SALINITY News

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From Directors' Desk

Recently concluded Conference of the Parties to the UN Convention to Combat Desertification (COP14) adopted the 'Delhi Declaration' that, among other things, renews global commitment to tackling the pressing issues of land degradation, climate change and biodiversity loss that world faces today. It acknowledges that land restoration practices remain vital to human well-being: an area that reflects our unending commitment to the society. We, at ICAR-CSSRI, have left no stone unturned to bring cheers on farmers' faces in several environmentally harsh salt-affected areas, and remain focused- often swimming against the tide- to ensure that farmers having degraded salty soils and waters do not remain lame-duck landowners.

Some research outcomes provided in this issue of Salinity News (July-December 2019) include: Diversity and abundance of culturable microbial populations in salt affected soils; Direct Seeded Rice- a way to arrest soil degradation due to waterlogging and soil salinization in TBP command area; Identification of salt responsive genes in grass halophyte *Urochondra setulosa*; Conserved moisture to cash: autonomous adaptation through muskmelon improves farmers' livelihoods in arid, Rajasthan; Drip irrigation in rice-wheat cropping system: a promising resource conservation technology; and *Moringa oleifera*: a viable crop for salt affected soils. A MANAGE sponsored training program was organized during August 19-23, 2019. Advanced training on 'Functional Characterization of Differential Gene Expression under Salt Stress' was conducted from 11-13 September, 2019. Rabi Kisan Mela was organized in collaboration with Department of Agriculture and Farmers' Welfare, Govt. of Haryana at Palwal on 13th September, 2019. Hindi Pakhwada was organized during 14-28 September, 2019. Model training course on 'Advancements in Soil, Water and Plant Analysis Techniques' was conducted during 16-21 September, 2019. CCSNAIM sponsored training programme on 'Innovative Marketing Practices for Enhancing Farmers Income in Salt Affected Regions' was held during 18-20 September, 2019. An International Capacity Building Programme on 'Use of Poor Quality Water in Agriculture' was organized during 23rd October-5th November, 2019. Five one day training programs on "Management of Alkali Soils and Water" for capacity building of stakeholders were conducted during November-December, 2019. Institute celebrated Swachhata Pakhwada from 16th to 31st December, 2019. Hon'ble Union Minister of State for Agriculture and Farmers Welfare Sh. Kailash Chaudhary visited the Institute and interacted with different stakeholders on Farmers' Day celebrated on 23rd December, 2019.

In This Issue.....

(Parbodh Chander Sharma)

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Diversity and abundance of culturable microbial population in salt affected soils

The rhizosphere comprises soil microenvironment in the proximity of root region where the average count of microorganisms is very high than rest of the non-rhizospheric bulk soil. Rhizospheric soil of the 6 different biotypes grown in saline soils at Nain Experimental Farm, Panipat, showed appreciable culturable microbial diversity compared to the non-rhizospheric soil. Bacterial population (5.14×10^6) and fungal count (8.83×10^4) were found to be the highest in mustard rhizosphere (EC_e~5.04 dS m^{-1}) followed by *Spergulla* rhizosphere (EC_e~2.33 dS m^{-1}). Similar results were found for actinomycetes as they were highest in mustard rhizosphere (51.5×10^5) followed by Phalaris minor rhizosphere (11.9×10^5). More microbial population mustard rhizosphere compared uncultivated plant's rhizosphere inspite of higher EC_e may be due to better rhizospheric development because of more production of plant exudates and better growth due to fertilizer applications.

Population of beneficial microbes *viz*., phosphate solubilizing bacteria (PSB), zinc solubilizing bacteria (ZSB), nitrogen fixing bacteria (NFB), *Pseudomonas*, and *Azotobacter* varied with EC_e. However, their populations were high in rhizospheric soil in comparison to non rhizospheric soil. Azotobacter (1.87×10^2) and other nitrogen fixing populations (2.64×10^2) were found to be highest at lower EC and in the rhizosphere of Spergulla. However,

Spergulla arvensis grown at Nain farm

ZSB (1.87×10^2) was highest in Chenopodium rhizosphere (EC_e~3.04 dS m^{-1}). PSB population (3.88×10^2) was found highest in mustard rhizosphere. Less microbial population was observed in high more saline (EC_e ~ 10-12 dS m^{-1}) than in low saline (EC_e ~ 2-7 dS m^{-1}) soils. Wheat rhizospheric soil (EC_e~10.01 dS m^{-1}) showed higher bacterial, fungal and other microbes types in comparison to non rhizospheric soil. Culturable microbial diversity of soil at different salinity levels was expressed using Shannon diversity index and higher diversity index (0.14-0.24) was found in rhizospheric soil in comparison to non rhizospheric ones (0.13-0.19).

