Theme 1

Innovations in reclamation and management of salt affected soils

Saline Vertisols in Gujarat: Ideal options for their management

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Abstract

Global demand for food, fiber and bio-energy is growing at arapid rate. Growth rate in agriculture in most developing countries has failed to catch up with the increase in population growth. One of the principal constraints in achieving the desired growth rate in food grain production is land and water degradation mainly resulting from anthropogenic activities. A major factor contributing to human induced land degradation is soil salinisation. Salinity development in the country charts a parallel path with irrigation development. As inadequate attention has been paid in the planning stage of irrigation projects, the problems of water logging and salinity have increased at an alarming rate. Vertisols are dark montmorillonite-rich clays are also called heavy cracking clay soils or swell-shrink soils. The development of salinity and sodicity in black soils region is generally associated with poor drainage and water logging. Vertisols are the soils with good water holding properties. However, a large proportion of all water held between the basic crystal units is not available to plants. When these soils are irrigated, the high seepage leads to a shallow water table build-up causing secondary salinisation or sodiumisation. Vertisols are imperfectly to poorly drained and hydraulic conductivity is low resulting in limited leaching of soluble salts. These adverse physical properties and poor workability of are the major obstacles in agricultural land use. Though Vertisols have considerable potential for agricultural production, they need special management practices (tillage and water management) to secure sustained production.

The saline Vertisols of Bhal area and Bara tract in Gujarat are generally very deep (150-200 cm), fine textured with clay content ranging from 45-68 per cent. These soils are calcareous in nature with calcium carbonate (2 to 12% $CaCO_3$) occurring in the form of nodules, kankar and powdery form and exhibit alkaline reaction. While the soils of Bhal area are highly saline, the soils of Bara tract have significant concentration of soluble salts in sub-soils. The agricultural uses of Vertisols in Gujarat range from very extensive (grazing, collection of firewood, charcoal burning etc.), through smallholder post-rainy season crop production to small and large-scale irrigated agriculture. Cotton is known to perform well on saline Vertisols primarily because it has a vertical root system that is not severely damaged by cracking of the soil. Management practices for crop production ought to be primarily directed at water control in combination with conservation or improvement of soil's fertility level. The management practices devised to improve water regimes comprise (a) removal of excess surface water and storing the same in small ponds which solves problems on individual farmer's fields. But the soil erosion caused by furrow systems needs to be tackled by bringing the runoff water safely along the grassed waterways to the lowest part of the field. A participatory approach involving all stakeholders is needed to solve this problem on a watershed scale and (b) Storage of excess water within the watershed that provides irrigation needs of vegetables etc.

Studies conducted at RRS, Bharuch indicated (1) for saline Vertisols of Bara tract with low ground water during rabi season, the land should be ploughed upto a shallow depth of 4-5 cm, where the moisture controlled section prevails. Seeds of rabi season crops should be sown in this moisture controlled section to attain perfect germination. The moisture controlled section would provide the moisture to the crop for the rest of the period and the upper ploughed soil will act as soil mulch.

(2) In the area with high saline ground water during rabi season and with fine textured soils deep summer ploughing need be adapted in order to break the capillaries to minimize the ground flux to the surface. (3) In areas with high saline ground water and where water stagnation occurs for a period of over 10-15 days during kharif/monsoon season, short duration paddy or ragi (finger millet) are ideal options followed by low water requiring crops like seed spices. (4) Canal irrigation should be restricted to rabi season crops only with a provision of single distribution system within the water distribution network for applying both the surface water and ground water either by cyclic or mixing modes. The main canal should be deeper and below the surface, so that the farmers can lift the water for irrigating crops and the same canal will be used as surface drain during kharif season. (5) Low water seed spices can be grown with the residual moisture (during rabi season) and ragi can be taken up in the kharif season with limited irrigation. While dill and fennel form cash crops, ragi provides the stable food.

Other management strategies and economically viable options that are field tested include (a) Biosaline agriculture using economic halophytes and forage species; (b) Cultivation of herbaceum cotton varieties in rainfed coastal saline areas: (c) Conjunctive use of saline ground water with surface water for crops like wheat, dill, safflower, mustard; (d) Cultivation of salt tolerant wheat varieties: (e) Cultivating low water requiring crops like spices with high water productivity; and (f) Bioremediation through salt tolerant microbes and fungi. The beneficial effects of these interventions and their impact on farming in coastal saline Gujarat are discussed.

Comparative Efficacy of Different Crop Residues, Green Manures and Gypsum in Improving Biological Properties of Sodic Vertisols

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Abstract

Purna valley is an east west elongated basin with slight convexity to south, occupying the part of Amaravati, Akola and Buldana districts of Vidarbha region in Maharashtra state of India. The major problems of these soils are native salinity/sodicity, poor hydraulic conductivity, high degree of swell shrink potential, compact and dense subsoil and incomplete leaching of salts from soil due to severe drainage impairments. The Kutasa village was selected for present study is 32 km from Akola and 10 km away from the Purna river. The pH of experimental sites varied from 8.27-8.34, the electrical conductivity (EC) between 0.20-0.25 dS m^{-1}, the organic C content between 5.23-5.71 g kg^{-1}, the $CaCO_3$ content between 9.67-10.60 %, the cation exchange capacity between 52.17-53.47 cmol(p^+) kg^{-1}) and ESP between 10.39-11.29. The field experiments on cotton (2011) followed by green gram in kharif and chickpea in rabi season (2012) were conducted on farmers fields in Purna valley of Vidarbha region of Maharashtra. The treatments comprised of five different green manures (sunhemp, dhaincha, cowpea, green gram and leucaena loppings), two crop residues (cotton stalk and farm waste as biomulch), gypsum and control.

There were nine treatments replicated on three farmers fields on Vertisols treating each farmer as one replication. The application of crop residues and green manures significantly enhanced the, CO_2 evolution, soil microbial biomass carbon, permanganate oxidizable carbon and dehydrogenase activity over the application of gypsum and control. The application dhaincha and sunhemp in situ green manuring showed highest potential to improve biological properties of these soils. The different treatments of organic amendments followed the sequence dhaincha > sunhemp > cowpea > leucaena loppings > green gram > cotton stalk > biomulch for improving biological properties. The results thus suggest the potential of different crop residues and green manures in improving biological properties in sodic Vertisols under high pH and ESP.

Drainage discharge, salt removal, nutrient dynamics and crop yield under controlled drainage system (CDs) in saline Vertisols of TBP irrigation command

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Abstract

Performance of conventional sub-surface drainage system (SSD) on the reclamation of waterlogged and saline soils depends mainly on proper drainage discharge to the nala through the outlets. Farmers at the tail-end of the TBP irrigation command who often face scarcity of water especially at the later part of crop growth are in practice of clogging the outlets so as to retain water in the field for the crop. This practice has lead to the inefficient SSD network in the command. Hence, controlled drainage system wherein a slight modification to the existing traditional SSD (50 m spacing) was designed at Agricultural Research Station, Ganagavati during 2012-13 and continued during *kharif* 2013.

At crop harvest, average soil salinity was 4.27 vs. 6.20, 5.09 vs. 8.34, 5.90 vs. 11.98 and 5.19 vs. 13.80 dS/m at 0-15, 15-30, 30-60 and 60-90 cm depth under conventional and controlled drainage systems respectively. The total drain outflow depth over the sampling period was 186 and 260 percent higher during Kharif 2012 and 2013 under conventional SSD compared to controlled SSD system respectively. During these years, average salinity of drainage water was 2.90 and 3.61 dS/m and 2.03 and 3.21 dS/m under conventional and controlled SSD systems respectively. In terms of salt removal, 1939 and 4600 kg/ha and 560 and 1217 kg/ha under these two systems of SSD was observed. Loss of nitrogen was comparatively more than phosphorus and potash. The loss of nitrogen)NO_3-N(over the season was 6.59, 21.33 kg/ha and 3.0, 7.5 kg/ha during Kharif 2012 and 2013 in conventional and controlled SSD respectively. Though there was not much difference in grain yield between the systems, it increased from 38.4 to 46.8 q/ha and 37.6 to 45.8 q/ha under conventional and controlled SSD systems respectively during the course of the study.

Potential role of Fly ash in improving hydro-physical characteristics of partially reclaimed sodic soils for increasing wheat yield

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Abstract

Sodicity is major problem in Indo-Gangetic plains affecting agricultural production and livelihood of farmers. Sodic soils are characterized with very poor physico-chemical properties having high pH (>8) and ESP (>15). These soils are rich in soluble salts of sodium and are dominated with alkaline hydrolysis. Presence of sodium on clay micelle favors dispersion of aggregates. Soil dispersion causes clogging of pore spaces and alters the hydro-physical behavior of sodic soils and infiltration rate, hydraulic conductivity and moisture transmission characteristic of soil get affected. Plant becomes unable to extract nutrients and water for their development and growth. After reclamation of sodic soil with gypsum the pH of the soil and ESP are drastically reduced upto the critical limit for crop production but the physical properties of soil does not improve to the desired level for cultivation resulting poor productivity of wheat crops.

Fly ash is generated in huge amount from thermal power plants during energy generation. Annually about 112 million tons of fly ash is being generated in India and projections revealed that may go up to 170 million tons by the year 2015. The fly ash is disposed by dry or wet land filling operations; however this fetches the environmental concern. During last few decades fly ash is being explored for other potential uses in cement, bricks, road embankments, for land reclamation and as soil amendments. For this pond fly ash is explored for its potential uses for improving soil physical characteristics. Fly ash being an amorphouos ferro-alumino silicate with low density and silty texture could be used as an alternate material in improving the reclaimed and un-reclaimed sodic soils to boost the productivity. Various concentrations of fly ash were mixed with partially reclaimed sodic soils before wheat planting. Application of fly ash alone at the rate of 3%, 2% and 1% increased wheat yield by 14.33, 30.94 and 32.07%, respectively over the control. The soil bulk density and hydraulic conductivity were also improved significantly over the control plots. Fly ash incorporation also favors the bacterial and fungal population with in the soil over the control soils. Availability of micro nutrients like Cu, Zn and Fe increased significantly in soils where fly ash was added.

Standardizing irrigation requirements and date of planting for salt tolerant rice and wheat on partially reclaimed sodic soil

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Abstract

Rice-wheat system occupies 12.3 m ha in north India, of which 10 m ha is in the Indo-Gangetic Plains, where soil sodicity is very common and reclamation with gypsum is very expensive that deters small and marginal farmers to use gypsum. The use of salt tolerant varieties of rice and wheat can be a boon for small and marginal farmers in this region. This cropping system requires more than 170 cm water, which leads to decline in groundwater table at 0.5-2.0 m per year. In this backdrop a field experiment was conducted to standardize irrigation water requirement of salt tolerant rice and wheat varieties in relation to different dates of planting on partially reclaimed sodic soil.

In rice (CSR 30) treatments consisted of three irrigation schedules (continuous submergence(CS)/Farmers practice (FP), 3 days after disappearance of ponded water (DAD) and 5 DAD) and four dates of transplanting (21 June, 1 July, 11 July and 21 July) in strip plot design with three replications. One month old seedlings were transplanted in all the treatments. Differential irrigation schedules were imposed after one month of transplanting. Different irrigation schedules, CS/FP (3.65 t ha^{-1}), 3 DAD (3.57 t ha^{-1}) and 5 DAD (3.59 t ha^{-1}) did not but dates of transplanting influenced rice grain yield significantly. No interaction between irrigation schedules and dates of transplanting was observed. Maximum grain yield was recorded when transplanting was done on 1 July (4.09 t ha^{-1}) followed by 21 June (3.81 t ha^{-1}). Transplanting of CSR-30 after 1 July resulted in 15.2 and 25.7% reduction in grain yield with every 10 days delay, respectively. Irrigation scheduling at 5 DAD and 3 DAD saved 24.6 and 9.6 % of irrigation water compared to CS. Mean irrigation water used varied between 84.7 to 112.4 cm for different irrigation schedules and 81.0 to 132.7 cm for different dates of transplanting. Higher irrigation water productivity was observed in 3 and 5 DAD schedules than continuous submergence/FP across the dates of transplanting. The mean irrigation water productivity was 0.436, 0.359 and 0.331 kg m^{-3} in 5 DAD, 3 DAD and continuous submergence schedules, respectively. Data on lodging was recorded at harvest and it was observed that the lodging was positively correlated with quantum of irrigation water applied. Salt tolerant wheat varieties KRL-210 and KRL-213 were grown under three irrigation schedules (IW/CPE =1.0, 0.8 and 0.6) with four dates of sowing (10 Nov., 20 Nov., 30 Nov. and 10 Dec.). Across date of sowing and variety the significantly higher grain yield was recorded when irrigation was scheduled at IW/CPE = 1.0 (7.45 t ha^{-1}) than 0.8 (6.45 t ha^{-1}) and 0.6 (6.27 t ha^{-1}) ratio. Both KRL-210 (8.36 t ha^{-1}) and KRL-213 (8.26 t ha^{-1}) yielded higher when sowing was done on 20 November and irrigation was scheduled at IW/CPE = 1.0; however, under water stress treatment (IW/CPE = 0.6), grain yield was higher when sowing was done on 10 November (Table 1). Irrigation water productivity (IWP) increased with decreased irrigation frequency, IW/CPE = 1.0 (2.07 kg m^{-3}) to 0.8 (2.30 kg m^{-3}) and 0.6 (3.10 kg m^{-3}). However, IWP decreased linearly with delay in date of sowing from 10 November to 10 December (3.04-1.92 kg m^{-3}). IWP was significantly higher in KRL-210 (2.53 kg m^{-3}) than KRL-213 (2.45 kg m^{-3}). Rice equivalent yield of rice-wheat system was higher under optimum irrigation schedule (CS/IW/CPE=1.0) with 2nd date of planting (1 July/20 Nov.).

Labile carbon dynamics and sensitivity analysis under 6-year old *Eucalyptus tereticornis* plantation in sodic soils of Trans-Gangetic Plains of India

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Abstract

Soil salinity and sodicity are serious issues worldwide; amelioration through plantation forestry is a low cost and effective technique to overcome these abiotic stresses. A field study on amelioration potential under 6-year old *Eucalyptus tereticornis* was conducted at Raina Farm, Kurukshetra, Haryana, India. Changes in soil organic carbon (SOC), soil carbon stock, microbial biomass carbon (MB-C) and permanganate oxidizable carbon (POXC) was considered as indicators for soil amelioration. The objective of the study was to determine the changes in different soil depths (0-15, 15-30, 30-45, 45-60, 60-75, 75-90 and 90-105 cm) and tree canopy cover (mid canopy, canopy edge and canopy gap) under 6-year old *Eucalyptus tereticornis* plantation on sodic soils. SOC, MB-C, POXC and soil carbon stock was significantly influenced by soil depth and tree canopy cover.

All the parameters decreased with soil depth, irrespective of the tree canopy cover. Mid canopy showed greater soil amelioration through maximum organic inputs from litter fall, dead root debris and root exudates followed by canopy edge and least in canopy gap. Soil pH and electrical conductivity was reduced by 3.4 % and 2.6 %, respectively, in mid canopy as compared to canopy gap. Soil carbon stock, POXC and MBC was highest under canopy edge followed by mid canopy. Across the tree canopy cover, soil carbon stock in upper depth (0-15 cm) was higher by 72.3% than the lowest soil depth (90-105 cm) studied. Whereas, POXC and MBC were more than three and almost two times, respectively in upper soil depth as compared to the lowest soil depth studied. F statistics is used for sensitivity analysis of labile carbon fraction under block plantation of 6-year old *Eucalyptus tereticornis*. Among the labile carbon fraction studied, POXC was found to be highly sensitive followed by MB-C in terms of tree canopy cover. POXC was also found to be highly sensitive followed by SOC in terms of soil depth. The results indicated that *Eucalyptus* based plantation forestry has significant impact on soil carbon sequestration and reclamation of sodic soils, which ultimately enhanced the productivity of the land use system.

Innovations in reclamation and management of salt affected soils

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Abstract

Two major types of salt affected soils may be distinguished: the saline and alkali (sodic) soils. Saline soils have an excess of neutral soluble salts such as chlorides and sulphates of Na^+, Ca^{2+} and Mg^{2+}. Plant growth is adversely affected due to reduced water uptake and ionic imbalance and/or nutrient stress. Alkali soils, on the other hand, have Na_2CO_3 and $NaHCO_3$ which upon hydrolysis produces alkalinity. This leads to high pH and ESP and also to reduction in the availability of several essential plant nutrients. Crops grown on these soils invariably suffer nutritional disorders resulting in low yields. Reclamation of these soils can be accomplished by partial or complete removal of exchangeable Na by application of suitable amendments and following a package of cultural practices. The reclamation technology involves integrated use of amendments preferably gypsum based on gypsum requirement of soil for rice based cropping system, balanced and integrated use of chemical fertilizers and organic/green manures which helps in maximizing and sustaining yields, improving soil health and input use efficiency. The results have demonstrated that amelioration of sodicity is the logical first step and a pre-requisite for sustainable reclamation and improving the chemical fertility of sodic/alkali soils. In saline soils, leaching with good quality water and establishment of sub-surface drainage to lower the depth of water table and suitable cropping system is essential. Therefore, proper diagnosis of fertility problems and their management is essential for effective utilization of salt affected soils and sustaining crop production.

Sodicity of underground irrigation water coupled with nutrient deficiencies and/or specific ion toxicity pose a serious problem for sustaining crop productivity in the country. Use of poor quality ground water constitutes about 30-80 per cent of total ground water development. The management practices for optimal crop production with sodic water irrigation must aim at preventing the build-up of sodicity and toxic ions in the root zone to levels that limit the productivity of soils system as well as minimize the damaging effects on crop growth. Efficient, balanced and integrated nutrient management strategies are extremely important to increase yields to match the potential yields obtained under good quality irrigation water. Therefore, we focus on the nutrient dynamics as influenced by sodicity of irrigation water and discuss how these issues relate to the nutritional problems and suggest long-term remedial measures to utilize poor quality waters for improving and sustaining crop productivity.

Variation in Soil pH, EC, Cations and Anions Concentration under different land uses in a Saline-Sodic Soil

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Abstract

Six land-uses namely *Tamarix articulata*, *Acacia nilotica*, Kainth, Karonda-Mustard, Aloevera-*Prosopis alba*, *Prosopis alba*-Mustard situated at Bir forest, Hisar were studied to evaluate the changes in soil pH, EC_2, EC_e, cations and anions content. For this purpose soil samples were collected up to a depth of 200 cm with an interval of 20 cm. Results showed that Aloevera -Prosopis system recorded highest $pH_{1:2}$ (8.95) and EC_2 (2.04 dS m^{-1}) at 0-20 cm depth whereas lowest $pH_{1:2}$ (8.13) and EC_2 (1.03 dS m^{-1}) were associated with *Tamarix* and *Acacia nilotica* plantation. With increase in depth, $pH_{1:2}$ and EC_2 of the soil increased significantly. At 140-160 cm depth, highest $pH_{1:2}$ (8.69) and at 60-80 cm depth, highest EC_2 (3.08 dS m^{-1}) were associated with Aloevera-*Prosopis alba* and Karonda plantation, respectively. At 20-40 cm depth, highest $pH_{1:2}$ (9.13) among the land uses was observed under Karonda plantation. Highest pH (8.48) and EC (7.83) of the saturated extract were also observed under Aloevera-Prosopis system at 0-20 cm depth. At lower depths, ECe was increased significantly under all the land uses, highest (14.1 dS m^{-1}) being associated with Acacia at 80-100 cm depth. Higher content of calcium and magnesium throughout the soil depth were observed under Prosopis-mustard and *Tamarix* plantations than other land uses. At 0-20 cm depth, highest Ca (20 me L^{-1}) and Mg (31 me L^{-1}) content were observed under *Tamarix* plantation followed by Prosopis-mustard (4.0 and 8.5 me L^{-1}), Acacia ((1.0 and 1.85 me L^{-1}), Karonda (0.6 and 2.1 me L^{-1}), Kainth (0.6 and 1.35 me L^{-1}), and Aloevera (0.3 and 0.55 me L^{-1}). In most of the land uses calcium and magnesium content increased with depth. Significantly higher Na content throughout the profile were observed under Aloevera-prosopis (1717 me L^{-1} at 0-20cm) and Karonda (1370 me L^{-1} at 0-20 cm) plantations than other land uses. Bicarbonate and chloride content among the land uses as well as along depth significantly varied.

Rainfall variability and need of groundwater recharge structure for crop production in low lying area

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Abstract

Climate change is likely to increase uncertainty of highly variable rainfall patterns. The sustainability of agriculture in north- western Indian states is threatened due to wide variability in rainfall in cropping season and its erratic distribution, alarming decline of water table, and increase in pumping cost and deterioration in groundwater quality. For the study of rainfall variability and return period of storm events, 41 years weather data (1972-2013) of district Karnal were collected from agro-meteorology of CSSRI, Karnal. Potential amount of rechargeable water from 10 ha catchment area of recharge structure was estimated with drainage coefficient method. Categorization of monsoon rainfall based on long period average (LPA) and coefficient of variation (CV) indicates during last 10 years period (2004-2013), 6 years during the received deficient rainfall (18-57% lower than LPA), 2 years normal rainfall and 2 years excess rainfall (9-70% higher than LPA). In early two decades (1981-1990 and 1991-2000), one day maximum rainfall ($\geq$ 50 mm) was mainly confined in June and July months but in last 13 years period (2001-2013) it is shifted to August and September months of the year. The potential amount of rechargeable water from consecutive two days maximum rainfall in monsoon months from 10 ha catchment area of recharge structure was 1245 and 1570 m^3 in 5 and 10 years return period. Since, the area has flat topography, generated volume of runoff has to be dispose off to save the standing crop otherwise crop will be damaged very badly in low lying area.

The vertical drainage by using individual farmer based recharge structure, developed by CSSRI, Karnal could be a viable alternate. The structures, installed at a low lying location, where runoff got accumulated and adversely affected the production of rice during rainy season and of wheat during occasional heavy winter rain, have proven highly effective in augmenting groundwater, improving its quality and enhancing farmers' income by saving submerged crops. The post installation monitoring and evaluation revealed an additional income of Rs 1-2 lakh from low lined area by saving submerged rice and wheat crop during extreme rainfall event. These structures also improved groundwater condition by recharging surface stagnated water at faster rate than natural. During the monsoon period, rise in groundwater level of 1-3 m beneath the installed recharge structures was recorded at different sites. The improvement in salinity and RSC of groundwater at different selected sites ranged from 0.3- 2.4 dS/m and 0-4.46, respectively, underneath the recharge structures. The overall result of the study suggests use of small groundwater recharge structure in low lying area for saving crop by draining excess water resulting from extreme rainfall event, arresting declining groundwater table and improving water quality.

Effect of mini-sprinkler irrigation system on crop productivity and natural resource saving in rice-wheat cropping sequence

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Abstract

Rice-Wheat cropping system is the most important irrigated agro-ecosystem of India, which contributes about 32 % to the national food basket. In fact both rice and wheat are the two most important crops and the staple food of millions of Indian people. This production system is labour, water, and energy –intensive and is becoming less profitable as these resources are becoming increasingly scare and costly. Keeping these views in aim a field experiment has been continuing from 2011 to evaluate the influence of resource conservation strategies through tillage, residue and water management for addressing crop productivity and natural resource saving under rice-wheat cropping system on semi-reclaimed sodic soils. Three adopted resource conservation *vis-à-vis* conventional practices (CV) were imposed 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.

A mini-sprinkler irrigation system has been installed in 1.0 acre area with 12960 lh^{-1} $acre^{-1}$ discharge rates at 2 $kgcm^{-2}$ pressure along with 90 % uniformity coefficient. The criteria for irrigation scheduling for wheat was considered to be the cumulative pan evaporation of 7 days. Sprinkler irrigation system saved 38.85 % more water over the surface irrigation. Zero tillage with 100% rice straw mulch produced highest wheat yield (5.38 t ha^{-1}) under surface irrigation system followed by 5.13 t/ha in zero tillage with 100 % rice straw mulch under mini sprinkler irrigation system. Around 0.86 times higher additional wheat grain water productivity was in ZT with rice residue as compared to conventional wheat sowing. Electric energy 2.16 % was saving in mini sprinkler irrigation in comparison to conventional wheat sowing. Nitrogen use efficiency (NUE, kg grain kg^{-1} nitrogen applied) in wheat crop observed 68.4 where nitrogen applied through mini sprinkler system. Application of nitrogen fertilizer through mini sprinkler irrigation saved 50% of recommended with 100% rice crop mulch. Problem of crop lodging was noticed at grain filling and dough stages under sprinkler system. Rice crop produced maximum biological yield 16.70 t/ha in DSR with minimum tillage in mini sprinkler irrigation system, saved 57.88 % of irrigation water with water productivity 2.18 kg/m^{-3} which was 2.27 times higher than conventional rice transplanting (0.959 kg/m^{-3}). However, DSR with minimum tillage saved irrigation water by 33.3 % with water productivity of 1.14 kg/m^{-3}. Irrigation in rice crop with mini sprinkler system saved 32.60 % electric energy in comparison to conventional rice transplanting.

Eucalyptus Tree Height Model for Maximizing Net Return and Optimizing Tree Stand Period

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Abstract

Canal irrigated area over the globe is mostly affected with waterlogging and salinization in absence of proper drainage layout. In India nearly 3.95 million hectare of productive agricultural is suffering due to severe waterlogging and 6.75 million ha due to salt build up. Globally only 10-20% of the irrigated land is equipped with drainage while 40-60 percent is in need of drainage. Situations where traditional drainage practices are not feasible bio-drainage is being recommended. Due to high evapotranspiration (ET) demand and tolerance to salinity, sodicity and waterlogging, eucalyptus is recommended to biodrain waterlogged salt affected areas. Eucalyptus is also a good source of timber. The demands for wood and wood products are growing steadily in developing nations due to growing population. Forest cover of India is only 23.1% against global average of 31.0%. Prices of timber wood and other products are soaring high in India and other developing countries where agricultural forestry is becoming increasingly a viable option for farmers. Farmers prefer fast growing, short duration with high economic return tree plantation with minimum associated risk. Eucalyptus is one such tree species grown in 100 countries across six continents. The rapid growth rate of eucalyptus and the quality of its wood make it the world's leading industrial reforestation species. Eucalyptus hair roots can penetrate the soil to a depth of up to 10 m in two years making use of large volumes of soil for its growth. This enables it to grow in very poor soils. It is suited to all types of soils and climate of Indian subcontinent. It can tolerate pH up to 11.0, 9.2 and 8.8 in sand, clayey and loamy soils, respectively. It can also tolerate waterlogging once established. It does not compete the crops because of its peculiar conical crown, less shade and pronounced tap root system.

Fish pond and raised and sunken bed based integrated farming systems were demonstrated as successful model to reclaim and manage sodic soils under waterlogging. Eucalyptus plantation along field boundary showed good timber production potential. There were 220 eucalyptus trees planted on the outer boundary of raised and sunken beds at different times. Present average DSH of 32.8 cm and DBH of 27.4 cm were recorded. Out of 220 eucalyptus trees 60 are having average girths of 60.0 cm and 49.6 cm and diameters of 19.1 cm and 15.9 cm at shoot and breast heights, respectively. Expected net return from 60 eucalyptuses is about Rs. 48000.00. Having been transplanted during first year of the project, the total expected return from eucalyptus plantation would have become Rs. 1.76 lakh. Raised and sunken bed based integrated farming system gives suitable platform to grow eucalyptus in waterlogged sodic soils with minimum investment. Total 492 eucalyptuses were planted on fish pond boundaries and showed reasonably good growth rate. Modelling of eucalyptus tree height with time is essentially required for maximizing net return and deciding tree stand cycle. A hypothesis was developed to describe the height of eucalyptus tree under waterlogged sodic soil conditions and later transformed to a governing equation and solved for its solution. A power form equation developed from the hypothesis which described eucalyptus tree height with its age pretty well.

Alleviation of salt stress by using Arbuscular mycorrhizal fungi

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Abstract

Food and nutritional security of the ever increasing population calls for sustained productivity from the limited land and water resources, which is further, thwarted by the multiplicity of resource degradation problems. In that series salt-affected soil is one of the serious abiotic stresses that cause reduced plant growth, development and productivity worldwide. The salt-affected soils occupy approximately 7% of the global land surface. Understanding the mechanisms that enable plant growth under saline conditions is therefore required. To deal with saline soils and minimize crop loss, biological process such as mycorrhizal application would be a better option. Arbuscular mycorrhizae constitute a key functional group of soil biota that can greatly contribute to crop productivity and ecosystem sustainability.

Mycorrhizal symbiosis alleviate the adverse effect of salinity on plant productivity by employing various mechanisms, such as defending roots against soil-borne pathogens, improving rhizospheric and soil conditions, modifying microbial communities, enhancing antioxidant enzymes activity, maintaining membrane integrity, stimulating plant growth regulators, enhancing plant nutrient acquisition, maintaining K+/Na+ ratio and inducing biochemical changes (accumulation of proline, betaines, polyamines, carbohydrates and antioxidants), physiological changes (leaf gas exchange rate, photosynthetic efficiency, relative permeability, water status and abscissic acid accumulation), molecular changes (the expression of genes: PIP, Na+/H+ antiporters, Lsnced, Lslea and LsP5CS) and ultra-structural changes. Many research and study over many years has broadened our understanding of the multi-complex processes directing plant mycorrhiza symbiosis in ameliorating salt stress in plants. So the development of AMF inocula that confer sustained salt tolerance to plants would have enormous practical applications.

Optimization of date of sowing and planting geometry for sugarbeet under saline Vertisol of TBP command

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Abstract

A field experiment was carried out during 2010-11 to 2012-13 at Agricultural Research Station, Gangavathi, Karnataka to see the effect of sugarbeet to different date of sowing and planting geometry under salt affected soils with the objective is to study effect of sugar beet to different dates of sowing and to different planting geometry. The experiment was laid out in a split plot design with three replications. Four dates of sowing viz., D_1: August I fortnight, D_2: August II fortnight, D_3: September I fortnight and D_4: September II fortnight as main plot treatments and four planting geometry viz., S_1: 45 x 20 cm, S_2: 45 x 30 cm, S_3: 60 x 20 cm and S_4: 60 x 30 cm were as subplot treatments. The variety Indus from Syngenta Seeds Pvt Ltd. was used as a test hybrid.

The study of three years revealed that, August I fortnight sowing of sugarbeet seeds had significantly higher root yield (39.67 t/ha), weight of 10 beets (13.99 kg), more number of beets per plot (182) and TSS per cent (21.66%) than other dates of sowing. The weight of 10 beets and number of beets per plot was differed significantly with respect to planting geometry geometry, but there was no significant difference in root yield and TSS% of sugarbeet. The sugar beet sown at 60 x 30 cm had recorded significantly higher weight of 10 beets (14.91kg) followed by at 60 x 20 cm, 45x 30 cm and 45 x 20 cm (14.30, 12.97 and 13.78 kg, respectively). The interaction of dates of sowing and planting geometry was found nonsignificant. The august I fortnight sowing had given significantly higher gross return, net returns and benefit cost ratio (Rs. 71410, Rs.43968 ha^{-1} and 2.61, respectively) as compared to other dates of sowing.

Growth and physiology of bael (*Aegle marmelos* Correa) cultivars under salinity stress

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Abstract

One year old, grafted plants of bael cultivars NB-5, NB-9, CB-1 and CB-2 grown in normal (Soil EC_e 1.28 dS m^{-1}), medium (6.49 dS m^{-1}) and high (10.7 dS m^{-1}) saline soils and irrigated with normal water, exhibited salt stress symptoms as yellowing, scorching and chlorosis of the leaf edges followed by the necrosis and abscission of leaves. Salinity stress significantly increased membrane injury in all the genotypes but NB-5 plants recorded lesser damage as compared to others. There were also significant reductions in relative water content and chlorophyll (a, b and total) values with increasing salt stress in all the genotypes but these reductions were less pronounced in NB-5 plants.

The effects of salt stress on chlorophyll degradation, presumably due to increased activity of the enzyme chlorophyllase, were characterized as the yellowing of leaves which failed to produce the optimum amounts of photosynthates leading to reduced plant growth and vigour. Accumulation of significantly higher proline and soluble sugars under elevated salinity in NB-5 indicated its higher salt tolerance as compared to other genotypes. Salinity stress caused significant increases in leaf Na^+ concentrations in all the genotypes but NB-5 plants maintained a favourable ionic balance in terms of Na^+/K^+ ratio resulting in good plant performance under salinity. The plants of NB-9 and CB-2 varieties could not sustain Na^+ toxicity and did not survive at high salinity.

Long term effect of *Jatropha curcas* on amelioration of salt affected soils

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Abstract

Sodicity, whether natural or anthropogenic in origin, causes severe stress to plant growth and its yield. In India about 3.77 million ha are reported as sodic soil out of which 1.37 million ha sodic soil found in Uttar Pradesh alone. Gypsum is being proven as an universal sodicity reclaiming agent but owing to its high cost, limited sources and less availability, there is need to explore some other alternatives that are cheap, easily available and must be eco friendly. For this a study was initiated in 2006 to explore the potential effect of *Jatropha curcas* on sodic soil reclamation. After 8 years of the Jatropha plantation its long term effect on bio-amelioration on sodic soil was studied. From the study it was observed that the pH of the surface soil (0-15cm) decreased to 8.4 from the initial value of 9.6. Carbonate and bicarbonate decreased from 2.00 and 4.50 meq/l to 1.00 and 0.50 meq/l, respectively. Calcium content increased significantly to 3.00 meq/l. Addition of leaf flitter and biomass to the soil increased organic carbon and total nitrogen significantly over the initial soil values. Accumulation of biomass also favors microbial growth in the soil. Six different types of bacterial species (four Gram -ve rod shaped; two Gram +ve coccai) and three different fungal species were isolated from rhizosphere soil. Plantation of *Jatropha curcas* found effective in reducing soil pH, EC and ESP, increasing soil organic carbon content and helps increasing activities of the soil microflora which helps in ameliorating the salt affected soils and favour plant growth.

Stimulating nitrogen use efficiency in rice-wheat systems by critical assessment of plant availability during crop growth in reclaimed sodic soils

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Abstract

Nitrogen (N) fertilization in agriculture is the most important as well as one of the most expensive agricultural practices for a farmer. Suitability of a soil fertility management practice can be best assessed by the availability of nitrogen in soil for crop growth, especially at critical growth stages. Nitrogen use efficiency is often used criteria for optimization of doses. Sodic soils (high sodium in soil) are usually only partially reclaimed (to 15-30 cm depth) for crop production using gypsum ($CaSO_4$). Therefore these soils have basic pH (8-9) even after reclamation of surface layers, underlain with sodic subsoil horizons. Since the pH of these soils usually remains basic even after reclamation, availability of nutrients is minimal under these conditions. Post reclamation management to address crop nutrition as well as long term soil health is of immense importance for these soils. In a long-term experiment, ion exchange membranes were used as plant root simulators to determined ammonium and nitrate nitrogen available in soil solution, with differences in fertilization sources (organic and inorganic). Ion exchange membrane strips were installed in the treatments continuously throughout rice season and were removed at 15 days intervals. Treatments included no fertilizer (control, O), recommended doses of inorganic fertilizers (fertilizer N=180 kg ha^{-1}; I) and reduced inorganic fertilizer (N= 100 kg ha^{-1}) 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).

