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Sustainable Production of Groundnut (*Arachis hypogaea L.*) Through Screening and Selection of Soil Salinity-Tolerant Genotypes

Otitoloju Kekere[1*]

[1]Department of Plant Science and Biotechnology, Adekunle Ajasin University, Akungba Akoko, Ondo State Nigeria.

Author's contribution

The study was designed, analyzed and discussed by the author. The author takes full responsibility for the whole study including data collation, manuscript drafting and editing.

Original Research Article

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ABSTRACT

Crop plants that are tolerant to soil salinity are needed for a sustainable food production in areas where there is salt build-up caused by irrigation practices. Ten groundnut (*Arachis hypogaea L.*) genotypes (ICGY-6M-5236, ICG-IS-11687, ICGY-5M-4746, ICG-IS-6646, ICG-IS- 3584, ICG49-85A, UGA-7-M, RRB12, RMP91 and RMP12) were screened in laboratory and field studies to identify those tolerant to soil salinity. Plants were irrigated with 0 (control), 25, 50, 100, 150 and 200mM NaCl solution, prepared artificially from table salt. Germination rate and percentage germination decreased with increasing salinity. RRB12, RMP91 and RMP12 did not germinate up to 200mM while others germinated with low percentages. Agronomic characters were significantly reduced by salinity above 50mM NaCl. Biomass and growth decreased with increasing salinity. Mortality of 25-40% was caused at 150mM but only ICGY-5M-4746 and ICG-IS-6646 did survive at 200mM with 52.17 and 55.16%, respectively. Plants irrigated with saline water had lower yield than the control. However, ICGY-5M-4746 did not produce pods at 200mM while ICG-IS-6646 produced pods without seeds at maturity. There was a large variation in germination, plant survival and yield among the genotypes. ICGY-5M-4746, ICG-IS-6646 and ICG-IS-3584 with high survival and yield under high salinity were identified as salt tolerant genotypes and recommended for planting in soil with salinity below 200mM NaCl. The traits from the salt tolerant genotypes could be a source for developing salt tolerant variants for improvement in groundnut production.

**Corresponding author: Email: kekereekunnoi@yahoo.com;*

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1. INTRODUCTION

Groundnut (*Arachis hypogaea L*.) is an annual plant belonging to Fabaceae family. It is grown in more than 100 countries around the world under different agro-climatic conditions, and Nigeria is one of the major producing countries [1]. Groundnut is the 13th most important food crop of the world, the world's 4th most important source of edible oil and 3rd most important source of vegetable protein. Its seeds contain high quality edible oil (50%), easily digestible protein (25%) and carbohydrate (20%). Globally, 50% of groundnut produced is used for oil extraction, 37% for confectionery use and 12% for seed purpose. Its haulms (vegetative plant part) also provide excellent hay for feeding livestock [1]. Groundnut world production (millions tonnes), harvested area (millions ha) and yield (tonnes/ha) increased from 15 to 36, 17 to 24 and 0.9 to 1.5 respectively, between 1960s and 2007. Its production, harvested area and yield are projected to increase to 68millions tonnes, 35millions ha and 2.0tonnes/ha in 2050 respectively, to meet up with increasing human population for food and industrial use. Unfortunately, its production is decreasing while its demand is increasing. Groundnut as an oil crop in oil equivalent growth rate has decreased from 2.8 in 1990 to 1.5 in 2005, which may further decrease to 1.4 in year 2030 [1]. This decrease is largely due to climatic variations, biotic influence and abiotic stresses [2].

