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Biomass Production, Productivity and Physiological Changes in Moth Bean Genotypes at Different Salinity Levels

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Abstract: Responses of three genotypes (CZM-105, HM-61 and RMB-108) of moth bean (*Vigna aconitifolia*) grown under four levels of NaCl salinity (0, 5, 10 and 15 dS m^{-1}) were studied on plant growth, seed yield and nitrogen metabolism at the maturity stage. Increasing salinity levels progressively decreased plant height, leaf area, shoot dry matter and seed yield in all the genotypes. However, CZM 105, displayed higher salt tolerance whereas RMB-108 was most sensitive with 48.5% reduction in seed yield at 15 dS m^{-1} of NaCl. Genotype HM-61 displayed an intermediate tolerance to salinity. Salt-induced changes in the levels of total chlorophyll, soluble protein, free amino acids and activities of nitrate reductase, glutamine synthetase, glutamate synthase and glutamate dehydrogenase were consistently less in tolerant genotype CZM 105 as compared to moderately tolerant HM-61 and salt sensitive genotype RMB-108 at all levels of salinity.

Key words: Moth bean, nitrogen metabolism, plant performance, salinity

Introduction

Legumes have generally been recognised to be sensitive or moderately tolerant to salt stress (Lauchli, 1984). However, genotypic differences in this regard have been identified in a number of legumes such as pigeonpea (Johansen *et al*., 1990), chickpea (Lauter and Munns, 1986), soybean (Abel and Mackenzie, 1964). In most of these studies, genotypic responses have often been related to Na and Cl uptake and also to the variations in the ratio of K to Na in the tissue. There has been lesser effort to link these with salt-induced metabolic deviations (Lahiri *et al*., 1996). It has been further reported (Garg *et al*., 1999) that levels of certain leaf metabolites and activities of enzymes of nitrogen assimilation were significantly less affected in tolerant than sensitive genotypes of Indian mustard under salt stress. In view of the scanty information in moth bean, the present investigation was undertaken to ascertain salinity induced alterations in growth, yield and nitrogen metabolism of selected genotypes of moth bean under varying levels of NaCl.

Materials and Methods

The present study was conducted in year 2005 with three genotypes (CZM-105, HM-61 and RMB-108) moth bean (*Vigna aconitifolia*) under pot culture conditions. Plants were grown in sealed glazed pots containing 40 kg loamy sand soil (7.1% clay, 5.9% silt, 63.1% fine sand and 24.1% coarse sand) having 0.28% organic carbon and 0.023% total nitrogen. The soil contained 80, 15 and 120 kg ha^{-1} of available N, P and K, respectively. A basal dose of 40 kg ha^{-1} of P_2O_5 sand 20 kg ha^{-1} of K_2O was given to all pots at the time of sowing.

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Salinity treatments were initiated 20 Days after Sowing (DAS) by irrigating plants with water of 0, 5, 10 and 15 dS m^{-1} NaCl salinity by dissolving required quantity of NaCl to tap water (designated as 0 dS m^{-1}), Plants were irrigated 3 times with saline water at 20, 27 and 34 days by providing each time 2 litre salt solution per pot whereas control plants received tap water. There were 20 replicates (pots) under each of the 12 treatments and two plants were maintained in each pot.

At the maturity (45 Days) two upper most fully expanded leaves were analysed, in triplicate, for total chlorophyll (Arnon, 1949), soluble protein (Lowry *et al*., 1951), free amino acids (Jawarski, 1971). At the same time, activities of nitrate reductase (Yemm and Cocking, 1955) was also determined in triplicate in the same set of leaves.

Data were also recorded on leaf area of plants under all treatments by using the LICOR LI-3000 leaf area meter. Plant performance was adjudged from the final plant height, seed yield and shoot dry matter at harvest. Data were recorded on ten replicates (20 plants) in each case. The significance of the data were assessed by analysis of variance by adopting factorial design where genotypes and salinity constituted the two variables.

Results and Discussion

Increasing NaCl levels progressively and significantly decreased plant height, dry matter of shoot and seed yield in all the genotypes (Table 1). However, reduction was maximum in genotype RMB-108 followed by HM-61 and minimum in CZM-105. At 15 dS m^{-1} salinity, reduction in plant height varied from 10.4 to 21% being minimum in cv. CZM-105 and maximum in cv. RMB-108. Increased salinity on an average decreased seed yield to the extent of 8.8 to 27.5% in different genotypes. Among the three genotypes, CZM-105 with only 17.1% reduction displayed a higher tolerance to salinity as compared to 48.5% reduction in genotype RMB-108 at 15 dSm^{-1} NaCl. Genotype HM-61 displayed intermediate salt tolerance with 24.2% reduction in seed yield at the same level of salinity. Shoot dry matter also decreased significantly with increasing salinity levels in all the genotypes. However, at 15 dS m^{-1} genotype RMB-108 experienced about 42.8% reduction as compared to only 18.2% reduction in cv. CZM-105 and 30.8% reduction in cv. HM-61. Data on leaf area at the maturity further showed similar trend of results with maximum reduction in cv. RMB-108 and minimum in cv. CZM-105 at all levels of salinity. The overall data on plant performance indicated that moth bean genotypes exhibit significant differences to NaCl salinity. Thus CZM-105 may be categorized as tolerant, HM-61 as moderately tolerant and RMB-108 as sensitive to salt stress in the present investigation. Lahiri *et al*. (1996) have also reported cv. FS-277 to be salt sensitive among 10 varieties of cluster bean under soil salinity conditions.

