

Effect of Salinity on Morpho-physiological and Seed Quality Attributes of Brassicas

V.P. Agarwal^{1*}, B.L. Kakralya¹ and S. Gupta²

¹ Department of Plant Physiology, S.K.N. College of Agriculture, Jobner 303 329, India

² College of Agriculture, S.K. Rajasthan Agricultural University, Bikaner 334 006, India

Received: May 2011

Abstract: The experiment was conducted in non-saline (ECe 2.1 dS m⁻¹ and pH 7.8) and saline field (ECe 7.5 dS m⁻¹ and pH 8.4) to study the effect of salinity on morpho-physiological parameters, photosynthetic efficiency, water relation parameters, biochemical and seed quality parameters in four *Brassica* genotypes namely T-59, CS-52, YST-151 and NDYS-2. Salinity reduced the plant height, number of branches plant⁻¹, leaf area plant⁻¹, leaf area index, number of siliqua plant⁻¹, number of seeds siliquae⁻¹, test weight, above ground phytomass productivity (biological yield), seed yield (economic yield) and harvest index. Salinity also reduced the relative water content, photosynthetic efficiency and transpiration rate at all the growth stages. In general, osmotic potential was increased, but relatively decreased in genotype CS-52. Salinity increased the total soluble sugars, but decreased protein and oil contents. It is concluded that genotype T-59 exhibited higher seed production potential among four *Brassica* genotypes under both saline and non-saline conditions due to better physiological and yield potential.

Key words: Brassicas, harvest index, leaf area index, siliquae, water-use efficiency, relative water content.

Brassicas are the second most important oilseed crop, next to soybean, both in terms of area and production (Anonymous, 2008-09). It is the most important *rabi* oilseed crop of the country. These crops are grown under wide range of agro-climatic regions due to some socio-economic reasons. Brassicas yield 30 to 48% edible oil. Mustard oil is also used in soap making, mixtures for softening leather. The oilcake is mostly used as a cattle feed. At present mustard has been identified as a good crop for bee keeping. There is a great scope for increasing the production of mustard by bringing more area under cultivation and/or by increasing productivity. The problems of soil salinity and sodicity in mustard growing areas are very common and attaining serious threats in recent times. The salinity problem is increasing every year because of the use of poor quality (brackish) irrigation water as well as poor drainage system. The salinity affects the water status of the plant and biochemical reactions of the cells (Munns *et al.*, 1982; Ghuge *et al.*, 2011) causing turgor reduction, inhibition of membrane function or enzyme activity (Wyn Jones and Gorham, 1983), inhibition of photosynthesis (Walker *et al.*, 1981), induction of ion deficiency due to inadequate transport/selectivity mechanism (Jescheke, 1984) or increased use of metabolic energy for non growth processes involved in the maintenance of tolerance (Yeo, 1983; Siddiqui *et al.*, 2009). If salt

affected soils are brought under cultivation then the overall production can be substantially increased. Therefore, a field experiment was conducted to evaluate the performance of *Brassica* species under saline soil with respect to morpho-physiological and seed quality attributes.

Materials and Methods

Seeds of T-59 and CS-52 genotypes of Indian mustard (*Brassica juncea* (L) Czern & Coss) and YST-151 and NDYS-2 genotypes of yellow mustard (*Brassica campestris* var. yellow sarson (L) Duth and Full) were obtained from NRC on Rapeseed and Mustard, Sewar, Bharatpur (Rajasthan). Seeds were sown in both normal (pH 7.8 and ECe 2.1 dS m⁻¹) and specially prepared saline field (pH 8.4 and ECe 7.5 dS m⁻¹) in the Department of Plant Physiology, SKN College of Agriculture, Jobner (Rajasthan). The plots were 4 x 3 m with row to row and plant to plant spacings of 45 cm and 15 cm, respectively. Observations on plant height, number of branches per plant, leaf area per plant, leaf area index (LAI), number of siliqua per plant, number of seeds per siliquae, test weight (1000-kernel weight), biological yield, economic yield and harvest index (HI) were recorded at the harvest. Leaf area was measured using leaf area meter (Model LI-3100, LICOR, USA). To determine LAI, leaf area was divided by ground area. HI was calculated by dividing biological yield to economic yield. Observations on osmotic potential (Janardhan *et al.*, 1975), relative