Nitrogen availability scenarios indicated decrease in available NH_4^+-N and increase in NO_3^--N as rice crop growth progressed, in all the treatments. Except for treatment with no fertilizer inputs, there were no significant changes in total-N, NH_4^+-N and NO_3^--N available, as summed over full season, even in soils with reduced inorganic inputs. Conversely, supplementing reduced inorganic fertilizer doses with organic sources sufficed plant available nitrogen pools in soil to support plant growth and yield equivalent to high dose inorganic fertilizers treatment (I). Total amount of available N (NH_4^+-N + NO_3^--N) recorded in full season was in the order PC (186 µg cm^{-2}) > I (181 µg cm^{-2}) > WS (177 µg cm^{-2}) > FYM (176 µg cm^{-2}) > GM (176 µg cm^{-2}) > LEG (174 µg cm^{-2}) > O (90 µg cm^{-2}). About 65 - 72% of this was available in form of NH_4^+-N, and rest was in NO_3^--N form. Except for initial phase (18-48 DAT) and ending phase (93-109 DAT), there were no significant differences in available N amongst inorganic (I) and organic supplemented treatments (LEG, GM, FYM, WS, PC). The N-availability status recorded throughout the season in soil indicated a close relationship with mineralizable carbon (C_{min}) which varied in the order LEG (298 µg C g^{-1} soil) > FYM (279 µg C g^{-1} soil) > GM (263 µg C g^{-1} soil) > WS (232 µg C g^{-1} soil µg C g^{-1} soil) > PC (217 µg C g^{-1} soil) = I (217 µg C g^{-1} soil) > O (182 µg C g^{-1} soil), over a short 23d period. The crop residue treatments, PC and WS released nutrients slowly, thus minimizing losses and maintaining optimum levels of availability until end of season. These could be the appropriate alternatives to immediately replace conventional management practices for rice-wheat cropping systems in Indo-Gangetic region.

Evaluating productivity potential and nitrogen use efficiency of sunflower hybrids grown under semi-arid irrigated conditions of northwest India

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Abstract

Increasing costs of N fertilizers and the negative impact of excessive fertilization on the environment have made improvement in nitrogen use efficiency (NUE) a desirable goal in crop production. The identification and development of N efficient genotypes and improvement in N management strategies will require understanding the relationship between physiological processes and biomass/yield formation. With this background, to determine the genetic variability for yield and NUE under varying N application rates in sunflower, the present investigation was carried out in split-plot design with three replications comprising four sunflower hybrids (PSH 996, PAC 3789, PSH 569 and SH 3322) in the main plots while N fertilizer application rates viz., N_0 (control), N_{40} (40 kg N ha^{-1}) , N_{80} (recommended N, 80 kg N ha^{-1}), N_{100} (100 kg N ha^{-1}) and N_{120} (120 kg N ha^{-1}) were assigned to the subplots.

Progressively linear and significant increase in seed yield was recorded with each incremental dose of N over the preceding one only upto N_{100}, though the yield enhancement was noticed up to N_{120}. Seed yield registered its highest value at N_{120} (2069 kg ha^{-1}) elucidating 1.2, 5.7, 26.3 and 85.1% yield superiority over N_{100}, N_{80}, N_{40} and N_0, respectively. The crop fertilized with lower N application had significantly higher NUE following the order of $N_{40}>N_{80}>N_{100}>N_{120}$ with nitrogen utilization, uptake, agronomic and physiological efficiency decreased with increasing N fertilization rate. Variations for N harvest index were not significant at different N rates though it marginally increased with increasing N rates. Significant and positive response of N fertilization on SPAD and LAI values was observed. Averaged across N levels, highest seed yield of 1858 kg ha^{-1} was recorded with PSH 996 significantly out yielding other hybrids excelling 4.4-11.6% in seed yield and 5.0-16.5% in oil production. PSH 569 registered significantly higher values for chlorophyll content (41.47) and leaf area index (2.28). This work will complement other studies to identify cultivars with greater tolerance to suboptimal nutrient availability and to characterize NUE, and thereby establish a baseline for breeding N efficient sunflower genotypes to be grown under semi arid tropical conditions in India and similar environments.

Consumptive use, water use efficiency, soil moisture use and productivity of fenugreek (*Trigonella foenum-graecum* L.) under varying IW-CPE ratios and fertilizer levels on calcareous alkali soils of South West Rajasthan

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Abstract

Results of a field experiment conducted at Udaipur (*rabi* seasons of 2011-12 and 2012-13) with objective to optimize the productivity and water use of fenugreek through use of appropriate IW-CPE ratio and fertility level; reveal that IW-CPE ratio of 1.0 registered significantly higher performance of pooled yield and registered an enhancement of 45.48, 27.50 and 11.90% in seed yield and 41.42, 23.72 and 10.26% in haulm yield at IW-CPE ratio of 1.0 over IW-CPE ratios of 0.4, 0.6 and 0.8, respectively. IW-CPE ratio of 1.0 also recorded significantly higher residual soil moisture at 0-15 cm (36.41%) and 15-30 cm (23.94%) soil depths 40 DAS and consumptive use (11.58 kg mm ha^{-1}) over different lower IW-CPE ratios. However, WUE at IW-CPE ratio of 1.0 (11.58 kg mm ha^{-1}) was significantly lower than lower IW-CPE ratios of 0.8 (9.34 kg mm ha^{-1}), 0.6 (8.63 kg mm ha^{-1}) and 0.4 (8.61 kg mm ha^{-1}). Results further reveal that 40 kg N + 40 kg P_2O_5 ha^{-1} recorded significantly higher pooled seed yield (8.38 and 20.69% higher), haulm yield (5.57 and 17.60% higher) and biological yield (6.30 and 18.39% higher) under 40 kg N + 40 kg P_2O_5 ha^{-1} over 20 kg N + 20 kg P_2O_5 ha^{-1} and control, respectively. Application of 40 kg N + 40 kg P_2O_5 ha^{-1} recorded significantly higher consumptive use over different lower fertility levels but WUE under each lower fertility levels up to 40 kg N + 40 kg P_2O_5 ha^{-1} recorded significantly higher WUE over it immediately higher fertility level.

Increase the Availability of Iron in Calcareous Soil

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Abstract

Low availability of iron (Fe) leads its deficiency, which is one of the serious nutritional disorders in aerobically-grown rice on calcareous soil of Bihar. Aerobic rice is gradually catching the imagination of people due to water crisis threatening the sustainability of irrigated rice ecosystem across the globe. A gradual decline in the productivity of aerobic rice is associated with very low availability of Fe in soils, because of insolubility of Fe(III) oxides. Rice is inherently a poor source of Fe and growing it on potentially Fe-deficient soils further reduces Fe concentration in grain. Several cultural practices have been attempted to increase the iron availability to overcome from its deficiency. Seed treatment offers an approach to economize on Fe application to the aerobic-rice grown on calcareous soil. In view of this, a preliminary greenhouse experiment was conducted on calcareous soil to evaluate the effectiveness of soaked seeds of two rice cultivars (IR-64, Fe-inefficient and Pusa Sughand-3, Fe-efficient) in solutions of 0.5*M* $FeSO_4.7H_2O$, 0.25*M* $FeSO_4.7H_2O$ and 0.05*M* Fe-EDTA for 12 and 24 hours before sowing. As a follow up to the preliminary experiment, second greenhouse experiment was conducted to evaluate the methods of iron application as soil (67 mg $FeSO_4.7H_2O$ kg^{-1}), foliar sprays (3% $FeSO_4.7H_2O$ solution, thrice 40, 60 and 75 days after sowing of rice) and seed treatment (seed soaked in 0.05*M* Fe-EDTA for 12 hours) to increase the iron availability under aerobic rice cultivars (IR-64 and Pusa Sugandh-3) grown on calcareous soil.

The results showed that the Fe^{2+} content and dry matter yield exhibited a highly significant increase in cases where seeds had been soaked with 0.05*M* Fe-EDTA solutions, followed by 0.5*M* and 0.25*M* $FeSO_4.7H_2O$ for 24 hours of IR-64 rice, whereas in case of Pusa Sugandh-3 highest ferrous-iron and dry matter yield were recorded under 12 hours-seed soaking in solution of 0.05*M* Fe-EDTA. Ferrous-iron (Fe^{2+}) and yield were higher in case of Pusa Sugandh-3 compared to IR-64. Thus the cultivar selection was the most effective tool for arresting chlorosis; but seed treatment with Fe-EDTA reduced the severity of chlorosis in case of Fe-inefficient rice cultivar. Soil application of Fe (67 mg $FeSO_4.7H_2O$ kg^{-1}), improved the DTPA and NH_4OAc extractable Fe content in soils. Foliar application of 3% $FeSO_4.7H_2O$ solution was more effective in enhancing the yield of rice as well as enriching the milled rice with Fe compared to soil application over control. Ferrous-iron content in rice plants proved to be a better index of Fe nutrition status compared to total plant Fe and chemically extractable soil Fe. The Fe^{2+} content of $\geq$ 42 mg kg^{-1} in plants (on dry weight basis) appeared to be an adequate level at 45 days after sowing for direct seeded rice grown under upland aerobic condition.

Fish culture led farming system production from reclaimed sodic land pond area

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Abstract

Aquaculture led agrarian practices in sodic land and water condition are foreseen as other alternative for income generation and one of the tool for natural resource management in the country. The fish growth based on supplementary feed (down size farm grain@1-5% of body weight of fish) from the small pond (0.1ha) and large pond was 600-1500g from the initial stocking size (10-15g) of different type of carp fish fingerling i.e. *Catla catla* (Catla), *Labeo rohita* (Rohu), *Cirrhinus mrigala* (Mrigal), *Ctenopharyngodon idella* (Grass carp), *Cyprinus carpio* (Common carp) at the rate of 10,000 Nos./ha stocking density after twelve month of culture of the species. Repeated bottom racking of pond was done as one of the tool for sediment nutrient mineralization. The standard method of pond management practices were followed with permissible modification for fish culture. The physico-chemical and hydro biological parameters of pond soil &water were studied during period under experimentation. The productivity of fish biomass from the small pond (0.1ha) was 3.5 and 5.0 ton/ha/year during first and second year respectively. The BC ratio for the small pond was 3.57& 4.38 for fish and 3.33 & 4.16. (0.2 ha area) for vegetable cultivation in same period. In the first year bundh of new pond was used for growing pigeon pea, broad bean, pea, Cucurbeat, Methi, Palak, Elephant foot yam **(**Zimikand) *Amorphallus paeonifolius*, Banana, Guava etc in relation to farming system practices along with fish culture activity in the pond. The cucurbit & and elephant foot yam were manured with fish waste manure. In the second year bundh of same pond was used for growing Pigeon pea, Potato, Cauliflower, Garlic, Broad bean, Cucurbits, Methi, Palak, Banana, Guava etc. in relation to farming system practices along with fish culture activity in the pond. The cucurbit, potato& and elephant foot yam were manured with fish waste manure at small pond dyke. The EC_2 of different plot where cultivation of crop was done found at the level of 0.36-1.90 dS/m. Pigeon pea has shown third year retuning behavior due to continuance of pervious year crop. All the plants except pegionpea were irrigated through pond water during summer and rest of period ground water tube well. It has been observed that due to latent heat of pond water severity of winter chill and frost was less in the crop beside banana plant. During peak summer pegionpea on the peripheral area of the pond were luxuriantly green. This is due to capillary action of water flow from high concentration to low concentration near deep hair root zone area of the pegionpea of the pond dyke. Mortality of fishes was observed due to prolong cloudy weather. The pond management strategy along with constraints of sodic land ponds are also discussed in great deal. The study indicated sustainable productive utility of such land for adopting freshwater aquaculture in relation to farming system practices.

Vertical allocation of Soil carbon forms and water stable aggregate under block plantation of *Eucalyptus tereticornis*

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Abstract

Plantation forestry emerged as a potential low cost tool for mitigation of climate change through enhanced soil carbon sequestration. This present study evaluated the influence of 4-year old *Eucalyptus tereticornis* based plantation forestry on soil aggregate fractions and various pools of carbon in seven soil depths (0-15, 15-30, 30-45, 45-60, 60-75, 75-90 and 90-105 cm) at Raina Farm, Kurukshetra, Haryana. Results indicated that most of the soil quality enhancing properties concentrated at the soil surface (0-15cm) compared to other soil depths. In general, total carbon (TC), total organic carbon (TOC) and organic carbon (OC) decreased with soil depths, whereas, no such pattern was observed in case of total inorganic carbon (TIC). Across the soil depth, mean TC was 11.9 g kg^{-1}, which was 16.7% and almost 7 times higher than TOC and TIC, respectively. Water stable macro (> 0.25 mm) and micro (< 0.25 mm) aggregates was highest (33.5 and 24.8%) under 30-45 cm and 0-15 cm soil depths, respectively. Estimated mean total water stable aggregate was 35%, in which 64.3% were macro aggregates and rest 35.7% were micro aggregates. Mean macro aggregates were higher by 80.0% than micro aggregates. Higher proportion of fine particulate organic carbon, particulate organic carbon, silt plus clay associated organic carbon and non-hydrolysable organic carbons were found in upper soil depth (0-15 cm). Mean weight diameter, geometric mean diameter, aggregate ratio and aggregate stability were statistically significant and highest (1.06 mm, 0.93 mm, 6.74 and 0.41) in 75-90 cm soil depth under 4-year old *Eucalyptus tereticornis* based plantation forestry. Block plantation of *Eucalyptus tereticornis* might be a better option for mitigating green house effects by sequestering atmospheric carbon and improving soil aggregate stability, which ultimately improved soil health and enhanced the productivity of the system.

Effect of Different Organic and Chemical Amendments on Changes of Salt Composition of Saline-Sodic Soil

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Abstracts

Short-term laboratory study (Jan to April, 2012) was taken to investigate the changes in salt composition after the leaching of monovalent and bivalent ions in saline-sodic soil. Soil samples were collected from 0-15 and 15-30 cm soil depth at Nain farm, Panipat, Haryana. Basically the problems like salinity, sodicity, saline-alkalinity and waterlogging were prevailed at this site. The soil samples were air-dried, powdered and passed through a 2-mm sieve and used for determining physical and chemical properties. The PVC columns with a 10.3 cm inner diameter and 40 cm long soil column were used and filled with ground dry-soils sampled up to 30 cm depth (bulk density of 1.50 g cm^{-3}). Organic and inorganic amendments were mixed thoroughly with soil samples up to 15 cm soil layer in each column. The different organic and chemical amendments (triplicate) comprise gypsum@50% GR and 100% GR (4.1 g/column and 8.2 g/column, respectively), pressmud @10 and 20 t ha^{-I} (8.4 g/column and 16.8 g/column, respectively), flyash @10 and 20 t ha^{-I} (8.4 g/column and 16.8 g/column, respectively) and FYM @10 and 20 t ha^{-I} (8.4 g/column and 16.8 g/column, respectively) along with control using deionised water. Prior to filling the columns, a disk of zeolite perforated filter was placed at the bottom of each column to facilitate leaching (to prevent the passage of soil particles). Here, deionized water was applied as water treatment up to the mark of 6 cm increment. Following each deionized water application, the leachate (1^{st} 2^{nd}, 3^{rd} and 4th) samples were collected at specified certain time intervals (48 hours). Prior to addition of amendments to the soil, its pH_I (9.18), pH_e, (11.5), EC_2 (8.84 dS m^{-1}) and EC_e (42.9 dS m^{-1}) were measured at 0-15 cm layer. Slight or negligible changes in soil pH were observed under soil column study, while EC value decreased from 9.72 to 3.30 dSm^{-1} in gypsum @ 50% GR and from 12.73 to 5.60 dS m^{-I} in 100% GR and from 16.37 to 8.48 dSm^{-1} pressmud @ l0t ha^{-I} and from 13.99 to 3.86 dS m^{-I} in 20 t ha^{-I} amended treatments from 2^{nd} leachate to 4th leachate, respectively. Cations like $Na^{+,}$ K^{+}, Ca^{2+} and Mg^{2+} concentrations decreased from 2^{nd} leachate to 4th leachate in control, both the gypsum treatments (i.e. 50% and 100% GR) and both the pressmud treatments (10 and 20 t ha^{-1}). After 4th leaching, anions $CO3^{2}$- and $HC0_3^{-}$ concentrations showed dissimilar results in gypsum @ 50% GR and 100% GR and pressmud @ 20 t ha^{-I} treatments as compared to other anions. After 4th leaching, in gypsum @ 50% GR and 100% GR and pressmud @ 20 t ha^{-I} treated sets, anions Cl^{-} and SO_4^{2-} concentrations decreased from 2^{nd} leachate to 4th leachate. This study showed that a laboratory experiment by using soil column has advantage in that the solute concentration and its temporal variability in the outflow water can be measured. Even though the period is too short to compare all treatments; the study, however showed that to reclaim the saline-sodic soil, application of gypsum (i.e. 50% and 100% GR) and pressmud (10 and 20t ha^{-1}) are the best ways to mitigate these types of soil problems when compared to flyash and FYM treated samples.

Unlocking production potential of degraded coastal land through innovative land management practices

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Abstract

Agriculture in the coastal region of our country is less productive and risk prone. Coastal land resource is vulnerable to various process of land degradation like salinization, waterlogging, drainage congestion, etc. Unlocking the production potential of degraded land in coastal region is the biggest challenge towards achieving food security of the country. Implementing innovative land management practices in combination with productive utilization of opportunities of the coastal areas like excess rainwater and vast brackishwater resources could be a best approach to meet the challenge. Land shaping is an innovative land management practice which provides the scope for unlocking production potential of salt affected degraded land, achieving food security and enhancing livelihood of the poverty stricken farming communities in the coastal region. This technology addresses the key challenges like land degradation (salinity), drainage congestion and scarcity of fresh water for irrigation and in turn have the potential to enhancing production, productivity, income and employment.

Different land shaping techniques like farm pond, deep furrow & high ridge, shallow furrow & medium ridge, paddy-cum-fish cultivation, broad bed & furrow, tree tier, pair bed and brackishwater aquaculture pond techniques for improving drainage facility, rain water harvesting, salinity reduction and cultivation of crops and fish (freshwater and brackishwater fish) for livelihood and environmental security were tested on about 400 ha salt affected degraded and low-productive land in disadvantaged areas in Sundarbans region of Ganges delta (West Bengal) and *Tsunami* affected areas in Andaman & Nicobar Islands covering 32 villages in 4 districts viz. South 24 Parganas and North 24 Parganas districts in West Bengal and South Andaman and North & Middle Andaman districts in Andaman & Nicobar Islands. With land shaping techniques, different land situations like, high land, medium land and low (original) apart from rainwater harvesting structures like farm pond/furrows/trenches etc. were created in low-lying and degraded farmers' fields. Raising of land and creating water harvesting structures reduced the problem of drainage congestion during *kharif* season and this provided the scope for growing high value crops like vegetables during this season and it also facilitated early sowing of *rabi* crops so that the farmers could get better return. It was observed that the salinity build up in the soil of different land situations especially medium land and highland/ridges/ dikes in land shaped area was reduced by 40-65%. Due to creation of different land situations and following cultivation of crops round the year org. C, av. N, P & K and biological activity like microbial biomass C in surface soil have been increased under land shaping techniques compared to land without land shaping. About 1950 water storage structures were created under different land shaping techniques and 13,05,000 m^3 rainwater has been harvested annually in these structures in the study area and with harvested rain water about 260 ha areas which were earlier under mono-cropping with rice due to shortage of irrigation water have been brought under irrigation for growing multiple crops round the year. The cropping intensity has been increased upto 240 % from a base level value of 100% due to implementing the land shaping techniques. Land shaping techniques have increased the income of the households by 6-9 times or even more compared to base line value. Average net income per ha of farm land has been increased from Rs.22000 to Rs. 1,23,000 in Sundarbans and Rs.22400 to Rs. 1,90,000 in Andaman & Nicobar Islands. Brackishwater

aquaculture was demonstrated through shaping of land into more than 110 shallow depth pond in the coastal areas of Sundarbans particularly near the brackishwater rivers which was remain almost fallow and not being utilized for any agricultural activity on account of high soil salinity. Farmers were getting benefitted from this brackishwater aquaculture with a net income of about Rs. 1,50,000 ha^{-1} of pond area.

Farming activities under land shaping techniques have enhanced the employment opportunities for the farm families in the study areas. As the farmers get employment in their own farm land throughout the year, this has checked the seasonal migration rate of the farm family in search of their livelihood. These techniques were financially viable and attractive proposition for the coastal region. However, major constraints for adoption of land shaping techniques were marginal land holdings that too divided into several parcels, high initial investment, presence of acid sulphate soils near surface or at shallow depth at places, distance from residential village etc. Though the technology have been well adopted at farm level, there is lack of information on larger watershed or basin level hydrological impacts such as availability of rainwater for downstream flow, groundwater recharge etc. There is a need to understand and resolve issues on large scale dissemination of land shaping technology covering the areas of input-supplies and management, market and marketing environment – the driver of change in cropping pattern and production, credit needs and absorption of the farmers, and the role financial institutions therein. More intensive study should be undertaken to address those issues so that the land shaping will be adopted in a large scale for the sustainable agricultural development in the salt affected coastal region.

Desalinization and Reclamation of coastal saline soils of Maharashtra

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Abstract

A strong embankment is required to be constructed at least to a height greater than the height of maximum tide to stop ingress of sea water side stop of 2:1 with stone pitching towards creek side and 1:1 towards land side. The deep-drains of 1.5 to 2 Meter depth are found effective to remove excess salts with 100 m drain distance showed 85% reduction in soil salinity. Horizontal desalinization by flushing salt in to side drains and makes it suitable for growing rice in *kharif* supported with age old practice ulkatani or ploughing the land during summer season. Surface dug out farm pond showed added advantage of reclaiming an area upto a radius distance of 27 meters by periodical pumping of saline water into the drain and flushing it out. The periodicity of pumping, intensity and distribution of rainfall were major factors governing the leaching and recharging processes in such pond.

Effect of factory effluent, organic manures and inorganic fertilizers on growth, yield and nutrient uptake by okra in lateritic soil of Konkan

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Abstract

A field experiment on "Effect of factory effluent, organic manures and inorganic fertilizers on growth, yield and nutrient uptake by okra in lateritic soil of Konkan" was conducted with Randomized Block Design comprising thirteen treatment combinations replicated thrice at Central Experiment Station, Pangari Block, Wakawali, Dr.B.S. Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri during *Kharif*, 2012, where the effect of application of effluent concentrations @ 25, 50, 75 and 100 per cent along with 100, 75, 50 and 25 per cent RDF with FYM and vermicompost was studied.

The data on the growth parameters, yield attributing characters, yield and uptake of N, P, K, Zn, Cu and Na revealed that the application of lower dose of effluent i.e. 25 per cent effluent + 100 per cent RDF + FYM (T_3) had recorded the higher favorable parameters. The data on soil fertility indicated that the application of effluent resulted in a significant increase in soil pH, EC, organic carbon, available N, P, K, Ca, Mg and micronutrients (Fe, Mn, Zn, Cu and Cl), Na contents in the soils, indicating build up of soil fertility with the increasing doses of effluent, which further increases with organic manure addition.

Considering the green fruit yield response, uptake by plants and build up of soil fertility, application of 25 per cent effluent with 100 per cent RDF and FYM was found to be suitable for okra in lateritic soils of Konkan.

Effect of Seed rates and Nitrogen levels on direct seeded rice variety panvel 1 under coastal saline soil condition

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Abstract

An experiment was conducted during Kharif season of 2009-10, 2010-11 & 2013-14 at Khar land research station, Panvel Pargoan farm, to study the effect of Seed rates and Nitrogen level on direct seeded rice variety panvel 1 under coastal saline soil condition. The experiment was carried out in split plot design with 3 replications. There were 16 treatments consist of 4 seed rates(40, 60, 80 & 100 kg ha^{-1}) as main plot and 4 nitrogen levels (0, 50, 100, 150 kg ha^{-1}) as sub plot treatments. The three years pulled data revealed that when rice crop seeded @ 100 kg ha-1 recorded significantly higher grain yield (42.76 q ha^{-1}) than rest of treatments except seed rate 80 kg ha-1(38.80 q ha^{-1}). In case of fertilizer levels, the maximum grain yield (42.28 q ha^{-1}) recorded from application of Nitrogen @ 150 kg ha^{-1}. The interaction effects were nonsignificant, maximum grain yield (48.59 q ha^{-1}) obtained from seed rate 100 kg ha^{-1} + 150 kg N ha^{-1}. In case of straw yield, it was revealed that when rice crop seeded @ 100 kg ha^{-1} recorded significantly higher straw yield (52.53 q ha^{-1}) than rest of treatments. In case of fertilizer levels, the maximum straw yield (45.23q ha^{-1}) recorded from application of Nitrogen @ 150 kg ha^{-1}. The interaction effects were nonsignificant, maximum straw yield (52.53 q ha^{-1}) obtained from seed rate 100 kg ha^{-1} + 150 kg N ha^{-1}.

Assessment of Nutrient status of soil from Cashew orchard of Lateritic soil of Konkan

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Abstract

Representative surface soil samples from depth of 0-15 cm were collected at different three stages (viz. before fertilizer application, after fertilizer application and at harvest) of Ratnagiri district. The collected soil samples were analyzed to assess the nutrient status of soil. The soils were slightly acidic in reaction. The electrical conductivity showed variation at all stages, it increases after fertilizer application and declines at harvest stages. Organic carbon content of soil at different stages showed an increase upto fertilizer application stage, but it decreased at harvest stage.

The N, P_2O_5, and K_2O content in cashew orchard after fertilizer application stage was found to significantly increase. The highest N content *i.e.* 827.87 kg ha^{-1} observed after fertilizer application stage. Thereafter, decreasing trend of available N at harvest stage is observed in all the samples. The average P_2O_5 content *i.e.* 32.04 kg ha^{-1} was recorded after fertilizer application and decrease gradually 24.72 kg ha^{-1} at harvest. Similar trend are observed in available K_2O content in soil, it showed highest availability content after fertilizer application. The DTPA extractable (Fe, Mn, Zn and Cu) micronutrient status of the soil at different stages showed similar maximum availability after fertilizer application and thereafter it decreases at harvest stage in all micronutrient.

Conservation tillage on energy utilization, soil health and crop yield under rice-cotton cropping system in coastal agro-ecosystem

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Abstract

Considering the benefit of conservation tillage in rice based cropping system a field experiment was carried out at coastal region of West Bengal to evaluate its impact on soil health, energy utilization and crop yield under rice-cotton cropping system. The design of experiment is split-split plot with cropping system (rice-rice and rice-cotton) (Kharif—rabi) as main plot treatments and tillage type (zero tillage (ZT), Reduced tillage (RT), and Conventional tillage (CT) as sub plot treatments. The ZT was defined as no puddling- transplanting of rice during kharif, and no puddling transplanting of rice or cotton during rabi season; RT defined as one summer plough-transplanting of rice under no puddling during kharif, and one ploughing-no puddling and direct seedling for rabi rice and one ploughing for rabi cotton; and CT defined as one summer plough, two puddling-transplanting of rice during kharif and one ploughing, two puddling-transplanting of rice or two ploughing followed by cotton seeding/transplanting during rabi. The second year of the study showed that there was 10-23% yield reduction in case of ZT than other treatments and yield reduction was more in rice-cotton system than rice-rice system. The weed infestation was higher in no till system and it was more in rice-cotton system than rice-rice system. The soil salinity (EC) was more in rice-cotton system than rice-rice system in both the seasons and organic carbon was slightly more in rice-rice system than rice-cotton system. Exchangeable Mg was slightly more than exchangeable Ca. Exchangeable Na was relatively more in cotton-rice system than rice-rice system. Bulk soil EC analysed using salinity probe also indicated higher EC in rice-cotton system than in rice-rice system.

Though there was no significant difference in soil properties among treatments, increase in bulk density was noticed in case of zero tillage than other treatments. The operation wise energy utilization pattern in each treatment was evaluated. More than 80% of energy was used for indirect energy of application of inorganic fertilizer. Rice-rice system was more efficient in energy utilization than rice-cotton system and the results showed reduced tillage under rice-rice system was most efficient than other treatments.

Soil micronutrient deficiency management for quality forage and livestock production

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Abstract

To ascertain the status of micronutrient in soil-plant-livestock continuum samples of soil, fodder and blood were collected from various locations. Among green fodders Ca content ranged from 0.31-1.15 %, P 0.12-0.31 %, Mg 0.22-0.41 %, Cu 5.67-15.03 ppm, Zn 13.12-59.37 ppm, Mn 31.22-50.26 ppm and Fe 89.64-317.26 ppm. In dry forages, Ca content ranged from 0.33-0.94 %, P 0.03-0.11 %, Mg 0.08-0.28 %, Cu 2.33-8.67 ppm, Zn 10.36-24.83 ppm, Mn 28.22-189.97 ppm and Fe 109.61-323 ppm. Green leguminous fodders were generally good source of almost all macro and trace element analyzed, while non-leguminous fodders were low in P, Cu and Zn. Similarly, dry leguminous forages were poor source of P and Zn and dry non-leguminous forages were meager source of P, Mg, Cu and Zn. Blood sample also collected and there was wide spread deficiency of Zn Cu and P in all the regions. To augment the micronutrient concentration in forages a field experiment was conducted to develop the best INM practice. Seed priming and VAM application with 50% recommended dose of micronutrients (RDM) were effective in producing green and dry forage yield of sorghum + cowpea and oat equivalent to 100% RDM (20 kg Zn, 10 kg Mn and 5 kg Cu /ha), resulting in 50% saving of the micronutrient fertilizer recommended for these crops.

There was significant increase in the Zn, Cu and Mn content in oat due to adoption of best management practices identified in field experiment. Similar results were also obtained for sorghum but extent of enrichment was relatively less than oat. Micronutrient enrichment in forages was in the range of 1.1-1.2, 1.4-1.6 and 1.1-1.2 times for Zn, Cu and Mn, respectively. Feeding trial conducted on adult sheep showed that micronutrient biofortification in oat and sorghum resulted in significant increase in nutrient intake and body retention. Absorption coefficient of Zn from biofortified oat (20.03%) was also significantly higher than the normal fodder (16.7%). For other nutrients absorption coefficient was not significant.

Agroforestry Options for Improving Livelihood and Rehabilitation of Degraded Sodic Lands

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Abstract

Worldwide, salt – affected areas are estimated to range from 340million ha to 1.2 billion ha (FAO 2007). Millions of hectares of these salt affected soils are suited for agricultural production but are unexploited because of salinity/sodicity and other soil and water related problems. In India, salt affected soils occupy about 6.73 million hectare; 3.60 million hectare are sodic soils. Indo-Gangetic plains lies between 21^0 55' to 32^0 39^0N and 73^0 45' to 88^0 25'E comprising of the states of Punjab, Haryana, Uttar Pradesh and part of Bihar (North), West Bengal (south), and Rajasthan (north) is having about 2.7 million hectare salt affected soils. This area is progressively expanding because of improper soil and water management and development of water logging and soil salinization upon introduction of irrigation in arid, semi-arid, and sub-humid regions. Sizable area of sodic soils in the Indo- Gangetic plains has been reclaimed through chemical amelioration techniques and is now supporting rice-wheat cropping system. However, a large tract of alkali soils is constituted by village panchayat lands (lands having common property rights), government lands reserved for specific purposes, and the lands lying abandoned near roads, canals, and railway tracks. Reclamation of such lands for crop production through chemical amendments is posing social problems owing to common property rights. Reclamation of sodic soils may be achieved through different Agroforestry systems which ameliorates the soil to various degrees through the addition of large amount of organic matter and nutrients from litter and fine roots and improve the physical and chemical properties as well as biological activity in the soil.

Long-term field studies were conducted at Central Soil Salinity Research Institute, Regional Research Station, Lucknow (26° 47′ 58″ N and 80° 46′ 24″ E) to monitor the performance of different agroforestry systems on livelihood improvement and rehabilitation of degraded sodic lands. Tree-based silvicultural system consists of ten multipurpose tree species (*Terminalia arjuna, Azadirechta indica, Prosopis juliflora, Pongamia pinnata, Casuarina equisetifolia, Prosopis alba, Acacia nilotica, Eucalyptus tereticornis, Pithecellobium dulce and Cassia siamea),* silvipastoral system characterized by tree species *Prosopis juliflora* and *Acacia nilotica* along with grass species (*Leptochloa fusca*, *Panicum maximum*, *Trifolium alexandrium* and *Chloris gayana), pastoral system comprises of* grass species (*Leptochloa fusca, Panicum maximum, Trifolium alexandrium* and *Chloris gayana) and silviculture system with Jatropha curcas* were evaluated. Ten years study revealed that among the Agroforestry systems evaluated, silvipastoral system proved highly sustainable and economically viable option for improving livelihood and rehabilitation of degraded sodic lands. The growth of ten-year-old tree species planted in combination with grasses was significantly higher over the silviculture systems. Tree biomass yields planted under silvipastoral systems were significantly higher than the sole plantation of tree species. Among the fodder species evaluated under pastoral system C*hloris gayana* found highly sodicity tolerant, shade loving and palatable grass species. Inter-cultivation of medicinal and aromatic crops like Tulsi (*Ocimum basilicum L.)* and Matricaria (*Matricaria chamomilla*) with *Jatropha curcas* for four years found highly remunerative agroforestry system under sodic soils. Fodder yield under the pastoral system was significantly higher than the silvipastoral system during initial years but it was at par with that of silvipastoral systems after eight years of plantation. Soil rehabilitation in terms of reducing soil pH,

displacing Na^+ from the exchange complex, increasing organic carbon and available N, P and K. Improvement in soil physical properties such as bulk density, porosity, soil moisture and infiltration rate was higher in silvipastoral system than other Agroforestry systems evaluated. The microbial biomass carbon under silvipastoral systems was higher than the silviculture and pastoral systems.

Impact of Land Configuration under Coastal Saline Soil Condition on Yield and yield attributes of rainfed Bajra

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Abstract

A field experiment was conducted (2009-2012) at Bajra sub Research Station, J.A.U., Mahuva (Gujarat) on Coastal alluvial soil in SPD consisting of land configuration treatments. The results obtained that significantly higher grain and fodder yield, test weight and effective tillers per plant from main plot treatment with broad bed furrow system than ridge and furrow system. Almost similar results were observed on test weight and effective tillers per plant in case of sub plot treatment i.e. application of mulch @ 3 t ha^{-1}.

Response of Groundnut (*Arachis Hypogaea L.*) to phosphate solubilizers under costal saline soil

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Abstract

A field experiment was conducted on coastal saline soil during kharif 2013 at Agricultural Research station, J.A.U., Khapat (Dist: Porbandar, Gujarat) grown groundnut cv. GG-13.The results revealed that the T_{12}: 50% recommended dose of N and P through Urea and rock phosphate along with Y_1 (*Geotricum* spp.) Inoculated seed gave significantly higher pod (2917 kg ha^{-1}) and haulm (2792 kg ha^{-1}) yield, higher P content in soil and P uptake by pod over their full recommended dose in the form of urea and DAP (control) and P uptake by haulm was significantly higher with T_{16}: seed inoculation with Y_1.

Impact of organic mulch, soil configuration and soil amendments on yield of onion and soil properties under coastal saline condition

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Abstract

A field experiment was conducted in a coastal saline region of Saurashtra of Gujarat state at Junagadh district during 2010-2013 on the impact of surface organic mulch, soil configuration and soil amendment on yield of onion crop. Pearl millet husk was applied as surface organic mulch at 3 t/ha. Gypsum was broadcast at 5 t/ha and incorporated before sowing. The furrow of 15 cm deep by 45 cm wide was made. The result revealed that the treatment of flat bed with surface organic mulch gave significantly higher onion bulb yield. The effect of the gypsum and soil configuration was found non-significant on the yield of onion bulb in the pooled data. At the end of the experiment soil analysis data indicate that significantly lower EC and ESP was recorded with mulch treatment in Flat bed or ridge and furrow method. Thus the mulch treatment was effective for reducing soil salinity. Similarly, the maximum net return of Rs.22220 per ha with net CBR 1:22.2 was also noted with flat bed with mulch treatment.

