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Effect of Saline Water on Relative Water Content, Rate of Photosynthesis, Chlorophyll Content and Yield of Indian Mustard (*Brassica Juncea* L.)

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Abstract

Effect of salinity on relative water content, rate of photosynthesis, total chlorophyll content and seed yield plant^{-1} of Indian mustard (viz., Urvashi, Basanti, Varuna, Rohini and Ashirwad) of five genotypes showed increasing trend with 3 dS m^{-1} salinity over normal salinity in all characters, but further increase in salinity beyond 3 dS m^{-1} recorded significant reductions in all above mentioned crop characters up to highest salinity of 12 dS m^{-1}. Among genotypes, Urvashi registered significantly highest values of all crop parameters, while Ashirwad performed poorest in all cases. Thus, Urvashi proved to be more salt tolerant than other genotypes, while Ashirwad proved to be most susceptible towards irrigation water salinity.

1. Introduction

The mustard (*Brassica juncea* L.) is an important *rabi* oilseed crop grown in across the Northern plains of India. In India, the total cultivated area, production and productivity of these crops are 5750 thousands ha, 5833 thousands tonnes and 1014 kg ha^{-1}, respectively. Uttar Pradesh is the second largest mustard producing state in the country. The area, production and productivity of these crops in Uttar Pradesh were 883.5 thousands ha, 991.9 thousands tonnes and 1123 kg ha^{-1}, respectively (Damodaram and Hegde, 2010).

Saline soil is a serious problem which affects the yield of agricultural crops by decreasing both the growth and photosynthesis. It was found that production of dry matter is severely reduced with salinity in glycophytes, but is still maintained in halophytes. Halophytes plants respond to salinity by accumulating $Na^+$and Cl^-, particularly in the older leaves (Apse et al. 1999). Excessive salts in soil adversely affect the crop growth and yield (Munns and Tester, 2008). Salinity is also considered as the major abiotic stress that restricts the economic and efficient utilization of available land resources by affecting adverse soil fertility and crop productivity and quality. The present study was aimed to evaluate the biochemical and physiological basis of tolerance of *Brassica juncea* L. to NaCl and $CaCl_2$ stress.

2. Materials and Methods

A pot experiment using 25 cm diameter pots was conducted in the Department of Crop Physiology, C.S. Azad University of Agriculture and Technology, Kanpur during *rabi* season of 2008-09 and 2009-10. The five newly evolved mustard genotypes viz., Urvashi, Basanti, Varuna, Rohini and Ashirwad were tested alongwith standard check at 5 levels of irrigation water salinity viz., normal, 3, 6, 9 and 12 dS m^{-1}. The experiment was Complete Randomized Design and replicated four times. Sowing was done during first week of October in each year. The soil was sandy loam in texture with 7.8 pH, 0.33 EC, 8.2 ESP, 18.9 CEC and 0.52% organic carbon. Irrigation water of different salinity levels was prepared in laboratory by adding required quantities of NaCl and $CaCl_2$ (4:1). Tap water was used for normal treatment of salinity. Pots filled with soil were irrigated with different treatments water before sowing. Five plants were grown in each pot. A uniform dose of 120 kg N, 60 Kg P and 60 kg K ha^{-1} through urea, di-ammonium phosphate and muriate of potash, respectively was applied to each treatment pot. The irrigations were applied light and frequent to keep the salt distribution uniform in whole pot soil. In general, irrigations were applied at weekly interval. The observations were recorded on relative water content, rate of photosynthesis, chlorophyll content and seed yield $plant^{-1}$.

Relative water content of second leaf from top was determined at 70 days after sowing using the method described by Weatherlay and Slatyer (1951). Photosynthetic rate was recorded in second top leaf at 70 days after sowing with the help of portable CO_2 gas analyzer system (Model Cl-301 CID, USA) at around 12.00 noon at saturation point of light intensity. Total chlorophyll content of leaves was determined using the method described by Arnon (1949).

3. Results and Discussion

3.1. Relative water content

Increasing levels of salinity reduced leaf turgidity upto 12 dS m^{-1} level, where significantly lowest water content was recorded during both years. The salinity levels of 6, 9 and 12 dS m^{-1} decreased relative water content by 2.97, 4.18 and 4.98% during 2008-09 and 3.46, 3.30 and 9.82% during 2009-10, respectively (Table 1). These results showed that rate of decrease in leaf turgidity increased with increasing levels of salinity beyond 3 dS m^{-1} salinity levels. The reason may be explained that increased osmotic potential in the media results decreased relative water content in leaves. It is thus directly related with exosmosis due to high concentration of salts in growing media. Similar observations were also reported by Burman et al. (2003).

