INFLUENCE OF FERTILITY-SALINITY INTERACTIONS ON GROWTH, WATER STATUS AND YIELD OF INDIAN MUSTARD (*BRASSICA JUNCEA*)

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SUMMARY

The present investigation was carried out with *Brassica juncea* cv. RH-30 to study the effect of salinity on various physiological characteristics and use of phosphatic and sulphur fertilizer to mitigate the salinity effects. Under saline irrigation, plant height and dry weight of leaves declined over non-saline control. Fertilizer applied in combined form (60 kg P ha^{-1} + 30 kg S ha^{-1}) exhibited maximum alleviation of the adverse effects of salinity. Salt stress showed significant reduction in plant water status in terms of relative water content, water potential and osmotic potential. Application of both phosphorus and sulphur improved the water status but the higher level of sulphur (30 kg S ha^{-1}) showed poor response. Yield and its attributes adversely affected by salinity. Both phosphorus and sulphur improved the yield under salinity up to some extent however the combination of two fertilizers proved better in reviving the yield characters.

***Key words*: *Brassica juncea*, osmotic potential, relative water content, salinity, test weight, water potential.**

INTRODUCTION

Indian mustard is the second important oil seed crop after groundnut in India and is grown in area of about 68.57 lakh ha with production of 69.74 lakh tones (Anonymous 2000). Rapeseed and mustard is generally grown in arid and semi-arid regions, which are generally, affected either by salinity of soil or irrigation water. Another reason for low productivity is inadequate supply of nutrients. Farmers generally grow rapeseed and mustard mainly on marginal and sub marginal soils that too without application of fertilizers and irrigation considering this a risky crop. Salinity is one of the major widespread environmental stress, that limits growth and development of most of crop plants and the effects are severe in case of salt sensitive plants. Adverse effects of salinity on plant growth may be due to extra expenditure of energy for osmotic adjustment or in repair system, non-availability of water and disturbance of nutrients causing deficiency and ion toxicity to plant (Pasternak 1987). The most common and conspicuous effect of salinity is growth retardation. Moreover, salinity resulted in lesser branching and leaf number, dark green leaves, restricted root development, decrease in fresh and dry weight of various plant parts, reduction in size of fruits, and decrease in number and size of seeds and consequently, the yield (Ansari *et al*. 1998). Phosphorus (P), is one of the major constituent in crop nutrition and known to play an important role in salinity-fertility interaction and increase plant vigour in relation to salt tolerant capacity (Gibson 1988). Phosphorus nutrition has been implicated in modifying the effect of salinity on the growth of glycophytes (Feigin 1985). Sulphur (S), another important nutrient is known to play an important role in

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photosynthesis and nitrogen fixation. In this study an attempt was made to understand the relationship between crop performance (growth and yield) of mustard under different levels of phosphorus and sulphur interacting with salinity.

MATERIALS AND METHODS

The experiment was conducted in sand culture in the screen house of College of Basic Sciences and Humanities, C.C.S. Haryana Agricultural University, Hisar. Mustard crop (cv. RH-30) was raised in cemented pots, filled with 6 kg of dune sand. Some of the physico-chemical characteristics of dune sand used are (i) Mechanical analysis = sand (93.3%), silt (3.0%), clay (3.7%), (ii) Texture = sand, (iii) Saturation capacity =25%, (iv) pH = 8.2, (v) ECe = 0.8 dSm^{-1} at 25 ^0C, (vi) $CaCO_3$ = absent, (vii) Organic carbon = 0.06%, (Viii) CEC = 2.56 Cmol (+) kg^{-1}, (ix) Available nutrients (ppm) = N(10.3), P(2.5), K(18.0), (x) Taxonomic class = Typic torrispamments. Ten seeds were sown in each pot at field capacity and after 15 days of sowing (DAS) thinning were done and three plants of uniform size were maintained per pot. After thinning, pots were supplied with phosphorus and sulphur alone and in combinations. Crop was supplied with equal quantity of nutrient solution (Hoagland's) at a regular interval of 15 days. The desired salinity levels (ECe 0, 8 and 12 dSm^{-1}) were obtained by adding Cl and SO_4 salts of Na, Ca and Mg [Na: (Ca+ Mg) =1:1, Ca: Mg = 1:3, Cl: SO_4= 7:3 on milliequivalent basis] at 55 DAS (reproductive stage) and sampling was done after 10 days. Non-saline water irrigated plants were kept as control. Three levels of phosphorus and sulphur were supplied in each pot. Phosphorus (KH_2PO_4): 20, 40 and 60 kg ha^{-1}, Sulphur (K_2SO_4): 10, 20 and 30 kg ha^{-1} and combinations (KH_2PO_4 + K_2SO_4): 20 +10, 40 +20, 60 + 30 kg ha^{-1} were used. Additional amount of K^+ was compensated in control by addition of KCl. Observations were recorded at reproductive stage (65DAS). Factorial completely randomized design (CRD) design was used for statistical analysis. Plant height, dry weight, leaf water potential was determined from the third fully expanded leaf by using pressure chamber (Model-3000 series, Plant Water Status Console, Soil Moisture Equipment Corporation, Santa Barbara, California, USA). Relative water content (RWC) was calculated using formula developed by Barrs and Weatherley, (1966). Leaf osmotic potential was measured with a model 5100-B vapour pressure osmometer (Wescor, Inc. Logan, Utah, USA). Yield and its attributes viz. number of siliquae per plant, number of seeds per siliqua, seed yield per plant, test weight (1000-seeds weight) were recorded at maturity.

