5th National Seminar on Climate Resilient Saline Agriculture: Sustaining Livelihood Security-2017

5th National Seminar

Climate Resilient Saline Agriculture: Sustaining Livelihood Security








ABSTRACTS

(21 - 23 January 2017)

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Indian Society of Soil Salinity and Water Quality, Karnal, Haryana

Swami Keshwanand Rajasthan Agricultural University, Bikaner, Rajasthan

ICAR-Central Soil Salinity Research Institute, Karnal, Haryana

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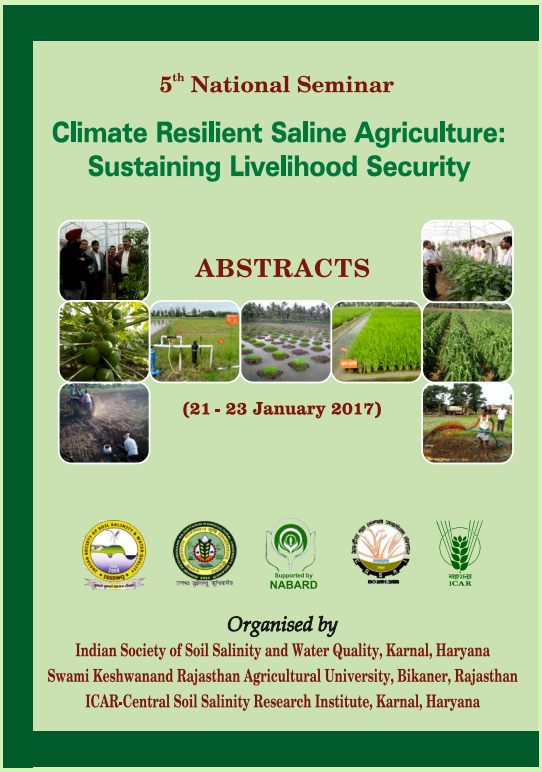

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Dr RK Yadav
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Kachhwa Road, Karnal - 132 001, Haryana, India
Tel: 0184-2209310 (O)
Fax: 0184-2290480
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Abstracts

5th National Seminar

Climate Resilient Saline Agriculture: Sustaining Livelihood Security

21 – 23 January 2017

Editors

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Anshuman Singh
Gajender Yadav
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I J Gulati
P C Sharma

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Organizing

5th National Seminar

On

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Organizers

FOREWORD

Agriculture holds the key to nation's stride towards attaining its objectives of food security, poverty alleviation and inclusive growth. The application of science and technology in Indian agriculture has led to a remarkable progress not only in food grain production but also in horticulture, animal husbandry and fisheries. We are leading producers of rice, wheat, pulses, fruits, vegetables etc. In spite of these developments, the current agriculture is stressed by pressures of burgeoning population, climate change and other production constrains.

The committed endeavours in agricultural research and development have helped transcending the boundaries of production and productivity despite the serious constraints of dwindling size of holdings, vagaries of weather and climatic variability marked with recurrent incidences of calamities like droughts and floods, apart from over exploitation of natural resources and poor quality irrigation water in resource poor conditions. In order to sustain the achievements made in farming sector, there is a need to develop innovative technologies and also transfer the same among farming community. The farmers in India have been the crusaders of several revolutions in agriculture. Central Soil salinity Research Institute has developed several innovative technologies in the field of salt affected soils and use of poor quality water in agriculture in the changing climatic scenario. It is planned to bring the researchers, policy planners, farmers, and developmental personnel's on a common platform to evolve comprehensive and holistic recommendations for climate resilient saline agriculture sustaining livelihood security in resource poor natural resource conditions in the country.

In view of this background, scientific community engaged in reclamation and management of salt affected soils and poor quality waters had formed Indian Society of Soil salinity and Water Quality to address the issues of stressed environment at global, national, regional and local levels. The **5th National Seminar on "Climate Resilient saline Agriculture: Sustaining Livelihood Security"** would focus on the issues related to resource poor conditions for betterment of the farming community and will benefit all concerned and contribute to Indian agriculture in changing climatic scenario for transfer the technological advancements to disseminate the information to the grass root level workers and farmers for their livelihood security. The themes in this seminar cover modern tools and techniques for diagnosis and prognosis of salt affected soils and poor quality waters, challenges in reclamation and management of salt affected soils, advancements in reclamation and management of poor quality waters, climate resilient approaches for enhancing agricultural productivity, multiple stress tolerance in biological systems, knowledge initiatives and policy dimensions and a special session on Western India.

I am grateful to all my colleagues for timely and valuable inputs for this National Seminar.

(Parbodh Chander Sharma)
President, Indian Society of Soil salinity and Water Quality &
Director, ICAR-Central Soil Salinity Research Institute, Karnal

09 January 2017

Indian Society of Soil Salinity and Water Quality

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Contents

Theme I

Modern Tools and Techniques for Diagnosis and Prognosis of Salt Affected Soils and Poor Quality Waters

Assessment and mapping of salt affected soils of Koppal district in TBP command area of Karnataka

Vishwanath J, Anand SR, Rajkumar RH and Karegoudar AV

Agricultural Research Station, University of Agricultural Sciences, Gangavathi – 583 227, Karnataka

E-mail: vishwasws@gmail.com

Abstract

Twin problems of waterlogging and soil salinity, attributed to intensive water use and neglect of drainage, emerged as a severe constraint to sustainable crop production in the Tungabhadra project (TBP) command area of Karnataka. Despite high severity, exact estimates on the extent of salinity are lacking making it imperative to accurately delineate the salt affected areas through intensive ground truth to arrive at a close approximation of the problem. With the aid of GPS and toposheet, soil samples were collected on a grid basis (5' x 5' = 9 x 9 km) from Koppal (Gangavathi taluk) district during May 2014. A total of 282 soil samples (0-15, 15-30, 30-60 and 60+ cm) from 16 grids (73 sampling points) representing 59 villages were collected and characterized for soil salinity appraisal. At surface soil (0-15 cm), $pH_{1:2.5}$, pH_s, $EC_{1:2.5}$ and EC_e varied from 9.40 to 5.85, 8.15 to 5.31, 24.0 to 0.10 (dSm^{-1}) and 64 to 0.25 (dSm^{-1}), respectively, with an average of 8.12, 7.37, 1.68, and 4.38, respectively. Soil $pH_{1:2.5}$ increased with the depth. Among cations, average Na^+ content was more than Ca+Mg followed by K. In case of anions, average Cl^- content was more than HCO_3^- followed by SO_4^{2-}. Nearly 15% of surface samples had EC_e >4.0 dS m^{-1}. Further, per cent of samples with >1 $(CO_3+HCO_3)/(Cl+SO_4)$ and $(Na/(Cl+SO_4)$ ratios were to the extent of 22 and 43, respectively indicating that the soils are slowly transforming into sodic. Nearly 18% of the samples had SAR >13. At lower depths, the mean EC_e was less than the surface value. Similar to the surface soil, Na^+ and Cl^- were dominant among cations and anions, respectively. Not only the values of $(CO_3+HCO_3)/(Cl+SO_4)$, $(Na/(Cl+SO_4)$ ratio and SAR increased with the depth but the number of samples falling under this category also increased with depth from 21.9 to 30.6, 42.5 to 65.3 and 17.8 to 34.4, respectively.

Delineation and mapping of ground water quality through grid survey in Karur district of Tamil Nadu

M Baskar, P Balasubramaniam, P Pandiyarajan and MJ Kaledhonkar

AD Agricultural College and Research Institute, Tamil Nadu Agricultural University, Trichy – 620 009, Tamil Nadu

[1]ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana

E-mail: mbaskar_uma@rediffmail.com

Abstract

Many areas of Karur district of Tamil Nadu are affected with the problem of poor quality water. In this context, 153 water samples (open and bore wells) were collected from different parts of Karur district to evaluate the groundwater quality. The water samples were analyzed for pH, EC, cations (Ca, Mg, Na and K) and anions (CO_3, HCO_3, Cl and SO_4). Quality parameters like SAR and RSC were calculated. Classification of water quality was done on the basis of EC, SAR and RSC values as suggested by CSSRI, Karnal. Out of the 8 Blocks *viz.*, Aravakurichi, Kadavur, Karur, Krishnarayapuram, Kulithalai, K. Paramathi, Thanthoni and Thogaimalai of the district, the proportion of good quality samples was higher in Thogaimalai block (66.6 %)

and K. Paramathi block (65.4 %). The proportion of good quality water was lowest in Karur and Thanthoni (12.5% each) blocks. Presence of marginally saline (7.7 to 37.5 %) and marginally alkali (11.1 to 37.6%) water was observed in all the blocks. Saline water is prevalent in Aravakurichi (5.9%), Karur (31.3%), K.Paramathi (3.8%), Thanthoni (16.7%) and Thogaimalai (5.6%) blocks. Alkali water was found in almost all the blocks (5.9 to 17.6%) except in K. Paramathi and Thogaimalai blocks. High SAR saline water was found in Kulithalai block (6.7%). In general, the distribution of cations was in the order of Ca, Mg >Na > K. However in high RSC water samples, the distribution of cations was in the order of Na > Ca, Mg > K. Similarly, the distribution of anions was in the order of HCO_3>Cl>SO_4 when water quality was good (EC <2 dS m^{-1}). But the distribution of anions followed the order of Cl>HCO_3>SO_4 in marginally saline waters (EC 2-4 dS m^{-1}) and Cl>SO_4>HCO_3 when water salinity was above 4.0 dS m^{-1}. Out of the total samples collected from Karur district, 38.6% were of good quality, 18.3% marginally saline, 7.8% saline, 0.70% high SAR Saline, 26.1% marginally alkali and 8.5% were alkali in nature.

Studies on properties of saline soils in Uppugunduru region of Prakasam district, Andhra Pradesh

K Nancy Jasmine, P Prasuna Rani, PRK Prasad, Y Ashoka Rani and R Lakshmipathy*

Agricultural College (ANGRAU), Bapatla – 522 101, Andhra Pradesh

****E-mail: pprasuna09@yahoo.com***

Abstract

Salt stress is a major environmental threat to soil health and crop productivity. Uppugunduru village in Prakasam district suffers from soil salinity limiting the choice of crops grown. The present study was carried out by collecting 100 representative soil samples during last week of June 2014 from Uppugunduru region of Prakasam district. The soils were analysed for physical and physico-chemical properties and nutrient status following standard methods. Soil texture in the studied samples was clay to sandy clay. Water holding capacity was relatively high in clay soils ranging from 32.98 to 70.81% with a mean value of 51.94%. Higher bulk density values were recorded in sandy clays than clay soils. The soils were found to be neutral to moderately alkaline in reaction. The electrical conductivity of saturation extract (EC_e) varied from 0.74 (non-saline) to 40.02 dS m^{-1} (severely saline) with a mean value of 13.61 dS m^{-1}. The soils of the region were low to medium in organic carbon, low in available nitrogen and medium to high in available phosphorus and potassium. The soil microbial and enzyme activities were estimated in selected soils having EC_e of 4, 12, 22 and 36 dS m^{-1}. Data revealed that fungi were more sensitive than bacteria and actinimycetes to salt stress as fungal population drastically declined (91.49%) compared to moderate reductions (about 37%) in bacteria and actinomycetes when EC_e increased from 4 to 36 dS m^{-1}. The enzyme activity also followed a declining trend with increasing salinity. Dehydrogenase and alkaline phosphatase activities declined by 45.95% and 75%, respectively when EC_e increased from 4 to 36 dS m^{-1}. The dominant natural vegetation at different salinity levels in selected fields were identified and it was observed that some plants like *Croton sparsiflorus* are capable of growing up to the highest salinity of 36 dS m^{-1} while *Tribulus terrestris* grew only up to 12 dS m^{-1}. *Cressa critica* plants were observed in fields with EC_e above 22 dS m^{-1}.

Estimation and spatial characterization of dominant cations and anions contributing to soil salinity and sodicity using Electromagnetic Induction method in salt affected soils

Bhaskar Narjary, MD Meena, Satyendra Kumar, SK Kamra and DK Sharma
ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
E-mail: bhaskar.narjary@icar.gov.in

Abstract

Accurate information on spatial variability in salinity and sodicity (sodium adsorption ratio-SAR) at the field scale is one of the basic requirements for effective salinity management in agricultural lands. Cost effective, rapid, easy and less labour intensive geophysical electromagnetic induction method by EM-38 was used for determination of dominant cations and anions responsible for soil salinity and sodicity (SAR) *in situ*. Electrical conductivity sampling assessment and prediction (ESAP) software was used for the prediction of soil salinity and sodicity at field scale. The study area covers 12 ha land at the CSSRI Experimental Farm, Nain, Panipat. EM-38 horizontal and vertical survey observations at 20 x 20 m grid spacing were taken over 12 ha area. For calibrating EM-38 readings, 21 optimal sampling locations were identified in the field. Based on the EM horizontal and vertical survey readings, soil samples were collected at 15 cm depth interval up to 90 cm depth (i.e., 0–15, 15–30, 30 –60 and 60 –90 cm) and were analyzed for electrical conductivity of saturated extract (EC_e), saturation percentage (SP) and moisture content (GMC), cations (Ca^{2+}, $Mg^{2+}$and Na^{1+}), anions (CO_3^{2-}, HCO_3^{1-}, Cl^{1-}) and SAR using wet chemistry procedure. Dominant cations and anions responsible for soil salinity were identified using Pearson's correlation analysis. Spatial distributions of soil salinity and SAR at the field scale were quantified and mapped using ordinary kriging (OK) interpolation method employed in Arc-GIS 9.3. Results revealed that sodium (Na^{1+}) and chlorine (Cl^{1-}) ions were strongly correlated with apparent conductivity (EC_a) measured by EM-38 as well as soil saturated extract (EC_e) and SAR. Apparent conductivity (EC_a) based multiple linear regressions (MLR) calibration strongly predicted soil salinity at all depths while only upper surface soil layer (0-15 cm) was strongly correlated with observed SAR. Quantitative evaluation of soil salinity for the bulk average profile (0-90 cm) indicated that less than 99% area of the field had EC_e above 4 dS m^{-1}. Due to higher Na^{1+} ion, areas of greater sodicity (SAR) coincided with the areas of higher salinity (EC_e). Therefore, combined use of electromagnetic induction techniques (EM-38), prediction (MLR model in ESAP) and mapping software (OK in Arc-GIS 9.3) are helpful in preparing quantifiable soil salinity map. This could serve as a basis for any rehabilitation effort of salt affected soils according to their actual degree of salinity.

Assessment of groundwater quality in Upper Wardha command area of Maharashtra

PR Kadu, SM Jadhao, BA Sonune and YB Taide
Department of Soil Science and Agricultural Chemistry,
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola – 444 104, Maharashtra
E-mail: prkadu67@gmail.com

Abstract

The well and canal water samples were collected from left bank canal of Upper Wardha project which is constructed on Wardha river. Out of 14 samples 7 samples were collected from well and 7 from canal. All the

water samples were moderately alkaline with pH ranged from 7.3-8.1 and low to medium in salinity which was varied from 0.49-1.20 dSm^{-1}.

The ionic concentration and the proportion of monovalent to divalent cations govern the behaviour of water. The total ionic concentration increased proportionately in water to change the electrical conductivity. Calcium ranged between 2.1-3.1 $meqL^{-1}$, and magnesium 2.5-5.7 $meqL^{-1}$ whereas sodium from 0.24-5.51 $meqL^{-1}$. The ratio between calcium and magnesium ranged from 0.1-0.8 indicating the dominance of magnesium. The carbonate and bicarbonate ranged from 2.7-3.6 $meqL^{-1}$ and 2.7 - 4.6 $meqL^{-1}$ respectively. The chloride and sulphate was ranged from 2-3.8 $meqL^{-1}$ and 0.04-5.4 $meqL^{-1}$ respectively. The SAR varied from 0.13-3.48 and RSC was from 0.1-1.5.

The quality of well and canal water is moderately saline and low in sodium (C_2S_1) to highly saline but low in sodium (C_3S_1). Normaly this kind of water is not suitable for irrigation in Vertisols of this area with very high clay, smectitic mineralogy and very low hydraulic conductivity. The irrigated soils showed the 3 to 4 times increase in exchangeable sodium and hydraulic conductivity from somewhat poorly to very poorly drained than recently or non-irrigated soils. This indicates that the C_3S_1 well and canal water of the Upper Wardha canal command area cannot be used for irrigation whereas C_2S_1 water can be used where moderate amount of leaching occurs and these soils should be cultivated with low water requiring crops.

Spectral properties of salt affected soils and development of soil reflectance library – A Lab study of selected soils of Haryana, India

Arijit Barman, Rajeev Srivastava[1], Yagani Sinha[2], Ashim Datta, RA Nasre[1], DS Mohekar[1], M Sethi and RK Yadav

ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana

[1]ICAR-National Bureau of Soil Survey and Land Use Planning, Nagpur – 440 033, Maharashtra

[2]M.Sc. Scholar, Dr. Punjabrao Deshmukh Krishi Vidyapeeth, Akola – 444 104, Maharashtra

E-mail: arijitbarman1988@gmail.com

Abstract

As traditional methods of salinity measurement based on saturation extract parameters (EC_e, pH_s, Na^+, K^+, Mg^{++}, Ca^{++}, CO_3^{2-}, HCO_3^-, Cl^- and SO_4^{2-}) are tedious and time consuming, the potential for spectral detection and quantification of soil salinity and sodicity in Vis-NIR range in Inceptisols was assessed. This study is an attempt to build a soil reflectance spectral library for rapid and cost effective assessment of soil salinity and alkalinity. Results indicated that the salinity absorption features were more pronounced around 1900 nm followed by 1400 and 2200 nm. Salt concentration was inversely related with reflectance value in saline soils due to retention of moisture and resulting hygroscopicity. Shifting of higher wavelengths at 1900 nm was found to correlate well with increase in salt concentration. A relatively high correlation of EC_e, saturated extract Na^+ and Cl^- with soil reflectance values was found between 1420 to 2020 nm in comparison to other soil properties. An increased use and application of VNIR would help establish a detailed spectral library through captured reflectance in ENVI. This would later prove an asset in dealing with salt degradation more effectively and efficiently.

Monitoring spatio-temporal changes in soil salinity of subsurface drainage project using Electromagnetic Induction technique

AL Pathan, Bhaskar Narjary, Ramesh Abhishek, Satyendra Kumar, DS Bundela and SK Kamra
ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
E-mail: aslampathan88@gmail.com

Abstract

Effective control of soil salinity by lowering the water table below crop root zone is the major objective of installing sub-surface drainage (SSD) projects in waterlogged saline areas. Since salinity is highly dynamic in nature, its assessment and monitoring over large areas assumes greater significance. In this study, an Electromagnetic Induction (EMI) technique was used for rapid appraisal of spatio-temporal changes in soil salinity in a SSD project area at Siwana Mal (Jind district) over a period of three years (2012 to 2015). Apparent conductivity (EC_a) measurements at 70 to 80 locations using EM-38 were taken each time in both horizontal and vertical modes. Thirty six soil samples (12 locations with 3 depths) were collected from the same locations of EM-38 measurements to develop the correlation equation. The correlation equations were used to convert EC_a readings into the actual electrical conductivity (EC_e). EC_e estimates were compared with the observed soil salinity in 0-15, 15-30, 30-60 and 0-60 cm depth intervals and resulted in good correlation coefficient (R^2) of 0.71, 0.86, 0.91, 0.90 and 0.85, 0.84, 0.85, 0.87 for 2012 and 2015, respectively. To determine the spatial area under different salinity ranges, spatial soil salinity maps with contour interval of 2 dS m^{-1} were generated using Surfer version 9 software. These spatial salinity maps were used to characterize depth-wise changes in the soil salinity. Significant reduction in soil salinity was observed in all the layers *i.e* 0-15, 15-30, and 30-60 cm during June 2015 since the installation of SSD system in June 2012. The area under moderate salinity (EC_e 8-16 dS m^{-1}) reduced from 56.4 to 30.0% whereas the area under non-saline (normal) soil (EC_e <4 dS m^{-1}) increased from 6.6 to 18.7%. The highest improvement was observed in the first layer (0-15cm) where slightly saline area (4-8 dS m^{-1}) reduced from 66.3 to 23.2% and the non-saline area EC_e (<4 dS m^{-1}) increased from 1.3 to 20.5% over a period of three years. The study revealed that EM-38 probe can be effectively used to monitor the spatio-temporal and vertical changes in soil salinity in the SSD projects.

Comparative assessment of soil salinity in subsurface drainage using electromagnetic and electrical resistivity survey techniques

SD Vibhute, SK Kamra, RS Tolia, DS Bundela and R Abhishek
ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
E-mail: ds.bundela@icar.gov.in

Abstract

Assessment of soil salinity at spatial and temporal scales is necessary for the effective reclamation and management of salt-affected soils. In the present study, two salinity survey methods *viz.*, electrical resistivity and electromagnetic induction were applied to assess soil salinity in two blocks of subsurface drainage project site at Katwara village (Rohtak district) in Haryana. Narrow electrode spacing approach along with Wenner's array configurations in electrical resistivity (ER) survey method was adopted to record electrical

resistance at shallow depths (up to 1.5 m). Four electrode spacings *viz*., 0.3, 0.6, 1.0 and 1.5 m were used to measure electrical resistivity data which was processed using IPIWIN2 tool to get electrical resistivity of homogeneous soil layers. From these values of electrical resistivity depth wise, soil electrical conductivity was calculated. Simultaneously, EM-38 meter was used to measure bulk soil salinity up to 1.5 m depth and multiple regression equations were used to calculate depth wise EC_e. EM readings in vertical position, horizontal position and soil moisture data were used as dependent parameters in multiple regression equation. Subsequently, EC_a values of resistivity meter and EM-38 were compared with the measured EC_e values. The coefficient of determination value was found to be 0.60 for the ER method and in case of EM-38; it varied from 0.7 to 0.9. Although EM-38 meter has given better results than ER survey, ER survey being a promising approach needs to be further investigated with different configurations for improving its accuracy.

Delineation of crop residues burnt areas using remote sensing and GIS techniques: A case study of Karnal, India

Neeraj Kumar, Vivekanand, Ramesh Abhishek, Satyendra Kumar and Bhaskar Narjary

ICAR–Central Soil Salinity Research Institute, Karnal – 132 001, Haryana

E-mail: abhishek816@live.com; neerajwre@gmail.com

Abstract

Agriculture plays a major role in India's gross domestic product (GDP) and contributes about 17.95% to the total GDP. Out of the total agricultural land (6.74 Mha) in country, paddy crop occupied 1.29 M ha and wheat 2.60 M ha in 2014-15. Although a sizeable crop area is being harvested by machines, a major problem with machine harvesting is that they do not harvest the crop from ground surface and leave about 60% of the crop residue over surface. Disposal of residues, particularly in the rice crop, is a difficult task for the farmers. Generally farmers burn the remaining residues in the field itself. In Haryana and Punjab, the residue burning period starts from mid-April to mid-May for wheat and mid October to November for paddy. Exact estimation of the area where residues burns is one of the pre-requisites to adopt effective measures to prevent this harmful practice. Identification of such areas is not possible without help of remote sensing & GIS techniques. Presently, satellite sensors capable of detecting day-to-day anomalies in thermal regime of a given area are available and can be used for this purpose. This study was conducted in Karnal district of Haryana to find out the total area where crop residues were burnt in the year 2016. Data from VIIRS sensor of NASA/NOAA Suomi National Polar-orbiting Partnership (SNPP) satellite was used to the thermal anomalies of 375 square meters. The study used Arc GIS model by overlapping thermal anomalies on the boundary of district Karnal. Results showed that the first and last anomalies appeared on 12 September and 4 November, 2016 respectively. It was noted that out of 167.55 Sq km cropped area, crop residue burning was prevalent in about 104.06 Sq km area. On 11 and 17 October, 2016 burning was seen in the maximum area of 100 and 74 Sq km, respectively.

Monitoring of waterlogging and soil salinity in the IGNP command using Geoinformatics

DS Bundela, Gaurav Dongre, Kaushal Kumar, Bhaskar Narjary, RL Meena and AK Mandal*

[1]ICAR- Central Soil Salinity Research Institute, Karnal – 132 001, Haryana

****E-mail: gauravdongre9@gmail.com***

Abstract

Secondary salinization is one of the major problems in Indira Gandhi Canal Command. The extent of the problem has further increased due to deterioration in canal condition, decrease in ground water quality in good quality zone and improper use of poor quality ground water in water deficit areas. Geoinformatics, a cost effective tool, was applied to assess and monitor the spatial extent of secondary soil salinization and waterlogging in the IGNP command. In this study, a spatial geodatabase of the IGNP Command was generated from digitization of 1:50,000 scale OSM series topographic maps, 1:500,000 scale soil map and 1:50,000 scale canal network maps. The database helped in delineating various canal commands and their bio-physical attributes for assessing the secondary salinization. Pre-monsoon watertable data of the stage-I from 2005 to 2016 was analysed and it was found that the watertable was within 2 m (critical waterlogging) at Masitawali, Chohlinyawali, and Gandheli sites (Hanumangarh district) during pre-monsoon 2016. Multi-temporal Landsat OLI and ETM data of four different years (21 Feb 1999, 19 Feb 2010, 19 Feb 2011 and 4 Feb 2016) were processed using three image enhancement models and Gaussian algorithm. Three major hot spot areas in the stage-I and II were identified. The hot spots in the stage-I were located in the commands of Suratgarh branch, Naurangdesar distributary and Rawatsar branch. Area under waterlogging in the stage-I was monitored from 1999 to 2016 and has decreased by 3.2 times. The area affected by salinization also decreased by 43% from 2011 to 2016.

Theme II

Challenges in Reclamation and Management of Salt Affected Soils

Factors and processes of soil degradation in Purna Valley of Central India

VK Kharche and RK Naitam[1]
Department of Soil Science and Agricultural Chemistry
Dr. Punjabrao Deshmukh Krishi Vidyapeeth, Akola – 444 104, Maharashtra
[1]*ICAR- National Bureau of Soil Survey & Land Use Planning, Nagpur – 440 033, Maharashtra*
E-mail: vilaskharche@rediffmail.com

Abstract

Soil-physiographic relationships provide a fair understanding of variability across the landscape needed for sustainable agricultural planning. Keeping this in view, the swell-shrink soils of the Ramagarh village of Purna valley in Amravati district, Maharashtra in semi-arid region of central India were studied for their morphological, physical and chemical characteristics and mapped at 1:8000 scale using geographical information system. The soils of Ramagarh village are very deep, dark grayish brown to very dark grayish brown in colour, clay in texture and exhibit medium, moderate, sub angular blocky structure in the surface layers while the subsoil horizons had medium, weak to strong angular blocky structure. Soils of the study area are alkaline in reaction, calcareous in nature and had low to medium organic carbon content. In general, the pH, $CaCO_3$ and exchangeable sodium percentage (ESP) increased with depth in all the soils. Because of high smectitic clay content and ESP down the profile, these soils have impeded drainage and show ponding of water in the rainy season. The study indicated soil chemical degradation in terms of sodicity and as per the US soil taxonomy, 18.2% area of the total geographical area of the village suffered from severe sodicity. The higher ESP was related to corresponding decrease in exchangeable Ca and increase in exchangeable Mg. The soils of the uplands are classified as *Sodic Haplusterts* and low land soils belong to *Typic Haplusterts* category at sub-group level. The micro variations in the topography and prevailing semi-arid overhead climate modified the properties of black swell-shrink soils developed from the similar parent material. The study also revealed that topography and climate are the important factors causing soils degradation in the region.

Land modification of waterlogged sodic soil in Sharda canal command for livelihood generation and sustainable crop production

VK Mishra, CL Verma, YP Singh, T Damodaran, SK Jha, Sanjay Arora, AK Singh, SK Singh[1] *and DK Sharma*
ICAR- Central Soil Salinity Research Institute, Regional Research Station, Lucknow – 226 002, Uttar Pradesh
[1]*ICAR- National Bureau of Fish Genetic Resource, Lucknow – 226 002, Uttar Pradesh*
E-mail: vkmishra_63@yahoo.com

Abstract

Sharda Sahayak is one of the major canal commands which provides irrigation to 17.80 lakh ha agricultural lands in 16 districts of Uttar Pradesh. About 0.12 to 0.18 mha sodic land lying in canal command suffer from shallow water table conditions. Waterlogged sodic soils cannot be reclaimed sustainably through gypsum-based technology. To address these problems, a pond-based farming system model for harvesting the canal seepage water for multipurpose use under waterlogged sodic conditions has been initiated in a farmer participatory mode. Out of the total area of 8.0 ha, 0.6 ha land has been shaped to create farm pond for fish

rearing, and raised beds for crop production, repectively. Land modification has made possible to grow different crops such as rice–wheat, tomato-mustard, vegetables, and fodder on raised beds. Rice and wheat productvity were 4.02 t ha^{-1} and 4.26 t ha^{-1}, respectively, with B:C ratio of 2:1. The yield of mustard was 1.29 t ha^{-1} with B:C ration of 1:1. The vegetable system was more profitable in comparison to rice-wheat and tomato-mustard systems. The benefit cost ratio of pisciculture was 5:1. The overall average cost benefit ratio of system was 1.33. The soil pH of all the system was almost less than 9.0. The organic carbon varied from 0.34-0.57 % and 0.24- 0.33 % in surface and subsurface soil, respectively. The depth of water in pond was >0.5 m in month of July to March. Thus, the approach is a financially viable and attractive proposition for the management of waterlogged sodic soils in canal command. However, for larger adoption of the technology some socio-economic constraints and initial cost in model development need to be addressed.

Effect of depth and frequency of irrigation methods on wheat in sodic vertisols of south-west Madhya Pradesh

RK Sharma, UR khandkar and SC Tiwari

College of Agriculture, RVS Krishi Vishwavidhyalaya, Indore – 452 001, Madhya Pradesh

E-mail: rajesh1953_sharma @rediffmail.com

Abstract

Sodic black soils are found in approximately 21965 ha area in different parts of south-west Madhya Pradesh having low rainfall and insufficient irrigation facilities. Presence of excessive exchangeable sodium in sodic black soils tends to modify soil water plant relationship due to reduction in saturated and unsaturated hydraulic conductivity which in turn causes initial swelling followed by particles dispersion and translocation. The conventional water management practices are no longer adoptable in such sodic soils as they require slow, frequent and low volume irrigations as compared to normal soils because crop suffers on account of both moisture stress and aeration under higher quantum of irrigation by normal irrigation practices. This study aimed to arrive at optimum depth and frequency of irrigation for growing wheat on sodic Vertisols using the prevalent methods of irrigation *i.e.*, Border strip irrigation (BSI) and sprinkler irrigation (SI). The study was carried out during the years 2013-14, 2014-15 and 2015-16 in sodic black soils of Salinity Research Station, Barwaha (76^0 0' 27"E and 22^0 14' 48" N), district Khargone, Madhya Pradesh. The experimental soil belongs to order Vertisols (Haplusterts-Sodic phase) and had high CEC 40 cmol (p+) kg^{-1} and ESP (35 $\pm$ 2.0) with low EC_e (0.8 to 1.49 dS m^{-1}) and moderate pH (7.92-8.31) with some minor spatial variability. The soil is clay in texture (clay 54.6%, silt 34.4% and sand 11.0%) with almost negligible steady state infiltration rate (terminal rate). The bulk density of plough layer soil (0-15 cm) is in the range of 1.40 to 1.45 (Mgm^{-3}). The wheat crop (HI-1077) was sown on 18 November 2015 and harvested on 16 April 2016. The stream size used to irrigate borders was 8 LPS. Results revealed that among various depths and frequencies in sprinkler as well as border strip irrigation minimum water expense was observed in sprinkler irrigation with irrigation depth 3 cm. To ensure water saving and high yield, one may irrigate wheat crop in sodic black soils by sprinkler irrigation with 3 cm depth scheduled on the basis of 1.2 IW/CPE ratio. However, in case of border strip method irrigation with COD 85% scheduled on 1.2 IW/CPE ratio gives the best results. The study also revealed that sprinkler irrigation with depth 3 cm and border strip irrigation with COD 85% scheduled on 1.2

IW/CPE ratio obtained higher water productivity (WP). Soil moisture contribution ranged between 4.66 to 3.47 and 4.99 to 4.14 cm/m soil depth in BSI and SI systems, respectively. The soil pH, EC and ESP ranged from 7.9 to 8.31, 0.80 to 1.49 dS m^{-1} and 33.5 to 34.4, respectively. It is inferred that the sprinkler irrigation with irrigation depth 3 cm scheduled on the basis of 1.2 IW/CPE ratio was found the most suitable option for obtaining higher water productivity of wheat crop in sodic black soils.

Improvement in soil properties and yield potential of sugarcane with installation of subsurface drainage in Vertisols of Gujarat

Anil R Chinchmalatpure, Sanjay Kad and SK Kamra

ICAR-Central Soil Salinity Research Institute, Regional Research Station, Bharuch – 392 012, Gujarat

E-mail: rcanil2014@gmail.com

Abstract

Soil and water are essential resources for the sustainable human life. In many irrigated tracts of India, soils suffer from the twin menaces of waterlogging and salinity severely affecting the land productivity. More than 1.0 million ha soils in Black Soil Region (BSR) of India are suffering from excess water and salinity which need special curative interventions. Adoption of sub-surface drainage (SSD) technology has been suggested to sustain the soil health in in BSR. A systematic study was conducted in 45 ha area in Mulad village of Surat district of Gujarat suffering from salinity and waterlogging problems for the last one decade. Vertisols, due to their poor hydraulic conductivity, low infiltration rates, high clay content and narrow workable moisture range are highly prone to waterlogging and salinity, if not managed properly. Farmers of this village had been reporting yield reduction in sugarcane. SSD was installed with 30 m drain spacing and 1.3 to 1.5 m drain depth in the year 2012. Performance evaluation was done in 2016. Results indicated that there is a reduction in soil electrical conductivity from initial high values of 1.2-7.3 dS/m to 0.47-3.90 dS/m up to 90 cm soil depth. The current salinity level is below the threshold level of 4.0 dS/m and is expected to further reduce with time by desalinisation process through SSD. The salinity of drainage water varied from 1.3 to 4.4 dS/m which is expected to further reduce to levels <2.0 dS/m to make it utilizable for irrigation. The chemical composition of drainage water, however, indicates excess sodium salts of carbonates and chloride and sodicity problem in drainage water as reflected by SAR more than 10 and residual sodium carbonate more than permissible limit of 2.5 meq L^{-1} in the most of water samples. The pH of drainage water was found within acceptable range and the concentration of cations is also expected to decrease in subsequent years of operation of SSD. The changes in the soil properties like EC_e, SAR, pH and ESP of different soil layers in different blocks before and after SSD indicated the positive impact of the SSD on soil properties. Sugarcane yield increased significantly from mean 40 t/ha before SSD to mean 96 t/ha after SSD. Subsurface drainage technology is not only technically and economically viable but is also socially acceptable as reflected from socio-economic analysis conducted in the study area.

Characterization of salt affected soils of Punjab for reclamation and management

AK Mandal
ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
E-mail: ak.mandal@icar.gov.in

Abstract

Salt affected soils in Punjab occupy large areas in the south-west and central regions and vary widely in salt composition, internal drainage and pedogenic processes. Continued irrigation with sodic (RSC) ground water has enhanced salt enrichment leading to soil structural deterioration and poor crop productivity. Ten soil profiles were collected from old and recent alluvial plains covering seven districts and analyzed to assess precise reclamation and management options. In irrigated areas, waterlogging occurred in sandy alluvial plain (Pedon 1 and 2) showing loamy sand to sandy loam soil texture, low CEC and the significant contents of $CaCO_3$ calcretes (15.5%) at 0.5 m depth. The Na^+, Cl^-, $SO_4^{2-}$and at places Ca^{2+} and Mg^{2+} salts were dominant and indicated the saline nature of soil. Sodic soils (Pedon 3 and 4) were located in the recent alluvial plain that showed high pH_s (9.3 to 9.9), ESP (72.1 to 81.0) and higher contents of Na^+, CO_3^{2-} and HCO_3^- salts. Sodic soils (Pedon 5 and 6) were also located in the old alluvial plain under canal irrigation, and showed high water table depth (2.0 m), high pH_s (8.8 to 9.1), high surface salt content (EC_e 20.8 dS m^{-1}) and ESP (54.1 to 81.2). The blocky soil structure indicated impermeable soil strata and Na^+ saturation of soil matrix. At places, sodic soils were reclaimed (Pedon 7, 8 and 9) as evident from low surface pH_s (8.6) and were being used for rice-wheat crops. In the sub-surface layers, these soils showed higher pH_s (9.0 to 10.2) and higher contents of Na^+, CO_3^{2-} and HCO_3^-. Barren sodic soil (Pedon 10) was located in the old alluvial plain of central Punjab showing brackish ground water with high RSC. Sodic soils were also located in the Ghaggar plain of Patiala district showing moderate pH_s (8.9 to 9.2), ESP (64 to 76), $NaHCO_3$ content (5.0 to 5.5 $meqL^{-1}$) and SAR (46 to 52). Suitable management options and alternate land uses were suggested for growing salt tolerant crops, horticulture and forestry plantations with proper water management practices.

Evaluation of spacing and controlled subsurface drainage system on soil properties, water table, crop yield and nutrient losses in rice fields of TBP Command of Karnataka

AV Karegoudar, Viswanath J, Anand SR, Rajkumar RH, RL Meena[1], SK Ambast[2] and MJ Kaledhonkar[1]
Agricultural Research Station, University of Agricultural Sciences, Gangavathi – 583 227, Karnataka
[1]ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
[2]ICAR-Indian Institute of Water Management, Bhubneshwar – 751 016, Odisha
E-mail: avkaregoudar12@gmail.com

Abstract

A study was carried out for four consecutive seasons to evaluate the performance of conventional and controlled subsurface drainage (SSD) system with a lateral spacing of 40 (2.62 ha), 50 (2.8 ha) and 60 m (4.0 ha) at Agricultural Research Station, Gangavati from *Kharif* 2012 to *Kharif* 2015. At 40 m spacing, soil salinity in different depths under conventional SSD reduced from 8.05 to 6.39 (0-15cm), 9.94 to 9.38 (15-30 cm), 9.70 to 7.63 (30-60 cm) and 8.66 to 7.61 dS m^{-1} (60-90 cm). In case of controlled drainage system, it reduced from 7.33 to 5.3 (0-15 cm), 9.18 to 7.53 (15-30 cm), 8.63 to 9.72 (30-60 cm) and 8.16 to 9.92 dS m^{-1} (60-90 cm) at different depths. At 50 m spacing, soil salinity under conventional SSD

reduced from 4.30 to 2.56 (0-15cm), 5.1 to 3.36 (15-30 cm), 5.93 to 3.06 (30-60 cm) and 5.25 to 2.91 dS m^{-1} (60-90 cm). Under controlled drainage, it reduced from 6.28 to 4.87 (0-15 cm), 8.3 to 7.63 (15-30 cm), 12.01 to 9.28 (30-60cm) and 13.85 to 6.86 dS m^{-1} (60-90 cm). At 60 m spacing, soil salinity reduced from 7.69 to 6.51 (0-15cm), 10.25 to 8.15 (15-30 cm), 11.01 to 9.33 (30-60 cm) and 11.55 to 10.03 dS m^{-1} (60-90 cm) under conventional SSD. In case of controlled drainage, it reduced from 5.99 to 5.34 (0-15 cm) but showed slightly increased salinity at lower depths: 6.29 to 6.48 (15-30 cm), 6.43 to 6.93 (30-60cm) and 6.10 to 6.75 dS m^{-1} (60-90 cm). In conventional SSD system, the average drain discharge over four seasons was 0.78, 2.05 and 1.12 mm/d for 40, 50 and 60 m spacings, respectively. In case of controlled drainage system it was 0.40, 0.57 and 0.78 mm/d for 40, 50 and 60 m spacings, respectively. Although no consistency was observed among different spacings, the drain discharge was higher under conventional over the controlled system. Irrespective of the system, the average salinity of the drainage effluent was higher at close spacings compared to wider spacing. Under conventional SSD, the salinity of drainage effluent was 4.19, 2.50 and 3.07 dS m^{-1} against 3.73, 2.7 and 2.07 dS m^{-1} at 40, 50 and 60 m spacings, respectively under controlled SSD. In accordance with the drainage discharge, the average salt removal was 0.68, 1.12 and 0.846 t ha^{-1} under conventional against 0.31, 0.53 and 0.305 t ha^{-1} under controlled SSD at 40, 50 and 60 m spacings, respectively. Irrespective of the spacings, drainage discharge and salt removal were higher in conventional over the controlled system. In addition, loss of nitrogen over the sampling period in 40, 50 and 60 m spacings over the four seasons was 2.36 vs. 0.78, 7.09 vs.3.94 and 5.58 vs.3.53 kg ha^{-1} under conventional and controlled SSD systems, respectively. The per cent increase in paddy grain yield was in general higher under conventional (15.0, 41.4 and 35.5 at 40, 50 and 60 m) as compared to controlled SSD (8.9, 30.6 and 26.8 at 40, 50 and 60 m).

Relative efficiency of amendments in reclamation of sodic Vertisols and their effects on crop production

UR Khandkar, SC Tiwari, RK Sharma and SK Verma[1]
College of Agriculture, RVS Krishi Vishwa Vidyalaya, Indore – 452 001, Madhya Pradesh
[1]RVS Krishi Vishwa Vidyalaya, Gwalior – 474 002, Madhya Pradesh
E-mail: sasrvskvv@gmail.com; udaykhandkar56@rediffmail.com

Abstract

Reclamation and utilization of sodic Vertisols is of prime importance in view of the ever increasing population pressure and demand of food grains and other commodities. Among the amendments, gypsum is the cheapest and most convenient source for reclamation of such soils but the availability of mined gypsum has gradually decreased over time. Hence, it is necessary to develop cheap and effective technology utilizing the locally available resources without affecting the ecological balance for the reclamation of sodic Vertisols. Distillery waste (Spent Wash) may be used as an amendment as it contains huge amounts of calcium and magnesium. It also contains appreciable amounts of essential nutrients and organic carbon. The present investigation was undertaken to study the effect of amendments on paddy and its residual effect on wheat grown in sodic Vertisols. A field experiment was conducted in RBD with 3 replications during two consecutive years in *Kharif* and *Rabi* 2007-08 and 2008-09 at Salinity Research Farm, Barwaha, district Khargone, M.P. with paddy (var. Kranti)- wheat (var. GW 173) cropping sequence. The treatments consisted of control, FYM @ 5 t ha^{-1}, vermicompost @ 5 t ha^{-1}, gypsum @75% GR, gypsum @75% GR+FYM @ 5 t ha^{-1}, gypsum @75% GR + vermicompost @ 5 t ha^{-1}, spent wash 2.5 lakh L ha^{-1}, spent wash 5.0 lakh L ha^{-1} and spent wash 10.0 lakh L ha^{-1}. The experimental soil belongs to fine smectitic family of typic heplusterts- sodic phase having pH_s 8.4, EC_e 1.4 dS m^{-1} and ESP 38.8. The plant height, effective tillers, length of panicle/ear head, grain and straw yield of paddy and wheat significantly increased over control with the application of spent wash @ 5.0 lakh L ha^{-1} in both the years. Application of spent wash @ 5.0 lakh L ha^{-1} increased the grain yield of paddy by 43.8 and 39.7% and of wheat by 44.7 & 85.2 % over control during 2007-08 and 2008-09, respectively. Uptake of Ca, Mg and K in grain and straw of paddy and wheat also significantly enhanced

with 5.0 lakh L ha^{-1} spent wash over control. However, the uptake of sodium significantly decreased during both the years except by paddy grain and straw during 2008-09. Organic carbon, available nitrogen and potassium status improved with the application of spent wash @ 5.0 lakh L ha^{-1} in the year 2007-08 and 2008-09. Soil ESP was reduced from 38.8 (initial) to 17.8 and 17.1 at wheat harvest in 2007-08 and 2008-09.

Exploring land and water management options for farming in low lying areas in coastal region of Maharashtra

KD Patil, JJ Palkar, SS Khobragade and MJ Kaledhonkar
Khar Land Research Station, Dr. BS Konkan Krishi Vidyapeeth, Panvel – 410 206, Maharashtra
E-mail: klrs59@rediffmail.com

Abstract

Maharashtra has a 720 km long sea coast where saline soils occupy an estimated area of 65000 ha. These coastal saline soils have developed due to tidal ingress of sea/creek water and capillary rise of salts from ground water during hot summer season. About 45000 ha land protected by the embankment have been brought under cultivation. In coastal saline soils, rice is the only crop taken in *Kharif* season and no cropping is possible in the *Rabi* season due to lack of irrigation water and rise in salinity. Hence, a study was undertaken to develop an ideal and profitable model of farming system for the region in one hectare land area. The main components consisted of crops such as rice, vegetables, coconut, spices, sapota, livestock and poultry with vermicomposting, kitchen garden and ornamental fish constituting the complementary enterprises. Cost of production through crops, fisheries, poultry, horticulture crops and vermicompost were Rs. 18067, 99895, 8149, 52763 and 19846, respectively. The gross returns from these components were Rs. 26501, 250000, 9040, 80350 and 30750, respectively. The gross expenditure was Rs. 198720 and the gross returns were Rs. 396641 with a B:C ratio of 1.99 from this Integrated Farming System in coastal saline soils.

Testing o integrated farming system Models under waterlogged sodic conditions in Sharda Sahayak Canal Command

Chhedi Lal Verma, YP Singh, AK Singh, SK Jha, T Damodaran, VK Mishra, SK Singh[1], DK Sharma[2] and Manjul Kumar
ICAR-Central Soil Salinity Research Institute, Regional Research Station, Lucknow – 226 002, Uttar Pradesh
[1]ICAR- National Beaureau of Fish Genetic esource, Lucknow *– 226 002, Uttar Pradesh*
[2]ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
E-mail: lalc_verma@yahoo.com

Abstract

A large scale sodic land reclamatio programme was initiate long back in Uttar Pradesh keeping 1.23 million hectare of sodic soils in view long back using gypsum based technology. Out of intial total sodic so nearly 10 to 15% of sodic soil is located in canal commands and remain waterlogged. About 0.20 mha of sodic land had been reclaimed. Waterlogged sodic soils still remain unattended as gypsum based sodic land reclamation technology is ineffective under shallow water table conditions. Lowering of water table by elevating field beds improves internal drainage and improves salt leaching in soil. There was a need to develop a sustainable technology for reclamation and management of waterlogged sodic soils. A land modification based integrated farming system model has proven its ability to reclaim and manage waterlogged sodic soils. A study was taken up in three villages namely Lalai kheda, Patwa kheda and Salempur Achaka to test suitability of land modification based integrated farming system models under varying situations of water logging and water logging coupled with sodicity. The area of ponds were 2356,

817 and 1225 m^2, raised field beds area 2336, 1307 and 2041 m^2 and total area of integrated farming system models were 4692, 2114 and 3266 m^2 in Lalaikheda, Patwakheda, Salempur Achaka villages, respectivel . Water table of the area fluctuated within a range of 0 to 1.5 m below surface during rainy to extreme summer. Initial soil pH of the of Lalai kheda and Patwa kheda sites ranged between 8.96 to 9.69 and EC ranged 0.203 to 1.147 dS/m, up to depth of 0 to 120 cm. Soil pH in Salempur Achaka ranged 7.49 to 7.98 and EC 0.065 to 0.189 dS/m . Soil pH of raised beds immediately after construction ranged 9.01 to 9.30, 9.20 to 9.85 27 and 8.00 to 8.27 and corresponding EC ranged 0.188 to 0.562, 0.326 to 0.737 and 0.194 to 0.485 dS/m in a profile depth of 0 to 120 cm. Early maturing salt tolerant rice (CSR 43) and vegetables was transplanted in Lalai kheda, and Patwa kheda fields. Lalaikheda and Patwakheda field was sown with salt tolerant wheat (KRL 210) while Salempur Achaka village field was planted with potato, onion, garlic, dill, menthe, onion, carrot, chilly, radish and coriander during *Rabi* season. In Lalai kheda pond spawn of C. idella (grass carp) @ 2 million/ha while fish stocking was done in Patawa kheda and Salempur Achaka's ponds. The rice productivity of elevated field beds ranged fror 43 to 54 q/ha. Gross returns from crops, vegetables and fish were Rs. 97340, 16905 and 49685 from Lalaikheda, Patwakheda ans Salempur integrated farming system models, respectivel . All three models showed encouraging response and fast decline in water table afi canal closers were also observed in the area.

Reclamation of saline soils through subsurface drainage technology in Haryana – An economic impact analysis

R Raju, K Thimmappa, Parveen Kumar, Satyendra Kumar and RS Tripathi

ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana

E-mail: r.raju@icar.gov.in

Abstract

Soil salinity is one of the major land degradation problems in India which adversely affects the productivity of agricultural lands in different parts. In India, saline soils occur in 2.96 mha area spread in 12 states and Andaman and Nicobar Islands. Out of the total area, Haryana has 49157 ha salinity affected area. Sub-surface drainage (SSD) technology and improved irrigation management are identified as the most appropriate strategies for sustaining and enhancing the agricultural productivity in waterlogged saline soils. However, installation cost of SSD is very high and an individual farmer cannot adopt this technology on a small scale. This technology can be implemented on large scale with the financial support from the government or other agencies. Haryana operational pilot project has played a major role in installing SSD systems in different parts of the state. It has a target of SSD installation in 1,000 ha area annually. The present study is an attempt to work out the cost of installing SSD system and to examine the economic feasibility and financial viability of this technology in the long run. Findings revealed 44.24% reduction in soil salinity, 49.50% reduction in drainage water salinity and a remarkable reduction in watertable depth (35.80%) in the soils having SSD. As a consequence, there was a considerable (20.32%) increase in cropping intensity, shift in the cropping pattern towards more remunerative crops and significant increase in crop yields. The yield increases in rice, cotton, wheat and mustard crops were 20.46, 16.26, 19.75 and 15.01%, respectively. The combined result of these changes ultimately led to a substantial increase in farm income

after the installation of SSD in farmers' fields. Along with significant increase in the yield of major crops in the project area, a significant proportion (26.60%) of the fallow land was also brought under cultivation. The installation cost was estimated as Rs. 62000/ha. The financial analysis carried out on four alternative crop rotations showed that rice-wheat cropping system provides the highest benefit with a net present worth of Rs. 112862 and a three years payback period. The internal rate of return was estimated to be 39.64% and benefit-cost ratio was 2.71. Thus, the SSD technology proved technically feasible, financially viable and socially acceptable in the rehabilitation of waterlogged saline soils of Haryana.

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

D Burman, UK Mandal, SK Sarangi, S Mandal, KK Mahanta, S Raut, B Maji and TD Lama

ICAR-Central Soil Salinity Research Institute, Regional Research Station, Caning Town – 743 329, West Bengal

E-mail: burman.d@gmail.com

Abstract

The land shaping techniques (LSTs) are most problem solving and suitable approaches for augmenting livelihoods of the farming communities in coastal areas addressing the problems like waterlogging in *kharif* and scarcity of good quality irrigation water and reduction of soil salinity during *rabi*. Experiences indicated that LSTs are capable to harness the benefits, in short period (3-4 years) and continue to be at least for few more years. Long-term effect of such techniques, particularly on soil, soil water and overall sustainability in long-term is not well understood. Therefore, the impacts of different land shaping techniques viz. farm pond, deep furrow and high ridge and paddy cum fish practicing from <3-5 years to >15 years on soil and water quality and also economics were studied. Soil salinity in the profile of different land situations like high land, medium land and original low land created under farm pond technique which implemented since <3 years and >15 years indicated that soil salinity build-up was less in all the land situations as compared to control (without land shaping). Salinity of water in the water harvesting structures under land shaping technique was higher during post monsoon period in newly implemented (<3 years) land shaping technique as compared to old (>15 years) farm pond. However, during monsoon season salinity of the water was similar in both the cases. The organic carbon and available NPK was higher under different land situations created under land shaping techniques as compared to control. Among different years of implementation of land shaping technique organic carbon and available nutrient status was higher under old land shaped plots as compared to new land shaped plots. The B:C ratio was higher for farm pond followed by deep furrow and high ridge and paddy-cum-fish land shaping techniques. The duration of implementation of land shaping techniques did not affect the economics of land shaping techniques.

Effect of Coal Thermal Power flyash on enzymatic activities of sodic soils

Shefali Srivastava, Hina Hayat[1], VK Mishra[2], SK Jha[2] and T Damodaran[2]
Uttar Pradesh Water Sector Restructuring Project-II,
Uttar Pradesh Irrigation Department, Lucknow – 226 002, Uttar Pradesh
[1]Dr. RML Avadh University, Faizabad – 224 229, Uttar Pradesh
[2]ICAR-Central Soil Salinity Res. Institute, Regional Research Institute, Lucknow – 226 002, Uttar Pradesh
E-mail: shefali_0122@yahoo.co.in

Abstract

India has an estimated area of 6.27 M ha of the salt affected soils of which 1.37 M ha area is spread in the central Indo-Gangetic Plains (Uttar Pradesh). These soils have abundance of sodium carbonate, bicarbonate and sulphate, and usually show very low enzymatic activities resulting in poor crop growth. As enzymatic activities plays a major role in the nutrient mobilization for plant development, a pot experiment was conducted to explore the potentiality of flyash in enhancing the enzymatic activity in a sodic soil (pH 10, ESP 70.2% and organic carbon 0.17%). Results indicated that FDA activity was high (44.15 µg fluorescein/g/h) up to the 2.5% w/w flyash application whereas it decreased when higher dose of 5% which was at par with 25GR application. In case of dehydrogenase activity, the same trend was observed with highest activity (7.34 µg TPF/g soil/day) in 2.5% flyash treatment. The activity of alkaline phosphatases was not significantly affected in flyash as well as gypsum treated soil. The activity of urease was also found to enhance (58.42 µg NH_4^+/g soil/hr) over control with the application of 2.5% flyash whereas it was the maximum in 50GR treated pots. Flyash application also increased soil microbial activities which might be useful in improving the nutrient mobilization in plants grown under sodic soil conditions.

