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MODULATION OF PLANT WATER RELATIONS BY GIBBERELLIC ACID IN MOTHBEAN UNDER SALINITY

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SUMMARY

Two genotypes of mothbean namely "IPCMO-912" and "FMM-96" were grown in non-saline and saline nursery. Plants were sprayed with gibberellic acid at 35 and 45 days after sowing in addition to pre-soaking seed treatment. The water relation parameters were estimated in leaves from 30 days to 50 days after sowing at an interval of 5 days. The water potential, osmotic potential and turgor potential decreased due to salinity in both the genotypes. However, the decrease was much higher in "FMM-96" than "IPCMO-912". Salinity caused significant decrease in leaf transpiration in both the genotypes. The fall in plant water relation parameters under salinity was alleviated to some extent by gibberellic acid treatment in the two genotypes. The hormone was more effective in alleviating salinity stress in "FMM-96" than "IPCMO-912".

Key words : **Gibberellic acid (GA_3), mothbean, salinity stress.**

INTRODUCTION

Mothbean (*Vigna aconitifolia*) is an important legume, grown in semi-arid and arid areas of India particularly in Rajasthan State. Rajasthan ranks first, both in respect of area and production giving an annual production of 1.5 to 3.3 lac tonnes and average yield of 128 kg/ha, accounting for 82% of total mothbean production in the country. It is one of the cheapest and excellent sources of protein (23.6%) and is mainly used in Bikaneri Bhujia, Papad and Namkeens, providing year long employment to the people of this area. Among various crop plants, the cultivation of grain legumes including mothbean has generally been found to be more sensitive to soil salinity (Lauchli 1984). With the emphasis given to increasing cereal production, the cultivation of mothbean and other legumes has been forced to marginal lands including those prone to salinity problem (Mahala 1998). Therefore, improvement in the salinity tolerance of mothbean is of immense importance.

Salt stress is a serious problem in arid and semi-arid zones where rainfall is not sufficient to leach down salts from the plant root zone. One of the important reasons for harmful effect of salt on the plant is due to the osmotic pressure of the external salt laden soil solution. Physiological responses of plants for survival in the stressed environment are based on their ability to express pre-existing defense programme and/or adaptation in which plants adjust to the stress. Under stress conditions the adaptive responses of the plants are elicited mainly through changes in the endogenous levels of phytohormones (Levitt 1980) and metabolic changes especially involving proline. Salt stress results in significant increase in the accumulation of proline in tomato and mulberry (Aziz *et al.* 1998, Kumar *et al.* 2000). It has been noted that hormone application before stress helped mungbean to overcome the stress effect to some extent by maintaining the intracellular water potential and ion balance which ultimately reduced the necessity of

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accumulating higher levels of proline (Chakraborti and Mukherji 2002). The restoration of hormonal equilibrium under the new environment, therefore, plays a central role in the survival of plants under stress conditions (Amzallag and Lerner 1995). Few other studies have shown that pre-soaking of seeds with 100 or 200 ppm of GA_3 or IAA is able to alleviate the detrimental effect of NaCl-salinity in soybean (Zaidi and Singh 1993, 1995). In view of above, the present investigation was undertaken to quantify the effect of GA_3 through seed treatment and spray in alleviating detrimental effect of salinity stress on water relation parameters of mothbean.

MATERIALS AND METHODS

Seeds of two genotypes of mothbean (*Vigna aconitifolia*) *viz.*, "IPCMO-912" and "FMM-96" (both developed and released from Rajasthan Agricultural University, Bikaner) were sown in a non-saline field (EC 2.25 dS/m) and saline nursery (EC 6.4 to 7.0 dS/m). Two sets of seeds were soaked in distilled water and GA_3 (100 ppm), respectively for four hours. The seeds pre-soaked in distilled water were sown in non-saline and saline soil. Seeds presoaked in GA_3 were sown only in saline soil and not under non-saline soil, as the objective of experiment was to see the ameliorative effect of gibberellic acid under saline conditions not under normal soil conditions. The plants from GA_3 treated seeds were also sprayed with GA_3 (100 ppm) at 35 DAS (vegetative stage) and 45 DAS (flowering stage) to replenish effective concentration of gibberellic acid. Plant water relation parameters were recorded in leaves of both the genotypes from 30 days to 50 days after sowing at five days interval. Leaf water potential was measured by pressure chamber (PMS Instruments Co., USA) as described by Scholander *et al.* (1965). Osmotic potential was measured using vapour pressure osmometer (WESCOR 500, USA). Turgor potential was calculated indirectly by subtracting osmotic potential from water potential (Lange *et al.* 1976) and transpiration rate was estimated by quick weighing method (Srivastava and Kumar 1993).

