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Effect of different soil moisture regimes and salinity level on growth and yield in mustard

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ABSTRACT

Soil moisture stress and salinity resulted reduction in almost all the growth, yield and yield attributes in mustard var. RH-30. Salinity behaved similarly to soil moisture stress and the magnitude of reduction increased with the increase in their level accordingly. Chloride type of toxicity was found to be more harmful than that of sulphate toxicity. The results obtained in the present study suggested that maintenance of wetter irrigation under salinity could go a long way in maximizing the crop production in mustard.

Key words: Drought, Growth parameter, Mmstard, Salinity, Yield.

INTRODUCTION

Drought and salinity are both of the limiting factors in the crop production in the arid and semi arid regions of the world. Despite large area under oil seeds cultivation and India being third largest producer of rape seed/ mustard in the world, their production is not keeping pace with the rapid increase in population. Generally the crop is faced with the problem of salinity coupled with saline under ground water or scarcity of water. Hence crop suffers salt stress and drought stress at various stages of crop, growth and development, leading to reduced yield and even some time the crop failure. Systemic studies were therefore conducted at different soil moisuture regimes and salinity levels on growth and yield parameters in mustard var. RH-30.

MATERIALS AND METHODS

Mustard (*Brassica juncea*) cultivar RH-30 was grown in earthen pots (Dia 30 cm) filled with 5.500 kg of yellow sand under natural condition of green house. After thinning three plants of uniform size were maintained in each plot. The plants were supplied with nutrient solution (Arnon and Hoagland, 1946) at regular intervals. Different soil, moisture regimes (Irrigation at 50,25,12.5 and 6.0 % of soil saturation) were superimposed over the salinity levels by gravimetric method through out the crop stand. Sampling was done at vegetative stage (35-40 days after sowing), flowering stage (45-60 days after sowing) and harvesting of the crop at 150 days after sowing. Three sets of replicates were used in each case to get conclusive data.

Two types of salinity i.e. chloride and sulphate were prepared by using the mixture of salts of NaCl, $MgCl_2$, $CaCl_2$ and $MgSO_4$ (Cl^- -7 : 3, SO_4-3 : and 7 meq basis).

OBSERVATIONS RECORDED

(A) Growth parameters: The height of the plants was measured as main shoot length in centimeters (cm). Number of leaves for plant were counted at each sampling stage. All the leaves were detached from the stem and branches and their area was determined by using Portable Leaf Area Meter (Model Li-3000, Li-cor,USA). The plants under each treatment were removed from the soil and separated into different parts i.e leaves, stem and root and fresh weight was recorded. Then separated components were wrapped in a piece of paper and allowed to dry in an oven at 85°C to a constant weight.

(B) Yield and its attributes: The following data of yield and its attributing characters were recorded at the time of harvest.

i) Number of siliqua per plant. ii) Number of seeds per siliqua. iii) Siliqua length. iv) Straw and grain yield per plant

(C) Oil content: Oil content was estimated by the method of Gupta *et al.* (1985) using NMR, MK III-9 new port Analyser equipped with 2 ml sample coil assembly.

(D) Statistical analysis: To calculate the critical difference (CD) three factorial Complete Randomized Design(3-Factorial–CRD) was employed to test at 5% level significance.

RESULTS AND DISCUSSION

(A) Response of mustard var. RH-30 to different soil regimes: The results presented in Table 1, clearly indicated that with the increase in dryness of soil moisture regimes, there was a significant reduction in the plant height, number of leaf per plant, leaf area, fresh and dry weight of stem and root and there was maximum reduction in the soil moisture

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regime M_3 level (Irrigation at 6.0% of soil saturation). Further it was observed that there was relatively more reduction in these growth parameters at flowering stage than during vegetative stage under the dry soil moisture regimes. But on the contrary, though fresh weight of leaves decreased significantly with the increase in dryness of the soil moisture regimes and there was maximum reduction in the soil moisture regimes M_3 but in this case there was relatively more reduction in fresh weight of leaves at vegetative stage than during at flowering stage.

