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Seed Source (Provenance) Variation in *Acacia nilotica* (L.) Willd. for Salinity Tolerance

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Abstract: Ten provenances (seed sources) of *Acacia nilotica* were screened for seed germination and seedling growth in media having salinity (chloride or sulphate) from 4 to 16 dS m^{-1} in laboratory conditions. Banaskantha, Chandigarh, Patna, and Bhopal provenances tolerated salinity up to 8 dS m^{-1} at seed germination and seedling growth stages, while that of Coimbatore, Baharampur and Dharwad were sensitive even at low (4 dS m^{-1}) level of salinity. Chloride-dominated salinity was more injurious to *A. nilotica* than SO_4-dominated salinity particularly at lower concentrations. However at higher levels both sulphate-dominated salinity (16 dS m^{-1}) as well as chloride-dominated salinity, were equally injurious. Protein and total carbohydrate contents were maximum in Banaskantha and Chandigarh provenances. Protein content declined significantly as the level of salinity increased, and sugar content showed a reverse trend i.e., it increased with increasing salinity. The study is useful in screening the salinity-tolerant seed sources at an early stage.

Key words: *Acacia nilotica*, provenances, salinity, seedling growth, protein, carbohydrate.

At the global level 23% of the total cultivable area is saline (Tanji, 1990). In India alone, about 20.48 lakh ha of land is affected with salinity or alkalinity (Anon., 2000). The situation is aggravating with time, particularly in the region, where low quality water is used for irrigation.

Acacia nilotica (L.) Willd (black kikar) is an integral tree component of agroforestry systems in India. The potential of *Acacia nilotica* as a multipurpose tree has been recognized world-wide. It is widely used in semi-arid regions for production of fuel-wood, timber and forage in energy plantations or agroforestry systems (National Academy of Sciences, 1983; Singh and Toky, 1995). Beniwal *et al.* (1995) studied the genetic variation in N_2, fixing abilities of 18 provenances of this species collected from all over India (9°N to 34°N latitude; 72°E to 92°E longitude). They observed significant differences amongst provenances in growth and amount of N_2 fixed and stored in plants. Similarly, wide variation in foliar biochemical and nutrient contents were also observed (Krishan and Toky, 1995). Krishan and Toky (1996) also reported variations in seed characteristics and seed germination of *Acacia nilotica*. Studies are, however, lacking in eco-physiological variations such as salt tolerance among seed sources of *Acacia nilotica*. The density of this multipurpose tree species is high particularly in semi-arid areas of north-western, central and Deccan regions of India, where salinity is a dominant factor. This is precisely the reason for the selection of this tree species to study tolerance to salinity. The present work is, therefore, an attempt to study the effect of salinity (4 to 16 dS m^{-1}) on seed germination and early seedling growth of 10 provenances of *Acacia nilotica.*

Materials and Methods

Seeds of *A. nilotica* for the present study were collected from germplasm bank located at the campus of CCS Haryana Agriculture University, Hisar, India. These seed sources of *Acacia nilotica* represent different provenances collected from all over India (Krishan and Toky, 1996). In the present study, seeds collected from 10 provenances were taken.

The salinity levels (4 to 16 dS m^{-1}) were prepared by using mixtures of salts: NaCl, $MgCl_2$, $MgSO_4$ and $CaCl_2$ for chloride-dominated salinity and Na_2SO_4, $MgCl_2$, $CaCl_2$ and $MgSO_4$ for sulphate-dominated salinity. The ratio of Na:Ca + Mg was 1:1, whereas it was 1:3 in Ca: Mg. The anion ratio for chloride-dominated salinity was 7:3 for Cl:SO_4. For sulphate-dominated salinity, the cation ratio remained the same but anion ratio became SO_4:Cl = 7:3 on meq. basis (Datta and Sharma, 1990).

