

# Genetic Responds Of Two Varieties Of Amaranthus On Different Salinity Concentrations Grown In Mubi, Nigeria

Mshelmbula BP\*, Florence L, Midawa SM, Yusuf CS

Dept. of Biological Sciences, Adamawa State University, Mubi  
Corresponding author email: barkapeter5@gmail.com

---

**Paper Information**

Received: 14 October, 2016

Accepted: 30 December, 2016

Published: 20 March, 2017

---

**ABSTRACT**

The result of this study showed that the growth performance of the two varieties of amaranth were greatly reduced, in terms of number of leaves per plant in the saline treated plant exposed to the highest saline concentration compared to the control. *Amaranthus cruentus* had more number of leaves (6.63) than *Amaranthus hybridus* (5.67) and *Amaranthus hybridus* had higher survival rate than *Amaranthus cruentus* (1.83). Although both test plant varieties responded to varying saline concentrations in various ways, both tends to show similar responds. Also, the number of days to germination increases with increased salinity concentrations the two amaranth varieties was both adversely affected by higher saline concentrations, where increased salinity concentrations caused reduction in shoot length Also, the leave breadth was better in the control and the plants with lower amounts of NaCl concentration (0.025 and 0.05), this implies that *Amaranthus hybridus* and *Amaranthus cruentus* tolerate moderate salinity levels, while the plants with higher salinity concentrations (0.075, 0.01, 0.15) had leave breadth that were small, and eventually died because of high amounts of salt.

© 2017 PSCI Publisher All rights reserved.

---

**Key words:** *Amaranthus hybridus*; *Amaranthus cruentus*; salinity; concentrations; growth

---

**Introduction**

Salinity is one of the world's most serious environmental problems in agriculture. It is estimated that about one-third of the world's cultivated land is affected by salinity (PerezAlfocea et al., 1996).

Salt accumulation in soils induces physiological and metabolic disturbances in crops affecting development, growth, yield and quality of crops (Pardossi et al., 1999; Mavrogianopoulos et al., 1999; ). Reduction in growth results from salinity effects on dry matter allocation, ion relations, water status, biochemical reactions or a combination of many physiological factors

Amaranth is native to South and Central America where its cultivation by the Aztecs dates back 5000 to 7000 years ago (Kauffman and Weber, 1990; Stallknecht and SchulzSchaeffer, 1993). Amaranth was both an important food crop for the Aztecs, and an important item in their religious ceremonies (Myers, 1996). Currently, amaranths are widely grown as a green leafy vegetable or as grain crop in many parts of sub-tropical and tropical Asia, Africa and Central America.

The *Amaranthus Hybridus* and *Amaranthus Cruentus* crop are known locally as "tete" (yoruba), "green" (Igbo) or "aleho" (Hausa) Most of the species from amaranthus are summer annual weeds and are commonly referred to as pigweed (Bensch et al., 2003). Amaranth species are cultivated and consumed as a leaf vegetable in many parts of the world; four species of amaranthus are documented as cultivated vegetable. In eastern Asia: *Amaranthus Cruentus*, *Amaranthus lolitum*, *Amaranthus Dubius* and *Amaranthus Tricolor* (Costae 2003).

**Materials and Method****Study Area**

The study area is Mubi, is located in the north eastern part of Nigeria between latitude 10° 14'N and 10° 18' N of the equator and longitude 13° 14'E and 13° 19E of the Green-wish meridian. It occupies a land of about 725.85km with an estimated population of about 300,000 people. The area has tropical climate with an average temperature of 32°C and lies within the solar savannah vegetation zone in Nigeria. There has an average relative humidity from 28 %- 45% and annual rainfall of about 1056mm (Adebayo and Tukur, 1999).

### Collection of Materials

Clean seeds of *Amaranthus hybridus* and *Amaranthus cruentus* were obtained from the Mubi Main Market. The seeds were kept in the Agricultural laboratory of the Adamawa State University Mubi. The seeds were treated for viability using floatation method, after which it was treated with dress force (20% Imidacloprid, 20% Metalaxyl – M, 20% Tebuconazole), until it was ready for planting.

