**	0.761**						
T	0.336**	0.628**	0.846**					
DM	0.442**	-0.0 10ns	0.288**	0.159 ns				
Na	-0.085 ns	-0.145 ns	-0.149 ns	-0.069 ns	-0.131 ns			
K	-0.004 ns	-0.091 ns	-0.061 ns	0.044 ns	-0.049ns	-0.045ns		
K/Na	0.047 ns	-0.012 ns	0.043 ns	0.064 ns	0.096ns	-0.609**	0.789**	
TI	0.233**	0.615**	0.543**	0.472**	-0.036ns	-0.089ns	-0.183ns	-0.112 ns

PH – Plant height (cm), GY- Grain yield (g/ m row length) T- tillers /m row length,
DM- days to maturity and TI- Tolerance index; ** r is significance at levels of 0.1%

conducted in sodic microplots at pH_2 9.1 in an augmented randomized block design with five blocks and 24 test entries in each block with four checks (Kharchia 65, HD 2009, KRL 19 and HD 2851). Proprieties of the trait distribution were estimated by ANOVA analysis. According to Kurtosis and Skewness estimation trait distribution reflects the variability observed between studied lines. All the morphological and physiological values in the whole population showed a relatively normal distribution around a population mean that lies between the parental values. Some RILs had more extreme values than the parental lines showing a transgressive segregation; this is obvious for all traits under salt-stressed conditions (Table 49). RILs are inbred

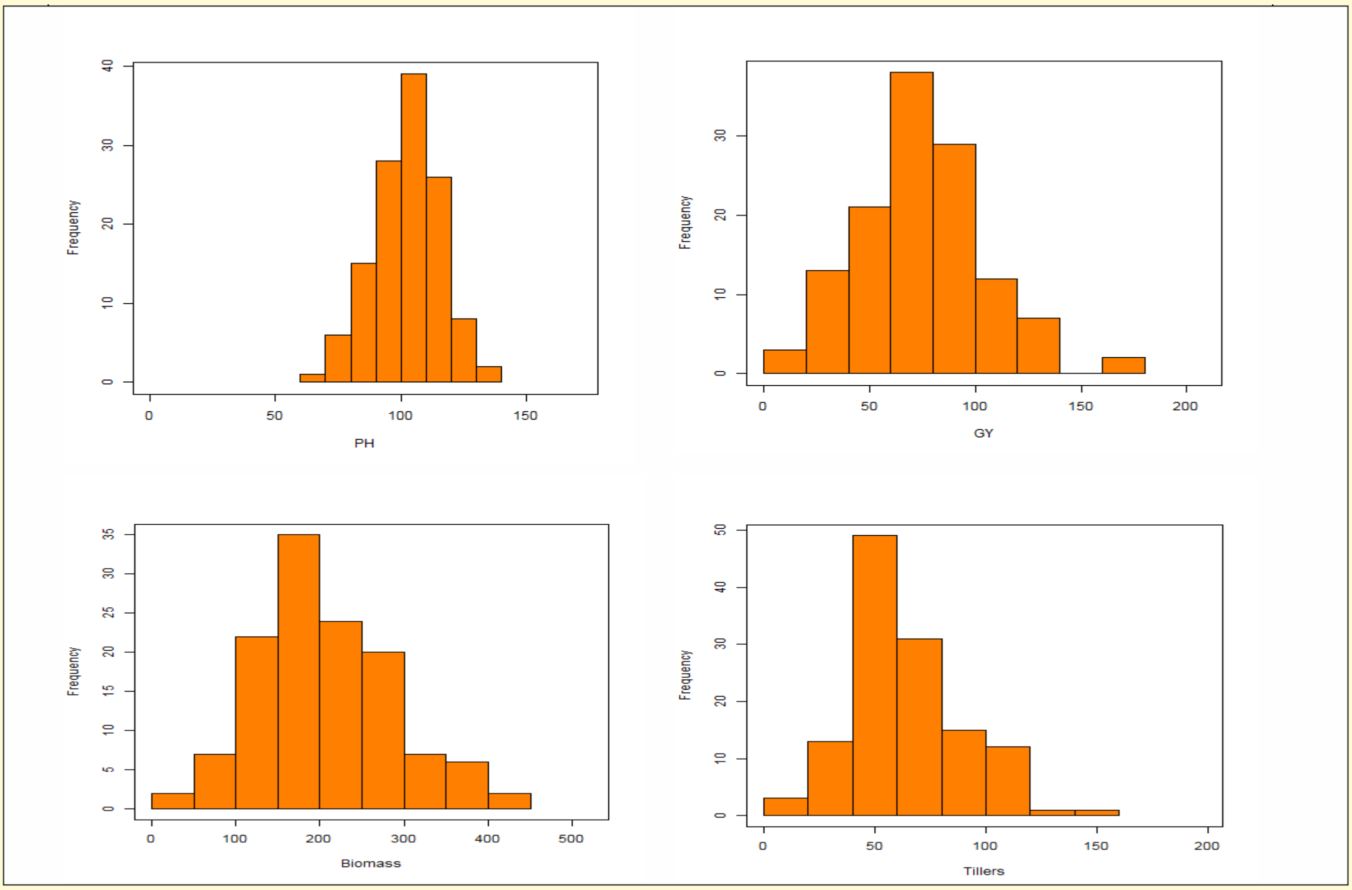


Fig. 25: Frequency distribution plots for plant height (PH), grain yield (GY). biomass (BM) and tiller number (TN) in RILs of Kharchia 65 x HD 2009

lines derived from a cross of two diverse parents in which the individual genes are resolved into homozygous progenies. If we construct a histogram on such a population, the number and size of phenotypic classes obtained is directly related to the number of genes influencing the trait (Fig.25). Height is the perfect example of quantitative inheritance where we expect large number of alleles acting additively to give normal distribution. Correlations between measured traits showed 13 significant out of 32 possible correlations under stress condition (Table 50) with twelve positive correlations. A strong positive correlation was observed between TI, grain yield, biomass and tillers. Negative association was observed between K/Na ratios with Na^+ contents. On the other hand, Na^+ and K^+ concentrations in leaves were not correlated with tolerance index and yield components in the studied mapping population.

Summary of Wheat Breeding Programme at Division

- KRL 283, KRL 327 and KRL 330 were found promising and selected for promotion as new varieties for salt affected soils of Uttar Pradesh. Release proposal of the entry KRL 283 has already been send to the UP State Varietal Release Committee and release proposals for KRL 327 and KRL 330 are under progress.
- KRL 238 entry performed better than the national check KRL 19 in three year testing under AICW&BIP trials as well as station trials. Based upon performance, it was selected for incorporation in U.P State Varietal Development Programme 2015-16.
- Twenty entries (KRL 370-390) were performing better than all the checks (Kh.65, KRL 19 and KRL 210) under station trials (conducted in saline/alkaline conditions). These entries were send for their evaluation under salinity/alkalinity nursery 2015-2016 and IPPSN 2015-16.
- About sixty quintal breeder seed (2.18 t of KRL 210 and 3.86 t of KRL 213) and nucleus seed of salt tolerant wheat varieties KRL210, KRL213, KRL19 and KRL1-4 was produced at Karnal for distribution to various seed producing agencies and farm sale to the farmers generating the revenue of Rs 3,62,813/-only.
- Two hundred sixty crosses (160 Single Cross and 100 Three Way Cross) were attempted between 43 parents (18 salt tolerant CSSRI lines and 25 higher yielding and disease resistant cultivars from different sources) during Rabi 2015.
- 1500 Wheat Germplasm lines were evaluated with five checks for salinity tolerance. Out of 1500 germplasm, 28 high yielding disease resistant germplasm were identified for future screening and improvement.
- Six hundred entries of working germplasm based on plant type, salt tolerance and productivity were maintained besides 400 doubled haploid lines of three different crosses (Ducula4/*2 Brookton, HD2329/Camm and D4-13/Tammarin Rock) were also maintained for further use in the breeding programmes.

Molecular genetic analysis of resistance / tolerance in rice, wheat, chickpea and mustard including sheath blight complex genomics - Wheat (Sub-project 2) - CSSRI, Karnal (P.C. Sharma, Arvind Kumar and Ashwani Kumar)

Soil samples have been collected from experimental sites and soil samples analysis is underway for pH_2, EC_2 and soil fertility status. Morpho-physiological traits like early seedling vigour, days to 75 % spike emergence, no. of tillers/meter and plant height (cm) in mapping population (KRL 99 X PBW 525) has been completed and data entry and statistical analysis are in progress. Chlorophyll content at booting stage using SPAD meter has been recorded and leaf samples have been collected and kept for drying in oven for Na^+, K^+, Ca^+ analysis. Morphological data for reproductive stage salt tolerance like spike length, no. of spikelets per spike, number of grains per spike, days to maturity, grain weight per spike (g), 1000 TKW (g) biomass yield and grain yield/plant (g) will be recorded at harvesting. Emasculation and pollination for the development of mapping population (KRL 99 x HD 2009) in 300 individuals has been completed.

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, Krishnamurthy S.L. and Preeti Rana)

This project is aimed to transfer major quantitative trait loci (QTL) for salinity tolerance into locally adapted high yielding rice varieties 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. 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. F_1s were used as male parent and recipient parent of previous 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. 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 the 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. 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_2F_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 seeds of BC_3F_3 were harvested in November, 2014

A total of 400 seeds of BC_33F_1 population along with parents were sown in hydroponics in glass house during February 2014 and used for further foreground and recombinant selection The markers RM 3412 was used for foreground selection and RM 493 and G11a were 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. These plants were selfed to produce BC_3F_2 seeds.

Seeds of selected BC_3F_2 plants along with parents were sown in field in kharif 2014. Almost 700 plants of each population were screened for fore ground and recombinant selection with markers RM 3412, RM 493 and G11a and 50-60 plant progenies were found desirable. Finally, 20 BC_3F_2 progenies of Pusa 44/FL478 and 33 BC_3F_2 progenies of Sarjoo 52/FL478 were selected after


Before stress (EC ~1.2 dS m^{-1})


After stress EC~10 dS m^{-1}

Fig 26 : BC_3F_4 lines of Pusa 44/ FL478 and Sarjoo52/FL478 before stress and after stress

Fig. 27 : Effect of salinity stress on NILs (Pusa 44/FL478) along with parents (Pusa 44, FL478) and check (IR29)

stringent phenotypic and genotypic selection. Selected plants were selfed to produce BC_3F_3 seeds. At maturity, seeds were harvested from each plant and stored carefully.

Production of BC_3F_4 seeds- BC_3F_3 seeds of two populations (Pusa 44/FL478 and Sarjoo 52/FL478) were sown in nursery in kharif 2015. Five lines of each NIL (Near Isogenic Line) were transplanted in the field in normal soil. One set of these BC_3F_3 lines of two populations have been sent to ICAR-NRCPB, New Delhi for background selection. For DUS (Distinctiveness, Uniformity and Stability) characterization of these lines, morphological traits were recorded in field while lab tests are in progress. BC_3F_4 seeds have been harvested from these lines and stored. (Fig. 26).

To validate the presence of Saltol QTL into these NILs, BC_3F_4 seeds along with parents (Pusa 44, Sarjoo 52, FL478) and check (IR29) were evaluated for seedling stage salinity tolerance under hydroponics. Two levels of salinity viz., 6 dS m^{-1} and 10 dS m^{-1} were applied to the 14 days old plants and data were recorded for SES score, shoot length, root length and fresh weight. Salt stress at EC_{iw} 10 dS m^{-1} significantly affected the growth of these NILs (Fig. 27). However; few lines were showing better performance than recurrent parent. Background selection and ionic analysis results will further clear the status of introgressed region from FL478 into these lines.

After the foreground and recombinant selection in BC_3F_1 generation, desirable plants were selected and BC_3F_2 seeds were harvested from these plants. These BC_3F_2 plants have been planted in glass house. Foreground and recombinant selection of these plants is in progress. Desirable BC_3F_2 plants will be identified after phenotypic and genotypic selection and BC_3F_3 seeds will be produced.

Cereal Systems Initiative for South Asia (CSISA) – Objective 2 (Strategic experimental platforms for future cereal systems) (NARES team: P.C. Sharma, Ashim Datta and D.K. Sharma; CGIAR team: H.S. Jat, R.K. Malik and A. McDonald)

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

At Karnal Research Platform, a set of conservation agriculture (CA) based cropping system management scenarios were compared with business as usual farmers practice in the region to address the issues of deteriorating natural resources, plateauing yields, water, labour and energy shortages and emerging challenge of extreme climate variability being faced by the farmers. Further objective was to design next generation of cereal systems that are highly productive, resource efficient, sustainable, and adapted to the expected changes in environmental and socioeconomic drivers. These near-production scales, long-term experiments have been designed to assess the performance of different agricultural systems (scenarios), using a wide range of indicators (crop rotation, tillage, crop establishment, crop, water and residue management). Four scenarios in the experiment are: Scenario I - Rice (puddled)-wheat (conventional) cropping system as in farmers' practice;

Scenario II- achieving higher yield in same cropping system by adding moongbean i.e. rice (puddled)-wheat (ZT)-mungbean (ZT). Scenario III- to address present day problems in agriculture by direct seeded rice (DSR)-wheat (ZT)-moongbean (ZT) cropping system, AND Scenario IV- futuristic one by replacing rice with maize in maize (ZT)-wheat (ZT)-mungbean (ZT) cropping system.

During rabi 2014-15, wheat cv. HD 2967 was sown in all the four scenarios. Seed yield significantly differed among different scenarios. In Scenario I, fields were kept fallow during summer 2015, whereas mungbean (cv. SML 668) was sown after wheat harvesting in other three scenarios. Whole biomass of moongbean was retained in the field itself. During kharif 2015, rice cv. Arize 6129 seedlings were transplanted in scenario I as per farmers' practice, while in Scenario II, rice cv. Arize 6129 seedlings were transplanted in line. In Scenario III, rice cv. Arize 6129 was directly sown using turbo seeder and maize cv. DKC 9125 was directly sown using multi-crop planter in Scenario IV. Significant differences were recorded in rice and maize yields in different scenarios (Table 51). In last six years of experimentation, around 79, 75 and 97 tones residue has been added in Scenarios II, III and IV, as per the plan outlined. Four Scenarios are being evaluated at research platform (RP-I) at Karnal. Results of Karnal Research Platform consistently demonstrate that CA based systems appear to be a suitable and profitable alternative to conventional rice-wheat system in Northwest India to address the issues of rising scarcity of water, labour, and energy. In 6th year, transplanted rice (Sc II) provided the higher yield (7.90 t ha^{-1}) and it was at par with Sc I and Sc IV. In 6th year, ZT wheat provided highest yield (5.41 t ha^{-1}) in Scenario IV (ZT maize-wheat-mungbean) followed by ZT rice (DSR)-what-mungbean (5.38 t ha^{-1}) and TPR-wheat-mungbean 5.38 t ha^{-1}. Water savings of around 24 and 70 % were recorded with DSR (Sc II) and maize (Sc IV), respectively over the business as usual. Highest system yield was recorded with Sc II compared to other scenarios. During wheat season 2014-15, water application in different scenarios ranged from 289 to 364 mm.

A new strategic research (RP-II) study has been initiated from Kharif 2014 at Karnal to explore the scope and implications of replacing rice with maize in northwest India by closely monitoring the risks involed. These include probability of secondary salinization by replacement of rice with maize, market volatilities and economic risks associated with large scale adoption of maize- a commodity not publically procured unlike rice. The highest yield (7.70 t ha^{-1}) of rice was recorded with Zero-till dry drill seeded rice (ZT-DSR) followed by ZT-Wheat over the PTR (puddled transplanted rice) and conventional till drill seeded rice (CT-DSR), whereas maize yield of 6.94 t ha^{-1} was recorded with maize-wheat-mungbean crop with recharge structure. Maize on permanent bed saved >35% of irrigation water as compared to ZT flats. However similar amount of saving in irrigation water was observed with DSR over PTR. The highest yield 5.52 t ha^{-1} of ZT wheat was recorded in ZT-DSR and CT-DSR followed by fresh bed CT-wheat 5.44 t ha^{-1}. The lowest yield 5.03 t ha^{-1} of wheat was recorded with permanent bed system ZT-Wheat over the PTR (puddled transplanted rice) and CT-DSR, whereas maize yield of 6.94 t ha^{-1} was recorded with maize-wheat-mungbean crop with recharge structure. Maize and wheat on permanent bed saved 29% and 13% of irrigation water, respectively, as compared to ZT flats. However, similar amount of saving in irrigation water was observed with DSR over PTR. However, ZT-DSR and ZT-wheat saved almost 28% and 12% of irrigation water over the farmer's practice or business as usual.

Table 51 : Crop productivity (t ha^{-1}) in different scenarios during 2015 cropping season

Scenario	Crop Yield (t ha^{-1})		
	Wheat 2014-15	Rice/maize 2015	System (rice equivalent)
I	5.01a	7.48a	12.49b
II	5.38a	7.90a	14.73a
III	5.38a	6.20b	12.33b
IV	5.41a	7.63a	13.08 b

It was also demonstrated that after four years, seed bank of *Phalaris minor* reduced by 90-100% in continuous ZT wheat with retention of previous crop residues (full rice or 65% maize residues) as mulch compared to conventional till system. Similarly, weed seed bank of other weed species *(Coronopus didymus, Melilotus alba, Rumex spp, Anagallis arvensis)* also declined in full CA-based cropping systems compared to conventional till system. Weed problem in wheat reduced over time, and hence herbicide use also decreased in continuous ZT with rice residue mulch compared to conventional system. From the last three years (2012-13 onwards), no or spot application of herbicide has been applied in ZT wheat plots for weed control. ZT and residue retention also increased soil C content in the upper 15 cm soil layer. After 5th wheat crop, soil C increased by 45% in zero-till rice-wheat-mungbean and by 42% in zero-till maize-wheat-mungbean systems, respectively compared to conventional rice-wheat system (0.47%). However in rice-wheat-mungbean (CT/TPR-ZT-ZT) system, soil C increased by 28% in the upper surface layer and by 24% in sub surface layer (15-30 cm) from the initial level. The availability of primary macro nutrients such as N, P and K varied under different CA based Scenarios. Scenario 3 recorded higher available N and P, whereas K was higher in Scenario 4 over other scenarios in the upper surface soil layer (0-15 cm). Diversifying the RWCS in IGP will improve the number of lignocellulose decomposing fungi as it was observed by metagenomics results in which CA based maize-wheat-mungbean system (Scenario 4) showed the highest activity/number of saprophytic fungi as compared to other scenarios.

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 five breeding lines including five checks (Kranti, CS 54, Varuna, CS 56 and Pusa Bold) were evaluated in IVT for seed yield in screening trial in reclaimed alkali soils (pH 8.1 to 9.5) at Karnal. Seed yield ranged from 1.08 to 1.88 t ha^{-1} (Mean 1.56 t ha^{-1}, CD (0.05%) 0.34 t). Fourteen lines gave significantly higher yield over the best check Varuna (1.48 t ha^{-1}) with CS 700-2-1-4 (1.88 t ha^{-1}) followed by CS 508-1P2 (1.85 t ha^{-1}) recording the maximum seed yield.

Further, thirty six breeding lines including five checks (Varuna, Pusa Bold, CS 54, Kranti and CS 56) were evaluated in AVT for seed yield in screening trial in reclaimed alkali soils (pH 8.1 to 9.5) at Karnal. Seed yield ranged from 1.14 to 2.29 t ha-1 (mean 1.11 t ha^{-1}, CD (0.05%) 0.50). Twenty six lines gave significantly higher yield over the best check CS 54 (1.69 t ha^{-1}) with CS 1500-1-1-3-2-1 (2.29 t ha^{-1}) followed by CS 15000-1-2-2-2-1 (2.26 t ha^{-1}) recording the maximum seed yield (Table).

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

Thirty five breeding lines including five checks (Kranti, CS 54, Varuna, CS 56 and Pusa Bold) 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). Seed yield ranged from 0.50 to 2.33 t ha^{-1} (mean 1.19 t ha^{-1}, CD (0.05%) 0.35 t). Twenty six lines gave significantly higher yield over the best check CS 54 (0.80 t ha^{-1}) with CS 1000-1-3-3-4 (2.33 t ha^{-1}) followed by CS 700-2-1-4 (2.27 t ha^{-1}) recording the maximum seed yield. In AVT, thirty six breeding lines including five checks (Varuna Pusa Bold, CS 54, Kranti and CS 56) were evaluated for seed yield in screening trial in saline soils (ECe 9.2-15.4 dS m^{-1}) at Nain Farm (Panipat). Seed yield ranged from 0.42 to 2.08 t ha^{-1} (mean 1.81 t ha^{-1}, CD (0.05%) 0.53 t). Twenty five lines gave significantly higher seed yield over best check Kranti (0.84 t ha^{-1}) with CS 15000-1-2-2-2-1 (2.08 t ha^{-1}) followed by CS 13000-3-2-2-5-2 (1.95 t ha^{-1}) giving the maximum seed yield.

Development and evaluation of segregating material (F_6 and F_8) of mustard in semi – reclaimed alkali soils

Seventy three breeding lines including seven checks (CS 2007-25, CS 2007-6, CS 54, Kranti, CS 56, Pusa Bold and Pusa Jaggnath) were evaluated in F6 generation for seed yield in reclaimed alkali soils (pH 8.1 to 9.5) at Karnal. Seed yield ranged from 0.82 to 1.98 t ha^{-1} (mean 1.50 t ha^{-1}, CD (0.05%) 0.43 t). Forty seven lines gave significantly higher seed yield over the best check CS 56 (1.38 t ha^{-1}) with CS 2013-51 (1.98 t ha^{-1}) followed by CS 2013-64 (1.90 t ha^{-1}) (Table 52)

Sixty six breeding lines including five checks (CS 54, Krishna, Kranti, Pusa Bold and CS 52) were evaluated in F8 generation for seed yield in reclaimed alkali soils (pH 8.1 to 9.5) at Karnal. Seed yield ranged from 0.80 to 1.86 t ha^{-1} (Mean 1.34 t ha^{-1}, CD (0.05%) 0.65 t). Thirty seven lines gave significantly higher seed yield over the best check CS 52 (1.31 t ha^{-1}) with CS 2009-335 (1.86 t ha^{-1}) followed by CS 2009-215 (1.79 t ha^{-1}) giving the maximum seed yield (Table 53).

Table 52 : Development and Evaluation of segregating material (F6)-2014-15

Sr. No.	Genotype	F_6Karnal Yield (t ha^{-1})	F_6 Nain Yield (t ha^{-1})	Sr. No.	Genotype	F_6 Karnal Yield (t ha^{-1})	F_6 Nain Yield (t ha^{-1})
1	CS 2013-1	1.60	1.19	38	CS 2013-38	1.49	0.44
2	CS 2013-2	1.54	0.77	39	CS 2013-39	1.52	0.94
3	CS 2013-3	1.78	1.28	40	CS 2013-40	1.39	0.45
4	CS 2013-4	1.33	1.68	41	CS 2013-41	1.50	0.58
5	CS 2013-5	1.36	1.90	42	CS 2013-42	1.47	0.54
6	CS 2013-6	1.14	0.64	43	CS 2013-43	1.71	0.55
7	CS 2013-7	1.43	1.11	44	CS 2013-44	1.66	0.45
8	CS 2013-8	1.28	1.44	45	CS 2013-45	1.41	0.58
9	CS 2013-9	1.60	0.75	46	CS 2013-46	1.33	0.91
10	CS 2013-10	1.29	0.75	47	CS 2013-47	1.77	0.77
11	CS 2013-11	1.18	0.89	48	CS 2013-48	1.40	0.50
12	CS 2013-12	1.40	0.86	49	CS 2013-49	1.35	0.50
13	CS 2013-13	1.60	0.36	50	CS 2013-50	1.53	0.64
14	CS 2013-14	1.76	1.15	51	CS 2013-51	1.98	1.00
15	CS 2013-15	1.26	1.52	52	CS 2013-52	1.81	0.78
16	CS 2013-16	1.71	0.75	53	CS 2013-53	1.69	0.56
17	CS 2013-17	1.25	0.91	54	CS 2013-54	1.51	1.02
18	CS 2013-18	1.25	0.79	55	CS 2013-55	1.54	0.49
19	CS 2013-19	1.41	0.96	56	CS 2013-56	1.60	0.64
20	CS 2013-20	1.56	0.84	57	CS 2013-57	1.70	0.55
21	CS 2013-21	1.69	0.61	58	CS 2013-58	1.76	0.59
22	CS 2013-22	1.65	0.60	59	CS 2013-59	1.71	0.54
23	CS 2013-23	1.88	0.45	60	CS 2013-60	1.63	0.59
24	CS 2013-24	1.53	0.55	61	CS 2013-61	1.44	0.56
25	CS 2013-25	1.77	0.46	62	CS 2013-62	1.60	0.55
26	CS 2013-26	1.69	1.19	63	CS 2013-63	1.48	0.99
27	CS 2013-27	1.71	0.79	64	CS 2013-64	1.90	1.17
28	CS 2013-28	1.50	0.98	65	CS 2013-65	1.69	0.59
29	CS 2013-29	1.70	0.82	66	CS 2013-66	1.68	0.60
30	CS 2013-30	1.01	0.50	67	CS 2007-25	1.27	0.59
31	CS 2013-31	1.13	0.47	68	CS 2007-6	1.13	0.62
32	CS 2013-32	1.06	0.45	69	CS 54	1.29	0.73
33	CS 2013-33	1.35	0.50	70	Kranti	1.20	0.35
34	CS 2013-34	1.06	0.53	71	CS 56	1.38	0.50
35	CS 2013-35	1.07	0.44	72	Pusa Bold	1.03	0.35
36	CS 2013-36	1.03	0.41	73	Pusa Jaggnath	0.82	0.35
37	CS 2013-37	1.32	0.49				
Mean						1.50	0.73
CD $_{5\%}$						0.43	0.44
Range						0.82-1.98	0.35-1.90
Best check						CS 56 (1.38)*	CS 54 (0.73)*
No. of Superior lines over best check						47	30
Top two lines						CS 2013-51 (1.98)*	CS 2013-5 (1.90)*
						CS 2013-64 (1.90)*	CS 2013-4 (1.68)*

***Figures in parentheses are yield (t ha^{-1})**

Table 53 : Development and Evaluation of segregating material (F_8)-2014-15

Sr. No.	Name of Genotype	Yield (t ha^{-1})	Sr. No.	Name of Genotype	Yield (t ha^{-1})
1	CS 2009 -103	1.39	34	CS 2009 -257	1.07
2	CS 2009 -105	1.10	35	CS 2009 -259	1.76
3	CS 2009 -106	1.30	36	CS 2009 -260	1.42
4	CS 2009 -112	1.15	37	CS 2009 -261	1.59
5	CS 2009 -118	1.18	38	CS 2009 -263	1.42
6	CS 2009 -130	0.91	39	CS 2009 -264	1.33
7	CS 2009 -138	1.09	40	CS 2009 -265	1.55
8	CS 2009 -140	1.09	41	CS 2009 -313	1.68
9	CS 2009 -144	1.16	42	CS 2009 -315	1.36
10	CS 2009 -151	1.09	43	CS 2009 -316	1.65
11	CS 2009 -154	1.36	44	CS 2009 -330	1.59
12	CS 2009 -156	1.15	45	CS 2009 -332	1.55
13	CS 2009-201	1.16	46	CS 2009 -333	1.64
14	CS 2009 -204	1.45	47	CS 2009 -334	1.49
15	CS 2009 -208	1.58	48	CS 2009 -335	1.86
16	CS 2009 -215	1.79	49	CS 2009 -336	1.47
17	CS 2009 -216	1.66	50	CS 2009 -340	1.35
18	CS 2009 -219	1.46	51	CS 2009 -341	1.21
19	CS 2009 -224	1.72	52	CS 2009 -345	1.53
20	CS 2009 -227	1.25	53	CS 2009 -346	1.46
21	CS 2009 -229	1.62	54	CS 2009 -347	1.35
22	CS 2009 -241	1.34	55	CS 2009 -401	1.26
23	CS 2009 -243	1.06	56	CS 2009 -413	1.33
24	CS 2009 -244	1.29	57	CS 2009 -414	1.18
25	CS 2009 -245	1.43	58	CS 2009-418	1.20
26	CS 2009 -246	1.13	59	CS 2009 -422	0.80
27	CS 2009 -247	1.40	60	CS 2009 -437	1.13
28	CS 2009 -248	1.25	61	CS 2009 -440	1.05
29	CS 2009 -250	1.68	62	CS 54	1.28
30	CS 2009 -251	1.36	63	Krishna	0.93
31	CS 2009 -253	1.45	64	Kranti	0.92
32	CS 2009 -255	1.68	65	Pusa Bold	0.92
33	CS 2009 -256	1.36	66	CS 52	1.31
Mean					1.34
CD 5%					0.65
Range					0.80-1.86
Best check					CS 52 (1.31)*
No. of Superior lines over best check					37
Top two lines					CS 2009 -335 (1.86)*
					CS 2009 -215 (1.79)*

*Figures in parentheses are yield (t ha^{-1})

Table 54 : Performance of mustard strains in IVT (saline/alkaline conditions)-2014-15

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-14-1	CS 7003-3-2-6	**2.34**	**2.13**	**2.24***	**5.4**	**4.9**	**5.5**	**39.9**
2	CSCN-14-2	TM 196	1.78	1.50	1.64	4.4	4.8	4.7	39.1
3	CSCN-14-3	Kranti (NC)	1.77	1.51	1.64	4.5	4.8	5.0	39.0
4	CSCN-14-4	CS 13000-3-2-2-5-2	1.89	1.50	1.70	5.5	4.8	5.0	38.8
5	CSCN-14-5	CS 2009-105	2.27	1.58	1.93	5.0	4.6	5.3	39.1
6	CSCN-14-6	CS 54 (NC)	**1.84**	**1.63**	**1.74**	**4.8**	**4.4**	**6.1**	**39.0**
7	CSCN-14-7	CS 2800-1-2-3-5-1	**2.29**	**1.90**	**2.10***	**5.1**	**4.9**	**5.3**	**39.3**
8	CSCN-14-8	RH 749 (Filler)	1.78	1.43	1.60	4.2	4.3	5.6	38.9
9	CSCN-14-9	RH 406 (Filler)	1.77	1.45	1.61	4.7	4.5	5.2	39.0
10	CSCN-14-10	DRMRIJ 31 (Filler)	1.79	1.44	1.61	5.0	4.3	4.4	39.2
		GM	1.95	1.61	1.78				
		CD (5%)	0.32	0.26					
		DOS	12.10.2014	18.10.2014					
		C.V.	9.59	9.53					
		ECe (dS m^{-1}) /pH	11.0	9.3					

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

Table 55 : Performance of mustard strains in AVT (saline/alkaline conditions)-2014-15

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-14-11	CS 1100-1-2-2-3	2.50	2.45	2.48*	5.0	5.1	4.5	39.9
2	CSCN-14-12	CS 13000-3-1-1-4-2	1.73	1.55	1.64	4.7	4.7	5.9	39.0
3	CSCN-14-13	CS 54 (LR)	1.87	1.67	1.77	4.4	4.9	5.4	39.0
4	CSCN-14-14	Kranti (NC)	1.71	1.54	1.62	4.2	4.0	4.2	39.1
5	CSCN-14-15	RH 406 (Filler)	1.80	1.58	1.69	4.6	4.4	4.7	39.1
6	CSCN-14-16	CS 8000-1-2-8	2.03	1.92	1.98	5.0	5.0	6.1	39.2
7	CSCN-14-17	DRMRIJ 31 (Filler)	1.72	1.51	1.62	4.5	4.8	5.1	39.0
8	CSCN-14-18	Kranti (Filler)	1.71	1.51	1.61	4.1	4.1	4.1	38.8
9	CSCN-14-19	CS 15000-1-2-2-2-1	2.18	2.01	2.09*	5.1	5.2	4.4	39.3
10	CSCN-14-20	CS 54 (Filler)	1.85	1.64	1.74	5.1	5.2	5.2	39.1
		GM	1.91	1.71	1.82				
		CD (5%)	0.33	0.29					
		DOS	12.10.2014	18.10.2014					
		C.V.	10.13	10.05					
		EC_e (dS m^{-1}) pH	11.0	9.3					

Table : 56. Influence of different fertility level at different locations on promising entries in salinity/ alkalinity conditions

Entries	Genotype	Fertility Levels				
		75% of Recommended	100% of Recommended	125% of Recommended	150% of Recommended	Mean Yield (q ha^{-1})
Ag 11	CS-1100-1-2-2-3	2098.77	2275.56	2313.58	2359.51	2261.85
Ag 12	Kranti	1511.11	1612.35	1785.19	1879.01	1696.91
Ag 13	CS 54	1561.73	1740.74	1814.82	1840.99	1739.57
Ag 14	CS 52	1555.56	1768.89	1794.32	1883.95	1750.68
	Mean	1681.79	1849.38	1926.975	1990.86	1862.25
	CD (P= 0.05)	Entries (E)= 96.63		Fertility (F)= 72.65	F at same level of E=N.S.	
					E at same level of F=N.S.	

Development and evaluation of segregating material (F_6) of mustard in saline soils

Seventy three breeding lines including seven checks (CS 2007-25, CS 2007-6, CS 54, Kranti, CS 56, Pusa Bold and Pusa Jaggnath) were evaluated in F6 generation for seed yield in saline soils (ECe 9.2-15.4 dS m^{-1}) at Nain Farm. Seed yield ranged from 0.35 to 1.90 t ha^{-1} (mean 0.73 t ha^{-1}, CD (0.05%) 0.44). Thirty lines gave significantly higher seed yield over the best check CS 54 (0.73 t ha^{-1}) with CS 2013-5 (1.90 t ha^{-1}) followed by CS 2013-4 (1.68 t ha^{-1}), recording the highest seed yield.

Monitoring and evaluation of promising salt tolerant strains of Indian mustard (*Brassica juncea*) in AICRP on rapeseed mustard salinity/alkalinity trial -2014-15

Ten genotypes were evaluated in IVT under saline conditions (KAR 1; ECe 11.0 dS/ m) at experimental farm Nain Farm Panipat and alkaline conditions (KAR 2; pH 9.3) at Karnal. Significant differences were observed in seed yield among the genotypes evaluated, both under salinity and alkalinity stresses. Under salinity stress, seed yield ranged from 1.77 to 2.34 t ha^{-1} (mean 1.95 t ha^{-1}, CD(0.05%) 0.32 t) at Nain and 1.43 to 2.13 t ha^{-1} (mean 1.61 t ha^{-1}, CD (0.05%) 0.26) at Karnal. Genotypes CSCN-14-1 (2.34 t ha^{-1}) followed by CSCN-14-7 (2.29 t ha^{-1}) at Nain and CSCN-14-1 (2.13 t ha^{-1}) followed by CSCN-14-7 (1.90 t ha^{-1}) at Karnal showed the highest seed yield (Table 54).

Similarly, ten genotypes were evaluated in AVT-I+II under saline conditions (EC_e 11.0 dS m^{-1}) at Nain and alkaline conditions (pH 9.3) at Karnal. Significant differences were observed in seed yield among the genotypes evaluated, both under salinity and alkalinity stresses. Under salinity stress, seed yield ranged from 1.71 to 2.50 t ha^{-1} (mean 1.91 t ha^{-1}, CD(0.05%) 0.33 t) at Nain and 1.51 to 2.45 t ha^{-1} (Mean 1.71 t ha^{-1}, CD (0.05%) 0.29) under high alkaline conditions (pH 9.3) at Karnal. Genotypes CSCN-14-11(2.50 t ha-1) followed by CSCN-14-19 (2.18 t ha^{-1}) at Nain and CSCN-14-11(2.45 t ha^{-1}) followed by CSCN-14-19(2.01 t ha^{-1}) at Karnal showed the highest seed yield (Table 55).

Monitoring and evaluation of salinity/alkalinity entries of Indian mustard as influenced by different fertility levels in All India Coordinated Research Project on rapeseed mustard trial-2014-15

Four genotypes were evaluated in under alkaline conditions (pH 9.3) at Karnal with four nitrogen levels; 75%, 100%, 125% and 150% of the recommended dose. Significant differences were observed in seed yield among the genotypes evaluated. CS 1100-1-2-2-3 responded favorably to the additional dose of N, 100% RDF was found suitable for this genotype (Table 56).

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

Performance of nine promising under of Indian mustard viz. CS 52-SPS-1-2012, CS 2009-105, CS 245-2-80-7, CS 614-4-1-4-100-13, CS 1100-1-2-2-3, CS 8000-1-2-8, CS 15000-2-2-2-1 along with salinity check variety CS 54 and one high yielding check Pusa Bold were evaluated under different salinity waters of EC_{iw} 2, 12, 15 and 18 dS m^{-1}, in four replications. Salinity stress was applied at sowing time and maintained throughout the experiment. The maximum mean shoot dry weight at seedling stage was recorded by CS 8000-1-2-8 (2.99 g $plant^{-1}$) and CS 54 (2.88 g $plant^{-1}$) and the minimum by Pusa bold (1.77 g $plant^{-1}$). Further, CS 1100-1-2-2-3 (0.423 g $plant^{-1}$) and CS 15000-2-2-2-1 (0.419 g $plant^{-1}$) recorded the maximum root dry weight under similar conditions while it was minimum in Pusa Bold (0.23 g $plant^{-1}$). At harvesting stage, the minimum mean cellular Na/K ratio in shoots was observed in CS 2009-105 (3.14) and CS 8000-1-2-8 (3.72) across all salinity levels. The Maximum mean Na/K ratio was observed in CS 54 (6.05) and Pusa Bold (6.02) across all salinity levels whereas in root, CS 614-4-1-4-100-13 (5.43) and CS 52-SPS-1-2012 (10.97) recorded the minimum and maximum mean Na/K, respectively, amongst different genotypes evaluated (Table 57).

The maximum mean seed yield under different salinity levels was recorded by CS 614-4-1-4-100-13 (18 g $plant^{-1}$) followed by CS 2009-105 (17.4 g $plant^{-1}$). Genotype CS 15000-2-2-2-1 and CS 8000-1-2-8 recorded the minimum mean seed yield of 13.95 and 15.10 g $plant^{-1}$, respectively, under salinity stress. Further, the minimum percentage reduction in seed yield at 15 dS m^{-1}, compared to control was recorded in CS 52-SPS-1-2012 (23%) followed by CS 245-2-80-7 (25%) and CS 1100-1-2-2-3 (34%), whereas high yielding check Pusa Bold recorded the maximum percentage reduction (44%) at this level. Better performing genotypes CS 2009-105 and CS 614-4-1-4-100-13 recorded improved seed yield along with minimum accumulation of Na in shoot and also minimum Na/K ratio in shoot across all salinity levels. Mean while, the minimum seed yield in genotype CS 15000-2-2-2-1was not associated with maximum

Table: 57. Performance of nine mustard genotypes under varying salinity levels at harvesting stage

Genotypes	Mean across five salinity levels (2, 9, 12, 15 and 18 dS m^{-1})				
	Shoot Na*	Shoot Na/K	Root Na*	Root Na/K	Seed yield (g $plant^{-1}$)
CS 54	30.12	6.05	40.21	8.69	16.16
Pusa Bold	26.71	6.02	54.81	8.42	16.70
CS 52 -SPS-1-2012	25.02	3.91	45.97	10.97	17.27
CS 2009 -105	22.34	3.14	47.55	9.97	17.46
CS 245 -2-80-7	25.61	3.81	45.27	9.92	15.10
CS 614 -4-1-4-100-13	25.39	4.19	38.70	5.43	18.04
CS 1100 -1-2-2-3	23.42	4.36	49.08	7.47	15.93
CS 8000 -1-2-8	19.58	3.72	49.31	5.52	15.10
CS 15000 -2-2-2-1	19.62	3.90	54.69	7.88	13.95
CD (P=0.05)					
Genotypes (G)	4.17	0.90	5.06	1.23	0.96
Salinity (S)	3.11	0.67	3.77	0.91	0.71
G x S	9.34	2.01	11.32	2.75	2.15

* mg/g dry wt.

Na/K ratio in shoot at harvesting stage amongst different genotypes evaluated.

Study on genetic variation in ionic composition and salt tolerance of Indian mustard (*Brassica juncea L.*) genotypes under AICRP

Seventeen genotypes (PHY-14-119 to PHY-14-135) provided by ICAR-DRMR, Bharatpur and 9 promising genotypes developed by CSSRI were evaluated for their capacity to maintain cellular ion homeostasis under salinity stress in sand (control, 12 and 15 dS m^{-1}) culture conditions. At maturity stage, the minimum mean cellular Na^+ content in shoots was observed in PHY 14-126 (9.8 mg/g dry weight) and PHY 14-127 (11.9 mg g^{-1} dry weight) across all salinity levels. The maximum mean Na^+ content was observed in PHY 14-131 (17.5 mg g^{-1} dry weight) and PHY 14-119 (15.8 mg g^{-1} dry weight) across all salinity levels. Furthermore, the maximum mean cellular K^+ content in shoots was observed in PHY 14-129 (14.6 mg g^{-1} dry weight) and PHY 14-131 (13.9 mg g^{-1} dry weight) across all salinity levels. Whereas in root, PHY 14-130 (28 mg g^{-1} dry weight) and PHY 14-120 (47.9 mg g^{-1} dry weight) recorded the minimum and the maximum mean Na^+ content, respectively, amongs different genotypes evaluated.

Special attainments/innovations-2014-15

Identified a mutant CS52-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 58).

Special Achievements :

- Developed and submitted four genotypes (CS 700-2-1-4, CS 508-1P2, CS 900-1-2-2-1-3 and CS 1600-1-1-1-1-1) to AICRP on Rapeseed & mustard for IVT Salinity/Alkalinity Trial 2015-16.
- Developed and submitted two genotypes (CS 2800-1-2-3-5-1 and CS 7003-3-2-6) to AICRP on Rapeseed & mustard for AVT-1 Salinity / Alkalinity Trial-2015-16.
- Developed and submitted one genotype (CS 15000-1-2-2-2-1) to AICRP on Rapeseed & mustard for AVT-2 Salinity/Alkalinity Trial-2015-16.
- Developed and submitted one genotype CS 1100-1-2-2-3 to AICRP on Rapeseed & mustard for AVT-2 II year Salinity/Alkalinity trial-2015-16.
- Developed and submitted one genotype CS 1100-1-2-2-3 to NBPGR for registration as national genetic stock which could be utilized as potential donor for salinity/ alkalinity tolerance.
- Developed 22 Backcrosses Inbred Lines (BILs) in BC2F1 generation and 4 Recombinant Inbred Lines (RILs) population (250 lines of each) in F_5 generation according to objectives of project (Fig 28).

Table 58: Different characteristics of mutant CS 52-SPS-1-2012

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	200	5	11	80	45	5	15	5.0	1.50
CS 54	184	5	12	82	50	6	15	5.5	1.75
CS 52-SPS -1-2012	165	6	12	80	50	5	15	9.1	2.15

Name of genotype	Oil%	Protein%	Erucic acid%	Crude fiber%
Kranti	37.2	18.8	46.3	11.0
CS 54	38.6	19.8	49.6	11.5
CS 52-SPS-1-2012	39.8	20.2	34.6	9.5

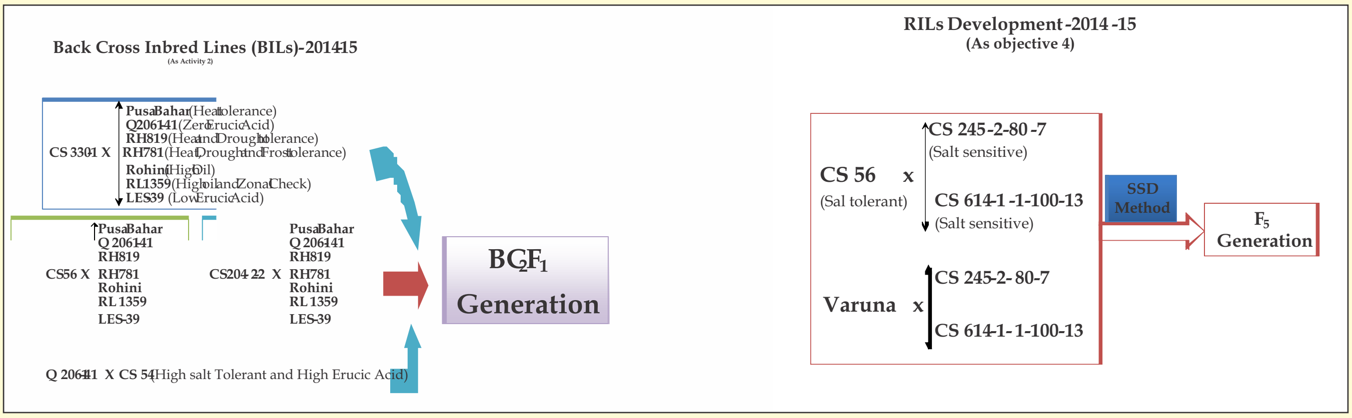


Fig. 28: Development of BC_2F_1 generation and RILs

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

During the year 2014-15, breeder seed (graded) of Indian mustard varieties CS 52 (1.20 t), CS 54 (2.75 t) and CS 56 (2.60 t) was produced for distribution to central and state govt. agencies. Similarly, nucleus seed of CS 52 (0.28 t), CS 54 (0.50 t) and CS 56 (0.30 t) was also produced.

Further 0.12 ton breeder seed (graded) of Chickpea variety Karnal Chana-1 (CSG8962) was produced for distribution to central and state govt. agencies during the year 2014-15.

Molecular genetic analysis of resistance / tolerance in rice, wheat, chickpea and mustard including sheath blight complex genomics - Mustard (Sub-project 4) - CSSRI, Karnal (P.C. Sharma, Jogendra Singh and Vineet T.V.)

Identification of salt tolerant QTLs - Phenotyping of F_6 population of 250 RILs of CS 56 (salt tolerant) and CS 614-1-1-100-13 (salt sensitive) is being done at seedling and maturity stage for traits like Na, K, chlorophyll and osmolytes (glycine betaine and proline) in leaves, root and shoot under salinity in field conditions.

Metabolite profiling of contrasting genotypes in stress induced and non- stressed plants-250 RILs (at EC 12 dS m^{-1}) and nine contrasting genotypes sown in pots under five salinity levels (EC 2, 9, 12, 15 and 18 dS m^{-1}) for metabolite profiling of contrasting genotypes at seedling stage and maturity in leaves, root and shoot.

Improvement of salt tolerance in chickpea through physiological and breeding approaches. (Anita Mann, P.C. Sharma and Jogendra Singh)

Collection of chickpea germplasm: A total of 117 chickpea germplasm lines (Table 59) were collected from different institutes; 50 lines from ICRISAT, Hyderabad; 52 lines from IIPR, Kanpur and 15 lines from CCS Haryana Agricultural University, Hisar. Salt tolerant variety Karnal Chana-1 (CSG 8962) released by CSSRI Karnal was used as check in all the experiments.

Experimental plan: Twenty seeds from each of chickpea lines were used for seed multiplication.

Based on the number of seeds available, the experiment was divided into three groups;

Expt 1. Microplots- 36 lines (seeds more than 60); Expt 2. Germination trays- 60 lines (seeds less than 60) and Expt 3. Pot experiment-16 lines (HAU lines)

Thirty six chickpea lines were sown in microplots (2x2 sq m) under controlled conditions in normal soil. Germination started on 4th day and 50 % germination occurred 6 days after sowing. complete germination (100%) was observed on 10th day after sowing. Seeds from Kanpur did not germinate. A total of three saline irrigations as control (normal tap water), 6 dS m^{-1} and 9 EC were applied for studying the effect of salinity on chickpea. First saline irrigation was applied 30 days after germination, second saline irrigation 60 days after germination and third saline irrigation was applied at 90 days after germination.

Table 59 : List of chickpea germplasm collected from different institutions

SEEDS FROM ICRISAT					
Sr.No	CODE	Type	Sr.No	CODE	Type
1	ICC 32	Kabuli	27	ICC 9942	Desi
2	ICC 283	Desi	28	ICC 10399	Desi
3	ICC 867	Desi	29	ICC 10755	Kabuli
4	ICC 1083	Desi	30	ICC 10885	Kabuli
5	ICC 1431	Desi	31	ICC 11121	Desi
6	ICC 1915	Desi	32	ICC 11284	Desi
7	ICC 2242	Desi	33	ICC 12155	Desi
8	ICC 2263	Desi	34	ICC 12824	Desi
9	ICC 2580	Desi	35	ICC 12866	Desi
10	ICC 4495	Desi	36	ICC 12952	Desi
11	ICC 4533	Desi	37	ICC 12968	Desi
12	ICC 4951	Desi	38	ICC 13077	Kabuli
13	ICC 4973	Kabuli	39	ICC 13283	Kabuli
14	ICC 5003	Desi	40	ICC 13357	Kabuli
15	ICC 5337	Kabuli	41	ICC 14595	Desi
16	ICC 5845	Desi	42	ICC 14669	Desi
17	ICC 5879	Desi	43	ICC 14778	Desi
18	ICC 6263	Kabuli	44	ICC 14799	Desi
19	ICC 6306	Desi	45	ICC 15264	Desi
20	ICC 6816	Desi	46	ICC 15435	Kabuli
21	ICC 6877	Desi	47	ICC 15518	Kabuli
22	ICC 7272	Kabuli	48	ICC 15606	Desi
23	ICC 7819	Desi	49	ICC 15868	Desi
24	ICC 8318	Desi	50	ICC 15888	Desi
25	ICC 8522	Desi	51	ICC 15996	Desi
26	ICC 8950	Desi	52	ICC 17258	Desi
Seeds from IIPR, Kanpur					
Sr.No	CODE	Type	Sr.No	CODE	Type
53	EC 381608	Desi	78	IC 269033	Desi
54	EC 381609	Desi	79	IC 269320	Desi
55	EC 381610	Desi	80	IC 269367	Desi
56	EC 381611	Desi	81	IC 269368	Desi
57	EC 381615	Desi	82	IC 269395	Desi
58	EC 381617	Desi	83	IC 269399	Desi
59	EC 381620	Desi	84	IC 269410	Desi
60	EC 381621	Desi	85	IC 275632	Desi
61	EC 381622	Desi	86	IC 305420	Desi
62	EC 381624	Desi	87	ICC 1206	Desi
63	EC 381887	Desi	88	ICC 13817	Desi
64	EC 381889	Desi	89	ICC 15562	Desi
65	Flip 02 -54C	Desi	90	ICC 15653	Desi
66	Flip 02 -59c	Desi	91	ICC 15994	Desi
67	Flip 03 -52c	Desi	92	ICC 16024	Desi
68	Flip 03 -77c	Desi	93	ICC 16032	Desi
69	Flip 82 -150	Desi	94	ICC 16076	Desi
70	Flip 85 -85c	Desi	95	ICC 16080	Desi
71	IC 209036	Desi	96	ICC 166	Desi
72	IC 268964	Desi	97	ICC 16906	Desi
73	IC 268999	Desi	98	ICC 170	Desi
74	IC 269006	Desi	9	ICC 2701	Desi
75	IC 269014	Desi	100	ICC 3342	Desi
76	IC 269028	Desi	101	P-284 -1	Desi
77	IC 269029	Desi	102	P-924	Desi
Seeds from HAU Hisar					
Sr.No	CODE	Type	Sr.No	CODE	Type
103	C-235	Desi	111	H 09 -96	Desi
104	HC 1	Desi	112	H 10 -21	Desi
105	HC 3	Des i	113	H 10 -41	Desi
106	HC 5	Desi	114	H 11 -58	Desi
107	H 07-120	Desi	115	HK 1	Kabuli
108	H 08-18	Desi	116	HK 2	Kabuli
109	H 08-71	Desi	117	HK 4	Kabuli
110	H 08-75	Desi	118		Desi
Seeds from CSSRI, Karnal				Karnal Chana 1 **(CSG 8962)**	Desi

Screening of germplasm in microplots

There was no effect on chlorophyll after first saline irrigation. Days to 50 % flowering was delayed after second saline irrigation although line ICC 17258 was early flowering (30 days after germination).

Screening at germination stage

Four sets of each 16 chickpea lines were sown in sand in germination trays under varying salinity levels: 3, 6, 9 and 12 dS m^{-1} with one set of control. Salinity was maintained with irrigation from Nain farm water (ECiw 16 dS m^{-1}). Seeds from IIPR, Kanpur did not germinate in sand as well. ICC 2701(black seed) and ICC 1206 did not germinate at all salinity levels. Karnal chana $^{-1}$ did not germinate at 12 dS m^{-1} salinity.

Root and shoot fresh weight were taken along with root and shoot length. The root-shoot length decreased with increasing salinity. The root-shoot length of Karnal chana^{-1} was not affected by salinity exceeding 6 dS m^{-1}.

Fifteen lines from HAU were sown in pots with control (normal irrigation), 6 dS m^{-1}, 8 dS m^{-1} and 10 dS m^{-1} with saline irrigation (Fig 14). Days to 50% flowering was delayed in the susceptible lines. Final grouping for salt tolerance will be done after harvesting and with complete analysis of all the parameters.

Molecular genetic analysis of resistance / tolerance in rice, wheat, chickpea and mustard including sheath blight complex genomics - Chickpea (Sub-project 3) - CSSRI, Karnal (P.C. Sharma, Anita Mann and Jogendra Singh)

The main aim of this project is to map the important genomic regions / QTLs controlling salinity tolerance traits in chickpea. This is a network project involving various components with salinity/sodicity component being dealt by ICAR-CSSRI, Karnal.

Phenotyping of mapping population (DCP 92-3 X ICCV-10) for salinity/sodicity tolerance

A total of 117 germplasm lines were collected from ICRISAT, IIPR and CCS HAU for salt tolerance screening (ECiw 6 dS m^{-1}, pH 9.0). Various physiological indicators of stress tolerance like root length, fresh and dry weight of root & shoot; chlorophyll content; Na^+/K^+ ratio; osmolytes accumulation; harvest index and stress tolerance index are under observation.

Refinement of screening techniques for tolerance to salinity- 233 RILs (DCP 92-3 x ICCV 10) from IIPR and 50 advanced breeding lines from IARI are being screened for salt tolerance (ECiw 6 dS m^{-1}, pH 9.0).

Genetic enhancement of tomato (*Solanum lycopersicum*) and okra (*Abelmoschus esculentus L*) for salt tolerance (S.K. Sanwal, P.C. Sharma, Anita Mann, Raj Kumar and A.K. Rai)

Characterization of okra genotypes at different sodicity levels.

Twenty four okra lines including released varieties and advance breeding materials collected from Indian Institute of Vegetable Research (IIVR), Varanasi were evaluated under sodic soil for yield and contributing traits. The levels of sodicity in sowing plots were pH-8.0±0.2 (control), pH-8.5±0.2, pH-9.0±0.2 and pH-9.6±0.2. With the increase in sodicity, yield declined in all the varieties. The percent yield reduction at highest sodicity (pH-9.6±0.2) was in range of 34.18-60.84. Variety Kashi Kranti recorded the highest yield under all four levels of sodicty. The other

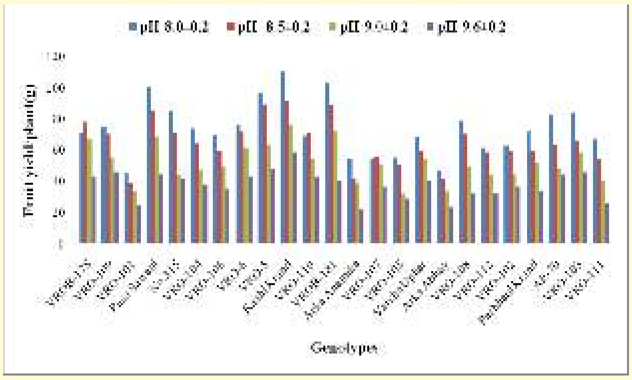


Fig. 29: Performance of different genotypes of okra under sodicity stress conditions

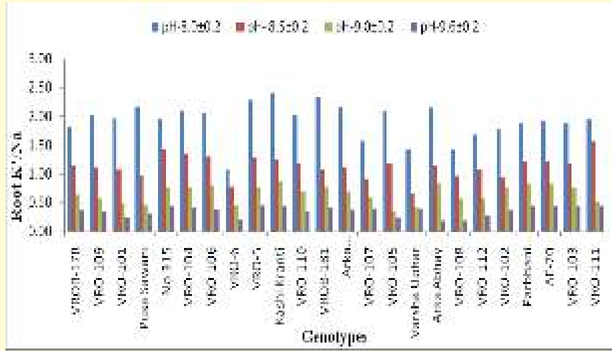


Fig. 30: Root K/Na ratio of 24 genotypes of okra at different sodicity level

promising lines were Pusa Sawani, VRO-5 and VROB-181 (Fig 29). The number of fruits/plant, average fruit weight and fruit length also decreased with increasing sodicity. The plant height also reduced with the increase in sodicity and the percent reduction was 17.52-61.62 at flowering stage (45 DAS) and 25.67-78.11 at maturity stage. The flowering was early under stress conditions than normal soil in all the genotypes.

Na^+ concentrations in roots and shoots increased significantly with increase in soil pH and there was a significant difference among the varieties. In roots, Na^+ concentrations varied from 4.58 % (VRO-105) to 6.67 % (VRO-107) in control while at maximum sodicity it varied from 8.27 % (VRO-104) to 15.25 % (VRO-102). Na^+ concentrations in shoots ranged from 2.3 (VROB-178) to 8.6 (VRO-104) in control while at maximum pH it ranged from 0.7 (VRO-106) to 2.48 (Parbhani Kranti). Shoot and root K^+ significantly decreased in all the varieties with increasing sodicity. K/Na ratios in roots and shoots considerably declined with increasing sodicity. The maximum root K/Na ratio was recorded in the genotypes Kashi Kranti, VROB-178 and VRO-5 in control as well as at highest sodicity (Fig. 30).

The maximum K/Na ratio in shoots was recorded in VRO-6 followed by VRO-5 in control while at maximum pH the genotypes VRO-5, NO. 315 and VRO-106 had better ratio as compared to other genotypes.

Physiological and biochemical basis of salinity and drought stresses tolerance in rice and wheat cropping system. (Ashwani Kumar, Arvind Kumar and Krishnamurthy SL)

Diurnal changes of gas-exchanges in wheat varieties differing in salt tolerance

Photosynthetic rates were measured across a range of variable intercellular CO_2 concentrations (50 – 800 ppm) in four wheat varieties. Kharchia 65 (salt tolerant) and KRL 210 (moderately salt tolerant) showed photosynthetic rate of 19.74 and 9.19 µmol m^{-2} s^{-1} while HD 2009 (salt sensitive) and HD 2851 (salt sensitive) showed -27.65 and -17.65 µmol m^{-2} s^{-1} at 50 ppm intercellular CO_2 concentration which increased with increasing CO_2 concentration (Fig 31). More negative Pn (Photosynthetic rate) values were observed upto 200 ppm intercellular CO_2 concentration in these sensitive varieties.

- Changes in photosynthetic activities (diurnal) of wheat varieties were significant but these differences could not be expressed in control conditions. Lowest photosynthetic rate (Pn) was seen in the early morning, increasing with day time and reaching maximum (33-37 µmol m^2 s^{-1}) between 10:00 AM to 02:00 PM, thereafter, Pn decreased in all the wheat varieties. Similar trends of increase and decrease were observed for gS and E.
- At stress treatment of 100 mM NaCl with 50 % water deficit, significant reductions in grain weight/plant were observed in HD 2009 (73.64 %) followed by HD 2851 (57.54 %), KRL

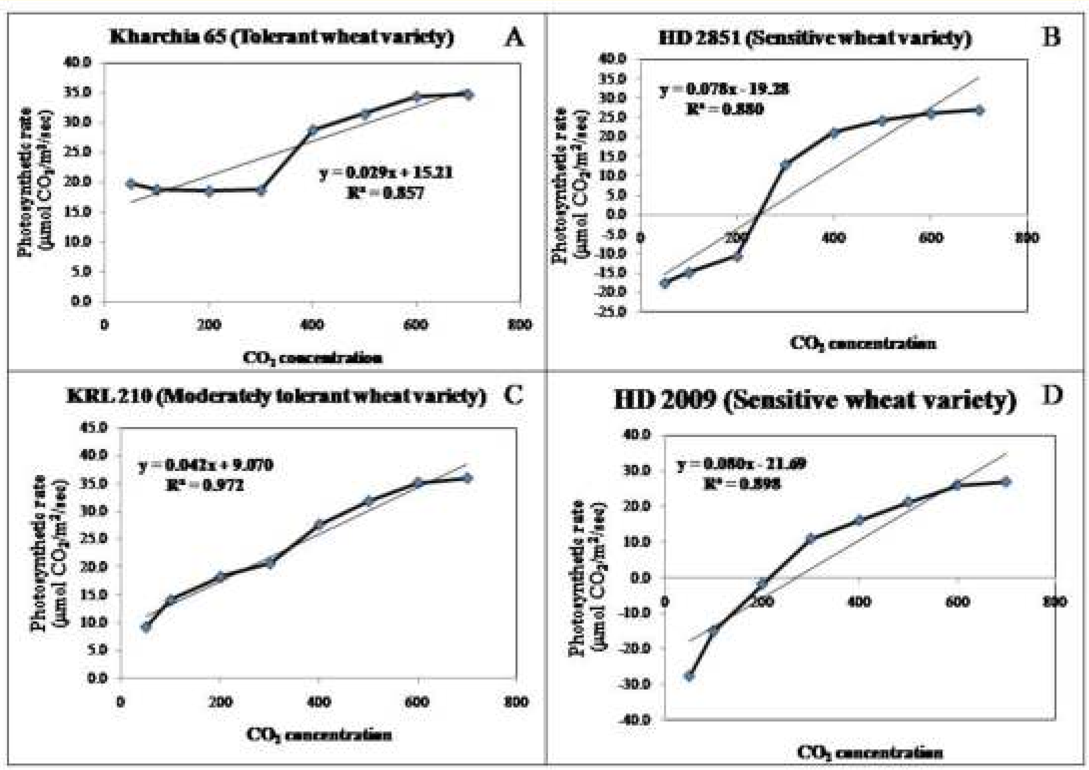


Fig. 31: Effect of variable intercellular CO_2 concentration on photosynthetic rate in different wheat varieties; (A) Kharchia 65, (B) HD 2851, (C) KRL 210 and (D) HD 2009.