Soil moisture stress adversely affected the growth of Brassica plants. All the growth parameters were significantly reduced over control. The magnitude of reduction increased with the increase in soil moisture stress i.e. drier soil moisture regimes and there was maximum reduction in all the above growth parameters under the soil moisture regime M_3, i.e. irrigation given when soil saturation reached at 6.0% level. Water stress induced reduction in growth parameters have been reported earlier by Nandwal (1989), Hamid *et al.* (1991) and Ravinder *et al.* (1990). The soil moisture stress resulted in decrease in the endogeneous water status within the plants as observed i.e. there was significant reduction in relative content, leaf water potential and osmotic potential as reported by the author elsewhere (Jagbir *et al.*, 1996) and this reduction was more and more under the dry soil moisture regimes and thus creating a situation within the plant which is not conducive to the synthetic machineries and because of that growth of all the parameters decreased significantly.

A perusal of Table 2 would indicate that number of siliqua per plant, number of seeds per siliqua, siliqua length, grain weight, straw weight, 1000 seed weight and oil content as well decreased significantly with the increase in dryness of the soil moisture regime and there was maximum reduction in the soil moisture regime M_3. The productivity of plants was observed to be badly affected by the soil moisture stress. The grain and straw yield per plant was significantly reduced under drier irrigation regimes. The reduction in straw yield can be attributed due to reduction in root weight, stem and leaf weight and leaf area per plant along with decreasing synthetic capacity of the plants due to impaired photosynthetic and further synthetic process as evidenced as a result of decrease in water status within the plants affecting all the physiological processes (Jagbir *et al.*, 1996). The reduction in grain yield under soil moisture was observed due to reduction in number of siliqua per plant, number of seeds per siliqua, length of siliqua alongwith decrease in 1000 seed weight. Adverse effect of moisture stress on yield and its attributes in brassica were elucidated by Singh *et al.* (1990). Not only the quantitative aspect of the productivity in terms of grain yield was observed to be reduced under soil moisture but also quality of the grains was also observed to be adversely affected as it regulated a significant reduction in the oil contents of the grains which is very important

Table 1: Effect of different soil moisture regimes on growth parameter in mustard var. RH- 30.

Stage	Moisture level	Plant height (cm)	No. of leaf	Leaf area (sq. cm)	Fresh wt of leaves (g plant^{-1})	Fresh wt of stem (g plant^{-1})	Fresh wt of root (g plant^{-1})	Dry wt of leaves (g plant^{-1})	Dry wt of stem (g plant^{-1})	Dry wt of root (g plant^{-1})
Vegetative	M_0	24.5	8.5	484.50	5.19	6.23	3.87	2.02	1.73	1.31
stage	M_1	20.4	7.6	268.66	2.61	4.45	2.57	1.15	1.34	1.12
	M_2	16.4	6.2	159.34	1.64	3.61	1.71	0.99	1.10	0.81
	M_3	11.6	5.2	95.64	0.98	2.41	0.60	0.05	0.14	0.33
Flowering	M_0	117.3	13.6	691.28	11.62	46.98	28.25	2.78	9.37	2.53
stage	M_1	97.3	11.1	318.38	6.76	32.34	17.00	1.47	7.93	1.26
	M_2	65.3	9.4	149.70	5.19	27.57	8.74	1.25	4.06	1.10
	M_3	43.2	7.7	66.03	3.82	12.96	6.56	0.43	0.63	0.74
CD at 5% level of significance		0.7294	0.1884	56.50	0.6173	3.4298	1.0532	0.1617	0.2911	0.2116

Table 2: Effect of different soil moisture regimes on yield and their attributes in mustard var. RH- 30.