Priyanka Chandra, Awtar Singh, Madhu Choudhary, A. K. Rai, Kailash Prajapat and R.K. Yadav

DSR (Direct Seeded Rice) - A way to increase crop and water productivity in TBP command area

Puddled transplanted rice (PTR) is an important crop in Tunga Bhadra Project (TBP) command area where poor water management has resulted in the development of waterlogging and soil salinity in over 25% of the command area. A field experiment on direct seeded rice (DSR) and puddled-transplanted rice (PTR), with or without laser leveling, was conducted on Vertisols at Agricultural Research Station (ARS), Gangavathi, Karnataka. Results revealed that total irrigation water applied was 23.2 and 18.1% less under DSR with and without laser leveling, respectively, compared to traditional transplanting without laser leveling. Significantly higher paddy yield was recorded under PTR in laser leveled field (5833 kg ha^{-1}) compared to PTR with traditional leveling (5056 kg ha^{-1}). Similarly yield under DSR with traditional leveling was 4893 kg ha^{-1} while it was 5682 kg ha^{-1} with laser leveling. Water production efficiency of PTR was higher under laser leveled land (0.51 kg m^{-3}) compared to traditional leveled land (0.40 kg m^{-3}). DSR laser leveled land gave the highest value of 0.58 kg m^{-3} while it was 0.47 kg m^{-3} with traditional leveled land. The B:C ratio was also significantly higher

under DSR in laser leveled land (3.11) compared to traditional leveled land (2.87), PTR in laser leveled land (2.66) and PTR under traditional leveled land (2.44). As per 2018 appraisal, the DSR technology has been adopted in about 27,000 ha area in Raichur, Koppal and Bellary districts of TBP command saving 20-25% irrigation water, 50% seed, 25-30% fertilizers and saving on labour and energy. Additional income is estimated at Rs. 15000 ha^{-1} $season^{-1}$ with adoption of DSR technology.

Rajkumar R Halidoddi, J.Vishwanath, S.R. Anand, A.V. Karegoudar, M.J. Kaledhonkar and BL Meena

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Identification of salt responsive genes from grass halophyte (*Urochondra setulosa*) through next generation sequencing

Urochondra setulosa is an obligate grass halophyte that can survive up to 1000 mM NaCl. This study reports novel *de novo* transcriptome of *Urochondra* leaves. Grass root cuttings were collected from native saline habitat of Rann of Kutchh, Gujarat and were established at ICAR-CSSRI, Karnal in lysimeters filled with sandy soil in a screen house. The treatment levels of salinity i.e. ECe ~30 dS m^{-1}, EC_e ~40 dS m^{-1} and EC_e ~50 dS m^{-1}were maintained through saline water irrigation (3:1 chloride dominated salinity) in three replicates along with control. Leaves were harvested at vegetative stage after 48 hour of saline irrigation. RNA sequencing was performed on IlluminaHiSeq to generate paired end 2x150 base pair reads. Approximately 45.01-48.39 million raw sequencing reads per sample were assembled into contigs corresponding to gene products. A total of 345,729 differentially expressed genes (DEGs) were identified with 68,455 up-regulated, 69,759 down-regulated and 207515 neutrally regulated unigenes. Venn diagram depicts the common up-regulated and down-regulated genes at three saline levels in Urochondra (Fig.1). These genes are involved in various metabolic pathways particularly signal transduction, glycolysis, starch and sucrose metabolism etc. Gene Ontology analysis revealed biological processes as the most abundant (1931 terms) followed by molecular function (1505 terms) and cellular component (521 terms). In biological processes category, about 143 DEGs were related to salt stress responsive genes. Significant distribution of genes encoding transcription factors such as BTB/POZ, WRKY, MYB, NAC, DREB, AP2-EREBP, bHLH,