210 (45.58 %) and Kharchia 65 (28.64 %).

- Mean percent reduction in effective tillers/plant ranged from 43.4% (CSR 36) to 75.5% (Pusa 44). On an average, CSR 10 produced highest number of productive tillers (6.1/plant) followed by CSR 36 (5.5/plant), both being significantly superior to IR 26 and Pusa 44 (3.2 and 3.1/plant) over different treatments of salt and drought stress.
- Highest reductions in biomass were observed in Pusa 44 (70.27 % and 77.85 %) at 50 per cent water deficit with 50 and 100 mM NaCl from the respective control and the lowest reduction was observed in CSR 36 (43.3% and 48.4%).

Understanding the adaptation mechanism of wild forage halophytes in the extreme saline-sodic Kachchh plains for enhancing feed resources. Funded by NFBSFARA (Ashwani Kumar)-

- A higher amount of Na^+ accumulated in leaves than roots with increasing stress conditions in grass and non grass halophytes i.e. 9.4% in *Dicanthium annulatum*, 22.25% in *Suaeda nudiflora*, 4.35% in *Sporobolus marginatus*, 4.33% in *Urochondra setulosa* and, 5.8% in *Aleuropus lagopoides.*
- These halophytes restrict Na^+ accumulation in root zone with accumulation of 0.38% Na^+ in *D. annulatum*, 2.25% in *S. nudiflora*, 1.04% in *S. marginatus*, 0.92% in *U. setulosa* and, 0.88% in A. *Lagopoides* than their respective control conditions.
- A very high increase in proline content was seen in these halophytes with increasing stress conditions with approx. 10 times more proline accumulation i.e. 4.86 mg/g in *D. annulatum*, 7.44 mg g^{-1} in *S. nudiflora*, 5.1 mg g^{-1} in *S. marginatus*, 7.2 mg g^{-1} in *U. setulosa*, 7.75 mg g^{-1} in *A. lagopoides* at ECe 35 dSm^{-1} providing higher osmotic adaptations.
- Increased ascorbate enzyme activity was found under different stress conditions in all the halophytes. Maximum activity (43.9 ascorbate decomposed min^{-1} g^{-1} protein)

was observed in Sporobolus marginatus at pH^{-10}.0 whereas Suaeda and Aeluropus showed less activity under salt as well as mixed (salt with sodic) stresses. A similar increasing trend was observed in peroxidise activity over all the stresses imposed but maximum peroxidase activity (59.45) was observed in Aeluropus at 35 dsm^{-1} whereas minimum increase was observed in Sporobolus marginatus.

- Protein profiling of Sporobolus under different stresses indicated that there was synthesis of specific polypeptide band of 98.1 and 47.9 kDa with all treatments except at ECe 15 dSm^{-1} (Fig 32).Different stress conditions of salt and sodic,

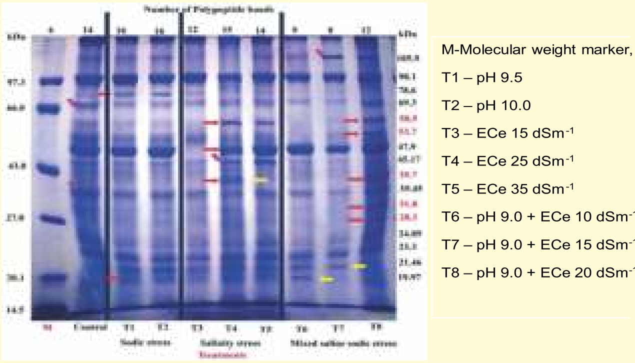


Fig. : 32 Salt stree induced changes in protein profiling of Sporobolus marginatus

increased accumulation of glycine betaine in all the halophytes studied. Maximum glycine betaine was observed at ECe 35 dSm^{-1} in Urochondra (30.8 mg g^{-1}) and then in Aeluropus (28.05 mg g^{-1}).

AGROFORESTRY IN SALT AFFECTED SOILS

Effect of salinity on growth and physico-biochemical changes in bael (*Aegle marmelos Correa*) genotypes. (Anshuman Singh, M. D. Meena, P. C. Sharma and D. K. Sharma)

Considering the fact that plant-based solutions are important for the productive utilization of salt-affected soils (SAS) and poor quality water and (considering environmental sustainability and productivity potential of salt tolerant trees and crops) a project was taken up to assess the feasibility of commercial cultivation of bael (*Aegle marmelos Correa*) in saline soils. Four bael cultivars; namely Narendra Bael-5, Narendra Bael-9, CISH Bael-1 and CISH Bael-2, grown in normal soil (1.3 dS m^{-1}) were marked with different saline (EC_{IW} 0.5, 3 and 6 dS m^{-1}) waters to study the salt-induced changes in physico-biochemical relations and plant growth.

The initial signs of salt toxicity appeared as complete yellowing of leaves; subsequent development of cholorotic lesions and senescence in the sensitive cultivars. Salt tolerant cultivar NB-5 did not show leaf yellowing and other stress symptoms with use of 3 dS m^{-1} water in this cultivar for irrigation, only chlorosis appeared in some of the upper leaves under higher salining (6 dS m^{-1}). Increasing salt concentration in irrigation water adversely affected stem length, stem girth and inter-nodal length in all the cultivars (Table 60). While NB-5 showed only marginal decrease, other cultivars exhibited significant reductions in stem length with the application of 3 dS m^{-1} saline water. Application of 6 dS m^{-1} water caused moderate (NB-5) to high decreases (NB-9, CB-1 and CB-2) in stem length and the maximum decrease (20%) was observed in cultivar NB-9. Stem girth was not significantly affected with increasing salinity of irrigation water in all the tested cultivars. All the cultivars, except NB-5, showed significant decrease in inter-nodal length at 3 dS m^{-1} salinity. Irrigation with 6 dS m^{-1} water caused moderate reductions in all cultivars with the minimum (3.73 cm) and the maximum (4.03 cm) reductions noted in NB-5 and NB-9 cultivars, respectively.

Salinized plants showed significant reduction in shoot fresh and dry weights with application of both 3 and 6 dS m^{-1} waters. Irrigation with 3 dS m^{-1} water moderately decreased shoot fresh and dry weights in both NB-5 and CB-1 cultivars but irrigation with higher salinity (6 dS m^{-1}) decreased shoot fresh weight by 25, 55, 42 and 60% in NB-5, NB-9, CB-1 and CB-2, respectively, as compared to respective controls. The percent reductions in shoot dry weight in NB-5, NB-9, CB-1 and CB-2 cultivars at 6 dS m^{-1} salinity level were 29, 47, 42 and 52, respectively, as compared to control. Application of low salinity (3 dS m^{-1}) water caused only marginal reductions (12-15%) in root fresh

Table 60: Effect of saline irrigation on stem length (cm), stem thickness (cm) and inter-nodal length (cm) in bael cultivars

Cultivar	EC_{iw} (dS m^{-1})	Stem length (cm)	Stem girth (cm)	Inter-nodal length (cm)	Shoot fresh weight (g)	Shoot dry weight (g)	Root fresh weight (g)	Root dry weight (g)
NB-5	0.5	98.2cd	3.53ab	4.46bc	1343.7c	653b	628d	397.7c
	3	92.3de	3.47bc	4.32cd	1203.3d	579.3c	530.7g	324.3ef
	6	88.7e	3.43bc	3.73g	1010f	463.7e	490.7h	287.7g
NB-9	0.5	112.7a	3.57ab	4.53ab	1139.3e	568c	598e	403c
	3	92de	3.4bc	4.23de	791.6h	347g	479.7h	308f
	6	89.3e	3.4bc	4.03f	511j	302h	347i	246.7h
CB-1	0.5	111a	3.8ad	4.5ab	1485a	694.7a	812a	427.3b
	3	104.3bc	3.57ab	4.13ef	1345c	527.7d	716c	359d
	6	98.3cd	3.53ab	3.87g	856.6g	404.3f	475.3h	251.3h
CB-2	0.5	110ab	3.8ad	4.6a	1418.3b	651.7b	741.3b	449a
	3	102.7c	3.63ab	4.3d	1024.7f	566.3c	553.3f	326e
	6	89e	3.4bc	3.83g	567.3i	309.7h	317j	218.3i

Means with at least one letter common in a column are not significantly different at 5% level of significance.

weight in NB-5 and CB-1 in comparison to 20 and 25% in NB-9 and CB-2, respectively over control. Likewise with 6 dS m^{-1} salinity, decrease in root fresh weight relative to control ranged from 22% in NB-5 to 42% in NB-9 and CB-1 and 57% in CB-2. Root dry weight also significantly decreased with increasing salinity in all the cultivars. At 3 dS m^{-1} salinity, NB-5 and CB-1 showed only marginal reductions (16-18%) over 25% in NB-9 and CB-2 as compared to respective controls. At high salinity (6 dS m^{-1}), the percent decrease in root dry weight relative to control was 28, 39, 41 and 51% in NB-5, NB-9, CB-1 and CB-2 cultivars, respectively.

Na^+ uptake by roots and its subsequent translocation to leaves with increasing salinity was the lowest in cultivar NB-5, followed by relatively higher in CB-1, and the highest in cultivars NB-9 and CB-2. While reverse was true for K^+ uptake in leaves and stems in the respective cultivars. In root tissues of all cultivars, K^+ decreased with increasing salinity.

Among bael cultivars, NB-5 outperformed others under saline (ECiw 3 or 6 dS m^{-1}) irrigations. In particular, restricted Na^+ uptake and preferential K^+ accumulation in leaf and stem tissues seemed to alleviate salt injury in NB-5. These observations indicated the scope for commercial cultivation of bael cultivar NB-5 in saline soils underlain with marginal quality water.

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 Dutta)

Soil salinity is a major constraint to crop production in arid and semi-arid regions of the world. Although, majority of the fruit species are categorized as sensitive to salt stress, wide genotypic differences within species suggest relatively higher tolerance of certain cultivars as compared to others. Guava (*Psidium guajava L.*), widely grown in arid and semi-arid climates, is a nutritional fruit with high potential value addition. Bael (*Aegle marmelos Correa*) cultivation is also gradually picking up in arid regions where soil salinity is a hindrance to crop production. Bael fruit has important medicinal values and is used to make a number of high value processed products. Realizing the suitability of guava and bael for the arid climates which also mostly suffer from soil salinity, a field experiment, has been started at Nain Experimental Farm Panipat.

Planting was done in pits each filled with mixture of soil and 5.0 kg farm yard manure (FYM) in September 2014 and established using best available water (BAW; pH 8.23, EC_{IW} 2.81 dS m^{-1} and SAR 4.96 mmol $l^{-1/2}$). Growth observations were recorded one year after planting in September, 2015. In bael cultivar NB-5, plant height marginally decreased by 8.3 and 18% with increasing soil salinity (EC_e) from 2.24 to 4.75 and 6.52 dS m^{-1}, respectively in comparison to control. Moderate salinity (6.52 dS m^{-1}) also decreased stem girth, branching and leaf count by 30.5, 49 and 34%, respectively over control. The highest reduction in growth and the lowest plant survival (76 %) occurred at the highest (10.57 dS m^{-1}) salinity. Based on leaf Na+ and K^+ levels, it was found that the leaf Na^+ concentration was below 0.2% (on dry weight basis) up to 6.52 dS m^{-1} salinity. As salinity increased from 6.52 dS m^{-1} to 10.57 dS m^{-1}, severe reductions in plant growth and high mortality were noted indicating salinity

Plant growth in bael under different salinity treatments.

Table 61 : Effect of salinity on fruiting in guava cultivar Allahabad Safeda

Soil salinity (ECe, dS m-1)	Fruits/plant	Fruit length (cm)	Fruit breadth (cm)	Fruit weight (g)	Yield/ plant (kg)	TSS (°Brix)
1.75 (Control)	9.6[b]	4.18[b]	4.4[b]	47.08[c]	0.45[c]	12.62[c]
3.43	24.8[a]	5.52[a]	5.5[a]	94.98[a]	2.36[a]	17.6[a]
5.62	12.2[b]	5.34[a]	4.6[b]	77.64[b]	0.94[b]	17.8[a]
7.45	2.8[c]	5.48[a]	5.16[a]	79.88[b]	0.22[c]	16.32[b]

tolerance threshold of about 6.5 dS m^{-1} in bael cultivar NB-5. Although salinity significantly decreased plant growth and reduced plant survival, mortality in control plants indicated that root disturbance caused by long distance transport (Lucknow to Karnal) and the 'initial transplanting shock' could also be partly responsible for injury.

In plant growth was not affected up to 5.6 dS m^{-1} salinity. Interestingly, plant height, stem girth and branching were either unaffected or significantly increased at both 3.4 and 5.6 dS m^{-1} salinity in comparison to control. Although growth of established plants did not decrease but plant mortality in both control and saline treatments indicated that root disturbance due to long distance transport and transplanting shock also resulted in poor establishment in saline soils. Based on salt induced inhibition of shoot and root growth, guava is ranked as moderately salt tolerant with a saturation extract salinity (ECe) tolerance threshold of about 4.7 dS m^{-1}. This threshold, however, only suggests the relative tolerance and the response to salinity may vary with climate, growing conditions and the genotype. In our case, the tolerance threshold was marginally higher (5.6 dS m^{-1}).

Effect of salinity on fruit yield and quality is presented in Table 61. Average number of fruits per plant in control plots was 9.6. Fruiting considerably increased (~158%) in marginally saline soils (3.4 dS m^{-1}) as compared to non-salinized plants, however, further increase in salinity from 3.4 to 5.6 dS m^{-1} significantly reduced fruiting. At 5.6 dS m^{-1} salinity, fruiting was about 50% lower relative to 3.4 dS m^{-1} but was still significantly higher (~27%) in comparison to control plants. A drastic reduction in fruiting occurred at the highest salinity as average fruits per plant decreased by about 70% relative to control. While fruits produced on control trees were somewhat roundish in shape, salinized trees had elongated fruits possibly due to significant increase in fruit length. The maximum average fruit yield (2.36 kg $plant^{-1}$) was noted at 3.4 dS m^{-1} salinity and the minimum (0.22 kg) at the highest salinity level (7.45 dS m^{-1}). The fruits on salinized trees had significantly higher total soluble solids (TSS) with the highest (17.8 °Brix) and the lowest (12.6 °Brix) TSS values recorded at moderate and control salinity levels. These observations suggested that bael and guava can tolerate soil salinity up to 6.5 dS m^{-1} and 5.6 dS m^{-1}, respectively. Application of FYM and irrigation with the best available water (EC_{IW} 2.8 dS m^{-1}) alleviated salt stress in both bael and guava plants as evident from marginal reductions in soil pH and significant decrease in salinity.

Identification of salt tolerant ber (*Zizyphus mauritiana Lam.*) rootstocks in a farmer participatory mode. (Anshuman Singh, Ashwani Kumar, Parvender Sheoran, R. K. Singh, D.K. Sharma, Raj Kumar and R.K. Yadav)

Growing salt tolerant cultivars is a sustainable strategy for productive utilization of salt-affected environments. Ber is a traditional fruit crop of Haryana, particularly in south-western part. About a dozen varieties i.e. Sindhura, Seb, Vilayati, Gola, Bawal Selection-2, Kaithali, Banarsi Kadaka, Umran and Illaichi are grown. Ber trees exhibit tolerance to adverse soil conditions, have low input requirements and thus can be grown in salt-affected *environments* characterized by limited water and nutrient availability. Ber has been identified as a potential fruit crop for Haryana

Table 62: Description of ber orchards existing in different districts of Haryana

Location	Geographic coordinates	Orchard area (ha)	Tree age (years)	Variety
Sulkhani, Hisar	N 29º 14′ 28.8″ E 75º 50′ 24.7″	0.2	20	Gola
Dobhi, Hisar	N 29º 08′ 6.4″ E 75º 29′ 56.4″	0.5	10	Gola
Arya Nagar, Hisar	N 29º 07′ 24.3″ E 75º 39′ 32.2″	1.6	16	Umran, Kaithali
Chautha Meel,	N 29º 12′ 07.2″ E 75º 40′ 59.9″	2	25	Umran, Kaithali, Gola
Hisar				
Neoli Kalan, Hisar	N 29º 10′ 45.7″ E 75º 37′ 29.2″	1.7	10	Umran, Gola
Durjanpur, Hisar	N 29º 15′ 03.2″ E 75º 40′ 08.2″	16	45	Umran, Kaithali, Gola, Mundia, Seb, Katha, Illaichi
Kali Ravan, Hisar	N 29º 17′ 02.9″ E 75º 32′ 52.0″	1.6	15	Umran, Kaithali, Gola, Katha
Motsara, Hisar	N 29º 15′ 11.4″ E 75º 34′ 41.1″	2.8	20	Umran, Kaithali, Gola,
Ghuda, Jhajjar	N 28º 63′ 56.1″ E 76º 64′ 44.1″	0.4	15	Gola
Jhajjar-1, Jhajjar	N 28º 62′ 71.1″ E 76º 64′ 48.0″	0.4	20	Gola
Jhajjar-2, Jhajjar	N 28º 62′ 59.2″ E 76º 64′ 60.1″	1	20	Gola, Umran, Illaichi
Hada Hedi, Rewari	N 29º 42′ 29.8″ E 76º 57′ 11.6″	1	~100	Lakhal, Najuk, Kala Gola, Bhoora Gola
Astal, Rewari	N 28º 04′ 09.7″ E 76º 53′ 23.4″	1	~ 100	Katha, Bagu Gola, Desi Gola
Kheda Murar, Rewari	N 28º 04′ 21.1″ E 76º 36′ 45.7″	0.2	~100	Bagu Gola
Nahchana, Rewari	N 28º 05′ 51.2″ E 76º 34′ 13.2″	0.8	15	Gola
Laduwas1, Rewari	N 28º 12′ 39.9″ E 76º 32′ 29.7″	0.4	10	Gola
Laduwas2, Rewari	N 28º 12′ 43.8″ E 76º 32′ 27.7″	0.6	10	Gola
Subhash Nagar, Mahendergarh	N 28º 03′ 44.4″ E 76º 07′ 33.3″	0.2	~100	Gola, Najuk, Katha
Kadiyanawal, Mahendergarh	N 28º 02′ 09.3″ E 76º 06′ 57.8″	0.3	~100	Bagu Gola, Jhari Ber

owing to high and medium demand of fruits in domestic and export markets, respectively. Salinity stress studies conducted in ber in India have mostly dealt with a single or few scion cultivars/non-descript seedlings and no attempts have been made to identify salt tolerant rootstocks. Keeping in view the socio-economic importance of ber cultivation in Haryana and other arid regions of the country, a project was started with the following objectives: 1. Screening of selected *Zizyphus* lines under ex situ salt stress conditions to identify the salt tolerant rootstock(s), and 2. identification of constraints in ber cultivation and capacity building of growers to address the gaps in profitable production. To achieve the above objectives, a survey was conducted for collections of ber fruits and *in situ* soil sampling in Hisar, Jhajjar, Rewari the silent findings of the study are summarised in Table 62 and Mahendergarh districts of the state.

Enhancing productivity potential of saline soil through agroforestry systems using saline irrigation. (R. Banyal, R.K. Yadav, Parvinder Sheoran, M.D. Meena, Bhaskar Narjary and D.K. Sharma)

Salinity is one of the rising problems causing significant yield losses in many parts of the world, especially the arid and semi-arid regions. In India, existing 6.74 Mha salt affected area is likely to significant in the ensuing decades increase. Some of this salt affected area can be improved and made productive by growing salt tolerant forestry and agro-forestry species. As, it is increasingly

Table 63: Yield of pearlmellet under *Eucalyptus* plantations

Plot No.	Yield (kg ha^{-1})	Soil EC_2 (dS m^{-1})
1	292-896 (545)	3.51-8.03 (5.34)
2	493-1098 (830)	1.53-8.33 (4.49)
3	638-1029 (920)	0.93-9.39 (2.43)
4	332-733 (549)	0.94-8.68 (3.02)
5	381-852 (569)	1.21-6.03 (3.89)
6	783-1160 (995)	0.53-3.77 (1.81)
Open	332-830 (631)	1.12-3.07 (1.93)

Table 64: Yield of melia under *Eucalyptus* plantations

Plot No.	Yield (kg ha^{-1})	Soil EC_2 (dS m^{-1})
1	416 -823 (612)	1.05 -7.44 (3.68)
2	636 -805 (725)	2.80 -4.75 (3.69)
3	508 -865 (635)	1.16 -2.21 (1.53)
4	401 -694 (546)	1.29 -5.50 (3.57)
5	340 -607 (518)	1.31 -5.32 (3.67)
6	301 -751 (576)	1.62 -6.08 (3.43)
Open	332 -830 (631)	1.12 -3.07 (1.93)

becoming difficult to meet the ever inflating demands for wood and wood products from the existing forest areas, there is need to bring more area under trees. Fertile lands cannot be converted into trees based systems because food grain production continue to be the now priority. However, alternative land uses as forestry and agroforestry may prove a viable option on salt affected soils. Establishing agroforestry systems with potential to produce in such conditions could help in meeting food, fodder, wood and environmental goals. Therefore, a research proposal has been framed and implemented to assess two agroforestry systems for productive utilization of saline soils.

Growth attributes (plant height, DBH, number of branches, longest branch, crown spread) of both Eucalyptus and Melia plantations increased over the previous season values. Eucalyptus attained higher plant height and number of branches as compared to Melia. DBH increased more than any other parameter in Eucalyptus and Melia. However, Melia recorded higher percent increment (267) as compared to 234 in Eucalyptus.

Yield of pearl-millet was influenced by varying soil salinity. However, a very poor and non-significant correlation between soil salinity and yield was recorded under both the plantations. (Table 63 & 64). Increasing soil salinity and germination percentage of rabi season under story companion crop of mustard had significant negative correlation of 0.79 and 0.75 under Eucalyptus and Melia, respectively.

Identification of high yielding and salt tolerant genotypes of pomegranate

(Raj Kumar, A Mann, M.D. Meena, Anshuman Singh, R.K. Yadav and D.K. Sharma)

With increasing population pressure and competition for good quality lands, intensive agriculture increasingly is being pushed to marginal lands. The arable lands are shrinking due to developmental activities. Currently, most of pomegranate cultivation is in arid and semi-arid regions of the world, where salinity is the main limitations for crop growth. Therefore, an experiment was initiated with the objectives of identify salinity-tolerant Indian cultivars of

Cuttings of 20 (18 unknown and 02 known) genotypes planted in nursery at different salinity levels

Table 65: Biochemical & Physico - chemical parameters in leaves of pomegranate genotypes (under control treatment)

Genotype	Proline (μgg⁻¹FW)	RWC (%)	Chlorophyll (mg g⁻¹FW)	Na^+ (%)	K^+ (%)	Ca^{+2} (ppm)	Mg^{+2} (ppm)	K^+/Na^+
Jaipur 1	142.43	94.59	0.751	0.26	6.62	7.662	1.845	25.46
Jaipur 2	175.39	91.07	0.604	0.34	3.04	14.89	3.084	8.94
Jaipur 3	336.91	88.89	0.387	0.12	3.7	14.8	2.703	30.83
Ajmer 1	139.13	73.96	0.500	0.3	3.62	14.11	2.759	12.07
Ajmer 2	152.32	89.00	0.568	0.22	4.38	14.57	2.626	19.91
Ajmer 3	145.72	86.36	0.505	0.36	3.38	13.96	2.442	9.39
Ajmer 4	60.02	90.20	0.650	0.28	4.42	14.11	2.498	15.79
Ajmer 5	135.83	92.75	0.242	0.32	4.52	17.71	3.038	14.13
Rajasmand 1	27.06	92.86	0.491	0.36	4.28	10.55	2.074	11.89
Rajasmand 2	135.83	92.16	0.459	0.26	4.78	17	2.837	18.38
Udaipur 1	79.80	84.62	0.337	0.34	4.32	10.69	1.977	12.71
Udaipur 2	122.65	90.07	0.368	0.2	5.62	14.83	2.54	28.10
Rajasmand 3	106.17	88.68	0.362	0.38	2.4	15.72	2.828	6.32
Rajasmand 4	214.94	94.44	0.411	0.18	9.76	10.74	2.144	54.22
Udaipur 3	198.46	93.85	0.557	0.36	7.42	11.79	2.119	20.61
Pali 1	63.32	96.83	0.423	0.1	4.62	17.36	3.133	46.20
Jodhpur 1	53.43	93.59	0.565	0.28	4.1	14.45	2.436	14.64
Nagaur	109.46	92.50	0.439	0.4	5.08	13.18	2.196	12.70
Ganesh	221.54	94.05	0.326	0.32	3.62	16.67	2.494	11.31
Bhagwa	13.87	92.86	0.766	0.36	5.26	18.23	2.827	14.61

pomegranate. The cuttings of twenty pomegranate genotypes (18 unknown and 02 known) were evaluated under salinity stress to identify the tolerant ones for commercial cultivation in salt-affected soils. Consistent with the research objectives, one experiment was also taken up to study the growth and physiological relations of these genotypes to soil salinity stress. These genotypes were collected from Jaipur (03), Ajmer (05), Rajasmand (04), Udaipur (03), Pali (01), Jodhpur (01), Nagour (01), Bikaner (02), respectively and grown under saline conditions. There were four salinity treatments i.e. T1 Control (soil EC_e <4 dS m^{-1}), T2 (~8 dS m^{-1}), T3 (~12 dS m^{-1}) and T4 (~16 dS m^{-1}). Soil analysis of the samples collected from these twenty different sites was done. Different growth and physio-biochemical parameters (Table 65) were recorded in salt stressed plants. After four months of planting, plant growth, survival (%), biochemical and physico-chemical parameters were recorded.

Only 150 plants survived out of 1200 cuttings. The cuttings under control showed 45.33 percent survival, whereas survival percentage was 2.67 at 8 dS m^{-1}, 1.33 at 12 dS m^{-1} and 0.67 at 16 dS m^{-1}, respectively. Only few of the tested genotypes survived at high salinity treatments indicating genotypic differences for salinity tolerance. On the basis of survivability of the cuttings; genotypes Jaipur 2 & 3, Ajmer 1 & 2, Rajasmand 4, Ganesh and Bhagwa have shown survival up to 8 dS m^{-1}, Jaipur 2 & 3, Udaipur 1 & 2 up to 12 dS m^{-1} and Udaipur 1 and Rajasmand 3 up to 16 ds m^{-1}. Better establishment and survival are also dependent on appropriate time of planting. On the basis of biochemical & physico-chemical parameter in pomegranate genotypes leaves the maximum proline content (336.91 µgg^{-1}FW) was observed in Jaipur 3 genotype, RWC (96.83 %) in Pali 1, Chlorophyll (0.766mg g^{-1}FW) in Bhagwa, minimum Na^{+} (0.1%) in Pali 1, maximum K^{+}(9.76%) in Rajasmand 4, $Ca^{+}2$ (18.23ppm) in Bhagwa, Mg^{+2} (3.133ppm) and K^{+}/Na^{+} (54.22 %) in Rajasmand 4. These observations suggest that genotypes Jaipur 3, Pali 1, Bhagwa and Rajasmand 4 have potential to grow under saline conditions. Although, this experiment need to continue further for evaluation of all the genotypes in different salinity levels under nursery as well as field conditions because better establishment and survival are also dependent on appropriate time of planting. During the month of December, cuttings of four pomegranate varieties i.e. Ganesh, Maridula, Muscat and G-137 were also brought from Abohar, Punjab and planted under normal soils which showed 100 percent sprouting in all the cuttings. To maintain the twenty different genotypes of pomegranate which have been collected from districts of Rajasthan, the progeny/mother block of these genotypes of pomegranate was established and two plants of each genotype were planted on reclaimed sodic soils at ICAR-CSSRI, Karnal during February, 2016.

To arrive at conclusion regarding suitability of screened cultivars for commercial cultivation in saline soils, and to see the response of pomegranate genotypes under saline conditions, some of the tolerant genotypes of experiment no. 1 have been planted on saline soils at Nain Experimental Farm during March, 2016.

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

Land modification based integrated farming system in waterlogged and waterlogged sodic conditions (Chhedi Lal Verma, Y.P. Singh, V.K. Mishra, S.K. Jha, A.K. Singh, S.K. Singh and T. Damodaran)

For sustaining agricultural productivity under waterlogged conditions, repeated gypsum application prove cost prohibitive. Lowering of water table below 2.0 m depth prior to the gypsum application for sustainable reclamation and management of waterlogged sodic soils is an essential requirement to avoid secondary salinization. All though, subsurface drainage (SSD) is a proven technology to lower water table under such conditions, availability of natural gravity outlet is a major constraint in the adoption of SSD in such area. Pumped outlet is expensive and beyond the reach of resource poor farmers. In seepage prone areas salt accumulation is prominent on soil surface whereas continuous seepage in the deeper soil profile keeps salts moving along the seepage water. The rate of seepage increases with the increasing soil depths. Consequently, the soil pH is much high at the surface and low towards deeper soil profiles.

Land modification by elevating field beds will improve internal drainage of the soil and will keep water table below a critical level. Fish pond and raised and sunken bed based integrated farming modules were hypothesized as a sustainable technology for reclamation and management of waterlogged sodic soils and were tested at Kashrawan village in Raebareli district for about five years. The fish pond model was tested over an area of one hectare and raised and sunken bed model over an area of 0.40 ha. For a very small land holding (< 0.25 ha), raised and sunken bed model can be quite useful but the width and depth combinations of raised and sunken bed need to be further studied. Multi- location trials are required to investigate the necessity of alteration in pond design. A study on land modification based integrated farming systems under waterlogged and waterlogged sodic conditions was initiated in Sharda Sahayak Canal Command with the objectives: to develop design criteria for fish pond and raised sunken bed systems, to study crop performance and land, water and crop productivity under different sizes of Integrated Farming System (IFS) models, to study salt and water balance of integrated farming models, and to educate farmers and state functionaries through field exposure visits.

Study was carried out in Lalaikheda, Patwakheda and Salempur Achaka villages of Lucknow district located in Sharda Sahayak Canal Command. The site is nearly 40 km away from Lucknow towards Raebareli. Water table of the area fluctuates within a range of 0.00 to 1.50 m during rainy season and to extreme summer.

Initial soil conditions of experimental sites at Lalaikheda, Patwakheda and Salempur Achaka

Table 66 : Soil EC and pH of newly constructed raised beds.

Village: Lalaikheda			Village: Patwakheda		Village: Salempur Achaka	
Depth	EC	pH	EC	pH	EC	pH
0-15	0.562	9.3	0.575	9.42	0.356	8.27
15 -30	0.242	9.22	0.46	9.38	0.274	8.16
30 -45	0. 232	9.1	0.326	9.2 0	0.485	8.19
45 -60	0.235	9.15	0.416	9.5 0	0.266	8.17
60 -75	0.199	9.01	0.49	9.6 0	0.314	8.00
75 -90	0. 188	9.06	0.342	9.39	0.208	8.16
90 -120	0.196	9.26	0.737	9.85	0.194	8.18

Initial soil pH of the selected sites in Lalaikheda, Patwakheda and Salempur Achaka villages ranged from 8.96 to 9.69, 9.47 to 9.93 and 7.49 to 7.98 and the corresponding EC ranged from 0.203 to 0.569, 0.368 to 1.1471 and 0.065 to 0.189 dS m^{-1}, respectively, in a profile depth of 0 to 120 cm. Organic carbon was low at all locations

Construction of Integrated Farming System

After demarcation of field boundaries, three integrated farming system models were constructed with help of JCB and hydraulic tractor trolley in the month of June 2015. Raised beds were leveled with the help of tractor mounted leveling blade. The area of ponds were 2356, 817 and 1225 m^2 and raised field beds were 2336, 1307 and 2041 m^2 in Lalaikheda, Patwakheda and Salempur Achaka villages, respectively. Corresponding total area of integrated farming system models were 4692, 2114 and 3266 m^2. EC and pH of raised field beds are presented in Table 66. Soil pH of raised beds immediately after construction ranged 9.01 to 9.30, 9.20 to 9.85 and 8.00 to 8.27 and the corresponding EC ranged 0.188 to 0.562, 0.326 to 0.737 and 0.194 to 0.485 dS m^{-1}, at Lalaikheda, Patwakheda and Salempur Achaka villages respectively, in a profile depth of 0 to 120 cm Table 67.

Crop Performance

Rice crop (CSR 43) was transplanted in Lalaikheda on 3rd August 2015 and Patwakheda on 4th August 2015. Recommended dose of fertilizers was applied in Lalaikheda. The selected Farmers planted vegetables such as bottle gourd, pumpkin, sponge gourd and okra on embankment Table 68. Eucalyptus saplings were also planted on one of the embankments in Patwakheda. The farmers transplanted rice (CSR 43) over raised bed and pumpking in ring basin on slope of pond. In

Table 67. Soil EC and pH after Kharif 2015

Village: Lalaikheda			Village : Patwakheda		Village: Salempur Achaka	
Depth	EC	pH	EC	pH	EC	pH
0-15	0.310	8.8	0.272	8.89	0.18	8.18
15-30	0.261	8.7	0.367	8.84	0.123	8.38
30-45	0.29	8.89	0.37	9.26	0.143	8.04
45-60	0.218	8.6	0.655	9.9	0.122	7.94
60-90	0.319	9.05	0.662	9.9	0.096	7.75
90-120	0.334	9.27	0.897	10.2	0.14	7.82

Performance of rice crop over raised beds (Kalwati and Jitendra Singh).

Salempur Achaka village, farmers initiated with early cauliflower vegetables which failed due to extreme heat and late monsoon. Thereafter, he planted brinjal, potato and carrot on raised beds.

Fish Stocking : Fish fingerling obtained from ICAR-NBFGR, Lucknow were stocked by the farmers in Patwarekheda and Salempur Achaka villages. Fish fingerling (5-10g size) was stocked for grow out culture in first two pond @ 10000 Nos./ ha with 20% catla, 30% rohu, 40% mrigal and 10% grass carp in July, 2015. Fish size increased to 325-650 g. Fish were fed with rice bran (50%) and oil cake (50%) @ 3-10% of total fish biomass per day except in winter months. In Salempur Achaka village the farmer also integrated poultry production with fish stocking. He fertilized fish pond with poultry droppings. He also put five ducks in pond for aeration. The farmer in Lalaikheda village stocked spawn of *C. idella* (grass carp) @ 2 million/ha.

Tables 68 and 69 show the crop productivity of rice and vegetables from Lalaikheda and Patwakheda fields. Grass return from crops and vegetables from Lalaikheda field was Rs. 14840.00 and from Patwarekheda field was Rs. 6345.00. Vegetables from Salempur Achaka field were yet to be harvested. First fish catch of 285 kg was obtained at Salempur Achaka while Lalaikheda farmer sold 150 kg of grass carp fingerlings and 125 kg were still left in the pond.

Salinity and pH variations in pond water are shown in Fig. 33. Water EC was observed to be the highest at Patwakheda site and the lowest in Salempur Achaka. EC initially increased and started decreasing after December, 2015. The pH of water in Patwakheda pond was high (>9.0) during the month of July 2015 due excessive falling of soils from side slopes but decreased continuously thereafter. The water pH of Salempur Achaka pond was minimum throughout, the year.

Table 68 : Yield and gross income from crops of Jitendra Singh (2336 m^2).

Jitendra Singh (Lalaikheda)				
S.N.	Crop	Yield, kg	Rate, Rs kg^{-1}	Total
1.	Rice	680	14.00	9520.00
2.	Bottle gourd	185 .0	12.00	2220.00
3.	Sponge gourd	50.0	15.0	750.00
	Pumpkin			
	Okra			
4.	Sesbania seed	35.0	35.00	1225.00
5.	Sesbania Stalk	375.0	3.00	1125.00
Total				**14840.00**

Table 69 : Yield and gross income from crop of Kalawati Devi (1306 m^2)

S.N.	Crop	Yield, kg	Rate, Rs kg^{-1}	Total
1.	Rice	280	13.00	3920.00
2.	Pumpkin	45	15.00	675.00
3.	Grass	350	5.00	1750.00
		Total		6345.00

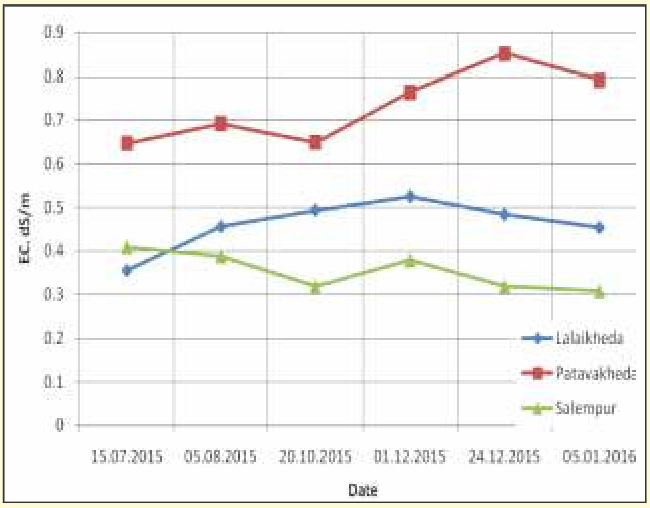


Fig. 33 : EC and pH variation in ponds.

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 Damodarn, S.K. Jha, Sanjay Arora, A.K.Singh, S. K. Singh and D.K. Sharma)

Sharda Sahayak Canal provides irrigation to 17.80 lakh ha arable area in 16 districts of U.P. Currently, it is suffering from the problems of waterlogging and sodicity. About 0.12 to 0.18 million ha sodic land suffers from shallow water table conditions in the Canal Command. Waterlogged sodic lands cannot be reclaimed sustainably through gypsum-based technology. To overcome this problem, pond based farming system module based on harvesting and management of canal seepage water has been initiated under farmers' participatory mode at Patawakhera (Sameshi), Lucknow. The total area of model was 0.80 ha., During 2015-16, rice–wheat, tomato-mustard, vegetables, and fodder crops were take on raised bed and fish was grown in the pond. Rice bran and mustard cake (2:1) was fed at 1% fish weight and 30 kg fresh cow dung day^{-1} was also applied.

Fish stocking in ponds.

Project Site -Patawakhera (Sameshi) , Lucknow

Soil Characteristics: The surface and sub-surface soil properties of the raised beds indicated that the soil pH in all the systems was below 9.0. The organic carbon varied from 0.34-0.57 % and 0.24-0.33 % in surface and subsurface soil, respectively. The fertility status of soil increased over the initial value. The available N and K were maximum in vegetable system where as available P was maximum in vegetable –mustard system. The fodder system alone increased the N and P contents over the control but did not show any change in available K content.

Water seepage in pond: Periodical measurement of water depth in canal and pond showed that when canal supply is restored the canal seepage starts recovering pond storage (Fig. 34). The amount of seepage water coming to the pond is initially high and recedes thereafter. The depth of water in pond > 0.5 meter was recorded in months of July to March, 2015 last week of April to second week of June. The water depth varied from 0.10 to 0.30 m. During these days, additional water was applied in pond through tube well for survival of fish.

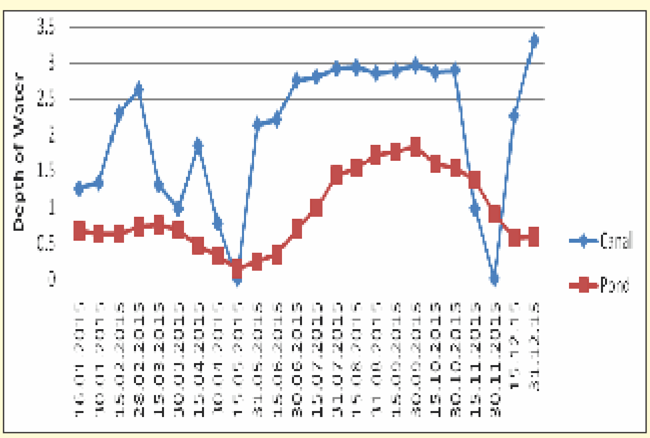


Fig. 34 : Water depth in pond and canal (m)

Pond water quality: Water pH (Fig. 35) and total dissolved salts (TDS) were analysed periodically Pond water pH reading was normal (7.37 to 8.58) . It was not affected by application of cow dung and fish feed. The TDS value varied from 302-360 ppm. The depth of water in pond and TDS value are inversely proportional.

Crop production and impact on farmers

In land shaping models, four systems viz, dhaincha-rice–wheat, tomato-mustard, vegetables and fodder were adopted on raised beds according to the needs of farmers. In pond, fish were grown (Table 70). The productivity of rice and wheat were recorded 4.02 and 4.26 t ha^{-1}, respectively, with B:C ratio of 2:1. In tomato and mustard cropping system, tomato was planted in the month of April. The overall productivity of tomato was below the normal productivity due to sodicity and poor fertility of soil. The mustard (cv.CS 54) was sown after tomato harvesting. The yield of mustard grain was 1.29 t ha^{-1} with B:C ratio of 1:1. The vegetable system was more profitable in comparison to rice wheat and tomato–mustard cropping systems. The yield productivity of spinach and cabbage was 7.01 and 47.96 t ha^{-1} respectively. The fodder (Napier hybrid CO-4) was planted on slopes of pond and on raised beds also. The B:C ratio for fodder system was the highest among all the adopted systems. The availability of fodder troughout the year except in extreme winter and summer (Fig. 36) made more impact on animal productivity. The average milk production enhanced by about 1.5 to 2.0 litre. The

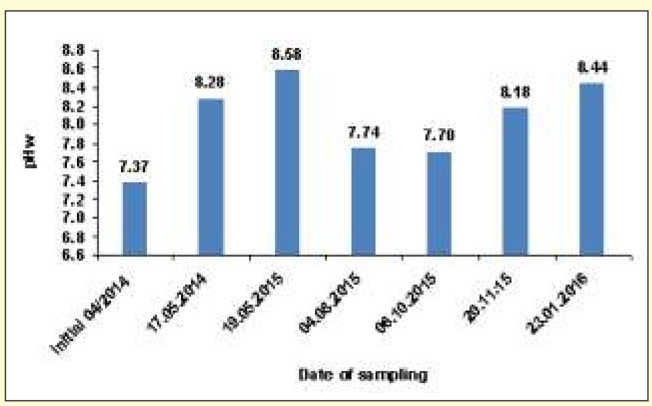


Fig. 35: Pond water pH

Table 70 : details of different cropping systems.

Cropping systems	Crops	Area (m^2)	Cost (Rs.)	Yield (t)	Productivity ($t\ ha^{-1}$)	Revenue (Rs.)	Cost benefit ratio
	Dhaincha	1340	3,135.0	0.69 (biomass)	5.20 (biomass)	-	NA
	Paddy (CSR 36)	1340	4,640.0	0.69	4.02	9,444.0	1:2.
	Wheat (KRL 19)	1000	3,791.1	0.54	4.26	8,094.0	1:2.
Cropping system 2	Tomato	1000	5,607.0	0.42	6.87	9,618.0	1:2
	Mustard (CS 56)	1440	3,087.0	0.69	1.29	5,580.0	1:1
Cropping system 3	Spinach	375	1,843.0	0.19	7.01	6,120.0	1:3
	Cabbage	417.9	2,373.0	0.20	47.96	6500.0	1:3
Cropping system 4	Napier Hybrid.	540.19	1,923.0	10.73	198.78	16095.0	1:8
Cropping system 5	Piciculture	3137.58	37,871.8	1.8	5.73	1,80,000.0	1:5
Average of the System							1.32

highest income (Rs.180000) was generated by fish production. The B:C ratio of pisciculture was recorded 5:1. The overall average B:C ratio of system (1.33) indicates that the land modification system in integration with different cropping system was not only beneficial towards the economic return but was also nutritional support to farmers family, especially the working women and children. The recurring income through vegetables and fodder made more impact on farmers' livellyhoods as evident from the repayment of bank loans and purchase of animals.

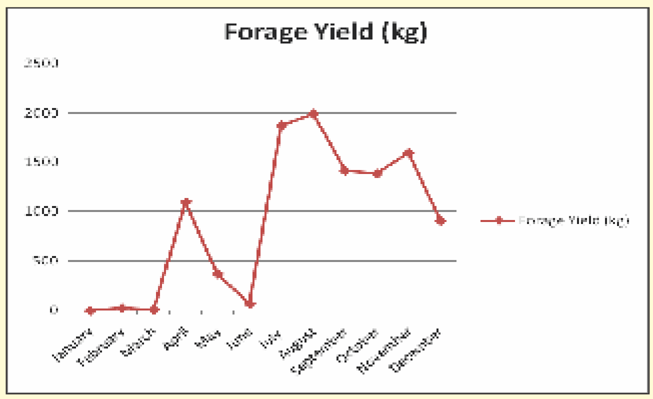


Fig. 36: Month wise fodder (Napier Hybrid CO-4) production in 2015

Status of the waterlogged sodic soils after intervention of the model (for 1 acre)

Ground water recharge for remediation of fluoride contaminated water in Unnao district of Uttar Pradesh (Chhedi Lal Verma, S.K. Jha, V. K. Mishra, S. K. Kamra and D. K. Sharma)

Fluoride ingestion in small amount (as per WHO; 0.6 ppm) is useful for bone and teeth development, but excessive ingestion causes a disease known as fluorosis. WHO standards and BIS:105001991, permit 1.5 ppm as a safe limit of fluoride in drinking water for human consumption. People in several districts in Rajasthan are consuming water with fluoride concentrations up to 24 ppm. Fluorosis continues to be an endemic problem. More and more areas are gradually becoming affected by fluorosis in different parts of the country. Children in the age group of 0 to 12 years are most prone to fluorosis as their body tissues are in formative stage during this period. In India, the most common cause of fluorosis is fluoride-laden water derived from bore wells. Nalgonda Technique, use of ion-exchange resins, reverse osmosis and use of activated alumina are the techniques to decontaminate fluoride laden water. These techniques are still out of reach of the poor farmers. Dilution of fluoride in drinking water seems to be an easiest solution to this problem. Farmers and rural people use hand pump water for drinking purposes and it is possible to use hand pump for ground water recharge through roof top harvested rain water to dilute the contaminated water. This study is being conducted fluoride-affected pasts in Unnao district of Uttar Pradesh with the following objectives : To design and construct ground water recharge structures suiting to abundant water supply from rain and canal, to study the efficacy of ground water recharge in diluting fluoride concentration, to design and construct ground water skimming structures under shallow water table conditions and testing their suitability, to design and test roof top harvesting and storage structure for a family and to educating and train farmers/school students about fluoride dilution technology through meetings and goshthis.

Red painting of fluoride affected hand pump.

Red painting of hand pumps

For increasing awareness among the villagers, fluoride concentration of each hand pump was measured and hand pumps with fluoride concentration above 1.0 ppm were painted with red circle indicating the risk with water. Farmers were educated about the associated health risk of excessive consumption of contaminated water. Open wells under use were also coloured.

Installation of recharge hand pump

One recharge hand pump was installed in Sirsahakheda village of Asoha block under medium water table conditions and the second one at Marksnagar village in Nawabganj block of Unnao district.

Pumping test before recharge: Pumping tests of hand pumps were performed under medium and shallow water table conditions (Fig. 37). It was seen that fluoride concentration (CF) increased in pumped water with time (t) under medium water table conditions and decreased with time under shallow water table condition. The range of CF under medium water table condition during pump test remained within 2.0 to 2.25 ppm and under shallow water table condition within 3.14 to 3.30 ppm. The following equation explained variation of CF with pumping time.

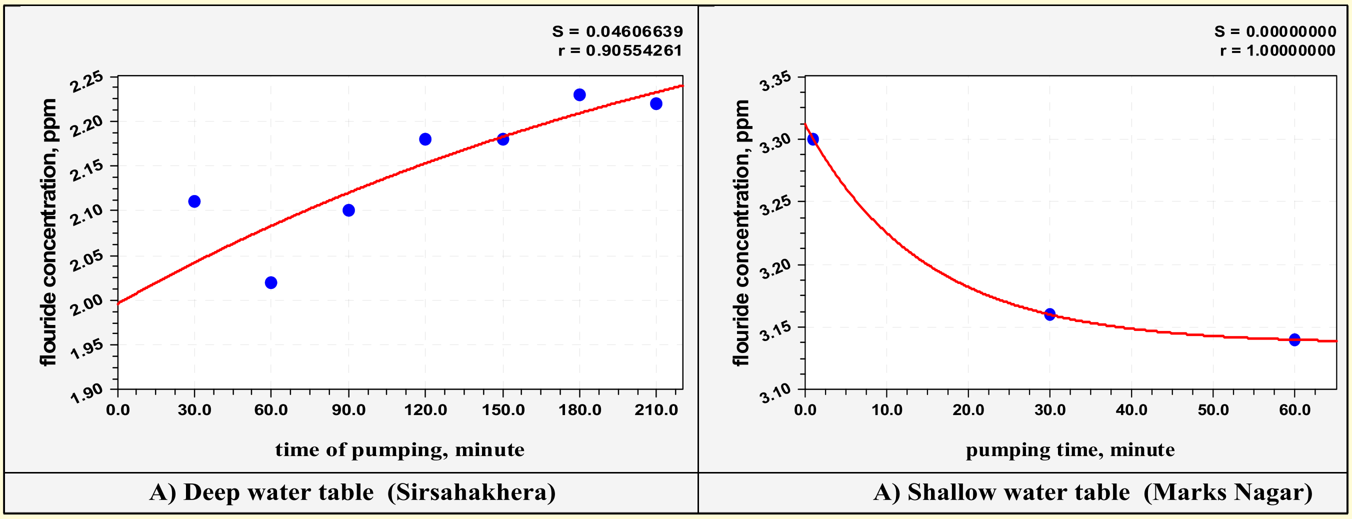


Fig. 37 : Punping set before recharge in deep & shallow water

1. Medium Water Table Condition:

$$C_F = 0.30300842\left(6.7567884 - e^{-0.0065710788t}\right) \quad (1)$$

2. Shallow Water Table Condition

$$C_F = \frac{3.1367939}{\left(1 - 0.052818335\,e^{-0.065767198t}\right)} \quad (2)$$

Integration of roof top harvesting structure

Roof of Ram Swaroop's house was observed to locate the outlet points and the most appropriate located in the close vicinity of hand pump was selected to minimize the cost of roof top water harvesting. One collector pipe was fixed for diverting rain water from roof top to the recharge hand pump. One overflow pipe was also provided to take care of excess rain water for safe drainage from roof top. Collector pipe was connected with supply pipe of same diameter on one end and on the opposite a plastic storage cum settling tank of 200 liter capacity was connected. The plastic tank served three purposes. It works as temporary storage structure for rain water where recharge rate of hand pump is low giving a prolonged opportunity for recharge with slow rate. Secondly, any particle and debris coming out of roof gets settled in storage tank and only clear water enters the recharge system. Thirdly, it allows the measurement of water entering the recharge system. It can be also equipped with an outlet for withdrawal of water for use during rainy time. A roof top harvesting structure was installed during the month of August. The outlet plastic pipe coming out of plastic tank was put directly to hand pump cylinder after removing its one way valve at bottom. This was done to avoid use of water from hand pump during recharge period.

Pumping test after recharge: This year was a extremely dry year. Only one spell of good rain was received after the integration of roof top harvesting system with recharge system. A minor located outside village remained dry throughout

Integration of roof top harvesting with recharge hand pump.

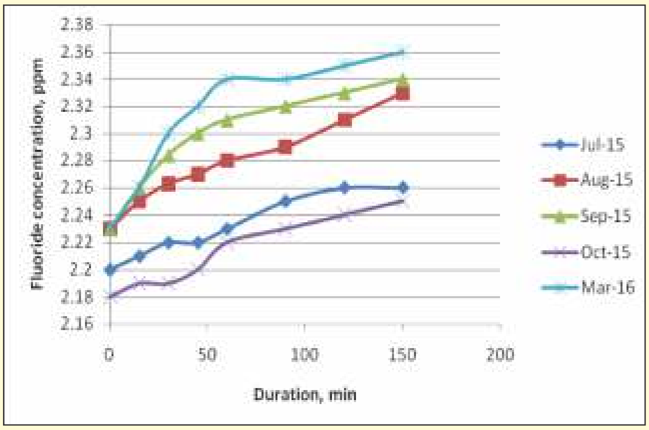


Fig. 38: Fluoride concentration during pumping

Kharif season. No recharge with canal water was possible this year. An amount of about 500 litre rain water was injected into the aquifer. The pumping test data with time and corresponding fluoride concentration are shown in Fig. 38. which indicate that CF in pumped water increasined continuously from July to September prior to recharge. A single spell of recharge with rain water during September month reduced the CF in pumped water during the month of October. The reduction in fluoride concentration does not seem prominent due to two possible reasons. The amount of rain water injected in the aquifer was too small and secondly farmers started pumping water for daily use after rainfall. Thus, there seems to be delay in pumping test.

Utilization of fly ash for increasing crop productivity by improving hydro-physical behavior of sodic soils of Uttar Pradesh (DST Funded) (V.K. Mishra, T. Damodran. 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 arount 120 m tons of fly ash. The current annual production of fly ash in India is approximately up to $90x10^6$ Mg which is likely to increase with the expansion of thermal power sector. Fly ash is an important portion of combustion and its properties depends on various factors like type of coal, combustion method etc. Fly ash is characterized (around $0.98g/cm^3$) and contains about 0.20% carbons. To explore the potentiality of fly ash in sodic soil reclamation and improvement in partially reclaimed sodic soil, two experiments were initiated with the first crop (rice) at Shivri Research farm, Lucknow. The experimental plan consisted of two experiments: one on barren sodic soil and second on partially reclaimed one.

Effect of fly ash on chemical properties of sodic Soil: In barren sodic soil, fly ash application decreased the soil pH (Table 71) compared to

Table 71 : Effect of fly ash on soil chemical properties (Barren sodic soil)

Treatment	pH (1:2)	EC dS m^{-1}	Na me l^{-1}	Ca me l^{-1}	Mg me l^{-1}	CO_3^{-2} me l^{-1}	HCO_3^- me l^{-1}
50%GR	9.3	0.90	4.4	3.7	0.98	2.3	4.1
25%GR	9.6	0.85	6.7	3.2	1.1	2.6	5.0
Fly ash (2.5% w/w)	9.7	0.96	7.9	3.6	0..8	1.9	6.6
Fly ash (5% w/w)	9.8	0.95	7.0	3.8	1.1	3.4	7.4
25% GR+ 2.5% Fly ash	9.6	0.97	5.3	3.6	1.2	4.7	11.9
25% GR+ 2.5% Fly ash + CR/Dhaincha	9.7	0.99	6.8	2.9	1.7	4.5	5.9
5% Fly ash + Dhaincha	9.7	0.79	5.6	4.8	0.98	1.9	6.9
Control	10.0	1.77	11.8	1.6	0.89	6.6	14.1
LSD (p=0.05)	0.24	NS	0.55	0.30	NS	0.58	1.22

control. The maximum decreased in soil pH (9.30) was recorded in gypsum treated plots. The pH value in 2.5 % and 5 % fly ash treated plots was 9.7 and 9.8, respectively whereas in control plot the pH was 10.0. The soil EC did not show significant change due to application of fly ash or gypsum either alone or in combination. Significant reduction was recorded in exchangeable Na^+ in gypsum and fly ash treated plots whereas exchangeable Ca^{2+} and Mg^{2+} significantly increased over the control. The CO_3 and HCO_3 application also significantly reduced by gypsum and fly ash. It appears from the data that the effect of fly ash @2.5 % w/w or 5% on sodic soil properties was not at par with gypsum (50 GR).

Soil physical properties: The soil physical properties were measured after harvest of wheat crop in second year. The highest value of mean weight diameter (MWD) was recorded in 50 GR plots followed by 25 GR. Fly ash significantly increased MWD over the control but it was significantly lower in comparison to 50GR. The combined application of fly ash with 25 GR was more effective over the same level of gypsum alone. Dhaincha as green manure before rice in combination with fly ash and gypsum further increased the MWD. The dispersible clay value of control indicates that the soil is highly dispersed due to high sodicity. The application of gypsum played significant role in flocculation process resulting in decrease in dispersible clay per cent by up to 38.5 %. Fly ash also reduced the clay dispersion per cent over control which might be due to increased exchangeable Ca^{2+} on clay micelle. Hydraulic conductivity of sodic soil was very poor (0.006 cm/hour). Application of gypsum (50GR) increased hydraulic conductivity by 20 times over control. Addition of fly ash at 2.5% w/w significantly increased the hydraulic conductivity over the control but its higher dose at 5% w/w did not show significant change which might be due to chocking of the soil pores.

Effect of fly ash on wheat and rice grain yield in sodic soil: The overall productivity of wheat was very poor in fly ash treated plots although it was significantly higher over control (Table 72). The maximum wheat yield (2.05 t ha^{-1}) in second year was recorded in 50GR treated plots. The combined application of lower doses of fly ash with gypsum 25GR and dhaincha as green manure yielded 1.44 t/ha grain yield and was at par with 25 GR. The rice yield was significantly lower in both fly ash treatments relative to gypsum treated plots. The higher doses of fly ash (5% w/w) decreased the yield in comparison to lower dose (2.5% w/w). The grain yield in 25 GR plots and in combined application of fly ash (2% w/w) and gypsum (25GR) was at par with each other.

Effect of fly ash on wheat and rice grain yield in partially reclaimed sodic soil: The wheat yield increased with increasing level of fly ash. The residual effect of dhaincha as green manure in combination with fly ash further enhanced wheat

Table 72 : Effect of fly ash on wheat and rice grain yield

Treatment	Wheat Grain Yield (2014 -15)	Rice Grain Yield (2015)
50%GR	2.05	3.66
25%GR	1.53	2.23
Fly ash 2.5% w/w	0.87	1.34
Fly ash 5% w/w	0.38	0.22
25% GR+ 2.5% Fly ash w/w	0.96	1.97
25% GR+ 2.5% Fly ash w/w+ CR/Dhaincha	1.44	2.13
5% Fly ash w/w+ CR/Dhaincha	0.80	1.02
Control	0	0.11
LSD (p=0.05)	0.15	0.42

Table 73 : Effect of fly ash on wheat and rice grain yield in partial reclaimed sodic soil

Treatment	Wheat yield (t ha^{-1}) 2014-15	Rice Yield (t ha^{-1}) 2015
Control	3.03	4.2
1%v/v Fly ash	3.25	4.2
1% v/v + Dhaincha	3.40	4.4
2%v/v Fly ash	3.37	4.7
2%v/v + Dhaincha	3.41	5.0
3%v/v Fly ash	3.52	4.8
3%v/v + Dhaincha	3.66	5.2
LSD (0.05%)	0.21	0.33

grain yield. The maximum yield (3.66 t ha^{-1}) was recorded with 3% v/v flyash with dhaincha where as minimum (3.03 t ha^{-1}) under control. The rice grain yield was also maximum in 3% v/v fly ash with dhaincha which might be due to nutritional support and improvement in soil structure. The yield under different level of fly ash was significantly different from each other. Application of 1 % v/v fly ash was not effective in enhancing the yield over control. (Table 73).

Effect of Fly ash on concentration (ppm) of heavy metals in soil : The concentration of Cu, Zn, Cd, and Pb (DTPA) increased with increasing level of fly ash where as reverse trend was recorded for Fe and Mn. The concentration of Ni and Cr were below the detectable limit in all treatments . The higher concentration of Cd and Pb in fly ash treated soil, especially at 2 and 3 % v/v seems to be major limitation for its commercial use. However, partitioning study of heavy metal concentration in different plant parts of the crops is necessary to arrive at final conclusion.

