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Yield and Quality of *Brassica* Cultivars as Affected by Soil Salinity

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Abstract. A field study was conducted at two different salt-affected locations (1) district Hafizabad having electrical conductivity of soil extract (ECe) = 6.46 dS/m and sodium absorption ratio (SAR) = 7.22 and (2) district Sargodha (ECe = 13.02 dS/m; SAR = 12.70) to test the yield response and quality of five brassica cultivars. The cultivars viz. sultan raya, BRS-II, rainbow, shiralle and dunkled were selected after preliminary screening against NaCl salt stress under hydroponic conditions. Basal dose of NPK was applied at the time of sowing. Growth and yield parameters i.e., plant height, number of branches, number of pods per plant and seed yield were compared. The rainbow and dunkled cultivars showed maximum plant height at both the sites while sultan raya and BRS-II produced more number of branches as compared to rest of the cultivars. Among all the cultivars, although, sultan raya out yielded on the basis of seed yield (1446 and 869 kg/ha) at site-1 and site-2, respectively, but there was about 40% decrease in seed yield at site-2 due to high salinity (13.02 dS/m) followed by BRS-II which showed about 45% yield reduction at the same site. Maximum oil contents were determined in the seeds of sultan raya followed by BRS-II and dunkled grown at both the sites. Generally, sultan raya maintained significantly high level of K^+ and less Na^+ in their tissues grown at both the sites. Overall, Brassica cultivar sultan raya showed promising results and better performance than rest of the cultivars at both the sites but there was a significant reduction in growth and yield of all cultivars at site-2 due to higher salinity.

Keywords: *Brassica* cultivars, soil salinity, growth and yield, crude protein, crude oil content, Na^+, K^+

Introduction

Edible oil is one of the basic requirement of our daily diet. Pakistan is suffering from acute deficiency in edible oil because of its increased consumption while local production stood at 0.857 mt which accounts for 31% of total availability and the remaining 69% is being made available through imports (PES, 2006). The domestic edible oil production from all sources is 2.56% annually over the last decades while the annual consumption rate has increased by 9% (GOP, 2005). The non true oil seed crops like cotton, maize etc. are contributing upto 73% towards the national edible oil production in the country. Whereas, the conventional oilseeds (rapeseed and mustards) are second in rank and contribute about 18-20% in the domestic edible oil production. Mustards (*Brassica compestris* L.) is an important oil seed crop, grown for centuries in different parts of the world. It is a rich source of oil and protein. The seeds have oil content as high as 46-48%. In Pakistan, it is the second most important source of oil after cotton. During 2004-2005, mustards and rapeseed were cultivated over an area of 257.2 thousand hectare with a production of 215.8 thousand tons and an average yield of 839 kg/ha (GOP, 2005) which is very low to meat our ever increasing requirements. But under saline soil conditions, growth and yield of *Brassica* sp. is much lower as compared to that obtained from productive lands which might be due to cultivation of genotypes susceptible to salinity. Successful oilseed crop production with good quality oil on moderately salt-affected soils demands the suitable variety selection particularly with better salt tolerance (Flowers, 2004; Mahmood *et al.*, 1999; Flowers and Yeo, 1995; Aslam *et al.*, 1993a; Qureshi *et al.*, 1990). Most of the oilseed crops of the world are sensitive to soil salinity; they show reduced growth rate and yield, and may have stunted fruits, leaves and stem (Bernstein, 1975). Obviously, the edible oil seed production from saline soils could be increased by two means, either by proper nutrition or growing tolerant varieties against salinity. In the present situation, the selection of salt tolerant genotypes is of great importance and is the only option to increase oilseed production from our limited resources. Consequently we must search for salinity tolerant oilseed crops and for this purpose the most promising crops are rapeseed and mustards. Under the prevailing conditions, per hectare yield of this crop is very low than that potential of different varieties under cultivation. Therefore, objective of this study was to find out the most suitable *Brassica* genotypes with better yield and quality for cultivation under saline soil conditions.