Phytoremediation for enhancing agricultural productivity of salt affected soils

Sheetal KR, Subbulakshmi V, Renjith PS, Birbal, Soni ML and Yadava ND
ICAR-Central Arid Zone Research Institute, Regional Research Station, Bikaner – 334 004, Rajasthan
E-mail: sheetalr69@gmail.com

Abstract

About 7% of world's total arable land is classified as salt affected lands, while in India it is around 6.73 million hectare (mha). With the requirement for more food driving agriculture to find new areas and methods for greater productivity, the reclamation of the barren salt affected lands attains utmost importance. Though there are multiple methods to manage and bring back such soils under cultivation, vegetative remediation is of interest, being more cost-effective and environment friendly. The other methods (leaching, organic/chemical amendments) have restrictions depending on type of soil, availability of water, chances for loss of soil nutrients and beneficial micro-organisms; in addition to being more expensive to farmers. Phytoremediation can be defined as the cultivation of salt-tolerant or accumulating (halophyte) plants for the reduction of soil salinity and/or sodicity. There are several halophytes which can be grown at very high levels of electrical conductivity. For examples *Eucalyptus occidentalis* and *E. sargentii* (useful landscape trees) can withstand salinity over 30 dS m^{-1}. About 290 tree species of economic importance have been documented which could tolerate salinity levels of 7 to 8 dS m^{-1}. These plants provide multiple benefits like

accumulation of salts from wider and deeper zones depending on its root system, simultaneously preventing its seepage into ground water. Studies have reported three mechanisms of halophytes: excluder, accumulator, and conductor plants; which are to be considered while selecting plants for this purpose. Several plants have been studied by many researchers for its soil reclamation abilities. Phytoextraction was seen to be more beneficial for EC and SAR reduction under non-leaching conditions, over other treatment options. Salt uptake by different species were seen to vary from 90 to >5000 kg ha^{-1} $year^{-1}$. In this aspect, the potential of native vegetation also needs to be taken into consideration. This achieves utmost importance in arid zones of western India where only salt tolerant species like Khara Lana (*Haloxylon recurvum*), Lani (*Salsola barysoma*), Luni (*Sueda fruticosa*) etc. may be used. These halophyte shrubs have a prime role in the rehabilitation and reclamation of salt affected lands. The efficiency of extraction may further increase with adoption of integrated management techniques (combination with amendments, biological techniques, agricultural practices and land management process. Establishment of perennial trees also allow for a more extended period of remediation. However, there is a great need to develop the proper agro-management techniques and conditions to maximize productivity of halophytic species and for genetic improvement of halophyte characteristics.

Impact of tillage and crop residue management on crop productivity, energy saving, water stable aggregate and infiltration rate under rice-wheat cropping system in sodic soil environment

Ranbir Singh, DK Sharma, PK Joshi, K Thimmappa, Martina Rani, Renu Kumari and Satyendra Kumar
ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
E-mail: ranbir.singh@icar.gov.in

Abstract

A long term experiment was conducted on tillage and residue management for enhancing soil quality and crop productivity under rice-wheat cropping system in sodic soil environment. Six adopted resource conservation technologies (reduce and zero tillage with and without crop residue) vis-à-vis conventional practices (with and without crop residue) were imposed. Hybrid rice cv. Arize 6129 and wheat cv. HD 2967 were taken as the test crops. Five years pooled data of grain yield of rice –wheat sequence indicated that conventional wheat sowing with crop residue incorporation increased grain yield by 10.45% compared to conventional practice (5.45 t ha^{-1}). Whereas, in reduced tillage with crop residue incorporation, increased additional wheat grain yield 3.05 % compared to without crop residue incorporation. In zero tillage, without crop residue recorded 5.39% higher grain yield compared to conventional wheat sowing. However, in zero tillage with crop residue retention recorded 8.99% higher wheat grain yield in comparison to conventional tillage method. In *Kharif* season, higher rice grain yield (7.69 t ha^{-1}) was recorded in TPR (transplanted rice) with crop residue incorporation with 3.78 % higher additional grain yield compared to TPR without crop residue management. Grain yield in DSR (direct seeded rice) increased by 4.68% with crop residue incorporation. However, grain yield in DSR under zero tillage without crop residue produced 6.72 t ha^{-1} which was 8.14% higher compared to zero tillage with crop residue retention due to more weed infestation and less plant population. Soil health improved with increasing water stable soil aggregate and infiltration rate with addition of rice and wheat crop residue simultaneously in conventional, reduce and zero tillage practices. Both rice and wheat crop productivity increased with addition of crop residue by improving soil quality.

Swell-shrink potential of Vertisols in Upper Wardha Command area in relation to clay content, mineralogy and exchangeable sodium under different ionic environments

PR Kadu, JG Giri, NM Konde, VK Kharache and SD Jadho
Department of Soil Science and Agricultural Chemistry,
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola – 444 104, Maharashtra
E-mail: prkadu67@gmail.com

Abstract

Soils of Upper Wardha command area were deep to very deep, clayey, calcareous, moderately to strongly alkaline, non-saline and classified as Typic Hapalustert and Sodic Hapalustert. The soils are under perennial canal irrigation with C_2S_1 water qualities. Magnesium absorption ratio (MAR) is prepared for assessment of water quality, ranged from 1.13 to 1.72. Ca was dominant cation followed by Mg, Na and K with high CEC (48.5 to 59.6 c mol (p^+) kg^{-1}) and base saturation (89 to 99 per cent).

The ESP, EMP and Ca/Mg ratio ranged from 0.9 to 17.1%, 20.0 to 49.7% and 0.6 to 3.8, respectively. Mineralogy of clay fraction dominated with smectite followed by vermiculite, chlorite, mica, kaolinite, quartz and feldspar. The high amount of Na-feldspar content is the source of sodium in the soil. Due to precipitation of soluble Ca^{2+} ions as $CaCO_3$, concentration of Mg^{2+} and Na^{2+} ions increased and this caused the dispersion and swelling of clays. Furthermore, because of injudicious irrigation and raised water table the upward movement of Na^+ initiated. These soils have high swell- shrink potential as COLE (0.17 to 0.27) and VSP (60.2 to 100%) values of all soils fall in the categories of very high (COLE >0.09) shrink-swell classes. The COLE and VSP showed positive correlation with clay, pH, CEC, ESP and SAR. Regression models developed by the step down regression equations explain the processes causing the soil swelling are:

COLE = - 0.0014 + 0.0021 ESP + 0.0023 CEC + 0.0011 Clay + 0.0015 SAR (R^2 = 0.88)
VSP = - 14.310 + 0.7370 ESP + 1.0156 CEC + 0.4927 Clay + 0.7255 SAR (R^2 = 0.87)

The high ESP, EMP, COLE and WDC impaired the HC (0.01 to 2.4) results in waterlogged soils. Therefore, proper selection of crops with provision of surface drainage and far-spaced irrigation are recommended.

Nutrient management in organically grown garlic in coastal saline soils

MM Patel, BK Patel, VR Naik, HK Joshi and VP Usadadia
Coastal Soil Salinity Research Station, Navsari Agricultural University, Danti-Ubharat, Navsari – 396 450, Gujarat
E-mail: mmpatel_nau@rediffmail.com

Abstract

A field experiment was conducted during the *Rabi* season of 2012-13 to 2014-15 at Coastal Soil Salinity Research Station, Danti-Ubharat, Gujarat. The objective was to study the effects of organic source of nutrient like manures and biofertilizers on growth, yield and economics of garlic (*Allium sativum*) grown in a saline soil of coastal South Gujarat. Results revealed that application of recommended dose of N @ 100 kg/ha of which 50% N was applied through bio-compost as basal dose and the remaining 50% through castor

cake 40 days after transplanting (DAT) gave significantly higher values of bulb weight and the minimum weight loss as compared to other treatments. In case of biofertilizers, treatment (with biofertilizer) leads to significantly higher plant height and bulb weight as compared to treatment (without biofertilizer). In case of bulb yield, treatment O_2B_2 and O_3B_2 were at par with each other and both were significantly superior over other treatment combinations. Treatment O_2B_2 also recorded higher gross income (Rs. 366174/ha), net income (Rs. 263039/ha) and B:C ratio (2.55). Application of the recommended dose of N @ 100 kg/ha of which 50% N through bio-compost as basal and remaining 50% N through castor cake at 40 DAT was found to be the best nutrient management practice to maximize the bulb yield and net income from organically grown garlic in coastal salt affected soils.

Effect of irrigation and date of sowing on Salicornia (S*alicornia brachiata* roxb.) in coastal saline soil

MM Patel, BK Patel, VR Naik, HK Joshi and VP Usadadia
Coastal Soil Salinity Research Station, Navsari Agricultural University, Danti-Ubharat, Navsari – 396 450, Gujarat
E-mail: mmpatel_nau@rediffmail.com

Abstract

A field experiment was conducted during 2012-13 to 2014-15 at Coastal Soil Salinity Research Station, Danti-Umbharat, Gujarat to study the effect of different moisture regimes and dates of sowing on production potential and profitability of salicornia in saline soils of coastal South Gujarat. The experiment was laid out in a large plot technique with four spot sampling replications, comprising of three dates of sowing (1 June, 15 June and 1 July) and three irrigation levels (0.6, 0.8 and 1.0 IW/CPE). Results revealed that sowing on 15 June resulted in significantly improved growth and yield attributes such as plant height, canopy spread, number of branches/plant, spikes per plant, segment per spike and plant dry biomass as compared to sowing on either 1 June or 1 July. Among the irrigation levels, both 0.8 and 1.0 IW/CPE were found statistically at par with each other and were significantly superior over 0.6 IW/CPE for plant growth and yield attributing parameters such as plant height, number of spikes per plant, spike length, segments per spike and plant dry biomass. Plant canopy spread and number of branches per plant was significantly higher when irrigation was scheduled at 1.0 IW/CPE ratio compared to 0.6 IW/CPE and 0.8 IW/CPE. Interaction effect was found to be significant on seed yield of salicornia. Treatment combination of 15 June sowing and irrigation at 0.8 IW/CPE recorded significantly higher seed yield (8.56 q ha-1), net income (Rs. 215052) and B:C ratio (2.81). Thus, it can be concluded that sowing of salicornia on 15 June and irrigation with sea water at 0.8 IW/CPE ratio on coastal saline lands were the best practices to increase the productivity and profitability.

Studies on soil properties from sea or creek side to landside in coastal districts of Konkan during pre-monsoon season

SS Khobragade, KD Patil, JJ Palkar and MJ Kaledhonkar
Khar Land Research Station, Dr. BS Konkan Krishi Vidyapeeth, Panvel – 410 406, Maharashtra
E-mail: klrs59@rediffmail.com

Abstract

The total area under saline soils in the coastal Konkan region of Maharashtra state is estimated to be 65000 ha. Konkan region comprises the five districts *viz.,* Palghar, Thane, Raigad, Ratnagiri and Sindhudurg. The coastal saline soils in this region have primarily formed due to periodical inundation of creek/sea water during high tides on cultivable land. Capillary rise of salts from ground water during summer season has also contributed to secondary salinization in many pockets. Soil samples from all five districts in coastal Konkan region were collected during pre-monsoon to study quality of soil and salinization. Soil samples were collected according to distance (0 to 10 km) at surface from sea/creek with GPS coordinates and analysed for different physico-chemical properties. Data revealed that soil salinity (EC) decreased with the increasing distance from the sea/creek. In Palghar, Thane, Raigad, Ratnagiri and Sindhudurg districts EC in soils in immediate vicinity of (distance- 0 km) sea/creek side were 7.69, 7.11, 12.80, 9.70 and 10.87 dS m-1, respectively. At 10 km distance, EC values in the soils of these districts were 0.19, 0.68 (at 2 km), 1.14, 0.43 and 0.14 dS m-1, respectively. Data showed wide variations in EC (between 0.07 to 12.8 dS m-1), pH (4.75 to 7.48) and Na+ content (1.569 to 267.023 meq L-1). SAR ranged from 0.354 to 33.821 without any RSC problem. The average P, K and organic carbon were 0.30 to 1.364 kg ha-1, 3.08 to 522.78 kgha-1 and 4.94 to 42.04 gm kg^{-1}, respectively. On the basis of analysis of surface soil samples collected according to distance from sea/creek in Palghar, Thane, Raigad, Ratnagiri and Sindhudurg districts, it is inferred that degree of salt stress progressively decreases with increasing distance from the sea/creek (0-10 km).

Effect of sub-surface drainage on paddy in Tunga Bhadra command area of Karnataka

Mallika K, MS Ayyanagowdar and Rahul Patil
College of Agricultural Engineering, University of Agricultural Sciences, Raichur – 584 104, Karnataka
E-mail: mallika496@gmail.com

Abstract

In India, the problems of salinity and alkalinity are increasing with time as a result of secondary salinization. Central Water Commission estimated that areas affected by waterlogging and salinity in the country are 8.5 and 5.5 mha, respectively. Waterlogging and subsequent salinization turn the productive lands into wastelands. In light of these facts, a study was conducted in the Tunga Bhadra command area of Karnataka during 2015-16 to evaluate the effects of tile drainage system in salt-affected soils. Water samples were taken fortnightly and analysed for different chemical properties. Water pH ranged from 7.02 to 8.13 and electrical conductivity varied from 4.33 to 14.69 dS m^{-1}. Similarly, Ca^{2+}+Mg^{2+}, Cl^{-}, Na^{+} and K^{+} values were in the range of 4.3 to 12.8, 14.9 to 22.3, 18.7 to 32.5 and 26.8 to 39.2 meq L^{-1}. Sodium adsorption ratio (SAR) ranged from 11.73 to 16.89. Results revealed that pH, Na^{+} and K^{+} increased from sowing to harvest of crop due to soil sodicity and the excess application of irrigation water and fertilizers. Excess nutrient leaching caused by intensive irrigation and rainfall can be controlled by providing a controlled drainage and the balanced use of fertilizers. Paddy yield increased considerably from 54.85 q ha^{-1} before drainage to 75.13 q ha^{-1} after the installation of sub-surface drainage.

Effect of tile drainage system on soil chemical properties and yield of rice (*Oryza sativa*) in upper Krishna command of Karnataka

Rahul Patil, P Balakrishnan and Mallika K
College of Agricultural Engineering, University of Agricultural Sciences, Raichur – 584 104, Karanataka
E-mail: rahul1235110@gmail.com

Abstract
A study was conducted during 2014-15 to assess the impact of tile drainage system in salt affected soils at Agricultural Research Station, Malnoor, Karnataka. The mean pH of samples ranged from 8.21 to 8.71 before sowing and 8.58 to 8.95 after harvesting. Similarly, electrical conductivity ranged from 8.84 to 12.09 dS m^{-1} before sowing and 7.25 to 12.06 dS m^{-1} after harvesting. Ca^{2+}+Mg^{2+}, Na^{+} and K^{+} were in the range of 34.68 to 39.76, 7.80 to 10.92 and 0.12 to 0.16 Meq/100g before sowing of crops. After crop harvesting, their respective values were in the range of 34.44 to 37.62, 7.10 to 9.40 and 0.20 to 0.27 Meq/100g. ESP values were in the range of 17.99 to 21.45 before sowing and from 17.07 to 19.90 after harvesting of the crop. Results revealed that pH and K^{+} increased due to sodic nature of the soil and the excess fertilizer application. ESP marginally decreased as compared to pre-sowing conditions. Gypsum needed to be applied in required amount to improve soil properties and crop yields. Paddy yield significantly increased from 42.01 q ha^{-1} to 62.00 q ha^{-1} after installation of the drainage system.

Yield, osmoregulation and ionic composition of sorghum grown in saline soils

K Adi Lakshmi, P Prasuna Rani, P Ratna Prasad, Y Ashoka Rani and R Lakshmipathy*
Agricultural College (ANGRAU), Bapatla – 522 101, Andhra Pradesh
****E-mail: pprasuna09@yahoo.com***

Abstract
Marginal Indian farmers having limited resources face cost and time related constraints in reclamation of the saline soils through conventional techniques. It is therefore, desirable to identify salt tolerant cultivars capable of producing high yields without any other intervention. Sorghum (*Sorghum bicolor*) is the fifth most important cereal crop of the world and the third most important source of staple food after rice and wheat for millions of people in India and is naturally drought and salt-tolerant and can produce high yields with low input use. Keeping these strengths of sorghum crop in mind, a study was conducted to evaluate the performance of three commonly grown sorghum varieties (Hytech, Laxmi and Mahalaxmi) at different salinity levels. The experiment was carried out in a factorial complete randomized design with three replications during *rabi* 2015-2016 at Agricultural College, Bapatla in soils of variable salinity (1.5, 5, 8 and 12 dS m^{-1}) collected from Uppugunduru region of Andhra Pradesh. Relative water content (RWC), chlorophyll, proline and total sugars in leaves and calcium, magnesium, sodium and potassium in the diacid extract of plant samples were analysed following standard methods. Considerable reduction in the yield was observed at highest salinity level. The per cent reductions in grain yield and stover yield were 60.92 and 51.07% as salinity increased from 1.5 to 12 dS m^{-1}. The maximum grain (21.93 g pot^{-1}) and stover (48.23 g pot^{-1}) yields were observed when Hytech variety was raised at 1.5 dS m^{-1} salinity. The highest leaf chlorophyll and RWC were recorded in Hytech variety at low salinity of 1.5 dS m^{-1}. Leaf proline and sugar contents increased with salinity at all stages of the plant growth. Cultivar Hytech recorded the maximum proline content at all stages of plant growth while it contained the maximum sugars at flowering and intermediate values at other two stages. The maximum Ca^{2+}/Mg^{2+} ratios of 1.718, 2.528 and 2.161 at 30 DAS, flowering and maturity were recorded at the highest salinity level of 12 dS m^{-1}, which were significantly higher than at other salinity levels at all growth stages. Ca^{2+}/Mg^{2+} ratio was high at flowering and maturity, while the Na^{+}/K^{+} was intermediate in Hytech variety compared to others. The study indicated that the Hytech variety performed better at high salinity compared to Laxmi and Mahalxmi due to its high capacity to maintain higher chlorophyll content, RWC, proline and Ca^{2+}/Mg^{2+} ratio.

Effect of micro irrigation techniques and fertilizer levels on root yield and quality of sugarbeet under saline Vertisols of Thungabhadra command of Karnataka

Anand SR, Vishwanatha J, Rupashri DH, Karegoudar AV and Rajkumar RH
Agricultural Research Station, University of Agricultural Sciences, Gangavathi – 583 227, Karnataka
E-mail: anuagron80@gmail.com

Abstract

A field experiment was carried out for a period of two years to assess the effect of different micro-irrigation techniques and fertilizer levels on root yield and quality of sugarbeet during *Rabi*/summer season from 2013-14 to 2014-15. There were 12 treatment combinations consisting of three irrigation methods (drip, sprinkler and furrow irrigation) as main plots and four different NPK levels (F1-100:50:50, F2-120:60:60, F3-150:75:75 and F4-200:100:100) as sub-plots which were replicated thrice. The initial soil pH was 8.12 and EC_e varied from 8-12 dS m^{-1}. The soil was medium deep black clay with initial soil N, P_2O_5, K_2O status of 232, 57 and 385 kg ha^{-1}, respectively. The results of two years pooled data revealed that among micro- irrigation techniques, drip method recorded significantly higher root yield of sugarbeet (39.04 t ha^{-1}), weight of ten beets (7.94 kg) and brix value (21.85 %) which was at par with the sprinkler method of irrigation. Among fertilizer levels, significantly higher root yield (43.31 t ha^{-1}), weight of ten beets (8.83 kg) and brix (23.67%) were recorded with fertilizer level NPK @ 200:100:100 kg ha^{-1} compared to 100:50:50 and 120:60:60 kg ha^{-1} levels but was at par with fertilizer level @ 175:75:75 kg ha^{-1}.

Effect of dilution on soil pH and EC under different land uses in saline-sodic soils

Ashim Datta, Nirmalendu Basak, Anil R Chinchmalatpure and Rakesh Banyal
ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
E-mail: ashimdatta2007@gmail.com

Abstract

Six land-uses namely Eucalyptus, Kainth, Karonda-Mustard (KM), *Prosopis alba*-Mustard, Aonla-Mustard and Jowar-Wheat situated at Bir forest, Hisar were studied to evaluate the effect of dilution on soil pH and EC. For this purpose, soil samples were collected up to a depth of 200 cm with an interval of 20 cm. Four soil: water ratios namely 1:2, 1:5, 1:10 and 1:15 were used for estimation of pH and EC of the soil. Results showed that KM system recorded the highest pH and EC in all the soil water ratios than the other land uses irrespective of the soil depth. At 0-20 cm depth, the highest (8.95) and the lowest (8.64) pH was observed at 1:10 and 1:2 soil water ratios, respectively. With depth, soil pH increased irrespective of soil water ratios and the highest pH (9.82) was observed at 60-80 cm soil depth under KM. Soil EC decreased with increase in dilution irrespective of soil depth and land uses. Highest salt content was observed under KM land use throughout the soil profile. At 60-80 cm soil depth, the highest EC_2 (3.08 dS m^{-1}) was observed. In most of the land uses, higher EC was observed with depth irrespective of soil water ratios. Except Eucalyptus land use, the percentage increase in pH was higher from 1:2 to 1:5 soil water ratios particularly at lower soil depths under KM system. Similarly, percentage increase in pH was consistently higher from 1:5 to 1:10 soil water ratio in all the land uses irrespective of soil depth. But soil pH at 1:15 soil water ratio did not increase significantly or was statistically at par and in some cases decreased compared to 1:10 soil water ratio.

Soil sustainability evaluation of North-west Gir Madhuvanti toposequence of South Saurashtra region of Gujarat

Chouthu Ram Hakla, NR Meena[1], Mahendra Chaudhary, Vipen Bhadu and Shiv Prasad Daroga
Junagadh Agricultural University, Junagadh - 362 001, Gujarat
[1]Maharana Pratap University of Agriculture & Technology, Udaipur – 313 001, Rajasthan
E-mail: crhakla65@gmail.com

Abstract

Six representative pedons were evaluated for their soil sustainability and their constraints by scoring method of the soils of different land slope of North-west Gir Madhuvanti toposequence of south Saurashtra region of Gujarat. The soils of hill slope belonging to Lithic Ustorthents (P_1) were placed in sustainable class (S_2). The soils of upper piedmont belonging to Lithic Ustorthents (P_2), lower piedmont belonging to Vertic Haplusterts (P_3), plain area belonging to Typic Haplusterts (P_4), depression area belonging to Sodic Haplusterts (P_5) and upper coast belonging to Fluventic Calciustepts (P_6) were placed in sustainable with high input class (S_3). In addition to this, the general mean score of weighted factors of soil constraints were found in the order of Hill Slope (23) < Lower Piedmont (27) < Upper Piedmont (28) < Plain Area (30) = Depression Area (30) = Upper Coast (30). Indicators of soil sustainability, such as effective rooting depth (20-90 cm), bulk density (1.23-1.43 Mg m^{-3}), texture (clayey), structure (sub-angular blocky), available water capacity (14-27 cm m^{-1}), saturated hydraulic conductivity (0.00-0.18 cm hr^{-1}), pH (6.79-8.28), EC (0.28-3.08 dS m^{-1}), organic carbon (0.54-0.84 % of surface horizon) and SAR (0.78-4.02) were compared with the limits as proposed by Lal (1994) to understand the severity of constraints for sustainability.

Evaluation of spacing of sub-surface drainage system on soil properties, water table and crop yield in farmers rice fields of TBP Command of Karnataka

AV Karegoudar, Viswanath J, Rajkumar RH, Anand SR, RL Meena[1], SK Ambast[2] and MJ Kaledhonkar[1]
Agricultural Research Station, University of Agricultural Sciences, Gangavathi – 583 227, Karnataka
[1]ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
[2]ICAR-Indian Institute of Water Management, Bhubneshwar – 751 016, Odisha
E-mail: avkaregoudar12@gmail.com

Abstract

The study was carried out during *Kharif*-2014 and *Rabi* 2014-15 to evaluate the performance of sub-surface drainage (SSD) system in an area of 50 ha block with spacings of 40, 50 and 60 m situated at Mallapur village, Sindhanur taluk, Raichur district. Mean soil pH and EC_e were 8.2 and 12.23 dS m^{-1}, 8.32 and 11.1 dS m^{-1} and 8.29 and 11.50 dS m^{-1} at 0-15, 15-30 and 30-60 cm depths, respectively. Hydraulic conductivity of the soil at 1.2 m depth varied from 0.089 to 0.451 m/day with a mean value of 0.161 m/day. At crop harvest during *Kharif*-2015, in general soil salinity under 40m spacing reduced from 20.88 to 15.54 (0-15 cm), 18.11 to 18.97 (15-30 cm), 17.6 to 13.04 (30-60 cm) and 13.65 to 13.26 dS m^{-1} (60-90 cm), respectively. Soil salinity under 50 m spacing varied from 6.45 to 6.44 (0-15 cm), 6.32 to 7.03 (15-30 cm), 6.85 to 8.74 (30-60 cm) and 7.98 to 7.36 dS m^{-1} (60-90 cm) respectively. At 60 m spacing, soil salinity reduced from 9.06 to 5.46 (0-15 cm), 7.7 to 5.77 (15-30 cm), 8.56 to 6.81 (30-60 cm) and 8.75 to 7.30 dS m^{-1} (60-90 cm), respectively. The depth to

water table which varied from 0.25 to 1.05 m initially was maintained at 0.92 to 1.18 m during the course of the study. Among three drain spacings (40, 50 and 60 m), the maximum reduction was observed in 40 m followed by 50 and 60 m drain spacings. The average drain discharge varied from 0.22 (40 m) to 0.27 mm/d (60 m), drainage water salinity from 9.32 (60 m) to 11.9 dS m^{-1} (40 m) and salt removal varied from 0.99 (60 m) to 1.36 t/ha (40 m), respectively over the course of study. Similarly, paddy grain yield varied from 45.11 (40 m) to 52.31 q/ha (60 m) from the initial level of 25-30 q/ha.

Impact of SAR water on dissolution of native $CaCO_3$ mineral in sodic soils

Nirmalendu Basak, SK Chaudhari[1] and DK Sharma
ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
[1]Indian Council of Agricultural Research, KAB-II, Pusa, New Delhi – 110 012
E-mail: nirmalendu.basak@icar.gov.in

Abstract

Reclamation of sodic soil is very important for sustaining the agricultural productivity in many regions of India. Inorganic substances *viz*. gypsum, pyrites, acids, acid-formers, phosphogypsum, fly ash, and organic material as press mud, bio-augmented material with gypsum are used as amendments. Due to declining availability of quality gypsum and competing industrial demand, it is needed to reduce the level of exchangeable Na and soil pH by enhancing the solubility of native $CaCO_3$ of calcareous sodic soils. We hypothesized that saline water with varying SAR have potential to dissolve native $CaCO_3$ mineral. A laboratory soil column study was conducted with 2 different soils *viz.*, calcareous sodic Inceptisols (pH_2, ESP and $CaCO_3$ 9.4, 45.0 and 17.1%, respectively), and cacareous sodic Vertisols (pH_2, ESP and $CaCO_3$ 9.1, 10.0 and 8.0%, respectively) in a completely randomized factorial design with three replications. High salinity (10 dS m^{-1}) with varying SAR (10, 20 and 30 $mmol^{1/2}$ $L^{-1/2}$) was applied in packed soil columns (15.0 cm depth × 13.5 cm *i.d.* column) with fixed soil bulk density of 1.35 Mg m^{-3}. Twenty pore volumes of different quality water were passed and leachates at the end of each pore volume were collected. Water quality parameters of soil leachates were analysed. After the leaching process ended, the soils in the columns were drained under gravity for 24 h, and then were evenly sectioned into five slices of 3 cm each and air dried for analyses. Entire pore volume of soil leachates indicated an increase in pH and EC with increasing SAR of incoming water with fix electrolyte concentration. Entire soil leachates detected higher values of SAR than incoming solution. However, the leaching solution was quasi-equilibrated with incoming SAR when Calcareous Sodic Inceptisols leached with high SAR 30 and Calcareous Sodic Vertisols leached with SAR 20. High SAR of incoming water favoured more leaching of Ca and Mg from soil compared to low SAR water. Soil pH decreased at all soil depth when soils were leached with SAR 10 and 20 for all soils. However, leaching with SAR 30 increased soil pH for all depth for Calcareous Sodic Inceptisols but remained unaffected for Calcareous Sodic Vertisols. A lower level of dissolution of $CaCO_3$ appeared when low SAR of 10 and 20 were applied. $CaCO_3$ content was unaffected when high SAR water was applied. The calculated saturation index of each leachates compared to SI in soil saturation extract indicated quality of water had potentiality of $CaCO_3$ dissolution at low SAR level. Low SAR water decreased the exchangeable sodium per cent (ESP) of Calcareous Sodic Inceptisols from 45.0 to 36.5. However, all the SAR water favoured ESP development in Calcareous Sodic Vertisols.

Conjunctive use of gypsum and municipal solid waste compost in reclamation of saline-sodic soil

Parul Sundha, Arvind K Rai, Nirmalendu Basak, RK Yadav and DK Sharma
ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
E-mail: parul34046@gmail.com

Abstract

Reclamation of sodic soils enhances the productivity of lands which otherwise remain barren and unproductive. Gypsum has been conventionally used to reclaim the sodic soils since the early years of 20th century. Currently, competing demand for the quality gypsum by other industrial sectors has necessitated the search for alternate reclamation agents. Usage of the Municipal Solid Waste Compost (MSWC) as soil conditioner is well established. It also has the potential for improving physical, chemical and biological properties of the sodic soils. Therefore, this study explored the potential of different organic amendments in the reclamation of a saline-sodic soil with additional stress of high sodium (SAR) saline-sodic irrigation water. Conventional amendment gypsum (G) *viz*., GR25 (25% gypsum requirement), GR50 and its combination with 10 and 20 t ha^{-1} of farmyard manure (F) and MSWC obtained from Karnal (KC) and Delhi (DC) were incubated with soil for one month at 60% field capacity. After 30 days of incubation, a soil column leaching experiment was carried out with completely randomized factorial design with three replications of the treated and control soils. Columns were sequentially leached up to ten pore volumes of saline-sodic water for a fixed 60 me L^{-1} total electrolyte concentration with variable SAR of 5.0 and 10 $mmol^{1/2}$ $L^{-1/2}$ and normal irrigation water. Nature, quantity and the independent integration of amendments had positive influence on decrease in soil alkalinity and quantity of the salts. Control soil had high pH_2 compared to the amended soils. Leaching with saline-sodic water released an appreciable quantity of electrolytes from soil. The ionic balance of electrolytes indicated an increase in the quantity of Na^+, Cl^-, CO_3^{2-} in leachates with increase in the SAR. In contrast, Ca^{2+}, Mg^{2+}, K^+, SO_4^{2-} levels declined whereas the quantity of released HCO_3^- remained same. Leaching with quality waters had paramount influence on decrease in both pH_2 and EC_2. The efficiency in decrease in pH_2 were GR50>GR25+KC/DC (10 t ha^{-1}) = GR25 + KC/DC (20 t ha^{-1}) = GR25 + F (20 t ha^{-1}) = GR25 + F (10 t ha^{-1}) >GR25. Changes in pH_2 and EC_2 showed inverse relation in different soil layers. Among the combination of amendments, GR25 + DC (20 t ha^{-1}) treated soil showed greater decrease for both soil pH_2 and EC_2 irrespective of water SAR. Multivariate statistical analysis indicated that leachate calcium concentration among the described 15 water quality parameters was most important to diagnose the soil pH_2 reduction during the reclamation of saline-sodic soil.

Assessment of micronutrients status under irrigated and rainfed cotton on saline Vertisols in Bara tract region of Bharuch district of Gujarat

Shrvan Kumar, Amaresh Das, Anil R Chinchmaltpure, Indivar Prasad, Monika Shukla and David Camus D
ICAR-Central Soil Salinity Research Institute, Regional Research station, Bharuch – 392 012, Gujarat
E-Mail: shrvan.kumar@icar.gov.in

Abstract

Soil fertility problems related to micronutrient deficiencies are threatening agriculture in irrigated and rainfed regions of the world. Micronutrient availability differs with the agro-climate, and is influenced by organic matter content, soil pH, exchange ions and soil texture. A systematic soil survey was conducted

under irrigated and rainfed cotton growing areas of Bara tract in Bharuch district (Gujarat). Two hundred and nineteen surface (0-22.5 cm) and sub-surface (22.5-45.0 cm) soil samples were randomly collected from irrigated (115) and rainfed (104) areas for analyses. Results revealed that concentration of available micronutrients iron (Fe), manganese (Mn), copper (Cu) and zinc (Zn) ranged from 3.0 to 20.9, 2.3 to 34.8, 0.7 to 4.3 and 0.05 to 1.2 mg kg^{-1}, respectively, in irrigated surface soils. Similarly, the corresponding values for sub-surface soils were 1.8 to 15.4, 2.3 to 29.6, 0.5 to 3.9 and 0.03 to 0.80 mg kg^{-1}, respectively. In case of rainfed surface soils, the above micronutrients in chronological order were 3.4 to 14.3, 2.2 to 19.3, 0.1 to 6.7 and 0.04 to 1.0 mg kg^{-1}, respectively while for sub-surface soils the order was 2.3 to 8.6, 1.7 to 13.5, 0.1 to 5.1 and 0.02 to 0.41 mg kg^{-1}, respectively. Results further revealed that surface layers had higher micronutrient contents than sub-surface layers. The micronutrients were found to be Mn ~ Fe > Cu > Zn in both system but their magnitude was high in irrigated soils as compared to rainfed soils. In both irrigated and rainfed situation, more than 78% DTPA-Zn soils exhibited 'low' status. Organic carbon was positively and significantly correlated with available Mn, Cu and Zn. Soil pH and $CaCO_3$ were generally negatively and significantly correlated with all available micronutrients. To alleviate Zn deficiency, use of organic manures like farm waste, compost, bio-compost, vermicompost *etc*. are advocated along with application of Zn in soil or through foliar spray in specific cases to get better crop yield.

Evaluation of *in-situ* green manuring and crop residue for sustaining crop productivity and amelioration of salt affected soils of Purna valley in Vidarbha region of Maharashtra

BA Sonune, VK Kharche, VV Gabhane, NM Konde, DV Mali, AN Paslawar, PV Mohod and RN Katkar
Department of Soil Science & Agricultural Chemistry,
Dr. Punjabrao Deshmukh Krishi Vidyapeeth, Akola – 440 033, Maharashtra
E-mail: basonune@gmail.com

Abstract

Purna valley in Vidarbha region of Maharashtra is a unique tract having native sodicity covering about 2.74 lakh ha area in 547 villages of Amravati, Akola and Buldhana districts. Major problems of these soils are native sodicity, poor hydraulic conductivity, compact subsoil, incomplete leaching of salts due to severe drainage impairments, high degree of swell shrink potential resulting in water stagnation in *Kharif* season and wide cracks in the summer season. In view of the above, a field study was carried at farmer's field to evaluate the effect of green manuring and crop residue management on soil health and crop productivity in salt-affected soils in Purna valley of Vidarbha region, Maharashtra from 2010-11 to 2014-15. The crop rotations were cotton-(greengram-chickpea)-cotton which is predominantly followed in the area. There were nine treatments replicated on three different farmers' fields. The treatments comprised of five different green manures (dhaincha, sunhemp, leucaena lopping and greengram), two crop residues (cotton stalk and farm waste) and gypsum. During first year, cotton was grown in *Kharif* and various green manuring crops were sown in between two rows of cotton which were buried in soil 30 DAS. The decomposed crop resides were applied to the soil before sowing. Gypsum application was made uniformly by mixing in the top soil layer. During the second year the residual effects of these treatments were studied. The pooled results showed that the application of *in situ* green manuring of dhaincha recorded significantly higher yield of crops which was at par with the application of gypsum @ 2.5 t ha^{-1}. The significant reduction in pH and ESP of soil was observed with the soil application of gypsum followed by *in situ* green manuring of dhaincha. The treatments encompassing various green manures significantly reduced the soil ESP over control. The application of various green manuring crops resulted in build up of fertility status of soil with significant improvement in SMBC, CO_2 evolution and DHA over application of gypsum and control. Among the various *in situ* green manure crops, dhaincha was found the most beneficial for improvement in physical, chemical and biological properties of the soil. The higher monetary returns and B:C ratio of cotton-greengram-chickpea

was obtained with *in situ* green manuring of dhaincha which was at par with the soil application of gypsum. Hence, it can be concluded that *in situ* green manuring with dhaincha is beneficial in sustaining the productivity of cotton-greengram-chickpea cropping sequence with improvement in soil health along with higher monetary returns in salt-affected soils of Purna valley of Vidarbha region of Maharashtra.

Evaluation of sub-surface drainage technology in TBP command area of Karnataka

Shrikantagouda, BS Polisgowdar, MS Ayyangowdar, M Nemichandrappa, J Vishwanath and AV Karegoudar
Agricultural Research Station, University of Agricultural Sciences, Gangavathi – 583 227, Karnataka
E-mail: shreekantamp@gmail.com

Abstract

Introduction of irrigated agriculture in the arid and semi-arid regions of India has resulted in the development of twin problems of waterlogging and salinity. These problems also occur in the valley bottoms of the Tungabhadra Irrigation Project (TBP). The subsurface drainage (SSD) system was installed at 40, 50 and 60 m drain spacings to reclaim the waterlogged and saline soils in an area of 50 ha farmers' fields at Mallapur village, Sidhanur taluk, Karnataka. The monitoring and evaluation of SSD system revealed that the watertable that used to be 0.25 to 1.05 m below ground level receded to 0.92-1.18 m below the surface. Soil pH and salinity decreased when compared with pre-drainage system. About 7% increase in hydraulic conductivity was observed. The total quantum of salt disposed along the drain discharge during *Kharif*-2014 and *Rabi*-2014-15 was the maximum in 40 m spacing (35.92 t ha^{-1}) followed by 50 m (23.53 t ha^{-1}) and 60 m (17.23 t ha^{-1}) drain spacings, respectively. Crop yield increased to the extent of 60.2, 50.4 and 40.8% in 40, 50 and 60 m drain spacings, respectively, during the post drainage situation. Cropping intensity increased from 147 to 171% after SSD installation. An economic analysis showed that 40 m drain spacing gave the maximum NPV (Rs. 2, 39, 314), B:C ratio (1.26), IRR (177 %) followed by 50 m and 60 m drain spacings.

Effect of micronutrients and potassium nitrate on yield, quality of soybean *(Glycine max L. Merrill)*

Udmale AB and Bhagyaresha R Gajbhiye
College of Agriculture, VN Marathwada Krishi Vidyapeeth, Latur – 413 512, Maharashtra
E-mail: kirandangade36@gmail.com

Abstract

A field experiment was conducted to evaluate the effect of multi micronutrients and potassium nitrate on yield, quality of soybean *(Glycine max* L. Merrill*)* during 2015-16 at College of Agriculture, Latur. The experiment was laid out in randomized block design with eight treatments and three replications. The results indicated that the growth and yield of soybean was significantly influenced by application of multi micronutrients and potassium nitrate. The growth parameters, yield attributes and yield of soybean were influenced significantly with application of RDF + multi micronutrient [grade 2] 0.5 % at 40 DAS + KNO_3@ 1% at 60 DAS. All growth parameters *viz;* plant height, nodules per plant, number of branches per plant and dry matter production per plant significantly improved at all the growth stages. Whereas, protein content, protein yield, oil content, oil yield and test weight of soybean seeds also increased with RDF+ multi micronutrient [grade 2] 0.5 % at 40 DAS + KNO_3 @ 1% at 60 DAS followed by RDF + multi micronutrient [grade 2] @ 0.5 % at 40 DAS + KNO_3 @ 1% at 75 DAS. Thus, it can be concluded that use of RDF + multi micronutrient [grade 2] 0.5 % at 40 DAS + KNO_3 @ 1% at 60 DAS leads to significant improvements in yield and quality of soybean.

Response of niger (G*uizotia abyssinica*) to sources and levels of sulphur

Gotte Moulika, Gajbhiye Bhagyaresha and Arigela kiran
College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Latur – 413 512, Maharashtra
E-mail: gottemoulika1990@gmail.com

Abstract

A field experiment was conducted to evaluate the response of niger **(***Guizotia abyssinica*) to sources and levels of sulphur during the year 2015-16 at College of Agriculture, Latur. The experiment was laid out in randomized block design with twelve treatments and three replications. The results of field study indicated that the growth, yield and quality of niger were significantly influenced by application of different sources (ammonium sulphate, elemental sulphur and gypsum) and levels (10, 20 and 30 kg/ha) of sulphur. The maximum increases in plant height (60.40 cm), number of branches (10.60), number of capitula (28.53) and number of seeds capitulam^{-1}(19.44) were recorded with RDF+ S 30 kg ha^{-1} through ammonium sulphate. Similarlty, the maximum test weight (4.83 g), protein content(27%), protein yield (130.6 kg/ha), oil content (31.6%) and oil yield (367 kg/ha) of niger were also noted with the use of RDF+ S 30 kg ha^{-1} through ammonium sulphate followed by RDF+ S 30kg ha^{-1} through gypsum.

Relationship of different forms of sulphur in soils of Paranda tehsil of Osmanabad district of Maharashtra

Kanchan A Wankhede and Bhagyaresha R Gajbhiye
College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Latur – 413 512, Maharashtra
E-mail: bhagyabr123@yahoo.co.in

Abstract

The present investigation was carried out to study the relationship of different forms of sulphur (S) in soils of Paranda tashil of Osmanabad district during 2013-14. For this purpose, total 180 soil samples (6 samples from each of the 30 villages) were collected from Paranda tahsil according to their representative depth. From each village, 2 soil samples of Vertisols (> 30 cm), Inceptisols (10-30 cm) and Entisols (0-10 cm) were collected and analyzed for S fractions. Different S fractions *viz*; total S, available S, organic S, water soluble S and non-sulphate S were low to medium in the sampled soils. Total S content varied widely from 500 to 3240.00, 315 to 2625 and 216 to 1630 mg kg^{-1} with a mean value 1746.17, 1507.13 and 1145.57 mg kg^{-1} in Vertisols, Inceptisols and Entisols, respectively. Available S in Vertisols, Inceptisols and Entisols ranged from 11.40 to 78.92, 11.87 to 58.50 and 8.73 to 46.12 mg kg^{-1} with mean values 24.32, 22.63 and 22.12 mg kg^{-1}, respectively. The organic S in Vertisols, Inceptisols and Entisols ranged from 13.75 to 43.75, 12.75 to 37.50 and 8.73 to 46.12 mg kg^{-1} with mean values 26.85, 25.59 and 22.12 mg kg^{-1}, respectively. The water soluble S ranged from 5.98 to 52.25, 4.92 to 40.00 and 4.12 to 42.00 mg kg^{-1} with mean values 19.92, 19.58 and 20.49 mg kg^{-1} in Vertisols, Inceptisols and Entisols, respectively. The non-sulphate S in Vertisols, Inceptisols and Entisols ranged from 463.73 to 3217.40 mg kg^{-1} with a mean 1719.87 mg kg^{-1}, 285 to 2591.25 mg kg^{-1} with mean 1481.53 mg kg^{-1} and 248.5 to 1601.25 mg kg^{-1} with a mean 1121.54 mg kg^{-1}, respectively. In Vertisols, Inceptisols and Entisols of Paranda tahsil, S fractions recorded positively significant as well as negative but significant correlation among themselves.

Effects of municipal solid waste compost and mineral fertilizers on soil chemical properties and yield of mustard–pearl millet cropping system

MD Meena, B Narjary, P Sheoran, HS Jat, PK Joshi, Anil R Chinchmalatpure and RK Yadav
ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
E-mail: md.meena@icar.gov.in; murliiari@gmail.com

Abstract

The aim of this study was to determine the role of organic amendments, municipal solid waste compost (MSWC) and rice straw compost (RSC) with and without mineral fertilizers (MF) on chemical properties of saline soil and yield of crops. A field experiment was conducted for three consecutive years during 2012-15. Soils treated with MSWC+50% RDF had significantly higher mean (of three year) soil organic carbon (SOC) relative to those treated with 100% RDF only, though it was statistically at par with RSC+50%RDF. Significant increase in soil fertility in terms of mean (of three year) available nitrogen (N), phosphorus (P) and potassium (K) was noted in plots receiving organic amendments along with MF than 100% RDF alone. RSC+RDF had 9, 10 and 7% higher availability of N, P and K, respectively than 100% RDF. Compared to the use of organic amendments alone, MSWC use gave better results with regard to available nutrients. Results indicated that mean (of three year) grain yields of mustard (2.38 t ha^{-1}) and pearl millet (2.44 t ha^{-1}) recorded with MSWC+RDF were significantly higher over the use of 100% RDF alone. However, 100% RDF produced 11 and 15% higher mean grain yield of mustard (*Brassica juncea*) and pearl millet (*Pennisetum glaucum*) respectively, than control. The magnitude of changes in mean soil electrical conductivity (EC) was significantly lower with MSWC+50% RDF followed by RSC+50% RDF than control. However, mean EC decreased by 34 and 22% with MSWC+RDF and RSC+50% RDF respectively, relative to alone use of 100% RDF. No significant differences were observed in mean soil pH amongst the treatments, though slightly lower values had with organic amendments along with mineral fertilizers.

Microbial and bio-chemical characterization of coastal saline soils under cotton

Sanjay Arora, Pooja R Thakor[1] and GG Rao*
ICAR-Central Soil Salinity Research Institute, Regional Research Station, Bharuch – 392 012, Gujarat
[1]Department of Biotechnology, VN South Gujarat University, Surat – 395 007, Gujarat
****E-mail: microbeguj@gmail.com***

Abstract

The rhizosphere or the zone of influence around roots harbours a multitude of microorganisms that are affected by both abiotic and biotic stresses. The dominant rhizobacteria that prefer living in close vicinity to the root or on its surface play a crucial role in sustaining the soil health and plant growth. This study was conducted at Samni and Vagra regions of Bharuch district in the coastal region of Gujarat. The climate of the region is semi-arid with hot and dry pre-monsoon summer months followed by monsoon period. Rhizospheric soil samples from different genotypes of cotton viz. *G. hirsutum*, *G. herbaceum* and *G. arboreum* cultivated in coastal saline soils were collected. Soil pH ranged between 7.65 and 7.9 while EC was found to be 1.27 dS m^{-1} in rhizosphere soil of *G. hirsutum* and 1.54 dS m^{-1} in soils under *G. arboreum*. Organic C content was 0.81, 0.45 and 0.51% in rhizosphere soil of *G. hirsutum*, *G. herbaceum* and *G. arboreum*, respectively. Available N content varied from 138 kg ha^{-1} to 188 kg ha^{-1} while available S content ranged between 6.87 and 18.55 mg kg^{-1}. It was observed that the maximum bacterial population (with $2.4x10^5$ cfu/g) on nutrient agar media were observed in cotton *G. arboretum* while bacterial population was only $2.1x10^4$ cfu/g in rhizosphere soil of *G. Hirsutum.* The minimum amount of microbial biomass C was

found in rhizospheric soil of *G. herbaceum* whereas the maximum amount in soils of *G. hirsutum*. The maximum amount of microbial biomass N was observed in rhizosphere soils of *G. arboreum* and the minimum in *G. hirsutum*. The lowest amount of MBP was recorded in rhizosphere soils of *G. hirsutum*. Isolated bacterial populations were *Bacillius* and *Cocci* with single arrangement and few in clusters. The maximum isolates were gram positive and rod shaped with spores. Bio-chemical tests showed that almost all the isolates lacked indole production and majority of them showed positive test for methyl red, Voges Proskaur, nitrate reduction and amylase production. The study shall help in strategizing soil management including organic amendments and fertilizer applications for sustaining the productivity of different genotypes of cotton grown on Vertisols.

Effect of zinc and iron application on yield and nutrient availability in salt affected soil under pearl millet (*Pennisetum glaucum*) -mustard (*Brassica juncea*) cropping sequence

BL Meena, RL Meena, Parveen Kumar, Ashwani Kumar and MJ Kaledhonkar

ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana

E-mail: blmeena2008@gmail.com

Abstract

Plant growth is depressed due to high salt concentrations in the growing substrate. In addition to osmotic stress, crop productivity is also adversely affected by specific ion toxicities, inadequate nutrient availability and cationic imbalances. Therefore, judicious management of plant nutrients especially zinc (Zn) and iron (Fe) in salt-affected soils should be given major emphasis. Keeping this in view, a study was conducted to evaluate the effect of zinc and iron application on yield and nutrient availability in pearlmillet (*Pennisetum glaucum*)-mustard (*Brassica juncea*) cropping sequence in a salt-affected soil. The treatments were T_1- Control, T_2- 5 kg Zn ha^{-1}, T_3- 6.25 kg Zn ha^{-1}, T_4-7.5 kg Zn ha^{-1}, T_5-7.5 kg Fe ha^{-1}, T_6- 10 kg Fe ha^{-1}, T_7- 12.5 kg Fe ha^{-1}, T_8- 5 kg Zn+l0 kg Fe ha^{-1}, T_9- 5 kg Zn ha^{-1}+l0 kg Fe ha^{-1} + 10 t FYM ha^{-1}, T_{10}-Foliar sprays of 0.5% $ZnSO_4$ (twice),T_{11}-Foliar sprays of 1% $FeSO_4$ (twice at 30 and 45 DAS) and T_{12}- Combined foliar sprays (0.5% $ZnSO_4$+ 1% $FeSO_4$; twice). Zinc and iron were applied to soil in the form of $ZnSO_47H_2O$ and $FeSO_47H_2O$, respectively at the time of sowing. Foliar sprays of respective nutrients were also applied with same chemicals as soil application at 30 and 45 days after sowing. The soil had initial EC_e of 10.71 dSm^{-1} and pH_s of 8.45 in the 0-15 cm surface. Results of experiment showed that grain yield of pearl millet (3.76 t ha^{-1}) and seed yield of mustard (2.29 t ha^{-1}) were 57 and 44% higher respectively, with the application of 5 kg Zn+10 kg Fe+10 t FYM as compared to control. 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. On an average, the maximum DTPA-Zn (0.84 mg kg^{-1}) and Fe (5.93 mg kg^{-1}) in soil were recorded under T_9 followed by T_8 after harvest of mustard. The combined application of 5 kg Zn+10 kg Fe with FYM significantly improved N and P status of surface soils over control. Potassium content did not significantly vary under different treatments except T_9. The potassium content was 570 to 720 kg ha^{-1} in soil. 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.

Problems and prospects of micro-irrigation in coastal salt affected soils of West Bengal

KK Mahanta, D Burman, SK Sarangi, UK Mandal and B Maji
ICAR-Central Soil Salinity Research Institute, Regional Research Station, Canning Town – 743 329, West Bengal
E-mail: mahantakk@rediffmail.com

Abstract

The coastal lands in West Bengal are flat with little or no slope and often suffer from inadequate drainage and waterlogging during the rainy season; and water scarcity and salinity in the post-monsoon period. A number of experiments were carried out at ICAR-CSSRI, RRS, Canning Town farm during the years 2001-04 and 2012-15 utilizing the modern irrigation techniques such as micro-sprinkler and drip irrigation systems using electric, gravity and solar power during the post-monsoon period in vegetable crops. Irrigations were scheduled based on cumulative pan evaporation data. Measurements were made to evaluate the salinity in the root zone and crop performance in terms of yield and return. In the gravity drip irrigation system, four crops *viz.*, okra, red beet, basella and cow pea were taken for the experimentation. Cow pea suffered the most while okra crop outperformed other vegetables in the flash flood prone fields. Frequent winds during the non-monsoon period affected the uniformity of water application through micro-sprinkler irrigation and caused high evaporation loss. Among the seven crops including tomato, beet, knol-khol, cabbage, cauliflower, chilli and okra, the highest return was obtained in tomato crop during the *Rabi* season as tomato fruits were in regular demand and fetched the high market price. Soil salinity in the root zone was less than 3 dS m^{-1} at the start of the season. Later, salinity decreased in drip irrigated plots but increased in the non-irrigated soils especially in the upper layers. Ample availability of solar energy during the *Rabi*/summer season led to 60 % saving of labour, 40-50 % saving of water and 20-30% increase in yield through solar drip irrigation in comparison to traditional manual irrigation. The results indicated that water use efficiency and productivity of the coastal lands can be significantly improved by solar-operated drip system.

Characterization of soils of Narmada canal command of Rajasthan for salinity and water logging

Mahesh Kumar, NR Panwar, PC Moharana, P Santra, Sharmila Roy and CB Pandey
ICAR-Central Arid Zone Research Institute, Jodhpur – 342 003, Rajasthan
E-mail: maheshcazri@gmail.com

Abstract

The Narmada Canal Project for Rajasthan part has been designed to utilize 0.50 MAF of Narmada water for a total of 2.46 lakh hectares CCA in Jalore and Barmer districts. Presently, Narmada canal is providing irrigation to about 2.39 lakh hectares area in both districts. Although availability of irrigation water from the canal has led to considerable increase in crop production, poor emphasis on drainage has resulted in waterlogging and salinization in many pockets. This study aimed to assess the changes in soil properties after the introduction of canal irrigation. Soils resource characterization in the canal command area was carried out through satellite image interpretation followed by ground truth verification and subsequent laboratory characterization. The soils were mainly classified into four soil series namely Sanchore, Dhorimanna, Chohtan and Alluvial soils (fine textured and coarse textured alluvial soil). Soils of Sanchore and Chohtan series together constitute about 50 % area of the Narmada command and occur in north and north eastern

parts of the command area. These soils are fine sand to loamy sand in texture, light yellowish brown to yellowish brown in colour mostly occurring on nearly level to undulating aeolian lands. The pH ranged from 8.2 to 9.5 and electrical conductivity from 0.076 to 1.62 dS m^{-1}. Dhorimanna soils are very deep, fine sand to loamy sand, excessively drained, light yellowish brown to yellowish brown in colour and having severe to very severe wind erosion problem and constitute about 25 % of the command area. The alluvial soils (fine and coarse textured) are characterized by stratified horizons which have been formed by Luni river and its tributaries. Soils are sandy loam-loam to clay loam in texture, imperfectly to moderately drained; lying on level to gentle sloping lands and occupy the central part of this command area. These soils are very deep (>100cm), yellowish brown to dark brown in colour, moderately to strongly effervescent throughout. The pH value varied from 7.8 to 9.5 and EC from 0.157 to 3.45 ds m^{-1}. Continuous irrigation with Narmada canal water improved the soil physicochemical properties. Soil organic carbon and phosphorus were 64 and 54% high, repectively, over rainfed crop lands. Depletion of available K in canal irrigated crop lands was recorded in comparison to open grazing land. Improvement in the micronutrient concentration in irrigated crop lands over rainfed was also observed. Canal irrigation has also induced secondary salinization and waterlogging at some locations. Salinity has arisen primarily from the pre-existing salt deposits in the sub-stratum. The sub-soil conditions and rising watertable (saline ground water) have resulted in waterlogging and salinity in some parts of Sanchore tehsil of Jalore district and has rendered hectares of land uncultivable in many villages irrigated with Bheemguda and Manki distributaries. Saturation extract analysis of these soils revealed that the pH_s and EC_e of these soils varied from 7.7- 9.5 and 1.6 to 41.5 dS m^{-1}. Among the cations, Na^+ was dominant followed by calcium+ magnesium. Chloride followed by sulphate was the dominant anion; present in the range 16 to 156 and 12-126 meq L^{-1}, respectively. Soils with low to moderate salinity could be used for growing the salt tolerant crops following salt leaching with the aid of suitable soil and water management practices. Soils with high salinity can be reclaimed by installation of sub-surface drainage followed by salt leaching.

