African Journal of Biotechnology Vol. 5 (20), pp. 1973-1979, 16 October 2006
Available online at http://www.academicjournals.org/AJB
ISSN 1684–5315 © 2006 Academic Journals

Full Length Research Paper

Effects of salinity on germination, growth and yield of five groundnut genotypes

J. K. Mensah*, P. A. Akomeah, B. Ikhajiagbe and E. O. Ekpekurede

Department of Botany, Ambrose Alli University, P.M.B. 14, Ekpoma, Nigeria.

Accepted 28 August, 2006

The effects of salinity on germination, growth and yield parameters as well as phenotypic variance and heritability of five groundnut genotypes (Ex-Dakar, RRB 12, RMP 12, RMP 91 and Esan Local) were investigated. Saline treatments were imposed by irrigating the seeds and plants with varying concentrations of brackish water having electrical conductivities of 0.015, 1.50, 2.60, 4.68, 8.90 and 17.0 mS/cm. The results revealed that salinity significantly delayed germination and also reduced the final percentages at electrical conductivities greater than 2.60 mS/cm. Seedling emergence, radicle elongation, plant height and dry matter weight also tended to decrease with increasing salinity. Agronomic characters such as number of leaves/plant and number of branches/plant were significantly reduced with salinities higher than 2.60 mS/cm. The genotypes under study proved more salt tolerant during the germination than during the vegetative stage of growth and the result identified Esan- Local, Ex-Dakar and RRB 12 as being more salt tolerant than the other genotypes under study. Treated plants maintained high heritability and genetic advance values in characters such as 100 seed weight, pods/plant and seeds/pod, indicating that the characters under study were controlled by additive genes and could be improved by selection. Thus salt tolerant traits from the tolerant genotypes (Esan-Local, RRB 12 and Ex-Dakar) could be a source for developing salt tolerant variants in groundnut.

Key words: Electrical conductivity, salinity, groundnut genotypes.

INTRODUCTION

Large areas of saline soils and brackish water resources are under utilized worldwide for crop production (Oputa, 1981). In the Niger Delta area of Southern Nigeria, (circa70, 000 km^2), about 30% of the soils are saline with electrical conductivities greater than 0.5 ms/cm and hence unproductive. Irrigated lands in the arid northern parts of the country are also increasingly becoming saltier due to over fertilization and may soon be faced with the same salinity problem. One of the ways to address this problem is through the identification and planting of suitable salt tolerant crops in these seemingly unproductive habitats.

Ungar et al. (1979), Swalem (2000) and Kafi and Goldani (2000) have earlier reported on the effects of saline soils on plant growth. Salinity is known to induce stress in plants; hence the ability of plants to tolerate and thrive in saline soils is of great importance in agriculture, since it indicates that the affected plants have genetic potential for salt tolerance, which is a highly desirable trait (Francois and Maas, 1994; Mahmood et al., 2000). Groundnut continues to be a predominant crop in the agricultural system of Nigeria because it is a major source of dietary oil (42-52%) and protein (25-30%), and an important cash income for both subsistence and urban dwellers (Olorunju et al., 2002). Currently, Nigeria produces 5.9% of the world's total production and 27.7% of Africa's total production. Saline soil, which causes reductions in yield, is one of the important abiotic constraints to groundnut production. Pulses in general are sensitive and have inadequate control over ion uptake, which leads to high internal salt concentrations and results in plant injury. However, tremendous variability exists regarding salt tolerance among different species/cultivars in all pulses (Chauhan and Singh, 2000). Consequently there is differential reduction in growth and yield when grown in salt affected soils.

Information on salt tolerance of local groundnut varieties is scanty. The objective of the present study is

*Corresponding authors E-mail: mensahmensah@yahoo.com

therefore to screen five genotypes commonly cultivated by the indigenous farmers to determine which genotypes can tolerate saline environments and thus help extend the present frontiers for their cultivation.

