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Relative tolerance of mustard (*Brassica juncea* L.) varieties under simulated soil salinity

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Abstract

An experiment was conducted to evaluate the salinity tolerance of four varieties of mustard. The treatment consisted of four varieties *viz*., GM 2 (V_1), GDM 4 (V_2), GDM 5 (V_3) and CS 54 (V_4) and four levels of soil salinity *viz*., Control (S_1), 4 dS/m (S_2), 6 dS/m (S_3), 8 dS/m (S_4) and 10 dS/m (S_5). Effect of salinity levels and varieties on germination, plant height at 45 DAS and harvest, number of branches per plant, number of siliquae per plant, seed yield, stover yield, crude protein content and oil content were recorded. All four mustard varieties showed reduced in all parameters significantly except crude protein, with each increase in salinity up to 10 dS/m. Among the different varieties tested in the experiment, variety V_4 (CS 54) reported the highest seed yield (46.70 g/pot), stover yield (156.69 g/pot), germination (87.78%), plant height at 45 DAS (85.35 cm) and harvest (177.08 cm), number of branches per plant (15.45) and number of siliquae per plant (273.62). Seed oil (40.43%) was significantly highest with variety V_4 (CS 54). Crude protein content in seed was not affected by different salinity levels and varieties. A significant interaction effect was found for plant height and yield. Overall, the relative tolerance of tested mustard varieties in sequential order: CS 54 (V_4) > GDM 4 (V_2) > GDM 5 (V_3) > GM 2 (V_1).

Keywords: Mustard, salinity level, variety, salt tolerance, growth, yield, quality

Introduction

In 2030, India's food grain requirement will be around 311 million tons. In 2050, the requirement will increase to 350 million tons when India's population hits 1.8 billion. Abiotic stress factors are believed to be the major source of reduction in crop yield out of various factors affecting production. Potential yield losses due to individual environmental stress are estimated at 40% by high temperature, 15% by low temperature, 17% by drought, 20% by salinity stress and 8% by other factors (Ashraf and Harris, 2005) [5]. The soil that remained unused under agriculture use is limiting, so we have to improve yield in both normal and problematic soil including salt-affected soil to achieve food security in the country. To ensure food security for the people, the Government of India has aimed of restoring 26 million ha of degraded lands, including salt-affected soils, by the year 2030 (Kumar and Sharma, 2020) [13]. Soil salinization is a global and dynamic issue. Experiment estimated that this problem would increase in the future due to an increase in temperature, increase in evaporation rate, rise in sea level, increase in the groundwater table, *etc*. Estimations indicated that in the world's total irrigated area, 10-15% of the area already suffers from the problem of salinity and half of all irrigated areas are susceptible to salinization (Wu *et al*., 2008) [27]. Salinity cause ionic and osmotic stress, as well as oxidative damage and adversely, affects plant germination, growth, physiology and productivity (Iterbe-Ormaetxe *et al*., 1998) [10]. It affects growth by inhibiting seed germination (Dash and Panda, 2001) [6], seedling growth (Ashraf *et al*., 2002) [4], DNA, RNA and synthesis of protein (Anuradha and Seeta-Ram, 2001) [3], enzymatic activity (Seckin *et al*., 2009) [17], and cell division (Tabur and Demir, 2010) [22]. The most general and apparent effects of salinity are reduced growth, darker leaves, restriction in root development, reduction in numbers of leaves, branches and fruits, reduction in the size of fruit and seed and ultimately reduction in yield (Ansari *et al*. 1998) [2]. There are many approaches for improving yield in saline conditions but the use of salt-tolerant variety is the most promising, less resource-consuming and socially acceptable approach.

India is highly deficient in oil seed production. To meet these demands India imports oil seeds and the national economy has to compensate for the foreign exchange. Indian mustard (*Brassica juncea*) is an important winter oilseed crop grown though out the world.