Performance of rice, wheat and mustard varieties under sodic soil conditions

Devendra Singh, Ravindra Kumar, SN Pandey and Vinod Kumar
CS Azad University of Agriculture and Technology, Kanpur – 208 002, Uttar Pradesh
E-mail: ravindracsa@gmail.com

Abstract

The present study was conducted to evaluate the performance of the salt tolerant varieties of rice, wheat and mustard was carried out under sodic soil conditions. Various demonstrations of rice, wheat and mustard were conducted at farmer's fields by CS Azad University of Agriculture and Technology, Kanpur during 2013-14 to 2015-16. The soil properties of experimental field were: pH- 9.10, EC- 0.87 dS m-1, exchangeable sodium percentage (ESP)- 48.20 and organic carbon 2.8 g kg-1. Different varieties of rice (CSR-36, CSR-23 and CSR-27), wheat (KRL-210, KRL-213 with check LOK-1 and PBW-343) and mustard (CS-52, CS-54, CS-56 with check Rohini and Varuna) were tested in randomized block design with recommended dose of fertilizers and agronomical practices were adopted as per requirement of crops. The results revealed that in rice crop the maximum yield was recorded in CSR-36 (4.352 t ha-1) followed by CSR-23 (3.982 t ha-1) and CSR-27 (3.768 t ha-1). In wheat, the highest yield was obtained in KRL-210 (2.931 t ha-1) followed by KRL-213 (2.817 t ha-1) and PBW-343 (2.518 tha-1). In mustard, highest yield was obtained in CS-56 (1.235 tha-1) followed by CS-54 (1.101 tha-1) and Varuna (0.914 t ha-1).

Impact of fly ash, gypsum and organic manures on rice-wheat cropping system in sodic soils

Ravindra Kumar, Devendra Singh, SN Pandey and Vinod Kumar
CS Azad University of Agriculture and Technology, Kanpur – 208 002, Uttar Pradesh
E-mail: ravindracsa@gmail.com

Abstract

A field experiment on effect of fly ash, gypsum and organic manures on rice-wheat cropping system in sodic soil was conducted at Crop Research Farm, Dalipnagar of CS Azad University of Agriculture and Technology, Kanpur during 2010-11 to 2014-15. Soil properties of the experimental field were: pH- 9.2, EC- 0.92 dS m^{-1}, exchangeable sodium percentage (ESP)- 45.20 and organic carbon- 2.3 g kg^{-1}. Grain and straw yield increased by 59.1% and 73.5% in rice and by 66.2% and 78.5% in wheat, respectively, with soil application of amendments and organic materials over control, while the highest increments of 128.8% and 124.8% in grain yield; and 132.5% and 134.4% in straw yield in rice and wheat, respectively, recorded with soil application of fly ash 20 t ha^{-1} + gypsum (50% GR) + GM @ 10 t ha^{-1} over control. Uptake of nitrogen varied from 18.3 to 35.6 kg ha^{-1}, P from 4.7 to 8.4 kg ha^{-1} and K from 5.4 to 9.2 kg ha^{-1} in rice from 20.5 to 37.8 kg ha^{-1}, from 4.8 to 9.2 kg ha^{-1} and from 5.8 to 9.9 kg ha^{-1} in wheat, respectively. Increase in the uptake of N, P and K under different treatments over control was due to decrease in soil ESP. Different physico-chemical properties of the soil improved when amendment applications were continued for four years. Soil pH, EC, ESP and organic carbon showed considerable improvement over initial status under the different treatments.

Effect of phosphorus levels and bio-organic sources on grain quality, nutrient uptake and economics of wetland rice (O*ryza sativa* L.)

RK Meena and SP Singh[1]
Department of Agronomy, SK Rajasthan Agricultural University, Bikaner – 334 006, Rajasthan
[1]*Department of Agronomy, Banaras Hindu University, Varanasi – 221 005, Uttar Pradesh*
E-mail: rupeshkumaragro@gmail.com

Abstract

A field experiment was conducted during *Kharif* season of 2013 at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. Experimental soil was sandy clay loam in texture with pH 7.35, electrical conductivity 0.15 dS m^{-1} and organic carbon 0.39%. Available N, P, K content in soil was 198.03 kg ha^{-1}, 23.7 kg ha^{-1} and 188.32 kg ha^{-1}, respectively. Experiment was laid out in factorial RBCD with four levels of phosphorus *viz.*, control, 50%, 75% and 100% recommended dose of fertilizers (RDP) and three bio-organic sources *i.e.* PSB, PSB + BGA and PSB + BGA + FYM (5 t ha^{-1}) replicated thrice. Recommended dose of fertilizers was used i.e. N_2-P_2O_5-K_2O (120-60-60 kg ha^{-1}). NPK were supplied through urea, diammonium phosphate (DAP) and muriate of potash, respectively. Half of the recommended dose of N and the full dose of K were applied as basal application and the remaining half N was applied in two equal splits at active tillering and panicle initiation stages uniformly to all the treatments. Variable rates of P were applied as per treatment. Four week old seedling of rice cv. HUR-105 was transplanted in the puddled fields keeping two seedlings $hill^{-1}$ at a spacing of 20 cm × 15 cm. After 10 days of transplanting, BGA was applied at the rate of

10 kg ha^{-1} in their respective treatments. Before transplanting, inoculants suspension of liquid PSB culture (*Bacillus polymyxa*) was prepared with water in ratio of 1:10 and seedling roots were dipped in solution for about 30 minutes under shade and transplanted immediately to their respective plots. Well decomposed FYM was applied basally as per treatment. Results revealed that maximum grain yield (50.97 q ha^{-1}), grain protein content (9.18%) and protein yield (471.36 kg ha^{-1}), gross return (Rs. 82324), net return (Rs. 44645) and higher uptake of NPK by grain (75.42, 11.79 & 15.57 kg ha^{-1}) and straw (41.38, 8.98 & 96.44 kg ha^{-1}) of rice were recorded with the application of 100% RDP (60 kg P_2O_5 ha^{-1}). Higher B: C ratio (1.20) was obtained with 75% RDP. Among bio-organics, combined use of PSB+BGA+FYM (5 t ha^{-1}) gave the maximum net return (Rs. 43085 ha^{-1}) and B: C ratio (1.16), grain yield, protein content, protein yield and uptake of NPK by grain and straw. Combined application of bio-organics increased N uptake in grain (30.31%) and straw (17.54%), P uptake in grain (38.21%) and straw (49.76%) and K uptake in grain (14.74%) and straw (16.81%) and protein content (19.30%) and protein yield (30.32%) over the use of PSB alone.

Crop productivity and soil fertility under soybean-sunflower cropping system in semi-arid conditions of Vidarbha region of Maharashtra

Nilam Kanase, VV Gabhane, AN Paslawar, NM Konde and SM Jadhao
Department of Soil Science and Agricultural Chemistry,
Dr. Punjabrao Deshmukh Krishi Vidhyapeeth, Akola – 444 104, Maharashtra
E-mail: nitinkonde75@gmail.com

Abstract

An experiment was conducted to assess the crop productivity and soil fertility under soybean-sunflower cropping system in semi-arid climatic conditions of Vidarbha, Maharashtra during 2007-08 and 2008-09 at Oilseed Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The experiment comprised of twelve treatments replicated thrice in randomized block design, involving various combinations of macro and micro nutrients, FYM and sunflower stalk. The experimental soil was alkaline in reaction having low organic carbon, available nitrogen and phosphorous. The results indicated that the incorporation of FYM along with recommended dose of fertilizers (30:75:30 NPK kg ha^{-1}) improved the grain and straw yield of soybean. While application of micronutrients along with recommended dose of fertilizers (80:40:60 NPK kg ha^{-1}) significantly increased the seed and stalk yields of sunflower. A positive response was observed in sunflower to the application of sulphur+ zinc+ boron + 100% NPK followed by sulphur+ zinc + 100% NPK and the residual effect of FYM and sunflower stalk incorporated in soil during kharif soybean. Soil fertility also improved with the integrated use of FYM, sunflower stalk and the recommended dose of fertilizers. While, in case of sunflower, soil fertility was greatly influenced with the additions of secondary and micronutrients. Hence, it can be concluded that the integrated nutrient management of chemical fertilizers along with FYM was found to be a useful approach to maintain the soil health and enhancing the productivity of soybean-sunflower cropping system in alkaline Inceptisols under erratic semi-arid climatic conditions.

Influence of nutrient management on herbage and oil yield of *Java Citronella* in Vidarbha region of Maharashtra

SP Nandapure, SG Wankhade, SM Jadhao, PG Ingole and SS Wanjari

Department of Soil Science and Agricultural Chemistry,

Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola - 444 104, Maharashtra

E-mail: sachin.nandapure@gmail.com

Abstract

The present study was carried out during *kharif* 2009-10 and 2010-11. The fertility status of the soil was moderate in organic carbon, low in available N and P and very high in available K while the soil micronutrient contents (Zn, Fe, Mn, Cu) were above the critical level. Experiment comprised of thirteen treatments replicated thrice in randomized block design, involving control (no fertilizer/manure), 5 t FYM ha^{-1}, 10 t FYM ha^{-1}, 80:20:40 kg NPK ha^{-1}, 100:30:60 kg NPK ha^{-1}, 140:40:80 kg NPK ha^{-1}, 5 t FYM + 80:20:40 kg NPK ha^{-1}, 5 t FYM + 100:30:60 kg NPK ha^{-1}, 5 t FYM + 140:40:80 kg NPK ha^{-1}, 10 t FYM + 80:20:40 kg NPK ha^{-1}, 10 t FYM + 100:30:60 kg NPK ha^{-1}, 10 t FYM + 140:40:80 kg NPK ha^{-1} and 100 kg N through FYM (based on FYM analysis).

The results from the two years of experimentation indicated that, the combined application of FYM + NPK @ 10 t + 140:40:80 kg ha^{-1} resulted in maximum plant height (140.20 cm) and number of tillers (58.43) followed by 5 t FYM + 140:40:80 kg NPK ha^{-1} which was significantly superior over rest of the treatments. Herbage yield was comparatively higher during the second year of the crop and it was increased successively with each combination of increasing FYM levels and graded doses of NPK. Significantly highest herbage yield was recorded with 10 t FYM along with 140:40:80 kg NPK ha^{-1}. The oil content recorded with the combination treatments of FYM + NPK was comparatively higher than the alone application of FYM and NPK doses. Significantly higher oil content (1.14%) was recorded with 10 t FYM + 140:40:80 kg NPK ha^{-1} than all other treatments except 10 t FYM + 80:20:40 kg NPK ha^{-1} and 10 t FYM + 100:30:60 kg NPK ha^{-1}, which was found at par with 10 t FYM + 140:40:80 kg NPK ha^{-1}. Further it was observed that the recovery of oil varied from 0.54 to 0.70 per cent and the highest oil recovery was also observed with 10 t FYM + 140:40:80 kg NPK ha^{-1}. Oil yield was more in second year than first year in all the treatments except, in control treatment. Further, it is observed that, significantly highest oil yield (184.42 kg ha^{-1}) of Java citronella was recorded with 10 t FYM + 140:40:80 kg NPK ha^{-1} which was 108.62, 48.16 and 11.58 per cent higher than the treatments FYM to supply 100 kg N, 140:40:80 kg NPK ha^{-1} and 10 t FYM + 100:30:60 kg NPK ha^{-1}, respectively.

From the results, it can be concluded that the conjunctive use of FYM along with chemical fertilizer (10 t FYM + 140:40:80 kg NPK ha^{-1}) was found beneficial to increase the plant height, number of tillers, herbage yield, oil content, oil recovery as well as oil yield of *Java citronella*.

Dynamics of micronutrient availability in rice-wheat cropping systems under organic vs. conventional management

Ajay Kumar Bhardwaj, Deepika Rajwar, Suresh Kumar Chaudhari and Dinesh Kumar Sharma
ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
E-mail: ajaybhardwaj@gmail.com

Abstract

Suitability of a soil fertility management practice can be best assessed by the availability of nutrients in soil for crop growth, especially at critical growth stages. Micronutrient availability in soils and to crop is an area of increasing interest recently due to role of micronutrient in human health. Micronutrient fortification in food products is very common now, due to lesser amounts available in the harvested crops. In this study, with different fertilization sources (organic and inorganic), ion exchange resin membranes were used as plant root simulators to determine micronutrient (Zn, Fe, Cu, Mn) availability in soil solution during crop growth in complete rice-wheat system. Ion exchange membrane strips were installed in the treatments continuously throughout the rice and wheat growing seasons and were replaced at intervals of 15 days. Treatments included: recommended doses of inorganic fertilizers (F), reduced inorganic fertilizer supplemented with organic inputs such as green manure (*Sesbania esculeata*; GM), legume (*Vigna radiata*; LEG), wheat straw (WS), paddy straw compost (PC) and farmyard manure (FYM). Micronutrient availability scenarios indicated diverse scenarios of availability as the crop growth progressed for all the treatments. For Zn the availability varied between 0.05 to 0.3 µg day^{-1} cm^{-2} for both rice and wheat seasons. In general, organic treatments were found to supply similar amounts of Zn compared to recommended dose treatment, though the daily availability varied with rainfall during the period. GM, FYM, LE treatments stood out with better availability of Zn in wheat season showing residual effects of materials applied in rice crop. In all there were insignificant differences for full season. Similar trends were observed for Mn, Fe and Cu. Our studies bring out intricate relations between management and micronutrient availability which can be useful for managing micro-nutrition in rice-wheat systems effectively.

Modification of inverse auger hole method for saturated hydraulic conductivity measurement

Rohit Pratap Ojha, Chhedi Lal Verma, Derrick M Denia[1], CS Singh and Manjul Kumar
ICAR-Central Soil Salinity Research Institute, Regional Research station, Lucknow – 226 002, Uttar Pradesh
[1]VSAET, SHIATS, Allahabad – 211 007, Uttar Pradesh
E-mail: lalc_verma@yahoo.com

Abstract

Saturated hydraulic conductivity or basic infiltration rate of soil is required for understanding design of subsurface horizontal drainage system, irrigation system, ground water abstraction struture ar recharge system. Large numbers of methods are available for in-situ as well as laboratory measurement of saturated hydraulic conductivity. Infiltrometer and inverse auger hole methods based on similar hypothesis are employed for measuring in-situ saturated hydraulic conductivity of soil. Infiltrometer method is suitable for measurement of vertical saturated hydraulic conductivity of surface soil while inverse augerhole method is suitable for determination of horizontal saturated conductivity of subsoil. Constant head permeameter is

useful for laboratory measurement of saturated hydraulic conductivity of disturbed soil sample taken with the help of core. Inverse augerhole covers sizable soil volume hence provides the best representative measured value of hydraulic conductivity. Available mathematical equation for calculation of saturated hydraulic conductivity assumes flat bottom of auger hole but auger used for making hole in soil makes a hemispherical cavity at the bottom of hole. Existing inverse augerhole method was modified for hemispherical bottom. The modified equation can be written as under

$$K_S = 1.15\, r \frac{\log_{10}(h_0 + r) - \log_{10}(h_t + r)}{(t - t_0)} \qquad (1)$$

An experiment was conducted to calculate subsurface saturated hydraulic conductivity in uncultivated untilled sodic soil by making an auger hole of 13.0 cm diameter up to 40 cm depth in sodic soil. The average value of saturated hydraulic conductivity measured with existing model was 0.69cm/day while with modified equation it was 0.65 cm/day. The value calculated by existing model is 5% higher than value obtained using modified model. Saturated hydraulic conductivity of uncultivated untilled sodic soil is quite low hence the difference is not very high but for normal conditions there may be sizable difference. The modified model is based on sound hypothesis compared to existing model hence, recommended for further field application.

Effect of crop intensification and establishment techniques on salt concentration in soil

Indu Bala Sethi, Rohitashav Singh, VK Singh, Sumit Chauturvedi and AP Singh
Department of Agronomy, GB Pant University of Agriculture & Technology, Pantnagar – 263 153, Uttarakhand
E-mail: indubalasethia2012@gmail.com

Abstract

The rice-wheat is the principal cropping system in South Asian countries that occupies about 13.5 million hectares in the Indo-Gangetic Plains (IGP), of which 10 million hectares are in India. This cropping system is dominant in most Indian states such as Punjab, Haryana, Bihar, Uttarakhand, Uttar Pradesh and Madhya Pradesh, which contributes 75% to the national food grain production. A field experiment was conducted in Norman E. Borlaug Crop Research center, G.B. Pant University of Agriculture and Technology, Pantnagar, District Udham Singh Nagar, Uttarakhand (India) during year 2015 - 2016. The experiment was laid out in a randomized block design (RBD) with nine treatment combinations T_1 (Rice (TPR) – Wheat – Continue), T_2 (Rice (TPR) - Vegetable pea - Groundnut, T_3 (Rice (DSR) - Vegetable pea - Maize (Grain), T_4 (Rice (DSR) - Potato -Cowpea (Grain), T_5 (Rice (DSR) - Vegetable pea - Maize (cob + fodder), T_6 (Rice (DSR) - Yellow Sarson - cowpea, T_7 Rice (DSR) (B)+Sesbania (F)- 2:1 (FIRBS 45cm * 30 cm) -Vegetable pea (B) + Toria (F)-2:1 (FIRBS) - Maize (B) (cob + fodder) + Mentha (F) 1:1(FIRBS), T_8 Soybean (B)+Rice (DSR) (F)-2:1 (NBS 60cm * 30 cm) - Wheat + Mentha (3:1) (NBS 60cm * 30 cm) - Continue (NBS 60cm * 30 cm), T_9 Maize (B) (cob + fodder) + Cowpea (B) +Sesbania (F)-2:1:2 (BBF 105cm * 30 cm) - Vegetable pea + Toria-3:1 (BBF) - Groundnut+Mentha-3:1(BBF) in Kharif, Rabi and Summer season, respectively and replicated thrice. The salt accumulation was reduced with diversification and bed planting system as compared to traditional cropping system.

Role of priming for soybean germination under saline soils: A review

Mahesh Jajoria
Research Scholar, SKN College of Agriculture, SKN Agriculture University, Jobner – 303 329, Rajasthan
E-mail: mahseh.bunti@gmail.com

Abstract

Soybean seed germination is referred as "epigeal", because food storage structure (cotyledons) in pulled above the soil surface. Dry and/or flooding, cool temperatures, lack of oxygen are conditions that can hinder soybean germination and emergence. Salinity is one of the major abiotic factors that limit plant growth and productivity in many regions of the world due to increasing use of poor quality water for irrigation and soil salinization. Germination process starts with the seed absorbing soil moisture until seed moisture content reaches about 50 per cent. The first sign of visual germination is the emergence of the hook shaped hypocotyls which straightens out pushing through the soil surface and pulling the cotyledons upward. Generally, emergence occurs about 5 to 21 days after planting, depending on the field conditions. Favorable soil conditions of soil temperature, moisture and oxygen can help soybean seedlings to develop faster and higher rates of survival. During priming, seeds are partially hydrated so before pre-germination metabolic activities proceed, while radical protrusion is prevented, and then seeds are dried back to the original moisture level. Seed priming is an effective way to improve seed and seedling vigor. Seed priming can enhance rates and percentage on germination and seedling emergence, which ensure proper stand establishment under a wide range of environmental conditions

Performance of irrigation scenarios and soil amendments on the productivity of rice under sodic soil conditions

A Alagesan, M Baskar, P Balasubramaniam, P Pandiyarajan and MJ Kaledhonkar[1]
AD Agricultural College and Research Institute, Tamil Nadu Agricultural University, Trichy – 620 009, Tamil Nadu
[1]ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
E-mail: alagesan2000@gmail.com

Abstract

The experiment was conducted during 2015-16 to study the performance of different irrigation scenarios and soil amendments under sodic soil conditions at research farm of AD Agricultural College and Research Institute, Tiruchirapalli, Tamil Nadu. The treatments comprised of irrigation scenarios (4) I_1: Canal water alone, I_2: Canal water: Alkali water (1:1 cyclic mode), I_3: Canal + Alkali water combined (50+50 %) per irrigation, I_4: Alkali water alone and soil amendments (4) S_1: Control, S_2: Green / green leaf manuring @ 6.25 t/ha, S_3: Distillery spent wash @ 5 lakh litres / ha, S_4: Gypsum 50 % GR + Green manuring with Daincha @ 6.25 t/ha were imposed as per the treatment schedule.

The results revealed that, among the irrigation management practices, application of alkali water alone (I_4) recorded a grain yield of 50.49 q ha^{-1}. The other treatments viz., I_3: Applicatiion of canal water + Alkali water (50+50), I_2: Application of canal and alkali water as 1:1 cyclic mode and I_1: Application of Canal water alone recorded with a grain yield of 56.22, 54.96 and 59.05 q ha^{-1} respectively. Among the soil amendments, the treatment S_3, application of distillery spent wash @ 5 lakh litres ha^{-1} recorded a highest yield of 59.40 q ha^{-1} followed by S_4; application of gypsum 50% GR+green manuring @ 6.25 kg ha^{-1}, S_2: green manuring @ 6.25 t ha^{-1} and S_1: control with a respective grain yield of 57.31, 54.32 and 49.68 q ha^{-1}. With respect to the interaction effect between irrigation water and soil amendments, the treatment combination I_1S_3: application of canal water irrigation combined with application of distillery spent wash @ 5 lakh litres ha^{-1} resulted significantly in higher grain yield of 64.60 q ha^{-1}.

Study of soil physicochemical parameters and nature of organic matter in relation to salinity in different landforms in a coastal soil of West Bengal

Shishir Raut, B Maji and D Burman
ICAR-Central Soil Salinity Research Institute, Regional Research Station, Canning Town – 743 329, West Bengal
E-mail: shi_cssri@yahoo.com

Abstract

Soil physicochemical parameters like pH, EC, saturated moisture content, texture, organic C were determined for soils coming under three different landforms namely, depressed low land, deltaic land and mudflat covering three villages of Gosaba Block in coastal West Bengal. The area covers approximately four square km. The humic components of organic matter, namely, humic acid and fulvic acid, were also separated out. Steady state cumulative infiltration was highest (50-60 mm) in deltaic upland soil and lowest (8-10 mm) in depressed soil. Organic Carbon content of all soils were high (<1.5%) and EC values were also low to high (2.5-14.3 dS/m). Saturated soil moisture was high in low land soil. The deltaic upland soils contained higher fraction of fulvic acid (0.17-0.2%) which enhanced infiltration, whereas depressed soils contained greater fraction of insoluble humic acid (0.30-0.35%) and exhibited less cumulative infiltration. The humic acid fulvic acid ratio decreased with soil depth.

Both the percentage of clay content and percentage of clay plus silt were significantly positively correlated with the percentage of organic carbon (r^2 = 0.75 and 0.72, respectively). With an increase in soil salinity, in general there was a decrease in organic matter content for all soils. The correction of soil pH and EC, and modification of soil texture with adoption of appropriate amendments were suggested for improving sorptivity particularly of the mudflat and depressed low land soils of the study area.

Influence of various sodicity levels on growth and cationic distribution in clonal *Eucalyptus* plantation

David Camus, Anil R Chinchmalatpure, Rakesh Garg, Shrvan Kumar, Indivar Prasad and Monika Shukla
ICAR-Central Soil Salinity Research Institute, Regional Research Station, Bharuch – 392 012, Gujarat
E-mail: davidcamus1984@gmail.com

Abstract

Levels of sodium, potassium, calcium and magnesium in plant tissues and growth of one and two year old Eucalyptus clone 413 were determined under different pH ranges (<8.2, 8.2-8.7, 8.7-9.2 and >9.2) at Raina farm, Salimpur, Kurukshetra district, Haryana (29° 52' N to 30° 12' N latitude and 76° 26' E to 77° 04' longitude). The electrical conductivity (EC_e) ranged from 0.48 dS/m to 1.27 dS/m while the sodium adsorption ratio (SAR) ranged from 2.05 to 14.86. The index of bioaccumulation were recorded with degree of accumulation being slight in Na (0.01 - 0.04) and Mg (0.04 - 0.07) but medium in Ca (0.11 - 0.22) and intensive (1.85 - 11.97) in K. The overall levels of the elements in plant tissues were K > Ca > Na > Mg. The Eucalyptus clone 413 performed better at pH ranges of <8.2 and 8.2-8.7 with mean annual increment (MAI) of 12.65 m^3/ha/year and 10.20 m^3/ha/year, respectively at the age of two years. Whereas, at pH ranges of 8.7-9.2 and >9.2, there was drastic (60%) reduction in volume. There was significant increase in proline production in two year old plantations (0.76 - 1.22 ug/g FW) when compared to one year old plantations (0.73 - 0.82 ug/g FW) from normal soils to higher pH soils. Even though the concentration of sodium ions in the soil varied from 2.72 to 15.42 me/L, the level of sodium ion uptake by leaves ranged from 0.11 to 0.13 percent. This is a clear indication of the capacity of Eucalyptus clone 413 to exclude sodium ions. The negative trend in the growth of clone 413 at higher pH levels may be due to osmotic stress or due to relatively high Na content (>11 me/L) in soils at pH levels >8.7 which hampers the root growth and may also cause nutritional disorders because of elevated soil pH.

Effect of crop residues and chemical amendments on biological properties of salt affected soils of Purna Valley of Maharashtra

SD Jadhao, DV Mali, VK Kharche, SM Jadhao, BA Sonune and Sunita Bagal
Department of Soil Science and Agricultural Chemistry,
Dr. Punjabrao Deshmukh Krishi Vidhyapeeth, Akola – 444 104, Maharashtra
E-mail: sdjadhao@rediffmail.com

Abstract

The laboratory incubation study was conducted at Dr. PDKV, Akola to study the effect of various crop residues, FYM and gypsum on soil biological properties of salt affected soil. Based on the ESP of salt affected soils, six sites of Purna valley were selected and soil samples were collected and analyzed for various chemical and biological properties before filling in pot. A pot containing 5 kg soil were kept with crop residues (cotton stalk, soybean straw and wheat straw) and FYM @ 5 t ha^{-1}, gypsum @ 2.5 t ha^{-1} and with no crop residues and gypsum (control). Biological properties were assessed after 30 and 60 days of incubation. The results indicate that, the application of FYM @ 5 t ha^{-1} showed higher microbial count (bacteria, fungi and actinomycetes), microbial biomass carbon, CO_2 evolution, urease activity, cellulose activity at 30 days of incubation. Among various crop residues application of soybean straw @ 5 t ha^{-1} showed its superiority in influencing all the soil biological properties. Slight reduction in all the biological properties was observed at 60 days of incubation period. The highest reduction observed in fungal population followed by bacteria and actinomycetes. Similarly SMBC, CO_2 evolution, enzyme activities (urease, cellulase and dehydrogenase) reduced with increased ESP level.

Nitrogen mineralization, microbial and urease activity kinetics as affected by soil salinity in wheat

Bharti, Gajender Yadav and Madhu Choudhary
ICAR- Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
E-mail: bhartidixit821@gmail.com

Abstract

The experiment was conducted to study the nitrogen mineralization, microbial and urease activity kinetics as affected by soil salinity in wheat, during Rabi season of 2015-16 at ICAR-Central Soil Salinity Research Institute, Karnal. The temporal changes in nitrogen mineralization, soil microbial population, and urease activity were determined under soil salinity and estimated ameliorating effect of rice straw and FYM. The experiment was laid out in split plot design with four levels of soil salinity (EC_e dS/m) viz; (Control, 1.75, 6, 8 and 11 dS m^{-1}) as main plot treatments. In sub-plot treatments seven combinations of different doses of nitrogen fertilizers along with soil mixing of rice straw and Farm Yard Manure (FYM) were applied. The effect of soil salinity on soil microbial count, nitrogen mineralization, urease activity is consistent in both the sampling cycles i.e. after crown root initiation (14 DAS) and after late jointing stage of wheat growth (54 DAS). Soil salinity reduced total bacterial count, exchangeable ammonical nitrogen (NH_4^+), soluble NO_3^- and urease activity. The effect of soil salinity on soluble $NO_3^-$was considerably higher than that of exchangeable NH_4^+ in both the cycles. The effect of all treatments combinations of nitrogen doses along with rice straw and FYM application was not consistent with the time after N application in both the cycles.

Theme III

Advancements in Reclamation and Management of Poor Quality Waters

Effect of canal and alkali water under cyclic mode on performance of rice and residual vegetables

P Balasubramaniam, M Baskar, P Pandiyarajan and MJ Kaledhonkar[1]
AD Agricultural College and Research Institute, Tamil Nadu Agricultural University, Trichy – 620 009, Tamil Nadu
[1]ICAR-Central Soil Salinity Research Centre, Karnal – 132 001, Haryana
E-mail: balu_tnau@yahoo.co.in

Abstract

A field experiment was initiated in 2008 to study the most suitable mode of using alkali water for supplemental irrigation with canal water and to find out a profitable vegetable crop grown after rice in alkali soil. Results of the five year experiments revealed that canal water irrigation for rice (M_2) recorded the maximum yield of 6.30 t /ha (5th year results 2014) followed by cyclic irrigation of canal water and alkali water in 1:1 ratio (M3). Lowest grain (4.31 t/ ha) and straw yield (5.34 t/ ha) recorded in alkali water irrigation. In respect of method of planting, adopting square planting (S_3) registered the maximum grain yield of 5.90 t /ha followed by line planting (S_2) and machine planting (S_4). The lowest grain and straw yield were recorded in conventional method of planting (S_1). After the harvest of rice crop, the each main plot was divided into 4 sub-plots and different vegetable crops viz., Okra, Cluster bean, Lab-lab and vegetable cow pea were sown following the harvest of rice crop in the same experimental plot during June 2014. All the vegetables performed well in M_2 treatment (Irrigating rice with canal and vegetable crops with alkali water) followed by Irrigating rice with canal and alkali water at the ratio of 1:1 cyclic mode subsequently irrigating vegetable with alkali water (M_3). The plot received both rice and vegetable with alkali water registered the lowest yield. Among the vegetables tried, Okra registered the highest yield of 6.83 t/ha in canal water irrigation which also recorded the highest income of Rs. 1.866 lakhs /ha. The post harvest soil samples were analysed for pH, EC and ESP. The results indicated that the pH value varied from 8.50 in canal to 9.04 in alkali water irrigation after 5 years. Canal water irrigation recorded the lowest EC value of 0.17 dSm^{-1} followed by cyclic mode of irrigation (0.19 dS m^{-1}). Highest EC was registered in alkali water irrigated plots (0.25 dS m^{-1}). Irrigation with alkali water continuously for five years increased the ESP to 32.23 and the lowest level of ESP 18.28 was recorded in canal irrigation.

Is water conditioner cum descaler improves quality of underground sodic water for irrigation

KS Sekhon, Sudhir Thaman, AS Sidhu, Anureet Kaur, OP Choudhary[1], GS Buttar[2] and Rajan Aggarwal[3]
Punjab Agricultural University, Regional Research Station, Bathinda – 151 001, Punjab
[1]Department of Soil Science, Punjab Agricultural University, Ludhiana – 141 004, Punjab
[2]Directorate of Extension Education, Punjab Agricultural University, Ludhiana – 141 004, Punjab
[3]Department of Soil and Water Engineering, Punjab Agricultural University, Ludhiana – 141 004, Punjab
E-mail: kss@pau.edu

Abstract

In south-west region of Punjab comprising districts of Bathinda, Mansa, Sri Muktsar Sahib, Faridkot, Fazilka and Ferozepur, approx. 70% of the underground water is brackish (saline, sodic and saline-sodic) in nature. Indiscriminate use of such waters for irrigation purpose deteriorates the physico-chemical properties of soil which ultimately reduces the crop productivity. The dependence on the use of underground saline and/or

sodic water for irrigation seems inevitable due to ever shrinking canal water supplies. A device known as water conditioner cum descaler based on the scientific principle of Magneto Hydro Dynamic Treatment (MHDT) is advocated by many manufactures to improve quality of underground brackish water. Farmers of the area have made several queries from time to time about usefulness of this device due to its high cost. A study was conducted from 2010-16 at PAU Regional Research Station, Bathinda on loamy sand soil with an aim to test the performance of water conditioner cum descaler regarding improvement in water quality; its influence on crop productivity and chemical properties of soil under cotton-wheat/*raya* cropping sequence. The experiment comprised of four treatments of irrigation viz. canal water (CW); raw tube well water (TW); purified tube well water (PTW); alternate raw tube well and purified tube well water (TW/PTW) with four replications in randomized block design. The residual sodium carbonate (RSC) and electrical conductivity (EC) of the raw tubewell water and canal water used for the study was 6.4 & 0.5 meq L^{-1}; and 2200 & 450 µmhos cm^{-1}, respectively. In PTW treatment, the brackish water is passed through water conditioner cum descaler fitted on tubewell delivery pipe. The results revealed that in cotton, treatments TW, PTW and PTW/TW produced statistically at par seed cotton yield which was significantly lower than CW treatment. In wheat and *raya*, different qualities of irrigation water had non-significant effect on grain yield. Irrigation with TW, PTW and TW/PTW exerted similar influence on pH, EC, sodium adsorption ratio (SAR) and organic carbon content of the surface layer of soil, which significantly differs from CW irrigation. The results showed no improvement in water quality parameters (EC and RSC) of PTW as compared to TW treatment and exhibited similar deleterious effect on soil properties at the termination of the experiment.

Soil solution electrical conductivity and nutrient concentration in salt affected soils under conjunctive saline water irrigation

Arvind Kumar Rai, Nirmalendu Basak, Bhaskar Narjary, Parul Sundha, RK Yadav, Satyendra Kumar, Gajender, AK Bhardwaj, Madhu Chaudhary, Anil R Chinchmalatpure and DK Sharma

ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana

E-mail: rai_arvindkumar@rediffmail.com

Abstract

In many farming situations of arid and semi-arid regions, limited availability of good quality water necessitates the conjunctive use of fresh and saline water to increase the crop yields. Assessment of the real time *in situ* electrical conductivity of root zone in salt-affected soil under saline water irrigation can help in developing proper soil-water-crop management practices. The total concentration of dissolved salts in the soil solution usually employed for measurement of soil salinity is empirical in nature and generally does not match with the electrical conductivity of the soil solution wetting the roots of the crop plant. Study analyses the dynamics of electrical conductivity (EC_{SS}) and nutrient concentration in soil solution collected from soil at field capacity after 24 h of irrigation using centrifugal filters. Soil samples were drawn from the ICAR-CSSRI Research Farm (Panipat) field under sorghum-wheat cropping system since 2014. Soil solution in quasi-equilibrium with soil solid phase was extracted and analyzed for different cationic and anionic constituents. The EC_{SS} and pH_{SS} were in the range of 3.1-42.05 dS m^{-1} and 7.61-8.56, respectively. The dissolved organic carbon (DOC) and total nitrogen in soil solution were in the range of 11.54-476.9 mg L^{-1} and 77.81-363.5 mgL^{-1}. Correlation matrix between different cationic and anionic constituents and their indices were

developed. Soil pH_2 was positively correlated ($r > 0.3$-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 DOC. Ca^{2+}/Mg^{2+} (CMR) was negatively correlated with pH_2. These findings suggests that EC_2 and SAR play important role in determining soil pH but cationic and anionic ratio also modify the soil pH at micro level. Biomass production of the salt tolerant wheat variety KRL-210 was only slightly affected by different soil solution parameters due to its adaptive mechanisms in the tested range. About 85.6% variability in DOC content of soil solution was explained by Ca+Mg, pH_{SS}, total nitrogen and $Na/(Cl^- + SO_4^{2-})$ ratio.

Temporal variations in soil nutrient dynamics of rice-prawn integration in *Pokkali* lands

Sreelatha AK, Manju Roshni K, Arya Lekshmi V and Anila T Sasi

Rice Research Station, Kerala Agricultural University, Vyttila, Kochi – 682 019, Kerala

E-mail: sreelatha.ak@kau.in

Abstract

Pokkali system of cultivation is a unique practice in many waterlogged coastal soils of Kerala. In this system, salt tolerant, tall varieties of rice are grown alternately with prawn/fish in the same field. While rice is grown during the monsoon season, prawn is cultured during rest of the year. In recent times, however, there has been an intensification of prawn culture in many areas. *Pokkali* fields are essentially wetlands subject to high tidal inundation and consequent changes in soil properties and salinity which need to be thoroughly studied. With this background, a study was conducted to evaluate the soil properties before and after rice- prawn cultivation in *Pokkali* soils. Soil samples were collected from a *Pokkali* field at Kumbalangi, Ernakulam district, Kerala where rotational rice-prawn cultivation has been carried out over the years. Samples were taken during two consecutive years *viz.*, 2014-15 and 2015-16 four times in the months of June (before rice crop), October (after rice harvesting), November (before prawn culture) and in May (after prawn harvesting). Soil pH before rice cultivation was neutral and changed to moderately acidic after rice harvest. Organic carbon content of the soil remained high before and after rice cultivation. Other major nutrients like P and K were high in content. Calcium was present in adequate amount whereas Mg was deficient. Soil sulphur levels were low to medium in the first year but high in the following year. Cu, Fe and Zn contents were adequate. Mn was adequate in the first year and deficient in the second year. Soil pH before prawn cultivation was moderately acidic and changed to neutral after prawn harvest. Organic carbon increased after prawn cultivation. Major nutrients like P and K were high. Calcium levels fluctuated within low and adequate ranges in both the years. Mg was very low while sulphur was medium to high in status. Cu and Zn were adequately present. While Fe remained high in both the years, Mn was low. Rice-prawn integration was found to be very beneficial and successful in *Pokkali* lands. In *Pokkali* cultivation, only rice panicles are harvested and rest of the plant is left to decay to provide nutrition to the prawn. Similarly, prawn excreta add to the soil nutrient content benefitting the succeeding rice crop. Based on these results, it seems that rice-prawn integration is an environmentally sustainable and economically viable method of cultivation in *Pokkali* lands. Monoculture of prawn could deteriorate soil and water quality and may result in the salinization of the area in long run.

Effect of water quality on exchange phase-solution phase behaviour of salt affected soils of Purna Valley of Vidarbha region of Maharashtra

SM Jadhao, PR Kadu, Bhargabi Chakraborty, SB Wadatkar, DV Mali and SD Jadhao
Department of Soil Science and Agricultural Chemistry,
Dr. Punjabrao Deshmukh Krishi Vidyapeeth, Akola – 444 104, Maharashtra
E-mail: satishchandra_i@rediffmail.com

Abstract

The effect of total electrolytic concentration (TEC) and sodium adsorption ratio (SAR) of water on ESR-SAR relationships of salt-affected soil was studied on the soils collected from salt-affected areas of Ramagarh village of Akola district, Maharashtra. Total twelve solutions, with four levels of TEC *i.e.*, 10, 20, 40 and 80 me L^{-1} and three levels of SAR *viz.*, 5, 10 and 15 $mmol^{1/2}L^{-1}$ were prepared for equilibration of soil samples. The Ca: Mg ratio was kept at 1: 1.5 in these solutions. Pure AR grade chloride salts of calcium, magnesium and sodium were used to prepare different quality waters. The SAR of equilibrium solution increased with increasing SAR levels and also with increasing TEC. With increasing depth, there was a sharp increase in the SAR values of the equilibrium solution as compared with equilibrating solution. It showed increasing trend with an increase in TEC levels. The highest increase in SAR_{eq} was recorded with 80 me L^{-1} TEC level. Higher ESP was recorded with higher TEC levels. Similarly, the Exchangeable Sodium Ratio increased with increasing TEC and SAR levels. The regression coefficient for ESR-SAR relationship increased with increase in TEC and SAR_{iw}.

Crop response to saline water with drip irrigation in coastal sandy loam soils

A Sambaiah, GV Lakshmi, M Raghu Babu M Latha, K Hema, PV Rao and K Anny Mrudhula
AICRP Saline Water Scheme, Agricultural College, ANGRAU, Bapatla – 522 101, Andhra Pradesh
E-mail: sambaiah3103@gmail.com

Abstract

An experiment was conducted on vegetable crops *viz.*, capsicum (*Capsicum annum*), cluster bean (*Cyamopsis tetragonoloba*) and palak (*Beta vulgaris*) using different salinity waters *i.e.*, BAW (Best Available Water; EC_{IW} 0.6 dS m^{-1}), 2, 4, 6 and 8 dS m^{-1} to study the response of these crops in sandy loam soils of coastal region of Andhra Pradesh. Crop yields varied depending on the groundwater salinity. Results showed that micro-irrigation with BAW treatment gave the highest yield followed by 2, 4, 6 and 8 dS m^{-1} salinity waters. High soil salinity leads to decrease in the crop yields. The respective mean yields at BAW, 2, 4, 6 and 8 dS m^{-1} were found to be 6.6, 5.3, 4.0, 3.0 and 1.9 t ha^{-1} in capsicum; 8.3, 7.2, 6.0, 4.9 and 3.3 t ha^{-1} in cluster bean and 8.8, 7.5, 5.1, 3.8 and 1.9 t ha^{-1} in palak. Yields of capsicum, cluster bean and palak followed an inverse linear relation with irrigation water salinity and the yield levels of 90, 75, 50% were realised at 1.2, 2.7 and 5.2 dS m^{-1}; 1.5, 3.2 and 4.5 dS m^{-1} and 1.5, 2.9 and 5.3 dS m^{-1} irrigation water salinity, respectively. Capsicum, cluster bean and palak were found economically viable up to 3.15, 4.25 and 4.50 dS m^{-1} irrigation water

salinity in open field cultivation. The order of salinity tolerance was found to be cluster bean > capsicum > palak. Salinity build up in the soil irrigated with different salinity water was found to increase from 40% with 2 dS m^{-1} to 48.5% wtih 4 dS m^{-1}, but the salinity build up was well below 1 dS m^{-1}. Soil nitrogen reduced by 24.1 and 25.7% under 2 dS m^{-1} and 4 dS m^{-1} salinity levels, respectively, compared to the initial values. Similar trend was found with phosphorous, but inverse trend was observed with regard to potassium. The clogging of drip laterals was not found but salt deposition was observed outside the emitter on the periphery of the laterals with 6 and 8 dS m^{-1} irrigation water salinity. The micro-irrigation system with saline irrigation waters (up to 6 dS m^{-1}) can be used effectively without clogging/scaling of salts on drippers in coastal soils. It is suggested to apply FYM @ 25 t ha^{-1} and foliar application of 19:19:19, N:P:K at 60 DAS, to reduce the ill effects of water salinity on crop yield.

Long-term effect of treated distillery effluent on soil, groundwater quality and yield of sugarcane

M Baskar, P Balasubramaniam, P Pandiyarajan and MJ Kaledhonkar

AD Agricultural College and Research Institute, Tamil Nadu Agricultural University, Trichy – 620 009, Tamil Nadu

[1]ICAR-Central Soil Salinity Research Institute, Karnal - 132 001, Haryana

E-mail: mbaskar_uma@rediffmail.com

Abstract

Long term field experiment was initiated during 2002 at EID Parry (I) Ltd., cane farm, Edayanvelli, Cuddalore District, Tamil Nadu to evaluate the long term effect of different rates of pre-plant application of treated distillery effluent (TDE) along with different combinations of N, P and K on the changes in soil physico-chemical properties, fertility status, exchangeable cations and cane yield. The experiment was continued for 13th crop season with the same layout. The TDE was applied at graded doses (main plot treatments), thoroughly mixed and allowed for natural oxidation. Different combinations of NPK fertilizers *viz.,* N alone, NP, NK, PK, NPK and control (without NPK) were imposed as subplot treatments. Results revealed that the application of graded doses of TDE significantly increased the yield of sugarcane. Cane yield increased by 52.1, 64.3, 76.4 and 84.8% when TDE was applied at the rates of 1.25, 2.5, 3.75 and 5.0 lakh lit ha^{-1}, respectively over control. The cane yield of sugarcane remarkably increased due to the application of inorganic fertilizers. Though significant response was observed for N and P fertilizers, differences between applications of N & NK and NP & NPK fertilizers were not significant indicating that the supply of K through PME was sufficient. The interaction effect revealed that TDE application @ 1.25 lakh litres ha^{-1} along with NP fertilizer (75% of recommended dose) is the most suitable dose for maximizing the cane yield. The graded doses of TDE along with NP significantly increased the soil available nutrients and organic carbon content besides improving the soil physical properties. Groundwater quality studies using piezometers revealed that application of distillery effluent remains only in surface layer and there is no vertical movement of salts from the TDE below 0.5 m.

Application of fungal consortium for Industrial wastewater treatment

Deepika Rajwar and JPN Rai
Department of Environmental Science, GB Pant University of Agri. & Technology, Pantnagar – 263 153, Uttarakhand
E-mail: deepika.rajwar@gmail.com

Abstract

Industrial progressions are causing the production of huge amount of venomous and recalcitrant pollutants, which are often disposed into the receiving water body without standardized treatment that ultimately damage the quality of aquatic ecosystem, affects its flora and fauna, and also causes soil toxicity. Bioremediation of these toxic pollutants using range of microorganisms has been extensively endeavoured. However, complete toxicity removal requires highly effective microbial approach that without being affected is capable of treating heterogeneous load of effluent continuously under extreme environmental conditions. To this, free fungal cells do not seem viable for a long-term treatment facing stressed conditions; therefore a fungal bio film is often preferred which generally shield the suspended growth that recovers fungal activity. Moreover, fungal consortium fastens the degradation process that demarcates its advantage from industrial point of view.

The aim of present study was to treat pulp and paper mill industry'swastewater using indigenous fungal consortium in repeated batch process under optimized conditions. For viable fungal growth the optimized environmental and cultural conditions, *viz.,*temperature, pH, inoculum ratio, agitation, carbon, nitrogen was 30°C, 5, 1:02 w/v, 140 rpm, glucose (0.5%), peptone (0.1%), respectively. An experiment employing repeated batch process for three consecutive cycles of 7 days each for wastewater treatment was performed that contained fungal consortium and previously optimized conditions. Out of the three treatment cycles, second cycle produced the maximum reduction of biochemical oxygen demand (BOD), chemical oxygen demand (COD) and color (Co-Pt) upto 92.50 %, 87.31% and 83.15%, respectively followed by third and first treatment cycle. It was also observed that reduction in pollutants load was dependent on biomass production which was 4.11 g/l at the end of first treatment cycle and showed 2.11 fold and 1.20 fold increments in biomass production after completion of second and third treatment cycle. SEM analysis confirmed the changes in mycelial structure during continuous degradation of wastewater that led to slow rate of biomass production in third treatment cycle. Present study manifests that the fungal consortium possess huge potential and stability to detoxify and degrade the wastewater, and further researches on how to increase their stability for prolonged large-scale wastewater treatment need to be explored.

Farmers' participatory approaches for sustaining RWCS using high RSC waters on sodic soils

Parvender Sheoran, Nirmalendu Basak, RK Yadav, Satyendra Kumar, RK Singh and K Thimappa
ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
E-mail: parvender.sheoran76@icar.gov.in

Abstract

Increase in cropped as well as irrigated area coupled with high cropping intensity and a major shift towards rice-wheat cropping system (RWCS) in Indo-Gangetic plains has led to over-exploitation of fresh

groundwater resources causing decline in water table. The lack of good water supplies for irrigated agriculture is now becoming a major issue that is forcing farmers to use poor quality (alkali) waters. Continuous use of such waters would result in build-up of soil sodicity and high proportion of exchangeable sodium ions in the root zone to levels limiting land crop productivity. In the backdrop of this situation, a field experiment was carried out at two locations in farmer's participatory mode representing bicarbonate dominated irrigation water residual alkalinity of 5.13 and 6.93 meq l^{-1}. The soils of the experimental sites is Acquic Natrustalfs with surface soil (0-15 cm) pH (1:2 soil:water) of >9.0 and sub-surface (>15 cm) pH of >9.5, low available nitrogen, medium to high available phosphorus and high available K content. Management approached included four RSC neutralizing ameliorants viz., available RSC water/untreated control (T_1); T_1 + gypsum @ 7.5 t/ha (T_2); T_1 + press mud @ 10 t/ha (T_3) and T_1 + gypsum @ 3.75 t/ha + press mud @ 5 t/ha (T_4) in main plots while two varieties one each as salt tolerant (CSR 30 basmati in rice and KRL 210 in wheat) and traditional ones (Pusa 1121 in rice and HD 2967 in wheat) in respective growing seasons were superimposed to the neutralization treatments. The objective of the study was to assess the productivity potential of selected crop's cultivars vis-à-vis changes in soil properties under continuous irrigation with high RSC and gypsum and press mud ameliorated waters.

Complementary effects of applying RSC neutralization ameliorants either individually or in combination revealed 8.5-10.6 and 10.2-16.5% higher yield of rice and wheat, respectively in comparison to continuous use of high RSC waters for irrigation in annual rotation for RWCS reflecting their effectiveness to counter adverse effect of RSC waters on crop productivity. Varietal difference indicated that rice yield decreased by 12.1 and 18.7% with CSR 30 Basmati and Pusa 1121, respectively with increasing residual alkalinity of irrigation water in sodic water irrigated plots (untreated control). CSR 30 basmati preformed relatively better than Pusa 1211 under stress environments owing to increased irrigation water residual alkalinity. Better tillering capacity and relative water content, lower Na/K ratio in shoot as well as root portion favoured the superiority of CSR 30 basmati. Salt tolerant wheat variety KRL 210 outclassed HD 2967 at both locations explicating 16.3 % (14.4-18.1%) mean yield advantage. Application of RSC neutralizing amendments showed their effectiveness in decreasing the soil pH and exchangeable sodium percentage (ESP) in comparison to untreated control. The relative decrease in pH was more pronounced in surface compared to sub-surface soil. Growing salt tolerant crop cultivars with effective and affordable RSC neutralizing ameliorants (gypsum/press mud) could be a management strategy to mitigate the adverse effect of residual alkalinity in irrigation water and sustaining crop yields under sodic soil dominated RWCS.

Pressurised irrigation in wheat for enhancing water productivity and nitrogen use efficiency

Ranbir Singh, DK Sharma, PK Joshi, K Thimmappa, Martina Rani, Renu Kumari, Subedar Patel and Satyendra Kumar
ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
E-mail: ranbir.singh@icar.gov.in

Abstract

This study was conducted with the aim to know the workability of the pressurized (mini-sprinkler) irrigation method under different operating pressure of installed sprinkler system in rice-wheat cropping sequence. This production system is labour, water and energy–intensive and is becoming less profitable as these resources are becoming increasingly scare and costly. Considering these facts, a field experiment was

conducted at ICAR-Central Soil Salinity Research Institute, Karnal, Haryana during 2011-2013 to study the effects of resource conservation strategies and mini-sprinkler irrigation on crop productivity under rice-wheat cropping system in a reclaimed alkali soil. Three adopted resource conservation viz.; direct seeded rice (DSR) with surface irrigation followed by wheat sowing in zero tillage with rice residue mulch; DSR with mini sprinkler irrigation system with wheat residue incorporation followed by zero tillage wheat with rice residue mulch and DSR with mini sprinkler irrigation system followed by zero tillage wheat with rice residue mulch *vis-à-vis* conventional practices (Cv) were imposed Zero tillage with 100% rice straw mulch produced highest wheat grain yield (6.30 t ha^{-1}) under surface irrigation method followed by 6.01 t ha^{-1} in zero tillage with 100 % rice straw mulch under mini sprinkler irrigation method. Mini sprinkler irrigation method in wheat saved irrigation water up to 37.1 % more over surface irrigation method. Irrigation through mini sprinkler method saved electricity up to 2.16% in comparison to conventional wheat sowing method. Nitrogen use efficiency in wheat crop under mini sprinkler irrigation method was observed up to 80.3 Kg grain Kg^{-1} nitrogen, saved 50% of recommended with 100% rice residue mulch.

Chemical properties of salt affected soils and performance of wheat under saline and alkali water irrigation

NK Arora, SK Chaudhari[1], JA Farooqi[2], AK Rai and Manisha

ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana

[1]Indian Council of Agricultural Research, NRM Division, Krishi Anusandhan Bhawan-II, New Delhi

[2]Deptt of Chemistry, School of Sciences, Indira Gandhi National Open University, New Delhi

E-mail: nk.arora@icar.gov.in

Abstract

Effect of different quality irrigation water *viz.,* normal tap water (NTW, EC 0.7 dS m^{-1}), dilute saline water (DSW, EC 5.0 dS m^{-1}; SAR 5.0 $mmol^{½}$ $L^{-½}$), concentrated saline water (CSW, EC 10.0 dSm^{-1}; SAR 5.0 $mmol^{½}$ $L^{-½}$), dilute alkali water (DAW, RSC 2.5 me L^{-1}) and concentrated alkali water (CAW, RSC 10.0 meL^{-1}) on soil chemical properties and its impact on growth and yield of wheat (cv. KRL 213) was evaluated in normal (pH_s 7.5, EC_e 1.0 dS m^{-1}), saline (pH_s 7.7, EC_e 10.6 dS m^{-1}) and alkali (pH_s 9.15, EC_e 2.9 dS m^{-1}) sandy loam soils in the micro-lysimeter. Compared to the initial values, soil EC_e increased by 9.5 and 12.5 times, and by 5.5 and 7.0 times due to DSW and CSW irrigation in normal and alkali soils, respectively. Contrary to this, decrease in EC_e was observed in all water treatments except CSW in saline soils. Increase in pH_s of normal and saline soils was more pronounced in case of NTW, DAW and CAW as compared to alkali soil. On application of DSW and CSW, decrease in pH_s was observed in alkali soil, whereas it remained constant in normal and saline soils as compared to the initial values. Exchangeable sodium percentage (ESP) invariably increased with the use of different quality waters in normal, saline and alkali soils. However, ESP increase was more pronounced under NTW, DAW and CAW in alkali soil as compared to normal and saline soils. Sodium concentration in saturation paste increased by 15 to 17 times in normal soil, and by 3.5 and 4.5 times in alkali soil under DSW and CSW, respectively. Sodium leaching was observed in saline soil under all water treatments except CSW where it increased by 1.2 times. Sodium build up increased by 1.5 to 2.0 times under all water treatments in normal, saline and alkali soils as compared to post rice sodium concentration. Significant increase in organic

carbon (OC; about 20%) was observed in surface samples in normal soil, whereas OC content was the least in saline and alkali soils. Calcium carbonate increased two to three times in all depths in three soils under DAW and CAW. Wheat yield reduced by about 4%, 11% and 34% under normal, saline and alkali soils, respectively in DAW as compared to NTW. Similarly, CAW caused reduction in grain yield by 31% and 87% in normal and saline soils, and virtually near total crop loss in alkali soil compared to NTW. DSW reduced yield by about 22% each in normal and saline soils and about 70% in alkali soil. Application of CSW reduced yield by 70% in normal soil and resulted in almost complete loss of cropin saline and alkali soils compared to NTW.