MATERIALS AND METHODS

This study was conducted in the laboratories and botanical gardens of the Department of Botany, Ambrose Alli University, Ekpoma (Latitude 06° 42° and Longitude 06° 08° E). The mean annual rainfall is about 1760 mm with a mean temperature range of 22-31°C, which makes it ideal for groundnut production. Seeds of four genotypes used in this study were obtained from the National Seed Service, Zaria, Nigeria, while the fifth (Esan Local), was supplied by local farmers through Edo State Agricultural Development Programme Office at Irrua, Edo state, Nigeria. The genotypes used in this study are RMP 91, Esan Local, Ex-Dakar, RMP 12 and RRB 12. Saline conditions were simulated using brackish water from the estuarine ecosystem of the Niger Delta area of Nigeria. Saline water of conductivity 17.0 ms/cm was collected from the Jones Creek near Kokodiabone in Warri South Local Government Area of Delta State, Nigeria (Figure 1) and serially diluted with distilled water to obtain different salinities of conductivities 1.50, 2.60, 4.68, 8.90 and 17.0 ms/cm with the aid of a conductivity meter (Corning type). Fresh water from Ebiekuma River within the university campus, Ekpoma, with an electrical conductivity of 0.015 ms/cm was used for the control experiment.

Germination studies

Germination tests were carried out on two layers of Whatman No. 1 filter papers in 9 mm diameters petri dishes containing the five solutions. Batches of twenty seeds of each genotype were germinated in the petri dishes, which were kept under plastic cover to reduce evaporation, and placed on the laboratory bench at room temperature 24-28°C. The seeds were observed daily and the test solutions changed on alternate days and the percentage germination determined (ISTA, 1976). Seeds for seedling emergence and radicle length determinations were sown separately in vermiculite chips in seed pans and measurements taken 10 days after planting.

Pot experiments

Seeds of the five genotypes were sown in plastic buckets of 40 cm height and 20 cm diameter. To ensure adequate soil fertility throughout the experiment period, NPK (15:15:15) was added during irrigation at a rate of 0.05 g in 100 ml water. The planted seeds were irrigated with the test solutions for the six treatments, replicated three times in a randomized split plot design with salinity as the main plots and genotypes as the sub-plots. The following agronomic, physiological and yield parameters were studied: plant height, number of leaves/plant, dry weight, number of pod/plant, seeds/pod, seed/plant, 100 seed weight and yield per plant. The physiological studies included relative water content and carbohydrate content of the leaves at 56 days after planting.

Relative water content

The third leaf of each selected plant was detached for Relative Water Content (RWC) determination. The detached leaf was weighed immediately and the measurement recorded as fresh weight (FW). The cut end of the leaf was placed in distilled water in a test tube; the tube was stopped with cotton wool and kept under light condition in the laboratory following the method outline by Slatyer (1960). After 5 h, the leaves were removed, blotted dry and re-weighed to obtain turgid weight (TW). The leaves were then dried over night at 80°C and re-weighed to obtain the dry weight (DW). The relative water content (RWC) was calculated using the following formula:

$$RWC = \frac{(FW\text{-}DW) \times 100}{TW\text{-}DW}$$

There were three replicates for each salinity treatment.

Carbohydrate content

A total of 0.1 g blended samples were homogenised with a mortar and pestle and the volume made up to 50 ml with distilled water. 1 ml portions of the resultant solution were placed in test tubes and 1 ml of 50% phenol solution was added to each tube followed by rapid addition of 3 ml conc. H_2S0_4. The tubes were cooled at room temperature and the absorbance read at 490 nm. The standard solution was prepared from 0.1 g of glucose dissolved in 100 ml distilled water in a standard flask. This gave a stock solution of 0.1 mg/ml. From the stock solution, serial dilutions for standard curve were made and used to estimate the concentrations of carbohydrate in the various plant materials for the different salinity treatments.

Genetic studies

The genetic analysis was based on those parameters related to the variations in concentrations of electrical conductivity/salinity effects. The mean squares at the treatment levels were taken as the phenotypic variance (PV). To obtain the genotypic variance (GV which is the proportion of the phenotypic variance caused by variations in genes, the mean square at the error level was subtracted from their corresponding phenotypic variance for all the treatments used. The genetic parameters were as follows:

(i) Heritability (Ho) according to Allard, (1999):

$$Ho = \frac{\delta^2 g}{\delta^2 ph} \times 100$$

Where $\delta^2 g$ = genotypic variance and $\delta^2 ph$ = phenotypic variance.

(ii) Genetic Advance (GA) and Genetic Gain (GG) values were determined following the methods of Johnson et al. (1955):

$$GA = \frac{\delta^2 g}{\delta ph} \times K$$

Where K = 2.06 (selection differential at 10%), $\delta^2 g$ = genotypic variance and δph = square root of phenotypic variance.