In arid and semi-arid regions of the world, yield relies largely on irrigation practices for crop production. Unfortunately, some of the water for irrigation purposes contain salt, which builds up in soil over a period of time. Soil salinization is a fast growing problem of agriculture, with about 23% of the world's cultivated land being saline, causing reduction in crop productivity and loss of arable land [2]. Soil salinity has been widely reported to negatively affect germination, growth and yield of many crop plants [3-7]. Unfortunately, this problem will continue as long as irrigation is being practiced, and it is expected that there would be about 30% arable land loss within the next 25 years due to salinity [2]. Therefore, selection of salt tolerant genotypes has become a necessity for sustainable crop production. Salinity has been reported to negatively affect germination of many groundnut genotypes [8-11]. Also, soil salinity has negatively affected growth and yield in most genotypes of groundnut [12-19]. Only few of groundnut genotypes can endure the salinity stress and also yield satisfactorily [11-12]. Those genotypes with high survival and seed yield are categorized as salinity tolerant genotypes. Thus, soil salinity must have contributed to reduced areas of groundnut cultivation and total productivity; hence selection of salt tolerant genotypes becomes a necessity to cope with its demand for food and industrial use. This selection will alleviate salinity stress and bring about more areas suitable for groundnut cultivation. This research is aimed at selecting salt tolerant accessions by investigating germination, growth and yield performance of 10 groundnut genotypes from Nigeria.

2. MATERIALS AND METHODS

2.1 Groundnut Genotypes

The ten genotypes were from different research centers within Nigeria. ICGY-5M-4746, ICG-IS-11687, ICGY-6M-5236, RRB12, RMP12 and RMP91 were from Zaria, ICG49-85A and

UGA-7-M from UNAAB (University of Agriculture Abeokuta), while ICG-IS-6646 and ICG-IS-3584 were from UNILORIN (University of Ilorin).

2.2 Preparation of Saline Water

Concentrations of 25, 50, 100, 150 and 200mM NaCl saline solutions were prepared in plastic kegs just before each treatment by dissolving weighed amount of commercially available salt in tap water to make the desired concentrations. One molar solution was prepared by dissolving 58.5 g (molar mass of NaCl) in water to make 1litre. This quantity (58.5g) was divided by 1000 to make 1mM solution, and was subsequently multiplied by the desired value of mM and number of litres to be prepared, to account for the amount of salt to be dissolved in water.

2.3 Germination Experiments

Twenty seeds of each genotype were placed on 2 layers of Whatman No. 1 filter papers soaked with the different saline solutions in petri dishes. Each treatment was replicated 3 times and arranged on laboratory bench at room temperature, in the Department of Plant Science and Biotechnology, Adekunle Ajasin University, Akungba Akoko, Ondo State Nigeria (70371N latitude, 50441E Longitude). The seeds were observed daily and germination was defined as emergence of radicle. The day of initiation of germination after sowing and the percentage of seeds that germinated at the end of the experiment were recorded.

2.4 Field Preparation and Experimental Set Up

The study was conducted at the experimental farm of Plant Science and Biotechnology Department, Adekunle Ajasin University, Akungba Akoko, Ondo State, Nigeria (70371N latitude, 50441E Longitude and 100m above the mean sea level). The soil had 5.60 pH, 6.19% clay, 4.29% silt, 89.7% s and, 2.89% C, 0.14% N, 9.02mg/100 g P, 6.24mg/100g Ca, 1.84mg/100 g Mg, 0.34mg/100g Na, 0.23 mg/100 K, 0.20mg/100 g H and 8.86mg/100g CEC. The field was prepared manually, and seedlings of the different genotypes of *A. hypogaea* were raised following recommended agronomic practices. Each genotype was sown in single row plots, seeds spaced at 20 cm with inter-row spacing of 45cm. Twenty days after seedling emergence, plants were thinned to one plant every 45cm. The experiment was conducted in randomized block design (RBD) with 5 replications. Seedlings were irrigated with saline water with 0 (control), 25, 50, 100, 150 and 200mM NaCl. Irrigation was done at the root zone of the plant to ensure that the relative level of soil salinity would be the primary cause of any observed effect rather than combined effect of soil and air-borne salinity. To prevent osmotic shock, plants were irrigated at the root zone by gradual 25mM increments at 2-day intervals to reach the maximum salinity level of 200mM NaCl after 14 days [20]. Survival, growth and yield of *A. hypogaea* at the different salinity levels were recorded after 12 weeks of treatment.