Spatial variation of groundwater quality of Guhla block of Kaithal district

Vijay Kant Singh, Ram Prakash, Sanjay Kumar, Satyavan and SK Sharma*

CCS Haryana Agricultural University, Hisar – 125 004, Haryana

E-mail: ramsansanwal@gmail.com

Abstract

The present study examined the quality of groundwater in Guhla block of Kaithal district of Haryana, India. Kaithal district lies in the north-eastern part of Haryana between 29°31'- 30°12' north latitudes and 76°10'-76°42' east longitudes, and has a total geographical area of 2317 sq. km. It is surrounded by Jind, Kurukshetra and Ambala district of Haryana and Patiala district of Punjab in north. The district is divided into six development blocks namely Kaithal, Guhla, Kalayat, Pundari, Rajound and Siwan. A total of 109 groundwater samples from running tubewells in the block were analyzed for ionic concentrations of CO_3^{2-}, HCO_3^-, Cl^-, SO_4^{2-}, Ca^{2+}, Mg^{2+}, Na^+ and K^+. Parameters such as electrical conductivity (EC), sodium absorption ratio (SAR) and residual sodium carbonate (RSC) were evaluated. According to AICRP classification, it was found that 63.2 % water samples were of good quality, 2.7 % marginally saline and 34.1 % alkali in nature. Out of the alkali water samples, 11.1, 22.1 and 0.9 % were marginally alkali, alkali and highly alkali, respectively. Out of 109 samples analyzed, the maximum water salinity EC_{IW} (2.31 dS m^{-1}) was found in village Theh Mukerian. Residual sodium carbonate (RSC) and sodium adsorption ratio (SAR) varied from 0.0-5.80 me L^{-1} and 2.55-14.39 (m mol $L^{-1})^{½}$, respectively. Spatial variable maps of EC, SAR, RSC and water quality of groundwater used for irrigation in the block were prepared through GIS to study the spatial variability.

Monitoring ground water quality for irrigation in coastal districts of Konkan region

JJ Palkar, KD Patil, SS Khobragade and MJ Kaledhonkar

Khar Land Research Station, Dr. BS Konkan Krishi Vidyapeeth, Panvel – 410 206, Maharashtra

E-mail: klrs59@rediffmail.com

Abstract

Water samples were collected in pre-monsoon and post-monsoon season from five different coastal districts of Konkan region of Maharashtra to assess the irrigation water quality and suitability. Water samples were collected from the lands adjacent to creeks and those lying at 10 km distance by using GPS instrument. In

post-monsoon (Nov-Dec, 2014), it was observed that pH and EC showed average value from 5.08 to 8.60 and 0.01 to 8.91 dSm^{-1}, respectively. Sodium content ranged from 0.02 to 17.11 meq L^{-1}. EC values during pre-monsoon (April-May, 2015) increased from 0.01 to 13.79 dSm^{-1}. Similarly, pH and Na^+ levels ranged from 6.34 to 8.90 and 0.11 to 21.67 meq L^{-1}, respectively. It was noted that water salinity declined with increasing distance from the seashore. As per the classification proposed by ICAR-CSSRI, Karnal, around 33.94% of the groundwater samples were found to be saline during the post-monsoon season (November-December, 2014) and about 57.79 % during the pre-monsoon season (April-May, 2015).

Status of fluoride in ground water in Sangat Block, district Bathinda, Punjab

BK Yadav, Sudhir Thaman and Deepak Kumar

Punjab Agricultural University, Regional Station, Bathinda – 151 001, Punjab

E-mail: bkyadav74@pau.edu

Abstract

Fluorine mainly occurs in the form of chemical compounds such as sodium fluoride or hydrogen fluoride, which are present in minerals of fluorspar, fluorapatite, topaz and cryolite. Fluoride pollution of the environment may occur either through natural or anthropogenic causes. Fluoride is beneficial to health if the concentration (C_f) of the fluoride ion (F^-) in drinking water is less than 1.5 mg L^{-1}, but a higher concentration causes serious health hazards. An investigation was undertaken to determine the concentration of fluoride in groundwater of Sangat block in district Bathinda. A total of 52 water samples from 10 villages of Sangat block were collected from working tubewells of farmers' field with the help of Global Positioning System. The study has been carried out for fluoride concentration as well as the quality appraisal of groundwater by focusing on variability of electrical conductivity (EC), pH, cationic or anionic composition and residual sodium carbonate (RSC). Results showed that pH, EC and RSC value varied from 6.98 to 8.28, 0.87 to 6.83 dS m^{-1} and nil to 6.20 me L^{-1} with an average of 7.57, 2.89 dS m^{-1} and 0.41 me L^{-1}, respectively. In all the samples, Na^+ was the predominant cation whereas Cl^- was the major anion. Fluoride value varied from 0.25 to 3.20 with an average of 1.39 mg $L^{-1.}$ The maximum fluoride concentration was found in village Doomwali (N 29°59.018', E 074° 43.678') while the minimum was found in Chak Ruldu Singh Wala (N 30°01.627', E 074° 46.481'). Out of total samples analysed, 58% samples were found within safe limit (<1.5 mg L^{-1}) and 42 percent samples were found beyond permissible limits (>1.5 mg L^{-1}) as per World Health Organisation norms, 1994.

Assessment of irrigation water quality of Jagner and Sainya blocks, Agra district, Uttar Pradesh

RS Chauhan, PK Shishodia, RB Singh and SK Chauhan

AICRP on Management of Salt Affected Soils and Use of Saline Water in Agriculture

RBS College, Bichpuri, Agra – 238 105, Uttar Pradesh

E-mail: aicrp.salinity@gmail.com

Abstract

Water plays a vital role in sustaining the human life on earth. While fresh water is increasingly becoming scarce, the problem of poor quality water is increasing worldwide necessitating investigations to evaluate water quality and suitability for irrigation. Considering these facts, a survey was conducted in Jagner and Sainya blocks of Agra district of Uttar Pradesh in 2012-13 by randomly collecting irrigation water samples

(50 from Jagner, 54 from Sainya) from different villages to cover entire area of these blocks. Water quality analysis results showed that 68% samples in Jagner block and 81.5 % samples in Sainya block were either saline or alkali. A Comparison with the water quality data from a survey conducted 40 years ago, it appeared that water quality has increased probably due to substantial reduction in water salinity and alkalinity in long term. Among 34% alkali water samples of Jagner block, 16% were highly alkali. Similarly, among 28% saline water samples, majority of the samples were high SAR saline (14%). In Sainya block, among 27.8% alkali waters, the major part 14.8% was of highly alkali and among 53.7% saline samples, the major part (38.9%) was of high SAR saline. The maximum EC_{IW} (dS m^{-1}), pH, RSC (meq L^{-1}) and SAR $(mmol/l)^{1/2}$ were 11.2 (Turkpura village), 8.8 (Singaich village), 8.2 (Nimena village) and 39.2 (Sarendhi village), respectively, in Jagner block. The corresponding values for Sainya block were 13.9 (Virai village), 8.5 (Mukhrai village), 13.2 (Silokhar village) and 15.7 (Sonra village), respectively. Cationic ($Na^+ > Mg^{2+} > Ca^{2+} > K^+$) and anionic ($Cl^- > SO_4^- > HCO_3^- > CO_3^-$) composition were same in both the blocks i.e. and. In Jagner block, the maximum samples (36%) were in EC class 1.5-3.0 dS m^{-1}, 40% in RSC absent class and 70 % in SAR 10-20 class. However, in Sainya block, the maximum samples were 35.2%, 51.8% and 57.4 % in respective classes of EC, RSC and SAR. With regard to fluoride composition, 87.7% samples had 0-2.5 ppm F while 12.3% contained 2.5-5.0 ppm F in Jagner block. In contrast, 100% samples of Sainya block had 0-2.5 ppm F.

Assessment of groundwater quality in Achhnera and Bichpuri blocks, Agra district, Uttar Pradesh

PK Shishodia, RS Chauhan, RB Singh and SK Chauhan
AICRP on Management of Salt Affected Soils and Use of Saline Water in Agriculture
RBS College, Bichpuri, Agra – 238 105, Uttar Pradesh
E-mail: pkshishodia1969@gmail.com

Abstract

Precise knowledge of irrigation water quality is very essential for the sound crop and irrigation management; especially in areas where multiple crops are raised in succession in the same land in a year. Consistent with this fact, a detailed survey was carried out for assessing the quality of groundwater in Achhnera and Bichpuri blocks of Agra district. GPS location, depth of watertable, tube well depths and other details were also collected. The collected samples were analyzed for cationic and anionic composition by following standard procedure. The EC_{IW}, SAR and RSC ranged from 1.9-25.4 (dS m^{-1}), 5.2-52.4 $(mmol/l)^{1/2}$ and 0.0-9.4 (meq L^{-1}) in Achhnera block and 1.7 – 23.2 (dS m^{-1}), 6.5-37.9 $(mmol/l)^{1/2}$ and Nil–8.4 (meq L^{-1}) in Bichpuri block, respectively. No sample was found in good category (A) class in Achhnera block, while only 4.4 % samples came under this category in Bichpuri block. In Achhnera block, 91.4% samples were found to be as saline (B class) and the rest 8.6% alkali (C) in nature. In Bichpuri block, 88.9% samples were saline (B) and the rest 6.6% were alkali (C). Saline water samples from Achhnera block were further categorized as marginally saline (B1-10.3%), saline (B2-1.7%) and high SAR saline (B3-79.3%). Similarly, water samples from Bichpuri block were categorized as marginally saline (B1-8.9%), saline (B2-nil) and high SAR saline (B3-80%). Out of total alkali water samples, none were marginally alkali (C1-nil) or alkali (C2-nil) but 8.6% were high alkali (C3) in Achhnera block. Similar results were recorded from Bichpuri block as neither marginally alkali nor alkali problems were noted and about 6.7% samples were high alkali (C3). The waters were of Na>Mg>Ca>K type with the dominance of chloride. Comparison of these results with previous data collected 40 years ago showed that problem of poor quality water has significantly increased in both the blocks.

Changes in chemical properties of soil, irrigated with Agra canal and ground water in Palwal district, Haryana

SK Chauhan, RL Meena[1] and MJ Kaledhonkar[1]
AICRP on Management of Salt Affected Soils and Use of Saline Water in Agriculture
RBS College, Bichpuri, Agra – 238 105, Uttar Pradesh
[1]ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
E-mail: coolyash40@yahoo.com

Abstract

A study was conducted in 2013-14 to assess the changes in soil chemical properties in famers' fields irrigated with the Agra canal water and underground water in Palwal district of Haryana. Three farmers' fields irrigated with Agra canal water and one irrigated with tube well water were selected. Soil samples were collect from the different depths (0-15, 15-30, 30-60 and 60-90cm) from different crops and seasons. The analysis of samples did not show any significant change in different soil properties in fields irrigated with Agra canal water since the last few years. However, soil salinity ($EC_{1:2}$) showed an increasing trend in the field irrigated with underground water since the last so many years. Sodium concentration was considerably higher in tube well irrigated soils compared with those receiving the canal water. The Ca^{2+} Mg^{2+}, HCO_3^-, Cl^-, SO_4^{2-} and SAR were found in all the soil samples but CO_3 and RSC were not detected in any of the samples.

Impact of Agra canal and tube well water irrigation on crops grown in Agra district, Uttar Pradesh

SK Chauhan, RS Chauhan, PK Shishodia and RB Singh
AICRP on Management of Salt Affected Soils and Use of Saline Water in Agriculture
RBS College, Bichpuri, Agra – 238 105, Uttar Pradesh
E-mail: coolyash40@yahoo.com

Abstract

A study was conducted on ten farmers' fields in Bichpuri area of Agra district of Uttar Pradesh. Of the selected farmers, 5 used Agra canal water for irrigation while the remaining 5 were dependent on groundwater for irrigation. We collected data on crop yields to calculate the cost of cultivation, net profit and benefit:cost (B:C) ratio. The sampled farmers grew diverse cereal, vegetable and legume crops. The crops irrigated with canal water gave the highest net return and B:C ratio *i.e.* wheat (Rs. 62,320 and 2.97), pearl millet (Rs. 14,525 and 1.39), fodder sorghum (Rs. 15,515 and 1.49), mustard (Rs. 68,135 and 4.36), berseem (Rs 14,180 and 1.19), moong (Rs. 27,280 and 1.85), radish (Rs. 47,770 and 3.14), potato (Rs.1,04,865 and 2.22), brinjal (Rs. 69,740 and 2.66), cauliflower (Rs. 1,42,795 and 4.57), cabbage (Rs.15,065 and 5.05), carrot (Rs. 87,215 and 4.20), tomato (Rs. 1,19,945 and 3.99), okra (Rs. 50,965 and 2.99) and capsicum (Rs. 1,24,750 and 3.54). When groundwater was used for irrigation, net return and B:C ratio significantly decreased in all the crops. The correcponding values of net return and B:C ratio for the aforementioned crops, in that order, were Rs. 53,185 and 2.22, Rs. 9,075 and 0.63, Rs. 1,24,65 and 1.00, Rs. 52,795 and 2.99, Rs. 10,980 and 0.79, Rs. 12,930 and 0.76, Rs. 40,520 and 2.35, Rs. 80,865 and 1.58, Rs. 59,540 and 2.03, Rs. 1,25,795 and 3.78, Rs. 1,22,265 and 3.73, Rs. 69,215 and 3.03, Rs. 86,945 and 2.63, Rs. 42,965 and 2.25 & Rs. 1,06,785 and 2.79, respectively.

Growth and physiological responses of chickpea (*Cicer arietinum* L.) under saline water irrigation

Gurpreet Kaur, Anita Mann and PC Sharma
ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
E-mail: gurpreetkaurcssri@gmail.com

Abstract

The present experiment was conducted to evaluate the salt tolerance potential of fifteen chickpea germplasm lines collected from CCSHAU, Hisar during *Rabi* 2015 along with CSG-8962 (Karnal Chana-1) as the salinity tolerant check. The experiment was conducted in trays filled with sand in randomized complete block design in 3 replications. Osmotic stress was imposed by applying saline irrigation water (EC_{iw} 6 and 10 dS m^{-1}) along with best available water (BAW) having EC_{iw} 0.6 dS m^{-1} (control). Data were recorded at seedling stage after 3-4 weeks of germination for fresh and dry weight of root and shoot, root length, shoot length, chlorophyll content, Na^+ and K^+ content. Root and shoot fresh weight decreased under saline irrigation. The maximum reduction in fresh weight of root (more than 65 %) was observed in HC-1 and HK-1 at EC_{iw} 10 dS m^{-1} whereas HC-5 and H10-41 showed the minimum reduction. Shoot weight was the maximum in HC-3 and H09-96 (0.71 and 0.58 g/plant) at 10 dS m^{-1} salinity. Similar results were observed for dry weights of root and shoot. Mean chlorophyll content was 1.003 µg g^{-1} FW which decreased by 30.31% at 6.0 dS m^{-1} and 57.93% at 10.0 dS m^{-1}. Out of 16 genotypes, H08-71 and H08-75 showed the minimum reduction in chlorophyll content when high salinity water (10 dS m^{-1}) was applied. Mean Na^+/K^+ was 0.11 in control but significantly increased to 0.398 under EC_{iw} 6.0 dSm^{-1} and 0.628 under EC_{iw} 10.0 dSm^{-1}. Out of the tested genotypes, HC-1, HC-3, HC-5, H09-96 and H10-21 maintained Na^+/K^+ below 0.5 even under high salinity (10.0 dS m^{-1}) treatment. On the basis of these findings, it can be concluded that these genotypes could be used as moderately salt tolerant genotypes for further studies and in breeding programmes.

Ground water quality assessment in Prakasam district of Andhra Pradesh

Y Sudha Rani, Mohana Rao Puli and GV Lakshmi*
AICRP Saline Water Scheme, College of Agriculture, ANGRAU, Bapatla – 522 101, Andhra Pradesh
****E-mail: mohanpuli007@gmail.com***

Abstract

The quality of irrigation water is determined by its chemical composition and conditions of use. The irrigation water quality depends on number of factors for successful application and beneficial uses. The soil salinity increases in direct proportion to the salinity of irrigation water and the total depth of water applied. The reduction in plant growth and crop yield is mainly caused by the increase in osmotic potential of soil solution due to addition of excessive salts through irrigation water. The increase in osmotic potential reduces the availability of water to plants, results in stunted growth and significant yield losses. Agriculture in Prakasam district is mainly dependent on groundwater due to low annual rainfall. Hence, a total of 306 groundwater samples were collected from 57 mandals of Prakasam district during October, 2015 along with GPS locations and were characterized following the standard procedures. The pH values of the groundwater samples in the study area varied from 6.5 to 8.9. Electrical conductivity ranged between 0.3 and 16.1 dS m^{-1} with a mean value of 2.0 dS m^{-1}. The order of dominance of cations was $Na^+ > Mg^{2+} > Ca^{2+}$, while it was $Cl^- > HCO_3^-$ among the anions. Na^+ concentration ranged from 0.8 to 57.7 me L^{-1} with a mean value of 10.4 me L^{-1}.

Cl^- concentration ranged from 0.4 to 156 me L^{-1} with a mean value of 12.2 me L^{-1}. Sodium adsorption ratio of groundwater ranged from 0.3 to 21.7 with a mean value of 3.8. Residual sodium carbonate ranged from nil to 10.4. Based on RSC, 78% of the water samples were found under safe limit and 14% samples were unsuitable for irrigation. The water samples were classified based on classification proposed by ICAR-CSSRI, Karnal. A total of 180 water samples were found to be good (58.6 %), 93 samples were marginally saline (30.3 %), 1 sample was saline (0.3 %), 8 samples were high SAR saline (2.6 %), 2 samples were marginally alkali (0.7 %), 11 samples were alkali (3.6 %) and 12 samples were highly alkali (3.9 %) in nature.

Performance of groundnut under saline water using drip irrigation system

K Anny Mrudhula, A Sambaiah, Y Sudha Rani and GV Lakshmi

AICRP Saline Water Scheme, Agricultural College, ANGRAU, Bapatla – 522 101, Andhra Pradesh

E-mail: anny.mrudhula1@gmail.com

Abstract

Groundnut is usually grown in sandy loam soils of coastal regions using groundwater. Of late, over exploitation of ground water is resulting in the deterioration of water quality and making water more saline. Use of saline water adversely affects plant growth and yield through osmotic effect and ion toxicity. The adverse impact of saline water can be mitigated to certain extent through drip system. Hence, an experiment was conducted for two years (2013-14 and 2015-16) during *Rabi* season at Agricultural College Farm Campus, Bapatla to evaluate the performance of groundnut varieties under variable irrigation water salinity. The experiment was laid out in split plot design with three replications. Three groundnut varieties *viz*., Anantha, Kadiri 6 and Kadiri 7 were considered as main treatments and five salinity levels of irrigation water *viz*., best available water (BAW 0.6 dS m^{-1}), 2, 4, 6 and 8 dS m^{-1} were considered as sub treatments. Plant height was significantly affected by salinity levels and groundnut varieties in both the years of study. The highest plant height of 27.2 cm and 43.15 cm was observed at a salinity level of 0.6 dS m^{-1} (BAW) in both the years, which was significantly higher than plant height recorded under 6 and 8 dS m^{-1} salinity levels. Kadiri 6 recorded the highest plant height (28.1 cm in 2015 and 40.35 cm in 2016) and was found to be at par with Anantha and Kadiri 7 varieties. Dry matter production was the maximum with BAW treatment (26.62 q ha^{-1} and 44.66 q ha^{-1}, respectively) and was found to be at par with 2 dS m^{-1} in 2015 and 2 dS m^{-1} and 4 dS m^{-1} in 2016 and these were significantly superior over rest of the salinity levels. Among three groundnut varieties, the highest dry matter accretion was registered in Kadiri 6 variety (25.39 q ha^{-1} and 36. 92 q ha^{-1}). The results revealed that the maximum pod yield of 16.00 q ha^{-1} and 20.52 q ha^{-1} was recorded with BAW (EC 0.6 dS m^{-1}) treatment during 2014 and 2015, respectively. Among the three groundnut varieties, Kadiri 6 produced the highest grain yield of 17.89 q ha^{-1} followed by Kadiri 7 (16.96 q ha^{-1}) variety.

Effect of gypsum and phosphogypsum on crops irrigated with alkali water in sodic soils

Ravindra Kumar, Devendra Singh, SN Pandey and Vinod Kumar

CS Azad University of Agriculture and Technology, Kanpur – 208 002, Uttar Pradesh

E-mail: ravindracsa@gmail.com

Abstract

A field experiment was conducted during 2009-10 to 2013-14 to study the effects of gypsum and phosphogypsum on crops irrigated with alkali water in a sodic soil. Soil application of both the amendments

and use of their equal amounts with alkali water passing through 15 cm bed was found significantly superior over RSCW (untreated plot) with respect to crop production. The maximum grain yields of rice (4.0 t ha^{-1}) and wheat (3.64 t ha^{-1}) were recorded with the application of phosphogypsum and alkali water passing through 15 cm treated bed and use of equal amount of phosphogypsum through soil application followed by gypsum and alkali water passing through 15 cm bed treatment and equal amount of gypsum through soil application. The use of best available water (BAW), soil application of gypsum and phosphogypsum were significantly at par with each other in case of rice and wheat yield. Changes in pH, electrical conductivity (EC), sodium adsorption ratio (SAR) and residual sodium carbonate (RSC) of alkali irrigation water were from 8.82 to 7.86, 119 to 152 and 1.51 dSm^{-1}, 10.97 to 5.31 and 5.20 m $mol^{-1/2}$, and 6.87 to 4.21 and 4.08 me L^{-1} when the alkali water was passed through 15 cm gypsum and phosphogypsum beds, respectively. pH, EC and exchangeable sodium percentage (ESP) decreased with different amendments. There was an increase in uptake of NPK, Zn, Ca and Mg with different amendments over control and decrease in uptake of Na due to decrease in ESP. The maximum and minimum nutrient uptake was recorded in alkali water passing through 15 cm phosphogypsum bed and untreated plots, respectively.

Chracterisation of groundwater quality of sugarcane growing area of Assand Block, Haryana

Vijay Kumar and BS Chahal[1]
CCS Haryana Agricultural University, Regional Research Station, Karnal – 132 001, Haryana
[1]*HAFED Sugar Mill, Assandh, Karnal – 132 001, Haryana*
E-mail: vijayarora559@gmail.com

Abstract

In India, about 8.7 mha of land is affected by varying degree of salinity, out of which alkali soils occupies 2.5 mha of land. Sugarcane, an important cash crop, is also grown under these conditions which cause significant reductions in cane yield. High pH and high levels of Na^+ salts present in water affect the plant growth and juice quality. Continued irrigation with high residual sodium carbonates (RSC) water deteriorate soil physico-chemical properties and lead to low cane yields and juice quality necessitating the use of suitable amendments like gypsum. Keeping this in mind, a study was undertaken to assess the groundwater quality in Assandh block of Haryana. One thousand seven hundred sixty four (1764) groundwater samples were collected from 111 villages. The water samples were analyzed for EC, cations (calcium+magnesium), and anions (carbonate, bicarbonate, chloride) and specific irrigation water quality indices (residual sodium carbonate) were determined. EC value of groundwater varied from 0.1 to 11 dS m^{-1} with mean value of 1.95 dS m^{-1}. Carbonate (CO_3^-) content varied from 0.0 to 0.5 me L^{-1} with mean value of 0.1 me L^{-1}, the HCO_3 varied from 0.38 to 20.5 me L^{-1} with mean value of 8.11 me L^{-1}. Chloride content varied from 0.45 to 34.0 me L^{-1} with mean value of 4.97 me L^{-1}. Among different cations, Ca+Mg varied from 0.60 to 30.5 meq L^{-1} with mean value of 7.43 me L^{-1}. RSC varied from 0.0 to 14.4 me L^{-1} with mean value of 3.1 me L^{-1}. Gypsum requirement ranged from 9 to 480 kg with mean value of 113 kg. Co-relation matrix indicated that EC was highly correlated with Cl^- (r=0.86) and Ca+Mg (r=0.62). Generally, the groundwater was not suitable for irrigation without neutralization with gypsum. Assandh Sugar Mill has advised the farmers to apply gypsum in required amounts to sustain high sugarcane yields under such conditions.

Tolerance of brinjal to saline water under drip and flood irrigation systems

Deepak Gupta, IJ Gulati, NS Yadava and AK Singh
Agricultural Research Station, SK Rajasthan Agricultural University, Bikaner – 334 006, Rajasthan
E-mail: dee_gu73@rediffmail.com

Abstract

In arid regions of Rajasthan, twin problems of freshwater scarcity and the saline groundwater have emerged as severe constraints to sustainable crop production. Under such water limited conditions, judicious use of irrigation water has become matter of serious concern. Drip irrigation provides an opportunity to utilize saline water in irrigation while lessening the impacts on soils and crops as reduced volumes of water are applied frequently to prevent excessive salt accumulation in the rootzone. Vegetable crops are more remunerative than field crops but at the same time are highly sensitive to salt throughout plant life-cycle. An experiment was, therefore, conducted during Kharif 2011 and 2012, to evaluate the performance of brinjal under saline irrigation applied through drip and flood methods. There were three levels of irrigation water salinity (EC_{iw} 0.25, 3.0 and 6.0 dS m^{-1}). Results showed that drip irrigation was superior over flooding at all the EC_{iw} levels and resulted in 26.5% higher fruit yield. The highest fruit yield of brinjal was obtained when 3.0 dS m^{-1} water was applied through drip. However, a significant decrease in yield was observed when high salinity water (EC_{iw} 6.0 dS m^{-1}) was used during both the years. At EC_{iw} of 3.0 dS m^{-1}, significant improvement in fruit weight was recorded. But further increase in salinity (at EC_{iw} 6.0 dS m^{-1}) caused significant reduction in average fruit weight and the marketable fruit yield. Besides appreciable reductions in water use, drip irrigation also lowered salt accumulation. Soil EC_e values recorded after crop harvest at 0-45 cm soil depth at 0, 15 and 30 cm lateral distances from the emitter shown that the maximum salinity was registered at 30 cm distance from emitters with 6.0 dS m^{-1} saline water. The trend clearly indicates that the soluble salt distribution in the root zone decreased gradually with the depth for all the treatments. The results showed that drip irrigation may be helpful in sustaining brinjal yields in areas affected by saline groundwater.

O**ptimization of water requirement for groundnut using saline water drip irrigation**

Deepak Gupta, IJ Gulati, NS Yadava and AK Singh
Agricultural Research Station, SK Rajasthan Agricultural University, Bikaner – 334 006, Rajasthan
E-mail: dee_gu73@rediffmail.com

Abstract

Area under groundnut is expanding in north-western arid plains of Rajasthan. Since soils of this region are sandy in nature and also suffer from groundwater salinity, optimizing water use is of great significance. Owing to high water use efficiency, drip irrigation is an effective technique for utilizing the saline groundwater while preventing excessive salt accumulation in crop rootzone to a great extent. An experiment was conducted for two consecutive years to work out the optimum drip geometry for groundnut irrigated with saline water. The treatment consisted of three levels of salinity of irrigation water (BAW, 4.0 dS m^{-1} and 8.0 dS m^{-1}) and three drip irrigation geometries (lateral x emitter) *viz.*, 60 cm x 30 cm, 90 cm x 30 cm and 120

cm x 30 cm. Data revealed that increasing salinity of irrigation water (EC_{iw}) caused significant reduction in the pod yield of groundnut during both the years. As compared to BAW (3.883 t ha^{-1}), pod yield significantly decreased by 29.6 and 65.6% at EC_{iw} of 4.0 and 8.0 dS m^{-1}, respectively. Similar trends were also noted in respect to other growth and yield attributes with reductions of 19.5 and 30.5% in plant height, 24.6 and 43.9% in number of pods/plant, and 28.9 and 63.7% in pod weight/plant, respectively, recorded at EC_{iw} of 4.0 and 8.0 dS m^{-1}. Drip geometry (lateral x emitter) of 60 cm x 30 cm resulted in the highest pod yield of 3.22 t ha^{-1}. As compared to laterals spaced at 60 cm, drip laterals spaced at 90 and 120 cm resulted in significant reductions, *i.e.*, by 17.5% and 35.6%, respectively, in pod yield. Respective reduction in growth and yield attributes was of the order of 8 and 20% in plant height, 8.1 and 27.3% in number of pods/plant, and 13.6 and 25.5% in pod weight/plant. Combined effects of treatments showed that groundnut recorded the highest pod yield (4.649 t ha^{-1}) when irrigated with BAW at lateral x emitter spacing of 60 cm x 30 cm. Increase in salinity beyond 0.25 dS m^{-1} resulted in significant reduction in pod yield irrespective of the drip geometries used. However, reduction was more pronounced EC_{iw} of 8.0 dS m^{-1}. When compared with 60 cm x 30 cm geometry, drip geometry of 90 x 30 cm caused significant reductions of 15.2, 20.3 and 17.8% in pod yield at irrigation water salinity levels of 0.25 dS m^{-1}, 4 dS m^{-1} and 8 dS m^{-1}, respectively. Reduction in pod yield under 120 x 30 cm geometry over 90 x 30 cm was of the order of 22.4, 14.0 and 36.3%, respectively, under 0.25 dS m^{-1} (BAW), 4 dS m^{-1} and 8 dS m^{-1} salinity of irrigation water. In soil moisture and salt dynamics study, moisture per cent of soil showed a deceasing trend as we move laterally away from the emission points. A gradient reducing soil moisture was observed in vertical profile of soil at almost all sampling locations. Minimum moisture content was obtained mid way between central lines in all the geometries at all levels of irrigation water salinity. Soil salinity showed an increasing trend from wetted/saturated zone to wetting zone indicating movement of salts with soil water. Higher soil salinity was observed at locations with lower moisture content. This may be perhaps due to salt accumulation on outward periphery of wetted zone extending upto wetting front due to pushing away of salts with moisture front.

Effect of groundwater quality on soil salinity and mustard in Sriganganagar district, Rajasthan

Bajrang Bali and BL Kumawat
College of Agriculture, SK Rajasthan Agricultural University, Bikaner – 334 006, Rajasthan
E-mail: bajrangverma5@gmail.com

Abstract

A survey was carried out in Gharsana tehsil of Sriganganagar district, Rajasthan to assess the quality of groundwater and its effect on physico-chemical properties of soils and chemical composition of mustard crop. Forty groundwater samples along with their corresponding 40 soil samples were collected from the 0-15 cm surface. Mustard plant samples were also collected from different survey villages. The groundwater samples were analyzed for chemical characteristics such as pH, EC_{iw}, SAR, RSC and potential salinity and it was found that majority of ground water of the study area is not suitable for irrigation. Results showed that fields irrigated with such water had high salt concentrations as indicated by pH_2, EC_2 and SAR_2 values in the soil samples. Salts accumulation in soil was closely related to the salt concentration of irrigation water, and soil salinity increased progressively and significantly as the potential salinity of irrigation water increased. Use of high EC_{iw} (8.60 dS m^{-1}), pH (9.69), SAR_{iw} (18.61), RSC_{iw} (12.30 meL^{-1}) and potential salinity (71.61 meL^{-1}) groundwater decreased the per cent K^+ and Mg^{+2} content in mustard leaves due to relative dominance of Na^+ ion resulting in increased Na^+ and Ca^{2+} content.

Effect of RSC water irrigation and zinc fertilization on nutrient ratios of fenugreek

RK Jakhar, BL Yadav and Amit Kumawat
Agricultural Research Station, SK Rajasthan Agricultural University, Bikaner – 334 006, Rajasthan
E-mail: rkjakhar_ss@rediffmail.com

Abstract

A pot experiment was conducted to evaluate the effect of different level RSC water and zinc fertilization on soil properties, yield and nutrient concentration in fenugreek on a loamy sand soil. The experiment comprising of 12 treatment combinations replicated three times was laid out in completely randomized block design with four levels of RSC water (control, 2.5, 5.0 and 7.5 mmol L^{-1}) and three levels of Zn (0, 10 and 20 mg $ZnSO_4$ ha^{-1} soil). Results revealed that with the use of high RSC (7.5 mmol L^{-1}) water, soil EC_e, different fractions of soil Zn and available Zn significantly decreased, while pH and ESP of soil increased significantly. Seed and straw yields of crop, P/Zn in straw and Ca/Mg ratios of seed and straw decreased significantly with all levels of RSC of irrigation water. Na/K, Na+K/Ca and Na/Ca ratio of seed and straw increased significantly. P/Zn and Fe/Zn ratios of seed also increased significantly. The increasing level of zinc significantly increased the seed and straw yield of crop, Ca/Mg ratio of seed and straw. While P/Zn, Zn/Fe, Na/K, Na + K/Ca and Na/Ca ratios of seed and straw decreased significantly.

Assessment of soil salinity in a sub-surface drainage project area using Electromagnetic Induction (EM38) technique

RS Tolia, SD Vibhute, AL Pathan, R Abhishek and DS Bundela
ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
E-mail: rahul.tolia@icar.gov.in

Abstract

Build-up of soil salinity in farmlands has led to decline of soil fertility which has, in turn, resulted in the heavy crop losses and low farm incomes in the affected areas. Unscientific irrigation management in arid and semi-arid regions along with climate change have further aggravated the soil salinity problem. Sub-surface drainage (SSD) is one of the novel reclamation technologies, which has helped farmers by reclamation of barren saline soils to restore the crop yield and farm income. Thus, there is a need to assess the soil salinity for designing effective SSD system. In this study, an advanced geo-physical tool EM-38 was used for rapid spatial measurement of soil salinity in a SSD project site at Siwanamal (Jind district, Haryana) with a grid survey at 100 m x 100 m spacing. The apparent electrical conductivity (EC_a) at each grid point was measured in both horizontal (EC_{aH}) and vertical (EC_{aV}) modes. Soil samples at same grid points up to 90 cm depth (0-15, 15-30, 30-60 and 60-90 cm) were taken covering entire range of slightly, moderately and severely affected areas. The orientation with highest coefficient of determination (R^2) value was used to convert EC_a into soil salinity of saturated extract (EC_e). For this, coefficients of determination (R^2) between EC_e and EC_a in different orientations (EC_{aH}, EC_{aV}, weighted average of EC_{aH} and EC_{aV}, and multiple linear regressions (MLR) of EC_{aH} and EC_{aV} were analysed. The R^2 values for the MLR ranging from 0.90 to 0.987 were found to be best in all four soil depths, individually or collectively. Spatial variability maps of soil salinity were plotted for each depth individually and cumulatively using Surfer 9.0 and the extent of salinity level in each soil layer were

calculated and at the same, contour map of surface elevation was plotted for the SSD blocks. Declining salinity level trend in the SSD project area with decreasing depths was found. For 0-15 cm depth, 100% slight salinity area (4-8 dS m^{-1}) was found, which got changed to 61.7% slight salinity (4-8 dS m^{-1}) area and 38.3% (<4.0 dS m^{-1}) normal soil area for whole strata of the soil (0-90 cm depth). High soil salinity level was found near the manhole 1, because of surface gradient is towards manhole 1 as well as use of manhole 1 for pumping of saline drainage water for irrigation by the farmers.

Management of saline water for irrigation in agriculture

Shashi Verma and Arvind Kumawat
Amity School of Applied Sciences
Amity University Rajasthan, NH-11C Kant Kalwar, Jaipur-303 007, Rajasthan
E-mail: sverma@jpr.amity.edu

Abstract

In many parts of India, groundwater is either saline or alkali due to continental monsoonal climate. This situation has necessitated the adoption of improved agronomic practices to manage the salinity and sodicity hazards in soils and crops. There should be some changes in the standard crop and water management practices when using saline water. For example, providing for a leaching requirement is not appropriate when the growing season for post-monsoon winter crops starts with a surface-leached soil profile, because it would increase the salt load. High salinities during the initial stages of growth are particularly harmful. Further, if benefits are to be gained from frequent saline irrigation, the amount of water applied per irrigation needs to be reduced. This is not possible with most widely practiced surface irrigation methods, but can be achieved with sprinkler and drip methods. However, in India, the large-scale use of such systems is not yet technically and/or economically feasible. Another management goal is to simultaneously encourage the utilisation of carried over rainwater in the soil profile/shallow water tables. Monsoon-induced salt leaching decreases with increasing clay content, SAR_{iw}, and is enhanced with increasing chloride salinity. Additional doses of phosphorous to alleviate the effects of chloride toxicity and the use of organic materials to enhance the efficiency of applied nitrogen are recommended under saline-irrigated conditions. Contrary to the general belief that soils irrigated with high-SAR saline water may regain their infiltration capacity when the electrolytic concentration of ingoing water is greater than the flocculation value, irreversible reductions are induced under cyclic saline-rainwater infiltration where sub-soil layers, ingressed with clays from the plough layer, control steady intake rates. Thus, the use of gypsum) is advocated with use of SAR_{iw} >20 water. Gypsum is also needed for soils irrigated with saline water with an Mg: Ca ratio >3 and rich in silica. Other cultural practices, such as furrow planting, increasing the plant density and post-seeding irrigation in crops like mustard, also prove useful. Water-quality standards which were too conservative have been replaced by site-specific guidelines where factors such as soil texture, rainfall and crop tolerance have been given due consideration.

Effect of plant bio-regulators on germination and seedling growth of *Pennisetum glaucum* L. under salinity conditions

Taramani Yadav[1], Gajender, RK Yadav, HS Choudhary[1] and Deepa Joshi[1]
[1]Research Scholar, ICAR-National Dairy Research Institute, Karnal – 132 001, Haryana
ICAR-Central Soil salinity Research Institute, Karnal – 132 001, Haryana
E-mail: tarandri05@gmail.com

Abstract

Germination is a complex and dynamic stage of plant life cycle, with numerous interactive metabolic processes changing from storage to mobilization phase. One of the first physiological disorder taking place in seed germination under salt stress is decrease in water uptake by seed due to more –ve water potential of germination medium. Seed germination in the most of crops reduced and delayed with increasing salinity. Although higher salinity decreases germination, the detrimental effect of salinity is generally less severe under proper seed treatment with plant bioregulators (salicylic and thiourea). In order to evaluate the effect of plant bioregulators to mitigate the salt stress on seed germination and seedling characteristics of pearl millet crop, a laboratory experiment was conducted in 2016 at ICAR-CSSRI, Karnal, Haryana. The seeds were tested for germination with water of different salinity comprised of control (tap water, 0.6 dS m^{-1}), 3 dS m^{-1} and 6 dS m^{-1}. Seeds were treated with different concentrations and durations of salicylic acid (SA) and thiourea (TU) plant bio-regulators and control (without treatment), Salicylic acid (0.5, 0.75, 1, 1.25 mM) and Thiourea (125, 250, 500, 1000 ppm) for 1, 2, 3 and 4 hours in each treatment. For germination percentage two replicates of 50 seeds each were kept between moist, rolled paper towels in an incubator at 20°C. Treatments were arranged in a factorial experiment with completely randomized design (CRD). Tests were monitored for germination at 5 days intervals up to 15 days. Seedlings were evaluated as normal, abnormal or dead seeds according to the ISTA rules (International Seed Testing Association, 2011). Germination percentage (GP), plumule, radical length and seedling dry weights were recorded according to the ISTA method. The results of this study indicated that salinity levels, plant bioregulators and their concentration had significant effect on seed germination percentage. Seed germination was 80% and 78 % with tap water (Control EC 0.6 dS m^{-1}) at 5 day and 10 day respectively. The germination percentage increased significantly with mild salinity EC ~3 dS m^{-1} but reduced with the application of 6 dS m^{-1} salinity to 75 % at 10 days after setting germination test. Thus the percent of molded seeds were higher at 6 dS m^{-1}. Salicylic acid (SA) had significantly improved the germination percentage ie 84% and 80% at 5 and 10 days, respectively over control (79 and 76% at 5 and 10 days). Seed treatment with thiourea (TU) had slight positive effect on germination percentage, but not significantly higher over control. Thiourea is more effective @ 500 ppm concentration and 1 hour soaking of seeds found better in case of both SA and TU treatments, although not significant. The percentage of moulded seed was reduced significantly by application of both SA and TU at 5 days. Radical length was significantly higher (11 cm) with treatments of both SA and TU over control (9 cm) at 5 days. There was no significant effect of growth regulators on plumule length. The dry weight of seedling at 15 days was significantly higher with application of thiourea. Preliminary results indicated the positive effect of mild salinity on germination of *Pennisetum glaucum*. Seed treatment with SA is effective in mitigating the adverse effect of medium salinity of water upto 6 dS m^{-1}. The effectiveness of biolegulators in mitigating irrigation water salinity depends on concentration and duration of seed treatment.

Efficient water management in wheat using micro irrigation

Raj Pal Meena, RK Sharma, SC Tripathi, SC Gill, RS Chhokar and Kailash Prajapat
ICAR-Indian Institute of Wheat and Barley Research, Karnal – 132 001, Haryana
E-mail: adityarajjaipur@gmail.com

Abstract

The intensive agricultural practices have resulted into severe over exploitation of the natural resources, especially water, which has caused a severe imbalance in demand and supply. The agriculture sector makes use of 75% of the water withdrawn from various sources. India's land and water resources are under considerable stress as the competition between food production and population growth surges relentlessly. As a result of this demand-supply gap, groundwater table in various parts of India is decling at an alarming rate. Therefore, efforts must be focussed on reversing the trend in water resources depletion by adopting efficient irrigation technologies. The prevalent irrigation methods are less efficient due to more water losses through leaching and evaporation. Wheat crop is quite sensitive to water stress but too much moisture can also lead to yield losses from diseases, lodging, nutrient losses due to leaching, etc. Micro irrigation can be an effective tool for improving the water use efficiency in rice-wheat cropping system. This study, therefore, was carried out with an objective of improving the water use efficiency for wheat production.

A field experiment was carried out at the experimental farm of ICAR-Indian Institute of Wheat and Barley Research, Karnal during Rabi season of 2015-16. The climate of Karnal is sub tropical with mean maximum and minimum temperature of 34 to 39^{o}C during summer and 6 to 7^{o}C during winter, respectively. The rain during the wheat period was 62.1 mm. Soil of experimental field was sandy clay loam in texture with pH of 7.16 (1:2.5 soil:water), EC of 0.180 (dS/m) with 0.40 % OC, 164 kg/ha available N, 6.64 kg/ha available P and 288.0 kg/ha available K. During the Rabi season of 2015-16, the experiment was conducted in randomized block design with five treatment combinations replicated thrice. Irrigation scheduling treatments were 60 mm check basin irrigation, sprinkler irrigation with 60% potential evaop-transpiration (PE), sprinkler irrigation with 80% PE, drip irrigation with 60% PE and drip irrigation with 80% PE. The sowing was done using 100 kg/ha seed rate and nutrients (150:60:30, N:P:K) and weed control measures were applied as per recommended package of practices.

The highest yield (54.12 q/ha) was recorded in drip irrigation with 80% potential evapo-transpiration which was significantly higher than other irrigation treatments. The maximum water use was in check basin irrigation system (466 mm) with least water use efficiency (1.1 kg/m^3). The maximum WUE (2.4 kg/m^3) was recorded with drip irrigation at 60 % PE followed by sprinkler irrigation at 60 % PE (2.3 kg/m^3) and drip irrigation with 80 % PE (2.0 kg/m^3).

Precise irrigation scheduling and accurate method of irrigations can reduce irrigation costs and increase water productivity of crop. In view of the ever decreasing availability of good quality water, irrigation application by micro irrigation system may become essential and practical in the days ahead. The findings revealed that micro irrigation system is efficient and could be adopted even for irrigation in cereals like wheat for improving the water use efficiency. Favourable water regime and micro climate created by micro irrigation system facilitate higher crop yield.

Alleviation of saline water stress in tomato (*Lycopersicon esculantum Mill.)* by irrigation scheduling and foliar application of salicylic acid and potassium sulphate

Dinesh Kumar[1] Ramandeep Kaur[1] and IJ Gulati

[1]Research Scholar, College of Agriculture, SK Rajasthan Agricultural University, Bikaner – 334 006, Rajasthan

E-mail: dkrachiata@gmail.com

Abstract

One of the main hurdles in boosting the agricultural production in arid and semi arid areas of world is the scarcity of good quality water for irrigation. The quality of irrigation water plays a key role in judging its suitability for crop production. Soil and water salinity is an abiotic stress and limiting factor which affects almost every aspect of physiology and biochemistry of a plant, resulting in reduction in its yield. The research entitled "Alleviation of Saline Water Stress on Tomato (*Lycopersiconesculentum Mill.)* Plants by Irrigation Scheduling and Foliar Application of Salicylic Acid and Potassium Sulphate was conducted at Niche Area of Excellence, SK Rajasthan Agricultural University, Bikaner during *rabi* season of 2015-16. With 24 combinations comprising three levels of irrigation water volume (1.0 volume, 0.8 Volume and 0.6 Volume), two levels of irrigation schedule (Daily and third day irrigation) in plots and two levels of salicylic acid (control and 1.5 mM) and two levels of potassium sulphate (control and 500 ppm) in sub-plots were tested. The Treatment combinations were replicated three times in SPD and allocated randomly to different plots by using random number from the table of Fisher. The result shown that biochemical parameters APX, SOD, POX and CAT activity significantly increased with the increase in irrigation interval from daily irrigation to third day irrigation. The effect of irrigation levels on APX, SOD, POX and CAT activity significantly increased from 1.0 vol. (full volume of water required by crop) to 0.8 vol. (80% of full volume of water required by crop) and at par to 0.6 vol. (60 % of full volume of water required by crop). The application of salicylic acid and potassium sulphate resulted in significant increase in APX, SOD, POX and CAT activity over control at application of 500 ppm and 15 m mol, respectively. The physiological parameters viz. electrolyte leakage and relative leaf water content (RLWC) decreased with the decreasing irrigation levels from 1.0 vol. to 0.8 vol. and at par to 0.6 vol. The electrolyte leakage and RLWC decreased with the increase in irrigation interval from daily to third day irrigation. With the application of salicylic acid and potassium sulphate the physiological parameters increased significantly. The quality parameters also fluctuated with the treatments. The TSS and ascorbic acid content of tomato decreased with the increase in irrigation levels as well as irrigation intervals, and increased with the application of salicylic acid and potassium sulphate. Similar results were found with the yield and yield attributes, fruits/plant, avg. diameter of fruit, avg. weight of fruit and yield of fruits decreased with the increase in the irrigation interval and irrigation levels and increased with the application of salicylic acid and potassium sulphate. The soil was non-significantly affected with all the treatments of research.

Germination of finger millet and little millet varieties under different levels of saline water irrigation

Monika Shukla, Anil R Chinchmalatpure, Indivar Prasad, Shrvan Kumar and David Camus
ICAR-Central Soil Salinity Research Institute, Regional Research Station, Bharuch – 392 012, Gujarat
E-mail: monika.shukla@icar.gov.in

Abstract

Soil salinity is a major problem of Gujarat state and 2.22 million hectare area is salt affected. Ground water quality in the region is also poor having variable salinity and therefore, there is a scarcity of good quality water for agriculture. Millets are small-seeded grasses that are hardy and grow well in dry zones as rain-fed crops, under marginal soil fertility and limited moisture. They are also unique due to their short growing season so possibility can be explored to adopt these crops for cultivation on saline soils. Seed germination and early seedling growth are crucial periods for crop cycles under salt stress, and determine the survival of plants. A petriplate experiment was conducted during August 2015 at ICAR-Central Soil Salinity Research Institute, Regional Research Station, Bharuch to study germination of finger millet and little millet varieties under application of different levels of saline water. Experiment was laid out in petriplates with two crops; Finger millet (*Eleusine coracana Gaertn.*); three varieties - GN-4, GN-5 and GNN-6 and Little millet (*Panicum sumatrense*); two varieties - GV-1 and GV-2; with five salinity levels (Distill water; EC 4, 8 12 and 16 dSm^{-1}). Fifty seeds of each variety were germinated on filter paper in closed Petri dishes with different level of saline water using a completely randomized design with three replications. Germinated seeds were counted daily from each replication and the growth parameters were calculated on the 15th day. According to the method of Wang and Wang (2006), salt damage index (*Salt damage index SDI % = (germination percentage under the control condition - germination percentage under salt stress)/ germination percentage under the control condition X 100*) was adopted to evaluate the salt tolerance of these varieties. Results revealed that at salinity level of 16 dSm^{-1}no seed of any variety seed was germinated. At salinity level of 12 dSm^{-1} germination of seed of all three variety of finger millet was severely affected and seed of both varieties of little millet did not germinate. Highest germination per cent (87 and 93 %) and lowest salt damage index (0.0 and 1.8 %) observed at salinity level of 4 dSm^{-1} in finger millet (GNN-6) and little millet (GV-2) respectively. At salinity level of 8 dS m^{-1} finger millet (GNN-6) and little millet (GV-2) showed maximum germination percentage (72 and 78 %) and lowest salt damage index (17.3 and 17.5%). Gradual reduction was observed at increased level of salinity upto 8 dS m^{-1}, and at 12 dS m^{-1}, severe reductions were observed for shoot length, root length and fresh & dry weight of seedlings in all varieties. These results indicated that salt stress of more than 8 dSm^{-1} level strongly inhibited seed germination and plant growth of finger millet and little millet. However, differences in salt tolerance among crops may also occur at different growth stages, thus it should be evaluated for different growth stages. Further, at field condition these crops can be tested for response of various levels of saline water irrigation at different growth stages.

Theme IV

Climate Resilient Approaches for Enhancing Agricultural Productivity

Strategies for climate resilient agriculture in saline tracts of Vidarbha region, Maharashtra

SM Taley and KA Jadhav
Agro-ecology and Environment Centre, Dr. Punjabrao Deshmukh Krishi Vidhyapeeth, Akola – 444 104, Maharashtra
E-mail: smtaley@rediffmail.com

Abstract

A study was conducted on different cropping systems with and without protective irrigation in deep black soils with the objective to investigate the impact of rain water conservation measures on productivity, profitability and water use efficiency through suitable double cropping system. The study was conducted for the period of 2010-11 to 2015-16. The results showed that in double cropping system of green gram-chickpea, the yield of green gram was significantly higher (i.e. 5.15 q ha^{-1}) under contour cultivation with protective irrigation (PI) over the yield recorded in contour cultivation without PI. Chickpea provided with PI grown after soybean gave significantly higher yield of 12.47 q ha^{-1} in comparison to contour cultivation without PI. Soybean under contour cultivation with PI recorded significantly higher yield of 10.65 q ha^{-1} as compared to yield recorded under contour and across the slope cultivation without PI. Chickpea yield after harvesting of soybean was significantly superior under PI over other practices of soil moisture management. Significantly higher chickpea equivalent yield of 21.24 q ha^{-1} was observed in soybean–chickpea cropping system compared with the chickpea equivalent yield of 18.43 q ha^{-1} recorded in green gram-Chickpea cropping system under PI. The higher net returns of Rs. 54267 per ha was found in soybean-chickpea cropping system under PI and the lowest of Rs. 19046 in Green gram–Chickpea cropping system without PI. Double cropping system of green gram - chickpea and soybean-chickpea under PI gave a higher B:C ratio.

Harnessing productivity potential of degraded sodic lands through *Jatropha* based intercropping systems

YP Singh, VK Mishra, DK Sharma, Gurbachan Singh and Sanjay Arora
ICAR-Central Soil Salinity Research Institute, Regional Research Station, Lucknow – 226 002, Uttar Pradesh
E-mail: ypsingh_5@yahoo.co.in

Abstract

Mono-culture of jatropha (*Jatropha curcas* L.) is not an economically viable option for the farmers as it takes about 4-5 years to give the economic returns. In this study, the potential of jatropha as an alternative crop for biomass and bioenergy production, income generation and in sodic soil bioremediation were studied. Results revealed that plantation of jatropha at 3x3m spacing with inter-cultivation of sweet basil-matricaria (SB-M) cropping system for four years was more economically viable than planting at 3x2m spacing and the other rotations tested in the study. Improvement in soil properties evidenced by decrease in soil pH and EC, and increase in organic carbon was also found under SB-M cropping system with jatropha as the main crop. The maximum soil microbial biomass carbon was recorded with SB-M cropping system followed by sorghum-wheat (S-W) and maize-linseed (M-L) and the lowest values were found in the control plot where no intercrop was planted in jatropha plantation. Continued Intercropping with jatropha stimulated soil microbial population leading to improvements in sodic soils. Growing of medicinal and aromatic crops as intercrop in jatropha plantations for four years appears to be more suitable land use system than jatropha monoculture as simultaneous improvements in soil properties, bioenergy generation and farmers' income occured.

Nutrient and residue management of ZT-direct seeded basmati rice-ZT wheat cropping system under partially reclaimed sodic soils

Parveen Kumar, DK Sharma, RK Yadav, AK Rai and Ashwani Kumar
ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
E-mail: pkumarcssri@gmail.com

Abstract

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 is reduced. Higher loss of N due to denitrification (N_2O, NO), leaching (NO_3) and volatilization results into higher N requirements necessitating efficient N management in DSR. Deficiencies of Zn and Fe are also of concern and need corrective measures to enhjance the spread of DSR technology. In this context, direct seeding of salt tolerant rice cultivar CSR 30 basmati was done during *Kharif* under ZT with 16 treatment combinations of residue and nutrient management. After the harvest of the rice, salt tolerant wheat cultivar KRL 210 was sown during *Rabi* season under ZT with recommended package of practices. Results indicated that physiological traits, yield attributes and yield of DSR Basmati rice were not affected due to application of rice residues as mulch @ 5t/ha. Effective tillers/hill, grains/panicle and 1000-grain weight was statistically similar in all the nutrient management treatments. However, the maximum values of panicle length (23.0 cm), relative water content (76.0) and chlorophyll content (SPAD reading 33.7) were recorded where recommended dose of fertilizer (RDF) was supplemented with CSR-BIO (seed treatment + soil application), which was significantly higher than RDF and some other treatments tested in this study. Grain yield of ZT-DSR basmati was the highest in treatment RDF+20% higher N with top cutting (31.1 q/ha) closely followed by treatment RDF+10% higher N (30.8 q/ha) and treatment RDF+CSR-BIO (30.8 q/ha). Significantly lower grain yield was observed in treatments RDF and 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.

***In-vitro* biological hardening – An approach for inducing tolerance to sodicity in banana *var*. Grand Naine**

T Damodaran, VK Mishra, SK Jha and DK Sharma
ICAR-Central Soil Salinity Research Institute, Regional Research Station, Lucknow - 226 002, Uttar Pradesh
E-mail: damhort73@gmail.com

Abstract

The salt affected soils are an important ecological entity in the landscape of any arid and semi-arid regions. In India, such problematic soils occupy nearly 6.73 million ha and represent a serious threat to country's ability to provide food and livelihood security to the burgeoning population. In Uttar Pradesh alone, the salt affected soils accounts for about 1.37 million ha. These lands after reclamation are supported with rice wheat system cropping pattern for restoring the productive potential. However, with the demand for more economic returns and prevent rural migration, there is a need for technology to support the cultivation of commercially valued crop like banana, tomato etc. ICAR-Central Soil Salinity Research Institute, Regional Research Station, Lucknow has taken an initiative of developing eco-friendly technologies for cultivation of banana and tomato in the reclaimed sodic soils whose pH ranged from 8.8 to 9.3.