Evaluation of *rabi* vegetable crops under solar drip irrigation system using harvested rain water in Sundarbans region

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Abstract

In Sundarbans area the lands are flat with little or no slope and often suffer from inadequate drainage, submergence, and waterlogging during rainy season. The low lands and heavy textured surface soil provides the farmers little option to grow vegetables during this season. In post monsoon period (*rabi* season), rainfall is very low and erratic and there is scarcity of fresh water for growing crops. Only around 10% of cultivable land is used for cultivating vegetables during the *rabi* season. A field experiment was carried out at ICAR-CSSRI, RRS,Canning Town farm during the rabi season of 2013-14 to evaluate the performance of vegetables under solar drip irrigation system. The upland created by land shaping techniques adjacent to the farm pond was selected for cropping. Four types of crops such as Tomato, Beet, Knol-khol, and Chilli were chosen on the basis of suitability to the soil type and market demand. Normal dose of fertilizers was applied in three splits during the crop growing period. All the crops except chilli performed well in terms of economic production, the former was affected due to infestation of leaf curl virus, which is a major problem for chilli cultivation in the Sundarbans. The net return was highest in case of tomato due to higher market demand as well as price. The cost of cultivation of rabi season vegetables was reduced due to introduction of solar drip irrigation system as there was 60 % saving of labour.

Theme 2

Advances in remediation and management of poor quality waters

Sodic Irrigation Management for Sustaining Crop Productivity

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Abstract

Irrigation water is one of the most critical and scarce resource for agricultural production in arid and semiarid regions. The lack of good water supplies for irrigated agriculture is now becoming a major issue that is forcing farmers to use low quality waters. Due to limited surface water resources, good quality underground aquifers are continuously getting depleted. Ground waters in many arid and semi-arid areas contain high concentration of soluble salts that can adversely affect crop production. Nonetheless injudicious use of sodic waters poses grave risks to soil health by deteriorating physical, chemical and biological properties of soil. Development of salinity, sodicity and toxicity problems not only reduces crop productivity but also limits choice of crops to be grown. It is therefore imperative that irrigation development plans are carefully drawn and executed to sustain crop production with minimum deterioration of soil health with long-term use of sodic water. Options are now becoming available have now emerged to judiciously use sodic waters. This has led to the replacement of too conservative water quality standards by site-specific guidelines where factors like soil texture, rainfall and crop tolerance have been given due consideration. Nevertheless, appropriate selection of crops, improvement in water and fertility management, maintenance of soil structure and tail water return systems are still necessary. Some available technologies and practices for sustaining irrigation with sodic waters are discussed.

Advances in remediation and management of poor quality waters of Rajasthan

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Abstract

Reliable screening is an integral part of salt related management programme. All crops do not tolerate salinity equally well. The ability of crops to tolerate salinity has usually been determined by measuring one or more of the three criteria (i) plant survival (ii) absolute plant growth or yield, and (iii) relative growth or yield. In addition to intergenic variations, crop cultivars have been identified in their rating for higher yield potential, salt tolerance and stability under saline environments. Results of an experiment on performance of ber with saline water using drip irrigation revealed that highest yield was obtained at 0.8 PET for both saline and BAW water. Further, no significant difference was observed in yield levels for saline and BAW water, both under mulched and unmulched conditions. It can be inferred that saline water upto 8.0 dS/m can be successfully used for ber cultivation under drip irrigation without any significant reduction in yield. Results of experiments to study the tolerance of okra, brinjal and onion with different salinity levels of irrigation water (0.25, 3.0 & 6.0 ds/m) under drip and flood method of irrigation revealed that maximum yield of these vegetables obtained under drip irrigation with water having EC 3.0 dS/m and a significant decrease in yield was observed with water having EC 6.0 dS/m.

Often water of more than one quality is available at the same location. One such situation commonly arises when farmers have limited supplies of canal water along with saline ground water. The existing fresh and saline water supplies could be suitably combined in several ways for optimizing output. Saline water in conjunction with good quality water can be used if one or two irrigation or good quality water is applied at the initial stages rather than at later stages. If two sources of water of variable quality are available, under mixing mode, mixing of good and saline irrigation water should be done in such a way that EC of mixed water does not exceed beyond 3.75 dS/m for groundnut and 5.0 dS/m for wheat under flood irrigation system in light textured soil. Magnetized water can mitigate the injurious effect of salts and enhances the length of plumule and radicle in presence of salt stress. Therefore, it is supposed that magnetized saline water could be used for growing of crops successfully. Research finding on use of RSC water indicated that in pearl millet, cluster bean and mustard crop water having RSC up to 4.0 me/l can be safely used for irrigation without any adverse effect on yield in light textured soils provided gypsum is added to the soil @ 50 % GR. Barley can tolerate RSC of irrigation water up to 8.0 me/l. Gypsum application reduced the alkalinity of soil and was also helpful in restricting further degradation of alkali. Gypsum @860 kg/ha is required for neutralizing of each me/l RSC of water per irrigation. Three years' study on mitigating adverse effect of high RSC water revealed that for sustainable production of pearlmillet-wheat crop rotation in sandy coarse textured soils under sprinkler system with water having RSC around 10.0 me/l gypsum @ equivalent to 5.0 mel^{-1} RSC neutralization of each irrigation with FYM @10t/ ha should be added in soil treated water. As the major proportion of saline water cannot be used for drinking and most of it is not suitable for agriculture too. Now, due to advancement in management technologies, it is possible to irrigate with salty water, which in past was considered unsuitable for agriculture and to get bumper crops of small areas.

Technological interventions for use of poor quality waters for sustainable crop production in diverse agro-climatic conditions of India

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Abstract

Irrigation has long played a key role in feeding the burgeoning world population particularly countries like India and China and is expected to play a greater role in the future. As supplies of good quality irrigation water are expected to decrease in several regions due to increased municipal-industrial-agricultural competition, available freshwater supplies need to be used more efficiently. In India, many parts of the arid and semi-arid regions, ground water is of poor quality and farmers have to face several problem which leads to unsatisfactory returns from their lands. Most of the ground water is highly saline and also has high residual sodium carbonate which is a serious problem. Amongst the various categories of poor quality waters, alkali water have greater irrigation potential by virtue of low salinity and amenability for reclamation in semi-arid and arid regions. Scarcity of good quality water in these regions often forces the farmers to use available poor quality water including treated/ untreated sewage water for irrigation. In addition reliance on the use and reuse of saline and/or sodic drainage waters, generated by irrigated agriculture seems inevitable for irrigation. The same applies to salt affected soils, which occupy about 6.73 million hectares of the agricultural lands and warrants attention for efficient, inexpensive and environmentally acceptable management. Technologically and from a management perspective, a couple of strategies have shown the potential to improve crop production under irrigated agriculture while minimizing the adverse environmental impacts. In arid and semi arid regions, water is becoming an increasingly scarce resource and planners are forced to consider any sources of water which might be used economically and effectively to promote further development. Concern about the proper utilization of poor quality waters for crop production in areas where their use is inevitable is not new.

The strategies involved are use of amendments for neutralization of sodic waters using gypsum, phosphogypsum, distillery spent wash, pyrites and other industrial by products acidic in nature. In case of continuous use of saline water, salts can be leached through subsurface drainage, raised and sunken bed technique, conjunctive use with canal water, use of sprinkler and drip irrigation systems tolerant crop and tree species, alternate land use. In coastal saline soils, improved doruvu technology proved a beneficial technique of using good quality rain water overlying the saline waters whereas land shaping interventions helped in in-situ rainwater harvesting for managing salinity. Controlled subsurface drainage proved better for conserving water and nutrients in saline Vertisols. In low rainfall areas where underground water is poor, low cost recharge technology provides 2-3 life saving irrigation to low water requiring crops in dry regions. Treated sewage effluent could be used to grow flower and fodder crops in the vicinity of urban areas. These strategies foster dedicating soils to crop production systems where saline/sodic waters predominate and their disposal options are limited. Plant production systems based on salt tolerant plant species using drainage waters may be sustainable with the potential of transforming such waters from environmental burden into an economic asset. Such a strategy would encourage the disposal of drainage waters within the irrigated regions where they are generated rather than exporting these waters to other regions via discharge into main canal, streams or rivers. Being economically and environmentally sustainable, these strategies could be the key to future agricultural and economic growth and social wealth in regions where saline/sodic drainage waters are generated.

Irrigation potential of industrial treated effluent from Aniline- TDI Plant: Ideal Crop Interventions

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Abstract

Environmental pollution is the major problem associated with rapid industrialisation, urbanisation and rise in living standards of people. For developing countries, industrialisation is a must and still this activity is very much in demand to build self reliant and in uplifting nation's economy. However, industrialisation on the other hand has also caused serious problems relating to environmental pollution, thus indicating the industrial wastes seem to be a by-product of growth. The country like India can ill-afford to lose them as mere waste. To minimize the harmful effects of such wastes on land, recycling and reprocessing of wastes from different sources and/or putting them to productive use is necessary. Increasing efficiencies in crop production management and the continuing increases in crop yields have increased demands on water resources for irrigation purpose. A major mechanism that can be used to achieve greater efficiencies is the reuse of water that once would have been discarded into the environment after use. Recycled water or treated industrial effluent water can have the advantage of being a constant, reliable water source and reduce the amount of surface/ground water to be used. As water is becoming a scarce commodity for agriculture, possibilities of using treated effluent in diverse crop interventions thus merits attention.

The Aniline-Toluene Di-isocyanate Plant of Gujarat Narmada Fertilizers and Chemicals Ltd., Bharuch, a main producer of TDI uses Benzene as the precursor produces effluent which is subjected to different treatment processes, before releasing the treated effluent downstream through Garamia Kans. The treated effluent has been used for irrigation either as sole or in dilution with best available water in diverse crop interventions viz., oilseed crops, spices, forages, floriculture and biofuel species. The treated effluent from the petrochemical unit has been effective in increasing the oil seed crops yields mainly due to the nutrients is contained and also due to the absence of any toxic constituents.

Results of the study indicated that yield of oil seed crops increased to a tune of 22.2 per cent in castor and 8.46 per cent in mustard with the treated effluent over BAW. The increase under diluted effluent irrigation is marginal. In seed spices, the yield increased to a tune of 30.8 per cent in fenugreek, 18.1 per cent in dill and in ajwain, the increase was only 10 per cent with treated effluent over BAW. Among the forages, yield in rajka bajra increased to a tune of 49 per cent, 38.4 per cent in fodder sorghum and 22.98 per cent in maize under the treated effluent over BAW. Even with the diluted effluent, the forages sorghum, maize and rajka bajra showed 26, 17.8 and 31.4 per cent increase in biomass, over the control. Among the flower species, tube rose showed increased number of spikes to a tune of 35.2 per cent by pure effluent (treated) and 26.6 per cent under diluted effluent treatment over BAW. In the biofuel species, Jatropha curcas, the plants irrigated with treated effluent at 20 and 30 day interval, however, showed only a marginal difference in seed yield. By foregoing the yield loss of 12 per cent under 30 day interval irrigation, a huge amount of precious effluent can be saved when compared to the irrigation given at 20 day interval. Studies also indicated that plants irrigated at 30 days interval had higher water productivity of 6.17 kg/cu.m followed by

plants irrigated with 20 days interval (3.26 kg/cu.m.) and 10 days interval (1.82 kg/cu.m). Irrigating the crop at 30 days interval thus provides an opportunity for saving the marginal quality water like industrial effluent. In all the interventions, irrigating the crops with diluted effluent resulted in 50 per cent in water savings, treated effluent as sole source of irrigation resulted in one hundred per cent savings in fresh water, thus indicating the efficacy of the treated effluent.

Potential of Sewage Recycling in *Eucalyptus* Plantations

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Abstract

The gap between wastewater generation to its treatment and safe disposal has been widening in resource constrained developing countries of the world. In India, the total sewage generation is about 38,254 MLD (13.97 km^3/year), of which only 11,787 MLD (4.30 km^3/year i.e. about 31%) is given primary treatment (Kaur et al., 2012). Estimates suggest that the wastewater generation will reach 132000 MLD by the year 2051 when country's population is expected to stabilize (CPCB, 2009). The conventional wastewater treatment methods are energy and cost-intensive. Therefore, the most of developing nations dispose off wastewater either raw or after partial treatment in surface water bodies leading to their eutrophication, inject deep in groundwater thus polluting it or used for irrigation in peri-urban agriculture contaminating the food chain with pathogens and toxic substances.

Wastewater irrigation in high transpiration rate forest species has been proposed for its recycling and conservation of inherent nutrients in biomass and thus providing multiple benefits like fuel wood, environmental sanitation and ecosystem-restoration. However, there are contradictions on their water use potential because of lack of long-term information on loading rates that these plantations can carry. Thus, a 10 year long-term study was conducted to assess the temporal changes in growth and water use patterns of *Eucalyptus tereticornis* block plantation (1250 stems ha^{-1}) irrigated with wastewater at variable loading rates of 1.0, 1.5, 2.0, 2.5 and 3.0 ID/CPE ratio keeping irrigation depth fixed at 70 mm. A block of 2 rows of 40 plants, separated by 2 rows as buffer, was supplied irrigation at each of loading rates. These were monitored for growth, carbon assimilation, transpiration rate and consumptive use of water at six monthly intervals.

The growth in terms of height, DSH, DBH, biomass and carbon assimilation increased with increasing rates of wastewater application up to loading rate of 2.5 ID/CPE, but the transpiration increased only up to loading rate of 2.0. After 10 years of growth, plant height, DBH, dry biomass and carbon assimilation increased from 19 m, 21 cm, 274 tha^{-1} and 87 tha^{-1} under irrigation at 1.0 ID/CPE to 21.6m, 23.4cm, 308 tha^{-1} and 102 tha^{-1} with 2.5 ID/CPE, respectively. The annual transpiration of plantation irrigated at 2.0 ID/CPE increased from ~820 mm in 3rd year to an almost stabilized figure of ~1700 mm in 7th year. The transpiration rates increased with age until 7th year in proportion to tree growth rates. The maximum mean annual transpiration of *Eucalyptus* varied from annual open pan evaporation and potential evapo-transpiration by a factor of 0.57 and 0.59 times in 3rd year to high as 0.94 and 1.10, respectively from 7th year of growth onwards. Observations suggest that *Eucalyptus* plantations can serve as safer potential sites for regulated sewage disposal at loading rates at $\leq$ 2.0 ID/CPE.

Utilization of sewage water with drip irrigation: Study on backpressure

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Abstract

The backpressure was calculated from the soil parameters i.e. saturated hydraulic conductivity and sorptive number and including cavity radius which is affected by both soil and emitter configuration. Experiment was conducted to determine saturated hydraulic conductivity and sorptive number. There was wide variability in these parameters. The effect of cavity radius is highlighted. At present backpressure predicting equation is valid for limited discharge only. The research gap solution may help expansion of drip irrigation technology globally.

Utilisation of distillery spent wash as an alternate source for Gypsum for boosting the rice yield in sodic soils

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Abstract

Distillery spent wash (DSW) a waste water generated from distillery industries is highly acidic (pH 4- 5) and contains fairly good amount of Ca and Mg and other essential plant nutrients. Hence this could be used as an organic amendment to improve the soil properties particularly in reclamation of non-saline sodic soils. Therefore to study the influence of DSW on soil properties and yield of rice crop in sodic soils, the on farm field experiments were conducted at 6 locations in Thiruchirapalli district of Tamil Nadu. Distillery spent wash was applied @ 5 lakh liters per hectare and DSW reclamation technology procedure was followed. The results showed that application of DSW @ 5 lakh litres per hectare along with package of practice tremendously increased the grain and straw yield of rice. The grain yield increased to the tune of 1560 to 2428 kg / ha in various locations due to application of DSW along with package of practice when compared to control. The initial soil properties at various locations indicated that pH varied from 8.6 to 10.0, EC varied from 0.68 to 1.18 dSm^{-1} and ESP varied from 24 to 32 per cent. The post harvest soil analysis revealed that application of DSW considerably reduced the pH and ESP of soil. The pH reduced to the level of 8.3 - 8.8 and ESP to the level of 14 - 19 per cent. Application of DSW slightly increased the EC of post harvest soil. The potential of distillery spent wash to supply H^+ (since DSW is highly acidic), Ca^{++} and Mg^{++} has been used as a basic principle to reclaim the sodic soil (i.e., to replace Na^+ ions in the soil exchange complex). The application of DSW not only reclaimed the sodic soils but also supplied the essential nutrients especially K, N, S and other micronutrients. Hence the DSW can be used as an alternate source for gypsum to reclaim the sodic soil and to increase the yield of rice crop.

Response of cotton (*Gossypium hirsutum L.*) to drip and surface irrigation in saline Vertisols of Thugabhadra irrigation command area under conservation agricultural practices

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Abstract

Field experiment was conducted in saline (6-8 dSm^{-1}) Vertisols during 2011-12 to 2013-14 for evaluating the response of cotton (*Gossypium hirsutum L.*) to applied irrigation water (IW, 0.8, 1.0 and 1.2 ET) with drip and furrow irrigation method under zero till mulch (paddy straw @ 6.85 t ha^{-1}) and no mulch treatments. The pooled data of three years revealed that the soil moisture content was significantly more in mulch with 1.2 ET and least in no mulch with furrow irrigation in all the three growth stages of the crop and at all the four depths of soil (0-15, 15-30, 30-45 and 45-60 cm). Significantly higher seed cotton yield was obtained in case of drip irrigated at 1.2 ET (27.16 q ha^{-1}) which was on par with drip irrigated at 1.0 ET (26.16 q ha^{-1}) and least in case of furrow irrigation (21.05 q ha^{-1}). Among mulch treatments, significantly higher yield was obtained in case of mulch treatment (26.49 q ha^{-1}) compared to no mulch treatment (23.01 q ha^{-1}). Net saving in irrigation water through drip irrigation was 44, 29.4 and 16.8 per cent at the irrigation levels of 0.8, 1.0 and 1.2 ET, respectively as compared to the irrigation through furrow method. In ET treatments, water production efficiency was significantly higher in drip irrigated with 0.8 ET (0.78 kg m^{-3}) followed by drip irrigated with 1.0 ET (0.67 kg m^{-3}), drip irrigated with 1.2 ET (0.59 kg m^{-3}) and least in flood irrigated treatment (0.38 kg m^{-3}). In mulch treatments, significantly higher water production efficiency were obtained in mulch treatment (0.65 kg m^{-3}) compared to no mulch treatments (0.56 kg m^{-3}).

Soil C pools and N mineralization as influenced by application of soil organic amendments and saline irrigation on Vertisol

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Abstract

An incubation laboratory experiment was conducted to ascertain the effect of soil amendments including industrial wastes on soil properties and nutrient mineralization under different levels of salinity (2 and 8 dS/m). The treatment included, farmyard manure (FYM), horse manure (HM), vermicompost (VC), fly ash (FA), biological sludge (BS), phosphogypsum (PG), ETP sludge (ETPSL) and pressmud (PM). After addition of amendments water of 2.0 and 8.0 dS/m were added to amount equal to 50% of field capacity and incubated at 28°±1°C for 8 weeks. The loss in weight due to the moisture loss was replenished. Sampling was performed at 1, 2, 4, 6 and 8 weeks interval and the soils were analyzed for different for soil properties. Soil organic carbon (SOC) values ranged from 0.25 to 2.75% in salinity level 2dS/m and 0.32 to 1.85% with 8dS/m. SOC was build up of in 2nd to 4th week and thereafter got stabilized or slightly declined. At 2dS/m salinity, maximum SOC was observed in VC amended soil followed by fly ash and HM. While at 8dS/m salinity, maximum SOC was observed in VC amended soil followed by HM, FYM and fly ash amended soils. As compared to the control (0.42% OC), there was build up of 1.79% of SOC at the 4th week in soils amended with VC at imposed salinity of 2dS/m and only at 2nd week of incubation, PG resulted in the maximum SOC content. At 8dS/m salinity, 1.9% SOC was observed in soil amended with VC followed by 1.79% SOC in HM amended soil at 8dS/m which was attained only after 4th week of incubation.

Maximum total C content was observed in soil treated with vermicompost at salinity level of 2 dS/m. Whereas, the highest total carbon (%) was noted in soil under treatment of phosphogypsum (PG) and biological sludge (BS) at salinity level of 8 dS/m. There was net decline in total C content after 4th week of incubation in all the treatments. Maximum build up of total C was observed in PM treated soil at 2dS/m or 8dS/m salinity, while minimum in case of BS at 2dS/m and VC at 8dS/m. Mineralizable N content decreased in all the treatments at both salinity levels. The maximum mineral N content was observed at 8th week of incubation in soil amended with horse manure followed by vermicompost and farm yard manure at both salinity levels. However, as compared to control, minimum amount of mineral N was noted in fly ash amendment. Among industrial wastes, higher N was mineralized in biological sludge (BS) than ETPSL or press mud at both levels of salinity. Decrease in available nitrogen status was observed when salinity was increased from 2dS/m to 8dS/m. At 8dS/m salinity level the alkaline phosphatase activity was maximum in soil treated with phosphogypsum and horse manure as compared to other amendments. Alkaline phosphatase increased at 4th and 6th week of incubation in all treatment over early stages of incubation at 8dS/m salinity level.

Low cost technology for dilution of saline groundwater aquifer through rain water recharge at farmer's field

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Abstract

The shortage of water resources of good quality is becoming an important issue in the arid and semi-arid zones. For this reason the availability of water resources of marginal quality such as drainage water, saline groundwater and treated wastewater has become an important consideration. The Ground water recharging work was initiated in 2005-06 in Operational Research Project at Odara Village, Bharatpur district of Rajasthan with that to reduce the salinity level of groundwater and maintain the water table. The ground water salinity of selected farmers was varied from 10.0 to 23.5 dS/m. Tube well bore were used for recharging of ground water by diverting the runoff, at farmers fields. The wheat crop was shown on selected farmer's field. 4 to 5 irrigations were applied at regular interval from the same bore well. The qualitative measurement of discharge water was also made. It was observed that at the time of first irrigation, the EC_{iw} was 2.0 to 6.6 dS/m, in second irrigation 5.2 to 10.0 dS/m, in third irrigation the 9.0 to 16.9 and further forth irrigation, the EC_{iw} increased up to 9.7 to 18.0 dS/m. The EC_{iw} depends on rain fall and rainfall pattern. The EC_{iw} increased with increasing irrigations. The impact of ground water on grain yield of wheat was also observed and found that about 10 to 15% yields increased as compared to un-recharged site. In general wheat yield increased 0.3 to 0.5 ton/hectare with recharge water as compared to those farmers which who used the saline water as such. It was also observed that at first site on third irrigation and other sites on second, third and fourth irrigation the water behaved as un-recharged and has almost reached as initial or some higher salinity in fourth irrigation and later at farmer's field. After harvest of *rabi* crop the soil salinity was less as compared to un-recharge site.

Effect of alkali water and gypsum application on growth and yield of wheat and soil properties in sodic soil

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Abstract

A field experiment was conducted at Crop Research Farm, Nawabganj during 2009 to 2014 with the initial pH 9.5, EC 2.42 dSm^{-1}, organic carbon 1.2 g kg^{-1} and exchangeable sodium percentage (ESP) 57.10. Tube-well water used for irrigation was alkaline in nature with pH 8.2, EC 1.19 dSm^{-1}, SAR 10.2 m $mol^{1/2}$ $L^{-1/2}$ and RSC 8.8 me L^{-1}. Application of gypsum @ 25%, 50% and 100% GR alone and in combination with alkali water passing through 15 cm gypsum bed was found significantly superior over control. The maximum grain and straw yield (38.43 and 43.63 q ha^{-1}) was recorded with the application of gypsum @ 50% GR and alkali water passing through 15 cm gypsum bed treatment in comparison to control. The changes in pH, EC, SAR and RSC values of alkali irrigation water were from 8.2 to 7.8, 1.19 to 1.47, 10.2 to 4.7 m $mol^{1/2}$ $L^{-1/2}$, and 8.83 to 4.02 me L^{-1}, respectively when the alkali water was passed through 15 cm gypsum bed. The maximum reduction in pH, EC and ESP was recorded 8.0, 1.87 dSm^{-1} and 20.0, respectively with the application of gypsum (50% GR) + 15 cm gypsum bed treatment. Use of alkali irrigation water (control) considerably raised the value of pH, EC and ESP of soil to 10.0, 2.83 dSm^{-1} and 66.15, respectively from the corresponding initial values. Highest B: C ratio (2.47) with net return of Rs. 43964 was accrued with the soil application of gypsum (50% GR) + gypsum bed (15 cm) treatment of alkali water followed by soil application of gypsum (100% GR) and lowest B: C ratio (1.11) with net return of Rs.3354 was observed in control plot. There was increase in uptake values of N, P, K, Zn and Mg due to different treatments over control, whereas, relatively lower uptake of Ca due to high concentration of exchangeable Na appeared to increase the adverse effect of sodium on plant growth in sodic soil and decrease in uptake value of Na due to decreasing level of ESP.

Effect of saline water irrigation and organic input management on performance of fennel (*Foeniculum Vulgare* Mill.) in semi-arid conditions

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Abstract

The use of organic inputs is popularly associated with natural and environment friendly techniques for sustainable agriculture. It comprises a system which avoids chemical inputs for production of crops. As we are aware that the availability of good quality irrigation water is meager and the alternate is use of poor quality waters for irrigation. Increasing shortage of good quality irrigation water in arid and semi arid regions of the country is forcing the farmers to utilize saline and alkali ground water for irrigation. India is a leading producer of spices and condiments; and the seed spices have unique position being the commodity of economic importance. In India, seed spice fennel (*Foeniculum Vulgare* Mill.) is grown in Gujarat, Rajasthan, Madhya Pradesh, Haryana and Uttar Pradesh covering an area of 100 thousand ha with production of 143 thousand tonnes in the year 2012-13. Since the crop is widely grown in arid and semi-arid regions where soil and water often contain high concentration of salts, farmers resort to irrigate it with saline groundwater.

A field experiment was conducted to assess the impact of saline water irrigation and organic input management options for sustaining productivity of high value spice crop fennel (var. Hisar Swarup HF-33). Saline water of low (EC_{iw}, 1.9 dS m^{-1}) and high (EC_{iw} 8.6 dS m^{-1}) salinity were used for irrigation to test the performance of the crop. These types of waters are commonly encountered in arid and semi-arid regions. Eight inorganic and organic input options were used to verify the hypothesis whether the adverse effect of saline water irrigations can be mitigated through organic inputs. Surprisingly the average seed yield of fennel with low and high saline water use was at par (1.56 ± 0.02 t ha^{-1}) showing its suitability for saline irrigation. Average seed yield of fennel under inorganic and organic input treatments ranged from 1.41 to 1.71 t ha^{-1}. The trend in yield over the years reveals that application of organic inputs in various combinations can play an important role in sustaining the yield through improvement in fertility of salt-affected soils especially when irrigated with poor quality water. Amongst all the combinations, farmyard manure + vermicompost (50:50 ratios for equivalent N) produced economically remunerative and sustainable yields over the years with a net income of about Rs 1.24 lakh per ha.

Impact of Agra canal water on ground water quality and soil properties in District Palwal (Haryana)

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Abstract

A survey was carried out at Management of salt affected soils and use saline water in Agriculture Project R.B.S. College, Bichpuri, Agra during 2009-10. To see the impact of Agra canal water on ground water quality and soil properties the site was selected in Palwal (Haryana) away 50 km from Okhala barrage. Five samples each from Agra Canal water and near by Agra Canal area underground water and three soil samples (Soil Profile up to 90 cm) each from canal water and underground water irrigated soils, were collected. These samples were analyzed with AAS at Directorate of Rapeseed and Mustard Research Sewar, Bharatpur (Raj). In all the samples of both Agra canal water and underground water, the heavy metals like Pb, Cr, Cd, Co, Zn, Fe and Mn were determined and found more than the limits given by the CPCB and WHO. The underground water near the Agra canal can't be used for drinking purpose for human beings as well as animals. As per soil samples analysis, the cations, anions and available nutrients were found maximum in soil irrigated with Agra canal water compare to underground water.

Evaluation of Underground irrigation water of Etawah district (U.P.)

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Abstract

Water is essential natural resource for sustaining all kinds of living beings and their environment. Irrigation water is one of the most critical but scare resource for agricultural production in India. Indiscriminate use of poor quality waters leads to development of salinity, sodicity and toxicity in the soil. To assess quality of underground irrigation waters 730 samples from eight blocks of Etawah district were collected and analyzed for Electrical Conductivity (EC), Residual Sodium carbonate (RSC), Sodium Adsorption Ratio (SAR) and presence of toxic elements like F, Li, NO_3 ions. The EC, SAR and RSC ranges from 0.46 to 10.0 dS/m, 0.31 to 42.2 $(mmol/l)^{1/2}$ and Nil to 25.7 me/l in all the eight blocks of Etawah district. After analysis 51.6% samples are classified under good quality (A) class, whereas, 8.1% as saline (B) and 40.3% samples come under alkali (C) class in the whole district. Saline water are further categorized under marginally saline (B_1-3.3%), Saline (B_2-1.3%) and high SAR saline (B_3-3.5%) classes in whole district. The alkali waters are also again sub grouped and found as marginally alkali (C_1-20.9%), alkali (C_2-2.2%) and high alkali (C_3-17.2%) in the block of Etawah district. The waters are of Na>Mg>Ca>K types. In 96 per cent samples, fluoride was found in safe category (0-2.5 ppm) and only 4.4 per cent samples were found in 2.5-5.0 ppm category. The nitrate was also determined in nitrate contain samples only and it was found that in these samples 92 per cent samples are in 0-2.5 (me/l), while as in 2.5-5.0 me/l category 3.3 per cent samples and rest of samples (4.2 per cent) were found in more than 10.0 me/l category.

Aquaculture of carps in triple salinity (saline-sodic soil & saline water) condition–a scientific study at CSSRI outreach experimental farm (Nain village Haryana)

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Abstract

High saline soil and water are unsuitable for arable cropping. Therefore a need is arising for its utilization for different type of aquaculture practices. The CSSRI outreach research farm of Nain village ($29^0$19'7.09'' to $29^0$19'10.0'' N latitude and $76^0$47'30.0'' to $76^0$48'0.0''E longitude) is located about 65 kms from its main campus Karnal. In the year 2012 to 2013 an experiment on aquaculture was conducted in the newly created 0.2ha pond. Different type of carp fish fingerling i.e. *Catla catla* (Catla), *Labeo rohita* (Rohu), *Cirrhinus mrigala* (Mrigal), *Ctenopharyngodon idella* (Grass carp), *Cyprinus carpio* (Common carp) were stocked at the size of 10g and at the stocking density of 10,000 Nos./ha. The standard method of pond management practices were followed with permissible modification for fish culture. The physico-chemical and hydro biological parameters of pond soil &water were studied. Standard pond management practices were followed with certain modification. Harvesting of 600-1000g size carp fishes was done after one year. Carp at (Nain village) pond had a production of 3.5tone/ha/ year using floating feed@5-10% of body weight of fish) with halophyte (Nonia plant/Noon-khari - *Suaeda fruiticosa*) from the nearby saline land as fodder for grass carp in the pond. Major soil and water parameter were bottom soil pH (8.97-9.73) , EC_2 (0.69-3.59) and pond water EC of 1.10-25.8 dS/m. Cases of mass mortality of fishes (400-600g) after six month rearing of carps was observed due to multiple factor. Presence of thick (30cm) Kankan stone/layer in the downwards profile below 1.20-1.50 meter created netting constraint for fisher and gears both in the peripheral area of pond. High water temperature, high pH, low wind actions were also observed to be major aquaculture constraints in this type of pond. Salinity buildup in bottom soil due to rain flooding of catchments, saline soil erosion, high evaporation of water etc. were also observed beside bird predation in aquaculture pond. This experimental study indicated possibilities of aquaculture with diversification of farming practice and species for the salt affected land and water pond of this part of country.

Evaluation of quality of underground irrigation water of Raibareli district, Uttar Pradesh

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Abstract

To evaluate the water quality is most important for Human being and agriculture. Keeping in view these facts the evaluation of water quality appraisal of the underground irrigation water of Raebareli district was done. Eight hundred thirty two underground water samples were collected from Raebareli district during 2011-12 for assessing the quality of water for irrigation. Total 832 samples were collected from different tehsils of the district.All the water samples were collected from running tube wells. The running tube wells were selected randomly for collection of water samples. Each selected tube well was run for three to four hours and then the samples were collected in thoroughly cleaned plastic bottles, properly leveled and brought to the laboratory for further chemical analysis. These underground water samples were analyzed for pH, EC, cations and anions. Sodium adsorption ratio (SAR) and residual sodium carbonate (RSC) were worked out.The ranges of pH, electrical conductivity, sodium adsorption ratio and residual sodium carbonate were from 7.0 to 8.3, 0.28 to 4.82 dSm^{-1}, 0.2 to 16.2 and 0.0 to 10.2 $meqL^{-1}$ in of district, respectively. The minimum and maximum values of CO3, HCO_3, SO_4 and Cl (anions) were recorded 0.0 to 3.2, 0.6 to 20.2, 0.2 to 9.0 and 0.4 to 35.0 $meqL^{-1}$ with a mean value of 0.5, 3.3, 1.5 and 5.7 $meqL^{-1}$ and Ca, Mg, Na and K (cations) were 0.8 to 30.2, 0.4 to 12.8, 0.6 to 25.9 and 0.01 to 0.12 $meqL^{-1}$ with a mean value of 4.9, 2.1, 4.3 and 0.03 $meqL^{-1}$ respectively. Sodium and calcium was dominant cations followed by magnesium and potassium. In case of anions, chloride and bicarbonate was dominant ion followed by sulphate and carbonate in the underground irrigation water of the district. Out of 832 water samples, 726 (87.26%) belongs to category good, 95 (11.42%) marginally saline, 2 (0.24%) saline, 2 (0.24%) highly saline, 3 (0.36%) marginally alkaline, 3 (0.36%) highly alkaline and 1 (0.12%) samples belongs to alkali in the district.

Effect of Irrigation Schedules of Domestic Wastewater on Fodder Sorghum

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Abstract

An experiment was conducted to evaluate the effect of domestic wastewater irrigation schedules on fodder sorghum. The experiment was conducted in factorial RBD with 4 replications, consisting of 9 treatment combinations of 3 quality water irrigation modes i.e. tube well water (TW), cyclic use of TW and sewage (SW) and sewage water at 3 regimes of ID/CPE ratio 0.8, 1.0 and 1.2. Results showed that sewage water irrigation and ID/CPE ratio 1.2 have resulted in significant increase in *chl-a*, *chl-b*, TSP, LAI as well as green fodder yield compared to TW and ID/CPE ratio 0.8, respectively. Across the water quality treatments, *chl-a* content in fodder at both the cuts, increased gradually with increase in use of sewage water for irrigation. The highest *chl-a* was recorded with SW irrigation at 1st cut (32.06µg/ml) and at 2nd cut (27.16µg/ml). The SW use recorded 19.18% higher *chl-a* at 1st cut and 9.56% at 2nd cut compared to TW. The highest *chl-a* observed at ID/CPE (1.2) at 1st and 2nd cut was 32.91 and 27.96µg/ml, respectively. The SW recorded 22.09% higher *chl-b* at 1st cut, 40.35 % at 2nd cut compared to TW. *Chl-b* content increased with gradual increase in ID/CPE ratio from 0.8 to 1.2.

A decreasing trend was observed for proline content with increase in sewage water use and ID/CPE ratio. Maximum proline accumulation was observed with TW at 1st cut (11.46µg/g) and 2nd cut (10.5µg/g). Proline content increased with gradual decrease in ID/CPE ratio from 1.2 to 0.8. The highest mean proline content observed at 1st and 2nd cut was 12.2 and 10.64µg/g, respectively with ID/CPE ratio 0.8. Protein content increased gradually from TW to SW irrigation at both cuts. The highest TSP recorded with SW irrigation at 1st cut (33.42mg/g) and at 2nd cut (29.0mg/g). The irrigation with SW resulted in 11.73% higher TSP at 1st cut, 11.92% at 2nd cut compared to TW. TSP increased with irrigation under ID/CPE ratio 1.2 at both cuts. The highest mean TSP recorded was 34.81mg/g at 1st and 30.5mg/g at 2nd cut with ID/CPE ratio 1.2. The highest LAI of 3.98 was observed in SW irrigation as compared to TW. The highest mean LAI of 3.9 was achieved when irrigation was scheduled at ID/CPE ratio of 1.2, while the lowest LAI of 3.5 was observed at ID/CPE ratio of 0.8. The increase in green fodder yield in sewage water irrigation was 14.39% at 1st cut and 25.0% at 2nd cut of sorghum as compared to tube well water use.