The soil that was used for planting (mixture of sandy, loamy and clay soil) were collected around the Botanic-garden of Adamawa State University Mubi. Top soil (0-10cm) were collected for use. The soil was sun dried to constant weight, and thereafter, 5kg of the soil were measured into palm nursery poly bags of 30cm in weight and 15cm in diameter. They were perforated at the bottom. The bags were placed in the screen house at a spacing of 60cm x 30cm as proposed by Okeleye et al., (1999).

An analytical reagent (NaCl = 58.44) was obtained from the Agricultural Laboratory of the Adamawa State University Mubi.

### Method of preparation of the Saline Solution

#### Salt preparation

Salt solution of 1 M NaCl was prepared by dissolving 58.8 g of NaCl crystals in a universal bottle upon which distilled water was added onto to make up 1 L. Corresponding ratios of 25/1000, 50/1000, 75/1000, 100/1000 and 150/1000 gave 25, 50, 75, 100 and 150 mM respectively. Pure distilled water was considered to be 0 mM, thus representing the control. The experiment was conducted in two phases; germination study and field study.

#### Germination test

Conducted in the Biological Laboratory of Adamawa State University, Mubi Nigeria. Approximate Seeds sizes of both species of *Amaranthus hybridus* and *Cruentus*, were randomly selected and soaked in distilled water for 2 hours before being transferred into glass Petri dishes. Twenty (20) seeds of each crop species will be sown into each glass Petri for the following NaCl concentrations 0, 0.025, 0.050, 0.075, 0.10 and 0.15g/L respectively. The seeds were placed between folds of moistened filter paper in the glass Petri dishes at room temperature of 27.5°C. The seeds of both species in the glass Petri dishes were moistened every 12 hours with varying concentrations (0.0, 0.025, 0.050, 0.075, 0.10 and 0.15 g/L) of NaCl salt and observations were recorded every 24 hours for radical emergence as indicative of germination. Seeds were considered to have germinated when up to 1 mm radicle emergence from the seed was noticed.

#### Field Study

Black polythene bags measuring 25 x 25 cm were filled with sandy-loamy soil from the Botanical Garden Adamawa State University, Mubi Nigeria. Three seeds were randomly chosen and sown into each potted bag at a depth of 1 cm and after germination. Masking tapes were used to label the bags appropriately. Salt solutions of NaCl corresponding to 0.025, 0.050, 0.075, 0.10 and 0.15g/L was used for watering the plants in the potted bags on twelve (12) hourly bases, throughout the period of experimentation. Distilled water was labelled 0.0g/L and considered as the control. The experimental period lasted for eight (8) weeks. At the end of the eighth (8<sup>th</sup>) week, results were collected for different parameters.

#### Data Collection

Data will be collected on the following observation

#### Number of Day to Seed Germination

Germination of seeds of *Amaranthus hybridus* and *Amaranthus cruentus* sown in all the experimental polls will be subsequently noted, until they are fully matured.

#### Percentage of Seed Germination/ survival

The percentage of seed germination will be calculated using the formula below

$$\frac{n}{N} \times 100$$

N

Where n= number seeds germinated.

N= Total number of seeds planted (=10)

#### Number of Leaves per Plant

Number of leaves per plant after germination will be continuously counted on weekly basis.

**Plant length**

The plant length was measured using meter rule.

**Leave breadth**

The leave breadth was measured using a thread and meter rule

**Stem Girth**

The stem girth was measured using a thread and meter rule.

**Seedling Germination**

The number of seed germinated was counted manually

**Seedling Length**

Seedling length was measured using a thread and meter rule.

**Number of Days to First leaf maturity**

The experiment will also include the first leaf maturity in all the plants.