RESULTS AND DISCUSSION

Plant treated with combined form of fertilizers (phosphorus and sulphur) showed the highest plant height and dry weight in saline as well as non-saline conditions (Table 1). Increase in salinity levels from 8 to12 dSm^{-1} led to a significant reduction in plant height and dry weight of leaves was observed as compared to non-saline plants. A progressive increase in plant height as well as dry weight of leaves was recorded with increasing level of phosphorus and sulphur irrespective of saline and non-saline condition except at higher level of sulphur (30 kg ha^{-1}) whereas decrease in plant height and dry weight was observed under saline conditions. However, the combined effect of fertilizers was more beneficial under saline conditions. Inhibitory effect of salinity on growth has been reported in *Brassica* (Kuhad *et al*. 1989), wild wheat (Delzoppo *et al*. 1999) and Barley (Cho and Kim 1998). Reduction in plant growth has been attributed to reduced water absorption due to osmotic effect, nutritional deficiency on account of ionic imbalance and decrease in many metabolic activities. Salinity induced reduction in growth, due to decrease in critical water level, ionic imbalance (Flower *et al.* 1988) and seedling vigour as well as metabolites in root and leaf tissues may be modulated by Phosphorus either by replenishing the ions or through increased metabolites (Khan *et al*. 1994). Promotry effect of sulphur on growth parameters may be attributed to enhanced levels of some amino acids (Tomar *et al*. 1997). Similar increase in growth parameters with combination of phosphorus and sulphur were reported earlier in *Brassica spp.* (Jain *et al*. 1995).

Water status measured in terms of relative water content (RWC), leaf water potential and leaf osmotic potential decreased significantly under salinity (Table 2). The decrease was progressive with increase in salinity

Table 1. Effect of phosphorus and sulphur fertilisers and their interaction with salinity on leaf dry weight and plant height of *Brassica juncea* L.

Fertilizers	Level of fertilisers (kg/ha)	Leaf dry weight (g $plant^{-1}$)				Plant height (cm)			
		Salinity level (dSm^{-1})							
		0	8	12	Mean	0	8	12	Mean
Phosphorus	20	0.488	0.390	0.345	0.408	99.2	87.4	76.2	87.8
	40	0.545	0.410	0.381	0.445	113.5	97.5	87.2	99.4
	60	0.649	0.512	0.463	0.541	120.2	99.5	88.4	102.7
	Mean	0.561	0.437	0.396	0.464	110.9	94.8	83.9	96.6
Sulphur	10	0.445	0.348	0.290	0.361	95.4	82.7	80.5	86.2
	20	0.507	0.386	0.362	0.418	98.7	85.5	81.0	88.4
	30	0.519	0.299	0.186	0.335	98.8	60.5	55.7	71.5
	Mean	0.490	0.344	0.279	0.374	97.5	76.2	72.4	83.4
Phosphorus	20+10	0.574	0.495	0.462	0.510	105.7	90.2	78.5	91.5
+	40+20	0.629	0.501	0.490	0.540	115.6	100.1	91.5	102.4
Sulphur	60+30	0.692	0.535	0.499	0.575	125.7	105.5	95.7	108.9
	Mean	0.632	0.510	0.484	0.542	115.6	98.6	88.5	100.9
CD at 5%		FS = 0.011 FL = 0.011 SL = 0.011 FSxFL = 0.018 FSxSL = 0.018 FLxSL = 0.018 FSxFLxSL = 0.032				FS = 3.550 FL = 3.550 SL = 3.550 FSxFL = 6.149 FSxSL = N.S. FLxSL = 6.149 FSxFLxSL = N.S.			