RESULTS AND DISCUSSION

Leaf water potential is an important parameter to indicate water status of the plant. The results showed that the salinity caused decrease in leaf water potential of both the mothbean genotypes (Table 1) but the decrease was more in "FMM-96" (169%) than "IPCMO-912" (114%). The decrease in leaf water potential in the two genotypes might be due to the reduced soil water potential during salt stress. Further, higher decrease in leaf water potential in "FMM-96" seems to be due to more transpiration losses than that in "IPCMO-912". This is supported by data on

Table 1. Effect of gibberellic acid on leaf water potential in mothbean cultivars under salinity at different days after sowing (DAS).

Cultivar	Treatment	Leaf water potential (MPa)				
		30 DAS	35 DAS	40 DAS	45 DAS	50 DAS
IPCMO-912	Non-saline	-0.74	-0.81	-0.88	-0.91	-0.95
	Saline	-1.56	-1.73	-1.79	-1.93	-1.94
	Saline + GA_3	-1.23	-1.27	-1.32	-1.36	-1.41
FMM-96	Non-saline	-0.65	-0.71	-0.78	-0.83	-0.86
	Saline	-1.69	-1.91	-1.97	-2.01	-2.06
	Saline + GA_3	-1.33	-1.37	-1.51	-1.63	-1.64
	S.Em ±	0.013	0.013	0.048	0.008	0.011
	CD (P = 0.05)	0.041	0.040	0.151	0.25	0.35

transpiration (Table 4). In addition to supply potential, transport resistance also plays a significant role in changing leaf water potential (Sterne *et al.* 1977, Sharma 1995). Pre-soaking seed treatment and subsequent sprays of gibberellic acid restored the leaf water potential to some extent (up to 28% increase over salinity control) in both the genotypes. Gibberellic acid might have helped in increasing water absorption from the soil by way of increasing root length (our unpublished results). Gibberellic acid-induced increase in leaf water potential has been observed earlier by Urwiler and Stutte (1988) in soyabean.

Salinity also decreased the leaf osmotic potential in both the genotypes at all the growth stages but the magnitude of the decrease was more in "FMM-96" than "IPCMO-912"(Table 2). Similar reports are available for *Vicia faba* (Sharma 1995) and *Phaseolus vulgaris* (Peter *et al.* 1988). The gibberellic acid treatment partially restored the leaf osmotic potential in both the genotypes. However, response of gibberellic acid application was more in "IPCMO-912"(27% increase over salinity control) than in "FMM-96" (20% increase over salinity control). Increase in osmotic potential has also been reported in *Phaseolus vulgaris* with ABA (Martinez *et al.* 1995), in soyabean with gibberellic acid application (Urwiler and Stutte 1988).

Leaf turgor potential (LTP) is an important parameter in the osmotic adjustment of the plant. The results of this study show that although there was a decrease in turgor potential, it was positive at all the stages (Table 3). Positive turgor potential, which was further increased due to application of gibberellic acid suggests for osmotic adjustment in the two mothbean genotypes. This is further supported by increased accumulation of solutes like proline and soluble sugars due to application of gibberellic acid under salinity in these genotypes (our unpublished results). However, it is evident from the results that genotype "IPCMO-912" had better osmotic adjustment since its turgor potential decreased to lesser extent (31%) than "FMM-96" (44%) under salinity. In an earlier study, application of ABA had been reported to increase osmotic and turgor potential under salinity in *Phaseolus vulgaris* (Martinez *et al.* 1995).