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Materials and Methods

A field study was conducted to test the yield response and quality of five *Brassica* cultivars during 2005-2006 at two different salt-affected locations, one at Soil Salinity Research Institute, Pindi Bhattian, district Hafizabad (Site-1) having ECe = 6.46 dS/m and SAR = 7.22 and the other at Farmer's field in district Sargodha (Site-2) of which ECe was 13.02 dS m^{-1} and SAR = 12.70. Physicochemical analysis of the soil was done from a composite sample of each site collected before crop sowing (Table 1). Seeds of different *Brassica* genotypes were collected from Oilseed Programme, National Agricultural Research Centre, Islamabad, Pakistan. Among these cultivars, sultan raya, BRS-II, rainbow, shiralle and dunkled were selected after preliminary screening against a salt stress of 150 mM NaCl under hydroponic conditions. Experiment was laid out in randomized complete block design (RCBD) with three replications. A Basal dose of NPK @ 80, 100 and 50 kg/ha as urea, SSP and SOP were applied at the time of sowing. The crop was allowed to stand till maturity. Three irrigations were applied with canal water throughout the growth season. Data on growth and yield parameters i.e., plant height, number of branches per plant, number of pods per plant, number of seeds per pod and seed yield were collected randomly (average of five plants per replication) at the time of crop maturity. Samples for chemical analysis were collected at the time of harvest and oven dried at 60 °C to a constant weight. Dried plant samples were ground to pass through a 40-mesh screen in a Wiley Mills. Then samples were digested in a di-acid mixture of nitric acid and perchloric acid (2:1) to estimate Na^+, K^+, Ca^{+2} and Mg^{+2} concentration in the plant tissues by atomic absorption spectroscopy. Crude protein in seeds was determined by Kjeldahl method and crude oil percentage in seeds by Soxhlet apparatus (AOAC, 1990). The results were analyzed statistically with the help of MSTAT-C package on computer. (Gomez and Gomez, 1984).

Table 1. Physicochemical analysis of soil and soil texture at experimental sites

Parameters	Units	Values	
		Site-1	Site-2
pH	–	8.07	8.40
ECe	dS/m	6.46	13.02
SAR	–	7.22	12.47
$CaCO_3$	%	2.50	3.78
Organic matter	%	0.16	0.09
N	mg/kg	0.03	0.02
P	mg/kg	2.56	2.43
K	mg/kg	35.00	19.83
Sand	%	31	29
Silt	%	35	28
Clay	%	34	43
Textural class		Sandy loam	Sandy clay loam

Results and Discussion

Growth and yield. The data presented in Table 2, indicate that the cultivar rainbow has maximum plant height closely followed by dunkled at both the sites while sultan raya and BRS-II beard more number of branches per plant. Comparatively a stunted growth and less number of branches were observed at site-2 (Sargodha) which was presumably because of high salinity at this site. Most of the oilseed crops are sensitive to high soil salinity due to which they show reduced growth and yield, and may have stunted fruits, leaves and stem (Ahmed *et al*., 2005; Mahmood *et al*., 1999; Sharma, 1986; Bernstein ,1975). When number of pods per plant were counted, the case was entirely different at both of the sites. The cultivar dunkled produced maximum number of pods per plant at site-1 (SSRI Farm, Pindi Bhattian, Hafiabad) while this number was higher with rainbow at site-2 (Farmer's field, Sargodha). In spite of this, it was interesting to note that maximum number of seeds and seed yield were harvested with sultan raya even at site-2 but approximately 40% reduction in yield occurred at this site followed by BRS-II which showed about 45% yield reduction due to high salinity (13.02 dS/m). Adverse effects of higher salinity on plant growth and yield have been reported by Aslam *et al*. (1993a). Grattan and Grieve (1992) reported that the nutritional imbalance, and uptake of toxic ions under stressed conditions caused huge reduction in crop yields. Similar results have also been discussed by Flowers (2004), Flowers and Yeo (1995), Aslam *et al*. (1993b), Yeo and Flowers (1986), and Richards (1983).

Oil and protein contents. There were significant differences in oil and protein contents of different *Brassica* genotypes under varying salt-affected soil conditions (Table 3). Maximum percentage of oil content (42.27%) was observed in the seeds of sultan raya followed by BRS-II (39.92%) and dunkled (38.89%) at SSRI Farm, Pindi Bhattian while at Sargodha site, this percentage decreased by 3.56% in seeds of sultan raya, 4.45% in BRS-II and 4.68% in seeds of dunkled most probably due to high salinity at this site. Excessive absorption of toxic elements cause suppression in plant growth and hence yields with poor quality as well. Accumulation of excess Na^+ may cause metabolic disturbances in processes where low Na^+ and high K^+ are required for optimum functioning. Furthermore, nutritional imbalance as a result of depressed uptake, shoot transport, chlorophyll breakdown and impaired internal distribution of mineral ions presumably have caused less percentage of oil contents in seeds (Munns, 1993;

Table 2. Growth and yield of *Brassica* cultivars as effected by soil salinity at different sites (average of three repeats)

Brassica cultivars	Plant height (cm)	No. of branches/ plant	No. of pods/ plant	No. of seeds/ pod	Grain yield (kg/ha)
		Site-1 (SSRI farm, Pindi Bhattian, Hafizabad)			
Sultan raya	164	5.60	148.67	16.33	1446
BRS-II	188	5.13	149.07	15.24	1233
Rain bow	197	3.73	147.13	14.02	853
Shiralle	189	4.53	148.73	14.98	980
Dunkled	191	4.73	155.73	15.00	773
LSD	2	0.67	4.07	0.88	174
		Site-2 (farmer's field, Sargodha)			
Sultan raya	89	4.56	68.04	12.28	869
BRS-II	75	4.34	71.82	10.86	778
Rain bow	112	3.01	74.49	10.22	616
Shiralle	97	3.47	65.11	10.99	787
Dunkled	100	3.88	62.55	9.09	584
LSD	9	0.61	2.32	1.05	76

