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Screening of mustard (*Brassica juncea*) varieties under different quality of saline water irrigation in semi-arid conditions of Haryana

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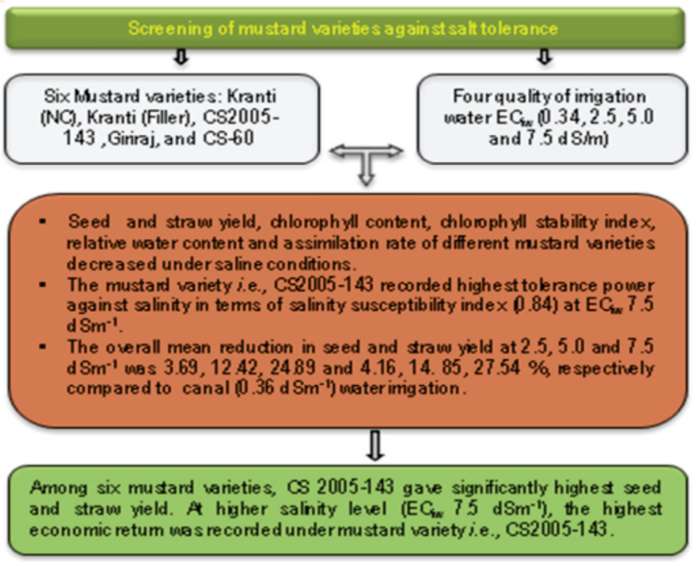
Abstract

Aim: Screening mustard varieties under saline water irrigation, and to evaluate the salt tolerant mustard varieties for semi-arid conditions of Haryana.

Methodology: This study was conducted in permanent pucca plots measuring 2m x 2m with six mustard varieties (Kranti; NC, Kranti; Filler, CS2005-143,Giriraj,CS-54, and CS-60) and four quality of irrigation water, *i.e.*, EC_{iw} 0.36, 2.5, 5.0 and 7.5 dS m^{-1} in a Completely Randomised Design with three replications in sandy loam soil.

Results: The data on seed yield, straw yield and other physiological parameters indicated decrease with increasing salinity of irrigation water. The interaction between varieties and saline water irrigation was in significant. Among six mustard varieties, variety CS 2005-143 showed significantly higher seed and straw yield (24.47 and 74.37 q ha^{-1}) as compared to the remaining varieties. However, the variety Kranti (NC) attained the lowest seed and straw yield (15.47 and 45.53 q ha^{-1}). The overall mean reduction in seed and straw yield at 2.5, 5.0 and 7.5 dS m^{-1} was 3.69, 12.42, 24.89 and 4.16, 14.85, 27.54% as compared to canal water (0.36 dS m^{-1}), respectively. Physiological parameters like chlorophyll content, chlorophyll stability index (%), relative water content (%), assimilation rate declined under salinity stress. The maximum reduction was noticed at higher salinity level (7.5 dS m^{-1}). Variety CS 2005-143 benefited higher among other varieties at each salinity levels.



Interpretation: Among the six mustard varieties, CS 2005-143 performed better in terms of seed yield, straw yield, and other physiological parameter at higher salinity levels(7.5 dS m^{-1}).

Key words: Chlorophyll content, Mustard varieties, Saline water, Semi-arid areas

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Introduction

Globally, the major threat to sustainable agriculture and likelihood is the increasing area under salt affected soils. Saline soils contain excess of soluble salts that adversely affects the plant growth and crop production. In India, the total salt affected soil is estimated to be approximately 6.7Mha, and in Haryana about 2,32,556 ha. In arid and semi-arid areas, the water table is decreasing day by day due to scanty rainfall and over use of underground water for crop production and community uses. Due to scanty rainfall and high temperature, the excess of soluble salts gets accumulated over the soil surface, making soil saline. In Haryana, about 55% irrigation water is of poor quality (Priyanka *et al.,* 2020). Due to the lack of good quality/canal waters in Haryana,farmers are forced to use poor quality water for crop production.

Continuous use of poor quality water has led to the accumulation of salt in the soil profile and impaired crop production. Several researchers have reported that growing crops under saline conditions causes a significant reduction in plant and growth, crop yield (Zamani *et al.,* 2011; Shanker *et al.,* 2016; Priyanka *et al.,* 2022; Harisha *et al.,* 2022) as well as economic losses (Priyanka *et al.,* 2020). The reduction in crop yield is mainly due to osmotic effects, specific ions effect, nutrient imbalance, and ion toxicity (Ankush *et al.,* 2021; Singh *et al.,* 2021). Proper selection of crop varieties, appropriate method of irrigation, on-farm agronomic practices, and adequate use of soil amendments, and other organic manures are suitable to sustain crop production in long term under poor quality water irrigation (Sharma and Minhas, 2005).