2.5 Survival and Growth Determination

Plant survival was monitored till the end of the experiment (12 weeks after treatment), which was equivalent to 114 days after sowing. Plant height was measured with meter rule. The

leaves and primary branches on individual plants were counted. At maturity, pods were harvested and the vegetative plant parts were oven-dried and weighed.

2.6 Yield Measurement

Fresh pods were sun dried at harvest. Number of pods per plant, number of seeds per pod, number of seeds per plant and 100 seed mass were recorded.

2.7 Statistical Analysis

Data were subjected to single factor ANOVA and means were separated with Tukey Honest Significant Difference (HSD) test using SPSS version 17.0 software (SPSS Inc., Chicago, IL, USA) at 95% level of significance.

3. RESULTS

The results indicated that salinity delayed germination and reduced germination percentage with large genotypic variations (Table 1). Salinity of 25-50mM did not delay germination but higher concentrations delayed germination by 1-2 days depending on the genotype. Salinity considerably reduced percentage germination in the genotypes. However, RRB12, RMP91 and RMP12 did not germinate up to 200mM, others germinated but with low percentages. Plant mortality increased with an increase in salinity in water used for irrigation (Table 1). Mortality varied with genotypes. Salinity below 60mM did not cause mortality in any of the genotypes but higher level did, which increased with an increasing salinity. The lowest mortality of 24.14 and 24.56% were obtained at 150mM for ICGY-5M-4746 and ICG-IS-6646, respectively. In addition, only the two genotypes did survive at 200mM with 52.17 and 55.16 %, respectively. Plant height, number of leaves, number of nodes on primary stem, number of primary branches and biomass of vegetative parts were lower under salt stress than in control (Tables 2 and 3). The decrease in the growth parameters occurred in all the genotypes, with increase in the concentration of salt in water of irrigation. Data could not be taken for the genotypes at 200mM as a result of complete mortality, except ICGY-5M-4746 and ICG-IS-6646 that survived.

Generally, salinity negatively affected yield with yield parameters decreasing as salt concentration increased (Tables 4 and 5). The number of pods and related yield traits produced by *A. hypogaea* irrigated with saline water showed extreme variations among genotypes (Table 4). Of the 2 genotypes that survived at 200mM, ICGY-5M-4746 did not produce pods while ICG-IS-6646 produced pods without seeds.

Table 1. Germination performance and survival of groundnut (*Arachis hypogaea*) genotypes under salinity stress

Groundnut genotype	Percentage germination						Days of initiation of germination						Plant percentage survival					
	0	25	50	100	150	200	0	25	50	100	150	200	0	25	50	100	150	200
ICG-IS-6646	100[a].	100[a]	100[a]	90.34[a]	68.86[b]	48.88[b]	3.12[a]	3.04[a]	3.3[a]	4.06[ab]	4.07[ab]	4.05[ab]	100	100	98.23	85.75	75.82	55.16
ICG-IS-3584	100[a]	100[a]	100[a]	80.70[a]	60.54[b]	56.67[b]	3.03[ab]	3.06[ab]	3.06[ab]	4.00[a]	4.04[a]	4.00[a]	100	100	85.74	74.23	60.02	-
ICGY-5M-4746	100[a]	100[a]	100[a]	89.55[a]	64.33[b]	31.71[c]	3.11[b]	3.11[b]	3.05[b]	5.04[a]	5.00[a]	5.00[a]	100	100	97.57	81.34	72.44	52.17
ICG-IS-11687	100[a]	100[a]	97.75[a]	80.23[a]	49.75[b]	52.34[b]	3.21[b]	3.21[b]	3.04[b]	4.05[abb]	5.00[a]	6.03[a]	100	100	86.84	72.20	60.20	-
ICG49-85A	100[a]	100[a]	92.28[a]	81.45[a]	50.34[b]	27.14[c]	3.21[b]	3.21[b]	3.07[b]	5.06[ab]	5.02[ab]	6.00[a]	100	100	87.33	73.00	52.00	-
ICGY-6M-5236	100[a]	100[a]	96.32[a]	84.74[a]	51.35[b]	23.47[c]	3.10[b]	3.00[b]	3.20[b]	5.00[a]	5.07[a]	5.03[a]	100	100	85.46	75.23	54.04	-
UGA-7-M	100[a]	100[a]	92.33[a]	81.80[a]	52.12[b]	32.86[bc]	3.20[b]	3.04[b]	3.10[b]	5.00[ab]	5.00[ab]	6.00[a]	100	100	84.57	72.00	51.27	-
RRB12	100[a]	100[a]	91.25[a]	83.46[a]	48.60[b]	-	3.13[b]	3.32[b]	3.05[b]	4.00[a]	5.00[a]	-	100	100	81.38	72.92	50.35	-
RMP12	100[a]	100[a]	94.12[a]	86.65[a]	48.56[b]	-	3.04[b]	3.15[b]	3.05[b]	4.02[a]	4.02[a]	-	100	100	83.75	75.10	52.62	-
RMP91	100[a]	100[a]	92.04[a]	84.56[a]	45.90[b]	-	3.21	3.13	3.06	4.05	5.11	-	100	100	80.88	74.08	53.64	-