Table 1: Descriptive Statistics of Growth Parameters

Parameters	Saline conc.	Mean	Std. Error	95% Confidence Interval for Mean	
				Lower Bound	Upper Bound
No. of Lvs (AC)	0.025	8.75	0.478714	7.2265198	10.27348
	0.05	7.75	0.478714	6.2265198	9.27348
	0.075	8.75	0.25	7.9543884	9.545612
	0.10	0	0	0	0
	0.15	0	0	0	0
	0.0	14.5	0.288675	13.581307	15.41869
	Total	6.625	1.083159	4.3843146	8.865685
Survival (AC)	0.025	3	0	3	3
	0.05	3	0	3	3
	0.075	2	0	2	2
	0.10	0	0	0	0
	0.15	0	0	0	0
	0.0	3	0	3	3
	Total	1.83333	0.280183	1.253731	2.412936
No. of Lvs (AH)	0.025	7.5	0.645497	5.4457397	9.55426
	0.05	8.5	0.5	6.9087768	10.09122
	0.075	6	0	6	6
	0.10	2	1.224745	-1.897685	5.897685
	0.15	0	0	0	0
	0.0	10	1.080123	6.5625651	13.43743
	Total	5.66667	0.788658	4.0352043	7.298129
Survival (AH)	0.025	3	0	3	3
	0.05	3	0	3	3
	0.075	3	0	3	3
	0.10	1	0.408248	-0.299228	2.299228
	0.15	0	0	0	0
	0.0	3	0	3	3
	Total	2.16667	0.260063	1.628685	2.704648

Plant length of control *Amaranthus cruentus* plant was 16.125 + 1.712cm, a value that is higher than plant height of control *Amaranthus hybridus* 13.63 + 0.85 cm (table 1b). comparing plant response to saline agent in terms of plant height, *Amaranthus cruentus* plant responded better in height, with a range of plant height (9.35-11.20cm) that were better than the *Amaranthus hybridus* plant (4.48-8.23cm.. comparatively, leave breadth was at lower saline concentrations in both plants.

**Results**

Table 1, shows descriptive statistics of growth parameters of the two plant types in the present study. Number of leaves of 0.025% saline treated *Amaranthus cruentus* Plant (ACP) was 8.75 + 0.47 compared to 7.75 + 0.47 leaves in 0.05% saline treated plant. There are no leaves in the plant whose propagules were treated with 0.10% and 0.15% saline solution. This

was because the plants actually died upon treatment. This may be as a result of saline toxicity or possible deleterious saline effects.

Comparatively, the *Amaranthus hybridus* plant. (AHP) plant survived at 0.10% salinity concentration. This is a marked sign of tolerance. In both control plants, there were more numbers of leaves per plant in the *Amaranthus cruentus* (14.50 + 0.29) than in *Amaranthus hybridus* (10.00 + 1.08).

As presented in table 1a, apart from plants pre-treated with 0.15% saline solution, an average of 3 out of 3 plants survived germination stage.

Table 1, Contd...

Parameters		Mean	Std. Error	95% Confidence Interval for Mean	
				Lower Bound	Upper Bound
Plant length (AC)	0.025	11.2	0.108012	10.856257	11.54374
	0.05	9.35	1.057119	5.9857764	12.71422
	0.075	5.925	0.160078	5.41556	6.43444
	0.10	0	0	0	0
	0.15	0	0	0	0
	0.0	16.125	1.712394	10.675399	21.5746
	Total	7.1	1.256245	4.5012587	9.698741
Plant length (AH)	0.025	8.225	0.103078	7.8969609	8.553039
	0.05	8.175	0.311916	7.1823437	9.167656
	0.075	7.725	0.205649	7.0705319	8.379468
	0.10	4.475	1.491853	-0.272742	9.222742
	0.15	0	0	0	0
	0.0	13.625	0.850857	10.917192	16.33281
	Total	7.0375	0.900741	5.1741759	8.900824
Plant Breadth (AH)	0.025	2.825	0.062915	2.6247755	3.025225
	0.05	2.225	0.047871	2.072652	2.377348
	0.075	2.2	0.040825	2.0700772	2.329923
	0.10	0.775	0.271953	-0.090475	1.640475
	0.15	0	0	0	0
	0.0	3.45	0.210159	2.7811813	4.118819
	Total	1.9125	0.251179	1.3928961	2.432104
Plant Breadth (AC)	0.025	3.275	0.460751	1.8086841	4.741316
	0.05	2.3	0.385141	1.0743105	3.525689
	0.075	1.275	0.025	1.1954388	1.354561
	0.10	0	0	0	0
	0.15	0	0	0	0
	0.0	3.9	0.227303	3.1766203	4.62338
	Total	1.79167	0.327812	1.1135357	2.469798

There is no significance difference in plant stem girth between the two plant species (table 1c). Seed germination index was better in *Amaranthus hybridus* (ranges, 10.25-17.75) compared to *Amaranthus cruentus* plant (5.50-13.50). There were similar germination indices in both control plants.