Phytoremediation potential of *Brassica juncea* exposed to brass and electroplating industry effluent fed soils

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Abstract

An experiment was conducted to evaluate phytoremediation potential of *Brassica juncea* exposed to brass and electroplating industry effluent-fed soil. A supporting experiment was also conducted in parallel with synthetic binary and single metal solutions of Cd and Cr to assess their impact on growth of plants. The values of Bio-Concentration Factor (BCFs) were highest in S2 treatments (i.e., BCF_{shoot} = 55 and BCF_{root} = 120). BCFS were higher for Cd than Cr. Translocation Factor for both Cd and Cr decreased with exposure duration and later, attained treatment dependent saturation values. The highest per cent removals for Cd (68%) and Cr (55%) were observed in S2 treatment. In single metal treatments, the percent removals for Cr (i.e., 34%, 40% and 50% at 16.5^{Cr}, 10.5^{Cr} and 7^{Cr} treatments, respectively) were higher than that for Cd (i.e., 15%, 35% and 53% at 10.5^{Cd}, 7^{Cd} and 4.5^{Cd} treatments, respectively). The photosynthetic pigments increased in S2 and S3 treatments due to supply of micronutrients, whereas the values decreased in other treatments. The total protein content from 10-25 kDa increased under all treatments except 10.5Cd+16.5Cr and 7Cd+10.5Cr. The levels of Non-protein thiols (NP-SH) and cystein increased with metal accumulation and exposure duration under all treatments except 7.5^{Cd}+10.5^{Cr} 10.5^{Cd}+16.5^{Cr} treatments, wherein decrease after certain period of time was observed. This study suggested that *B. juncea* can be a good candidate for remediation of metal salts affected soils.

Effect of micro-irrigation on yield and water production efficiency of beetroot *(Beta vulgaris L.)* in saline Vertisols of Thungabhadra irrigation project command area of Karnataka

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Abstract

Field experiments were conducted during 2007-08 and 2008-09 at Agricultural Research Station, Gangavati under different salinity levels to optimize the micro irrigation requirements of beetroot *(Beta vulgaris L.)***.** Irrigation methods consists of drip irrigation (0.6, 0.8, 1.0 and 1.2 ET) and surface irrigation (0.8, 1.0 and 1.2 ET). Soil salinity levels consist of < 4, 4-8 and 8-12 dSm^{-1} in the experimental plot. Pooled data of two years revealed that, irrespective of salinity levels, significantly higher beetroot yield of 18.08 t ha^{-1} was recorded with drip irrigated at 1.2 ET which was on par with drip irrigation at 1.4 ET (16.96 t ha^{-1}). Among salinity levels, significantly higher beetroot yield (19.07 t ha^{-1}) was recorded in soil salinity block of < 4 dSm^{-1} followed by 4-8 dSm^{-1} (16.61 t ha^{-1}). Interaction effect with respect to yield due to irrigation and soil salinity levels found non-significant. However, highest and lowest water production efficiency of 76.07 kg $(ha\text{-}mm)^{-1}$ and 65.79 kg $(ha\text{-}mm)^{-1}$ was obtained with drip irrigation at 0.6 ET and surface irrigation in 0.8 ET, respectively. Nevertheless, soil salinity buildup was marginally lower at 1.4 ET under drip irrigation as compared to surface method of irrigation at harvesting stage. The net returns and benefit-cost ratio were highest in drip irrigation at 1.2 ET and soil salinity of < 4 dSm^{-1}.

Impact of Eucalyptus Plantation on Soil Characteristics and Lowering Down of Water-table in Canal Command Area

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Abstract

Introduction of canal irrigation in arid and semi-arid regions has caused rise in groundwater table followed by waterlogging and secondary salinization of soils. In India, about 6.41 million land in considered waterlogged, out of which 4.75 million ha is due to sub-surface waterlogging and 1.66 million ha due to surface ponding. In conventional engineering based sub-surface drainage techniques, although are efficient in controlling waterlogging and salinity in irrigated lands; but are relatively expensive and may cause environmental problems. As an alternative to conventional drainage or as preventive measure, the use of fast-growing trees with high transpiration rate, often referred to as biodrainage, has been advocated. *Eucalyptus* is one of the most preferred plantations for such situations. In one experiment clonal *Eucalyptus* was grown on bunds in 4m x 5m space in block plantation along canal to reduce the seepage in farmers' fields.

Along with growth parameters, the soil characteristics and water table were also observed at initial stage as well as after six years of growth. More than 90 % of the trees survived and average plant height was observed to be 22.8 ± 2.4m and average diameter at breast height (DBH) was 57.8± 10.46 cm. The initial soil pH and electrical conductivity (ECe) of entire soil profile (0-90 cm) were 8.0 and 5.1, respectively. The initial organic carbon content was 0.23 (%). Na, K, Ca and Mg contents were 2.9, 1.6, 2.5 and 2.3me/l, respectively (mean of 3 profiles 0-90 cm soil). After six years of growth the soil pH was 7.6 and ECe value reduced to 0.23 (dS m^{-1}). The organic carbon contents increased to 0.72 in 0-15 cm layer and 0.52% in entire soil prifile from initial 0.27 % in 0-15 cm layer and 0.18% in profile showing the potential of carbon sequestering in both wood and soil. The soil aggregates (0.25 mm) increased significantly. Eucalyptus plantation not only gave high biomass and sequestered carbon but despite of continuous seepage also lowered water table by 1.25 m from surface.

Engineering Technologies for Management of Saline Groundwater

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Abstract

Groundwater meets 60 percent irrigation and 80 percent drinking water requirements of India. It is, however, getting afflicted due to alarming decline of water table in fresh groundwater regions and waterlogging and soil salinization in irrigated areas of arid and semi arid regions. Central Soil Salinity Research Institute (CSSRI) has done pioneering work on subsurface drainage (SSD) technology for amelioration of waterlogged saline soils and on groundwater recharge (GR) for augmentation of groundwater in falling watertable areas. An overview of CSSRI's contributions on SSD and GR in India is presented in this paper.

Of the 6.74 million hectare salt affected lands of India, severely waterlogged saline soils occur in about 2 million hectare arid/ semi- arid alluvial north western states and more than 1 million hectare each in coastal and black cotton heavy soil (*vertisol*) regions. SSD, practiced extensively in United States, Pakistan, Egypt, China and Australia, is relatively new in India. A number of pilot scale SSD projects, undertaken by CSSRI during 1980's, have slowly paved the way for mechanically installed large projects in the states of Haryana, Rajasthan, Gujarat, Punjab, Andhra Pradesh, Maharashtra and Karnataka. About 50000 ha waterlogged saline soils have been reclaimed with SSD in India with significant improvement in crop intensity, yields, land value and farmers' income. The cost of providing subsurface drainage is about Rs. 75000/ ha in alluvial soils of northwest India and Rs. 90,000 / ha for heavy textured soils of Maharashtra and Karnataka. Both the material and installation costs cover about half of the total cost. Disposal of saline drainage effluent, high cost and post drainage pumping requirement have been found to be deterrents to the success of this technology. Involvement of farmers, sharing of construction and operating cost and government subsidy are also vital aspects. Sustaining the productivity of irrigated agriculture without environmental degradation is a challenging task and demands a regional perspective for management of waterlogged saline soils.

Artificial recharge of excess rain and canal water can defer decline of fresh groundwater to some extent. Over the past 6 years, CSSRI has installed small GR structures in 60 farmers' fields in Haryana, Punjab, Uttar Pradesh and Gujarat. These consist of a bore well coupled to a recharge filter consisting of layers of coarse sand, small gravel and boulders in a brick masonry chamber. The recharge structures, installed at low lying locations and having intake rate of 4-6 litre/ sec, have proven effective in augmenting groundwater, improving its quality (salinity, alkalinity, fluoride concentration) and enhancing farmers' income by saving of submerged crops. The payback period of 30- 45 m deep structures, costing Rs. 70000- 100000 has been estimated as 1- 2 years. The clogging of the recharge filter is a major constraint while the quality of recharging water is an issue to be considered. Research in underway to devise improved designs of recharge filters, including radial and biological filters, to minimize clogging problem.

Theme 3

Frontier approaches for improving multiple stress tolerance

Multiple-Abiotic Stress Tolerance in Sugarcane

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Abstract

Sugarcane being a long duration crop faces vagaries of all the weather conditions prevailing round the year and experiences more than one abiotic stress along with aggravation of other abiotic and biotic stresses in the same crop cycle. At times, more than one abiotic stresses prevails at certain locations and thus multiple-stress tolerance becomes more relevant in sugarcane. Among the indigenous canes growing in India *Hemja, Khari, Khagari* and *Ikri* were tolerant to drought and waterlogging. Among these *Hemja* was well adapted to early drought and late waterlogging and *Khagari* grew well even under 6 feet of water for over three months. *Katha* was widely adaptable, tolerant to drought, flooding and frost. Several varieties exhibiting multiple-abiotic stress tolerance (mainly drought/ rainfed / waterlogging / salinity / low temperature) have been identified in sugarcane. These include BO 34, BO 70, BO 109, BO 128, Co 210, Co 285, Co 6907, Co 86011, Co 8371, Co 87025, Co 8362, Co 87205, Co 87263, Co 87268, Co 98014, CoLk 94184, CoSi 86071, N 11, NCo 310, UCW 5465 (drought / rainfed / waterlogging), BO 106, Co 8145, Co 88019,Co 94008, Co 99004, Co 2001-13, Co 2001-15, Co M 7125, Co S 510, CoS 797, HM 645 (drought / rainfed and salt stress), BO 99, Co 395, Co 453, Co 87263 (waterlogging and salt stress), Co 312, Co 421 (drought / rainfed and low temperatures), Co 285, Co Pant 90223 (drought / rainfed, waterlogging and low temperatures) and BO 90, Co 290, Co 7717, Co C 671, Co 85004, Co 87268, Co Se 96234, Co Pant 97222, Co Pant 93227, HM 661(drought / rainfed, waterlogging and salt stress). Co 290, Co 86249, Co 94008 and D 109 have exhibited wider adaptability against multiple-abiotic stress tolerance while Co Se 96234 has exhibited tolerance to all the stress conditions, in general. Although many physiological and biochemical characteristics have been identified to evaluate sugarcane varieties for tolerance to a particular abiotic stress, attributes like trehalose and betaine contents have been shown to be related to multiple abiotic stress tolerance in this crop.

Effect of Nod factors on germination and seedling growth of maize grown under salt stress condition

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Abstract

Salinity provokes a wide range of changes in growth and development of plants and reduces the productivity. Many techniques are used to improve tolerance of plants to salinity. Priming is believed to be an effective technique that increases germination characters of a crop at an early stage under saline soil conditions. It has been proposed that nod factors (LCO- Lipo-chitooligosaccharide) acts as an endogenous signal molecule response for inducing stress tolerance in plants. This research is focused on to study the efficacy of LCO nod factor (produced by *Bradyrhizobium japonicum*) against salt-tolerance of maize grown under salt stress conditions in a FCRD design (factorial completely randomized design) replicated four times. The factors of the experiment are different priming (LCO priming @ 4 ml/kg of seed & non priming) and salinity levels (0, 2, 4, 6, 8 and 10 dsm^{-1}). The results showed that increasing salinity levels decreased the growth parameters of maize, however maize primed with nod factor, significantly increased the germination percentage, relative germination rate, root length and shoot length as compared to non primed seeds. Thus seed priming with LCO molecule improved the seed vigour and resistance to salinity stress of maize.

Assessment of soil fungal diversity in different scenarios of Conservation Agriculture by means of Next Generation Sequencing

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Abstract

This study aimed to assess the diversity of soil microbial communities, samples have been collected from near production scale long term experiments designed for different agricultural systems (scenarios), using a wide range of indicators (crop rotation, tillage, crop establishment, crop, water and residue management). The four scenarios *viz*., Rice (CT/TPR)-wheat (conventional) rotation as in farmers' practice where rice and wheat residues were removed (scenario I; farmers practice of business as usual), Rice-wheat-mungbean (CT/TPR-ZT-ZT) rotation where full (100%) rice and partial (anchored) wheat residue retained on soil surface, while full mungbean residue were incorporated (scenario II), Rice-wheat-mungbean (ZT-ZT-ZT) where full (100%) rice and mungbean; partial (anchored) wheat residue retained on soil surface (scenario III), Maize-wheat-mungbean (ZT-ZT-ZT) where maize (65%) and full mungbean; partial (anchored) wheat residue retained on soil surface (scenario IV; futuristic system). Best management practices were followed with respect to tillage, crop establishment, crop-water and residue management under different scenarios II, III and IV. Most of the biochemical decomposition of organic plant biomass is carried out by heterotrophic microorganisms, among which fungi are an important. Diversity of microbial population in soil in relation to various agricultural practices was evaluated. To date, the effects of agricultural practices on soil microbial abundance and structure were mostly studied by using classical tools based on the cultivation of microorganisms in different types of media. This study was carried out with recent development of culture-independent molecular tool of high throughput sequencing technology (pyrosequencing/next gen sequencing), which allows obtaining thousands of sequences from a single soil DNA sample which may helped better assessing the huge diversity of soil microbial communities. Samples were collected from 0-15 cm soil depth for soil fungal diversity. Total DNA was extracted and sequenced by Illumina MiSeq, that generates shorter reads but achieves deeper sequencing.

Based on the fungal taxonomic diversity results, it was found that dominant phyla belongs to the Ascomycota (55–73% of all fungal sequences), followed by Basidiomycota (0.17-3% of all fungal sequences) and Glomeromycota (0.16-3% of all fungal sequences). Highest abundance (73.57%) of Ascomycota was found in scenario IV as comparative to scenario I (55.43%), II (68.05%) and III (71.39%) respectively. These Ascomycota and Basidiomycota phyla are dominating fungi in soils and mainly belong to the saprotrophic soil fungi and are responsible decomposition of organic residues. Diversified cropping systems (maize-wheat-mung bean) in IGP with CA based best management practices showed the positive effect on residue decomposing microbial community.

Genetic diversity of salt tolerant endophytic strains of *Bacillus* species from sodicity-tolerant polyembryonic mango root stock

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Abstract

The application of endophytic bacteria in agricultural production depends on our knowledge of the bacteria and our ability to modify the beneficial microbes in plants. Therefore the study of beneficial native bacteria associated with plants and their ecological role is of significant importance. Study of the bacterial activity in plant roots is important to understand the molecular mechanism that confers sodicity tolerance to plants the tolerance. Mango is highly sensitive to soil salinity and sodicity therefore, its expansion to larger areas for cultivation is restricted. The two salt tolerant polyembryonic mango root stock (ML-6 and ML-2) developed at CSSRI, RRS, lucknow through natural selection were evaluated for genetic diversity of endophytic bacteria. In this study, 16 isolates of endophytic bacteria were isolated and assessed for PGPEB (Plant Growth Promoting Endophytic Bacteria), extracellular enzyme activity and taxonomic grouping. Significant differences were observed in bacterial population based on molecular finger printing. The Na^+, K^+ partitions and bacterial diversity in different plant tissue as characterized by RFLP pattern and phylogenetic analysis based on 16S rRNA sequences indicated that the isolates grouped under four major phylogenetic clusters: low G+C Gram positive bacteria, *Firmicutes, Proteobacteria and Bacteroidetes.* Endophytic bacteria from the phylum *Firmicutes* were predominant in the root portion 60.0% (Na^+ - 7.72 ± 0.05; K^+- 2.08 ± 0.85) and stem portion 75.0% (Na^+ - 5.79 ± 0.05; K^+- 13.58 ± 0.53) respectively. Most isolates that exhibited extracellular enzymatic activity and PGPR traits in 3.0 M NaCl concentration belonged to the genus *Bacillus* and *Bacillus clausii, Bacillus pumilus, Bacillus licheniformis* (CSR-M-06, CSR-M-08, CSR-M-09, CSR-M-16). They also exhibited stronger activities in extracellular enzymes such as amylase, protease, cellulase and lipase than other isolates. In conclusion, elucidation of the origin of the potential endophytes clarifies influence of these in biocontrol properties and plant growth enhancers of their ability to elicit 'induced systemic tolerance' against sodic soil.

Diversity of Soil Microbes from Paddy soils of Sitapur and their screening for Salt and pH Tolerance

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Abstract

A large, diverse, and active population of soil organisms is the most important indicator of a healthy soil. A study was conducted with the objective to isolate and characterize salt and pH tolerant soil microbes. Soils samples were collected from the 20 paddy soils of Sitapur, Uttar Pradesh. The soil samples were analysed for physical, chemical and bio-chemical soil properties. Soil pH ranged from 6.35 to 8.64, EC from 0.04 to 1.11 dS/m and falling in textural class of loamy sand to silty clay loam. Organic carbon content ranged from 2.1 to 5.4 g kg-1 while microbial biomass C content ranged from 60 mg/kg to 182 mg kg^{-1}. Available N, P and K content ranged from 81.9 to 179.8, 5.9 to 19.9 and 154.3 to 232.2 kg ha^{-1}, respectively. From the microbiological analysis of soil samples, it was found that all soils contain abundance of microorganisms on nutrient agar plates at 37^{o}C for 24 hours. The colony forming unit of bacterial population per gram soil ranged from 4.65×10^{6} to $3.60x10^{4}$. Fungal population on potato dextrose agar ranged between $14x10^{4}$ to $102x10^{4}$ MPN/g soil.

Out of the total bacterial isolates, 132 isolates tolerated 5% NaCl concentration while 47 isolates were able to tolerate 10% and only 5 could tolerate 15% NaCl concentration in the media. Almost all the isolates could tolerate pH upto 9 while only 121 out of 132 could tolerate pH upto 11 in the media. Most of the isolated bacteria were Gram-positive and of rod shaped. There was a great variation in their colony characteristics. Gram's staining showed 103 were cocci while 34 were bacilli. Eleven isolates were yellow pigmented and 46 were creamy or off white. The dominant fungal isolates were *Aspergillus, Cladosporium, Rhizopus, Trichoderma* and *Penicillium*.

Response of perennial forage grasses to different soil salinity under Tungabhadra Project area of Karnataka

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Abstract

A field experiment was carried out for 3 years during 2011-12 to 2013-14 on "screening of perennial forage grasses for salt tolerance under saline conditions of TBP irrigation command". Six perennial forage grasses (Rhodes grass, Para grass, Grazing guinea grass and Guinea grass, DHN-6 and DHN-9) were planted in three rows each in natural salinity gradient plot where soil salinity varied from 2.0 dS/m to 20.0 dS/m. There were 22 plots with size of 5.0 m x 1.80 m in each grass. Further, based on initial soil EC plots were considered as 11 blocks (Each 2 plots as one block). Water table depth and water salinity in these blocks were recorded through 11 observation wells. The pooled data indicates that, before planting, the ECe ranges from 3.70 to 18.50 while, at the end of the year 2011-12, the soil salinity varied within the block and ranged from 3.20 to 18.10. Similarly, during 2012-13 and 2013-14 also soil salinity varied within block and ranged between 3.65 to 18.50 and 4.87 to 16.54, respectively. Similarly, depth of water table and water salinity was interrelated wherein deeper water table depth was associated with lower water salinity during winter and vice versa during summer. With regard to green biomass yield, Rhodes, Para and Grazing guinea grasses were higher at soil salinity of < 4.0 dS/m. However, at soil salinity range of 4.0 – 8.0, there was <10% decrease in these forage grass yields, while 50% decrease in forage yield of Guinea grass was noticed at same salinity range.

Further, drastic reduction in forage yield in all the forage grass studied was recorded in the soil salinity range of 8-12, 12-16 and >16 dS/m. The two forage grasses *viz.*, DHN-6 and DHN-9 were vitiated during summer 2012 due to high salinity and deeper water table. This indicates that, Rhodes, Para and Grazing guinea grasses can be successfully grown under soil salinity range of 4-8 dS/m.

Overcoming Salinity Barriers in crops grown in Sub-Tropical India with Special Reference to Sugarcane Crops

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Abstract

Alkalinity and salinity are major problem in sub tropical parts of India where irrigation is essential for crop production. The alkaline/saline soils and the sodic waters affect the sugarcane yield and the sugar recovery as these soils and the waters are not suitable to sugarcane crop. Therefore, the varieties should be developed which are resistant/tolerant to salinity/alkalinity so that these may be grown under such conditions successfully. To overcome the saline sodic soils many methods have been devised which are given below. Major sources of salinity in these regions are salt-rich irrigation water and improper irrigation management. The effects of salinity on crops include inhibition of growth and production, and ultimately, death. There are two main approaches to alleviating the adverse effects of salinity on sugarcane crops: (i) development of salt-tolerant cultivars by screening, conventional breeding or genetic engineering, and(ii) the traditional approach dealing with treatments and management of the soil, plants, irrigation water, and plant environment. The success of the first approach is limited under commercial growing conditions, because salt-tolerance traits in plants are complex.

The present paper reviews, analyzes, and discusses the following traditional approaches: (i) improving the plant environment, (ii) exploiting interactions between plant roots and bacteria and fungi, and (iii) treating the plant directly. With respect to improving the plant environment, we review the possibilities of decreasing salt content and concentration and improving the nutrient composition and concentration in the root zone, and controlling the plant's aerial environment. The interactions between salt-tolerant bacteria or mycorrhizal fungi and root systems, and their effects on salt tolerance, are discussed. These treatments aimed at alleviating salinity hazard by treating the plant directly include priming of seeds and young seedlings, using proper seed size, applying non-enzymatic antioxidants, plant growth regulators or compatible solutes, and foliar application of nutrients. It can be concluded from the present review that the traditional approaches provide promising means for alleviating the adverse effects of salinity on agricultural crops.

Comparative performance of *Eucalyptus tereticornis* clones under different environmental conditions

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Abstract

Vital importance of *Eucalyptus tereticornis* in farm forestry and its wide acceptance by farmers throughout India prompted to carry out this study. In the present investigation, twenty clones of *Eucalyptus tereticornis* were evaluated under two environmental conditions. Analysis of variance indicated significant clonal differences for total height, diameter at breast height, clearbole height, unforked height, current annual increments and mean annual increments of total height, diameter at breast height, clearbole height and unforked height. Planting sites were found significantly different for all the growth parameters. The mean squares due to genotype (clone) x environment interactions were significant for all the characters, which indicated that the clones interacted significantly with environments. Clone no. 132 was found most promising among twenty clones tested at Bithmara (Hisar) and Seonthi (Kurukshetra) with high mean performance for total height, unforked height, MAI of total height, MAI of diameter at breast height and MAI of unforked height in both the environments. Clone no. 71 was found significantly superior than general mean for total height, diameter at breast height, CAI of total height, MAI of total height and MAI of diameter at breast height in both the environments. Clone no. 3 was found significantly superior than general mean for clearbole height, unforked height, CAI and MAI of clearbole height and unforked height. Clone no. 132 was found superior for total height, unforked height, MAI of total height, MAI of diameter at breast height, MAI of clearbole height and MAI of unforked height in better environment. Clone no. 6 was found superior for poor environment for total height, clearbole height, unforked height, MAI of total height, MAI of clearbole height and MAI of unforked height.

Early growth performance of some *Hevea* clones from on-farm trials in Garo Hills of Meghalaya

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Abstract

Meghalaya is one of the potential states for rubber cultivation in the North East India. Rubber cultivation can provide scope for rural employment for the tribal population of Meghalaya. In Meghalaya, the Garo hills regions, situated at 25^{o} 65.438' N latitude, 90^{o} 39.129' E longitude and 77-78 m above the mean sea level are suitable for rubber cultivation compared to that of the Khasi and Jaintia hills of the state. The topography of the Garo hills regions is mostly undulated and close to the border of Assam state. Rubber is a major crop of economic importance in this region of Garo Hills. The study was conducted at Mendipathar, North Garo Hills of Meghalaya. This region is experiencing moderate rainfall (2400 mm) with minimum temperature remaining as low as 5 ^{O}C during winter and maximum temperature of 35 ^{O}C with long sunshine hours and altitude ranging from 150 m to 600 m MSL. Six clones viz., RRIM 600, RRII 203, PB 235, RRII 417, RRII 422 and RRII 429 were planted in blocks of 100 plants at 4.5m x 4.5m spacing in July, 2009. Two On Farm Trials (OFT) were established in 2009 at Mendipather, North Garo Hills, Meghalaya.

The trials were initiated to study the performance of certain selected clones of *Hevea brasiliensis* in farmers' field and the clones were planted in the field of two progressive farmers at Mendipather. Six clones *viz*., RRIM 600, RRII 203, PB 235, RRII 417, RRII 422 and RRII 429 were planted in blocks. Data on girth and other secondary characters recorded during the initial years have been analysed for the present study. The highest girth was recorded in RRII 429 followed by RRII 417 whereas the lowest girth was recorded in RRII 422. Maximum bark thickness was recorded in RRII 417 followed by PB 235 and RRII 429. Performance of the clones based on absolute girth suggests the superiority of RRII 429 and RRII 417 over RRIM 600 in the local agro-climatic conditions of North Garo Hills.

Mitigation of Salinity through Varietal Selection in Wheat for Saline Vertisols

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Abstract

Soil salinity is one of the major environmental constraints in agricultural crop production. Salt affected soils occur to a tune of 6.73 M ha in India of which Gujarat, a western province accounts for 2.22 M ha i.e. 32.8 percent of country's total and thus needs a holistic approach for evolving economically viable agro- management strategies. Wheat is one of the most important food crops of India with a production of 95.85 MT (Ministry of Agriculture, 2014). Gujarat contributes about 4.8 MT (Department of Agriculture, Gujarat, 2014) to the national wheat bowl. Efforts have been made for past several years to overcome problem of soil salinity through selection/development of salt tolerant germplasm. It clearly shows that large variation is present in crop species like wheat in response to soil salinity which is genetically controlled. In view of above, experiments were conducted at Central Soil Salinity Research Institute, Regional Research Station, Bharuch for two years during 2012 and 2013 to find out salt tolerant wheat accessions suitable to saline Vertisols of south Gujarat. In Rabi 2012, 84 wheat accessions were tested in augmented design (Federer, 1956) which were selected from Salinity/Alkalinity nursery of All India Coordinated Research project (AICRP) of wheat. The experiment was irrigated with saline water (EC 9.3 dS/m) coupled with sub-surface salinity prevailing in the field which provided ideal condition for selection of salt tolerant lines.

Data revealed that 16 accessions were superior from national checks KRL 210 and KRL 213 in terms of yield and other agronomic features. These 16 accessions were again tested in Rabi 2013 in larger plots and plethora of agronomic as well as biochemical traits were studied to validate previous results and to explore mechanism of salt tolerance in superior accessions. Analysis of variance revealed that plant height and biomass were statistically significant characters. It was also found that these traits were positively and significantly correlated with the yield (r=0.60; 0.32). Genotypic variability was of higher proportion in total phonotypic variability for some important traits like biomass, K content in tissue and plant height which clearly indicates that these characters can be improved through selection.

High heritability was found to be associated with K^+ ion content and plant height (h^2=0.48, 0.30). RWP 2012-17 was found to be highest yielder (5.1 t ha^{-1}) followed by Raj 4372 and LDP 2012-24. Five entries performed well above the check KRL-210 (20-35% superiority). In superior accessions like RWP 2012-17, Raj 4372 and LDP 2012-24, K/Na ratio, a better salt tolerance indicator, was found to be high (2.50-3.0). Chlorophyll content in leaf tissues was also found to be higher in tolerant accessions. Chlorophyll content and K content in leaf tissue was generally higher in tolerant accessions at the time of flowering which suggest that these two traits play an important role in imparting salt tolerance. Above findings also suggest that tolerant genotypes maintain better ionic status in tissues which helps in efficient functioning of chlorophyll leading to better photosynthesis and thus yield.

Introgression of *Saltol* QTL to Mega Rice Varieties of India

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Abstract

Salinity is one of the major obstacles to increasing production in rice growing areas worldwide. Most of the traditional salt-tolerant donor varieties of rice are low yielding with numerous undesirable traits that are carried forward due to linkage drag in the recombinants. Therefore necessitate for development of high yielding salt tolerant varieties and incorporation of tolerance to the existing high yielding varieties to increase rice production in salinity prone areas. In this study, we have focused on introgression of *Saltol* QTL to mega varieties of different regions namely, Pusa 44 (Haryana), PR114 (Punjab) and Sarjoo 52 (Uttar Pradesh). Marker Assisted Selection Back Cross (MABC) technique was used to develop the salt tolerant rice genotypes using molecular markers. The genotypes namely, Pusa44, PR114, Sarjoo 52 were selected as recurrent parents while FL478 was used as a donor parent to introgress the *Salto*l QTL conferring salt tolerance. Crossing was done between them and F_1 seeds were produced. Backcrossing was done with respective recurrent parent to produce BC_3F_2. In every back cross generation, we carried out foreground and recombinant selection with markers RM3412; G11a and RM493, respectively and also carried out stringent phenotyping as similar to recurrent parent. Further background selection is in progress.

Mapping of QTLs linked with high salt tolerance in Indian Mustard (*Brassica Juncea*)

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Abstract

In India, nearly 6.73 million hectare area is affected with salinity and sodicity stresses covering various states of the country. Further, the arid and semiarid areas in different states are associated with saline underground water, which have to be used for irrigation purpose. The Indian mustard is a major oilseed crop for such areas. India ranks second in the world with regard to production of Brassicas and supplies nearly 7 percent of the world's edible oil. However, Indian mustard production still remains insufficient to meet even the daily requirement of its people let alone fulfilling prospects of fruitful export. This low economic yield can be attributed to the crop's susceptibility to a number of abiotic and biotic stresses, among which of alarming concern, is the salt stress.

High salinity adversely affects germination; however, in addition to affecting the water balance of the plant, salt poses another problem to plants: excess accumulation of salt ions in cells is toxic, and potentially fatal. Salt ions impair enzyme function, inhibit protein synthesis, affect the structure and permeability of cell membranes, inhibit photosynthesis, and lead to the production of toxic reactive oxygen species. All of these impairments ultimately leading to lowered economic productivity. Selection for salt tolerance is difficult as the soil shows patches and many a times selection may be misleading. Marker assisted selection for monitoring the salt tolerance genes will be more precise provided good genes/QTL linked with robust DNA marker are available. This research aims at mapping of QTL for salt tolerance (using RILs developed from salt sensitive line CS 614-1-1-100-13 and CS-56 variety as a source for salinity) to genetic up scaling of salt tolerance and ultimately enhance the genetic potential of Indian mustard to cope up the changing climatic conditions.

Molecular characterization of wheat varieties under combined boron and salt stress

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Abstract

Three wheat varieties differing in their tolerance to salinity were evaluated under hydroponics culture technique for interactive/combined effect of excess boron and salinity. Roots samples were collected after 20 days of sampling from different treatments i.e. control, 50 ppm B + 60 mM NaCl, 100 ppm B + 60 mM NaCl, 50 ppm B + 100 mM NaCl and 100 ppm B + 100 mM NaCl respectively. Results indicated that combined salinity and boron stress significantly reduced soluble sugars and protein content with increased proline concentrations in the roots. KRL 35 (salt tolerant) showed 5 specific polypeptides of 89.13, 53.4, 46.21, 32.35, and 31.10 kDa. Likewise, KRL 210 (moderately salt tolerant) showed *de novo* synthesis of 53.4 and 19.13 kDa whereas three specific polypeptides (24.05, 19.13 and 17.52 kDa) appeared in the salt intolerant variety (HD 2009). The synthesis of common polypeptide of MW 25.12 kDa was observed in all the three varieties with increase in stress treatments. Enhanced expression of 25.12 kDa proteins in present study, particularly in susceptible genotypes induced protein synthesis under salt and boron stress condition; such altered and enhanced expression of protein may be responsible for the survival and growth of the plants under high level of NaCl + B and affecting the functional capabilities of seeds to perform in the stress environment.

Genotype × environment interaction in rice genotypes for salt tolerance using AMMI analysis

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Abstract

Rice is the staple food and most important cereal crop which contributes more to our food requirements and is considered as highly sensitive to salt stress. Genotype × environment (G×E) interaction effects are of special interest for identifying the most suitable genotypes with respect to target environments, representative locations and other specific stresses. Analysis of G×E interaction can reduce the noise from the actual genotypic worth thus improving the selection efficiency of the breeding trials especially for salt tolerance. The present experiment was carried out to assess the extent of genotype × environment interaction for grain yield, to evaluate rice genotypes for their yield performance and stability of yield and other traits across salt affected soils in a set of 27 rice genotypes using additive main effects and multiplicative interaction (AMMI) model during 2013. The G×E effects were partitioned into four principal components (PC) and (PC 1-PC 3) were found highly significant for all the traits. Under salt stress environments the PC 1 contributed the highest of 45 % of the total G×E interaction followed by PC2 of 28%. The genotypes Bulk 212 (3568 kg/ha), CSR 2K 232 (3439 kg/ha), Bulk 18 (3404 kg/ha), CSR 11-117 (3359 kg/ha), CSR 10M2-27 (3357 kg/ha), NDRK 11-2 (3318 kg/ha), CSR 11-121 (3255 kg/ha), NDRK 50041 (3193 kg/ha), CSR 11-143 (3174 kg/ha), CSR 27-192 (3111 kg/ha), and NDRK 50042 (2909 kg/ha) had more than the average grain yield and more than CSR 36 (2842 kg/ha) which is national check for salt stress environments. The genotypes CSR 10-M27, Bulk 212, CSR 2K 232, Bulk 18, CSR 11-117, CSR10 M2-27, NDRK 11-2, CSR 11-121, CSR 11-143 and CSR 27 -192 can be considered as the most stable in salt affected soils. The genotype Bulk 212 was found to be the highest yielding variety in most of the environments across the salt stress environments. These rice genotypes could be used for commercial cultivation in salt affected soils and also used in the further breeding programme to transfer the salt tolerance to high yield varieties.

Genetic variability and association analysis for grain yield components among *SALTOL* QTL introgressed rice genotypes under normal and saline environments

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Abstract

Genetic variability parameters, correlation and path coefficient analyses were studied for nine quantitative traits in *SALTOL* QTL derived rice genotypes across normal and saline stress environments for two years. Analysis of variance showed highly significant differences due to environments for all the characters recorded. Based upon the overall parameters of genetic variability and genetic advance, phenotypic selection for biological and grain yield in both environments, whereas for tillers number, spikelet fertility and harvest index under salt stress is likely to be more effective in trait improvement. In both environments, grain yield was positively correlated with plant height, biological yield, 1000 grain weight, spikelet fertility and harvest index. Spikelet fertility was positively correlated with panicle length and biological yield under salinity only. At genotypic level, the traits total tillers/plant, panicle length and harvest index exerted positive direct effects on grain yield in both environments. Biological yield and spikelet fertility caused positive direct effects in normal environment. However, both these traits caused negative effects under salinity stress. Similarly, positive correlation of 1000 grain wt. with grain yield was revealed through its direct effect and indirect effects via productive tillers, panicle length and harvest index under salt stress. The overall analysis revealed that traits biological yield, spikelet fertility and harvest index could be effective indirect selection criteria for yield improvement under both normal and saline environments in this marker assisted breeding derived material.

Role of biotechnology in abiotic stress tolerance and crop improvement

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Abstract

Developing crops that are better adapted to abiotic stresses is important for food production in many parts of the world today. Anticipated changes in climate and its variability, particularly elevated temperature, rising CO_2, drought and salinity affect plant growth and pose a major threat to sustainable agriculture. This has become a hot issue due to concerns about the effects of climate change on plant resources, biodiversity and global food security. Plant adaptation to abiotic stresses involves key changes in the '-omic' architecture. Biotechnology is nowadays changing the agricultural and plant scene in three major areas: (1) growth and development control (vegetative, generative and reproduction/propagation), (2) protecting plants against the ever-increasing threats of abiotic and biotic stress, (3) expanding the horizons by producing specialty foods, biochemicals and pharmaceuticals. Abiotic stress conditions such as salinity and drought are the most common natural causes of lack of food and famine in arid and semi arid regions, and the most serious environmental threats to agriculture in many parts of the world. Here, we presents two key biotechnology approaches, molecular breeding and genetic engineering, and their integration with conventional breeding to develop crops that are more tolerant of abiotic stresses.