FS = Fertilizer Source FL = Fertilizer Levels SL = Salinity Levels

levels from 0 to 8 and 12dSm^{-1}. Improvement in water status was observed in both saline as well as non-saline plants with the application of fertilizers. Treatment with phosphorus, sulphur and their combination resulted in significant increase in RWC and leaf water potential of saline plants. Application of phosphorus maintained considerably high RWC and leaf water potential irrespective of the level. However, sulphur treatment at 30 kg ha^{-1} adversely affected RWC under saline irrigation. Application of fertilizers caused further decrease in osmotic potential. However, the decrease was more pronounced with sulphur application. Interaction of the two fertilizers decreased the osmotic potential in normal as well as under saline conditions. Decrease in leaf water potential and osmotic potential with increasing levels of salinity has been reported previously in wheat (Delzoppo *et al*. 1999), muskmelon (Caravajal *et al*. 1998) and *Brassica* (Madan *et al*. 1994). Increase in osmotically compatible solutes played an important role in decreasing the osmotic potential of cytoplasm (Saleik *et al*. 1993). Delane *et al*. (1982) and Hanson and Hitz (1982) reported that decrease in osmotic potential was responsible for maintenance of turgor pressure of plants under saline conditions. Decrease in relative water content in *Brassica* under salinity was also reported by Madan *et al*. (1994). Application of phosphorus developed the root system to explore deeper layers of soil. Husain and El-Zeing (1990) also reported the role of phosphorus in improving osmotic pressure and cell sap concentration.

Table 2. Effect of phosphorus and sulphur fertilisers and their interaction with salinity on relative water content, leaf water potential and leaf osmotic potential in *Brassica juncea* L.

Fertilisers	Level of fertilisers (kg ha^{-1})	Relative water content (%)				Leaf water potential (-MPa) Salinity levels (dSm^{-1})				Leaf osmotic potential (-MPa)			
		0	8	12	Mean	0	8	12	Mean	0	8	12	Mean
P	20	80.46	68.45	58.79	69.23	0.67	0.79	0.88	0.78	1.10	1.21	1.29	1.20
	40	81.70	72.16	60.25	71.37	0.53	0.68	0.79	0.67	1.13	1.26	1.32	1.24
	60	82.70	73.65	63.55	73.30	0.50	0.63	0.68	0.60	1.14	1.28	1.36	1.26
	Mean	81.62	71.42	60.86	71.19	0.57	0.70	0.78	0.68	1.12	1.25	1.32	1.23
S	10	78.50	67.17	56.51	67.39	0.69	0.81	0.88	0.79	1.17	1.27	1.30	1.25
	20	80.16	70.46	60.15	70.25	0.62	0.72	0.74	0.69	1.19	1.31	1.34	1.28
	30	81.60	60.54	47.26	63.13	0.61	0.88	0.90	0.79	1.20	1.70	1.94	1.61
	Mean	80.08	66.05	54.64	66.85	0.64	0.80	0.84	0.75	1.19	1.43	1.53	1.38
P+S	20+10	85.47	70.75	62.51	72.91	0.62	0.75	0.81	0.72	1.05	1.15	1.21	1.14
	40+20	86.55	73.26	64.17	74.66	0.51	0.68	0.68	0.62	1.08	1.19	1.26	1.18
	60+30	87.65	74.75	66.06	76.15	0.50	0.63	0.63	0.58	1.11	1.22	1.29	1.21
	Mean	86.55	72.92	66.25	74.57	0.54	0.68	0.71	0.64	1.08	1.19	1.25	1.18
CD at 5 %		FS = 1.389 FL = 1.389 SL = 1.389 FSxFL = 2.405 FSxSL = 2.405 FLxSL = N.S. FSxFLxSL = 4.166				FS = 0.013 FL = 0.013 SL = 0.013 FSxFL = 0.023 FSxSL = 0.023 FLxSL = N.S. FSxFLxSL = 0.039				FS = 0.111 FL = 0.111 SL = 0.111 FSxFL = 0.191 FSxSL = N.S. FLxSL = N.S. FSxFLxSL = N.S.			

FS = Fertilizer Source FL = Fertilizer Levels SL = Salinity Levels

Under saline conditions, the number of siliqua per plant, number of seeds per siliqua, seed weight and test weight decreased significantly compared to non-saline conditions irrespective of fertilizer used (Table 3 and 4). Phosphorus application increased the number of siliqua per plant, seed weight and test weight under saline conditions. Sulphur also increased the number of siliqua per plant, seed weight and test weight but higher level (30 kg ha^{-1}) of sulphur decreased it. However, combination of two had edge over individual fertilizer in improving the yield. Similar decrease in seed yield, test weight and siliqua per plant under salinity reported earlier in *B. crinata* (Thakral 1996) and raya (Sharma and Gill 1994). The percentage of shriveled seeds per siliqua increased with an increase in salinity may exert its influence by impairing the seed filling or seed development (Dhawan *et al*. 1987). Patel and Shelke (1998) observed that increase in length of siliqua, seed/ siliqua, weight of seed and test weight with phosphorus and sulphur application. The increased yield due to sulphur is imminent as *Brassica* has higher sulphur requirement. Not only the Sulphur but also Phosphorus is deficient in soils because of formation of Fe and Al complexes and fixing most of the available P. The P and S proved to be beneficial due to the better balanced application (Jaggi 1998). The decrease in yield with the higher level of S may be due to simultaneous increase in the total salt content in the soil solution.

