



Varietal led ecological resilience

through KRL 210 in salt stressed wheat

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Regaining the agricultural potential and maximizing opportunities for profitable farming in salt affected areas is vital for food security and is associated with economic development. Crop performance of two wheat varieties; salt tolerant KRL 210 and highly adapted HD 2967 was evaluated in sodicity prone Ghaghar basin of Haryana. Better resilience and increased adaptability of salt tolerant KRL 210 offered better opportunity to harvest reasonable wheat yields under irrigation induced sodicity stress and helped in transforming the traditional farming into an ecologically sustainable and profitable venture. The useful insights generated may convince policy planners and developmental agencies while formulating the wheat developmental programme in salt-affected ecologies.

Keywords: Salt tolerant variety, Sodic agroecosystems, Wheat

BREAD wheat (*Triticum aestivum* L.) is considered as a moderately tolerant crop to salt stress, though the tolerance limit varies with plant species, growth stages, kind of land degradation, prevalent climatic conditions and adopted farming practices. Sodic soils with high proportion of dispersive sodium (Na⁺) ions on the clay lattice (ESP >15%) result in weak structural stability, poor soil aeration and root penetration, restricted nutrient and water uptake, and reduced metabolic activities; thereby adversely affecting plant growth and wheat productivity. Research evidences have shown yield reduction to the tune of 20–43% for wheat, cultivated on salt-affected soils. Current estimates suggest that salinity-induced land degradation accounts for 4.1 million tonnes loss of wheat production valued at 0.76 billion US\$ annually.

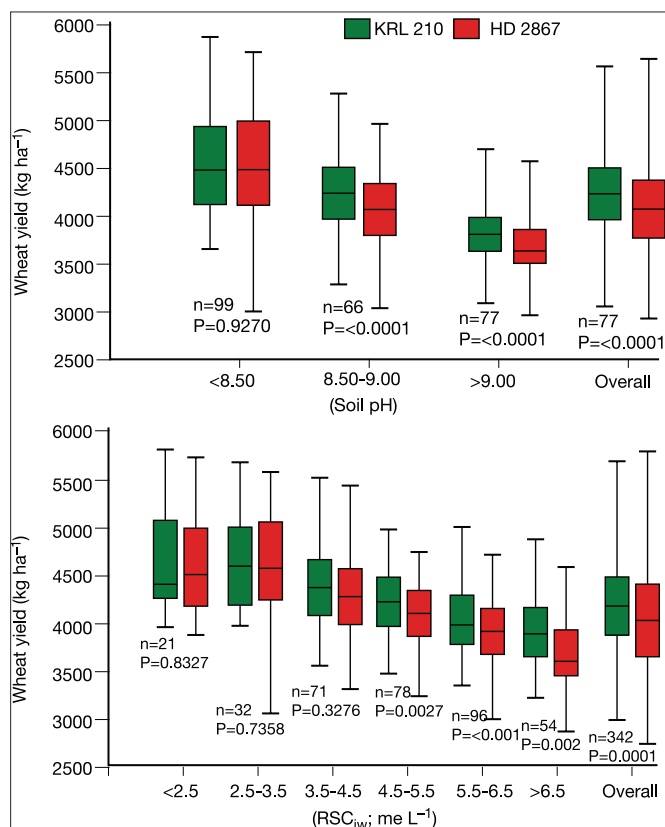
To cope up stressful conditions and realize anticipated yields, plant-assisted adaptive approach is quite remunerative relative to chemical amendment-based land reclamation. Till date, ICAR-Central Soil Salinity Research Institute, Karnal, Haryana has developed 5 wheat varieties (KRL 1–4, KRL 19, KRL 210, KRL 213 and KRL 283) for salt-affected ecologies. Despite their potential importance in stabilizing the wheat production in salinity prone areas, the farmers' knowledge and adoption of these salt tolerant varieties is quite low. To address such challenges, demonstrating

and conducting participatory field trials will increase farmers' acceptability towards adoption of stress tolerant varieties under degraded farm situations, to enhance crop resilience, stabilize crop production in areas where irrigation induced sodicity stress is limiting agricultural productivity to a greater extent.