Table 1, contd...

Parameters		Mean	Std. Error	95% Confidence Interval for Mean	
				Lower Bound	Upper Bound
Stem Girth (AC)	0.025	1.425	0.047871	1.272652	1.577348
	0.05	1.075	0.094648	0.7737863	1.376214
	0.075	0.7	0.057735	0.5162614	0.883739
	0.10	0	0	0	0
	0.15	0	0	0	0
	0.0	1.225	0.025	1.1454388	1.304561
	Total	0.7375	0.119147	0.4910248	0.983975
Stem Girth (AH)	0.025	1.15	0.06455	0.944574	1.355426
	0.05	1.625	0.025	1.5454388	1.704561
	0.075	1.15	0.028868	1.0581307	1.241869
	0.10	0.5	0.173205	-0.051216	1.051216
	0.15	0	0	0	0
	0.0	1.55	0.125831	1.149551	1.950449
	Total	0.99583	0.124598	0.7380832	1.253583
Seed Germination (AC)	0.025	13.5	2.629956	5.1303074	21.86969
	0.05	13.25	2.594064	4.9945314	21.50547
	0.075	10	2.54951	1.8863221	18.11368
	0.10	6.75	0.629153	4.7477548	8.752245
	0.15	5.5	0.957427	2.4530396	8.54696
	0.0	20	0	20	20
	Total	11.5	1.217327	8.9817681	14.01823
SeedGermination (AC)	0.025	17.75	0.629153	15.747755	19.75225
	0.05	16.25	0.853913	13.532469	18.96753
	0.075	13.5	0.957427	10.45304	16.54696
	0.10	10.25	0.478714	8.7265198	11.77348
	0.15	5	0.57735	3.1626138	6.837386
	0.0	20	0	20	20
	Total	13.7917	1.069978	11.578249	16.00508

Table 1d shows seedling length as growth parameters to test plant response to application of saline solution. Seedling length was 2.87+ 8. 0.11 cm in control for *Amaranthus cruentus* plant, compared to 2.90 +. 0.12 cm in the *Amaranthus hybridus* plant.as shown in the *Amaranthus cruentus* plant there was germination and emergence of seedlings in 0.10% and 0.10 treatments before plants gave way to the toxic effects of saline at higher concentrations.

Table 1, contd...

Parameters		Mean	Std. Error	95% Confidence Interval for Mean	
				Lower Bound	Upper Bound
Seedling Length (AC)	0.025	2.4	0.08165	2.1401543	2.659846
	0.05	2.3	0.08165	2.0401543	2.559846
	0.075	2.075	0.149304	1.5998482	2.550152
	0.10	1.225	0.118145	0.8490086	1.600991
	0.15	0.875	0.131498	0.4565154	1.293485
	0.0	2.875	0.110868	2.5221692	3.227831
	Total	1.95833	0.150231	1.6475562	2.26911
Seedling Length (AH)	0.025	2.125	0.110868	1.7721692	2.477831
	0.05	2.075	0.149304	1.5998482	2.550152
	0.075	1.9	0.129099	1.4891479	2.310852
	0.10	1.2	0.297209	0.2541475	2.145852
	0.15	0.8	0.108012	0.4562565	1.143743
	0.0	2.9	0.129099	2.4891479	3.310852
	Total	1.83333	0.153659	1.5154653	2.151201

Table 2, shows that results obtained in the entire parameters measured were significant at 5% confidence limit. This implies that the application of saline solution can affect direct toxic or mutagenic effects as the case may be.

