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Determination of Salinity Effect on the Germination, Growth and Yield of Okra (Abelmoschus esculentus L. Moench.)

Augie, M.A.[1*]; Buah, J.D.[2]; Okeseni, O.[3]
[1]Department of Soil Science, Kebbi State University of Science and Technology, Aliero, Kebbi State, Nigeria
[2]Department of Biological Sciences, Federal University of Dutsin-ma Katsina State, Nigeria
[3]Department of Plant Biology, Federal University, Zuru, Kebbi State, of Ilorin, Nigeria
Corresponding author email: musaamaduaugi@gmail.com

Abstract**—** *This study was aimed at accessing the morphological effect of salinity on the germination, growth and yield of Abelmoschus esculentus using Clemson spineless variety through inducement of salinity at 0, 4, 6, 8, and 10g NaCl. Result shows that seed germination was inhibited and seedling emergence was delayed as NaCl treatments increased in concentration. C. spineless emerged faster at 4g NaCl treatment with germination percentage of 44%, while 100% germination was recorded in all the control experiment. Clemson spineless at maturity, shed leaves, chlorosis and leaf burns around edges occurred which invariably had effect on leaf area, the reduction in leaf area varied at different NaCl concentration. C. spineless stem height was significantly reduced by NaCl treatments. Fruits yield and quality of the crop was significantly hampered by salinity (above 4g salt concentration) which is a reflection of its little tolerance to salinity and the rate at which its reduces its fruit yield. All the fruit parameters considered decreased as salinity increased. Chlorophyll contents was significantly reduced by increasing salinity, which accounts for the low yield recorded at these various treatments level since photosynthetic activities is invariably inhibited by presence of excess NaCl. Ca and K were the predominant elements found in the digested fruits sample of Clemson spineless under Atomic Absorption Spectrum (AAS) at different NaCl concentrations (6g and 8g), while Mg, Na and P were significantly less compared to Ca and K. therefore, salinity is a major abiotic factor that hampers the overall performance of these vegetable crops in salient ways and must be curbed in other to meet increasing global demand for okra*.

Keywords**—** *Salinity, Okra, Clemson spineless, AAS, NaCl, Germination, Chlorophyll, Mineral elements*.

I. INTRODUCTION

The term vegetable is somewhat arbitrary, and largely defined through culinary and cultural tradition. It normally excludes other main types of plant food, fruits, nuts and cereal grains but includes seeds such as pulses (Kochhar, 2006). Vegetables were first gathered in the wild by hunter-gatherers and then brought into cultivation in numerous locations around the world, most likely between the years 10,000 BC and 7,000 BC, when a new agricultural way of life emerged. Initially, only plants that naturally grew nearby would have been farmed; however, as time went on, trade introduced exotic crops from other places to supplement native varieties. Nowadays, as long as the climate permits, the majority of vegetables are grown worldwide, and crops may be grown in protected habitats in less ideal regions (Kochhar, 2006).

China is the largest producer of vegetables, and global trade in agricultural products allows consumers to purchase vegetables grown in faraway countries. Subsistence farmers who just produce enough food for their family to agribusinesses with enormous tracts of land dedicated to a single crop. Grading, storing, processing, and marketing follow crop harvesting, depending on the type of vegetable in question (Shannon and Grieve 1999).

Vegetables, which are typically low in fat and carbohydrates but high in vitamins, minerals, and fibre, can be consumed raw or cooked and are crucial to human nutrition. Many governments urge people to eat a lot of fruit and vegetables; five or more pieces per day are frequently advised (Gruda, 2005).

Because they can produce a noticeably higher income per hectare than traditional mainstay crops, vegetables are particularly significant crops for farmers with modest holdings. Vegetables are, however, often regarded as being more susceptible than staple crops to adverse environmental circumstances, such as temperature extremes, drought, salt, water logging, excess and insufficient mineral nutrients, and pH variations in the soil (Shannon and Grieve, 1999). The widespread climatic change that is occurring in many regions of the world is expected to make these environmental challenges worse. The production of most crops, including vegetables, is constrained by excessive levels of soluble salts in soil and water in many parts of the world, especially in arid and semi-arid regions (FAO, 2002; AVRDC, 2006).