*E-mail: vishnuprakash.agarwal@rediffmail.com

Table 1. Morpho-physiological variations of four Brassica genotypes under non-stress and salt stress conditions at harvest

Genotypes	Plant height (cm)		No. of branches plant ⁻¹		Leaf area plant ⁻¹ (cm ²)		Leaf area index		No. of siliquea plant ⁻¹	
	Non-stress	Salt stress	Non-stress	Salt stress	Non-stress	Salt stress	Non-stress	Salt stress	Non-stress	Salt stress
T-59	161.3	47.30	17.3	3.30	1451.00	88.30	2.15	0.130	108.70	21.0
CS-52	175.0	63.30	10.3	3.00	1101.80	54.30	1.63	0.080	152.00	11.3
YST-151	159.0	**	24.7	**	2139.00	**	3.17	**	179.30	**
NDYS-2	103.0	**	23.6	**	842.40	**	1.25	**	199.70	**
CD(P=0.05)	10.55	2.02	1.82	0.15	145.42	3.07	0.24	0.005	14.68	0.78

** Plants did not survive.

water content (Slavik, 1974) and total soluble sugars (Dubois *et al.*, 1951) of leaves were recorded at pre-flowering stage by standard procedures. The rates of photosynthesis and transpiration were measured using infrared gas analyzer (Model LI-6200, LICOR, USA) at pre-flowering, flowering and

Lowry *et al.* (1951), whereas oil was estimated by petroleum ether (sprit) extraction method (cold percolation method).

Growth and yield observations were recorded in five replications and data were analyzed using randomized block design (Chandel, 1978).

Table 2. Effect on yield and yield components of four Brassica genotypes under non-stress and salt stress conditions

Genotypes	No. of seeds siliquea ⁻¹		Test weight (g)		Biological yield plant ⁻¹ (g)		Economic yield plant ⁻¹ (g)		Harvest Index* (%)	
	Non-stress	Salt stress	Non-stress	Salt stress	Non-stress	Salt stress	Non-stress	Salt stress	Non-stress	Salt stress
T-59	17.0	9.0	4.38	3.96	35.3	2.7	9.00	0.8	25.3 (30.2)	28.8 (32.5)
CS-52	12.4	7.4	4.03	2.67	31.0	2.3	7.8	0.3	25.0 (30.0)	12.0 (20.3)
YST-151	23.2	**	3.52	**	30.3	**	2.2	**	7.4 (15.7)	**
NDYS-2	31.2	**	3.46	**	30.0	**	2.00	**	6.6 (14.9)	**
CD(P=0.05)	2.01	0.47	0.41	0.15	2.94	0.15	0.55	0.03	2.61	0.98

*Values in parentheses are the transformed values. **Plants did not survive.

pod-formation stages. Water-use efficiency (WUE) was estimated by dividing rate of photosynthesis to transpiration. Protein and oil contents of seeds were recorded after crop harvest. Proteins were determined following the method described by

Results and Discussion

Data revealed that salinity significantly reduced plant height, number of branches per plant, leaf area per plant, LAI, number of siliquea per plant,

Table 3. Photosynthesis ($\mu\text{mol m}^{-2} \text{s}^{-1}$), transpiration rate ($\text{mmol m}^{-2} \text{s}^{-1}$) and water use efficiency (WUE) of four Brassica genotypes under non-stress and salt stress conditions