The approach of acquired systemic resistance was utilized to impart tolerance to abiotic stress with the help of endophytic inoculation. A study was conducted to develop the protocol for *in-vitro* biopriming in tissue culture banana plantlets var. Grand Naine with the potential salt tolerant bacterial isolates CSR-A-16 (*Lysinibacillus sphaericus*), CSR-A-11 (*Lysinibacillus fusiformis*) and CSR-M-16 (*Bacillus licheniformis*), CSR-A-18 (*Alcaligenes sp.*). The above isolates were grouped into five different consortia for assessing their efficacy in alleviation of salt stress during the growth period. The technology was developed and patented for a four tier priming system. The bio-primed plants were assessed for the efficacy in the field with a complete package of application (POA) protocol where it was found that plantlets treated with the consortia five involving CSR-A-11, CSR-A-16 and CSR-M-16 producing more plant height, girth with an average bunch weight of 32.00 kg compared to 6.00 kg obtained in untreated controls. The treatment with C-5 consortia has also increased the expression of the Reserve Oxygen Scavenging (ROS) enzyme Super oxy dismutase to enable the plant to alleviate the salt stress.

Evaluation of alternative crops under different tillage methods for direct seeded rice (DSR) fallows in Thungabhadra command area of Karnataka

Anand SR, Vishwanatha J, Rajkumar RH and Karegoudar AV

Agricultural Research Station, University of Agricultural Sciences, Gangavathi – 583 227, Karnataka

E-mail: anuagron80@gmail.com

Abstract

A field experiment was carried out for a period of three years to evaluate different alternative crops under different tillage methods for rice (DSR) fallows during *Rabi*/summer season from 2013-14 to 2015-16. There were nine treatment combinations consisting of three tillage (zero, minimum and conventional) methods as main plots and three crops (Sorghum, sunflower and cluster bean) as sub-plots. These treatments were replicated thrice. The initial soil pH was 8.25 and EC_e was in the range of 8-10 dS m^{-1}. The soil was medium deep black clay soil with clay content above 50%. The initial soil N, P_2O_5, K_2O values were 220.5, 55.0 and 365.0 Kg ha^{-1}, respectively. Pooled data of three years revealed that among the different tillage methods, zero tillage gave significantly higher grain and straw yield of all the three crops (15.33 and 21.44 q ha^{-1}) compared to the minimum (11.81 and 17.78 q ha^{-1}) and conventional tillage (10.66 and 15.89 q ha^{-1}). Among crops, sorghum grain and straw yield was significantly higher (17.24 and 30.56 q ha^{-1}) than sunflower (11.63 and 14.00 q ha^{-1}) and cluster bean (8.92 and 10.56 q ha^{-1}). Interaction effects of tillage methods and crops were also found to be significant. Among the treatments, zero tillage with sorghum recorded significantly higher grain yield as compared to other tillage methods. Generally, sorghum and sunflower crops performed better under zero tillage. Soil pH and EC_e were not affected by the tillage methods and crops sown.

Effect of various tillage practices and crop residue incorporation on Zinc fractions in partially reclaimed heavy textured sodic soils of Central Indo-Gengetic Plains of Uttar Pradesh

SK Jha, VK Mishra, AK Singh, YP Singh and DK Sharma
ICAR-Central Soil Salinity Research Institute, Regional Research Station, Lucknow – 226 002, Uttar Pradesh
E-mail: jhask_01@yahoo.com

Abstract

Zinc (Zn) deficiency is widespread in the soils of semi-arid parts of Indo-Gangetic plains of India. Therefore, the knowledge of Zn (%) which exists in various chemical pools in soils, status in the soil is very important for the crop production. The dynamics between the different pools will only determine the bio-availability of Zn to plant uptake and their translocation. Different tillage practices and the incorporation of crop residues (CR) may influence Zn concentration of the soil. Therefore, a field experiment was carried out in partially reclaimed heavy textured sodic soils to understand the dynamics and chemistry of Zn fractions under different tillage practices and crop residue incorporation under rice-wheat cropping system. The sequential analysis of Zn fractions was carried out for non-specifically adsorbed, specifically adsorbed, organically bound, Al and Fe bound, Mn-oxide bound and residual Zn in the soil. The results revealed that non-specifically adsorbed Zn (soluble + exchangeable) was the maximum (0.336 mg Zn/kg) in zero tillage in rice-zero tillage wheat system (ZTR-ZTW) whereas organically bound Zn was the maximum (2.492 mg Zn/kg) in zero tillage rice-zero tillage wheat where crop residue was incorporated (ZTR-ZTW+CR). Between Al and Fe bound and Mn-oxide bound Zn, the former was found to be maximum (5.94 mg Zn/kg) in ZTW-ZTW+CR followed by the direct seeded rice-sesbania-zero tillage in wheat + crop residue (DSR-SES-ZTW+CR). A good correlation (r=0.81) was found between organically bound Zn and non-specifically adsorbed Zn and between specifically adsorbed and non-specifically adsorbed Zn (r =0.80) suggesting the existence of dynamic equilibrium between these fractions. The mobility factor (MF), an index of the relative metal lability and availability of a metal ion in soils was also determined for Zn, which was found to be highest (2.70 %) in ZTR-ZTW+CR. It is concluded that incorporation of crop residue in zero tillage may mitigate Zn deficiency in soils.

Raised bed sowing - A climate change adaptive maize cultivation practice for coastal saline region

SK Sarangi, B Maji, UK Mandal, KK Mahanta, S Mandal and PC Sharma[1]
ICAR-Central Soil Salinity Research Institute, Regional Research Station, Canning Town – 743 329, West Bengal
[1]*ICAR-Central Soil Salinity Research Institute CSSRI, Karnal – 132 001, Haryana*
E-mail: sksarangicanning@gmail.com

Abstract

The coastal areas are mostly mono-cropped with poor yields in K*harif* rice. During *Rabi* season, salinity is the main problem restricting the choice of crops that can be grown. The cropping intensity is low and most of the land remains fallow during the *Rabi* season due to seasonally high content of salts in the root zone. Salinity problem has increased in recent years due to climate change effects. Therefore, measures to reduce the salinity and conserve the soil moisture are essential for the successful cultivation of *Rabi* crops. Under such conditions, certain innovative crop establishment methods may also give good results. In the present study, *Rabi* crops like maize and rapeseed were sown under three tillage practices *viz.* direct/dibble sowing

of seeds immediately after harvest of *Kharif* rice by making a hole at the point of seeding and covering the seeds by dry farm yard manure (FYM); second tillage practice was conventional/normal tillage after the drying of the residual soil moisture from the fields and then ploughing by a tractor followed by secondary tillage operations by power tiller and third tillage practice was making raised beds (RBS). Dibbling was done immediately after harvest of *kharif* rice to use the residual soil moisture, whereas normal sowing and RBS was done when soil moisture attained tillable condition. The direct sowing helped in the early establishment of rapeseed which resulted in its maturity under favourable temperature/winter conditions. With delay in its sowing, the temperature increased and resulted in severe incidence of mustard aphid leading to the lowest yield. Maize crop however responded differentially to the establishment method and it produced the highest yield and net return with raised bed sowing. This system reduced the irrigation water requirement by 10-18%, increased irrigation water productivity by 50-80% and the soil salinity in the month of April reduced by 37% in comparison to other methods of establishments. RBS method helped maize crop to withstand the occasional waterlogging caused by torrential rains during dry season. This study revealed that cultivation of hybrid maize by RBS is highly profitable and climate resilient management practice for salt affected coastal region of India.

Soil carbon changes with management and its relation to climate resilience in rice-wheat systems

Ajay Kumar Bhardwaj, Bhumija Kaphaliya, Sharif Ahamad, Suresh Kumar Chaudhari and Dinesh Kumar Sharma
ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
E-mail: ajaybhardwaj@gmail.com

Abstract

Carbon (C) is the backbone of soil health and sustainable productivity. Soil C pool strongly responds to crop and soil management practices such as tillage and residue management. Carbon storage in soil has been identified as one of the important means to counter global warming. Rice-wheat is the most prevalent cropping system in the Indo-Gangetic region. Being very energy intensive, the rice-wheat cropping systems have low build-up (or depletion) of soil organic C, which ultimately leads to degradation of soil health and long-term productivity. We used long term rice-wheat cropping experiments (2005-2016) on a sandy loam soil at ICAR-CSSRI, Karnal, to study seven rice-wheat management systems, including five with reduced inorganic fertilizer doses in combinations with organic sources [LEG- legume (*Vigna radiata*), GM-green manure (*Sesbania aculeata*), FYM- farmyard manure, WS- wheat straw, PS-paddy straw], compared to 'full recommended doses of inorganic fertilizer' (F) treatment and 'no fertilizer at all' (O) treatment. Organic C and different fractions of organic C comprising very labile, labile, less labile and non-labile were determined. Management indices indicative of C sequestration (Lability Index, C Management Index, C Sequestration Potential) were calculated to interpret management effects. Calculations were done for estimating plant C assimilation each year, ex-situ contributions of C, and soil organic C fractions. C input to soil was estimated annually by measuring the entire C added to the soil. To analyze the effects of climatic fluctuations on these management systems, weather data for all years was divided into rain-excess and rain-deficit seasons, on the basis of seasonal rainfall during rice and wheat season separately, and trends in changes with rainfall and temperature were analyzed. Our results indicated that with increased C return to soil, the most significant contributions went to very labile carbon (C) fractions. Soil C stock showed decreasing trend with increase in depth and was found the maximum in case of GM (1724.14 g m2) at 0-15 cm depth. Plant assimilated C, and

C return to the soil were the maximum in case of GM i.e. 20.8 ± 1.3 and 7 ± 0.3 t ha^{-1}, respectively. LE and GM management showed no responses to increased soil C inputs in different years, perhaps indicating nutrient richness shadowing the beneficial effects of soil C (beyond a certain level). In case of rice, during rainfall excess years, grain yield responded linearly to C input to soil for all treatments (O, F, FYM, WS and PS) except LE and GM where there were no significant effects. During rainfall-deficit years, green manure turned responsive to C input yet LE still had no effect of C input on grain yield. In case of wheat, in rainfall excess years, all treatments responded positively and significantly in response to C input to soil. In rainfall deficit years, the LE and GM had no significant interaction. On the other hand, WS and RS had negative correlations between yield and C input. Our studies indicated that total nutrient pool as well as availability played important role to determine yield responses and climate resilience.

CA based sustainable intensification of cereal system in North-western Indo-Gangetic plains of India

HS Jat, PC Sharma[1], Arvind Kumar[1], LK Singh, Ashim Datta[1], Madhu Choudhary[1] and ML Jat

International Maize and Wheat Improvement Centre, New Delhi – 110 012

[1]ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana

E-mail: h.jat@cgiar.org

Abstract

Cereal based systems sustainability in the face of increasing scarcity of resources (water, labour and energy) with expected climate change in the recent past has resulted in lower factor productivity, crop productivity and profitability of rice-wheat (RW) system in the western Indo-Gangetic Plains (IGP) at a higher rate than before. RW system occupies about 10.5 million ha area and contributes about 40% to the national food basket. Intensive conventional production practices like tillage, water and energy required for production are not only leading to low inputs efficiency and farm profits but are also contributing to green-house gas (GHG) emissions. It is imperative to diversify the current cropping system and their management practices which can address the challenges of food and nutrition security by increasing the productivity and profitability with the same or fewer resources. Sustainable intensification is an approach of reorienting agricultural system to support food security under new realities of climate change including erratic changes in temperature and rainfall. Conservation agriculture based practices through minimizing mechanical soil disturbance and permanent soil cover combined with appropriate crop diversification/intensification have shown potential to sustain productivity, improve profits while arresting natural resource degradation in intensive RW system of western IGP. Several practices such as zero tillage (ZT), establishment methods, direct seeding of rice (DSR), residue retention and precision nutrient, water management have been evaluated in cereal systems as alternatives to conventional practices. New crop rotation might have positive yield, income and environmental footprints and it may vary with component technology and its layering with other CSA technologies. Recently evidence has been collected and it was found that DSR followed by ZT wheat produced the higher system yield (12.62 Mg/ha) and net returns (Rs. 117000/ha) by 10 and 31%, respectively. However, ZT maize-wheat-mungbean produced similar yield (11.88 Mg/ha) with 66% less water and higher net returns (Rs. 123100/ha) by 33% compared to the farmers' practice. Conservation agriculture (CA) based RW system increased the system productivity and profitability by 20-25% with 30% less energy, water and GHG contribution compared to farmers' practice. Sustainable intensification helps in maximizing the crop productivity and profitability while minimizing the adverse effects of associated climatic risks by improving adaptive capacity.

Potential of fungi in crop residue degradation under rice-wheat cropping system

Madhu Choudhary[1,2], PC Sharma[2], HS Jat[3] and Neelam Garg[1]*

[1]Kurukshetra University, Kurukshetra – 136 119, Haryana

[2]ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana

[3]International Maize & Wheat Improvement Centre, New Delhi – 110 012

E-mail: madhu.choudhary@icar.gov.in

Abstract

Rice-wheat rotation is a predominant cropping system in north-west Indo Gangetic Plains (IGP) of India, where *in situ* burning of crop residues by majority of the farmers' tends to deteriorate the soil and environmental quality. Facing inadequate availability of suitable machines such as happy seeder, reaper binders and bailers, farmers have no other option but to burn the rice residues. Even if rice residues are removed from the field at a high labour and energy cost, there is virtually no demand in the market. It has thus become imperative to develop new solutions for the economic utilization of rice straw. Use of microbial isolates for the rapid *in situ* decomposition of straw may be such an approach. Considering the potential of many fungi in lignocellulose degradation, different fungal strains were isolated from the soils of rice- and maize-based conservation agriculture (CA) experiment, and were evaluated for lignocellulolytic enzymes activity. A large number (72) of fungi were isolated and screened for zone formation on carboxy methyl cellulose and tannic acid agar plates. Further, isolates having I_{CMC}> 0.5 and very good dark brown zone were selected again for further screening. Based on the activities of lignocelluloytic enzymes, *viz.*, CMCase, Fpase, Cellobiase, Xylanase and laccase in submerged fermentation, 11 isolates were selected for solid state fermentation. The selected isolates were further studied for enzymatic secretions and potential to degrade lignocellulosic crop residues in solid state fermentation. Isolate RPWM 2/2 showed the maximum CMCase (3.79 IU/g of substrate), Fpase (1.11 IU/g of substrate) and Xylanase (17.53 IU/g of substrate) activities. Isolate RZWM 3/2 showed the highest activity of cellobiase (1.79 IU/g) and RPW 1/6 showed the highest laccase activity (5.74 CU/g) which was statistically similar to RZWM 3/2 (5.28 CU/g).The maximum dry mass loss was achieved with RPW 1/3 (31%) followed by RPW 1/6 (29%), RZWM 3/2 (26%) and RPWM 2/2 (21%). Crop residue was also analyzed for the biochemical changes before and after fermentation. The maximum cellulose loss of about 42% was seen with RPW 1/6 and RPW 1/3 followed by RPWM 2/2 (37.10%) and RZWM 3/2 (33.31%). The maximum loss of hemicellulose was obtained with RPW 1/6 (44.69%) followed by RPWM 2/2 (41.38%), RPW 1/3 (36.95%) and RZWM 3/2 (31.01%). The highest lignin loss was observed by RZWM 3/2 (16.52%) followed by RPW 1/3 (15.23%), RPW 1/9 (13.65) and RPW 1/10 (12.74%). Four fungal isolates (RPW 1/3, RPW 1/6, RPWM 2/2 and RZWM 3/2) showed higher enzymatic activities and more loss of dry mass and cell wall constituents over the others. These isolates were identified by ITS region sequencing as *Aspergillus flavus*, *Aspergillus terreus*, *Penicillium pinophilum* and *Alternaria alternate,* respectivly. Pot experiments showed that none of these isolates induced any symptom of crop disease. The findings suggest possibility of microbe-based management of crop residues for clean environment.

Evaluation of small recharge structures as drainage option for crop saving from submergence during extreme rainfall conditions

Satyendra Kumar, SK Kamra, Bhaskar Narjary, RK Yadav and Neeraj Kumar
ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
E-mail: s.kumar2@icar.gov.in

Abstract

High intensity rain results in stagnation of land surface in low lying areas lacking proper drainage facility. Such extreme rainfall events are likely to occur more frequently in future due to climate change. The accumulated runoff volume has to be disposed off for saving the standing crop which will otherwise be damaged badly. The individual farmer based small recharge structure, developed by ICAR-CSSRI, Karnal could be a viable option as localized vertical drainage system for disposing the accumulated runoff water. A study was conducted to evaluate the impact of such structure on preventing crop failure and high farm income. The cavity type small recharge structure was installed in Sawant village of Karnal district where water table depth was at 19 m below the ground level. The cavity was formed at 35 m from the ground surface. Initially, graded sand, gravel and boulder based vertical filter was constructed, which was modified further with an inlet screened pipe into the well pipe in masonry chamber. The land holding of the farmer was 1.5 ha and his whole area was flood prone due to low lying bowl shaped topography. Runoff water of about 40 ha got accumulated and he lost his crop almost every year. The disposal rate of recharge structure was estimated to be 5-7 litre per second. This structure saved 100% percent rice crop on 1.5 ha land where it was installed, in addition to the crop saving of 20 % in 2 ha and 50 % in 1 ha of neighbouring fields. Reduction in total loss of wheat crop on 1.5 ha land was recorded in addition to 50 % loss reduction in 10 ha neighbouring fields. It was estimated that farmer is getting additional income of about Rs 81000/- each year by saving his crop from submergence during extreme rain in addition to augmenting groundwater resources and improving its quality. The overall results of the study revealed that small recharge structure can work effectively as vertical drainage facility in low lying area for draining the excess water resulting from extreme rainfall event and saving the crop from adverse impact of water submergence.

Carbon sequestration potential on conservation tillage practices under rice based cropping system in coastal saline soils

Uttam Kumar Mandal, D Burman, Sourav Mullick, Dibyendu Bikas Nayak, SK Sarangi and B Maji
ICAR-Central Soil Salinity Research Institute, Regional Research Station, Canning Town – 743 329, West Bengal
E-mail: uttam_icar@yahoo.com

Abstract

Considering the benefit of conservation tillage in rice based cropping system a field experiment was carried out to evaluate the impact of conservation tillage on soil health in coastal region of West Bengal during 2011. 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 as sub-sub plot treatments. The soil properties analysed after kharif harvest indicated that salinity was reduced considerably during kharif

cultivation. EC was slightly higher under rice-cotton system than rice-rice system. Exchangeable Mg was slightly more than exchangeable Ca. Exchangeable Na was relatively more in cotton-rice system than rice-rice system. The salinity probe was used to evaluate the bulk soil salinity during the month of May. The rice-rice system showed lower bulk soil EC than rice-cotton system particularly at 0-30 cm and 30-60 cm soil depth. Also zero tillage plots at surface depth showed higher bulk soil EC than other tillage treatments might be because of higher capillary rise of saline ground water at surface depth in zero tilled plot than other treatments.

There was reduction in bulk density and increase in organic C in ZT than other treatments in surface depth. 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 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 and was linearly related with cumulative C inputs to the soils. The results indicated for sustenance of SOC level (zero change due to cropping) a minimum quantity of 1.86 Mg C /year 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 concentration of H_2SO_4 and microbial biomass C were also analyzed 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. In initial period of experiment, the yield reduction was up to 28% in case of zero tillage treatment than other treatments.

Treatment-wise net return and benefit: cost ratio (BCR) was calculated and it varied between Rs. 29235/- to 43267/ha and 1.8-2.34 under rice-rice system and Rs. 14464 - 29554/ha and 1.3-1.65 under rice-cotton system. Operation wise energy used was calculated and fertilizer contributes more than 70% of input energy. Treatment under reduced tillage condition was most efficient in utilizing energy. In most of the cases chemical fertilizer and pesticides consumed more than 70 % of energy utilization.

Performance of commercial vegetable crops under naturally ventilated protected cultivation structure in saline environments

Rameshwar Lal Meena, Babu Lal Meena, Anshuman Singh, SK Sanwal and MJ Kaledhonkar
ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
E-mail: rlmeena69@gmail.com

Abstract

The most of vegetables are low gestation period and high income generating crops. Many vegetables are now grown under protected structures in off-season to fetch remunerative prices. However, meager information is available regarding the performance of vegetable crops under salinity in protected cultivation. Therefore, a study has been started with three vegetable crops; capsicum (var. Indra), hot chilli (var. Kranti) and tomato (var. Cibelia) to evaluate the effects of saline irrigation on their productivity, profitability and sustainability under a low cost, naturally ventilated polyhouse structure. There were six saline water treatments including the best available water (BAW). Capsicum and chilli were transplanted on 04 August 2015 and tomato on 26 August 2015. After the initial establishment period of 15 days, saline water

treatments were initiated. The vegetables were grown on 15 cm high raised beds at 45 cm x 30 cm spacing. Saline water was applied using drip system under gravity flow. The recommended dose of water soluble fertilizers was mixed with the irrigation water. Results of the first year study showed good response of crops even under high salinity treatments. The highest fruit yield (63 t ha^{-1}) of capsicum was obtained with BAW. Only slight reduction in capsicum yield was noted with increasing salinity in irrigation water; capsicum yield was 62.2 t ha^{-1} at EC_{iw} 6 dS m^{-1} and 58.2 t ha^{-1} at 8 dS m^{-1}. Similarly, the highest fruit yield (48.5 t ha^{-1}) in chilli was obtained under EC_{iw} of 6 dS m^{-1} followed by EC_{iw} 10 dS m^{-1} (45.7 t ha^{-1}) and EC_{iw} 4 dS m^{-1} (45.2 t ha^{-1}). The highest fruit yield (116.2 t ha^{-1}) of tomato was obtained at EC_{iw} of 6 dS m^{-1} followed by EC_{iw} 10 dS m^{-1} (111.0 t ha^{-1}) and EC_{iw} 4 dS m^{-1} (111.0 t ha^{-1}). Harvesting in all the three crops was staggered over months (capsicum 15 pickings; chilli 13 pickings; and tomato 28 pickings) indicating that high and consistent fruit yields can be obtained with the use of saline water under improved management practices. Studies are underway to assess the impacts of continued irrigation with saline water on soil properties and practices such as leaching with the harvested rainwater to overcome the rootzone salinity.

Multi-enterprise agriculture: An option for ecologically sustainable food and nutritional security of small holders in reclaimed sodic soils

Gajender, HS Jat, R Raju and RK Yadav

ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana

E-mail: gajender.icar@gmail.com

Abstract

Continuity of rice-wheat system in Indo-Gangetic plains of India has raised serious concerns on degradation of soil health and shrinking water resources. Integration of various farm enterprises and farming system diversification may offer solutions to these problems, especially for the increasing number of small holders. A study on Multi-enterprise agriculture is being carried out at the ICAR-Central Soil Salinity Research Institute (CSSRI), Karnal, to improve water, nutrient and energy use efficiency in reclaimedsodic environment.Total 2.0 hectare area is diversified under crop components viz; grains (rice-wheat, maize-wheat-moong, winter maize-soybean, pigeonpea-mustard-fodder maize), vegetables, horticulture, fodder production (1.0 ha area) and subsidiary components viz; fisheries, dairy, fruits, vegetables (on dykes of the pond), poultry, mushroom, gobar gas plant and solar heater are inremaining 1.0 ha area. The integration of multiple components is exploited to make judicious, multiple and synergistic use of farm inputs, resources and byproducts for generating regular income and employment. Each component was evaluated at the field and farm level for its profitability, sustainability and resource use efficiency in comparison to prevalent rice-wheat system after six years of studies (2007-2013). The productivity in different cropping systems was worked out on the basis of marketable produce from 2007-08 to 2013-14. In food-grain production, the highest system productivity in terms of rice equivalent yield (REY) was recorded with rice-wheat-moong cropping system (12.2 t ha-1) followed by rice-wheat (11.1 t ha-1) and maize-wheat-moong (7.0 t ha-1). The average net income from crop and subsidiary components together was 348595/-, out of which 72020/- came from crop (including fodder), 35880/- from vegetables and fruits and 195650/- from subsidiary components from an area of 2.0 ha, which was substantially higher than conventional rice-wheat cropping

system (302250/-). Recycling of component byproducts has helpedin reducing input use and restoring the ecosystem sustainability. Soil bulk density, saturated hydraulic conductivity, available nitrogen and phosphorus were increased, while reduction in soil pH and EC under diversified system. Multiple use of water in fisheries, horticulture and vegetable crops on pond dykes reduced the total water requirement under diversified agriculture (21495 m^3) as compared to rice-wheat (36000 m^3). This system required lower specific energy (4.33 MJ kg^{-1}) than rice-wheat (4.87 MJ kg^{-1}). Thus, on farm production of cereals, vegetables, fruits, milk, an egg, fishes enhanced the consumption of these products by farm family and ensures food and nutritional security of small farmers. Multi-enterprise agriculture system helped in enhancing farmer's income by increasing agricultural productivity in a sustainable manner to minimize the adverse impact of possible crop failure due to climatic hazards and to restore confidence in agriculture by creating sustained employment opportunities.

Evaluation of different crop sequences on partially reclaimed salt affected soils

DK Kathmale and BM Kamble

Agricultural Research Station, K Digraj, Sangli – 416 305, Maharashtra

E-mail: kathmaledk@rediffmail.com

Abstract

A field experiment was conducted during 2014-15 at Agricultural Research Station, K Digraj, Sangli (Maharashtra) to evaluate the performance of different crop sequences based on yield, economics and soil health indices in partially reclaimed salt-affected soils so that the best crop sequence can be recommended for such conditions. The initial soil pH and electrical conductivity values (pH_s- 7.95 and EC_e- 2.83 dS $m^{-1,}$ ESP-5) indicated that experimental soil was marginally saline. Initial values of available NPK were 234, 10.32 and 514 kg ha^{-1}, respectively. The experiment was laid out in randomized block design with three replications. The treatments comprised of eight crop sequences viz. *kharif* soybean and paddy followed by *rabi* wheat, maize, onion and chickpea. Results revealed that during *Kharif* season soybean gave higher seed yield (21.37 q ha^{-1}), gross monetary returns (Rs. 74780 ha^{-1}), net monetary returns (Rs. 42050 ha^{-1}) and B:C ratio was (2.28) as compared to rice crop. Among different *Rabi* crops, onion recorded higher soybean equivalent yield (34.68 q ha^{-1}), gross monetary returns (Rs. 121388 ha^{-1}), net monetary returns (Rs. 57888 ha^{-1}), but B:C ratio was the highest in chickpea. The soybean equivalent yield and economics of *Kharif-Rabi* crop sequences as influenced by various treatments revealed that soybean-onion crop sequence recorded the highest soybean equivalent yield (55.45 q ha^{-1}), gross monetary returns (Rs. 210695 ha^{-1}) and net monetary returns (Rs. 114465 ha^{-1}) as compared to other crop sequences. However, the highest B:C ratio (2.40) was recorded in soybean-chickpea crop sequence and it was at par with soybean–wheat, soybean-maize and soybean-onion crop sequences.

Diversified rice-based cropping systems for enhancing crop productivity and profitability under South Gujarat conditions

LJ Desai, JD Thanki and RA Dungarani
NM College of Agriculture, Navsari Agricultural University, Navsari – 396 450, Gujarat
E-mail: ljdesai@nau.in

Abstract

A field experiment was conducted at Farming System Research Farm, Navsari Agricultural University, Navsari (Gujarat) during 2007-08 to 2011-12 on heavy black soil to evaluate the productivity, resource-use efficiency and profitability of rice (*Oryza sativa* L.)-based cropping systems. Ten such cropping systems were evaluated in randomized block design with three replications. The productivity of the different cropping systems was computed by converting the yield of all crops into the paddy equivalent yield (PEY), based on the prevailing market price and divided by the number of days per year that crops occupied the land in a particular system. Profitability was calculated using the prevailing market price of different commodities in the different years of the experiment. The rice-sorghum (grain purpose)-sorghum ratoon (grain purpose) recorded significantly higher PEY (kg/ha), which was at par with rice-green gram-groundnut, rice-green gram-sorghum (grain purpose) + black gram (1:1), rice-sweet corn-black gram and rice-fenugreek-green gram + residue incorporation. Among the different crops sequences, rice-sweet corn-black gram recorded the maximum water productivity (kg grain/ha-mm) followed by rice-green gram-sorghum (G) + black gram (G) (1:1) crop sequence. The system productivity (kg grain yield/ha/day) and profitability were the highest under rice-sorghum (grain purpose)-sorghum ratoon (grain purpose) followed by rice-green gram-groundnut crop sequence in case of productivity, while system profitability (Rs/day/ha) in case of rice- sweet corn-summer black gram crop sequence.

Isolation and screening of rhizospheric bacteria for salt tolerance, PGPR properties and growth vigour of tomato seeds in sodic soils

Awtar Singh, T Damodaran[1], Garima Gupta[1] and RK Yadav
ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
[1]ICAR-Central Soil Salinity Research Institute, Reg. Res. Station, Lucknow – 226 002, Uttar Pradesh
E-mail: singhawtar91@gmail.com

Abstract

Soil salinity and sodicity adversely affect the crop growth, productivity and soil health. In India, total area under salt-affected soils is about 6.7 million ha, out of which saline and sodic soils cover 2.9 million ha and 3.7 million ha, respectively. In addition to salinity, indiscriminate use of chemical fertilizers and pesticides has also played a significant role in declining soil fertility, crop productivity and the functions of soil microbiota in different areas of the Indo-Gangetic plains of India. To address these problems, utilization of the plant growth promoting rhizobacteria (PGPR) as biofertilizers and bioremediation agents can be a good option. In this study, a total of 43 rhizospheric bacteria isolated from the sodic soil were screened for various plant growth promoting properties like phosphate solubilisation, indole acetic acid (IAA) production, siderophore production and hydrogen cyanide (HCN) production. Further, the isolates were also screened

for salinity tolerance in nutrient agar supplemented with 10%, 15%, 20%, and 25% sodium chloride (NaCl). Bacterial isolates were subsequently assessed for germination and vigour index enhancement of tomato seeds in a sodic soil (pH 9.15, EC 0.751 dS m^{-1} and ESP 37) under pot culture experiments in polyhouse. Results revealed that out of 43 isolates, 11 isolates (CSSR-AS-3, CSSR-AS-5, CSSR-AS-9, CSSR-AS-11, CSSR-AS-12, CSSR-AS-20, CSSR-AS-35, CSSR-AS-4, CSSR-AS-7, CSSR-AS-10, and CSSR-AS-15) exhibited comparatively higher growth in the 10% NaCl supplemented media than others. While 7 cultures (CSSR-AS-3, CSSR-AS-5, CSSR-AS-8, CSSR-AS-9, CSSR-AS-11, CSSR-AS-12 and CSSR-AS-20) tolerated 15% NaCl concentration, only 5 isolates (CSSR-AS-3, CSSR-AS-5, CSSR-AS-9, CSSR-AS-11, and CSSR-AS-12) were able to survive and grow at 20% NaCl level. CSSR-AS-35 and CSSR-AS-37 showed higher HCN and IAA production suggesting their role in growth promotion and disease resistance. Seven isolates (CSSR-AS-4, CSSR-AS-5, CSSR-AS-7, CSSR-AS-27, CSSR-AS-33, CSSR-AS-34 and CSSR-AS-40) showed strong HCN production. Four isolates (CSSR-AS-3, CSSR-AS-5, CSSR-AS-18 and CSSR-AS-27) led to more than 75% germination with higher vigour index in tomato seeds in sodic soils. Out of 43 isolates, 17 isolates were found superior over others on the basis of salinity tolerance, PGPR properties, germination percent and vigour index of tomato seeds. However, only 4 isolates (CSSR-AS-3, CSSR-AS-5, CSSR-AS-18 and CSSR-AS-27) enhanced the seed germination above 75% with higher vigour index. Thus, the present study suggests the need for further evaluation of these 4 promising isolates on crop growth and yield in salt-affected soils under field conditions.

Performance of pomegranate genotypes in saline soils

Rajkumar, Anshuman Singh, RK Yadav, Anita Mann, Murli Dhar Meena and DK Sharma
ICAR- Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
E-mail: rajhorticulture@gmail.com

Abstract

Due to its xerophytic characteristics pomegranate is a suitable crop for dryland regions characterized by water scarcity, salinity and nutrients deficiency. India is the world leader in pomegranate production. Cultivation of horticultural crops on highly deteriorated salt affected soils irrigated with saline water may improve economic conditions of the farmers. Keeping these facts in view, an experiment was conducted to evaluate different pomegranate genotypes, collected from Rajasthan, India for their salt tolerance potential. Survey of pomegranate growing areas of Rajasthan was conducted during August, 2015. Hardwood cuttings (15-20 cm length) of 18 unknown and 2 known genotypes were collected and grown in normal (EC_e~2.4 dS m^{-1}) and saline soils (EC_e ~8, 12 and 16 dS m^{-1}). Four months after planting, different growth and physiological parameters were recorded. Survival of cuttings significantly decreased with increasing salinity with mean survival of about 3% at 8 dS m^{-1}, 1.33% at 12 dS m^{-1} and 0.67% at 16 dS m^{1} indicating genotypic differences for salt tolerance. The lowest (66.67 %) and the highest (100 %) survival of cuttings under control conditions were recorded in Bhagwa and Rajasmand 2 genotypes, respectively. Genotypes Jaipur-2, Jaipur-3, Ajmer-1, Ajmer-2, Rajasmand-3, Rajasmand-4, Udaipur-1, Udaipur-2, Ganesh and Bhagwa survived up to salinity level of 8 dS m^{1}. However, only 5 of these genotypes (Jaipur-2, Jaipur-3, Rajasmand-3, Udaipur-1 and Udaipur-2) could tolerate salinity level of 12 dS m^{-1} and only 2 (Udaipur-1 and Rajasmand-3) could survive at the highest salinity (16 dS m^{-1}) level. On the basis of survival and plant growth, these genotypes are under evaluation in naturally saline soils (EC_e upto 15.61 dS m^{-1}) at Nain Experimental Farm, Panipat. After five months of planting in the field, the maximum plant height (105.45 cm) was observed in genotype Jaipur 2

followed by 97.85 cm in Udaipur 1 and 93.7 cm in Ajmer 1. The highest average numbers of branches (16) were recorded in Ajmer 2 followed by 15 in Bhagwa and 13.67 in Udaipur 3. The maximum stem diameter (2.02 cm) was recorded in Udaipur 2 followed by Ajmer 2 (1.7cm) and Rajasmand 4 (1.65 cm). Plant spread was the maximum (90.35 cm) in Ajmer 2 followed by in Udaipur 1 (89.53 cm) and Bhagwa (84.53 cm). It was found that Ajmer 2, Udaipur 1 and Bhagwa genotypes performed better under saline conditions.

Response of cotton *(Gossypium hirsutum L.)* to fertigation in saline soils under conservation agriculture practices

RH Rajkumar, J Vishwanatha, AV Karegoudar, SR Anand, RL Meena[1], SK Ambast[2] and MJ Kaledhonkar[1]
Agricultural Research Station, University of Agricultural Sciences, Gangavathi – 583 227, Karnataka
[1]ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
[2]ICAR-Indian Institute of Water Management, Bhubneshwar – 751 016, Odisha
E-mail: halidoddiraju@gmail.com

Abstract

A field experiment was conducted during 2013-14 to 2015-16 at Agricultural Research Station, Gangavathi to study the response of cotton (*Gossypium hirsutum L.*) to fertigation through drip irrigation in saline soils (6-8 dS m^{-1}) under conservation agriculture practices. The experiment consisted of conservation practices such as mulch and no-mulch treatments as the main treatment and different fertilizer levels *viz.*, 50%, 75%, 100% and 125% of recommended dose of fertilizers (RDF) as the sub-treatments. The pooled data of three years revealed that significantly higher soil moisture was retained in mulch treatment in all the three growth stages of the crop and at two soil depths (0-15 and 15-30 cm) compared to no-mulch treatments. Among fertilizer levels, there was no significant difference. In case of germination percentage, there was no significant difference between mulch and no-mulch and also among the fertilizer level treatments. Significantly higher plant height was observed in mulch (125.8 cm) compared to no-mulch treatment (121.3 cm) under conservation practice. Similarly, in case of fertilizer levels, significantly higher plant height (126.5 cm) was observed in 125 % RDF compared with 50 % RDF (119.6 cm). No significant difference in monopodial branches per plant was observed either due to mulch, fertilizer levels or their interaction. Significantly higher sympodial branches were observed in mulch treatment than no-mulch treatment. In case of fertilizer levels, no significant difference was observed. Interaction effect of mulching and fertilizers levels on sympodial branches was observed. Between mulch and no mulch treatments, significantly more numbers of bolls per plant (32.8) and higher single boll weight (.52 g/boll) were obtained in mulch treatment. In case of fertilizer levels, significantly more number of bolls per plant and higher single boll weight were recorded in 125 % RDF level (33.1 and 5.83 g/boll) which was at par with 100 % RDF (32.1 and 5.44 g/boll) and least in the case of 50 % RDF (29.7 and 4.82 g/boll). Accordingly, significantly higher seed cotton yield was obtained in mulch (29.0 q/ha) compared to no-mulch (24.4 q/ha) treatments. Among fertilizer levels, 125% RDF gave significantly higher (28.3 q/ha) seed cotton yield compared to 50% RDF (24.57 q/ha) but was at par with 100 % (27.13 q/ha) and 75 % RDF (26.78 q/ha). Irrespective of fertilizer levels, significantly lower seed cotton yields observed under no-mulch treatments could partly be attributed to intense weed infestation in these plots compared to mulched treatments.

Effect of sub-surface drip irrigation on soil properties, growth and yield of salt tolerant sugarcane *(Saccharum officinarum)* in saline Vertisols of Tungabhadra command, Karnataka

RH Rajkumar, J Vishwanatha, AV Karegoudar, SR Anand, AT Dandekar and MJ Kaledhonkar[1]

Agricultural Research Station, University of Agricultural Sciences, Gangavathi – 583 227, Karnataka

[1]ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana

E-mail: halidoddiraju@gmail.com

Abstract

A field experiment was conducted during 2014-15 and continued during 2015-16 at Agricultural Research Station, Gangavathi to assess the effect of subsurface drip irrigation on soil properties, growth and yield of salt tolerant sugarcane (*Saccharum officinarum)* in saline vertisols of Tungabhadra command area. The experiment was laid out in saline soils (4-6 dS m^{-1}) with irrigation methods *viz*., surface drip, subsurface drip and furrow irrigation (control) as main treatments and irrigation levels *viz*., 0.8, 1.0 and 1.2 evapotranspiration (ET) as sub-treatments. A salt tolerant sugarcane variety Co-91010 was planted in paired row system (0.6x1.20x0.6 m). Results of the pooled data of two years revealed that more soil moisture was retained in surface drip irrigation method compared to subsurface drip irrigation at 0-15 cm soil whereas in subsurface soil (15-30, 30-45 and 45-60 cm) more moisture was retained in subsurface drip compared to surface drip irrigation method due less evaporation. The higher soil moisture content was observed in Y-direction (along drip lateral) compared to X-direction (perpendicular to drip lateral) because of strip wetting. In case of vertical (Z-direction) soil profiles, soil moisture retention was less compared to lateral directions (X & Y direction) in both the methods of drip irrigation. Significantly higher cane weight was recorded in subsurface drip (1557 g) compared to furrow irrigation (1250 g) among irrigation methods and significantly higher weight was recorded at 1.2 ET (1463 g) compared to 0.8 ET (1340 g) among irrigation levels. Among irrigation methods, significantly higher cane yield (136.70 t ha^{-1}) was recorded in subsurface drip followed by surface drip (128.20 t ha^{-1}) and least in the furrow irrigation (108.6 t ha^{-1}). Among irrigation levels, significantly higher yield (130.4 t ha^{-1}) was recorded at 1.2 ET irrigation level compared to 0.8 ET (117.7 tha^{-1}) but at par with 1.0 ET (125.5 t ha^{-1}) level of irrigation. Among irrigation methods, significantly higher water use efficiency (WUE) of 87.60 kg ha^{-1} mm^{-1} was recorded in subsurface drip irrigation followed by surface drip method (81.90 kg ha^{-1} mm^{-1}) and least in case of furrow irrigation (69.4 kg ha^{-1} mm^{-1}) method. Among irrigation levels, significantly higher WUE (85.8 kg ha^{-1} mm^{-1}) was recorded at 0.8 ET followed by 1.0 ET (79.7 kg ha^{-1} mm^{-1}) and least in case of 1.2 ET (73.4 kg ha^{-1} mm^{-1}). The brix percentage was not affected by different irrigation methods and levels and the interaction between irrigation methods. Generally, the brix percentage varied from 20.1 to 20.7 in all the treatments. With regard to sugar-water use efficiency (S-WUE), subsurface drip irrigation (1.81 kg m^{-3}) recorded significantly higher S-WUE followed by surface drip irrigation (1.67 kg m^{-3}) and it was least under furrow irrigation (1.4 kg m^{-3}). Among irrigation levels, significantly higher S-WUE was recorded at 0.8 ET (1.72 kg m^{-3}) followed by 1.0 ET (1.65 kg m^{-3}) and the least at 1.2 ET (1.51 kg m^{-3}) level.

Mitigating the effect of late sowing on pearl millet *(Pennisetum glaucum)* yield through management practices

Manoj Kumar, Shankar Lal Yadav, SS Takar and Om Vir Singh
AICRP on Pearl Millet, Agricultural Research Station, Mandor, Jodhpur – 342 003, Rajasthan
E-mail: mkagro86@gmail.com

Abstract

In western Rajasthan, late arrival of monsoon often compels the farmers for the delayed sowing of pearl millet crop in the last week of July or first week of August causing drastic reduction in grain yield. This experiment was conducted to develop agronomical management practices to mitigate the negative effect of late sowing on pearl millet yield at the experimental field of AICRP on Pearl Millet (ICAR), Mandor during *Kharif*, 2015. The performance of early maturing hybrid, RHB 177, recommended for Zone A1 was evaluated under two dates of sowing *i.e.* July 25-30 (D_1) and August 10-15 (D_2) with five nutrient management practices *i.e.* T_1 (RDF of Zone A1), T_2 (RDF + FYM @ 5.0 t/ha), T_3 (125% of RDF), T_4 (T_2 + NPK foliar spray (19:19:19 grade) @ 0.5% at 20-25 DAS) and T_5 (75% RDF + FYM @ 5.0 t/ha). Thus, 10 treatment combinations were evaluated in split plot design with three replications keeping dates of sowing in main plots and nutrient management practices in sub-plots. The treatment T_4 (RDF + FYM @ 5.0t/ha + NPK foliar spray @ 0.5% at 20-25 DAS) produced significantly higher grain yield (1236 Kg/ha) over RDF (925 Kg/ha). The treatment T_4 (RDF + FYM @ 5.0t/ha + NPK foliar spray @ 0.5% at 20-25 DAS) also outperformed other treatments in terms of grain yield. However, differences in dry fodder yield among different treatments were non-significant. The delayed sowing D_2 reduced the grain yield as well as fodder yield to the tune of 16.0% and 12.9% compared to the D_1 sowing. However, other traits like total number of tillers/plant, effective number of tillers/plant, ear head length and dry fodder yield were found statistically at par in the two dates of sowing.

Effect of climate on rice-wheat sustainability in Northern Haryana

Randhir Singh, Madan Singh, BS Hansra[1] and Randhir Singh[2]*
ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
[1]AICPHT & CCM, Amity University, Noida, Uttar Pradesh
[2]Indian Council of Agricultural Research, KAB-II, New Delhi – 110 012
****E-mail: madan.singh@icar.gov.in***

Abstract

The study was undertaken on rice-wheat cropping system in Haryana. Four rice-wheat growing districts *i.e.*, Karnal Kurukshetra, Kaithal and Ambala were selected. From each district, two blocks and from each block two villages were randomly selected. From each village, 20 farmers were selected by using stratified random sampling technique, thus constituting a sample size of 160 farmers. Data were collected by using personal interview method during 2011 from the small, medium and large categories of the farmers on the basis of land holding size. Results indicated that the mean monthly maximum temperature of about 21^0C and minimum temperature of 6.5^0C in the months of December, January and February produced the optimum

grain yield of wheat (4.68 Mg ha^{-1}). The probability of receiving high intensity rainfall increased in the month of September which adversely affected the yield of rice crop. Majority of the farmers responded that deep groundwater table provides good quality of irrigation water. Adoption of resource conservation measures was also responsible for higher productivity of rice-wheat cropping system in these areas.

Magnitude of green manuring in carbon sequestration under cotton in Purna valley

NM Konde, VK Kharche, PR Kadu, BA Sonune, RP Gore, SK Pawar and DV Mali
Department of Soil Science and Agricultural Chemistry
Dr. Punjabrao Deshmukh Krishi Vidyapeeth, Akola – 444 104, Maharashtra
E-mail: nitinkonde75@gmail.com

Abstract

An experiment was carried out to study the magnitude of green manuring in carbon sequestration under cotton crop in Purna Valley at selected farmers' fields during 2015-16. The treatments comprised of five different green manures, two crop residues, gypsum and control. Accordingly, nine treatments replicated on three farmers' fields using randomized block design. Results showed that ESP of soil was significantly influenced by various treatments. In respect of biological properties, soil microbial biomass carbon (SMBC) was observed to significantly increase in soils treated with different organic amendments. SMBC was comparatively lower with the use of gypsum and in control, while it was the highest 168.72 µg g^{-1} soil, under *in situ* green manuring with dhaincha. Similar results were noted in respect of soil microbial biomass nitrogen which was the highest (79.39 µg TPF g^{-1} 24 h^{-1}) with the incorporation of dhaincha followed by sunhemp green manure (68.66 µg TPF g^{-1} 24 h^{-1}). In case of soil respiration, among all the treatments, dhaincha *in situ* green manuring resulted in 53.10 mg 100 g^{-1} soil respiration which was significantly at par with sunhemp *in situ* green manuring (50.99 mg 100 g-1 soil). The highest (15.21 Mg ha^{-1}) carbon stock was noted with the *in situ* green manuring of sunhemp followed by cow pea green manuring. Dhaincha and sunhemp incorporation also led to remarkable increase in caron sequestration under cotton. Similarly, it also contributed positively in sequestration of CO_2 in upper as well as subsoil. Therefore, adoption of green manuring and crop residues are advocated for improvement of carbon sequestration and ultimately for reclamation and increasing productivity of crops in degraded lands of Purna valley.

Influenece of crop residues on carbon fractions in degraded Vertisols of Purna valley

NM Konde, SM Jadhao, Nilam Kanase, SD Jadhao, Suraj Lakhe and PT Aghav
Department of Soil Science and Agricultural Chemistry
Dr. Punjabrao Deshmukh Krishi Vidyapeeth, Akola – 444 104, Maharashtra
E-mail: nitinkonde75@gmail.com

Abstract

Declining soil carbon is one of the most challenging issues in rainfed areas necessitating the identification of suitable organic amendments to overcome this problem. In this regard, a pot culture experiment was conducted during 2015-16 to assess the influence of crop residues on carbon fractions in degraded Vertisols of Purna valley. There were twelve different treatments replicated thrice in factorial completely randomized

design using soybean as the test crop. Three different crop residues along with FYM and phosphocompost were evaluated in normal and salt-affected soils (SAS) collected from Purna valley. The soils were analyzed for all carbon fractions at 30, 60, 90, and 120 days after sowing (DAS). Incorporation of FYM @ 10 t ha^{-1} resulted in higher organic carbon content to the extent of 10.07 g kg^{-1} in normal and 9.70 g kg^{-1} in SAS at 30 DAS followed by phosphocompost, soybean straw, cotton stalk and wheat straw. While organic carbon gradually decreased till 120 DAS, inorganic carbon was stabled after 60 DAS. The highest water soluble carbon was recorded with the use of FYM (49.44 mg kg^{-1} in normal & 45.91 mg kg^{-1} in SAS). The highest water soluble carbohydrate was also recorded with FYM (232.00 µg g^{-1} in normal and 204.67µg g^{-1} in SAS). The highest soil microbial biomass carbon (SMBC) was noted at 60 days after sowing in normal and SAS where FYM was added. Soil respiration was the maximum with the application of soybean straw @ 10 t ha^{-1} at 30 DAS. Therefore, it is concluded that the use of FYM, phosphocompost and crop residues improved the carbon dynamics in the soil. Use of farm yard manure, phosphocompost and soybean straw are advisable for long term management of carbon in problem soils of Purna Valley

Smart nitrogen management practices for better crop yield and environmental safety

Vipen Bhadu, BA Patel, JV Prajapati, RL Vasava and CR Hakla
BA College of Agriculture, Anand Agricultural University, Anand – 388 110, Gujarat
E-mail: mr.vipenbhadu@gmail.com

Abstract

Nitrogen is one of the key nutrients that limit crop growth in many production systems. However, improper nitrogen management in crops often proves harmful to the surrounding environment. Inorganic fertilizers are one of the key inputs of modern agriculture but they are increasingly becoming more expensive leading to higher production costs. Imprudent use of fertilizers and other high energy inputs is leading to decline in production and productivity of various crops, deterioration of soil health and adverse impact on environment. Due to increased mineralization of nitrogen, its retention capacity in the soil has reduced. Increased emissions of nitrous oxide from agricultural lands deplete the stratospheric ozone layer and contribute to global warming. Air pollution caused by nitrogen gases (nitric oxide and nitrogen dioxide), acid deposition by nitrogen oxide and relentless leaching of nitrate into groundwater are some of the harmful effects of indiscriminate use of nitrogenous fertilizers. Efficient nutrient management, especially of N, in irrigated areas is indispensable for the crop production. This state of affairs has necessitated 'Environmentally Smart Nitrogen Management' to optimize N use in crops for the maximum returns while minimizing the environmental harm. In arid and semi-arid areas, besides the concern over water and nutrient management, the growing land degradation process due to chemical soil degradation (salinization and/or sodification) also contributes to unsustainable and declining crop yields. Under 'Smart Nitrogen Management' approach, the time and amount of nitrogen application are determined prior to crop sowing/planting, taking into account the factors such as soil N supply, crop N demand, fertilizer N efficiency and the prevailing fertilizer and crop prices. Farmers can use different type of nitrogen management methods like Precision Nitrogen Management, Real-time Nitrogen Management (by using leaf colour chart), Site-specific Nitrogen Management, Need-based Nitrogen Application and Split or Slow-release N Management. Smart applications of N fertilizers are thus synchronized with the N needs of crop. Hence, it helps in saving the N fertilizers and curtails the cost of cultivation, results in higher crop yields and prevents environmental harm to a great extent.

Assessment of climate change impacts on crop water requirement in Sundarban region of coastal West Bengal

TD Lama, D Burman, B Maji, SK Sarangi, KK Mahanta and UK Mandal
ICAR-Central Soil Salinity Research Institute, Regional Research Station, Canning Town – 743 329, West Bengal
E-mail: tashi.lama@icar.gov.in

Abstract

Climate change is considered as one of the major threat to the sustainability of fragile ecosystem of Sundarbans. Adverse impacts of climate change on the agricultural production could threaten the food and livelihood security of the resource poor farmers. With rising temperature and changes in the rainfall pattern, climate change would affect the water balance, as well as, water requirement of agricultural crops. Effective rainfall, crop ET and irrigation water requirement of rice, maize and tomato for the post rainy season (rabi) were estimated with CROPWAT model using the downscaled MarcSim weather data (2016-75) for RCP 6.0 (IPCC-AR5) scenario obtained from an ensemble of all 17 GCMs and using the actual weather data for the base period (1966-2015). Although the average decadal rainfall, effective rainfall and reference ET were lower for the MarcSim generated data in comparison to the observed data for the base period, there was an increasing trend of these parameters during 2016-2075. The increase in decadal crop ET varied from -1.32 to 1.27 %, -0.15 to 12.50% and -7.45 to -5.08% over the base period for rice, maize and tomato, respectively. On the other hand, the effective rainfall during the crop growth period reduced by 21 to 29 % over the base period. The decadal irrigation requirement for the different crops showed an increasing trend and was highest during the 2066-75 decade for maize (12.5%) as compared to rice (5.8%) and tomato (2.6%). Advancing the sowing time for the crops led to a decrease in the irrigation requirement, while delayed sowing attributed to higher water requirement of the crops.

Conservation Agriculture for improving yield, profit and water use efficiency of rice-wheat cropping system in reclaimed sodic soils of north-west India

AK Yadav, PC Sharma, HS Jat[1] Ashim Datta, Madhu Choudhary and ML Jat[1]
ICAR- Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
[1]International Maize and Wheat Improvement Centre (CIMMYT), New Delhi – 110 012
E-mail: yadav.arvind580@gmail.com

Abstract

In Indo-Gangetic Plains of India, overexploitation of groundwater resources, depletion of soil health, increasing input costs, labour and energy shortages, crop residues burning and climate change induced weather risks are the major factors threatening the sustainability of intensive cereal systems. Conservation agriculture (CA) based practices and resource efficient cropping systems are developed and promoted as solutions to these challenges. An experiment was therefore initiated to explore the scope in terms of system productivity, profitability and resource use and implications (in terms of dynamics of salinity) of diversifying rice with maize on reclaimed sodic soils of NW India. Conservation agriculture based maize-wheat system was found more remunerative and as potential alternative to input intensive rice-wheat system in NW India. CA based management practices provide opportunity of increasing crop productivity while saving precious

water and increasing the farmers' profits. DSR followed by ZT wheat produced 10 and 31% higher system yield and net returns, respectively, compared to conventional system. Water use under DSR system was 19% lower as compared to puddled rice. CA based management increases the system-level land productivity with higher resource use efficiencies and economic returns.

Melia based agro-forestry systems for climatic resilience in saline ecologies

Rakesh Banyal, RK Yadav, Parvender, MD Meena, Bhaskar Narjary and DK Sharma
ICAR-Central Soil salinity Research Institute, Karnal – 132 001, Haryana
E-mail: drbanyal08@gamil.com/rakesh.banyal@icar.gov.in

Abstract

Salinity can be directly linked with the significant yield losses from the existing land uses. In India, 6.75 million hectares (mha) land area is salt affected and is likely to increase up to 20 m hectares by the end of 21st century. The introduction of *Melia composita* and Pearl millet on saline soils not only provides the green coverage but can also give good economical returns to the farmers. Therefore, an experiment was conducted at ICAR-CSSRI Experimental Farm, Nain, Panipat Haryana in 2016. Five irrigation regimes (I) (EC_{iw}: I_1-best available water, I_2-4 dS/m, I_3-8 dS/m, I_4-12 dS/m and I_5-control) including control where no irrigation was applied and four in Pearlmillet crop was resorted in cyclic mode with best available water.

Melia plantations established successfully and responded non- significantly to the application of varying salinity irrigation regimes. However, the survival percentage decreased with the increase in the level of salinity from EC_2<1 to 12 dS/m. Growth parameters (plant height, bole height, DBH and crown spread) showed invariable non-significant response to the irrigation regimes and showed little bit higher values when grown as sole component without Peralmillet. *Melia* trees showed non-significant effect of Peralmillet on their establishment and growth.The Pearl millet yield was reduced as the salinity level increased. However, the effect was statistically non-significant. The higher yield (7.89 q/ha) of Pearl millet was obtained when best available water (ECiw<1 dS/m) was used and low yield (5.42 q/ha) with (EC_{iw} 12 dS/m) higher saline water. It is observed that low salinity water may be beneficial in getting higher yield of the Pearl millet in such soils. The yield of Pearl millet was found to be more under *Melia* trees as compared to the control (open-devoid of trees). The effect of trees on Pearl millet yield was worked out to be statistically non-significant. The yield difference between treatment combinations of tree+crop and sole crop lowered down with the increase in the salinity level of the irrigation water. The higher Pearl millet yield may be ascribed to the fact that the *Melia* and Pearlmillet showed synergistic effect to each other. Soil salinity analyzed on the basis of electrical conductivity and pH values at the time of sowing of Peralmillet and harvesting thereof which gave invariable response to the irrigation regimes. The Pearlmillet was sown in rainy season (July, 2016) and gave almost similar level of pH and EC_2 with the harvesting of the same crop (Nov., 2016). But, it is also observed that pH and EC_2 value of the plots having Peralmillet were remained almost same but, it is higher in the fallow plots. The study clearly recommends that *Melia* based agroforestry system would be beneficial for rehabilitation of saline ecologies with ecological and livelihood security of the masses inhabiting saline areas.