The genetic gain (GG) was calculated in terms of the genetic advance (GA) expressed as a percentage of the population mean X.

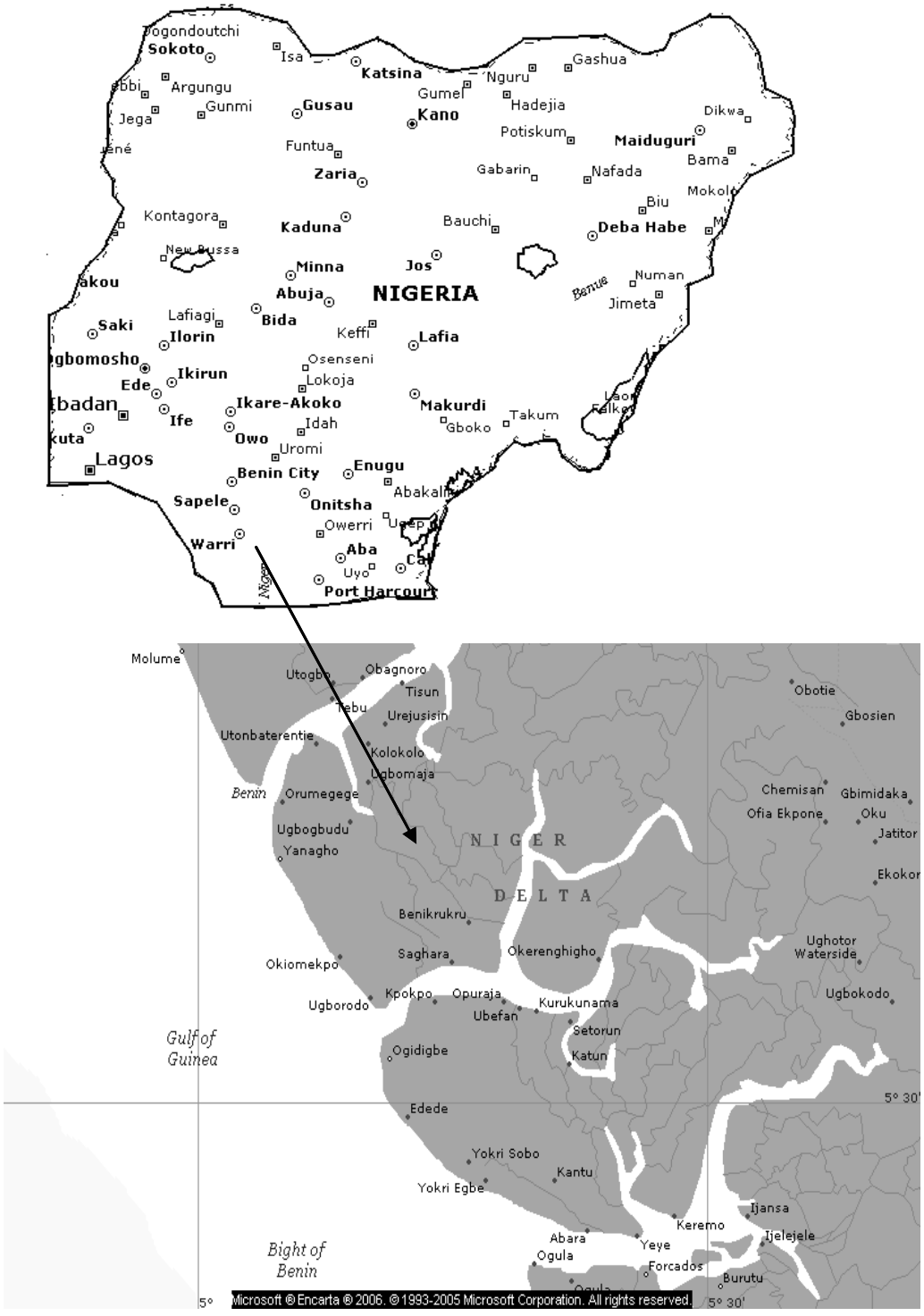

Figure 1. Map of the Niger Delta Region showing the Jones Creek where saline water was collected for this study.

RESULTS AND DISCUSSIONS

The results obtained from the germination studies are shown in Table 1. The five genotypes responded differentially to the different levels of salinity. As the concentration increases, there were corresponding decreases in the percentage germination and seedling emergence. The most effective concentrations, which depressed the germination counts, were saline solutions with electrical conductivities of 8.90 and 17.00 ms/cm.