Irrigation has also contributed to increasing salinisation of agricultural lands and has caused the destruction of agriculture in some areas, it is now estimated that 10% of the world's crop lands are affected by salinity through the irrigation of lands, as much as 20-27% may be salt affected and up to 37% may be saline, sodic or waterlogged (Shannon, 1995). In United States, 23% of irrigated cropland is saline or sodic and if both irrigated and non irrigated lands are considered saline affected soils cover more than 19.6 Mha, salinity is inevitably associated with irrigation (Shannon, 1995). Of all the common vegetable crops, tomato, okra, pepper, cabbage, lettuce has received most research attention regarding the effects of abiotic stresses including salt stress. Despite the dietary importance and economic value of vegetables, much less is known about the

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physiological and molecular responses of these to salt stress (Gruda, 2005). Therefore the aim of this research is to study the effect of salinity on the morphology of *Clemson spineless* using growth parameters, Chlorophyll concentration and Nutritional analysis of the fruits.

II. Materials and Method

Study Area

The study was carried out in a Greenhouse at University of Ilorin, Botanical Garden between September 2014 and March 2015. Unilorin Botanical Garden lies between latitude 8°30´N and longitude 4° 33´E/ latitude 8.500°N and 4.550°E.

Experimental Design

Clemson spineless was used for this experiment. The Tomato variety used is Tomato UC-82-B gotten from Nigeria Stored Product Research Institute in Ilorin, Kwara state (NSPRI). Viable seeds were sown on 8th September, 2014 inside plastic pots containing loamy soil with punctured holes to avoid water logging. Twenty five (25) plastic pots of five replicates was prepared and labeled. The pots were irrigated with different concentrations of Saline water (NaCl). Five different concentrations of salinity was prepared at 0, 4, 6, 8 and 10g diluted in 10 litres of tap water respectively applied to 10 kg of garden soil, the control pots contained no salinity. Seeds of Tomatoe UC-82-B variety were sown in the appropriate pots already labeled.

Sources of NaCl treatment

The Industrial Salt (NaCl) used was gotten from the laboratory of plant biology; University of Ilorin.

Sowing and watering of the plants

The pots containing soil was irrigated every other day with NaCl salt dissolved in 10 litre of water in a bucket for each concentration and allowed to stay for a week so as to penetrate well in the soil particles before the seeds were sown. Ten viable seeds of Tomato were sown separately in each of the pots and were thinned down to three per pot after total germination percentage was recorded.

Percentage Seed Germination

The average seed germination in the five replicates was determined and percentage germination was calculated as follows;

$$\text{Percentage seed germination} = \frac{\text{Number of seeds that germinated}}{\text{Total number of seed planted}} \times 100$$

$$= \frac{\text{Average number of seeds that germinated}}{\text{Total number of seeds planted in each pot}} \times 100$$

Growth parameters:

Plant Height: Three tagged plants of each treatment was used in determined the plant height using a measuring tape. The height (cm) was determined every two weeks by measuring the length of shoot from the soil surface to the apex of the plant.

Leaf Number: The leaves of each plant was counted visually and recorded. Leaves from the tagged plant from each treatment were counted every two weeks.

Leaf length and Breadth: Three leaves were selected for measurement every two weeks. The length and breadth of the selected leaves were taken with the aid of a 30 cm plastic metre ruler. The leaf area of each plant was determined using this formula: LA=L×B×Franco's constant (0.75) and the average recorded.

Stem Girth: The stem girth was determined using a thread, rolled over the middle of the plant stem once and then stretched over a 30 cm metre ruler.