Evaluating ionic and oxidative responses of Indian mustard (*Brassica juncea* L.) to varying levels of salinity stress

Vijeta, PC Sharma, Jogendra Singh and Vineeth TV

ICAR- Central Soil Salinity Research Institute, Karnal – 132 001, Haryana

E-mail: vijetaviju92@gmail.com

Abstract

Indian mustard *(Brassica juncea* L.) is an important oil seed crop of northern India, in which negative impact of salinity on yield has been reported. Main physiological modules adversely affected by salinity include osmotic stress, ion toxicity and oxidative stress. Present study was carried out to dissect the ionic, osmotic and oxidative stress modules of salt stress tolerance in mustard at varying salinity levels viz., 0, 9, 12, 15 and 18 dS m^{-1}. Nine genotypes of Indian mustard viz., Giriraj, RH 749, CS 1100-1-2-2-3, CS 15000-2-2-1, CS 2800-1-2-3-5-1, CS 7003-3-2-6 and CS 700-2-1-4 along with salinity check variety CS 54 and one high yielding check variety of Krishna were grown in earthen pots. Stress was applied at the time of sowing by using different salt concentrations (0, 9, 12, 15, 18 dS m^{-1}) and maintained throughout the experiment. All the mustard cultivars evaluated showed an apparent decrease in intracellular K content and yield under imposed salinity stress. By contrast an increase in intracellular Na, proline, malondialdehyde, hydrogen peroxide and ascorbate peroxidase (APX) activity were observed for all cultivars. Maximum mean root Na was observed in CS 7003-3-2-6, whereas it was minimum in CS 54. On the contrary, CS 7003-3-2-6 showed the least intracellular Na content in its shoot tissue depicting a very efficient salt compartmentation ability of this genotype. The K/Na ratios evaluated for all cultivars were noted to be highly correlated with the salinity scores thus indicating that the K/Na ratio serves as a reliable indicator of salt stress tolerance in mustard. Maximum accumulation of proline was observed in CS 1100-1-2-2-3 while it was minimal in CS 7003-3-2-6. There was a differential pattern of accumulation of the ROS species H_2O_2 across the mustard cultivars. Maximum H_2O_2 accumulation was observed in CS 2800-1-2-3-5-1 while CS 7003-3-2-6 exhibited minimum levels of ROS under high salt stress. Peroxidation of the membrane lipids also increased with increasing salt stress with CS 700-2-1-4 showing elevated levels of malondialdehyde content which was equivalent to check variety Krishna, whereas minimum value was recorded in CS 2800-1-2-3-5-1. Ascorbate peroxidase activity increased with increasing salt stress. Maximum mean APX activity was recorded in CS 700-2-1-4 which was less than the check variety while CS 15000-1-2-2-2-1 exhibited minimum activity of the enzyme under stress. Salt stress significantly reduced the yield of all mustard cultivars. CS 700-2-1-4 maintained the highest yield under salt stress, while minimum was observed in CS 7003-3-2-6.

Biochemical response of coconut seedlings under climate change variables along with imposed drought conditions

Mukesh Kumar Berwal, S Kanan[1] and KB Hebbar[1]
ICAR-Central Institute for Arid Horticulture, Bikaner – 334 006, Rajasthan
[1]ICAR-Central Plantation Crops Research Institute, Kasaragod – 671 124, Kerala
E-mail: mkbiochem@gmail.com

Abstract

The interaction effect of climate change variables elevated CO_2 and elevated temperature (ET) with drought on total sugar, reducing sugar, total phenolics, membrane stability, and carbonic anhydrase, peroxidase and polyphenol oxidase enzymatic activity of coconut seedlings was studied in an open top chamber (OTC) at Central Plantation Crops Research Institute (CPCRI), Kasaragod. Seedlings were exposed to ambient (normal CO2 and temperature), elevated CO_2 (550 and 700 ppm), ET (3 °C above ambient) and ET + elevated CO_2 (550 ppm CO_2 + 3 °C). In each OTC, a set of seedlings were subjected to drought (25% FC). Total and reducing sugars significantly increased under elevated CO_2 as well as under elevated temperature conditions. Carbonic anhydrase (CA) activity significantly increased under elevated CO2 while drastically reduced under elevated temperature, imposed drought also adversely affect the CA activity. Total phenolic content significantly increased under elevated temperature as well as imposed drought. Membrane stability is adversely affected by elevated temperature as well as imposed drought. Epicuticular wax content is drastically reduced by elevated temperature but increased under drought. Antioxidant enzymes, peroxidase and polyphenol oxidase activity significantly increased under elevated CO_2 as well as elevated temperature but decreased under drought conditions, while superoxide dismutase activity is drastically reduced by both elevated temperature as well as imposed drought. Elevated CO_2 compensated for water stress to some extent but elevated temperature adversely affect the membrane stability, epicuticular wax content and CA activity.

Evaluation of integrated farming system for enhancing the livelihood of farmers in salt affected areas of Tamil Nadu

M Selvamurugan, M Baskar, P Balasubramaniam, P Pandiyarajan and MJ Kaledhonkar[1]
AD Agricultural College and Research Institute, Tamil Nadu Agricultural University, Trichy – 620 009, Tamil Nadu
[1]ICAR-Central Soil Salinity Research Centre, Karnal – 132 001, Haryana
E-mail: muruganens@gmail.com

Abstract

The salt affected soils forms as important ecological entity in Tamil Nadu as in many other states of India. Economic use of salt-affected lands for agriculture has special reference to Tamil Nadu, which has about 4.7 lakh hectares of salinity/ alkalinity affected land. Moreover, the salt affected area is increasing continuously due to various factors *viz.,* intrusion of sea water and continuous irrigation with saline water. At present, it experiences huge recurring losses in terms of limited productivity. It is imperative to develop strategies that enable adequate income and employment generation, especially for small and marginal farmers of salt affected land. Under this condition, it is necessary to integrate land based enterprises like fishery, poultry,

duckery, apiary, field and horticultural crops, etc. within the bio-physical and socio-economic environment of the farmers to make farming more profitable and dependable. The Integrated Farming System (IFS) aims at increasing income and employment from small-holdings by integrating various farm enterprises and recycling crop residues and by-products within the farm itself. With this in view, an experiment was conducted to compare the conventional cropping system and integrated farming system in terms of income and profitability in salt affected land of Tamil Nadu. Both the pure crop and crop with fisheries and poultry components were included in 0.40 ha each. An overall income of Rs. 117328/- was obtained from all three components of IFS program and the profit contribution from fisheries and poultry component were 59% and 24% respectively. In comparison with a pure crop program for 0.40 ha, the IFS program (0.30 ha for crop and 0.10 ha for poultry and fisheries) has yielded high net returns and BC ratio of 2.97 which is 1.42% higher than the crop alone program. Therefore, it is recommended to adopt IFS program to increase the income and livelihood of all types of farmers of salt affected land areas of Tamil Nadu.

Crop residue management in saline soils for enhancing agriculture productivity, soil fertility and sustainable environment

Kamla Kumary Choudhary, RD Jat and SK Kakraliya
ICAR-Central Arid Zone Research Institute, Jodhpur – 342 003, Rajasthan
E-mail: kamlaskn04@gmail.com

Abstract

Salinity is a serious threat to global agriculture. About 20% of the world's cultivated area and nearly 50% of the irrigated croplands are affected by soil salinity. Dry regions, which mostly depend on irrigation for crop production, are even more vulnerable to soil salinity. About 1–2% of the irrigated areas in dry regions become unsuitable for crop production for some fraction of the year due to salinity. In irrigated agriculture, salt comes to the fields with the irrigation water and, when not leached out, accumulate in the soil profile and surface through evaporative water loss, a process that removes the soil water but concentrates salts in the topsoil (secondary salinization). Climate change and global warming are recent issues of concerned for the scientist community. The emission of GHGs are major contributions towards there issues burning of residues release a significant amount of GHGs it is reported that 70, 7 and 0.7% of carbon present in rice straw is emitted as CO_2, CO and CH_4, respectively, while 2.1% of N in straw is emitted as N_2O upon burning. Crop residues burning in Punjab, Haryana and Uttar Pradesh is the biggest contributor in the rise of pollution levels. Rice straw produced in large quantity and having higher silica contents is rather tedious to manage this much volume of rice straw as it is poor feed for animals. The common farm practice to get rid of rice straw is burning, which results in lead to losses of plant nutrients such as nitrogen (80%), phosphorus (25%), potassium (21%), sulfur (4-60%), and air pollution (in the form of CO_2) 13 Mg ha^{-1} subsequently depriving the soil of its precious organic matter and adverse effect on soil physico-chemical & biological properties and wastage of valuable C and energy rich residues. Crop residues are important role play in maintaining soil quality and this concept is gaining strength in today's agriculture. It is believed that application of crop residues for improving soil productivity in agriculture system may reduce the use of mineral/chemical fertilizers. Thereby use of crop residue in salt affected soils might be an efficient solution to prevent the salinity due to accumulation of soluble salts in the root zone.Crop residue management practices should be selected to enhance crop yields with a minimum adverse effect on the environment.

Study of soil microbial diversity under conservation agriculture based management scenarios

Madhu Choudhary, Neelam Garg[1], HS Jat[2], Ashim Datta and PC Sharma

ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana

[1]Kurukshetra University, Kurukshetra – 136 119, Haryana

[2]International Maize and Wheat Improvement Center, New Delhi – 110 012

E-mail: madhu.choudhary@icar.gov.in

Abstract

The diversity and abundance of different soil fungi and bacteria were studied in conservation agriculture(CA) based management scenarios in reclaimed sodic soils. These scenarios were based on wide range of indicators (crop rotation, tillage, crop establishment, water, nutrient and residue management). The four scenarios *viz*., Rice {conventional tillage (CT)/transplanted rice (TPR)}-wheat rotation(Farmers practice; Sc1); Rice-wheat-mungbean {CT/TPR- ZT (zero-tillage)-ZT}with 100% residue retention/incorporation (Sc2); Rice-wheat-mungbean (ZT-ZT-ZT) with 100% residue retention (Sc3), Maize-wheat-mungbean (ZT-ZT-ZT) with 65% of maize and 100% of wheat-mungbean residue retention (Sc4). Different agriculture practices affect soil properties differently and the microorganisms that live in these habitats respond to changing soil conditions. Culture-based methods and microscopic study can only reveal a fraction of the diversity so study was carried out using molecular tool of next generation sequencing. In total 53 bacterial phyla were found, out of which mostly are present in all scenariosexcept very few that are specific to particular scenarios. In all scenarios *Proteobacteria, Acidobacteria, Actinobacteria* and *Bacteroidetes* were the major phyla which jointly covered more than 70% of total phyla present in the soil. The most abundant phyla was *Proteobacteria* which represented the dominant phylum in all the four scenarios (24-37%) consisted of four prevailing classes- *Alphaproteobacteria* (45.83%), *Deltaproteobacteria* (18.47%), *Betaproteobacteria* (17.75%), and *Gammaproteobacteria* (16.86%). A second abundant phylum was *Acidobacteria* (20-32%), which consist of three prevailing classes- *Acidobacteria-6* (32.40%), *Solibacteres* (16.61%) and *Chloracidobacteria* (12.39%). Shannon-Wiener diversity index (H) of bacteria was found 8.8% higherin Sc1, 7.5% in Sc 2 and 2.7% in Sc3 as compared to Sc 4. Results of fungal metagenomic study showed that only 3 phyla were present in all four scenarios. All scenarios were dominated by *Ascomycota* followed by *Basidiomycota* and *Glomeromycota*. *Ascomycota* ranged from 55 to 74%, in an order of increase in Sc1< Sc2< Sc3< Sc4, however, *Basidiomycota* and *Glomeromycota* did not followany trend both of these were found 0 to 3%. Diversified cropping systems (maize-wheat-mungbean) in north-west with CA based best management practices showed the positive effect on residue decomposing fungal community. H index of fungi wererecorded 10% higher in Sc 4, 3.7% in Sc3 and 8.4% in Sc 2 as compare to Sc 1. Metagenomic study of soil microbes clearly showed that CA with all three proven principles (No-tillage, residue retention and crop diversification) in maize-wheat-mungbean system resulted in higher fungal diversity and species richness compared to dominant rice-wheat system but the bacterial diversity was found vice-versa as it was more in conventional practices (Sc1) as compared to CA based scenarios (Sc2 to 4).

Effect of preceding intercropping systems and nitrogen levels on wheat in Western Haryana

Niranjan Kumar Barod, Satish Kumar, AK Dhaka and Rajesh Kathwal

Department of Agronomy, CCS Haryana Agricultural University, Hisar – 125 004, Haryana

E-mail: nijubarod@gmail.com

Abstract

The investigation entitled "Response of nitrogen application in wheat succeeding pigeon pea intercropped with pearlmillet and greengram" was carried out at the research farm of Chaudhary Charan Singh Haryana Agricultural University, Hisar during *kharif* and *rabi* season 2011-12 and 2012-13. It comprised of 3 treatments in *rabi* and the treatments were replicated thrice in *rabi* season The experimental design was split plot. There were three levels of nitrogen *viz.* 75 percent, 100 and 125% of recommended dose in sub plots and twelve different intercropping systems of *kharif* season in main plots. The wheat variety WH 1021 was tested for the study. Based on aforesaid investigation it was found that intercropping systems influenced the growth parameters of both main and intercrop. The effect of different intercropping treatments as succeeding wheat nitrogen requirement was found significant. Wheat produced significantly higher grain (45.56, 4562 q ha^{-1}), straw (7626, 7429 q ha^{-1}) and biological yield (121.82, 119.91 q ha^{-1}) when planted after pigeon pea (75 cm)+greengram (1:1 or 1:2) treatment as compared to pearlmillet intercroping tretments at the same row spacing and row ratio. Application of 100 percent RDN being at par with 125 % RDN produced significantly higher grain (45.21, 45.35 q ha^{-1}), straw (73.69, 74.61 q ha^{-1}) and biological yield (118.90, 119.96 q ha^{-1}) of wheat as compared to 75 % RDN *i.e.* (42.47, 42.56 q ha^{-1}), (68.10, 70.57 q ha^{-1}) and (110.57, 113.13 q ha^{-1}). Interaction between N levels and intercropping systems was found non-significant.

Weed management in rice-brahmi intercropping system

Neeshu Joshi and V Pratap Singh

College of Agriculture, GB Pant University Agriculture & Technology, Pantnagar – 263 145, Uttarakhand

E-mail: neeshu.joshi@gmail.com

Abstract

A field study on direct (dry) seeded rice-brahmi intercropping system was conducted during *kharif* 2016 to find out the effect of weed management practices in rice-brahmi intercropping system on growth and yield of both crop. The experiment was conducted at N.E. Borlaug Crop Research centre, Pantnagar in Randomized Block Design consisting of 10 treatments with 3 replications with two ratios i.e. 2:1 and 1:1 of rice and brahmi and sole crop of both the crop along with combination of three weed management practices i.e. application of pendimethalin 1 kg/ha supplemented with two hand weeding at 30 and 45 DAS, pendimethalin at 1 kg/ha and pendimethalin at 1 kg/ha fb cyhalofop-butyl 100 g/ha supplemented with one hand weeding at 30 DAS and weedy.

The major weed flora in weedy plot at 60 DAS in 1:1 ratio were *Cyperus rotundus* (48.1%), *Echinochloa colonum (10.4%), Echinochloa crussgalli (14.15%), Alternanthera sessillis (11.8%), Caesulia axillaris (5.66%) and Cyperus iria (9.9%)* and in 2:1 ratio were *Cyperus rotundus (48.6%), Echinochloa colonum (8.41%),*

Echinochloa crussgalli (14.95%), Alternanthera sessillis (12.14%), Caesulia axillaris (7.47 %) and Cyperus iria (8.41 %) recorded in experimental plot.

Amongst both ratios (1:1 and 2:1) of DSR and brahmi, the application of pendimethalin at 1000 g/ha applied as pre emergence fb cyhalofop-butyl at 100 g/ha as post-emergence supplemented with 1 HW at 45 days after sowing/planting was found superior than other weed control. Treatments comprising sole rice and sole brahmi also gave significantly good results towards reducing the density as well as dry matter accumulation of weeds at 60 DAS over the weedy check. Highest grain (5.3 t/ha) and straw yield (9.8 t/ha) and land equivalent yield (1.52 and 1.47) of rice in 1:1 and 2:1 ratio was recorded with the application of pendimethalin applied as pre at 1000 g/ha fb cyhalofop-butyl as post emergence at 100 g/ha along with 1 HW at 45 DAS in sole crop DSR. Brahmi herbage yield was found maximum in sole brahmi (7.4 t/ha) with thrice HW (30, 45 and 60 DAS) with land equivalent yield of 1.0. Highest net returns and benefit cost ratio was found in the treatment of sole brahmi (Rs 717000/ha) which was followed by sole crop of DSR (Rs 64860/ha). Among the two row ratios, maximum net returns and benefit cost ratio was found in 1:1 ratio in the treatment in which pendimethalin was applied as pre at 1000 g/ha fb cyhalofop-butyl as post emergence at 100 g/ha along with 1 HW at 45 DAS (Rs 595323/ha).

Effects of different tillage, mulch and deficit irrigation with saline water on growth and yield of fodder sorghum

Pooja Gupta Soni[1], Arvind Kumar Rai, Parveen Kumar, Nirmalendu Basak, RK Yadav, Parul Sundha and Rakesh Kumar[1]
[1]ICAR-ational Dairy Research Institute, Karnal – 132001, Haryana
ICAR-Central Soil Salinity Research Institute, Karnal – 132001, Haryana
E-mail: poojagupta.agri@gmail.com

Abstract

Water scarcity and the predicted impact of climate change will necessitate the use of alternate available water resources in agriculture, such as saline water, to narrow the gap between demand and supply of freshwater. Bringing these resources into sustainable productive use will offer opportunities to increase agriculture production, especially in developing countries. An experiment was conducted to evaluate the effects of different tillage, mulch and deficit irrigation with saline water on growth and yield of fodder sorghum during *Kharif*, 2015 at Nain Experimental Farm, CSSRI, Panipat. The experiment was conducted in Split Plot Design with 3 replications consisting of three tillage treatment *viz.* zero, conventional and reduced tillage in main plot and six treatments comprising irrigation (100, 80 and 60 percent of water requirement) and mulch (0 and 5 t ha^{-1} rice straw) combination in subplots. Initial electrical conductivity of the saturation extract (EC_e) of the surface soil of the experimental site varies in the range of 4-36 dS m^{-1}. Fodder sorghum (*cv.* HSSG-5000)-wheat (cv. KRL-210) cropping system was adopted. *Kharif* season was rainfed and *Rabi* season was irrigated with saline water (8 dS m^{-1}) as per the treatment. Irrigation and mulch treatment were applied in rabi season and residual effects were observed in kharif season. Deficit irrigation (60% WR) with saline water produced significantly higher green fodder yield at harvest (59.4 t/ha), whereas 100 % WR recorded lowest green fodder yield (53.5 t/ha). The highest leaf to stem ratio on dry biomass basis was observed in those treatments which used 100% WR (0.50) for irrigation. On the other hand, the lowest leaf to stem ratio was observed in treatment using 60% WR (0.46) for irrigation at harvest. There were no significant difference in the other biometric parameters like plant height, number of leaves, tillers per plant in all the treatments of tillage treatment, deficit irrigation and mulch.

Influence of intercropping systems on residual soil fertility and yield of pigeon pea, pearl millet and green gram under western Haryana conditions

Niranjan Kumar Barod, Satish Kumar, Anil Kumar Dhaka and Rajesh Kathwal
Department of Agronomy, CCS Haryana Agricultural University, Hisar – 125 001, Haryana
E-mail: nijubarod@gmail.com

Abstract

The investigation entitled "Response of nitrogen application in wheat succeeding pigeon pea intercropped with pearlmillet and greengram" was carried out at the research farm of Chaudhary Charan Singh Haryana Agricultural University, Hisar during *kharif* and *rabi* season 2011-12 and 2012-13. It comprised of 12 treatments and was replicated thrice in randomized block design. Based on aforesaid investigation it was found that intercropping systems influenced the grain, straw and biological yield were significantly highest in sole crop *i.e.* pigeonpea (1983 and 2059, 2059 and 5947 and 7777 and 8006 kg/ha) respectively, pearlmillet (2122 and 2218, 5999 and 6200 and 8121 and 8418 kg/ha) respectively, and greengram (1319 and 1402, 3925 and 4175 and 5244 and 5576 kg/ha) respectively during 2011 and 2012 crop seasons. Highest N availability was recorded under greengram sole which did not differ significantly from various intercropping treatments except pearlmillet sole. Significantly lowest N availability was recorded under pearlmillet sole during 2011 and 2012 crop seasons.

Triticale - A miracle in the world of cereals in changing soil and climatic conditions

Akash Gaurav Singh[1], AK Sharma and IJ Gulati
[1]Research Scholar, College of Agriculture, SK Rajasthan Agricultural University, Bikaner – 334 006, Rajasthan
E-mail: singhag@uasd.in

Abstract

"*Triticale* is a product of a century of dreams and forty years of active pursuit of the all-but-impossible" Triticale (X. Triticosecale Wittmack) is one of the most successful man-made cereals and was synthesized to obtain a cereal that combines the unique grain quality of its wheat (*Triticum sp.*) parent with tolerance to abiotic and biotic stresses of the rye (Secale spp.) parent. It was found to have superior tolerance to low nutrient availability, drought, frost, soil acidity, aluminium and other element toxicities and salinity. Wherever intensive breeding efforts have been sustained, modern triticale cultivars are on a par with the best common wheat in terms of their yield potential under favorable conditions and are often more productive than most wheats when planted in different types of marginal soils. However, the popularization of triticale has been hampered due to its instability for grain yield. An important measure to enhance the pace of progress in this crop of recent origin is the enlargement of its genetic base through crossing well adapted high yielding triticale.

Salinity in soil or water is one of the major stresses that limit plant growth and productivity worldwide. More than 800 million hectares of land throughout the world are salt affected (including both saline and sodic soil), equating to more than 6% of the world's total land area. The increasing occurrence of dry periods in many regions of the world and the salinity problems associated with irrigated areas frequently result in the consecutive incidence of drought and salinity on cultivated land. Ion toxicity, osmotic stress and nutrient imbalance are the factors associated with the deleterious effect of salinity on plant growth and productivity.

Triticale seems to be an interesting alternative to other cereals, particularly bread wheat, in environments where growing conditions are unfavourable or in low-input systems.

It is widely recognized that 'Green Revolution' technology is disseminated more slowly in marginal environments affected by low water availability and drought. A growing water scarcity in some irrigated cereal production environments means that cereals are increasingly subjected to drought caused by few irrigation. In India, the majority of the farmers do not apply sufficient irrigation at appropriate growth stages which reduces the yield of wheat and other cereals. Therefore, triticale may be considered as one of the crop to be included under these prevailing environments.

Climate smart agriculture practices for sustainable productivity of rice-wheat cropping system in the Indo-Gangetic plains of India

SK Kakraliya[1], Ishwar Singh[1], HS Jat[2] and ML Jat[2]

[1]Research Scholar, Chaudhary Charan Singh Haryana Agricultural University, Hisar – 125 004, Haryana

[2]International Maize and Wheat Improvement Centre, New Delhi – 110 012

E-mail: kakraliyask@gmail.com

Abstract

Agriculture is a backbone of the Indian economy and the rice–wheat cropping system is the rib of backbone, but overexploitation of ground water and other available natural resources has resulted increasing scarcity of resources (water, labour and energy), higher cost of production, diminishing factor productivity, deteriorating soil health shrinking land with emerging concerns of climate change will be a much more challenging task than ever before. These new emerging issues have put a big question mark on the sustainability of rice–wheat cropping system. Climate smart agriculture (CSA) offers an attractive alternative to sustainable productivity with efficient use of available resources. Therefore, A participatory strategic research was conducted during, 2014–2016 at farmers' fields in three different climates smart villages *viz.* Birnarayana, Anjanthali and Chandsamand of Karnal, Haryana, India under CIMMYT-CCAFS program with the objective of developing and validating portfolios of climate smart agriculture practices in a rice-wheat rotation of Western IGP to provide options and strategies for sustaining productivity and ensure food security in the face of climate change. Six scenarios (S) were established with the various layering of CSAPs including water smart, energy smart, weather smart, carbon smart, nutrient smart and knowledge smart and farmer practices scenario (S1) was used as the base line to compare different sets of CSAP as the five scenarios. Result showed that in 2015-16 high magnitude of CSAP helps in maximizing crop productivity (10-15%) and profitability (20-25%) while minimizing the adverse effects of associated climatic risks by improving adaptive capacity and reducing mitigation potential of GHG (25-30%) compared to farmer practices scenario (S1). Our study results indicates that the layering of CSA practices have additive effects in terms of improving productivity through better adaptation and also minimizing environmental footprints.

Precision nitrogen management for increasing productivity, profitability and partial factor productivity of rice using Green-Seeker in climate smart villages of Haryana

Love Kumar Singh, HS Jat and ML Jat

International Maize and Wheat Improvement Centre, New Delhi - 110 012

E-mail: kumarluv85@gmail.com

Abstract

Continually skewed nutrient use led soil nutrient imbalances and low factor productivity is one of the major concerns of agriculture in India. However fertilizer response ratio (i.e. grain yield per unit of fertilizer use) decreased dramatically from 13.4 to 3.7 kg grain/ kg NPK during 1970 to 2005 due to inappropriate nutrient management approaches. The approach of 'more inputs- more output' is now known to be ecologically intrusive, economically unsustainable and environmentally unsafe. Hence, innovative tools and techniques for precision nitrogen management in smallholder systems for example Green-Seeker sensor have shown potential to provides site/farmer-specific fertilizer nutrient prescription for enhancing productivity, profitability and use efficiency. Green-Seeker is an integrated optical sensing and application system that measures crop status in response to the crop's N-requirements and provides prescription for precision N application for estimated attainable yield. We hence, conducted participatory validation trials on Green-Seeker guided N application in rice within 24 climate smart villages (CSVs) of Karnal district of Haryana India and evaluated for crop yield, profits and partial factor productivity of N compared to farmer's fertilizer practice. Result showed that higher yield of rice was recorded under Green-Seeker guided N application which ranged from 3.43 to 5.61 t/ha compared to farmer's N-management practice that varied 3.31-5.42 t/ha across all the CSVs. Similarly, higher net returns ranged from 35183-57301/ha and averaged at 44952/ha were recorded with Green-Seeker based N-application compared to farmer's practice which ranged at 33672-53692/ha). Green-Seeker based N application improved the partial factor productivity of N (PFP-N) by 2.5 kg grain/kg-N compared to farmers practice.

Indigenous know-how to cope up climate change in different farming systems

NS Dahiya[1], Preethi S[2], Gayatri Gujar[2], V Singh and AK Jhirwal[2]

[1]Department of Livestock Production Management, College of Agriculture

SK Rajasthan Agricultural University, Bikaner – 334 001, Rajasthan

[2]Department of Livestock Production Management, College of Veterinary and Animal Science

Rajasthan University of Veterinary and Animal Sciences, Bikaner - 334 001, Rajasthan

E-mail: nsinghdahiya@gmail.com

Abstract

Agricultural production and food security are strongly interlinked, and the impact of climate change would have major implications in determining socio economic fabric of all nations and the globe. It is predicted that for every two-degree rise in temperature, the agriculture GDP of India will reduce by five percent. In this context the worst hit are small-holder producers, as their ability to cope with the speed and intensity of climate events as they are happening, is an issue of concern. The need for a climate resilient approach to

agriculture is critical for India with 60 per cent of Indian agriculture being rain fed and more than 80 per cent agriculturists are small-holder farmers. Indigenous knowledge provides the backbone of successful climate change adaptation in farming, livestock and fisheries. Some climate resilient practices that can be adapted for sustained production are i) Soil and land management interventions: It includes Conservation agriculture, Integrated soil fertility management, Site-specific nutrient management, Laser-assisted precision land levelling methods. ii) Crop management : Crop-specific innovations complement other practices that aim to improve crop production under climate change, e.g. soil management, agro-forestry, and water management. Crop-specific innovations include breeding of more resilient crop varieties, diversification and intensification. Longer-term adaptation interventions include changes to crops cultivated iii)Livestock management: Improved or modified livestock management practices include improved grazing management, use of improved pasture and agro-forestry species, better use of locally available feeds, the judicious use of highly nutritious diet supplements and concentrates, and breeding for heat-tolerance or resistance to harsh climates. iv) Water management: Agriculture is the largest user of the world's freshwater resources, using 70 % of the available supply. Improved water management can be achieved through capture and retention of rainfall, and improved irrigation practices. Agro-ecological zones and farming systems are extremely diverse. Thus, interventions need to be targeted to specific contexts. Decision support to match practices and technologies with agro-ecological zones is a priority in the context of climate change and variability; farmers need to adapt quickly to enhance their resilience to increasing threats of climatic variability such as droughts, floods and other extreme climatic events. in the context of climate change and variability, farmers need to adapt quickly to enhance their resilience to increasing threats of climatic variability such as droughts, floods and other extreme climatic events. The key thematic issues on environment stress and livestock production includes: early warning system, multiple stress research, simultaneously, simulation models, water experiments, exploitation of genetic potential of native breeds, suitable breeding programme and nutritional intervention research. Livestock farmers should have key roles in determining what adaptation and mitigation strategies they support if these have to sustain livestock production in changing climate.

Effect of different sources of sulphur on yield and uptake of nitrogen and phosphorous in wheat

Anurag Sangwan, BS Duhan, Ram Prakash and Partap Singh Sangwan*
Department of Soil Science, College of Agriculture
CCS Haryana Agricultural University, Hisar – 125 004, Haryana
****E-mail: dr.bsduhan@gmail.com***

Abstract

Sulphur deficiency in crops is gradually becoming widespread due to continuous use of sulphur free fertilizers, high yielding crop varieties, intensive multiple cropping systems coupled with higher productivity. There are different sources of sulphur such as elemental sulphur, gypsum, potassium suplhate, pyrite, bentonite sulphur. Therefore, to compare effect of these sources a pot experiment was conducted in the screen house, at CCS Haryana Agricultural University, Hisar. Results of the experiment revealed that grain yield of wheat increased significantly with each increment of sulphur levels over control from 7.68 to 9.25 g/pot. Straw yield also increased with levels of sulphur over control from 11.35 g/pot to 14.71 g/pot. Amongst various sources of sulphur, the highest grain yield (8.82 g/pot) and straw yield 13.17 g/pot were obtained by potassium sulphate over all other sources.

Nitrogen uptake by wheat grain and straw increased with levels of sulphur up to 60 ppm from 84.70 to 122.95 and 43.69 to 98.75 mg/pot over control. Amongst the sources of sulphur, potassium sulphate

recorded the highest nitrogen uptake (110.30 mg/pot) by wheat grain and (98.13 mg/pot) by wheat straw over other sources. Phosphorus uptake by grain and straw also increased with the sulphur levels from 0 to 60 ppm and ranged from 37.45 to 42.54 and 18.15 to 20.22 mg/pot, respectively. The uptake of potassium in wheat grain increased significantly with levels of sulphur however, this increase was non-significant between two successive levels of sulphur application. In case of wheat straw, potassium uptake increased with sulphur levels upto 40 ppm over control (115.30 mg/kg). Amongst different sources, potassium sulphate recorded the highest sulphur uptake by both grain and straw 41.11 and 160.80 g/pot respectively. Sulphur uptake by wheat grain and straw increased from 0.63 to 1.82 and from 0.59 to 2.94 mg/pot respectively with the application of sulphur. The highest sulphur uptake by grain (1.44 mg/pot) and straw (2.05 mg/pot) were observed with the application potassium sulphate over other sources of sulphur.

Effect of sulphur and organic manures on yield and nutrient uptake by wheat

Anurag Sangwan, BS Duhan, Ram Prakash and Partap Singh Sangwan*
Department of Soil Science, College of Agriculture
CCS Haryana Agricultural University, Hisar – 125 004, Haryana
E-mail: dr.bsduhan@gmail.com

Abstract

Pot experiment was conducted in the screen house, CCS, Haryana Agricutural University, Hisar to study the effect of sulphur and organic manures on yield and nutrient uptake in wheat. The results from the experiment indicated that the grain yield of wheat increased significantly with the increase in application of sulphur as well as organic manures. The grain yield was observed maximum at highest level of 60 mg/kg sulphur. The magnitude of increase was 20.1, 47.6 and 72.6 at 20, 40 and 60 mg/kg sulphur application, respectively over control. Amongst various sources of organic manures, the grain yield of wheat was observed maximum under treatment of vermicompost followed by poultry. The magnitude of increase in grain yield was 16.9, 22.6, 27.8 and 20.5 per cent under the treatment of farmyard manure, poultry manure, vermicompost and pressmud, respectively. The interaction between organic manures and sulphur was found to be significant. The same trend was observed in case of straw yield with respect to sulphur level and organic manure sources.

Nitrogen uptake by wheat grain and straw increased with increasing level of sulphur up to the level of 60 ppm and increase was from 79.0 to146.2 and 44.00 to 91.7 mg/pot respectively over control. Amongst the different sources of organic manures vermicompost recorded the highest nitrogen uptake (127.30 mg/pot) by wheat grain and (77.70 mg/pot) by wheat straw over all other sources. Phosphorus uptake by grain and straw also increased with the increase in sulphur levels from 0, to 60 ppm and increase was ranged from 33.46 to 58.06 and 17.34 to 27.20 mg/pot, respectively. The uptake of potassium increased with incrase in sulphur levels and increase was from 33.3 to 57.7 by wheat grain and from 96.80 to 173.4 mg/pot by straw. Amongst different sources, poultry manure recorded the highest sulphur uptake 947.4 (mg/pot) by grain and in case of sulphur uptake by straw, Vermicompost recorded the highest 148.10 mg/pot respectively. Sulphur uptake by wheat grain and straw increased from 59.76 to 69.16 and from 34.72 to 45.30 mg/pot respectively with the application of sulphur. The highest sulphur uptake by grain (68.23 mg/pot) and straw (45.83 mg/pot) were observed with the application vermicompost over all other sources.

Theme V

Multiple Stress Tolerance in Biological Systems

Soil salinity tolerance among recently released groundnut cultivars of India

AL Singh, Nisha Goswami, Narendra Kumar, K Chakraborty, PV Zala, CB Patel and Vidya Chaudhari
ICAR-Directorate of Groundnut Research, PB 5, Junagadh – 362 001, Gujarat
E-mail: alsingh16@gmail.com

Abstract

Groundnut (*Arachis hypogaea* L.) is an important oilseed and emerging food crop of India. It is grown in about 5.5 million ha area mainly in Gujarat, Andhra Pradesh, Karnakata, Rajasthan, Tamil Nadu, Maharastra, Madhya Pradesh and Telangana states as a rainfed crop with 1-2 protective irrigations. Gujarat, with 30 % area contributing to 40% of the total groundnut production, has the largest stretch of coastal belt where groundnut is grown with two protective irrigations to minimize the yield losses caused by mid or late season drought which is of common occurrence in these regions. Sprinkler irrigation in sandy soils of Rajasthan, especially in areas around Bikaner district, has revolutionized groundnut production during the last 5-7 years and Rajasthan has gradually emerged as the 3rd largest groundnut producing state of India. However, soil salinization continues to be a serious problem severely hampering groundnut production. Thus, there is an urgent need to manage soil salinity through high yielding and salt tolerant cultivars. Although field screening of groundnut cultivars has been carried out in the past, many new high yielding cultivars are now available and need to be tested for their salt tolerance. In this context 20 recently released groundnut cultivars were screened in the field at two salinity levels (2 dS $m^{-1}$and 4 dS m^{-1}) during summer 2015, by growing these in screening plots under standard package of practices and recording the germination, plant survival and yield attributes. Imposition of soil salinity delayed the germination by 7-10 days followed by seedling mortality (0-68%), reduction in germination rate (8-41%), plant height, number of pods per plant and pod and haulm yields. In general, these groundnut cultivars showed 15 % lesser germination and 34 % lesser pod yield at 4 dS m^{-1} than at 2 dS m^{-1} salinity. Among these, three cultivars *i.e.* VRI 16, LGN 1 and VRI 4, with > 70 % reduction in pod yield were very sensitive to salinity hence should not be grown even at the locations with mild salinity. On other hand, cultivars TLG 45, CO 3 and JGN 23 showed comparatively lesser reduction in yield and other attributes producing >130 g m^{-2} pod yield under salinity and hence are suitable for cultivation in areas with salinity up to 4 dS m^{-1}.

Diversity and potential of halophytes for saline lands in hot arid climatic conditions

JP Singh and VS Rathore[1]
ICAR-Central Arid Zone Research Institute, Regional Research Station, Jaisalmer – 345 001, Rajasthan
[1]*ICAR-Central Arid Zone Research Institute, Regional Research Station, Bikaner – 334 006, Rajasthan*
E-mail: jai.singh@icar.gov.in

Abstract

Global food production needs to be increased by 70% by 2050 to feed the growing population. However, accelerated loss of productive soils to rapid urbanization and land degradation, and reduced availability of fresh water seem to be severe limitations to achieve this goal. Soil salinity, as a major form of land degradation, affects about 7 % of the earth's land with adverse impacts on soil quality and crop yields especially in arid and semi-arid regions. Although a number of chemical-based and engineering interventions

are available to enhance the productivity of saline lands, they suffer from the problems of high cost and technical glitch. Over time, plant-based solutions have emerged as a viable option to sustain the productivity of degraded soils. Halophytes, the plants able to complete their life cycle in NaCl rich substrates otherwise harmful to other species, provide an attractive option for the reclamation and economic utilization of the salt-affected environments. Very high salt tolerance in halophytes is attributed to their unique morphological, physiological and anatomical traits. Hot arid region of India has rich diversity of salt tolerant plant species considerably differing with each other with regard to taxonomy, plant forms, salt tolerance and habitat. Taxonomically, species representing Poaceae, Cyperaceae, Chenopodiaceae and Asteraceae families constitutes a major proportion of the salt tolerant species. Among herbaceous species, those belonging to Poaceae are the most abundant. In case of halophyte woody perennials, species belonging to Chenopodiaceae, Tamaricaceae and Salvadoraceae families are the important ones. The dominant herbaceous genera with the highest number of taxa are *Sporobolus* and *Sesuvium* in true halophytes, and *Cyperus*, *Heliotropium, Eragrostis, Pulicaria* and *Portulaca* in facultative halophytes. True halophyte species such as *Aeluropus lagopoides* and *Cressa cretica* are very important in the region. *Haloxylon, Salsolaa, Suaeda, Tamarix, Salvadora* and *Prosopis* are important salt-tolerant genera of shrubs/trees. Halophytes have immense economic and ecological significance in hot arid regions. These plants can be grown using land and water unsuitable for conventional crops and can provide fodder (*Chloris, Sprobolus, Aeluropus, Suaeda*), food (*Suaeda fruticosa*), fuel, wax and oils (*Salvadora* spp.), phytomedicine (*Cressa cretica*), bioactive phytochemicals (*Salsola baryosma, Haloxylon recurvum*) and industrial products (*Haloxylon recurvum*). Besides providing economic products, several such halophytes have high potential for the desalination saline soils and the restoration of wetlands. This potential assumes immense significance in arid areas where insufficient precipitations and inadequate irrigation prevent salt leaching from the rhizosphere, and suitable physical and chemical methods are expensive. Therefore, considering the vast economic and ecological potential of halophytes, concerted efforts should be made to promote their cultivation in highly salt-affected soils to lessen the pressure on good quality arable lands and water in an environmental friendly manner.

AASATU Bio-regulator: For multiple stress tolerance and sustainable food and forage production

SM Kumawat, NS Yadava[1] and MP Sahu
Swami Keshwanand Rajasthan Agricultural University, Bikaner – 334 006, Rajasthan
E-mail: sagarskrau@gmail.com

Abstract

Environmental degradation in the form of declining soil fertility, receding water table, raising salinity/sodicity and degradation of irrigation water quality are some of the serious impacts caused by modern intensive agriculture and climate change, thus threatening the sustainable agricultural production. Multiple stresses adversely affect plant metabolism leading to reduced growth and production potential of plants. Thus, it is critical to understand and characterise the plant responses to changing environmental condition in general and in arid and semi-arid agro-ecosystems in particular. The present paper describe how exogenous applications of plant bio-regulators (PBRs) in very low concentrations at the suitable crop growth stage(s) under 'Low External Input and Sustainable Agriculture' (LEISA) based systems improve the plant response to stress conditions which finally leads to enhanced growth and crop yield. A wide range of chemical and

hormone-based PBRs have been used for different crops under multiple stresses. However, here, three selected PBRs namely Ascorbic Acid (AA), Salicylic Acid (SA) and Thiourea (TU) collectively referred to as 'AASATU bio-regulators' are being used on large scale for overcoming the multi-stresses *viz.*, salinity, drought and high temperature under arid and semi-arid eco-systems. The economic viability of their use is also discussed. These PBRs regulate root growth for improving plant water/nutrient status, photosynthetic efficiency and source-sink homeostatis for overall improvement in plant growth. The adoptability and applicability of AASATU bio-regulators on research experiments, field demonstrations and on farmers' fields has still not showed any adverse effects on the biological system (soil-water-plant). It therefore, appears that there is a great scope for the use of AASATU bio-regulators in modulating crop response to multiple stresses for higher and sustainable crop yields.

Grafting: A tool for increasing salinity tolerance in *Solanaceous* and *Cucurbitaceous* vegetable crops

SK Sanwal, PC Sharma, Anita Mann, Rajkumar and AK Rai
ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
E-mail: sksanwal2016@gmail.com

Abstract

Salinity is one of the major limiting factors for the growth and yield of vegetable crops. More than 800 million hectares of land throughout the world are salt-affected including both saline and sodic soils corresponding to more than 6% of the world's total land area. Most of the vegetable crops are highly susceptible even to low salinity. Water deficit, ion toxicity and nutrient imbalance are three major constraints for plant growth under saline environment. Grafting has been shown to be an effective technique to enhance the plant growth and productivity by mitigating salt stress in *Solanaceous* and *Cucurbitaceous* vegetables. Grafting is not much effective in enhancing crop yields when plants are grafted onto their own rootstocks but grafting onto other rootstocks considerably enhances the salt tolerance. Proposed explanations for grafting-induced salt tolerance are (i) higher accumulation of proline and sugar in the leaves, (ii) higher antioxidant capacity in the leaves, (iii) lower accumulation of Na^+ and/or Cl^- in the leaves. Grafting can alleviate ion toxicity by limiting the transport of Na^+ and in some cases also of Cl^- to the shoot while storing these in the roots, which are typical tissue tolerance mechanisms. The higher accumulation of compatible solutes and osmolytes in leaf cells can increase plant survival and delay leaf senescence in the grafted plants. An efficient antioxidant system that reduces oxidative damage plays a key role in enhancing salt tolerance of grafted plants. In addition, induction of hormones may also enable grafted plants to adapt to salinity more efficiently. Rootstock grafted tomato plants showed less salt-induced oxidative damage due to high activities of catalase, ascorbate peroxidase, dehydroascorbate reductase and glutathione reductase. Despite increasing activities of antioxidant enzymes, grafting also improved net CO_2 assimilation rate and efficiency of photosystem II. However, an appropriate rootstock needs to be carefully selected and grafting timing, salt stress level, and time of exposure to salt need to be considered to reach to valid conclusions. It has also been reported that grafted plants show reduced accumulation of toxic ions and maintain higher K^+ levels than self-rooted plants. This leads to enhanced production and root-to-shoot transport of cytokinins which positively influence the source-sink relations. Cytokinins also delay the leaf senescence and help in maintaining shoot growth and fruit yield.

Salt tolerant plant growth promoting bacteria: A tool for sustainable agriculture under saline stress

Anukool Vaishnav

ICAR-National Bureau of Agriculturally Important Microorganisms, Mau Nath Bhanjan – 275 103, Uttar Pradesh

E-mail: anukoolv7@gmail.com

Abstract

Semi-arid regions are characterized by harsh soil and environmental conditions such as osmotic stress, nutrient imbalance and extreme temperature. Some plant growth promoting rhizobacteria (PGPR) not only exhibit tolerance to such adverse conditions but also enhance plant stress tolerance via a mechanism referred to as induced systemic tolerance (IST). Some beneficial effects of PGPR include nitrogen fixation, increased availability of essential plant nutrients, promotion of root growth, enhanced plant–microbe symbioses and disease control. The present work deals with the isolation and characterization of salt tolerant rhizobacteria with respect to their functional plant growth promotional activities. In addition, IST mechanism mediated by PGPR strains and effects of nitric oxide (NO) in salinized *Glycine max* plants were also studied. We isolated 43 bacterial isolates from the rhizosphere of soybean plants grown in Bundi district of Rajasthan, India. Out of 43 isolates, 6 were found to tolerate sodium chloride (NaCl) up to 10% (1.7 M). Out of them, one bacterial isolate AU was able to retain PGP activities (IAA, Pi-solubilization, siderophore, ACC-deaminase and beneficial VOCs production) up to 10% NaCl. Based on 16S rRNA sequencing, AU strain was found most closely related to *Pseudomonas simiaeoli* type strain (AJ936933) with 99.93% similarity. Analysis of the IST response provides an understanding of the molecular mechanisms employed by AU strain for plant growth promotion in soybean plants under salt stress. Plants inoculated with AU strain showed significant increase in salt tolerance as evident from their higher biomass, water and chlorophyll contents, and lower osmotic stress injury compared to non-inoculated plants exposed to salinity stress. Increase in proline accumulation and antioxidant activity coupled with reduced N^+ uptake and high K^+ and P accumulation also contributed to their salt tolerance. Effects of sodium nitroprusside (SNP)- a NO donor, on bacterial metabolism and its role in PGPR-plant interaction under salinity were also investigated. Expression study of bacterial volatile organic compounds (VOCs) revealed that three new VOCs were produced by AU bacterial strain after treatment with SNP. Of them, two VOCs namely, 4-nitroguaiacol and quinoline were found to promote soybean seed germination under 100 mM NaCl stress. A chemotaxis study revealed that SNP treatment altered root exudates profiling which was found to strongly attract AU bacterial cells as compared to non-treated root exudates. Gene expression study showed that *POX, CAT, VSP* and *NR* were up-regulated whereas, *HKT1*, *LOX*, *PPO*, and *Gmp5cs* were down-regulated in bacterial strain + SNP inoculated plants under salt stress. Furthermore, protein expression analysis by Western blotting confirmed that vegetative storage protein (VSP), gamma-glutamyl hydrolase (GGH) and RuBisCo large chain proteins were significantly up-regulated during salt stress in bacterial strain + SNP inoculated plants. These results suggested that AU bacterial isolate has potential to alleviate salt stress in soybean plants and its application along with NO could be a viable technology to modify the rhizosphere environment in salt-affected soils.

Improvement of salt tolerance in pearl millet: Physiological and biochemical approaches

Ashwani Kumar, Parvender Sheoran, Anita Mann, PC Sharma, Charu Lata, DK Sharma and SK Gupta[1]
ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
[1]*International Crops Research Institute for the Semi-Arid Tropics, Hyderabad – 502 324, Telangana*
E-mail: ashwani.kumar1@icar.gov.in

Abstract

The present study was undertaken to assess the response of eight pearl millet lines collected from ICRISAT, Hyderabad for salt tolerance on the basis of different physiological and biochemical traits. The experiment was conducted in completely randomized block design in pots filled with soil having EC_2 of 1.97 dS m^{-1} in 3 replications at ICAR-CSSRI, Karnal during *Kharif* 2015. Osmotic stress was imposed by applying irrigation water of varying salinity (EC_{iw} 3, 6 and 9 dS m^{-1}) along with the best available water (BAW; EC_{iw} 0.6 dS m^{-1}) as control. Out of 8 pearl millet lines, ICMB 07999 and 03222 lines showed mean relative water content above 75%. The maximum electrolyte leakage was observed in ICMB 03222 (42.25 %) at 9 dSm^{-1} salinity. Chlorophyll concentration reduced with increasing salinity in all the lines and the maximum reductions were noted in ICMB 01222, ICMB 07999 and ICMB 06888 (37.5 µg ml^{-1}) and the minimum in ICMB 05888 (30.7 µg ml^{-1}). The highest proline content was recorded in ICMB 07999 (6.38 mg g^{-1} FW) at EC_{iw} of 9 dS m^{-1}. ICMB 9522 and ICMB 06111 were found to be the promising ones maintaining lower Na^+/K^+ ratio with relatively higher yield at the highest salinity (9 dS m^{-1}) in comparison to others.

Mapping QTLs for sodicity tolerance in rice (*Oryza sativa* L.) using Bulked Segregant Analysis

SL Krishnamurthy, V Kumar, S Tiwari[1]*, KT Ravikiran, PC Sharma and NK Singh*[1]
ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
[1]*National Research Centre for Plant Biotechnology, New Delhi – 110 012*
E-mail: krishnagene@gmail.com

Abstract

Rice is the most important cereal crop with the maximum contribution to the global food requirements. In India, about 6.73 m ha land area is salt-affected out of which 3.77 and 2.96 m ha are afflicted by sodicity and salinity problems, respectively. Modern high yielding rice varieties are particularly sensitive to high salt stress. There are salt tolerant landraces and traditional varieties of rice but with limited information on genomic regions (QTLs) and genes responsible for their salt tolerance. A total of 215 recombinant inbred lines of CSR11/MI48 were evaluated under three sodicity levels: normal (pH ~7.5), moderate (pH ~ 9.5) and high (pH ~ 9.9) sodicity stress for 3 consecutive years (2009, 2010 and 2011). A total of 30 tolerant and 30 sensitive RILs were selected based on salt susceptible index (SSI) for grain yield and were used for bulk segregant analysis (BSA) using a 50K SNP chip to identify the genomic regions. The RIL population showed mean grain yield (g) per plant of 15.04, 7.39 and 2.21 under normal, moderate and high sodicity, respectively. Tolerant parent CSR11 gave mean grain yield/plant (g) of 12.12, 9.42 and 4.37 whereas the sensitive parent MI48 gave mean grain yield/plant (g) of 16.73, 6.20 and 2.12 under normal, moderate and high sodicity, respectively. Tolerant parent CSR 11 showed significantly less grain yield reduction of 22% than the susceptible parent MI 48 showing 63% yield reduction under moderate sodicity. Tolerant parent CSR11

showed lower SSI for yield under moderate (0.44) and high sodicity (0.75) as compared to the sensitive parent MI48 showing SSI of 1.24 under moderate and 1.02 under high sodicity across three seasons. SSI for grain yield ranged from 0.54 (RIL106) to 0.9 (RIL9) for top 30 RILs whereas it ranged from 1.03 (RIL 20) to 1.38 (RIL131) for the bottom 30 RILs. We identified a total 21 QTLs for SSI for grain yield on rice chromosomes 1, 2, 3, 5, 6, 8, 9 and 12 in the CSR 11/MI48 RILs. Out of them, 5 were in the regions reported earlier in the CSR27/MI48 F2/F3 and RILs with one common parent. The remaining 16 were novel QTLs for salt tolerance in the CSR 11/MI48. The method of QTL mapping reported here is a fast method to make physical map of any particular trait using a reasonably high density array, which is cost effective and time saving. These QTLs could be used in MAS for improving the reproductive stage sodicity tolerance in rice.

Physiological indicators of salinity tolerance in chickpea

Anita Mann, Gurpreet Kaur, Jogendra Singh and PC Sharma

ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana

E-mail: anitadgr13@gmail.com

Abstract

India accounts for over one third of the total world area under pulses and over 20% of the total world production. Still, every year India has to import about 3-4 million tonnes of pulses to meet the annual demand. In India, pulses are mostly cultivated on rainfed marginal lands which suffer from one or more biotic and abiotic stresses. Chickpea, one of the most important staple food legume crops worldwide, is cultivated in regions adversely affected by water stress and salinity. Studies have been initiated at ICAR-CSSRI, Karnal for improvement of chickpea for enhanced productivity under saline conditions. Chickpea germplasm was collected from ICRISAT, Hyderabad. Initial screening at early vegetative stage was carried out to find out the physiological indicators of salt stress at moderate (EC_{iw} 3 and 6 dS m^{-1}) and high (EC_{iw} 9 and 12 dS m^{-1}) salinity levels. Seeds of 15 chickpea lines, along with one check (CSG-8962), were germinated in sand having desired levels of salinity created by saline irrigation. Out of sixteen germplasm lines, no germination was found in ICC 2701 and ICC 1206 while CSG 8962, Karnal chana-1 and ICC 13283 did not germinate at higher salt stress of EC_{iw} 12 dS m^{-1}. Physiological indicators of salt tolerance in terms of Na^+ and K^+ ions have been estimated, based on which, genotypes with greater salt tolerance have been identified which can be used for further studies on stress tolerance mechanism as well as for use as parents in the breeding programmes. Salt susceptibility index (SSI) showed that five lines were less susceptible and survived up to EC_{iw} 12 dS m^{-1}. Four lines were found highly sensitive with respective SSI values of 87.25 %, 77.43, 76.79 % and 74.07% at EC_{iw} 12 dSm^{-1}. Karnal Chana-1 including these four lines showed SSI values ≥50 % whereas nine chickpea lines had SSI less than 40 % upto EC_{iw} 9 dS m^{-1}. These preliminary screening results at early vegetative stage can be taken as criteria for further salt tolerance mechanism studies in the most salt sensitive legume chickpea.