Seeds were treated for 24 h in saline solution of 4 to 16 dS m^{-1} and then were surface-sterilized with 0.1% $HgCl_2$ solution for 10 seconds, and then rinsed thoroughly with distilled water. The seed coat dormancy was removed by soaking the seeds in water for 24 h (Bimlendra and Toky, 1993). Twenty five seeds were placed in each petri plate (10 cm dia.), lined with filter paper moistened with 20 mL of saline water or with tap water (control). The plates were kept in BOD incubator, at 25°C with 12 h light period. Observations were recorded after 28 days of sowing according to rules of ISTA (1985).

The dried plant material was stored for biochemical analysis. The proteins were estimated by using Folin-Ciocalteau's phenol reagent method (Lowry *et al.,* 1951). Total soluble carbohydrates were estimated colorimetrically according to the phenol sulphuric acid method (Dubois *et al.,* 1956).

The mean value of five replications was calculated and data were subjected to analysis of variance (ANOVA) using randomized block design. Significant differences between treatments and control were compared ($P>0.05$).

Results and Discussion

Among 10 provenances of *Acacia nilotica*, maximum seed germination was recorded in Patna provenance (71%), followed by Roorkee (45%), Bhopal (41%), and Banaskantha (40%), while minimum was observed in Baharampur provenance (21%) (Table 1). The different behavior shown by the provenances at the germination stage might be because of internal osmotic ion toxicity effect rather than for restriction of imbibitions as reported earlier (Rehman *et al.,* 1997).

Seedling growth in terms of dry weight, length of plumule and radicle also varied significantly ($P<0.05$) among provenances in response to salinity. Weight of plumule and radicle was maximum in Chandigarh provenance, followed by Banaskantha, Bhopal, Gurgaon and Patna provenances. Similarly, length of the plumule and radicle was the highest in Bhopal and Patna provenances, respectively. However, Coimbatore and Roorkee provenances

Table 1. Response of seed sources (provenances) of A. nilotica to salinity (values of all the salinities pooled)

Seed source	Seed germin-ation (%)	Dry weight (mg/seedling)		Length (cm)		Protein content (mg g^{-1})		Sugar content (mg g^{-1})	
		Plumule	Radicle	Plumule	Radicle	Plumule	Radicle	Plumule	Radicle
Dharwad	33	7	6	8	6	16	13	58	24
Jalandhar	34	6	8	9	4	18	16	41	39
Bhopal	41	8	7	10	5	23	13	57	47
Gurgaon	27	9	6	8	4	18	14	55	46
Baharampur	21	7	5	9	5	18	15	51	33
Chandigarh	28	10	6	8	7	21	13	48	49
Patna	71	9	6	6	10	18	17	54	36
Coimbatore	29	7	4	6	3	15	11	46	44
Banaskantha	40	10	6	6	5	23	16	63	49
Roorkee	45	8	7	7	3	19	16	60	49
CD at 5%	1.19	1.19	0.24	0.63	0.81	0.24	0.26	1.10	1.08

showed poor growth of radicle, indicating wide variations in response to salinities by different seed sources (Table 1).

Protein and sugar contents of plumule and radicle also showed significant differences among provenances. The provenances such as Chandigarh, Banaskantha, Baharampur, Patna and Jalandhar had lesser decrease in protein content under saline conditions and more decrease was observed in case of chloride-dominated salinity. Protein content of radicle also followed more or less the same trend, suggesting thereby the adaptive nature of the provenances such as Chandigarh, Banaskantha, Patna and Jalandhar. Sugar content of plumule and redicle was maximum (63 mg g^{-1}, 49 mg g^{-1}, respectively) in Banaskantha provenance and minimum (41 mg g^{-1}, 39 mg g^{-1}, respectively, in Jalandhar provenance (Table 1).

Seed germination decreased significantly with increase in levels of salinity. At 12 dS m^{-1}, the decrease in germination was more than 65% and at 16 dS m^{-1}, it further decreased to 80% (Table 2).