Salinity adversely influenced the concentrations of certain leaf metabolites at the maturity (Table 2). Increased NaCl levels progressively decreased total chlorophyll content. The reduction was

Table 1: Influence of NaCl salinity on growth and seed yield of moth bean genotypes

Salinity levels (dS m^{-1})	Plant height (cm) Genotypes				Seed yield (g $plant^{-1}$) Genotypes				Dry weight of shoot (g $plant^{-1}$) Genotypes			
	CZM-105	HM-61	RMB-108	Mean	CZM-105	HM-61	RMB-108	Mean	CZM-105	HM-61	RMB-108	Mean
0	85.0	83.8	88.0	85.6	8.25	8.10	8.55	8.30	22.9	23.7	24.8	23.8
5	80.5	78.8	80.2	79.8	8.00	7.36	7.35	7.57	21.2	21.3	19.6	20.7
10	77.9	74.0	73.2	75.0	7.36	6.90	6.81	7.02	20.1	18.7	18.0	18.9
15	76.2	72.1	69.6	72.6	6.84	6.14	5.09	6.02	18.6	16.4	14.2	16.4
Mean	79.9	77.2	77.7	-	7.61	7.12	6.95	-	20.7	20.0	19.2	-
-	Salinity	Genotype	S×G		Salinity	Genotype	S×G		Salinity	Genotype	S×G	
LSD	2.0	1.7	3.5		0.74	0.62	1.24		2.6	NS	NS	

(p = 0.05)

Table 2: Influence of NaCl salinity on levels of total chlorophyll, soluble protein and free amino acids (mg g^{-1} dw) at the flowering stage in moth bean genotypes

Salinity levels (dS m^{-1})	Total chlorophyll Genotypes CZM-105	HM-61	RMB-108	Mean	Soluble protein Genotypes CZM-105	HM-61	RMB-108	Mean	Free amino acids Genotypes CZM-105	HM-61	RMB-108	Mean
0	7.68	7.52	7.89	7.70	59.5	64.3	79.5	67.8	15.3	20.0	25.5	20.3
5	7.59	7.24	7.14	7.32	56.9	60.4	69.7	62.3	14.3	18.1	20.2	17.5
10	7.19	6.95	6.70	6.95	54.2	57.0	64.0	58.4	13.5	15.6	18.2	15.8
15	6.94	6.51	6.20	6.55	50.4	54.6	61.0	55.3	13.0	13.9	16.7	14.5
Mean	7.35	7.05	6.98	-	55.2	59.1	68.5	-	14.0	16.9	20.1	-
-	Salinity	Genotype	S×G		Salinity	Genotype	S×G		Salinity	Genotype	S×G	
LSD	0.49	NS			4.43	3.84	7.67		0.97	0.85	1.69	

($p = 0.05$)

Table 3: Influence of NaCl salinity on activities of nitrate reductase at the flowering stage in moth bean genotypes

Salinity levels (dS m^{-1})	Nitrate reductase (μg NO_2 g^{-1} dw h^{-1}) Genotypes CZM-105	HM-61	RMB-108	Mean
0	228.2	280.4	309.0	272.5
5	211.2	213.4	213.1	212.6
10	185.6	189.4	188.5	187.8
15	145.5	162.2	152.0	153.2
Mean	192.6	211.3	215.5	-
-	Salinity	Genotype	S×G	
LSD	2.0	1.7	3.5	