Although, mustard is a salt tolerant crop among the oilseed crops, but their production is highly affected by salinity (Ashraf and McNeilly, 2004). However, the yield of mustard under saline water irrigation can be improved by cultivating the right salt tolerant varieties with balanced use of saline water (Singh et al., 2021). Ahmadi and Ardekhani, 2006 conducted a laboratory/greenhouse and field experiments to evaluate the effects of salinity levels ranging from 1 to 12 dS m^{-1} on germination rate, 8 leaf seedling dry matter, seed yield, and seed oil content of the 8 Canola (Brassica napus) cultivars: ACSN1, Falcon, Shirali, Ceres, Tower, Cobra, Global, and Oyerka. Statistical results revealed that the factors: salinity, cultivar, and their interaction had significant effect on germination rate and 8 leaf seedling dry matter. Based on statistical analysis seed yield was significantly influenced by both salinity and cultivar at the 5% significance level; while the cultivar factor had a significant effect on seed oil content, salinity did not show any effect on seed oil content. In earlier period, many researcher have demonstrated the successful use of saline water for higher crop production (Malash *et al*., 2008; Minash *et al*.,2007). The majority of crop plants are susceptible and cannot survive under high salinity conditions due to the physiological and biochemical disorders, leading to a series of metabolic changes like enzymatic and photosynthetic activities (Priyanka, 2020; Singh *et al.,* 2021). In addition, imbalance uptake of nutrients, shoot transport, chlorophyll collapse and impaired distribution of ions effect and untimely maturity of plants under salt stress may be major cause of reduction of oil content (Ali *et al.,* 2013).

Hence, the proper selection of mustard varieties is important to cope up the adverse effects of salinity. However, it is vital choosing the right mustard varieties to counteract the negative effects of salinity. Therefore, keeping in view the above fact and to find out the solution for farmers, the present study was carried out to evaluate the salt tolerant mustard varieties under different quality of saline water irrigation in semi-arid conditions of Haryana.

Materials and Methods

The experiment was conducted in permanent (continues using for same quality of water) pucca micro-plots measuring 2 m x 2 m during Rabi season 2020-21, at research farm of Soil Science Department, CCS Haryana Agricultural University, Hisar. The research area is located at $29^{0}10'$ N latitude and $75^{0}46'$ E longitude, 215.2 m above mean sea level in semi-arid, sub-tropics region with cool winters (1.5 and 4^{0}C), hot summers (40 and 46^{0}C) and average rainfall around 429 mm. The research was conducted with four quality of irrigation water EC_{iw} (0.3, 2.5, 5.0 and 7.5 dS m^{-1}) and six mustard varieties (Kranti (NC), Kranti (Filler), CS2005-143 ,Giriraj, CS-54 and CS-60) in completely Randomised Design with three replications in sandy loam soil with the recommended dose of chemical fertilizers (urea, single super phosphate and muriate of potash) for mustard crop N,P and K @ 60,20 and 20 kg ha^{-1}. A calculated amount of phosphorous, potash and half dose of nitrogen was applied at the time of crop sowing whereas the second half dose of nitrogen from of urea, was applied in the after first irrigation.

Different quality of irrigation water of desired ECi Canal (0.36), 2.5,5.0 and 7.5 dSm^{-1} was prepared by mixing of saline tube well water with canal water in a mixing tank (Table 2). Initial soil properties of experimental site are given in Table 1. The texture of experimental plot was as follows: sandy loam, texture low in organic carbon (0.31%), low in available N (101.10 kg ha^{-1}) and medium in available P (16.09 kg ha^{-1}), K (238.12 kg ha^{-1}) alkaline pH (8.10). The soil EC_e of different plots was 1.71, 3.94, 7.10 and 9.52 irrigated with canal (0.36), 2.5, 5.0 and 7.5 dSm^{-1} quality of irrigation waters. Chlorophyll stability index (CSI) was determined by the according to Sairam *et al.* (1997). Salinity susceptibility index (SSI) was calculated by the formula given by Fischer and Maurer (1978). Chlorophyll content (SPAD units), assimilation rate (By infrared gas analyzer (IRGA LCi-SD, ADC Biosciences) was measured by non-destructive methods whereas relative water content was determined by the method of Weatherly (1950). The agro-metrological data related to the experimental site during rabi season (2020-21) revealed that the mean monthly rainfall ranged between 0 to 19.9 mm, minimum temperatur was 5.0 to 14.8°C and maximum temperature 17.4 to 34.4°C, respectively. The seed and straw yield was estimated from the harvest of the net plot and expressed in quintal ha^{-1}. Soil samples were analysed for EC, pH, OC, nitrogen, phosphorous and potassium as per standard laboratory procedures (Jackson, 1973).