Genotypes	Stages/Parameters	Pre-flowering		Flowering		Pod-formation	
		Non- stress	Salt stress	Non- stress	Salt stress	Non- stress	Salt stress
T-59	Photosynthesis	64.48	12.29	33.77	7.43	22.46	5.02
	Transpiration	3.52	2.53	3.45	1.54	1.83	0.68
	WUE	18.32	4.86	9.79	4.82	12.27	7.38
CS-52	Photosynthesis	65.22	7.94	38.88	5.84	17.41	1.92
	Transpiration	4.19	1.12	4.85	0.96	1.68	0.58
	WUE	15.57	7.09	8.02	6.08	10.36	3.31
YST-151	Photosynthesis	51.18	**	31.69	**	16.79	**
	Transpiration	4.23	**	5.16	**	1.61	**
	WUE	12.10	-	6.14	-	10.43	-
NDYS-2	Photosynthesis	36.16	**	26.92	**	9.99	**
	Transpiration	4.65	**	5.63	**	1.59	**
	WUE	7.78	-	4.78	-	6.28	-
CD(P=0.05)	Photosynthesis	4.51	0.49	2.76	0.34	1.57	0.20
	Transpiration	0.36	0.06	0.41	0.06	0.18	0.04
	WUE	0.98	0.18	1.22	0.18	0.52	0.10

**Plants did not survive.

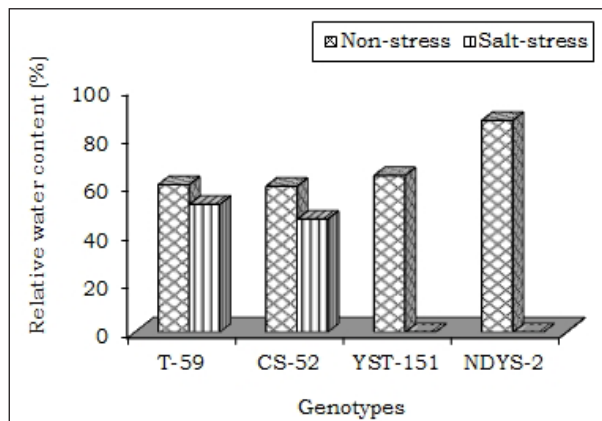


Fig. 1. Relative water content of four Brassica genotypes under non-stress and salt stress conditions (Plants of YST-151 and NDYS-2 did not survive due to high seedling mortality).

number of seeds/siliquae, test weight, biological yield per plant, economic yield per plant and HI in all the genotypes (Tables 1 & 2). Plants of CS-52 (Indian mustard) attained maximum height under both normal (175.00 cm) and saline conditions (63.33 cm) at physiological maturity. Other such parameters like number of branches per plant, leaf area per plant and LAI were highest in genotype YST-151, whereas number of siliqua per plant and number of seeds per siliquae were highest in genotype NDYS-2 under non-saline condition at harvest. The plants of YST-151 and NDYS-2 did not survive due to high seedling mortality under saline conditions. Yield attributing characters like test weight, biological yield, economic yield and HI were highest in genotype T-59 under both saline and normal soils.

The relative water content (Fig. 1), photosynthetic efficiency, transpiration rate and WUE (Table 3) were reduced on account of salinity

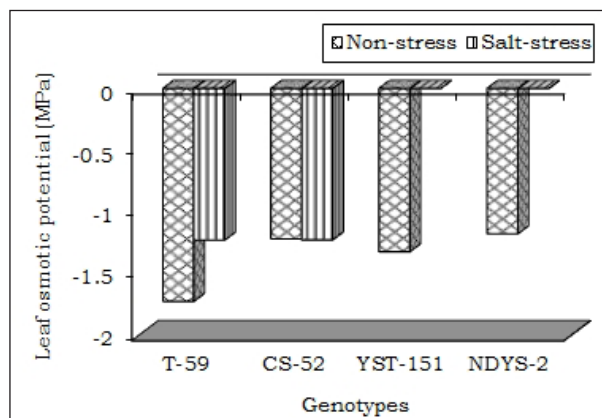


Fig. 2. Leaf osmotic potential of four Brassica genotypes under non-stress and salt stress conditions.

at all the growth stages (Kumar *et al.*, 1994; 2000; Nilsen and Orcutt, 1996; Suresh *et al.*, 1996; Ashraf *et al.*, 2004; Munns, 2005; Dubey *et al.*, 2005). Under non-saline condition, relative water content (RWC) and osmotic potential (Fig. 2) were highest in genotype NDYS-2 followed by other three genotypes. The rate of photosynthesis, transpiration and WUE at pre-flowering and flowering stages were highest in CS-52; NDYS-2 and CS-52, respectively, but, these attributes were highest in T-59 at pod-formation stage under normal field.