In each variable, plants were irrigated with water of 0= 0mM NaCl (control), 25= 25mM NaCl, 50= 50mM NaCl, 100= 100mM NaCl, 150= 150mM NaCl, 200= 200 mM NaCl. Each value is a mean of 3 replicates

Table 2. Plant height, number of leaves and number of nodes on primary branches of groundnut (*Arachis hypogaea*) genotypes under salinity stress

Groundnut genotype	Plant height (cm)						Number of leaves/plant						Number of nodes on primary stem					
	0	25	50	100	150	200	0	25	50	100	150	200	0	25	50	100	150	200
ICG-IS-6646	20.64^{a}	19.18^{a}	18.69^{a}	18.01^{a}	17.33^{a}	12.76^{b}	46.31^{a}	45.85^{a}	45.39^{a}	42.62^{a}	41.01^{a}	22.65^{a}	28.45^{a}	26.44^{a}	25.77^{a}	24.83^{a}	21.89^{a}	9.21^{b}
ICG-IS-3584	20.64^{a}	20.64^{a}	20.13^{a}	17.49^{ab}	15.46^{ab}	-	45.72^{a}	45.72^{a}	44.59^{a}	38.74^{b}	34.01^{b}	-	27.11^{a}	27.11^{a}	26.44^{a}	22.97^{ab}	20.30^{ab}	-
ICGY-5M-4746	19.65^{a}	18.63^{a}	18.35^{a}	17.24^{a}	15.85^{a}	12.15^{b}	46.23^{a}	46.00^{a}	44.63^{a}	42.57^{a}	39.82^{ab}	16.23^{b}	25.76^{a}	24.42^{a}	24.06^{a}	22.60^{a}	18.78^{ab}	7.43^{b}
ICG-IS-11687	19.69^{a}	18.51^{a}	18.04^{a}	16.62^{ab}	14.27^{ab}	-	41.00^{a}	40.60^{a}	37.99^{a}	35.98^{a}	25.73^{b}	-	25.81^{a}	24.26^{a}	23.65^{a}	21.79^{a}	18.70^{b}	-
ICG49-85A	19.71^{a}	19.42^{a}	19.12^{a}	18.39^{a}	9.12^{b}	-	44.45^{a}	41.79^{a}	40.72^{a}	40.99^{a}	31.94^{b}	-	27.97^{a}	27.55^{a}	27.14^{b}	26.09^{b}	12.94^{c}	-
ICGY-6M-5236	19.71^{a}	19.32^{a}	18.26^{a}	17.29^{a}	12.27^{b}	-	40.00^{a}	39.40^{a}	38.81^{a}	37.31^{a}	18.51^{b}	-	25.72^{a}	25.22^{a}	23.83^{a}	22.57^{a}	16.01^{b}	-
UGA-7-M	20.48^{a}	20.34^{a}	20.07^{a}	18.58^{ab}	11.66^{b}	-	45.55^{a}	45.25^{a}	44.65^{a}	43.44^{a}	25.34^{b}	-	28.14^{a}	27.95^{a}	27.58^{a}	25.53^{a}	16.03^{b}	-
RRB12	23.07^{a}	22.42^{a}	22.10^{a}	20.63^{a}	13.32^{b}	-	41.14^{a}	40.85^{a}	40.26^{a}	39.39^{a}	21.01^{b}	-	26.33^{a}	25.58^{a}	25.21^{a}	23.54^{a}	15.20^{b}	-
RMP12	22.19^{a}	21.76^{a}	19.60^{a}	18.44^{a}	8.93^{b}	-	41.14^{a}	40.34^{a}	36.33^{b}	36.60^{b}	18.97^{c}	-	24.75^{a}	24.27^{a}	21.86^{a}	20.57^{a}	9.96^{b}	-
RMP91	21.85^{a}	21.70^{a}	21.39^{a}	20.30^{a}	11.16^{b}	-	40.83^{a}	39.68^{a}	39.10^{a}	38.24^{a}	23.58^{b}	-	24.90^{a}	24.72^{a}	24.37^{a}	23.13^{a}	12.71^{b}	-