Farmer FIRST approach

To improve farmers' understanding and knowledge regarding technological break in wheat improvement and sustain agri-food production in sodic environments, CSSRI led Farmer FIRST Programme (FFP) was implemented in 5 villages (Mundri, Geong, Sampli Kheri, Kathwar and Bhaini Majra) of Kaithal district, Haryana typically representing salt-affected Ghaghar basin of Haryana. This farmer-centric approach provides strong support for continual farmer-scientist interface, linking formal and informal knowledge for need-based technology integration, refinement and assessment in participatory mode, and develops demand driven location-specific technologies for productivity enhancement and strengthens rural livelihoods.

Assessing status of soil and irrigation water quality: Bicarbonate dominated high residual alkalinity in irrigation water (RSC_{iw}) was the major cause of concern for predominance of sodic soils and reduced wheat yields in the area. Nearly 40% of the total area (3247



Box and whisker plots showing the range of wheat yields in response to variable sodicity stress (soil pH and RSC_{iw})

ha in selected 5 villages) was confirmed with sodicity problems of varying nature, while 90% area had underground water with RSC_{iw} >2.5 me/L (63% alkali, 18% marginally alkali and 9% highly alkali). Majority of the affected area (44%) had RSC_{iw} ranging between 4.5–5.5 me/L, being maximum in Bhaini Majra (84%) followed by Geong (66%) and Kathwar (45%).

Technology dissemination and assessment: To show feasibility of potential of salt tolerant wheat variety KRL 210 (CSSRI bred, salt tolerant, 95–100 cm height, 140–145 days duration) in comparison to most dominant HD



Field view of wheat variety KRL 210

2967 (IARI bred, highly adapted, 100–105 cm height, 145–150 days duration), a total of 342 comparison trials (126 in 2016–17, 112 in 2017–18, 70 in 2018–19 and 34 in 2020–21) were conducted in participatory mode. These pair-wise comparison trials were allocated to farmer managed plots representing a broad range of soil (soil pH: 8.21–9.68) and water (RSC_{iw}: 2.1–7.7 me/L) induced sodicity stress. Depending on the farmers' willingness to allocate their lands for varietal comparison, the plot size varied from 500–2000 m² depending on the land availability, and individual farmer was considered as a replicate for data collection within the comparison trials.

By comparison, the overall grain yield increased by 163 kg/ha in salt tolerant KRL 210 with 4% yield superiority in comparison to traditional HD 2967 for wheat harvested across 342 locations in sodicity-affected Ghaghar basin of Haryana. It is interesting to note that both the varieties were equally competitive and produced similar wheat yields at soil pH ≤8.5 and RSC_{iw} ≤4.5 me/L; thereafter, the yield differences between two varieties continued to broaden with each

Table 1. Impact assessment of wheat varieties in response to variable sodicity stress (soil pH and RSC_{iw}) in the salt-affected Ghaghar basin of Haryana

Parameter	Wheat yield (kg/ha)		Yield difference (+/-) over HD 2967	Area (ha)	Total monetary benefits (lacs)
	KRL 210	HD 2967			
<i>Soil sodicity (soil pH)</i>					
<8.50	4593	4586	7	1949	2.32
8.50–9.00	4256	4057	199	1242	42.07
>9.00	3873	3583	285	58	2.81
				Total	47.20
<i>Residual alkalinity in irrigation water (RSC_{iw})</i>					
<2.5 me/L	4639	4674	–35	186	–
2.5–3.5 me/L	4717	4764	–47	323	–
3.5–4.5 me/L	4517	4440	78	474	6.29
4.5–5.5 me/L	4267	4073	194	1416	46.76
5.5–6.5 me/L	4035	3783	252	809	34.71
>6.5 me/L	3900	3611	289	40	1.97
				Total	89.73

gradual increase in sodicity stress confirming the better tolerance and performance of KRL 210 compared to traditional HD 2967. Yield reduction to the tune of 15.7% was realized in KRL 210 as against the 21.9% in HD 2967 with the increase in soil pH from <8.5 to >9.0. The corresponding reductions of 16.0% and 22.8%, respectively were observed when the residual alkalinity in irrigation water increased from RSC_{iw} <2.5 me/L to >6.5 me/L. Furthermore, the confidence interval of the regression coefficients indicated lesser yield reduction of 770–1100 kg/ha in KRL 210 for each unit increase in soil pH, compared with 1300–1590 kg/ha for HD 2967. The corresponding yield reduction remained 290–330 kg/ha in KRL 210 and 370–480 kg/ha in HD 2967 for each unit increase in RSC_{iw}. Farmers' opinion further highlighted the relative advantage of KRL 210 in terms of early maturity (5–7 days earliness), higher per day productivity, better factor (fertilizer N) productivity and chapati quality as well as better tolerance to water stagnation under sodic conditions.