It contributes about 27.8% to the country's oilseed economy (Shekhawat *et al*., 2012) [20]. Mustard belongs to the *cruciferae* family and *brassica* genus (Musil, 1950) [14]. It is mainly grown for oil, vegetable and condiment purposes. Mustard is the better source of income, especially for the farmers which are small and marginal. In India, it is the second main edible oilseed crop. Indian mustard (*B. juncea*) is recommended for both saline and sodic soils (Kumar, 1995) [12]. It requires relatively fewer inputs and irrigation than wheat and its limit for salt tolerance are nearly the same as that of wheat.

Materials and Methods

A pot experiment was conducted in the net house at the Department of Soil Science and Agricultural Chemistry, B. A. College of Agriculture, Anand Agricultural University, Anand (Gujarat) during the *rabi* season of the year 2020-21. The experiment comprising twenty-treatment combinations was laid out in a Completely Randomized Design (Factorial) replicate three times. The soil used in the experiment was loamy sand in texture, having pH 8.11, EC 0.28 and organic carbon 0.40 percent. The available N, P_2O_5 and K_2O were 197, 35 and 304 kg/ha, respectively at the time of sowing. Salinity levels were Control (S_1), 4 dS/m (S_2), 6 dS/m (S_3), 8 dS/m (S_4) and 10 dS/m (S_5). The targeted soil salinity was artificially prepared by dissolving the required amount of $MgCl_2$, $CaCl_2$, NaCl and $MgSO_4$. The mustard seeds of four varieties, GM 2 (V_1), GDM 4 (V_2), GDM 5 (V_3) and CS 54 (V_4) were sown in the pot. Six seeds were sown in each pot (15 kg capacity) and germination was recorded after one week. Three plants per pot were maintained under normal practices. Urea and DAP were applied as per the recommended dose of fertilizer (25:50:00). The yield and yield attributing characters were recorded at the harvest of the crop. Oil content was measured by the Soxhlet extraction method given by Sankaran, 1966 [16] and crude protein content was estimated by Kjeldahl's method (Kanwar and Chopra, 1967) [11] and nitrogen content of respective components multiplied by the factor of 6.25 as suggested by Gassi *et al*. (1973) [8]. The procedure of Pance and Sukhatme (1985) [15] was used for data analysis.

Results and Discussion

Germination

Results revealed that the seed germination was significantly varied due to the studied varieties of the mustard crop. Statistically, the maximum germination (87.78%) was observed for the variety CS 54 (V_4), while the lowest germination (72.22%) was given by GM 2 (V_1). The different levels of salinity significantly reduced germination. The higher germination (88.89%) was observed under Control (S_1), while it remained statistically at par with salinity level S_2 (4 dS/m). Above salinity level S_3 (6 dS/m), germination was significantly inhibited due to increased salt in the soil. Soil salinity of 10 dS/m (S_5) significantly reduced the seed germination, with only a germination of 66.66%. An interaction effect was found non-significant for seed germination. Reduced germination might be due to salt present in the soil solution developing higher osmotic pressure which restricts the flow of water in the seed. Resemble results were reported by Sharma *et al*. (2013) [19] and Shanker *et al*. (2016) [18].

Table 1: Effect of different varieties and soil salinity levels on germination percentage, plant height (cm) of mustard at 45 DAS and harvest and No. of branches and siliquae per plant.

Treatments	Germination (%)	Plant height (cm)		No. of branches/ plant	No. of siliquae/plant
		At 45 DAS	At harvest		
Variety					
V_1: GM 2	72.22	70.21	144.30	13.77	242.45
V_2: GDM 4	81.11	81.72	168.19	14.75	261.88
V_3: GDM 5	77.77	78.58	160.98	14.29	259.63
V_4: CS 54	87.78	85.35	177.08	15.45	273.62
S.Em. ±	2.15	0.98	2.04	0.14	3.75
CD (P=0.05)	6.15	2.80	5.82	0.40	10.72
Salinity levels					
S_1: Control	88.89	88.93	181.65	15.68	284.68
S_2: 4 dS/m	86.11	82.51	170.03	15.18	272.16
S_3: 6 dS/m	80.55	78.43	162.35	14.65	259.76
S_4: 8 dS/m	76.38	74.68	154.15	14.02	245.47
S_5: 10 dS/m	66.66	70.30	144.99	13.30	234.90
S.Em. ±	2.41	1.09	2.28	0.16	4.20
CD (P=0.05)	6.88	3.13	6.51	0.44	11.99
V × S interaction					
S.Em. ±	4.81	2.19	4.56	0.31	8.39
CD (P=0.05)	NS	6.26	13.02	NS	NS
CV (%)	10.45	4.80	4.85	3.69	5.60