Table 1. Effect of salinity on germination and seedling development of five groundnut genotypes from Nigeria.

Parameter	Cultivar	Salinity measured as electrical conductivity (mS/cm)					
		0.015	**1.50**	**2.60**	**4.68**	**8.90**	**17.0**
Germination (%)	Esan Local	70.0	68.5	55.2	50.4	48.4	46.4
	RRB 12	56.0	56.0	51.0	47.6	45.1	42.6
	RMP 91	57.0	50.0	37.0	33.7	30.8	27.8
	Ex-Dakar	80.0	80.0	75.2	70.4	67.6	64.8
	RMP 12	50.0	48.0	42.5	37.5	36.3	35.0
	Mean	62.6	60.0	52.1	47.9	45.6	43.3
Emergence (%)	Esan Local	70.0	67.3	55.0	48.0	44.0	38.0
	RRB 12	55.0	54.0	49.0	45.0	41.0	36.4
	RMP 91	57.0	49.0	35.0	30.0	29.0	21.0
	Ex-Dakar	79.0	78.0	74.0	68.0	60.0	54.0
	RMP 12	50.0	48.0	40.0	36.0	35.0	30.0
	Mean	62.2	59.3	50.6	45.4	41.8	34.0
Root length (mm) at 10 DAP	Esan Local	14.3	15.8	12.6	10.2	9.8	9.0
	RRB12	12.5	12.0	10.3	9.9	9.3	8.7
	RMP91	11.1	12.0	9.0	8.4	8.1	7.9
	Ex-Dakar	12.0	12.0	10.4	8.5	8.3	8.0
	RMP12	8.5	8.5	6.4	5.9	5.2	5.0
	Mean	11.1	11.5	9.1	8.2	7.7	7.3
Plant height (cm) at 56 DAP	Esan Local	32.4	34.0	27.2	24.0	22.1	20.1
	RRB12	22.6	22.2	24.2	20.9	19.2	17.4
	RMP91	22.7	23.4	19.8	18.7	16.0	13.2
	Ex-Dakar	36.8	33.7	32.4	29.1	25.6	22.0
	RMP12	23.2	23.5	16.4	14.6	13.7	12.7
	Mean	27.5	27.6	24.0	21.5	19.3	17.1
Number of Leaves/ plant at 56 DAP	Esan local	50.3	49.4	41.5	38.5	36.4	34.3
	RRB12	43.6	43.0	40.5	33.5	32.9	32.3
	RMP91	42.7	42.0	37.0	26.5	22.9	19.3
	Ex-Darkar	42.4	40.6	35.0	31.1	29.4	27.7
	RMP12	40.1	40.2	37.2	38.1	30.5	24.9
	Mean	43.8	43.0	36.2	31.5	29.6	27.7
Primary Branches / plant at 56 DAP	Esan local	6.1	6.0	5.9	5.6	5.1	4.6
	RRB12	5.7	5.9	5.6	5.1	4.6	4.5
	RMP91	5.6	5.6	5.4	5.0	4.7	4.4
	Ex-Dakar	5.6	5.6	5.3	5.0	4.8	4.6
	RMP12	4.9	5.4	5.0	4.0	3.9	3.8
	Mean	5.6	5.7	5.4	4.9	4.6	4.3

DAP = Days after planting.

The cultivar, Ex-Dakar recorded the highest percentage germination while RMP 91 recorded the least in the different saline solutions. The percentage seeding emergence in the field was however lower than what was recorded for the germination percentages. The ability of a seed to germinate and emerge under salt stress indicates that it has genetic potential for salt tolerance (Tejovathi et al., 1988). The effect of the saline conditions was more on number of days to achieve germination (speed of germination) and percentage seedling emergence than percentage germination (Table 2). The present result agrees with the reports of Francois et al. (1984)

Table 2. Summary of the effects of saline conditions on five germination characteristics of groundnut genotypes.

Conductivity of caline solution (mS/cm)	Germination Characteristics			
	No. of days to germination	Germination (%)	Emergence (%)	Radicle length at 10 DAP (cm)
0.015	3	72.4	62.6	11.1
1.50	3	72.0	60.5	11.5
2.60	3	70.8	52.1	9.1
4.68	4	70.0	47.9	8.2
8.90	5	69.6	45.6	7.7
17.7	**>6**	**60.8**	**40.0**	7.3

Table 3. Effects of Salinity on some physiological and yield parameters of five groundnut genotypes.