Among genotypes, Urvashi being at par with Varuna maintained significantly higher leaf turgidity than other genotypes during 2009-10. Trend was almost similar during 2008-09, but genotypes did not differ significantly. Lowest relative water content was recorded in Ashirwad during both years. It might be attributed to salt tolerance capacity of genotypes which is a genetic factor. Interaction effect of genotypes x salinity was found significant during 2009-10. It indicated that at lower levels of salinity from normal to 9 dS m^{-1} levels, difference between genotypes was not significant, but at 12 dS m^{-1} salinity level, genotype Ashirwad recorded significantly lowest relative water content, while other genotypes remained at par. These results corroborate to the findings of Burman et al. (2001).

3.2. Rate of photosynthesis (μ mol CO_2 m^2S^{-1})

The salinity level of 3 dS m^{-1} increased photosynthesis significantly over normal salinity during both years (Table 2).

Table 1: Effect of saline irrigation water on relative water content (%) of mustard genotypes at 70 DAS

Varieties	Salinity levels dS m^{-1}					Mean
	Normal	3 EC_{iw}	6 EC_{iw}	9 EC_{iw}	12 EC_{iw}	
	Rabi, 2008-09					
Urvashi	84.71	84.87	80.87	77.80	73.90	80.43
Basanti	82.62	82.85	79.79	76.17	71.50	78.98
Varuna	82.90	83.17	80.30	76.35	71.80	78.90
Rohini	82.67	82.72	79.05	74.52	70.70	77.93
Ashirwad	82.15	83.00	79.72	76.02	68.32	77.84
Mean	83.01	83.32	80.35	76.17	71.24	78.82
		V	S		V×S	
SEd±		2.28	2.28		5.10	
CD (p=0.05)		4.55	4.55		N.S.	
	Rabi, 2009-10					
Urvashi	84.17	84.65	80.37	78.55	74.15	80.38
Basanti	82.77	83.00	79.57	76.00	70.77	78.42
Varuna	83.20	83.50	80.27	76.75	71.60	79.06
Rohini	82.05	82.75	79.40	74.87	70.20	77.85
Ashirwad	81.75	82.32	79.32	76.25	69.08	73.24
Mean	82.79	83.24	79.78	76.48	66.66	77.79
		V	S		V×S	
SEd±		0.97	0.97		2.17	
CD (p=0.05)		1.93	1.93		4.33	

Table 2: Effect of different salinity levels on rate of photosynthesis (μ mol $CO_2m^2s^{-1}$) of mustard genotypes at 70 DAS

Varieties	Salinity levels dS m^{-1}					Mean
	Normal	3 EC_{iw}	6 EC_{iw}	9 EC_{iw}	12 EC_{iw}	
	Rabi, 2008-09					
Urvashi	31.07	31.17	30.00	28.92	26.70	29.55
Basanti	30.25	31.00	29.75	27.72	24.27	28.59
Varuna	31.02	31.05	29.95	27.90	25.07	29.00
Rohini	30.27	30.77	29.25	27.57	24.82	28.54
Ashirwad	30.15	30.52	28.90	26.20	23.47	27.85
Mean	30.53	30.90	29.57	27.66	24.87	28.70
		V	S		V×S	
SEd±		0.13	0.13		0.28	
CD (p=0.05)		0.25	0.25		0.57	
	Rabi, 2009-10					
Urvashi	31.10	31.32	30.08	29.00	26.50	29.60
Basanti	30.20	30.93	29.62	27.63	24.53	28.58
Varuna	30.85	31.00	29.65	27.98	25.18	28.93
Rohini	30.28	30.70	29.40	27.28	24.77	28.48
Ashirwad	30.15	30.20	28.63	26.08	23.23	27.66
Mean	30.51	30.83	29.47	27.59	24.84	28.65
		V	S		V×S	
SEd±		0.12	0.12		0.26	
CD (p=0.05)		0.23	0.23		0.52	

The increasing levels of salinity viz., 6, 9 and 12 dS m^{-1} reduced photosynthesis rate than normal by the margins of 4.3, 10.5 and 19.5% during 2008-09 and 4.4, 10.5 and 19.4% during 2009-10, respectively. In case of genotypes, significant highest rate of photosynthesis was recorded in Urvashi followed by Varuna and Basanti, while lowest was recorded in Ashirwad genotype during both years. The reason for decrease in photosynthesis rate with increase in salinity levels may be explained that when plants were exposed to saline media, gas exchange of their leaves reduced. This reduction is attributed to salt damage of photosynthetic tissue to stomatal effects and consequent restriction of CO_2 availability for carboxilation to acceleration of senescence (Passarkli, 1994). Burman et al., (2001) also reported that leaf area par plant of different genotypes might be responsible for rate of photosynthesis.