Statistical analyses: The entire experimental data for different growth and yield parameters were statistically analysed by ANOVA) to test the significance of overall difference among treatments by F-test and conclusions were drawn at 5% probability level.

Results and Discussion

The data on mustard seed and straw yield, presented in Table 3 and 4, revealed that the seed and straw yield of different mustard varieties decreased with increasing levels of irrigation water. Among six mustard varieties, CS 2005-143 attained significantly highest seed and straw yield (24.47 and 74.37 q ha^{-1}) compared to the remaining salt tolerant varieties at EC_{iw} 7.5 dS m^{-1}, whereas the lowest seed and straw yield (15.47 and 45.53 q ha^{-1}) was obtained in variety Kranti (NC). The overall mean reduction in seed and straw yield at 2.5, 5.0 and 7.5 dS m^{-1} was 3.69, 12.42, 24.89 and 4.16,14.85, 27.54 %, respectively, as compared to canal water irrigation (0.36 dS m^{-1}). All the mustard varieties showed a decreasing trend with the increase in salinity levels. Whereas, the interaction between factors was found to be non-significant. The main reason behind low yield is the osmotic stress under this situation plants face difficulties in absorbing water and nutrients it, thereby causing injuries to plants. Other possible reasons could be specific ion effects and

Table 1: Initial physico-chemical properties of soil at study site

Soil properties	Values
Texture	Sandy loam
pH (1:2)	8.10
ECe(dS m^{-1}) of different water irrigated plots	
Canal (0.36)	1.71
2.5	3.94
5.0	7.10
7.5	9.52
Organic carbon (%)	0.31
Available nitrogen (kg ha^{-1})	101.10
Available phosphorus (kg ha^{-1})	16.09
Available potassium (kg ha^{-1})	238.12

Table 2: Quality parameters and ion composition of irrigation waters

Treatments (dS m^{-1})	EC (dS m^{-1})	pH	SAR (mmol l^{-1})^{½}	Ion concentration (meq l^{-1})							
				Na^+	K^+	Ca^{2+}	Mg^{2+}	CO_3^{2-}	HCO_3-	Cl-	SO_4^{2-}
Canal (0.36)	0.36	7.66	0.62	0.70	0.08	0.64	1.92	NIL	0.78	1.39	1.11
2.5	2.51	7.75	7.03	14.84	0.56	2.10	6.80	NIL	1.01	16.03	7.70
5.0	5.00	7.86	10.61	31.02	1.11	4.31	12.79	NIL	1.31	31.01	14.93
7.5	7.50	7.97	13.52	47.52	1.49	6.21	18.50	NIL	1.51	55.24	17.12

Table 3: Seed yield (q ha^{-1}) of mustard genotypes under AVT-1 treated with different concentrations of saline water

Genotypes	EC_{iw} (dS m^{-1})				Mean
	Canal (0.36)	2.5	5.0	7.5	
Kranti (NC)	20.76	19.88	17.56	15.47	18.42
Kranti (Filler)	21.13	20.30	18.15	15.56	18.79
CS 2005-143	30.98	29.96	27.61	24.47	28.26
Giriraj	21.74	20.90	19.07	15.75	19.37
CS-54	24.07	23.21	21.19	17.89	21.59
CS-60	27.65	26.70	24.58	20.76	24.92
Mean	24.39	23.49	21.36	18.32	
CD (p=0.05)	Salinity (S) = 1.25,	Variety (V) = 1.53,	SxV= NS		

Table 4: Straw yield (g m^2) of mustard genotypes under AVT-1 treated with different concentrations of saline water

Genotypes	EC_{iw} (dS m^{-1})				Mean
	Canal (0.36)	2.5	5.0	7.5	
Kranti(NC)	64.57	61.76	57.72	45.53	57.39
Kranti(Filler)	67.50	66.26	54.65	47.42	58.96
CS 2005-143	93.66	89.216	82.59	74.37	84.96
Giriraj	66.27	64.17	57.65	46.17	58.57
CS-54	76.22	71.21	59.83	53.44	65.18
CS-60	85.86	82.54	74.20	62.12	76.18
Mean	75.68	72.53	64.44	54.84	
CD (p=0.05)	Salinity (S) = 3.82,	Variety (V) = 4.64,	SxV= NS		