In each variable, plants were irrigated with water of 0= 0mM NaCl (control), 25= 25mM NaCl, 50= 50mM NaCl, 100= 100mM NaCl, 150= 150mM NaCl, 200= 200 mM NaCl. For each parameter, means with the same letter(s) [in superscript] in the same row are not significantly different at P = 0.05 (Tukey HSD)

Table 3. Number of primary branches and biomass of vegetative parts of of groundnut (*Arachis hypogaea*) genotypes under salinity stress

Groundnut genotype	Number of primary branches						Biomass of vegetative parts (g)					
	0	25	50	100	150	200	0	25	50	100	150	200
ICG-IS-6646	5.07	4.81	4.73	4.11	4.07	3.27	7.13	6.59	6.46	5.86	5.66	2.13
ICG-IS-3584	5.26^{a}	5.23^{a}	5.08^{a}	4.84^{ab}	3.53^{ab}	-	7.42^{a}	7.42^{a}	7.24^{a}	6.29^{a}	5.85^{ab}	-
ICGY-5M-4746	5.10^{a}	5.05^{a}	4.73^{a}	4.53^{a}	4.20^{a}	3.02^{b}	5.06^{a}	4.77^{a}	4.70^{a}	4.42^{a}	3.90^{a}	1.67^{b}
ICG-IS-11687	5.04^{a}	4.96^{a}	4.89^{a}	4.89^{a}	2.33^{b}	-	5.45^{a}	5.19^{a}	5.05^{a}	4.66^{ab}	4.00^{ab}	-
ICG49-85A	5.41^{a}	5.09^{a}	5.02^{a}	4.86^{ab}	3.24^{b}	-	7.97^{a}	7.11^{a}	7.00^{a}	6.73^{ab}	4.25^{b}	-
ICGY-6M-5236	5.06^{a}	5.03^{a}	4.96^{ab}	4.83^{ab}	2.81^{c}	-	5.38^{a}	4.54^{a}	4.29^{a}	4.06^{ab}	3.13^{b}	-
UGA-7-M	5.23^{a}	5.19^{a}	5.12^{a}	5.01^{a}	2.67^{b}	-	8.04^{a}	7.44^{a}	7.00^{a}	6.80^{ab}	4.42^{b}	-
RRB12	5.50^{a}	5.39^{a}	4.93^{ab}	4.89^{ab}	2.54^{b}	-	4.46^{a}	3.95^{ab}	3.55^{ab}	3.40^{ab}	2.37^{b}	-
RMP12	5.71^{a}	5.60^{a}	5.12^{a}	5.08^{a}	2.63^{b}	-	4.47^{a}	4.12^{a}	3.68^{ab}	3.19^{ab}	1.42^{b}	-
RMP91	5.71^{a}	5.55^{a}	5.47^{a}	5.35^{a}	3.30^{b}	-	4.45^{a}	3.85^{ab}	3.49^{ab}	3.27^{ab}	2.03^{b}	-