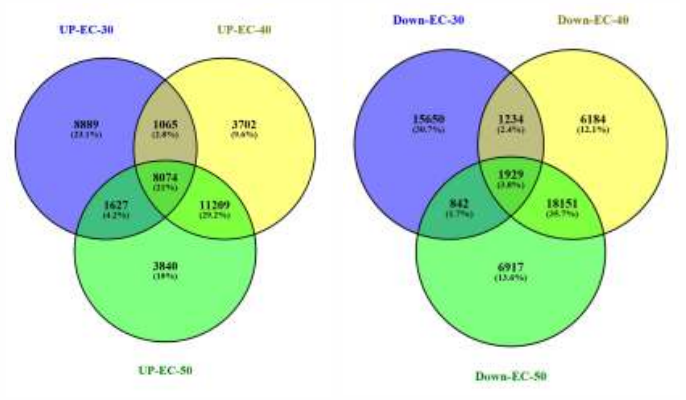

Fig.1.Venn diagram of DEGs at different saline levels in *Urochondra setulosa*

bZIP, and MADS was observed, as the major transcriptional regulators of secondary metabolism. The up-regulation of genes for photosynthetic enzymes, MAPK pathway, transcription factors, transporter proteins, antioxidative enzymes, cell membrane proteins and enzymes for synthesis of compatible solutes with increasing levels of salinity suggested the reasons for salt tolerance ability of halophyte *Urochondra*. This study provides first comprehensive and comparative evaluation of Urochondra setulosa transcriptome. Functional unigenes and pathways identified here provide useful information for improving salinity stress tolerance in crop plants.

Anita Mann, Naresh Kumar, CharuLata, Ashwani Kumar, Arvind Kumar and B L Meena

Conserved moisture to cash: autonomous adaptation through muskmelon improves farmers' livelihoods in arid, Rajasthan

Autonomous adaptation strategy is commonly developed and used by the material resource-poor farmers (MRP) in resource scarce regions. This study attempts to understand how farmers in Pali district of Rajasthan, India experience multiple stressors and respond to them through local autonomous strategies. A study was carried out with 20 key informants from four purposively selected villages having landholdings in Hemawas check dam area of Pali district. Results indicated that over 84.0% of the farmers were experiencing delayed onset and early withdrawal of monsoon. Respondents believed that, in addition to climate variability, socio-political changes are also adversely impacting their livelihoods. Growing water scarcity has compelled them to utilize soil moisture conserved in Hemawas dam catchments to grow diverse crops. Lands where farmers earlier grew wheat, barley, chickpea and mustard, now suffer from water scarcity and

Muskmelon in conserved moisture of saline soil

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salinity, and are being used to grow muskmelon varieties Chandra, Madhu and Kajari. If is seen as an opportunistic adaptation with high profit realizations. Muskmelon cultivation is gathering momentum in such marginal soils as it adapts well to the adverse conditions, requires the least use of external inputs (cost 5,000-7000 ha^{-1}) and provides handsome returns (Rs. 30,000-50,000 ha^{-1}) within 3 months. In the uplands adjacent to the dam, farmers still cultivate late sown varieties of barley and wheat. When water recedes from the catchment area, at the higher topography some farmers grow salt tolerant mustard (CS 52) and wheat (KRL 210) in saline soils. These two varieties provide food security to farmers, and surplus amount is sold to arrange inputs for growing muskmelon crop. This study provides insights as how formal and informal knowledge can be hybridized to co-produce more robust adaptation to convert stressors into opportunity.

Ranjay K. Singh, Dheeraj Singh, Anshuman Singh, A. Goswami, A. Upadhyay, P. Sheoran, Satyendra Kumar and DK Sharma

Drip irrigation in rice-wheat cropping system: A promising resource conservation technology

Rice–wheat system, occupying nearly 10.3 M ha area in the Indian Indo–Gangetic Plains (IGP) is key to national food and livelihood security. The water table in north-western region is going down at an alarming rate of ~0.33 m yr^{-1}. Drip irrigation system with high water application efficiency saves considerable water. With this hypothesis, a three-year field experiment (2016-2018) was conducted at ICAR-CSSRI, Karnal to assess the feasibility of drip irrigation in rice-wheat cropping system. Two adopted resource conservation vis-à-vis conventional practices (CV) were imposed viz. drip irrigation system in reduced tilled direct seeded rice (DSR) and zero tilled wheat with 100% rice residue mulched (DRIP-DSR-W), surface irrigation system in reduced tilled DSR and ZT wheat with 100% rice residue mulched (SUR-DSR-W), and surface irrigation system in conventional puddle transplanted rice (PTR) and conventional tilled wheat with 100% residue removed (PTR-CW, farmers' practice) were laid out in randomized complete block design with four replications. Drip irrigation system saved 71.6 and 41.8% irrigation water and 26.7 and 40.0% nitrogen, respectively, in