Stage	Moisture level	No. of siliqua/Pl	No. of Seeds/siliqua	Siliqua length (cm)	Grain wt. (g plant^{-1})	Straw wt. (g plant^{-1})	1000 seed wt. (g plant^{-1})	Oil content (%)
Maturity	M_0	136	106	4.1	2.70	31.16	5.45	32.27
stage	M_1	95	95	3.8	2.52	27.57	4.52	27.64
	M_2	76	90	3.2	1.70	22.05	4.24	26.33
	M_3	28	55	3.0	1.29	16.93	4.06	24.33
CD at 5% level of significance		1.9493	5.2556	0.2192	0.4874	119.1077	0.8593	0.6256

quality criteria of the produce in the market. Decrease in oil quality under water stress was reported earlier by Nagaraj (1990).

(B) Response of mustard var. RH-30 to different salinity level: It was clear from the results presented in Table 3 that with the increase in salinity level, in general, resulted in corresponding decrease in the plant height, number of leaves, leaf area, fresh weight of leaves, stem and root and dry weight of leaves, stem and root. Further there was maximum reduction at the higher level of salinity i.e. 16m mhos/cm EC_e and significant differences in terms of all growth of parameters were observed under the two type of salinity. Similarly, there was also a significant reduction in all parameters over control as well. Although there was significant reduction in plant height, number of leaves, leaf area over control under both types of salinity at both the stages but there was more reduction at the second stage, i.e. flowering stage. Chloride type of salinity resulted in more reduction in these parameters than sulphate and more reduction at later stages i.e. flowering. As far as the fresh weight of leaves and stem was concerned both of them also showed corresponding decrease with the increase in salinity level and maximum reduction occurred at the higher level of salinity (16 m mhos/ cm EC_e). There was significant difference in terms of fresh weight of leaves and stem under two types of salinity but it was more under chloride type of salinity. Although there was significant reduction in both the parameters over control under both types of salinity at both the stages but there was more reduction at vegetative stage as compared to that of flowering stage. Similarly with the increase in salinity level there was corresponding decrease in fresh weight of root, dry weight of leaves, stem and root

Table 3: Effect of different salinity levels on growth parameters in mustard var. RH- 30.

Stage	Type of salinity	Salinity level	Pl height (cm)	No. of leaf	Leaf area (cm)	Fresh wt of leaves (g plant^{-1})	Fresh wt of stem (g plant^{-1})	Fresh wt of root (g plant^{-1})	Dry wt of leaves (g plant^{-1})	Dry wt of stem (g plant^{-1})	Dry wt of root (g plant^{-1})
Vegetative stage	Chloride	S_0	21.3	8.0	450.38	5.55	6.53	3.72	2.22	1.82	1.31
		S_1	18.3	7.5	245.31	3.42	5.43	3.12	1.80	1.34	1.22
		S_2	15.5	7.0	102.54	2.85	4.22	2.44	0.50	0.74	0.86
		S_3	12.3	6.0	56.48	2.57	3.52	1.23	0.10	1.10	0.46
	Sulphate	S_0	20.4	8.4	445.41	5.45	6.42	3.81	1.92	1.89	1.28
		S_1	18.5	7.5	303.30	3.69	6.13	3.07	1.22	1.42	1.26
		S_2	15.7	6.8	150.21	3.13	5.31	2.86	0.87	0.91	0.76
		S_3	12.7	6.3	90.66	2.73	3.82	1.74	0.15	0.19	0.56
	Chloride	S_0	110.2	13.5	673.23	11.42	48.62	28.53	2.85	9.42	2.53
		S_1	96.7	10.4	394.26	10.65	42.71	25.32	2.20	6.44	2.00
		S_2	84.3	7.8	145.54	9.24	37.22	20.11	1.40	2.54	1.62
		S_3	45.6	6.3	47.25	8.33	25.82	15.43	0.61	0.58	0.93
Flowering Stage	Sulphate										
		S_0	115.3	13.7	680.40	11.45	46.70	28.05	2.80	9.54	2.59
		S_1	108.8	10.3	351.02	10.63	40.22	25.96	1.77	7.09	1.94
		S_2	92.6	8.5	102.40	9.69	35.51	22.15	1.22	2.33	1.48
		S_3	65.2	7.8	80.53	9.06	30.22	18.24	0.88	0.70	0.72
CD at 5% level of significance			1.48	0.19	2.67	0.11	0.06	0.06	0.06	0.04	0.10

Table 4: Effect of different salinity levels on yield and their attributes in mustard var. RH- 30.