Reproductive parameters

Fruit Number: The numbers of fruits in each of the plants were counted visually and recorded

Fruit Fresh Weight: The fresh weights of the plants was determined using a weighing balance (g)

Fruit Dry Weight: The fruits of Okra, Tomato and pepper were dried at room temperature (20-26^{0}C) for 4-5 weeks and the weights were determined using a weighing balance

Fruit Diameter: The fruit diameter was measured using a venire caliper

Fruit Circumference: The fruit circumference was determined by placing the centre of the fruit in a venire caliper to the nearest centimeter and readings was recorded.

Data analysis

The experiment was arranged according to completely randomized design with five replicates, each replicate having 10 seeds. The data's recorded were analyzed statistically using SPSS and Origin 7.0.

Chlorophyll Determination:

Estimation of Chlorophyll Content by Acetone Incubation Method

Leaf tissue of plants (50 mg) was placed in a sample bottle containing 5 mL of 80% buffered acetone (80 mL of acetone made up to 100 mL with 20 mL of 2.5 mM sodium phosphate buffer, pH 7.8) and the sample bottle were placed under refrigeration for three days. The extract liquid was filtered through glass wool to remove leaf pieces and transfered to another graduated tube (Makeen, *et al*., 2007)

Determination of chlorophyll concentration

1. Obtain a clean cuvette for the spectrophotometer/colorimeter and fill two-thirds full with 80% acetone; this is the blank. Wipe the cuvette with a tissue and put it into the spectrophotometer, then set the wavelength to 663 nm. Cover the cuvette chamber and set the spectrophotometer to 0 absorbance with the blank in place. Remove the blank and save for the next measurement.
2. Gently swirl your first extract in the test-tube and fill a second cuvette two-thirds full. Wipe it clean, insert into the spectrophotometer, and close the hatch. The readout should give you the absorbance at 663 nm, the A_{663}. Record this number, and repeat step 2 with the other extracts.
3. Change the wavelength to 645 nm. Reinsert the blank cuvette, and re-zero the spectrophotometer at the new wavelength. Remove the blank and insert a cuvette containing your first extract. Read and record A_{645}. Repeat for the other extracts.

Calculations:

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Use Arnon's equation (below) to convert absorbance measurements to mg Chl g-1 leaf tissue

Chl a (mg g-1) = [(12.7 × A_{663}) - (2.6 × A_{645})] × ml acetone / mg leaf tissue

Chl b (mg g-1) = [(22.9 × A_{645}) - (4.68 × A_{663})] × ml acetone / mg leaf tissue

Total Chl = Chl a + Chl b.

Digestion of fruit samples: Aqua Regia Method

1g of each sample of *Clemson spineless* was weighed into a clean digestion flask. Nine mills (9ml) of concentrated HNO3 and 3ml of concentrated HCl was added into the samples in the digestion flask, the whole sample was then heated in an hot plate until all brownish fumes were expelled out (Nitrogenous compound), which confirmed that the sample is digested and the sample was then allowed to cool at room temperature and few mls of distilled water was added and the mixture was filtered into 25mls standard flask, which was then transferred into plastic reagent bottle for AAS (Atomic Absorption Spectrometry) determination.

Determination of mineral content of the fruits

The nutrient contents after digestion was determined by placing each samples in an atomic absorbance spectrophotometer (AAS)

Soil sampling and sample analysis

Soil samples from 0 to 15cm depth were collected using hand trowel. The hand trowel was used to scoop out the soil from a depth of 15 cm at 10 different points from the experimental plot. The Analysis of the Soil samples was done at the department of agronomy, University of Ilorin. The procedures for Physico-chemicals analysis are explained as follows:

Soil texture was achieved using Bouyoucous or hydrometer method (Gee and Bauder, 1986),