Rice crop with drip irrigation

rice and wheat crops. The grain water productivity was 3.81 and 1.92, and nitrogen use efficiency was 1.20 and 1.87 times higher in drip irrigated rice and wheat crop, respectively, than surface irrigated puddle transplanted rice and wheat. The grain yield in drip irrigated rice was 6.77 t ha^{-1}, at par with surface irrigated PTR (6.94 t ha^{-1}). While, in wheat yield advantage of 8.5% was recorded in drip irrigation treatment (5.76 t ha^{-1}) compared to surface irrigation treatment (5.31 t ha^{-1}). So, with considerable saving in inputs, drip irrigation system is best bet to sustain the productivity of rice-wheat system in western Indo-Gangetic plains of India.

Ranbir Singh, Sonia Rani, Ajay Singh and Satyendera Kumar

Moringa oleifera : A viable crop for salt affected soils

Drumstick (*Moringa oleifera* Lam.) is a fast growing, drought tolerant species adapted to diverse agro-climatic conditions. It is highly valued for its nutritional and medicinal properties. Although categorized as moderately tolerant to salinity stress, little is known about its performance in salt affected soils. Accordingly, an experiment was conducted at ICAR-CSSRI, Karnal to evaluate its salinity and sodicity tolerance. One month old seedlings, raised in HDPE bags (60x75 cm), were exposed to four sodicity (pH_2: 8.2, 8.6, 9.0 and 9.4) and irrigation salinity (EC_{iw} <2, 4, 8 and 12 dS m^{-1}) treatments. Plant survival

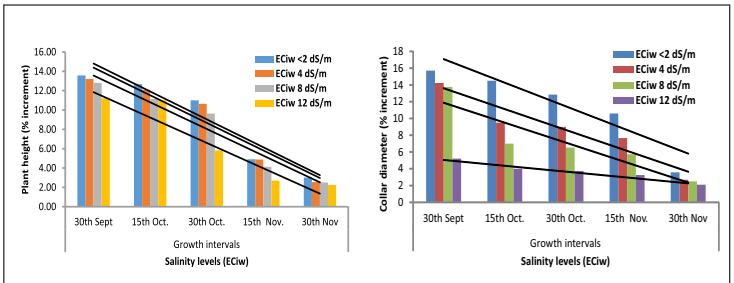

Fig. 1. Percent growth increment under salinity regimes

declined with increasing sodicity: only about 53.0% plants survived at pH_2 9.4 compared to control. Similarly, plant

height and collar diameter showed consistent declines with increase in soil pH level. Plant survival also decreased with increasing water salinity with only 66.7% and 57.8% plants surviving at ECiw levels of 8.0 and 12.0 dS m^{-1}, respectively. Despite poor survival rate, growth performance was better up to EC_{iw} 8 dS m^{-1} (Fig. 1.0). Comparative evaluation revealed that seedlings performed better in saline than in sodic conditions. Leaf Na+ increased from 0.13 to 0.18% under sodicity and from 0.08 to 0.11% under salinity in three month old seedlings. Contrarily, leaf K^+ declined from 2.75 to 1.88% in sodic and 2.63 to 2.35% in saline treatments. The findings revealed relatively better adaptability of drumstick in saline than in sodic conditions.

R Banyal, Rajkumar, RK Yadav and PC Sharma

MANAGE sponsored training programs

MANAGE sponsored training program was organized on "Technologies for Doubling Farmer's Income on Salt Affected Soils" during August 19-23, 2019 in which 15 trainees from State Departments, ICAR Institutes and SAUs participated. The trainees were trained on 4 major aspects viz., identification and characterization of salt affected soils and water, reclamation of salt affected soils and poor quality waters, salt tolerant crop varieties and alternate land use systems for productive utilization of salt affected soils. A field/study visit was also conducted for the trainees for one day during the training programme during which the trainees were given exposure to technologies developed by ICAR-CSSRI, Karnal, Model Dairy Farm of ICAR-NDRI, Karnal, seed processing unit of ICAR-IARI RRS, Karnal and commercial fish production farm of a progressive farmer in Karnal.