In each variable, plants were irrigated with water of 0= 0mM NaCl (control), 25= 25mM NaCl, 50= 50mM NaCl, 100= 100Mm NaCl, 150= 150mM NaCl, 200= 200mM NaCl. For each parameter, means with the same letter(s) [in superscript] in the same row are not significantly different at P = 0.05 (Tukey HSD)

Table 4. Yield performance of groundnut (*Arachis hypogaea*) genotypes under salinity stress

Groundnut genotype	Number of pods/plant						Number of seeds/pod						Number of seeds/plant					
	0	25	50	100	150	200	0	25	50	100	150	200	0	25	50	100	150	200
ICG-IS-6646	18.12^{a}	16.23^{a}	13.04^{b}	11.45^{b}	9.10^{bc}	4.21^{c}	2.01^{a}	2.01^{a}	1.97^{b}	1.85^{b}	1.78^{b}	0.00^{c}	36.42^{a}	32.62^{a}	25.69^{b}	21.18^{b}	18.20^{c}	0.00^{d}
ICG-IS-3584	15.23^{a}	13.12^{a}	11.23^{b}	9.36^{bc}	5.20^{c}	-	2.03^{a}	2.03^{a}	1.98^{b}	1.72^{b}	1.51^{b}	-	30.92^{a}	26.63^{b}	22.24^{b}	16.10^{c}	8.85^{d}	-
ICGY-5M-4746	16.13^{a}	15.53^{a}	13.11^{a}	6.70^{b}	7.07^{b}	-	2.02^{a}	2.02^{a}	1.95^{b}	1.86^{b}	1.74^{b}	-	32.58^{a}	31.37^{b}	25.56^{b}	19.11^{c}	16.30^{c}	-
ICG-IS-11687	15.42^{a}	14.44^{a}	9.55^{b}	6.90^{bc}	4.18^{bc}	-	1.67^{a}	1.67^{a}	1.55^{a}	1.50^{a}	1.00^{a}	-	25.75^{a}	24.11^{a}	14.80^{b}	10.35^{b}	4.18^{c}	-
ICG49-85A	18.53^{a}	15.31^{a}	6.30^{b}	5.23^{b}	3.22^{c}	-	2.04^{a}	2.04^{a}	1.89^{b}	1.81^{b}	1.28^{b}	-	37.80^{a}	31.23^{b}	13.08^{c}	9.47^{cd}	4.12^{d}	-
ICGY-6M-5236	16.23^{a}	13.61^{a}	9.20^{ab}	4.48^{b}	3.11^{c}	-	1.34^{a}	1.32^{a}	1.30^{a}	1.30^{a}	0.62^{b}	-	21.75^{a}	17.97^{b}	12.50^{c}	5.82^{d}	1.93^{e}	-
UGA-7-M	18.11^{a}	13.45^{ab}	8.72^{c}	4.24^{cd}	2.20^{d}	-	1.51^{a}	1.50^{a}	1.48^{a}	1.44^{a}	0.84^{b}	-	27.35^{a}	20.18^{b}	12.91^{c}	6.11^{d}	1.85^{e}	-
RRB12	15.70^{a}	13.62^{a}	7.28^{b}	6.03^{b}	2.23^{c}	-	1.41^{a}	1.41^{a}	1.38^{a}	1.35^{a}	0.72^{b}	-	22.14^{a}	19.20^{b}	10.05^{c}	8.14^{c}	1.61^{d}	-
RMP12	16.10^{a}	14.14^{a}	6.67^{b}	5.03^{b}	3.08^{c}	-	1.54^{a}	1.53^{a}	1.38^{a}	1.37^{a}	0.71^{b}	-	24.79^{a}	21.63^{a}	9.20^{b}	6.89^{bc}	2.19^{d}	-
RMP91	15.04^{a}	13.09^{a}	7.75^{b}	3.05^{c}	1.06^{d}	-	1.42^{a}	1.42^{a}	1.40^{a}	1.39^{a}	0.82^{b}	-	21.36^{a}	18.59^{b}	10.85^{c}	4.24^{d}	1.87^{e}	-