Interaction effect of genotypes x salinity was found significant, which was additive type and did not alter the position of genotypes due to salinity levels and vice-versa. However, genotypes showed differences in reduction of photosynthesis rate at increased levels of salinity. From 3 dS m^{-1} to 12 dS m^{-1} salinity level, photosynthesis rate reduced by largest margin of 23.1% in genotype Ashirwad, while by lowest margin of 14.9% in Urvashi on mean basis of both years data. It might be attributed to leaf area surface of different genotypes. The results were also reported by Burman et al. (2001).

3.3. *Chlorophyll content (mg g^{-1} fresh weight of leaf tissue)*

Increase in salinity level above 3 dS m^{-1} reduced chlorophyll content significantly in progressive manner upto 12 dS m^{-1} salinity level during both years. The rate of decrease from 3 dS m^{-1} to 6, 9 and 12 dS m^{-1} levels was found 7.6, 12.5 and 23.5% during 2008-09 and; 8.4, 14.0 and 24.4% during 2009-10, respectively (Table 3). Among genotypes, significantly maximum chlorophyll content was recorded in Urvashi and minimum in Ashirwad.

The interaction effect was significant. It could not alter the position of genotypes due to salinity levels and vice-versa. It indicated that chlorophyll content reduced from 3 dS m^{-1} salinity to 6, 9 and 12 dS m^{-1} levels in genotypes Urvashi, Basanti, Varuna and Rohini and Ashirwad by the rates of 13.8, 25.4, 23.1, 29.0 and 27.4% during 2008-09 and by 15.7, 24.8, 23.9, 30.2 and 29.0% during 2009-10, respectively. Thus, rate of reduction in chlorophyll content due to increased salinity was minimum in Urvashi and maximum in Rohini genotype. Decrease in chlorophyll with increased salinity is associated with higher activity of chlorophyllase enzyme (Reddy and Vora, 1986). Differences in chlorophyll content of genotypes might be associated with salt tolerance capacity of genotypes which is a genetic character. These results are in accordance to the findings of Burman et al. (2001).

3.4. *Seed yield*

The seed yield plant^{-1} increased significantly with 3 dS m^{-1} salinity over normal salinity (Table 4). It might be associated with increase in relative water content and rate of photosynthesis which increased the translocation of photosynthetates from source to sink. Beyond 3 dS m^{-1} salinity, seed yield reduced significantly at 6, 9 and 12 dS m^{-1} levels by the margins of 12.9, 21.3 and 28.3% during 2008-09 and by 11.4, 21.9 and 27.8% during 2009-10, respectively. Such yield reductions might be attributed to decrease in relative water content, rate of photosynthesis and chlorophyll content which resulted in lesser accumulation of assimilates and their translocation from source to sink. Thakral et al. (1996) also reported similar yield results.

Among genotypes, Urvashi produced significantly highest seed yield plant^{-1}, while lowest was produced in Ashirwad. It might be associated with different metabolic process which also observed highest in genotype Urvashi. Burman et al. (2001) also reported yield variations among different genotypes of mustard under salinity conditions. These results proved that genotype Urvashi is most tolerant to salinity while Ashirwad is most susceptible among the genotypes tested.

Table 3: Effect of saline irrigation water on chlorophyll content (mg g^{-1} fresh weight of leaf tissue) of mustard genotypes at 70 DAS