Organic carbon (OC) was determined using the Walkley-Black wet digestion (Walkley and Black, 1934). Organic matter (OM) in percentage was determined according to Walkley and Black (1934) through calculation, thus: Organic matter (%) = % Total organic carbon x 1.72; where 1.72 is the conversion factor. Total nitrogen expressed in percentage was determined by modified Micro Kjeldahl wet digestion method as described by Bremmen (1996). **Soil pH** was measured in a 1: 2.5 soil-water suspension using glass electrode pH-Meter E520. Exchangeable acidity (Al +H) in centimole per kilogram (cmol kg^{-1}) was determined titrimetrically using 1M potassium chloride extraction and titrated with 0.05N sodium hydroxide as used by International Institute of Tropical Agriculture (IITA) (1979). Exchangeable cations; Calcium (Ca) Magnesium (Mg), sodium (Na) and potassium (K) were determined following the method of Anderson and Ingram (1993). While savailable phosphorus (P) in part per million (ppm) was extracted and determined by the Bray 1 method (Kuo, 1996).

III. Result and Discussion

TABLE 1: Physico-chemical properties of the experimental top soil.

Soil parameter determined	values
Physical properties:	
Particle size distribution	
Silt (%)	14.00
Clay (%)	5.04
Sand (%)	80.96
Textural class	Loamy sand
Chemical properties:	
PH	8.60
Total acidity ($cmolkg^{-1}$)	1.10
Organic carbon (%)	2.16
Organic matter (%)	3.74
Total Kjedhal Nitrogen	0.03
Available phosphate	0.022
Base saturation (%)	1.10
Cation exchange capacity	2.53
Ca ($cmolkg^{-1}$)	0.09
Mg^{2+} ($cmolkg^{-1}$)	1.07
K^{+} ($cmolkg^{-1}$)	0.03
Na^{+} ($cmolkg^{-1}$)	0.24

TABLE 2: Effect of NaCl treatments on germination count of *Abelmoschus esculentus* seeds (Var. *Clemson spineless*)

NaCl Treatment	2WAP	4WAP
Control	8.20±1.09^{a}	10.00±0.00^{a}
4g	7.00±1.00^{b}	10.00±0.00^{a}
6g	3.2±0.45^{c}	8.2±1.09^{b}
8g	3.00±0.71^{c}	6.00±0.71^{c}
10g	3.00±0.00^{c}	4.40±0.89^{d}

Means followed by the same letter (s) within the same column are not significantly different at P<0.05 WAP=Weeks after planting.

The germination count for control at 2WAP was significantly different from all the NaCl treatments, while 4g NaCl treatment is significantly different 6, 8, and 10g (P<0.05)

The germination count for control at 4WAP was not significantly different from 4g salt concentration, but had significant difference with 6, 8 and 10g (P<0.05)

Table three below indicates germination of *C. spineless* was fast and for control, at 4g NaCl treatment germination was prolonged. Number of germinated seeds decreased as NaCl concentrations increased.

The leaf number at 2WAP for control was not significantly different from 4g salt concentration, but had significant difference from 6, 8 and 10g at (P<0.05)

The leaf number at 4WAP for control was significantly different from other treatments while 6, 8 and 10g were not significantly different at (P<0.05)

The leaf number for control at 6WAP was significantly different from all the NaCl treatments at (P<0.05)