Effect of Lipo-Chitooligosaccharide on salt tolerance and phyto-toxicity of roots of maize

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Abstract

In agriculture, salinity is an extensive problem, posing threat and reduces the productivity of crops. Research in the use of signaling molecules to enhance crop performance is still in the nascent stage in India. LCO (Lipo-chitooligosaccharide) is a unique signalling molecule that, when present at the time of planting, enhances a plant's nutritional capabilities and drives the natural growth processes such as root and shoot development, immediately and irrespective of the variety, soil, and other environmental conditions. Germination and early seedling growth are important phases for maize as it is sensitive to salt stress. Salt stress can be detrimental to subsequent growth of maize and productivity. In the present study, the effect of priming with LCO signaling compound on growth and establishment of maize seedling grown under induced salinity levels as a lab experiment in FCRD replicated four times. Primed and non primed seeds of maize were sown in petri dishes and watered with saline solutions of six concentrations (0, 2, 4, 6 8 and 10 dsm^{-1}). Results of analysis of variance showed that salinity levels and LCO priming affected seed establishment parameters of maize significantly and also the phytotoxicity of the non primed maize seedling is increased while salt tolerance is decreased with increasing levels of salinity.

Development of Integrated Disease Management for Root Rot of Ashwagandha

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Abstract

The root rot of ashwagandha [*Withania somnifera* (L.) Dunal] is an important disease causing significant economic and yield losses. Investigations were carried out in the Department of Plant Pathology and Agronomy Farm of RCA, MPUAT, Udaipur during 2011-12. This disease was observed for the first time at RCA and adjoining areas. The fungal pathogens were isolated, purified and identified as *Fusarium solani* and *Rhizoctonic solani* and their pathogenicity was confirmed on ashwagandha diseased roots. *In-vitro* physiological studies revealed that fungus grew well on potato dextrose agar and Malt extract media, Maximum mycelial growth and dry mycelial weight were recorded at 25± and 30±1°C temperatures and pH 7.0. *In -vitro* nutritional studies revealed that fungus grew well on carbon sources, maltose and sucrose, in nitrogen sources, potassium nitrate and peptone.The fungicides, SAAF, Carbendazim, Propiconazole and Hexaconazole were found most effective to inhibit the growth of the pathogen. Botanical formulations such as neem oil, neem and jatropha cake extracts were most effective to inhibit the growth of the pathogens. Local isolates of *Trichoderma viride* strain recovered from Ashwagandha rhizosphere showed high efficacy in supressing the pathogens in dual culture. In field trial, seed treatments with integration of fungicides, neem cake manure, neem oil and *T. viride* agent evaluated as seed treatments individually as well as in different combination of seed treatment and soil application of neem cake was found effective integrated treatment (ST SAAF + neem cake manure + *T. viride*) and soil application of neem cake manure@500g/plot showed minimum per cent root rot and maximum per cent germination and maximum yield of Ashwagandha as compared to their individual applications over the untreated control.

Effect of Conservation Agricultural practices on Growth and yield attributes of Rice after 5 years of cultivation

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Abstract

A field experiment was conducted in a randomized complete block design with 2000 m^2 plot size (100 m × 20 m) at the CSISA experimental research platform located at the Central Soil Salinity Research Institute (CSSRI), Karnal, Haryana, India (29°70'N, 76°96'E) to study the effect of different conservation agriculture practices on the growth and yield attributes of rice in rice-wheat cropping systems. The treatments were Business-as-usual (T_1) (Rice-wheat, Rice-puddling, Wheat-conventional till); Integrated crop and resource management (T_2) (Rice-wheat-mungbean, Rice-puddling, Wheat-zero till, Mungbean-zero till); Conservation agriculture (CA) - based systems (T_3) (Rice-wheat-mungbean, Rice- zero till, Wheat-zero till, Mungbean-zero till). The treatments were different with respect to crop sequence, tillage, establishment method, residue management, and other management practices and were evaluated for some growth and yield attributes of rice (plant height, root length, plant fresh wt, dry weight, root fresh weight and dry weight, test weight, no of tillers, no of panicles, length of panicle, no of leaves etc.) after five years of continuous wheat and rice crop (2009-2014). Rice variety was Arize 6129. Results showed that treatment T_2 recorded highest plant height (127 cm) followed by T_1 (115 cm) and T_3 (105.5 cm) at 90 DAS. Maximum root length of rice was observed under Treatment T_2 (23 cm) followed by T_1 (18.3 cm) whereas T_3 recorded lowest (16.5 cm) root length at 90 DAS. At harvesting stage, the maximum dry weight of plant was recorded in T_2 (119 g) followed by T_3 (114 g) and T_1 (96 g). Treatment 2 recorded highest panicle length (28.7 cm), no. of grains per panicle (281) and test weight (23 g). Highest grain and straw yield was also observed under treatment 2.

Physiological responses of *Dicanthium annulatum* (grass halophytes) under saline conditions

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Abstract

The experiment was undertaken with the objective to determine physiological responses of *Dicanthium annulatum* (Poaceae) under saline stress condition. The experiment was conducted in randomized block design in microplots at CSSRI, Karnal, had 4 treatments i.e. Control (ECe-0.43), ECe-15 dSm^{-1}, ECe-25 dSm^{-1} and ECe-35 dSm^{-1} in with 3 replications. *Dicanthium* showed only 15-20% germination response under different salinity levels. So establishment was done through rootslips. Physiological (Gas exchange attributes) and biochemical parameters (Total soluble sugars, Protein, Proline) of grass halophyte were taken at monthly intervals. Plant height shows decreasing trend with increased stress i.e. 131.7 cm at control which reduced to 48.6 cm at ECe 35 dSm^{-1}. Highest photosynthetic rate was recorded in control treatment (36.04 μmol m^{-2} s^{-1}) which decreased with increasing stress conditions i.e. at ECe 35 dsm^{-1} (19.84 μmol m^{-2} s^{-1}) Whereas reduction were also recorded in rates of stomatal conductance (0.367 mmol m^{-2} s^{-1}) and transpiration rate (4.87 mmol m^{-2} s^{-1}) at ECe 35 dsm^{-1} as compared to control. With the intensified stress conditions, *Dicanthium* accumulated higher total soluble sugars i.e. 14.4 mg/g DW at ECe 35 dSm^{-1} as compared to control conditions i.e. 5.6 mg/g. Marginal decrease was observed in protein content across stress treatments, though it increased with the increase in concentration of salt stress i.e. 12.8 mg/g FW at ECe 15 dSm^{-1} which increased to 13.5 at ECe 35 dSm^{-1}. Seven fold increase was noticed for proline content with minimum accumulation in non stress plants (0.865 mg/g FW) which increased with increasing stress condition and showed maximum accumulation at ECe 35 dSm^{-1} (4.862 mg/g FW). Therefore, our results conclude that *Dicanthium* performed better in terms of osmolytes accumulation to maintain physiological efficiencies.

Effect of water logging on wheat genotypes under sodic conditions

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Abstract

Eleven wheat varieties KRL 99, KRL 3-4 and Kharchia-65 (salt tolerant varieties) Brookton, Ducula-4 and HD 2009 (salt-susceptible) and five other varieties DBW-17, BH 1146, KRL 240, NW 4018 and KRL 238 were grown in pots under sodic and water logged conditions to investigate the individual and combined effects of sodicity and water logging on plant height (cm), tiller number, grain weight and biomass/plant. Four treatments i.e. normal (pH 7.8), pH 7.8 + water logging, pH 9.3 (sodic) and pH 9.3 (sodic) + water logging were imposed. Surface sterilized seeds were sown (10 per pot) on 2nd week of November using randomized block design of four replicate pots for water logging & drained treatments. Stress treatments caused significant reduction in the plant height, tillers of in all wheat varieties relative to control; sodicity + water logging caused maximum reduction. Similar trends were observed for biomass and grain yield. Water logging treatment imposed at growth stages reduced the plant biomass, number of tillers and grain yield of wheat.

In terms of plant height (cm) KRL 3-4, Kharchia 65, KRL 238 and BH 1146 (91.2, 83,76 and 96 cm) were performed better under sodic and water logging condition while the genotypes Brookton, Ducula-4, HD 2009 and DBW 17 were showed the poor performance. Growth reduction was accompanied by yellowing of leaves in normal as well as sodic conditions. Wheat genotypes showed maximum productive tillers in Kharchia 65 (4 per plant) and minimum in HD 2009, Ducula 4 and NW 4018 (1 per plant) under combined stress condition. The genotypes KRL 3-4, Kharchia 65, KRL 238, KRL 99 and BH 1146 were showed (31.2, 25.9, 27.9, 28.0 and 26.4 g/plant) grain yield and (91.1, 87.2, 81.4, 72.5 and 78.9 g/plant) biomass while the genotypes (KRL 240, HD 2009, Ducula 4, NW 4018 and DBW 17) showed maximum reductions in grain yield and biomass under combined stress.

Sugar beet-A Sugar Crop for Saline/Alkaline Conditions

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Abstract

Abiotic stresses like waterlogging, drought and low temperatures lead to or aggravate salt stress. Salt stress affects the chemical composition of sugarcane, sugar synthesis, its accumulation and its overall growth and development adversely, causing colossal losses in sugarcane and sugar productivity. Along with, salinity / alkalinity also aggravates certain abiotic and biotic stresses like boron toxicity, salt blight and infestation of shoot borers, thereby limit the utilization of sugarcane as a sugar crop under salt stress conditions. Sugar beet, a potential sugar crop, is a halophyte, capable of tolerating a salinity level of 9.5 m mhos/cm, also happens to be a scavenger of sodium salts (removes about 500 kg of sodium salts/ ha per season), can be useful in reclaiming such soils. The reclaiming potential of sugar beet is attributed to one of its constituents, betaine (0.3%), an important osmoregulant, making it one of the most suitable crop for converting several thousand hectares of uncultivable *usar* lands cultivable. Sugar beet has potential to produce 10-12 t / ha of sugar comparable to sugarcane in sub-tropical India with reduced crop duration of six months (as compared to sugarcane being a one year crop). In addition sugar beet crop may produce 3900 to 8761 l / ha of ethanol. Tropicalised sugar beet hybrids have been developed from sugar beets which are traditionally grown in extreme climate in certain American (like southern parts of California) and European (like southern Spain and southern Italy) locations. These hybrids have been selected for their heat tolerance as well as to the diseases occurring in the tropical areas of the world. This crop, with all the advantages of sugar beet, when used as a supplementary crop (with sugarcane) may serve to increase crushing duration in a sugar mill and augment sugar/ alcohol production. It may also be rather more useful, especially for the sugar mills in whose vicinity there are saline / alkaline soils.

Eco-physiological responses of *Aeluropus lagopoides* (grass halophytes) and *Suaeda nudiflora* (non-grass halophytes) under salt affected environments

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Abstract

The halophytes (*Suaeda nudiflora* and *Aeluropus lagopoides*) collected from extreme saline sodic Kachchh plains, Bhuj (Gujrat), were established in microplots research facility of CSSRI, Karnal to evaluate their eco-physiological responses under different salt affected environments. The experiment was designed in two factorial randomized block design having 2 grass halophytes and 9 different treatments of salinity/sodicity i.e. control, sodic (pH_2: 9.5 and 10.0), saline (ECe: 15, 25, 35 dSm^{-1}) and saline-sodic (pH_2 9.0 with ECe: 10, 15, 20 dSm^{-1}). Eco-physiological responses were summarized in terms of gas exchange attributes, ionic relations (Na^+, K^+ and Cl^- content) and biochemicals (total soluble sugars, protein and proline content). Both these grasses showed maximum gas exchange properties when these were grown in control conditions. Highest photosynthetic rate (33.5 and 34.5 µmol CO_2 m^{-2} s^{-1}) was recorded in control treatment which was decreased with the intensified stress and found minimum under stress condition of pH_2 9.0 + ECe 20 dSm^{-1} (16.9 and 18.1µmol CO_2 m^{-2} s^{-1}) in *S.nudiflora* and *A.lagopoides* respectively. Reductions were also noticed in the rates of stomatal conductance and transpiration rate under different saline/sodic levels.

As the stress conditions prevailed, these halophytes accumulated higher amount of Na^+ and Cl^- in their leaves. *Aleuropus* accumulated 10.23% Na^+ at ECe 35 dSm^{-1}, which was approx. 6 times higher than control (1.65%) and 2 times than pH_2 9.0+ECe 20 dSm^{-1} (5.8%) stress level whereas *S. nudiflora* accumulated 2.75% Na^+ in control which increased to 17.33% at ECe 35 dSm^{-1} and 22.25% at pH_2 9.0 + ECe 20 dSm^{-1} treatment. Chloride content showed similar trend of increase but in *A. lagopoidus*, it showed reverse trend i.e. 8.14% in control and 2.47% in pH_2 9.0 + ECe 20 dSm^{-1} treatment. Increased accumulation of K^+ i.e. 39.5% and 103.3% was observed at ECe 35dsm^{-1} in *S. nudiflora* and *A. lagopoides* respectively with respect to control treatment. TSS content was decreased with sodic environment while these showed increased pattern with salinity. Protein content was maximum (12.83and 16.65mg/g) in control decreased to a minimum amount (9.37and 12.45mg/g) at pH_2 9.0 + ECe 20 dSm^{-1} in *S. nudiflora* and *A. lagopoides* respectively. Approx. 10 times higher proline accumulation was observed with increasing stress conditions which showed higher osmotic adaptations. This study confers the eco-physiological potential of these halophytes and these could be used as good material for forages under salt affected environments.

Study of different Genotypes of Groundnut (*Arachis hypogaea* L.) and their relative salt tolerance under simulated saline soil condition

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Abstract

A green house experiment was conducted at Junagadh during 2012-2013 in galvanized pots (75 x 60 x 30 cm) containing 120 kg soil to evaluate the salt tolerance of three spreading (GG-12,GG-13 and JSP-11391), three semi-spreading (GG-20,TG-26 and JSSP-22302) and four bunch (GG-6,GG-7,GG-5 and J-33533) genotype of groundnut (*Arachis hypogaea* L.) using four levels of salinity (control,4,8,and 12 EC dS/m).The results showed that as the salinity levels increased the germination count, plant height and pod and haulm yield decreased significantly but reverse was true in case of Na/K ratio. The varieties GG-12 (Spreading), GG-20 (Semi-spreading) and J-33533 (bunch) showed better performance at all the salinity levels than the other varieties tested in their respective groups.

Effect of N levels, seedlings per hill and spacing on performance of rice varieties in coastal rainfed lowlands during wet (*kharif*) season

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Abstract

The *Sundarbans*, forming the lower Gangetic delta, is located in the eastern coastal part of India and southern part of Bangladesh, where rice is the only crop grown on about 98% of the cultivated area under rainfed conditions during the wet *(kharif*) season. Growing other crops is difficult during this period due to waterlogging. Farmers of the coastal region often practice suboptimal main field management practices,which leads to poor yields (≈1.5- 2.0 t ha^{-1}), below the national average of 2.39 t ha^{-1}(Government of India, 2011-12). Development of suitable main field management practices along with improved varieties is of prime importance for increasing the productivity of rice in the coastal region. Farmers usually grow low yielding rice varieties, especially in the wet season, with often improper nutrient management in the main field. The varieties grown are either long-duration traditional landraces or old varieties, which are no longer fitting within these rice ecologies. On-station trials on main field management were conducted to study the effect of variety, number of seedlings $hill^{-1}$, hill spacing and nitrogen levels in the main field on yield of rice. Results revealed that a fertilizer dose of 50-20-10 kg N-P_2O_5-K_2O + 5 t FYM ha^{-1}, two seedlings $hill^{-1}$ and a hill spacing of 15 x 15 cm were found to be optimum as management practices for improved productivity and economic returns of transplanted *kharif* rice in coastal rainfed lowlands. The improved variety Amal-Mana produced about 14% higher grain and straw yields over traditional variety Geetanjali during *kharif* season.

Salt tolerant crops: Ideal option to mitigate coastal salinity in Western India under changing climatic scenario

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Abstract

Climate change is expected to result in increased frequency of abiotic stresses like drought, heat stress, submergence, increased soil salinity etc. Among these, salinity stress severely affects crop growth and productivity, posing serious challenge to food security and sustainability. As per FAO/UNESCO estimates, a total of 800 Mha is affected by salinity worldwide. In India, nearly 6.73 Mha of land is affected by salinity, of which Gujarat state, with 1600 km long coast line accounts for about 33 per cent ie., 2.2 Mha, and thus needs a holistic approach for sustainable crop production in coastal agro-ecosystem. Interdisciplinary research on identification and evolving salt tolerant crops and their genetic improvement for salt tolerance through collection, conservation, evaluation and utilization of germplasm in crops like cotton, wheat, and maize is underway at Central Soil Salinity Research Institute, Regional Research Station, Bharuch, Gujarat (India).

Research indicated that crop species like Asiatic cotton (*Herbaceums and Arboreums*) performed better than American cotton (*Hirsutums),* due to their deep root morphology, effective ion partitioning and lower Na/K ratio in leaves under saline conditions. Herbaceum cotton, G Cot 23 was found ideal accession for cultivation in salt affected coastal lands under rain fed scenario. In Maize, flowering stage was found the most susceptible for salt stress. Maize hybrid DKC 9081 was superior as compared to OPVs and composites. The increased salt tolerance was ascribed to high chlorophyll, high cytosolutes like sugar, ions and proline in leaves at flowering, primarily resulting in better osmoregualtion during salinity stress. Wheat varieties like KRL 210 and KRL 19 with yield potential of 3.8-4.0 t/ha have been found ideal for coastal saline soils. Field studies conducted over the years have shown that, wheat accessions such as RWP 2012-17 and KRL 213, having low Na/K ratio in leaves with high seed test weight were more tolerant to saline conditions. These salt tolerant accessions have been tested at various locations in coastal saline soils of Saurashtra, South Gujarat and Central Gujarat, and performed better than conventional varieties in farmers' fields. Due to its cost effectiveness and eco-friendly nature, this approach has potential to bring coastal saline soils under cultivation for sustainability of agro-ecosystem and livelihood security of the farming community.

Salinity effect on rice genotypes and its correlation with yield and its components

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Abstract

Salt tolerance is a quantitative trait controlled by many genetic components. Yield and its components are the most important traits which are adversely affected by it. Therefore, it is important to find the direct and indirect effects of salinity on yield. In pursuit to find a correlation between yield and its yield contributing attributes under normal and saline condition, an experiment was conducted on 34 genotypes in both saline and normal condition to exactly pinpoint those attributes whose contribution is most important in determining yield. The study revealed that grain yield is most sensitive to high salinity (ECiw~10 dS/m) and showed 55 percent decrease in yield as contrast to normal. The attributes contributed to yield are also affected, with reduction of biological yield by 52 percent, productive tillers per plant by 30 percent, plant height by 27 percent, total tiller per plant by 23 percent and panicle length by 17 percent. Subsequent analysis of variance revealed that there is significant variability among genotypes for all the traits under normal and saline environment. The highest and positive correlation was noticed between yield and harvest index (0.68 and 0.79) followed by yield and biological yield (0.65 and 0.73) under normal and saline environment respectively. The trait biological yield per plant showed the highest and positive direct effect of 0.70 and 0.60 with grain yield per plant in normal and saline, respectively. The selection of plants through traits such as panicle length and biological yield could be best strategy in improvement of yield under salt stressed conditions.

Impact of varying salinity levels on germination and seedling vigour in wheat (*Triticum aestivum* L.)

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Abstract

Salinity is one of the environmental factors that have a critical influence on the germination of seeds and subsequent establishment of seedlings in the soil. In order to investigate salinity stress on wheat germination indices, an experiment was carried out at CSSRI, Karnal, India to create salinity stress, at the levels of 0 (as control), 6, 9, 12 and 15 EC and six wheat (*Triticum aestivum* L.) cultivars (KH-65, KRL-99, PBW-343, PBW-621, HD-2851, and HD-2009) were tested. For each treatment, rate of imbibition, germination rate, percent germination, seedling vigour and Sodium (Na)/Potassium (K) content were compared. Rate of seed germination was significantly reduced with increasing salt concentrations. The strongest inhibition of germination occurred as the salt concentrations were increased. Growth of young seedlings was also reduced w.r.t. length and biomass. Higher salinity levels were inhibitorier to imbibitions and seedling root elongation. The seed vigour measured as vigour index-I showed significant difference among the saline treatments. The vigour index-II based on seedling dry weight was also measured. The sodium content was increased under salinity stress in both root and shoot of all the genotypes, similarly, potassium content was found lower in all the treatments. However, Na/K ratio was more altered in shoots as compared to roots.The seed vigour measured in terms of vigour index and speed of germination indicated the superiority of KRL-99 seed under saline environment over all other varieties. In conclusion, the present findings indicate that early seedling vigour of wheat is severely compromised in saline environment and an early screening for salt tolerance can be achieved in wheat seeds using petridish experiments.

Direct Seeded Rice Technology in Reclaimed Salt Affected Soils of Haryana: Empirical Learning on Farmers Knowledge and Adoption

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Abstract

The conventional system of rice production (CT- TPR) in Haryana is water, labour and energy intensive, adversely affecting the natural resources. Therefore to sustain agricultural system and natural resources more efficient alternative methods of rice production are needed. Direct Seeded Rice (DSR) is one of the technologies which is water, labour and energy efficient along with eco-friendly characteristics and have potential to minimize environmental and resource risk. To assess the adoption pattern regarding DSR technologies in reclaimed soils, a study was undertaken in seven villages of three districts of Haryana with 40 farmers selected purposively. The study revealed that the majority (70%) of the farmers had medium level of knowledge regarding DSR technology. Most of them (85%) were well acquainted with regard to choice of recommended varieties, field selection, optimum seed requirement, method of sowing, weed management and plant protection measures. However they had poor knowledge about seed treatment, management of weedy rice (Rani-jeeri) and residue incorporation. About 65 % farmers belonging to medium level of adoption category. It was found that two-third of the farmers adopted CSR 30 as first choice followed by Pusa 1121 and Pusa 1509, more than 90% of the farmers sow their crop in the first fortnight of June using recommended seed rate (7-8 kg seed/ acre). To control weeds, more than 80% of the farmers used recommended herbicides. The main reasons for adopting DSR technology were required less of labour, reduced cost of cultivation, less water and energy. Majority of the farmers claimed that unavailability of quality seed and machine at proper time, luxuriant weed growth, inadequate technical know how are the constraints limiting crop production. The farmer's education, social participation, extension contacts had shown significant and positive correlation with respect to adoption rate. The study concludes that DSR can be an efficient resource conservation technology over conventional transplanted rice. It is provided well planned and adopted under DSR.

Screening of 1000 breadwheat (*T. aestivum L.*) germplasm in sodic soils

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Abstract

The study was carried out at CSSRI, Karnal to screen 1000 breadwheat germplasm lines under sodic conditions (pH_2 9.1). During Rabi 2009-10 results conformed that 25 germplasm lines performed better over sodicity tolerant check Kharchia 65. A lot of genetic variability was observed among the screened lines as evident from the yield attributes. Grain yield/per plot (1mt. row length with 30 cm spacing apart) recorded with mean value of 113 gm and ranged from 8-311 gm. Number of days to heading ranged from 79-131 with a mean value of 100. Most of the studied lines were tall as evident from plant height that ranged from 70-160 cm (mean 117 cm). Yield in terms of 1000 grain weight also showed variability that ranged from 11-50 gm. These selected 25 germplasm lines showed great scope for improving yield under stress condition and can be utilized as a potential source of salt tolerance.

Salt Tolerant Varieties: Performance and Replacement by Farmers in Saine and Sodic Environment of Haryana

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Abstracts

Soil salinity has been a serious concern for global agriculture throughout the human history (Lobell et al., 2007). According to FAO Land and Nutrition Management Service (2008), over 6% of the world's land is affected by the salinity, which accounts for more than 800 million hectares of land in 100 countries. As per estimates of CSSRI, NRCSA and NBSSLUP (2012), total 6.74 Mha of land in India is affected by salt. Rice (*Oryza sativa L.)* and wheat (*Triticum aestivum L.*) based agroecosystems (RWAS) DOMINATE THE AGRICULTURAL LANDSCAPE OF Haryana State of India. However, Salinity of the agricultural land poses a serious threat to sustainability of RWAS. Among various approaches used in management of salt affected soils, use of salt tolerant varieties has been an effective, economic and eco friendly approach. In this direction, ICAR-Central Soil Salinity Research Institute(CSSRI), Karnal, has developed and released a number of salt tolerant varieties of rice and wheat. Therefore study was conducted to analyse dynamics of varietal performance and replacement by farmers, technological gap in saline and sodic environment of Haryana state of India.

Study was carried out with 50 farmers from Jind, Sonepat and Karnal districts of Haryana. Data were collected through personal interview and focussed group discussion. Selected farmers were having soil pH in the range of 7.9 to 9.1 and electrical conductivity in the range of 0.13 to 10.78 dS/m. About 36% of them were small and marginal. It was found that average yield of CSR 30 was 13.59 q/acre and that of CSR 36 was 18.65 q/acre. In wheat average yield of KRL 210 was the highest (20.12 q/acre) followed by KRL 213 (19.50 q/acre). Performance of varieties as perceived by farmers was recorded on scale of one to five. In rice, CSR 30 was more popular among farming community because of its high nutritional value (4.91 on five point scale) and price in the market (4.87). Farmers perceived CSR 36 variety more salt tolerant with score of 4.80. In wheat, KRL 19 scored high (4.70) for salt tolerant, while KRL 213 scored high (3.67) in terms of compatibility to abrupt climatic variability. Yield over the existing variety and price in the market were the two most important factors behind varietal replacement as reported by the farmers.

Phyto-remediation potential of halophytes and other salt tolerant plant species for Coastal Saline Soils

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Abstract

About 6.73 million hectares of land is salt affected in India. Agricultural salinity is a major environmental constraint affecting crop production. In coastal saline soils of western coast of India, certain halophytes are dominant. These economically useful halophytes and salt tolerant plant species can effectively remove salt from soil which includes *Salvadora persica, Suaeda nudiflora, Salvadora oleoides, Hibiscus sabdariffa* (khati bhindi), *Cressa cretica, Mirabilis jalapa* and a mangrove *Avicennia marina*. These have potential to remove substantial amounts of sodium from soil upto 25 dS/m as evident from elemental analysis of leaf and stem under salinity stress. Certain multipurpose tree species *Casuriana equisetifolia, Acacia catechu, Leucaena leucophala* and *Albezia lebbeck* were able to survive under high salinity stress upto 15 dS/m.

Field and pot experiments were initiated with different halophytes plant species were conducted at CSSRI, Regional Research Station, Bharuch to ascertain the efficacy of halophyte plants for salt removal from soil under different imposed salinity levels. It was observed that there was 4% and 27% higher plant height of *Salvadora persica* grown in field, under EC 15 dSm^{-1} treatment compared to EC of 2.5 dSm^{-1} and 30 dSm^{-1} , respectively at 90 days after planting. In shoots, Na content increased by 42% at salinity level of 30 dSm^{-1} over 2.5 dSm^{-1}. There was 4% drop in activity of dehydrogenase enzyme in soil was noticed when salinity level increased from 2.5 dSm^{-1} to 30 dSm^{-1}. Rhizospheric soil bacteria population declined up to 80% at salinity level of 30 dSm^{-1} compared to 2.5 dSm^{-1}. In pot study with salinity treatments of 2.5, 7.5, 15, 20, 25 and 35 dSm^{-1} on Vertisol, *Savladora oleoides* growth was found to be influenced. Maximum shoot height was 77.85 cm and minimum shoot height was 70.7 cm in 7.5 dSm^{-1} and 35 dSm^{-1} treatments, respectively. Sodium content of leaves in *S. oleoides* were increased up to 40% when salinity raised from 2.5 dSm^{-1} to 20 dSm^{-1}, thereafter fall in Na content was observed. In stem, up to 32% increase in Na content was recorded at salinity of 35 dSm^{-1} compared to 2.5 dSm^{-1}. The proline content of fresh leaves was increased from 90 µg/g to 340 µg/g when salinity increased from 2.5 to 35 dSm^{-1}. Maximum number of branches of *Suaeda nudiflora* was found at 7.5 dSm^{-1}. The increase in number of branches from 27 to 52 were recorded, when salinity was increased from 2.5 dSm^{-1} to 35 dSm^{-1}. Plant height increased up to 57.8 cm at salinity of 15 dSm^{-1}. There was increase in root length from 8.2 cm to 23.5 cm when salinity level was raised from 2.5 dSm^{-1} to 15 dSm^{-1}, but further increase in salinity ceased the growth of roots in *S. nudiflora*. There was 52% and 14% rise in Na content of leaves and stem respectively when salinity was increased from 2.5 dSm^{-1} to 30 dSm^{-1}. Proline content of fresh leaves was minimum of 440 µg/g at lower salinity level and maximum of 840 µg/g at highest salinity level. Thus, salinity enhanced proline synthesis in leaves of *Suaeda nudiflora*. The population of rhizosphere bacteria increases up to 32 $*10^5$ at salinity level of 15 dSm^{-1}; further salinity resulted in decrease in number of bacteria ($7*10^5$) at 35 dSm^{-1} salinity level.

Effect of Fluoride and Phosphorus on the Yield of Barley in Sodic Soils

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Abstract

A screen house testing was followed by the laboratory incubation experiment which was carried out to study the effect of fluoride and phosphorus at different ESP levels of the soil. In laboratory, effect of incubation periods on the extractability of F and P in soil at different levels was carried out. The soils of different ESP levels were prepared and their observed ESP were recorded as 6.2, 27.1, 43.7 and 54.9. Under incubation studies, the fluoride and phosphorus levels were 40 and 160 mg/kg and 12.5 and 50 mg/kg, respectively, at incubation periods of 1, 3, 7, 14, 21, 28 and 35 days at temperature of 25±2^{o}C. Moisture was maintained at field capacity by addition of distilled water. The results indicated that the extractability of fluoride in soil increased with increasing levels of F and P application along with increased ESP. Similarly, Olsen's extractable phosphorus in soil also increased with increasing levels of F, P and ESP levels. However, the extractability of both F and P decreased with increase in incubation periods.

In screen house experiment, the effect of varying levels of fluoride (0, 40, 80 and 160 mg/kg soil) and phosphorus (0, 12.5, 25 and 50 mg/kg soil) at two ESP levels (6.2 and 27.1) were conducted to investigate their impact on the yield of barley. The results revealed that with increasing application of P, the grain yield increased by 51.3 and 50.8 per cent at ESP 6.2 and 27.1, respectively. The results presented that the grain and straw yield of barley decreased with increasing levels of fluoride from 0 to 160 mg/kg soil along with increasing ESP levels. The grain yield decreased with increasing levels of fluoride in the soil. It decreased by 10.7 and 15.9 per cent at ESP 6.2 and 27.1, respectively. The adverse effect of added fluoride was more marked at ESP 27.1 and the deleterious effect of added fluoride was counteracted to some extent by addition of phosphorus.

The fluoride concentration in both grain and straw increased with increasing levels of added F and P concentration in soil along with increase in ESP levels. The phosphorus concentration also increased with added P in soil but it decreased with increasing levels of F and ESP. The application of fluoride also resulted in decreased concentration of K, Ca, Zn, Cu, Mn and Fe in both the barley grain and straw but it increased Na concentration in both grain and straw.

Influence of Nanoparticles on Soil Microbial Communities and Nitrogen Transformation

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Abstract

Current widespread use and application of nanotechnology will likely spread nanomaterials into agricultural soils. However, there is little information related to effects of nanoparticles (NPs) on soil biological processes especially nitrogen transformation in soil. Series of laboratory experiments were conducted to quantify the stress effect of three widely-used NPs (nano-ZnO, nano-Fe_2O_3 and fullerene, C_{60}) on soil nitrogen transformation and soil microbial population by incubating Inceptisol for 60 days. The NPs were incorporated in an Inceptisol to give a final concentration of 0.066% (w/w) for nano-ZnO and nano-Fe_2O_3 and 0.013% (w/w) for fullerene. The soils were incubated under two moisture regime viz. submerged and 45% of water holding capacity. There were variable observations on population of microbial groups in soils. The negative effect of NPs is evident in the case of bacteria, but this effect seems specific to type of NPs and type of microbial groups. For example, bacterial population was lower in soils treated with nano- ZnO than nano-Fe_2O_3 or fullerene. Whereas, population of ammonia oxidizing bacteria (AOB) found to be significantly ($p<0.005$) higher in case of nano-ZnO or fullerene treated soils. The results reveal that continuous 60 days water logging of soil significantly ($P<0.05$) reduced the population density of AOB, nitrification activity, urease activity, nitrate concentration and flooding nullified the negative impacts of NPs on soil. Overall, the study demonstrates the undesirable effects of metal oxide and carbon based nanomaterials on soil, which underscores the necessity for taking remedial measure in the disposal of wastes and sludge containing these nanoparticles. Further, study revealed that the NPs can affect different nutrient transformation processes in soil and, may imbalance soil ecosystem

Theme 4

Application of modern tools and techniques for diagnosis and prognosis of salt affected soils and poor quality waters

Geo-referenced Soil Fertility Assessment for Optimized Fertilizer Use in Salt Affected Soils of Purna Valley in Maharashtra

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Abstract

The geo-referenced soil fertility monitoring was carried out in saline tract of Purna valley under the project "Management of Soil Health and Fertility for GPS-GIS Based Model Soil Fertility Maps". The 282 surface soil samples were collected from Daryapur, Bhatkuli, Anjangaon, Amravati and Chandur Bazar tehsils in Amravati district, 324 samples from Telhara, Akot, Akola and Murtizapur tehsils in Akola district and 162 soil samples from Jalgaon Jamod, Sangrampur, Shegaon and Malkapur tehsils in Buldhana district during 2011 and 2012. The 768 geo-referenced soil samples were collected and latitude, longitude and altitude were recorded using Global Positioning System (GPS).

In salt affected soils of Purna valley the soil pH ranged from 7.00 to 9.15 while electrical conductivity varied from 0.10 to 0.99 dS m^{-1}. The free $CaCO_3$ varied from 1.0 to 31.87 per cent. The highest percentage of $CaCO_3$ was found in Bhatkuli (88.89%), Anjangaon (89.59%), Amravati (72.92%), Akot (77.38%), Akola (87.26%), Murtizapur (77.38%), Shegaon (66.7%) and Malkapur (56.7%). Organic carbon content in the soil ranged from 1.01 to 9.90 g kg^{-1} in which 39.8 % samples were found low.

The available nitrogen varied from 84.3 to 305.5 kg ha^{-1} out of which 97.7 % samples were found deficient. The available phosphorus ranged from 2.01 to 52.2 kg ha^{-1} and its deficiency was 53.66 per cent. The available potassium noticed between 67.2 to 996.8 kg ha^{-1}. The potassium deficiency was found in Akola (33.34%) and Murtizapur (28.57%) tehsils. The available sulphur ranged from 1.03 to 56.9 kg ha^{-1} wherein 24.6 % samples were deficient. The micronutrient status of the soil showed that available zinc ranged from 0.10 to 6.00 mg kg^{-1} wherein 57.2 % samples were deficient. The available iron ranged from 1.7 to 45.3 mg kg^{-1} out of which 36.02 % samples were deficient. The available copper ranged from 0.14 to 11.11 mg kg^{-1} and available manganese varied from 1.22 to 62.17 mg kg^{-1}. The available copper and manganese were found sufficient in most of soils. The nutrient index of nitrogen was found low (1.02) while nutrient indices of phosphorus (1.89) and sulphur (2.13) were noticed in medium category. The nutrient index of K (2.81) was high. The nutrient indices of Zn, Fe, Mn and Cu were found to be 1.66, 1.55, 3.00 and 2.65 respectively. The nutrient index of zinc and iron was found low while that of iron was medium. The nutrient indices of Mn and Cu were recorded high in the tehsils of Amravati district. Whereas, in the tehsils of Akola district the nutrient index of nitrogen (1.05), phosphorus, zinc (1.34) was found low, while potassium (2.00), sulphur (1.78) and iron (1.91) was medium and high in copper (2.73) and manganese (2.61). In Buldhana district tehsils nutrient index of nitrogen (1.00) and zinc (1.39) was found low, phosphorus (1.73), potassium (2.77), sulphur (2.07) and iron (2.49) was noticed in medium category, while copper (2.88) and manganese (2.83) was recorded high. The most crucial nutrients which need immediate attention in these salt affected soils are nitrogen, zinc and sulphur.