Chief Guest with trainees

Training on functional characterization of differential gene expression under salt stress

Three days short training on "Functional characterization of Differential Gene Expression under Salt Stress" was conducted at ICAR-CSSRI, Karnal from 11-13 September 2019. Training was inaugurated by Dr P. C. Sharma, Director, ICAR-CSSRI. He briefly explained about various technologies developed by CSSRI for reclamation of saline and sodic soils. He informed that approximately 2.14 M ha area has been reclaimed through these technologies. A total of 29 participants from various academic institutes attended this training. During three days programme, lectures along with hands-on practical's covering the topics from an exposure to NGS data and its biological interpretation, differential gene expression with validation, functional characterization under salt stress etc were covered. One day session was held at ICAR-IASRI, New Delhi, where the participants were exposed to various bioinformatics softwares for NGS data analysis.

Trainees with Director, ICAR-CSSRI

Rabi Kisan Mela

Rabi Kisan Mela was organized in collaboration with Department of Agriculture and Farmers'Welfare, Govt. of Haryana at Netaji Subhash Chandra Stadium, Palwal on 13th September, 2019. Shri Mehar Chand Gehlot, Vice Chairman, Livestock Development Board and member IMC, ICAR-CSSRI, Karnal Haryana was the Chief Guest of the Mela. In his inaugural remark, he said that ICAR-CSSRI, Karnal is playing a pivotal role in improving agricultural productivity in salt and water stressed regions of the country. He observed that farmers of the region need to adopt integrated farming systems developed by ICAR-CSSRI, Karnal to obtain regular income while conserving the

precious natural resources. Dr. P. C. Sharma, Director, ICAR-CSSRI, Karnal, in his welcome address, presented an overview of improved salt tolerant varieties, doable salinity management and resource conservation technologies to achieve the goals of higher productivity, natural resource conservation and climate change adaptation. About 2500 farmers participated in Kisan Mela, which showcased improved technologies for salinity management, crop diversification, integrated farming, horticultural crops and mushroom cultivation. Free analysis of soil and water samples; exhibition of improved agricultural technologies developed by ICAR institutes, government agencies and private companies; sale of high yielding, salt tolerant seeds of wheat and mustard, and Farmer-Scientist Goshthi were the main attractions of the Mela.

Farmers in Rabi Kisan Mela

Model Training Course

Dr. P.C. Sharma, Director, ICAR-CSSRI with trainees

A Model Training Course entitled "Advancements in Soil, Water and Plant Analysis Techniques using Sophisticated Equipment with respect to Salinity and Sodicity Management" was held during 16-21 September, 2019 at ICAR-CSSRI Karnal. The main purpose of this training program was to impart exposer to the participants regarding soil, water and plant analysis techniques using various sophisticated instruments. During the training course, 75% time was allotted for lab practical work and 25% for theoretical and field visits. During the program, hand-on lab exercises was conducted on characterization of irrigation water and practical assessment of electrical conductivity, total dissolved solids, residual sodium carbonate (RSC), sodium adsorption ratio (SAR) and specific ion determination using ion chromatograph (IC).

CCS NIAM Sponsored Training Programme

The Institute organized 3 days training programme sponsored by CCS National Institute of Agricultural Marketing, Jaipur on "Innovative Marketing Practices for Enhancing Farmers Income in Salt Affected Regions" during 18-20th September, 2019. A total of 30 progressive farmers/agri-entrepreneurs from 20 villages covering seven districts of Haryana and Punjab states participated in the training programme. During the three days training programme, a total of 19 resource persons delivered their lectures/conducted field visits (12 lectures delivered in the class room and 7 field visits with spot lecture). The trainees were acquainted with several aspects of agricultural marketing viz.,technologies for enhancing farmers' income in salt affected regions, Govt. policies and schemes related to agricultural marketing and innovative marketing practices to be followed for fetching higher income. In field/study visit, the trainees were given exposure to technologies developed by ICAR-CSSRI, Karnal.

Chief Guest with trainees

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Hindi Pakhwada

Hindi Pakhwada was organized at ICAR-CSSRI Karnal during 14-28 September, 2019. Dr. Rekha Sharma, Principal, Pt. Chiranjilal Sharma Govt. P.G. College, Karnal inaugurated the program. In her address, she appreciated the works being done in Hindi by the Institute and requested audience to adopt Hindi language in day to day working. Dr. P.C Sharma, Director, ICAR said use of Hindi is increasing day by day in internet and even our Government representatives are addressing in Hindi in different gatherings at global level.