Table 5: Salinity at different soil depth post harvest of mustard

Depth	ECe (dS m^{-1})			
(cm)	Canal	2.5	5.0	7.5
0-15	1.98	4.43	7.71	10.24
15-30	1.80	4.00	6.96	10.04
Mean	1.89	4.22	7.34	10.14

Table 6: Economic analysis of different mustard varieties (Rs. ha^{-1}) in Hisar district of Haryana

Genotypes/ treatment combination	Cost of cultivation	Gross return	Net return	B:C ratio
		Canal water irrigation (EC_{iw} 0.36dS m^{-1})		
Kranti(NC)	50193	102991	52799	2.05
Kranti(Filler)	50193	105005	54812	2.09
CS 2005-143	50193	153423	103231	3.06
Giriraj	50193	107718	57526	2.15
CS-54	50193	119548	69355	2.38
CS-60	50193	137159	86966	2.73
		EC_{iw} 2.5 dS m^{-1}		
Kranti(NC)	50508	98618	48111	1.95
Kranti(Filler)	50508	101021	50514	2.00
CS 2005-143	50508	148236	97728	2.93
Giriraj	50508	103602	53095	2.05
CS-54	50508	115048	64540	2.28
CS-60	50508	132409	81902	2.62
		EC_{iw} 5.0 dS m^{-1}		
Kranti(NC)	50737	87426	36690	1.72
Kranti(Filler)	50737	89863	39126	1.77
CS 2005-143	50737	136646	85909	2.69
Giriraj	50737	94441	43704	1.86
CS-54	50737	104517	53780	2.06
CS-60	50737	121717	70981	2.40
		EC_{iw} 7.5 dS m^{-1}		
Kranti(NC)	50959	76489	25530	1.50
Kranti(Filler)	50959	77096	26138	1.51
CS 2005-143	50959	121223	70264	2.38
Giriraj	50959	77855	26896	1.53
CS-54	50959	88533	37574	1.74
CS-60	50959	102746	51788	2.02

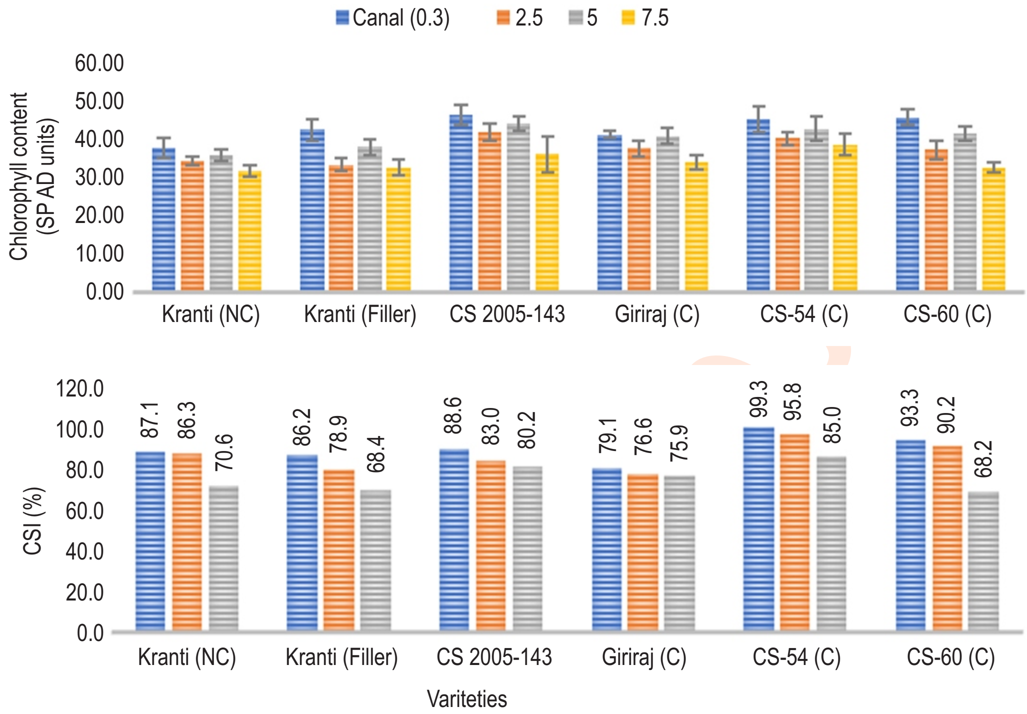

Fig. 1: Chlorophyll content (SPAD units)and chlorophyll stability index (CSI %) of mustard varieties treated with different concentrations of saline water (0.3,2.5,5.0 and 7.5 dS m^{-1}).