It could be inferred that, fertility of soils in Purna valley region in Vidarbha region of Maharashtra was low in nitrogen and zinc, medium in phosphorus, sulphur and iron, high in potassium, copper and manganese, which needs to be managed judiciously to maintain the soil health for obtaining optimum crop productivity.

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

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Abstract

Salinization of soil and water resources is one of the major threats for the sustainability of agriculture in arid and semi-arid regions of the country and has resulted in accumulation of salts at soil surface, and in sub-soil and groundwater by natural or human-induced factors. Quantity and quality of groundwater for irrigation has also impacted crop productivity and soil salinization. Therefore, accurate diagnosis, extent and distribution of salt-affected soils and poor quality groundwater are needed for effective planning and implementing of land reclamation measures in order to prognose crop productivity and soil salinity in the future. In the country, the first attempt for countrywide assessment of salt-affected soils and saline groundwater was made in 1966 and 1972, respectively. Subsequently, aerial photography and satellite remote sensing were applied to produce soil salinity and groundwater maps of districts and irrigation projects as well as of the country. Surface soil encrustation diagnosed by remote sensing may not be representative of the deeper soil condition and groundwater quality. Therefore, combining remotely sensed data and geophysical surveys data with spatial modeling was applied to prognoses the salinization of land and groundwater.

The national estimates on salt-affected soils and groundwater quality were obtained, compared and reconciled using GIS resulting in acceptable extent of 6.74 and 19.34 million hectares, respectively. Recent Indian satellite sensors (Resourcesat-2, Cartosat-2B, RISAT-1 and IMS-1 HySI) and airborne electromagnetic surveys along with improved digital data processing techniques and GIS have enhanced the capability of accurate diagnosing and mapping of salinized soils and groundwater on district scale. This improved spatial information were input to a spatial hydrologic and salinity model which has predicted the impact of reclamation measures on reduction of soil salinity and improvement of groundwater quality. The use of higher resolution foreign satellite data (Landsat-8, GeoEye-1, WorldView-3, IKONOS-II, and EO-1 Hyperion), airborne electromagnetic survey data (FEM and TEM) and ground penetrating radar data has also been explored.

Survey and characterization of underground water for irrigation in Dharwad district, Karnataka.

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Abstract

Dharwad district with an area of 4273 sq. km (427329ha) lies in the northern part of Karnataka state between 15^0 02' 00''to 15^0 48' 00" north latitude and 74^0 43' 30" to 75^0 33'25'' east longitudes with an annual average rainfall of 769mm. The district has 5 taluks with net sown area accounts nearly 72.09% of the total geographical area. During 2011-12 and 2012-13, a total of 313 underground water samples representing different villages in Dharwad (69 samples), Navalgund (34 samples), Hubli (56 samples), Kalaghatagi (97 samples) and Kundagol (57 samples) taluk were collected and analyzed for their irrigation quality.

Frequency of occurrence of good quality water in the taluks surveyed followed the order: Kalghatagi (93.80%) > Hubli (71.4%) >Dharwad (65.2%) > Kundagol (63.2%) > Navalgund (23.5%). Dharwad district as a whole, 63.4% of ground water samples was good quality water. Saline water samples were reported only from Kundagol and Navalgund to the extent of 8.8%. Alkali waters were found in Hubli, Kundagol, Dharwad and Navalgund to the extent of nearly 12, 12, 21 and 35% respectively. However, district as a whole different categories of problematic water altogether were less than 10%.

Application of Remote Sensing for Diagnosis of Salt Affected Soils

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Abstract

Salt affected soils are found both in inland areas and in coastal areas. The salinity problem in coastal soils is due to their formation under marine influence. Subsequently salt affected soils in coastal areas may also be formed due to their periodical inundation with brackish tidal water, as well as upward capillary rise of brackish water to surface soil from brackish ground water table present at shallow depths. Salt affected soils in inland areas are primarily developed due to accumulation of salts in soil profile because of high evapo-transpiration loss as compared to precipitation for leaching of salts. Some other of salt affected soils are formed due to introduction of large scale faulty irrigation system with less provision of drainage compared to input of irrigation water or injudicious application of large quantity of irrigation water. This has raised ground water table of the area close to the soil surface causing waterlogging and salinization of soil which has caused large areas of formerly productive lands into unproductive lands in many countries. Use of poor quality water without proper provisions for leaching of salts may also cause development of saline soils.

Soil salinization is a major form of land degradation in agricultural areas. In the past conventional methods have been used to detect soil salinity which took lot of time. But for monitoring and eventual control of salinity problem, remote sensing and GIS techniques are very useful which gives relevant data particularly for a wide area in a short period of time. The saline fields sometime show high uniformity in texture and in places gypsum is present in the deep subsoil which can be differentiated through ground truthing. The field data can be collected in the middle of the growing season of crop and about the time of satellite data capturing. The land cover points of different features can be taken with GPS. The presence of salts at the terrain surface can be detected from remotely sensed data either directly on bare soils, with salt efflorescence and crust, or indirectly through the biophysical characteristics of vegetation as these are affected by salinity. The two different methods (empirical and biophysical) needs two different types of satellite data support LANDSAT 7 ETM and ASTER in two different crop calendar dates. The salinity index, which is produced by the combination of different bands such as ASTER bands: (band 4-band 5) / (band 4+ band 5) has an accurate detection of salinity in the bare agricultural soils, particularly of fallow lands. The 2nd method, the biophysical method needs to be applied during the growing season. The method is based on detecting the crop reaction to soil salinity via the osmotic forces and the increasing surface resistance due to stomata closure. The relationship between the surface resistance of a crop (calculated from a Landsat enhanced Thematic Mapper image using the SEBAL method) and the EC obtained in the field is encouraging. Both types of classification, unsupervised and supervised, are used for proper identification of salinity, mostly at regional level. For assessing coastal ground water salinity geo-physical technique can be effectively utilized.

Assessing ESR-SAR Relationship under different quality water on Texturally Different Salt Affected Soils

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Abstract

The influence of total electrolyte concentration (TEC) and sodium adsorption ratio (SAR) of water on exchangeable sodium ratio-sodium adsorption ratio (ESR-SAR) relationships of normal clay loam, saline silty loam and calcareous sodic loam soils was studied in a laboratory experiment. Twelve solutions, encompassing three TEC levels *viz*., 25, 50, and 100 me L^{-1} and four SAR levels *viz*., 5, 10, 20 and 30 $mmol^{1/2}$ $L^{-1/2}$ were prepared to equilibrate the soil samples using pure chloride salts of calcium, magnesium and sodium at Ca: Mg = 2:1. SAR of equilibrium solution decreased as compared to the equilibrating solution and more so in waters of low TEC and low SAR. At all electrolyte concentration, SAR values were less than to the equilibrium solution because of addition of Ca and Mg from mineral dissolution or supply of calcium and magnesium from exchange sites. At higher TEC levels, considerable increase in ESP was observed when it was corrected for anion exclusion and more so in calcareous sodic loam followed by saline silty loam and normal clay loam soils.

The exchangeable sodium in all the soils increased by 2.1 to 3.8 fold and 1.1 to 2.1 fold, respectively, irrespective of TEC and SAR showing a positive interaction of TEC and SAR in sodification/ ESP build-up of soils. CEC and silt + clay content played a major role in the visual disparity in sodification of these soils. Gapon's selectivity coefficient values were perceptible in the order of calcareous sodic loam > saline silt loam > normal clay loam. This indicates the preference of normal clay loam soils for Ca^{2+} + Mg^{2+} than that of Na^{+} on the exchange complex, whereas loam soil exhibited high affinity for sodium. Regression coefficient of ESR-SAR relationships was maximum for sodic loam followed by saline silty loam and normal clay loam soil. The exchange equilibrium was strongly affected by TEC of the solution phase. Variation in soil pH was gradual with respect to TEC and SAR of equilibrating solution and a sharp change was observed. At a fixed TEC, critical ESP values observed were calcareous sodic loam > saline silt loam > normal clay loam. The SAR_{eq} needed for critical ESP built-up was calcareous sodic loam, saline silt loam and normal clay loam, respectively.

Estimation of gross soil erosion based on Universal Soil Loss Equation using Remote Sensing and GIS

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Abstract

Out of total geographical area of 328 M ha of India, about 188 M ha area is affected by various types of land degradation problems in which about 113.3 M ha is affected by water erosion. The negative impact of soil erosion includes reduction in soil productivity, silting of dams and reservoirs, deficits in water availability, pollution of water courses, serious damages to properties by soil-laden runoff, and desertification of natural environments. The degradation ultimately results in changes in river morphology, reduction in carrying capacity, sedimentation and eutrophication of reservoir/lakes, floods, poor crop yield etc. The present study was undertaken at Department of Soil and Water Conservation Engineering, GBPUA&T, Pantnagar to *estimation of gross soil erosion based on* Universal Soil Loss Equation in the Chaukhutia sub-catchment of Ramganga river catchment in Uttarakhand, India. The Chaukhutia sub-catchment covers total area of 57000 ha. Different thematic maps of the study area were prepared using survey of India toposheets (1:50,000 scale) and satellite imagery of study area with the help of ArcGIS software. Rainfall data was used to calculate the R-factor. K-factor was calculated using soil data of study area. LS-factor was calculated using Digital Elevation Model. CP-factor was calculated using satellite imagery of study. Universal Soil Loss Equation (A=RKLSCP) was used to estimate the gross soil erosion. Annual gross soil erosion was 101.95 ton ha^{-1}. It is suggested that suitable soil and water conservation measures should be implemented to ensure sustainability and economic viability in the Chaukhutia sub-catchment of Ramganga river basin.

Survey, Characterization and Mapping of Ground Water Quality of Gwalior District of Madhya Pradesh

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Abstract

One hundred sixty one ground water samples were collected from open and tube-wells located in different villages. Geographical position of the wells/ tube wells was recorded with the help of Global Positioning System (GPS). The samples were analyzed for salinity/ sodicity parameters as per the standard procedures. The open wells vary in depth from 2 to 20 m, whereas the tube-wells pump out water from 10 to 150 m depth. The quality of groundwater samples collected from the district indicates that pH, EC, SAR and RSC range from 7.6 to 9.1, 0.4 to 3.8 dSm^{-1}, 0.5 to 14.0 and 0.2 to 7.3 meL^{-1}, respectively. Out of 161 samples 126 (78.3 %) samples were classified as good quality (A) waters, whereas, 6 (3.7 %) samples falling under saline (B_1) and 29 (18.0 %) samples comes under alkali (C) waters. The alkali waters were again sub divided under marginally alkali (C_1- 12.4 %), alkali (C_2 - 3.7 %) and highly alkali (C_3 - 1.9 %) categories. Bhitarwar tehsil was most badly affected by poor quality waters (28 %) followed by Dabra (26%) whereas Gwalior tehsil (12%) was least affected. The waters were of Ca-Na-Mg types with the dominance of bicarbonates followed by chlorides/ carbonates. There was significant positive association of Na with HCO_3, Cl, SO_4 and SAR in all the tehsils. Correlation coefficient values between Na and SAR ranged from 0.87 to 0.92. HCO_3 showed a significant positive correlation with SAR and RSC both in different tehsils and district as a whole. The 'r' values in between HCO_3 and RSC ranged from 0.47 to 0.68, whereas, between CO_3 and RSC it ranged from 0.36 to 0.62. Highly significant and positive correlation was observed between SAR and RSC of the ground waters. The map showing area of saline and alkali waters was generated using GIS technique.

Identification of geochemical processes controlling groundwater fluoride in Unnao district Uttar Pradesh using graphical and multivariate statistical approach

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Abstract

A geochemical assessment of groundwater fluoride was carried out by using a hydro-chemical approach with graphical and multivariate statistical method for identifying the occurrence of various geo-chemical processes that are responsible for high fluoride in the groundwater in the Unnao district Uttar Pradesh. The results indicated that different natural hydro-geochemical processes such as simple dilution, natural weathering of rocks minerals especially carbonates bearing minerals, silicate weathering and various ion exchange processes are the key factors that govern the water chemistry of high fluoride contamination in groundwater. During both pre-monsoon and post-monsoon period, the ground water was found to be alkaline in nature which was a prominent factor for mobilizing fluoride from fluorite mineral. The cations dominance followed the order:Na>Mg>Ca>K while anions dominance was HCO_3>Cl>CO_3>SO_4. Majority of the sampled water was of Na-HCO_3 type in both the seasons. During pre-monsoon, 36.36% of the sampled water was found to exceed the desirable limit prescribed by Bureau of Indian Standard whereas it was only 22.72% in the post monsoon period. Fluoride had a significant positive correlation with CO_3, HCO_3 and sodium adsorption ratio (SAR).

Mapping and Characterization of Salt Affected Soils in Kaithal district of Central Haryana for Reclamation and Management

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Abstract

Soil salinity/alkalinity and water quality are major constraints causing reduced productivity in Kaithal district of Central Haryana. Visual interpretation of IRS LISS III Resourcesat for March, May and October 2009-10 revealed the presence of salt affected soils as barren patches and intermixed with cropped areas in the irrigated areas. Spectral analysis of salt affected soils showed high reflectance from barren salty surfaces while mixed signatures for salt stress and poor crop stand indicated the presence of moderate and slightly salt affected soils which is authenticated by ground truth. The presence of temporary waterlogging (higher water absorption) is common in salt affected soils due to low permeability, infiltration and hydraulic properties. Due to mixed spectral signatures, these areas were identified on the strength of ground truth only. The ground truth study revealed salt build-up due to the application of poor quality ground water for irrigation.

The salt affected soils in Kaithal district were sodic and saline in nature. Sodic soils were distributed in Pundri (2.1%), Kaithal (3%), Guhla (1.1%) and Siwan (1.1%) blocks while saline soils were distributed in Kalayat (2.6%) and Rajound (1.3%) blocks. Based on the physico-chemical characteristics, these soils were further classified as slight, moderate and strong for reclamation and management. The low internal drainage was common in sodic soils underlain by clay and clay loam texture at sub-surface layers. The presence of thick layer of precipitated calcium carbonate concretions (calcareous layer) were found at a depth of 1m below the surface. A total area of 26301 ha (11.3%) is salt affected in Kaithal district, of which sodic (17570 ha, 7.3%) and saline soils covered 9388 ha (4%) respectively. The ground water quality was commonly sodic in Cheeka sub-division showing high RSC (12.7 me L^{-1}), saline in Kalayat block (SAR 33.6) and sodic in Kaithal block, at places RSC showed as high as 6.5 me L^{-1}. Based on the soil physico-chemical characteristics and the quality of ground water, suitable reclamation and management options were also suggested to improve soil productivity.

Water and Pumping Energy use trends of Rice under varying Irrigation regime under partially reclaimed sodic soils

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Abstract

Timely application of controlled volume of water is one of the major objectives of irrigation. This become mandatory under sodic environment where over irrigation results into building of excessive soil moisture in the root zone and further worsening to water stagnation at surface due to low infiltration rate. In this endeavor it has been experienced that applying controlled volume of water through surface method is a herculean task. Normally it is believed that while practicing irrigation through surface method, a water user applies 30% to 50% higher volume than desired which is manageable to a great extent through various water saving techniques. This suggests that type of technology plays an important role. On other hand inefficient use of water also suggest inefficient use of energy while pumping. Keeping this in view a field study was conducted to estimate the water and energy use pattern in rice through surface method (scheduled at 2 DAD, 3 DAD and 4 DAD), and two type of sprinkling nozzles (sprinkler and LEWA scheduled at daily, one day interval and 2 day interval) under sodic environment.

The results reflects that pumping cost for providing irrigation once in one hectare varied with type of irrigation method used and observed as Rs. 2398/ha, 2291/ha and 1632/ha for surface, sprinkler and LEWA methods. This resulted in water saving by sprinkling method in the range of 20% to 30% and energy in the range of 5% to 30% over surface method of irrigation. The best performing intervention based on yield, applied irrigation water productivity and energy productivity was analyzed under different irrigation regime. It was observed that under surface methods 3 DAD resulted in higher water and energy productivity of Rs. 5.0 per m^3 of water and Rs. 1.25 per unit cost of diesel used respectively with marginal loss in yield over 2 DAD. Whereas, under sprinkling methods irrigation schedule at 2-day interval resulted in higher water and energy productivity of Rs. 5.58 per m^3 of water and Rs. 1.27-1.80 per unit cost of diesel used respectively as well as higher yield of rice.

Spatio-Temporal Changes in Watertable Depth and Salinity in a Salt Affected Soil (Nain Farm of CSSRI)

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Abstract

Water logging and poor water quality are serious environmental problems adversely affecting the crop yield, soil health and socio-economic conditions of the farming community. Monitoring of water table fluctuations and water quality, both spatially and temporarily, is important to evaluate the impact of water logging and salinity on crop production over large areas. Nain (Panipat) experimental farm of CSSRI, covering an area of 12 ha in a depressional location and having shallow and saline ground water conditions, gets waterlogged during rainy season. A surface drain, passing 3-4 m away from the western boundary of the farm, gets flooded during high intensity rains, whose water is transferred to 2 farm ponds constructed in the Nain farm for experimental studies. For monitoring water table fluctuations in the farm, 18 observation wells were installed in a grid in such a way to effectively evaluate the impact of a pumping from a tubewell, seepage from drain and ponds and natural recharge for working out the water balance of the farm.

During the year 2013, ground water table in the farm fluctuated between 3-4 m below the ground surface during pre monsoon season. A constant rise in water table was recorded in all observation wells during monsoon months of August, September and October, 2013. Combined effect of about 30 cm rainfall occurring during August and September, 2013 and seepage from constantly flowing adjoining drain throughout the monsoon season contributed to the rise of watertable to almost ground level. Because of saline nature, withdrawal of groundwater by pumping from the farm tubewell was virtually nil. Maximum groundwater rise was recorded in September, 2013. Observation wells installed near pond and drain area recorded the maximum (2.0- 3.2 m) rise in watertable and corresponding 1.0- 18.0 dS/m reduction in groundwater salinity. Near the tubewell, however, water table rise of 1.5-2 m did not indicate any improvement in groundwater salinity. Minimum rise of 0.5-1.5m in watertable and minimum improvement in ground water salinity was observed in observation wells located away from the pond and drain. The results point out clearly that seepage from ponds and drain had a dilution effect leading to floating of a shallow good quality water layer in Nain farm. This, however, was a short duration phenomenon since notable increase in ground water salinity was observed immediately after the monsoon season.

Soil Biological Quality in Sodic Black Soils of Purna Valley in Vidarbha Region of Maharashtra

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Abstract

The present investigation was carried out in the Purna valley of Vidarbha region of Maharashtra to assess the soil biological degradation due to salinization and sodification. Eight soil samples (0-20 cm) were collected from the salt affected soils in the Purna valley on the basis of earlier characterization and existing field variability. The fresh soil samples were subjected to biological analysis. The soils were moderately to strongly alkaline in reaction (pH 7.9 to 8.5) with electrical conductivity of 0.33 to 0.48 dSm^{-1} while the ESP varied from 5.4 to 8.9. In respect of soil biological properties, the most important indicators of soil biological quality were identified as soil respiration (23.1 to 36.3 mg CO_2 evolved 100 g^{-1} soil 24 hr^{-1}), soil microbial biomass carbon (SMBC) of 175.1 to 297.7 mg kg^{-1} of soil and soil enzyme activities like dehydrogenase (20.41 to 28.74 µg TPF g^{-1} soil 24 h^{-1}) and urease (12.50 to 20.70 mg NH_4-N released 100 g^{-1} h^{-1}) which were significantly reduced in these soils as sodicity increased. Microbial population viz; bacteria, fungi and actinomycetes were also reduced along with sodicity. The lower levels of respiration rates can be attributed to the lower carbon content in these soils under prevailing semi arid climate. These results indicate that fungi were most susceptible organism, bacteria were intermediate to tolerant and actinomycetes were tolerant to the sodic conditions.

Available Nitrogen, Phosphorus and Potassium status in some soils of Haryana

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Abstract

Soil samples were collected from farmer's field at different villages in Karnal, Kurukshetra and Kaithal districts of Haryana. Soils were analysed for characterizing the physico-chemical properties and available nitrogen, phosphorus and potassium content. Electrical conductivity of soils under Karnal, Kurukshetra and Kaithal samples were ranged between 0.12 to 1.03, 0.11 to 2.06 and 0.16 to 0.96 dS m^{-1} respectively whereas mean value was 0.38, 0.59 and 0.34 dS m^{-1} respectively. pH of the soil samples were ranged between 7.1 to 10.2, 7.4 to 9.6 and 7.1 to 10.2 and mean value was 8.6, 8.4 and 8.7, respectively.

Overall results show that soils were normal to alkaline in character irrespective of the location of the soils in these districts. Available nitrogen status in soils under Karnal was 54.9 to 176 kg ha^{-1} with mean, mode and median value of 117.8, 124.0 and 124.0 kg ha^{-1}. Available nitrogen in soils under Kaithal district was 78.4 to 286.0 kg ha^{-1} with mean, mode and median value 118.5, 126.0 and 107.5 kg ha^{-1}. In Kurukshetra district, available nitrogen in soil was ranged between 71.0 to 140.0 kg ha^{-1} with mean, mode and median value of 114.2, 116.0 and 116.0 kg ha^{-1}, respectively. Available soil nitrogen status was found low in these districts except in some soils under Kaithal. Available phosphorus in soils under Karnal, Kaithal and Kurukshetra was ranged between 10.2 to 82.0, 16.0 to 52.0 and 11.2 to 90.0 kg ha^{-1} with mean, mode and median respectively was 29.6, 19.0, 23.0; 25.3, 21.0, 23.5 and 39.1, 38.0, 38.0. Available potassium status in soils under Karnal district was found in the range of 74.0 to 946.0 kg ha^{-1} while in Kaithal and Kurukshetra it was 117.6 to 756.0 kg ha^{-1} and 59.0 to 529.5 kg ha^{-1} with mean, mode and median value 294.7, 233.0, 237.0; 324.8, 421.0, 330.0 and 196.1, 109.0, 139.0. Overall results depicted that status of available potassium in soils largely varied with type and location of soils in these districts. It is concluded that available nitrogen was generally found in the lower range whereas available phosphorus and potassium was mostly varied with type and location of the soil sampling sites and found in the low-medium to high range.

Groundwater quality mapping of Dabwali block of Sirsa district, Haryana

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Abstract

Proper planning and management of groundwater requires spatial assessment and mapping of groundwater quality. The present study was aimed to characterise the groundwater quality and delineate its spatial variations in Dabwali block of Sirsa district, Haryana. 112 water samples were collected from existing tubewells and analysed for different chemical composition (Na^+, Ca^{2+}, Mg^{2+}, K, CO_3^{2-}, HCO_3^-, Cl^-, SO_4^{2-}) and parameters (pH, EC, SAR and RSC). To study the spatial distribution of different parameters (EC, pH, SAR, RSC and water quality according to AICRP criteria), maps were prepared. The results of analysis were interpreted according to four different classification criteria i.e. AICRP, Manchanda, USSL and Piper to check its suitability for irrigation purpose. According to AICRP criteria, out of seven categories, maximum 31.3 percent of samples were found in marginally saline and minimum 8.0 percent were found in saline, whereas, no sample was in alkali and high alkali categories. According to Manchanda criteria, out of five categories, maximum 31.3 percent of samples were found in normal and minimum 8.9 percent were found in marginally saline. According to USSL, groundwater quality of the district was observed under C2S1, C3S1, C3S2, C3S3, C4S2, C4S3 and C4S4 categories. According to Pipper criteria, in the block, 14.3, 84.8 and 0.9 percent samples were under good (Ca^{2+}-Mg^{2+}-Cl^- and Ca^{2+}-Na^+-HCO_3^- type), poor (Na-Cl type) and marginal (Ca-Cl or Ca-SO_4 type) categories, respectively.

Storm based rainfall- runoff model using kinematic wave theory

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Abstract

The hydrological behavior of a watershed is quite complex due to spatial and temporal variability of physiographic and climatic characteristics and interdependent processes involved in the rainfall-infiltration-runoff relationship. Modelling of hydrological processes provides an effective means for estimation of runoff required for planning and execution of water resources projects. A kinematic wave model, based on the dynamic wave theory, has been applied for study of rainfall-runoff phenomenon in the present study. Hydrologic investigations were carried out in the Zonal station of National Agricultural Research Project at Shenda Park, Kolhapur, Maharashtra, located at $16^0$45' N latitude and $74^0$14' E longitude for runoff prediction in a 12 ha watershed. The rainfall and runoff data collected for the years 2004 to 2006 and double ring infiltration data of year 2006 for this watershed were analysed to develop hyetographs, rainfall intensity-infiltration-time relationships. In the runoff estimation model, infiltration was considered as a loss whereas other losses due to initial abstraction, depression storage etc. were assumed negligible. Equal time interval blocks on the time scale of the storm event were used to define rainfall intensity and time decay infiltration rate while total runoff during a storm period was estimated by summation of runoffs during different time intervals. The model results on runoff volume corresponding to storm events during the year 2004-2006 were 20-35% higher than observed values. The higher predicted values could be attributed to the use of only one infiltration rate curve data and assumption of negligible abstraction losses other than infiltration in the study. Based on results of this study, it can be stated that the developed model using storm rainfall and infiltration data can be applied for determination of surface runoff of any watershed.

Theme 5

Social, economic and policy dimensions in saline environments

Reducing farm income losses through land reclamation: A case study from Indo-Gangetic plains

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Abstract

Soil sodicity is a major problem in arid and semi-arid regions of Indo-Gangetic plains in India which negatively impacts crop productivity and farm income. A large proportion of sodicity-affected soils in Indo-Gangetic areas occur on land inhibited by resource poor farmers. Several efforts have been made by the central and state governments to check soil degradation and increase agricultural productivity through land reclamation programmes in salt-affected regions of India. The present study is an attempt to measure the impact of land reclamation on reduction in farm income losses. The study sourced data from published records and survey from farm households in Uttar Pradesh, India. Analysis revealed that land reclamation has contributed substantially to improve the soil health, crop productivity and farm income. All uncultivated degraded lands in pre-reclamation period have been put under cultivation in post-reclamation period and the cropping intensity has significantly increased. The farm income losses were reduced substantially in post-reclamation period. The study has concluded that land reclamation made a significant contribution to livelihood security of resource poor farmers in salt-affected regions. The study has suggested that a large part of agricultural land is being abandoned in India due to severe sodicity related problems and need to be reclaimed on priority basis to improve land productivity and farm income of resource poor farmers.

Scope and implications of sustainable intensification in reclaimed salt affected soils of Western IGP

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Abstract

The cascade of environmental changes and steady increase in irrigated areas in India would lead to secondary salinization consequentially leading to estimated 20 m ha salt affected areas by 2050 compared to the current estimate of 6.73 m ha. It is estimated that about 1.8 m ha of salt affected area has been reclaimed so far by the adoption of reclamation technologies and this area alone is contributing nearly 15 million tonnes food grains (paddy and wheat) annually, mostly from western IGP besides generating on-farm and off-farm employment for millions. Sustainable intensification opportunities (including viable diversification and cropping system optimization options) while addressing the challenges of NW India (water shortages, natural resource degradation, emerging climatic variability) for national food security is of utmost importance. In NW India, due to rising concerns related to overexploitation of groundwater resources leading to a decline in the groundwater tables, increasing cultivation cost, scarcity of labor and energy, soil and water quality degradation, poor management of crop residues particularly burning leading to climate change, so there is increased interest among researchers and policy makers in diversifying *kharif* rice (water, labor, energy, and capital intensive crop) with maize and/or intensifying the current rice-wheat cropping system with other crops. Agricultural intensification increases food production from the defined agro-ecosystem by maximum utilization of fixed resources (land, light and temperature etc.) along with optimum use of agri-inputs for attaining sustainable production levels with higher input use efficiency. Increasingly, sustainable intensification is being considered as "*an important component of the overall strategy for ensuring food security, poverty alleviation, health for all, rural development, enhancing productivity, improve environmental quality and preserve natural resources*" in the defined domain. With limited scope for further expansion of area under agriculture in India, production gains can be accomplished through intensification of agriculture by pursuing one or more strategies including: (i) increasing yields per hectare; (ii) increasing cropping intensity per unit of land and (iii) changing land use. Sustainable intensification opportunities includes (i) promotion of improved production technologies for alternate crops to diversing rice; (ii) restoration of soil health (relay cropping of mungbean); (iii) adoption of integrated farming system (IFS) - a holistic approach is required to address the issues in NW India (water shortages, natural resource degradation, emerging climatic variability) for national food security.

In IGP, the climatic/total yield gap (difference between climatic potential yield and district average yield) in three major cereal crops i.e. rice, wheat, maize are 61%, 45% and 76% respectively, whereas, the respective management yield gaps (difference between experimental plot yields to district average yield) are 58%, 26% and 68% (Gupta, 2013). The majority of these gaps are due to poor crop management practices, availability of quality seed and other inputs and power supplies. Assessing the potential role of innovative technologies such as conservation agriculture (CA) is essential since risk, profitability, and environmental quality outcomes can be significantly conditioned not simply by crop choice, but also by the specific production practices employed by farmers. CA aims to devise strategies to reorient rice-wheat (RW) cropping system through system intensification in NW India through resilient cropping system and management scenarios by using a wide range of indicators (crop rotation, tillage, crop establishment, crop, water and residue

management) with business as usual (farmers practice) in the region to address the issues of degrading natural resources, stagnating yields, climatic changes besides water, labour and energy shortages being faced by the farmers (Gathala *et al.*, 2013).

Despite the emphasis on diversification, there are several 'unknowns' about potential markets, higher economic risks for producers associated with crops that are not generally publically procured, as well as uncertainties about underlying hydrology processes and associated resource quality considerations – including the need to manage irrigation in ways that reduce the probability of secondary salinization in salt-affected soils. It is important to note that climate and market-based risks are dynamic and have a great role in deciding intensification approaches. Determining the temporal aspects of diversification and addressing the issue of when it makes sense for policy makers, value chain actors such as feed mills, and individual farmers to invest are also salient concerns.

This study begins to explore the prospects and implications of cereal systems diversification and intensification in the NW - IGP in order to determine plausible impacts on food security, livelihoods, and environmental quality. To overcome formidable problems of RW system, sustainable intensification emerged an important alternative to achieve output growth, to create employment generation and to sustain natural resources in NW India while maintaining food accessibility and quality of environment. Adoption of agricultural intensification through diversified systems in NW India may be a productive way to build resilience into agricultural systems for national food security.

Land degradation management in an island ecosystem for providing livelihood support

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Abstract

Land is one of the most important natural resources necessary for the survival and well being of mankind the degradation of which will not only affect the land productivity but the livelihood of people who depend on it. Coastal salinity due to inundation of sea water, acid-salinity, water logging are the major types of land degradation occurring in the tropical island ecosystem of Andamans, India. In addition, the cultivated land available before 2004 tsunami was shrunk by 14% due to tsunami and its after effects. Though submergence of low lying areas during monsoon is a major concern but equally availability of fresh water during dry season restricts the agricultural activities. Therefore adoption of appropriate management technology is essential to manage both land and rain water as the region is also projected to suffer from sea level rise and flooding.

The coastal village of Chouldhari in South Andaman suffers from water logging and acid saline condition (pH 4.8 to 6.5). Crop production and agriculture development is very difficult because of low-lying topography and proximity to sea. The farmers used to cultivate only traditional long duration rice variety (C-14-8) during rainy season with poor management practices resulting in low yield (1.8 to 2.2 t/ha). There was no suitable rainwater harvesting structures to store the abundant rain water so as to use it for rearing livestock as well. Several measures including bunding of coastal areas, surface drainage with one-way sluice gate, salinity tolerant rice varieties and broad bed and furrow system of suitable dimension was carried out in a participatory mode to manage degraded coastal land and for enhancing livelihood opportunities.

Salt and other toxic substances from the raised beds have been leached out by the rainwater resulting in proper soil conditions (pH 6.0 – 6.5; EC 0.75 – 1.25dSm^{-1}) for plant growth. It also facilitated drainage of excess water and provided better physical condition for round the year vegetable cultivation. In the furrows 4476 m^3 ha^{-1} rainwater was harvested which was used for providing 2-3 life saving irrigations during dry periods in addition to fish culture. Cropping intensity has increased from 90% to 170 – 218 %. The vegetables grown in the raised beds accounted for 60% and fish in the furrow accounted for 40% of the total revenue from the intervention area. The combined effect of higher crop, fish and water productivity resulted in higher employment generation of 175-213 mandays. The net income increased from Rs. 22,000 per ha to 1,40,000 – 2,25,000 per ha. Improvement brought out by land shaping methods and diversification of agricultural activity resulted in higher productivity and livelihood security.

Compounded Agricultural Vulnerability: Synergy of Formal and Informal Adaptation to Multiple Stressors

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Abstract

When climate variability, ecological stress (salty agroecosystem) and socio-economic factors, for which developing robust technology is a tough task, are intermingled together, they cause compounded vulnerability. This needs location specific adaptive practice. The present study-conducted with 60 small, marginal and large-scale farmers of different age groups (18-85 years) of Haryana, is based on the three years (2012-2014) of intensive empirical participatory research works in salt affected agroecosystems of Siwanamal village, Jind district of Haryana. Objectives of study were (i) to record the perception of selected farmers about climate variability and its impact on ecological stress and thereby affecting agriculture; and (ii) to know the farmers' adaptations led by formal and informal knowledge systems. Results revealed that population of indigenous plant species (e.g. *Butea frondosa*, *Acacia nilotica, Mangifera indica*, *Salvadora persica*, *Thespesia populnea*, *Dalbergia sissoo,* etc.) and local breeds of animals (goat and sheep) reduced at alarming rate due to the increasing salinity of agroecosystem socio-economic changes in last 20 years. PRA exercise indicated that the indigenous cropping systems led by pulses, coarse grains and millets, and oil seeds are completely lost due to the compounding impact of climate, rising soil and water salinity and their interactions with socio-economic and policy factors. Majority (85.4%) of elderly farmers perceived that climate is 'no more normal (no more drizzling rains and *loo*)' as it was 30 years back.