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)

In India, about 90 million tons of municipal solid waste (MSW) is generated annually and dumped in dump yards. Its dumping is increasing at a rate of 1–1.33% annually. Indiscriminate disposal of MSW creates environmental problems such as methane emission causing greenhouse effect, smell and dirt causing health problems and leachate contaminating the ground water, etc. Management of MSW is a major challenge faced by the governments. According to Central Pollution Control Board (CPCW) report, Uttar Pradesh produces about 5515 tons of MSW per day. Various governments have developed MSW plants to convert it in to municipal solid waste compost (MSWC) but the cost of processed MSW compost available in the market is very high and beyond the reach of small and marginal farmers. Therefore, it is of utmost importance to develop low cost technology for composting of MSW through standardizing the methods of on-farm composting of raw waste.

Only few studies have dealt with the impact of MSW amended on salt affected soils. Therefore, the present study was planned to standardize the methods of on-farm composting of MSW and evaluate potential effectiveness of organic MSWC in amelioration of sodic soils; monitor the combined effect of organic Municipal Solid Waste Compost (MSWC) and inorganic amendments on soil quality and biochemical changes ; find out the efficacy of inorganic amendments used in conjunction with municipal solid waste compost on soil productivity, crop yield and quality in sodic soils and to adjudge the economic feasibility of MSWC in respect of nutrient/ fertilizer savings.

After completion of decomposition process (120

Table 74 : Quality characteristics of decomposed municipal solid waste compost

Treatment	pH	EC	Total N (%)	Total P (%)	Total K (%)	Ca (ppm)	Total C (%)	C:N
T_1- 100% MSW	7.48	0.68	0.43	0.41	0.57	250	11.14	25.89
T_2-100% MSW + Microbes	7.54	0.70	0.51	0.40	0.56	270	11.31	22.17
T_3- 50% MSW + 50% AW + Microbes	7.59	0.49	0.58	0.40	0.58	250	13.63	23.50
T_4-100% MSW + EW	7.32	0.58	0.51	0.41	0.65	210	11.19	21.94
T_{5}-50% MSW + 50% AW + EW	7.72	0.63	0.56	0.40	0.76	230	13.69	24.44
T_6-100% MSW + Microbes + EW	7.33	0.90	0.65	0.40	0.67	240	12.03	18.51
T_{7}-50% MSW+ 50% AW + Microbes + EW	7.36	0.66	0.79	0.39	0.74	260	13.54	17.13

days), quality parameters like total N, total P, total C, Ca, Mg, K etc of the MSWC prepared through all the treatments were analyzed. At the same time, chemical composition of inorganic amendments like gypsum and phosphogypsum was also analyzed. It was observed that the MSWC prepared through on farm composting treatment T_7 (50% Municipal Solid Waste + 50% Agricultural Waste + Microbes + Earthworm) were very rich in nutrients (Table 74).

Microbial changes in the decomposed MSW were analyzed to monitor the quality of developed compost. Based on chemical and MSWC waste compost prepared in treatment T_7 was superior in quality. Addition of microbial culture enhanced bacterial and fungal population in the composting material. This was further enhanced when earthworm was added along with the agricultural waste.

To evaluate the synergistic effect of MSWC and inorganic amendments on soil properties and sustainability of rice-wheat cropping system, an experimental site having high sodicity (ph >9.8) was selected at ICAR-CSSRI, Research Farm, Shivri Lucknow . Before initiating the reclamation process, soil samples were collected from 25 places (0-15cm) from a 2500 m^2 plot and a composite sample as prepared. The soil of the experimental field was highly alkaline having pH 9.8, EC 1.47, organic carbon 0.13%, Na 4.90 me/100g, K 0.80 me/100g and CO_3+HCO_3 12.50 me l^{-1}.

MSWC in combination with gypsum and phosphogypsum was applied in the field and complete reclamation protocol was followed. After 10 days of leachings soils samples were again collected from all the treated plots to monitor the changes in soil properties.

To evaluate the synergistic effect of MSWC and inorganic amendments on soil properties and productivity of rice-wheat cropping system a field experiment was conducted at Shivri. Thirty days old seedling of rice cv CSR 36 were transplanted in field in July and uniform quantity of recommended dose of N, P, K and Zinc (150N:60P:40K:25Zinc sulphate) was applied in all the treatments . The maximum plant height was

Initial soil condition of selected site for experiment recorded with treatment T_3 and minimum with T_6. Number of filled grains and 1000 grain weight were higher in treatment T_3 whereas number of effective tillers/hill was higher in treatment T_1. The maximum grain yield was recorded under T_3 (application of gypsum @25% GR + 10 t ha^{-1} Decomposed MSW) followed by T^7 Treatment (@25% GR + 10 t ha^{-1} Industrial processed Municipal Solid Waste) which was significantly higher over control (gypsum @50% GR) and Phosphogypsum @50% GR (LSD= 2.98) (Table 75).

To monitor the effect of treatments and cultivation of salt tolerant variety of rice, soil samples were again collected after harvesting of rice from 0-15cm soil depth. There was significant improvement in soil properties (Table 76).

Transplanted rice in the experimental field

Table 75 : Plant growth and yield of rice under different treatments

Treatments	Height (Cm)	Effective Tillers/hill	Filled grain/ panicle	1000 Grain wt (g)	Grain Yield (t ha^{-1})
T_1:G@ 50% GR	105.77	14.20	69.99	23.40	4.74
T_2:PG@ 50% GR	115.93	12.97	86.33	25.80	4.44
T_3:G @ 25% GR + DMSWC @ 10 t ha^{-1}	118.37	10.40	104.00	26.97	4.93
T_4:PG@ 25% GR+ DMSW @ 10 t ha^{-1}	112.66	11.00	79.55	23.97	4.53
T_5:G@ 12.5% GR + DMSW @ 10 t ha^{-1}+ Pressmud @10 t ha^{-1}	109.40	11.97	60.98	22.93	4.06
T_6:PG@ 12.5% GR+ DMSW@10 t ha^{-1} + Pressmud @10 t ha^{-1}	113.99	11.50	77.44	25.27	3.81
T_7:G @ 25% GR+ IPMSWC @10t ha^{-1}	103.97	12.93	69.99	22.87	4.75
T_8:PG@ 25% GR + IPMSWC @ 10t ha^{-1}	106.55	10.86	86.11	22.73	4.50
$LSD_{0.05}$	ns	2.79	ns	2.19	2.98

G: Gypsum, PG: Phosphogypsum, DMSWC: Decomposed municipal solid waste compost,
IPMSWC: Industrial processed municipal solid waste compost.

Table: 76. Synergistic effect of organic and inorganic amendments on soil properties

Treat ments	pH	EC	OC (%)	Na (ppm) *	K (ppm) *	Avl. N (Kg ha^{-1})	CO_3 (meq l^{-1})	HCO_3 (meq l^{-1})	Cl (meq l^{-1})	Ca (meq l^{-1})*	Mg (meq l^{-1})*
T_1	9.17	0.76	0.34	267.4	9.92	92.50	3.00	5.00	3.66	5.16	4.50
T_2	8.88	0.62	0.32	227.06	7.81	103.10	00	5.33	3.33	5.83	5.00
T_3	8.80	0.90	0.28	105.92	8.48	121.04	1.00	3.33	2.66	4.83	4.83
T_4	8.96	0.65	0.32	215.24	9.54	77.35	00	4.00	3.33	4.83	5.33
T_5	8.93	0.58	0.27	161.49	10.92	94.07	00	4.16	3.16	4.66	4.16
T_6	9.16	0.61	0.33	240.22	9.90	177.61	00	4.25	4.25	4.75	5.25
T_7	9.23	0.76	0.36	222.51	9.46	114.98	1.00	5.33	4.66	4.83	5.60
T_8	8.97	0.83	0.32	223.18	9.23	190.24	2.00	6.16	4.16	5.00	3.50

*Ammonium acetate extract

Stress tolerant rice for poor farmers in Asia and South Africa (STRASA) (Y.P. Singh and V. K. Mishra)

Mother Trials

A total of 15 genotypes Viz.CPWF-05-15, Bulk 19, CSR-89-IR 14,Bulk 22, Bulk 18, RIL178, BMZ20, CSR2K-255, CSR 2K-219, CSR-89IR-15, CSR-2K-232, CSR-2K-242, CSR-2K-242,CSR-2K-262, CSR-10M2-27,CSR12B-23 were evaluated at C, Shivri farm, Lucknow and Marsanda in Sitapur district at soil pH 9.4 and 9.6, respectively. Three times replicated trials with 30-35 days old nursery were transplanted on 14.07.2015 and 17.07.2015 at Shivri and village Marsanda, respectively. Recommended dose of fertilizer (120:60:40 kg NPK ha^{-1}) and zinc sulphate @ 25 kg ha^{-1} was applied at both the locations. Among the genotypes evaluated, two naemly CSR- 2K -262 and CSR 12 B 23 ranked 1st and 2nd at Shivri and CSR 2K 262 and Bulk 22 ranked 1st and 2nd at Marsanda site (Fig 39).

Baby Trials

To scale out the high yielding salt tolerant varieties CSR 36 and CSR 43, farmer managed baby trials were conducted on 40 farmers field in Patwakhera and Sakra villages of Lucknow district. These varieties were compared with the traditional varieties and planted at soil pH ranging from 9.0 to 9.6. On the basis of crop cutting yield data collected from 40 farmers fields of Sakra and Patwakhera villages, CSR 36 and CSR 43 yielded 10.85 and 7.32%; and 27.21 and 21.76% higher, respectively, 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 irrigation (Fig 40).

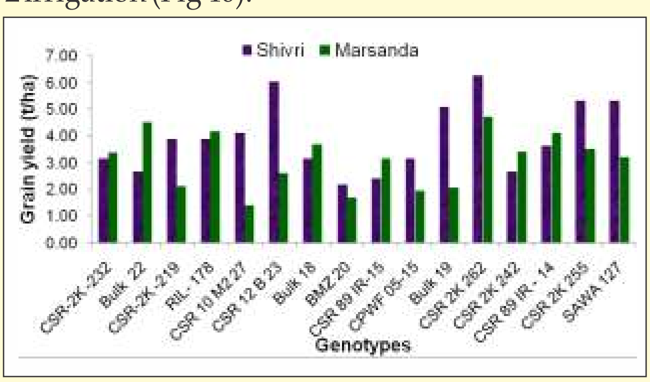


Fig. 39. Performance of different genotypes at Shivri and Marsanda sites

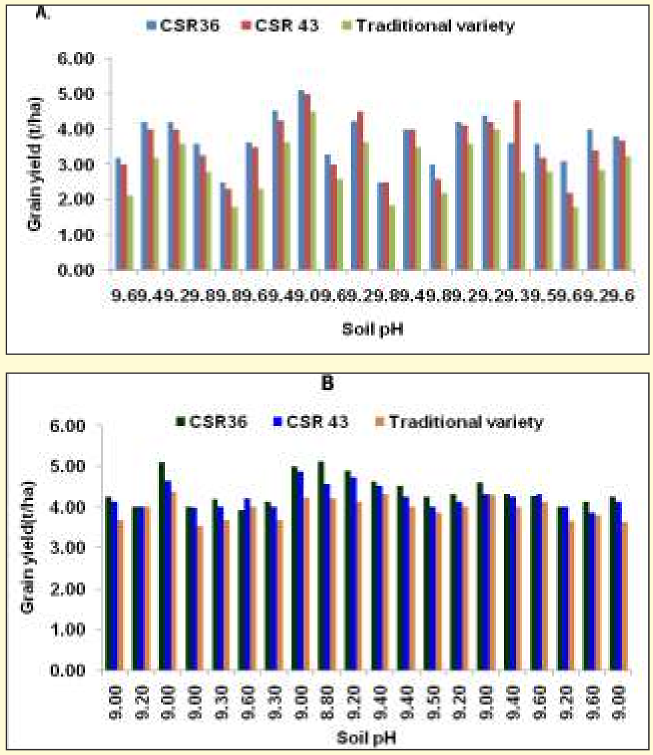


Fig. 40 Performance of salt tolerant and traditional varieties at (A) Shivri and (B) Marsanda

There was significant reduction in grain yield with increasing soil pH. Variety CSR 36 produced maximum yield at high pH levels and showed high sodicity tolerance as compared to CSR 43 and traditional varieties. However, at lower pH (up to 9.30), CSR 43 give higher yield over both CSR 36 and traditional varieties (Fig. 41).

Stress tolerant breeding network trial (STBN)

An experiment consisting of 30 rice genotypes/cultures including 5 checks was conducted at Shivri farm, Lucknow in Randomized Block Design (RBD) with three replications. The soil pH_2 of the experimental field ranged from 9.5-10.2 and mean EC was around

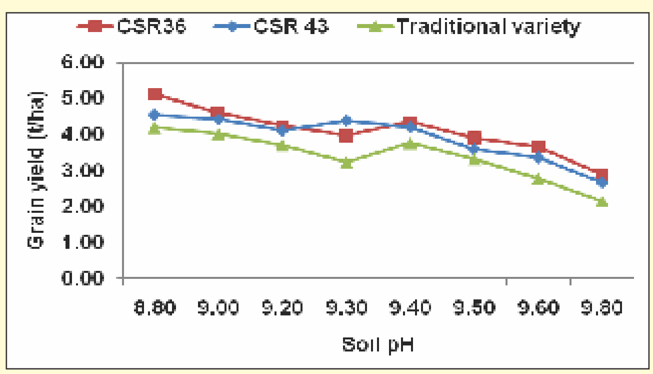


Fig.41. Performance of salt tolerant and traditional varieties at different sodicity levels

Performance of different genotypes under STBN trial

1.63. The recommended dose of fertilizer (150N:60P:40K) was applied in three splits. Among the genotypes evaluated, two highest yielding genotypes were IR 87848-301-2-1-3-B and IR 87830-B-SDO2-1-3-B (Fig. 42).

Front line demonstration

Front line demonstrations of salt tolerant varieties CSR 36 and CSR 43 were conducted on 80 farmers field in KVK Etawah, Mainpuri, Raebareli, Sant Ravidas Nagar, Kannauj, Hardoi, Kaushambi and Pratapgarh. The grain yields of both CSR 36 and CSR 43 were significantly higher over traditional varieties at all the locations (Fig.43).

Seed production and dissemination

During the year 2014-15, about 11.46 t seed of salt tolerant varieties was produced at Shivri farm and sold to the targeted farmers through different government and non government agencies .

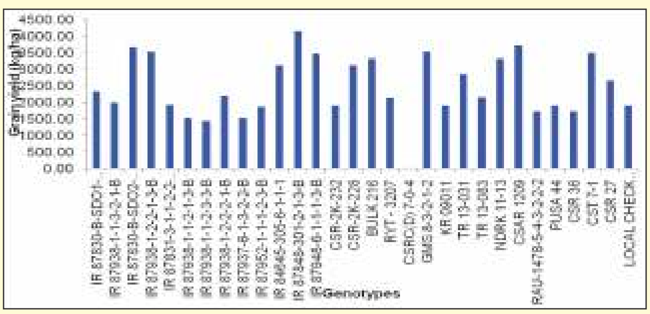


Fig.42: Grain yield of STBN entries under higher sodic conditions

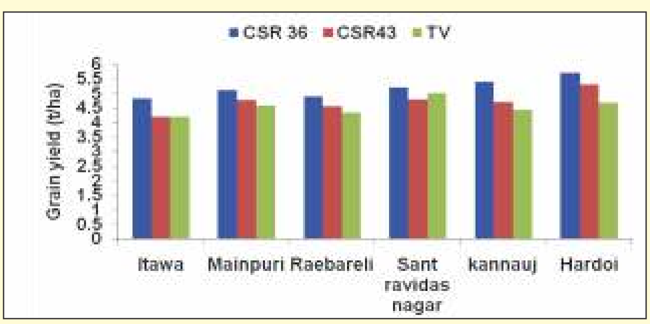


Fig. 43: Performance of CSR 36 and CSR 43 under front line demonstrations

Crop and resource management practices for rainfed lowland systems in eastern India (ICAR-W3) (Y.P. Singh and V. K. Mishra)

A field 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- cabbage -wheat and rice-beetroot-wheat was conducted at Shivri Farm with the objectives: To monitor the yield optimizing level of sodicity for short duration variety; Increasing cropping intensity of salt affected soils with the introduction of short duration variety CSR 43; To find out the economically viable rice based cropping system for salt affected soils. The cropping schedule of all the three cropping systems is given in Table 77. Cost economics of all three cropping systems was calculated on the basis of minimum support price of rice, and the market prices of cabbage and beetroot. The maximum income was recorded with rice-cabbage-wheat cropping system as compare to rice-wheat and rice-beetroot-wheat cropping systems. With the introduction of short duration variety 'CSR 43' inclusion of an additional short duration crop is possible in between traditional rice-wheat cropping system to fetch additional income. With the introduction of short duration variety, the cropping intensity of partially reclaimed sodic soils increased up to 300%. Early maturity of CSR 43 is helpful in saving 2-3 irrigations costing about Rs. 6000/ha. Moreover, such water saving approach could be extremely useful in conserving the depleting water tables. With the introduction of CSR 43, we identified certain other short duration crops like, toria, spinach, cabbage and beetroot which can be grown successfully without significant loss in wheat yield and enhanced incomes to the farmers (Fig. 44.

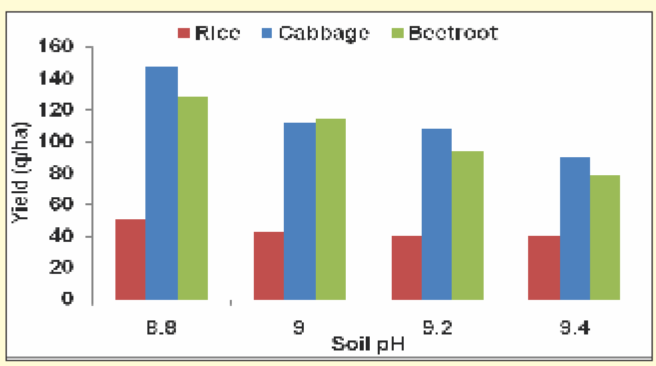
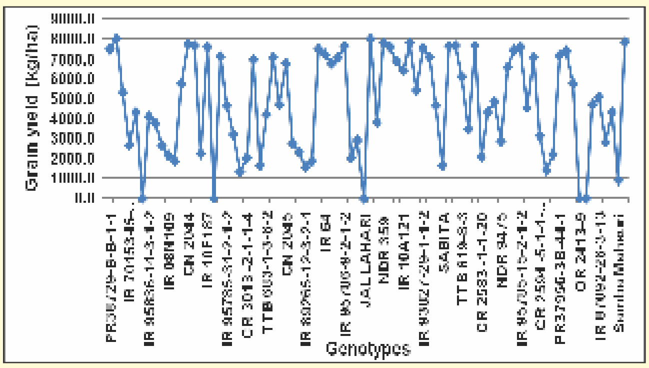


Fig. 44. Yield of rice and other short duration crops

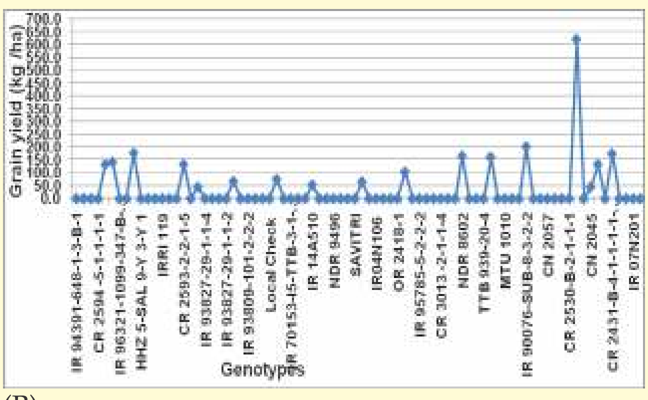
Table 77 : Cropping schedule of different cropping systems with CSR 43

Schedule	Rice	Cabbage	Beet root
Date of transplanting /sowing	02.07.2015	05.10.2015	10.10.2015
Date of harvesting	01.10.2015	13.12.2015	8.12.2015
Total duration (days)	116	70	60
Date of wheat sowing	24.11.2015	20.12.2015	10.12.2015

Multi Environment Trial (MET):A multi-environmental field trial consisting of 80 rice entries was conducted under high sodicity (pH >9.8) and normal soil (pH 8.6) environments at Shivri Farm, Lucknow. Thirty days old seedlings were transplanted on 28th June, 2015. A uniform dose of fertilizer @ 150 N : 60 P:40 K and 25 kg zinc sulphate was applied in three splits. Under normal soil conditions, 37 entries produced > 4.0 t ha^{-1} grain yield, 25 entries 2-4 t ha^{-1} and 18 entries produced 2 t/ha^{-1} grain yield. However, under high sodicity environment none of the entry produced > 0.2 t ha^{-1} except entry IR 10N 101 which produced 0.64 t ha^{-1} grain yield (Fig. 45 A&B).



(A)



(B)

Fig. 45 : Performance of rice entries
(a) under normal soil and
(b) under high sodicity environment

Screening and evaluation of wheat, mustard and rice genotypes for sodic soils (Y.P. Singh and V.K. Mishra)

All India Coordinated Wheat Improvement Trial

During rabi 2014-15, all India coordinated wheat improvement trial was conducted at Shivri Farm, Lucknow. The initial soil pH of the experimental field ranged from 9.0-9.5. The trial consisted of 11 entries viz. SPLAST 1, SPLAST 2, SPLAST3, SPLAST4, SPLAST5, SPLAST6, SPLAST7, SPLAST8, SPLAST9, SPLAST10 and SPLAST11 including 3 checks. The experiment was laid in Randomized Block design with six replications having row spacing 23 cm and 4m row length with a net plot size of 4 mx 2 m. Wheat crop was sown on 21.11.2014 and harvested on 6.04.2015. Among the genotypes/varieties screened, genotype SPLAST8 produced the maximum grain yield (3.64 kg plot^{-1}) followed by genotypes SPLAST-1(3.30 kg plot^{-1}) and the minimum (0.46 kg plot^{-1}) in SPLAST-06.

All India Salinity /Alkalinity Tolerance Nursery Trial

All India Salinity/Alkalinity Tolerant Nursery Trial on wheat, consisting of 18 entries including 4 checks (Kharchia 65, HD 2009, KRL 19 and KRL

All India Coordinated Wheat Improvement Trial

210) with a plot size 1.8 m^2 was conducted at Shivri Farm, Lucknow. The experiment soil pH_2 was >9.5. Two rows of 3 m length each were sown on 21.11.2014. Only 6 genotypes germinated and none of the genotype reached to the maturity stage because of high sodicity.

All India coordinated Trial on Rapeseed Mustard

Ten lines were evaluated in IVT under alkali condition (pH_2 9.2) at Shivri Farm, Lucknow. The genotypes were sown on 22.10.2014 and harvested on 13.03.2015. Each genotype was sown in 7.5 m^2 area and replicated three times. Significant differences were observed in seed yield among the genotypes evaluated. Seed yield ranged from 336 to 628 g $plot^{-1}$. Genotype CSCN14-6 (628g $plot^{-1}$) followed by CSCN14-1(550 g $plot^{-1}$) and CSCN14-9 (543 g $plot^{-1}$) produced the highest seed yield. Other AVT trial consisting of 10 genotypes was also conducted during Rabi 2014 at Shivri farm, at the same site. The genotypes were sown on 22.10.2014 and harvested on 13th March 2015. Each genotype was grown in a net plot area of 10.5 m^2. Significant differences were observed in seed yield amongst the genotypes evaluated. Seed yield ranged from 293 to 449 g $plot^{-1}$. Genotype CSCN14-11 produced the maximum grain yield (449 g $plot^{-1}$) followed by CSCN14-12 (433 g $plot^{-1}$) and CSCN14-19 (412 g $plot^{-1}$) whereas minimum grain yield (293g $plot^{-1}$) was obtained in CSCN14-20.

Another experiment to evaluate the performance of four promising rapeseed-mustard entries viz. AG 11 to AG 14 under different fertility levels was conducted at Shivri. Three times replicated experiment consisting of four N levels viz. 75% of RDF, recommended dose of fertilizer, 125% of RDF and 150% of RDF and four rapeseed-mustard genotypes with 3 replication was laid under split plot design at pH 9.0. Maximum grain yield was recorded with genotype AG-13 at all the N levels. The grain yield of all the genotypes at 150% of RDF was significantly higher except AG13.

Alkaline and Inland Saline Tolerant Variety Trial (IVT-AL& ISTVT) in rice

To evaluate comparative performance of promising elite cultures for alkalinity and inland salinity tolerance a field experiment consisting of 36 entries with four alkaline and one local check was conducted at Shivri Farm, Lucknow. The pH of experimental field was 9.8. The experiment was conducted in a Randomized Block Design with four replications. The crop was transplanted on 24th July, 2015 with five rows of 9 m length having gross plot size of 9 m^2. Among the genotypes, 3905, 3924 and 3902 were found to be promising in highly sodic soils. Six genotypes, *viz* 3930, 3926, 3929, 3914, 3918 and 3909 did not produce any grain in saline soil.

Advance Varietal Trial Alkaline and Inland Saline Tolerant Variety Trial (AVT-1 AL& ISTVT

Eighteen advance rice entries were evaluated under high sodicity conditions (pH 9.4) at Shivri Farm, Lucknow during Kharif 2015. The trial was conducted in RBD with two replications. Each genotype was planted in 12 rows of 6 m length having gross plot size of 15m^2. Thirty days old nursery was planted on 21.07.2015. Genotype 1709 recorded the highest grain yield 5.0 t ha^{-1}) followed by 1702 (4.5 t ha^{-1}), and 1703 94.4 t ha^{-1}) (Fig. 46)

All India Coordinated Agronomy Trial

Nitrogen response trials on selected AVT-2 rice cultures under high and low input management environments were conducted at Shivri Farm, Lucknow, during Kharif 2015 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 the promising and stable genotypes based on the grain yield efficiency index. Treatments consisted of three nitrogen levels (N_1-50% of recommended dose, N_2-100% of recommended dose and N_3-150%

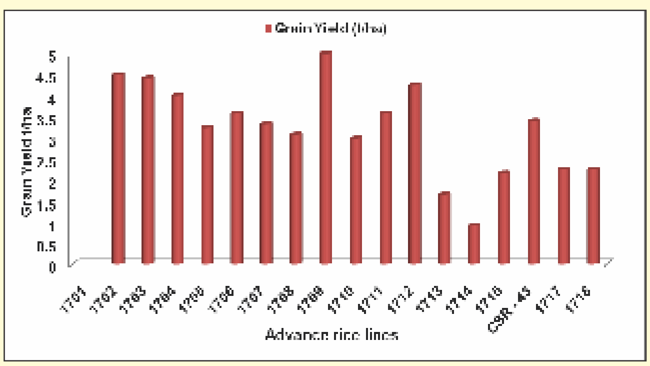


Fig. 46 : Grain yield of Advance Alkaline and Inland Saline Tolerant Variety Trial (AVT-1 AL& ISTVT)

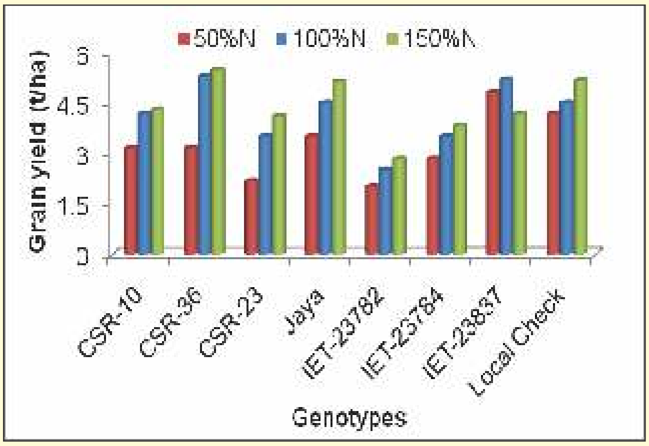


Fig. 47: Grain yield of varieties/cultures under high and low N levels

of recommended dose) in main plot and eight rice cultures/varieties viz. IET 23782, IET 23784, IET 23837, CSR 23, CSR 36, Jaya, CSR 10 and one local check (Ganga Kaveri) 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 8.4 m^2. The soil pH of experimental at field was 9.3. Grain yield of all the entries increased with increasing levels of N. The maximum grain yield (5.50 t ha^{-1}) was recorded with CSR 36 at 150% of recommended dose followed by Jaya (5.13 t ha^{-1}) and IET 23837 (4.17 t ha^{1}). (Fig. 47)

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 and Y.P. Singh)

Characterization of potential rhizospheric bacteria/fungi from plants/salt tolerant crop varieties grown in sodic soils (pH > 9.5)

A total of 47 isolates were screened for PGPR potential and salinity tolerance. Thirteen bacterial and one fungal isolate which exhibited higher PGPR characters and salt tolerance in 10% NaCl media were further characterized using 16Sr-DNA. Purified PCR products from the 16SrRNA genes of pure culture isolates representing all major RFLP patterns were sequenced on an ABI3730 automated sequencer (Applied Biosystems, USA) with primers 27 f and 1492r. All reference sequences were obtained from the National Center for Biotechnology Information (NCBI) and the 16S rDNA similarity sequences searches were performed using the BLASTN tool in the NCBI website (Table 78).

Analysis of extracellular enzyme activity: Endophytic bacterial isolates were analysed for production of four enzymes, i.e., protease, amylase, cellulase and lipase by plate method under (0.1, 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0 M) NaCl stress. Fourteen newly isolated endophytic bacterial isolates were screened for production of extracellular enzymes. The screening of isolates in 0.1 to 3.0 M of NaCl concentration indicated that actively hydrolysing enzymes with higher salt concentration could be detected in qualitative form by direct correlation of the diameter of the zone of substrate hydrolysis and colony growth. Nine isolates showed positive hydrolytic activity. These nine isolates were further selected for screening in sodic soils in tomato var. NS585.

Screening of salt tolerant PGPR isolates for sodicity tolerance in tomato hybrid NS585

A total of nine strains were assessed for their efficacy of growth promotion in tomato cv NS585 in sodic soils (pH 9.23 and EC 0.515). A loopful of bacterium was inoculated into the CSR patent protected culture media and incubated in a rotary shaker at 150 rpm for 48 h at room temperature (28±2°C). After 48h of incubation, the broth containing 6 x 10^8 CFU ml^{-1} was used for treating the tomato seeds @ 1% for 2 h and for foliar application during flowering and fruiting stages of the crop. The culture grown in CSR patent media were inoculated in FYM @ 3 L / 100 kg of FYM / acre. Significant increase in yield and plant height was observed in treatments involving the strains CSR-A-16, CSR-A-11, CSR-M-16 and CSR-A-18 (Table 79). Application of rhizobacteria and endophytic strains increased the root and shoot dry weights.

Screening of salt tolerant bacterial consortia for sodicity tolerance in tomato hybrid NS585: Consortia of compatible microbes among the four bacterial strains were made as shown in Table 80

Table 78 : Partial sequencing of salt tolerant isolates with higher PGPR activities using 16 S rDNA

S.No	Scientific name	Strain Name	NCBI, ID. NO.
1	*Lysinibacillus sphaericus*	CSR -A -16	KU745625
2	*Lysinibacillus fusiformis*	CSR -A -11	KU745624
3	*Bacillus licheniformis*	CSR -M -16	KC768636
4	*Bacillus megatarium*	CSR -M -8	KF382761
5	*Bacillus coagulans*	CSR -M -6	JQ768242
6	*Bacillus pumilus*	CSR -M -12	KC433667
7	*Bacillus flexus*	CSR -C -7	KU855379
8	*Bacillus tequilensis*	CSR -C -9	KU860545
9	*Pseudomonas mendocina*	CSR -C -10	KU860546
10	*Agromyces tropicus*	CSR -C -5	KU860548
11	*Pseudomonas sp.*	CSR -C -1	KU867577
12	*Bacillus licheniformis*	CSR -C -14	KU860547
13	*Trichoderma konengiopsis*	CSR -T -2	JQ764321
14	*Bacillus subtilis*	CSR -A -18	B.I -768236

Table 79 : Efficacy of the bacterial strains in tomato var.NS585 grown in sodic soils

S. no.	Strains	Yield q ha^{-1}	Plant Height (cm)	Root Dry weight (g)	Shoot dry weight (g)
1	CSR -A -1	44.2e	32.23c	0.28	2.4
2	CSR -A -9	93.4c	36.32c	0.21	2.54
3	CSR -A -11	154.5b	65.55a	0.69	6.2
4	CSR -A -13	42.1e	38.12c	0.35	3.76
5	CS R-A -16	163.5b	66.15a	0.66	6.52
6	CSR -A -17	67.4d	39.56c	0.42	3.2
7	CSR -A -18	155.5b	65.89a	0.64	6.4
8	CSR -A -20	52.5d	57.22b	0.48	4.1
9	CSR -M -16	186.5a	69.56a	0.83	7.2
10	Control	21.1f	19.11d	0.18	1.98

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

and were assessed for growth and yield parameters in tomato cv.NS585 grown in sodic soils of pH 9.14 at Shivri Farm, Lucknow

A loopful of bacterium was inoculated into the CSR patent protected culture media and incubated in a rotary shaker at 150 rpm for 48 h at

Table 80 : Microbial consortia of compatible salt tolerant bacterial strains

C1	CSR-A-11 + CSR-A-18 + CSR-M-16
C2	CSR-A-18 + CSR-B-2 + CSR-M-16
C3	CSR-A-16 + CSR-B-2 + CSR-A-18
C4	CSR-A-11 + CSR-A-16 + CSR-A-18
C5	CSR-A-11 + CSR-A-16 + CSR-M-16

room temperature (28±2°C). After 48h of incubation, the broth containing 6 x 10^8 CFU ml^{-1} was used for treating the tomato seeds @1 % for 2 h and for foliar application during flowering and fruiting stage of the crop. The culture grown in CSR patent media were inoculated in FYM @ 3 L / 100 kg of FYM / acre. Significantly higher yield and plant height were observed in treatments involving the consortia C5, C4 and C2 (Table 81). The consortia comprising of C-5 (CSR-M-16, CSR-A-11 and CSR-A-16) did not have any sodicity (soil pH 9.12) effect in the crop. gave the highest yield of 55.5 t ha^{-1} with higher lycopene content (166.57mg kg^{-1}) while the control exhibited the highest mortaility index with an yield of 12.00 t ha^{-1} and lycopene content of (44.22 mg kg^{-1}).

Stress related enzymes

The activities of the stress related enzymes, superoxide dimutase (SOD), and proline assessed in various treatments showed highly significant differences between treatments. Invariably, the microbial inoculated plants showed 2-3 times higher activity than control. Among the six treatments the treatments involving consortia 5 (C5) showed higher activities of SOD and proline than other treatments and control.

Bio-hardening of banana plantlets for inducing salt tolerance

An innovative protocol for in-vitro bio-hardening of banana TC plantlets with the help of salt tolerant microbes (CSR-M-16 – *Bacillus licheniformis:* CSR-A-11- *Lysinibacillus fusiformis and* CSR-A-16 – Lysinibacillus sphaericus) and VAM (rooting is induced without any external source of harmone only through auxins produced by endophytes) . The technology reduced the duration from 80 to 45 days for hardening and resulted in profuse rooting. There was a significant difference in the root length and number of roots among the bio-primed and the control where rooting was induced with the use of IBA. Bio-hardened plantlets produced 40% more root bio-mass than control.

Table 81 : Efficacy of the bacterial strains in tomato var. NS585 grown in sodic soils

Consortia	Plant height (cm)	Yield / Plant (kg)	Yield (t ha^{-1})	Lycopene mg/100g.	Shoot Dry wt. (g)
C1	71.67b	1.49b	32.34d	9.43b	41.19b
C2	82.33c	1.66c	31.63cd	12.62c	53.74b
C3	75.00b	1.32b	26.44bc	9.92b	41.48b
C4	94.33d	1.92d	47.74e	12.87c	90.23c
C5	101.67e	2.24e	55.47f	16.65d	123.48d
CONTROL	59.33a	0.36a	12.79a	4.43a	15.36a

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

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 continued since kharif 2013 under rice-wheat system included various tillage practices with and without crop residue additions (Table 82). During rabi 2015, wheat was harvested and the yield was found to be maximum (3.63 t ha^{-1}) in the treatment consisting of zero tillage in wheat, puddling in rice with crop residue addition (ZTW-PudR+CR) followed by the treatment zero tillage in wheat-summer ploughing in rice where crop residue was added (ZTW-SP+CR) which was at par with ZTW-ZTtrans+CR. In aerobic condition, however, the maximum yield of 3.12 t ha^{-1} was recorded in ZTW-DSR+CR. In kharif season, the rice yield on the other hand, was maximum (5.66 t ha^{-1}) in CTW-PudR+CR followed by ZTW-SP+CR which was on par with ZTw-ZTR+CR. The data revealed that zero tillage practices contributed in enhancing the yield. Comparison between zero tillage and conventional tillage practices where crop residues were incorporated, severled that soil characteristics improved as the pH which was lowest in the zero tillage treatments especially where crop residue was incorporated and sesbania was used for brown manuring (Fig. 48).

With regard to nutrient built up the available N and available P were the maximum (161 kg N/ha and 37.3 P kg/ha, respectively) in ZTW-DSR-SES+CR followed by ZTW-ZTtrans+CR whereas available K was found to be maximum (328.5 kg/ha) in conventional tillage practices (CTW-PudR). Among available micronutrients (DTPA extractable), Zn and Cu were the maximum in ZTW-ZTtrans+CR which were 2.2 and 3.6 kg/ha, respectively whereas Mn was dominant in ZTW-DSR-SES+CR and Fe was in the conventional tillage practices (CTW-PudR+CR) .

Since crop residue incorporation was an important component of the treatments, the study of its decomposition and the nutrient release mechanism has to be undertaken by studying the soil enzymatic activities. It is well known that the enzymes play a critical role in the decomposition

Table 82 : Details of the treatments of experiment

Treatments	Details
CTW-PudR+CR	Conventional tillage in wheat -Puddling in rice +crop residue
CTW-PudR	Conventional tillage in wheat -Puddling in rice
ZTW-ZTR+CR	Zero tillage in wheat -Zerto tillage in rice+crop residue
ZTW-ZTR	Zero tillage in wheat -Zerto tillage in rice
ZTW-DSR+CR	Zero tillage in wheat -direct seeding in rice+crop residue
ZTW-DSR	Zero tillage in wheat -direct seeding in rice
ZTW-SP+CR	Zero tillage in wheat -summer ploughing in rice+crop residue
ZTW-SP	Zero tillage in wheat -summer ploughing in rice
ZTW-DSR-SES+CR	Zero tillage in wheat -direct seeding in rice -sesbania+crop residue
ZTW-DSR-SES	Zero tillage in wheat -direct seeding in rice -sesbania
ZTW-PudR+CR	Zero tillage in wheat -Puddling in rice+crop residue
ZTW-PudR ZTW-DSR-	Zero tillage in wheat -Puddling in rice
AERO+CR	Zero tillage in wheat -direct seeding in rice -aerobic condition +crop residue
ZTW-DSR-AERO	Zero tillage in wheat -direct seeding in rice -aerobic condition
CTW-DSR-AERO+CR	Conventional tillage in wheat -direct seeding in rice -aerobic condition +crop residue
CTW-DSR-AERO	Conventional tillage in wheat -direct seeding in rice -aerobic condition

of organic materials and the transformation of organic matter thereby release available nutrients to plants. The fluorescein-diacetate (FDA) activity in the soil was determined which is a good indicator to estimate total microbial activity in soil. It revealed that FDA activity was found to be maximum in the treatment CTW-PudR+CR (5.23 µg/g/hr) followed by ZTW-PudR+CR and a very good correlation was found between microbial biomass carbon (MBC) and FDA activity (R^2=1). Dehydrogenase activity was found to be maximum in the treatment ZTW-SP+CR (20.6 µg/g/hr) followed by ZTW-PudR+CR whereas urease activity was found to be maximum (380.5 mg/g/hr) in the treatment ZTW-ZTtrans+CR followed by ZTW-DSR-SES+CR (375.6mg/g/hr). The bio-available phosphorous in soil is present either as H_2PO_4- or HPO_4^{2-}. In alkali soil, the dominant phosphate ion is HPO_4^{2-} . Therefore, alkaline phosphatase activity in the soil was determined which was found to be maximum (127.1mg/g/hr) in the treatment ZTW-ZTtrans+CR followed by ZTW-DSR-SES+CR (120 ug/g/hr).

It is therefore concluded that crop residue incorporation enhanced macro and micronutrients in the soil particularly, under zero tillage with crop residue incorporation. The enzymatic activities in the soil promoted decomposition of crop residue by increasing microbial activities and subsequently released various nutrients.

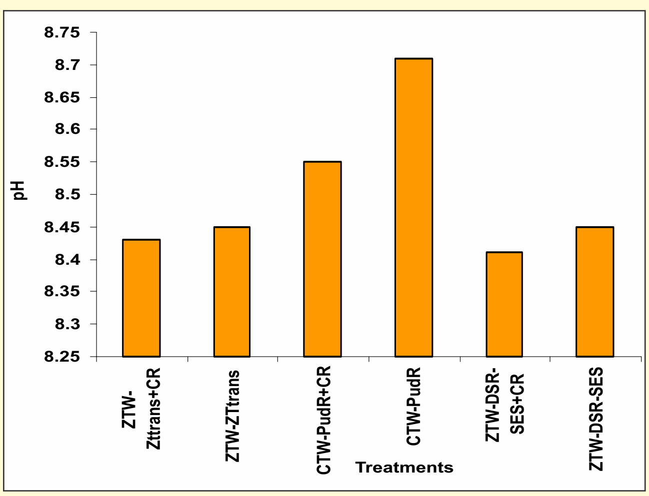


Fig. 48 : pH variation in zero tillage and conventional tillage practices

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 order to assess the best possible management practices for lesser emission of green house gases (GHGs) under rice–wheat cropping system in salt affected soils of IGP of Uttar Pradesh, the experiment was continued since 2013. Carbon dioxide (CO_2) was measured by EGM-4 CO_2 gas analyzer periodically which was found to vary each time. In March, 2015, when wheat crop was standing in the field, CO_2 emission was found to be maximum (530 ppm) in conventional tillage (CTW-PudR) whereas in zero tillage (ZTW-DSR-SES) the emission was lesser (482 ppm) as compared to conventional practices. In the month of June, however, the emission of CO_2 was maximum in the treatment where zero tillage practices were followed and crop residue was incorporated (ZTW-DSR-SES+CR). This might be due to the fact that the extreme heat during June month could have resulted in more decomposition of crop residues and subsequently more CO_2 emission. In the month of October, 2015, the emission was found to be maximum (505 ppm) in treatment (ZTW-ZTtrans+CR). The carbon mineralization study was also carried out which indicated that highest CO_2 evolved in the soils where crop residue was incorporated. The treatment ZTW-PudR+CR recorded the highest carbon mineralization (129.4 mg CO_2-C).

The maximum organic carbon built up was noted in the treatment ZTW-ZTtrans+CR followed by ZTW-DSR-SES+CR as shown in Fig. 49. The total carbon content determined by CHNS analyzer was also found to be highest in the zero tillage treatment (ZTW-DSR-SES+CR) which was 1.09 %; at par with ZTW-DSR+CR.

The GHGs were also collected from the chambers installed in various treatments and analysed through the gas chromatograph (GC). During August, 2015 when rice crop was in ponding

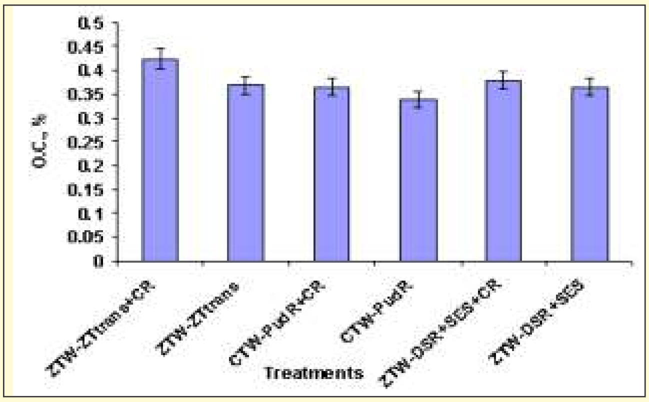


Fig. 49 : Carbon built up in the different tillage practices

condition, the CO_2 emission was highest (1411 ppm) under the treatment ZTW-DSR-SES+CR followed by ZTW-DSR+CR whereas CH_4 was the maximum (62.9 ppm) in ZTW-SP+CR followed by CTW-PudR+CR. The maximum N_2O (0.734 ppm) was observed in ZTW-DSR followed by CTW-PudR. With respect to control, no significant increase of N_2O was observed in other treatments and no correlation between these three gases was found in rice season when ponding was there. Comparing zero tillage and conventional tillage, the results indicated that conventional tillage (CTW-PudR+CR) emitted higher CO_2 gas (791 ppm) compared with zero tillage (ZTW-ZTtrans+CR). Similarly, zero tillage emitted lesser CH_4 and N_2O compared to conventional tillage (Fig. 50). In the month of October, however, the maximum CO_2 emission (810 ppm) was noted in conventional tillage followed by ZTW-DSR-SES whereas CH_4 was highest in ZTW-DSR-SES+CR (2.71 ppm). The N_2O emission on the other hand was the maximum in the zero tillage in wheat-summer ploughing in rice. In the month of January, 2016 (wheat season), the highest CO_2 emission was recorded in CTW-PudR+CR (672 ppm). A very good correlation (R2=0.93) was

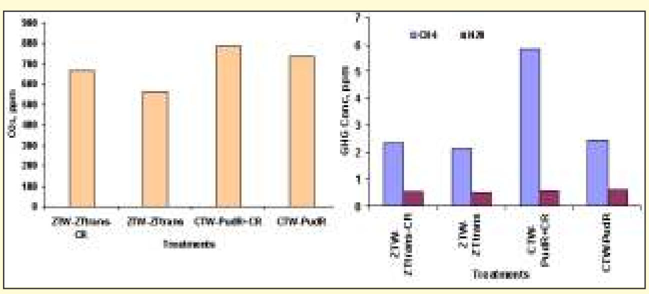


Fig. 50 : Emission of green house gases during rice season in August

found between CO_2 and CH4. In conclusion, CO_2 emission was found to be maximum in the conventional tillage treatments where crop residue was incorporated which conforms with the C-mineralization study too. Therefore, zero tillage practices being less GHGs emitter may be preferred over the conventional practices.

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)

GypCal Mobile App

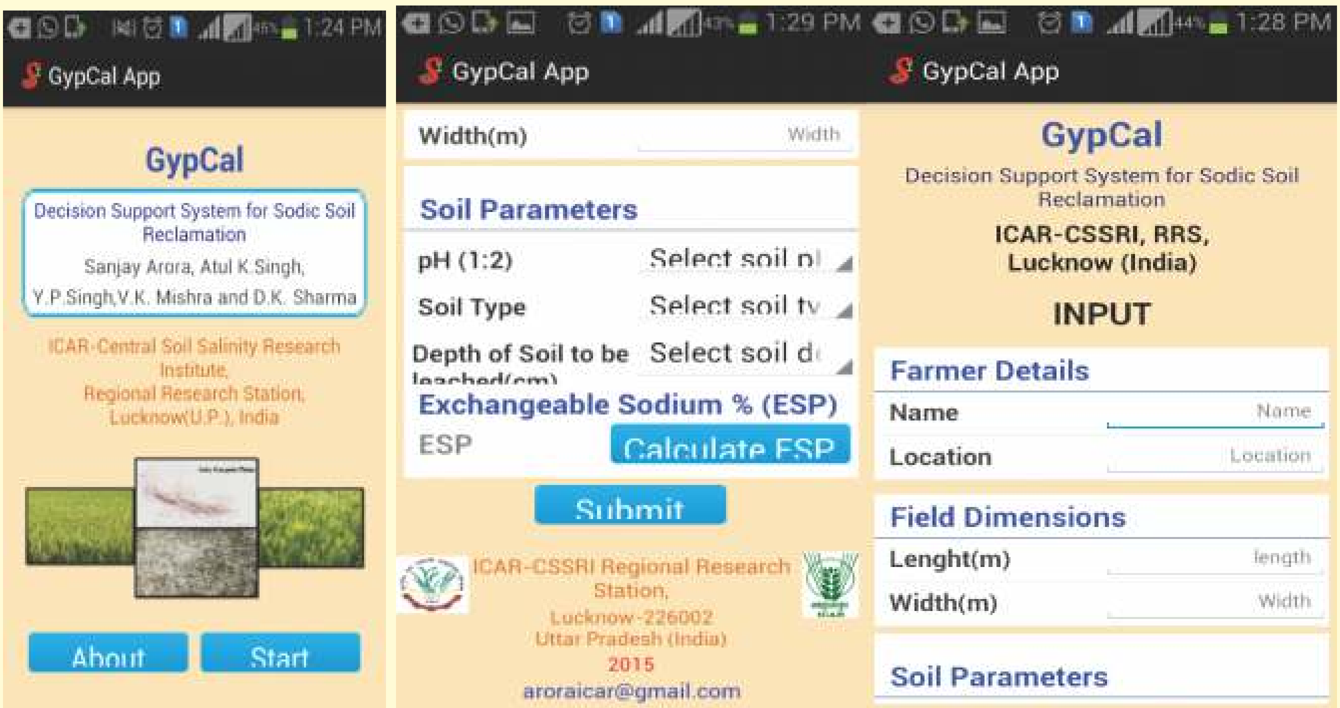
The GypCal mobile application was developed on Android platform. This App is user friendly and can be useful for field functionaries, researchers, line department officials as well as farmers desirous of chemical reclamation of sodic soil for optimizing crop production in Indo-Gangetic plains by calculating the gypsum requirement in bags (of 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 mobile app calculates the gypsum requirement on the basis of the mathematical equations obtained through curve fitting. The application is compatible with the basic android handset mobile/tab. The application was validated for different soils from diverse sodic areas. It was found to be effective not only for sodic areas in Indo-Gangetic areas but also for other areas viz. Punjab and Jammu (Table 83).

Ca-Na exchange equilibrium

An equilibrium exists between the soluble and exchangeable cations in soils. Many theoretical exchange equations have been developed to describe the equilibrium between exchangeable and soluble cations in the soil. It has been postulated that Na^+/Ca^{2+} selectivity coefficients strongly depend on the solid/solution ratio but are independent of the exchange composition and

Table 83 : Validation of GypCal model

Soil pH	GR by graphical method (t ha^{-1})	GR by GypCal (t ha^{-1})	Change in pH as per GypCal
9.7 (Jammu)	13.0	11.5	9.2
10.1 (Khiranwali)	15.2	13.6	9.6
8.8 (Sangrur)	3.0	2.2	8.4
9.8 (KVK Dhaura)	14.4	13.2	9.2
10.2 (Raebarelli)	15.4	13.0	9.5
9.9 (Amethi)	14.2	12.0	9.1



total electrolyte loading in the solution. The distribution of Na/Ca between the solution phase and exchange sites is not intuitive; being controlled by complex multicomponent exchange. Exchange sites have a high exchange affinity for Ca. An experiment was conducted to study the exchange phase-solution phase behavior of sodic soils from Indo-Gangetic plains for exchange behaviour/equilibria of Ca-Na from total electrolyte concentration of 50 meq/l of Ca:Na solution. This procedure was repeated three times and only the final equilibrium solution was analyzed for Na^{+}, Ca^{2+}, Mg^{2+} and Cl^{-}.

Normalized exchange isotherm of Na depict the relation between the equivalent fraction of adsorbed Na (Q_{Na}/Q_{0}) and equivalent fraction in the equilibrium solution (C_{Na}/C_{0}) of Ca-Na exchange. Isotherm remains below the diagonal indicating preferential adsorption of Ca over Na in the soil with all the soil amendments viz. gypsum and gypsum+pressmud (Fig 51).

All the values were positive for standard free energy change showing preference of soil for Ca^{2+} relative to Na^{+}. The ΔGr values increased with increase in ESP indicating the Ca preference of soil also increased correspondingly.

The activity coefficient of adsorbed Na^{+} and Ca^{2+} against equivalent fractions of Na^{+} for Ca-Na exchange in sodic soil was estimated. The values of equivalent fraction of Na^{+} (fNa) first increased and then decreased to unity, while those of FCa continued to decrease with increasing Na-saturation suggesting an increase in binding

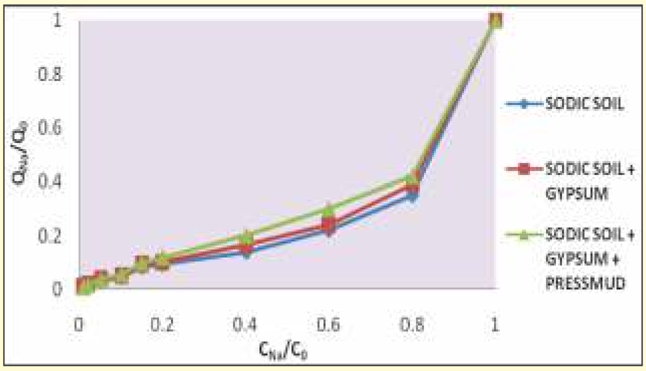


Fig. 51 : Normalized exchange isotherm of Na for Ca-Na exchange in sodic soil

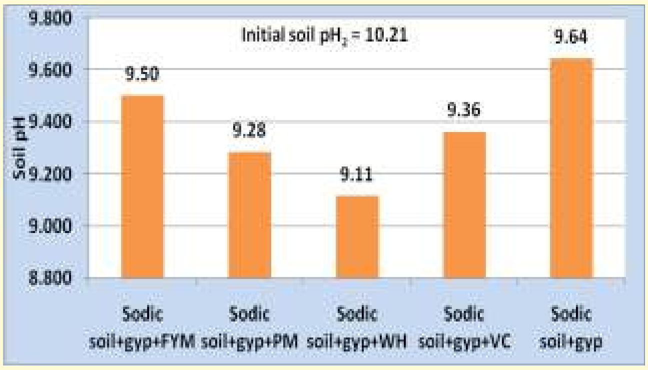


Fig. 52. Comparative efficiency of organic amendments with gypsum on pH of sodic soil

energy of Ca^{2+} ions. Smaller values of fCa than fNa at all levels of Na-saturation indicated that Na was relatively loosely bound to the exchange sites and had higher escaping tendency (Table 84).

Comparative efficiency of organic amendments in sodic soil reclamation

An incubation experiment was conducted in laboratory with sodic soil (pH 10.21) amended with gypsum along with different organic amendments like FYM, pressmud, water hyacinth and vermicompost. The treated soils in flasks were incubated at 60% water holding capacity and 28±1°C temperature. The experiment was conducted for 64 days in completely randomized block design with three replications. The C mineralization in terms of CO_2 evolution from the soil was studied. It was observed that after completion, the maximum reduction in pH of the sodic soil was observed in soil treated with gypsum along with water hyacinth (9.11) followed by soils amended with gypsum+pressmud (9.28), gypsum+vermicompost (9.36) compared to pH 9.64 in sodic soil amended only by gypsum after 64 days of incubation (Fig. 52). It was observed that maximum soil microbial biomass C and dehydrogenase activity was at 42 days after incubation which declined slightly at later incubation periods. However, there was higher microbial biomass C content and dehydrogenase actvitiy in sodic soil amended with water hyacinth followed by FYM and pressmud.

Table 84 : Activity coefficient of adsorbed Na^+ and Ca^{2+} against equivalent fractions of Na^+ for Ca-Na exchange in sodic soil

Q_{Na}/Q_O	Sodic soil		Sodic soil + gypsum		Sodic soil + gypsum + PM	
	fNa	fCa	fNa	fCa	fNa	fCa
0.1	1.33	0.88	1.28	0.88	1.42	0.87
0.2	1.42	0.77	1.41	0.77	1.44	0.77
0.3	1.37	0.68	1.36	0.69	1.38	0.69
0.4	1.32	0.61	1.32	0.61	1.32	0.63
0.5	1.26	0.55	1.27	0.54	1.25	0.56
0.6	1.21	0.49	1.21	0.49	1.21	0.49
0.7	1.15	0.43	1.16	0.43	1.16	0.44
0.8	1.10	0.38	1.10	0.39	1.10	0.39
0.9	1.05	0.34	1.05	0.35	1.05	0.35
1.0	1.00	0.30	1.00	0.31	1.00	0.32

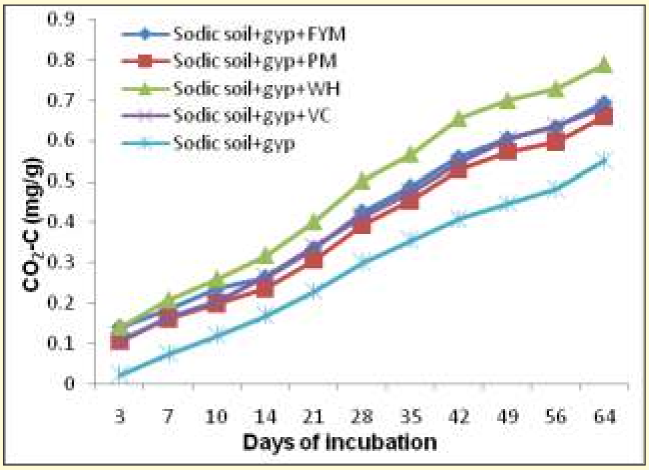


Fig. 53 : Cumulative C mineralization as influenced by amendments in sodic soil

Kinetics of C mineralization per day were also estimated and it was observed that there was cumulative increase in CO_2 flux by 24.1 per cent in sodic soil amended with FYM or vermicompost along with gypsum while 43.2 per cent in water hyacinth amended sodic soil in presence of gypsum @ 50% GR at 64 days (Fig. 53). Pressmud application with gypsum in sodic soil resulted in 19.6 per cent higher C mineralization.

Chemical reclamation of sodic soil

The sodic soil was treated with gypsum and phosphogypsum along with organic amendments for reclamation following the complete protocol. It was observed that soil pH reduced more in surface soil amended with phosphogypsum @ 50GR compared to gypsum@50GR. It was also observed that PG @ 25GR with organic amendment was more effective in reducing surface soil pH compared to mineral gypsum @ 50 GR with organic amendment (Fig. 54). Similarly, exchangeable Na content in the pre- and post-reclamation surface soil was reduced substantially when reclamation was done using PG @ 25GR coupled with organic amendment as compared to gypsum @ 25GR with organic amendment (6).

Sodic soil reclamation and crop production

Pot experiments were conducted in sodic soil amended with gypsum or phosphogypsum alone and in combination with pressmud and water hyacinth to evaluate the effect on crop production. It was observed that there was increase in fresh weight of spinach by 13.5% at 45 DAS when PG @ 50% GR was applied over G @ 50% GR in sodic soil. However, addition of pressmud along with chemical amendments (mineral gypsum or phosphogypsum) increased yield of spinach to the tune of 15% over chemical amendments alone (Fig 55). Application of G @ 12.5% GR+water hyacinth and PG @ 12.5% GR+water hyacinth resulted in 21.4% and 31.6% higher yield, respectively, over G @ 12.5% GR+pressmud and PG @12.5% GR+pressmud.

Use of halophilic PGP microbial inoculation along with chemical and organic amendments in sodic soil significantly enhanced the growth and yield of spinach, paddy and wheat in pot experiment. It were noted that maximum increase in spinach fresh weight, i.e., 115.8% and 102.9% was obtained in treatment PG @ 12.5% GR+water hyacinth+bioincoulant and G@12.5%GR+water hyacinth+bioincoulant, respectively over control (G@50%GR). The maximum yield of wheat was observed in sodic soil amended with PG@12.5%GR+water hyacinth +bioincoulant followed by G @ 12.5%GR+water hyacinth+bioincoulant and PG@12.5%GR+ water hyacinth. The wheat yield was superior by 16.4% and 21.4% over treatments where gypsum or phosphogypsum @12.5GR was applied along with pressmud indicating beneficial effect of bio-inocluation with halophilic PGP coupled with water hyacinth as organic amendment.

The field experiment was continued on sodic soil (initial pH_2=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 30 m^2. The treatments imposed were, T1: Gypsum @ 50 GR; T2: Gypsum @ 25 GR; T3: Gypsum @ 12.5 GR; T4: Phosphogypsum @ 25 GR; T5: Gypsum @ 25 GR+pressmud; T6: Phospho-gypsum@ 25 GR+ pressmud; T7: Gypsum @ 25 GR+ pressmud +bio-inoculant; T8: Gypsum@ 12.5 GR+ pressmud; T9: Phosphogypsum @12.5 GR +pressmud; T10: 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.