Dr. Rekha Sharma addressing the gathering

International Training Programme on "Use of Poor Quality Water in Agriculture"

A short-term International Capacity Building Programme on "Use of Poor Quality Water in Agriculture" was organized at ICAR-CSSRI, Karnal, India during 23 October to 05 November 2019. This programme was jointly sponsored by AARDO and Ministry of Rural Development, Govt. of India. Nine delegates from AARDO member countries (Malaysia, Malawi, Morocco, R.O. China, Sri Lanka, Syria, Tunisia, Zambia) are participated. The programme was inaugurated by Dr. Gurbachan Singh, Ex Chairman, ASRB, New Delhi. The programme was divided into plenary sessions of presentations on various issues of poor quality water, and hands on practical trainings and field visits to apprise the delegates on parameters of poor quality water and management issues. The hands on practical trainings were; in situ examination of salt affected soil profile for reclamation and management, gypsum/amendments requirement in reclamation of sodic soil and irrigation water, assessment of poor quality parameters as EC, TDS, RSC, SAR and specific ions in irrigation water and bioremediation of poor quality water etc. Valedictory Function was held on 5th November 2019. Dr Manoj Nardeo Singh, Secretary General, AARDO and the Chief Guest, highlighted the problems of poor quality water in AARDO member countries and the relevance of this capacity building programme for sustainable use of poor quality water in these countries. Dr P. C. Sharma, Director ICAR-CSSRI described the achievements of CSSRI, and its vast experience in organizing such training programmes.

Dr. Manoj Nardev Singh, Sec. Gen. AARDO with participants

Farmers' Training Programme

ICAR-CSSRI in collaboration with Haryana Land Reclamation and Development Corporation (HLRDC organized 5 one day's training programme on "Management of alkali soils and water" for Capacity Building of Stakeholders under Pilot Project for reclamation and sustainable management of alkali soils and adoption of rainwater recharging in Nilokheri Block of District Karnal during November-December, 2019. This training programme was attended by 200 farmers from sodicity affected villages of Nilokheri block. Participating farmer trainees were exposed to techniques of identifying and reclaiming sodic soils, ways and methods of managing of alkali (high RSC) water, salt tolerant crop varieties for the region, etc. The trainees were also exposed to field, experiments, multi-enterprise farming model, conservation agriculture based crop diversification, etc

Dr. P.C. Sharma distributing the Certificates

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Farmers' Day

The Institute organized farmers' day on 23rd December, 2019 on the eve of birth anniversary of Late Prime Minister Chaudhary Charan Singh. Hon'able Union Minister of State for Agriculture and Farmers Welfare Sh. Kailash Chaudhary graced this occasion as Chief Guest. He visits several experimental sites of the Institute. Later on, he addressed the gathering of scientists, farmers and other staff. He told that there has been an important role of scientists and farmers for ensuring food security in the country. He observed that researchers, developmental agencies and agri-entrepreneurs will have to work together in order to make farming a profitable occupation. The farmers have to come forward to undertake agri-enterprises.

Dr. P. C. Sharma, Director, ICAR-CSSRI apprised the gatherings regarding the role and achievements of the Institute in developing technologies and salt tolerant varieties for the management of salt affected soils. Later on, Hon'able Minister visited Nadana village in the Nilokheri block which is one of the adopted villages of CSSRI to showcase the crop residue management and conservation agriculture technologies. This village is now totally free from residue burning by the farmers. Addressing a gathering of 500 farmers including 100 farmers from Punjab in this village, the Honorable Minister expressed distress over crop residue burning in North India and asked the farmers to use the machineries available for in situ management of crop residue. He told that by adopting such practices there will be improvement in the general health of soil and environment.

Sh. Kailash Chaudhary addressing the farmers'

NOTABLE VISITORS

Dr. S.K. Malhotra, Agriculture Commissioner, Govt. of India, interacting with Director, ICAR-CSSRI, Karnal

Paper in Science Journal

A research paper "Fields on fire: Alternatives to crop residue burning in India" published in the world's topmost scientific journal Science, in august 2019 evaluated the public and private costs and benefits of ten farming practices to manage rice residue, including burn and non-burn options. Happy Seeder-based systems (Mulch SMS+Happy Seeder) emerged as the most profitable and scalable residue management practice and showed ~10% (INR 5300 ha^{-1}) more profitable than burning option (burn+zero-till) and ~20% (INR 11500 ha^{-1}) more profitable than the most common burn system (burn+disc harrow). Happy Seeder options reduces the Particulate pollution by more than 98% (1 kg ha^{-1} $year^{-1}$), GHG by ~80% (933 CO2eq kg ha^{-1} $year^{-1}$) and ground water withdrawals by ~20% (1412 m3 ha^{-1} $year^{-1}$) than the farmers' practice (burn+disc harrow) in rice-wheat system of NW India.

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