Parameter	Cultivars	Salinity measured as electrical conductivity (mS/cm)					
		0.015	1.50	2.60	4.68	8.90	17.00
Dry weight of vegetative parts at 54 DAP (g)	Esan local	6.2	6.8	6.9	4.7	3.0	3.7
	RRB12	4.3	4.7	5.2	4.7	4.4	3.6
	RMP12	4.3	4.3	4.4	3.7	2.2	1.6
	Ex-Dakar	4.2	3.8	3.4	2.4	1.9	1.7
	RMP12	4.5	4.2	4.1	3.6	3.5	3.5
	Mean	4.7	4.8	4.8	3.8	3.0	2.8
Relative water Content of leaves (%)	Esan local	84.26	81.14	89.53	88.28	88.45	85.00
	RRB12	84.8	83.00	85.50	84.79	81.90	79.50
	RMP91	81.60	80.80	76.70	78.50	78.00	78.50
	Ex-Dakar	78.50	76.50	74.51	70.00	70.00	70.00
	RMP12	70.28	71.44	71.32	72.50	70.00	72.50
	Mean	79.89	78.58	79.51	78.81	77.67	77.10
Carbohydrates in leaves (%)	Esan local	3.6	3.5	3.5	2.3	2.8	1.6
	RRB12	2.6	2.6	2.6	2.6	2.1	2.1
	RMP91	3.1	3.2	3.7	3.3	2.6	1.9
	Ex-Dakar	2.5	2.3	2.3	2.1	2.4	2.3
	RMP12	2.4	2.6	2.8	2.4	2.2	2.0
	Mean	2.84	2.84	2.98	2.54	2.42	1.98
Number of pod/plant	Esan local	23.0	21.8	20.9	14.7	8.8	8.4
	RRB12	16.3	15.9	14.6	11.2	6.3	6.1
	RMP91	16.1	15.2	13.8	10.0	6.0	5.7
	Ex-Dakar	16.0	15.7	15.5	10.9	8.4	63
	RMP12	16.0	16.0	13.5	11.1	7.0	6.5
	Mean	17.48	16.92	15.66	11.58	7.3	6.6
Number of Seeds/pod	Esan local	1.8	1.9	2.1	1.71	1.6	1.50
	RRB12	1.4	1.6	1.8	1.4	1.35	1.30
	RMP91	1.4	1.7	1.7	1.38	1.35	1.30
	Ex-Dakar	15	1.8	1.8	1.5	1.4	1.3.
	RMP12	1.3	1.9	1.7	1.25	1.30	1.27

Table 3. Contd.

	Mean	1.48	1.78	1.82	1.45	1.40	1.33
Number of Seeds/plant	Esan local	41.4	41.4	43.9	25.2	14.1	12.6
	RRB12	22.8	25.4	26.3	15.7	8.6	7.6
	RMP91	22.5	25.8	23.5	13.8	8.1	7.4
	Ex-Dakar	24.0	28.3	27.9	16.4	11.8	8.2
	RMP12	20.8	30.4	23.0	13.9	9.1	8.3
	Mean	26.30	30.26	28.92	17.00	10.34	8.88

and Francois (1985) on sorghum and squash, respectively, where they observed decreases in percentage germination and seedling emergence with increases in salinity.

The radicle length of the five groundnut genotypes differed under the different salinity levels as shown in Table 1. The Esan Local genotype had the longest radicle length (9.0 mm) and hence the least affected by the saline conditions and this was followed by RRB 12 (8.7 mm) while RMP12 (5.0 mm) was the most adversely affected by the saline solutions. The trends observed in the germination and shoot emergence studies as well as radicle length determinations were similar; that is, increasing salinity (measured by the electrical conductivity of the irrigation water) led to reductions in the value of the specific parameter under study. The present observations are in line with earlier reports in wheat (Hurd, 1974), goat weed (Singh and Jain, 1989) sorghum (Sullivan and Ross, 1979) and chickpea (Al-Mutawa, 2003) where increases in salinity also led to decreased radicle lengths.