Salinity caused significant decrease in leaf transpiration rate of both the genotypes of mothbean (Table 4). The magnitude of the decrease was higher in "IPCMO-912" (65%) than in "FMM-96" (63%). This shows higher transpiration losses in "FMM-96" than "IPCMO-912" under salinity. Similar reports are also available in *Vicidfaba* (Sharma 1995), pearl millet (Gupta *et al.* 1987) and beans (Meiri and Poljakoff-Maber 1970). The decreased transpiration caused by salinity might be

Table 2. Effect of gibberellic acid on leaf osmotic potential in mothbean cultivars under salinity at different days after sowing (DAS).

Cultivar	**Treatment**	**Leaf osmotic potential (MPa)**				
		30 DAS	**35 DAS**	**40 DAS**	**45 DAS**	**50 DAS**
IPCMO-912	Non-saline	-1.26	-1.32	-1.38	-1.38	-1.42
	Saline	-1.94	-2.09	-2.14	-2.26	-2.51
	Saline + GA_3	-1.69	-1.72	-1.75	-1.81	-1.84
FMM-96	Non-saline	-1.32	-1.18	-1.24	-1.28	-1.29
	Saline	-1.99	-2.19	-2.23	-2.26	-2.30
	Saline + GA_3	-1.73	-1.74	-1.86	-1.99	-2.01
	S.Em ±	0.085	0.021	0.022	0.026	0.091
	CD (P = 0.05)	0.267	0.066	0.070	0.082	0.286

Table 3. Effect of gibberellic acid on leaf turgor potential in mothbean cultivars under salinity at different days after sowing (DAS).

Cultivar	**Treatment**	**Leaf turgar potential (MPa)**				
		30 DAS	**35 DAS**	**40 DAS**	**45 DAS**	**50 DAS**
IPCMO-912	Non-saline	0.52	0.51	0.50	0.48	0.47
	Saline	0.38	0.36	0.35	0.33	0.37
	Saline + GA_3	0.46	0.45	0.43	0.43	0.43
FMM-96	Non-saline	0.49	0.47	0.46	0.45	0.43
	Saline	0.30	0.27	0.26	0.25	0.24
	Saline + GA_3	0.39	0.37	0.35	0.36	0.37
	S.Em ±	0.026	0.024	0.023	0.024	0.024
	CD	0.083	0.075	0.072	0.075	0.075
	(P = 0.05)					

due to increased resistance to the transpirational flow of water caused by increased leaf diffusive resistance. Application of gibberellic acid increased the leaf transpiration rate in both the genotypes under salinity. However, the increase was more in "FMM-96" (120% increase over salinity contorl) than "IPCMO-912" (116%). Earlier studies have also shown increase in LTR under salinity with various hormones in wheat (Malibari 1993) and *Phaseolus vulgaris* (Martinez *et al.* 1995). The present study thus shows that detrimental effect of NaCl-salinity on water relation parameters of mothbean can be alleviated significantly by GA_3 through pre-soaking seed treatment and spray at vegetative and flowering stages once, using 100 ppm concentration only.

Table 4. Effect of gibberellic acid on leaf transpiration rate in mothbean cultivars under salinity at different days after sowing (DAS).

Cultivar	**Treatment**	**Leaf transpiration rate (mg g^{-1} fresh wt. $min.^{-1}$)**				
		30 DAS	**35 DAS**	**40 DAS**	**45 DAS**	**50 DAS**
IPCMO-912	Non-saline	18.90	20.17	20.93	20.96	20.62
	Saline	8.03	8.76	8.40	7.54	7.18
	Saline + GA_3	15.03	16.08	16.05	15.93	15.49
FMM-96	Non-saline	18.61	19.96	20.77	20.98	20.46
	Saline	9.05	9.63	9.34	8.01	7.54
	Saline + GA_3	16.13	17.08	17.03	16.78	16.58
	S.Em ±	0.821	0.778	0.352	0.760	0.724
	CD	2.580	2.444	1.106	2.387	2.274
	(P = 0.05)					

REFERENCES

Amzallag, G.N. and Lerner, H.R. (1995). Physiological adaptation of plants to environmental stress. In : M. Pessarketi (ed.), Handbook of Plant and Crop Physiology, pp. 557-576. Marcel Deckker, New York.