ion imbalance (Singh and Panda, 2012). Our results are in conformity with the findings of previous studies (Bybordi., 2010; Kripa *et al.,* 2011; Toorchi *et al.,* 2011; Rameeh, 2013 and Zaman *et al.,* 2015; Ahmed *et al.,* 2021). Priyanka *et al.* (2020) tested four mustard varieties under saline water irrigation of EC_{iw}7 dSm^{-1} and found that variety CS-58 gave higher seed and straw yield as compared to other varieties. Lohar (2022) also investigated five mustard genotypes, *i.e.,* CS 2009-99, CS 2005-143, CS 60, CS 2007-165 and CS 2009-313 with varying salinity levels for irrigation water *i.e.,* canal water irrigation (EC_{iw} 0.3 dS m^{-1}; 2.5dS m^{-1}, 5.0 dS m^{-1} and 7.5 dS m^{-1}), and observed that CS 2009-99 recorded highest seed and straw yield (20.39 and 61.96 q ha^{-1}) followed by CS 2005-143 (19.72 and 57.82 q ha^{-1}), CS 60 (19.26 and 57.54 q ha^{-1}), CS 2007-165 (17.90 and 54.54 q ha^{-1}) and CS 2009-313 (15.28 and 44.96 q ha^{-1}), respectively at EC_{iw} 7.5 dS m^{-1}. Farmers are facing the problems of increasing area of poor quality water for irrigation and at the same time dealing with the lowering of the ground water table. Particularly in this situation, exploring groundwater with certain management practices can be used for maintaining crop yields in the semi arid areas. Our result suggests that farmers can grow mustard variety upto ECiw 7.5 dS m^{-1}.

Chlorophyll content (SPAD units) and chlorophyll stability index of mustard varieties decreased from 45.36 to 36.07 and 88.95 to 74.72 with increasing salinity levels of irrigation water, *i.e.,* control to 7.5 dS m^{-1}. The maximum chlorophyll content was observed in variety CS-54 (40.63) which was at par with variety CS2005-143 (38.03), while the minimum was recorded in variety Kranti (NC) (33.33) at 7.5 dS m^{-1} EC_{iw}. The decreasing chlorophyll content in mustard varieties under salt stress is either due to inhibition of production or enhanced degradation of active chlorophyll molecule by the enzyme chlorophyllase (Priyanka *et al.,* 2022). The breakdown of chlorophyll pigments and the instability of pigment protein complex have been suggested as the cause of chlorophyll reduction ((Nandal and Hooda, 2017). Likewise, chlorophyll stability index also showed a declining trend under salt stress (Fig. 1). Chlorophyll content acts as the key physiological pointer indicating plant stress due to its water maintenance capacity (Dawood *et al.,* 2014; Rady *et al.,* 2015). Reduced in chlorophyll content under stress conditions may be due to thylakoid membrane disorders, deprivation will be more than chlorophyll formation due to the synthesis of chlorophyllase enzyme which is mainly liable for chlorophyll degradation and injurious to photosynthetic machinery. Less availability of water content also reduces the chlorophyll content and assimilation rate (Rady *et al.,* 2015). The relative water content and assimilation rate (µmol CO2 $m^{-2}s^{-1}$) was lesser at higher salinity level (EC_{iw}7.5 dS m^{-1}). The reason could be increased osmotic potential in the soil solution resulting low relative water content in mustard varities. Because of high concentration of salts in the soil solution, it is thus directly related to exosmosis (Shanker *et al.,* 2014). Lenis *et al.* (2011) also reported higher chlorophyll content in salt tolerant varieties as compared to sensitive