Table 2: ANOVA Summary Table

		Sum of Squares	Degree of freedom	Mean Square	F-value	Sig.
No. of LvsAC	Between Groups	640.375	5	128.075	317.979	*0.000
	Within Groups	7.25	18	0.403		
	Total	647.625	23			
SurvivalAC	Between Groups	43.333	5	8.667	.	*0.000.
	Within Groups	0	18	0		
	Total	43.333	23			
NoLvsAH	Between Groups	303.333	5	60.667	27.3	*0.000
	Within Groups	40	18	2.222		
	Total	343.333	23			
SurvivalAH	Between Groups	35.333	5	7.067	63.6	*0.000
	Within Groups	2	18	0.111		
	Total	37.333	23			
PlengthAC	Between Groups	822.095	5	164.419	60.343	*0.000
	Within Groups	49.045	18	2.725		
	Total	871.14	23			
PlengthAH	Between Groups	410.659	5	82.132	39.744	*0.000
	Within Groups	37.198	18	2.067		
	Total	447.856	23			
L BreadthAH	Between Groups	33.314	5	6.663	79.292	*0.000
	Within Groups	1.512	18	0.084		
	Total	34.826	23			
L BreadthAC	Between Groups	54.363	5	10.873	39.497	*0.000
	Within Groups	4.955	18	0.275		
	Total	59.318	23			
S GirthAC	Between Groups	7.654	5	1.531	150.978	*0.000
	Within Groups	0.183	18	0.01		
	Total	7.836	23			
S GirthAH	Between Groups	7.952	5	1.59	46.36	*0.000
	Within Groups	0.617	18	0.034		
	Total	8.57	23			
SeedGermAC	Between Groups	560.5	5	112.1	7.836	*0.000
	Within Groups	257.5	18	14.306		
	Total	818	23			

Table 2, contd...

		Sum of Squares	Degree of freedom	Mean Square	F-value	Sig.
SeedGermAH	Between Groups	600.708	5	120.142	69.202	*0.000
	Within Groups	31.25	18	1.736		
	Total	631.958	23			
SdLengthAC	Between Groups	11.508	5	2.302	43.611	*0.000
	Within Groups	0.95	18	0.053		
	Total	12.458	23			
SdLengthAH	Between Groups	11.018	5	2.204	19.685	*0.000
	Within Groups	2.015	18	0.112		
	Total	13.033	23			

	No. of Lvs (AC)	Survival (AC)	No. of Lvs (AH)	Survival (AH)	Plant length (AC)	Plant length (AH)	Plant length (AH)	Plant Breadth (AH)	Plant Breadth (AC)	Leaf Girth (AC)	Leaf Girth (AH)	Seed Germination (AC)	Seed Germination (AC)	Seedling Length (AC)	Seedling Length (AH)
0.025	8.75	3	7.5	3	11.2	8.225	8.225	2.825	3.275	1.425	1.15	13.5	17.75	2.4	2.125
0.05	7.75	3	8.5	3	9.35	8.175	8.175	2.225	2.3	1.075	1.625	13.25	16.25	2.3	2.075
0.075	8.75	2	6	3	5.925	7.725	7.725	2.2	1.275	0.7	1.15	10	13.5	2.075	1.9
0.10	0	0	2	1	0	4.475	4.475	0.775	0	0	0.5	6.75	10.25	1.225	1.2
0.15	0	0	0	0	0	0	0	0	0	0	0	5.5	5	0.875	0.8
0.0	14.5	3	10	3	16.125	13.625	13.625	3.45	3.9	1.225	1.55	20	20	2.875	2.9

Table 2 shows Pearson’s correlation coefficient comparing selected growth parameters of the test plants. There was significance positive correlation ( $r = 0.898$ ,  $p < 0.01$ ) between number of leaves of the *Amaranthus cruentus* plant and the survival index of the same plant. This simply implies that the survival of plant under influence of saline solution can guarantee the possession of more leaves in the test plant.