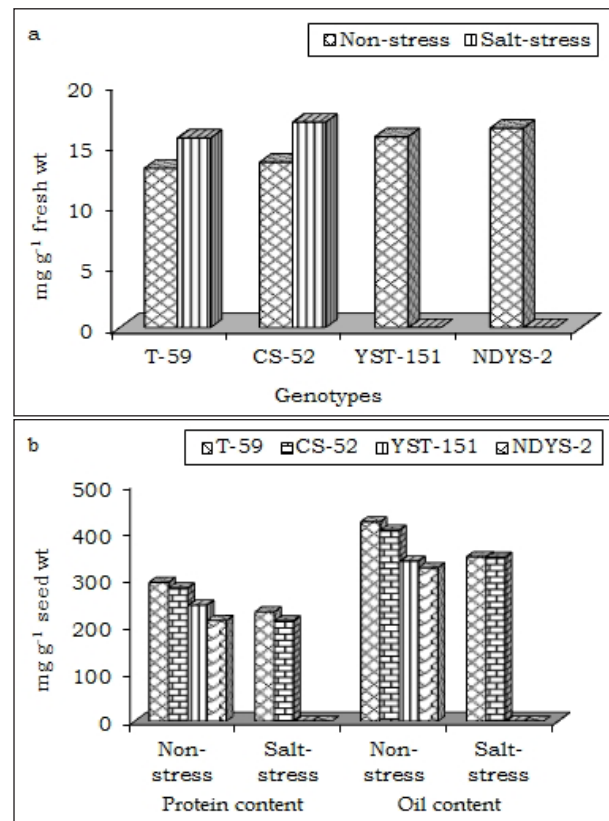


Fig. 3. Total soluble sugars (a), protein content and oil content (b) of four Brassica genotypes under non-stress and salt stress conditions.

Under saline soil, highest RWC, photosynthetic efficiency and transpiration rate were recorded in genotype T-59 at all the growth stages, while WUE was highest in genotype CS-52 at pre-flowering and flowering stages, but during pod-formation stage it was highest in genotype T-59. In general, osmotic potential was increased on account of salt stress, but non-significantly decreased in genotype CS-52 (-1.229 MPa) followed by T-59 (-1.231 MPa), which were statistically at par.

The salinity significantly increased total soluble sugars (TSS), whereas protein and oil contents were reduced (Fig. 3). Total soluble sugars (mg g⁻¹ fr. wt. of leaves) were highest in NDYS-2 under normal

field, but protein and oil contents were highest in T-59 followed by other genotypes under saline and non-saline conditions. These findings are in close agreements to the observations reported by other workers including Kumar *et al.* (2009) and Nazir *et al.* (2001).

Thus, the field performance of T-59 was found better than other three genotypes of brassicas in semi-arid environment with respect to growth, yield, photosynthesis, water relation and quality attributes. Genotypes of yellow mustard proved very sensitive to soil salinity.