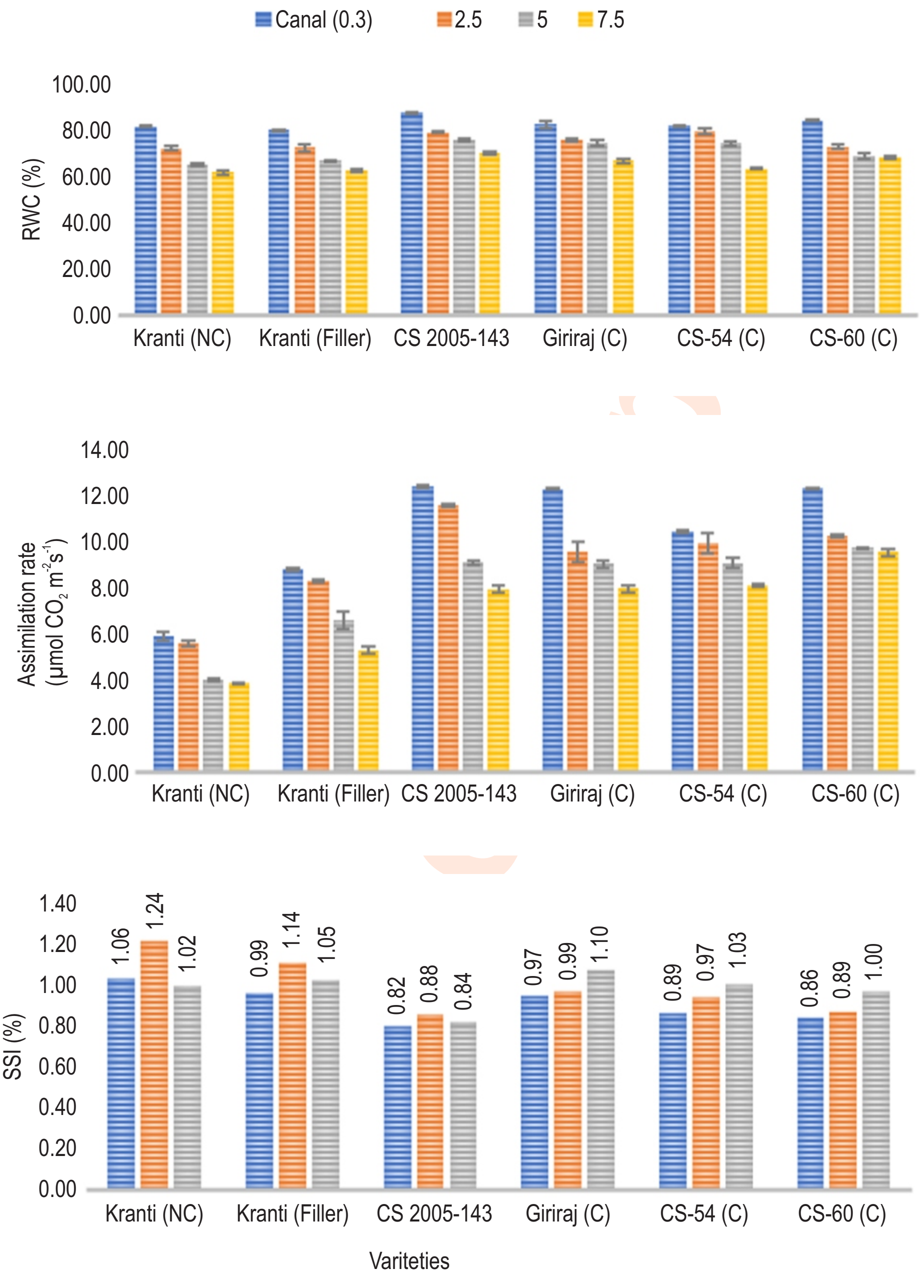

Fig. 2: Relative water content (RWC), assimilation rate and salinity susceptibility index (SSI) of mustard varieties treated with different concentrations of saline water (0.3,2.5,5.0 and 7.5 dS m^{-1}).

soyabean genotypes. Moreover, salinity susceptibility index is used to test the sensitivity of genotypes to salinity stress. The values less than one reveal the genotypic tolerance whereas the values less <1 was recorded at 7.5 dSm^{-1} of salinity in CS2005-143 (0.84) in the tested mustard genotypes (Fig. 2).