TABLE 3: Effect of NaCl treatments on leaves number of *Clemson spineless*

NaCl Treatment	2WAP	4WAP	6WAP	8WAP	10WAP	12WAP	14WAP	16WAP
Control	3.80±0.45^{a}	7.80±0.45^{a}	14.80±0.84^{a}	17.80±0.84^{a}	19.20±0.45^{a}	22.20±0.45^{a}	23.80±0.45^{a}	24.00±0.71^{a}
4g	3.60±0.55^{a}	5.80±0.45^{b}	11.20±1.09^{b}	14.00±1.00^{b}	14.40±0.89^{b}	20.80±1.30^{b}	22.40±0.89^{b}	22.40±0.89^{b}
6g	2.20±0.45^{c}	4.00±0.71^{c}	7.20±1.30^{c}	12.20±1.09^{c}	13.20±0.45^{c}	14.60±0.55^{c}	16.00±0.00^{c}	16.40±0.55^{c}
8g	2.00±0.00^{c}	3.60±0.55^{c}	6.00±.70^{cd}	10.40±0.89^{d}	11.60±0.89^{d}	13.00±0.71^{d}	14.00±0.71^{d}	14.20±0.45^{d}
10g	2.00±0.00^{c}	3.80±0.44^{c}	5.80±.44^{d}	8.80±0.84^{e}	10.00±0.71^{e}	12.60±0.54^{d}	13.20±0.45^{e}	13.60±0.55^{d}

Means followed by the same letter (s) within the same column are not significantly different at P<0.05 WAP=Weeks after planting

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TABLE 4: Effect of NaCl treatments on the leaf area of *Clemson spineless*

NaCl Treatment	2WAP (cm^2)	4WAP (cm^2)	6WAP (cm^2)	8WAP (cm^2)	10WAP (cm^2)	12WAP (cm^2)	14WAP (cm^2)	16WAP (cm^2)
Control	6.97±0.02^a	12.34±0.00^a	18.81±0.11^a	24.26±0.11^a	28.70±0.00^a	30.18±0.11^a	30.20±0.10^a	30.47±0.52^a
4g	6.53±0.00^b	10.53±0.03^b	16.90±0.71^b	23.99±0.35^a	26.75±0.14^b	29.66±0.63^a	29.80±0.67^a	30.01±0.60^a
6g	4.81±0.36^c	9.84±0.18^c	12.61±0.01^c	16.43±0.32^a	19.48±0.04^c	25.64±0.05^b	25.67±0.08^b	25.73±0.06^b
8g	4.24±0.02^d	9.13±0.11^d	11.75±0.03^d	14.73±0.02^b	16.66±0.26^d	18.76±0.47^c	18.84±0.41^c	19.49±0.34^c
10g	3.32±0.14^e	8.55±0.01^e	10.93±0.00^e	12.73±0.18^c	14.30±0.18^e	17.58±0.39^d	17.75±0.48^d	18.39±0.08^d

Means followed by the same letter (s) within the same column are not significantly different at P<0.05 WAP=Weeks after planting

TABLE 5: Effect of NaCl treatments on the stem girth of *Clemson spineless*

NaCl Treatment	2WAP	4WAP	6WAP	8WAP	10WAP	12WAP	14WAP	16WAP
Control	0.56±0.05^a	0.82±0.04^a	1.42±0.04^a	1.74±0.05^a	1.78±0.43^a	2.12±0.04^a	2.32±0.04^a	2.34±0.05^a
4g	0.50±0.07^a	0.74±0.05^b	1.08±0.04^b	1.48±0.04^b	1.72±0.08^a	1.96±0.05^b	2.10±0.00^b	2.16±0.08^b
6g	0.42±0.04^b	0.54±0.05^c	0.80±0.07^c	1.06±-0.05^c	1.24±0.05^b	1.32±0.04^c	1.54±0.05^c	1.62±0.08^c
8g	0.32±0.04^c	0.40±0.00^d	0.600±0.00^d	0.80±0.00^d	1.oo±0.00^{cd}	1.16±0.11^d	1.28±0.84^d	1.30±0.07^d
10g	0.34±0.05^c	0.40±0.00^d	0.50±0.00^e	0.72±0.04^e	0.86±0.05^d	1.12±0.08^d	1.18±0.04^e	1.30±0.00^d

Means followed by the same letter (s) within the same column are not significantly different at P<0.05 WAP=Weeks after planting