Rainfall has become intense with reduced number of rainy days (74.6% response)- as was observed in observatory data also, and high aberrations have increased the risks in salt affected agroecosystem. Long dry spell of 2012 and drought of 2014 after combining soil salinity (EC 2.84 to 8.67 and somewhere 11.0 to 16.0; with pH 7.29 to 8.77) and use of marginal quality water have increased vulnerability of rice crop grown by resource-poor farmers. About two third of them have planted rice twice in both the years (raised in good soils, taken on exchange basis or purchased from other farmers), thus management cost increased with either major yield penalty or complete loss of crop (about 18.2% farmers) caused by compounding vulnerability. For such vulnerability, using synergy of adaptation with sub-surface drainage, agronomic manipulation led by farmers' knowledge, use of salt tolerant wheat (KRL210 and rice varieties (CSR 30) (formal knowledge) and institutional networks of farmers helped them to sustain the crop yields. Although, the crop yields varied among small (e.g. 35.0 q/ha of wheat KRL 210) and marginal (38.0q/ha), and large farmers (42.0 to 62.0 q/ha) which was further governed by their adaptive capacity and stress posed by diverse soil salinity (with EC 2.5 to 6.5, yield of wheat was 38.0 to 60.0 q/ha). Performance of salt tolerant wheat variety KRL 210 was better (*rabi* season) as compared to the moderately salt tolerant rice variety CSR30 during *kharif* season. Three years data indicated that it was due to the high salinity (EC 4.5-16.5) during summer and high temperature during longer dry spell as compared to lower temperature and relatively low salt deposition in the crop root zone during *rabi* season. The zero-till

adaptive practice (led by farmers' idea) and collective sharing of resources (water, seeds, energy and machines) later on have improvised adaptive capacity of farmers to increase wheat crop yield followed by the rice yield. This has enabled few of them to create market networks with good quality seeds of KRL210 and improved their livelihood. Some agronomic interventions in terms of DSR with normal (Pusa 1121 and Pusa 1509) and salt tolerant rice variety CSR30, and use of good quality canal water (using underground pipe) during 2014 through institutional network under marginal saline soils improved the performance of wheat crop (KRL210).

During the entire adaptive practices, lessons were taken by farmers about DSR, as the performance of this was poor in more than 75.0 cases due to maladaptive practices under it as compared to the transplanted rice and same varieties. This was due to compounding effects of ineffective management, longer dry spell, use of poor quality water and less adaptive capacity of farmers. It was concluded that when vulnerability is of compounding nature, risks are more and adaptations need to be integrated.

Feasibility and Impact of salt tolerant Herbaceum cotton and Wheat Cultivation in coastal saline soils of Gujarat State

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Abstract

Impact studies of any technological intervention plays a pivotal role in assessing the overall output of any plan scheme. It provides ample feedback about the technologies, their implementation; the shortcomings experienced in achieving the goals along with the feedback of the beneficiaries and provides some guidelines to the implementing agencies for taking corrective measures, if any for the success of the scheme. Thus, the evaluation of the study plays an important role in ensuring the benefits of the scheme/project to reach the end users. Gujarat state, a Western province in India has bounty of natural resources and the state has become country's strong economic pillar. The agricultural scenario in the state is also gaining momentum with every passing year. Soil and water salinity problems are essentially multi-sectorial and are complex in nature.

A long coast line measuring 1600 km, frequent floods, droughts and anthropogenic activities though become obstacles in the development of the State, the Government and the public showed character in bringing the state to normalcy without any hiccups. About 6.73 Mha of land is salt affected in India of which 2.22 Mha is present in Gujarat State. Of this, about 60 per cent area is affected by coastal salinity problems with highly saline ground water. Several technological interventions have been found to utilize such resources for the benefit of the state. Water, being the critical component particularly in the coastal areas, its conservation and proper utilization further boosts the agricultural scenario in the region. Deterioration of soil and water quality provides an opportunity for their conservation and judicious use. Excessive withdrawals of water for irrigation in the coastal area results in sea water ingress and thus make the problem even worse. In the coastal saline areas, fresh water is becoming scarce for agriculture as a result of increasing domestic and industrial use. The amount of farmland available for food production is also declining because of salinisation. Areas with problems of inland salinity, coastal salinity (South Gujarat) and water logging in Gujarat state have been included to address the problems faced by the farming community. Since studies at farm or household level are important for understanding farmers' response and develop strategies to cope with changes to his environment, the technological interventions developed by CSSRI RRS ie., identifying elite Desi cotton lines and salt tolerant wheat cultivars were taken in different farm units in South, Central and Saurashtra regions of Gujarat .

In this context, efforts were made with various NGO partners to see the prospects of cultivating salt tolerant and better cotton (G. Cot 23) and wheat (KRL 21 and KRL 19) cultivars and to understand the impact of these salt tolerant wheat and cotton varieties. The studies found that desi cotton, G Cot 23 was more suitable and profitable to farmers in saline and rain fed conditions over hybrids (hirsutums) or Bt hybrids. Desi cotton accessions G. Cot 23 gave yield in the range of 16 to 19 q/ha under the average salinity of 7.6-8.0 dS/m. Desi cotton, G. Cot 23 in view of it's salt tolerance and better response to saline water (ground water is saline in the region) is getting an edge over hybrids and Bt lines, which, while being salt sensitive also do not respond to saline water irrigation. In saline areas of Southern, Central and Saurashtra areas of Gujarat (EC range 5.9 to 7.2 dS/m), salt tolerant wheat varieties KRL 210 and KRL 19 gave yield in the range of 36 to 39.5 q/ha. KRL 210 and KRL

19 gave 7.30 q/ha and 9.41 q/ha higher yield than Lok 1 (the locally grown variety) , indicating the supremacy of these lines for saline situations. The increase in number of takers for the selected cotton and wheat varieties clearly indicated their impact on the improved agricultural scenario in the coastal saline areas of Gujarat state. However, a strong institutional support and intervention is needed for further up- scaling these interventions.

Homestead Production Systems in Coastal Salt affected areas of Sunderban – Status and Market Opportunities

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Abstract

Majority of the households (HH) in the study area are having some kind of homestead production system (HPS) adjacent to their dwelling house irrespective of the operational holding size. In coastal areas of West Bengal the operational farm holding size is very small (<0.5 ha per HH) and that too are fragmented over few more plots, resulting further reduction of operational holding size. The poor farming communities are poverty stricken, having very low investment capacities and land productivity is very low due to acute shortage of irrigation water in non-monsoon months. Therefore, the HPS systems are having enormous importance for improving livelihoods and towards attaining household level food security in this region. Homestead production systems, with an average area of 0.11 acre, are comprised of several key resources like water, fish, horticultural crops, livestocks etc. the pond and the water in the pond is the most important resources of the HPS and whole gamut of activities are dependent by utilizing the water. Besides, aquaculture in the homestead pond, growing vegetables, fruits, trees etc. in the dyke or homestead gardens was the major activity under HPS. A number of vegetables were grown in the homestead gardens like brinjal, okhra(bhindi), potato, cabbage, cauliflower, pumpkin, yam, spinach, colocasia, amaranthus, cucumber, bitter gourd, beet, carrot etc. Vegetables are of cultivation under the HPS was 0.03-0.06 acre. Availability of fish, vegetables and livestock products from the HPS were quite smaller in quantity, but contributed greatly towards the daily households requirement and thus reducing the externally dependence and making the farm family more self-reliant. Under the current practices, the financial analysis (IRR, BCR and NPV) of the current system indicated that the system was nto generating the sufficient income for long term investment, if the contribution of family labouers are imputed and added as cost but it has multiple functions, utility and value to the HH in coastal areas under study.

The market linkage with the production system was very weak primarily due to very low marketable surplus. The utilization of these available homestead water resources are not to their potential. With scientific/improved interventions these resources can be used more efficiently and the productivity of the whole HPS can be enhanced significantly. The HPS resources including pond and dykes area can be utilized more intensively and can be made more contributing their livelihoods. Farmers need technical and financial support to enhance their investment capacities as well as technical support to make their resource use more productive. Enhancing the production level would increase the quantity of marketable surplus and thereby increase the contribution of HPS to the regional production.

Diversified Agriculture for Livelihood Security of Small Farmers in Reclaimed Sodic Soils

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Abstract

The benefits of technologies developed during green revolution were confined to large and resourceful farmers in India, because the majority of small and marginal farmers face different types of problems than large farmers. They have to be dependent on farm income for their routine household needs and other requirements. The sustainability of rice-wheat system in Indo-Gangetic plains is a serious concern due to degrading soil health and shrinking water resources in rapidly changing climatic scenario. Besides this, the profits from these crops have been reduced over the time and thus causing un-sustainability and migration of farmers to urban areas. Integration of various farm enterprises and farming system diversification may offer solutions to agricultural problems of the increasing number of small and marginal category farmers. Therefore, suitable agricultural technologies are the need of the hour for small land holders. The concept of integrated farming system may prove better than specialized or single commodity based farming system. In reclaimed sodic soils of Indo-Gangetic plains, integrating diversified agriculture may be an efficient alternative to rice-wheat cropping system for small land holders in terms of revenue generation, energy, soil health and resource use. This study is a part of the multi-enterprise agriculture model developed at the Central Soil Salinity Research Institute (CSSRI), Karnal to improve water, nutrient and energy use efficiency in reclaimed/salt stressed environment. In this crops are integrated with vegetables, horticulture, dairy, fisheries, poultry & duckery, bee-keeping and mushroom cultivation. Total gross income of Rs. 1000-1200/day and net income of Rs. 700-800/day is being generated from about 2.0 hectare land area and by-products of these enterprises are recycled within the system.

Besides a source of regular income, the model acts as the most vital technology in conserving resources and energy at farm level. Recycling of farm wastes and other byproducts of the components ensures environmental quality. The potential of integration of multiple components is exploited to make judicious use of farm inputs, resource management, regular income and year round employment generation. Conservation and judicious use of farm resources has been found to help in restoring the ecosystem for sustainability. Apart from improving soil health, resource use efficiency and residue recycling, such a system would avert ground water depletion and save the environment from being polluted with the burning of crop residues and used it for productive purposes. Perennial and intensive vegetation on and around the pond as well as different crop components is helping in sequestration of large carbon pools. This model helps 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. This model is highly suitable for small and marginal land holders.

Economic Impact of Water Harvesting Works in Coastal Area of Amreli district of Saurashtra region in Gujarat

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Abstract

Gujarat state, a Western province in India has bounty of natural resources and the state has become country's strong economic pillar. The agricultural scenario in the state is also gaining momentum with every passing year. The State is sharing the longest coastal line in the country i.e. 1600 km out of which Kutch and Saurashtra cover about 1125 km. Excessive withdrawal of water for irrigation in the coastal area resulted in sea water ingress which further worsens the problem further. Every year on an average, 0.5 to 1.0 km distance from the coastline is affected by sea water ingress. Frequent floods, droughts and anthropogenic activities though become obstacles in the development of the coastal areas, the Government and the public, showed character in bringing the state to normalcy without any hiccups. Water, being a critical component particularly in the coastal areas, its conservation and proper utilization further boosts the agricultural scenario in the region. Deterioration of soil and water quality provides an opportunity for their conservation and judicious use. Looking at these issues, the Gujarat State Land Development Corporation with its wide network, had taken up providing interventions for mitigating saline water ingress in the coastal areas, improvement of ground water recharge with devises like percolation tanks, conserving rainwater in water storage structures to meet the crop, human and livestock needs and also to introduce soil and crop management measures for maximizing crop production in the coastal area.

The coastal Amreli district has both ground and surface water resources which are developed in form of ponds, check dams and *Bandharas*. The ground water resources which were once providing potable water have become saline due to their over-exploitation. Thus, major emphasis was given to water conservation measures comprising check dams, percolation tanks, farm ponds and salinity mitigation structures like reclamation bunds. Series of check dams constructed in Daterdi, which while serving as water reservoirs also augmented the ground water recharge resulting in high water table in the adjoining open wells. This scenario helped the farmers to go for cash crops like Bt cotton, castor, groundnut, onion, along with wheat, and millets. Improvement of ground water status, and prolonged availability of conserved water in check dams resulted in yields of ground nut to a tune of 66 per cent, cotton by 34 per cent and wheat by 33 per cent. Improvement of ground water status and prolonged availability of conserved water in check dams increased the agricultural crop production in the region particularly in Daterdi village which accounted for 75.22 per cent increase in net revenue. Results are discussed in relation to the water conservations measures adapted.

Improving saline agriculture through ICAR-CSSRI intellectual property

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Abstract

India implemented the Intellectual property rights in agriculture which provide an avenue for royalties or fees to the inventor for use of the invention/technology. Intellectual property of ICAR-Central Soil Salinity Research Institute (CSSRI), Karnal consist a total of thirty eight technologies developed and commercialized such as reclamation of sodic soil using gypsum, subsurface drainage technology for waterlogged saline soils, auger-hole technology for aforestation of salt affected soils. A patent has been filed for CSR-BIO a bio-growth enhancer for higher productivity of agri-horti crops in normal and sodic soils. Salt tolerant varieties i.e. rice varieties (Basmati-CSR 30, CSR 36, CSR 43, CSR 23, CSR 27, CSR 13 and CSR 10), wheat varieties (KRL 213, KRL 210, KRL 19 and KRL 1-4) and mustard varieties (CS 56, CS 54 and CS 52) have been developed and registered under Protection of Plant Varieties & Farmers Rights (PPV&FR) Act, 2001. In year 2013-14, total seed production of these varieties is more than 450 q while the revenue generated from commercialization of IP protected technologies is about Rs. 82.45 lakh. By using these technologies about 2.00 m ha salt affected land of India has been reclaimed at rate of 45,000 ha annually, contributing about 15 million tons of food grains to the national food basket every year. These technologies are put in public domain which is adopted by the farmers, NGOs and Govt. Institutions for improving socio-economic profile and ensuring food security for better livelihood.

Economic Impact of Subsurface Drainage Technology for Reclamation of Saline Soils in Haryana

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Abstract

To sustain and enhance the agricultural productivity in waterlogged saline soils, subsurface drainage technology and improved irrigation management, has been identified as the most appropriate strategy. But subsurface drainage technology for saline soil reclamation is very costly and an individual farmer cannot adopt in small scale. This technology can be implemented in large scale with the support of government or other financing agency. Haryana operational pilot project is taking a lead role in installing this technology in Haryana. The present study is an attempt to work out the cost of installing subsurface drainage system and to examine the economic feasibility and financial viability of this technology in the long run. The findings show that, after the installation of subsurface drainage, a maximum area of fallow land was brought under cultivation; the cropping pattern changed in favour of more remunerative crops and crop yield has been significantly increased. These gains from drainage are helping to increase land productivity, providing employment to the farmers and, hence increasing their farm income. The installation cost was estimated Rs. 62,000 per hectare. The financial analysis was estimated for four alternative crop rotations, of which rice-wheat cropping system provides highest benefit with a net present worth of Rs. 1,18,262 and a three years payback period. The Internal rate of returns estimated to Rs. 39.64 percent and benefit-cost ratio was 2.71. Thus, the subsurface drainage technology, proved technically feasible, financially economic and socially beneficial in waterlogged saline soils of Haryana.

Evaluation of different weed management options on weed dynamics, productivity and economics of maize in northern Karnataka

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Abstract

Results of a field study involving 15 weed control treatments (T_1: Atrazine 1.00 kg ha^{-1} PRE, T_2: Metribuzin 0.25 kg ha^{-1} PRE, T_3: Alachlor 0.50 kg + atrazine 1.0 kg ha^{-1} PRE, T_4: Glyphosate 1.00 kg pre plant fb atrazine 0.375 kg + alachlor 0.50 $kgha^{-1}$ PRE, T_5: Glyphosate 1.00 kgpre plant fb 2,4-D 2.00 $kgha^{-1}$ POST, T_6: Glyphosate 1.00 kg ha^{-1} pre plant + castor oil 4.00 l ha^{-1}, T_7: Atrazine 1.25 kg fb atrazine 1.50 kg ha^{-1} PRE, T_8: Atrazine 1.00 kg PRE fb 2, 4-D 2.00 $kgha^{-1}$ POST, T_9: Alachlor 1.00 kg PRE fb oxyfluorfen 0.20 kg ha^{-1} POST, T_{10}: Atrazine 1.50 kg ha^{-1} PRE, T_{11}-Oxyfluorfen 0.15 kg ha^{-1} PRE, T_{12}: Maize + cowpea as a cover crop, T_{13}: Maize + moong bean as a cover crop, T_{14}: Weed free check and T_{15}: Weedy check) in maize during *Kharif*, 2010 showed that among different chemical weed control options, T_7 recorded significantly higher grain yield (54.02 q ha^{-1}) but variations were at par with T_1, T_2, T_3, T_8 and T_9. Weed free check recorded higher maize grain yield (56.01 q ha^{-1}) but variations were at par with T_1, T_2, T_3, T_7, T_8, T_9 and T_{10} which yielded 48.99, 47.85, 49.15, 54.02, 48.91, 48.86 and 48.41 q ha^{-1} of maize grain, respectively. Total weed dry matter under T_7 30, 60, 90 DAS and at harvest (3.10, 4.10, 5.23 and 6.03 g m^{-2}, respectively) was also at par with T_1, T_2, T_3, T_8 and T_9; however weed free check recorded significantly lower total dry weed biomass at various stages of maize crop (1.19, 1.28, 1.28 and 1.24 g m^{-2} 30, 60, 90 DAS and at harvest, respectively) over different chemical weed control options (T_1, T_2, T_3, T_7, T_8 and T_9). Similarly, weed index recorded under T_7 at various stages of maize crop (61.07, 64.36, 59.47 and 55.07% at 30, 60 and 90 DAS and at harvest, respectively) were at par with T_1, T_2, T_3, T_8, T_9, T_{10} and T_{11} however, weed free check again recorded significantly lower weed index (85.02, 88.92, 90.10 and 90.73% at 30, 60 and 90 DAS and at harvest, respectively) over these treatments. However, T_7 recorded significantly higher net return (Rs 41514 ha^{-1}) over weed free check (Rs 21354 ha^{-1}).

Theme 6

Special session on Central India

Effect of sewage water and spent wash application on soil properties of a Typic Ustochrepts

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Abstract

The continuous use of raw poor quality water generally leads to build up of metals and organic residues in the soils depending upon composition, rate and frequency of irrigation as well as characteristics of the soils. Sometimes, build up of the metals in agricultural soils may create phytotoxicity to crops, which warrants judicious use of sewage and other waste water.

Over all on the basis of horizon differentiations, sixty (60) soil samples were collected from twelve profiles were excavated at both experimental sites representing, various irrigation practices (i.e. tube well, mixed with effluent and only effluent application mode) of sewage water and spent wash.

The water received from tube well was found normal and good in quality as per classification of irrigation water at both the locations with only slight variations. Sewage water had slightly higher amount of dissolved salts and pH as compared to tube well water. Sewage water is categorically of poor quality and alkaline in nature (high SAR and RSC value) and may not be safe for irrigation purpose for long time. Sewage water contained fairly higher amount of potassium, nitrogen, organic carbon and iron. Soil pH, EC and organic carbon showed highest value when it was irrigated with spent wash at location Rairu. The salinity or sodicity build up was not observed in soil profile at both the locations whether it was irrigated with sewage water or spent wash as evidenced by the change in values of EC, ESP and SAR. There was enrichment in soil fertility status of soil when the soil was irrigated with sewage water or spent wash and even in mix mode. The OC, N, P, K and micronutrient (Zn, Mn, Cu &Fe) status of soil was improved tremendously with the application of these waters although it was higher with spent wash. The analysis of metallic ions (Pb, Co, Cr & Ni) present in soil profile indicated high accumulation of these heavy metals in soil profiles. Accumulation of these heavy metals in soil profiles was comparatively higher when it was irrigated with spent wash.

Influence of Gypsum, FYM and Phosphorus on Growth and Yield of Mustard grown on sodic soil

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Abstract

A field experiment was conducted at RVSKVV Salinity Research Farm, Barwaha, District Khargone, M. P. during *rabi* season of 2012-13 to assess the effect of gypsum, FYM and phosphorus on growth and yield of mustard. Mustard variety Varuna was used as the test crop. The experimental soil belongs to fine smectitic hyperthermic family of Typic Heplustert- sodic phase having pHs 8.63, ECe 1.44 dsm^{-1}, O.C. 0.28 % , Available N 137, P_2O_5 11.4 and K 420 kg/ha. The cation exchange capacity and ESP of soil were 36.40 $cmol(p+)kg^{-1}$ and 43.90, respectively. Gypsum requirement was 18.0 t/ha. The experiment was conducted in factorial randomized block design with three replications.

The treatment comprised of three levels of gypsum (0, 50 and 75% of GR), two levels of FYM (0 and 20 t/ha) and three levels of phosphorus (0, 40 and 80 kg/ha) and their combinations. Gypsum @ 75 % GR, FYM @ 20 t/h and phosphorus @ 80 kg/ha alone significantly increased the seed by 28.0, 16.7 and 37.6 %, respectively over control. Interaction between gypsum x FYM and FYM x phosphorus for seed yield was significant. Maximum seed yield was recorded when gypsum @ 75 % GR along with FYM @ 20 t/ha and FYM @ 20 t/ha along with phosphorus @ 80 kg/ha was applied. Addition of gypsum @ 75%GR, FYM @ 20 t/ha and phosphorus @ 80 kg/ha alone significantly improved the growth parameters like plant height, branches and siliqua per plant and yield attribute such as seeds per siliqua in mustard.

Ravine reclamation and control – a watershed based approach

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Abstract

Ravines represent the most degraded form of once cultivated fertile land. All attempts to reclaim ravines so far have gone in vain. Since formation of ravines was a function of uncontrolled run-off, the management of rain-water on watershed basis was an appropriate approach for ravine control and reclamation. The main components of the new technology for water-shed based reclamation and control of ravines is identification of the main gully of the watershed and its stabilization through appropriate design of gabion masonry structures. If run-off water from upper part of the watershed (hill slope/table land) results in formation of shallow/medium ravines in cultivated land, a water diversion bund has to be constructed to divert the run-off into tank or grassed water way. Shallow and medium ravines can be reclaimed by stabilising the main gully as grassed waterway and by construction of contour/graded bunds on both sides of the stabilised main gully. Side gullies in case of medium and shallow ravines are controlled by the rise of bed level of main gully consequent to silt deposit in it. But in case of deep ravines, besides stabilisation of main gully masonry plugs with deep foundation (at least 30cm, below the original flow line) have to be constructed to control deep side-gully. Earthen gully plugs recommended earlier are not successful as tried in NICRA Project. The idea of reclaiming deep and very deep ravines by just afforestation does not work because of too steep sides of gullies and their inaccessibility. The strategy has to be a combination of limited land shaping, construction of appropriate mechanical structures and creation of vegetative cover. Structures for run-off collection at appropriate place have also to be built. As regards utilisation of ravinous land, agri-horti system or agrihortipastoral systems have to be adopted for different situations selecting the right tree species and right varieties of crops and grasses.

Micronutrient Status in the Salt Affected Soils of Bhind district of Madhya Pradesh

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Abstract

The salt-affected soils Chambal Command area of Bhind district of Madhya Pradesh were studied for their micronutrient status. The area lies between $25^0$50' and $26^0$50' N latitude and $78^0$10' and $79^0$08' N longitude and comprises typical wastelands of the district. Five typical pedons (Gohad-P2, Loharpura-P4, Chitora-P8, Tukeda-P10 and Parechha-P13) selected for the study were classified as *Aeric Halaquepts* (P2), *Vertic Natragids* (P4), *Sodic Haplocalcids* (P8), *Typic Natrargids* (P10) and *Sodic Haplocambids* (P13) based on sub-surface diagnostic horizons and soil moisture regimes. All the soils were high in ECe (5.0 to 31.0 dSm^{-1}) and ESP (17.8 to 61.5%) but somewhat low in pHs ranging from 7.5 to 8.8. The statuses of available micronutrients (Cu, Fe Zn and Mn) were found sufficient.

Table: 1 DTPA extractable Zn, Cu, Mn and Fe in the profiles (mg kg^{-1})

Location	Depth (m)	Cu	Fe	Zn	Mn
Pedon – 2 : Location Gohad loamy, mixed hyperthermic family of Aeric Halaquepts					
26º 24’ 17.7” N; 78º 26’ 59.8” E	0.00-0.15	0.344	3.472	2.028	7.250
	0.15-0.30	0.260	2.286	0.966	5.590
	0.30-0.75	0.260	2.240	0.756	4.782
	0.75-1.22	0.170	2.084	0.556	4.560
	1.22-1.65	0.112	1.330	0.276	2.654
Pedon – 4 : Location Luharpura,fine,smectitic hyperthermic family of Vertic Natrargids					
26º 16’ 49.4” N; 78º 39’ 50.0” E	0.00-0.15	0.454	4.376	3.510	9.164
	0.15-0.38	0.428	3.112	0.950	8.954
	0.38-0.80	0.392	2.842	0.834	8.540
	0.80-1.25	0.358	2.702	0.684	8.536
	1.25-1.70+	0.344	2.434	0.626	7.732
Pedon – 8:Location Chitora, loamy, mixed hyperthermic family of Sodic Haplocalcids					
26º 19’ 34.5” N; 78º 30’ 12.2” E	0.00-0.15	0.778	5.330	2.894	6.652
	0.15-0.35	0.676	2.676	1.422	4.560
	0.35-0.52	0.574	2.602	1.298	3.582
	0.52-0.80	0.570	2.178	1.222	3.366
	0.80-1.25	0.550	2.058	0.890	2.260
	1.25-1.55	0.524	2.008	0.826	2.188
	1.55+	0.318	1.934	0.758	1.932
Pedon –10: Location Tukeda, fine,smectitic hyperthermic family of Typic Natrargids					
26º 24’ 31.3” N; 78º 19’ 43.7” E	0.00-0.10	0.680	3.722	0.542	4.440
	0.10-0.23	0.602	3.046	0.414	3.932
	0.23-0.46	0.568	3.040	0.358	3.466
	0.46-0.65	0.556	2.884	0.354	3.256
	0.65-0.99	0.548	2.780	0.308	2.930
	0.99-1.42	0.460	2.718	0.298	2.082
	1.42+	0.354	2.710	0.208	2.046
Pedon–13:Location Parechha, loamy, mixed hyperthermic family of Sodic Haplocambids					

26º01’ 37.1” N; 78º 56’ 27.5” E	0.00-0.06	0.886	5.004	2.642	9.158
	0.06-0.17	0.706	5.002	0.396	7.176
	0.17-0.37	0.608	3.796	0.394	5.924
	0.37-0.57	0.590	3.092	0.338	4.028
	0.57-1.16	0.534	2.966	0.266	3.992

Effect of cropping systems on economics in newly reclaimed ravinous soils of Chambal region of Madhya Pradesh

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Abstract

Crop production in newly reclaimed ravinous soils according to potential level of crops is a challenging task. It cannot be achieved without selection of the crops on the basis of drought tolerance, nutrient responsive and better survivalist under stress conditions. The results reveals that the clusterbean recorded highest income (Rs 65415/ha) followed by pearl millet (Rs 41612/ha) than other crops under the *Kharif* season. Amongst the *Rabi* season the gram crop gave higher income (Rs 29223/ha) closely followed by wheat (Rs 28110/ha). The maximum system productivity was recorded for pearl millet –wheat with total income Rs 107144/ha and was closely followed by clusterbean-gram (Rs 101961/ha). However, the lowest profitability was noted under sesamum-mustard (Rs 51263/ha) and soybean-mustard (Rs53217/ha) cropping systems.

Evaluate the suitability of different plants for plantation in newly reclaimed ravinous soils of Chambal to resist erosion

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Abstract

Severe water erosion is a most common event in Chambal command region due to coarse sandy structure of soil. Madhya Pradesh having 6.83 lakh ha area under ravines, out of that 5.7 lakh ha area is in Chambal division of the state. Chambal basin suffers severely with the problem of land degradation due to ravine formation. After reclamation of the ravenous soil it should be needed to adapt appropriate erosion management practice to maintain it, otherwise erosion takes place again. Plantation may be the better option for the same. Keeping this aspect in mind a field experiment was conducted on newly reclaimed ravinous soils to evaluate the survival of different plants at Aisaha village of Morena district, which is selected under Niche Area of Excellence project and 80 km far from RVSKVV, Gwalior university head quarter. The area is situated at Latitude 26^{o}40’40.84 N and Longitude 78^{o}06’29.21 E with altitude ranges 150 to 240 m above mean sea level. Six species (drumstick, aonla, guava, ber, pomegranate and Custard apple) of fruit tree and ten species of silvi-medicinal (arjuna, neem, mahua, gugul, babool, karanj, adusa, siras, khamer, seasham) saplings were transplanted in pits of 30 x 30 x 45 cm. The excavated pit was filled with vermi-compost (1.5 kg/plant), DAP100 g/ plant) MOP (80 g/plant) neem cake (500 g/plant) and chlorpyriphos (6-7 ml/plant). The soil of experimental field was low in available nitrogen (175 kg/ha), medium in available phosphorus (7.12 kg/ha) and potash (350 kg/ha) having pH 8.64, and electrical conductivity 0.255 dS/m. The experiment was replicated 3 times in RBD design with 3 m row to row and plant to plant distance. The results revealed that the highest height of the plant was recorded under drumstick plant (4.1 m) which was followed by seasham (2.6 m), ber (2.4 m) and karanj (2.4 m) after one year from the planting date. The diameter of the stem was also found highest in drumstick plant (17.24 cm) and was followed by ber (9.55 cm) and seasham (7.4 cm). However, the perfect survival was observed in adusa (100%) and was followed by babool (96.00%) and siras (92.00%). Thus, it was concluded that the drumstick and ber is suitable fruit plants, babool, adusa, siras and karanj are the most suitable silvi-medicinal plants under newly reclaimed ravenous soils in respect to vigorous growth and survival.

Biomass carbon production as influence by different modules for management of Chambal ravines.

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Abstract

Erosion through ravines causes many problems on bank of Chambal river in Madhya Pradesh. It damages rangelands, croplands and infra-structures. Plantation of different fruit trees (*Moringaoleifera, Amblicaofficinalis,Psidiumguajava, Ziziphuszezuba, Punicagrantum, Annonasquamosa*), forest/Medicinal trees (C*enchrusciliaris*, *Azardirechtaindica*, *pongamiapinnata*, A*lbizialebbeck, Dalbergiasissoo* and *Acacia nilotica*)) and some grasses (lemon grass, pamarosa,para and napier grass) under four management modules *viz.* M_1-diversified cropping system, M_2-Agri-horticultural, M_3-Horti-pastoral, M_4-Silvi-medicinal and M_5-Silvi-pastoral were raised during 2012 at 3x3 m spacing. Trees absorb carbon dioxide from the atmosphere through the natural process of photosynthesis and store the carbon (C) in their leaves, branches, stems, bark and roots. The performance of *Moringaoleifera* was the best with trees attaining an average height of 4.7 m in M_1 and M_2 Modules. The highest biomass carbon wasassimilated 90.1t ha^{-1} in Module M_3, followed by79.3, 55, 24.4, and 10.2t ha^{-1}in, M_2,M_5,M_4 and M_1, respectively. The average biomass carbon was found highest in grasses followed fruit and forest trees in its early stages. In different plants the highest biomass carbon was yielded 26.7 t ha^{-1}in *Moringaoleifera* followed by 10.6 t ha^{-1} in *Ziziphus zezuba* whereas biomass carbon in other plants was ranges between 7.5 to 0.15 t ha^{-1}.While para grass and plamarosa produces 41.8 t ha^{-1} and 29.4 t ha^{-1} biomass carbon. The study shows that the total carbon was highest in M_4module, while in plants and grasses the total carbon was highest in teak (*Tectonagrandis*) and napier grasss (*Pennisetumpurpureum*), respectively.

Effect of raised bed planting on the growth characters and yield of soybean (*Glycine max*)

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Abstract

On farm testing were conducted in Dhar district of Madhya Pradesh during 2013 to assess the effect of raised bed planting on growth characters and yield of soybean crop. The raised bed planting was found better in term of plant population, plant height, number of branches per plant,,number of root nodules per plant, seed yield weight per plant, seed index, seed yield, comparison with normal flat bed sowing for soybean crop . The highest productivity of 16.06 q/ha observed in the raised bed planter whereas it was found lowest under normal flat bed sowing (12.05 q/ha). Highest net return (Rs 32592 per ha) and B: C ratio (2.73) were recorded under raised bed planter system whereas, the lowest net return (Rs 19055) and B: C ratio (2.04) per ha was recorded under normal flat bed.

Water harvesting in sodic black soil under rainfed condition of south-west Madhya Pradesh

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Abstract

The black saline-alkali soils generally persist in the areas having low rainfall and insufficient irrigation facilities. Owing to negligible infiltration rate such soils retain water on surface, which hampers agricultural operations and ultimately reduced productivity of potentially low productive sodic black soils further. Black sodic soils are potentially saline / alkaline in compacted sub-surface horizons (Murthy et. al. 1981). Due to compacted sub-surface horizons coupled with low infiltration these soils exhibits as high as 40% runoff (Sharma 1994). The black soils having ESP beyond 10 leads to sever structural degradation due to high degree of clay dispersion (Gupta and Verma, 1983). Dispersed clay clogs the pores and induced increased water retention on surface. Deep cracks do not develop in sodic black soils because of higher water retention capacity and alkali contents which otherwise a qualifying characteristic of black soils (Sharma and Verma.1998).Above physico-chemical properties make sodic soil potentially high to yield more runoff, which can be utilized for improving production by giving supplemental irrigation. The above situation stresses the need of harvesting excess runoff for recycling especially in sodic vertisols agri-ecoystem under rainfed condition by harvesting the same in small dug out pond. Thus a study was conducted on water harvesting through a small dug out pond constructed across an ephemeral stream along with quantifying runoff potential and infiltration under differential ESP levels.in contemporary sodic black soil of south-west madhya pradesh.

The study was carried out in a sodic black soils soil (pHs- 8.6, ECe- 3.5 dS m^{-1}, ESP between 10 to 35) at Soil Salinity Research Station, Barwaha, District Khargone (76^0 1'E and $22^0$14'N). To assess drainage need daily rainfall data of 11 years period (1989 to 1999) recorded at Barwaha Farm and was subjected to depth duration frequency analysis to work out consecutive days maximum rainfall for 5, 10 and 20 years recurrence interval. Subtracting basic infiltration value from consecutive days rainfall assesses agricultural drainage need. The basic infiltration rate was ascertained by developed equation for soils having differential ESP. Verma and Sharma (2001) reported that basic infiltration at 35 ESP becomes almost zero in sodic black soils. Drainage need was assessed by considering the fact that soils are saturated and therefore evapotranspiration, raindrop interception etc are negligible as far as drainage is concerned. The renovation of water harvesting pond to enhance storage capacity and development of uncultivated field for this experiment were done during last year. During year 2010 various farming system viz. raise and sunken bed, Sole crop, agro-horticulture, agro-forestry were developed. Under RS system on raised bed cotton crop and paddy in sunken were grown. Ber and sapota fruit plant along with tomato and brinjal vegetable crops were grown in agro-horticulture system, Similarly, Neem (*Azadirachtaindica*), and Babool (*Accacia nilotica*) were planted under agro-forestry system. These systems were developed in the sodic Soils of Soil Salinity Research Farm, Barwaha, district Khargone, Madhya Pradesh. Under various farming system yield were recorded, Data on rainfall,

evaporation and stage of water level in the pond was also recorded on daily basis to work-out percolation loss in the pond during prevailing dry spell. The study reveals that basic infiltration rate decreases sharply with increase in ESP. The basic infiltration rate observed at ESP levels 10, 15, 22 and 35 are 4 mm/hr, 1 mm/hr, 0.5 mm/hr and almost negligible respectively. The estimated value of surface drainage need suggests that crops grown in sodic black soils having ESP greater than 10 may necessarily have to be provide with surface drainage system and there is enough run off potential to harvest the same for later use. The run off potential enhances with increase in ESP levels and it would be maximum beyond 35 ESP. In sodic black soils having ESP greater than 10, the drainage needs for crops with one day tolerance period vary between 175-79, 224-128 & 229-113 mm per day for recurrence interval of 5,10 & 20 years respectively. Similarly drainage need values for crops with 2, 3 & 4 days tolerance period vary as (136-40, 157-61, 178-82 mm per day), (99-3, 114-10, 105-12 mm per day) and (80-0, 93-0,93-0 mm per day) respectively. For proper designing the surface drainage in sodic black soils assessed drainage needs can be utilized successfully. The stored water could manage to deliver 4380 mm depth of water for irrigating 1.34 ha.