Similarly, there was also highly significant positive correlation ( $r = 0.936$ ,  $p < 0.01$ ) between plant breadth of *Amaranthus cruentus* plant and the stem girth of the same plant. This simply implies that the improved plant leave breadth under influence of salinity can guarantee the possession of stem girth in the test plant. However, there was significance negative correlation ( $p < 0.05$ ) between the concentration of sodium chloride and all the parameters measured. This implies that any increase in saline solution concentration would decrease the plant’s capacity to respond favourably.

Table 3: Pearson’s Correlation coefficient comparing selected growth parameters of test plants

	NoLvsAC	SurvivalAC	NoLvsAH	PlengthAC	PbreadthAH	PbreadthAC	SeedGermAC	SdLengthAC	SdLengthAH	SeedGermAH	LVGirthAH	LvGirthAC	PlengthAH	SurvivalAH
Conc	-0.031	-0.399	-0.219	-0.076	-0.202	-0.157	0.05	-0.186	-0.043	-0.245	-0.288	-0.421*	-0.009	-0.430*
NoLvsAC	1	0.898**	0.889**	0.927**	0.940**	0.878**	0.796**	0.938**	0.902**	0.879**	0.845**	0.865**	0.900**	0.852**
SurvivalAC	0.898**	1	0.907**	0.901**	0.913**	0.889**	0.717**	0.918**	0.830**	0.901**	0.897**	0.969**	0.807**	0.912**
NoLvsAH	0.889**	0.907**	1	0.873**	0.878**	0.866**	0.751**	0.889**	0.798**	0.877**	0.868**	0.871**	0.805**	0.842**
PlengthAC	0.927**	0.901**	0.873**	1	0.933**	0.956**	0.810**	0.931**	0.903**	0.908**	0.839**	0.909**	0.878**	0.787**
LBreadthAH	0.940**	0.913**	0.878**	0.933**	1	0.904**	0.778**	0.960**	0.939**	0.950**	0.907**	0.905**	0.953**	0.919**
LBreadthAC	0.878**	0.889**	0.866**	0.956**	0.904**	1	0.837**	0.901**	0.862**	0.888**	0.783**	0.936**	0.819**	0.761**
SeedGermAC	0.796**	0.717**	0.751**	0.810**	0.778**	0.837**	1	0.845**	0.863**	0.780**	0.726**	0.744**	0.775**	0.641**
SdLengthAC	0.938**	0.918**	0.889**	0.931**	0.960**	0.901**	0.845**	1	0.967**	0.953**	0.912**	0.895**	0.910**	0.889**
SdLengthAH	0.902**	0.830**	0.798**	0.903**	0.939**	0.862**	0.863**	0.967**	1	0.917**	0.886**	0.817**	0.941**	0.824**
SeedGermAH	0.879**	0.901**	0.877**	0.908**	0.950**	0.888**	0.780**	0.953**	0.917**	1	0.888**	0.898**	0.908**	0.878**
S GirthAH	0.845**	0.897**	0.868**	0.839**	0.907**	0.783**	0.726**	0.912**	0.886**	0.888**	1	0.828**	0.899**	0.935**
S GirthAC	0.865**	0.969**	0.871**	0.909**	0.905**	0.936**	0.744**	0.895**	0.817**	0.898**	0.828**	1	0.781**	0.862**
PlengthAH	0.900**	0.807**	0.805**	0.878**	0.953**	0.819**	0.775**	0.910**	0.941**	0.908**	0.899**	0.781**	1	0.858**
SurvivalAH	0.852**	0.912**	0.842**	0.787**	0.919**	0.761**	0.641**	0.889**	0.824**	0.878**	0.935**	0.862**	0.858**	1

\*. Correlation is significant at the 0.05 level (2-tailed).