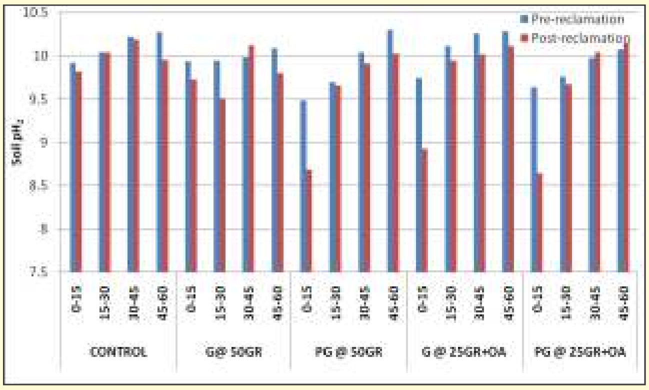


Fig. 54. Effect of chemical + organic amendments for sodic soil reclamation on soil pH

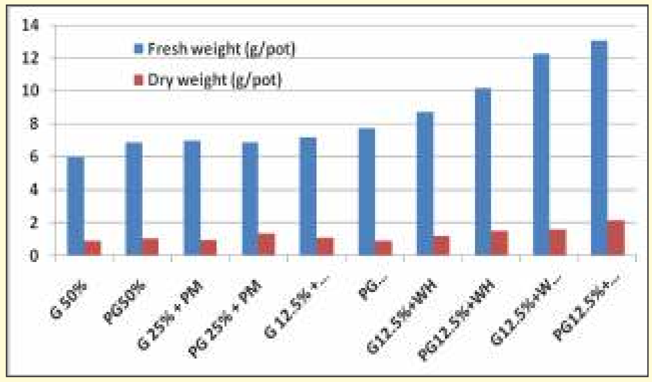


Fig. 55 : Effect of amendments on spinach

Maximum grain and straw yields of wheat (rabi 2014-15) were obtained in treatment where gypsum @ 25% GR+ 10t pressmud along with bio-inoculant was applied which was at par with treatment PG @ 25% GR + pressmud. Grain yield as well as straw yield was 77.5% and 71.5% higher with the combined use of phosphogypsum @ 25%GR and pressmud as compared gypsum @ 50% GR alone (Fig 56).

During kharif 2015, the maximum grain yield of paddy was observed in treatment plot where phosphogypsum @ 25GR+pressmud was applied and it was superior by 14.7 and 8.3 per cent compared to gypsum@50GR and gypsum@25GR+pressmud, respectively. Straw yield was found to be influenced by the application of organic and inorganic amendments in combination with bio-inoculant. Paddy straw yield was 17.8 and 28.4 per cent higher when the above treatments were compared. However, grain yield in plots amended with gypsum @ 12.5 GR+pressmud+bio-inoculant was higher by 6 per cent over gypsum @ 12.5 GR+pressmud. Straw yield was also maximum in phosphogypsum @ 25 GR+pressmud treatment where it was 28.4 per cent higher than gypsum @ 25GR+pressmud. (Fig. 57).

After harvest of paddy, depthwise soil samples were collected from different plots. It was noted that soil pH ranged from 9.22 to 10.32 (mean of 3 replications) in all the treated plots as compared 9.84 in unamended plots. The lowest soil pH (9.22) was noted in treatment T6 (PG_{25GR}+Pressmud). Exchangeable Na^+ content ranged from 11.68 to 26.18 Cmol/kg which in general increased to 15.75 to 27.22 Cmol/kg in lower soil layers indicating leaching of ions from surface to sub-surface layers with the application of amendments. However, there was increase in exchangeable Na content in some plots when compared to the initial.

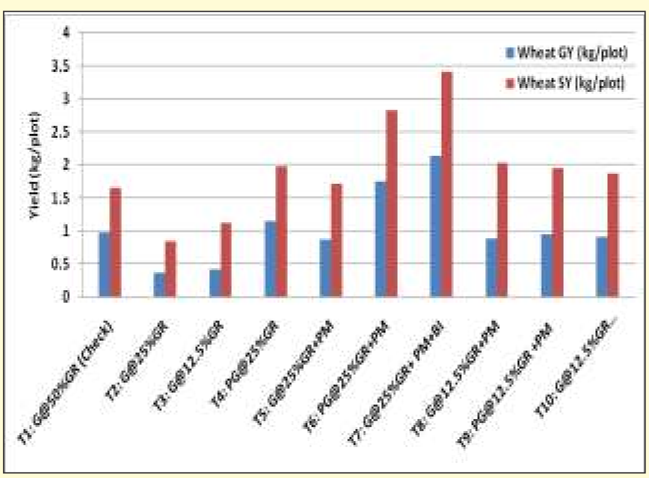


Fig. 56. Effect of amendments on wheat

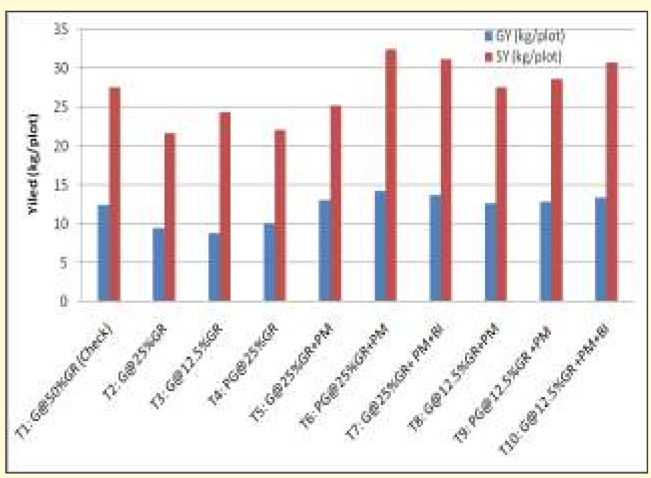


Fig. 57. Effect of amendments on grain and straw yield of paddy

Dissolution of native $CaCO_3$

The release of Ca+Mg ions was studied from calcareous sodic soils of Samastipur and Muzaffarpur districts of Bihar having varying contents of native $CaCO_3$. The soil samples were amended with water hyacinth @ 10 tha^{-1} at field capacity moisture and incubated at 28±1°C for 60 days. The release of Ca+Mg increased due to dissolution of $CaCO_3$. After 60 days of incubation, 14.4 to 22.6 per cent higher release of Ca+Mg was observed in water hyacinth amended soils as compared to no water hyacinth application (Table 85). The study indicates that native $CaCO_3$ dissolution can help in ameliorating sodic effect when water hyacinth was applied to sodic calcareous soils. This organic amendment was better than pressmud as per our previous experiment results. Different kinetic models were used to fit the release of Ca+Mg with respect to time period from the mineral gypsum amended with water hyacinth.

Modifications proposed in GR method: It was observed that the Schoonover method measures about 4 times that of gypsum requirement as compare to exchangeable Na which is certainly due to soluble carbonates. In our previous study it was observed that heavily loaded soluble carbonate soils single /leaching 20 ml removes only a part of alkaline salts resulting in only marginal decline in the inflated GR. Repeated washing with 10 ml increments of 60% alchol is suggested till excess of all soluble carbonates are removed. This will give accurate exchangeable sodium with saturated gypsum solution. The method is more effective in saline-sodic soils. Earlier, we also observed that washing with distill water also reduces GR of sodic soil by 20.2 to 56.5 per cent . However, removal of soluble carbonates as determined in these soils by our suggested modification is nearly complete and has brought the GR values close to exchangeable-Na levels.

Table 85 : Effect of Water Hyacinth on native $CaCO_3$ dissolution in Sodic Calcareous soils of Bihar

Days	Treatment	$CaCO_3$ 2%	$CaCO_3$ 10%	$CaCO_3$ 22%	$CaCO_3$ 28%
2D	-WH	4.15	5.15	5.30	5.58
	+WH	4.65	5.24	5.71	5.81
7D	-WH	4.85	5.22	5.65	5.69
	+WH	5.25	5.47	5.82	6.02
15D	-WH	4.98	5.30	5.88	5.90
	+WH	5.12	5.49	5.94	6.41
30D	-WH	5.18	5.61	6.04	6.22
	+WH	5.72	6.25	6.58	7.12
60D	-WH	5.20	6.40	8.05	8.95
	+WH	6.02	7.85	9.77	10.11

GypKIT: The kit has been developed that can estimate gypsum requirement of sodic soil directly in the field. It is useful in calculating the accurate amount of mineral gypsum required for reclamation of sodic soil under test. This is based on titrimetric method of quantitative sodic soil gypsum requirement to provide proper estimate at farmers' doorstep. The kit comes with solutions and vessels required for quantitative estimation. The solutions have shelf life of 6 months at room temperature and preferably kept in refrigerator away from sunlight. It can be useful for 5 sample analysis and instruction manual is made available with the kit in hindi/English. The approximate cost of one kit is Rs. 27/-. It can be easily used by farmers/rural youth/field functionaries following instructions. The estimation of sodic soil gypsum requirement using laboratory method and through GypKIT was done to ascertain the accuracy of the kit. The kit was found to give valid results for different sodic soil collected from Indo-Gangetic plains of U.P. (Table 86) as well as its use in farmers field at Unnao and Raebareilli was found to give proper estimation of GR (Table 87).

Soil quality and production efficiency of Calcareous sodic soils: To see the contribution of various soil parameters towards production efficiency, influence intensity of these parameters were determined for calcareous sodic soils of Bihar Table 88. It was observed that soil free $CaCO_3$ per cent and ESP have greatest influence followed by pH, organic carbon, CEC and EC which were having influence intensity to the tune of 10-12%. Thereafter, influence intensity followed the trend as available N (8%)> available P (6%) and the least influence intensity was noticed for available K content which was around 6%.

Table 86. Validation of GypKIT

Soil sample	Schoonover method	GypKIT
Sandila	1.1	1.3
Dhaura	1.8	1.95
Vishnupur	0.2	0.25
Shivri	1.45	1.5
Samesi	1.35	1.6
Santrah	1.2	1.35
Baratikhera	0.7	0.6
Shivri I	2.3	2.35
Bihar (S)	2.6	2.65
Bihar (M)	2.55	2.65

Relative soil quality (RSQI) and production efficiency indices (RPEI) for calcareous sodic soils were worked out. It was observed that soil quality wise, strongly calcareous sodic soils were not suitable for wheat (RPEI=53) but suitable for rice (RPEI=62). Relative soil quality index (RSQI) was 55 and RPEI was 59 in case of moderately calcareous sodic soils revealing that these soils were suitable both for wheat and rice crop as values for rice were 69 and 77, respectively indicating suitability of moderately sodic soils for rice crop. In case of slightly calcareous sodic soils, both RSQI and RPEI values for rice and wheat were in Class I, thus showing suitability of these soils for these crops.

GypKIT – A field kit for Gypsum requirement

Table 87: GypKIT use in farmers field (Unnao & Raebareilli)

Soil sample (farmers field)	Soil pH_2	Schoonover method	GypKIT
1	9.83	1.55	1.6
2	9.53	1.9	2.0
3	10.44	1.3	1.45
4	10.31	1.25	1.25
5	9.39	2.3	2.35
6	9.28	2.25	2.3
7	9.73	1.8	1.95
8	9.9	1.4	1.45
9	9.87	1.55	1.6
10	10.04	1.8	1.8
11	10.07	1.05	1.1
12	9.87	1.7	1.7
13	9.64	1.8	1.6
14	10.07	1.25	1.3
15	9.91	1.7	1.8
16	9.8	2.1	2.3
17	9.79	2.25	2.4
18	9.71	2.05	2.1
19	9.4	2.2	2.4
20	8.38	2.75	2.9
21	8.47	2.75	2.7

Table 88 :Soil quality and production efficiency indices values of calcareous sodic soils of Bihar

Soils	RSQI		RPEI	
	Wheat	Rice	Wheat	Rice
Strongly calcareous sodic	44	57	53	62
Moderately calcareous sodic	55	69	59	77
Slightly calcareous sodic	82	76	84	81

Bioremediation of salt affected soils of Uttar Pradesh through halophilic microbes to promote organic farming

(Sanjay Arora and Y.P. Singh)

The isolated halophilic bacteria from sodic soils were tested for their tolerance to different salts like Na_2SO_4 and Na_2CO_3. It was observed that all of 19 halophilic bacterial isolates were able to tolerate Na_2SO_4 concentration upto 5% but only 4 could tolerate upto 5% level of Na_2CO_3 (Table 89).

The promising isolates in terms of salt tolerance, pH tolerance, temperature tolerance and having plant growth promotion traits were bio-chemically characterized and screened. The halophilic bacterial strains of Azotobacter, Azospirillum and Pseudomonas were tested in pots as seed inoculation in wheat and seedling inoculation in paddy.

Identification of isolated bacterial strain was done by 16S rRNA gene sequencing. Genomic DNA of bacterial isolates was amplified with universal primers (forward and reverse). The purified amplified PCR product of 1.5 kb was sent for gene sequencing.

Salt removal efficacy of the promising halophiles were tested in liquid media as well as in sterile soil. It was observed that consortia of CHB1 and CHB2 were able to remove substantial amount of Na from the liquid media and in different pH soil. These were able to remove up to 6294 mg/kg of Na in soils having soluble Na level of 7728 mg/kg (Table 90). The isolated PSB cultures on Pikovaskay's media were tested for their efficacy in phosphate solubilization from tri calcium phosphate. It was observed that phosphate solubilization efficiency of the 12 isolates varied from 125 to 267 while phosphate solubilization index varied between 25 and 167. Also, halophilic isolates were screened for temperature tolerance. It was noted that most of them could survive upto 45^{O}C under incubation.

Rhizobium strains were also isolated from the rhizosphere sodic soils and tested for theirp H tolerance. The five rhizobial isolates were observed to sustain up to pH 9.0 while only 4 could survive at pH 11.0.

Table. 89. Salt tolerance of PGP bacterial isolates

Isolate No.	2.5% Na_2SO_4	5% Na_2SO_4	2.5% Na_2CO_3	5% Na_2CO_3	10% Na_2CO_3
1	+++	+++			
2	+++	+++			
3	+++	+++			
4	+++	+++			
5	+++	+++	+++	+	+
6	+++	+++	+++	+++	++
7	+++	+++			
8	+++	+++			
9	+++	+++			
10	+++	+++			
11	+++	+++	+++	+++	+
12	+++	++			
13	+++	+++	+		
14	+++	+++			
15	+++	+++			
16	+++	+++			
17	+++	++	+++	+	
18	+++	++			
19	+++	+++			

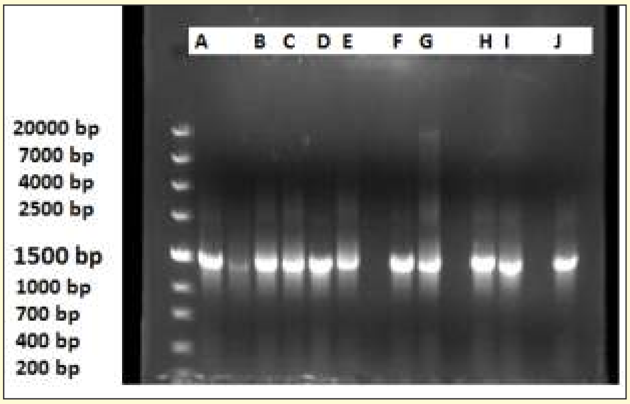
These halophilic PGP isolates were tested for plant growth promotion in sodic soil (pH 9.6) in pot as well as field (pH 9.4) experiment. It was observed that grain yield of wheat in field increased from 3.13 t ha^{-1} to 4.13 t ha^{-1} when consortia of halophilic N-fixers and P-solublizers were used for inoculation (Table 91). Similarly, straw yield also increased with inoculation of these halophilic isolates.

Effect of incoluation on soil sodicity in terms of Na content was also monitored and it was found that Na content decreased with inoculation in surface soil layers indicating the remediation potential of these strains. Further, improvement in soil-biochemical properties with increase of microbial biomass C upto 137 µg/g in surface soil was found as compared to 82 µg/g in control (Table 83). Inoculation of halophilic plant growth promoting isolates in paddy seedlings resulted in improved soil- biochemical properties. It was observed that in surface soils, Na content substantially reduced and microbial biomass C, enzyme activities as well as available N and P content got enhanced. Surface soil pH got reduced substantially in consortia inoculation in field experiment. Maximum reduction in Na content was noted in plots where consortia of Halo-Azo and Halo-PSB were inoculated where it was found to be 197.4 mg/kg compared to surface soil from control plot where it was 323.8 mg/kg. However, in sub-surface layers in all the experimental plot, there was accumulation of sodium.

To prepare the bio-formulations of these promising halophilic strains of PGP as individual and in consortia, different additives were tested in order to standardize the media. It was observed that addition of some additives to phosphate buffer performed well in stabilizing media with enhanced shelf- life compared to other additives.

Table 90. Halophilic bacterial inoculated in sterile soil to test their efficacyfor soluble Na removal from sodic soil

	Na^+ (mg/kg)			
Soil	Untreated (Control)	CHB1	CHB2	CHB1+ CHB2
Soil 1 (pH=9.2)	4018±112	3389±87	3896±92	3528±123
Soil 2 (pH=9.8)	6451±241	4575±166	5830±127	5391±187
Soil 3 (pH = 10.1)	7728±198	5235±202	6100±214	6294±258



DNA- PCR amplification

Table 91 : Effect of inoculation of halophilic bacterial strains on wheat

Treatment	Grain yield (t ha^{-1})	Straw Yield (t ha^{-1})
Control (FYM)	3.31	5.03
FYM+HB1	3.74	5.65
FYM+HB2	4.01	6.11
FYM+HB3	3.99	5.87
FYM+Consortia	4.13	6.25
CD(5%)	0.11	0.17

Initial soil pH = 9.4; Org. C= 0.21%; Plot size: 30m^2

Table 92. Effect of inoculation of halophilic bacterial strains on soil properties

Treatment	Soil depth(cm)	Na (mg/kg)	K (mg/kg)	Av. P (mg/kg)	MBC (µg/g)	DHA (µg TPF/g/h)
Control (FYM)	0-15	323.8	28.70	9.9	82	12.45
	15-30	855.75	26.50	5.5	68	10.24
	30-60	205.7	25.80	4.9	41	7.48
FYM+HB1	0-15	269.7	29.95	14.6	116	19.65
	15-30	533.2	29.50	7.4	75	11.22
	30-60	551.1	23.20	4.1	52	10.02
FYM+HB2	0-15	226.4	24.00	11.8	137	15.88
	15-30	413.8	23.65	5.0	94	12.24
	30-60	735.1	21.50	4.3	61	7.15
FYM+HB3	0-15	240	25.95	15.6	104	13.16
	15-30	731.3	21.65	12.9	66	8.15
	30-60	904.2	22.80	6.2	52	6.11
FYM+Consortia	0-15	197.4	20.40	12.9	129	16.80
	15-30	326.3	15.75	6.6	91	9.62
	30-60	466.4	18.65	4.8	64	8.54

Field testing at farmers fields to promote organic farming in sodic lands

The bio-formulations of halophilic N-fixers and phosphate solubilizers have been prepared and tested on sodic soils in experimental fields, pots as well as farmers' fields. Promising results have been obtained in paddy, wheat, mustard and fodder crops. At farmers field also yield of paddy (t/ha) was influenced by halophilic bioformulations and salt tolerant variety (CSR 36) (Table 93).

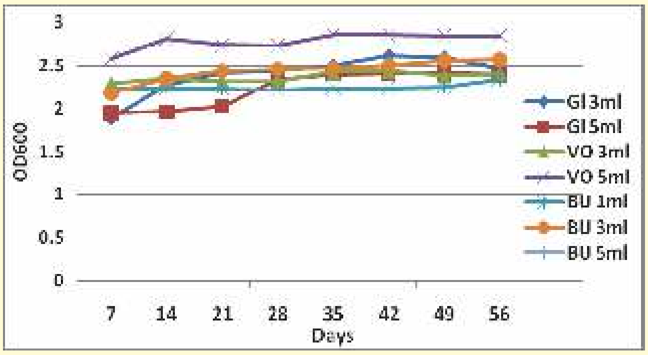


Fig. 58: Standardization of media for shelf life of liquid bioformulation

Bioformulations - Halo-Azo and Halo-PSB

Table 93 : Effect of bioformulations (Halo-PSB+Halo-Azo) on paddy yield at farmers field

Sr No	Farmer Name	Village & District	STV (CSR36 + Halo-PSB+Halo Azo) (t ha^{-1})	Traditional Variety–Farmers practice (t ha^{-1})
1	Sh. Manoj Kumar	Vill.-Ulrapur, Distt.-Unnao	4.25	2.54
2	Sh. Raghu Raj	Vill.-Ulrapur, Distt.-Unnao	3.75	2.45
3	Sh Raj Kumar Yadav	Vill.-Ulrapur, Distt.-Unnao	3.86	2.47
4	Sh. Pappu Yadav	Vill.-Ulrapur, Distt.-Unnao	4.03	2.35
5	Sh. Babu Lal	Vill.-Ulrapur, Distt.-Unnao	4.64	2.74
6	Sh. Ram Jeewan	Vill.-Maljha, Distt.-Unnao	4.57	2.76
7	Sh. Barati Lal	Vill.-Maljha, Distt.-Unnao	4.60	3.14
8	Sh. Asharfi Lal	Vill.-Maljha, Distt.-Unnao	4.13	2.84
9	Sh. Rakesh	Vill.-Maljha, Distt.-Unnao	3.50	2.18
10	Sh. Girja Shankar	Vill.-Maljha, Distt.-Unnao	3.86	2.06
11	Sh. Roop Narayan	Vill.-Maljha, Distt.-Unnao	5.25	3.51
12	Sh. Surender Kumar Yadav	Vill.-Maljha, Distt.-Unnao	3.57	2.02
13	Sh. Paltu	Vill. - Koni, Distt.-Raibarelli	3.27	2.54
14	Sh. Buddhiram	Vill. - Koni, Distt.-Raibarelli	3.57	2.65
15	Sh. Sunder	Vill. - Koni, Distt.-Raibarelli	3.22	2.39
16	Shri. Nankau	Vill. - Koni, Distt.-Raibarelli	2.85	2.01
17	Sh. Ram Pal	Vill. - Koni, Distt.-Raibarelli	3.98	3.02

The four types of bio-formulations named Halo-Azo, Halo-PSB, Halo-Rhizo and Halo-Mix can be effectively be used in sodic soils for improving crop growth and yield as well as improve the soil fertility and health.

Impact assessment of pesticides on environment using EIQ tool under rice cropping system (NCIPM-CSSRI Collaborative Project) (Sanjay Arora)

The surface soils of the 20 paddy fields of Sitapur were analysed for various physicchemical properties (1). The soil pH ranged from 6.35 to 8.64 and EC ranged from 0.04 to 1.11 dS m^{-1}. Soil organic carbon content varied from 2.1 to 5.4 g kg^{-1} and the soils were loamy sand to silty clay loam in texture (Table 94). Available N, P and K content varied from 81.9 to 179.8, 5.9 to 19.9 and 154.3 to 232.2 kg ha^{-1}, respectively.

The population (cfu g-^{1}) of bacteria ranged from 196 $\times 10^4$ to 56 $\times 10^5$. Bacterial population in paddy soils of Shuklapur was maximum followed by Padariya II and Tiwaripur I. Least bacterial load was observed in paddy rhizosphere soil of Sarwahanpur I from Sitapur (Fig 59). A total of 137 bacterial isolates were isolated from soils. Most of the isolated bacteria were Gram-positive and rod shaped. There was a great variation in their colony characteristics. Gram's staining showed 103 were cocci while 34 were bacilli. Similarly, fungi isolated on potato dextrose agar was found to be maximum in soil of Dafra II followed by Ohripur and Ghuripur. In paddy soils of Dafra and Sarwahanpur, fungal population was minimum.

Soil bacterial populations drastically reduced from 6.2×10^5 cfu g^{-1} to 1.8×10^4 cfu g^{-1} on nutrient agar after 24 hours of growth in soil from farmers' practice of

Table 94. Properties of soil

Soil properties	Range	Mean
Soil pH (1:2)	6.35 – 8.64	7.82
EC (dS m^{-1})	0.04 – 1.11	0.46
Organic C (g kg^{-1})	2.1 – 5.4	3.42
Available N (kg ha^{-1})	81.9 – 179.8	128.6
Available P (kg ha^{-1})	5.9 – 19.9	12.5
Available K (kg ha^{-1})	154.3 – 232.2	180.7
Textural class	loamy sand to silty clay loam	-

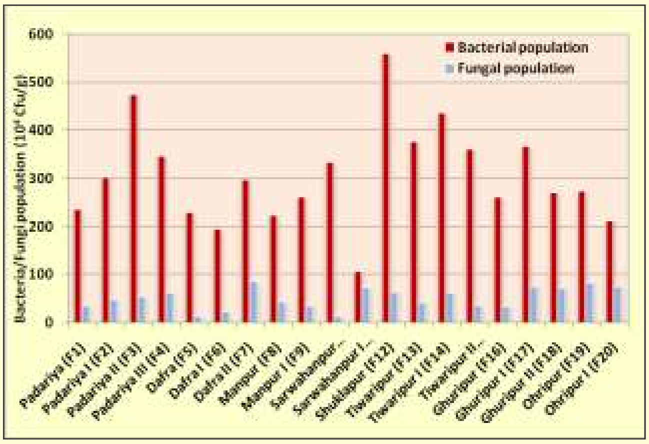


Fig. 59: Soil bacteria and fungi population

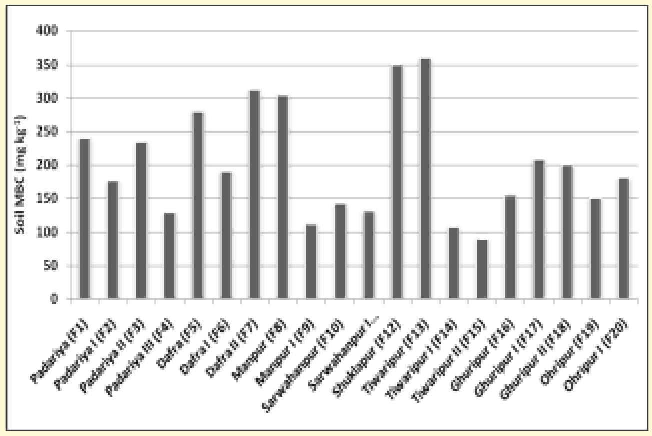


Fig. 60 : Soil MBC content in rhizosphere of paddy

using pesticides. Similarly, where safer pesticides were used, bacterial load in soil enhanced from 5.4 $x10^4$ cfu g^{-1} to $4.1x10^5$ cfu g^1.

Microorganisms form a vital part of the soil food web, therefore microbial biomass is considered to be a measure of potential microbiological and ecosystem functioning. Soil microbial biomass C (MBC) was maximum of (360 mg kg^{-1}) in F13 from farmers' paddy field of Tiwaripur followed by 350 mg kg^{-1} in F12 field at Shuklapur, Manpur, Sitapur. Minimum amount of soil microbial biomass C was noticed to be 90 mg kg^{-1} in F15 field from Tiwaripur II (Fig. 60).

In field conditions, soil MBC content after harvest of paddy showed variations from 60 mg kg^{-1} to 182 mg kg^{-1} where safer pesticides were used while in modules where farmers used overdoses of pesticides, SMBC content ranged between 24 to 118 mg kg-^{1}.

Out of the total bacterial isolates, 132 isolates tolerated 5% NaCl concentration while 47 isolates were able to tolerate 10% and only 5 could tolerate 15% NaCl concentration in the media. All the bacterial isolates were tolerant to alkaline pH upto 11 in the media maintained by 1N NaOH (Table 95). It was observed that at 48 hours there was some effect and only 132 and 129 isolates out of 134 survived upto pH 9 and 11, respectively.

Table 95 : Screening of bacterial isolates for tolerance to pH of media

pH	24 hrs	48 hrs
5	125	126
7	134	134
9	132	132
11	134	129

Almost all the isolates could tolerate pH upto 9 while only 121 out of 132 could tolerate pH upto 11 in the media. Most of the isolated bacteria were Gram-positive and of rod shaped. There was a great variation in their colony characteristics. Gram's staining showed 103 were cocci while 34 were bacilli. Eleven isolates were yellow pigmented and 46 were creamy or off white. The dominant bacterial isolates were gene sequenced for molecular identification and the results are presented in Table 86. The dominant fungal isolates were identified based on classical taxonomy through microscopic examination and were found to belong to fungal groups Aspergillus, Cladosporium, Rhizopus, Trichoderma and Penicillium.

The selected isolates were biochemically characterized as per the standard procedures and it was observed that out of selected 10 salt tolerant bacterial isolates, 6 were able to reduce nitrate and only four produced ammonia. Six of the isolates were positive for citrate utilization and only two were negative for HCN production. None of the isolate produced indole. Oxidase and Catalase enzyme activity was found to be positive in 8 and 2 bacterial isolates, respectively. Only three bacterial isolates were motile.

Dehrydrogenase activity was maximum of 26.4 µg TPF/g/h in soil from the paddy field of Dafra (F7) followed by 22.8 µg TPF/g/h in soil of F13 (Tiwaripur. Minimum activity of dehydrogenase enzyme (3.82 µg TPF/g/h) was observed in paddy

Table 96 : Genetic identification of dominant isolated soil bacteria

Isolate No.	Molecular identification
CS1	*Enterobacter cloacae*
CS2	*Bacillus sp.*
CS3	*Bacillus pumilus*
CS4	*Aneruri nobacillus migulanus*
CS5	*Bacillus subtilis*
CS6	*Bacillus megaterium*
CS7	*Bacillus flexus*
CS8	*Bacillus cerus*
CS9	*Achromobacter denitrificans*
CS10	*Paenibacillus sp.*

soil from Tiwaripur II (F15).

Pronounced positive relationship exists between colony forming units of microbes (bacterial counts) from soils and dehydrogenase activity of soils. The MBC was positively correlated with DHA (r =0.920) (Fig. 61).

In the laboratory incubation experiment, it was observed that soils applied with 2,4-D showed drastic reduction in dehydrogenase activity as compared to control. It was observed that there was reduction of dehydrogenase activity in soil by 42.97, 58.24, 28.68 and 43.96 per cent when applied with chlorophyiphos, 2,4-D, carbofuron and carbedazim, respectively as compared to control soil (Fig. 62).

For assessing the effect of pesticides on soil C mineralization a laboratory incubation study was conducted with paddy soil of Sitapur. It was observed that soils applied with 2,4-D showed reduction in soil organic C content as well as total C content as compared to control (Fig.). There was reduction of soil organic C content from 4.4 g kg^{-1} in control to 4.2 g kg^{-1} in soils applied with chloropriphos or carbofuron while 4.0 g kg^{-1} in soil having residue of 2,4-D and carbedazim. Total C content in soil was found to decrease by reduced by 17.3, 15.4 and 3.8 per cent when soil was applied with 2,4-D, carbofuron and carbedazim, respectively as compared to control soil.

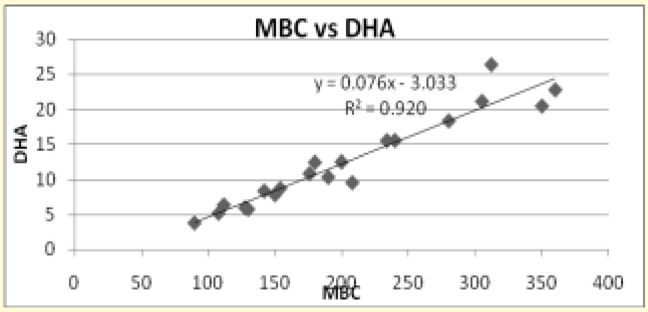


Fig. 61 : Relationship between soil MBC and dehydrogenase activity

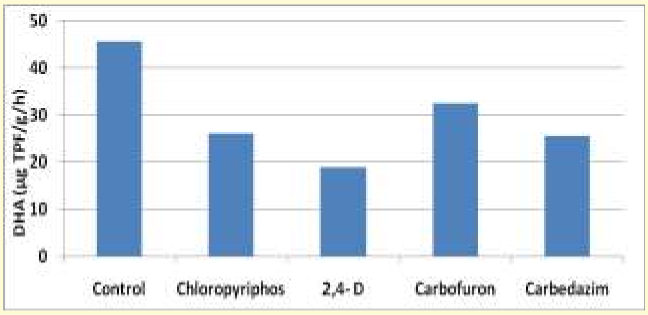


Fig. 62 : Pesticides effect on soil dehydrogenase activity

It was observed that 2,4-D application resulted in maximum decline of soil DHA as compared to chlorophyriphos, carbofuron and carbendazim. There was not much variation on soil organic C when pesticides were applied. However, maximum decrease in soil total organic C was in soils having residues of 2,4-D. Alkaline phosphatase activity in soil was reduced in all the treatments except chloropyriphos.

The enhanced and indiscriminate use of pesticides has led to the depletion of soil fertility, microbial populations and reduction in crop production. The impact of commonly used pesticides in paddy was assessed on the soil properties including soil microbial populations, microbial biomass carbon and enzymatic activity. Soil bacterial populations were drastically reduced in soil from farmers' practice of using pesticides. Soils applied with 2,4-D showed reduction in soil organic C content, total C content and also resulted in maximum decline of soil DHA as compared to chlorophyriphos, carbofuron and carbendazim. In the study it was found that carbofuron, chlorophyriphos and carbendazim application has less effect on soil biological health compared to 2,4-D application.

Managing water and energy efficiency in RW (rice-wheat) cropping systems under partially reclaimed sodic soils through controlled irrigation techniques (Atul Kumar Singh, C. L. Verma, Y. P. Singh and Sanjay Arora)

Performance of different irrigation methods namely, surface, sprinkler and LEWA was observed at different scheduling in rice and wheat under partially reclaimed sodic soil to evolve appropriate irrigation plans for water and energy savings. The different irrigation schedules followed in wheat crop through surface, sprinkler, and LEWA were 0.6 IW/CPE ratio, 0.8 IW/CPE ratio and 1.0 IW/CPE ratio. The depth of irrigation in rice and wheat applied through surface method was 6.0 cm at each irrigation and 4.0 cm at each irrigation by LEWA and sprinkler.

Rabi – wheat crop

The irrigation scheduling in wheat crop was planned on the basis of IW/CPE ratios (1.0, 0.8 and 0.6) in case of all the three irrigation systems. The experimentation started with wheat sowing on 12th Nov. 2014. To impose the planned irrigation schedule, daily rainfall and evaporation data from Pan evaporimeter were recorded.

The rainfall trend showed occurrence of several rainfall event during the wheat growing stages between 12th Nov, 2014 to 5th April, 2015. The total rainfall received during wheat growing period was 90.2 mm in total 10 rainfall events. The maximum depth of rainfall in a single day was 22 mm on 27th Feb., 2015.

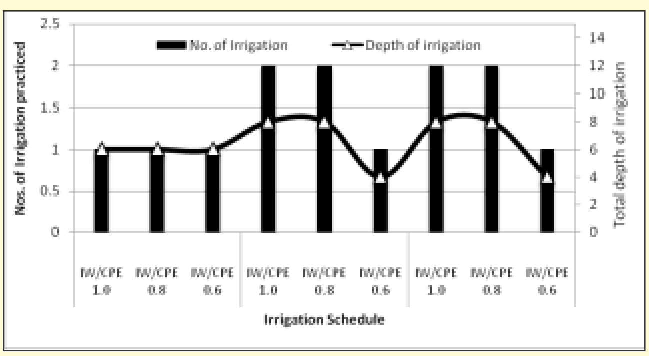


Fig. 63: Number of irrigation practiced abd total depth of water applied in wheat

Water Used To Practice Irrigation

The trends of number of irrigation and irrigation depth practiced are depicted through Fig. 63. It was further analysed in terms of water and energy productivity.

It was observed that the maximum number of three irrigation was practiced by sprinkler and LEWA when irrigation was scheduled at IW/CPE ratio of 1.0 and 0.8 resulting into 8 cm of irrigation depth. Whereas, in all other irrigation the only one irrigation could be practiced.

Assessment and refinement of existing irrigation practices of major crops grown under sodic environment (Atul Kumar Singh, C. L. Verma, Y. P. Singh and Sanjay Arora)

Keeping in view the importance of efficient water management practices, the project aims to apply low depth of irrigation at varying intervals to save irrigation water and pumping energy as well as 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 season in reclaimed sodic soils. The method of irrigation adopted was surface with different irrigation schedules during kharif and rabi. During kharif, irrigation was applied at two depths (5 cm and 7 cm) at 2 days, 3 days, & 5 days interval after disappearance of water and when soil moisture tension reached at 7.5 kPa and 10 kPa besides one schedule as control where 7.5 cm of water was applied with the appearance of cracking in the top layer. During rabi seasons wheat and sugarbeet crops were taken. Two irrigation depths (3 cm and 5 cm) at 30%, 50% and 70% depletion of soil moisture from field capacity and at IW/CPE ratio of 0.8 and 1.0, besides one schedule as control where irrigation was applied at different crop stages of wheat.

Wheat crop (2014-15)

Water and energy used : The frequency and depth of irrigation water applied and cost of fuel incurred was measured and analysed. In wheat crop, during the whole growing period, a maximum of 4 irrigations were applied when irrigation was practiced at 30% , 50% and 70% of SMD with 3 cm of irrigation depth, 30% and 50% of SMD with 5 cm of irrigation depth and incase of control plots. This was followed by 3 irrigations at 70% of SMD with 5 cm of depth of irrigation, 2 irrigations at IW/CPE ratio of 0.8 (3 cm of irrigation depth) and 1.0 (3 cm of irrigation depth) and one number of irrigation at IW/CPE ratio of 0.8 (3 cm of irrigation depth) and 1.0 (5 cm of irrigation depth). The numbers of irrigation had direct impact on the depth of irrigation water used and fuel consumed to operate the irrigation pump. It was observed that highest depth of irrigation amounting to 24 cm was practiced and 2.3 litre of fuel consumed to irrigate control plots followed by 20 cm of irrigation depth and 1.9 litre of fuel consumed incase of 30% of SMD (5 cm of irrigation depth) and 50% of SMD (5 cm of irrigation depth).

Irrigation water & energy productivity and wheat yield trends

The water and energy productivity and wheat grain yield trends under different irrigation regimes are depicted in Fig. 64. It was observed that highest grain yield of 3.1 t ha^{-1} was obtained when irrigation was scheduled at 70% of SMD (applying 3 cm and 5 cm depth of irrigation) followed by 2.8 t ha-^{1} in case of 50% of SMD (3 cm depth of irrigation) and IW/CPE ratio – 1.0 (3 cm depth of irrigation). The water and energy productivity reflects that highest water and energy productivity of 5.2 Kg/m^{3} and Rs. 6.2 per unit cost of diesel, respectively, was achieved when irrigation was scheduled at IW/CPE ratio of 1.0 (applying 3 cm and 5 cm of irrigation depth) followed by 4.6 Kg/m^{3} (irrigation water productivity) and Rs. 6.2 per unit cost of diesel

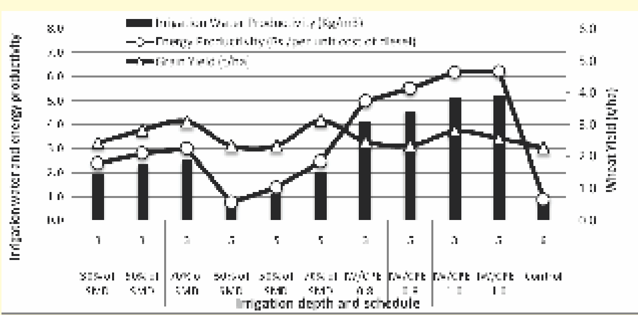


Fig. 64 : Water and energy productivity of wheat under varying irrigation regime

(irrigation energy productivity) in case of IW/CPE ratio of 0.8 (5 cm depth of irrigation). The results reflect higher irrigation water and energy productivity when irrigation is scheduled based on IW/CPE ratios but relative decline in yield is also observed.

Sugarbeet crop (2014-15)

Water and energy used to practice irrigation in sugarbeet

The number of irrigation, depth of irrigation water applied and cost of fuel incurred was measured and analysed. In sugarbeet crop, during the whole growing period, a maximum of 8 irrigations were applied when irrigation was practiced at 30%, 50% and 70% of SMD (applying 3 cm depth of irrigation), 30% and 50% of SMD (applying 5 cm depth of irrigation). This was followed by 7 number of irrigations at 70% of SMD (applying 5 cm depth of irrigation), 6 number of irrigations in case of control, 5 number of irrigations at IW/CPE ratio of 0.8 (applying 3 cm depth of irrigations) and 1.0 (applying 3 cm depth of irrigation) and three number of irrigation at IW/CPE ratio of 0.8 (3 cm of irrigation depth) and 1.0 (applying 5 cm depth of irrigation). These irrigation events include one pre germination irrigation at 6 cm depth, which was applied in each irrigation regime. It was observed that a total of 41 cm depth of irrigation each was applied when irrigation was scheduled at 30% of SMD (5 cm depth of irrigation) & 50% of SMD (5 cm depth of irrigation) followed by 36 cm irrigation depth at 70% of SMD (5 cm depth of irrigation) and in control plot, 27 cm irrigation depth at 30%, 50% & 70% of SMDs (3 cm depth of irrigation), 18 cm depth of irrigation at IW/CPE – 0.8 (3 cm depth of irrigation) & IW/CPE – 0.8 (3 cm depth of irrigation) and 16 cm of depth of irrigation at IW/CPE – 1.0 (5 cm depth of irrigation) & IW/CPE – 1.0 (5 cm depth of irrigation). This trend of irrigation depth reflects similar trends incase of fuel consumed to operate the water extraction mechanism. It is observed that a maximum of 4 litre of diesel was consumed to irrigate plots in which irrigation was scheduled at 30% of SMD (5 cm depth of irrigation) and 50% of SMD (5 cm depth of irrigation).

It was observed that highest sugarbeet root yield of (38.6 t/ha^{-1}) was obtained when irrigation was scheduled at 30% of SMD (applying 3 cm depth of irrigation) followed by 38.3 t ha^{-1} incase of irrigation at 50% of SMD (3 cm depth of irrigation), 36.1 t ha^{-1} when irrigation was done at 70% of SMD (applying 3 cm depth of irrigation) and 34.1 t ha^{-1} in control plots. The irrigation water productiovity (Kg/m^3) values were 11, 10.1 and 10.2 when irrigation was scheduled at 30% 50% 70% of SMD respectively. The energy productivity (Kg per unit cost of diesel) of these plots was 79, 72.6, and 73.3 respectively. The highest irrigation and water productivity and energy productivity of 13.0 Kg/m^{3}and 93.8 Kg per unit cost of diesel, respectively was observed in case of IW/CPE – 1.0 (applying 5 cm depth of irrigation) followed by 11.9 Kg/m^{3}and 85.9 Kg per unit cost of diesel in case of IW/CPE – 0.8 (applying 3 cm depth of irrigation). All though the irrigation water productivity and energy productivity of these plots are highesr because of lower depth of total irrigation water application but the yield comparison with respect to high yielding irrigation regimes plots reflects decline in sugarbeet root yield by 15 to 30 percent.

Kharif crops

Water and energy used to practice irrigation

The water use pattern depicted in Fig. 65, shows the number of irrigation practiced and the amount of water applied while implementing irrigation schedules in irrigated area under different irrigation regimes. It is observed that maximum number of 14 irrigations were practiced when irrigation was scheduled at 10 kPa (5.0 cm of irrigation depth) amounting to 70 cm of total depth of irrigation followed by 13 irrigation at 2 DAD (7.0 cm of irrigation depth) amounting to 91 cm of total depth of irrigation. The lowest total depth of irrigation applied was 35 cm through 7 irrigation events when irrigation was scheduled at 5 DAD (5.0 cm of depth of irrigation

This resulted lowest use of energy while pumping the groundwater for irrigation when irrigation was scheduled at 5 DAD (5.0 cm of irrigation depth) over control as well as other irrigation schedules.

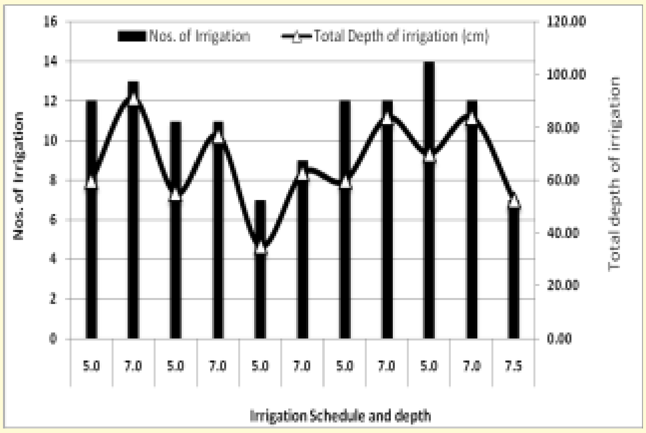


Fig. 65 : Number of irrigation practiced and volume of water applied in rice

Irrigation water & energy productivity and rice yield trends

The water and energy productivity and wheat grain yield trends under different irrigation regime are depicted in Fig . 66.

It was observed that highest irrigation and energy (pumping) productivity can be achieved in rice by practicing irrigation at 5 DAD (5.0 cm of irrigation depth). The irrigation and energy productivity under this schedule were 0.98 Kg/m^3 and 1.96 Rs. per unit cost of diesel used. The corresponding rice yield observed was 3.4 t ha^{-1}. The highest rice yield was recorded (4.4 t ha^{-1}) when irigation was schedlued at 3 DAD (7.0 cm of irrigation depth), the corresponding irrigation water productivity was 0.57 Kg/m^3 and energy (pumping) productivity was 1.19 Rs. per unit cost of diesel used. The lowest irrigation water productivity of 0.29 Kg/m^3 and energy productivity of Rs. 0.59 per unit cost of diesel used with rice yield of 2.6 t ha^{-1} when irrigation was scheduled at 2 DAD (7.0 cm of irrigation depth).

Wheat crop

Irrigation schedule at 70% of SMD (applying 3 cm and 5 cm depth of irrigation) resulted in the highest wheat grain yield of 3.1 t/ha followed by 2.8 t/ha in case of 50% of SMD (3 cm depth of irrigation) and IW/CPE ratio – 1.0 (3 cm depth of irrigation). The highest water and energy productivity (5.2 Kg/m^3 and Rs. 6.2 per unit cost of diesel) when irrigation was scheduled at IW/CPE ratio of 1.0 (applying 3 cm and 5 cm of irrigation

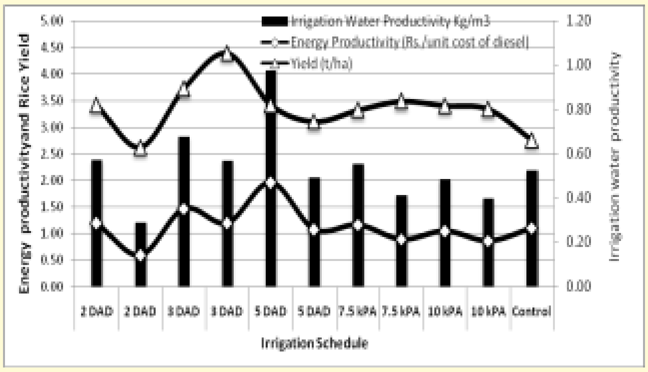


Fig. 66 : Water and energy productivity of Rice under varying irrigation regime

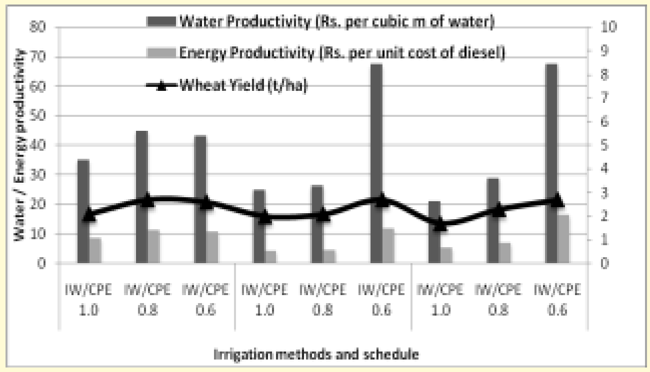


Fig. 67: Water and energy productivity of wheat under varying irrigation regime

depth) followed by 4.6 Kg/m^3 (irrigation water productivity) and Rs. 6.2 per unit cost of diesel (irrigation energy productivity) in case of IW/CPE ratio of 0.8 (5 cm depth of irrigation) (Fig. 67)

Sugarbeet crop

The highest sugarbeet root yield of (38.6 t ha-^{1}) was obtained when irrigation was scheduled at 30% of SMD (applying 3 cm depth of irrigation) followed by 38.3 t ha-^{1} in case of 50% of SMD (3 cm depth of irrigation). The highest irrigation and water productivity and energy productivity of 13.0 Kg/m^3 and 93.8 Kg per unit cost of diesel, respectively were observed in case of IW/CPE – 1.0 (applying 5 cm depth of irrigation) followed by 11.9 kg/m^{3}and 85.9 kg per unit cost of diesel in case of IW/CPE – 0.8 (applying 3 cm depth of irrigation). Although irrigation water productivity and energy productivity of these plots were higher because of lower depth of total irrigation water application, but they cawad decline in sugarbeet root yield by 15 to 30 percent in comparison to highest sugarbeet yielding irrigation schedule.

Rice crop

The performance of various irrigation schedules reflects that practicing irrigation by applying 5 cm of water 5 days after dissappearnce of water results in highest water and energy productivity of 0.98 Kg/m^3 and 1.96 Rs. per unit cost of diesel used over other irrigation schedules. The highest rice yield (4.4 t ha^{-1}) was recorded when irigation was schedlued at 3 DAD (7.0 cm of irrigation depth); the corresponding irrigation water productivity was 0.57 Kg/m^3 and energy (pumping) productivity was 1.19 Rs. per unit cost of diesel used.

The water and energy productivity trend under varying irrigation regimes showed lower water and energy productivity values at higher IW/CPE ratios and vice versa. The water and energy productivity under surface irrigated plots ranged between 35 Rs./m^3 (at IW/CPE of 1.0) to 43.3 Rs./m^3 (at IW/CPE of 0.6), incase of sprinklers 25 Rs./m^3 (at IW/CPE of 1.0) to 67.5 Rs./m^3 (at IW/CPE of 0.6) and incase of LEWA 21.25 Rs./m^3 (at IW/CPE of 1.0) to 67.5 Rs./m^3 (at IW/CPE of 0.6). The relationship of water and energy productivity trend with yield pattern shows lower yield at higher IW/CPE ratios and vice versa. This trend has changed in comparison to previous years. Yield of wheat under surface irrigated plots obtained was 2.1 t ha^{-1}, 2.7 t ha^{-1} and 2.6 t ha^{-1} for IW/CPE ratios of 1.0, 0.8 and 0.6 respectively, incase of sprinkler irrigated plots the yield obtained was 1.7 t ha^{-1}, 2.3 t ha^{-1} and 2.7 t ha^{-1} for IW/CPE ratios of 1.0, 0.8 and 0.6 respectively and 2.2 t ha^{-1}, 2.3 t ha^{-1} and 2.7 t ha^{-1} in case of LEWA at IW/CPE ratios of 1.0, 0.8 and 0.6 respectively.

Constraints in the adoption of sodic land reclamation technology in Uttar Pradesh

(K Thimmappa, R.S.Tripathi, R. Raju, and Y.P. Singh)

Land degradation due to sodicity is a serious problem in Indo-Gangetic basin of Uttar Pradesh. The sodic soils are widely distributed in different parts of Uttar Pradesh and occupy 1.35 M ha, which is 5.68 per cent of the total geographical area of the state. Gypsum is the main amendment for sodic land reclamation. A constraint analysis study was carried out to know the problems faced by the farmers to reclaim their sodic soils. Household survey was conducted in Unnao,

Table 97 : Major constraints faced by the farmers in reclaiming sodic lands

Sl.No.	Major constraints	Opinion (%)
1.	Low investment capacity	89
2.	Non availability of desired quantities of gypsum	92
3.	Lack of knowledge about reclamation technology	98
4.	Expensive to adopt due to high amendment cost	83

Raibareilly and Hardoi districts of Uttar Pradesh. The results showed that the cost of reclamation varied with the level of solicity. The barren C category lands required highest investment of Rs. 75780 ha^{-1} when reclaimed through gypsum (50% GRV). The moderately degraded B and slightly degraded B^{+} category lands required Rs. 66580 ha^{-1} and Rs. 56080 ha^{-1}, respectively.

Farmers knew the advantages of gypsum technology. Still they are unable to reclaim their sodic lands. They face many constraints in reclaiming their sodic land (Table 97). Majority of the farmers opined (98%) that they lack knowledge about reclamation technology. They lack knowledge in terms of how much gypsum to apply, how to apply and when to apply. Non availability of gypsum is another major constraint as 92% farmers reported that gypsum is not available even in the nearby agriculture departments. Resource poor farmers opined that their low investment capacity (89%) hinders the reclamation activities due to high amendment costs (83%).

Farmers are willing to reclaim the sodic land if government gives subsidy. Majority of the farmers opined that if they get 90% subsidy, they would participate in the reclamation programme. As subsidy offer decreases, the willingness to participate in the progrmme declines. A few farmers (3%) opined that they would reclaim their land without subsidy provided they get technical assistance to reclaim their land and there is no hindrance in the availability of gypsum.

RECLAMATION AND MANAGEMENT OF SALT AFFECTED VERTISOLS

Breeding and evaluation of field crops for salt tolerance in saline vertisols (Monika Shukla, Anil R. Chinchmalatpure and D. K. Sharma)

Major crops of the region include cotton, wheat and maize Our earlier studies indicated that *herbaceum* and *arboreum* cotton performed better under saline conditions over hirsutums and Bt cotton. Salt tolerant varieties of wheat also responded favourably to saline water irrigation. Thus, in the absence of assured canal water irrigation, saline ground water can be effectively used for wheat production in Bara tract either as such or in conjunctive mode. In this backdrop, experiments were continued to identify salt tolerant lines of cotton (*G. herbaceum* and *G. arboreum*) , wheat and maize and to understand the physiological traits imparting salt tolerance and to assess their utility in breeding programmes.

F_3-F_4 generation advancement of eight cotton *(G. herbaceum)* segregating populations was done in microplots at two salinity levels to explore the hidden potential of segregating generation at different. salinity treatments. Eight crosses were planted with six plants per cross per salinity level (EC_{iw} 8 and 12 dS m^{-1}). Soil sample (0-15 & 15-30 cm depths) analysis before and after completion of study showed that soil EC_2 increased from 0.5 to 2.2 dS m^{-1} in some microplots while average salinity at the end of experiment was 1.6 dS m^{-1}.

All the crosses performed differently under controlled saline environments indicating genetic variability in the crosses for salt tolerence. Root and shoot biomass was higher under low salinity l (8 dS m^{-1}) as compared to higher salinity (12 dS m^{-1}) K/Na ratio indicated that there is gradual reduction in ratio with increasing salinity (Table 98), but the extent of reduction was lesser in tolerant crosses viz. CSB-1, CSB-2 and CSB-10 compared to other line potential uptake of potassium over sodium ions may be responsible for this trend. Tolerant crosses had high shoot/root ratio which was again significantly correlated with high chlorophyll content in these crosses. Although chlorophyll content in leaf tissue reduced with increasing salinity, the extent of reduction was less in tolerant lines. Salt susceptible crosses showed more proline accumulation in leaves than tolerant ones. In Kharif, 2015-16, all the crosses were planted in native saline field of Samni farm for generation advancement (F_4-F_5) in order to isolate transgressive segregants for yield and salinity tolerance.

Samni field trial 2014-15

Two evaluation trials with 10 and 15 entries, respectively of herbaceum, arboreum and hirsutum accessions were conducted at Samni farm (EC_{iw} = 9.6 dS m^{-1}). Vertisols of experimental area suffer from subsurface salinity which often extends beyond the root zone of crops. High salinity at surface may be attributed to irrigation with highly saline ground water.

Screening and generation advancement of segregating population of desi cotton genotypes in microplots

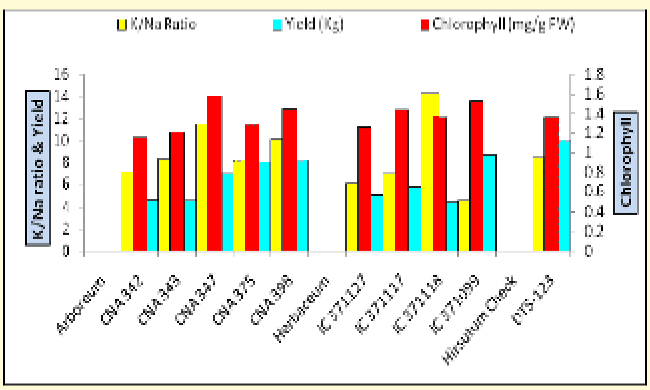


Fig. 68 : Biochemical and agronomic features of cotton genotypes

Desi cotton trial – I (Ten entries)

Ten desi cotton genotypes (5 *arboreum*, 4 *herbaceum* and 1 *hirsutum* drought tolerant check) which were found superior in Kharif, 2013 trial were evaluated in replicated field trial at Samni farm in large plots (2.0 m x 1.2 m). Agronomic and biochemical parameters related to these accessions (Table 99) revealed that among arboreums, CNA 398 was the highest yielder which may be attributed to high chlorophyll content in leaves and maintenance of high K/Na ratio in leaf tissues (Fig. 68). Again IC 371099 was best performer among herbaceoms due to high leaf chlorophyll level at flowering. However, low K/Na ratio suggests mechanisms other than ion partitioning involved in salinity tolerance in this line. Herbaceums were found to be better performing under saline conditions than arboreums. Overall, DTS-123 was the best performer, which yielded marginally higher than CNA 398 and IC 371099. Superior performing genotypes were selected for further evaluation in Kharif, 2015-16.

Desi cotton trial – II (15 entries)

Fifteen cotton accessions comprising of herbaceum and arboreum species were planted in replicated trial with three replication and plot size of 3.0 X 1.8 m. Each plot was having three rows per entry. These accessions were selected from screening trial of Kharif, 2013. Data indicated that salt tolerant desi cotton genotype V-797 maintained desirable - K/Na ratio in leaves during critical crop stages, but it was a low yielder. Open boll type arboretum accessions were high yielder than closed boll types. Genotypes such as GVhv 682, GVhv 235, Gbav 109, GBav 124, GBav 120, GBav 131 and Gheti were superior in terms of yield. These genotypes were selected for screening and evaluation in large plots in next year. Uptake of K over Na along with better leaf chlorophyll levels during critical growth stages of crop seem responsible for good performance of these genotypes under saline conditions.

Wheat: During rabi 2014, 10 wheat entries were evaluated at Samni Farm. The plot size was 4.0 m X 2.4 m with row to row spacing of 20 cm with three replications. Crop was irrigated 4 times with saline ground water (EC_{iw}=10.5 dS m^{-1}) during the entire crop period. KRL 345, KRL 346 and KRL 347 were found superior to KRL 210 in terms of yield. These genotypes were selected for further evaluation in large plots next year. These genotypes showed chlorophyll stability and high K/Na ratio in leaf tissues (Fig.69).

Rabi maize: During rabi 2014, two maize trials namely "Hybrid Trial" and "Varietal trial" were conducted at Bharuch under saline irrigation (EC_{iw} = 3.2 dS m^{-1}) on saline Vertisols. Each trial consisted of 7 entries (Table 100) in RCBD design with three replications. These entries were selected on the basis of superior performance in previous year trial. Detailed investigation involving morphological, physiological and biochemical parameters (Table 101) revealed that DKC 8081 was best among hybrids (Fig. 70) while DMRQPM-0903 was best among the varieties (Fig.71) Public sector hybrid Prakash and PMH-4 also showed good yield potential under saline water irrigation Ion analysis in flag leaf before and after flowering revealed that high K/Na ratio before flowering was contributing towards tolerance and thus high yield.

Generation advancement and germplasm acquisitions

Eight superior crosses of cotton were planted at Samni Farm for generation advancement from F_4-F_5 in kharif, 2015-16 in large progeny rows under native saline environment. F_1-F_2 generation advancement of five new crosses of arboreum was done in lysimeters with saline water treatment, which were again planted in Samni farm for further advancement in kharif, 2015. New germplasm of cotton, wheat and maize was acquired through collaborations with universities, public and private institutions.