TABLE 6: Effect of NaCl treatments on the stem height of *Clemson spineless*

NaCl Treatment	2WAP (cm)	4WAP (cm)	6WAP (cm)	8WAP (cm)	10WAP (cm)	12WAP (cm)	14WAP (cm)	16WAP (cm)
Control	6.04±0.05^a	9.24±0.17^a	12.58±0.13^a	18.80±0.14^a	26.06±0.05^a	31.88±1.08^a	33.50±0.00^b	33.60±0.00^a
4g	5.38±0.16^b	8.88±0.08^b	11.76±0.22^b	17.42±0.43^b	25.60±0.07^b	29.50±0.34^b	34.62±0.16^a	34.90±0.00^a
6g	4.68±0.39^c	6.34±0.29^c	8.78±0.26^c	11.36±0.23^c	15.46±0.13^c	23.24±0.21^c	26.76±0.05^c	25.88±1.95^b
8g	4.14±0.09^d	4.84±0.09^d	6.62±0.35^d	8.98±0.08^d	13.36±0.21^d	18.38±0.11^d	22.10±0.10^d	22.40±0.00^c
10g	3.50±0.20^e	4.14±0.15^e	5.17±0.09^e	8.70±0.12^d	11.60±0.00^e	16.18±0.13^e	19.14±1.65^e	19.32±1.72^d

Means followed by the same letter (s) within the same column are not significantly different at P<0.05 WAP=Weeks after planting

TABLE 7: Effect of NaCl treatments on the fruit parameters of *Clemson spineless*

NaCl Treatment	Fruit Number	Fruit (cm) Length	Fruit Diameter	Fruit Circumference	Fruit (g) Fresh weight	Fruit (g) Dry weight
Control	16.40±1.14^a	5.48±0.91^a	1.08±0.13^a	3.94±0.27^b	7.78±0.88^b	2.23±0.17^a
4g	16.80±1.30^a	5.18±0.38^a	1.12±0.08^a	4.62±0.17^a	8.98±0.33^a	2.14±0.11^a
6g	12.60±1.67^b	3.54±0.22^b	1.08±0.08^a	3.68±0.11^c	5.68±0.33^c	1.83±0.13^b
8g	10.80±1.09^b	2.66±0.21^c	1.04±0.09^{ab}	3.26±0.24^d	4.70±0.35^d	0.38±0.31^c
10g	5.20±1.64^c	2.60±0.35^c	0.94±0.05^b	2.98±0.13^e	2.30±0.45^e	0.29±0.02^c

Means followed by the same letter (s) within the same column are not significantly different at P<0.05

The leaf number for control at 8WAP, 10WAP, 12WAP, 14WAP and 16WAP is significantly different from other treatments at P<0.05

The leaf numbers of *C. spineless* was impaired by increasing concentration of NaCl treatments which is much evident as the plant grows attains fruiting stage (Table 3).

The leaf area at 2WAP-6WAP for control was significantly different from all NaCl treatments, while at 12WAP-16WAP it was not significantly different from 4g salt concentration but had significant difference from 6, 8 and 10g NaCl treatments at (P<0.05).

The table above indicates that the leaf area of *C. spineless* was large for control and was not affected at 4g NaCl concentration, but increased salt concentration (above 4g) reduced leaf area (Table 4).

The stem girth for control at 2WAP was not significantly different from 4g salt concentration, but significantly different from 6, 8 and 10g at (P<0.05)

The stem girth for control at 4WAP-8WAP was significantly different from all the NaCl treatments at (P<0.05).

The stem girth for control at 10WAP was not significantly different from 4g salt concentration, but significantly different from 6, 8 and 10g at (P<0.05).

The stem girth for control at 12WAP-16WAP was significantly different from all NaCl concentrations at (P<0.05). The table below indicates that stem girth of *C. spineless* reduced significantly as salt concentrations increased (Table 5).

The stem height for control was significantly different from all the NaCl treatments at 2WAP-12WAP, while at 16WAP control was not significantly different from 4g salt concentration, but significantly different from 6, 8 and 10g at (P<0.05).