\*\* Correlation is significant at the 0.01 level (2-tailed)

**Key:**

NoLvsAC	SurvivalAC	NoLvsAH	PlengthAC	PbreadthAH	PbreadthAC	SeedGermAC	SdLengthAC	SdLengthAH	SeedGermAH	SGirthAH	SGirthAC	PlengthAH	SurvivalAH
No. of Lvs (AC)	Survival (AC)	No. of Lvs (AH)	Plant length (AC)	Leaf Breadth (AH)	Leaf Breadth (AC)	Seed Germination (AC)	Seedling Length (AC)	Seedling Length (AH)	Seed Germination (AH)	Stem Girth (AH)	Stem Girth (AC)	Plant length (AH)	Survival (AH)

## Discussions

From table 1a, the growth performance of the two varieties of amaranth were greatly reduced, in terms of number of leaves per plant in the saline treated plant exposed to the highest saline concentration compared to the control. It is noteworthy to state that *Amaranthus cruentus* had more number of leaves than *Amaranthus hybridus* and *Amaranthus hybridus* had higher survival rate than *Amaranthus cruentus* (table 1a).

This might be that salinity caused reduction in the number of leaves in *Amaranthus* plant varieties. This finding agrees with work done by Silvia et al., (2003) and Amador and Dieguez (2007) who reported that salinity induced reduction of leaves. There was general decrease in number of leaves in both amaranth varieties with increased saline concentrations (Mshelmbula et. al., 2015). This therefore suggests that both species would be best cultivated under moderate saline concentration than low or very high NaCl concentrations. Although both test plant varieties responded to varying NaCl concentrations in various ways, both tends to show similar responds.

Also, the number of days to germination increases with increased salinity concentrations which coincides with the findings of Amador et al., (2006), Amador and Dieguez (2007), Mahmood et al., (2009), Muhammed and Hussain (2010) and Ghaloo et al., (2011) who reported that increase in NaCl concentrations increases the days to germination, or reduces the survival rate.

According to Ratnakar and Rai (2013), root and shoot lengths are the most important parameters for studying salt stress, this is obvious as roots are in direct contact with the soil salinity, and the effects are then translocated and manifested along the shoots. From table 1b therefore, the two amaranth varieties were both adversely affected by higher NaCl concentrations, where increased salinity concentrations caused reduction in shoot length. Hence at lower salinity levels, both studied parameters are good halophytes.

Heidari et al., (2001) while studying the effects of NaCl concentration on *Helianthus annuus* suggested that reduction in plant growth is due to decreasing turgor pressure in the soil under saline environments. The test plant with the high NaCl concentration show stunted shoot length, and thereafter some dried out completely, this agrees with the findings of (Romero Aranda et al., (2001) which states that response of vegetables to presence of increased amount of salt is primarily stunted growth. Also, the leave breadth was better in the control and the plants with lower amounts of NaCl concentration(0.025 and 0.05), this implies that *Amaranthus hybridus* and *Amaranthus cruentus* tolerate moderate salinity levels, while the plants with higher salinity concentrations (0.075,0.01,0.15) had leave breadth that were small, and eventually died because of high amounts of salt. The stem girth of both test plant was better in the control and the plants with lower salinity concentrations when compared to the higher saline concentration (table 1c).

In seedling germination for both amaranth varieties, increased salt concentration caused decrease in germination rate. Most reduction in germination rate was observed noticeably in higher saline concentration. These results were in agreement with Kaymak et al., (2009) who found that the lowest concentration of saline solution significantly affected germination rate.

The length of the seedlings was higher in lower concentration (table 1d). This result was similar with Jamil et al., (2005) who reported that germination of Brassica species (cabbage, cauliflower, and canola) decreased with increased salinity.