Paddy and 0.082 ha. Cotton. This irrigation in turn showed synergistic improvement in the yield of paddy and cotton by 81% and 64 % respectively. On an average percolation loss in pond was observed as 0.034 m^3 per day per m^2 wetted area of pond during dry spell. Within two years of time pond depth reduced to 1.65 m. from 2 m. initial storage depth due to siltation, which undermined the capacity of pond from 1190 m^3 to 981.52 $m^{3.}$ The stored water in pond of 1890 m^3 could manage to deliver 1510 mm depth of water for irrigating paddy, cotton, brinjal and tomato crops in a total cropped area of 1.583 ha during the year 2012.Average percolation loss through the pond during the extended spell of 23 days was observed around 17 mm/ day. The study finally implies that sodic black soils do have higher runoff harvesting potential and better for water harvesting as compared to its counter parts. The water harvesting is a must to improve or rather to take production in such soils. The life saving irrigation in turn showed synergistic improvement in the yield of paddy and cotton. One of the demerits of water harvesting in sodic black soils is siltation in ponds which can be simply taken care of by desiltation in pond ones in three years.

Risk management approaches for drinking water in scarce areas

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Abstract

Increased water demand from rapidly growing population and economic development, environmental needs, change in rainfall, flood contamination of good quality water and over abstraction of groundwater are factors responsible for shortage of quality drinking water. Water quality is increasingly being acknowledged as a central factor in the water crisis. Public perceptions of the human health risks associated with water quality deterioration have been increasing in recent years. Understanding of the determinants of such perceptions and the communication of these perceptions to the policy makers will facilitate water quality management. Managing risk effectively requires making sensible decisions within the constraints of knowledge and resources.

Risk management is an exercise of decision-making under uncertainty. The multiple barrier approach to assuring safe drinking water is founded on the maintenance of multiple unit processes and procedures to ensure that pathogens and undesirable chemicals do not reach the consumer's tap. Maintaining these barriers to exposure is critical because, by and large, each barrier in series can offer orders of magnitude (log) levels of protection to the drinking water supply. The level of barriers required must be a function of the level of challenge posed by the source water. Barriers are often thought of in terms of treatment technology but additional critical barriers involve source water protection, distribution security and monitoring/response capabilities. Undertaking a 'forensic analysis' of historic incidents can highlight the aspects of risk management that are often ignored. The assessment methodology is organized into six steps: (1) understand your system; (2) identify hazards, hazardous events and sources; (3) estimate risk for each identified hazard/event; (4) plan preventive measures for each identified hazard/event; (5) implement and monitor preventive measures; and (6) document a risk management plan.

Research studies are needed in relation to water quality and risk perception for a basic conceptual model which can be utilized and tested in terms of the factors which influence perceptions of water quality risks held by the public. The conceptual model should incorporate both individual perception of risks as well as group perception of risks. Acceptable risk needs to be systematically defined and various causative factors or issues should be delineated. Research is also needed on institutional and interdisciplinary barriers to the development and transmission of information needed by policy makers and the general public in their formation of risk perceptions.

Impact of Green Mannuring through Dhaincha (*Sesbania aculeata*) on Soil Properties, Productivity and Economics of Rice-Wheat Cropping System

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Abstract

The rice-wheat cropping system of India is vital for food security. It contributes to more than 70% of total cereal production of India. The productivity of rice – wheat system is stagnating or declining due to poor crop stand, poor soil condition and imbalance use of fertilizer. Therefore, the present On Farm Trials were carried out to evaluate the effect of green mannuring on soil properties, productivity and economics of the cropping system. Present study was carried out at farmer's field in Datia district by Krishi Vigyan Kendra, Datia. The experiment was laid out with three treatment T_1 : Green mannuring with *Sesbania aculeata* + 75% RDF (90:45:30::N:P:K, kg/ha) in both crop T_2 : 100% RDF (120:60:40::N:P:K, Kg/ha) in both crop T_3 : Farmers Practice (69:46:0::N:P:K, kg/ha in both crop). Total 12 trials were laid out during 2012-13 and 2013-14. Respondent farmers were selected on the basis of personnel discussion and survey. The 0.4 ha. area of every farmer was used for trial. Every farmer can treat as a replication for statistical analysis. The results revealed that there is a significant increase in Rice equivalent Yield (7.07 t/ha/year) is obtained with the use of Green mannuring through Dhaincha + 75% Recommended Dose of Fertilizer (RDF) in both the component crop over Farmers Practice (5.84 t/ha/year). Similarly, net profit (Rs. 1, 87,404/ha/year over Rs. 1, 44,808/ha/year) and B:C ratio (4.12 over 3.42) were obtained. The effect of green mannuring on chemical properties of soil i.e. pH (5.9% increase), EC (10.52% increase) and available organic carbon (53.17% increase), P (37.50% decrease) and K (17.70% increase) was clearly observed.

Effect of different rice based cropping systems on chemical properties of soil under irrigated conditions

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Abstract

The soil is one of the most important natural resource, which are important for crop production. The soil properties are significantly affected by their parent material and management system. To identify the appropriate cropping system which is useful to maintain sustainability of soil the present investigation was carried out at JNKVV, Kuthuliya Farm, Rewa in which ten cropping system (rice-wheat, rice-chickpea, rice-berseem fodder+ seed, rice-potato-wheat, rice-garlic, rice-toria-onion, rice-lentil, rice-greenpea-wheat, rice-chichpea-linseed and rice-mustard) were tried. The soil of experimental field was silty clay loam in texture, neutral in reaction (pH 7.25), medium in organic carbon (0.56%), low in available nitrogen (224 kg/ha) and phosphorus (8.2 kg/ha) and high in available potash (315 kg/ha). The results indicated that the pH value and electrical conductivity were decreases under all the rice based cropping systems as compare to initial level. The organic carbon status was increased 3.57 to 30.35 per cent under different rice based cropping system over initial status. The maximum increase in organic carbon status was observed in rice-potato-wheat followed by rice-chickpea, rice-greenpea-wheat and rice-lentil cropping system. The available nitrogen status was decreased by 60-65 per cent under different rice based cropping system as compared to initial status. The available phosphorus status was increased by 14.63 to 134.87 per cent under different cropping systems. The maximum increase in available phosphorus status was 134.87 per cent in rice-berseem and rice-lentil followed by rice-chickpea and rice-mustard cropping system. The available potash was decreased by 34.39 to 51.56 per cent over initial stage under different cropping system.

DTPA-micronutrient status and their correlation with soil properties under different cropping systems in alluvial soils of Gwalior district

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Abstract

The stagnation in crop productivity cannot be boosted without invidious use of micronutrients fertilizers to overcome existing deficiency imbalances. Therefore, an attempt was made to find out the micronutrients status and their correlation with soil properties in different cropping systems of Gwalior district of Madhya Pradesh. Most of the soil showed pH value in the neighborhood of 7.5 $\pm$ 0.5. In some cases pH was noticed as 6.3 and 8.32. The electrical conductivity of soil water suspension (1:2) ranged between 0.18 and 0.74 dS/m at 25^0C with mean value of 0.47 dS/m. The electrical conductivity of soil water suspension was low in the entire sample. Organic carbon content of the soils of Gwalior district may be considered low to medium as most of the soils were found to certain less than 0.75% of it. The range of variation of $CaCO_3$ within soils of Fallow – Mustard, Pearlmillet – Mustard, Pearlmillet – Wheat and Rice – Wheat cropping systems were from 1.6 to 3.2, 1.6 to 3.2, 1.6 to 3.2 and 1.6 to 3.7%, respectively. Most of the soil samples were non-calcareous in nature. The entire area of different cropping systems for DTPA-Zn varied from 0.20 to 1.20 mg/kg with an average value 0.52 mg/kg. 86% samples are low in pearlmillet – wheat cropping system. The DTPA-Fe varied from 0.45 to 8.29 mg/kg with an average value 2.28 mg/kg. 66% samples are low in pearlmillet – wheat cropping system. The DTPA-Cu of the soils ranged from 0.02-0.54 mg/kg with mean value of 0.11 mg/kg. 98% samples are low in pearlmillet – wheat and rice – wheat cropping system. For the entire area of different cropping systems, DTPA-Mn of the soils ranged from 0.28 to 8.36 mg/kg with mean value of 2.17 mg/kg. 70% samples are low in pearlmillet – wheat cropping system. Only 18% samples low in rice – wheat cropping system. The availability of Zn increased significantly with increase in organic carbon, available N, P and K and DTPA Fe.DTPA-Fe had significant and negative correlation with sand, significant and positive correlation with silt, clay, DTPA-Zn and DTPA-Mn. Availability of Cu increased significantly with increase available phosphorus. The DTPA-Mn showed significant and positive correlation with only DTPA-Fe.

Study of ground water quality categories in Bhind district

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Abstract

Most of the water used for irrigation is of good to excellent quality and is unlikely to present serious salinity constraints. The extent to which the salt accumulate in the will depend upon the irrigation water quality, irrigation management and the adequacy of drainage. Salinity control, however, becomes more difficult as water quality becomes poorer. A ground water survey of the Bhind district was conducted by Salt Affected Soils Project, College of Agriculture, Indore during 2007-08. The mean maximum and minimum temperature in summer are 44.0 and 23.6 °C respectively. The difference between mean summer and mean winter temperature is more than 5°C thus the soils qualify for hyperthermic regime. The 90% of the rainfall is received from south-west monsoon during July to Sept. and rest in winter. The area comes under the Agro-Ecological Region 4 characterized by hot semi arid climate with alluvium derived soils (N8D2). The average annual precipitation ranges from 690 to 850 mm. the PET is 1400 to 1900 mm. the annual water deficit is 700 to 1000 mm. Three hundred two ground water samples were collected from different villages of each tehsils of the district. Out of total samples 53, 62, 47, 70, 16, 18, and 36 samples were collected from Gohad, Bhind, Ater, Mehgaon, Raun, Mehona and Lahar tehsils of the district. Out of these 302 samples, 158 belongs to category A, 20 belong to category B1, 7 belong to B2, 5 belong to B3, 47 samples belong to C1, 47 belong to C2 and 18 belong to C3 category respectively. On the basis of percent of water samples come under different category are as 52 % belong to A category, whereas 48 % come under saline and alkali water category. As far as, alkali water category is concerned, 37 % samples come under this category (C1, C2 & C3).

Study the salinity status of soil in Bhind district

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Abstract

Soil is major natural resource that plays a key role in the agriculture production system of this country through which food and nutrition security are insured. The quality of this resource depends either on its origin, nature or management practices. Salinity is caused by the accumulation of soluble salts in the root zone. These excess salts reduce plant growth and vigour by altering water uptake and causing ion-specific toxicities or imbalances. On the basis of analysis of surface soil samples of Bhind district it is inferred that problem of salinity/alkalinity exist in substantial area of this district. The texture varies from sandy loam to clay loam. The climate of the area is semi-arid with extreme summer and winter seasons. June is the hottest month and January is the coldest month. The mean maximum and minimum temperature in summer are 44.0 and 23.6 °C respectively. The difference between mean summer and mean winter temperature is more than 5°C thus the soils qualify for hyperthermic regime. The 90% of the rainfall is received from south-west monsoon during July to Sept. and rest in winter. The annual rainfall of the district is less than 620 mm. The pH of saturation extract varied from 7.8 to 9.8, the ECe has wide range between 1.47 to 12.20 dSm^{-1}, the SAR from 1.9 to 89.7 $(mmol\ L^{-1})^{½}$ and the base saturation from 26.3 to 45.8%. The cation exchange capacity having range between 5.2 to 36.4 C mol $(P^{+})\ Kg^{-1}$ and ESP from 8.8 to 56.5. The dominant cations are Ca, Mg and Na and anion is Cl. The major exchangeable cations Ca ranges between 2.1 to 18.3, Mg from1.1 to9.6 and Na from1.6 to11.1 C mol $(P^{+})\ Kg^{-1}$. Analysis of saturation extract of soil samples of different Tehsils of Bhind district indicate that dominating cations are Ca and Na and Cl and HCO_3 anions on the surface soils.

Response of mustard (*Brassica juncea* L.) to irrigation scheduling and zinc levels in Chambal command area of Madhya Pradesh

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Abstract

A field experiment was conducted during the winter season of 2008-09 to 2011-12 on sandy clay loam soil to evaluate the effect of irrigation and zinc levels on yield, irrigation water use efficiency and economics of mustard (Brassica juncea L. Czern and Cross) at Zonal Agriculture Research Station, Morena. Mustard crop with 2 irrigations (40 & 70 DAS) maintained taller plants (182.3 cm), higher leaves/plant (21.11), braches/plant (9.06), seed weight/plant (12.39 g), 1000-seed weight (4.87 g), production efficiency (18.11 kg/ha/day) and produced more seed yield (2.23 t/ha) over single irrigation applied at 40 DAS (19.7 t/ha) and 60 DAS (1.71 t/ha), respectively. Among the nutrient levels, 125% recommended dose of fertilizer (RDF) registered significantly higher values of all the growth and yield attributing characters, water use efficiency, production efficiency as well as produced more seed yield (2.16 t/ha) over other nutrient levels. Maximum net returns Rs. 58216/ha and Rs. 55258/ha were recorded with application of 2 irrigation and 125% RDF, respectively. However, the maximum benefit: cost ratio were recorded with 2 irrigations (5.04) and 100% RDF (5.00).

Effect of balanced nutrients and irrigation on yield and water use efficiency in mustard

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Abstract

An increase in mustard seed yield by the application of balanced dose of fertilizer and irrigation management was 33.33 in comparison to farmer's practices. Initial observations indicate that good health of soil was observed when organic manure was applied. The intake rate, bulk density and available N, P, K improved mustard yield over farmer's practices. Different sizes of border strips were maintained at farmer's field to provide irrigation in mustard crop. The experiment (OFWM) was carried out on 9 locations at Sikrouda village in Morena block. It was found that 4 -5 m wide strip recorded the average yield of 2250 kg/ha, where as 1500 kg / ha yield was obtained under farmer's practices. Farmer normally tends to apply more water per irrigation and thereby wastes 44.46 % water and gets lower yields. The water use efficiency under improved water management was recorded 150 kg/ha-cm while 83.33 kg/ha-cm under farmers practices.

Effect of Zn and Cu micronutrients on growth, yield and economics of China aster [C*allistephus chinensis* (l.) Nees]

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Abstract

A field experiment was conducted during the *Rabi* season of 2006-07 at Horticulture Nursery, Collage of Agriculture, Gwalior (M.P.). The result in regards to plant growth parameters, most of the growth parameters significantly increased with each increment in concentration of $ZnSO_4$ and $CuSO_4$ up to 0.6 per cent. The treatment combination Z_3C_3 produced significantly higher weight of fresh floral head (174.89 g) followed by Z_2C_3 (162.67g) and Z_3C_2 (162.29 g) against the control plot. The length and width of floral head was recorded significantly higher with Z_3C_3 treatment combination (5.78 cm &5.32 cm) followed by Z_3C_2 (5.58cm & 5.04 cm) against control. The significantly maximum number of floral heads per plant was produced by Z_3C_3 (62.80) treatment combination which was followed by Z_2C_3 (60.38) and Z_3C_2 (59.25) treatment combinations. The maximum benefit in yield of floral heads accrued with the foliar application of 0.6 per cent $CuSO_4$ (178.62 q/ha) and $ZnSO_4$ (167.63 q/ha). Among the treatment combinations Z_3C_3 recoded significantly higher yield (193.87 q/ha) followed by Z_2C_3 (180.52 q/ha) and Z_3C_2 (180.32). The minimum net profit of Rs. 1,46,400 along with benefit: cost ratio of 5.01 was obtained when both micro nutrients were not applied and that net profit reached to its maximum amounting Rs. 3,11,250 with benefit: cost ratio 9.25 per hectare in plots where 0.6 per cent $ZnSO_4$ + 0.6 per cent $CuSO_4$ was sprayed at 30 and 35 days after planting followed by 0.4 per cent $ZnSO_4$ + 0.6 per cent $CuSO_4$ (net income of Rs 2,87,400 with benefit: cost ratio 8.66).

Micronutrients (Fe, Mn, Cu and Zn) status in soils of Morena district of Madhya Pradesh

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Abstract

A soil survey was carried out during 2010-11 in Morena district of Madhya Pradesh by Department of Soil Science, College of Agricukture, Gwakior (M. P.). The availability of micronutrients to plants is influenced by soil characteristics. Work on micronutrient in soils of Morena district of Madhya Pradesh has not been done much more so far. Therefore, an attempt has been made to know the status of micronutrients (Fe, Mn, Cu ans Zn) and correlate them with other soil characteristics and availability status of other nutrients. Soils are mostly sandy loam to loam in texture. There were 120 soil samples were collected from 12 villages covering three tehsils of the district and analyzed for the basic soil parameters pH, EC, OC and $CaCO_3$. The results indicated that soil of Morena district is normal in reaction and soluble salts. Surface soil sample were non calcarious with low to medium organic carbon content. Most of soil sample were sufficient in available Fe (100%), Mn (63%) and Cu (67%). However, Zn was also in marginal range (63%0 in availability. Micronutrient Mn was strongly and positively associated with Fe. The association of Zn with Fe and Mn also found positive and significant on an average 0.5854 mg/kg increase in Mn was noted with unit change in Fe. Similarly 0.02697 and 0.01002 mg kg/ha increase in Zn was rgistered with unit change in Fe and Mn, respectively.

Soil fertility status of oilseed and pulse growing fields of Bhitarwar block of Gwalior district

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Abstract

Soil fertility refers to the inherent capacity of a soil to supply essential nutrient to plant in adequate and right proporation for optimum growth. Decline in soil fertility is the main cause of low crop productivity. Soils of India are generally poor in fertility, as these have consistently been depleted of their finite nutrient resources due to continuous cultivation for many centuries.

Gwalior district is situated in the gird agro climatic zones of Madhya Pradesh. The soils of the district are under the broad group of alluvial soils and medium black soils in patches the farmers of Bhitarwar block grown Sesame/greengram/ blackgram in *kharif* and mustard/ chickpea in *rabi* season under rainfed area. Cropping systems play an important role in sustainable soil health. Leguminous based cropping system show higher fertility status as compared to cereal based cropping system; but the information of soil fertility build up/depletion under different cropping system is lacking for the Gwalior districts of M.P. Hence the efforts have been made to study the fertility status in oilseed and pulse growing soil. One hundred four surface (0-15 cm) soil samples collected from oilseed (sesame & mustard) and pulse (greengram/blackgram & chickpea) growing fields of Bhitarwar block of Gwalior district in the year 2012-13.

Results indicate that the Soil pH and electrical conductivity were more or less same in different cropping system. Status of available N, P, K & S (kg $ha^{-1)}$ in studied field ranged from 128.2-304.2, 8.6-35.6, 104.6-386.2 & 8.4-32.5 with an average value of 216.5, 16.3, 202.2 & 16.8 kg ha^{-1} respectively. Under different cropping pattern, Maximum average value of available NPKS was recorded in Fellow-Gram. Leguminous based cropping system show higher status of available nitrogen, oilseed based cropping system show low status of available potassium and sulphur in soils as compared to pulse growing cropping system. Soil pH and Electrical Conductivity (EC) do not show any specific relationship with NPK&S under different cropping system. In general, organic carbon content of the soils of investigated area, showed positive relationship with NPK&S under different cropping system.

Considering the concept of soil nutrient index, the soils of Bhitarwar block of Gwalior district were found in category of low fertility status for nitrogen, phosphorus and sulphur and medium with respect to potassium. The value worked out from nutrient index for NPKS were 1.42, 1.58, 1.83 and 1.52 respectively, against the nutrient index values <1.67 for low, 1.67-2.33 for medium and >2.33 for high fertility status.

Potassium status of soil and uptakes as influenced by integrated use of FYM and fertilizers in pearlmillet – mustard cropping sequence

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Abstract

Pearl millet – mustard cropping sequence got popularized during last several years under limited and assured irrigated condition, in alluvial soil region of Northern Madhya Pradesh. Although most of the alluvial soils have been reported to be rich in potassium but intensive cultivation of high yielding varieties of crops in multiple cropping system and continuous application of N and P fertilizers at optimum and high rates accelerate the depletion of K and consequent response of K fertilizer. To formulate sound fertilizer recommendation, potassium supplying capacity of soil is essential. This will depend not only on the available K content of soil, but a sound knowledge of different forms of K and their relationship with each other is also required In views of above, the present investigation has been planned.

Present study were conducted during 2012-13 and is a part of on goining experiment with pearl millet- mustard cropping sequence in progress since 2001. The soil of experimental field is alluvial belonging to inceptisol hyperthermic family of Typic Ustochrept. There were sixteen treatments viz; T_1-control, T_2-50% NPK, T_3-75% NPK, T_4-100% NPK, T_5-150% NPK, T_6-100% NP, T_7-100% N, T_8-100%NPK-S, T_9-50% NPK + Azotobacter, T_{10}-75% NPK+ Azotobacter, T_{11}-100% NPK+Azotobecter, T_{12}- 100% NPK+Azo+PSB, T_{13}- 50% NPK+ FYM, T_{14}- 75% NPK+ FYM, T_{15}-100% NPK+ FYM, T_{16} 100% NPK+ FYM+ Azo+ PSB, each treatment was replicated three times in a randomizes block design.

The perusal of data revealed a declining trend (37 to 101 kg ha^{-1}) as compared to its initial level (250 kg ha^{-1}) of available K status which indicates considerable mining of available K after 10 years of intensive cropping. Maximum decline (-101 kg ha^{-1}) was observed in control followed by 100% NP. The magnitude of decline decreased with increasing levels of NPK application. Among the inorganic fertilizers, continuous application of N, NP adversely affected the available K content of the soil, which may be attributed to non application of potassic fertilizer, which also resulted in nutrient imbalance in the soil. Continuous omission of K in pearl millet- mustard caused mining of its native pools also resulted reduction in yield. Highest available K status (212 kg/ ha^{-1}) of soil was found in the treatment 100% NPK+FYM followed by 150% NPK (195 kg ha^{-1}).

The relationship of different forms of potassium show highly significantly and positively indicated that there exited an equilibrium between these forms of K and depletion of one is instantly replenished by one or more of the other forms of K.

Long Term Effect of fertilizer and manure application on profile distribution of various phosphorous fractions in vertisol

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Abstract

A field experiment was conducted on vertisol soil of Jabalpur, Madhya Pradesh, during kharif 2009-10 in a deep black soil (Vertisol) classified a Typic *Haplustert*., to evaluate the forms of inorganic P along with status of available major nutrients i.e. N, P and K as well as physicochemical parameters of soil under study in fertility treatments of long term fertilizer experiments. The eight treatment combinations comprised of different doses of fertilizers viz., 50, 100 and 150 % NPK, 100% NP,100% N,100% NPK + FYM, 100% NPK-S and control with four replications in a randomize block design. From the results obtained under long term experiment with continuous addition of fertilizers further last 36th years in black soil of Jabalpur improved the physicochemical properties of the soil in rendered the remarkable improvement in organic carbon content as well as status of various P forms. The Ca-P form was found to be predominantly in higher amounts followed by Fe-P and Al-P while Saloid-P contributed least content. The productivity of soybean was gently influenced with balanced fertilizer application over imbalanced applications. However, maximum yield was noted when 100% NPK+FYM was in practiced specially soybean-wheat grown in an intensified cultivation in black soil (vertisol) of central India.

Anthocyanin analysis of different Karonda processed products during storage

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Abstract

The Karonda products (jelly, jam, candy and squash) are consumed and liked by everyone whether a child, an old, a poor or a rich man. The commercial candy, jelly and squash in our country is quite expensive. This gave an idea to standardize the unconventional jelly, jam, candy and squash making by using karonda fruits and to assess their physico-chemical and organoleptic qualities during storage. An experiment was carried out at Post-harvest Technology Laboratory of Department of Horticulture. Allahabad Agricultural Institute-Deemed University, Allahabad. In this experiment maximum anthocyanins were studied in processed products. Results showed that the maximum retention of anthocyanin was recorded in candy (4.78) mg/100g) for 0 days of storage, while minimum was in jelly (0.10 mg/100g) for 120 days of storage. It was clear from the experiment that the trend of anthocyanins was decreasing in storage.

Microbial technology for removal of heavy metals from waste waters

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Abstract

Wastewaters from industries like electroplating, tanneries and paints contains high concentration of heavy metals like Pb, Cd, Cr and Ni, which are toxic to living organisms even at low concentration. These heavy metals enter into human beings and animals through food chain and cause many metabolic disorders. Physico-chemical methods to remove heavy metals are expensive and these do not remove heavy metals up to desired level. Biomass of microbes acts as adsorbent to remove heavy metals from wastewater at low cost and in eco-friendly way. The ability to remove heavy metals from wastewater varies greatly among microbes. This needs to be exploited for removal of heavy metals from wastewater through efficient microbes. Scientists at CSSRI have developed a few efficient fungi and bacteria for removal of heavy metals from wastewater. Optimum conditions such as pH, concentration of heavy metal, inoculum size etc. have been worked out for maximum removal of heavy metals from wastewaters by efficient microbes. Six fungi i.e. *Aspergillus niger*, *A. terreus*, *Phanerochaete chrysosporium*, *A. awamori*, *Trichoderma longibrachiatum*, *T. fasciculatum* and four bacteria namely *Bacillus cereus*, *B.sp.*, BS18 and Ni 16 were tested for removal of Pb, Cd and Ni from liquid medium containing 20, 40 and 60 ppm concentration of these heavy metals. Out of six fungi, maximum removal of Pb, Cd and Ni was observed by *T. longibrachiatum* (9.63 mg/g), *T. fasciculatum* (18.59 mg/g) and *A. terreus* (3.88 mg/g) at 60 ppm concentration respectively (Fig.1). In case of bacteria, maximum removal of Pb, Cd and Ni was observed by *B. cereus* (16.66 mg/g), *B. sp.* (49.95 mg/g) and *B. sp.* (2.51 mg/g) at 60 ppm concentration respectively. The optimum pH for removal of heavy metals by fungi was pH 5.0 for Pb and Cd and pH 4.5 for Ni. The optimum pH for removal of heavy metals by bacteria was pH 7.5 for Pb and Cd and pH 6.5 for Ni. Mechanism for removal of heavy metals by efficient microbes from wastewater has been studied by FTIR (Fourier Transform Infra-red) and SEM (Scanning electron microscope) . The FTIR analysis of untreated and heavy metal (Pb, Cd, Ni) treated *T. longibrachiatum* indicated the involvement of functional groups such as –NH, -OH, -CH, and C=O in the binding of Pb Cd and Ni with *T. longibrachiatum*. Consortium of six fungi and one bacterium grown on waste materials like pressmud, rice straw, charcoal and sludge indicated encouraging results for removal of heavy metals from industrial effluents. Consortium of efficient microbes can be used for bioremediation of industrial wastewater for heavy metals.

Isolation of salt tolerant microorganisms from salt affected soil

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Abstract

At present 6.73 million hectare area in our country is affected by soil salinity and sodicity. Salt affected soil contains higher percentage of salts of Na, K, Ca and Mg. These soils are highly deficient in plant nutrients. Plants and microorganisms are adversely affected in salt affected soil due to high concentration of salts and low availability of nutrients. Salt tolerant microorganisms help plants in overcoming the effect of salt stress by different mechanisms. They can overcome salt stress by production of plant growth promoting substances. The ability of microbes to improve plant growth in salt affected soil varies greatly. Hence there is need to isolate salt tolerant microorganisms from salt affected soil for better plant growth and crop productivity. Keeping this thing in mind, 200 bacterial isolates and 11 actinomycetes isolates were isolated from 68 salt affected soil samples. The pH_2 and EC_2 of these samples varied from 7.9 to 10.97 and 0.987 to 15.75 dS/m respectively. All the bacterial and actinomycetes isolates were further screened for salt tolerance on cultural media containing different level of sodium chloride (10%, 15% and 20%). Results indicated tolerance of 43 bacterial isolates and 4 actinomycetes isolates up to 20 % sodium chloride. These salt tolerant bacterial and actinomycetes isolates were further studied for phosphorous solubilisation on pikovasky agar medium. Some of the salt tolerant bacterial and actinomycetes isolates showed phosphate solubilisation on solid media. Highly salt tolerant isolates of bacteria and actinomycetes will be further studied for other plant growth promoting activity like siderophore production, indole acetic acid production and ammonia excretion. This study will be of considerable use in enhancing the growth of crop plants in salt affected soils.

Innovations in reclamation and management of salt affected soils

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Abstract

Soil and water are vital natural resources crucial to the sustenance of life on earth. Processes underlying in soils have direct or indirect impact on the ecosystems and ultimately the soil quality determines the prosperity of the nation. Irrigated agriculture is one of the approaches used especially in the semi-arid and arid regions of the world so that food security for the burgeoning population pressure is achieved. However, unscientific soil, water and crop management practices over the years are resulting in altered hydrological balance in soil and thus leading to the degradation of heavy textured low hydraulic conductivity and impervious substrata (poor drainage) of black soils to waterlogging and secondary salinization. Siltation of natural drain was also considered to be one of the major causes for water logging and salinization in the irrigation commands. Due to insufficient rainfall and/or use of marginal quality groundwater for crop production is as well resulting in the development of salt affected soils under rain-fed agriculture situations. The causes may vary but their effects on crop growth and yield are mostly alike through osmotic, ion-specific effects, imbalanced nutrition of crops, soil physical constraints etc. A reconciled estimate in 2006 by CSSRI, NRSA and NBSS&LUP indicates that about 6.73 Mha of land is salt affected in India and is predicted to raise to 11.7 Mha by 2025 if appropriate steps are not taken to arrest further soil degradation. Karnataka is blessed with five major irrigation commands viz., Tungabhadra, Malaprabha and Ghataprabha, Upper Krishna and Cauvery projects. It is estimated that nearly 96,215ha, 1,10,961ha (including outside the command area due to lift irrigation), 62,317 ha and 12,000 ha is considered to be affected by water logging and/or soil salinity in the above project areas respectively representing 26.5, 20.1, 10.0 and 2 percent of total area of the command.

Hence, decline of arable land and renewable fresh water resources for sustenance of agriculture to achieve food security of the escalating population saline agriculture is eminent. And, sustainable agricultural production in salt affected soils through innovative irrigation, soil, water and crop management technologies is possible but is to be monitored constantly. In the management of waterlogged and saline soils, threshold salinity and depth to water table for crops needs to be worked out so that appropriate soil and crop management techniques could be developed for a given set of conditions. Since, soil salinity and waterlogging in irrigated fields are generally associated together, working out further leaching requirement of saline soils with different water table depths help us to plan pre-sowing irrigation managements in order to achieve improved germination and crop yield in salt affected soil. Of late, with the development of improved irrigation techniques (surface/subsurface drip/sprinkler system) wherein water as well as nutrient use efficiencies are much higher than the traditional irrigation methods, there is scope for effective management and arresting further increase in area of salt affected soils apart from working out irrigation requirement of crops. The influence of presence or absence of crop residue on soil moisture availability and soil salinity were also regarded as important tools in the management of these soils.

The need for lowering water table and thereby maintaining the effective root zone of crops free from excess soluble salts through drainage is important in waterlogged saline soils. Field drainage requirements depend on surface features, soil type, soil hydrological parameters and crop salt tolerance. The feasibility of various drainage options like interceptor drainage, sub-surface drainage, vertical drainage, integrated drainage systems etc., are to be carefully studied and executed for effective reclamation of these soils. Further, to overcome the limitations of sub-surface drainage

system with regard to excessive and continuous drainage discharge of water and loss of nitrogen, a slight modification to the traditional SSD through a control devise also requires our attention. Because, as suggested by Dr. A.K. Singh, Hon'ble Vice-Chancellor, RVSKVV, Gwalior our strategy of irrigation should be demand driven and not supply driven.

The problem of salinity and water logging are considered as regional and global problems and the engineering means of reclamation many times are most often cost-prohibitive and remain out of the economic realms of most farmers. The concept of bio-drainage wherein deep rooted tree species with high evapo-transpiration (ET) rate could serve as an alternative mode to the cost-prohibitive engineering solutions to prevent seepage from unlined and/or inappropriately lined nalas in the adjacent fields. In a long-term (15 years) study at ARS, Gangavathi, out of six tree species, *Acacia nilotica* followed by *Casuarina equisetifolia* found promising species from the point of bio-ameliorative effects (improvement in soil organic carbon, porosity, infiltration rate, hydraulic conductivity and aggregate stability and decline in bulk density and erodibility of soil etc.) apart from effectively arresting emerging seepage flow from the canals. Similarly, under extreme conditions of high water table and salinity and where vast areas have become salinized and options are limited under such circumstances growing certain fruits viz., Jamun and wood apple and multipurpose tree species such as *Acacia auriculiformis, A. ferugenia, Albizzia lebbeck, Glyricidia maculate* and *Casuarina equisetifolia* is also an important means of management/reclamation of waterlogged saline soils profitably.

Despite maintaining better soil and water relations to avoid such situations, identification of suitable crop/cropping sequence and alternate land uses (forage grasses, medicinal and aromatic crops etc) for saline/waterlogged soils along with studies on the effects of crop residues is one of the keys to manage these problematic soils profitably. In recent years, production of bio-ethanol is gaining importance. Sugarbeet being a short duration crop (5-6 months) and requiring less water (about 1/3 to ½ of sugarcane) than sugarcane can substitute for sugarcane especially for production of bio-ethanol to the extent of 6,000 to 7,500 lit per ha along with higher sugar recovery. Sugarbeet can fit well under saline soils up to ECe 7-8 dS/m without any yield loss but could be still raised up to 12 dS/m with 20-25% yield reduction. Unlike fields in the irrigation command, dry land agriculture suffers from adequate soil moisture to support plant growth. Paradoxically, saline and sodic soils are also associated with arid and semiarid soils. In-situ rainwater harvesting is an important approach to retain excess rainwater as soil moisture, however the effectiveness of which depends on the manipulation of surface features of the land. Dissolution and reaction of applied gypsum in sodic soil reclamation also demands soil moisture and is a matter of concern in dry-land soils. Hence, appropriate field layout or design to boost in-situ rainwater harvesting needs to be worked out.

Use of industrial effluents in reclamation of salt affected soils, developing IFS model, conservation agriculture practices (laser leveling, zero tillage/direct seeding, crop residue management etc.) as a tool to conserve natural resources viz., soil and water for sustainable agriculture in salt affected soils are also under the umbrella of reclamation and management of salt affected soils which are to be explored wherever feasible. Requirement of any of the reclamative or management options of salt affected soils mentioned above and/or elsewhere in the literature largely depends on soil and hydrogeological characteristics, soil, water and crop management practices, climate, economic incentives etc. Overall, a comprehensive and long-term strategy adaptable to the prevailing situations can lead to success in the reclamation and management of salt affected soils.

Effect of municipal solid waste compost and chemical fertilizers on soil biological properties of saline soil in a mustard-pearl millet cropping system

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Abstract

Salinity stress hinders microbiological properties of soil. The use of municipal solid waste compost (MSWC) as soil organic amendment is an economic and environmental interest. However, little information is available about the effectiveness of MSWC in saline environment of arid and semi-arid regions of India. We assessed the effectiveness of different organic amendments *viz.* MSWC, gypsum enriched compost (GEC), rice straw compost (RSC) and chemical fertilizers on biological properties of saline soils under mustard-pearl millet cropping system. Integrated use of MSWC @ 8 t ha^{-1} along with 50% recommended dose of NPK fertilizers (RDF) increased dehydrogenase (DHA) and alkaline phosphatase activity (APA) by 73 and 120% respectively, over unfertilized control plot after mustard harvest. Application of 25% RDF along with organic amendments (MSWC @ 4 t ha^{-1} + RSC @3.5 tha^{-1} and GEC @ 3.5 t ha^{-1}) resulted significantly higher amount of microbial biomass carbon (MBC), urease activity, Walkley and Black Organic Carbon (WBC) over unfertilized control plot after mustard and pearl millet harvest. As far as concerning the soil EC_e (electrical conductivity of soil saturated extract) and pH, treatments did not significantly change after harvest of mustard. However, after harvest of pearl millet soil EC_e was significantly lower under treatment receiving organic amendments along with 25% RDF than other treatments.

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