Table 1.1: Interaction effect of different varieties and soil salinity levels on plant height (cm) at 45 DAS and harvest

Treatments	Plant height at 45 DAS (cm)				Plant height at 45 DAS (cm)			
	V_1	V_2	V_3	V_4	V_1	V_2	V_3	V_4
S_1	85.20	90.27	87.21	93.01	174.70	183.05	178.14	190.72
S_2	77.82	84.76	82.02	85.43	159.56	175.85	168.17	176.55
S_3	67.58	83.04	78.46	84.62	140.23	173.38	160.87	174.93
S_4	63.93	77.99	74.44	82.34	131.09	159.91	152.64	172.96
S_5	56.53	72.54	70.75	81.36	115.92	148.75	145.07	170.23
CD (P=0.05)	6.26				13.02			

Plant height at 45 DAS and harvest

Data presented in Table 1 showed that significantly the tallest plant at 45 DAS and harvest (85.35 cm and 177.08 cm) was given by variety CS 54 (V_4). Significantly lowest plant height at 45 DAS and harvest (70.21 cm and 144.30 cm) was given by variety GM 2 (V_1). The result indicated that minor increased salt concentration significantly decreased plant height. The 7.22% and 6.40% reduction in plant height at 45 DAS and harvest were observed even at salinity level 4 dS/m, compared to Control. Variety and salinity produced a significant interaction effect on plant height. The higher plant height at 45 DAS and harvest (93.01cm and 190.72 cm) were recorded with treatment combination V_4S_1 (CS 54 × Control). However, it remained statistically at par with V_2S_1 and V_3S_1. The shortest plant at 45 DAS and harvest (56.53 cm and 115.92 cm) was observed in treatment combination V_1S_5 (GM 2 × 10 dS/m). Reduced plant height under salinity might be due to inhibition in cell division and expansion (Akhtar *et al*., 2002) [1]. This is in conformity with Uddin *et al*. (2005) [24].

Number of branches and siliquae per plant

The varietal difference was observed significant for the number of branches and siliquae per plant. It was observed that variety CS 54 (V_4) gave a significantly maximum number of branches (15.45) and siliquae per plant (273.62), while the minimum number of branches (13.77) and siliquae per plant (242.45) given by GM 2 (V_1). The rise in salinity level diminished the number of branches and siliquae per plant. A significantly maximum number of branches (15.68) and siliquae per plant (284.68) was recorded under the Control condition (S_1). However, it reduces up to 13.30 branches and 234.90 siliquae per plant at a salinity level
10 dS/m. Here, the development of the interaction effect was not found for both attributes. These are conformity with Islam *et al*., 2006 [9], Wani *et al*., 2013 [26] and Shanker *et al*. (2016) [18].