Aziz, A., Martin-Tanguy, J. and Larher, C. (1998). Stress induced changed in polyamine and tyramine levels can regulate proline accumulation in tomato leaf discs treated with sodium chloride. *Physiol. Plant.* **104** : 195-202.

Chakrabarti, N. and Mukherji, S. (2002). Growth regulator mediated changes in leaf area and metabolic activity in mungbean under salt stress conditions. *Indian J. Plant Physiol.* **7** : 256-263.

Gupta, S., Lal, P., Muralia, R.N., Kumar, A. and Srivastava, J.P. (1987). Effect of soil salinity and alkalinity on morphological parameters of pearlmillet. *Ann. Arid Zone* **26** : 25-32.

Kumar, S.G., Madhusudhan, K.V., Srinivasulu, N. and Sudhakar, C. (2000). Stress responses in two genotypes of mulberry (*Morus alba* L.) and NaCl salinity. *Indian J. Expt. Biol.* **38** : 192-195.

Lange, O.H., Kappen, L. and Schulz, E.D. (1976). Water and Plant Life. Springer-Verlag, Berlin.

Lauchli, A.C. (1984). Salt exclusion. An adaptation of legumes for crops and pastures under saline conditions. In : R.C. Staples and G.H. Toermmiessen (Eds.), Salinity tolerance in plants, pp. 171-88. John Wiley and Sons, New York.

Levitt, J. (1980). Response of Plants to Environmental Stress, vol. II. Water, Radiation, Salt and other Stresses, New York.

Mahala, S.C. (1998). Modulation of physiological and biochemical attributes of salinity tolerance by growth regulators in mothbean (*Vigna aconitifola* L.). Thesis submitted to RAU, Bikaner.

Malibari, A.A. (1993). The interactive effects between salinity abscisic acid and kinetin on transportation, chlorophyll content and growth of wheat plant. *Ind. J. Plant Physiol.* **36** : 232-235.

Martinez, R., Cachorro, P., Ostiz, A. and Cerda, A. (1995). Abscisic acid and osmotic relation in *Phaseolus vulgaris* shoots under salt stress. *J. Plant Growth Regulations* **14** : 99-104.

Meiri, A. and Poljakoff-Maber, A. (1970). Effect of various salinity regimes on growth, leaf expansion and transpiration rate of bean plants. *Soil Sci.* **109** : 26-34.

Peter, M.N., Volkenburgh, E.V. and Cleland, R.E. (1988). Salinity stress inhibits bean leaf expansion by reducing turgor, not wall extensibility. *Plant Physiol.* **88** : 233-237.

Scholander, P.F., Kammel, H.T., Brad, S.E.P. and Hemmiugern, E.A. (1965). Sap pressure in vascular plants. *Science* **148** : 339-349.

Sharma, S.K. (1995). Effect of salinity on growth performance and internal distribution of Na^+, K^+ and Cl^- in *Vicia faba* L. *Indian J. Plant Physiol.* **38** : 69-72.

Srivastava, J.P. and Kumar, A. (1993). Current perspectives in water loss from plants and stomatal action. In : M. Pessarakli (Ed.), Handbook of Plant Physiology and Crop Physiology, pp. 45-49. Marcel Dekker, New York.

Strene, R.E., Kaufman, M.R. and Zentmyer, G.A. (1977). Envrionmental effects on transpiration and leaf water potential in avocado. *Physiol. Plant.* **41** : 1-6.

Urwiler, M.G. and Stutte, C.A. (1988). Influences of GA_3 on soyabean reproductive growth. In : A.R. Cook (ed.), Proc. Plant Growth Regulators Society of America, pp. 67-68. Ithaca, New York, USA.

Zaidi, P.H. and Singh, B.B. (1993). Dry matter partitioning and yield attributes of soyabean as affected by soil salinity and growth regulators. *Legume Research* **16** : 139-143.

Zaidi, P.H. and Singh, B.B. (1995). Modulation of adverse effect of salinity by growth regulators in soyabean I. Photosynthetic area, pigment, efficiency and plant growth. *Plant Physiol. Biochem.* **22** : 136-142.