LSD = least significant difference

Table 3. Oil, protein content in seeds and ionic concentration (%) in tissue of *Brassica* cultivars as effected by soil salinity at different sites (average of three repeats)

Brassica cultivars	Oil content	Protein content	Na^{+}	K^{+}	Ca^{+2}	Mg^{+2}
		Site-1 (SSRI farm, Pindi Bhattian, Hafizabad)				
Sultan raya	42.27	18.11	3.11	9.26	2.86	3.57
BRS-II	39.92	14.54	4.01	7.03	2.64	3.54
Rain bow	36.02	14.31	3.86	6.87	3.11	3.58
Shiralle	35.75	13.98	3.46	4.70	2.58	3.57
Dunkled	38.89	16.89	3.63	6.12	2.18	3.49
LSD	1.97	1.07	0.14	1.98	0.43	- -
		Site-2 (farmer's field, Sargodha)				
Sultan raya	38.71	18.67	3.93	6.49	3.89	3.59
BRS-II	35.47	16.74	5.18	5.82	2.69	3.54
Rain bow	33.95	14.88	4.57	5.30	2.01	3.55
Shiralle	31.68	14.04	4.38	5.04	2.59	3.50
Dunkled	34.21	15.53	4.47	4.45	2.53	3.52
LSD	2.99	1.82	0.59	0.65	1.04	- -

LSD = least significant difference

Krishnamurthy *et al*., 1987). Resembling interpretations have also been reported by Ahmed *et al*. (2005), Ali *et al*. (2003), Kinraide (1999), Yeo and Flowers (1986), Gorham *et al*. (1985), Flowers and Yeo (1981), and Flowers *et al*. (1977). Rest of the cultivars produced comparatively less percentage of oil contents in seeds at both the sites. The ranking order of decrease in crude oil percentage in seeds of different *Brassica* genotypes at both the sites were as: sultan raya > BRS-II > dunkled > rainbow > shiralle.

Minimum protein contents were observed in seeds of shiralle (13.98%) closely followed by rainbow (14.31%) and BRS-II (14.54%) at SSRI Farm, Pindi Bhattian while at Farmer's field in Sargodha district, minimum percentage of protein was recorded with shiralle (14.04%) and rainbow (14.88%) followed by dunkled. Again *Brassica* specie sultan raya maintained higher percentage of protein content in seeds at both the sites. The ranking order of decrease in percentage of protein content in seeds of different *Brassica* genotypes at SSRI

Farm, Pindi Bhattia were as: sultan raya > dunkled > BRS-II > rainbow > shiralle while this order at Sargodha site was as: Sultan Raya > BRS-II > Dunkled > Rainbow > Shiralle. Overall, comparatively a slight increase in percentage of protein content in seeds of *Brassica* cultivars at Sargodha site-2 might be probably due to more N-uptake. Since salt stress is considered for the elevation of ionic concentration in plant shoot and root which ultimately play an important role by activating enzymes known to be related with excessive utilization of nutrients. Perhaps a similar situation has prevailed that increased protein contents under stress condition. This is supported by the investigation of Ahmed *et al.* (2005), Mahmood *et al.* (1999), Rashid (1996), Yan and Wang (1992) and Verma and Neue (1984).

Ionic concentration. Ionic concentration (Na^+, K^+ and Ca^{+2}) in tissues of different Brassica cultivars differed statistically but Mg^{+2} concentration was found to be non-significant at both the sites (Table 3). Minimum Na^+ and maximum K^+ concentration was observed in tissues of sultan raya even at Sargodha site but at this site a slight increase in Na^+ and decrease in K^+ concentration of plant tissues was observed presumably due to high salinity. However, comparatively better performance of sultan raya in maintaining higher level of K^+ and less percentage of Na^+ content in plant tissues at both the sites might be because of its genetic ability for better salt tolerance. These results could be supported by the findings of Flowers (2004), Ali *et al.* (2003), Sadiq *et al.* (2002), Mahmood *et al.* (1999), and Sinha (1991).

Conclusion

Better production could be obtained from moderately saline soils by cultivation of suitable genotype tolerant to salinity. Among all genotypes under study, sultan raya showed promising results and comparatively better performance even under high salinity (13.02 dS/m) and produced adequate yield with better quality. These results lead to conclude that sultan raya could be safely cultivated on moderately salt-affected soils.

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