Trials are being conducted in 2015-16 for cotton *(kharif)*, wheat and maize *(rabi)*. Three evaluation trials viz. 15 lines of *Gossypium* arboreum (segregating population); 40 lines of *Gossypium herbaceum* (segregating population) and varietal trial of 30 accessions of Arboreum, Herbaceum

Table 98 : Biochemical and physiological parameters recorded for different crosses in saline micro plot

Pedigree	Code	K/Na ratio in leaf tissue				Chlorophyll (mg g^{-1}) FW in leaf tissue			Proline	Biomass in grams			
		Before Flowering	Flowering	After Flowering	Mean	Before flowering	Flowering	% Reduction in chlorophyll	(µg g^{-1}) FW	Root	Shoot	Total	Shoot /Root ratio
GBhv 291 x GShv 297/07	CSB-1	15.9	17.6	13.9	15.8	1.3	1.2	7.0	11.7	73.0	263.0	336.0	3.6
G.Cot.23 x GShv 378/05	CSB-2	11.2	10.2	21.6	14.3	1.2	1.3	-11.2 ↑	12.5	45.3	126.7	172.0	2.8
GBhv 287 x GShv 451/08	CSB-3	14.6	7.8	4.3	8.9	1.3	0.7	49.3	14.6	62.0	133.0	195.0	2.1
GShv 451/08 x GBhv 290	CSB-5	11.7	8.2	3.1	7.7	1.5	1.0	35.4	15.1	68.0	94.0	162.0	1.4
GShv 378/05 x GShv 433/08	CSB-6	9.8	11.0	4.9	8.5	1.4	0.9	33.2	13.6	52.0	138.0	190.0	2.7
GBhv 291 x GBhv 283	CSB-7	7.2	4.5	5.8	5.8	1.4	1.1	20.6	14.8	32.0	66.4	98.4	2.1
GShv 297/07 x GBhv 290	CSB-8	7.5	6.7	5.8	6.7	1.4	0.9	31.6	13.2	33.2	73.5	92.0	2.2
GShv 297/07 x GShv 273/07	CSB-10	24.0	10.3	5.8	13.4	1.3	1.2	11.0	10.7	31.5	97.5	99.0	3.1

Table 99 : Performance of desi cotton accessions in comparison to drought tolerant hirsutum check DTS-123

	Plant Height (cm)	Chlorophyll (mg g^{-1} FW)	Sodium (ppm)	Potassium (ppm)	K/Na Ratio	Yield per plot (grams)
Mean Square	**6346.06****	**0.34****	**673.90****	**5878.80****	**140.87****	**71233371.80****
CNA 342 (A)	97.7^{de}	1.15^{c}	20.57^{bcd}	145.93^{b}	7.1^{bcd}	4707.5^{fg}
CNA 343 (A)	101.75^{d}	1.21^{bc}	18.86^{cde}	156.85^{ab}	8.4^{bcd}	4613.5^{fg}
CNA 347 (A)	133.05^{b}	1.58^{a}	15.36^{de}	177.47^{ab}	11.55^{ab}	6959.5^{d}
CNA 375 (A)	116.8^{c}	1.29^{abc}	24.27^{bc}	200.32^{a}	8.25^{bcd}	8019^{c}
CNA 398 (A)	116.45^{c}	1.45^{abc}	18.41^{cde}	182.7^{ab}	10.1^{abc}	8201.5^{c}
IC 371127 (H)	131.55^{b}	1.26^{abc}	26.31^{b}	161.38^{ab}	6.15^{cd}	4996^{f}
IC 371117 (H)	144.75^{a}	1.44^{abc}	25.56^{bc}	179.5^{ab}	7^{bcd}	5760.5^{e}
IC 371118 (H)	143.6^{a}	1.37^{abc}	13.13^{e}	188.3^{ab}	14.3^{a}	4531.5^{g}
IC 371099 (H)	136.5^{b}	1.53^{ab}	34.31^{a}	158.43^{ab}	4.6^{d}	8662^{b}
DTS-123(C)	95.4^{e}	1.36^{abc}	23.16^{bc}	195.05^{ab}	8.45^{bcd}	10005^{a}
C.D. (5%)	2.86	0.18	4	28.98	2.55	243.27

Table 100 : Details of maize genotypes being tested for salt tolerance

S.No.	Hybrids	Varieties/Inbreeds
1	900 M GOLD	GM-6
2	DKC7074	GAYMAH-1
3	DKC 8081	GWL-8
4	DKC9117	GYS-0705
5	PRAKASH	DMRQPM 0903
6	PMH-4	CML 260
7	VIVEK HYBRID 9	GWL-15

and Hirsutum species in two replications at Samni farm has been conducted. At Bharuch, 16 accessions of Herbaceum cotton have been evaluated in microplots under saline irrigation (EC_{iw} 8 & 16 dS m^{-1}). In the rabi, 2015-16, experiments are underway for evaluation of 22 lines of wheat in two replications at Samni farm. A total of 16 entries of maize are being evaluated to find out stability of salinity tolerance over the years. Germplasm nursery consisting of 32 maize accessions is also being evaluated at Bharuch.

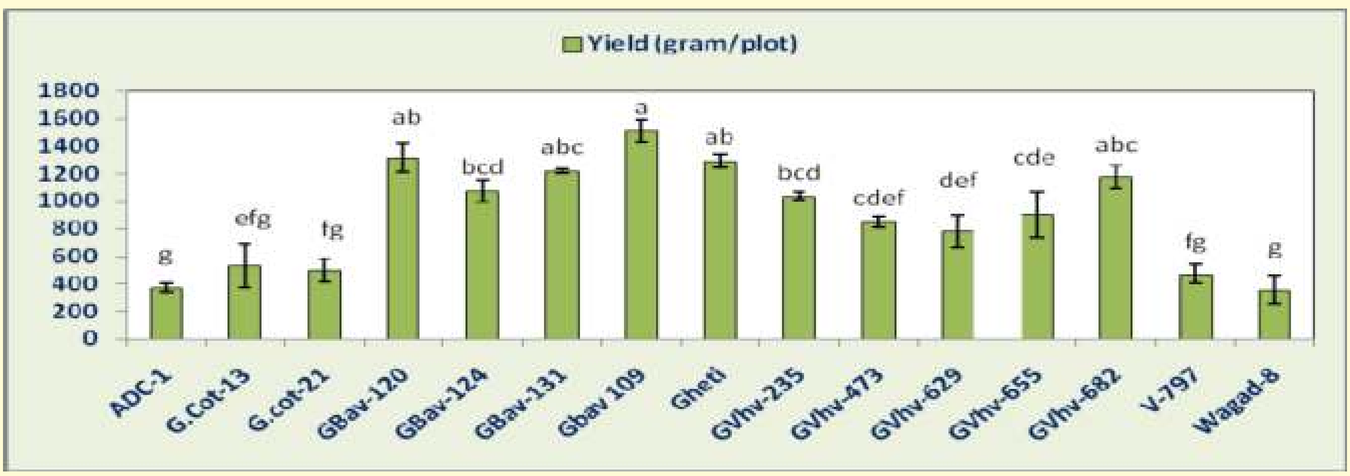


Fig. 69 : Performance of wheat genotypes under saline irrigation

Table 101: Agronomical and physiological parameters observed in maize hybrids and varieties

	Cob Yield/Plot (kg)	Chlorophyll (mg g^{-1})	Na (ppm) before flowering	K (ppm) before flowering	K/Na ratio before flowering	Na (ppm) after flowering)	K (ppm) after flowering	K/Na ratio after flowering)	Biomass (Kg)	Flag leaf area (cm^2)
Hybrids										
900 M GOLD	9.59 ± 0.29	2.83 ± 0.12	5.50 ± 0.43	69.92 ± 1.41	12.83 ± 0.80	6.41 ± 0.21	44.53 ± 5.65	6.92 ± 0.45	16.36 ± 1.79	224.77 ± 54.00
DKC7074	9.77 ± 0.32	2.33 ± 0.10	5.34 ± 0.81	48.33 ± 7.49	9.55 ± 0.29	7.59 ± 0.62	50.67 ± 6.01	6.74 ± 0.33	14.36 ± 0.88	268.72 ± 45.75
DKC 8081	13.79 ± 0.87	2.47 ± 0.15	3.95 ± 0.46	55.79 ± 8.58	14.34 ± 0.45	9.84 ± 2.04	45.94 ± 3.69	5.36 ± 0.70	19.12 ± 0.06	253.57 ± 10.87
DKC9117	9.95 ± 0.22	2.13 ± 0.13	4.17 ± 0.27	56.31 ± 1.19	13.64 ± 0.75	8.98 ± 2.03	52.44 ± 3.80	6.42 ± 0.33	19.45 ± 0.08	211.86 ± 15.83
PRAKASH	9.76 ± 0.20	1.36 ± 0.14	4.44 ± 0.65	54.98 ± 4.85	12.96 ± 0.41	7.91 ± 1.48	49.49 ± 5.59	6.54 ± 0.70	14.35 ± 0.23	257.71 ± 34.05
PMH-4	10.19 ± 0.94	2.75 ± 0.23	4.52 ± 0.26	40.17 ± 4.78	8.82 ± 0.57	10.92 ± 2.53	44.93 ± 6.29	4.66 ± 0.25	15.29 ± 1.27	252.65 ± 24.49
VIVEK HYBRID 9	12.43 ± 0.81	2.44 ± 0.04	5.01 ± 0.78	57.70 ± 7.03	12.00 ± 0.31	8.43 ± 0.49	61.81 ± 17.32	7.55 ± 0.49	11.87 ± 1.52	208.45 ± 51.51
Varieties/Inbreds										
GM-6	8.40 ± 0.39	1.18 ± 0.14	6.08 ± 0.98	60.88 ± 1.02	10.53 ± 1.61	6.69 ± 0.88	38.47 ± 3.33	5.84 ± 0.32	10.50 ± 1.62	283.67 ± 52.61
GAYMAH-1	7.80 ± 0.65	1.15 ± 0.27	4.40 ± 0.46	60.95 ± 4.10	13.99 ± 0.83	7.12 ± 0.95	36.61 ± 2.80	5.23 ± 0.34	14.22 ± 2.80	329.01 ± 28.94
GWL-8	8.05 ± 0.53	1.38 ± 0.17	4.80 ± 1.13	57.66 ± 0.92	13.84 ± 3.98	7.17 ± 0.79	39.41 ± 0.56	5.63 ± 0.58	10.54 ± 1.60	324.19 ± 45.39
GYS-0705	8.18 ± 0.35	1.31 ± 0.06	6.37 ± 0.48	49.65 ± 9.29	8.06 ± 1.90	7.55 ± 0.68	37.55 ± 1.92	5.07 ± 0.55	12.96 ± 0.09	242.64 ± 9.83
DMRQPM 0903	8.81 ± 0.71	1.16 ± 0.04	5.68 ± 0.46	48.24 ± 4.71	8.62 ± 1.06	9.66 ± 1.35	48.39 ± 1.54	5.26 ± 0.88	11.05 ± 2.19	295.69 ± 41.15
CML 260	8.44 ± 0.61	1.26 ± 0.07	4.82 ± 0.80	47.11 ± 5.77	10.67 ± 2.70	8.69 ± 1.36	50.98 ± 8.73	5.84 ± 0.11	11.46 ± 3.95	286.55 ± 12.78
GWL-15	7.25 ± 0.14	1.44 ± 0.14	4.51 ± 0.75	46.37 ± 10.33	10.21 ± 1.01	8.71 ± 1.29	44.48 ± 0.72	5.31 ± 0.68	9.02 ± 2.03	291.46 ± 12.79

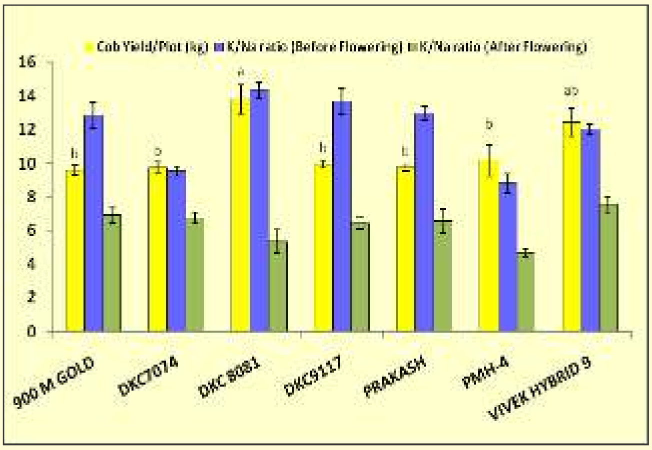


Fig. 70: Performance of maize hybrids under saline water irrigation

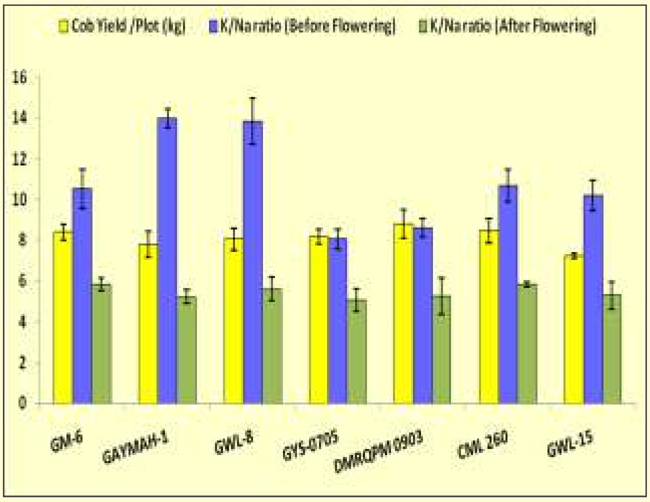


Fig. 71 : Performance of maize verities under saline water irrigation.

Maize crop under saline water irrigation

Soil physical characteristics and nutrient dynamics in Vertisols with subsurface salinity (Anil R. Chinchmalatpure, Vinayak Nikam and David Camus D.)

Field morphology of seven soil pedons irrigated with canal/tubewell water and five soil pedons under rainfed cultivation were studied. Horizon-wise soil samples were collected and analysed for different physical aand physico-chemical properties. The characteristics of soils (Table 102) of Jambusar and Amod talukas under irrigated and rainfed conditions showed that the soils are slight to moderately alkaline in nature and their pH increased with depth. These soils were saline in nature with EC_e ranging from 0.9 to 20 dS m^{-1}. The EC_e ranged from 1.0 to 20.0 (Rainfed-Pedon 1), 0.9 to 4.1 (Irrigated-Pedon 2), 0.8 to 7.4 (Rainfed-Pedon 3), 2.0 to 12.9 dS m^{-1} (Irrigated-Pedon 4). Salinity also increased with soil depth. The saturation extract showed dominance of Na^+ ions followed by CO_{2+} and Mg^{2+}, while preponderance of Cl^- ions and low concentration of CO_3^{2-} and HCO_3^- ions were also found. Under rainfed cotton field (Pedon 1-Nadiad), Na^+,0 Ca^{2+}, Mg^{2+} and K^+ cations ranged from 17.7 to 128.3 me l^{-1}, 1.0 to 7.0 me l^{-1}, 1.0 to 8.5 me $l^{-1}$and 0.2 to 1.1 me l^{-1}, respectively. Among anions Cl^-, CO_3^{2-} and HCO_3^- ranged from 3.8 to 98.5 me l-1, 0.0 to 2.0 me l^{-1} and 1.3 to 2.8 me l^{-1}, respectively. Under irrigated condition (Pedon 2), Na^+, Ca^{2+}, Mg^{2+} and K^+ cations and Cl^-, CO_3^{2-} and HCO_3^- anions showed lower values as compared to rainfed condition. Under rainfed cotton field (Pedon 3-Amod), Na^+, Ca^{2+}, Mg^{2+} and K^+ cations ranged from 7.1 to 68.3 me l^{-1}, 1.0 to 3.0 me l^{-1}, 1.5 to 5.5 me $l^{-1}$and 0.0 to 0.1 me l^{-1}, respectively. Among anions Cl^-, CO_3^{2-} and HCO_3- ranged from 2.8 to 49.5 me l^{-1}, 0.0 to 2.5 me $l^{-1}$and 2.3 to 3.0 me l^{-1}, respectively. Under irrigated condition of Amod (Pedon 4), Na+, Ca^{2+}, Mg^{2+} and K^+ cations and Cl-, CO_3^{2-} and HCO_3^- anions showed higher values as compared to rainfed condition. Saturation extract Na^+, Ca_2^+, Mg^{2+} and K^+ cations ranged from 19.2 to 104.3 me $^{l-}$1, 1.0 to 12.5 me l^{-1}, 1.5 to 14.5 me l^{-1} and 0.0 to 0.3 me l^{-1}, respectively for irrigated soil. Similarly, Cl^-, CO_3^{2-} and HCO_3^- content ranged from 10.5 to 96.3 me l^{-1}, 0.0 to 1.0 me l^{-1} and 2.0 to 3.0 me l^{-1}, respectively.

Table 102 : Physico-chemical properties soils and ionic composition of saturation extract under rainfed and irrigated cotton field of Nadiad village at Jambusar

Depth (cm)	pH	EC_e dS m^{-1}	Exchangeable cations (me/100 g soil)				Ionic composition of saturation extract (me l^{-1})						
							Cations				Anions		
			Ca	Mg	Na	K	Ca^{++}	Mg^{++}	Na^+	K^+	Cl^-	CO_3^-	HCO_3^-
Pedon 1 (Rainfed Cotton field, Nadiad, Jambusar)													
0-18	8.5	1.0	19.5	10.8	4.2	1.0	1.0	3.5	21.7	0.2	3.8	2.0	2.5
18-40	8.6	1.6	17.3	10.5	8.2	1.1	1.5	1.0	17.7	0.4	8.5	1.5	2.8
40-66	8.6	4.9	15.0	11.5	16.3	1.3	1.5	2.0	40.4	0.2	28.5	1.5	1.5
66-86	8.3	6.4	14.5	10.0	13.3	0.0	1.0	3.0	63.5	0.3	38.5	2.0	1.3
86-102	8.2	20.0	19.0	4.8	23.3	0.0	3.5	4.5	29.8	1.1	62.5	1.0	1.5
102-130	8.2	14.1	15.3	8.0	2.5	1.2	7.0	8.5	128.3	0.9	98.5	0.0	2.3
Pedon 2 (Canal Irrigated Cotton field, Nadiad, Jambusar)													
0-18	8.2	0.9	24.5	7.5	1.9	ND	1.0	2.5	10.4	0.1	4.0	1.5	2.3
18-37	8.4	0.9	19.3	11.8	1.7	ND	1.0	3.0	10.0	0.4	14.5	2.0	2.5
37-58	8.3	1.4	22.3	6.0	1.6	ND	1.0	2.5	15.0	0.4	8.8	1.5	2.3
58-78	8.3	2.9	12.5	14.3	13.3	ND	0.5	2.5	32.8	0.4	10.8	0.0	3.0
78-108	8.2	4.1	12.0	13.3	0.6	ND	1.0	3.0	47.3	0.2	24.5	0.0	2.8
108-136	8.3	2.4	10.8	13.3	0.8	ND	1.5	1.5	8.6	0.2	30.0	0.0	2.0

Table 103 : Physico-chemical properties soils and ionic composition of saturation extract under rainfed, irrigated and borewell cotton field

Depth (cm)	pH	EC_e dS m^{-1}	Exchangeable cations (me/100 g soil)				Ionic composition of saturation extract						
							Cations				Anions		
			Ca^{++}	Mg^{2+}	Na^+	K^+	Ca^{2+}	Mg^{+2+}	Na^+	K^+	Cl^-	CO_3^-	HCO_3^-
Pedon 3 (Rainfed Cotton field, Amod)													
0-28	8.2	0.8	29.0	8.8	ND	0.6	1.0	2.0	7.1	0.0	2.8	0.0	2.3
28-62	8.4	1.2	18.8	16.8	ND	0.5	1.5	1.5	11.5	0.0	3.8	2.5	2.8
62-82	8.5	1.0	23.8	10.3	ND	0.4	1.0	2.5	10.3	0.1	4.5	2.0	2.3
82-115	8.5	1.9	17.5	17.8	ND	0.4	0.5	2.5	20.4	0.0	9.3	1.0	2.8
115-133	8.4	3.3	26.5	7.3	ND	0.4	1.5	3.0	39.9	0.0	18.8	0.0	3.0
133-150	8.3	7.4	11.8	13.3	ND	0.3	3.0	5.5	68.3	0.1	49.5	0.0	2.3
Pedon 4 (Canal Irrigated Cotton field, Amod)													
0-24	7.7	8.1	20.50	15.75	ND	0.73	11.5	9.0	55.7	0.3	58.8	0.0	2.5
24-49	8.1	2.4	19.50	16.50	ND	0.53	2.0	1.5	26.3	0.1	14.0	0.0	2.5
49-76	8.2	2.0	27.25	8.25	ND	0.48	1.0	2.0	19.2	0.0	10.5	1.0	2.8
76-102	8.2	2.2	17.00	18.75	ND	0.46	1.0	1.5	24.3	0.0	13.0	0.0	3.0
102-136	8.1	7.3	21.00	18.25	ND	0.52	4.5	6.5	60.4	0.1	46.8	0.0	2.5
136-150	8.1	12.9	13.25	15.25	ND	0.35	12.0	14.5	104.3	0.1	96.3	0.0	2.0
Pedon 5 (Tube well irrigated Cotton field, Pahaj, Vagra)													
0-19	7.7	1.5	22.00	19.25	ND	0.68	2.5	2.5	14.5	0.1	5.0	1.5	2.8
19-46	8.2	0.8	28.00	12.00	ND	0.52	1.0	1.5	9.3	0.0	9.5	2.0	2.5
46-74	8.3	0.8	33.00	7.50	ND	0.45	1.5	1.5	7.9	0.1	8.5	1.0	3.5
74-99	8.2	0.9	24.50	14.50	ND	0.46	1.0	2.5	9.5	0.1	6.3	1.0	2.8
99-120	8.2	1.1	23.25	16.50	ND	0.41	1.0	1.5	10.7	0.0	9.0	1.5	2.8
120-132	8.4	1.5	19.50	12.25	ND	0.24	1.5	2.0	14.4	0.0	7.3	1.0	3.0

Table 104: Saturated hydraulic conductivity (Ks) under irrigated and rainfed sites of Nadiad village (Jambusar taluka) and Amod

Site description	Depth (cm)	Bulk density (Mg m^{-3})	Ks (cm hr^{-1})
Rainfed			
Pedon 1 (Cotton), Nadiad, jambu sar	0-18	ND	0.257
	18-40	ND	0.023
	40-66	ND	0.001
	66-86	ND	0.000
	86-102	ND	0.004
Pedon 3 (Cotton), Amod	0-28	1.37	0.339
	28-62	1.40	0.151
	62-82	1.21	0.009
	82-115	1.26	0.012
	115-133	1.23	0.000
	133-150	1.32	0.001
Canal Irrigated			
Pedon 2 (cotton), Nadiad, Jambusar	0-18	ND	0.136
	18-37	1.39	0.121
	37-58	1.43	0.040
	58-78	1.21	0.004
	78-108	1.27	0.001
	108-136	1.23	0.000
Pedon 4 (Cotton), Amod	0-24	ND	0.222
	24-49	1.27	0.188
	49-76	1.35	0.048
	76-102	1.29	0.026
	102-136	1.12	0.026
	136-150	1.41	0.005
Tube well irrigated			
Pedon 5 (cotton), Pahaj, Vagra	0-19	1.37	0.393
	19-46	1.42	0.148
	46-74	1.45	0.149
	74-99	1.41	0.125
	99-120	1.37	0.092
	120-132	1.17	0.080

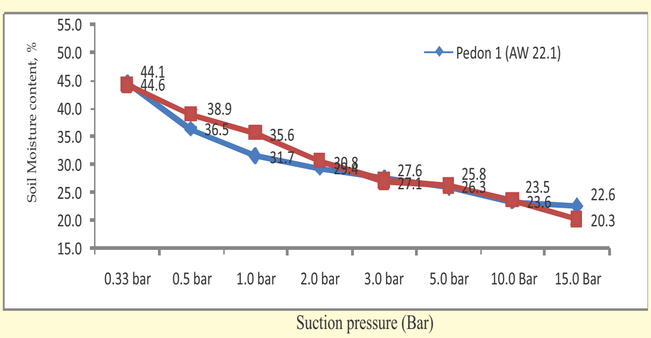


Fig. 72 : Soil moisture retention curve for rainfed (Pedon 1) and irrigated (Pedon 2) field of Nadiad village, Jambusar

Saturated hydraulic conductivity of soils under canal irrigation, rainfed and tube well irrigation was studied and it was found that under canal irrigated condition, saturated hydraulic conductivity (Ks) value ranged from 0.0 to 0.136 and 0.005 to 0.222 cm hr^{-1}, respectively for Nadiad, Jambusar (Pedon 2) and Amod (Pedon 4). Under rainfed condition, Ks value ranged from 0 to 0.257 and 0 to 0.339 cm/hr, respectively in Pedon 1

(Nadiad) and Pedon 3 (Amod). Similarly, Ks value ranged from 0.08 to 0.393 cm/hr for tube well irrigated condition in Pedon 2 (Pahaj village, Vagara). Among these pedons, saturated hydraulic conductivity was decreased drastically with soil depth in rainfed and canal irrigated soils as compared to tube well irrigated soils (Table 104).

Water retention at 1/3 bar (field capacity) showed retention (above 30%) in both irrigated and rainfed profiles, All the Vertisols showed more or less similar levels of water retention in deeper layers though there were differences in surface layers. Available water (difference between 1/3 bar and 15 bar) levels were in general higher (Pedon 2 & 4) in irrigated soil as compared to rainfed soil (Pedon 1 & 3).

Water retention increased with soil depth (up to 90 cm) at both field capacity (FC) and permanent wilting point (PWP). Under rainfed condition (Pedon 1), available water ranged from 19.7 to 24.1% and increased with soil depth (Pedon 1). Available water was also higher under irrigated pedon 2 (21.1 to 26.8%) as compared to rainfed pedon1 and its higher values were noticed in the deeper layers. Similarly, in irrigated pedon 4, available water ranged from 9.0 to 34.1% while in Pedon 3 these values ranged from 12.6 to 21.5%. In tube well irrigated cotton Pedon 5, available water ranged from 14.6 to 23.5%.

Under rainfed Pedon 1, water retained at FC was 44.6% and at PWP was 22.6% while this pedon showed 22.1% available water (Fig. 72). Similarly, in irrigated fields (Pedon 2), water retained at FC was 44.1 %, at PWP was 20.3 % and available water was 23.8%. Same results were found for Pedon 3 (rainfed) and Pedon 4 (irrigated) i.e. 18.5% and 21.6% available water were found in rainfed and irrigated soil profile, respectively. In tube well irrigated cotton field (pedon 5) water retained at FC was 41.7% and at PWP was 21.5% while available water content was 20.2%.

Prospects of cultivating desi cotton genotypes and salt tolerant wheat varieties in saline vertisols (Nikam Vinayak Ramesh and D. K. Sharma)

The study area lies in Bharuch district and experiences hot sub tropical climate. Soil of the region is black cotton soil and is characterized by presence of sub surface salinity. Ground water is mostly saline, and limited canal water is available for irrigation. Considering the above scenario, the study was conducted to find out perception and adoption a desi cotton and salt tolerant wheat varieties in saline Vertisols and to study constraints faced by farmers in growing these varieties. From the study area, 15 farmers cultivating desi cotton (G Cot- 23) variety from Jambusar taluka and 25 farmers cultivating salt tolerant varieties (STV) (KRL 19 & KRL 210) from Amod, Vagra, Bharuch and Jambusar talukas of Bharuch district were selected. Data pertaining to socio economic indicotors, biophysical constraints cost of cultivation, perception about salt tolerant varieties and constraints faced were collected by personally interviewing the farmers. Soil samples were also collected to assess the salinity status.

Map of Bharuch district

Study was initiated with 15 cotton growing farmers from Jambusar taluka of Bharuch district in 2014-15. These farmers were given seeds of desi cotton variety (G Cot-23) which is tolerant to salinity as compared to other cotton varieties as part of technology demonstration. In study area, only 11 farmers were able to grow desi cotton and data regarding the perception of farmers towards desi cotton was collected. The pH of soils of study area ranged from 7.55 to 8.82 and EC_2 ranged from 0.32 to 1.52 dS m^{-1}.

Economic analysis of STV cultivation

Data related to various aspects of cost of cultivation were collected using recall method. Economic analysis of the same is given in Table 105. It was observed that cost A involving various operational costs was Rs.18353/- per ha for the farmers growing desi cotton variety. Desi cotton (G Cot 23) required less irrigation than other varieties.

Average yield of desi cotton (G Cot- 23) obtained at farmers field was 0.81 t ha^{-1}. Farmers could earn gross income of Rs. 34425/- per ha and net income of Rs. 16073/- per ha. B: C ratio was 1.87.

Perception of the farmers about desi cotton STV (G Cot-23): Majority of the farmers perceived benefits of STV of desi cotton in terms of cheaper seeds materials, low cost of cultivation, suitability in rainfed conditions and better growth in moderate saline soil compared to other hybrid and Bt. cotton. Half of the respondents agreed that salt tolerant varieties help in increasing standard of living of the farmers. About 72 per cent farmers reported benefits of STV in terms of less irrigation requirement. Regarding crop characteristics, more number of farmers perceived STV having less boll drops in saline and less intercultural operations. About 50 per cent of the farmers perceived STVdepth, desi cotton is having high demand in market and high price than hybrid and Bt. cotton.

Table 105. Economic analysis of STV cultivation

Sr. No	Particulars	Cost (Rs. ha^{-1})
A	**Cost component**	
	Field preparation	3350.0
	Manures	1550.0
	Seed and sowing	1000.0
	Chemical fertilizers	2152.0
	Intercultural operations	4013.0
	Weeding	2937.0
	Picking and harvesting	3350.0
	Total	**18352.0**
B	**Production**	
	Yield of main produce (t ha^{-1})	0.81
	Value (Rs.4250 per quintal)	**34425**
C.	B:C ratio	1.87

While analyzing different constraints (Table 106) faced by the farmers, non availability of quality seeds and lack of knowledge were found to be the major production constraints. Among labour constraints, high cost of labour was a severe limitation. Among marketing constraints, heavy fluctuation in price every year was ranked the highest by majority of the farmers (55 %).

Wheat crop: Study was taken up with 25 wheat growing farmers from Jambusar, Vagra, Amod, Hansot and Bharuch talukas of Bharuch district in 2014-15. These farmers were given seeds of salt tolerant varieties (STV) viz. KRL 210 and KRL 19 as part of technology demonstration.

Soil Salinity status of the selected area: It was found that that surface salinity was low in the studied field. As depth increased, EC of the soil also increased. The EC_2 at 15-30 cm depth ranged from 0.26 to 1.84, indicating presence of sub-surface salinity in the region (Table 107). Soil pH, also increased with the depth. At 15-30 cm, pH ranged from 7.14 to 8.92.

Economic analysis of STV cultivation: Data relating to various aspects of cost of cultivation were collected using recall method. Economic analysis of the same is given in Table 108. It was observed that cost A involving various operational costs was Rs.23077/- per ha for the farmers growing salt tolerant varieties. STV required less number of irrigation than other varieties. Therefore farmers growing STV could save cost of 1-2 irrigations. Average yield of salt tolerant wheat varieties obtained at farmers field was 3.04 t ha^{-1}. Farmers could earn gross income of Rs. 54720/-


Desi cotton at farmers' fields

Table 106. Constraints faced by desi cotton STV (G Cot-23) growing farmers

Constraints	Least severe*	Not so severe*	Severe*	Quite severe*	Very Severe
A) Production constraints					
Non-availability of good quality seeds	27.27	63.64	9.09	0.00	0.00
Non availability of information/ package of practices	18.18	45.45	18.18	18.18	0.00
Non availability of manures/fertilizer in time	9.09	54.55	27.27	9.09	0.00
Non availability of insecticides and pesticide in time	18.18	72.73	9.09	0.00	0.00
B) Labour constraints					
Non-availability of labour during peak period	9.09	18.18	18.18	45.45	9.09
Lack of technical skill to the labour	36.36	27.27	18.18	18.18	0.00
High cost of labour	0.00	9.09	18.18	63.64	9.09
C) Economic constraints					
High cost of plant protection chemicals	27.27	36.36	27.27	9.09	0.00
High cost of fertilizers	27.27	54.55	18.18	0.00	0.00
High cost of seed material	63.64	36.36	0.00	0.00	0.00
Unawareness of credit facilities	0.00	90.91	9.09	0.00	0.00
D) Marketing constraints					
Problems of transportation	9.09	54.55	27.27	9.09	0.00
Heavy fluctuation in prices every year	9.09	18.18	45.45	27.27	0.00
Poor procurement policy of government	9.09	18.18	27.27	36.36	9.09
Lower price at the harvesting stage	9.09	9.09	54.55	18.18	9.09
E) Environment constraints					
Delayed sowing because of late monsoon	0.00	18.18	18.18	27.27	36.36
High rainfall and flooding damage the crop	0.00	18.18	27.27	18.18	36.36
Lower yield because of non availability of water after rainy season	18.18	27.27	27.27	27.27	0.00
Cyclone and high wind speed damage the crop	0.00	54.55	36.36	9.09	0.00

* Figures show percentage of farmers response for given statement

Table 107 : Soil salinity status of the selected villages

Soil depth , cm	pH	EC_2
0-15	7.2 to 8.94	0.26 to 1.28
15-30	7.14 to8.92	0.30 to 1.84

Table 108 : Economic analysis of STV cultivation

	Particulars	**Cost (Rs. ha^{-1})**
A	Cost component	
	Field preparation	3973
	Manures	1541
	Seed and sowing	1544
	Chemical fertilisers	3830
	Irrigation	5343
	Weeding	1709
	Plant protection	1187
	Threshing and harvesting	3200
	Misc. expenses (artisans etc.)	750
	Total	**23077**
B	Production	
	Yield of main produce (t ha^{-1})	3.04
	Value (Rs.18000 t)	**54720**
C.	B:C ratio	2.37

per ha, net income of Rs. 31643/- per ha and B: C ratio was 2.37

Perception of the farmers about salt tolerant varieties of wheat: Majority of the farmers perceived benefits of STV in terms of higher grain and straw yield. Half of the respondents agreed that STV helped increase their standard of living. About 58 per cent farmers (Table 109) reported benefits of STV in terms of less irrigation requirement. In crop characteristics, more number of farmers perceived STV to be having less lodging and grain shattering problem. About 50% farmers perceived STV more compatible to the changing climatic situation.

Constraints faced by STV growing farmers: Non availability of quality seeds and lack of knowledge were the major production constraints as reported by the farmers. Among labour constraints, 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 (44 %). Among marketing constraints, heavy fluctuation in price every year was ranked highest by majority of the farmers (40 %). Among general constraints, 24 per cent farmers ranked fragmentation of land holding as quite severe constraint.

Performance of salt tolerant varieties of wheat on farmers' fields at Kalak and Anor villages

Table 109 : Perception of the farmers about salt tolerant varieties

Particulars	Strongly disagree*	Disagree*	Neutral*	Agree*	Strongly Agree*
A) Economic benefit					
Increase in Grain yield	0.00	0.00	8.33	50.00	41.67
Increase in Straw yield	0.00	0.00	16.67	41.67	41.67
Reduction in cost of cultivation	0.00	8.33	41.67	25.00	25.00
Increase in income	0.00	8.33	25.00	41.67	25.00
B) Social benefits					
Increase in standard of living	0.00	0.00	52.00	24.00	24.00
Increase in social participation	0.00	0.00	48.00	52.00	0.00
Food security of the household	0.00	0.00	24.00	48.00	28.00
Upliftment of small and marginal farmers	0.00	0.00	12.00	60.00	16.00
C) Agronomic practices					
Reduced use of fertilizers	0.00	16.67	58.33	25.00	0.00
Reduction in weed	0.00	0.00	100.00	0.00	0.00
Reduction in number of irrigations	0.00	0.00	25.00	58.33	16.67
Reduction in number of labour days	0.00	16.67	25.00	50.00	8.33
D) Crop characteristics					
More number of tillers	0.00	0.00	4.00	32.00	64.00
Less lodging	0.00	8.33	8.00	28.00	64.00
Less grain shattering	0.00	16.67	25.00	33.33	25.00
Decrease in incidents of pests and diseases	0.00	16.67	41.67	41.67	0.00
Early maturity	0.00	0.00	66.67	16.67	16.67
E) Environment benefit and Improvement in quality of output					
Improvement of soil texture	0.00	16.00	76.00	8.00	0.00
Compatibility to changing climate	0.00	0.00	41.67	50.00	8.33
Grain quality	0.00	0.00	16.00	72.00	12.00
Straw quality	0.00	0.00	4.00	88.00	8.00
Ecofriendliness	0.00	0.00	12.00	64.00	24.00

* figures show percentage of farmers response for given statement

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 (Anil R. Chinchmalatpure, Vinayak Nikamand D. K. Sharma)

The Aniline-TDI Complex the Unit-2 of GNFC Limited located at Bharuch primarily deals with the manufacturing of Toluene diisocyanate and Aniline. This concern has established a well developed effluent treatment plant which produces about 500 M_3 of treated effluent from the 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. In order to understand the feasibility of using these effluents in crops, their impact on soil health, salinity development and crop production and produce quality over a long run a field trial was initiated to assess the suitability of the treated effluents in different crops viz., forages and woody biomass species 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.

The treated effluent from the ETP Unit was analysed for different chemical properties. Data indicated that chemical parameters viz., pH,

Table 110 : Green fodder yield (t ha^{-1}) of different fodder species with effluent irrigation and different nitrogen levels

Treatments	I1			I2			I3		
	N1	N2	N3	N1	N2	N3	N1	N2	N3
F1	24.83	29.94	32.33	26.55	34.66	40.77	29.94	35.14	32.60
F2	18.38	18.55	32.99	18.83	40.16	41.16	23.88	30.00	24.49
F3	11.16	12.01	13.49	2.02	19.52	19.77	6.16	22.38	8.66
Fodder, CD (5%) = 6.93; Irrigation, CD (5%) = 6.71; Nitrogen CD (5%) = 6.82									
Fodder x Irrigation x Nitrogen, CD (5%) = 6.63									
F1= Sorghum-CSV-21F; F2= Sorghum-GFS-5; F3= Sudan grass I1= BAW; I2 = BAW+Effluent (1:1); I3= Effluent N1= Control ; N2 = 40 kg N/ha; N3 = 80 kg N/ha									

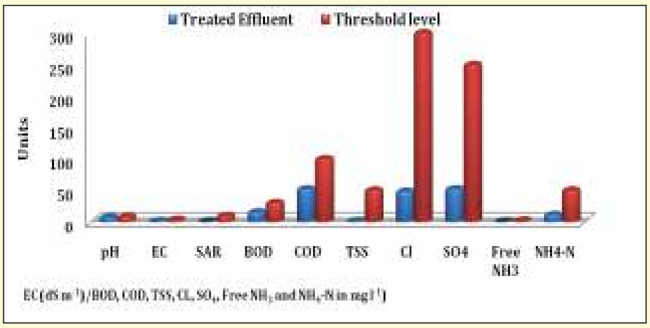


Fig. 73. Chemical composition of treated effluent

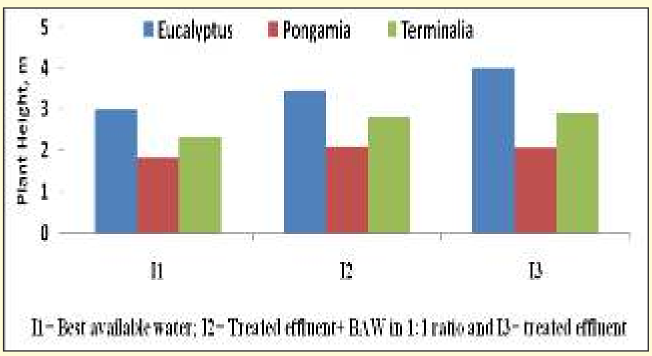


Fig. 74 : Plant height (m) of biomass species under effluent irrigation

electrical conductivity, BOD, COD, total soluble solids, chloride, sulphate, SAR, free ammonia and ammonical nitrogen are well within the threshold values (Fig. 73) meant for irrigating the field crops.

Soils at the experimental site are almost neutral to slightly alkaline in reaction and soil salinity ranged from 0.7 to 1.75 dS^{-1}m. Organic carbon content of these soils was also low and calcium carbonate content ranged from 3.6% to 5.9%. 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 to 42.2 cmol/kg and exchangeable sodium percentage (ESP) ranged from 2.1 to 3.7 which increased with depth. These soils are clayey with clay content up to 50 per cent and have the as dominant clay mineral montmorillonite. Soil samples collected after crop harvest were analysed for soil salinity and pH and it was found that there was no increase in soil pH as well as EC of the soils indicating no deleterious effect of effluent on soil properties. Similarly soils under woody species showed no increase in soils EC and pH under effluent irrigation. Treated effluent was found to be very effective in growing biomass woody species like eucalyptus, Terminalia and pongamia as plant height was observed more in effluent irrigated plant compared to BAW and Effluent+BAW (Fig 74).

Experiment was conducted using three fodder species viz. sorghum CSV 21F, Sorghum GFS-5 and sudan grass with different effluent irrigation treatments like BAW (I1), BA W+effluent (1:1 ratio) (I_2) and pure treated effluent (I_3) along with different doses of nitrogen like control (N_1), 40 kg N/ha (N_2) and 80 kg N/ha (N_3). From results, it was observed that sorghum CSV-21F and sorghum GFS-5 performed better in all the treatments indicating these forage species can be suitably grown with the use of treated effluents. Mixing of BAW and treated effluent in 1:1 ratio was found to be beneficial among the treatments (Table 110)

Performance of guava orchards with forage intercropping and pruning intensity on saline vertisols of Gujarat

(David Camus. D, Anil R. Chinchmalatpure and Vinayak Nikam)

Guava is the third largest fruit crop grown in Gujarat. Intercropping is possible in guava orchards only before the pre-bearing stage. Guava starts bearing fruits after 3-4 years of planting and during this time period the interspaces should be fully utilized by rasing the intercrops. Moreover, Gujarat has the highest share of dairy output in the country and there is always a demand and market for fodder, so marginal lands like saline vertisols can be used for fodder production whereas the arable land can be used to grow food crops. Considering this scenario, an experiment was carried out to evaluate the performance of three forage species viz. fodder sorghum CSV 21F, Rijka bajra and Sweet Sudan grass in one year old guava orchards grown on saline Vertisols of Samni experimental farm, Bharuch. The standard package of practices for these fodder crops were followed. Irrigation treatments like Best Available Water (BAW), saline water with EC_{iw} 4dS m^{-1} and saline water with EC_{iw} 8 dS m^{-1} were given to guava orchards only. The maximum green fodder yield recorded in fodder sorghum CSV 21F (F1) in guava plots irrigated with BAW(I_1) and in guava plots irrigated with saline water EC_{iw} 4dS m^{-1}(I_2) was 5.99 t ha^{-1} and 5.91 t ha^{-1}, respectively followed by fodder sorghum CSV 21F (F1) in guava plots

Table 111 : Green fodder yield and yield related attributes of Fodder sorghum CSV-21F, Rijka bajra and Sweet sudan grass grown as intercrop in guava orchard

Sl. No.	Treatments	Green fodder yield (t ha^{-1})	Plant height (cm)	Leaf stem ratio	Crude fibre (%)
1	I1F1	9.40	206	0.30	29.32
2	I1F2	7.16	152	0.42	32.61
3	I1F3	7.29	145	0.44	26.00
4	I2F1	8.46	206	0.23	26.46
5	I2F2	6.95	145	0.43	28.87
6	I2F3	7.12	163	0.43	29.20
7	I3F1	8.34	185	0.30	27.89
8	I3F2	6.95	141	0.43	30.73
9	I3F3	7.03	156	0.45	27.60
	CD (P=0.05)	1.40	30.93	0.04	NS

F1-Fodder sorghum CSV-21F, **F2**-Rijka bajra & **F3**-Sweet sudan grass
I1- Best Available Water, **I2**-saline water with EC_{iw} 4 dS m^{-1} & **I3**-saline water with EC_{iw} 8 dS m^{-1} (applicable to guava plants)

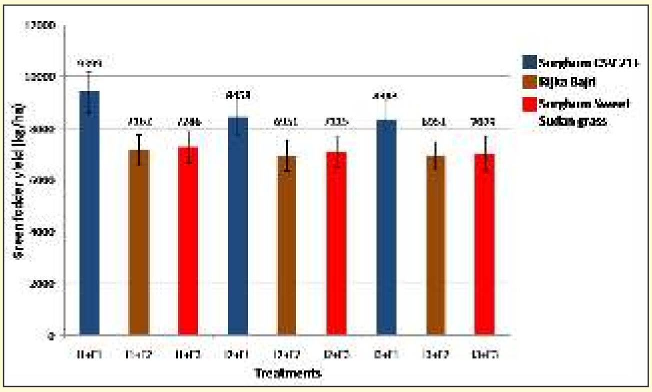


Fig. 75 : Green fodder yield (kg ha^{-1}) of different fodder crops in saline

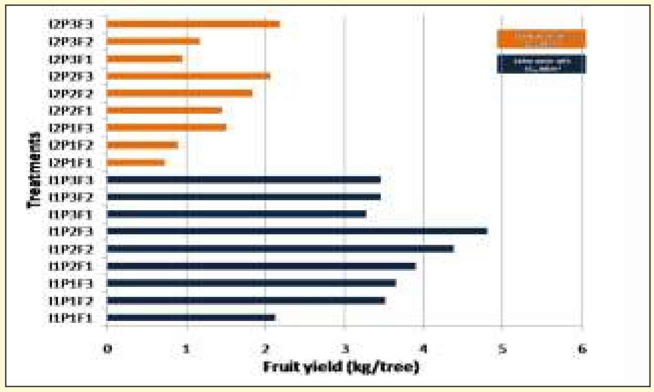


Fig. 76 : Winter season fruit yield (kg tree^{-1}) of guava cv Allahabad safeda

irrigated with saline water EC_{iw} 8dS m^{-1}(I_3) (5.57 t ha^{-1}). There was no significant difference in green fodder yield of fodder sorghum CSV 21F (F_1) grown under guava orchards under different irrigation levels. A similar trend was also observed in other fodder crops . However, the yield of fodder sorghum CSV 21F was comparatively higher when compared to Rijka bajra (F_2) and Sweet Sudan grass (F_3) (Fig 75.)

The plant height was also significantly higher in fodder sorghum CSV 21F (F1) at 2.02m (I1F1), 1.99m (I2F1) and 1.95m (I3F1) followed by Sweet sudan grass(F3) at 1.57m (I1F3), 1.54m (I2F3) and 1.54m (I3F3) and Rijka bajra (F2) at 1.48m (I2F2), 1.47m (I1F2), and 1.45m (I3F2), respectively. But in case of leaf stem ratio, an indicator of fodder quality, fodder sorghum CSV 21F had lower values compared to Rijka bajra (F2) and Sweet sudan grass. The crude fiber percent showed non significant differences in all the treatments (Table 111). When yield is considered as a major factor fodder sorghum CSV 21F performed well whereas sweet sudan grass and Rijka bajra yields were 25 percent less than Fodder sorghum CSV 21F but with better forage quality

Guava being a pruning responsive crop, another experiment was carried out in 8 year old guava orchard in which no previous pruning operations have been done. The orchard was subjected to different pruning intensity treatments,, saline water irrigation and fertilizer levels. The pruning of guava cv Allahabad safeda was done in the first week of June 2015 with three pruning intensities viz. 25cm and 50cm from the shoot tips and the unpruned trees as control followed by irrigation and fertilizer treatments at sensitive stages.

Pruning at 25 cm level gave better results in all the treatment combinations compared to 50 cm level and control. The maximum yield was recorded in the plants pruned at 25cm level (3.9-4.8 kg/tree) followed by 50 cm level (3.2-3.4 kg/tree) and unpruned trees (21.-3.6 kg/tree) in winter season crop with saline water irrigation of 4 dS m^{-1}.But the yield reduced by half in all pruning treatments when saline water irrigation of 8 dS m-1 was used (Fig. 76). The average number of fruits per tree also showed a trend similar to fruit yield. The fruit set percentage was maximum in trees pruned at 25 cm level (67-70%) followed by 50 cm level (61-70%) and minimum in unpruned trees (57-66%).

Pruning at 25% (P2) in combination with saline irrigation 4 dS m-1 and fertilizer level of 1000g: 250g: 250g NPK/tree/yr + 50kg FYM/tree/yr (F3) gave maximum yield of 4.81 kg/tree in winter season. Even though yield was maximum with 1000 gm of N application there was not much significant difference when 500 gm of N was given in most of the treatments. Hence pruning intensity of 25 cm from the shoot tips combined with saline water irrigation of 4dS m^{-1} and fertilizer level of 500 g: 250 g: 250 g NPK/tree/yr + 50kg FYM/tree/yr was found to be optimum for better yield in saline Vertisols .

Impact evaluation of sub-surface drainage technology for reclamation of water logged saline soils in Maharashtra

(Sanjay Vasant Kad, R. K. Singh, R. Raju. and D. S. Bundela)

The soil salinity and waterlogging problems are adversely impacting major and medium irrigation projects in Maharashtra. Maharashtra is having

Field without SSD

Crop in SSD installed field

606,759 ha of area under salt affected soils of which 422,670 ha and 184,089 ha are sodic and saline soils, respectively. Sizable area of waterlogged saline soils occur in canal and lift irrigation commands and low lying areas at the downstream end of the watershed in Sangali, Satara, Kolhapur and Pune districts of Western Maharashtra. The main factors which are responsible for causing soil salinity are excess and faulty irrigation methods, cropping system, poor drainage, salty water and semi-arid climate. For overcoming the problems of salinity and water logging; subsurface drainage (SSD) technology is one of the effective measures of reclamation, which lowers the water table and in Maharashtra a total of 7145 ha has been approved for installation of SSD in Sangli, Kolhapur, Satara and Pune districts but only 2051 ha area has been put under SSD in Reclaim I, II and III project. Besides, farmers using their own resources in about 648 ha area HAVE installed SSD.

The overall focus of this study is the impact evaluation of subsurface drainage technology for reclamation of waterlogged saline soils in Maharashtra and also its impact on crop productivity, farm income and livelihood security of farmers. The aim is also to find out constraints faced by the farmers before and after adopting SSD technology.

Study area

The present study was carried out in Kasbe Digraj (Reclaim II) village in Miraj Taluka of Sangli district in Maharashtra. The village is under Krishna river command where lift irrigation is the major irrigation source.

In Kasbe Digraj, the subsurface drainage project was installed under RKVY scheme where government took initiative to reclaim waterlogged saline soils. The Kasbe Digraj village is having 1065 ha area under waterlogged and saline soils; out of which 523 ha (49.10%) land has been covered with SSD with cost of Rs. 553.33 lakhs and about 1159 farmers got benefitted from this technology (Table 112). The average cost of SSD installation was Rs. 52000/- per ha at time of project implementation.

The data were collected using personal interviews, focus group discussions and PRA techniques from 30 farmers of Kasbe Digraj who have installed SSD in their field. Majority of the farmers (43.33%) were in the old age category followed by middle age (36.66%) category. More than 56% farmer respondents were have education level of high school and above. About 50 % famer's belonged to medium and large land holding category followed by 30% marginall farmers benefited from SSD project.

Impact of subsurface drainage

In the project area, sugarcane is the major crop which occupies about 78% area followed by cereals and pulses (12%), fruits and vegetable (7%) and oilseeds (3%). The farmers are cultivating sorghum, bajra, and wheat as cereals, banana, guava, and mango as fruits, soybean and groundnut as oilseeds and chili, tomato and brinjal as vegetable crops. After completion of SSD projects the cropping pattern became more diversified than earlier. Agriculture was the main source of income to all respondents followed by dairy business. The average agricultural income of farmers increased from 1.25 lakh to 2.65 lakh (212%) per annum after installation of SSD.

Table 112: Salient features of Kasbe Digraj subsurface drainage project.

Parameters	Kasbe Digraj
Proposed area under SSD project (ha)	1065
Actual Area covered under subsurface drainage (ha)	523 (49.10%)
Total Farmers (beneficiaries) covered (No.)	1159
Type of drainage system	Pipe drainage with natural outlet
Total pipe length	336 km
Years of installation	2006 to 2009
Total cost of SSD Project (Rs. in Lakhs)	533 .33
Approximate cost of installation (Rs./ha)	52000.0

Table 113 : Yield of crops before and after subsurface installation

Crop	Unit	Yield		Percentage increase in yield
		Before SSD	After SSD	
Sugar cane	t ha^{-1}	48.9	106.0	217
Wheat	t ha^{-1}	1.08	2.95	273
Soyabean	t ha^{-1}	0.96	2.74	285
Ground nut	t ha^{-1}	0.78	2.30	294

Before installation of SSD the average yield of sugarcane, wheat, soybean and groundnut was 48.9 t ha^{-1}, 10.8, 9.6 and 7.8 q ha^{-1}, respectively, which increased to 106.0 t ha^{-1} for sugarcane, 2.95 q ha^{-1} for wheat, 27.4 q ha^{-1} for soyabean and 2.3 q ha^{-1} for groundnut after installation of SSD (Table 113).

Constraints faced by farmers

Majority of farmers agreed that non availability of loan facility (> 70%), unavailability of machine on time, use of low quality materials (> 45%), high cost of PVC drainage pipes (>80%), delay in find fundS for SSD and lack of knowledge about SSD and expertise in SSD installation were serious constraints while most of the agreed that change in layout of SSD at time of actual installation (66%), improper spacing between laterals and clogging and blocking of drain pipes were the least serious problems.

After installation of SSD, there was increase in famers income and crop yield. Cooperation among the farmers led to active participation right from the planning, through implementation and maintenance of the system and turned out as the, key to success of the SSD project. Knowledge of SSD and awareness creation are the key factors for successful participation of stakeholders in the implementation of SSD to reclaim waterlogged saline lands.

COASTAL SALINITY MANAGEMENT

Study of soil salinity in relation to land use and land cover in coastal areas of West Bengal using Remote Sensing and GIS (Shishir Raut, S.K. Sarangi, B. Maji and T.D. Lama)

This study encompasses the quantitative analysis of land use and land cover change in three different Blocks of Coastal West Bengal namely, Canning 1, Basanti and Gosaba (21°31'N -22° 21' N and 88° 34'E-88° 44' E), using remote sensing technologies and Geographic Information System. IRSP6L3 satellite data for 12th April, 2013 and IRSP6L4 data for 12th February, 2015 were analyzed to make the land use maps in ARC-GIS 10. Different features were made by on screen digitization. The changes in land uses for these years were also studied. Rice yield and acreage data for the dry seasons of 2009-10 to 2014-15 were collected from individual farmers (30) and statistically analyzed to find the changes in acreage and yield data. The normalized difference vegetation index (NDVI) values for different features like rice, bare soil, water body, forest etc. were also studied from both the images. In the NDVI images from both IRSP6L3 and IRSP6L4, it was found that rice was having an NDVI value of 0.20-0.46, bare soil was having NDVI value of 0.11-0.20, water body <0, uncultivated grass 0.35-0.40 and forest cover was having NDVI value of 0.36-0.55.

In the image different features namely, cultivated, presently cultivated, presently fallow, aquaculture, mudflat, mangrove, forest, habitation, river etc. were identified. In 2013, there was 445.3 sq. km cultivated area which was around 33.6% of total study area (1327 sq.km). During this period around 89 sq. km was having crops standing on the fields (presently cultivated). Approximately 98.5 sq. km was fallow pasture (7.42% of total area). Due to increased salinity of soil, farmers had converted their agricultural lands into aquaculture ponds (45.2 sq. km). In the images (Fig. 77) 21.6 sq. km was coming under mangrove and 108.7 sq. km under forest cover. In the year 2015, both permanently cultivated and presently cultivated lands were less (385.8 sq. km and 67.7 sq. km, respectively) than those found in 2013 (445.3 sq. km and 89 sq. km, respectively). The fallow land acreage increased to 179.4 sq. km in 2015. Thus, there was 3.5% decrease in cultivated area and 1.6% decrease in presently cultivated area. Similarly, in the year 2015 there was 6.1 % increase in the fallow lands. The areas coming under other features remained same in both the years.

The yield of rice was low in 2014-15 as compared to 2009-10 but did not significantly decrease ($t=2.03 < t_{0.05,58}$) during these five years. Similarly, the acreage under dry season (0.15-0.2 ha per farmer) decreased in 2014-15 as compared to 2009-10 but the change was not significant. The study area comprises of four soil series namely, Sonakhali, Gosaba, Tangrakhali and Nikarighata. Rice yield and acreage data from these series were collected from farmers. Effect of soil series on rice yield was

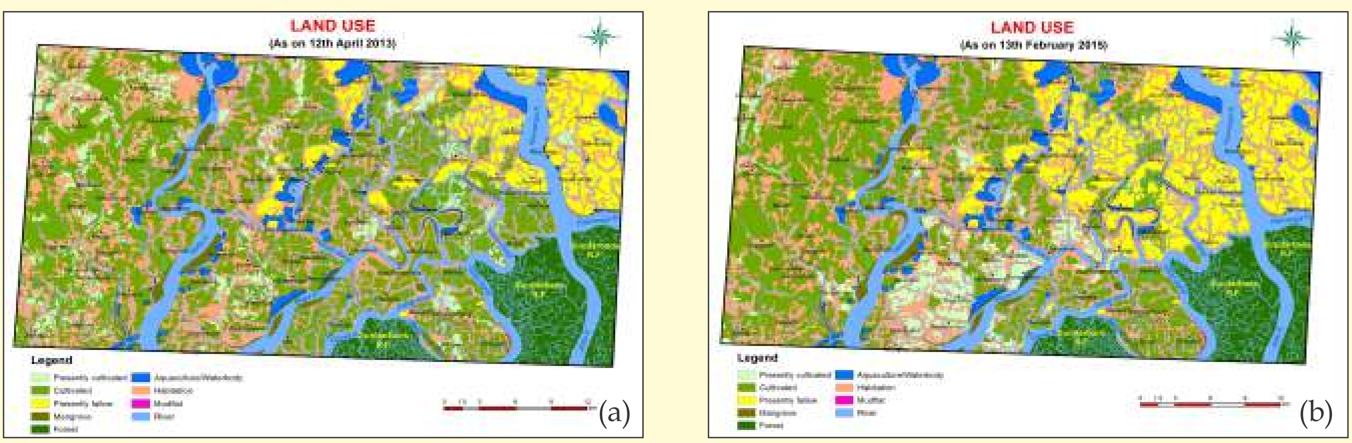


Fig. 77 : Land use map(a) April, 2013 (IRSP6L3)&(b) Feb., 2015 (IRSP6L4)

statistically tested by one way ANOVA. The average acreage of rice did not significantly differ among the four soil series ($F_{3,30} = 2.07$; $p = 0.129$). However, rice yield data differed significantly with soil series ($F_{3,30} = 13.6$; $p < 0.001$). Nikarighata series registered the highest mean yield (5.5 t ha^{-1}) and Tangrakhali registered the lowest mean yield (2 t ha^{-1}).

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)

The solar drip irrigation experiment was carried out at Canning Farm during rabi season of 2014-15 to evaluate the performance of different vegetable crops. The designed dripper discharge rate was 2.4 lh at 1 kg cm^{-2} pressure. The uniformity coefficient and the irrigation efficiency of this irrigation system were evaluated to be 92.5 and 87.2 percent, respectively. As the pump had to be operated through solar energy, the solar energy available at Canning town in different months was also calculated. The solar energy received in a day was minimum in the month of July (1.3 MJ) and highest in the month of September (20.1 MJ). Based on daily average for different months it was found to be the highest in the month of March and lowest during December.

The initial soil quality at the start of the rabi season is presented in Table 114. Immediately after the post rainy season, the field was not saline (EC_e<4 dS m^{-1}). Later the soil salinity in the root-zone

The crop field before rabi cropping

Table 114 : The soil quality of the field at the start of the cropping season

Depth(cm)	EC_e	$pH_{(1:2)}$
0 - 15	2.82	6.73
15 - 30	2.65	6.35
30 - 45	2.46	7.02
45 - 60	2.35	7.12

decreased due to the drip irrigation and increased in the non-irrigated soil.

Seven vegetables namely tomato, beet, knol-khol, cabbage, cauliflower, brinjal and okra were taken as the experimental crops during the rabi season and sown/transplanted in the month of November. Normal dose of fertilizers was applied in three splits through the fertigation tank during the crop growing period. Okra crop was taken after harvesting of the cauliflower, knol-khol and cabbage. All the seven vegetable crops performed well in terms of production. The water requirement of the vegetable crops ranged from 36 cm to 60 cm. The TEY was highest in case of tomato (Table 115) due to higher market demand as well as price. Hence, tomato was the best crop during rabi season 2014-15. The cost of cultivation of rabi season vegetables reduced due to introduction of solar drip irrigation system as there was savings of about 60 % of labour and 40~50% of irrigation water. The production of the vegetables in the drip method increased by 20-30% than crop cultivated under conventional.

Table 115 : Tomato equivalent yield (TEY) of rabi crops

Sl. No.	Crop	Variety	Yield (t ha^{-1})	Price (Rs.)	TEY
1	Cauliflower	Juhi 50	31.54	10	21.03
2	Cabbage	DC -65	32.85	8	17.52
3	Knol-khol	Jupitor	21.33	10	14.22
4	Tomato	Dev	36.64	15	36.64
5	Red Beet	Red globe	25.6	9	15.36
6	Brinjal	Noory	17.85	10	11.90
7	Okra	Avantika	5.36	12	4.29

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)

West Bengal is the highest rice producer and presently accounts for around 15% of total rice production (106 million tones) in the country. The coastal districts of West Bengal, South and North 24 Parganas, produce around 15 lakh tones of rice from an area of 6 lakh ha (both kharif and rabi seasons). The average yield of rice in the salt affected areas within these districts is below (2 t ha^{-1}) than average overall rice yield (2.5 t ha^{-1}) in these districts. Scope for expansion of area under rice is limited in both kharif and *rabi* seasons. Efforts since the beginning have been to develop salt tolerant rice varieties at this research station. Several rice varieties including Mohan (CSR 4), CSR 6, Canning 7, CST 7-1, Sumati (CSRC (S) 2-1-7), Utpala (CSRC(S) 11-5-0-2), Bhutnath (CSRC(S) 5-2-2-5), CSRC(S) 21-2-5-B-1-1, CSRC (S) 7-1-4 and Amal-Mana have been evolved and released for the coastal salt affected areas and continuous efforts are being made for the in large scale adoption.