Economic feasibility and Impact assessment: The economic benefits calculated through anticipated yield advantage with salt tolerant KRL 210, generated additional income of ₹47.2 lacs for wheat cultivated on 40% affected area confirmed with soil pH ≥8.5 (Table 1). Similarly, the replacement of HD 2967 with KRL 210 in areas having groundwater RSC_{iw} ≥2.5 me/L may generate additional income of ₹89.2 lacs. The enhanced seed exchange and participatory seed production of good quality seed of salt tolerant KRL 210 ensured timely seed availability at farmers' doorsteps improving

their crop yields and rural livelihood in areas dominated by sodic soils (soil pH ≥8.7) and irrigated with high RSC waters (RSC ≥4 me/L). More than 1,000 farming families covering additional 400+ ha area have been directly and indirectly benefitted with this formal network of seed exchange, informal marketing to maintain seed supply chain and combat location specific ecological vulnerability in the study domain and neighbouring villages. Increased knowledge and awareness instigated fellow farmers to further expand the area under its cultivation.

SUMMARY

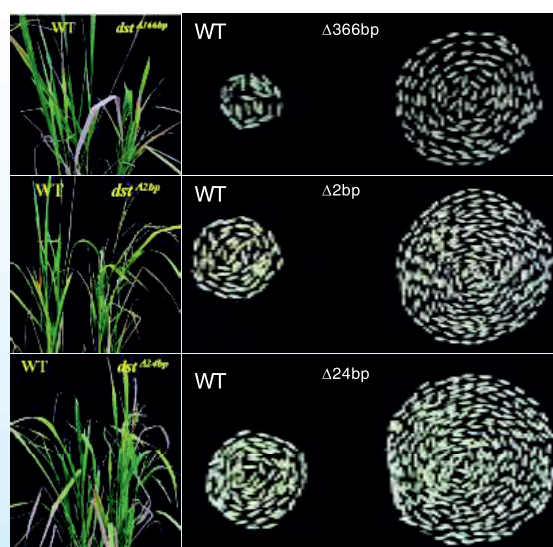
The intervention through inclusion of tolerant varieties can be an important strategy to counter yield reduction under salty ecology. Significant change in farmers' perception has been noted towards cultivating salt tolerant wheat variety KRL 210 in problematic areas dominated by sodic soils and high RSC waters. This enhanced ecological resilience has helped to stabilize wheat production and generate additional income to the farmers under the existing levels of sodicity stress. The fields' insights will certainly help convincing the developmental agencies and receive government attention while formulating the policy guidelines for wheat developmental programme in salt-affected ecologies.

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Genome editing for improvement of drought and salt tolerance in rice

Genome editing is a precision mutagenesis tool for genetic improvement of crops. CRISPR-Cas9 genome editing was used to develop mutants of *DST* (*Drought and Salt Tolerance*) gene encoding a Zinc finger transcription factor for improving salt and drought tolerance in rice. Three homozygous transgene free mutants were developed. WT and *dst* mutants grown in the same pot were exposed to three cycles of -90 kPa drought stress and recovered. Under these stress conditions, only about 25% WT plant survived, while *dst* mutants showed 100% survival. Further, *dst* mutants produced significantly higher yield than that WT plants both under non-stress and drought stress conditions. Similarly, WT and *dst* mutants grown in same pot were irrigated with 200 mM salt stress after panicle initiation, and were recovered after 15 days. All three *dst* mutants were more tolerant to salt stress and produced more grains as compared with wild-type MTU1010.

Source : ICAR Annual Report 2021-22



Genome edited *Drought and Salt Tolerance (DST)* gene knock out mutant of MTU1010 exhibit enhance tolerance to salinity stress. Salt stress (200 mM) was imposed after panicle initiation for 15 days, and then recovered; WT, MTU1010; *dst*^{Δ366 bp} *dst*^{Δ2bp} and *dst*^{Δ24bp} are mutants of MTU1010 with 366, 2 and 24 bp deletions, respectively.