Similarly, the growth parameters like length and dry weights of plumule and radicle, decreased significantly at 8, 12 and 16 dS m^{-1}, respectively, recording more than 60 to 75% reduction. These results were similar to the work, which showed decreased germination with increasing salinity (Catalan *et al.*, 1994). Bimlendra (1999) carried out detailed investigation on ecophysiological parameters such as growth, water potential and biochemical contents of 1-year-old plants of 10 seed sources of *Acacia nilotica* and observed wide variation among seed sources in response to rising level of salts (SO_4 or Cl) up to 16 dS m^{-1}. Many halophytes also exhibit such sensitivity at seedling emergence (Ayers, 1952; Kuddah and Ghowail, 1964; Greenway and Munns, 1980). This indicates that while the seeds are capable of using their reserves and germinate, salt concentration becomes limiting to further seedling development. The variations observed on ecophysiological tolerance among provenances may be genetical, since wide variations have already been reported in seed germination and seedling growth (Krishan and Toky, 1996), nitrogen fixing abilities (Beniwal *et al.*, 1995; Toky *et al.*, 1995) and biochemical contents (Krishan and Toky, 1995), among the same provenances of *Acacia nilotica.*

increase in sugar content was more in plumule (20%) as compared to that of radicle (14%) at 16 dS m^{-1} (Table 2). This increase in sugar content may be because of the tendency of the embryo to adapt to the salinity. These results are in agreement with the findings of Sharma *et al.* (1993) and Hans (1997). Weimberg and Shannon (1988) suggested that in wheat, increased carbohydrate levels might lead to adaptive mechanism for overcoming the adverse

Table 2. Effect of salinity on seed germination and early seedling growth of A. nilotica (values of all the salinities pooled)

Seed source	Seed germination (%)	Dry weight (mg/seedling)		Length (cm)		Protein content (mg g^{-1})		Sugar content (mg g^{-1})	
		Plumule	Radicle	Plumule	Radicle	Plumule	Radicle	Plumule	Radicle
Control	79	13	10	11	7	27	14	53	35
4	46	11	8	10	7	20	19	54	42
8	29	7	6	9	6	18	13	56	43
12	22	5	4	7	4	10	12	59	47
16	13	3	2	3	1	6	6	63	40
CD at 5%	2.26	0.66	1.81	1.42	1.81	0.5	5.8	0.23	0.19

Protein contents of plumule declined significantly even at 4 dS m^{-1}. However, radicle showed an increase in protein content (30%) at 4 dS m^{-1}, then it declined, but the decline was lesser than that of plumule protein content even at 16 dS m^{-1} (75% and 25%, respectively). Similar results have been reported from crop plants (Reddy and Dass, 1978; Garg and Garg, 1982; Sharma *et al.*, 1996). This reduction in protein content may be because of enhanced degradation of protein under saline conditions (Reddy and Vora, 1985) due to increased protease activity.

The total carbohydrate content of plumule and radicle increased significantly with the increasing salinity levels. This

effects of salts. Sheoran (1980) also suggested that salinity decreased α–amylase activity enhancing carbohydrate contents in part of embryo. The provenances selected in the present study showed significant variations in bio-chemical and nutrient contents. These differences may be attributed to genetic variations among seed sources.

The effect of types of salinities is exhibited in Table 3. Chloride- and sulphate-dominated salinities in general, had an adverse effect on growth and the reduction was significant as the levels of salinity increased. Germination was adversely affected in chloride-dominated salinity as compared to sulphate-dominated at all the

Table 3. Effect of type of salinity (chloride or sulphate) on germination percentage and seedling growth of A. nilotica