Tomato crop under drip irrigation in production stage during rabi season

Farmers' rice variety in the coastal region

Farmers in the coastal region grow several rice varieties, particularly in kharif season. To understand details of these, information was collected through primary surveys as well as through Focused Group Discussion. It was noted that around 38% of the farmers were growing more than one rice varieties and nearly 7% of the farmers were growing more than 3 rice varieties in kharif season. Average yield of these rice varieties were estimated to be 2.62 t ha^{-1} and average allocation to rice area (under kharif) was 0.25 ha. Major farmers' variety in kharif season were Dudheswar, Pankaj, Malabati, Gobindobhog,

Table 116 : Comparative economics of farmers' rice variety vs. CSSRI rice variety (Rs ha^{-1})

Particulars	*Kharif* season		*Rabi* season
	Farmers' variety	CSSRI Variety	Farmers variety
Seed	2250	2250	3150
Labour	7500	7500	9375
Fertiliser	1500	1500	9000
Irrigation	0	0	11250
Manures	0	0	2250
Pesticides	1500	1500	3750
Intercultural operations	5625	5625	3000
Harvesting, carrying and threshing	11250	11250	5625
Total Cost	29625	29625	47400
Yield (t ha^{-1})	2.62	3.85	4.95
Value of paddy	36750	50050	74250
Value of by-product	6750	6750	5250
Gross Return	43500	56800	79500
Net Return	13875	27175	32100
Output-input ratio	1.47	1.92	1.68

Patnai, Sabita and Geetanjali. The economics of the rice varieties indicated that CSSRI rice varieties (Amal-mana) gave high yield and profit over the existing farmers' varieties. Popularity of CSSRI rice varieties developed earlier (e.g., Canning 7) is gradually declining. Farmers' are more careful in choosing rice variety for rabi season and prefer high yielding rice varieties having good market demand. However, Amal-Mana rice variety was gaining popularity among the farmers in the region and it was estimated to provide 35-40% higher yield as compared to the existing varieties in kharif season (Table 116). Varietal preferences during kharif and rabi are distinctly different. Two rice varieties, Lalminikt and Sadaminikit together accounted for over 80% of the rice area in rabi season. Higher yield, better quality and better market price are the primary objective in rabi whereas low risk, stability of yield, tall and long duration of varieties are the major factors for varietal adoption in kharif. Lack of suitable rice varieties it more challenging to grow rice in rabi due to high salinity. Farmers' are continually looking for such varieties from CSSRI and there is a need to increase the option for rice varieties in the rabi season.

Contribution of selected salt tolerant rice varieties produced and disseminated by CSSRI to farmers' economy

One of the key ways to analyse the impact of rice varieties on farmers' economy is to examine the demand for purchasing rice varieties by the farmers over period of time. CSSR RRS, Canning has been producing several rice varieties as seed paddy and farmers are regularly purchasing these seeds for growing in their fields. Once preferred by the farmers, the seeds of these varieties are further exchanged among the fellow farmers or they keep seeds for the next cropping season and thus the variety dissemination process continues. Consistent or repeated purchase of specific paddy seed is indicative of farmers' demand for specific rice varieties.

Contribution of selected salt tolerant rice varieties (Amal-Mana, SR-26B, Sabita and Canning 7) as produced by CSSRI RRS Canning, purchased and owned by farmers has been estimated in terms of area coverage and economic gain in salt affected areas. Primary surveys on rice growers indicated that average yields obtained by the farmers were 3.85 t ha^{-1} for Amal-Mana, 3.05 t ha^{-1} for SR-26B & Sabita and 4.50 t ha^{-1} for Canning 7. The varietal contribution has been estimated to be Rs 358 million, Rs. 264 million, Rs. 136 million and Rs. 24 million for SR-26B, Amala-Mana, Sabita and Canning 7, respectively (Table 117).

Seeds of different rice varieties produced and sold at Canning Station during 2001-2015 and trend in farmers demand for paddy seed indicated mixed-consistency in varieties preference. Contribution in terms of area coverage and economic gain due to adoption of major salt tolerant rice varieties produced by RRS Canning and purchased by the farmers indicated, salt tolerant rice varieties have

Table 117: Contribution of selected salt tolerant rice varieties on farmers' economy under salt affected areas of West Bengal

Varieties (period)	Seed (kg)	No of farmers	Estimated area (ha)	Production (tones)	Value of production (million Rs)	Remarks
Amal-Mana (2010-2015)	8294	396	848	3265	264	Consistent and increasing demand
SR-26-B (2001-2015)	19721	950	1441	4393	358	Consistent and good demand
Sabita (2010-2015)	8523	302	546	1666	136	Consistent and increasing demand
Canning 7 (2002-2012)	982	65	67	291	24	Declining demand

good potential to contribute to national exchequer and there is a growing demand for such varieties among the farmers. Due to higher Seed Replacement Rate (SRR) during rabi (76%) as compared to kharif (22%), actual demand for salt tolerant rice varieties is more in rabi. So, there is a need to broaden the choice of available options for rabi season taking into account the farmers' need and preferences.

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, K.K. Mahanta, S. Mandal, S. Raut and B. Maji)

This research project was conducted to study the long term impact of land shaping techniques and rain water harvesting on soil and water quality 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 practiced from <5 years to >15 years on soil and water quality and also on economics were studied.

Salinity of the harvested rain water under different land shaping techniques was monitored round the year. Salinity of water in the pond under farm pond technique and in deep furrow under deep furrow & high ridge techniques was higher during post monsoon period than in monsoon season. Soil salinity at the bottom of the reservoir up to 15 cm depth was monitored periodically. Soil salinity

Farm pond land shaping technique during kharif season

was higher during post monsoon period. The salinity of water and soil of the reservoir was higher under deep furrow & high ridge compared to farm pond techniques especially during post-monsoon period. The salinity of water and soil of reservoir did not vary with the year of implementation.

Soil salinity in the profile of the different land situations like high land, medium land and original low land created under farm pond technique implemented, since <5 years and > 15 years indicated that soil salinity build up was less in all the land situations compared to control (without land shaping). The organic C and available N & P were higher under different land situations created under farm pond land shaping technique implemented since years compared to control (Table 118). Among the different years of implementation of land shaping techniques, OC and available N & P were higher under old land shaped plots compared to newer plots. Similar trend was observed for deep furrow & high ridge

Table 118 : Soil salinity and nutrient status under farm pond land shaping technique

Land situations	Duration of implementation	ECe (dS m^{-1})	OC (%)	Av. N (Kg ha^{-1})	Av. K (Kg ha^{-1})	Av. P (Kg ha^{-1})
High land	>15	3.09	0.91	287.2	288.3	20.1
	<5	3.82	0.56	256.4	305.6	20.5
	>15	4.53	0.89	265.0	267.0	19.6
Medium land	<5	4.61	0.47	210.5	305.8	18.9
Low land	>15	7.84	0.48	223.4	320.0	14.7
	<5	7.56	0.47	225.5	300.3	18.6
Pond	>15	1.76	1.23	367.8	389.1	40.8
	<5	1.89	1.24	367.0	359.5	36.4
Control	-	12.4	0.53	186.4	314.1	12.3

and paddy-cum-fish land shaping techniques.

The B:C was higher for farm pond followed by deep furrow & high ridge and paddy-cum-fish land shaping techniques. The duration of implementation of land shaping techniques did not affect the 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 systems a field experiment was carried out to evaluate the impact of conservation tillage on soil health in coastal region of West Bengal. The design of experiment was 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 residue (R) and no residue (NR) were taken as sub-sub plot treatments. Depth wise soil properties indicated that at surface there was reduction in bulk density and increase in

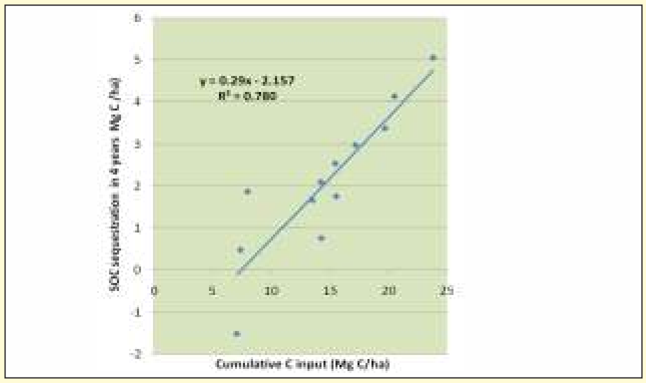


Fig. 78 : Relationship between cumulative C inputs to soil and changes in soil organic C stock

organic C in ZT than other treatments. The soil organic C stock was determined up to 45 cm soil depth and it was highest in RT with residue followed by CT with residue, ZT with residue, RT without residue, CT without residue and the lowest in ZT without residue treatment. Organic C stock was more in rice-rice system than rice-cotton system. The total quantity of soil organic C sequestered within four years of experiment varied from -1.51 to 5.05 Mg C ha^{-1} and was linearly related with cumulative C inputs to the soil (Fig. 78). The results indicated that for sustenance of SOC level (zero change due to cropping) a minimum quantity of 1.86 Mg C yr^{-1} is required to be added per hectare as inputs. Treatment-wise fraction of soil organic C like very labile, labile, less labile and nonlabile C determined at different

Table 119 : Treatment of organic C fraction and microbial biomass C under rice-rice and rice-cotton systems

Treatments	MBC (µg g^{-1} soil)	Very labile	Labile	Less-labile	Non-labile
Rice-Rice					
ZTNR	287.17	0.152	0.066	0.132	0.272
ZTR	412.44	0.195	0.110	0.107	0.378
RTNR	211.56	0.210	0.102	0.098	0.245
RTR	408.68	0.224	0.083	0.117	0.327
CTNR	361.33	0.200	0.063	0.102	0.290
CTR	448.51	0.180	0.071	0.100	0.300
Rice-Cotton					
ZTNR	308.25	0.156	0.083	0.083	0.243
ZTR	299.32	0.127	0.093	0.102	0.342
RTNR	245.77	0.146	0.073	0.102	0.239
RTR	345.20	0.117	0.159	0.105	0.371
CTNR	277.80	0.112	0.093	0.122	0.200
CTR	374.16	0.161	0.132	0.078	0.322
Initial	**-**	**0.175**	**0.0365**	**0.175**	**0.263**

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.

concentration of H_2SO_4 and microbial biomass C were also analyzed (Table 119) and passive pool of soil C faction was more than active pool in treatments when crop residue was added. After four years of experiment in zero tillage, there was 12-18% reduction in yield than other treatments. Treatment-wise net return and B:C ratio were calculated. They varied from Rs. 29235 to 43267 and 1.8-2.34, respectively per hectare under rice-rice system and Rs. 14464 - 29554 and 1.3 -1.65 per hectare under rice-cotton system.

NICRA: Climate change mitigation and adaptation strategies for salt affected soils with the objective of management of sea water intrusion due to climate variability in coastal regions (U.K. Mandal, B. Maji, K.K.Mahanta , S. Raut and A.K. Bhardwaj)

Sundarbans in West Bengal of India by virtue of its strategic location in the Eastern coast on the Bay of Bengal falls in the most climate change vulnerable zones. Temporal trends of weather parameters of Canning Town (22o18'52'' N Latitude, 88o39'45'' E Longitude, elevation 10 m msl) representing Indian Sundarbans were analysed by non-parametric Mann-Kendall test and Sen's slope approaches. Analysis of long term rainfall data (1966-2014) indicated that Canning receives mean annual rainfall of 1818.5 mm (±344.8 mm) with a considerable variation (CV=18.95%). Out of 49 years, 35 years received normal (within long period average ± CV), 6 years received deficit (25-43%) and 8 years received excess rainfall (35-19%) Results revealed that total annual rainfall trend decreased non-significantly at the rate of 1.00 mm yr^{-1} (Table 120). On an average, pre monsoon (during the month of March, April and May) contributes 13.2% , monsoon rainfall during the month of June, July, August and September contributes 74.3% and post monsoon rain during October to February contribute 12.5% of total annual rainfall (Fig. 79). On an average, 84 rainy days in a year were recorded in the region. During

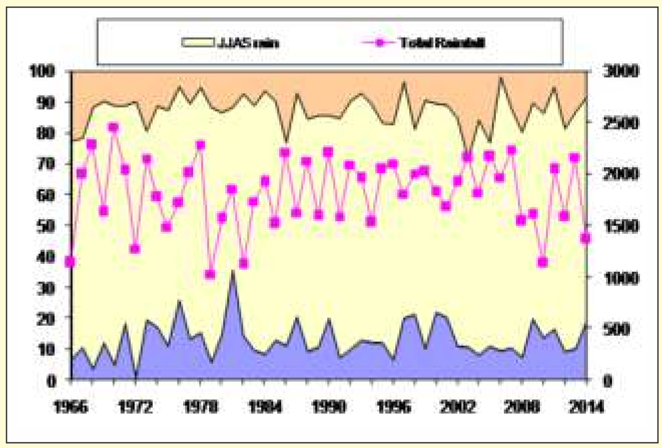


Fig. 79: Temporal variation of long period (1966-2014) annual and seasonal rainfall distribution at Canning Town

Table 120 : Trend analysis of long period rainfall distribution and rainy days at Canning (1966-2014)

Rainfall (mm)	Total annual rainfall (mm)	Pre-monsoon rain (MAM) (mm)	Monsoon (JJAS)(mm)	Post monsoon (ONDJF)(mm)	Rainy days	Extreme rain (Number of days when rainfall in a day >100mm
Minimum	1030.8 (1979)	12.0	12.0	12.0	12.0	12.0
Maximum	2461.3 (1970)	663.9	663.9	663.9	663.9	663.9
Mean	1818.5	240.0	240.0	240.0	240.0	240.0
SD	344.8	121.0	121.0	121.0	121.0	121.0
CV(%)	18.9	50.4	50.4	50.4	50.4	50.4
Kendall's Tau	-0.023	0.027	0.027	0.027	0.027	0.027
Sen's Slope	-1.003	0.466	**0.466**	**0.466**	**0.466**	0.466

Table 121 : Statistical analysis of annual temperature trends at Canning Town

Temperature (^oC)	Maximum Temperature(^oC)	Minimum Temperature(^oC)	Mean Temperature(^oC)
Minimum	30.15	20.73	25.69
Maximum	31.51	22.98	27.07
Mean	30.85	21.88	26.38
SD	0.318	0.452	0.308
CV(%)	1.030	2.064	1.167
Kendall' Tau	-0.032	0.089	0.030
Sens's Slope	-0.0007	0.0035	0.0006

last ten years (2005-2014), the number of rainy days reduced to 78.8 days/year. Contribution of monsoon months declined marginally at the rate of 0.60 mm, while pre (MAM) and post-monsoon months increased non-significantly at an annual rate of 0.47 mm and 0.28 mm, respectively. The maximum temperature reflected marginal rising trend in eight months from May to November and February and decreasing trend during December, January, March and April, whereas minimum temperature manifested rising trend during March-November and decreasing trend during December-February (Table 121). Bright sunshine hours declined significantly at an annual rate of 0.05 hours yr^{-1}. Reference crop evapo-transpiration (ET_0) calculated using FAO Penman-Monteith method revealed that annual ET_0 significantly decreased at the rate of 5.60 mm yr^{-1}, which may be due to gradual decline in bright sunshine hours in the region. Pre and post-monsoon rainfall meet the 49 and 54% of crop evapo-transpiration demand. There was 2.7 times surplus rainfall than crop evapo-transpiration during monsoon months indicating very high scope of water harvesting to tackle water logging during the monsoon season and unavailability of fresh water for irrigation during the lean season.

The sea level (SL) data for the trend analysis was sourced from Permanent Service for Mean Sea Level (PSMSL: www.psmsl.org) world's archive of mean monthly and mean annual tide-gauge records. In India, 27 PSMSL data points are existing. The PSMSL data are presented in two formats: metric and revised local reference (RLR), i.e., relative to common datum. RLR datum is arbitrarily taken as approximately 7 m below the mean sea level (MSL) to avoid negative values in gauge records. In India, at present, a real time network of tide gauges has been established by the Survey of India (SOI) and National Institute of Ocean Technology (NIOT). The network comprises of 50 (36 by SOI and 14 by NIOT) state-of-the-art tide gauges transmitting real time data through satellite communication to Indian Nation Centre for Ocean Information (INCOIS) at Hyderabad. There are seven PSMSL stations at Sagar, Gangra, Haldia, Diamond Harbour, Garden Research, Khidirpur and Trebeni along the Hugli, West Bengal in Sundarbans region. Tide gauge data from three stations were used for trend analysis and results indicated that the rate of sea level changes for three stations Diamond Harbour, Garden Reach and Haldia were found to be +4.85, +8.22, and +3.0 mm yr^{-1}.

Stress-tolerant rice for Africa and South Asia (STRASA - Phase 2) Stress tolerant rice for coastal soil (B. Maji, D. Burman, S. K. Sarangi and S. Mandal)

Under the participatory research programme on 'Stress tolerant rice for Africa and South Asia (Phase 3)' funded by Bill and Melinda Gates Foundation (BMGF), farmers are involved in selecting rice lines/varieties included in researcher-managed trials (Mother trials) and in farmer-managed trials (Baby trials). Trials were conducted during *rabi* and *kharif* seasons at different parts of Sundarbans in the coastal region of West Bengal with the major thrust to identify the 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

Table 122: Grain yield of different entries under Mother trials during rabi and kharif seasons

Rabi 2014-15		*Kharif* 2015		
Varieties/ lines	Shimulhati village	Varieties/ lines	Gabberia village	Dakshin Mokamberia village
	Grain yield (t ha^{-1})		Grain yield (t ha^{-1})	
WGL20471 (Lalminikit)	4.83	Amal-Mana	4.31	3.87
IET 4786 (Sadaminikit)	4.34	Geetanjali	4.03	3.99
Annada	4.42	SR 26 B	3.33	3.69
Boby	4.38	Sabita	4.63	4.05
Lalat	4.22	Swarna Sub - 1	1.53	1.96
BRRI DHAN-47	4.24	CSR(D) 21-2-5-B-1-1	3.70	3.51
BINA-8	4.46	Dinesh	1.94	3.45
CSR-34	3.79	Patnai - 23	2.31	3.27
CSR-22	4.02	CST 7-1	1.85	2.80
IR 64-Saltal	4.12	CD (0.05)	0.70	0.32
CD (0.05)	0.28			

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 under this project.

Evaluation of promising salt-tolerant germplasm through PVS trials

During *rabi* season of 2014-15, one on-farm Mother trial was conducted at Shimulhati village of Sandeshkhali I Block in North 24 Parganas District. A set of 10 promising varieties/new lines viz. WGL20471 (Lalminikit), IET 4786 (Sadaminikit), Annada, Boby, Lalat, BRRI DHAN-47, BINA-8, CSR-34, CSR-22 and IR 64-Saltal were evaluated under trial. In preferential analysis (PA), WGL20471 (Lalminikit) and IET 4786 (Sadaminikit) emerged as the most preferred rice varieties. The varieties preferred the most by the farmers were salt tolerant, high yielding, pest and disease tolerant and fetched better market price. Farmers did not prefer CSR34 and CSR 22 because of their small panicles, less grain per panicle and expected low yield. Pearsons' correlation between the preference scores indicated that there was strong significant correlation between the

STBN trial was visited by scientists from IRRI along with scientists from RRS, Canning Town preference scores of male and female farmers, moderate significant correlation between the preference scores of all farmers and researchers and strong significant correlation between the preference scores of all farmers and grain yield of rice varieties/lines. The highest grain yield was produced by WGL20471 (4.83 t ha^{-1}) while lowest grain yield was produced by CSR22 (4.02 t ha^{-1}) .

During *kharif* season of 2015, two on-farm Mother trails were conducted at Gabberia village of Sandeshkhali II Block in North 24 Parganas District and Dakshin Mokamberia village of Basanti Block in South 24 Parganas District. A set of 9 promising varieties/new lines viz. Amal-Mana, Geetanjali, SR 26 B, Sabita, Swarna Sub-1, CSR(D) 21-2-5-B-1-1 (Namita Dipti), Dinesh, Patnai -23 and CST 7-1 was evaluated in the single-factor experiment in RCBD with 3 replications. In Mother trials, Amal-Mana, Sabita and Geetanjali emerged as the most preferred rice varieties. Swarna Sub-1 and CST 7-1 emerged as least preferred varieties in the PA. Those varieties were preferred most by the farmers due to traits like tall plant height, long panicles with more grains, no minimum infestation of pests and diseases, more tillers, good grain type, overall good performance of crop, more straw for fodder/ thatching /fuel and expected high yield, etc. Farmers did not prefer Swarna Sub-1 and CST 7-1 because of their small panicles with unfertile grains, poor tillering, and expected low yield. Pearsons' correlation between the preference scores indicated that there was very strong significant correlation between the preference scores of male and female farmers, moderately significant correlation between the preference scores of all farmers and researchers and strong/very strong significant correlation between the preference scores of all farmers and grain yield of rice varieties/lines. The highest grain yield was produced by Sabita (4.34 t ha^{-1}) while the lowest grain yield was produced by Swarna Sub-1 (1.75 t ha^{-1}) (Table 122).

Evaluate promising lines and management practice through farmer's managed trials

Twelve Baby trials were conducted during rabi season in farmers' fields at different villages in South 24 Parganas and in North 24 Parganas Districts of Sundarbans region. Three varieties viz. WGL20471 (Lalminikit), IET 4786 (Sadaminikit) and Annada were given to farmers for the trials during rabi. In Baby trials, the planting treatments like conventional transplanting and line spacing (20 cm X 15 cm) were taken as the management practices. About 10-18% improvement in grain yield of rice varieties was recorded at line spacing over farmers' practice of conventional spacing of planting during rabi season.

Salinity tolerant breeding network (STBN)

STBN trial was conducted at Canning experimental farm during Kharif 2015. The soils of the experimental site have Hyperthermic temperature and Aquic moisture regime. The soils are heavy in texture (silty clay) and normal in soil reaction. Soil salinity during dry moths is very high (EC_e, 9-12 dS m^{-1}). However, it is less than 4 dS m^{-1} during kharif season. The experiment consisted of 25 rice genotypes (IR 87830-B-SDO1-2-3-B, IR 87938-1-1-3-2-1-B, IR 87830-B-SDO2-1-3-B, IR 87938-1-2-2-1-3-B,IR 87831-3-1-1-2-2-BAY B, IR 87938-1-1-2-1-3-B, IR 87938-1-1-2-3-3-B, IR 87938-1-2-2-2-1-B, IR 87937-6-1-3-2-2-B, IR 87952-1-1-1-2-3-B, IR 84645-305-6-1-1-1, IR 87848-301-2-1-3-B, IR 87948-6-1-1-1-3-B, CSR-2K-232, CSR-2K-228, BULK 216, RYT - 3207, CSRC(D) 7-0-4, GMS 8-3-2-1-2, KR 09011, TR 13-031, TR 13-083, NDRK 11-13, CSAR 1209 and RAU-1478-5-4-3-2-2-2), 4 check varieties (PUSA 44, CSR 36, CST 7-1 and CSR 27) and 2 local check varieties (Canning-7 and Amal-Mana). The experiment was laid out in Randomized Block Design (RBD) with three replications. Days to 50 % flowering of the entries in the trial ranged from 71 days (KR 09011) to 115 days (CSRC(D) 7-0-4 and Amal-Mana, Local check) with a mean of 90 days. Plant height of the entries varied from 96 cm (RAU-1478-5-4-3-2-2-2) to 173 cm (Amal-Mana, Local check) with a mean height of 118cm. Stress score at vegetative stage varied from 1 (IR 87938-1-2-2-1-3-B, IR 87938-1-1-

2-3-3-B, RYT – 3207, KR 09011, TR 13-031, CSAR 1209, PUSA 44 and Amal-Mana (Local check) to 5 (IR 84645-305-6-1-1-1 and IR 87848-301-2-1-3-B) with a mean value of 3. At reproductive stage, stress score varied from 1 (IR 87938-1-1-2-3-3-B, RYT - 3207, KR 09011, TR 13-031, CSAR 1209, PUSA 44 and Amal-Mana (Local check)) to 5 (IR 87848-301-2-1-3-B, BULK 216 and CSR 27) with a mean value of 3. There was no stress for BLB, blast and other diseases. Number of tillers per plant of the entries ranged from 8 (IR 87938-1-1-3-2-1-B, IR 87831-3-1-1-2-2-BAY B, IR 87938-1-1-2-3-3-B, IR 84645-305-6-1-1-1, RYT - 3207 and GMS 8-3-2-1-2) to 16 (BULK 216) with a mean value of 10. Number of reproductive tillers varied from 8 (IR 87937-6-1-3-2-2-B, R 87938-1-1-3-2-1-B, IR 87831-3-1-1-2-2-BAY B, IR 87938-1-1-2-3-3-B, IR 84645-305-6-1-1-1, RYT – 3207 and GMS 8-3-2-1-2) to 16 (BULK 216) with a mean value of 10. Panicle length of the different entries under trial ranged from 16.4 cm (RAU-1478-5-4-3-2-2-2) to 27.4 cm (IR 84645-305-6-1-1-1) with a mean of 21.9 cm. Number of seeds per panicle varied from 42 (CSR-2K-228) to 123 (CSR 36) with a mean value of 85. Number of un-filled grains per panicle varied from 7 (CSR-2K-228) to 35 (TR 13-031) and mean value for the entries is 20.7. Spikelet fertility of the entries under trial ranged from 60.7% (IR 87830-B-SDO2-1-3-B) to 85.8% (CSAR 1209) with a mean of 75.8%. In the trial, 1000 grain weight of the entries varied from 23.4 g (IR 87938-1-1-2-3-3-B and IR 87948-6-1-1-1-3-B) to 31.5 (CSR-2K-232) with a mean weight of 26.3 g. Grain yield of the entries varied from 1736.5 to 4465.6 kg ha^{-1} with mean yield of 3089.5 kg ha^{-1} (Fig. 80). Out of all the entries

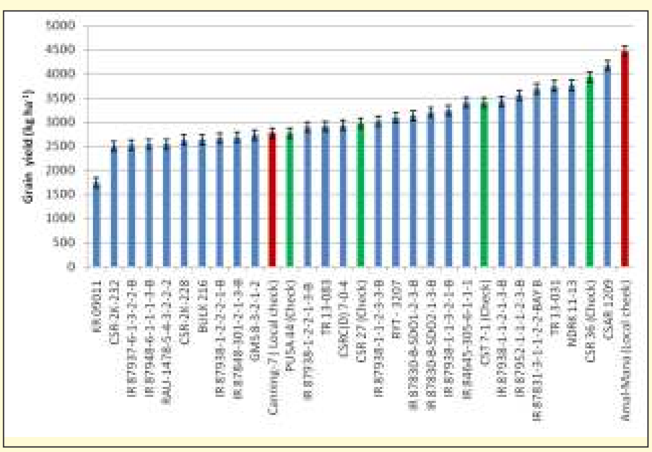


Fig. 80 : Mean grain yield of the entries under STBN trial

higher grain yield was recorded from Amal-mana, Local check (4465.6 kg ha^{-1}), CSAR 1209 (4171.4 ha^{-1}), CSR 36 (3932.3 ha^{-1}), NDRK 11-13 (3772.5 ha^{-1}), TR 13-031 (3749.2 ha^{-1}), IR 87831-3-1-1-2-2-BAY B (3695.2 kg ha^{-1}), IR 87952-1-1-1-2-3-B (3561.9 kg ha^{-1}). Straw yield of the entries varied from 3503.7 to 9397.9 kg ha^{-1} with mean yield of 4896.0 kg ha^{-1}.

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 the externally funded project on 'Future Rainfed Lowland Rice Systems in Eastern India (IRRI-ICAR W3)' funded by International Rice Research Institute (IRRI), research experiments were conducted both during wet (kharif) and dry (rabi) seasons at coming Farm, as well as in the farmers' fields (on-farm) during the reported period. Experiment on increasing nitrogen use efficiency (NUE) of low land rice was carried out during kharif 2015 with use of prilled and neem coated urea(NCU). These sources were combined with different times and methods of application like soil and foliar spray. Rice variety Amal-Mana was used in the experiment. The grain yield was significantly higher when nitrogen source was neem coated urea and applied 75% to soil (50% one week after transplanting, 25% at tillering) and 25% foliar spray at reproductive stage (Table 123). However, straw yield was not affected due to different N management practices. Cost of cultivation was less in the use of NCU, mainly due to less infestation of pests. Although gross return, net return and benefit: cost ratio were higher with the use of NCU, economics was not different with the method of application. With NCU applied 75% to soil and 25% to the foliage, the net return was US $ 437 ha^{-1}, which was at par (US $ 375 ha^{-1}) with application of NCU 100% to soil (50% basal, 25% at tillering stage and 25% at PI stage). The B.C. ratio for these two treatments was 1.7 and 1.6, respectively and for other treatments it was 1.3-1.4.

The best result of the on-station study on improving NUE and economy was evaluated in comparison to farmers' practice in 8 on-farm locations in the Sundarbans region of West Bengal, covering three villages and two administrative blocks in the district of South 24 Parganas. Neem

Table 123 : Yield and economics of rainfed low land rice with different nitrogen management practices in Sundarbans region, West Bengal (mean data of 2014 and 2015).

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Cost of cultivation ($ha^{-1})	Gross return ($ha^{-1})	Net return ($ha^{-1})	BCR
T1	3.09	7.56	623	822	199	1.3
T2	3.43	8.15	617	836	219	1.4
T3	3.42	6.78	623	773	150	1.2
T4	3.51	7.42	619	801	182	1.3
T5	3.46	6.84	622	786	165	1.3
T6	3.64	7.13	614	839	224	1.4
T7	3.66	6.85	621	797	175	1.3
T8	4.57	8.81	616	1052	437	1.7
T9	3.31	7.29	619	841	223	1.4
T10	4.07	8.24	609	983	375	1.6
SEm±	0.13	0.57	2	46	46	0.1
$LSD_{0.05}$	0.39	ns	5	137	137	0.2

T1: 50% N basal with Prilled Urea (PU) +50 % N foliar, T2: 50% N basal with Neem Coated Urea (NCU) + 50 % N foliar, T3: 50% N one week after transplanting (1 WAT) with PU + 50% N foliar, T4: 50% N 1 WAT with NCU + 50% N foliar, T5: 50% N basal with PU + 25% N at tillering with PU + 25 % N foliar, T6: 50% N basal with NCU + 25% N at tillering with NCU + 25% N foliar, T7: 50% N 1 WAT with PU + 25% N at tillering with PU + 25% N foliar, T8: 50% N 1 WAT NCU + 25% N at tillering with NCU + 25% N foliar, T9: Recommendation with PU (50% basal, 25% at tillering and 25% at Pl), T10: Recommendation with NCU (50% basal, 25% at tillering and 25% at Pl).

Neem coated urea was introduced in the Sundarbans region through IRRI-ICAR W3 Project

coated urea application was introduced in the study area along with improved varieties Amal-Mana and Swarna-Sub 1. Improved varieties, farmers' own variety (varied from farmer to farmer) and two fertilizer sources (NCU and PU) were evaluated with four replications on each site. On-farm trial on NCU revealed its superiority over PU irrespective of the variety used. Amal-Mana in most cases resulted in higher yield over farmers, variety except in case of variety CR 1001 grown by one farmer co-operator. Swarna-Sub 1 produced the highest grain yield of 4.52 t ha^{-1} with the use of NCU, which was 10% higher over the use of PU.

Drum seeding of pre-germinated salt tolerant rice seeds treated with seed treating chemicals, line transplanting and farmers' practice (random transplanting) were evaluated at two sites in two villages of South 24 Parganas district of West Bengal during boro season of 2015-16. Demonstration and description of drum seeder machine was given to the farmers during this period.

The source of water for dry season rice (boro) in eastern India is mainly pumping of groundwater through shallow tube wells in addition to conserved surface water in farm pond, which is particularly used for growing vegetables. To reduce the irrigation water requirement of boro rice effective use of residual soil moisture after the kharif crop, optimum time of seeding and transplanting, and salt tolerant rice varieties are needed. Our hypothesis is that early seeding of boro rice will utilize the residual soil moisture and will therefore need less irrigation water. Early sown crop also avoids the higher temperature, evaporation, recession of groundwater table and salinity in the later part of growing season. Moisture conservation measures like use of hydrogel may reduce the water requirement for rice. Keeping these facts in view an experiment was conducted during boro season of 2015-16.

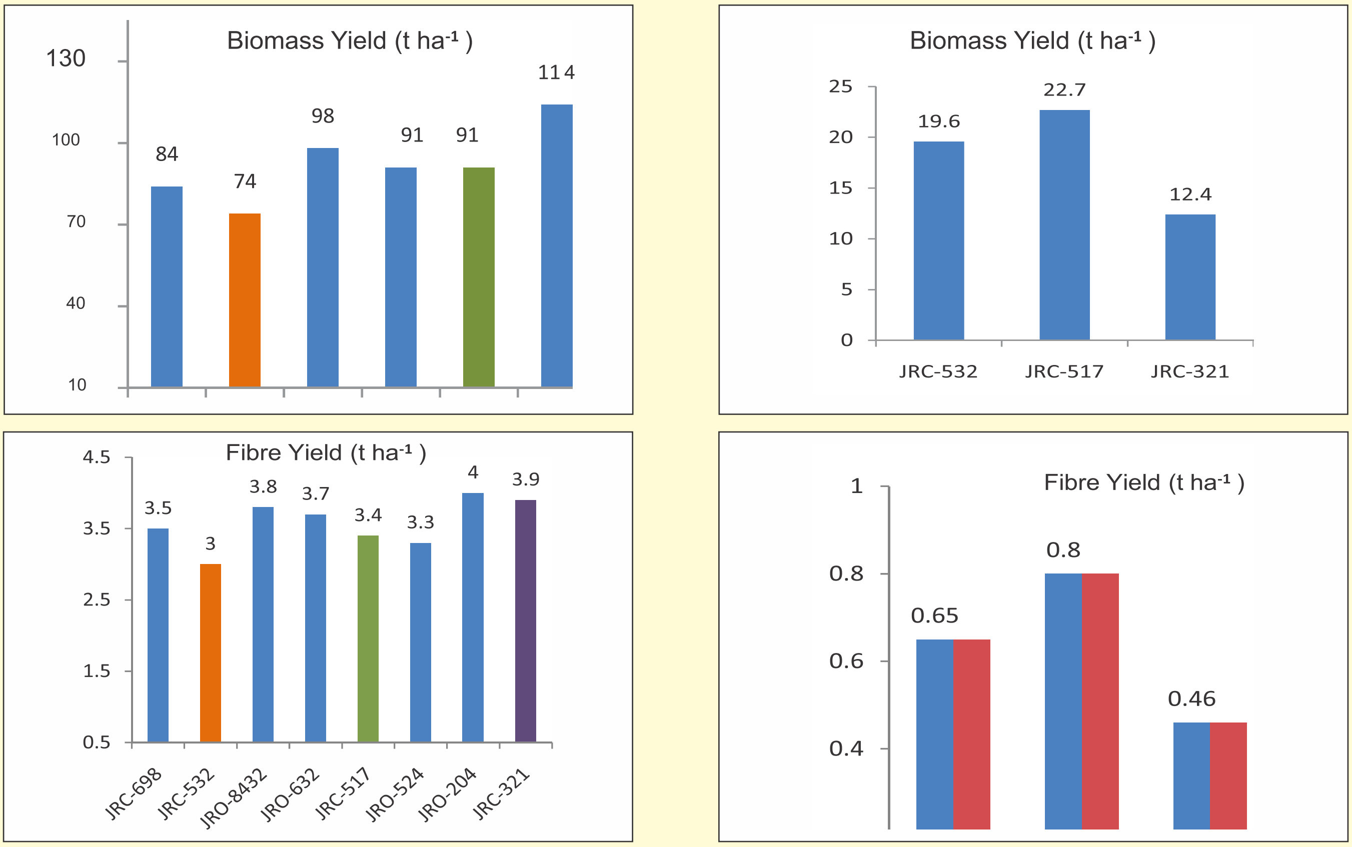


Fig. 81: Total above ground biomass and fibre yield of jute under high land and low land situation

Study the effect of salinity stress on jute (*C. capsularis* & *C. olitorius*) (M. Ramesh Naik Dhananjay Barman, Maruthi, R.T. and Uttam Kumar Mandal)

Though jute is one of major cash crops, jute cultivation is increasingly being being pushed to the marginal low productive lands to make more room for food crops. In order to find out salt tolerant jute varieties which can sustain salt stress and could produce higher yield in marginal coastal region, a project was initiated under inter institutional collaboration with CRIJAF, Barrackpore. Eight varieties of both *Olitorius* and *Capsularis* were sown during the last week of April, 2015 under high land condition whereas, three *Capsularis* varieties were sown during 2nd week of May under low land condition at, Canning Research Farm. The low land field was submerged since July because of heavy downpour in the month of July at Canning. The biomass and fibre yield for *Olitorious* and *Capsularis* varied from 91-129 t ha-1 and 3.3-4 t ha^{-1} and 74-102 t ha^{-1} and 3-3.9 t ha^{-1}, respectively under highland situation. The biomass and fibre yield for *Capsularis* were quite low under low land situation and it varied from 12.4 -22.7 q ha^{-1} and 0.46 - 0.8 t ha^{-1}, respectively (Fig. 81).

Land use options for enhancing productivity and improving livelihood in Bali Island of Sundarbans (K. D. Sah , K. Das, S. K. Reza , T. H. Das , Subhasis Mandal, D. Burman, U. K. Mandal, K. K. Mahanta, B. Maji, S K Sarangi and P. P. Chakraborty)

Sundarbans is a fragile coastal eco-system under Ganga-Brahmaputra delta system. An inter-institutional (ICAR-NBSSLU&P, RC-Kolkata, ICAR-CSSRI-RRS Canning and ICAR-CIFA, Rahara Center) project is being implemented under Tribal Sub-plan (TSP). The key objective of the project is to intensify agriculture and allied activities through promotion of integrated farming system for to livelihood security of the disadvantaged social groups. Primary focus of this project is to augment farm productivity through sustainable management of land and water resources in coastal salt affected areas of Sundarbans to enhance the farm income.

NBSS & LUP survey in the project site indicated that soils are very deep, grey to greyish black, poorly drained, silty loam to silty clay loam on the surface and silty clay to clay in the sub-subsurface. First 0-25 cm soil is slightly acidic (pH 5.4 to 6.6) and marginally saline (EC_2 of 1.4 to 2.4 dSm^{-1}) whereas the soils between 25 to 100 cm soil depth exhibit exchangeable acidity, resulting due to exchangeable Al^{+3} (3.2 to 5.1 cmol (p+)kg^{-1}) and EC_2 varying from 1.8 to 2.64 dS m^{-1}. Acid sulfate layer, when observed, occurs at the depth of 40 to 60 cm in Bali 1, whereas soils of Bali 2 contain acid sulfate layer between 80 to 100 cm. Soluble salt are mostly chlorides and sulfates of sodium, magnesium and calcium. Carbonates and bicarbonates are absent. Dominance of sodium and magnesium in solution and exchange phases along with silty clay loam texture makes the soil sticky under wet conditions and hard with cracks when dry. The subsoil remains under reduced or partially reduced condition with the mottles of different sizes in the dark colored horizons. Acid sulfate layer characterized with yellow mottles of jarosite are present at varying depth between 46 to 82 cm. Base saturation ranges from 57 to 73% on the surface and decreases with depth (from 42 to 50%). Exchangeable sodium is higher on the surface than sub-surface. Soils of Bali Island are rich in potassium, adequate in micro-nutrients and suffer from the acute shortage of phosphorus. Besides, socio-economic information has been collected for the study area. Majority of the people in the Bali Island are externally poor and almost fully dependent on agriculture for livelihoods. Schedule castes and schedule tribes constitute 59% and 4.5% of the Island population, respectively. Overall, the households in the Island are possessing very small land for agricultural operation (0.64 ha) and are dominated by the marginal farmers who have even smaller size of holdings (0.43 ha). Overall 84 % households are possessing less than a hectare of land that accounts for more than half (56%) of the total operational area. Small farmers, accounts for 13% of the total households, possessing about 31 % area of land. Share of land occupied by other categories of households are very negligible. Besides, the socio-economic profiling of the tribal farmers of Amlamethi village indicated, that they are extremely resource poor; 83 % having tiny operational holdings (0.18 ha) and 17% are landless. Around 40% are illiterate. Over 50% of farm families are not food self-sufficient. Primary occupation was daily wage earning, seasonal migration to other states (3-6 months) and nearby cities.

A number of technologies like farm pond, deep furrow and high ridge, shallow furrow and medium ridge and paddy cum fish cultivation have been developed for augmenting agricultural production. Farm pond technique is very popular in the region for water harvesting during kharif season and its subsequent utilization in the rabi season. After completing baseline information, selection of farmers and site has been completed based on discussion and suitability of the land and excavation work for the land shaping has been completed with 32 farmers. Inputs and other technical guidance are being provided to the farmers. There is improvement in homestead production system through vegetable cultivation. Growing vegetables (avg. area 0.08 ha) provided return over 3.51 times and the same was 1.65 times for paddy (avg. area 0.33 ha). Land shaping and soil management interventions are yielding positive results and farmers' are going confidence on such interventions. Some resource rich farmers are investing for land shaping techniques from their own resources.

Coastal saline tolerant variety trial (CSTVT) (S. K. Sarangi and B. Maji)

Under CSTVT, two trials were conducted during the kharif season of 2015. (1) IVT -CSTVT and (2) AVT-CSTVT. Out of 64 entries under IVT-CSTVT, highest grain yields were obtained from entry no. 4043 (6.39 t ha^{-1}), entry no. 4013 (5.99 t ha^{-1}) and entry no. 4008 (5.96 t ha^{-1}), The local check Canning 7 produced grain yield of 4.95 t ha^{-1}. Seed mixture, (of other varieties) were observed in the entries 4008, 4015, 4016, 4017, 4018, 4019, 4020, 4027, 4028, 4033, 4045 and 4049. Seeds of two entries 4042 and 4051 did not germinate. Therefore, seedlings could not be produced and no data could be generated for these two entries. Brown leaf spot disease was

CSTVT trial during kharif 2015 at Canning Town

Evaluation of Barley genotypes at Canning Town

observed in entry no. 4002 and entry no. 4014 was found to be highly susceptible to salinity. Out of the 64 entries 4041, 4043 and 4054 were found to be highly tolerant to salinity. Local check (Canning 7) flowered in 83 days, entries flowered with local check were 4003, 4013 and 4035. Entries flowered before local check were: 4004, 4005, 4007, 4014, 4022, 4023, 4032, 4039, 4062. Other entries flowered after the local check. Plant height varied from 67 cm in entry no. 4039 to 134.3 cm in entry no. 4002. Number of panicles per m^2 was the highest (684) in entry no. 4031 and the lowest (329) in entry no. 4036.

Out of 16 entries under AVT-CSTVT, the highest grain yields were obtained from entry no. 1803 (5.4 t ha^{-1}) and entry no. 1814 (5.0 t ha^{-1}). The local check [CSR 4 (Mohan)] produced grain yield of 4.3 t ha^{-1}. Days to 50% flowering varied from 90-128 days. Entries 1811 and 1816 flowered in 90 days, whereas entries 1807 and 1814 flowered in 128 days. The local check variety CSR 4 flowered in 90 days. Plant height was the lowest (68.3 cm) in entry no. 1811 and the highest (157 cm) in entry no. 1810. Average number of panicles per m^2 varied from 366 - 566 in entry no. 1801 and 1806, respectively. Off types (mixture of seeds of other rice varieties) were found in the entries 1801, 1806 and 1814.

All India co-ordinated wheat & barley improvement project (S. K. Sarangi, B. Maji and T. D. Lama)

Nineteen entries of barley received from IIWBR, Karnal were evaluated during rabi season of 2015-16. Evaluation was done in RBD with four replications. Uniform fertilizer dose of 60:30:20 kg N-P2O5-K2O ha^{-1} (1/2 N + full P & K basal, rest N 30 DAS) and row to row spacing of 23 cm was followed. Sowing was done on 25.11.2015 with soil salinity (ECe) of 6.14 dS m-1 at sowing the highest yield of 1.78 t ha-1was obtained from entry no. AVTSST-16, followed by AVTSST-9 (1.62 t ha^{-1}). The lowest yield of 0.17 t ha-1 and 0.21 t ha^{-1} was recorded by AVTSST-2 and AVTSST-5, respectively. Brown spot disease was observed in AVTSST-8 and AVTSST-17. The entries AVTSST-2 and AVTSST-5 were very late leading to very poor yield.

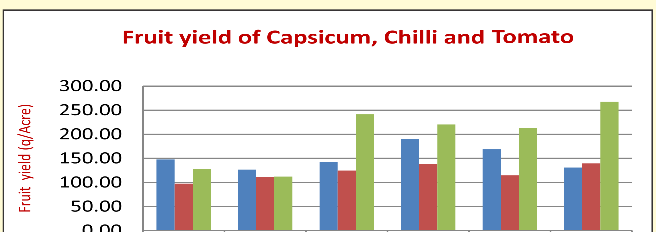
AICRP ON MANAGEMENT OF SALT AFFECTED SOILS AND USE OF SALINE WATER IN AGRICULTURE

Evaluation of commercial vegetable crops under protected cultivation structure in saline environments (R.L. Meena, B.L. Meena and Anshuman Singh)

This experiment was initiated during August 2015 with three vegetable crops; capsicum (var. Indra), chilli (var. Kranti) and tomato (var. Cibelia) grown in a naturally ventilated polyhouse. There were six saline irrigation treatments including the best available water (BAW) in all three vegetable crops. Capsicum and chilli were transplanted on 4th August 2015 and tomato on 26th August 2015. After initial establishment of seedlings for 15 days, saline irrigation treatments were started. The vegetables were grown at 45 cm x 30 cm spacings in raised beds of 15 cm height. Saline irrigation was done using drip system under gravity flow. The recommended dose of water soluble fertilizers was given with drip irrigation. The results obtained so far showed good response even under high saline water irrigation Fig. 82. Highest fruit yield (47.5 t ha^{-1}) of capsicum was obtained with application of 6 dS m^{-1} saline water followed by 8 dS/m (42 t ha^{-1}). Similarly, the highest fruit yield of chilli was obtained when salinity in irrigation water was 10 dS m^{-1} (34.75 t ha^{-1}) followed by irrigation 6 dS m^{-1} (34.5 ha^{-1}). The highest fruit yield (66.75 t ha^{-1}) of tomato was obtained with 10 dS m^{-1} saline water followed by 4 dS m^{-1} (60.25 t ha^{-1}) and 6 dS m^{-1} (55 t ha^{-1}). The fruit data (capsicum 13 pickings; chilli 11 pickings; and tomato 15 pickings) show the possibility of usingeven high salinity water for irrigating these vegetable crops with drip system under naturally ventilated protected cultivation structure.

Optimizing zinc and iron requirement of pearl millet-mustard cropping system on salt affected soils (B.L. Meena, Parveen Kumar, Ashwani Kumar and R.L. Meena)

Plant growth is depressed due to high salt concentrations in the growing substrate. In addition to osmotic stress, crop productivity is adversely affected due to specific ion toxicities, inadequate nutrient availability and cationic imbalances. Therefore, judicious management of plant nutrients in salt affected soils should be given majore emphasis. These soils are often found deficient in one or more micronutrients especially zinc (Zn) and iron (Fe). Due to the variation in chemical composition of salt affected soils, precipitation-dissolution reactions, adsorption kinetics and transformations of nutrients, and crop responses to applied nutrients greatly vary. Keeping this in view, a field experiment was initiated at Nain Experimental Farm during 2013 with pearl millet-mustard cropping system to optimize Zn and Fe requirement. The experiment comprised of 12 treatments replicated thrice in RBD. Zinc and iron were applied by $ZnSO_4.7H_2O$ and $FeSO_4$ $7H_2O$, respectively at sowing. Foliar



	BAW	ECiw 2	ECiw 4	ECiw 6	ECiw 8	ECiw 10
Capsicum	147.72	126.58	141.83	190.63	168.78	131.00
Chilli	97.42	111.33	124.75	138.10	114.71	139.49
Tomato	128.16	112.22	241.52	220.47	213.05	267.56

Fig. 82: The data in vegitable crops under different Salinity treatments

A view of different vegetable crops grown in naturally ventilated pollyhouse

Chilli and capsicum fruits produced with saline irrigation

sprays of inorganic salts of Zn and Fe ($ZnSO_4.7H_2O$ & $FeSO_4.7H_2O$) were also done 30 and 45 days after sowing. Results of experiment conducted during 2014-15 showed that grain yield of pearl millet (3.76 t ha^{-1}) and seed yield of mustard (2.29 t ha^{-1} pollyhouse) were 57 and 44% higher respectively, with the application of 5 kg Zn+10 kg Fe+10 t FYM as compared to control. Data given in Table 124 revealed that FYM applied to mustard results in significant improvement of soil fertility. The highest soil organic carbon (0.51%) was observed with 5 kg Zn+10 kg Fe + 10 t FYM (T_9) followed by T_8 (0.43%) and T_7 which were significantly higher as compared to other treatments. The maximum DTPA-Zn (0.84 mg kg-1) and Fe (5.93 mg kg^{-1}) were recorded in T_9 followed by T8. The results also revealed that combined application of 5 kg Zn+10 kg Fe with FYM significantly improved N and P status of surface soils by 55.8 and 35.7%, respectively, over control. Potassium (K) content was found non-significant under all treatments except T_9. The potassium content was 570 to 720 kg ha^{-1} in soil. It might be due to presence of potassium bearing minerals (illite and biotite) in

Table 124 : Effect of zinc and iron application on soil organic carbon, available N, P, K, Zn and Fe after harvest of mustard

Treatment	Organic carbon (%)	Available N (kg ha^{-1})	Available P(kg ha^{-1})	Available K(kg ha^{-1})	DTPA_Zn (mg kg^{-1})	DTPA-Fe (mg kg^{-1})
T1	0.33	139	10.7	570	0.69	4.50
T2	0.36	151	12.4	590	0.78	4.61
T3	0.37	157	13.6	606	0.80	4.73
T4	0.40	170	13.9	618	0.83	4.79
T5	0.38	174	12.7	608	0.72	5.02
T6	0.38	157	13.9	622	0.73	5.21
T7	0.41	165	14.3	648	0.73	5.27
T8	0.43	174	15.4	663	0.81	5.32
T9	0.51	189	18.2	720	0.84	5.93
T10	0.33	144	11.7	585	0.72	4.54
T11	0.34	149	11.9	589	0.69	4.83
T12	0.35	157	12.2	590	0.72	4.72
CD (P=0.05)	0.07	15	2.09	54	0.08	0.81

T_1- Control, T_2- 5 kg Zn, T_3- 6.25 kg Zn, T_4- 7.5 kg Zn, T_5- 7.5 kg Fe, T_6- 10 kg Fe, T7- 12.5 kg Fe, T_8- 5 kg Zn+10 kg Fe, T_9- 5 kg Zn+10 kg Fe + 10 t FYM per hectare, T_{10}- Foliar sprays of 0.5% $ZnSO_4$ (twice), T_{11}- Foliar sprays of 1% $FeSO_4$ (twice at 30 and 45) and T_{12}- Combined foliar sprays (0.5% $ZnSO_4$+1% $FeSO_4$; twice).

the experimental soil. The improvement in soil organic carbon could be a result of direct addition of organic matter through FYM and its beneficial effect on crop roots, nutrients availability and total microbial biomass carbon. The practice of Zn and Fe application with FYM improved and/or maintained the available NPK and micronutrients in 0-15 cm depth of the salt affected soils.

Plastic low tunnel technology for off season cultivation of vegetable crops in drip irrigation with saline water (AICRP Agra Centre)

The fruit yield of tomato and bitter gourd significantly decreased with increasing EC_{iw} levels in surface irrigation system. In contest, the fruit yield of tomato grown under plastic low tunnel with drip irrigation was at par at all salinity levels (canal water, 4 and 8 dS m^{-1}). Based on average of four years, tomato fruit yield in plastic low tunnels with drip irrigation at EC_{iw} 4 and 8 dS m^{-1} showed reduction of yield by 7.3 and 15.1% and reduction of 16.1 and 30.1% in surface irrigation, respectively (Fig. 83). In bitter gourd (average of three years), this reduction was 5.1% and 13.9% in drip and 21.8 and 39.8% in surface irrigation. Fruit yield of tomato and bitter gourd was 2.5 times higher in drip as compared to surface irrigation with saving of about 30% irrigation water.

The water use efficiency was 678.9, 621.9 and 578.8 (kg ha^{-1}-cm) under drip and 207.0, 180.7 and 147.1 (kg ha^{-1}-cm) under surface irrigation, respectively. The water use efficiency was higher in IW/CPE 0.75 (771.0 kg ha^{-1}-cm in surface irrigation) in drip and surface irrigation 228.6 kg ha^{-1}-cm as compared to other IW/CPE ratios. Soil analysis at

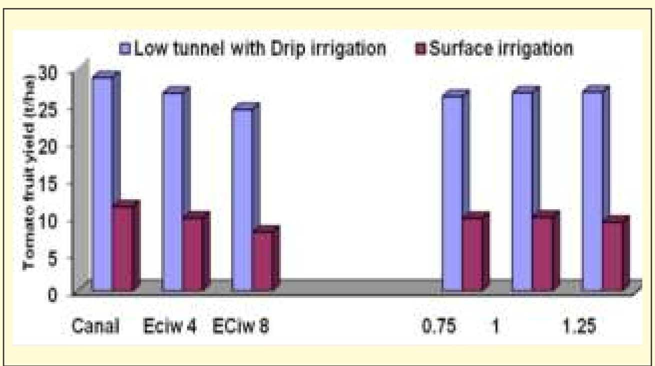


Fig. 83. Fruit yield of tomato under different treatments (Averaged of 4 years)

the harvest of tomato crop revealed that EC_e (average four years) of the surface soil (0-10 cm) ranged from 3.77 to 4.05 dS m^{-1} in control, 8.1 to 8.7 in EC_{iw} 4 and 11.27 to 12.05 (dS m^{-1}) in EC_{iw} 8 dS m^{-1}.

Evaluation of controlled drainage system in (saline) Vertisols of TBP irrigation command (AICRP Gangawati Centre)

Controlled drainage system with a slight modification in the existing traditional (sub surface drainage; (SSD) with 50 m spacing was designed at ARS, Gangawati. At paddy crop harvest, comparison of the two drainage systems over four seasons revealed that about 13, 13.9, 26 and 34.1 cm of irrigation water was saved under CDS as compared to conventional SSD. Data (Table 125) revealed that the average drain discharge of all four seasons in SSD was 3.28 mm day^{-1} against 1.11 mm day^{-1} in CDS. The average salinity of drainage water in SSD and CDS in all the seasons was 3.02 dS m^{-1} and 2.95 dS m^{-1} and the average salt removal over all seasons was 1.0 t ha^{-1} as compared to 3.5 t ha^{-1} under SSD. Both salt addition (1.58 t ha^{-1}) and removal (3.5 t ha^{-1}) were higher in SSD because of no regulation in the drainage outlet. In case of CDS, however, both addition of salt (1.11 t ha^{-1}) and removal (1.0 t ha^{-1}) were low due to regulation of drainage discharge. These data clearly indicated that reclamation was faster in conventional than controlled drainage. The loss of N under SSD was about 52.5% CDS. Paddy grain yield increased from 38.4 (prior to SSD) to 51.4 q ha^{-1} and 37.6 (prior SSD) to 48.3 q $h^{-1}a$ under conventional and CDS respectively.

Effect of methods of irrigation and water quality on performance of fruit trees in sodic environment ((AICRP Indore Centre)

This study was carried in sodic black soils of Madhya Pradesh. Initially three fruit crop viz., ber (Banarsi Kadka) and sapota (Kalipatti) and pomegranate were transplanted. Three irrigation systems (check basin, drip and embedded pipe (100 mm dia. perforated vertical PVC pipe of 40 cm length) with two qualities of water (normal and diluted distillery waste water) were used. The pomegranate failed to survive and was replaced

Table 125 : Drainage discharge rate, salinity, salt input and removal in different drainage systems

Period	Conventional drainage				Controlled drainage			
	Drain discharge (mm d^{-1})	ECdw (dS m^{-1})	Salt input (t ha^{-1})	Salt removal (t ha^{-1})	Drain discharge (mm d^{-1})	ECdw (dS m^{-1})	Salt input (t ha^{-1})	Salt removal (t ha^{-1})
Kharif 2012	5.91	2.90	1.48	1.94	2.06	2.03	1.31	0.56
Kharif 2013	2.60	3.61	1.53	4.61	0.79	3.21	1.35	1.22
R/S 2013-14	2.60	3.10	1.31	3.64	1.20	3.50	1.39	1.16
Kharif 2014	2.03	2.50	2.03	3.85	0.42	3.07	0.42	1.09

by sapota in 2010-11. The data presented in Table 126 revealed that the highest yields of ber (18.56 t ha^{-1}) and sapota (5.2 t ha^{-1}) were recorded in case of embedded pipe irrigation method with diluted spent wash (1:30 ratio) water. The fruit yield of ber was 84.8 and 41.3 % higher in case of diluted spentwash water applied through embedded pipe and drip irrigation methods over check basin method, respectively. Similarly sapota yield increased by 85.7 and 42.9 % in embedded pipe and over check basin method. Data also indicated yield improvement in case of irrigation with spentwash diluted irrigation in all the methods of irrigation as compared to irrigation with best available water.

Long term effects of distillery effluent on soil properties and yield of sugarcane (AICRP Trichy Centre)

Long term field experiment was continued to evaluate the long term effect of different rates of pre-plant application of post methanated distillery effluent (PME) along with different combinations of N, P and K on the changes in soil physico-chemical properties, fertility status, exchangeable cations, and cane yield. Increased in cane yield (Co 86032) was 52.1, 64.3, 76.4 and 84.8 per cent with 1.25, 2.5, 3.75 and 5.0 lakh L ha^{-1} of PME respectively, over control (Table 127). The effect of interrelation revealed that PME application @ 1.25 lakh l ha^{-1} together with NP fertilizer was the most suitable dose of for obtaining high cane yield. It was observed that application of PME @ 5.0 lakh l ha^{-1} reduced the soil pH to 8.0 from the initial pH of 8.42. In content, soluble salt content marginally increased i.e., 0.121, 0.135, 0.142 and 0.153 dS m^{-1} from the initial level of 0.10 dS m^{-1} due to application of distillery effluent @ 1.25, 2.50, 3.75 and 5.0 lakh L ha^{-1}, respectively. Long term use of PME increased the exchangeable cation contents of soil, particularly the beneficial cations (Ca, Mg and K). exchangeable Ca increased to 0.69, 0.82, 0.99 and 1.36 cmol (p+) kg^{-1} due to the application of distillery effluent @ 1.25, 2.50, 3.75 and 5.0 lakh l ha^{-1}, respectively, over control.

Table 126 : Yield and yield increment under different irrigation method and quality of water

Method	Best available water		Diluted spent wash water	
	Yield (kg ha^{-1})	% increase	Yield (kg ha^{-1})	% increase
Ber				
Check basin	8.08	-	10.04	-
Embedded pipe	13.76	70.27	18.56	84.78
Drip	10.69	32.43	14.19	41.30
Sapota				
Check basin	1.6	-	2.8	-
Embedded pipe	3.6	125.00	5.2	85.71
Drip	2.8	75.00	4.0	42.86

Table 127 : Effect of PME and fertilizers on physio-chemical properties of post harvest soils

PME Treatments (M)	Fertilizer levels (S)						Mean
	No fert.	N	NP	NK	PK	NPK	
Control	38.6	52.2	68.4	62.6	48.4	76.5	57.8
1.25 lakh L ha^{-1}	65.0	86.8	108	85.1	76.2	106.2	87.9
2.5 lakh L ha^{-1}	76.0	92.6	112.1	93.6	82.3	113.4	95.0
3.75 lakh L ha^{-1}	84.0	102	117.2	101.4	89.0	118.2	102.0
5.0 lakh L ha^{-1}	91.3	106	120.1	108.2	95.2	120.0	106.8
Mean	71.0	87.9	105.2	90.2	78.2	106.9	89.8
CD (p=0.05)	M=6.0	S=9.2	S x M=13.0		M x S=14.5		

Performance of wheat varieties under varying salinity of irrigation water at farmers' field (AICRP Bikaner Centre)

Four varieties of wheat viz., KRL 19, KRL 210, KRL 213 and Raj 3077 were evaluated for their performance under saline irrigation. Three modes of irrigation water application viz., BAW, cyclic irrigation with BAW and saline water and saline water (11.5 dS m^{-1}). A total of six irrigations were given for growing the crops. Results indicated that variety Raj 3077 yielded (2.54 t ha^{-1}) and proved significantly superior to KRL 210 (2.34 t ha^{-1}) and KRL 19 (2.37 t ha^{-1}) except KRL 213 (2.53 t ha^{-1}). The yield of wheat 2.86 q ha^{-1} with the application of saline and BAW alternately (cyclic mode) which was at par with BAW (30.5 q ha^{-1}). This clearly indicated that three irrigations of saline water could easily be used for raising the wheat crop without affecting the yield. However, use of high saline irrigation water alone caused significant reduction of 53.1 and 50 per cent, respectively over BAW and cyclic mode. Combined effect of treatments showed that all the four varieties performed equally in terms of grain yield under cyclic mode of irrigation but there was reduction in yield as compared to BAW in all the four varieties.