($p = 0.05$)

less (9.6%) in the tolerant genotype CZM-105 but was as high as 21.4% in sensitive cv. RMB-108 at 15 dS m^{-1} as compared to respective controls. Earlier studies have also indicated large decline in the level of total chlorophyll due to salinity stress in sensitive than tolerant genotypes of cluster bean (Lahiri *et al*., 1996) and other crops (Garg *et al*., 1990, 1999). The decline in soluble protein and free amino acids concentrations was also observed with increased salinity in all the genotypes (Table 2). However, the sensitive genotype RMB-108 experienced highest reduction in both soluble protein and free amino acids contents. For instance the reduction in soluble protein was 23.3% at 15 dS m^{-1} in cv. RMB-108 as compared to only 15.3% decrease in cv. CZM-105. Free amino acids also decreased by 34.6% in cv RMB-108 but only 15.0% in cv. CZM-105 at 15 dS m^{-1} indicating that tolerant genotype maintained better metabolic efficiency then the sensitive one. In all cases cv. HM-61 maintained intermediate position. Maintenance of higher protein and free amino acids concentrations under salt stress in tolerant as compared to sensitive genotypes is in concurrence with earlier reports in mustard (Garg *et al*., 1999; Burman *et al*., 2001), pearl millet (Sharma and Gill, 1991) and cluster bean (Lahiri *et al*., 1996). A simultaneous reduction in both protein and free amino acids contents under NaCl salinity indicate that synthetic process protein was more likely affected than the proteolysis (Levitt, 1980).

Increasing salinity levels progressively and significantly decreased the activities of Nitrate Reductase (NR) indicating a disruption of nitrate reduction and ammonia assimilation under salt stress. NR activity was particularly sensitive to salinity, as 36.2 to 50.8% reduction was observed at 15 dS m^{-1} in different genotypes (Table 3). However, the reduction was consistently less in cv. CZM-105 than HM-61 and RMB-108 at all salinity levels. Less reduction in NR under salt stress in tolerant as compared to sensitive genotypes has also been found in wheat (Garg *et al*., 1990), Indian mustard (Garg *et al*., 1999) and cluster bean (Lahiri *et al*., 1996).

References

Abel, G.H. and A.J. Mackenzie, 1964. Salt tolerance of soybean varieties during germination and later growth. Crop Sci., 4: 157-160.

Arnon, D.I., 1949. Copper enzymes in isolated chloroplants. Polyphenol oxidase in *Beta vulgaries*. Plant Physiol., 24: 1-15.

Burman, U., B.K. Garg and S. Kathju, 2001. Genotypic variations in growth, mineral composition, photosynthesis and leaf metabolism of Indian mustard under sodicity stress. Ind. J. Plant Physiol., 6: 374-380.

Garg, B.K., S. Kathju, Vyas and A.N. Lahiri, 1999. Genotypic Differences to Salt Stress in Indian Mustard. In: Management of Arid Ecosystems (Eds. Faroda, A.S., N.L. Joshi, S. Kathju and Amal Kar) Arid Zone Research Association and Scientific Publishers (India), Jodhpur, pp: 295-302.

Garg, B.K., S. Kathju, S.P. Vyas and A.N. Lahiri, 1990. Effect of saline water irrigation on tolerant and sensitive wheat varieties under disparate soil fertility conditions. Annal Arid Zone, 29: 179-189.

Jawarski, E., 1971. Nitrate reductase assay in intact plant tissues. Biochem. Biophys. Res. Comm., 43: 1274-1279.

Johansen, C., N.P. Saxena, Y.S. Chauhan, G.V. Subba Rao, R. Pundir, P.S. Kumar, J.V.D.K. Rao and M.K. Jana, 1990. Genotypic Variation in Salinity Response of Chickpea and Pigeonpea. In: Proceedings of the International Congress of Plant Physiology, Vol. 2 (Eds. Sinha, S.K., P.V. Sane, S.C. Bhargava and P.K. Aggarwal), Society for Plant Physiology and Biochemistry, New Delhi, pp: 977-983.

Lahiri, A.N., B.K. Garg, S.P. Vyas, S. Kathju and P.C. Mali, 1996. Genotypic differences to soil salinity in clusterbean Arid Soil Res. Rehabilit, 10: 333-345.

Lauchli, A., 1984. Salt exclusion: An Adaptation of Legumes for Crops and Pastures under Salinity Conditions. In: Salinity Tolerance in Plants: Strategies for Crop Improvement (Eds. Staples, R.C. and G.H. Toenniessen) John Wiley, New York, pp: 1171-187.

Lauter, D.J. and D.N. Munns, 1986. Salt resistance of chickpea genotypes in solutions salinized with NaCl or Na_2 SO_4. Plant and Soil, 95: 271-279.

Levitt, J., 1980. Responses of Plants to Environmental Stresses. Vol. 2 Academic.

Lowry, Q. H., N.J. Rosenbrough, A.L. Farr and R.J. Randall, 1951. Protein measurement with Folin-phenol reagent. J. Biol. Chem., 193: 262-275.

Sharma, P.C. and K.S. Gill, 1991. Effect of salinity on yield and ion distribution in pearl millet genotypes. Arid Soil Research Rehabilit, 6: 253-260.

Yemm, E.W. and E.C. Cocking, 1955. The determination of amino acids with ninhydrin. Analyst, 80: 209-230.