Differential responses of candidate genes, photosynthesis and cellular ion metabolism to varying levels of salinity stress in Indian mustard (*Brassica juncea* L.) genotypes

Jogendra Singh, Vineeth TV, PC Sharma and Vijayata Singh
ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
E-mail: Jogendra82@gmail.com, jogendra.singh@icar.gov.in

Abstract

Salt stress affects normal growth and development of crops by disturbing the cellular osmotic status and ion homeostasis. Salt tolerance is a very complex trait mediated by specific modulation of gene expression leading to multitude of changes in physiology and biochemistry at the cellular level. Cellular ion homeostasis and photosynthesis are two key components of salt stress tolerance which often gets perturbed under stress by activating a complex network of genes. This study was carried out to analyze and correlate the expression profile of key salt responsive genes with net carbon assimilation rate and cellular ion homeostasis under salt stress in mustard. An experiment was conducted in pot culture with salt tolerant CS52-SPS-1-2012 and sensitive mutant genotype CS614-4-1-4-100-13 along with two high yielding check varieties CS54 and Pusa Bold under salinity stress. Na/K ratio in shoot and root was the lowest in salt tolerant mutant CS52-SPS-1-2012 whereas highest in the salt susceptible mutant CS614-4-1-4-100-13. Comparison of differential distribution of Na^+ in individual leaves, branches and shoot revealed that Na^+ ions were not uniformly distributed in these tissues of four genotypes; but accumulated preferentially in older leaves, whereas sensitive genotypes showed significantly higher Na^+ concentration in all leaves, branches and shoot irrespective of their age. Dynamics of photosynthesis revealed a greater reduction in photosynthesis in sensitive genotypes. Transcript abundance analysis revealed the existence of a more efficient salt scavenging system composed of antiporters (*SOS1, SOS2, SOS3, ENH* and *NHX*) and antioxidant defense genes (*MPK1*, *DHAR3*, *APX1*, *APX4* and *MDHAR6*) in CS54 and CS52-SPS-1-2012 compared to Pusa Bold and CS614-4-1-4-100-13. In conclusion, an efficient salt scavenging system at gene level resulting in stable photosynthesis and cellular ion metabolism could be one of the major factors determining salt stress tolerance of CS54 and CS52-SPS-1-2012.

Varietal diversity and constraints in commercial ber (*Zizyphus mauritiana* Lam.) cultivation in Haryana, India

Anshuman Singh, Rajkumar, Ashwani Kumar, RK Yadav, Parvender, RK Singh and DK Sharma
ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
E-mail: anshumaniari@gmail.com

Abstract

A survey was conducted to identify the constraints affecting commercial ber (*Zizyphus mauritiana* Lam.) cultivation in Hisar, Rewari, Mahendergarh and Jhajjar districts of Haryana where problems of secondary salinity has considerably increased over the years. Ber trees require less care; have low water and agro-chemical needs and withstand sub-soil constraints (*e.g.*, salinity). Fruits fetch good prices in domestic and export markets. Orchards surveyed ranged from 0.2-2.8 ha in size. Orchard age varied from 10 years to over 100 years indicating, on one hand, continuity in the establishment of new orchards, and on the other,

conservation of the old orchards. While about 60% of the orchards had trees of only one or two cultivars, remainder were multi-varietal plantations consisting of three or more cultivars of different maturity groups likely to be more resilient to the market and climate shocks. Young orchards (≤ 25 years) mostly had either single or mixed stands of Gola (early), Kaithali (mid-season) and Umran (late) cultivars. In contrast, landraces such as Lakhal, Najuk, Katha, Reshmi, Illaichi, Bagu, Bhoora Gola and Kala Gola were also found in the old orchards of Rewari (Bawal area) and Mahendergarh districts. Soil and water salinity, erratic supply of canal water and the high incidence of powdery mildew disease were identified as the major hurdles to high orchard profits. Irrigation water salinity (EC_{IW}) was moderate (4-5 dS m^{-1}) to high (6-10 dS m^{-1}) at seven locations. Soil salinity (EC_e 60-100 cm depth) was very high (8-10 dS m^{-1}) at three locations. Salinity induced differences in fruit yield were evident as trees of a similar age grown under saline conditions produced considerably less fruits compared to those in normal soils. Fruit yield in Gola and Umran cultivars, for instance, was almost three-fold higher in normal than saline soils. Conjunctive use of saline groundwater and fresh canal water, and application of organic amendments such as farm yard manure and vermicompost were some of the practices adopted by the growers to overcome the salt stress.

Inter-varietal variation for response to salt and waterlogging in bread wheat (*Triticum aestivum* L.)

Arvind Kumar, Rachna Singh, Gaurav Kumar, PC Sharma, and YP Singh[1]

ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana

[1]*ICAR-Central Soil Salinity Research Institute, Regional Research Station, Lucknow – 226 002, Uttar Pradesh*

E-mail: arvind.kumar2@icar.gov.in

Abstract

Salt-affected and waterlogged soils are common in many irrigated regions of India. Seasonal heavy rains, floods and heavy irrigations on poorly drained and salt-affected soils pose the additional problem of waterlogging. Combined effect of sodicity and waterlogging prove more harmful to crops than sodicity alone. Considering these facts, a study was undertaken to assess the losses in yield and yield components in wheat under sodic and sodic-waterlogged conditions. The investigation was carried out at the experimental farm of ICAR-CSSRI, Karnal during *Rabi* season 2015-16 in a Randomized Complete Block Design (RCBD) with two replications. The experiment was setup in the microplots using 35 wheat varieties including some Australian varieties like Schomburgk, Ducula 4 and Brookton. All varieties were evaluated under four different treatments *i.e.*, normal (pH 7.5- 7.9), normal waterlogged (pH 7.3- 7.6), sodic (pH 8.9- 9.2) and highly sodic waterlogged (pH 9.1- 9.4). Waterlogging stress was imposed 24 days after sowing for 14 days. Significant ($P < 0.01$) genetic variation was observed for waterlogging tolerance, sodicity tolerance and their interaction among wheat genotypes. Sodicity and waterlogging decreased the yield and yield attributed traits such as plant height (cm), tillers m^{-1}, no. of spikes and plant biomass in wheat varieties. Average yield loss of about 42% was observed mainly due to decrease in tillers m^{-1} and no. of spikes in sodic soils than normal soils. In terms of plant height (cm), KRL 3-4, BH 1146, KRL 382, KRL 376 and KRL 377 performed better under sodic and waterlogged conditions while DW 1, DW 3 and HD 4530 were the weakest performer. The maximum productive tillers m^{-1} under sodic condition was observed in KRL 3-4 and KRL 387, and the minimum in DW 1 and DW 3 varieties. On the basis of reduction in grain yield in sodic waterlogged

treatments, varieties KRL 3-4, KRL 99, KRL 393, KRL 384 (0-20% yield reduction) were ranked as tolerant while HD 2851 and DBW 17 (> 60% yield reduction) were found to be sensitive. Interpretation of sodicity tolerance results showed that KRL 3-4 and KRL 374 were tolerant varieties whereas HD 2851, DW 1, DW 3 and HD 4530 were sensitive. Under sodic-waterlogged stress, KRL 3-4 was found to be tolerant, KRL 393, KRL 210, KRL 392, KRL 374 and KRL 376 were moderately tolerant and HD 2009, Brookton, Ducula 4, KRL 385, DBW 17, KRL 389, BH 1146 HD 2851, Schomburgk, DW 1, NW 1014, HD 4530 and DW 3 were sensitive varieties. In sodic waterlogged conditions, the energy-dependent ion discrimination at the root surface is disturbed leading to decreased Na^+ exclusion and increased salt uptake. A higher growth reduction, therefore, occurs under sodic-waterlogged conditions as compared to sodicity or waterlogged stresses alone. Screening results may be helpful in future to developing crop cultivars for sodicity and waterlogging tolerance.

Performance of promising sugarcane genotypes grown under saline soil conditions

BM Kamble, DS Potdar and DK Kathmale

Agricultural Research Station, K Digraj, Sangli – 416 305, Maharashtra

E-mail: bmkamble2007@rediffmail.com, bmkamble2007@gmail.com

Abstract

A field experiment was conducted during 2013-15 at Agricultural Research Station, K. Digraj, Sangli (Maharashtra) to evaluate the performance of different promising sugarcane genotypes under saline conditions. The experiment was laid out in a randomized block design with 14 treatments replicated twice. Genotypes screened were VSI 434, CoM 09022, CoM 09029, CoM 09043, CoM 09057, CoM 09060, MS 10001, CoM 10011, CoM 10051, CoM 11004, CoM 11007, CoM 11047, Co86032 and CoM 0265. The highest tillering ratio was recorded in Co86032 genotype. The highest cane girth was recorded in CoM 265 genotype which was at par with the cane girth values noted in MS 10001, CoM 11004, CoM 11007 and CoM 11047 genotypes. Inter-node length was significantly higher in CoM 9060 compared to other genotypes. Co 265 genotype produced the highest cane yield and it was at par with MS10001,Co 86032,CoM 11007, CoM 11004, CoM 11051, CoM 9060, CoM 9043, CoM 9029 and CoM 9022. VSI 434 genotype showed significantly higher commercial cane sugar values over others. Significantly higher commercial cane sugar yield was obtained in MS10001 as compared to other genotypes. Soil salinity (EC_e), SAR and ESP values decreased after harvesting of the sugarcane crop. Relatively high reduction in EC_e was recorded in soils under MS 10001, CoM 9057 and CoM 9027. Similarly, greatest decrease in soil SAR and ESP was noticed under MS 10001, CoM 9043 and CoM 11047. Results showed that sugarcane genotype CoM 265 produced the highest cane yield under saline conditions which was at par with the yield of MS10001 which also outperformed other genotypes with regard to the decrease in soil EC_e, SAR and ESP.

Performance of desi cotton (*G. herbaceum* L.) genotypes under controlled salinity in microplots

Indivar Prasad, Anil R Chinchmalatpure, Monika Shukla, Shrvan Kumar, Chandrakant Singh and G Gururaja Rao
ICAR-Central Soil Salinity Research Institute, Regional Research Station, Bharuch – 392 012, Gujarat
E-mail: indivar234@gmail.com

Abstract

Salt affected soils affect nearly 6.73 million hectare (M ha) area in India, out of which 2.22 M ha occur in Gujarat posing serious threats to sustainable agricultural production in the state. Among several approaches of agricultural salinity management, cultivation of high yielding and salt tolerant crop varieties could be the best strategy for sustainable crop production on saline Vertisols because of its economic viability and cost effectiveness. This experiment was conducted during *kharif* 2014-15 to evaluate the performance of F_4 segregating generation of 8 diverse crosses of *G. herbeceum* L. at two salinity levels (EC_{iw} 8 and 12 dS m^{-1}) in microplots at ICAR-CSSRI Regional Research Station Bharuch. Different physiological and biochemical traits implicated in salt tolerance were studied throughout the growing period of the crop. All the crosses performed differently under controlled saline environments of microplots indicative of significant genetic variability for salt tolerance. Lower seed cotton yield/plant was recorded at higher salinity level (12 dS m^{-1}) which implied that salinity had negative impact on yield. K^+/Na^+ ratio in leaf tissues, a reliable parameter for measuring the salt tolerance, was recorded at different stages (before flowering, flowering and after flowering). K^+/Na^+ ratio gradually declined with increasing salinity and the extent of reduction was lesser in high yielding crosses *viz.* GBhv 291 x GShv 297/07, G Cot 23 x GShv 378/05 and GShv 297/07 x GShv 273/07 compared to others. This may be attributed to preferential uptake of K^+ over Na^+ ions in these crosses. Root and shoot biomass were higher at low salinity (8 dS m^{-1}) as compared to high salinity (12 dS m^{-1}) which suggests that high salinity reduces the biomass production. Tolerant crosses had high shoot: root ratio which was again significantly correlated with their high leaf chlorophyll content. Although leaf chlorophyll content reduced with increased salinity, the extent of reduction was lesser in the tolerant crossess. Low yielding crosses showed more proline accumulation in leaf tissues than tolerant ones. These crosses were advanced to next generation to isolate transgressive segregants/variety as the final product.

Screening for salt tolerance in Indian bread wheat lines under field conditions

Arvind Kumar, Gaurav Kumar, Rachna Singh, PC Sharma, and YP Singh[1]
ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
[1]*ICAR-Central Soil Salinity Research Institute, Regional Research Station, Lucknow – 226 002, Uttar Pradesh*
E-mail: arvind.kumar2@icar.gov.in

Abstract

Soil and water salinity are major constraints for wheat production in many wheat producing states of India. High genetic diversity for salinity tolerance has been observed in Indian bread wheat (*Triticum aestivum* L.) genotypes. Hence, these genotypes can be evaluated under field and controlled conditions for identifying new genotypes with better performance under salt stress conditions. During the year 2015-16, we evaluated 80 promising Indian bread wheat lines with different levels of alkalinity tolerance along with three tolerant cultivars as checks under field conditions in at Karnal. Plants were grown under saline (EC_e 7.8-9.32) and

normal (0.75-0.45 dS m^{-1}) conditions. Significant genetic variation ($P < 0.01$) in salinity tolerance was observed among wheat genotypes. In this study, an equation was developed for estimating a stress tolerance score (STS). The results of the equation were identical to those of multivariate analyses. The STS equation is much easier to use than complicated multivariate analyses. Therefore, STS equation is suggested as a screening tool for identification of salt-tolerant wheat genotypes. Ten lines (KRL 390, KRL 391, KRL 392, KRL 393, KRL 394, KRL 395, KRL 396, KRL 397, KRL 398 and KRL 399) having higher salt tolerance than check varieties were identified. These lines can be used in the future wheat breeding programmes for developing high yielding and salt tolerant cultivars.

Halophyte plants in Ranns of Kachchh: Adaptation strategies under extreme salinity and its implications on fodder availability

Devi Dayal, Shamsudheen M and AK Mishra[1]
ICAR-Central Arid Zone Research Institute, Regional Research Station, Kukma, Bhuj – 370 105, Gujarat
[1]*ICAR-Central Arid Zone Research Institute, Jodhpur – 342 003, Rajastahan*
E-mail: devidayal.cazri@yahoo.co.in

Abstract

Kachchh, the second largest district of the country has more than 53% of the total geographical area under Ranns (saline marshy lands). Soil salinity in this regions ranges from 3.2 to 32 dS m^{-1} and sodicity in terms of pH from 8.0 to 10.0. Animal husbandry is the major source of livelihood for the local inhabitants. However, due to high environmental stress and huge population of livestock, the region always remains fodder deficient. Heavy grazing pressure degrades the natural resource diversity of the region. In this region, apart from inherent salinity, a significant portion of agricultural lands has recently developed secondary salinity due to faulty practices. This region is rich in halophytic plant diversity. Halophytic plants tolerate excess levels of salt and are valued as a fodder resource, source of oils or source of salt tolerant genes for agricultural crops. The major halophytes identified at Ranns of Kachchh were *Suaeda nudiflora, Aeluropus lagopoides, Urochondra setulosa, Cressa cretica, Cyperus* sp., *Tamarix gallica*, *Salvadora persica, Salvadora oleoides* and *Prosopis juliflora.*. Studies were conducted to identify morphological and anatomical features of halophyte plants under salinity. As salinity increased, trichomes developed in *Cressa cretica*, no. of pointed trichomes increased in *Urochondra*, thickened epidermis developed in *Aeluropus* and *Urochondra* and stomatal density increased in *Suaeda*. In various plant parts of *C. cretica*, the content of anions followed the pattern $Cl^- > SO_4^{2-}$ and $Na^+ > K^+$ among cations. The highest Na^+/K^+ ratio was observed in dicots compared to monocots. In *C. cretica*, higher Na^+/K^+ ratio was noticed in leaves followed by shoots and the lowest in roots indicating preferential accumulation of sodium over potassium in the leaves compared to roots. These plants also respond to salinity by manipulating anti-oxidants and osmolytes. The osmoprotectant glycine betaine linearly increased in *U. setulosa* with increase in salinity (0.0127 to 0.2755 mg g^{-1}). In *Aeluropus*, the content of superoxide dismutase linearly increased with salinity (0.3715 to 0.8408 mg g^{-1}). The study on nutritional quality of halophytes revealed their potential to serve as feed resource to tackle fodder deficiency in the region.

Stability of rice *(Oryza sativa* L.) genotypes assessed through AMMI and GGE biplots across various salinity stress locations

KT Ravikiran, SL Krishnamurthy, PC Sharma, TV Vineeth, YP Singh[1] and SK Sarangi[2]
ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
[1]ICAR-Central Soil Salinity Research Institute, Regional Research Station, Lucknow – 226 002, Uttar Pradesh
[2]ICAR- Central Soil Salinity Research Institute, Regional Research Station, Canning Town – 743 329, West Bengal
E-mail: rkravikirankt@gmail.com

Abstract

The present study was conducted to analyze the performance of 16 rice genotypes across six salinity stress locations during *Kharif*, 2015. The data recorded on grain yield (kg ha^{-1}) were analyzed using GGE and AMMI analyses. From AMMI1 biplot, genotype CSR 55 was found the most stable followed by CSR 56, NDRK 50046 and NDRK 50043 with above average yields. From AMMI2 biplot, the location Lucknow is the most discriminating and the genotype CSR 10 contributed highest to the interaction variance. From the GGE biplot, Lucknow location was found to be the most discriminating, but least representative of other environments. The vectors of the remaining locations were close indicating high correlation among them. Among the genotypes, CSR 55 showed the highest stability with above average yields. However, the genotype CSR 56 was close to ideal genotype. The "which-won-where" view divided the locations into three mega environments with Lucknow falling under first mega-environment; Karnal sodic microplots, Jind and Gautam Budh Nagar constituting the second and Karnal saline microplots and Nain coming under the third. Overall, the genotypes CSR 55 and CSR 56 can be considered most stable with higher above average yields. The Lucknow location is highly discriminating, but poor representative of other locations and hence can be used only for culling out inferior genotypes.

Morpho-physiological characterization and gene expression analysis of contrasting chickpea (*Cicer arietinum* L.) genotypes in response to salinity stress

Vijayata Singh, Jitender Giri[1], Jogendra Singh, Vineeth TV and PC Sharma
ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
[1]National Institute of Plant Genome Research, New Delhi - 110 067
E-mail: vijayatasingh.gpb@gmail.com

Abstract

Salinity is a major abiotic stress which reduces productivity of a broad range of crops, especially legumes. Chickpea (*Cicer arietinum* L.) is the second most important legume crop grown in more than 45 countries worldwide on 11.5 million ha with global production of 10.4 million tons. However, average yield of about 0.9 t/ha is far below the estimated yield potential of 6 t/ha under optimal growth conditions. The disparity between the actual and potential yields can be explained by large number of biotic and abiotic stresses that adversely affect the crop productivity. Among the abiotic stress, salinity leads to major losses. However, recent studies on salinity tolerance and ion accumulation have revealed chickpea as a highly salt stress sensitive crop. A better understanding of genes and their interactions with the environment could provide valuable insights with regard to crop response under saline conditions. In this study, morpho-physiological

characterization and differential gene expression of salt responsive genes was carried out in root and shoot tissues of two contrasting genotypes of chickpea *i.e.*, KC 1 (salt tolerant) and HC 5 (salt sensitive) under control and 120 mM NaCl stress conditions. KC1 showed significantly lower reduction in morpho-physiological traits and lower Na translocation from root to shoot suggesting a better Na exclusion and compartmentation ability of this genotype. In KC1, salt stress upregulated many genes involved in pathways underlying the salt tolerance. Five genes (*Non-specific LTP precursor*, *CapLea*-1, *H1*, *Trehalose-6-phosphate synthase* and *219*) pertaining to maintenance of cell membrane integrity, osmolyte accumulation and water retention capacity showed higher expression in shoot tissues of KC1 as compared to HC 5 during salinity stress. Further, four genes (*219*, *CapLea-1*, *Protein Kinase* and *non-specific LTP precursor*) playing central role in signalling, osmotic and ionic stress tolerance and regulation of cell growth showed higher expression in root tissues of KC1 as compared to HC 5. Identified genes with contrasting expression patterns in root and shoot tissues of KC I and HC 5 in response to salt stress are excellent targets for further functional studies to understand more specific molecular mechanisms of salt tolerance.

Differential responses of two rice varieties to salt stress: A morpho-physiological, biochemical and molecular perspective

Vijayata Singh, Jitender Giri[1], Ajit Pal Singh[1], Jyoti Bhadoria[1], Jogendra Singh, Vineeth TV and PC Sharma
ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
[1]National Institute of Plant Genome Research, New Delhi - 110 067
E-mail: vijayatasingh.gpb@gmail.com

Abstract

Soil salinity hinders normal crop growth and development by causing osmotic stress and specific ion toxicities. The alteration of ion ratios in plants is caused by the influx of Na through pathways that function in the acquisition of K. However, salt tolerance is a complex trait that requires various biochemical and physiological responses by eliciting a gene network when exposed to salt stress. Thus, the present study aimed to explore morpho-physiological and biochemical changes coupled with expression profiling of salt responsive genes under salt stress in two rice genotypes CSR 10 and MI48 with contrasting salt tolerance under control, 75 mM and 150 mM NaCl stress conditions. Increasing NaCl concentrations delayed and reduced the seed germination in both the genotypes. This reduction in germination percentage and germination index was higher in genotype MI48 (salt sensitive) than the CSR 10 (salt tolerant). CSR 10 maintained lower Na/K ratio in shoots, and restricted Na translocation from roots to shoots attributed largely to better salt exclusion from its roots and salt compartmentation within shoot. In CSR 10, salt stress specifically up regulated genes involved in several pathways underlying salt tolerance. Over expression of Group I genes (*DREB2A*, *DREB2B* and *LEA3*) and Group II genes (*HKT2;1*, *HKT1;*5, *NHX1* and *SOS1*) pertaining to the osmotic and ionic modules, respectively, were evident in CSR 10. These modules suppress the stress enhanced electrolyte leakage, loss of turgidity, promote higher compatible solute accumulation and maintain cellular ionic homeostasis leading to better salt stress tolerance. However, Group III genes (*CATA*, *CATB* and *POX1*) pertaining to oxidative module was largely unaffected by moderate as well as severe salt stress. Identified genes with contrasting expression patterns in roots in response to salt stress are excellent targets for further functional studies to understand more specific molecular mechanisms of salt tolerance in rice.

Practice of double transplanting (*Sanda* method) in rice: small holder farmers' adaptation to multiple stressors in a sub-humid climate

Ranjay K Singh, Anshuman Singh, Arvind Upadhyay, Ankit Goswami, Parvender, Satyendra Kumar, K Thimmappa and DK Sharma
ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
E-mail: ranjaysingh_jbp@rediffmail.com

Abstract

Small-holder farmers world over are increasingly experiencing the challenges caused by the extreme climate variability, land degradation, low incomes and weak policy support making them extremely vulnerable to climate change induced risks. Dismal adaptive capacity, virtual absence of an enabling policy environment and the weak interface with the formal knowledge providers are the factors compelling such farmers to develop their own location specific practices for effective adaptation to such stressors. This paper examines how small-holder farmers of eastern Uttar Pradesh (UP) are using the local knowledge for sustaining the rice yields in a multiple stress environment. Study was carried out with 45 key knowledge farmers selected randomly from 9 villages, *i.e.*, three each from three purposively selected districts (Azamgarh, Jaunpur and Gajipur) of eastern UP. Data were collected using intensive transect walk, participant observations, distant learning and informal interactions, and personal interviews using a structured questionnaire in combination with the soil testing results. Results indicated that farmers are experiencing reduced number of rainy days, extended summers and short winters than earlier. Some new insect-pests and weeds have emerged in the past two decades. Moderate to high soil sodicity (pH_2 8.4-10.1), waterlogging in low-lying lands in canal commands and acute labour shortages due to increased migration to cities and employment opportunities under MGNREGA scheme have considerably increased the vulnerability of these farmers. Furthermore, weak policy support and the poor access to the recommended technologies seem to have further decreased their adaptive capacity as evident from very low rice yields (1.8-3.5 q ha^1). As income from rice crop is a major source of livelihood to them, studied farmers are increasingly adopting the *sanda* method of double rice transplanting to enhance the resilience of the rice agro-ecosystems. In this method, farmers broadcast only about a fifth (6-8 kg ha^{-1}) of the recommended seed rate (30-40 kg ha^{-1}) in puddled fields around mid-May using tube well water. After about 25 days (*i.e.*, around 15th June), the seedlings are uprooted and transplanted in another field where they are grown for about 20 days (5-10 July). About 50-55 days old seedlings are then moved to the main fields. Rice crop grown using *sanda* technique withstands extended dry spells in the uplands and prolonged water inundation in the low-lying fields. Almost negligible incidence of pests and diseases ensures little or virtually no use of pesticides. Compared with the puddled transplanted rice, *sanda* method provides about 20-25% higher grain yield. This community-knowledge, which probably originated in the eastern parts of India, has gradually spread to the eastern UP via migrant labourers from Bihar and West Bengal. This method of rice growing represents a characteristic example of autonomous adaptation to alleviate the risks caused by multiple stressors. Notably, this method has now become a part of the agricultural contingency plan of the State Government. It is possible that *sanda* technique may be of immense use in rice-wheat system of north-western India where a multitude of problems including widespread land degradation, water scarcity, pest and disease outbreaks and declining crop yields have caused immense harm.

Alleviation of adverse effects of saline water irrigation in tomato using antioxidants

Uttam Kumar, IJ Gualti and SR Yadav
College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner – 334 006, Rajasthan
E-mail: uttamdewangan.1991@gmail.com

Abstract

Soil salinity is one of the major abiotic stresses that adversely affect plant productivity and quality. The present investigation was conducted at College of Agriculture, S.K. Rajasthan Agricultural University Bikaner, during K*harif* season of 2014-15. The experimental soil was sandy in texture with pH_2 8.17, EC_2 0.43 dS m^{-1} and CEC 4.39 cmol (p^+) kg^{-1}. Plants of tomato variety Pusa ruby were transplanted in open field during 1st week of August at 30 cm x 30 cm spacing. There were 18 treatment combinations comprising three levels of saline water (control 0.25 dS m^{-1}, 4 dS m^{-1} and 8 dS m^{-1}), three levels of humic acid (control, 750 ppm and 1500 ppm) and two levels of salicylic acid (control and 1.5 mM). Results revealed that increasing salinity of irrigation water significantly increased the plant Na^+, Cl^-, SO_4^{2-}-S, TSS and ascorbic acid. Plant Ca^{2+}, Mg^{2+}, no. of fruits per plant, average diameter, average weight, fruit yield, net returns and B: C ratio decreased significantly with the increase in salinity of irrigation water. Application of both humic acid and salicylic acid significantly increased plant Ca^{2+}, Mg^{2+}, TSS, ascorbic acid, no. of fruits per plant, average diameter, average weight fruit yield, net returns and B: C ratio. Plant Na^+, Cl^- and SO_4^{2-}-S decreased significantly with increase in the levels of humic acid and salicylic acid application. The combined effect of saline water of EC_{iw} 8 dS m^{-1} and 1500 ppm humic acid recorded the maximum TSS and ascorbic acid contents in tomato fruits. Combined soil application of humic acid (1500 ppm) with salicylic acid was found the most effective, which alleviated the deleterious impacts of salinity stress on yield and quality of tomato fruits. Application of humic acid + exogenous salicylic acid can enhance plant growth and yield in tomato under saline conditions.

Screening and characterization of salt tolerant microbes and their effect on wheat and mustard

Manjari, Harshpreet Kaur, PK Joshi and Madhu Choudhary
ICAR- Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
E-mail: manjarishri1989@gmail.com

Abstract

Plant growth promoting rhizobacteria are the soil rhizospheric bacteria which facilitates plant growth and development via production and secretion of various regulatory chemicals in rhizosphere and also aids in mitigation of salt stress from soil. In present study, 270 bacterial isolates were isolated from different salt affected areas of the country and screened for their tolerance to NaCl. Isolates were grown at four levels of NaCl concentration i.e. 5%, 10%, 15% and 20%. All the isolates showed good growth at 5% NaCl but at higher level of NaCl only few showed good growth. At 15% and 20% NaCl respectively 90 and 52 isolates grew well. These 52 isolates were further screened for plant growth promoting activities. Out of these 52 isolates, 21 isolates were selected for further study on the basis of plant growth promoting (PGP) traits such as ammonia excretion, Phosphate solubilization, Indole-3-acetic acid (IAA) and HCN production. These isolates were also checked for lipase, amylase and protease activities. Bacterial isolates STB 80, 10STB7B and STB 1 excreted respectively 0.057 µg/ml, 0.056 µg/ml and 0.051 µg/ml amount of ammonia. Isolate

15STB5C, STB 32 and STB80 produced IAA at amount of 6.97 ppm, 5.16ppm and 4.50 ppm, respectively. Phosphate solublization was recored highest by isolates 15STB2C (19.08ppm) followed by 10STB7B (16.93ppm) and STB 80 (15.06ppm). STB 133 and 15STB5C were showed positive results of HCN production. With respect to enzymatic activities STB 80 possessed amylolytic and lipolytic activity, 10STB7B, STB1, 15STB2C showed positive results for amylolytic activity while STB 32 and STB 38 for proteolytic activity. The seed germination experiment was performed for all the 21 isolates at 0, 60, 120 and 240 mM NaCl level. From seed germination experiment, it was observed that wheat seeds germinated better at all NaCl levels as compared to mustard seeds. STB1, 10 STB 7B, STB 80, STB 32, STB 133 isolates showed better seed germination as compared to other isolates. All 21 isolates were inoculated on mustard and wheat plants in pot house experiments. The initial ECe of soil was 5.36 dS/m and pH was 7.02. It was found that isolate 10STB3C (2) and STB 55 resulted 10.27% and 5.83% respectively increase in plant height of mustard and wheat as compare to uninoculated control. STB 32 showed 33.3% more tillers, STB 24 showed an increase of 62.7% in chlorophyll content of wheat plant sample. Plant biomass of wheat was observed 27.08% more in STB 32 inoculated pot whereas mustard plant biomass was 10.46% higher in STB1 inoculated pot. In case of wheat, isolate 5STB11B showed increase of 29.9% in grain yield and 10STB3C (2) showed an increase of 20.78% for mustard. It was inferred from pot house experiments that rhizobacterial isolates having PGP activities helped plants in their growth and productivity in saline soils.

Enhancing drought tolerance in crops through advance breeding methods

Manoj Kumar[1], Suman Sharma[2], Pawan Kumar[3]
[1]Dept. of Genetics and Plant Breeding, [2]Dept. of Extension Education,
Swami Keshwanand Rajasthan Agricultural University, Bikaner – 334 006, Rajasthan
[3]Rajasthan Agricultural Research Institute, SKN Agriculture University, Jobner – 303 329, Rajasthan
E-mail: manoj.vishnoi108@gmail.com

Abstract

Adaptation to abiotic stresses is a quantitative trait controlled by many different genes. Enhancing the tolerance of crop plants to abiotic stresses such as drought has therefore proved to be somewhat elusive in terms of plant breeding. Drought is one of the prime abiotic stresses in the world. Crop yield losses due to drought stress are considerable. Although a variety of approaches have been used to alleviate the problem of drought, plant breeding, either conventional breeding or genetic engineering, seems to be an efficient and economic means of tailoring crops to enable them to grow successfully in drought-prone environments. During the last century, although plant breeders have made ample progress through conventional breeding in developing drought tolerant lines/cultivars of some selected crops, the approach is, in fact, highly time-consuming and labour- and cost-intensive. Alternatively, marker-assisted breeding (MAB) is a more efficient approach, which identifies the usefulness of thousands of genomic regions of a crop under stress conditions, which was, in reality, previously not possible. Quantitative trait loci (QTL) for drought tolerance have been identified for a variety of traits in different crops. With the development of comprehensive molecular linkage maps, marker-assisted selection procedures have led to pyramiding desirable traits to achieve improvements in crop drought tolerance. However, the accuracy and preciseness in QTL identification are problematic. Furthermore, significant genetic x environment interaction, large number of genes encoding yield, and use of wrong mapping populations, have all harmed programs involved in mapping of QTL for high growth and yield

under water limited conditions. Under such circumstances, Transgenic and "omics" technologies promise to make progress in breeding for drought tolerance through a more fundamental understanding of underlying mechanisms of drought tolerance and identifying potential candidate genes. These new approaches provide opportunities to direct the continued breeding of genotypes giving stable yields under drought stress. Rapid advance in knowledge on genomics and proteomics will certainly be beneficial to fine-tune the molecular breeding and transformation approaches so as to achieve a significant progress in crop improvement in future.

Effect of thiourea and zinc on growth, yield and quality of cauliflower (*Brassica oleracea* var. Botrytis *L.*)

Manju Verma, MR Choudhary, Sunita Verma and RK Bairwa[1]*
SKN College of Agriculture, SKN Agriculture University, Jobner – 303 329, Rajasthan
[1]Research Scholar, College of Agriculture, SK Rajasthan Agricultural University, Bikaner – 334 006, Rajasthan
****E-mail: ramkishan00029@gmail.com***

Abstract

The experiment was conducted to study the effect of thiourea and zinc on growth, yield and quality of cauliflower (*Brassica oleracea* var. botrytis L.) during *Rabi* season of 2015-16 at SKN College of Agriculture, Jobner. The experiment consisted of 16 treatment combinations with four levels of thiourea (Control, 500, 750, and 1000 ppm) and four levels of zinc (Control, 2.5, 5.0 and 7.5 kg/ha) in randomized block design with three replications. The results indicated that application of 1000 ppm thiourea significantly increased plant height, number of leaves, leaf area, plant spread and total chlorophyll content in leaves, curd weight, curd yield, NPK and Zn content and ascorbic acid and protein content in curd of cauliflower and significant reduction in days to curd initiation and curd maturity. Although, application of 750 ppm thiourea was found statistically at par to 1000 ppm thiourea except curd weight and curd yield Similarly, application of zinc 7.5 kg/ha significantly increased all the growth, yield and quality parameters of cauliflower, but it was found statistically at par with zinc 5.0 kg/ha for growth and quality attributes.

The interactive effect of 1000 ppm thiourea along with 7.5 kg/ha zinc, being statistically at par to application of 1000 ppm thiourea + 5.0 kg/ha zinc but found significantly superior with respect to leaf area (1105.67 cm^2), total chlorophyll content in leaves (2.268 mg/g), average curd weight kg/plant (0.386 kg/plant), curd yield kg/plot (9.26 kg/plot) and yield q/ha (160 q/ha), maximum net returns (Rs 218077/ha) and B: C ratio (2.61). Further, it may be concluded that application of 1000 ppm thiourea along with 5.0 kg/ha zinc is worth recommendable for farmers of semi-arid zone IIIA to get significantly better yield, net return (Rs 202609/ha) and B:C (2.43) ratio from cauliflower.

Effect of sulphur and spacing on growth, yield and quality of knol-khol (*Brassica oleracea* var*. gonylodes*)

RK Bairwa[1], SP Singh[2], CK Dotaniya[1] and Manju Verma[2]
[1]Research Scholar, College of Agriculture, SK Rajasthan Agricultural University, Bikaner – 334 006, Rajasthan
[2]SKN College of Agriculture, SKN Agriculture University, Jobner – 303 329, Rajasthan
E-mail: ramkishan00029@gmail.com

Abstract

The experiment was conducted at SKN College of Agriculture, Jobner (Jaipur) during *Rabi* season 2013-14 on loamy sand soil. The experiment consisted of four levels of sulphur (0, 20, 40 and 60 kg S ha^{-1}) and four

spacing (30x20 cm, 30x30 cm, 45x30 cm and 45x45 cm). The total 16 treatment combinations were tested in randomized block design with three replications. The knol-khol variety Early White Viana was sown on 12 Sept. 2013 at different spacing. Results revealed that application of 60 kg S ha^{-1} to the knol-khol crop significantly increased the plant height at harvest, days to initiation of knob, days to marketable maturity of knob, diameter, volume of knob and total knob yield (q/ha), sulphur content in knob, protein content (%), ascorbic acid in knob (mg/100g), net return and B: C ratio as compared to control and 20 kg S ha^{-1} but statistically at par with 40 kg S ha^{-1}. The spacing of 45x45 cm significantly increased the sulphur content in knob, protein content (%) and ascorbic acid content in knob (mg/100g) as compared to 30x20 cm and 30x30 cm spacings, but statistically at par with 45x30 cm spacing, whereas, number of leaves per plant, chlorophyll content (mg/g) in leaves, fresh weight of knob per plant (g) and Knob: leaf ratio were found maximum at 45x30 cm spacing as compared to 30x20 cm spacing and 30x30 cm spacing being statistically at par with 45x45 cm spacing. The total yield, net returns and B:C ratio were found significantly higher at 30x30 cm as compared to 45x45 cm and 30x20 cm spacing which was found statistically at par with 45x30 cm spacing.

The combined application of 40 kg S ha^{-1} with 45x30 cm spacing proved to be most superior treatment combination in terms of diameter of knob, volume of knob, sulphur content in knob and 40 kg S ha^{-1} with 30x30 cm spacing in terms of total yield (qha^{-1}), net returns and B:C ratio. The total knob yield was significantly and positively correlated with diameter of knob, volume of knob and sulphur content in knob.

Effect of salinity and sodicity on yield and yield attributes of rice genotypes

Sharik Ali, RK Gautam[1], Ritu Mahajan[2], Parveen Kumar, DK Sharma and PC Sharma
ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
[2]ICAR-Central Agricultural Research Institute, Port Blair – 744 105, Andaman & Nicobar Islands
[2]Department of Biotechnology, Kurukshetra University, Kurukshetra – 136 119, Haryana
E-mail: sharik.ali85@gmail.com

Abstract

Salinity and sodicity of soil are the threats to the sustainability of crop yields. Salt tolerance is a quantitative trait, which is affected by environmental variation. It is important to understand the magnitude and nature of genetic variability and association of various agro-morphological traits with grain yield under normal, sodic and saline environments. The recommended strategies to overcome adverse effects of salt stress include, use of salt tolerant cultivars. However, each of these technologies has limited success under diverse environmental conditions. The use of salt tolerant genotypes has been considered the effective way of increasing crop production in salt affected soils. Yield is a complex quantitative character and is greatly influenced by environmental factors. Yield stability is a complex product of genetic yield potential and tolerance to stress conditions. Genetic variability is a prerequisite for initiating appropriate breeding procedures in crop improvement programmes. Many traits of agricultural importance are quantitative, i.e. based on polygenes. A study was carried out for evaluation of rice genotypes introgressed with *SALTOL* QTL including check varieties for salt tolerance. Twenty two rice genotypes including eighteen *SALTOL* QTL introgressed rice genotypes were evaluated under three environments of normal, moderate sodic (pH 9.5) and high saline (EC_{iw} 10dS/m) soil microplots during two years for nine quantitative traits viz. plant height (cm), total tillers/plant, productive tillers/plant, panicle length (cm), 1000 grain weight (g), spikelet fertility

(%), biological yield (t/ha), grain yield (t/ha) and harvest index (%). Significant differences among *SALTOL* QTL introgressed genotypes were observed for all the characters in different environments. Mean squares due to genotypes were highly significant for all the nine traits indicating that the genotypes were sufficiently different from each other for the traits studied in the non stress and two salt stress environments. The salinity and sodicity stress environments affected the growth and yield attributing parameters. It was observed that maximum grain yield was attained by IR 84645-305-6-1-B in normal, moderate sodic and high saline environments followed by IR 84645-275-3-2-B, IR 84649-95-1-1-B, IR 84649-275-4-1-B, IR 84649-129-5-1-B, IR 84649-320-3-1-B, IR 84649-292-3-1-B while IR 84649-320-21-1-B and IR 84649-33-24-1-B genotypes have showed high grain yield in high saline stress environment among all the 18 *SALTOL* introgressed rice genotypes. It is showed that salinity and sodicity had a negative impact on yield and adversely affected a number of yield components.

Deciphering the mechanisms of salt tolerance of wild grass and non grass halophytes using protein profiling

Charu lata[1], Ashwani Kumar[1], Sulekha rani[2], Anita Mann[1]
[1]ICAR- Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
[2]Dept. of Biotechnology, Kurukshetra University, Kuruksherta – 136 119, Haryana
E-mail: charusharmabiotech@gmail.com

Abstract

Globally more than 900 million hectares of land, approx. 20% of the total agricultural land (FAO, 2007), are affected by salt accounting for more than 6% of the world's total land area. Saline regions are marginal and unproductive areas which are rich in naturally salt-tolerant plants, i.e. halophytes. Halophytes have evolved several complex salt-tolerance strategies, which make them interesting models for understanding the physiological and molecular mechanisms. This research was planned to decipher the mechanism of wild grass and non grass halophytes for their sodicity and salinity tolerance using protein profiling. The present investigation was conducted on *Sporobolus marginatus* and *Sueda nudiflora* grown at control (without addition of external salts) and different saline (EC_e 30, 40, 50 dS m^{-1}) and sodic (pH: 9.5, 10.0) conditions in screen house of the Division of Crop Improvement, CSSRI, Karnal. Protein profiling was done at vegetative stage using 10 % acrylamide gel electrophoresis. A standard protein marker of range 14.3 -97.3 kDa was also run alongwith the samples. A total of 106 and 141 polypeptide bands were observed in *Sueda* and *Sporobolus* respectively. The range of bands observed was 6-17 per treatment. In *Sporobolus*, a prominent protein band of 53.09 kDa was seen with all treatments except at EC_e 30 dS m^{-1}. A polypeptide of 105.9 kDa appeared in control as well as with pH 9.5, and pH 10.0 but it disappeared at EC_e 30, 40 dS m^{-1} while it reappeared at ECe 50. Another polypeptide band of size 39.81 kDa was seen only at EC_e 40 dS m^{-1} which can be responsible for providing tolerance at such a high stress condition but its absence at other treatments suggest it not to be the single protein in playing any role in tolerance. It may suggest that salt and sodic stress induces quantitative changes in polypeptides and specific changes in the level of polypeptide for plant types due to variability in response to salt by individual treatment level. The identification of particular protein expressed, down regulated or up-regulated under stress conditions in these salt-tolerant grasses will provide insights into many salt-related genes associated with other abiotic and biotic stress responses. A number of candidate genes encoding transcription factors, ion transporters, osmoprotectants and antioxidants from salt tolerant grasses have been reported during salt stress.

Genetic and phenotophic tolerence of different livestock species

NS Dahiya[1], Preethi S[2], Gayatri Gujar[2], V Singh and AK Jhirwal[2]
[1]Department of Livestock Production Management, College of Agriculture
SK Rajasthan Agricultural University, Bikaner – 334 001, Rajasthan
[2]Department of Livestock Production Management, College of Veterinary and Animal Science
Rajasthan University of Veterinary and Animal Sciences, Bikaner - 334 001, Rajasthan
E-mail: nsinghdahiya@gmail.com

Abstract

Evolution is believed to be the process by which different living organism developed on this planet. Certainly, tolerance to various stress factors determined their existence. Organism from single celled amoeba to multi cellular mammals would not have experienced same kind of stress, because of which they had evolved their own mechanism to cope stress arising from various factors like environment, nutrition, management etc. According to Larcher, any biological system when exposed to stress , develops three ways of tolerance i.e. (a) evade or reduce stress by attaining dormancy, (b) evolve greater resistance to stress (c) recovery mechanism, if actually got damaged. Here we deal with various stress tolerance mechanism exhibited by the biological system. The plant or animal responds to stress through physiological, endocrinal, immunological, genetic and behavioural means. Factors like rise in heart rate, blood pressure and increased GI activity, panting etc. corresponds to the physiological response to stress, rise in cortisol, glucose and thyroxine levels in animals and production of auxin, ethylene and abscisic acid in plants are seen as hormonal response to stress. Whereas, altering the phenotype (phenotype plasticity) is seen as one of the genetic responses to stress, and through the defence action of granulocytes, natural killer cells, and cell mediated response etc. the biological system expresses its immunological tolerance to stress. Hence development of organism with multiple stress tolerance (tolerance to temperature, oxidative stress etc.) become indispensable with increasing climate change.

Evaluation of growth parameters of pearl millet and mungbean varieties under intercropping systems

Naresh Kumar, Mukesh Kumar, RC Bairwa and Soma Devi
College of Agriculture, SK Rajasthan Agricultural University, Bikaner – 334 006, Rajasthan
E-mail: karwasranaresh7@gmail.com

Abstract

A field experiment was conducted during *kharif*, 2015 at College of Agriculture, SK RAU, Bikaner. The experiment comprised of 12 treatments, two varieties of pearl millet and mung bean (HHB-67, RHB-177 and RMG-62, SML-668) and eight pearl millet + mungbean combinations of these varieties with row ratio (1:1 and 1:2) was laid out in Randomized Block Design (RBD) with three replications. The results showed that leaf area index at 45 DAS, and dry matter accumulation of pearl millet at harvest was recorded significantly higher in RHB-177+SML-668 (1:2) row ratio. There was no significant effect of different treatments on plant height, total number of tillers, dry matter accumulation at 30 DAS, leaf area index at 30 DAS and at harvest. Sole mungbean variety SML-668 among all treatments recorded significantly higher number of branches, plant height at harvest and leaf area index at 45 DAS and at harvest. The intercropping systems sole mungbean SML-668 gave a maximum return (Rs. 65006 ha-1) which was significantly higher than all other systems. However, among intercropping systems RHB-177+SML-668 (1:2) gave significantly maximum net return (Rs.58664 ha^{-1}) but it was at par with HHB-67+SML-668 (1:2) row ratio (Rs. 58125 ha^{-1}) in intercropping systems. It was concluded from one year study that intercropping of pearl millet + mungbean RHB-177+SML-668 (1:2) row ratio produced highest pearl millet equivalent yield, net returns and B:C ratio however, LER of HHB-67+RMG-62 (1:2) row ratio was higher among all the treatments.

Tolerance evaluation of coriander *(Coriandrum sativum* L.) to residual sodium carbonate in irrigation water

PS Renjith[1], RK Yadav[2] and Vineeth TV[2]
[1]ICAR-Central Arid Zone Research Institute, Regional Research Station, Bikaner – 334 004, Rajasthan
[2]ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
E-mail: renjithps6@gmail.com

Abstract

India is the largest producer and consumer of coriander (*Coriandrum sativum* L.) in the world, with Rajasthan, Madhya Pradesh and Gujarat as major production centres. However, farmers of these regions often suffer from crop losses due to problems of salt affected soil and use of poor quality groundwater with high RSC (Residual Sodium Carbonate) and Sodium Adsorption Ratio (SAR) for irrigation. Due to increased interest in the utilization of sodic water with/without prior reclamation for irrigation, there is a need for information on sodicity tolerance of various economically important plants including seed spices; that could be recommended for growing in areas where sodic groundwater is being used for irrigation. The present study was carried out to evaluate the suitability of coriander under water qualities varying in RSC for irrigation in the lysimeter facilities at the ICAR-Central Soil Salinity Research Institute-Karnal, Haryana. The experiment consisted of irrigating the crop with normal irrigation water (RSC nil), 2.5 meL^{-1} RSC water, 5 me L^{-1} RSC water, RSC 5 meL^{-1} + gypsum (to neutralize 2.5 $meqL^{-1}$ RSC) and RSC 5 meL^{-1} + sulphur (to neutralise 2.5 meL^{-1} RSC). The experiment was laid out in randomized block design with four replications in lysimeters of 2x2x2 m^3 size. The crop was grown with standard agronomic practices. The study indicated that application of RSC water affected the germination, growth, development and yield of coriander compared to irrigation with normal water. The highest germination percentage was recorded in control plots (78.9%) and the lowest in plots treated with RSC meL^{-1} 5 water (43.3%). The maximum decrease in growth and yield with delayed development and highest stress as observed by the membrane injury index was recorded in plants treated with RSC 5 meL^{-1} water. The seed yield (11.38 q ha^{-1}) obtained with fresh water (control) decreased to 10.25, 9.56 and further to 6.85 q ha^{-1} with RSC 5 meL^{-1}+ gypsum, RSC 5 meL^{-1} + sulphur and RSC 5 meL^{-1} + sulphur RSC 5 meL^{-1}, respectively. Plants treated with RSC 5 meL^{-1}+ gypsum(to neutralize2.5 meL^{-1} RSC) performed better than that treated with RSC 5 meL^{-1} + sulphur(to neutralize 2.5 meL^{-1} RSC); as indicated by parameters like growth, dry matter production, membrane injury and seed yield of the crop.

Wheat cultivation under sodic agro-ecosystems: Need for retrospection and revalidation of existing recommendations

Luxmi Kant Tripathi, Parvender Sheoran, RK Singh and RK Yadav
ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
E-mail: tripathicsa@gmail.com

Abstract

India currently suffers from about 6.73 million ha of salt affected soils in different agro-ecological regions. Out of this Indo-Gangetic region has about 2.7 million ha area consisting mostly of centuries-old barren sodic soils with no land use opportunities. The problems of soil and water quality are likely to increase mainly due to expansion in irrigated area without adequate drainage, intensive use of natural resources resulting in second generation problems and climate change in the future. The lack of good water supplies for irrigated agriculture is now becoming a major issue that is compelling farmers to use poor quality water. This is likely to further increase exponentially due to increasing urbanization and industrialization.

Five villages namely Mundri, Gyong, Kathwar, Sampli Kheri and Bhaini Majra were purposefully selected in Kaithal district of Haryana, where indiscriminate use of high residual alkalinity irrigation water in sodic soils constitutes a serious threat to the sustainability of agriculture. About 100 farmers were interviewed personally through structured questionnaire following stratified random sampling procedure. In addition, a total of 25 demonstrations, 5 each in selected villages were carried out under Mera Goan Mera Gaurav (MGMG) scheme to showcase the potential of CSSRI bred salt tolerant wheat variety KRL 210 vis-à-vis locally adapted high yielding cultivars in the farmers participatory mode.

About 72.5% of the farmers belong to small category having less than 2 ha farm size. Rice-wheat is the dominating cropping system of the region with only 10-12% area under sugarcane and need based fodder production. Out of total cultivable area, about 60-65% area is dominated by sodic soils having pH more than 8.2 and EC less than 1 dS/m. The water quality parameters indicated residual alkalinity of irrigation water (RSC) more than the permissible limits (>2 meq/l) in 94% samples while critically higher irrigation water salinity (EC_{iw} >2 dS/m) was observed in 2.3% samples. Nitrogen (<250 kg N/ha) was deficient in 97% tested soil samples while 63% samples accounted for low to medium (upto 20 kg P/ha) phosphorus in plant available form. Boron was critically deficient (<0.5 ppm) in about 87% samples. Two-third of the farmers completed wheat sowing by second week of November. About 58% of the farmers are using more than recommended N within 2-3 splits; first N within 0-10 days of irrigation application followed by second split N 10-14 days of first N application depending on the soil type and need based third split N with second irrigation.

The varietal interventions indicated that the high yielding cultivars (HD 2967/WH 1105/WH 711) performed equally good in relation to salt tolerant KRL 210 when the average soil alkalinity (pH) remains ≤.8 and residual alkalinity in irrigation water RSC ≤ 4.0 meq/l. Thereafter, with the deteriorating soil and water quality, average yield superiority with a margin of 4.7% (1.96 q/ha) was observed with salt tolerant KRL 210 over the existing ones at the farmers' fields. The study indicated that the farmers have developed their own long lasting practices to sustain crop production with inherent natural resource base. Though integration of farmers' traditional wisdom and scientific approach including soil test based reclamation/management of sodic soils, sustainable use of poor quality water and fertilizer scheduling, adoption of salt tolerant cultivars and integrated weed management will further help in upward upliftment and livelihood security of the farming fraternity. This study appeared to be a fit case for the revision and revalidation of recommended cultural practices particularly for wheat cultivation under sodic agro-ecosystems.

Isolation and characterization of plant growth promoting Halotolerant methylotrophic bacteria from rhizosphere and rocks

U Bitla, Kamlesh Kumar Meena, Ajay M Sorty, K Choudhary, KK Krishnani and NP Singh
ICAR-National Institute of Abiotic Stress Management, Malegaon, Baramati – 413 115, Maharashtra
E-mail: ubitla@gmail.com

Abstract

The plant leaf surfaces are considered as the most common habitat for pink pigmented facultative methylotrophs (PPFMs) utilizes C_1 compounds as their sole source of carbon.The plant surface frequently offers drastic environmental changes such as intense light, and nutrient scarcity. Sustenance of methylotrophs in such a harsh environments itself highlights their stress tolerance capabilities. Further, similar organisms from stressed environments like salinity, drought, acidity, alkalinity etc. could also serve as an option to mitigate diverse kind of abiotic stressors. Thus the halotolerant PPFMs may offer an additional advantage to use them as bio-inoculant under stress-prone situation. Considering the overall significance of methylotrophic bacteria we attempted to isolate the PPFMs from various habitats including phyllosphere,

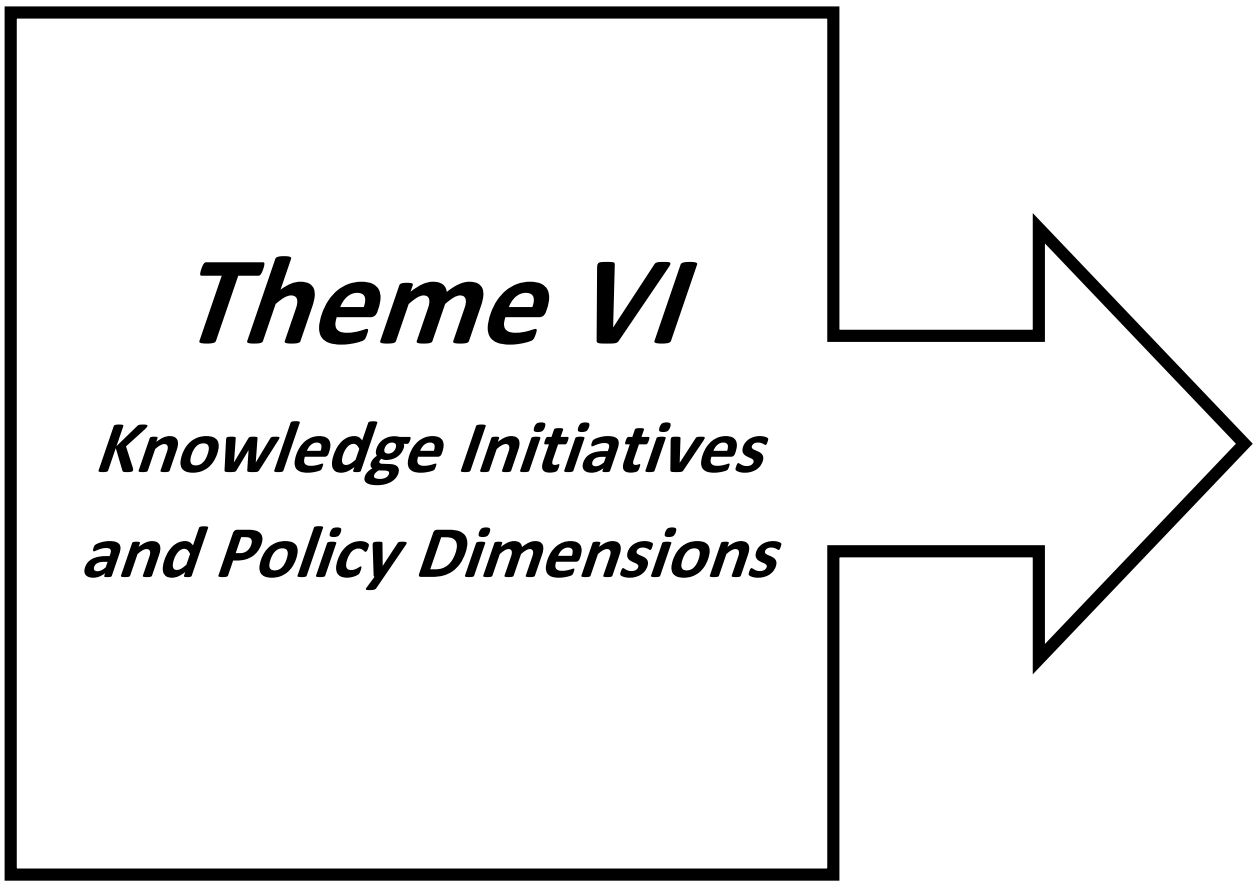
bulk soils and rock (endolithic). The halotolerant nature of these isolates encouraged to characterize them for their PGP attributes including siderophore, IAA, exopolysaccharide production, nitrogen fixation and phosphate solubilization. HPLC profile generated for the secreted metabolites of candidate isolates showed the presence of various unknown biomolecules in addition to plant-growth hormones like IAA, GA_3, and IBA. An i*n-vitro* experiment was also conducted to reveal the plant growth promotional potential of bacterial metabolites secreted under simulated saline growth conditions. The results obtained are strongly endorse the need to evaluate the isolates *in planta* to determine their actual PGP potential both under normal as well as salinity stressed conditions.