In each variable, plants were irrigated with water of 0= 0mM NaCl (control), 25= 25mM NaCl, 50= 50mM NaCl, 100= 100mM NaCl, 150= 150mM NaCl, 200= 200mM NaCl. For each parameter, means with the same letter(s) [in superscript] in the same row are not significantly different at P = 0.05 (Tukey HSD)

Table 5. 100 seed mass of groundnut (*Arachis hypogaea*) genotypes under salinity stress

Groundnut genotype	100 seed weight (g)					
	0	25	50	100	150	200
ICG-IS-6646	42.17^{a}	42.17^{a}	44.05^{a}	34.65^{b}	33.46^{b}	-
ICG-IS-3584	42.34^{a}	42.34^{a}	42.13^{a}	35.87^{b}	33.37^{b}	-
ICGY-5M-4746	41.74^{a}	41.74^{a}	41.15^{a}	36.45^{b}	32.14^{b}	-
ICG-IS-11687	38.46^{a}	38.46^{a}	35.43^{a}	28.20^{ab}	16.55^{b}	-
ICG49-85A	37.68^{a}	37.68^{a}	36.41^{a}	29.28^{ab}	20.11^{b}	-
ICGY-6M-5236	38.18^{a}	38.18^{a}	36.57^{a}	28.84^{ab}	12.57^{c}	-
UGA-7-M	37.66^{a}	37.66^{a}	32.78^{a}	27.20^{b}	20.69^{b}	-
RRB12	36.76^{a}	35.82^{a}	29.22^{b}	28.04^{b}	18.85^{c}	-
RMP12	36.74^{a}	36.29^{a}	31.81^{a}	25.31^{a}	16.13^{c}	-
RMP91	37.14^{a}	37.14^{a}	31.41^{a}	25.91^{b}	16.51^{c}	-

In each variable, plants were irrigated with water of 0= 0mM NaCl (control), 25= 25mM NaCl, 50= 50mM NaCl, 100= 100mM NaCl, 150= 150mM NaCl, 200= 200mM NaCl. For each parameter, means with the same letter(s) [in superscript] in the same row are not significantly different at P = 0.05 (Tukey HSD)

4. DISCUSSION

Reduction in percentage germination and delay in germination at high salt concentration in this study is in line with the result on some groundnut genotypes at electrical conductivities greater than 2.60mS/cm [8]. Seed germination of most non-halophytes may be inhibited by 0.5% salt [21]. Sodium chloride (NaCl) at osmotic tension of 0.0625 and 0.125MPa did not have significant effects on germination of *Sesamum indicum*, but higher osmotic tensions of 0.250 and 0.500MPa significantly reduced the percentage germination compared to the control. The few seeds that germinated at 0.500MPa were weak and chlorotic and did not proceed with radicle elongation and shoot development [8]. Negative effect of salinity on germination was also observed in guar [22]. Salinity influences seed germination primarily by lowering the osmotic potential of the soil solution sufficiently to retard water absorption by seeds [23]. Destruction and weakness of embryo by salt toxicity [24] must have been responsible for the delay and a reduction in percentage germination recorded in this study.