## References

- Adebayo AA, Tukur AL.1999. "Adamawa State in Maps" Paraclete Publisher Yola, Pp. 27-31.
- Amador BM, Dieguez ET.2007. Effects of salinity on germination and seedling characteristics of cowpea (*Vigna unguilata* (L.) Walp). Australian journal of Experimental Agriculture, 40 (3): 433-438.
- Amador BM, Troyo-Dieguez E, Garcia-Hernandez JL, Lopez-Aguilar R. 2016.Amaranth grain cooked" USDA national nutrient database, release SR-28.2015 retrieved on February 2016
- Bensch CN, Horak MJ, Peterson D. 2003. Inference of redroot pigweed (*Amaranthus retroflexus*), Palmer amaranth (*A. palmeri*), and common waterhemp (*A. rudis*) in soybean. Weed Sci. 51:37-43.
- Costae M, Demasou D.2001. "Stem morphology and anatomy in amaranthus L. (Amaranthaceae)- taxonomic significance" Journal Of The Torrey Botanical Society 128 (3): 254-251. doi: 10.2307/3088717
- Ghaloo SH, Soomro ZK, Klan NU, Kakar MS, Taran SA, Rajper AA. 2011. Response of wheat genotype to salinity at early growth stages. Pak. J.bot., 43 (1): 617-623).
- Heidari A, Toorchi M, Bandehagh A, shakiba Mr .2001. Effects of NaCl stress on growth, water relations, organic and inorganic osmolytes accumulation in sun flower (*Helianthus annuus* L.) <http://www.nrcs.usda.gov/technical/worldsoils/papers/desertification-africa.html>.
- Jamil M, Lee CG, Rahman SU, Lee DB, Ashraf M.2005. Salinity (NaCl) tolerance of Brassica species at germination and early seedling growth. Electron. J. Environ. Agric. Food chem. 4:970-976.
- Kauffman CS, Weber LE. 1990. Grain amaranth. In: J. Janick and J.E. Simon (Eds.), Advances in New Crops. Timber Press, Portland, OR, pp. 127-139.
- Kaymak HC, Güvenç I, Yaraş F, Dönmez MF. 2009. The effects of bio-priming with PGPR on germination of radish (*Raphanus sativus* L.) seeds under saline conditions. Turk J. Agric. For. 33: 173-179.
- Mahmood AT, Latif T, Arif M. 2009. Effects of salinity on growth, yield and yield components of basmati rice germoplasm. Pak. J. Bot., 41(6):3035-3045.
- Mansour, M.M.F., 2000. Nitrogen containing compounds and adaptation of plants to salinity stress. Biol. Plant. 43, 491-500.
- Mavrogianopoulos GN, Spanakis J, Tsikalas P. 1999. Effect of carbon dioxide enrichment and salinity on photosynthesis and yield in melon. Sci.
- Mshelmbula BP, Zakariya R, Mensah JK, Ikhajiagbe B.2015. Effect of salinity on germination, growth and yield performance of cowpea (*Vigna unguiculata* L.walp) Nigeria annals of natural sciences. Volume 15(1) 2015 (pp 018-023)
- Muhammed Z, Hussain F. 2010. Effects of NaCl salinity on the germination and seedling growth of some medicinal plant. Pak. J. Bot., 42(2): 889-897.
- Myers RL. 1996. Amaranth: new crop opportunity. In: J. Janick (ed.), Progress in New Crops, ASHS Press, Alexandria, VA, pp. 207-220.



- Okeleye K, Ariyo OJ, Olowe UI. 1999. Evaluation early and medium duration cowpea (*Vigna unguiculata* (L.) Walp) cultivars for agronomic traits and grain yield. Niger. Agric. J. 30:1-11.
- Pardossi A, Bagnoli G, Malorgio F, Campiotti CA, Tofnoni F. 1999. NaCl effects on celery (*Apium graveolens* L.) grown in NFT. Scientia Hortic. 81, 229-242.
- Perez-Alfocea F, Balibrea ME, Santa Cruz A, Estan MT. 1996. Agronomical and physiological characterization of salinity tolerance in a commercial tomato hybrid. Plant and Soil 180, 251-257.
- Ratnakar A, Rai A. 2013. Effects of sodium chloride salinity on seed germination and early seedling growth of *Trigonell foenum-graecum* L varieties. Peb, iota J. Env. res. 1(4) 304-309.
- Silva JS, de Lacerda CF, de Costa PHA, Eneas JEF, Filho G, Prisco JT. 2003. Physiological responses of NaCl stressed cowpea plants grown in nutrient solution supplemented with CaCl<sub>2</sub>. Braz. J. Plant Physiol., 15 (2): 87-94.
- Stallknecht GF, Schulz-Schaeffer JR. 1993. Amaranth rediscovered. In: J. Janick and J.E Simon (Eds.), New Crops. Wiley, New York, pp.211-218.