Table 3. Effect of phosphorus, sulphur fertilisers and their interaction with salinity on seed yield and number of silqua at harvest in *Brassica juncea* L.

Fertilizers	Level of fertilisers (kg/ha)	Seed yield (g $plant^{-1}$) Salinity levels (dSm^{-1})				Number of siliqua ($plant^{-1}$)			
		0	8	12	Mean	0	8	12	Mean
Phosphorus	20	1.88	1.14	0.83	1.28	41.00	31.33	18.33	30.22
	40	1.99	1.23	0.99	1.40	43.66	35.00	23.33	34.00
	60	2.17	1.57	1.20	1.65	46.00	43.33	33.66	41.00
	Mean	2.01	1.31	1.00	1.44	43.44	36.55	25.11	35.03
Sulphur	10	1.30	0.93	0.77	1.00	40.00	28.33	16.33	28.22
	20	1.59	1.11	0.93	1.21	43.00	32.66	21.33	32.33
	30	2.00	1.03	0.70	1.24	44.00	25.66	14.33	28.00
	Mean	1.63	1.02	0.80	1.15	42.33	28.89	17.33	29.52
Phosphorus+	20+10	1.89	1.23	1.04	1.39	43.66	32.00	23.00	32.89
Sulphur	40+20	2.20	1.51	1.19	1.63	48.33	39.00	32.33	39.89
	60+30	2.30	1.80	1.36	1.82	50.33	44.33	31.00	41.89
	Mean	2.13	1.52	1.20	1.62	47.44	38.44	30.78	38.89
CD at 5%		FS = 0.043 FL = 0.043 SL = 0.043 FSxFL = 0.075 FSxSL = 0.075 FLxSL = 0.075 FSxFLxSL = 0.131				FS = 1.171 FL = 1.171 SL = 1.171 FSxFL = 2.029 FSxSL = 2.029 FLxSL = 2.029 FSxFLxSL = 3.514			

FS = Fertilizer Source FL = Fertilizer Levels SL = Salinity Levels

Table 4. Effect of phosphorus and sulphur fertilizer and their interaction with salinity on test weight (g/1000 seeds) and number of seeds per siliqua at harvest in *Brassica juncea* L.

Fertilizers	Level of fertilisers (kg/ha)	Test weight (g/1000 seeds) Salinity levels (dSm^{-1})				Number of seeds per siliqua			
		0	8	12	Mean	0	8	12	Mean
Phosphorus	20	4.22	3.58	3.30	3.70	11.66	10.00	9.00	10.22
	40	4.56	3.64	3.37	3.86	12.33	10.33	9.33	10.66
	60	4.60	4.10	3.64	4.11	12.66	11.66	9.66	11.33
	Mean	4.46	3.77	3.44	3.89	12.22	10.66	9.33	10.73
Sulphur	10	3.89	3.38	3.19	3.49	11.33	9.33	9.00	9.89
	20	4.11	3.46	3.28	3.62	11.66	10.00	9.33	10.33
	30	4.12	2.94	2.45	3.17	12.00	10.66	9.66	10.77
	Mean	4.04	3.26	2.97	3.42	11.66	10.00	9.33	10.33
Phosphorus+	20+10	4.33	3.66	3.16	3.72	12.33	10.66	9.33	10.78
Sulphur	40+20	4.94	3.82	3.45	4.07	13.66	11.00	10.00	11.55
	60+30	5.01	4.47	3.98	4.49	13.66	12.00	10.66	12.11
	Mean	4.76	3.99	3.53	4.09	13.22	11.22	10.00	11.48
CD at 5%		FS = 0.052 FL =0.052 SL = 0.052 FSxFL = 0.079 FSxSL = 0.079 FLxSL = 0.079 FSxFLxSL = 01.29				FS = 0.50 FL = 0.50 SL = 0.50 FSxFL = 1.10 FSxSL = 1.10 FLxSL = 1.10 FSxFLxSL = N.S.			

FS = Fertilizer Source FL = Fertilizer Levels SL = Salinity Levels

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