The results of the field studies revealed decreases in plant height and vigour with increases in salinity. However, the Esan-Local, and RRB12 genotypes showed slight increases in vigour under low saline concentrations (1.50 mS/cm). The least mean plant height under 17.0 mS/cm salinity was recorded in RMP 12 (Table 1). Furthermore, there was a decrease in the mean number of leaves per plant with an increase in the salt concentration (>2.6 mS/cm). The result agrees with the report of Akomeah et al. (1991) in *Machaerium lunatus* where it was observed that low salinity of 1% seawater (with electrical conductivity of about 0.05 mS/cm) enhanced the production of leaves compared to control plants grown in distilled water as well as plants irrigated with higher saline solutions.

Generally, at high saline concentrations (8.9-17.0 mS/cm), the dry weight of the groundnut genotypes under study decreased. The present result is in agreement with the work of Hassan et al. (1970) in Barley, Abdul-Halim et al. (1988) in wheat, and Al-Mutawa (2003) in chickpea, in which the authors observed that high saline concentrations decreased the dry weights of the affected crops.

The carbohydrate and relative water contents of the leaves of the groundnut genotypes followed similar trends as the dry weight except in RMP 91 and RMP 12, which showed slight increases in carbohydrate content with increasing salinity. This observation agrees with the earlier reports of Rathert (1984) who reported that plants which are stressed by salinity accumulate starch and soluble carbohydrates in their leaves. However at higher concentration (8.9-17.0 mS/cm), the carbohydrate concentrations were lower than what was recorded in the control.

Available literature (Hurd, 1974; Singh and Jain, 1989 and Abdul-Halim et al., 1988) indicates that under salinity stress, plants tend to record low yields because of adverse effects of salinity on such parameters as relative water content, total dry weight, plant height and number of leaves per plant. This is because salinity inhibits plant growth by exerting low water potentials, ion toxicity and ion imbalance (Greenway and Munns, 1980; Sharma, 1997). The ability of any genotype to maintain agronomic parameters at near control levels therefore confers salt tolerance. Based on the total dry weight, number of leaves per plant, plant height and yield per plant, the order of salinity tolerance of the five groundnut genotypes is Esan-Local> Ex-Dakar >RRB12>RMP12> >RMP 91.

The broad based heritability estimates, genetic advance and genetic gain of the yield parameters in both the control and treated plants have been presented in Table 4. The genotypic variance (GV) ranged from 0.11 to 14.35 while the phenotypic variance (PV) ranged from 0.12 to 26.80. Consequently, the heritability estimates of 40.73-93.95% were moderate to high in both the control and treated plants. The results also show that, even though there were significant changes within the treatment means (Table 3), genetic parameters such as heritability and genetic gain were not adversely affected by the different salinities. The possible explanation is that the changes in the mean values of the characters as observed in the present investigations are mainly physiological in nature and would be reversed when grown under environments with lower electrical conductivities/salinity.

It could therefore be inferred from the present study that the yield characters under investigations could successfully be selected among the genotypes for impro-

Table 4. Variations in genetic parameters due to the effects of salinity on some agronomic and yield characters among five genotypes of groundnut from Nigeria.

Character	Treatment	Genetic Characteristics					
		Mean	Phenotypic Variance	Genotypic Variance	Heritability %	Genetic advance	Genetic gain
Plant height (cm)	Control	27.5	10.10	9.23	91.95	2.90	10.55
	Treated	21.9	9.91	9.31	93.95	3.16	14.41
No of pods/plant	Control	21.50	25.29	10.31	40.72	2.05	9.53
	Treated	18.33	26.80	10.20	38.06	1.97	10.74
No of seeds/pods	Control	1.44	0.12	0.11	85.71	0.32	22.47
	Treated	1.52	0.14	0.12	93.55	0.32	21.34
No of seeds/plant	Control	30.96	0.31	0.29	93.55	0.52	1.67
	Treated	27.86	0.34	0.28	82.35	0.58	2.09
100 seed weight (g)	Control	15.96	12.80	10.40	81.25	2.90	18.20
	Treated	14.82	11.90	10.43	87.65	3.02	20.40
Yield/plant (g)	Control	49.12	16.64	14.35	74.38	3.53	7.18
	Treated	41.90	17.28	13.88	80.32	3.34	7.96

vement in saline environments. Since the laboratory and pot experiments have identified Esan-Local, Ex-Dakar and RRB 12 as the most salt tolerant genotype, these genotypes could serve as a source of genetic material for the development of salt tolerant variants.

REFERENCES

Abdul-Halim RK, Salih HM, Ahmed AA, Abdulrahem AM (1988). Growth and Development of Maxipax wheat as affected by soil Salinity and Moisture levels. Plant and Soil 112:255-259.