Varieties	Salinity levels dSm^{-1}					Mean
	Normal	3 EC_{iw}	6 EC_{iw}	9 EC_{iw}	12 EC_{iw}	
	Rabi, 2008-09					
Urvashi	4.52	4.57	4.50	4.30	3.95	4.41
Basanti	4.47	4.49	4.17	4.02	3.35	4.10
Varuna	4.50	4.55	4.32	4.17	3.50	4.21
Rohini	4.47	4.48	3.90	3.65	3.18	3.94
Ashirwad	4.25	4.27	3.77	3.42	3.10	3.76
Mean	4.49	4.47	4.13	3.91	3.41	4.08
		V	S		V×S	
SEd±		0.05	0.05		0.12	
CD (*p*=0.05)		0.11	0.11		0.24	
	Rabi, 2009-10					
Urvashi	4.63	4.65	4.45	4.25	3.92	4.38
Basanti	4.43	4.47	4.18	4.02	3.36	4.09
Varuna	4.50	4.56	4.20	4.10	3.47	4.17
Rohini	4.47	4.51	3.87	3.60	3.15	3.92
Ashirwad	4.30	4.34	3.83	3.40	3.08	3.79
Mean	4.47	4.50	4.12	3.87	3.40	4.07
		V	S		V×S	
SEd±		0.04	0.04		0.09	
CD (*p*=0.05)		0.08	0.08		0.17	

Table 4: Effect of saline irrigation water on seed yield (g plant^{-1}) of mustard genotypes.

Varieties	Salinity levels dSm^{-1}					
	Nor-mal	3 EC_{iw}	6 EC_{iw}	9 EC_{iw}	12 EC_{iw}	Mean
		Rabi, 2008-09				
Urvashi	6.34	6.68	6.11	5.57	5.17	5.97
Basanti	6.05	6.32	5.54	4.96	4.37	5.44
Varuna	6.13	6.62	5.56	4.98	4.43	5.54
Rohini	5.64	5.67	4.78	4.40	4.15	4.92
Ashirwad	5.02	5.29	4.62	4.16	3.90	4.57
Mean	5.83	6.11	5.32	4.81	4.38	5.30
		V	S		V×S	
SEd±		0.12	0.12		0.27	
CD (p=0.05)		0.24	0.24		N.S.	
		Rabi, 2009-10				
Urvashi	6.24	6.73	6.09	5.47	5.01	5.95
Basanti	6.14	6.25	5.83	4.79	4.37	5.47
Varuna	6.18	6.44	5.63	4.94	4.44	5.53
Rohini	5.54	5.66	4.80	4.42	4.21	4.92
Ashirwad	5.01	5.32	4.58	4.12	3.88	4.58
Mean	5.87	6.07	5.38	4.74	4.38	5.29
		V	S		V×S	
SEd±		0.08	0.08		0.18	
CD (p=0.05)		0.16	0.16		N.S.	

4. Conclusion

Relative water content, rate of photosynthesis, total chlorophyll content and seed yield were influenced by soil salinity which were found increasing trend with 3 dS m^{-1} salinity over normal but beyond 3 dS m^{-1} recorded significant reductions in all above parameters. Among five genotypes of Indian mustard, Urvashi proved to be more salt tolerant and Ashirwad proved to be most susceptible than other genotypes.

5. References

Apse, M.P., Aharon, G.S., Snedden, W.A., Blumwald, E., 1999. Salt tolerance conferred by over expression of a vacuolar Na^+/H^+antiport in Arabidosis. Science 285, 1256-1258.

Arnon, D.I., 1949. Copper in isolated chloroplast polyphenol oxidase in *Beta vulgaris* L. Indian Journal of Plant Physiology 24, 1-5.

Burman, U., Garg, B.K., Kathju, S., 2001. Genotypic variations in growth, mineral composition, photosynthesis and leaf metabolism of ww Indian mustard under sodicity stress. Indian Journal of Plant Physiology 6(4), 374-380.

Burman, U., Garg, B.K., Kathju, S., 2003. Water relations, photosynthesis and nitrogen metabolism in Indian mustard grown under salt stress. Journal of Plant Biology 30(1), 55-60.

Damodaram, T., Hegde, D.M., 2010. Oil seeds situation: A statistical compendium. Directorate of Oil Seeds Research, Hyderabad, 36-60.

Munns, R., Tester, M., 2008. Mechanism of salinity tolerance. Annual Reviews of Plant Physiology 59, 651-681.

Passarkli, M., 1994. Hand Book of Plant and Crop Stress. Marcel Dekkar, New York, 78-80.

Reddy, M.P., Vora, A.B., 1986. Salinity induced changes in pigment composition and chlorophyllase activity of wheat. Indian Journal of Plant Physiology 14(4), 331-334.

Thakral, N.K., Chhabra, M.L., Singh, H., 1996. Effect of salinity on seed yields, its component characters and oil content in mustard. Crop Improvement 23(1), 131-134.

Weatherlay, P.E., Slatyer, R.O., 1951. Relationship between relative turgidity and diffusive pressure deficit in plant. Nature 177, 1085-1086.