The table above indicates that stem height of *C. spineless* is significantly reduced by increased NaCl treatments, though at 4g salt concentration stem growth is slow (Table 6).

The fruit number for control was not significantly different with 4g salt concentration, but had significant difference from 6, 8 and 10g at (P<0.05)

The fruit length for control are not significantly different from 4g salt concentration, but had significant difference from 6, 8 and 10g at (P<0.05)

The fruit diameter for control was not significantly different from 4, 6, and 8g salt concentrations, but had significant difference from 10g NaCl treatment at (P<0.05).

The fruit circumference and fresh weight was significantly different in all the treatments at (P<0.05).

The fruit dry weight for control is not significantly different from 4g salt concentration, but was significantly different from 6, 8 and 10g at (p<0.05)

The table above indicates that the fruits of *C. spineless* were not significantly affected by at 4g NaCl treatments, although at 6, 8 and 10g concentrations of NaCl the fruits are significantly reduced.

Chlorophyll a for Control was significantly different from all the NaCl treatments at (P<0.05)

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Chlorophyll b for Control was significantly different from all the NaCl treatments at (P<0.05)

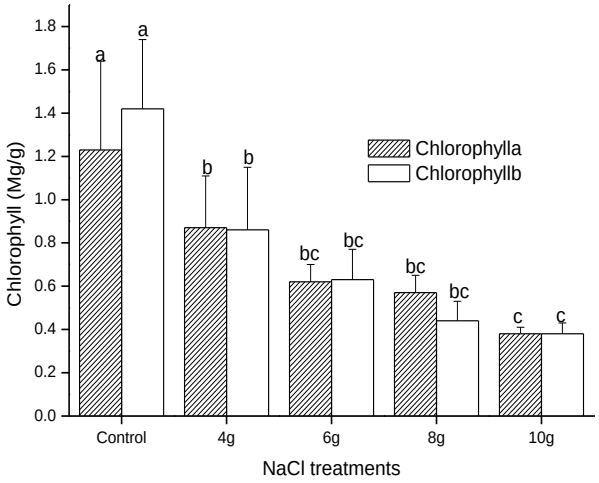

Fig. 1: Effect of NaCl treatments on Chlorophyll concentrations of *Clemson spineless* leaves

Ca, Mg, K, Na and P was significantly different in all the NaCl treatments and control at (P<0.05).

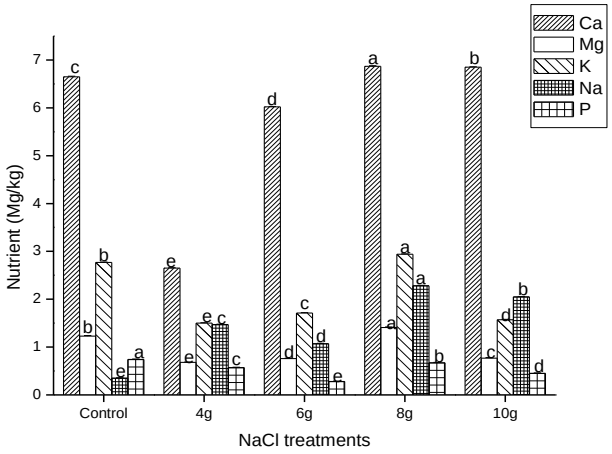

Fig. 2: Effect of NaCl treatments on the mineral contents of *Clemson spineless* fruits

Discussion

Germination

Abelmoschus esculentus species under study from the result obtained revealed that seed germination rates for all the control experiment was high (100% germination) compared to seeds under NaCl treatments, Okra seeds at 4g NaCl treatment germinated completely at 4WAP (100% germination) compared with control (100% germination at 2WAP) which is in agreement with Besma *et al.*, (2014) who reported that salinity adversely affect okra seed germination in his work on germination and seedling emergence of primed Okra seeds under salt stress and low temperature and (Lauchli and Grattan, 2007) who reported same in their research work on plant growth and development under salt stress that during germination most plants are tolerant although salinity stress delays the germination process.