Yield

The analysis of data presented in the Table 2 revealed that the influence of soil salinity levels, varieties and their interaction effect on mustard seed and stover yield was significant. Among varied tested varieties, variety CS 54 (V_4) had the highest potential to sustain salinity. Significantly highest mustard seed (46.70 g/pot) and stover yield (156.69 g/pot) were recorded with it. While significantly lowest seed (38.22 g/pot) and stover yield (128.33 g/pot) were reported by variety GM 2 (V_1). The seed and stover yield of mustard decreased considerably when the soil's salt concentration increased. Significantly maximum mustard seed (48.58 g/pot) and stover yield (163.01 g/pot) were obtained under Control (S_1). Statistically lowest seed (38.40 g/pot) and stover yield (128.86 g/pot) were obtained under salinity level S_5 (10 dS/m). The combined effect of salinity and variety was found significant. The variety CS 54 (V_4) produced the higher seed (50.81 g/pot) and stover yield (170.51g/pot) with treatment combination V_4S_1 (CS 54 × Control) which remained statistically at par with treatment combinations V_2S_1 and V_3S_1. Reduction in seed yield may be attributed to reduced photosynthesis, lesser accumulation of photosynthates and inhibited flow of food toward reproductive parts (Flowers *et al*., 1991) [7]. The present results are in close conformity with Uddin *et al*. (2005) [24] and Vadaliya *et al*. (2019) [25].

Table 2: Effect of different varieties and soil salinity levels on seed yield, stover yield, crude protein and oil content of mustard

Treatments	Seed yield (g/pot)	Stover yield (g/pot)	Crude protein (%)	Oil (%)
Variety				
V_1: GM 2	38.22	128.33	20.39	37.51
V_2: GDM 4	44.65	149.81	20.77	38.61
V_3: GDM 5	42.86	143.82	20.43	39.16
V_4: CS 54	46.70	156.69	21.07	40.43
S.Em. ±	0.56	1.92	0.25	0.36
CD (P=0.05)	1.61	5.50	NS	1.03
Salinity levels				
S_1: Control	48.58	163.01	21.08	40.92
S_2: 4 dS/m	45.07	151.25	21.03	40.05
S_3: 6 dS/m	42.76	143.49	20.78	39.37
S_4: 8 dS/m	40.71	136.70	20.39	38.12
S_5: 10 dS/m	38.40	128.86	20.04	36.18
S.Em. ±	0.63	2.15	0.28	0.40
CD (P=0.05)	1.80	6.15	NS	1.16
V × S interaction				
S.Em. ±	1.26	4.30	0.56	0.81
CD (P=0.05)	3.59	12.29	NS	NS
CV (%)	5.05	5.15	4.72	3.60

Table 2.2: Interaction effect of different varieties and soil salinity levels on seed and stover yield (g/pot) of mustard.

Treatments	Seed yield (g/pot)				Stover yield (g/pot)			
	V_1	V_2	V_3	V_4	V_1	V_2	V_3	V_4
S_1	46.55	49.32	47.65	50.81	156.19	165.49	159.88	170.51
S_2	42.51	46.31	44.81	46.67	142.65	155.38	150.35	156.60
S_3	36.59	45.37	42.86	46.23	122.76	152.23	143.83	155.13
S_4	34.59	42.61	40.67	44.98	116.42	142.97	136.47	150.95
S_5	30.88	39.63	38.32	44.78	103.63	132.99	128.58	150.26
CD (P=0.05)	3.59				12.29			

Quality parameter

Significantly highest oil content (40.43%) was obtained with variety CS 54 (V_4), while the lowest oil content (37.51%) for variety GM 2 (V_1). Increased salt concentration decreased oil content. Statistically higher oil content (40.92%) was noted in Control (S_1), however it remained statistically at par with salinity level S_2 (4 dS/m). Statistically lowest oil content (36.18%) was observed at salinity 10 dS/m (S_5). Effect of salinity and variety both were found non-significant for crude protein content. The combine effect of salinity and variety on oil and crude protein content was observed as non-significant. Increase in osmotic pressure of soil solution, imbalance of nutrients and essential elements that might be reason for diminished oil content (Toorchi *et al*., 2012) [23]. Singh *et al*., 2014 [21], Vadaliya *et al*., 2019 [25] observed similar results.

Conclusion

From the results of one season pot experiment, it can be concluded that the increased salt concentration in the soil diminished the growth, yield and quality of all mustard varieties. Variety V_4 (CS 54) exhibited its superiority for growth parameters, yield attributing character, yield and quality parameters.

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