Allard RW (1999). Principles of Plant Breeding, John Willey and Sons. New York.

Akomeah PA, Eze JMO, Bamidele JF (1991). Germination studies of an estuarine plant *Machaerium lunatus* (L.) G.F. Mey, Afr. J. Agric. Sci. 180:145-157.

Al-Mutawa MM (2003). Effect of salinity on germination and seedling growth of chick pea (*Cier arietinum* L.) genotypes. Intl. J. Agro. Biol. 5:227-229.

Chauhan MP, Singh IS (2000). Variability estimates and identifying chick pea genotypes for yield and yield attributes in salt affected soil. Legumes Res. 23:199-200.

Francois LE, Donovan T, Maas EV (1984). Salinity effects on seed yield, growth and germination of grain sorghum. Agron. J. 76:741-744.

Francois LE (1985). Salinity effect on germination, growth and yield of two squash cultivars. Hort. Sci. 20:1102-1104.

Francois LE, Mass EV (1994). Crop response and management on salt affected soils.pp. In Pessaraki, M. (ed), Handbook of Plant and Crop Stress. Dekker, New York. pp. 149-180.

Greenway H, Munns R (1980). Mechanism of salt tolerance in non-halophytes. Ann. Rev. Plant. Physiol., 31:149-190.

Haasan NA, Drew JV, Knusen DA, Olsen RA (1970). Influence of soil salinity on production, uptake and distribution of nutrients in barley and Com. I: Barley (*Hordeum vulgare L.).* Agron. J. 62:43-45.

Hurd KA (1974). Phenotype and drought tolerance in wheat. Agric. Method, 14:39-55.

ISTA (1976). International rules for seed testing association. Norway Seed. Sci. Technol. 4:2-49.

Johnson HW, Robinson HF, Comstock RE (1955). Estimation of genetic and environmental variability in soybean. Agron. J. 47:314-318.

Mahmood IA, Nawaz S, Aslam M (2000). Screening of rice (*Oryza sativa* L) genotypes against salinity. Intl. J. Agric. Biol. 2(1- 2):147-150.

Kafi M, Goldam M (2000). Effect of water potential and type of osmoticum on seed germination of three crop species of wheat, sugarbeet and chickpea. Agric. Sci. Tech. 15:121-133.

Olorunju PE, Alabi SO, Ntare BR, Pande S, Reddy V (2002). The application of biotechnology to groungdnut (*Arachis hypogaea* L.) with reference to the Groundnut Rosette Disease. Proc. Biotechnol.: Commercialisation and food security at Sheraton Hotel and Towers, Abuja-Nigeria Lad-Link International Agency for the Sheda Science and Technology Complex, Abuja. October 24-27, 2000.

Oputa CO (1981). Response of *Celosia argentea* L. to salinity, morphological changes and ionic adjustments. Niger. J. Sci. 3:45-53.

Rathert G (1984). Sucrose and starch content of plant parts as possible indicator for salt tolerance of crops. Austr. J. Plt. Physiol. 11: 491-495.

Sharma SK (1997). Plant growth, photosynthesis and ion uptake in chickpea as influenced by salinity. Indian J. Plant Physiol. 2:171-173.

Singh M, Jain R (1989). Factors affecting goatweed (*Scoparia dulcis)* seed germination. Weed Sci. 37: 766–770.

Slatyer RO (1960). Aspects of the tissue water relationship of an important arid zone species (*Acacia aneura* F.Muell) in comparison with two mesophytes. Bull. Res. Counc. Isr. Sec. D. 8:675-680.

Sullivan CI, Ross WM (1979). Selection for drought and heat resistance in grain sorghum. In, Stress physiology in crop plants. Mussel H, Staples RC (eds), John Wiley and Sons. New York. pp. 263- 281.

Swalem A (2000). Saline irrigation management and salt tolerance of chickpea varieties. *M.Sc.Thesis* No.207, Mediterranean Agronomic Institution (IAM) Bari. p. 166.

Tejovathi G, Khadeer MA, Anwer SY (1988). Studies on certain enzymes in salt tolerant and sensitive varieties of sunflower. Indian J. Bot. 11:113–117.

Ungar IA, Benner DK, McGraw DC (1979). The distribution and growth of *Salicornia europa* on inland salt pan. Ecology 60:39–336.