Rice–prawn integration in Pokkali (AICRP Vyttila, Kochi Centre)

The rejective of this severs project was to evaluate the rice-fish/prawn integration in Pokkali lands for maximising productivity at farmers' field of Kumbalangi, Ernakulam. The field was drained out followed by rice (Vyttila-6) cultivation and prepared for prawn cultivation. Mahua cake was applied @ 125 kg ha^{-1} in the field for pest and disease control. Fresh water was added and tiger prawn seedlings were released @ 37,500 seedlings/ ha on 5th March 2015. The prawn yield was 0.38 t ha^{-1} harvested in May, 2015. The B:C ratios for rice, prawn and rice-prawn integration system were 1.3, 3.5 and 2.02, respectively (Table 128). (change in the soil properties was noted and after prawn cultivation. The pH increased from 5.72 to 6.92, ECe 2.8 to 8.95 dS m^{-1}, iron from 150.6 to 870.6 ppm and organic carbon content from 1.89 to 2.12% after prawn cultivation.

Table 128: B:C Ratio of Rice-Prawn integration

Crop	Cost of Cultivation (Rs)	Returns (Rs)	B:C Ratio
Rice	37,700	50,000	1.32
Prawn	17,200	60,750	3.53
Rice -Prawn integration	54,900	1,10,750	2.02

Resource mapping and spatio-temporal monitoring (AICRP Port Blair Centre)

The quality of ground water throughout Car Nicobar Islands (Table 129) is neutral to alkaline in with pH ranging from 7.5–8.5. It is generally of calcium bicarbonate type, with bicarbonate content varying from 81 to 207 ppm with the mean value of 127.3 ppm. It greatly predominates over the chloride content varying between 46-218 ppm. The distribution of EC indicated that the water quality is well within the permissible limit with the mean EC of only 0.9 dS m^{-1}. Similarly, the SAR was also found to be low(< 1.5). There is no RSC found in any part of the island. Based on the EC, SAR and

Table 129 : Salient features of ground water samples collected during post monsoon period (Dec-2014) in Car Nicobar

Village Name	pH	EC (dS m^{-1})	HCO_3^- (mg L^{-1})	Cl^- (mg L^{-1})	Cl^-/HCO_3^-
Arong	8.20	1.08	121	109	0.90
Big Lapathy	8.10	0.69	89	85	0.96
Chuckchuca	8.30	0.73	88	96	1.09
Kakana	8.20	0.37	85	51	0.60
Kimious	8.10	1.52	206	218	1.06
Kimious (old)	8.40	1.42	180	202	1.12
Kimois_coastal	8.45	1.45	180	205	1.14
Kinmai	8.00	1.10	142	57	0.40
Kinyuka	8.20	0.70	96	90	0.94
Mallacca	7.80	0.34	142	82	0.58
Mus	8.40	0.79	92	112	1.22
Perka	7.90	0.80	83	78	0.94
Sawai	8.30	1.70	207	150	0.72
Small Lapathy	8.10	0.61	94	46	0.49
Tamaloo	8.10	1.10	171	143	0.84
Tapoiming	8.40	0.61	81	88	1.09
Tee-Top	8.30	1.30	150	140	0.93
Waste land (west)	7.80	0.56	142	82	0.58
Waste land (south)	8.10	0.61	81	88	1.09
Forest	7.45	0.60	115	95	0.83
Mean	8.1	0.9	127.3	110.9	0.9
SD	(0.2)	(0.4)	(43.4)	(50.3)	(0.2)

RSC values the quality of ground water is found to be good during the post monsoon season. This was mainly due to the dilution effect of high amount of monsoonal rainfall (2500 mm) received in this island. In addition, the quality of ground water has to be monitored during the dry season as well to determine the level of sea water intrusion into the coastal ground water resources.

TECHNOLOGY ASSESSED AND TRANSFERRED

Sub-surface drainage technology:

Haryana Operational Pilot Project: Subsurface drainage (SSD) is a proven technology developed by the Institute to rehabilitate waterlogged saline lands in different parts of the country. In Haryana state alone, SSD has been implemented in about 6700 ha in the past 10 years. In Haryana, 3 fleets of laser controlled trenchers and bucket excavators/backhoes type machines are used to install SSD in about 1,000 ha area per year. At current price levels, the cost of installation of SSD in Haryana is Rs. 70,000 ha^{-1} covering almost equally on drainage material and installation process. CSSRI provides technical guidance to the implementing agency, i.e, Haryana Operational Pilot Project (HOPP) in selection of new SSD project sites, appropriate revision(s) in the proposed interventions, layout of SSD at new sites; and monitoring and impact evaluation of the completed projects.

During June 2014 to December 2015, CSSRI team undertook visits to 23 new sites covering 5,650 ha area in 7 districts identified by HOPP for installation of SSD projects in future. Based on the extent and severity of the problem, CSSRI- HOPP team has recommended installation of SSD in 3,800 ha waterlogged saline area in 5 districts including 300 ha in Sirsa, 200 ha in Sonipat, 1,200 ha in Jhajjar, 600 ha in Fatehabad and 1,500 ha in Rohtak. All sites were characterized by shallow groundwater table (< 2 m) and marginal to highly saline soil and groundwater. During 2015- 2016, CSSRI approved designs (drain spacing, depth, slope and size of lateral and collectors) and layout plans, submitted by HOPP for 1,331 ha area in Banwasa, Kohla, Kathura and Katwada villages of Sonipat district after field investigations.

During 2015- 2016, the impact of SSD systems was evaluated for Siwana Mal (Jind), Mokhra Kheri (Rohtak) and Garhwal (Sonipat) project sites. At Mokhra Kheri site, pumping in 4 blocks resulted in marked improvements in soil quality as evident from notable reductions in soil and groundwater salinity (Fig. 84). Similarly, tangible improvements have been recorded in 38 ha area of block B4 at Siwanamal site. Laboratory analysis of soil samples and field salinity survey using EM38 probe indicated that areas having more than 8 dS m^{-1} salinity in 0- 60 cm reduced from 58.8% (in pre-installation phase; May 2012) to 35.3% (in post-installation phase; May 2015). Despite timely and appropriate installation of subsurface drains, inadequate pumping and poor upkeep of pumping houses are hampering the smooth progress at many sites.

Impact of SSD technology in canal command areas of Karnataka: An impact assessment study in Ugar Budruk village of Athani Taluk, Belgaum, Karnataka indicated the potential of SSD technology in restoring the productivity of waterlogged saline lands. Technical guidance provided by the Institute helped reclaim about 925 ha of waterlogged saline lands in the village benefitting over 600 farmers (Table 130). A strong majority of the beneficiaries (82.3%) were small and marginal farmers constituting about 57% of the total reclaimed area. The average land reclamation cost was estimated at Rs. 52000 per ha. Funds for the reclamation were provided by the

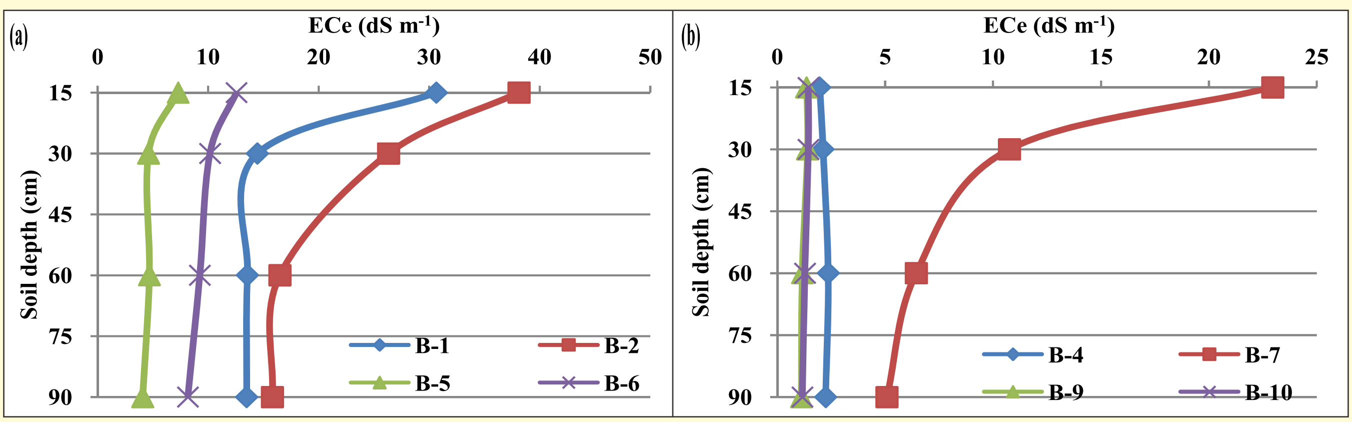


Fig. 84: Soil salinity profiles in non- pumping (a) and pumping (b) blocks of Mokhrakheri site.

Table 130 : Salient Features of SSD Project in Ugar BK

Parameters	Description
Area under subsurface drainage (ha)	925
Total Farmers/beneficiaries covered (No.)	644
Type of drainage system	Pipe drainage with natural outlet
Size (mm)-diameter	80
Depth (m)	1 to 2 (Perforated PVC pipes)
Spacing (m)	30
Total No. of Outlets/Blocks (Closed drains)	22 (3)
Total No. of Manholes	35
Years of installation	2009-10 to 2012-13
Total cost of SSD Project (Rs. in Lakhs)	499.51
Approximate cost of installation (Rs ha^{-1})	52000
Project Life (in years)	50

Department of Land Resources, Govt. of India (60%), Department of Watershed Development, Govt. of Karnataka (20%) and farmers' contribution (20%).

There was appreciable reduction in soil salinity (mean EC_e~2.5 dS m^{-1}) and pH (mean pH ~8.5) in the ameliorated lands. Before SSD installation, the affected lands were priced at Rs. 1.6 lakh per acre which increased to Rs. 8.6 lakh per acre in the post-reclamation phase. Land value considerably increased even in the most severely affected lands with per acre land prices showing a quantum jump (about 6-fold) in the post-reclamation period. Marked increase in land value was attributed to the tangible improvements in soil quality. Sugarcane is the major crop of the Ugar Budruk SSD project area, which occupies more than 90 percent of the cultivated area followed by oilseeds (5.7%), fruits and vegetables (1.2%), cereals and pulses (0.5%). The yield of major crops increased by up to 300%. The cane yield in planted and ratoon sugarcane crops, for example, increased to 119 t ha^{-1} and 82 t ha^{-1}, respectively in the post-SSD phase as compared to 42 t ha^{-1} and 26 t ha^{-1} respectively, in the pre-SSD phase.

CSR-BIO Technology- A Success Story: The CSR-Bio technology based on microbial consortium (Bacillus pumilus, Bacillus thurigensis and Trichoderma harzianum) in a dynamic media has been patented and commercialized. Apart from three firms which have been given the license for producing CSR-Bio, it is also being produced at ICAR-CSSRI Regional Research Station, Lucknow. The technology has till date covered about 10,800 ha area in 7 states of the country. The technology has been adopted by over 18,000 banana and flower growers of Tamil Nadu, Karnataka and Andhra Pradesh. In Uttar Pradesh, Uttrakhand, Bihar, and Madhya Pradesh states, it has become very popular among potato, vegetable and gladiolus growers (Table 131). Besides significant increase in crop yields (~20%), CSR-Bio use has been instrumental in decreasing the pesticide and fungicide usage by 3000 l, thereby lessening the production costs and minimizing the adverse impacts on environment and human health. Based on field evaluation results, the technology is also being promoted by many research institutes like ICAR-National Bureau of Agriculturally Important Micro-oganisms, Mau and YSR Agricultural University, Andhra Pradesh. The bio-formulation has been found to control major diseases like wilt in ixora, banana, tomato, chilli and coriander.

Land modification based integrated farming systems in waterlogged sodic soils: Considering the fact that land shaping improves soil drainage, keeps water table below a critical depth and alleviates salt stress, a study was conducted in Lalaikheda, Patwakheda and Salempur Achaka villages of Lucknow district located in Sharda Sahayak canal command. Initial soil pH of the selected sites in Lalaikheda, Patwakheda and Salempur Achaka villages ranged from 8.96 to 9.69, 9.47 to 9.93 and 7.49 to 7.98, respectively. After demarcation of field boundaries, three integrated farming system models were constructed in the month of June 2015. The pond area was 2356 m^2, 817 m^2 and 1225 m^2 and raised bed area was 2336 m^2, 1307 m^2 and 2041 m^2 at

Table 131 : Impact of CSR-BIO on the production of commercial horticultural crops.

Firm	Quantity produced (2012-14)	Area covered (ha)	% yield increase	Crops	Disease controlled
CSSRI RRS, Lucknow	22 tonnes (solid) 3000 L (liquid)	1200	15	Paddy, wheat, potato, banana, tomato, capsicum, okra, gladiolus, mango and guava (both salt affected and normal soils)	Tomato and banana wilt, potato blight, paddy smut
M/S Krishicare Bioinputs, Tamil Nadu	140 tonnes (solid) 1200 L (liquid)	2200	24	Ixora, banana, jasmine and Green house tomato	Ixora wilt, potato blight
M/S Alwin Industries, Madhya Pradesh	164 tonnes (solid) 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	Potato blight

Lalaikheda, Patwakheda and Salempur Achaka sites, respectively. The total area of integrated farming system models was 4692 m^2, 2114 m^2 and 3266 m^2, respectively. Farmers planted vegetables such as bottle gourd, pumpkin, sponge gourd and okra on pond embankment. Rice (CSR 43) was transplanted on raised beds. Fish fingerlings were also stocked in Patwarekheda and Salempur Achaka villages. In Salempur Achaka village, poultry production was also integrated with fish. Crop productivity of rice and vegetables from Lalaikheda and Patwakheda sites significantly increased leading to gross returns of Rs. 14840.00 and Rs. 6345.00 in Lalaikheda and Patwarekheda, respectively.

Impact of salt tolerant varieties in terms of production and revenue generation: During the year 2015-16, about 17.7 t Basmati rice, 7.1 t Non-basmati rice, 26 t wheat and 0.7 t Indian mustard Breeder and TL seeds of salt tolerant varieties were produced and distributed to various seed multiplication agencies, farmers and other stakeholders. The estimated area coverage was 0.66 million ha with salt tolerant basmati rice occupying the highest area (0.36 m ha) followed by the non-basmati rice (0.28 m ha), wheat (0.02 m ha) and mustard (0.09 m ha). The value of additional production obtained due to adoption of ICAR-CSSRI salt tolerant varieties of rice, wheat and mustard during 2015-16 would be 1.61 million tonnes giving estimated revenue of Rs. 2302 Crores at the national level (Table 132).

Sustainable use of alkali waters at farmers' field: A field experiment was initiated at farmers' fields to showcase the efficacy of improved management practices for sustaining the use of alkali water in rice-wheat cropping system. The experimental sites are located in village Mundri, District Kaithal,

A barren waterlogged sodic land (a) and rice crop on pond embankments (b).

Table 132. Estimated impact of the salt tolerant varieties of rice, wheat and mustard-during the year 2015-16

Crop/Variety	Multiplication Ratio	Production year	DAC Indent of Breeder Seed (q)	Certified Seed (q)#	Seed already sold (q) as certified/ TL seed	Total Seed (q) [E+F]	Estimated area coverage (ha) $	Estimated Produce (t) [Based on average productivity of crops in tones] @	MSPs (Rs./q)**	Estimated Value of Produce (Crore Rs.)
A	B	C	D	E	F	G	H	I	J	K
Rice										
Basmati CSR 30	**1:80**	2015	17	108800	160	108960	359568	719136	1450	1042.7
Non-basmati (CSR 10, CSR 13, CSR 23, CSR 27, CSR 36, CSR 43)		2015	13	83200	58	83258	274751.4	824254.2	1400	1154.0
Wheat										
KRL 19, KRL 1-4, KRL 210, KRL 213	**1:20**	2015	60.4	18120	203.2	18323.2	18323.2	54969.6	1450	79.7
Mustard										
CS 52, CS 54, CS 56	**1:100**	2014-15	0.05	500	6.5	506.5	8458.55	8458.6	3100	26.2
Total			90.45	210620	427.7	**211047.7**	**661101.15**	1606818		2302.6

**http://cacp.dacnet.nic.in/ViewContents.aspx?Input=1&PageId=36&KeyId=0
#Multiplication of seed from breeder to foundation and foundation to certified seed
$Total seed (q) is multiplied with factor (area covered by one quintal seed); Rice=3.3, Wheat=1, Mustard=16.7
@ Average productivity of Rice= 2 t ha^{-1}, Wheat= 3 t ha^{-1}, Mustard= 1 t ha^{-1}

Haryana. They are characterized by high RSC in tubewell water (RSCiw 5-7 meq l^{-1}). Two varieties of rice (Basmati CSR 30 /Pusa 1121) were grown with four sodic water neutralization treatments viz., RSC water (T_1); T_1 + gypsum @ 7.5 t ha^{-1} (T_2); T_1 + Pressmud @ 10 t ha^{-1}(T_3); T_1 + gypsum @ 3.75 t ha^{-1} + pressmud @ 5 t ha^{-1} (T_4). Crop management practices were adopted as per the standard recommendations.

Regardless of the dose and source of neutralization treatment, rice variety Pusa 1121 recorded ~10.7% yield superiority over the Basmati CSR 30. However, as RSCiw increased from 5.0 meq l^{-1} to 7.0 meq l^{-1}, CSR 30 performed relatively better than Pusa 1211 owing to lesser pollen sterility, better relative water content and lower Na^+/K^+ ratio in shoots and roots. Neutralization of RSC of applied irrigation water through different amendments (gypsum/pressmud) either individually or in combination recorded 16.8-23.7 higher rice yield as compared to crop irrigated with available RSC waters (Table 133).

Distribution of Soil Health Cards: Consistent with Prime Minister's call for balanced fertilizer use and sustainable soil health, ICAR-CSSRI, Karnal and its regional stations at Lucknow, Canning Town and Bharuch have made sincere efforts to provide soil health cards to the farmers. It is one of the major activities under '*Mera Gaon Mera Gaurav*' (MGMG) programme initiated by the Indian Council of Agricultural Research, New Delhi where soil samples are collected from the farmers' fields, analyzed in laboratory for different parameters and summarized in the form of Soil Health Cards. In 2015, a total of 346 soil samples collected from farmers' fields representing 78 villages from five states, namely, Haryana, Punjab, Uttar Pradesh, Gujarat and West Bengal. These samples were analysed to diagnose the soil related constraints to bring out the same in the form of soil health cards which were subsequently distributed among the farmers.

Impact of alkali soil reclamation technology in Uttar Pradesh: A recent study showed that state of Uttar Pradesh has reclaimed 712216 ha of alkali soils up to 2013-14 through gypsum-based technology developed by ICAR-CSSRI (Table 134). The severely affected lands constituted the highest (65%) proportion of reclaimed lands followed by the moderately affected (25%) and slightly affected lands (10%). Horticultural lands constituted 0.2% of the total reclaimed land. The highest additional paddy production was obtained from severely affected lands (3.9 t ha^{-1}) followed by moderately affected (3.18 t ha^{-1}) and slightly affected lands (1.76 t ha^{-1}). The reclaimed lands produced 2.45 million tonnes of additional paddy per annum. In monetary terms, it generated revenue of Rs. 33048 million. Furthermore, additional paddy production ensured food security of about 31.29 million people. The highest additional wheat production was obtained from moderately affected lands (3.17 t ha^{-1}) followed by severely affected (2.75 t ha^{-1}) and slightly affected lands (0.67 t ha^{-1}). The reclaimed lands produced 1.84 million tonnes of additional wheat per annum. The additional production of wheat provided food security to 20.43 million people. The severely affected lands contributed highest additional foodgrain production of 56% to the total foodgrain production followed by moderately affected lands (21%) and slightly affected lands (3%). The

Table 133: Interactive effect of RSC_{iw} neutralization treatments and genotypes on the rice yield at two locations during *kharif* 2015

Treatment	Yield (t ha^{-1}) Site I (RSC≈ 7.0)			Yield (t ha^{-1}) Site II (RSC≈ 5.0)			Overall Mean (t ha^{-1})
	CSR 30 Basmati	Pusa 1121	Mean	CSR 30 Basmati	Pusa 1121	Mean	
RSC water (Control)	2.33	2.59	2.46	2.73	3.14	2.93	2.69
Gyp @ 7.5 t ha^{-1}	2.80	3.04	2.92	3.18	3.58	3.37	3.15
PM @ 10 t ha^{-1}	2.97	3.11	3.04	3.38	3.74	3.56	3.29
Gyp @ 3.75 t ha^{-1} + PM @ 5 t ha^{-1}	2.98	3.21	3.09	3.33	3.82	3.58	3.34
Mean (t ha^{-1})	2.77	2.99		3.15	3.57		

Distribution of Soil Health Cards among the farmers on Soil Health Day

reclaimed alkali lands produced 4.30 million tonnes of additional foodgrains per annum and are contributing around 2% to the India's total foodgrain production.

Front line demonstrations (Randhir Singh, Parvender Sheoran, Ranjay K. Singh, K. Thimmappa and R Raju)

FLDs on rice : The frontline demonstrations of CSSRI rice varieties were conducted at 37 farmers' fields at Jind, Karnal and Kaithal districts under saline soil, sodic soil and RSC water conditions. In Jind district, the selected sites represented saline soils with soil EC2 ranging from 0.52-1.89 dS m^{-1} whereas sodic soils were predominate in Karnal district. There was a problem of sodic soils with high RSC water in Kaithal district (Table 135). The yield potential of CSR 30 was relatively higher in Karnal district as compared to Jind and Kaithal districts. Rice yield ranged from 1.15 to 3.8 t ha^{-1} a with average of 2.93 t ha^{-1} in the demonstration fields.

FLDs on rice : Rice transplanting is generally done by hired labourers without any due consideration to optimum plant population. It was observed that plant population generally remains 60-65% of the actual required for getting optimum grain yield. Such a low plant population could be problematic in salt affected soils where seedling mortality rate is relatively higher compared to normal conditions. Keeping this in view, 7 field demonstrations were done at farmers' fields in village Mundri (Kaithal) where soils are sodic in nature and water is of poor quality with high RSC content. Yield advantage ranging from 8.5 to 25.2% with a mean value of 15.6% was recorded in the demonstrated plots with spacing 20 x 15 cm against the farmers' practice of transplanted rice with hired labourer. The plant population was recorded at the harvest and it was found that plant population remained 81.6% in the demonstration plots against 55.4% under the farmer's practice .

Table 134. Impacts of gypsum-based sodic land reclamation in Uttar Pradesh

Particulars	Slightly affected	Moderately affected	Severely affected	Total
Total land reclaimed (ha)	71222	178054	462941	712216
Reclaimed land category (%)	10	25	65	100
Crop land (ha)	69823	174557	453848	698228
Horticultural land (ha)	1399	3497	9092	13988
Additional paddy production (t ha^{-1})	1.76	3.18	3.90	-
Additional rice production (t ha^{-1})	1.14	2.07	2.54	-
Total additional paddy production (MT)	0.12	0.56	1.77	2.45
Additional economic value-paddy (Rs million)	1659	7494	23895	33048
Food security-rice (million persons)	1.57	7.09	22.62	31.29
Additional wheat production (t ha^{-1})	0.67	3.17	2.75	-
Total additional wheat production (MT)	0.05	0.55	1.25	1.84
Additional economic value -wheat (Rs million)	632	7470	16849	24951
Food security - wheat (million persons)	0.52	6.12	13.79	20.43
Total additional food grain contribution (MT)	0.13	0.91	2.40	4.30
Total food grain contribution (%)	3	21	56	100

FLDs on wheat: Twenty five demonstrations were conducted on salt tolerant wheat variety KRL 210 in Kaithal and Jind districts covering 4 villages. In Jind, the average soil pH and EC in the demonstration plots was 8.37 and 2.24 dS m^{-1}, respectively. In Kaithal, soil pH ranged from 7.38 to 9.19, EC from 0.24 to 0.90 dS m^{-1} and water RSC ranged from 2.8 to 7.0 me l^{-1}. A total of 15 FLDs were conducted in Siwana Maal village of Jind district revealed that wheat variety KRL 210 was superior (10.6%) with yield ranging from 0.9 to 5.0 t ha^{-1} (mean 3.02 t ha^{-1}) in comparison to 0.8 to 4.3 t ha^{-1} (mean 27.3 t ha^{-1}) with HD 2967. Similarly, an overall yield advantage of 7.1% was recorded with KRL 210 in 10 FLDs conducted in Kaithal distrtict Table 136.

Intellectual Property Management and Transfer/Commercialization of Agricultural Technology renamed as National Agriculture Innovation Foundation (D.K. Sharma, Parveen Kumar, D.S. Bundela, Ranjay K. Singh, Jogendra Singh and Anshuman Singh)

The intellectual property right (IPR) regime provides rights to the innovators for their novel technology and facilitates transfer of IPR enabled technologies for commercialization through commercial, cooperative and public routes. IPR are major concerns in Indian agriculture which provides an avenue for royalties or other fees to the inventor for the use of the technology. The objectives of the project 'Intellectual property management and transfer/commercialization of agricultural technology' renamed as “National Agriculture Innovation Foundation” 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 institute and to generate income/resources through commercialization of IP.

ICAR-Central Soil Salinity Research Institute, Karnal has developed and commercialized a total of 38 technologies such as gypsum based reclamation of sodic soil, subsurface drainage technology for waterlogged saline soils, auger-hole technology for afforestation of salt-affected soils, groundwater recharge technology and management of poor quality water etc. Salt tolerant varieties of rice (CSR 43, CSR 36, Basmati-CSR 30, CSR 27, CSR 23 CSR 13 and CSR 10); wheat (KRL 213, KRL 210 and KRL 19); mustard (CS 56 CS 54 and CS 52) and Chick Pea (Karnal Chana 1) have also been developed and commercialized to have better productivity in salty environment. All these varieties and some promising genotypes of different crops have also been registered under the protection of Plant Varieties and Farmers Rights (PPV&FR) Act, 2001. These salt tolerant varieties are being cultivated in about 16,22,004 ha area and

Table 135: Soil and water quality and the yield potential of CSR 30 Basmati at different location in frontline demonstrations during kharif 2015

District	Village	No. of FLDs	Average yield (t ha^{-1})	Soil		Water		
				EC_2	pH_2	EC	pH	RSC
Jind	Siwana Maal	10	2.82	0.52-1.89	7.82-8.78	0.42-4.79	7.01-8.53	Nil
Karnal	Sambhli	1	3.75	-	-	-	-	-
	Kheri Sikander	1	3.25	-	-	-	-	-
Kaithal	Mundri	17	2.81	0.24-1.35	7.38-9.19	0.46-2.34	7.34-8.66	3.4-7.0
	Sampli Kheri	3	3.00	0.44-0.52	8.56-9.02	0.96-1.64	7.42-7.70	2.8-5.4
	Geong	5	3.50	0.33-0.90	8.54-8.80	0.53-1.62	8.00-8.65	3.6-6.2
Total/Mean		37	2 93					

Table 136: Comparative performance of wheat variety KRL 210 and HD 2967 in frontline demonstrations during Rabi 2014-15

District	Village	No. of FLDs	Average yield (t ha^{-1})	
			KRL 210	HD 2967
Jind	Siwana Maal	15	3.02	2.73
Kaithal	Mundri	6	3.91	3.57
	Geong	2	4.35	4.00
	Kathwar	2	3.90	3.80
Total/Mean		25	3.42	3.13

Front Line Demonstrations in rice

are significantly contributing to the national food basket. In the year 2014-15, total breeder seed production of the salt tolerant varieties was about 89 quintals. The revenue generation of Institute from IP protected technologies in year 2014-15 was Rs. 85.5 lakh.

A patent has been filed for CSR-BIO, recently developed as growth enhancer and nutrient mobilizer for agri-horti crops in normal and sodic soils. For the commercialization of CSR-BIO, public-private partnerships have been made through memorandum of understandings with M/s Krishicare Bioinput, Tiruchirapalli (TN); M/s Jay visions Agri-Tech, Ghaziabad, (U.P.) and M/s Alwin Industries, Bhopal, (M.P.). Seven salt tolerant bacterial isolates [*Bacillus aerophilus* (STB-1), *Bacillus aerophilus* (10STB-7B), *Bacillus lichenoformis* (STB-80), *Bacillus lichenoformis* (10STB3C/1), *Bacillus sonorensis* (15STB2C), *Bacillus stratosphericus* (15STB5C), *Bacillus lichenoformis* (STB133)] have been identified for the higher plant growth promoting activities and four of them with better potential have been deposited in ICAR-National Bureau of Agriculturally Important Microorganisms, Mau. A patent for Backpressure Measuring Equipment has been filed for use in subsurface drip irrigation system with poor quality water. A copyright for GypCal: a desktop based software application has been filed which provides straight forward decision support for reclamation of sodic soil following standard protocols and optimize crop yields in Indo-Gangetic plains of North India.

The technologies developed and commercialized have an important role in enhancing the production of salt affected soils and waters which contributes more than 16 million tones food grains in national food basket and reclaimed about 2.0 m ha area of sodic soils. 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 livelihood of thousands of poor farmers in different parts of the country.

Miscellanceous

केन्द्रीय मृदा लवणता अनुसंधान संस्थान

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TRAININGS IN INDIA AND ABROAD

Sr. No.	Name and Designation	Subject	Duration	Place
1.	Sh.Suresh Pal Rana, Asstt.	Training on pension and other retirement benefits	06.04.2015-09.04.2015	ISTM, New Delhi
2.	Dr. S. K. Sarangi, Sr. Scientist	ORYZA Training for Beginners	13.04.2015-17.04.2015	IRRI, Philippines
3.	Dr. R. Raju Scientist	Approaches for integrated analysis of agricultural systems in South Asia: field, to farm, to landscape scale	18.05.2015-23.05.2015.	CSSRI, Karnal
4	Sh. Dharam Pal Kansia Sr. Technical Asstt.	Agricultural Library in India: Policies Issues and challenges	17.06.2015-19.06.2015	IVRI, Barelly
5.	Dr. Vinayak Ramesh Nikam, Scientist Dr. R. Raju, Scientist	Summer school on Analytical Techniques for Decision Making in Agriculture	16.06.2015-05.07.2015	ICAR-NIAP New Delhi
6.	Sh. Randhir Singh, JAO Sh. Raj Kumar, Asstt. Sh. Ram Murat Rai, Asstt.	Training for running pay slip and asset management under FMS/MIS	22.06.2015-24.06.2015	IASRI, New Delhi
7.	Dr. D. Pal, ACTO Sh. Hari Mohan Verma, Sr. Technical Asstt.	Comptence enhancement training programme	19.08.2015-28.08.2015	NAARAM Hyderabad
8.	Dr. S. K. Sarangi, Sr. Scientist Dr. Monika Shukla, Scientist	Conservation Agriculture (CA): Developing Resilient Systems	02.09.2015-11.09.2015	CSSRI, Karnal
9.	Dr. Anita Mann Sr. Scientist	Training on high throughput omics data for mining of important genes/traits linked to agricultural productivity.	09.09.2015-12.09.2015	GBPUA&T, Pantnagar
10.	Sh. M.P. Bhatia, TO Sh. Randhir Singh, JAO	Training MIS/FMS	12.10.2015-14.10.2015	IASRI, New Delhi
11.	Dr. Gajender, Scientist, Dr. Nirmalendu Basak, Scientist	International training on crop production under saline stress	02.11.2015-26.11.2015	Israel
12.	Dr. Anshuman Singh, Scientist	Novel genomic tools and modern genetics and breeding apporoaches for vegetable crops improvement	07.11.2015-27.11.2015	IIVR Varanasi
13.	Dr. Anil R. Chinchmalatpure Head, RRS, Bharuach	Management Development Programme on Leadership Development (A pre-RMP programme)	30.11.2015-11.12.2015	ICAR-NAARM, Hyderabad
14.	Sh. A.K. Mishra, AAO	Training on communication skills	05.01.2016-06.01.2016	ISTM, New Delhi
15.	Dr. S.L. Krishnamurthy Scientist,	Attended National training on "Innovative techniques on varietal purity testing",	19.01.2016 23.01.2016	UAS, Bangalore
16.	Dr. David Camus Scientist	Exploitation of Underutilized Horticulture Crops for Sustainable production	11.02.2016-20.02.2015	ICAR-CIAH, Godhra
17.	Dr. Thimmappa K Scientist	Quantitative Techniques for Agricultural Policy Research	18.02.2016-09.03.2016	IARI, New Delhi
18.	Dr. Parvender Sheoran, Scientist	Agricultural Research Management	23-02-2016 05.02.2016	NAARM, Hyderabad
19.	Sh. Akshay Kumar Technical Officer	Competency Enchancement programme for Technical Officer of ICAR Institutes	01.03.2016 10.03.2016	NAARM, Hyderabad

DEPUTATION OF SCIENTISTS ABROAD

Sr. No	Name and designation	Subject	Period of deputation	Country
1.	Dr. S.K. Kamra, Principal Scientist	International conference and workshop on ecology, environment and energy	20.04.2015 - 22.04.2015	Taiwan
2.	Dr. A.K. Bhardwaj, Sr. Scientist	TWAS -UNESCO Associateship	01.05.2015 - 30.06.2015	Argentina
3.	Dr. Ranjay K. Singh, Sr. Scientist	Community knowledge led climate change adaptations (Endeavour Fellowship)	01.05.02015 - 30.09.2015	Australia
4	Dr. D.K. Sharma, Director	Australia -India Council Grant	08.02.2016 - 21.02.2016	Australia
5.	Dr. Randhir Singh, Head, TET	International Conference on "Global Warming and Biodiversity Conservation"	09.02.2016 - 12.02.2016	Dubai, UAE.
6	Dr. D.S. Bundela, Head, DIDE	Australia -India Council Grant	12.02.2016 - 21.02.2016	Australia

AWARDS AND RECOGNITIONS

- Dr. R.K. Singh received Endeavour Fellowship to work on "Community knowledge led climate change adaptations" at CDU, Australia from 1st May to 30th Sept. 2015.
- Dr. A. K. Bhardwaj received the UNESCO-Associateship in 'Chemistry' for collaborative research at Research Institute of Theoretical & Applied Physical Chemistry, La Plata, Argentina from 2015-17.
- Dr. Gajender Yadav and Dr. N. Basak received the MASHAV- Israel Fellowship on "Crop production under saline stress" at The Hebrew University of Jerusalem's Robert H. Smith Faculty of Agriculture, Food & Environment, Israel
- Dr. Randhir Singh, CTO, bestowed with the ICAR Cash Award-2014 for Technical Employee on occasion of ICAR foundation day held at Patna on 25th July, 2015
- Dr. T. Damodran received Excellence of Research Award-2016 by Samagra Vikas Welfare Society for outstanding research in organic horticulture.
- Dr Randhir Singh conferred Best Paper Award in the International Conference on "Global Warming and Biodiversity Conservation" (ICGB-2015) held during 09-11 February, 2016 at Hotel Fortune Grand, Dubai, UAE.
- Dr. Sanjay Arora got the Best Poster Award during International Conference on Natural Resource Management for Food Security and Rural Livelihoods, SCSI, NASC, New Delhi.
- Dr. Sanjay Arora got the Best Poster Award in XII Agricultural Science Congress held at NDRI, Karnal
- Dr. Randhir Singh was conferred "Outstanding Achievement in Agriculture Award 2015" by Society for Recent Development in Agriculture, Meerut.
- Dr. Jogendra Singh has been Awarded "Fellow" by Association for the Advancement of Biodiversity Sciences
- Dr. A.K. Bhardwaj bestowed with the Best Poster Award in 25th National Conference on "Natural Resource Management in Arid and Semi arid Ecosystems for Climate Resilient Agriculture and Rural Development held from February, 17-19 2016 at SKRAU, Bikaner.
- The following Scientists, Technical, Administrative and Skilled supporting staff have been awarded the CSSRI Excellence/Best Worker Awards:

❖ ICAR-CSSRI Excellence Award for Scientist for the Year, 2014

- Dr. S.K. Dubey, Head, RRS, ICAR-IIS & WC, Chhalesar, Agra
- Dr. S.K. Kamra, Principal Scientist, DIDE, ICAR-CSSRI, Karnal

❖ ICAR-CSSRI Excellence Award for Scientist for the Year, 2015

- Dr. P.C. Sharma, Head Crop Improvement, Division, ICAR-CSSRI, Karnal
- Dr. V.K. Mishra, Head ICAR-CSSRI, RRS, Lucknow

❖ ICAR-CSSRI best worker awards for Technical, Administrative and Skilled Supporting Staff.

- Sh. H.S. Tomar, ACTO
- Sh. Raj Pal, TA
- Smt. Jasbir Kaur, Assistant
- Sh. Satya Narain Sharma, Assistant
- Sh. Rajkumar, SSS
- Sh. Desh Raj, 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 and IRRI, Philippines)

National Collaborations

- Transgenics in crops-salinity tolerance in rice: functional genomics component (Funded by ICAR, New Delhi)
- Monitoring and evaluation of large-scale subsurface drainage projects in the state of Haryana (Funded by Haryana Operational Pilot Project, Department of Agriculture, 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, New Delhi)
- Intellectual property management and transfer/commercialization of agricultural technology system (Funded by ICAR, New Delhi)
- Network project on improvement of salt tolerance in wheat using molecular approach (IIWBR-CSSRI, Karnal).
- Inter-institutional collaborative project on evaluation of salinity tolerance of coriander, Fennel and Fenugreek Seed Spices (Funded by NRCSS, Rajasthan).

Collaborative Programmes at Regional Research Station, Canning Town

International Collaborations

- IRRI International collaborative programme on testing rice germplasm for coastal salinity (IRSSTN).
- CSIRO and Murdoch University, Australia – Cropping system intensification in the salt affected coastal zones of Bangladesh and West Bengal, India.
- Bangladesh Agricultural Research Institute, Bangladesh Rice Research Institute, Khulna University – Cropping system intensification in the salt affected coastal zones of Bangladesh and West Bengal, India.

National Collaborations

- Coastal salinity tolerant varietal trial (CSTVT) and national salinity and alkalinity screening nursery (NSASN) with IIRR, 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 and BCKV, West Bengal.
- Coastal salinity tolerant variety trial (CSTVT) with IIRS, Hyderabad.
- ICAR-Indian Institute of Wheat and Barley Research (IIWBR), Karnal, Haryana.
- Bidhan Chandra Krishi Viswavidyalaya (BCKV), West Bengal
- Tagore Society for Rural Development (TSRD), West Bengal
- ICAR-National Bureau of Soil Survey and Land Use Planning (NBSS&LUP), Kolkata Centre
- ICAR-Central Institute of Freshwater Aquaculture, Rahara, Kolkata
- ICAR-Central Research Institute for Jute and Allied Fibres (CRIJAF), Barrackpore.
- Department of Agriculture, Government of West Bengal.
- Department of Soil Conservation, Government of West Bengal.

Collaborative Programmes at Regional Research Station, Lucknow

International Collaborations

- Future rainfed lowland rice systems in Eastern India (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).
- NRMACSSRISOL201401400872. Bio-remediation of salt affected soils of Uttar Pradesh through Halophilic microbes to promote organic farming (UPCAR funded)
- NRMACSSRISOL201401500873. Land modification based integrated farming system under waterlogged and waterlogged sodic conditions. (UPCAR funded).
- NRMACSSRISOL201401600874. Assessment and refinement of existing irrigation practices of major grown under sodic environment (UPCAR funded).
- NRMACSSRISOL201401700875. Identification of salt tolerant microbes and development of dynamic substrate for cultivation of commercial crops in sodic soils (AMAAS 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; Department of Biotechnology, Maharishi Markandeshwer University, Mullana, Haryana; Deenbandhu Chhotu Ram University of Science & Technology, Murthal, Haryana and NDRI, Karnal, Haryana for Post Graduate teaching and research.
- National Research Centre on Seed Spices, Ajmer, Rajasthan for collaborative research
- Project Director, NCP, IGBP, IIRS, (NRSA), Department of Space, Dehradun, Uttrakhand
- 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.

LIST OF PUBLICATIONS

Journal Paper

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Chaudhari, S.K., Kumar, P., Mishra, A.K., Singh, K., Rai, P., Singh R. and Sharma, D.K. 2015. Labile carbon fractions build-up and dynamics under vertical stratification of Populus ypogeal and Eucalyptus tereticornis based agroforestry systems in Trans-Gangetic plains of India. *Annual Agricultural Research, (New Series)*, 36 : 1-9.

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PARTICIPATION IN CONFERENCE/SEMINAR/ SYMPOSIUM/WORKSHOP

Name	Title	Period
Dr. S. Mandal	International conference on managing critical resources: Food, energy and water organized by Indian Institute of Management Kolkatta, held at IIM Kolkatta	09.04.2015 - 11.04.2015
Dr.Anil R. Chinchmalatpure Dr. G.G. Rao	Seminar on Participatory management promises and problem, Gujarat State Centre, Ahemdabad.	17.04.2015- 18.04.2015
Dr. B. Maji Dr. D. Burman Dr. Y.P.Singh Dr. S. K. Sarangi Dr. S. L. Krishnamurthy	Stress Tolerance Rice for poor farmers of Asia and South Africa - Review and planning workshop at New Delhi	19.04.2015- 22.04.2015
Dr.R.L. Meena Dr.B.L.Meena Dr.Parvender Sheoran	XXIV Biennial Workshop of AICRP on Management of Salt Affected Soils and Use of Saline Water in Agriculture at Agra, Uttar Pradesgh	05.06.2015- 07.06. 2015
Dr. Ranjay K. Singh	Seminar on climate change: As part of the UN's 70th anniversary and leading up to the UN Climate Change Conference in Paris in December, 2015, Australia	10.06. 2015
Dr. Sanjay Arora	3rd Uttar Pradesh Agricultural Science Congress on "Strategic Governance and Technological Advancement for Sustainable Agriculture", SHIATS, Allahabad.	14.06.2015- 16.06.2015
Dr.Thimmappa K	Workshop on Data repository for knowledge management, NASC, New Delhi	04.07.2015 05.08.2015
Dr. P. C. Sharma Dr. Jogindra Singh	Participated in 22nd AICRP on Rapeseed & Mustard Group Meeting held at SIAM, Jaipur	03.08.2015- 05.08.2015
Dr.S.L. Krishnamurthy Scientist	Annual review workshop of National innovations on Climate Resilient Agriculture, CMFRI, Cochin	11.08.2015- 15.08.2015
Dr. Satyender Kumar	4th Annual workshop of NICR, CMFRI, Kochi	13.08.2015- 14.08.2015
Dr. P. C. Sharma Dr. Randhir Singh Dr. Arvind Kumar	Participated in 54th All India Wheat and Barley Research Workers Meet held at SDUAT, Dantiwada, Gujarat.	21.08.2015 - 24.08.2015

Dr. S.L. Krishnamurthy, Scientist	National workshop on "Water logging and Soil Salinity in Irrigated Agriculture, Chandigarh.	03.09.2015-04.09.2015
Dr. V.K. Mishra	Waterlogging and salinity in irrigated agriculture, CIBP, New Delhi.	03.09.2015-04.09.2015
Dr. B. Maji Dr. D. Burman Dr. U. K. Mandal Dr. T. D. Lama	National Seminar on Soil Health Management and Food Security: Role of Soil Science Research and Education, ICAR-NBSS and LUP, Nagpur	08.09.2015-10.09.2015
Dr. Anil R. Chinchmalatpure	One day workshop to develop a clear road map for agricultural development for Gujarat Plains and Hills region at ICAR-DMAPR, Boriabi, Anand	12.09.2015
Dr.Parvender Sheoran	25th Asian Pacific Weed Science Society Conference on "Weed Science for Sustainable, Agriculture, Environment and Biodiversity" PJTSAU, Hyderabad.	13.09.2015-16.09.2015
Dr. Anil R. Chinchmalatpure	State Level Seminar on "Soil and Water Quality: A concern-Salt affected soils at Dr. P.D.K.V., Akola.	02.11.2015-03.11.2015
Dr. Sanjay Arora	International Conference on Water Resource Management in the eastern Himalayan Region", Shillong	04.11.2015-05.11.2015
Dr. Y.P. Singh	Brain Storming Session on the emerging Role of Public Private Partnership in Strengthening of Agriculture/Horticulture for Livelihood Security at UP. Council of	04.11.2015-05.11.2015
Dr. S. Raut	Annual Convention of Indian Society of Soil Science, Bangalore,	05.11.2015-08.11.2015
Dr.Randhir Singh	Climate resilient livestock systems NDRI, Karnal	20.11.2015
	23rd District Level Bal Vigyan Congress on Climate Change Government Senior Secondary Girls School, Prem Nagar, Karnal	20.11.2015
Dr. Ashwani Kumar	XXIIIth International Grassland Congress on Sustainable Livelihood Security for Smallholder Farmers,	20.11.2015-24.11.2015
Dr.S.K. Sanwal Dr.Parvender Sheoran,	Brain Storming Session on "Managing Soil Health" NASC Complex, New Delhi.	23.11.2015

Dr. R. Raju	Conference on Inter- and Intra-Sectoral Dynamics for Transforming Indian Agriculture, CIFE, Mumbai.	02.12.2015-04.12.2015
Dr. Arvind Kumar	Breeding Management System (BMS) training under ICAR- ACIAR Collaborative project at IIWBR, Karnal.	03.12.2015 05.12.2015
Dr. B.L. Meena, Dr. S. Rout, Dr. Sanjay Arora	the 80th Annual Convention of ISSS at Bengaluru.	05.12.2015-08.12.2015
Dr. P.C. Sharma, Dr. S. L. Krishnamurthy Dr. Anita Mann Vineeth T.V.	3rd International Plant Physiology Congress, at JNU, New Delhi.	11.12.2015-14.12.2015
Dr. Sanjay Arora	National Workshop on "Natural Resource Management for Climate Resilient Agriculture in Lower Himalayas", PAU, RRS, Ballowal Saunkhri, Punjab.	22.12.2015-23.12.2015
Dr. B. Maji & other scientists	11th National Symposium of Indian Society of Coastal Agricultural Research (ISCAR) held at ICAR-Indian Institute of Water Management (IIWM), Bhubaneswar, Orissa,	14.01.2016-17.01.2016
Dr. K. K. Mahanta	50th convention of ISAE on symposium on agricultural engineering in nation building: (CAET), Orissa University of Agriculture and Technology, Bhubaneswar, Orissa.	19.01.2016 21.01 .2016
Dr.Randhir Singh	Conference on "Global Warming and Biodiversity Conservation" (ICGB-2015), Dubai, UAE.	09.02.2016-12.02.2016
Dr. Rakesh Banyal	International conference on "Natural Resource Management-Ecological Perspectives SKUAST-Jammu(J&K).	18.02.2016-20.02.2016
Dr. Arvind Kumar	Training on Recording of Data in Coordinated Wheat & Barley Trials and Nurseries at IIWBR, Karnal.	02.03.2016-05.03.2016
Dr. Y.P. Singh	4th U.P. Agricultural Science Congress at CSAUAT, Kanpur, Uttar Pradesh	02.03.2016-04.03.2016

LIST OF ONGOING 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 NRMACSSRISIL20140040086 2. 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, Nirmalendu Basak and M.L. Khurana, Soil Testing Lab. Karnal)

Priority Area - Reclamation and Management of Alkali Soils

3 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, A.K. Rai, D.K. Sharma, Satyender Kumar and Thimmappa K.)

4 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)

5 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 and Bhaskar Narjary)

6 NRMACSSRISIL201300400849. Cation exchange equilibrium and solute transport through different textured salt affected soils. (Nirmalendu Basak, S.K. Chaudhari and D.K. Sharma)

7 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 R.L. Meena)

8 NRMACSSRISIL201301300858. Diversifying agriculture on reclaimed sodic land in farmer's participatory appraisal. (Gajender , A.K. Rai, R.S. Pandey, R Raju, D.K. Sharma and K.S. Kadian).

9 NRMACSSRISIL201400100859. Effect of land uses on salt distribution and properties of salt affected soils. (Nirmalendu Basak, Ashim Datta, Anil R. Chinchmalatpure and Rakesh Banyal)

10 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)

11 NRMACSSRISIL201500100877. Impact assessment of CSR-BIO on livelihood security of farmers in salt affected regions. (Thimmappa K., T. Damodaran and Raju R.)

12 NRMACSSRISIL201501300889. Impact of secondary salinization and other stressors on agricultural systems: constraints analysis in South-Western Punjab. (R.K. Singh, Satyendra Kumar, Anshuman Singh, Nirmalendu Basak, Randhir Singh and D.K. Sharma)

Priority Area - Drainage Investigations and Performance Studies

13 NRMACSSRISIL2014001000868. Impact assessment of subsurface drainage technology in canal command areas of Karnataka. (R. Raju, Thimmappa K., A. L. Pathan).

14 NRMACSSRISIL201501400890. Performance evaluation of subsurface drainage systems in Haryana and to implement interventions for improving operational performance and impact. (D.S. Bundela, Bhaskar Narjary, A. L. Pathan, R. Raju, Parvender Sheoran, R.K Singh, S.K. Kamra and D.K. Sharma)

Priority Area - Management of Marginal Quality Waters

15 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)

16 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)

17 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, Madhu Choudhary and D.K. Sharma)

18 NRMACSSRISIL201500300879. Evaluation of commercial vegetable crops under protected cultivation structures in saline environment (R.L. Meena, B.L. Meena and Anshuman Singh)

19 NRMACSSRISIL201501500891. Assessing use of press mud/press mud compost in gypsum beds for neutralization of RSC in irrigation water. (R.K. Yadav, M.D. Meena, Satyendra Kumar, Parul Sundha, Madhu Choudhary and D. K. Sharma)

20 NRMACSSRISIL201502100897. Isolation, identification and evaluation of plant growth promoting bacteria for mitigating salinity stress in crops. (Madhu Choudhary, P.K. Joshi, Vineeth T.V., Gajender and M.D. Meena)

Priority Area - Crop Improvement for Salinity, Alkalinity and Waterlogging Stresses

21 P1-2011/CIS4.7-ISR-F30/0338. Development of Indian mustard *(Brassica juncea)* genotypes with improved salinity tolerance and higher seed yield. (Jogendra Singh, Vineeth T.V. and P.C. Sharma)

22 NRMACSSRISIL201200100842. Genetic enhancement of wheat with respect to salt and waterlogging tolerance. (Arvind Kumar P.C. Sharma and Y.P. Singh)

23 NRMACSSRISIL201300600851. Physiological and biochemical basis of salinity and drought stresses tolerance in rice and wheat cropping system. (Ashwani Kumar, Krishnamurthy S.L. and Arvind Kumar)

24 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 Datta)

25 NRMACSSRISIL201500800884. Identification of high yielding and salt tolerant genotypes in pomegranate. (Raj Kumar, R.K. Yadav, Anita Mann, M. D. Meena, Anshuman Singh and D.K. Sharma)

26 NRMACSSRISIL201500900885. Genetic enhancement of tomato (*Solanum lycopersicum*) and okra (*Abelmoschus esculentus L*) to salt tolerance. (S.K. Sanwal, P.C. Sharma, Anita Mann, Rajkumar and A.K. Rai)

27 NRMACSSRISIL201501000886. Improvement of salt tolerance in chickpea through physiological and breeding approaches. (Anita Mann, Jogendra Singh and P.C. Sharma)

28 NRMACSSRISIL201501100887. Development of rice genotypes for salt tolerance in rice: Conventional and Molecular approaches. (Krishnamurthy, S.L., P.C. Sharma, Ravi Kiran K.T., Vineeth T.V., Y.P. Singh and S.K. Sarangi)

Priority Area - Agroforestry in Salt Affected Soils

29 NRMACSSRISIL201400800866. Enhancing productivity potential of saline soil through agroforestry system using saline irrigation.(Rakesh Banyal, R. K. Yadav, Bhaskar Narjary, Parvender Sheoran, M. D. Meena and D. K. Sharma)

Priority Area - Reclamation and Management of Coastal Saline Soils

30 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)

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, SK Sarangi, T.D. Lama, B. Maji and S. Mukhopadhyay (NBSSLUP)]

35 NRMACSSRISIL201300800853. Impact of salt tolerant rice varieties of CSSRI on farmers' economy in costal salt affected area. (Subhasis Mandal, S. K. Sarangi, D. Burman, U. K. Mandal and B. Maji)

36 NRMACSSRISIL201401100869. 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)

Priority Area - Reclamation and Management of Salt Affected Vertisols

37 NRMACSSRISIL201200400845. Breeding and evaluation of field crops for salt tolerance in saline Vertisols (Monika Shukla, Anil R. Chinchmalatpure, Nikam Vinayak Ramesh and D.K. Sharma)

38 NRMACSSRISIL201300100846. Soil physical characteristics and nutrient dynamics in Vertisols with subsurface salinity (Anil R. Chinchmalatpure, N. V. Ramesh and David Camus D.)

39 NRMACSSRISIL201400200860. Prospects of cultivating desi cotton genotypes and salt tolerant wheat varieties on saline vertisols (N.V. Ramesh and D.K. Sharma)

40 NRMACSSRISIL201500200878. Performance of guava orchards with forage intercropping and pruning intensity on saline vertisols of Gujarat (David Camus. D., Anil R Chinchmalatpure and N.V. Ramesh)

41 NRMACSSRISIL201501200888. Impact evaluation of sub-surface drainage technology for reclamation of water logged saline soils in Maharashtra. (S. V. Kad, R.K. Singh, R. Raju and D.S. Bundela)

Priority Area - Reclamation and Management of Alkali Soils of Central and Eastern Gangetic Plains

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. Damodaran 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. Damodaran, S.K. Jha, A.K. Singh, Sanjay Arora, S.K. Singh (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 NRMACSSRISIL201500700883. Ground water recharge for remediation of fluoride contaminated water in Unnao district of U.P. (C. L. Verma, S.K. Jha, V.K. Mishra, S.K. Kamra and D.K. Sharma)

EXTERNALLY FUNDED RESEARCH PROJECTS

1. Cereal system initiative for South Asia – Objective 2 component (Phase-II). (Team Leader D.K. Sharma, P.C. Sharma (PI) and Asim Datta) – CIMMYT, Mexico
2. Intellectual property management transfer/commercialization of agricultural technologies. (Parveen Kumar, D.S. Bundela, R.K. Singh, Jogendra Singh and Anshuman Singh) – ICAR, New Delhi.
3. Guidance on identification of problem areas and design and evaluation of subsurface drainage projects in Haryana. [(Team leader D.K. Sharma, S.K. Kamra (PI), Parveen Kumar, Satyendra Kumar, R.L. Meena, Raju R., Bhaskar Narjary and Thimmappa K.)]-HOPP, Haryana
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, P.C. Sharma and Ravi Kiran K.T.) - NRCPB, New Delhi
5. Improvement of wheat for salt tolerance using molecular approach. (P.C. Sharma and Arvind Kumar) – IIWBR, Karnal
6. Establishment of National Database on rice. (S.L. Krishnamurthy and Jogendra Singh) - DBT, New Delhi
7. 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) –DBT-IRRI
8. Stress tolerant rice for poor farmers in Africa and South Asia (STRASA Phase 3). (D.K. Sharma, Krishnamurthy S.L, P.C. Sharma, Ravi Kiran K.T., B. Maji, D. Burman, S.K. Sarangi, S. Mandal, Vinay Kumar Mishra and Y.P. Singh)- BMGF
9. 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) - NICRA, ICAR, New Delhi
10. Understanding the adaptation mechanism of wild forage halophytes in the extreme saline-sodic Kachchh plains for enhancing feed resources. [(Ashwani Kumar (CPI), Arvind Kumar, Devi Dayal, Shamsudheen Mangalaseery and J.P. Singh)] - NFBSFARA, ICAR, New Delhi
11. 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) – DST, NEW Delhi
12. NRMACSSRISOL201401200870. Development of effective salt tolerant microbes to mitigate salt stress for higher crop production in salt affected soils. (P.K. Joshi and Madhu Choudhary) - AMAAS
13. NRMACSSRISOL201401300871. 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) -UPCAR
14. NRMACSSRISOL201401400872. Bio-remediation of salt affected soils of Uttar Pradesh through Halophilic microbes to promote organic farming. (Sanjay Arora and Y.P. Singh) -UPCAR
15. NRMACSSRISOL201401500873. Land modification based integrated farming system under waterlogged and waterlogged sodic conditions. (C.L. Verma, Y.P. Singh, T. Damodaran, A. K. Singh, S.K. Jha, V.K. Mishra and D.K. Sharma) -UPCAR
16. NRMACSSRISOL201401600874. Assessment and refinement of existing irrigation practices of major grown under sodic environment. (A. K. Singh, Y.P. Singh, C.L. Verma and Sanjay Arora) -UPCAR
17. NRMACSSRISOL201401700875. 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) – AMAAS
18. NRMACSSRISOL201401800876. Future rained lowland rice systems in Eastern India 15 (T-3) (Development of crop and nutrient management practices in rice) [(B. Maji & SK Sarangi (RRS Canning Town) and YP Singh & VK Mishra (RRS Lucknow)].
19. NRMACSSRICOP201500400880. Climate change mitigation and adaptation strategies for salt affected soils. (Ajay K. Bhardwaj, Ranbir Singh, R.K. Singh, Parul Sundha,

D. K. Sharma U.K. Mandal, Shishir Raut, K.K. Mahanta and B.Maji)-NICRA, ICAR

20. NRMACSSRICOP201500500881. Development of efficient and cost effective alternatives to gypsum using nanotechnology for sodic soils reclamation. [(Ajay K. Bhardwaj and Nitish Verma (IIT, Kanpur)]- CPRI, Shimla
21. NRMACSSRICOP201500600882. Wheat improvement for water logging, salinity and element toxicities in India (P.C. Sharma, Arvind Kumar and Nirmalendu Basak)- IIWBR, Karnal
22. NRMACSSRISOL201501600892. Molecular genetic analysis of resistance/tolerance in rice, wheat, chickpea and mustard including sheath blight complex genomics. [(Rice: component 1): Krishnamurthy, S.L., P.C. Sharma, Ravi Kiran K.T.) (Wheat: component 2): P.C. Sharma, Arvind Kumar and Ashwani Kumar) (Chickpea: component 3): P.C. Sharma, Anita Mann and Jogendra Singh) (Mustard: component 4): P.C. Sharma, Jogendra Singh and Vineeth V.)] – ICAR, New Delhi
23. NRMACSSRISOL201501700893. Novel Genetics Stocks: Multi-parent advanced generation inter-crosses (MAGIC) among diverse genotypes to facilitate gene discovery for various traits in rice. (Krishnamurthy, S.L. and P.C. Sharma) – IRRI-ICAR
24. NRMACSSRISOL201501800894. CRP on Agro-Biodiversity-Evaluation of rice germplasm for salinity/sodicity. (Krshnamurthy S.L., P.C. Sharma and Ravi Kiran K.T.)
25. NRMACSSRISOL201501900895. Identification of salt tolerant ber (*Zizyphus mauritiana* Lam.) rootstocks in a farmer participatory mode. (Anshuman Singh, Ashwani Kumar, Parvender Sheoran, R.K. Singh, Raj Kumar, R.K. Yadav and D.K. Sharma - RKVY
26. NRMACSSRISOL201502000896. Farmers' participatory diagnostic survey using modern techniques and demonstrating technological interventions for sustainable use of poor quality waters to enhance agricultural productivity in Haryana. (Parvender Sheoran, R.K. Yadav, D.S. Bundela, B.L. Meena, A.K. Mandal, R.K. Singh, Randhir Singh and D.K. Sharma) – RKVY
27. NRMACSSRISOL201502200898. CRP on Conservation Agriculture 'Productive utilization of salt affected soils through conservation agricultute”. (Ranbir Singh, A. K. Rai, P. Sheoran, Pathan A. L. and D.K. Sharma)

Collaborative Projects

1. Evaluation of seed spices for edaphic stresses. (R.K. Yadav and R.L. Meena) (O.P. Aishwath, R.S. Mehta, P.N. Dubey of NRCSS, Ajmer; B.K Jha ,Ranchi)
2. Land use options for enhancing productivity and improving livelihood in Bali Island of Sundarbans. [(S. Mandal) (NBSSLUP-Kolkata, CSSRI, RRS-Canning Town and CIFA – Kalyani)]
3. Study the effect of salinity stress on jute (C. capsularis &C. olitorius). [(Uttam Kumar Mandal, Co-PI) collaboration with CRIJAF, Barrackpore, Kolkatta)]
4. Impact assessment of pesticides on environment using EIQ tool under rice cropping system. [(Sanjay Arora, (CCPI) Collaboration with NCIPM, Pusa, New Delhi)]
5. Development of bioformulation(s) for low input organic farming [(T. Damodaran, CCPI) collaboration with NBAIM, Mau)]
6. Characterization and mining genetic variability in sugarcane germplasm against abiotic stress (Salinity/Alkalinity and low temperature) under subtropical India (Karnal)). [(Ashwani Kumar, Co-PI) collaboration with SBI,RRS, Karnal)]

Consultancy

1. Subsurface drainage for heavy soils of Maharashtra Karnataka and Gujarat (D.K. Sharma and S.K. Kamra)
2. 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. (Anil R. Chinchmalatpure and Nikam Vinayak Ramesh)
3. Evaluation of BAYER rice hybrids under salinity stress. (P.C. Sharma and Krishnamurthy, S.L.)