Influence of different *basmati* cultivars and nitrogen scheduling on nutrient content, uptake and nitrogen use efficiency

Mohinder Singh, Dharam Bir Yadav, Naveen Kumar, Rajbir Singh Khedwal, KR Dabur, Ram Prakash and NK Singh
Faculty of Agricultural Science, SGT University, Hisar – 125 004, Haryana
E-mail: mohinder27481@rediffmail.com

Abstract

Rice (*Oryza sativa* L.) is the most widely cultivated cereal crop in the world. Depending upon resource availability it can be cultivated by a number of ways. Dry direct seeding is now emerging as a new trend in rice cultivation. Proper scheduling of nitrogen favours efficient utilization throughout the crop growing season by providing desired amount of nitrogen to the plant during peak periods of growth and reducing leaching of nitrates in soil. In order to study the effects of different *basmati* cultivars, nitrogen scheduling on NPK content and NPK uptake in dry direct seeding conditions was studied for two crop growing seasons (2014 & 2015) at CCS HAU, Regional Research Station, Karnal. Four *basmati* rice cultivars (PB 1121, PB 1509, PB 1 and HB 2) were taken as main plot treatments and three nitrogen doses (90, 100 and 110 kg N ha^{-1}) with 3 and 4 splits in sub main plot treatment of split plot design. Results of the experiment indicated that N, P and K content and uptake were affected with cultivars and nitrogen scheduling. *Basmati* cultivar PB 1121 showed significantly higher (1.11 & 1.13%) N content in grains than in PB 1, PB 1509 and HB 2 while P (0.14 & 0.15%) and K (1.48 & 1.50 %) content was statistically alike with PB-1121 and significantly higher than rest of *basmati* cultivars under study during 2014 and 2015 respectively. Results also indicated that NPK content in straw of HB 2 cultivar was significantly higher (0.39 & 0.41%), (0.14 & 0.15%) and (1.48 & 1.50%) respectively than PB1 and PB 1509 but was statistically alike with PB 1121. Minimum N and P content were recorded with PB 1509 while K content with PB 1. Maximum N and K harvested by cultivar HB 2 (75.0 % 78 kg N ha^{-1}) (110.3 & 119.3 kg P ha^{-1}) respectively, was significantly higher than rest of cultivars, while maximum P uptake by PB 1121 which was significantly higher than that of PB 1509, PB 1 and HB 2. Among the nitrogen scheduling 110 kg N ha^{-1} with four splits treatment recorded maximum N, P and K (kg ha^{-1})harvested by the basmati cultivars (82.4 & 82.6 kg ha^{-1}), (26.3 & 27.8 kg ha^{-1}) and (120.5 & 125.2 kg ha^{-1}) respectively which was significantly higher than rest of treatments.


Theme VI
Knowledge Initiatives
and Policy Dimensions

Rex – The house of innovations and pioneering initiatives in saline land reclaimation

Rex Polyextrusion Pvt Limited, Sangli – 416 416, Maharashtra
E-mail: sgjoshi@rexpoly.co.in; stp@rexpoly.co.in

Abstract

In India, practice of conventional irrigation practices and over usage of water alongwith excessive fertilizer and pesticide applications have resulted in extreme contamination of lands. Waterlogging and Salinity have resulted in wasteland development and have increased the toxicity and deficiency of nutrients in soil. In agricultural terms, the soil should be considered as water logged when the waer table is with such a distance from the surface of the ground that it reduces the crop production below its normal yield that would be expected from the soil type of that area (Department of Irrigation, Uttar Pradesh, 2011).

Keeping these problems is view, the first requisite in the prevention of waterlogging and salinity problems is an adequate drainage system. Every farmer who applies water by surface irrigation or who deals with significant rainfall should have a sufficiently capable drainage facility to remove excess water.

Rex Polyextrusion Pvt. Ltd. has been working in the field of sub-surface for more than a decade, and has introduced single walled corrugated perforated and non-perforated pipes under the brand of GeoRex and a recent product in the form of a flat belt with omega shaped grooves under the brand of AquaRex. Both of these products are specially designed for Sub-surface drainage and due to their unique designs, can result in a long term solution for tackling waterlogging and salinity related problems.

Cost estimation of sub-surface drainage systems for reclamation of waterlogged saline lands

DS Bundela, MJ Kaledhonkar, SK Gupta, Mohan Lal[1], SK Kamra, DK Sharma, PC Sharma and SK Chaudhari[2]
ICAR- Central Soil Salinity Research Institute, Karnal – 132 001, Haryana
[1]Haryana Operation Pilot Project, Haryana Agriculture Department, Karnal – 132 001, Haryana
[2]ICAR-Natural Resources Management Division, KAB-II, Pusa, New Delhi – 110 012
E-mail: ds.bundela@icar.gov.in

Abstract

Expansion of irrigated agriculture in the arid, semi-arid and sub-humid regions of India has increased the area under twin problems of waterlogging and soil salinity adversely affecting the crop productivity. Nearly 2.96 million ha lands are affected by these problems spread across 16 states of the country. The annual crop production and monetary losses due to the salinity problem at the national level are 5.66 million tonnes and 8000 crore, respectively. Irrigation induced waterlogged saline lands characterized by shallow watertable and high concentrations of soluble salts (EC_e >4 dS m^{-1}) in the root zone have been reclaimed through large scale implementation of sub-surface drainage (SSD) technology for restoring the crop productivity. This technology has enhanced crop intensity by 40-50%, crop yield by 50-110% and farm income by 200-300%. Costs of installing SSD systems are substantial and vary considerably depending on agro-climatic conditions,

watertable and soil conditions. The cost of SSD system with M&E charges for drain spacing from 50 to 100 m for both pumped and gravity outlets in light and medium textured soils ranged from Rs. 85500 to 61000/ha and Rs. 76500 to 54500/ha, respectively. Similarly, in heavy textured soils (Vertisols), the cost with M&E charges for both pumped and gravity outlet systems varied from Rs. 130000 to 92000/ha, and Rs. 111500 to 78000/ha, respectively, for drain spacing from 30 to 50 m. Therefore, the most accurate cost estimates for different prevailing conditions in states are suggested for large scale implementation under various national development schemes for amelioration of waterlogged saline soils.

Performance and impact of salt tolerant wheat varieties on saline Vertisols of Gujarat

Vinayak Nikam[1], Anil R Chinchmalatpure, Sanjay Kad, G Gururaja Rao, Indivar Prasad, Shrvan Kumar and David Camus*

ICAR-Central Soil Salinity Research Institute, Regional Research Station, Bharuch – 392 012, Gujarat

[1]ICAR-National Institute of Agricultural Economics and Policy Research, New Delhi – 110 012

****E-mail: rcanil2014@gmail.com***

Abstract

Salinity is a major limitation to agricultural production in Gujarat. Use of salt tolerant varieties (STV) is considered as one of the economic feasible and ecologically viable approach to overcome this problem. An attempt was made to demonstrate the potential of salt tolerant varieties (STV) of wheat KRL 210 and KRL 19 developed by ICAR-CSSRI Karnal, in the study area of *Baratract* of Gujarat. Study was conducted with 53 farmers from Bharuch district during the year 2014-16. Data were collected through personal interviews with the farmers using a well structured interview schedule. Soil salinity of the study area was low at surface but increased with depth. Average EC_e at 0-15 cm layer was 1.28 dS m^{-1}, while at lower depth (60-90 cm) it was 4.15 dS m^{-1}. Soil pH also showed the same trend. At lower depth of 60-90 cm, average pH was 8.93. Economic analysis of STV cultivation revealed that total input cost involving various operational costs was Rs.23078 ha^{-1}. STV required less number of irrigation than other varieties, therefore farmers growing STV could save the cost of 1-2 irrigations. Average yield of STV of wheat obtained at farmers' field was 30 q ha^{-1}. Farmers could earn gross income of Rs. 54000 ha^{-1} and net income of Rs. 30922 ha^{-1}. B:C ratio for STV was 2.3. All the farmers agreed that cultivation of STV in salt affected areas helps in increasing their income. In terms of environmental benefits, 96% farmers agreed that saline land and moderately saline groundwater can be productively managed through STV. For agronomic practices, majority of the farmers agreed that STV had more number of tillers (96%) and less lodging and shattering tendency (92%). With regard to the quality of output, all farmers agreed that eating quality of salt tolerant wheat varieties was good. Thus farmers' response to salt tolerant wheat varieties was good, which helped them in increasing their income by bringing their saline land under cultivation and in securing household food security.

An estimation model for crop production losses due to soil sodicity

DK Sharma, K Thimmppa, Anil R Chinchmalatpure, AK Mandal, RK Yadav, SK Chaudhari[1] and Satyendra Kumar*

ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana

[1]Indian Council of Agricultural Research, NRM Division, KAB-II, New Delhi – 110 012

E-mail: thimpu@rediffmail.com

Abstract

Soil sodicity is causing enormous crop production losses in India. The present paper suggests a simple procedure for estimating production losses due to soil sodicity. Knowledge of crop production losses caused by soil sodicity would be helpful in guiding research and policy objectives by identifying the areas of intervention. The model used soil exchangeable sodium percentage (ESP) values of different categories of sodic soils, crops threshold ESP limit and the slope parameters to estimate the individual crop loss production factor. The utility of the model is illustrated in an empirical application to the sodicity affected Bihar state in India. According to this estimation, Bihar loses annually 501212 tonnes of agricultural production valued at 5066 million. The share of cereals in the total annual production losses w highest (62%) followed by cash crops (32%). Cereals suffered highest annual monetary loss of 4187million. Followed by the cash crops (670 million).

Livelihood generation for marginal and small farmers from cumin cultivation through adoption of scientific interventions in Pali district of Western Rajasthan

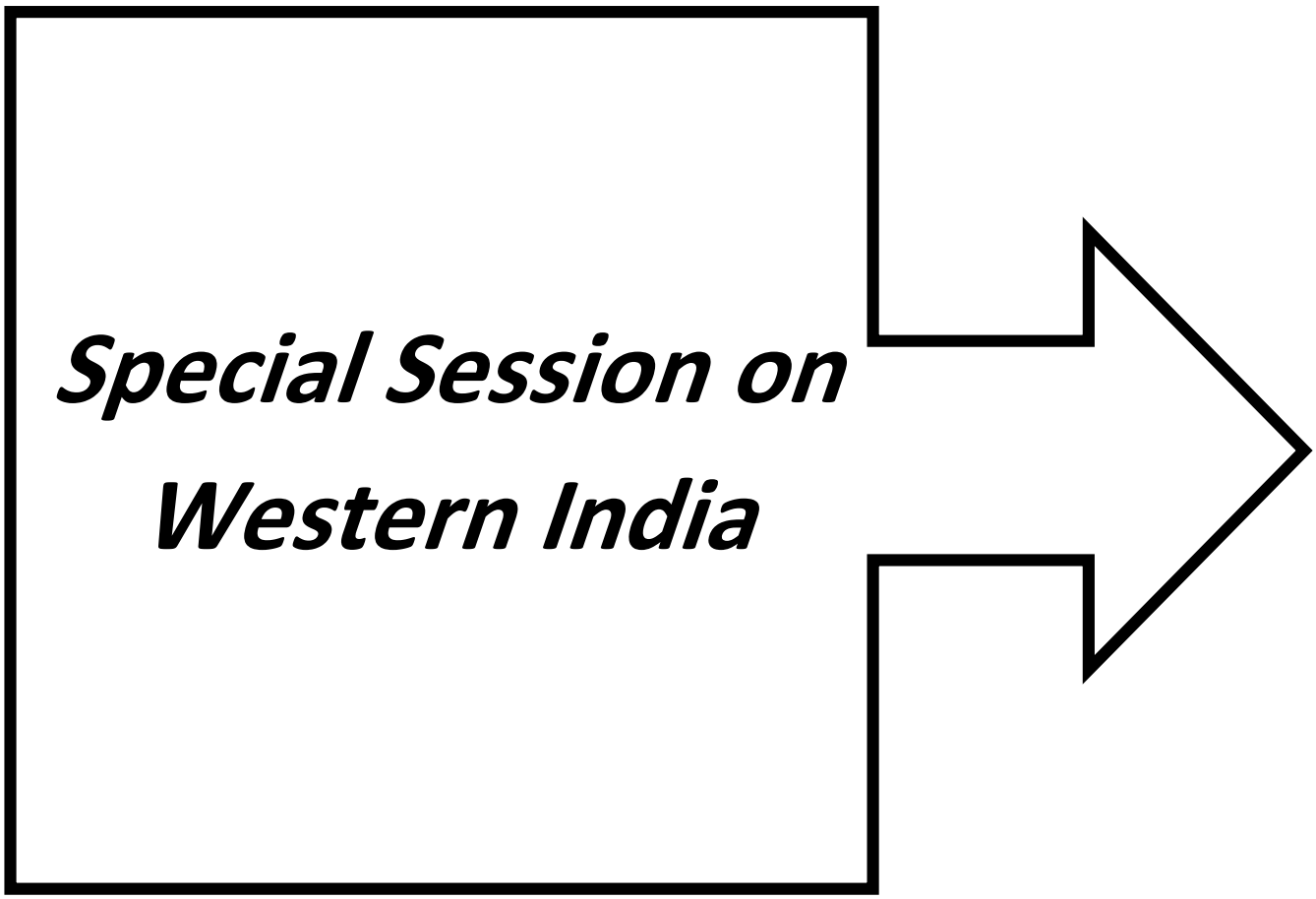
Chandan Kumar, ML Meena, MK Chaudhary and Dheeraj Singh

ICAR-CAZRI, Krishi Vigyan Kendra, Pali-Marwar – 306 401, Rajasthan

E-mail: chandankumarveg.sc@gmail.com

Abstract

Cumin is a predominant *Rabi* crop in the arid zones of Rajasthan. The crop accounts for 32.21 and 18.09% of area and production, respectively in Rajasthan. However, the average cumin yield in district (7.76 q ha^{-1}) is substantially lower than the national average (12.45 q ha^{-1}). There is considerable scope for cumin productivity enhancement in Pali district which is earmarked as an important Agro-export zone for cumin in the country. Keeping the above facts in mind, an on farm testing (O.F.T.) experiment was conducted at farmers' field during 2014-15 and 2015-16 to evaluate different varities of cumin. Pooled data of both years indicated that the highest production (9.57 q ha^{-1}), net return (Rs. 68,500/ha) and B: C (2.7) found in variety RZ (223). Variety RZ (19) gave the second highest production (7.3 q ha^{-1}), net return (Rs. 45,500 /ha) and B: C ratio (2.0). The lowest values were observed in local cultivars.


Special Session on
Western India

Management of arid fruit crops in saline environments

*PL Saroj and BD Sharma**
ICAR-Central Institute for Arid Horticulture, Bikaner – 334 006, Rajasthan
****E-mail: drbrijeshdutt@yahoo.co.in***

Abstract

Salinity is the saltiness or dissolved salt content (Such as Sodium Chloride, Magnesium and Calcium sulfates and bicarbonates) of a body of water or in Soil. Salt Stress is the osmotic forces exerted on plants when they are growing in a salt marsh or under other excessively saline conditions. Salinity remains one of men's oldest environment and horticultural problems and challenging to scientist for production and productivity in our country. Salinity is caused by various factors such as mineral weathering, use of faulty irrigation water, poor rainfall, high evaporation rates, etc. but canal irrigation has been held more responsible. Around 10% of the world's total arable land is salt affected. Various soil reclamation methods like leaching, flooding, scrapping, green manuring, etc. are being used conventionally for mitigation of the malady. Soil salinity has reduced crop yields up to 50% and consequently cropping has been abandoned in many areas. Excess soluble salts can be removed through scrapping the surface salt crust or flushing and leaching or through subsurface drainage depending on the problem. Crops also vary in their ability to tolerate salinity at different stages of growth. In most crops subjected to irrigations with saline waters, germination and early stages are generally the most sensitive and their tolerance increases with age. Salt tolerant cultivars and other management of arid fruit crops in saline soils are important solutions for crop production under saline soils.

Kharchia wheat: A boon crop for saline arid zones

Dheeraj Singh, MK Chaudhary, ML Meena and Chandan Kumar
ICAR-CAZRI, Krishi Vigyan Kendra, Pali-Marwar – 306 401, Rajasthan
E-mail: dheerajthakurala@yahoo.com

Abstract

Kharchia wheat, commonly known as red wheat, is indigenous to Kharchia village of Pali district of Rajasthan, India. It is globally recognized as wheat genotype with the highlest salt tolerance. This local landrace has been extensively used for the development of high yielding saline resistant varieties such as Kharachia 65, KRL 1-4, KRL 39 and KRL 19. The characteristic feature of Kharchia which distinguish it from other wheat varieties is that it can withstand the effects of salinity in soil and water more efficiently leading to very good yields under such conditions. Owing to these traits, it has been extensively used as a parent in wheat improment for salt tolerance in India and other. Considering its potential value for the future crop improvement programmes, it has been registered in the NBPGR, New Delhi by the Krishi Vigyan Kendra, Central Arid Zone Research Institute via Registration number INGR 99020. Kharchia wheat is grown in some villages of Marwar, Pali since a number of generations. According to the elder villagers, this wheat race has been domesticated and conserved by Kharchi community of Pali district since the last 200 years. Looking to its importance and the efforts of the community, the PPV&FR Authority, New Delhi has awarded the Plant Genome Saviour community awards to Kharchi village community for year 2012-13. Another unique feature of this wheat is that it is organically grown by the resource poor farmers of this zone. The organic attributes of this wheat and its unique properties are recognized by the natives of this area since long and they have very high rating of this landrace in their nutrition.

Conservation of soil moisture to earn cash: An autonomous and opportunistic agro-ecological adaptation in semi-arid climate of Rajasthan, India

Ranjay K Singh, Dheeraj Singh[1], Ankit Goswami, Arvind Upadhyay, Anshuman Singh, Parvender, Satyendra Kumar, Thimmappa K and DK Sharma

ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana

[1]ICAR-CAZRI, Krishi Vigyan Kendra, Pali-Marwar – 306 401, Rajasthan

E-mail: ranjaysingh_jbp@rediffmail.com

Abstract

Autonomous adaptation is a strategy developed and used by the material resource-poor farmers (MRP) in resource scarce regions of the world. This paper attempts to understand how local farmers experience multiple stressors and respond to them through local knowledge and practices. A study was carried out with a total of 20 key informants from four purposively selected villages lying in Hemawas check dam area of Pali district, Rajasthan, India. Data were collected using transect walk, focus group discussions, personal interviews, participant observations and telephonic discussions. Results indicated that an overwhelming majority (>84.0%) of the farmers were experiencing delayed onset and early withdrawal of monsoon, and erratic rainfall. Respondents believed that in addition to climate variability, socio-political changes are also adversely impacting their livelihoods. In response to the growing water scarcity, these farmers increasingly utilize the residual soil moisture in fields lying in the Hemawas dam catchment to grow diverse crops for sustaining their livelihoods. The lands where farmers earlier cultivated wheat, barley, chickpea and mustard crops, now suffer from water scarcity and salinity, are being increasingly diverted to grow muskmelon which is seen as an opportunistic adaptation with high profit realizations. It emerged during study that anomalies in atmospheric temperature and terminal heat during February-March have negatively impacted the *Rabi* crops. Muskmelon cultivation is gathering momentum in such marginal soils as it adapts well to the adverse conditions, requires the least use of external inputs and provides handsome returns in a short span of about 3 months. In the uplands adjacent to the dam, farmers still raise late sown varieties of barley and wheat crops (sowing is done even up to second week of January). When water recedes from the catchment area, locally available muskmelon seeds are manually sown in ploughed fields during the last week of February. Prior to sowing, the seeds are immersed in the lukewarm water followed by wrapping in moist jute bags. Wrapped seeds are kept overnight for hastening the germination. The farmers level the fields when the seedlings have attained an age of 2-3 weeks to retain the water for extended period of time. This practice also lowers the incidence of insect-pests. Easy market access through muskmelon contractors also makes it a lucrative adaptation activity. During the entire duration of muskmelon crop (March to May), there is minimal competition with other agricultural activities such that farmers are able to concentrate on raising a profitable crop. Muskmelon cultivation in the studied villages is essentially a women-dependent and women-empowering activity as they are almost exclusively responsible for raising and nurturing the crop for monetary benefits. This study provides an insight about how formal and informal knowledge can be hybridized to co-produce more robust adaptation strategies to convert stressors into opportunity.

Moringa – A multipurpose agroforestry tree for sustaining livelihood security in Western Rajasthan

Subbulakshmi V, Sheetal KR, Renjith PS, Birbal, Soni ML, Yadava ND
ICAR-Central Arid Zone Research Institute, Regional Research Station, Bikaner – 334 004, Rajasthan
E-mail: subbuforester@gmail.com

Abstract

The woody perennials play a very significant role in the nutrition of livestock in arid and the semi-arid lands of the world. Moringa (*Moringa oleifera*) is one of those trees which have attracted attention due to peculiar characteristics viz., fast growth, higher nutritional attributes, utilization as a livestock fodder crop, utilization of leaves and fruits as vegetable, use of seed oil in the manufacturing of perfumes and ability to grow under versatile conditions including hot, humid, dry tropical and subtropical regions, except for waterlogged conditions. Moringa is a drought tolerant tree, which can survive up to 48^{o}C, can tolerate frost in winter and grows with rainfall of 250-1500 mm per year. This species can tolerate water with an electrical conductivity (EC) of 3 dS m^{-1} during its germination phase, while at later stages its resistance to saline water increases. Moringa leaves are rich in nutrients like Fe, K, Ca, and vitamins, which are essential in feed for livestock weight gain and milk production. It is reported that, associative effects of Moringa leaves in feed improve the fermentation of wheat straw and reduce methane emission in ruminants, advocating the potential of Moringa leaves as supplement to diets primarily based on crop residues/poor roughages. Hence, a study has been initiated at Central Arid Zone Research Institute, Regional Research Station, Bikaner to tap the advantages of this multipurpose tree species. Moringa plantation has been established in 0.5 ha through direct sowing of seeds in the pits at 10m x 4m spacing during monsoon period. The plantation has been provided with water once in ten days for initial establishment. The trees have shown very fast growth in terms of height and girth. Four months after sowing, the height of Moringa trees ranged between 65.3 cm to 78.5 cm. The average basal girth and number of branches are 3.2cm and 11 respectively. These direct seeded Moringa seedlings were observed to have very strong basal and deep root system which may enable them to withstand the harsh conditions of arid region. Aside from the features of its root system, this species has a low requirement of maintenance in later stages, reduced necessity of fertilizers and irrigation, and a high capacity to re-sprout after harvesting of leaves. As Moringa trees grow fast and well in dry areas, it can play a role in the battle against desertification. Integrating *Moringa oleifera* in agroforestry systems can help to overcome the climate change effects on crops by improving micro climatic condition, moisture conservation and reducing wind erosion. Further it will help to sustain the livelihood security of the farmers by providing additional income through multiple products viz., fodder, food and medicine apart from increasing yield of intercrops in arid Rajasthan.

Status of fluoride in ground irrigation water of Ladnu tehsil (Nagaur district) and its effect on wheat and mustard crops

Rajendra Kumar Jakhar, NK Pareek, AK Singh and IJ Gulati
Agricultural Research Station, SK Rajasthan Agricultural University, Bikaner- 334 006, Rajasthan
E-mail: rkjakhar_ss@rediffmail.com

Abstract

The status of fluoride in groundwater of Ladnu tehsil (Nagaur district) and its effect on wheat and mustard crops were studied for two consecutive years. From the survey area, 100 ground water and soil samples were collected from 31 fluoride affected villages and analysed for fluoride content and categorised in five categories, *viz*. F_1 : < 2.0 mg L^{-1} fluoride, F_2 : 2.1 – 4.0 mg L^{-1} fluoride, F_3 : 4.1 – 6.0 mg L^{-1} fluoride, F_4 : 6.1 – 8.0 mg L^{-1} fluoride and F_5 : > 8.0 mg L^{-1} fluoride. Thereafter, for each category of fluoride water four sites were

selected for monitoring the changes in the soil and crops *i.e.* mustard and wheat and also in the quality of groundwater, as a result of use of fluoride waters. It was found that 99% of the samples were only marginally alkaline. 23% were in saline category and the rest 67% varied from slightly to moderately saline. Most of the waters had low to moderate sodicity hazard; only 27% waters had high to very high sodicity hazard. Waters of study area also have non alkali to medium alkali hazard and majority of waters falls in low alkali hazard category. Majority of the studied soils were marginally alkaline. Most of the soils had low to moderate sodicity hazard and only 3% represented high sodicity hazard. Fluoride content of groundwater varied from 1.60 to 8.80 mg L^{-1}, indicating a good degree of variation. Further, most of the waters (69%) of the study area had fluoride concentration from 2.1 mg L^{-1} to 6.0 mg L^{-1}. Positive correlations between soil fluoride and soil pH, soil fluoride and EC were observed indicating that fluoride content increases with soil pH and EC, respectively. While, positive and moderate relationship was observed between soil fluoride and sodium. Soil fluoride vs pH of water and soil fluoride vs EC of water also showed positive correlation. The study area lies in semi-arid climate and soils being alkaline have shown less build-up or adsorption of fluoride in soil. Further, the fluoride build-up in soil was in accordance to fluoride concentration in irrigation water and the average build-up in mustard crop was much less than wheat crop. With the increase in fluoride content of water and soil, an increase in fluoride content of plant was also observed, which resulted in decreased chlorophyll content of leaves, reduction in some plant nutrients (P, K) and thereby reduced crop yield. A highly significant correlation of soil and groundwater fluoride with plant fluoride indicated that both soil and water were the cause for fluoride accumulation in plant. However, accumulation of fluoride in plant varied with plant species i.e. more accumulation in wheat than mustard. Further, as expected much more fluoride content was observed in straw/stover as compared to grains/seed.

Open well irrigation in arid parts of Rajasthan: Adaptation to multiple stressors affecting agricultural sustainability

Arvind Upadhyay[1], Ankit Goswami[1], Ranjay K. Singh[1], Dheeraj Singh[2], Parvender[1], Anshuman Singh[1], Satyendra Kumar[1], Thimmappa K[1] and DK Sharma[1]

[1]ICAR-Central Soil Salinity Research Institute, Karnal – 132 001, Haryana

[2] ICAR-CAZRI, Krishi Vigyan Kendra, Pali-Marwar – 306 401, Rajasthan

E-mail: ranjaysingh_jbp@rediffmail.com

Abstract

Resource scarcity and exposure to multiple stressors have compelled the small-holder farmers world over to develop location-specific adaptation strategies to sustain their livelihoods; especially in risk-prone ecosystems. This paper attempts to understand two questions: (i) how agro-ecological knowledge of farmers of Pali district, Rajasthan, India is used to harvest the rainwater through open-wells to sustain the agricultural production, and (ii) how different stressors are impacting the socio-ecological resilience of these agro-ecosystems. To answer these questions, a study was carried out with 20 key informants from four purposively selected villages of Pali district. Data were collected through transect walk, soil and water sampling, focus group discussions, personal interviews, participant observations and telephonic discussions. Results indicated that rain water, open-well system and river water (Luni river at few places) constitute the main sources of water for sustaining crop and animal production. Over 85.0% of the studied farmers owned 1-4 open-wells (CV: 47.0%). On an average, 300 to 500 farmers obtained irrigation water from a single open-well to irrigate an average 2.72 ha (0.48-8.0 ha, with CV: 7.0%) of the crop land. During November to December, one open-well having 60-70 feet high watertable could supply water for about 15-18 hours which reduces to 6-8 hours during February-March. The major crops grown using open-well water are cumin,

wheat, mustard and fenugreek. At most of the locations, 25-30% of such wells have gone dry, and, at some places, as much as 80% of the open-wells (*e.g.*, in Rampura, Rohat block) are now dry. In such wells, the remaining water is too saline (EC_{iw} ~5.5-13.2) for irrigation. Reduced number of rainy days as well as restricted seepage from the drying Luni river seem to have accentuated the salinity problem. The water storage in the river bed has considerably reduced over time resulting in reduced seepage to the adjacent agricultural lands. These hydrological changes have adversely affected the soil health with far reaching consequences for water and nutrient availability and sustainability of the local cropping systems. Many locally adapted landraces in crops such as cumin and chilli are on the verge of extinction, while area under wheat has decreased. Farmers' dependence on external sources for seeds and other vital inputs has also increased. In a nutshell, rapidly declining watertable and the concurrent increase in salinity, likely to be aggravated by climate variability, may attain alarming proportions in the coming period. In order to overcome this situation, a multipronged, community-based approach with polycentric policy support is urgently required to revive the open-wells which were once the lifeline of these rural communities in Pali district of Rajasthan.

Effect of saline water sprinkler irrigation on yield of wheat genotypes under arid ecosystem

SM Kumawat, BL Kumawat and Deepak Gupta

Agricultural Research Station, SK Rajasthan Agricultural University, Bikaner - 334 006, Rajasthan

E-mail: sagarskrau@gmail.com

Abstract

Increase in agricultural productivity is essential to sustain the growing global food demands. However, different biotic and abiotic streses coupled with climate change impacts continue to be severe obstacles in achieving this goal. Diverse forms of land degradation including secondary salinization in different parts of the world also pose immense threat to sustainable agricultural production. Considering the fact that development of high yielding varieties was a key to the success of Green Revolution in India and elsewhere, selection of salt tolerant cultivars capable of producing high yields under salt stress conditions is one of the most viable approaches to harness the productivity of salt-affected soil and water resources. The hyper-arid region of Rajathan state is characterized by extreme temperature variations (below zero during winters and above 48 ^{0}C during summer), high wind velocity, pH ≥ 8.5, EC ≥ 2.5 dS m^{-1}, and poor fertility and low water retention capacity of soils. Keeping these facts in view, a field experiment was conducted with different wheat genotypes in a sandy loam soil at Agricultural Research Station and at farmers' fields in Bikaner district of Rajasthan. The results revealed that wheat grain yield did not differ significantly among the genotypes tested. The highest increase in straw yield was noted in Raj 4188 followed by KRL-210, KRL-213 and Raj 3077. Among wheat genotypes, Raj 4188 recorded the lowest harvest index which differed significantly compared to the rest of three wheat genotypes. At farmers' fields too, out of five wheat varieties tested at different locations, genotypes KRL-210 and KRL-213 performed better and gave higher grain and straw yields over KRL-19, Raj 4188 and Raj 3077. Results further indicated that application of saline irrigation (EC_{iw} up to 8.0 dS m^{-1}) did not significantly decrease grain and straw yields. However, grain yield decreased significantly at higher salinity level (EC_{iw} 12.0 dS m^{-1}) compared to the lower levels of EC_{iw}.

Although increasing EC_{iw} tended to decrease the harvest index, it did not differ significantly between best available canal water and tubewell water of 4.0 dS m^{-1} salinity. Soil EC_e was affected by saline irrigation. The maximum salinity was observed with the use of 12.0 dS m^{-1} water while the minimum EC_e was noted in BAW (EC_{iw} 0.25 dS m^{-1}) irrigated plots at different soil depths *i.e*, 0-15, 15-30 and 30-45 cm. Wheat grain yield was not affected adversely by saline irrigation through sprinkler irrigation. Wheat variety KRL-210 showed high salt tolerance under sprinkler irrigation both at research farm and farmers' fields on light soils.

Adoption of salt tolerant wheat varieties in saline areas Pali district of Rajasthan: Famers perception

ML Meena, Dheeraj Singh, MK Chaudhary and C Kumar

ICAR-CAZRI, Krishi Vigyan Kendra, Pali-Marwar – 306 401, Rajasthan

E-mail: mlmeenacazri@gmail.com

Abstract

Salinity has been a major factor constraining agricultural production in Rajasthan. Selection of salt tolerant varieties (STVs) is considered as one of the environmentally benign and cost effective approaches to overcome the salinity problem. Attempt was made to demonstrate potential of salt tolerant wheat varieties (KRL-210 and KRL- 19) in salt-affected lands of Marwar area of Rajasthan. Study was conducted with 120 farmers from Pali district of Rajasthan. Data were collected using personal interview of the farmers using a well structured interview schedule. It was found that all the farmers agreed that cultivation of STVs helped increase their income. In terms of social benefits, about 78.5% of the sampled farmers agreed that cultivation of STVs helped in the upliftment of small and marginal farmers and in achieving the household food security. In terms of environmental benefits, 96% of the farmers agreed that saline land and moderate saline ground water could be used for the cultivation of STVs. Majority of the farmers opined that STVs had more number of tillers (99.6%) and less lodging and shattering tendency (94.7%). All the farmers agreed that eating quality of salt tolerant wheat varieties was good. Despite these benefits, there is still a need to create awareness among the farmers in salt-affected areas of Rajasthan about the potential of salt tolerant cultivars in productivity and income enhancements.

Technological gap in adoption of recommended reclamation practices in saline soils of Pali district in rainfed areas of Rajasthan

ML Meena, Dheeraj Singh and MK Chaudhary

ICAR-CAZRI, Krishi Vigyan Kendra, Pali-Marwar – 306 401, Rajasthan

E-mail: mlmeenacazri@gmail.com

Abstract

About 2.5 million ha in India and 0.47 million ha in Rajasthan is affected by salinity diminishing the land productivity to varying degrees. An ex-post-facto research was undertaken to assess the technological gap and constraints faced by the farmers in the adoption of reclamation practices in saline areas of Pali district of Rajasthan. Survey of 160 farmers was conducted in five different salinity affected villages of Marwar Junction

block using interview schedule and direct interview method. The findings revealed that the overall technological gap in the adoption of recommended salinity reclamation practices was 93.0%. The highest technological gap was noticed with respect to accurate dosage of spent wash, application of mineral amendments and zinc sulphate, quantity of additional nitrogen and sulphur, and the splits of additional nitrogen. The overall technological gap of the respondents was significantly correlated at 1% for the variables such as educational status, saline soil, sources of information, economic motivation, scientific orientation, innovativeness and attitude towards group activity. The major constraints faced by all the respondents in adopting the recommended reclamation practices in saline soil are small fragmented land holdings, drainage problem, non-availability of suitable varieties and seeds during sowing, lower market value of RJ 4037 (wheat) variety, labour shortage and erratic monsoon or poor rainfall. The farmers in the study area suggested to promote cooperative farming and the the timely input subsidy. It is desirable that required information and inputs should be provided to the farmers in time to enable them to obtain high yields under adverse conditions.

RSC water management in groundnut (*Arachis hypogaea L.*) in dryland conditions of Rajasthan

Amit Kumawat, Rajendra Kumar Jakhar and PS Rathore

Agricultural Research Station, SK Rajasthan Agricultural University, Bikaner - 334 006, Rajasthan

E-mail: amit.agron@gmail.com

Abstract

The quality of irrigation water plays a vital role in crop production. The use of sodic water for irrigation adversely affects soil productivity by influencing the soil properties and nutrient uptake. This problem becomes more aggravated when the carbonate and bicarbonate of sodic water occur in association with sodium creating the problem of residual sodium carbonate (RSC). High RSC irrigation water is characterized by low total salt concentration. Groundnut (*Arachis hypogaea* L.) is the major oilseed crop of India. Looking into the increasing demand of oilseeds, it has become imperative to boost up the commercial production of oil. In order to lessen the pressure on overstretched prime lands and water, there is an urgent need to expand crop cultivation into marginal environments under improved management practices. These aspects have received very little attention with regard to groundnut cultivation in light textured soils irrigated with high RSC water in dryland areas of Rajasthan. Keeping this in view, a study was conducted on RSC water management in groundnut during *Kharif* 2011 under irrigated conditions of Bikaner district. Experimental soil was loamy sand (83.3% sand, 10.2% silt and 6.3% clay), slightly alkaline in reaction (pH 7.8), low in organic carbon (0.07%), available nitrogen (90.1 kg ha^{-1}), available phosphorus (16.2 kg ha^{-1}) and medium in available potassium (190.4 kg ha^{-1}). The experiment comprised of four treatments [untreated water, partially neutralized water, FYM 10 t ha^{-1} and gypsum application (equivalent to 5 me /l) for RSC neutralization]. The results revealed that application of gypsum (equivalent to 5 me/l) for RSC neutralization significantly enhanced the number of branches/plant, dry matter accumulation/plant, number of root nodules/plant, number of pods/plant, kernels/pod, seed index and shelling percent with the maximum yield of 2.45 t ha^{-1} in AES V of Bikaner district over other treatments. The next best treatment was FYM @ 10 t ha^{-1}.

Study of correlation between quality of irrigation water and soil properties of Sri Madhopur Panchayat Samiti, district Sikar, Rajasthan

Rahul Chopra and BL Kumawat
College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner - 334 006, Rajasthan
E-mail: r.chopra051988@gmail.com

Abstract

A groundwater survey was carried out to study the correlation between quality of irrigation water and soil properties in Sri Madhopur Panchayat Samiti of District Siikar, Rajasthan. One hundred irrigation water samples along with the corresponding 100 surface soil samples were collected from different villages of Sri Madhopur panchayat samiti. The results showed that pH of irrigation water positively correlated with SAR_2 (r = 0.044) of soil. Similarly, EC of irrigation water significantly and positively correlated with EC_2 (r= 0.427**), pH_2 (r= 0.124), SAR_2 (r= 0.164) and organic carbon (r= 0.027) content of soil. SAR of irrigation water significantly and positively correlated with SAR_2 (r= 0.250*), EC_2 (r= 0.094), pH_2 (r = 0.183), organic carbon (r = 0.054) content of soil and RSC of irrigation water positively correlated with pH_2 (r= 0.105) and SAR_2 (r= 0.115) of soil. Use of water with high EC (4.0 dS m^{-1}), SAR (8.6) and RSC(4.0) water adversely affected the maximum water holding capacity, total porosity, moisture equivalent, rate of percolation, and infiltration rate of soil. Application of saline- sodic water increased soil pH, EC, ESP and SAR. Salinity and sodicity at high level influenced organic carbon, N, P, and K content in soil. So, it can be concluded that use of poor quality irrigation water is harmful to the physical and chemical properties of the soil.

Partial neutralization of RSC of irrigation water to minimize the adverse effect in Indian mustard grown on sandy soil of Western Rajasthan

*Mangi Lal, BL Kumawat and Yogesh Sharma**
College of Agriculture, SK Rajasthan Agricultural University, Bikaner – 334 006, Rajasthan
****E-mail: yogeshcoabikaner@gmail.com***

Abstract

A field experiment was conducted at Agronomy Farm, College of Agriculture, Bikaner during *Rabi* 2012-13 to to study the effect of partial neutralization of RSC of irrigation water to minimize the adverse effects in Indian mustard grown on sandy soil of Western Rajasthan. The experiment comprising of 12 treatment combinations replicated three times, was laid out in randomized block design with three levels of RSC waters (control, 4 and 8 me L^{-1}) and four amendments (Control, FYM 10 t ha^{-1}, gypsum equivalent to 2 me L^{-1} RSC neutralization and FYM 10 t ha^{-1} + gypsum equivalent to 2 meq L^{-1} RSC neutralization). Results revealed that increasing RSC in water increased the soil pH and ESP while saturation paste salinity (EC_e), organic carbon and available NPK contents decreased significantly. The seed and stover yield, and quality like oil content and oil yield of mustard also decreased significantly. Application of FYM (10 t ha^{-1}) + gypsum equivalent to 2 me L^{-1} RSC neutralization significantly reduced the soil pH, EC_e and ESP besides significant improvement in organic carbon and available NPK content of soil at crop harvest. Significant increase was noted in seed and stover yield of mustard as well as oil yield and quality under FYM (10 t ha^{-1}) + gypsum equivalent to 2 meq L^{-1} RSC neutralization over control, FYM 10 t ha^{-1} and gypsum equivalent to 2 meq L^{-1} RSC neutralization

treatments. The interactive effect of RSC of waters and amendments significantly influenced the seed yield. The extent of decrease in seed yield with increasing levels of RSC water was found to be lowered with the application of different amendments. Treatment of moderate RSC (4 me L^{-1}) water with FYM 10 t ha^{-1} + gypsum equivalent to 2 me L^{-1} RSC neutralization proved as good as no RSC water, indicating that amendment use could enable sustained use poor quality irrigation water without any adverse effects on soil properties and crop yields.

Response of organic manures on growth, yield and quality of onion *(Allium cepa* L.) with saline water irrigation under arid conditions of Rajasthan

SR Yadav, Priyanka Bairagi[1] and BS Meena
Agricultural Research Station, SK Rajasthan Agricultural University, Bikaner – 334 006, Rajasthan
[1]Soil Testing Laboratory Ajmer – 305 006, Rajasthan
E-mail: sryadavskrau@gmail.com

Abstract

A field experiment was conducted at Niche area of Excellence Farm SK RAU, Bikaner during *Rabi* season 2012-13. The experiment was laid out in split plot design with four replications consisting of four levels of NPK fertilizers through drip irrigation (control, 75,100 and 125% RDF) in main plot and four levels of FYM (control, 10, 20 and 30 t/ha) in sub plot. The soil of experimental field was loamy sand in texture containing 78.85, 18.80 and 180.00 kg /ha available nitrogen, phosphorus and potassium respectively in 0-15 cm soil depth with pH 8.68, EC 0.28 dSm^{-1} and organic carbon 0.15 per cent.

Application of 30 t/ha significantly increased the equatorial and polar diameter of bulb, bulb weight, bulb yield and stover yield, soil organic carbon, available nitrogen, phosphorus and potassium in soil, nitrogen, phosphorus and potassium content in different physiological stages, leaf and bulb, nitrogen, phosphorus and potassium uptake by leaf and bulb, fertilizer use efficiency, net returns and B:C ratio over control, 10 and 20 kg FYM /ha, respectively.

Suitability of sulphur and molybdenum for quality and yield of fenugreek on sandy loam soil of Rajasthan

Mahendra Singh Manohar, AC Shivran, Ashok Choudhary
SKN College of Agriculture, SKN Agriculture University, Jobner – 303 329, Rajasthan
E-mail: ashokagro777@gmail.com

Abstract

A field experiment was conducted during *rabi* season of 2011-12 on sandy loam soil to study the suitability of sulphur and molybdenum on quality and yield of fenugreek. Results indicated that application of sulphur @ 60 kg/ha and molybdenum @ 1.5 kg/ha significantly increase the nitrogen, sulphur, molybdenum and their uptake, protein content, seed, straw and biological yield and it remained at par with the application of sulphur @ 40 kg/ha and molybdenum @ 1.0 kg/ha over rest of treatments. However, the molybdenum and sulphur content in straw unchanged under different levels of sulphur and molybdenum. Based on result of one year experimentation it is concluded that application of sulphur @ 40 kg/ha and molybdenum @ 1.0 kg/ha recorded significantly increase the N, S content and their uptake, protein content and seed yield (15.36 and 15.22 q/ha) of fenugreek.

Response of cluster bean [*Cyamopsis tetragonoloba* (L.) Taub.] to phosphorus and sulphur in Torripsamments of Rajasthan

Rekha Raiger, BL Kumawat, RC Sanwal, BC Kansotia, ML Raiger and HP Verma*
**Research Scholar, College of Agriculture, SK Rajasthan Agricultural University, Bikaner – 334 006, Rajasthan*
****E-mail: kansotia.bc@gmail.com***

Abstract

A field experiment to study the "Response of cluster bean [*Cyamopsis tetragonoloba* (L.) Taub.] to phosphorus and sulphur in Torripsamments of Rajasthan" was conducted to evaluate the effect of different levels of phosphorus and sulphur on nutrient availability, growth, yield attributes and yield, nutrient concentration and uptake of clusterbean in sandy soil at Agronomy Farm, College of Agriculture, Bikaner during *kharif* season of 2014. The experiment comprising 16 treatment combinations replicated three times, was laid out in randomized block design with four levels of phosphorus (Control, 20, 40 and 60 kg P_2O_5 ha^{-1}) and four levels of sulphur (0, 15, 30 and 45 kg ha^{-1}).

Results revealed that application of phosphorus upto 40 kg ha^{-1} significantly increased total and effective root nodules per plant, total leaf chlorophyll content, number of pods per plant, number of seeds per pod, test weight, seed yield, straw yield, N, P, K, S content and their uptake, protein content, gum content and gum yield. The available N, P and S content of soil increased significantly with increasing levels of phosphorus. Application of 40 kg P_2O_5 ha^{-1} significantly increased the net returns and B:C ratio of clusterbean over control and 20 kg P_2O_5 ha^{-1}. Application of 45 kg S ha^{-1} significantly increased the total and effective root nodules per plant, total leaf chlorophyll content, number of pods per plant, number of seeds per pod, test weight, seed yield, straw yield, N, P, K and S content and their uptake, protein content, gum content and gum yield. The available P and S contents increased significantly with application of different levels of sulphur upto 45 kg ha^{-1}. Highest net returns (Rs. 54970.59 ha^{-1}) and B:C ratio (4.11) were recorded under application of 45 kg S ha^{-1} over control, 15 and 30 kg S ha^{-1}.

Potential hybrids of pearl millet in hyper arid region of Rajasthan

Shiv Narayan, PC Gupta and NC Sharma
SK Rajasthan Agricultural University, Bikaner – 334 006, Rajasthan
E-mail: pcguptarau@yahoo.com

Abstract

Development of high yielding hybrids of pearl millet led to its increased productivity and stability largely in the region with relative better environments, while regions like western Rajasthan with poor environment still suffer from low productivity. This is because most of the hybrids recommended for this region resulted from the parents developed from programme not deliberately bred for arid areas and hence lacked the desired adaptability and the characteristics required for these areas. Pearl millet is an indispensable component of sustainable dry land farming in hyper arid regions of Rajasthan. The average yield of pearl millet in hyper arid regions is very low ranging from 3 to 4.60 q/ha. Such harsh conditions prevailing in this region require early maturing genotypes with high fodder and seed yield for sustainable production by

escaping drought situations. It is, therefore, imperative to develop and identify hybrids suitable for rainfed conditions with vagaries of monsoon. 40 crosses along with 3 check hybrids were evaluated in Randomized Block Design with 2 replications at Agricultural Research Station, Bikaner during kharif, 2015. On the basis of standard heterosis, cross RMS 6A x BIB86 (7.12 q/ha) and ICMA843A x BIB 112 (6.7 q/ha) were identified as potential for exploitation of heterosis for grain yield in arid areas. These crosses exhibited 185 and 168 per cent, respectively superiority in terms of seed yield over the best check hybrid RHB 177 (2.5q/ha). However, 5 other crosses could be identified as potential in terms of grain yield when compared to most popular check hybrid HHB-67. These crosses are RMS 6A x BIB 98, RMS 21A x BIB 50, ICMA843A x BIB 37, ICMA843A x BIB 50 and ICMA843A x 75. These crosses exhibited 123, 128, 108, 125, 155 per cent, respectively superiority in terms of seed yield over the check hybrid HHB-67 (2.07q/ha).

Effect of iron fertilization on growth, yield and quality of groundnut (*Arachis hypogaea L.) in arid regions of Rajasthan*

Tanuja Poonia[1] and SR Bhunia

[1]Research Scholar, College of agriculture, SK Rajasthan Agricultural University, Bikaner – 334 001, Rajasthan

E-mail: tannupoonia@gmail.com

Abstract

Groundnut is an annual legume as well as oilseed crop and is a member of the sub–family Papilionaceae of the family Leguminosae. It is an important oilseed crop of India, popularly known as peanut, earthnut, monkey nut and locally called as “moongphali”. It is world’s largest source of edible oil and ranks 13th among the food crops and 4th most important oil seeds crops of the world. Groundnut seed (kernel) contains 44–50 % oil, 26% protein and 10-20% carbohydrate .Iron is involved in the formation of chlorophyll even though it is not its constituent. Iron is a constituent of large number of metabolically active compounds like cytochromes (b, b_6, c_1 and a_3), heme and non heme enzymes and other functional metal proteins such as ferrodoxin and haemoglobin. Thus, best known role of iron is its catalytic function in biological oxidation-reduction and other metabolic processes in plants like oxidative photophosphorylation during cell respiration. The pH has a significant influence on the solubility of iron, which is minimum in pH range - 7.4 to 8.5, main characteristic of calcareous soils. Calcareous soils may contain high levels of total Fe, but in unavailable form to plants. Visible Fe deficiency or Fe chlorosis is common in many plants. Organic substances are important in dissolving and transporting metal ions to plant roots. Metals found in soluble complexes with organic acid. Chlorosis caused by actual deficiency of iron can be corrected easily by soil and or foliar application of $FeSO_4$. But in calcareous soils it is believed that chlorosis is essentially lime induced, indicating some disturbance in functioning of iron inside the plants despite its availability from the soils (iron chlorosis paradox).

Integrated disease management of soil borne plant pathogens for sustaining livelihood in Western arid region of Rajasthan

Mahendra Partap[1], Dinesh Kumar[1], Suresh Kumar, Soma Devi[1], AK Meena and SL Godara

[1]Research Scholar, SK Rajasthan Agricultural University, Bikaner – 334 006, Rajasthan

E-mail: mpbishnoi89@gmail.com

Abstract

Rajasthan is the largest state with 10.4% of total geographically area of India. Western Rajasthan encompasses most of the area of the Great Indian Desert (Thar Desert), is a large, arid reason in the north-western part of Indian subcontinent. About 60% of area and 40% of the total population of Rajasthan live in the Thar Desert. It is one of the most heavily populated desert areas in the world with the main occupations of its inhabitant's agriculture and animal husbandry. Agriculture is not a dependable proportion in this area after the rainy season, at least 33% crop fail. Agricultural production is mainly from *kharif* crops, bajra, mothbean, clusterbean and sesame. Over the past few decades the development of irrigation features including canals and tube wells have changed the crop pattern with desert districts in Rajasthan now producing *rabi* crops including wheat, mustard, chickpea and cumin seed along with cash crops. Certain agro climatic characters of this region like hot climate, very erratic rainfall, high evaporation and water scarcity are attributed for making sandy soils more conducive to pathogens like *Macrophomina* and *Fusarium* causing root rots and wilt in many economically grown plants. The major food grain and life line of Thar Desert bajra crop is suffered from very serious soil borne diseases downy mildew and ergot. Chickpea, moth bean, mungbean, cowpea and cluster bean are major legume crops grown in arid region in Rajasthan. Most of these crops are prone to various soil borne diseases like root rots and wilts etc. In mustard *sclerotinia* stem rot are most important disease and cause considerable yield losses. Major oil seed crop of this region groundnut suffers from some serious soil borne diseases like root rot, collar rot and stem rot. For improve living standard of people and sustaining livelihood in this region considerable efforts to develop cost effective IDM strategies to suit different farming systems prevailing in the region include cultural practices like crop–rotation, summer ploughing, soil solarisation, mixed or intercropping, resistant varieties and organic amendments (FYM and compost). Biological control of soil borne pathogens are most effective, economically and environment safely. Several bio-control agents like *Trichoderma harzianum, Pseudomonas fluorescence* and *Bacillus subtilus* etc. are use to suppress the population of soil borne pathogens in soil. These bioagents are used as seed treatment and soil application along with organic amendments. FYM and compost not only improve soil fertility but also suppress most common soil borne pathogens. Chemical pesticides are providing quick, effective and economic management of plant diseases. The fungicides thiram, carbendazim and mancozeb are good protestant against soil borne plant pathogens.

Soil fertility status of khejri based cropping system under varying land-use pattern in dryland conditions

Dinesh Kumar, DK Samadia, MK Jatav, SR Meena, BD Sharma and D Singh
ICAR-Central Institute for Arid Horticulture, Bikaner – 334 006, Rajasthan
E-mail: dkrachiata@gmail.com

Abstract

A long-term investigation was carried out adopting khejri based crop production site management approaches at ICAR-Central Institute for Arid Horticulture, Bikaner under hot arid agro-climate to understand soil fertility and scope of improvement in building-up of fertility levels. A wide spectrum of 47 situations with varying land-use patterns were studied with or without khejri planting models (3, 6 and 9 years) and for this virgin sand-dune landscape area was developed and studied for nutrient build-up and soil fertility characters over the period under site approach. The analyzed data of varying 47 situations under investigation depicted wide range for soil pH (8.27- 8.92), TDS (37 - 130 ppm), EC (0.057 - 0.203 dS m^{-1}), OC (0.068-0.100%), N (72.73-107.76 kg/ha), P (8.11- 11.56 kg/ha), K (181.84-246.00 kg/ha) and S (3.50-8.27 kg/ha). The treatment code KS-39 (field of khejri plantation of nine years age-old with cluster bean crop cultivation) exhibited more effectiveness for soil fertility build-up and status in comparison to different land-use patterns. Based on 6 years of khejri plantation, treatment code KS-13 (field of 4mx4m khejri plantation with three cluster bean crop during establishment period and normal field culture as organic plot) is found more effective for soil fertility build-up and status in comparison different land-use patterns of the period. Among khejri plantations of three years of establishment, treatment code KS-12 (field of 24mx4mx4m khejri plantation of 3 years from establishment with three rainfed cluster bean crop) depicted effectiveness for soil fertility build-up and status. The analyzed data indicated that the virgin sand-dunes land-scape developed as fields for crop culture is most effective for soil fertility build-up with khejri and three seasons of cluster bean culture adopting khejri based crop production sites.

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National Bank for Agriculture and Rural Development

Our Mission: Promotion of sustainable and equitable agriculture and rural prosperity through effective credit support, related services, institution development and other innovative initiatives.

- Research and Development on matters of importance pertaining to agriculture, agricultural operations and rural development including the provision of training and research facilities.
- Consultancy services related to Agriculture & Rural Development through subsidiary (NABCONS).

Our Functions:

- Provide Credit/Refinance for production credit and investment credit to eligible banks and financing institutions.
- Development functions undertaken through Farm Sector Promotion Fund (FSPF), Financial Inclusion Fund (FIF), Watershed Development Fund (WDF), Tribal Development Fund (TDF), Rural Infrastructure Development Fund (RIDF), etc.
- Supervisory functions in respect of Cooperative Banks and Regional Rural Banks.

Head Office Plot C-24, 'G' Block Bandra Kurla Complex, Bandra (East) Mumbai - 400 051

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