Salinity levels ($dS\ m^{-1}$)		Seed germination (%)	Dry weight (mg/seedling)		Protein content ($mg\ g^{-1}$)		Sugar content ($mg\ g^{-1}$)	
			Plumule	Radicle	Plumule	Radicle	Plumule	Radicle
Control		79	12	10	27	20	53	40
4	Cl	39	10	10	23	19	54	42
	SO_4	55	12	9	25	19	55	43
8	Cl	23	7	9	18	15	56	44
	SO_4	35	9	6	20	17	57	45
12	Cl	15	4	4	13	10	52	45
	SO_4	27	8	5	17	13	61	48
16	Cl	8	1	2	6	5	62	45
	SO_4	12	3	2	9	9	66	50
CD at 5%		2.5	0.60	0.68	2.5	1.6	2.4	2.0

levels. The decrease in germination was 20% at 4 $dS\ m^{-1}$, while it was 5% at 16 $dS\ m^{-1}$, indicating thereby that the deleterious effect of sulphate-dominated salinity was more at higher salinity levels.

Similarly, the growth parameters like seedling dry weights and protein contents were also affected as the salinity increased. Carbohydrate, however, showed a reverse trend in case of both the types of salinities i.e., an increase in carbohydrate content was observed with the increase in salinity. However, the increase was more in chloride-dominated salinity which could be attributed to the reduced α-amylase activity in saline conditions (Sharma *et al.*, 1993; Hans, 1997).

Conclusion

The results have clearly indicated that Banaskantha, Chandigarh, Patna and Bhopal provenances tolerated salinity up to 8 $dS\ m^{-1}$ at germination stage, while Baharampur and Coimbatore provenances appeared to be sensitive even at 4 $dS\ m^{-1}$ level of salinity. On the basis of dry weight of plumule and radicle, and then protein and sugar contents, it may be concluded that Banaskantha appears to be the most tolerant provenance. Chandigarh, Patna and Bhopal provenances can grow in highly saline conditions (8 $dS\ m^{-1}$) with less than 50% reduction in growth of seedlings while Baharampur and Dharwad provenances appear salt-sensitive and can withstand salinity only up to 4 $dS\ m^{-1}$. Overall, the effect of type of salinity on *Acacia nilotica* provenances was more of chloride-dominated than that of sulphate-dominated salinity.

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References

Anonymous. 2000. *Wastelands Atlas of India*. Govt. of India, Ministry of Rural Development, Department of Land Resources. New Delhi, pp. 81.

Ayers, A.D. 1952. Germination and emergence of several varieties of barley in salinized soil cultures. *Agronomy Journal* 44: 82-84.

Beniwal, R.S., Toky, O.P. and Sharma, P.K. 1995. Genetic variability in symbiotic nitrogen fixation between provenances of *Acacia nilotica* (L.) Willd. ex Del. *Genetic Research and Crop Evolution* 42: 7-13.

Bimlendra, K. 1999. Eco-physiological studies on some provenances of *Acacia nilotica* under saline conditions. *Ph.D. Thesis*, CCS HAU, Hisar.

Bimlendra, K. and Toky, O.P. 1993. Breaking of seed coat dormancy with acids in some arid zone trees. *Journal of Tree Sciences* 12: 11-14.

Catalan, L., Balzarim, Z., Lalesnik, E., Sereno, R. and Karlin, U. 1994. Effects of salinity on germination and seedling growth of *Prosopis flexuosa* (DC). *Forest Ecology and Management* 63: 347-357.

Datta, K.S. and Sharma, K.D. 1990. Effect of chloride and sulphate types of salinity on characteristics of chlorophyll content, photosynthesis and respiration of chickpea (*Cicer arietinum* L.). *Biologia Plantarum* 32: 391-395.

Dubois, M., Gilles, K.A., Hamilton, J.K., Roberts, P.A. and Smith, I. 1956. A colorimetric method for determination of sugars and related substances. *Analytical Chemistry* 28: 350-356.

Garg, B.K. and Garg, O.P. 1982. Growth and some metabolic changes in maize leaves as affected by saline-alkaline conditions due to sodium carbonate and sodium bicarbonate. *Indian Journal of Plant Physiology* 25: 220-228.