The mean EC_e of the soil profile post harvest varied from 1.89 dS m^{-1} in canal water irrigated plot to 10.14 dS m^{-1} in plots receiving saline water irrigation of EC_{iw} 7.5 dS m^{-1} (Table 5). Electrical conductivity decreased with increase in the depth of soil profile, *i.e.,* from 0-15 cm to 15-30 cm. The percentage increase in mean ECe was 55.21,74.25 and 81.36% at 2.5,5.0 and 7.5 dS m^{-1} EC_{iw} saline water irrigated plots as compared to canal water irrigated plots. Electrical conductivity indicates the total amount of salt present in soil. Continuous application of saline water for irrigation led to accumulation of soluble salts in the soil profile. Lohar (2022) conducted a experiment with five mustard genotypes and four quality of saline water and observed that continuous application of saline water for irrigation led to accumulation of soluble salts in the soil profile (Singh *et al*., 2021). The treatment wise economics of different mustard variety is depicted in Table 6. Results revealed that all the treatments and varieties were found economically profitable but canal water irrigation was found to be economically beneficial with the highest net returns of Rs. 103231, 86966, 69355, 57526,54812,52799 ha^{-1} and B: C ratio 3.06, 2.73, 2.38,2.15,2.09 and 2.05 in variety CS 2005-143, CS-60, CS-54,Giriraj, Kranti (Filler) and Kranti (NC), respectively. Whereas, CS 2005-143 variety gave the highest net return of Rs. 70264 ha^{-1} and B: C ratio of 2.38 at EC_{iw} 7.5 dS m^{-1} due to more tolerance against salt stress.

Priyanka *et al.* (2020) conducted a field experiment to evaluate the performance of different mustard varieties, *i.e.,* Kranti, Giriraj, CS-54, CS-58 under saline irrigation water (EC_{iw} 7.0 dS m^{-1}) at CCSHAU, Hisar. They found the highest net return and B:C ratio in CS-58 (39497 Rs. ha^{-1} and 1.77) followed by CS-54 (24346 Rs. ha^{-1} and 1.48) and Giriraj (39497 Rs. ha^{-1} and 1.36) over Kranti (39497 Rs. ha^{-1} and 1.25), respectively, at RDF (60:20:20) treatment under saline irrigation water (EC_{iw} 7.0 dS m^{-1}). The variety CS-58 showed best economic performance as compared to other genotypes.

Its concluded from the study that among all the c six mustard varieties, CS 2005-143 performed better in terms of seed yield, straw yield, and other physiological parameter at each salinity levels. Our result suggests that farmers can grow mustard variety CS 2005-143 up to ECiw 7.5 dS m^{-1} level in semi arid region of Haryana.

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References

Ahmed, F., I.M. Ahamed, A.S. Ahsan, B. Ahmed and F. Begum: Physiological and yield responses of some selected rapeseed/ mustard genotypes to salinity stress. *Bangladesh Agron. J.,* **24**, 43-55 (2021).

Ahmadi, S.H. and J.N. Ardekani: The effect of water salinity on growth and physiological stages of eight Canola (*Brassica napus*) cultivars. *Irrig. Sci.,* **25**, 11–20 (2006).

Ali, A., I.A. Mahmood, M. Salim, M. Arshadullah and A.R. Naseem: Growth and yield of different *Brassica* genotypes under saline sodic conditions. *Paki. J. Agri. Res.,* **26**, 9–15 (2013).

Ankush, R. Prakash, V. Singh, A., R.C. Popat, S. Kumari, N.I., Kumar, A. Dhillon and Gourav: Sewage sludge impacts on yields, nutrients and heavy metals contents in pearl millet–wheat system grown under saline environment. *Int. J. Plant Pro.,* **15**, 93-105 (2021).

Ashraf, M. and T. McNeilly: Salinity tolerance in brassica oilseeds. *Crit. Rev. Plant. Sci.,* **23**,157-174 (2004).

Bybordi, A.: Effect of salinity on yield and component characters in canola (*Brassica napus* L.) cultivars. *Notu. Sci. Bio.,* **2**, 81-83 (2010).

Dawood, M.G., M.T. Abdelhamid and U. Schmidhalter: Potassium fertiliser enhances the salt-tolerance of common bean (*Phaseolus vulgaris* L.). *J. Hort. Sci. Biotech.,* **89**, 185–192 (2014).

Fischer, R. and R. Maurer: Drought resistance in spring wheat cultivars. I. Grain yield responses. *Aus. J. Agric. Res.,* **29**, 897-912 (1978).

Harisha, C.B., K.K. Meena, K.M. Boraiah and P.S. Basavaraj: Response of turmeric to saline water irrigation on growth, physiology, antioxidant defence mechanism and productivity. *J. Environ. Biol.,* **43**, 685-693 (2022).

Jackson, M.L.: Soil Chemical Analysis. Prentice Hall of India Pvt.Ltd., New Delhi (1973).

Kripa, S., S.K.S. Parihar, K. Kuldeep, D. Kant and K. Arun: Relative salt tolerance of Indian mustard (*Brassica juncea*) genotypes in relation to germination, growth and seed yield. *J. Oils. Brass.,* **2**, 76-82 (2011).