Stage	Type of salinity	Salinity level	No. of siliqua/ Pl	No. of seeds/ siliqua	Siliqua Length (cm)	Grain wt (gm)	straw wt (gm)	1000 seeds wt. (gm)	Oil content (%)
Maturity stage	Chloride	S_0	136	95	4.3	3.35	30.93	5.55	31.55
		S_1	90	93	3.5	2.93	27.02	5.17	28.65
		S_2	52	88	2.7	2.62	22.75	4.81	22.26
		S_3	21	62	2.1	2.53	20.07	3.49	15.55
	Sulphate	S_0	134	98	4.2	2.99	31.19	5.40	31.24
		S_1	88	90	3.8	2.68	25.96	5.05	29.24
		S_2	62	81	3.2	2.72	21.72	4.46	25.65
		S_3	35	65	2.5	2.54	19.49	3.37	20.22
CD at 5% level of significance			1.5495	1.7780	0.1429	0.3473	1.9480	0.3940	0.0933

and there was maximum reduction at the higher level of salinity(16 m mhos/ cm EC_e). But in these cases there was no significant different in terms of values under two type of salinity, although it was significantly reduced over control. There was significant reduction in the values obtained over control under both types of salinity at both the stages but there was slightly more reduction at vegetative stage in case of fresh weight of root and dry weight of leaves where as reduction was observed more at flowering stage in dry weight of stem and root.

Salinity is known to affect adversely almost all the growth and development parameters. This statement is supported by many workers (Francois *et al.*, 1986; Taneja, 1992). The magnitude of reduction increased with increase in the salinity level and there was maximum reduction in all these parameters under the high level of salinity used i.e. S_3 (16 m mhos/ cm ECe). Water relations of plants showed a tremendous imbalance under salt stress situations as reported by Sharma and Kumar (1992); Jagbir *et al.* (1996) and this was reflected in terms of reduction in all the water potential components. Adverse water relations of plant and its parts which were essential for proper functioning of the physiological synthetic machinery was observed to affect adversely the process of photosynthesis and respiration. This may be due to the increase in the hindrances in the gasesous exchange in the leaves as well as adaxial stomatal conductance was observed to be significantly reduced under the saline conditions over control (Pastenak, 1987, Jagbir *et al.*, 1996).

The results obtained on the yield and its attributes of mustard var. RH-30 showed decrease trend and significantly increased with increase in salinity level (Table 4). There was maximum reduction at higher level of salinity (16 m mhos /cm EC_e). But it was noticed that there was more reduction in number of siliqua per plant, siliqua length, straw weight , 1000 seed weight and oil content in chloride type of toxicity but on the other hand sulphate type of toxicity was more prevalent in reduction of number of siliqua per plant and grain weight as compared to chloride toxicity. Soil salinity decreased vegetative growth more than grain yield (Francois *et al.*,1986). Several workers observed that soil salinity has adverse effect on crop yield affecting metabolic processes (Peak *et al.*, 1988). The results obtained in this study also corroborates the above findings. Flowering and fruiting formed timely in some whereas delayed in others under salt stress (Flower *et al.*, 1977).

The final grain and straw yield was observed to be affected adversely almost especially both under salt stress and water stress. There was significant reduction in the productive capacity of the plants under these conditions and the magnitude of reduction in grain and straw yield increased when the enhancement in the salt stress was combined with water stress i.e. drier irrigation regimes. The reduction in grain and straw yield can be ascribed to the relative more reduction in the growth parameters including stem, root and leaf growth as evidenced by decrease in their dry weights and grain yield reduction due to decrease in number of siliqua per plant, siliqua length and 1000 seed weight. Not only the quantitative aspects of growth and yield were adversely affected by salt and water stress but also the quality of the produce, as there were observed reductions in the oil content of the seeds as well. Maintaining better irrigation regimes as found to alleviate the harmful effects of salinity to a greater extent.

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