INSTITUTE ACTIVITY

Institute Management Committee Meeting

The 40th Institute Management Committee meeting was held on 11.01.2016 at CSSRI, Karnal under the Chairmanship of Dr. D.K.Sharma, Director, CSSRI, Karnal. The meeting was attended by the following IMC Members.

1.	Dr. D.K.Sharma, Director, CSSRI, Karnal.	Chairman
2.	Dr. S.K.Dubey, Head, IISWC, Regional Station, Agra	Member
3.	Dr. Pradip Dey, Project Coordinator, IISS, Bhopal	Member
4.	Dr. P.P.Biswas, Prin. Scientist, ICAR, New Delhi	Member
5.	Dr.Randhir Singh, Head, TET, CSSRI, Karnal.	Member
6.	Dr. S.K.Sharma, FAO, ICAR, New Delhi	Member
7.	Sh. Abhishek Srivastava, SAO, CSSRI, Karnal.	Member Sec.

The Meeting started with the confirmation of the proceedings of last meeting held on 08.06.2015. Subsequently, the research achievements of different Divisions, Regional Research Stations and Project Coordinating Unit were discussed for the period of May-December, 2015. This was followed by discussion on other activities carried out during May-December. 2015. These included activities by the Institute Rajbhasha Committee, different trainings and *Kisan Gosthis* organized during the period, the issues related to staff position, Institute budget and expenditure, sale of farm produce, publications, linkages and collaborations issues related to '*Swachh Bharat Abhiyaan*' and '*Mera Gaon Mera Gaurav*' programme were also discussed.

Institute Joint Staff Council Meeting

The Institute Joint Staff Council Meeting was held at CSSRI Regional Research Station, Canning Town (WB) on May 23, 2015, October 14, 2015, March 21, 2016 held at Karnal. The meeting was chaired by Dr. D.K. Sharma, Director and attended by Sh. Abhishek Srivastava, Sr. 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, Head, RRS, Canning. 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.

Institute Management Committee meeting in progress

Institute Joint Staff Council meeting in progress

WORKSHOP, SEMINAR, TRAINING, FOUNDATION DAY AND KISAN MELA ORGANISED

Kisan Goshthis and other activities under 'Mera Gaon Mera Gaurav' (MGMG) programme

'Mera Gaon Mera Gaurav' (MGMG) programme initiated by the Indian Council of Agricultural Research, New Delhi is being implemented by ICAR-Central Soil Salinity Research Institute, Karnal, Haryana and its Regional Research Stations at Lucknow, Bharuch and Canning Town since 27th May, 2015. Under MGMG, a total of 16 teams comprising of 63 scientists have been formed. These teams have adopted a total of 78 villages. Under MGMG programme, soil samples were collected from 346 farmers' fields representing 78 villages from five states, namely, Haryana, Punjab, Uttar Pradesh, Gujarat and West Bengal. These samples were analysed to diagnose the soil related constraints to bring out the same in the form of soil health cards. The soil samples were analysed for 12 parameters/elements to enable the farmers to alleviate stresses and nutrient deficiencies through appropriate agronomic interventions. In addition to this, water samples from those selected villages which suffer from the problem of poor quality saline and sodic waters were also collected and reports were provided to the concerned farmers. On an average, one farmer each from every adopted village in Haryana, Punjab, Uttar Pradesh and Gujarat, was provided the seeds of salt tolerant wheat varieties (KRL210/KRL213) to enhance the productivity of the salt-affacted lands while minimizing the use of chemical amendments such as gypsum. Fourteen pre-Rabi Kisan Goshthis were also organized in the adopted villages of Haryana, Punjab, Uttar Pradesh and Gujarat states in which more than 2000 farmers participated and interacted with the scientists to overcome diverse problems through appropriate soil and crop management practices.

International Training Workshop on Farming Systems Analysis in India

In South Asia, the natural resources are 3-5 times more stressed due to population and economic pressure compared to the rest of the world. Different agricultural technologies have been developed to address challenges of inappropriate management of production resources. Recognizing that farming systems are diverse and complex, with different interrelated components and enterprises carried out to satisfy a multiplicity of goals is vital in the development of technological and policy intervention that take into account their specific constraints and opportunities. The International Training Workshop on *"Approaches for integrated analysis of agricultural systems in South Asia: field, to farm, to landscape scale"* was jointly organized by CIMMYT and ICAR-CSSRI and supported by CCAFS, CSISA, SRFSI & ICAR-CA at CSSRI, Karnal, Haryana, India dated May 18-23, 2015. The

Dr. D. K. Sharma interacting with farmers during pre-Rabi Kisan Goshthi training workshop was directed towards researchers involved in farming systems research and agricultural development in South Asia and aimed to disseminate a comprehensive overview on the approaches and tools used for integrated assessment of agricultural systems at different levels, from field to region, based on the principles of systems and basic knowledge on modelling tools for the assessment of agricultural systems. The 30 participants includes young researchers with diverse disciplinary background and from range of national research intuitions, Agriculture universities as well as advanced institutions in India, Nepal, and Bangladesh. Dr. D.K. Sharma, Director, CSSRI, in his opening remark as chief guest stressed on the need of systems research in the region. He also shared as how partnerships with international centers like CIMMYT have helped in past while he cited the successful examples of conservation agriculture, sustainable intensification etc. In this regard, he stressed that farming systems approach is future and in that endeavor he was pleased to host this first International training workshop on farming systems. He illustrated the farmer participatory model wherein CSSRI provided land for cultivation to farmer against annual compensation on which farmer gained family nutritional security and income. Dr. Santiago Lopez Ridaura from CIMMYT Mexico highlighted the workshop objectives expecting inputs from the participants for both modules on integrated farming systems analysis through indicators and modelling tools for assessment of farming systems, based on farm characterization exercise. The course aimed to prosper new research to design technology that

Training participants with Director and the experts

fits existing farming systems, exposed participants to diverse group of farmers. *Dr. ML Jat, CIMMYT's* cropping systems agronomist while sharing the genesis of the workshop emphasized that 'this course is the first of its kind in the region'. This course is unique on many angles and demand driven which is basically organized to strengthen the capacity of young researchers in the region for taking farming systems approach forward for the livelihood security of the smallholder farmers of the region.

The key highlights of the workshop included collective exercise on characterization of farming systems and identification of indicators, integration of indicators for systems assessment, developing farming systems typology, multi-criteria analysis, farming system modeling includes model-based analysis using Fuzzy Cognitive Mapping, Landscape modelling using IMAGES, Whole-farm modeling using Farm DESIGN. Dr PC Sharma opined that with participatory exercises having farm visits and modelling, the workshop accounted good understanding on diversity of farming systems among the participants, to be used in their respective domains. The efforts imbibed by the facilitators produced the expected output securing farmers interest added to sustainable development.

'International Year of Soils' Celebrations

UN in its 68th General Assembly meeting suggested FAO Rome to declare 2015 as International Year of Soils. To celebrate the International Year of Soils, ICAR-CSSRI organized various programmes for increasing soil health awareness. These included painting and declamation contest among school students, kisan gosthis for prevention of soil and groundwater related problems faced by farmers and brain storming on “Healthy Soil for Healthy Life” amongst the scientists working on natural resource management. More than 34 and 32 students from different schools participated in painting and declamation competitions, respectively. On this occasion, Dr. D. K. Sharma, Director of the institute pointed out that sustaining agricultural production on salt affected soils is very important to feed the ever increasing

Brainstorming Session during International Year of Soils in progress

population of the country. He also informed about the efforts made and future plans of the institute for sustainable management of salt affected soils.PhotoIn the series of programmes, a kisan gosthi was also organized on soil health for increasing awareness among farmers. About 165 farmers participated in the gosthi. Sh. O. P. Dhankar, Hon'ble Minister of Agriculture, Govt. of Haryana inaugurated the gosthi and asked the farmers to get their soil health cards and further emphasized for balanced and integrated use of fertilizers. The Minster also praised the diversified agriculture model of the institute developed for small and marginal farmers. On this occasion, he also released the report of Vth Regional Committee of the ICAR. During the gosthi; scientist experts answered the soil and water related queries raised by the farmers.

To commemorate International Year of Soils 2015, institute organized a brain storming session on "Knowledge gaps and empowering reclamation of saline soils in changing climatic conditions" amongst internationally acclaimed scientists. This session was chaired by Dr. Gurbachan Singh Chairman, ASRB, New Delhi and attended by Dr. I. P. Abrol, Director, CASA, New Delhi was the Chief Guest Dr. J. S. Samra, Ex. CEO NRAA, New Delhi, Dr. P. K. Joshi, Director IFPRI, Dr. C. L. Acharya, Ex Director ISSS Bhopal, Dr. S. K. Chaudhari, ADG (SWM) NRM, ICAR, Dr. K.K.R. Bhardwaj, Ex PC, Dr. D. K. Sharma Director CSSRI Karnal, and Dr. P. C. Sharma also participated among other scientists of the institute. Dr. I. P. Abrol Chief Guest of the Brain Storming session emphasized that everyone should take utmost care for improving the health of soils and water. He further suggested that integrated and balanced fertilization is the key to better health of soil and crop productivity. Dr. Gurbachan Singh, Chairman emphasized that soil is the precious gift of nature and maintenance of its health should be paramount for all of us because it is the key to sustainable production. He also suggested that small and marginal farmers should adopt diversified agriculture model for better income, regular employment and improved nutrition.

66th Vanmahotsava

66th vanmahatsava was organized on 21st August 2015 on the theme '*Greening Every Home for Happiness*'. Under leadership of Dr. D. K. Sharma, Director, all officers and employees of the institute planted 160 saplings of different horticultural species on this occasion. While addressing the staff, Dr. Sharma mentioned that planting trees is one of the best ways to maintain the ecological balance. He further said that everyone should plant and care the trees for environmental integrity.

Planting of tree saplings by the Director

International Training Programme on Conservation Agriculture

A 10 days International Training Programme on Conservation Agriculture for capacity development of researchers of Indian NARES (ICAR, SAUs) and CGIAR institutes was concluded at ICAR-CSSRI during 02 September to 11 September 2015, under the Flagship of CSISA project funded by USAID and Bill & Melinda Gates Foundation (BMGF). The training programme was sponsored by CSISA, CIMMYT and was organized jointly by CSSRI and CIMMYT.

CA refers to a sustainable intensification system where crops are planted in minimum, no-till or reduced tillage systems with crop residue retention on the soil surface to address the issues of labour, water and energy shortage. 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. An introduction to and capacity development on CA is of immense importance to create a positive impact in the region. The 'Training Programme on Conservation Agriculture: Developing Resilient Systems' offers a unique opportunity for the scientific community working in the area of natural resource management.

Dr. Rameshwar Singh, PD, ICAR- Directorate of Knowledge Management in Agriculture New Delhi was the chief guest and highly appreciated this International training Programme for improving the productivity of crops and cropping system in different agro-ecological regions of India to sustain the livelihood of small holders. Dr. D.K. Sharma, Director, CSSRI and A. McDonald, Project Leader, 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. Depletion of underground water, declining fertility status associated with multiple nutrient deficiencies, increased concentration of green house gases in the atmosphere owing to large scale burning of rice and wheat residues are some of the end results of this farming system. 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. 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 while maintaining/preserving the natural resource base. Conservation agriculture offers a key solution for enhancing crop productivity and safeguarding the environment through prudent and efficient resource use in Indian IGP.

Drs. P.C. Sharma and HS Jat, coordinated this CA training programme with the aim of sharing experiences and in depth knowledge on various aspects of CA in the Indo-Gangetic plains of India. In the training programme, basic principles of CA

Dr. Gurbachan Singh, Chairman, ASRB, New Delhi addressing the training participants 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. Hands-on-training on Laser land leveler (LLL), Turbo seeder, multi crop planter, limit plot planter, bed planter, mechanical transplanted and green house gas (GHG) measurements was taken up.

Hindi Pakhwara

The Institute celebrated the Hindi Pakhwara during September 14-28, 2015. Dr. Arjava Sharma, Director, NBAGR, Karnal inaugurated the function on 14th September, 2015. On this occasion, he urged the staff to use Hindi in day to day work. During this celebration, 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. In the concluding function, Dr. D.K. Sharma, Director, 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.

CSSRI RRS Bharuch celebrated the Hindi Saptah during 10-9-2015 to 16-9-2015, events like quiz, letter, essay and precise writing and elocution were organized. The prizes for different events were distributed to the winners by the Chief Guest.

ICAR Organized Workshop to Develop Road Map for Services to Farmers in Agro-Climatic Zone-VI

Indian Council of Agricultural Research organized a workshop for 'Developing a Road Map for Technological Support, Extension and Demonstration Services to the Farmers in Trans-Gangetic Plains Region (Agro-Climatic Zone-VI)' at ICAR-Central Soil Salinity Research Institute on 5th October, 2015, Dr. K.M.L. Pathak, Deputy Director General (Animal Science), ICAR chaired the workshop and in his address emphasized the need to make agriculture more sustainable and profitable to farmers by providing solutions to their location specific problems. He urged the experts to suggest the best possible means and ways to overcome the problems being faced by the farmers and also requested them to include field constraints in research projects. Dr. D.K. Sharma, Director, ICAR-CSSRI and nodal officer of the workshop highlighted the important role of Trans-Gangetic Plains (Punjab, Haryana, Chandigarh, Delhi and Sri Ganganagar district of Rajasthan) in food security of the nation. He flagged various issues related to agriculture and allied sector which need immediate attention by the scientists and policy makers. Dr. B.S. Dhillon, Vice-Chancellor, PAU, Ludhiana, in his remarks, laid stress on farm mechanization and marketing strategies to reap higher benefits from farming. Farmers must focus on net profits rather than increasing the productivity. Dr. K. S. Khokhar, Vice-Chancellor, CCSHAU, Hisar, emphasized the need to adopt integrated farming system

Dr. Arjava Sharma, Director, ICAR-NBAGR, Karnal addressing the gathering during Hindi Pakhwara

Workshop in Agro-climatic Zone-VI in progress

models to make farming more productive and profitable. He also urged farmers to adopt resource conservation technologies to save cost and environment. Dr. Rajbir Singh, Director, ATARI, Ludhiana and nodal officer of the workshop, appraised the house on various extension initiatives for quick and effective dissemination of technologies and timely advisories to farmers in case of extreme climate events. Nearly 30 farmers from various districts of the region participated in the workshop and put forth their specific problems and issues which need attention and solution. Directors and senior officials from ICAR Institutes, State Agricultural and Animal Science Universities and KVKs of the region participated in the workshop and provided their inputs for providing solutions to specific problems of the farmers.

Pre-Rabi Kisan Mela

The pre-Rabi Kisan Mela was organized on 21st October 2015 in village Gyong (Kaithal) where more than 250 farmers and extension workers participated. Dr. D. K. Sharma, Director, CSSRI, Karnal, in his inaugural address, he stressed upon checking depletion of under-ground water by replacing rice with maize. The water demand of rice can further be decreased by adopting DSR technique and complimented with the sprinkler system. The farmers of an agroecosystems facing acute problems relating to underground water depletion can adapt the underground water recharge to mitigate the vulnerability caused by climate and other factors. Area under wheat in salt affected soils can be increased by adapting salt tolerant wheat varieties KRL-210 and KRL 213. He emphasized and urged to farmers to have soil and water testing and using soil health card to sustain soil health by using balanced nutrients and complimenting through compost and crop residues. The Head of KVK, Kaithal Dr Hariom expressed his concern about overexploitation of agrochemicals and polluting the food chain which can be minimized only once farmers are aware about rational use of such agrochemicals. During this Kisan mela, farmers have asked a number of questions relating to soil and water salinity and sodicity who were responded by the subject matter specialists. The water samples brought out by farmers were tested on the spot and remedial advisory was provided to them.

Soil Health Day Programme

The soil health day was organized on Dece. 5th, 2015 at ICAR-CSSRI, Karnal which was

Dr. D. K. Sharma, Director addressing the farmers during pre-Rabi Kisan Mela in Gyong, Kaithal

Sh. Amarendra Singh, OSD to Hon'ble Chief Minister, Haryana addressing the farmers and scientists

inaugurated by Shri Amrender Singh, OSD to Hon'ble Chief Minister, Govt of Haryana. Sh. Bakhsish Singh, Chief Parliamentary Secretary, Haryana was Guest of Honour. In this prgramme more than 200 farmers and 60 scientists participated. A total of 254 soil health cards were distributed to farmers by the chief guest and director of CSSRI. The objective of this extension activity was to distribute the soil health cards through mobilizing farmers of MGMG villages. They were motivated to bring soil and water samples for diagnosing the problems. The nodal officer of Soil Health Card Dr R. K. Yadav briefed about the process and methodology adopted for soil and water sampling techniques. He further narrated the role of soil health cards in managing soil and water resources and improving crop productivity. He reported that 76% of soil health cards were of sodic category, 5% from saline category and 15% of normal category. The 'N' availability was almost less in the all the analyzed soil samples, while 58% soil samples were found deficient in P and 22 % in K. Soil organic carbon was found less in 15% soil samples followed by medium in 66% soil samples and high in 19% soil samples. The chief guest appreciated efforts being made by CSSRI in reclaiming salt affected lands and improving poor quality waters. He emphasized about the polices and schemes being initiative by the central government to promote farmers welfare. The programme was also coordinated by the Technology Evaluation and Transfer Division.

"Jai Kisan Jai Vigyan" Week

In response to National initiative of Indian Council of Agricultural Research, New Delhi, Jai Kisan Jai Vigyan Programme was organized Dr. P.C. Sharma and his MGMG team on December 26, 2015 in Beer Narayana (Karnal, Haryana) in which about 100 farmers participated. Dr. D.K. Sharma, Director, ICAR-CSSRI, Karnal told the farmers about benefits of conservation agriculture, water recharge and balanced nutrition. He informed that by 2017, all the farmers in India will be provided soil health cards and requested the farmers to get their soil and water get analysed at ICAR-CSSRI, Karnal free of cost. The second programme in the series was organized on 29th December, 2015 in the village Dindayal Dham, Nagla-Chanderbhan of Mathura district (UP) where more than 200 farmers from nearby villages interacted with the team of scientists on issues related to soil health, management of poor quality water and animal health. The chief guests of this function were Dr. D. K. Sharma, Director, CSSRI, Karnal and Shri Padam Singh, Director, Dindayal Dham Smriti Sansthan. A total of 204 soil health cards were distributed to the farmers of adopted villages (Nagala Chandrabhan, Nagla Jalal, Daulatpur, Gadhi Pachauri and Rana Khema) under 'Mera Gaon Mera Gaurav' programme. Dr. Randhir Singh informed the farmers about different schemes launched by the Ministry of Agriculture and Farmers' Welfare such as Soil Health Card, Per Drop More Crop, Lab to Land, Mera Gaon Mera Gaurav, e-National Agriculture Market, Digital Agriculture, Paramparagat Krishi Vikas Yojana, National Gokul Mission, Neem Coated Urea, Blue

Revolution and Mission for the Integrated Development of Horticulture. The queries raised by the farmers of both the districts relating to agriculture, dairy and general issues were answered by the experts.

Swachh Bharat Abhiyan

The Swachh Bharat Abhiyan was organized in village Dabri district Karnal on 20 January 2016 as per the guidelines of the Government of India. The students and teachers of Government Senior Secondary School, Dabri organized *Prabhat Pheri* of the village under the guidance of CSSRI team and Nagar Nigam Officials of Karnal. A team of scientists from CSSRI organized quiz competition in the school and the winner students from different classes were honoured to encourage them towards cleanliness. Dr. D.K. Sharma educated the students about cleanliness being torch bearer of the nation. He advised the students to carry the message to their parents and requested them not to burn crop residue. The Nagar Nigam officials educated the students and teachers about cleanliness drive,avoid open defecation, toilet in every households, solid waste management, clean drinking water, drainage, toilets in community centre, three tier pond system, etc.

Swachhta Abhiyan: Various activities related to Swatch Bharat Abhiyan under "Mera Gaon Mera Gaurav" were conducted in the Primary School at village Samni, Bharuch district by ICAR-CSSRI Regional Research Station Bharuch on 7-10-2015.

International Training Programme

A five days (Feb 15-19, 2016) training of state agricultural extension officers, students and young professionals from CSSRI & IIWBR, Karnal was organized at CSSRI on "Participatory irrigation management for regional food and water security in northern India" in collaboration with IAFD, Australia, and CIMMYT CCAF. A total of 31 trainees attended this traing. The training was inaugurated by Dr. D. K. Sharma, Director, ICAR-CSSRI, Karnal. He emphasized about the judicious use of water in irrigation and cautioned about the rapidly declining fresh groundwater. The programme specifically aimed to enhance the skills and knowledge of the trainees to effectively address the emerging constraints in soil and water management for profitable crop production. The diverse issues related to climate smart agriculture, irrigation management under water scarcity and innovative participatory extension approaches were also discussed. The participants were also the field and practical exposure. The chief guest of closing ceremony Dr. Gurbachan Singh, Chairman, ASRB stressed upon the new technologies to be developed for rational use of water and harvesting of rainwater so that sustainability of agroecosystem could be maintained.

Swachha Bharat Abhiyan in Dabri village, Karnal

Foundation Day

CSSRI, Karnal celebrated its 47th Foundation Day on 1st March 2016 by organizing a Foundation Day lecture delivered by Dr. Arvind Kumar, VC, Rani

Field visit during International training programme

Laxmi Bai Central Agricultural University Jhansi. 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. Dr. Arvind Kumar addressed the gathering on subject 'Sustainable Approaches for Crop Production Technology in Salt- affected Soils'. He explained during the last four decades, these resources have been stretched and over exploited to meet food, fiber and shelter requirements of burgeoning human and livestock populations. Amongst these four, soil, a finite nonrenewable natural resource on a human time scale, has been increasingly subject to degradation and pollution and is simultaneously being usurped by domestic and industrial sectors. Since soils are the foundations for food, animal feed, fuel, natural fiber production besides a range of ecosystem functions, generating awareness on the life-supporting functions of soil is called for to reverse the degradation trends. In fact, it is only way to achieve the levels of food production necessary to meet the demands of food and nutrition for the population levels predicted for 2050.

Indian agriculture supports 18% of world population with only 9% of world's arable land and 2.3% of geographical area. Nearly one-third of the country's population lives below poverty line, and about 80% of our land mass is highly vulnerable to drought, floods and cyclones. Despite a stagnant cultivable area at around 142 million hectares, food grains production in the country over the past 10 years has increased from 198 million tonnes in 2004-05 to 255 million tonnes in 2012-13 at an average of about 6 million tonnes per annum. On the contrary, demand projections for food grains reveal that we may need at least 345 million tonnes in 2030, requiring almost the same rate of increase per annum but from shrinking land and water resources and aberrations in climate, which have already started impacting agricultural productivity in several agro-climatic regions and sub-regions of India. The coastal agro-ecosystem of India occupies an area of about 10.78 million ha along the 8,129 km coastline (Velayutham et al., 1998). The coastal eco-regions of India are marked as one of the traditionally backward and disadvantaged areas with low agricultural productivity. It has, therefore, been the endeavor of CSSRI to take research initiatives to address the problems of coastal ecosystem. Some of the technologies include: on-farm water harvesting structures to improve drainage and to facilitate double cropping, aquaculture, management of acid sulphate soils, integrated nutrient management, improved dorouv technology to skim fresh water floating on the saline water, reclamation of abandoned aqua ponds, land modification and land shaping technologies, variety development for deep and medium surface water stagnation during monsoon season etc. These technologies would go a long way in alleviating the poverty commonly witnessed in the coastal areas. About 200 scientists and other officers from Karnal based ICAR institutes participated in the function.

Rabi Kisan Mela

Rabi Kisan Mela was organized on 5th March 2016 at Karnal which was inaugurated by Chief Guest

Dr. Arvind Kumar, Vice Chancellor, RLBCAU, Jhansi delivering the Foundation Day lecture

Shri Harvinder Kalyan, Chairman, HAFED, Govt of Haryana. In this Kisan Mela more than 2000 farmers and students took active part and 53 stalls of different institutions and private companies showcased technologies and products to benefit the farmers. Shri Harvinder Kalyan appreciated the efforts being made by the CSSRI in transfer of technologies relating to soil and water reclamation and benefiting the farmers in salinity affected regions of the country. He requested the farmers to benefit from different schemes of the Central and State governments. He emphasized the need for a close co-ordination among different stakeholders to tackle the problems caused by salinity, climate change and socio-economic changes. During the Mela, a 'Farmer-Scientist Kisan Goshthi' was also organized to address the farmers' concerns relating to poor quality water, waterlogged salt-affected lands, and timely availability of the seeds of salt tolerant varieties. Dr. D. K. Sharma, Director, ICAR-CSSRI highlighted the contributions made by the Institute in strengthenening the farmers' livelihoods in salt-affected regions through the development and transfer of salinity mitigation and adaptaion technologies. The water samples brought by the farmers were sampled free of cost and the advisories were issued on the spot. Seeds of salt tolerant and other rice varieties (CSR-43, CSR-30, and Pusa-44) were also sold to the farmers. Celebration of Kisan Diwas at Bharuch: A 'Kisan Diwas' was celebrated on 23rd October, 2015, in which about 100 farmers and officials from the Agriculture Department, Agricultural College, NABARD, KVK and NGO participated and discussed different aspects of cultivation of salt tolerant wheat varieties (KRL210 and KRL 19). Seeds of these salt tolerant varieties were distributed among 40 farmers for on-farm trials.

Celebration of Kisan Diwas at Bharuch: A 'Kisan Diwas' was celebrated on 23rd October, 2015, in which about 100 farmers and officials from the Agriculture Department, Agricultural College, NABARD, KVKand NGO participated and discussed different aspects of cultivation of salt tolerant wheat varieties (KRL210 and KRL 19). Seeds of these salt tolerant varieties were distributed among 40 farmers for on-farm trials.

Sh. Harvinder Kalyan, Chairman, HAFED, Govt. of Haryana addressing the farmers during Rabi Kisan Mela

LIST OF SCIENTIFIC, TECHNICAL AND ADMINISTRATIVE PERSONNEL

Dinesh Kumar Sharma, Ph.D., Director

Division of Soil and Crop Management

R.K. Yadav, Ph.D., Head, (28.05.2015)[b]
Madhurma Sethi, Ph.D. Head(A) (27.05.2015)[a]
P.K. Joshi, Ph.D.
A.K. Mandal, Ph.D.
Ranbir Singh, Ph.D.
Parveen Kumar, Ph.D
A.K. Rai, Ph.D
R.K. Garg, Ph.D (16.09.2015)[a]
A.K. Bhardwaj, Ph.D.
Rakesh Banyal, Ph.D. (01.09.2015)[b]
Gajender Yadav, Ph.D.
Madhu Chaudhary, Ph. D.
Anshuman Singh, Ph.D.
Murli Dhar Meena, Ph.D.
Nirmalendu Basak, Ph.D.
Assim Dutta M.Sc.
David Cames D., M.Sc. (06.08.2015)[a]
Parul Sundha, Ph.D. (13.04.2015)[b]
Raj Kumar, Ph.D. (27.04.2015)[b]

Technical Officers

Naresh Kumar, Ph. D.
Raj Kumar
Sukhdev Parshad
Sahib Singh (31.08.2015)[c]
Dilbag Singh

Division of Crop Improvement

Parbodh Chander Sharma, Ph.D., Head,
S.K. Sanwal, Ph.D. (18.05.2015)[b]
Anita Mann, Ph.D. (13.04.2015)[b]
S.L.Krishna Murthy, Ph.D
Joginder Singh, Ph.D.
Ashwani Kumar, Ph.D
Arvind Kumar, Ph.D.
Vineeth TV, M.Sc. (13.04.2015)[b]
Ravi Kiran, M.Sc. (13.04.2015)[b]
Vijeyata Singh, Ph.D. (01.01.2016)[b]

Technical Officers

P.S.Tomar, B.Sc. (31.12.2015)[c]
G.C. Purty
Roshan Lal

Division of Irrigation and Drainage Engineering

D.S. Bundela, Ph.D., Head (30.12.2015)[b]
S.K. Kamra, Ph.D. Head (A) (29.12.2015)[a]
R.S. Pandey, Ph.D. (31.12.2015)[c]
Satyender Kumar, Ph.D.
Pathan Aslam Latif , M.Tech.(13.04.2015)

Technical Officers

Rajiv Kumar, M.Sc.
S.K. Srivastava, Diploma
Jai Parkash, M.Sc.
S.K. Dahiya
Mohinder Pal
Ram Pal (31.05.2015)[c]
Brij Mohan (30.06.2015)[c]
Sat Pal

Division of Technology Evaluation and Transfer

Randhir Singh, Ph.D., (10.08.2015)[b]
R.K. Singh, Ph.D. Head (A) (09.08. 2015)[a]
Parvender Sheoran, Ph.D.
K. Thimmappa, Ph.D.
R. Raju, Ph.D.

AICRP (Saline Water)

M.J. Kaledhonkar, Ph.D., P.C. (28.03.2016)[b]
D.K. Sharma Ph.D. PC (A) (27.03 2016)[a]
R.L. Meena, Ph.D.
Babu Lal Meena, Ph.D.

Technical Officers

Anil Kumar Sharma, M.A. (English)

Regional Research Station, Canning Town

D. Burman, Ph. D., Head, (01.01.2016)
B. Maji, 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.
T.D. Lama, Ph.D. (18.05.2015)

Technical officers

D. Pal, Ph. D
N.B. Mondal, Diploma
Sivaji Roy, M.Sc
P.K. Dhar, B. Sc.

S. Mandal, B.Sc.
A.K. Pramanik, BA.
L.K. Nayak,
D. Mukherjee
D. Banerjee

PS to the Head

A.K. Nandi, B. Sc.

Regional Research Station, Bharuch

Anil R. Chinchmalatpure, Ph.D. Head
G. Gururaja Rao, Ph.D., (30.06.2015)[c]
Sarwan Kumar, M.Sc.
Indivar Parshad, M.Sc.
David Camus D. M.Sc. (07.08.2015)[b]
Nikam Vinayak Ramesh, M. Sc. (17.11.2015)[a]
Monika Shukla, M.Sc.(01.05.2015)

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

Abhishek Srivastava, Sr. Admn. Officer
Ved Parkash, FAO (3.0.09.2015)[c]
Anil Sidharth (01.01.2016)[b]
Randhir Singh, Jr. Account Officer
A.K.Mishra, Asstt. Admn. Officer
Tarun Kumar, Asstt. Admn. Officer
Ranjeet Singh, Asstt. Admn. Officer

RTI Cell

K. Thimmappa, Ph.D., CPIO
Randhir Singh, Ph.D., APIO (30.06.2015)[c]
S.K. Srivastava, Diploma
Vinod Kumar, M.A.

Transparency Officer

Dr. A.K. Rai

Priortizing, Monitoring and Evaluation (PME) and Institute Technology Management Unit (ITMU)

Parveen Kumar, Ph.D

Technical Officer

Vinod Kumar, M.A. (Economic)

Publication and Supporting Services Unit

Parveen Kumar, Ph. D. CO
Anshuman Singh, Ph. D., OIC (01.07.2015)[b]
Randhir Singh, Ph. D. OIC (30.06.2015)[c]
Madan Singh, M.A. (Geography)

Hindi Cell

A.K. Srivastava, Sr. Admn. Officer, OIC

Technical Officers

S.K. Tyagi, Ph.D

Director Cell

Santra Devi, PS

Public Relation Officer

Randhir Singh, Ph.D (30.06.2015)
Anil Kumar (01.07.2015)

PS to Heads

Dinesh Gugnani
Rita Ahuja
Sunita Malhotra
Shashi Pal

Farm Section

H.S. Tomar, M.A., Farm Manager
Chander Gupt
Seth Pal
Jaswant Singh

Nain Farm

R.K. Yadav, Ph.D, OIC

Technical Officer

Dilbag Singh

Library

Meena Luthra, M.A., M. Lib. Sci., OIC,

Medical Unit

Dr. (Mrs.) Mahathi Parkash, M.B.B.S., SMO
Sunita Dhingra
Chanchal Rani
Geeta Rani

Estate Section

Satyender Kumar, Ph.D. CO
N.K. Vaid, M.Tech. OIC (Estate Civil)
S.K. Dahiya, OIC, Security
Ashwani Kumar, Diploma
Kulbir Singh, Diploma

* Superscripts a, b and c refer to date of relieving, joining and superannuation, respectively.

CSSRI STAFF POSITION

Statement showing the total number of employees and the number of Scheduled Castes(SC)/Scheduled Tribes (ST) as on 31.3.2016.

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	-	33	33	02	6.06	03	9.09
Lowest rung of Class-1	-	49	49	01	2.04	01	2.04
Class-II	-	68	68	17	25.00	04	5.88
Class-III	-	47	47	09	19.14	05	10.6
Class-IV (excluding sweepers)	-	53	53	15	28.30	05	9.43
Class-IV (only sweepers)	-	06	06	06	100	-	-
Total	**-**	**256**	**256**	**50**	**19.53**	**18**	**7.03**

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 31.3.2016.

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 2015

Main Institute, Karnal

During the year 2015, 673.7 mm rainfall was recorded at Agro-met Observatory, Karnal as compared to the mean annual rainfall of 738.7 mm (for the last 44 years). The year was a normal rainfall year (91% of the long-term mean annual rainfall). The maximum monthly rainfall of 244.9 mm was recorded in July. During the monsoon season, the highest rainstorm of 98.8 mm was recorded on 2nd march and the second highest of 84.0 on 13th July. The winter rainfall (January and February) was 43.5 mm as compared to the last year winter rainfall (115.0 mm). The winter rainfall and favourable weather conditions supplemented one irrigation demand of Rabi crops in January and February months. During March, there was heavy rainfall of 128.8 mm which supplemented the full irrigation demand of Rabi crops and could have ensured bumper yield in Rabi, but higher rainfall during April (68.2 mm) resulted in substantial crop loss as heavy rain storms spoiled the crop at maturity. There were 48 rainy days as compared to 43 during the last year. The minimum and the maximum air temperatures, 2.0° and 44.6 °C, respectively, were recorded on 30th January and 25th May, respectively. The lowest air relative humidity was 6% on 6th May while the highest (100%) was recorded on several occasions during the year. The highest soil temperatures at 5, 10 and 20 cm depths were 43.0, 40.0 and 39.0 °C on 18th June, 23rd May and 23rd May, respectively. The lowest values at same depths were recorded as 7.0, 8.0 and 8.5 °C on 30th January (5 cm, 10 cm) and 29th January. The total open pan evaporation during the year was 1326.5 mm; almost two times higher than the annual rainfall. The lowest evaporation of 0.5 mm was recorded on 4th January and the highest of 11.6 mm was on 12th June. The average sunshine hours per day were 6.6. The highest and lowest vapour pressure values were 29.3 (22nd July) and 5.9 (30th, 31st Jan. and 26th December) respectively. The average wind speed was 3.9 km per hour. The monthly weather parameters recorded at agro-meteorological observatory, CSSRI, Karnal for the year 2015arepresented in Table I.

RRS, Bharuach

Agro-meteorological observations (Table II) recorded at Cotton Research Station, Bharuch (latitude 22^{O}N, longitude 73.50^{O}E, and altitude 16.50 m) during 2015 revealed that this region received 471.6 mm rainfall spread over 31 days. Season's highest rainfall 157.5 mm was received during June followed by 134.6 mm and 131.5 mm in during September and July, 2015, respectively. The maximum air temperature ranged from 40.7 °C (May) to 28.4 °C (January) and the minimum air temperature varied from 13.5 °C (January) to 27.2 °C (June). Pan evaporation varied from 4.4 mm day-1 during June to 10.1 mm day^{-1} during May. The average bright sunshine hours varied from 3.9 during August to 9.9 hr/day during May. Mean relative humidity varied from 44 per cent during December to 74 per cent in July. The average wind speed varied from 2.5 kmph during October to 13.1 kmph during July 2015.

RRS, Canning Town

The onset of southwest monsoon was on 12th June, 2015. Total annual rainfall of 1953.3 mm was recorded during 2015. The maximum (838.4 mm) rainfall as well as the maximum number (28) of rainy days was recorded in the month of July. Rainfall received in the month of July was significantly higher compared to normal (49 years average rainfall for the month of July is 372 mm), causing flooding in the rice fields in the coastal areas of West Bengal. This adversely affected the growth of transplanted rice during the initial period of the kharif season. Due to meagre/slight rain after the monsoon period, supplemental irrigation was essential for cultivation of Rabi crops. There was total 86 rainy days in this year. The average daily sunshine hour was moderate. The minimum temperature reached its lowest (total mean monthly average 14.0^{0}C) in the month of January. The average mean monthly temperature of 19.3^{0}C in January rises very rapidly to 31.5^{0}C in the month of May. The relative humidity remained quite high throughout the year, which caused severe weed infestation and disease/pest attacks. The highest average wind velocity (9.9 KMPH) was recorded in May. The mean monthly weather parameters recorded at RRS, Canning, are presented in Table III.

Table I: Mean monthly weather parameters for the year 2015 recorded at the Agro-meteorological Observatory, ICAR-CSSRI, Karnal

Latitude: 29° 43' N
Longitude: 76° 58' E

Altitude : 245 m above the Mean Sea Level
I Time : 0722/0830 hours IST
II Time : 1422 hours IST

Month	Temperature, °C							Vapour pressure (mm of Hg)		Relative humidity (%)		Max. Temp, °C		Min. Temp, °C	
	Max.	Min.	Grass Min.	Dry bulb		Wet bulb						High/ date	Low/ date	High/ date	Low/ date
				I	II	I	II	I	II	I	II				
Jan.	15.7	06.8	00.7	08.3	15.2	08.2	12.8	08.1	09.3	98	75	22.5/2	10.0/10	11.5/3	02.0/30
Feb.	22.4	09.5	04.4	11.6	21.6	15.4	16.8	09.7	11.2	93	56	26.0/24	16.8/2	17.4/25	04.5/1
Mar.	25.6	12.8	06.7	15.3	25.1	14.5	19.0	12.2	12.9	92	54	33.5/29	16.8/2	19.6/29	07.0/10
Apr.	33.1	18.0	10.7	21.4	30.4	18.7	20.8	14.5	11.7	76	35	41.5/21	25.0/5	22.2/27	13.8/5
May	39.8	22.2	13.8	26.9	38.0	21.1	22.3	15.3	10.7	58	23	44.6/25	31.5/16	26.0/26	18.0/3
Jun.	37.4	24.5	14.6	27.5	35.8	23.3	24.8	18.9	16.7	69	40	43.0/9	31.0/26	26.2/23	21.0/1
Jul.	33.1	25.6	16.8	27.5	31.9	25.6	27.0	23.5	23.7	85	68	37.4/5	25.5/12	29.0/9	21.5/26
Aug.	32.7	25.1	11.9	26.6	31.6	25.7	27.7	24.3	25.3	93	73	35.0/29	27.0/9	26.5/14	21.0/16
Sept.	33.5	22.7	11.1	24.5	32.5	23.5	26.2	21.1	21.6	91	59	36.0/16	29.8/24	26.0/2	18.2/30
Oct.	32.0	17.6	11.5	20.1	31.0	19.3	22.6	16.3	15.7	92	46	35.0/13	26.0/29	23.0/13	12.6/29
Nov.	27.4	12.4	09.2	14.0	26.7	13.3	18.2	11.1	10.9	92	42	31.0/16	21.6/28	17.0/5	09.0/23
Dec.	21.2	06.8	02.7	08.5	20.7	08.2	14.8	08.1	09.1	96	50	26.6/2	18.0/26	12.5/10	02.8/25
Total:	--	--	--	--	--	--	--	--	--	--	--				
Average:	**09.5**	**17.0**	**09.5**	**19.4**	**28.4**	**18.1**	**21.1**	**15.3**	**14.9**	**86**	**52**				

(Contd….)

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	10.8	14.7	11.4	13.8	11.9	13.2	15.0	5	06.6/3	1.2	36.2	2.9	2.9
February	12.9	19.8	13.7	17.9	14.3	16.9	28.5	2	25.5/3	2.2	62.4	5.7	3.6
March	16.1	23.5	16.8	21.8	17.5	20.6	128.8	5	98.8/2	2.6	77.7	6.8	4.4
April	21.1	30.3	22.1	28.3	22.9	26.9	68.2	8	40.4/4	4.4	128.3	9.0	5.1
May	27.7	37.9	28.6	35.0	29.7	33.4	6.8	3	03.0/14	7.7	237.7	9.0	4.7
June	28.9	37.6	29.8	35.5	30.7	34.0	49.0	5	10.0/21	7.7	223.7	8.4	5.9
July	27.6	32.8	28.4	31.5	29.2	30.9	244.9	7	84.0/13	5.5	164.8	5.9	6.7
August	27.3	34.3	28.1	32.4	28.8	31.1	69.8	7	27.0/7	3.3	103.6	5.6	3.7
September	26.8	34.7	27.4	33.2	28.3	32.0	46.8	2	28.6/21	3.5	102.0	8.1	3.5
October	22.6	31.3	23.7	29.9	24.7	28.9	6.4	2	05.6/29	3.0	92.7	7.6	2.3
November	16.9	23.9	17.8	23.0	18.8	21.7	9.5	2	08.2/5	1.9	55.5	5.2	1.9
December	11.8	18.2	12.6	17.3	13.7	16.3	0.0	0	0.0/1	1.4	41.9	4.7	2.2
Total:	--	--	--	--	--	--	**673.7**	**48.0**	--	--	**1326.5**	--	--
Average:	**20.9**	**28.2**	**21.7**	**26.7**	**22.5**	**25.5**	--	--	--	**3.7**	**110.5**	**6.6**	**3.9**

* Rainfall < 2 mm is drizzle or trace.

Table II: Monthly average agro-meteorological parameters at Bharuch during 2015

Month	Temperature (^0C)		Rainfall (mm)	Total rainy days	Mean Relative humidity (M+E) (%)	Vapour pressure (mm)		Wind speed (km/hr)	Sunshine (hr/day)	EPan (mmpd)
	Max.	Min.				M	E			
January	28.4	13.5	11.8	1	51	10.4	8.9	3.8	8.3	4.9
February	32.9	16.8	0.0	1	43	11.3	9.0	3.6	9.0	6.7
March	35.2	20.6	15.0	0	42	13.1	11.5	4.8	8.6	8.4
April	37.8	24.2	0.0	0	51	19.6	14.8	6.5	8.4	9.5
May	40.7	27.2	0.0	0	53	23.4	17.0	9.3	9.9	10.1
June	35.0	26.8	157.5	9	72	24.4	23.3	10.1	6.3	4.4
July	32.9	26.8	131.5	9	74	24.1	23.2	13.1	3.9	4.9
August	33.1	25.8	21.2	5	72	23.3	21.2	9.0	4.4	4.7
September	33.3	24.9	134.6	6	70	23.1	20.5	5.4	6.0	5.7
October	36.8	23.5	0.0	0	55	19.5	16.8	2.5	8.3	7.5
November	34.4	20.2	0.0	0	49	15.1	13.2	2.8	7.5	6.5
December	30.9	14.3	0.0	0	44	9.4	8.9	3.5	8.5	5.1
Total			471.6	31						

Table III : Mean monthly weather parameters at Canning Town (Latitude 22015′ N, longitude 88040′E, altitude (AMSL)-3.0 M) during the year 2015

Month	Temperature (^0C)			RH (%)	Rainfall (mm)	Rainy days	Wind speed (km/hr)		BSH/ Day	Solar Radiation ($MJ/m^2/day$)
	Max.	Min.	Mean.				Min.	Max.		
January	24.6	14.0	19.3	50.3	17.9	01	3.4	17.9	6.3	10.3
February	28.5	16.8	22.7	42.1	15.0	01	4.1	19.7	7.0	13.5
March	32.4	20.5	26.5	34.7	10.9	02	4.3	20.9	8.2	17.0
April	33.7	24.2	28.9	50.0	106.9	07	7.8	29.5	6.5	15.3
May	35.5	27.4	31.5	55.9	89.6	04	9.7	30.2	8.0	14.5
June	33.7	26.8	30.2	64.5	274.2	15	9.9	33.5	4.8	11.3
July	31.6	25.8	28.7	79.5	838.4	28	6.5	27.8	1.3	9.2
August	32.3	26.8	29.5	73.1	399.8	15	7.7	28.7	3.7	11.5
September	32.6	26.3	29.4	66.4	172.2	11	5.5	24.7	4.4	12.6
October	32.3	24.7	28.5	56.0	21.5	02	3.3	19.7	6.1	14.3
November	30.1	19.8	25.0	46.3	1.4	0	2.5	16.0	6.9	12.7
December	26.3	16.3	21.3	45.3	5.5	0	2.7	15.5	3.1	8.5
Total	373.7	269.2	321.4	664.0	1953.3	86	67.6	284.1	66.3	150.7
Mean	31.1	22.4	26.8	55.3			5.6	23.7	5.5	12.6

AUTHOR INDEX

APPENDIX

Results-Framework Document (RFD) for ICAR-Central Soil Salinity Research Institute, Karnal (2014-15)

ISO 9001:2008
Certificate No. 14RQ11AW

Section 1

Vision, Mission, Objectives and Functions

Vision

Productive utilization of salt affected soils and poor quality water resources in varying agro-ecological situations.

Mission

Generating new knowledge and understanding of the process of reclamation and developing technologies for improving and sustaining the productivity of salty land and waters.

Objectives

- To undertake basic and applied research for generating appropriate agro-chemical/ biological/ hydraulic technologies for reclamation and management of salt affected soils and use of poor quality irrigation waters for sustainable production in different agro-ecological zones
- Evolve, evaluate and recommend strategies that promote adoption of preventive/ ameliorative technology
- To act as repository of information on resource inventories and management of salt affected soils and waters
- To be a nucleus of researches on salinity management and co-ordinate/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 and to collaborate with relevant national and international agencies in achieving the above goals

Functions

- To develop appropriate technologies for rehabilitation of salt-affected land and sustainable use of poor quality waters for irrigation
- To formulate policies to promote the adoption of preventive measures in the development of salt degraded land, and to provide expertise, training and consultancy for reclaiming salt degraded land and use of poor quality waters.

Section 2

Inter se Priorities among Key Objectives, Success Indicators and Targets

S.No.	Objectives	Weight	Action	Success indicators	Unit	Weight	Target/Criteria value				
							Excellent	Very good	Good	Fair	Poor
							100%	90%	80%	70%	60%
1.	Characterization and management of salt affected soils	45	Technology development	Technology for reclamation and management of saline and sodic soils	No.	35.0	8	7	6	5	4
				Identification/ screening of salt tolerant lines	No.	10.0	2000	1700	1500	1000	800
				Breeder seed produced	Qtls.	5.0	68	65	63	45	35
			Assessment and delineation of salt affected soils and waters	Resource maps / report / database on salt affected soils and waters developed	No.	5.0	4	4	3	2	1
2.	Productive utilization of marginal and poor quality waters	24	Technology development	Water management technologies	No.	18.0	6	5	4	3	2
				Mitigation technologies developed	No.	6.0	5	4	3	2	1
3.	HRD and capacity building	11	Transfer of technology	Front Line Demonstrations/ Farmers Fair/ Farmers Day/Exhibitions	No.	6.0	39	38	35	27	22
			Creation of awareness and knowledge	Training of SMS/Officers/Field functionaries	No.	5.0	9	8	7	5	4
4.	Publication / Documentation	5	Publication of the research articles in the journals having the NAAS rating of 6.0 and above	Research articles published	No.	3.0	25	24	22	20	18
			Timely publication of the Institute Annual Report (2013-2014)	Annual Report published	Date	2.0	June 30, 2014	July 02, 2014	July 04, 2014	July 07, 2014	July 09, 2014

5.	Fiscal resource management	2	Utilization of released plan fund	Plan fund utilized	%	2.0	98	96	94	92	90
6.	Efficient Functioning of the RFD System	3	Timely submission of Draft RFD for 2014-2015 for Approval	On-time submission	Date	2.0	May 15, 2014	May 16, 2014	May 19, 2014	May 20, 2014	May 21, 2014
			Timely submission of Results for 2013-2014	On-time submission	Date	1.0	May 1, 2014	May 2, 2014	May 5, 2014	May 6, 2014	May 7, 2014
7.	Enhanced Transparency / Improved Service delivery of Ministry/Department	3	Rating from Independent Audit of implementation of Citizens' / Clients' Charter (CCC)	Degree of implementation of commitments in CCC	%	2.0	100	95	90	85	80
			Independent Audit of implementation of Grievance Redress Management (GRM) system	Degree of success in implementing GRM	%	1.0	100	95	90	85	80
8.	Administrative Reforms	7	Update organizational strategy to align with revised priorities	Date	Date	2.0	Nov. 1, 2014	Nov. 2, 2014	Nov. 3, 2014	Nov. 4, 2014	Nov. 5, 2014
			Implementation of agreed milestones of approved Mitigating Strategies for Reduction of	% of Implementation	%	1.0	100	90	80	70	60
			potential risk of corruption (MSC)								
			Implementation of agreed milestones for ISO 9001	% of implementation	%	2	100	95	90	85	80
			Implementation of milestones of approved Innovation Action Plans (IAPs)	% of implementation	%	2	100	90	80	70	60

Section 3

Trend values for the success indicators

S.No.	Objectives	Actions	Success indicators	Unit	Actual value for FY 12/13	Actual value for FY 13/14	Target value for FY 14/15	Projected value for FY 15/16	Projected value for FY 16/17
1.	Characterization and management of salt affected soils	Technology development	Technology for reclamation and management of saline and sodic soils	No.	6	7	7	8	8
			Identification/ screening of salt tolerant lines	No.	1300	1500	1700	2000	2200
			Breeder seed produced	Qtls	60	63	65	68	70
		Assessment and delineation of salt affected soils and waters	Resource maps / report / database on salt affected soils and waters developed	No.	3	3	4	4	5
2.	Productive utilization of marginal and poor quality waters	Technology development	Water management technologies developed	No.	4	5	5	6	6
			Mitigation technologies developed	No	3	4	4	5	5
3.	HRD and capacity building	Transfer of technology	Front Line Demonstrations/ Farmers Fair/ Farmers Day/Exhibitions	No.	32	35	38	41	42
		Creation of awareness and knowledge	Training of SMS/Officers/Field functionaries	No.	7	7	8	8	9
4.	Publication/Documentation	Publication of the research articles in	Research articles published	No.			28		

		the journals having the NAAS rating of 6.0 and above							
		Timely publication of the Institute Annual Report (2013-2014)	Annual Report published	Date			02.07.2014		-
5.	Fiscal resource management	Utilization of released plan fund	Plan fund utilized	%			96		
6.	Efficient Functioning of the RFD System	Timely submission of Draft RFD for 2014-2015 for Approval	On-time submission	Date	-	-	May 16, 2014	-	-
		Timely submission of Results for 2013-2014	On-time submission	Date	-	-	May 2, 2014	-	-
7.	Enhanced Transparency / Improved Service delivery of Ministry/Department	Rating from Independent Audit of implementation of Citizens' / Clients' Charter (CCC)	Degree of implementation of commitments in CCC	%	-	-	95	-	-
		Independent Audit of implementation of Grievance Redress Management (GRM) system	Degree of success in implementing GRM	%	-	-	95	-	-
8.	Administrative Reforms	Update organizational strategy to align with revised priorities	Date	Date	-	-	Nov. 2, 2014	-	-
		Implementation of agreed milestones of	% of Implementation	%	-	-	90	-	-

		approved Mitigating Strategies for Reduction of potential risk of corruption (MSC)							
		Implementation of agreed milestones for ISO 9001	% of implementation	%	-	-	95	-	-
		Implementation of milestones of approved Innovation Action Plans (IAPs)	% of implementation	%	-	-	90	-	-

Section 4

Description and Definitions of Success Indicators and Proposed Measurement Methodology

Objective 1: Reclamation and management of alkali soils covers development of technology packages by conducting experiments in saline, alkaline and waterlogged soils. The experiments will be conducted on resource conservation, integrated water and nutrient management, use of poor quality waters, multi-enterprise agriculture and agroforestry models etc.

One of the most important strategy of managing salt affected soils is to screen and produce salt tolerant rice and wheat varieties. The institute produced breeder seed of salt tolerant rice, wheat and mustard varieties suitable to be grown in salt affected soils.

With respect to the database development of salt affected soils and poor quality waters, the action points/ success indicators cover assessment and delineation of salt affected areas and mapping in various districts of salt affected areas. This will be done using remote sensing and GIS/GPS techniques, observations of ground truths through digging the soil profiles in selected districts affected by salt affected soils and digitizing the existing maps.

Objective 2: Multiple water use, rainwater harvesting, irrigation technology and recharge filter, the action point/success indicators cover development/evaluation of technologies for improving marginal quality groundwater, augmentation of groundwater, utilization of poor quality water and sewage water application in horticultural crops. It may be achieved through rainwater harvesting for transporting surface water to aquifer through injection wells and application of modern irrigation system like sprinkler, drip for utilization of marginal quality water for irrigating horticultural crops for improving water productivity. This also covers development of recharge filter by evaluating different filter materials and evaluating different vegetative barriers as biological filter to reduce sediment load of recharging water. A set up to measure back pressure in sub-surface drip irrigation while using sewage water for horticultural crops will also be developed. Sewage water of residential quarters as well as office building will be collected in a sub-surface storage tank at farm and after primary filtration; its feasibility for use through sub-surface drip system would be assessed. For characterizing salt affected soil, pH, EC, Sodium Adsorption Ratio (SAR) and

Exchangeable sodium percentage will be determined and for characterizing poor quality water, pH, EC, SAR and Residual Sodium Carbonate will be analyzed.

Objective 3: Technology evaluation and impact assessment involves the assessment of different technologies developed by the institutes. With pre-designed interview schedule necessary information is collected from farmers by using appropriate sampling technique. The data are analyzed to find out the socio-economic impact of these technologies on farmers. The major techniques used for analysis are Benefit-cost ratio; net present value, internal rate of returns, payback period etc. With respect to transfer of technology, the institute is conducting front line demonstrations (FLDs), farmers' fair/farmers day, and exhibitions at both field as well as institute level. Organizing kisan mela for both rabi and kharif season. For capacity building of stake holders, the training of Subject Matter Specialist (SMS), state level officers and farmers level is organized. The farmer queries are solved through toll free phone. Farmers are benefitted with soil and water testing facility organized by the division.

Section 5

Specific Performance Requirements from other Departments

1. State agricultural departments, command area development authorities, Haryana land reclamation and Development Corporation, Uttar Pradesh land development and Reclamation Corporation for extension of technologies of reclamation of alkali/saline waterlogged soils.
2. Pro-active role is also expected from KVKs and NGOs for technology adoption.

Section 6

Outcome / Impact of activities of organization/ministry

S. No	Outcome / Impact	Jointly responsible for influencing this outcome / impact with the following organization (s) / department(s)/ ministry(ies)	Success Indicator (s)	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017
1.	Productive utilization of saline, sodic, waterlogged soils and poor quality waters	Haryana Land Reclamation and Development Corporation, Uttar Pradesh Land Development and Reclamation Corporation, State Dept. of Agriculture, State Dept. of Irrigation, CADA, State Agricultural Universities.	Hectares of land reclaimed	9500	10000	11000	12000	12500
			Tonnes of food grain per annum produced from reclaimed land	57000	60000	66000	72000	75000

Annual Performance Evaluation Report (April 1, 2014 to March 31, 2015) in respect of RFD of CSSRI

Name of the Division: NRM
Name of the Institution: CSSRI, Karnal

RFD Nodal Officer of the RSC: Dr. Parveen Kumar

S.No.	Objectives	Weight	Action	Success indicators	Unit	Weight	Target/Criteria value					Achievements	Performance		Percent achievements against target values of 90% col.	Reasons for shortfalls or excessive achievements, if applicable
							Excellent	Very good	Good	Fair	Poor		Raw score	Weighted score		
							100%	90%	80%	70%	60%					
1.	Characterization and management of salt affected soils	45	Technology development	Technology for reclamation and management of saline and sodic soils	No.	25	8	7	6	5	4	8	100	25.0	114.3	No shortfalls in the achievements. The excess achievement is based on the target
				Identification/ screening of salt tolerant lines	No.	10	2040	1700	1360	1020	680	2100	100	10.0	123.5	- do-
				Breeder seed produced	Qtls.	5	78	65	52	39	26	72	95.4	4.77	110.8	- do-
			Assessment and delineation of salt affected soils and waters	Resource maps / report / database on salt affected soils and waters developed	No.	5	5	4	3	2	1	4	90	4.5	100.0	NA
2.	Productive utilization of marginal and poor quality waters	24	Technology development	Water management technologies	No.	18	6	5	4	3	2	6	100	18.0	120.0	- do-
				Mitigation technologies developed	No.	6	5	4	3	2	1	5	100	6.0	125.0	- do-
3.	HRD and capacity building	11	Transfer of technology	Front Line Demonstrations/ Farmers Fair/ Farmers Day/Exhibitions	No.	6	47	38	29	20	11	44	96.7	5.80	115.8	- do-
			Creation of awareness and knowledge	Training of SMS/Officers/Field functionaries	No.	5	10	8	6	4	2	9	95	4.75	112.5	- do-
4	Publication /Documentation	5	Publication of the research articles in the journals having the NAAS rating of 6.0 and above	Research articles published	No.	3	29	24	19	14	9	27	96	2.88	112.5	- do-

			Timely publication of the Institute Annual Report (2013-2014)	Annual Report published	Date	2	June 30, 2014	July 02, 2014	July 04, 2014	July 07, 2014	July 09, 2014	June 25, 2014	100	2.0	-	-
5	Fiscal resource management	2	Utilization of released plan fund	Plan fund utilized	%	2	98	96	94	92	90	99.97	100	2.0	-	-
6	Efficient Functioning of the RFD System	3	Timely submission of Draft RFD for 2014-2015 for Approval	On-time submission	Date	2	May 15, 2014	May 16, 2014	May 19, 2014	May 20, 2014	May 21, 2014	March 05, 2014	100	2.0	-	-
			Timely submission of Results for 2013-2014	On-time submission	Date	1	May 1, 2014	May 2, 2014	May 5, 2014	May 6, 2014	May 7, 2014	April 28, 2014	100	1.0	-	-
7	Enhanced Transparency / Improved Service delivery of Ministry/Department	3	Rating from Independent Audit of implementation of Citizens' / Clients' Charter (CCC)	Degree of implementation of commitments in CCC	%	2	100	95	90	85	80	100	100	2.0	-	-
			Independent Audit of implementation of Grievance Redress Management (GRM) system	Degree of success in implementing GRM	%	1	100	95	90	85	80	100	100	1.0	-	-
8	Administrative Reforms	7	Update organizational strategy to align with revised priorities	Date of Updating organizational strategy to align with revised priorities	Date	2	Nov. 1, 2014	Nov. 2, 2014	Nov. 3, 2014	Nov. 4, 2014	Nov. 5, 2014	Oct. 31, 2014	100	2.0	-	-
			Implementation of agreed milestones of approved Mitigating Strategies for Reduction of potential risk of corruption (MSC)	% of Implementation	%	1	100	90	80	70	60	100	100	1.0	-	-
			Implementation of agreed milestones for ISO 9001	% of implementation	%	2	100	95	90	85	80	100	100	2.0	-	-
			Implementation of milestones of approved Innovation Action Plans (IAPs)	% of implementation	%	2	100	90	80	70	60	100	100	2.0	-	-

Total Composite Score: 96.70

Rating: Excellent







हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

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