Lenis, J.M., M. Ellersieck, D.G. Blevins, D.A. Sleper, H.T. Nguyen, D. Dunn, J.D. Lee and J.G. Shannon: Differences in ion accumulation and salt tolerance among glycine accessions. *J. Agron. Crop Sci.,* **197**, 302–310 (2011).

Lohar, M., S. Kumari, , R. Prakash, S. Devi and V. Kumar : Effect of water quality on biochemical and physiological parameters in different mustard (*Brassica juncea*) genotypes. *J. Soil Salin. Water Quali*, **14**, 236-243 (2022).

Malash, N.M., T.J. Flowers and R. Ragab: Effect of management and salinity of irrigation water on tomato yield, soil moisture and salinity distribution. *Irrig. Sci.,* **26**, 313–323 (2008).

Nandal, M. and R. Hooda: Analysing the impact of salinity on biochemical parameter of Indian mustard. *Int. J. Enginee. Res. Technol.,* **5**, 11 (2017).

Priyanka, R. Prakash, Ankush, S. Devi, Rajpaul and R. Singh: Physiological studies and nutrient accumulation in mustard varieties in response to fertilizer doses under saline condition in semi-arid region of North-western Haryana. *Indian J. Experim. Biol.,* **60**, 628-634 (2022).

Priyanka, R. Prakash, R. Yadav, N. Kumar and A. Dhillon: Performance of different Indian mustard (*Brassica juncea*) varieties with saline water and graded fertilizer doses under semi-arid conditions of Haryana. *J. Environ. Biol.,* **41**, 1599-1604 (2020).

Rady, M.M., M.S. Sadak, S.R. El-Lethy, E.M. AbdElhamid and M.T.

Abdelhamid: Exogenous a-tocopherol has a beneficial effect on *Glycine max* (L.) plants irrigated with diluted sea water. *J. Hort. Sci. Biotech.,* **90**, 195–202 (2015).

Rameeh, V.: Effect of salinity stress on yield, component characters and nutrient compositions in rapeseed (*Brassica napus* L.) genotypes. *Agri. Trop. Subtro.,* **46**, 58-63 (2013).

Sairam R.K., P.S. Deshmukh and D.S. Shukla: Tolerance of drought and temperature stress in relation to increased antioxidant enzyme activity in wheat. *J. Agron. Crop Sci.,* **178**, 171-178 (1997).

Shanker, K., S.K. Parihar, K.K. Kuldeep and A. Kumar: Relative salt tolerance of Indian mustard (*Brassica juncea*) genotypes in relation to germination, growth and seed yield. *J. Oils. Bras.,* **76**, 11 (2016).

Shanker, K., S.K.S. Parihar and S.K. Biswas: Effect of saline water on relative water content, rate of photosynthesis, chlorophyll content and yield of Indian mustard (*Brassica juncea* L.). *Int. J. Bio-Reso. Stress Manag.,* **5**, 37-40 (2014)

Sharma, B.R. and P.S. Minhas: Strategies for managing saline/alkali waters for sustainable agricultural production in South Asia. *Agri. Water Manag.,* **78**, 136-151 (2005).

Singh, A. and S.N. Panda: Effect of saline irrigation water on mustard (*Brassica juncea*) crop yield and soil salinity in a semi-arid area of North India. *Expert. Agri.,* **48**, 99-110 (2012).

Singh, J., P.C. Sharma and V. Singh:. Breeding mustard (Brassica juncea) for salt tolerance: Problems and Prospects. In Brassica Breeding and Biotechnology. *Intech Open* (2021). DOI: 10.5772/intechopen.94551

Toorchi, M., R. Naderi, A. Kanbar and M.R. Shakiba: Response of spring canola cultivars to sodium chloride stress. *Ann. Bio. Res.,* **2**, 312-322 (2011).

Weatherley, P.E. : Studies in the Water Relations of the Cotton Plant I. The Field Measurements of Water Deficit in Leaves. *New Phyto.*, **49**, 81-97 (1950).

Zaman, M.M., M.A. Mannan and S.C. Samanta: Salt induced changes in dry matter accumulation and yield of mustard. *Bangladesh Agron. J.,* **18**, 65-70 (2015).

Zamani, Z., M.T. Nezami, D. Habibi and M.B. Khorshidi: Effect of quantitative and qualitative performance of four canola cultivars (*Brassica napus* L.) to salinity conditions. *Adva. Envi. Bio.,* **4**, 422-427 (2011).