Greenway, H. and Munns, R. 1980. Mechanism of salt tolerance in non-halophytes. *Annual Review of Plant Physiology* 31: 149-190.

Hans, K. 1997. Effect of nutrients and plant growth regulators on germination, early seedling growth and metabolism of wheat (*Triticum aestivum* L.) seed sown under different levels of salinity. *M.Sc. Thesis*, CCS HAU, Hisar.

ISTA 1985. *Seed Science and Technology*. Proceedings of the International Seed Testing Association. International Rules for Seed Testing, USA. 520 pp.

Krishan, B. and Toky O.P. 1995. Variation in foliar biochemical and nutrient contents among provenances of *Acacia nilotica* sp. *indica*. *Journal of Tropical Forest Research* 8: 78-86.

Krishan, B. and Toky, O.P. 1996. Provenance variation in seed germination and seedling growth of *Acacia nilotica* sp. *indica*. in India. *Genetic Research and Crop Evolution* 43: 97-101.

Kuddah, M.T. and Ghowail, S.I. 1964. Salinity effects on germination of corn at different stages of development. *Agronomy Journal* 56: 214-217.

Lowry, O.H., Rosebrough, N.J., Farr, A.L. and Randall, R.J. 1951. Protein measurement with folin-phenol reagent. *Journal of Biological Chemistry* 193: 265-275.

National Academy of Sciences 1983. *Firewood Crops: Shrubs and Tree Species for Energy Production*. Vol. I & II. National Academy Press, Washington, D.C.

Reddy, M.P. and Vora, A.B. 1985. Effect of salinity on protein metabolism in bajra (*Pennisetum typhoides* S & H) leaves. *Indian Journal of Plant Physiology* 28: 190-195.

Reddy, S.M. and Das, V.S.R. 1978. Effect of salinity and alkalinity on chloroplast metabolism and mineral constituents of groundnut (*Arachis hypogea* L.). *Indian Journal of Plant Physiology* 21: 265-273.

Rehman, S., Harris, P.J.C., Bourne, W.F. and Wilkin, J. 1997. The effect of sodium chloride on germination and the potassium and calcium contents of *Acacia* seeds. *Seed Science and Technology* 25: 45-57.

Sharma, P.K., Verma, S.K., Datta, K.S. and Kumar, B. 1993. Effect of different levels of salinity on physiological and biochemical drifts, ionic accumulation, growth and yield of wheat (*Triticum aestivum*). *New Botanist* 20: 167-181.

Sharma, P.K., Verma, S.K., Datta, K.S. and Kumar, B. 1996. Salinity effects on some morpho-physiological water relations and mineral composition characteristics of two cultivars of wheat with varying salt-resistance. *Annals of Biology* 10: 39-50.

Sheoran, I.S. 1980. Changes in amylase during germination and early seedling growth of mung beans (*Vigna radiata* (L.) Wilezek) under different salts. *Indian Journal of Plant Physiology* 23: 169-173.

Singh, V. and Toky. O.P. 1995. Biomass and net primary productivity in *Leucaena*, *Acacia* and *Eucalyptus*, short rotation, high density energy plantation in arid India. *Journal of Arid Environments* 31: 301-309.

Tanji, K.K. 1990. Nature and extent of agricultural salinity. In *Agricultural Salinity Assessment and Management* (Ed. K.K. Tanji). American Society of Civil Engineers, New York.

Toky, O.P., Kaushik, N. and Sharma, P.K. 1995. Genetic variability in progenies of *Acacia nilotica* (L.) ex. Del. ssp. *indica* (Benth.) Brenan for nitrogen fixing ability. *Silvae Genetica* 44: 161-164.

Weimberg, R. and Shannon, M.C. 1988. Vigour and salt-tolerance in 3 lines of tall wheat grass. *Plant Physiology* 73: 232-237.