References

- Anonymous 2008-2009. *Economic Survey*. Ministry of Finance, Economic Division, Govt. of India, New Delhi.
- Ashraf, M. 2004. Some important physiological selection criteria for salt tolerance in plants. *Flora* 199: 361-376.
- Chandel, S.R.S. 1978. *A Handbook of Agricultural Statistics*. VI Ed. Achal Prakashan Mandir, Parmat, Kanpur.
- Dubey, R.S. 2005. Photosynthesis in plants under stressful conditions. In *Handbook of Photosynthesis* (Ed. M. Pessarakli), pp. 479-497. CRC Press, Florida.
- Dubois, M., Gilles, K., Hamilton, J.K., Roberts, P.A. and Swin, F. 1951. A colorimetric method for determination of sugar. *Nature* 168:169.
- Ghugre, S.A., Rai, A.N., Khandagale, B.G. and Penna, S. 2011. Salt-induced stress responses of brassica (*Brassica juncea* L.) genotypes. *Archives of Agronomy and Soil Science* 57(2): 127-136.
- Janardhan, K.V., Murthy, A.S.P., Giriraj, K. and Panchaksharaiah, S. 1975. A rapid method for determination of osmotic potential of plant cell sap. *Current Science* 44: 390.
- Jescheke, W.D. 1984. K-Na exchange at cellular membranes, intracellular compartmentation of cations and salt tolerance. In *Salinity Tolerance in Plants: Strategies for Crop Improvement* (Eds. R.C. Staples and G.H. Toenniessen), pp. 37-66. John Wiley and Sons, New York.
- Kumar, A., Chhipa, B.R. and Singh, Karan 2000. Plant water relations under water stress. In *Plant Productivity Under Environmental Stress* (Eds. Karan Singh and S.S. Purohit), pp. 1-10. Agrobios, Jodhpur, India.
- Kumar, A., Singh, D.P. and Singh, P. 1994. Influence of water stress on photosynthesis, transpiration, water use efficiency and yield of *Brassica juncea* L. *Field Crops Research* 37(2): 95-101.
- Kumar, G., Purty, R.S., Singha-Pareek, S.L. and Pareek, A. 2009. Maintenance of stress related transcripts in tolerant cultivar at a level higher than sensitive one appears to be a conserved salinity response among plants. *Journal of Plant Physiology* 166(5): 7-20.
- Lowry, O.H., Rosebrough, N.J., Farr, A.L. and Randall, R.J. 1951. Protein measurement with the folin-phenol reagent. *Journal of Biological Chemistry* 193: 265-275.
- Munns, R. 2005. Genes and salt tolerance: Bringing them together. *New Phytology* 167: 645-663.
- Munns, R., Greenway, H., Delane, R. and Gibbs, J. 1982. Ion concentration and carbohydrate status of the elongating leaf tissue of *Hordeum vulgare* growing at high external NaCl. II Cause of the growth reduction. *Journal of Experimental Botany* 33: 574-580.
- Nazir, N., Ashraf, M. and Rasul, E. 2001. Genomic relationships in oilseed *Brassica* with respect to salt tolerance-photosynthetic capacity and ion relations. *Pakistan Journal of Botany* 33: 483-501.
- Nilsen, E.T. and Orcutt, D.M. 1996. *Physiology of Plants under Stress: Abiotic Factors*, John Wiley & Sons Inc., New York.
- Siddiqui, M.H., Mohammad, F. and Khan, M.N. 2009. Morphological and physio-biochemical characterization of *Brassica juncea* L. Czern. & Coss. genotypes under salt stress. *Journal of Plant Interactions* 4: 67-80.
- Slavik, B. 1974. *Methods of Studying Plant Water Relations*. Springer Verlag, New York.
- Suresh, K., Lakkineni, K.C. and Nair, T.V.R. 1996. Relationship between leaf nitrogen and photosynthetic characteristics in *Brassica juncea* and *Brassica campestris*. *Journal of Agronomy Crop Science* 177(2): 107-113.
- Walker, R.R., Torokfalvy, E., Scott, N.S. and Kriedemann, E.P. 1981. An analysis of photosynthetic response to salt treatment in *Vitis vinifera*. *Australian Journal of Plant Physiology* 8: 359-374.
- Wyn Jones, R.G. and Gorham, J. 1983. Aspects of salt and drought tolerance in higher plants. In *Genetic Engineering of Plants. An Agricultural Prospective* (Eds. T. Kosuge, C.P. Meredith and A. Hollaender). Plenum Press, New York.
- Yeo, A.R. 1983. Salinity resistance: Physiologies and prices. *Physiologia Plantarum* 58: 214-222.