Salinity caused accumulation of salt in the root zone and hence, its effect started with an imbibition of seed as soon as it came in contact with saline water. The tolerance is a relative term depending mainly upon the intensity of salinity and relative performance of genotypes. Soil salinity has been earlier reported to cause death in several plants; *Hordeum vulgare* [25] and *Coriandrum sativum* [26]. Reduced plant survival in this study also agrees with the previous research that revealed that rye (*Secale cereale*) growth was reduced in the presence of salt, but 110mmol/L NaCl was the highest concentration allowing its growth to the three-leaf stage [5]. When the percentage of dead leaves in Hordeum species reached about 20% of the total, the rate of leaf production slowed down dramatically and some plants died [27]. All these might be responsible for mortality in *Arachis hypogaea*. Growth reduction under salinity stress has been reported in Triticum dicoccum farrum [5], *Oryza sativa* [3], *Vigna subterranea* [9] and *Coriandrum sativum* [26]. Many nutrients have essential roles in the process of cell division and cell extension and those would cease soon after the supply were halted, especially in tissues with little nutrient storage [28]. The growth reduction in A. hypogaea can therefore be attributed to disturbed/imbalance nutrition. Plant height was also reduced by salinity in Nigella sativa [29], which was attributed to suppression of internode growth. Decrease in plant height might be due to a reduced photosynthesis, which in turn limited the supply of carbohydrate needed for growth [28]. Growth decrease might have resulted from reduced turgor in expanding tissues caused by reduced water potential in root growth medium [2,30]. A decrease in the number of leaves under salt stress was due to leaf abscission, senescence and defoliation, coupled with an inhibition of lateral branches bearing the leaves, caused by Na+ and Cl- toxicity [31]. The reduction in the whole-plant photosynthesis under high salinity was accompanied by both reduced photosynthetic potential and smaller total leaf area. Salinity inhibits plant growth by exerting low water potentials, ion toxicity and ion imbalance [11]. Decreased dry mass of plant parts by salinity was probably due to the integrated reduction of the number of leaves and components of the leaf, which eventually resulted in poor overall plant biomass, since the leaf is the major source of carbohydrates required for growth. Soil salinity negatively affected yield in the groundnut genotypes similar to what has been reported in *Brassica napus* [32], *Hordeum vulgare* [25] and a local variety of *Arachis hypogaea* [10]. Also, the yield characters including 100 seed weight, number of pods and seeds per plant were reduced by salinity, and that the characters were controlled by additive genes which could be improved by selection [8]. They stated that plants tend to record low yields under salinity stress because of adverse effects of salinity on such parameters as relative water content, total dry weight, plant height and number of leaves per plant. A decrease in pod number was associated with an increase in ABA and pollen death. Pod size was reduced, leading to a decrease in the number of seeds.

It was observed that the significant decrease of yield components under salt stress in cowpea was partly related to a significant reduction of foliar chlorophyll contents, more than 50% essential for fruit production. Thus, a reduction in yield can be attributed to low chlorophyll content. Plants which are stressed by salinity had lower carbohydrate concentrations in their leaves than in control, which usually leads to reduced food storage in the seed, with resultant negative effect on yield [13]. A decrease in the number of leaves limited surface area available for light interception for photosynthetic activities, with consequential effect on growth and productivity [4,10].

Large genotypic variation in plant mortality and yield clearly indicated that there was an ideal salinity condition for screening and identification of salinity tolerant and sensitive genotypes [13]. There was plant mortality as well as pod bearing depending upon the salinity levels and genotypic variations in this study. It has earlier been reported that there are a few genotypes of groundnut that can endure the salinity stress and also yield satisfactorily [11-12]. Those genotypes with high survival and seed yield are categorized as salinity tolerant. The seed yield in a unit area (gm-2), a resultant of plant survival and yield parameters were identified as the best criterion for selecting the salinity tolerant genotypes in groundnut [11]. They ranked groundnut genotypes based on lesser mortality and better yield and top 10 genotypes were grouped as being salinity tolerant.

5. CONCLUSION

The research revealed that ICG-IS-3584, ICGY-5M-4746 and ICG-IS-6646 genotypes of *Arachis hypogaea* can withstand salt stress and produce good yield if grown in soil with salinity up to 150mM NaCl, while other genotypes are highly susceptible to salt stress. Those that can withstand salt stress hold immense promise to be grown in the coastal saline areas, and can be used in breeding programmes for developing salt-tolerant variants of groundnut.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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