Germination of Okra (*A. esculentus*) at 6, 8 and 10g NaCl inducement was adversely affected in numbers and duration (figure 2). Therefore *Clemson spineless* demonstrated salt tolerant at low concentration of NaCl (4g) during germination but is affected by increased NaCl concentration (6, 8 and 10g).

Growth

The leaves number of *A. esculentus* was not significantly affected at early stage of development by NaCl treatments but as the plants matures and attains reproductive stage the leaves number was observed to be less than the control which had significantly more number of leaves, these adverse effect in leaf number reduction in turns affect the leaf area as seen in the table 3 and inhibiting photosynthetic activities which is an important mechanism for plant to sustain growth and fruit yield. Similar report was given by Ali *et al.*, (2013) who reported salt stress symptoms on leaves such as chlorosis, shedding of mature leaves and burning leaves. Leaf area reduction of *C. spineless* is due to effect of salt stress (Table 4). Halsey, (2005) also gave a similar report that Na^+ and Cl^- can rise to toxic levels in older leaves resulting to death.

The stem girth was not affected at early stage of the plant developments but becomes reduced at later stage of developments and as NaCl concentration increases, *Clemson spineless* stem girth were reduced significantly from 4g NaCl treatments (12WAP-16WAP) with much severe reduction observed in 10g NaCl treatment as seen in table 5. This result in narrowing of vascular tissues which may impair water and nutrient conduction in the okra plant.

The stem height of *C. spineless* was not affected at 4g NaCl treatment at maturity, though it was delayed, which is in conformity with Ali *et al.*, (2013) who reported that salinity delays growth of plants.

The result obtained revealed that over all morphological traits (leaf number, leaf area, stem girth, and stem height) was hampered by NaCl treatments with much severe effect observed at 8g and 10g NaCl treatments.

Fruit yield

Table seven revealed that in C. *spineless*, salinity only had adverse effect on its performance at concentrations above 4g NaCl treatment because number of fruits harvested for control and 4g NaCl treatments were the same likewise in quality. Although at increased NaCl treatments (6, 8 and 10g) *C. spineless* fruit yield and quality was adversely affected by salinity. This finding is in conformity with Flowers *et al.*, (1977) who reported that period of salt-stress imposition varied from one developmental stage to the next and the adverse effect of salinity is most notable on fruits.

Chlorophyll

The leaf Chlorophyll a and b contents of *C. spineless* were reduced by all the salt concentrations, which also had detrimental effect on the leaf number and leaf area, and over all photosynthetic activities of the crop. Similar findings were also reported by Grattan and Grieve (1999)a on the salinity-mineral nutrient relations in horticultural crops.

Mineral analysis

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The interaction between salinity and nutrition's of plants is equally as complex, the interaction is highly dependent upon the plant species (or cultivar), plant developmental stage, the composition level of salinity and the concentration of nutrients in the substrate. Therefore, depending upon plants selected and conditions of the experiment, different results can be obtained (Grattan and Grieve, 1999).

Clemson spineless fruits analyzed, Calcium, Magnesium, Potassium and Sodium ion concentration was found to be high in 8g, and least in 4g, while Phosphorus was found to be high for control and minimum in 6g NaCl treatments. This result obtained is in conformity with Ivana and Zarko (2012) who stated that in most cases, excess of salts in soil solution leads to a reduction in phosphorus concentration; likewise in the tissues of plants the presence of NaCl can increase the concentration of K^+, Ca^{2+} and Na in pods and grains (Ivana and Žarko, 2012).

The result of the mineral analysis obtained obtain has no uniform order as the various mineral elements varies in concentration from one NaCl concentration to another, this may be due to the plant species, genetic composition, ecological factors and the biochemical interactions between salinity and nutrient uptake and this in conformity with Grieve and Grattan, (1999) who reported that Nutrient imbalances can result in salt-stressed plants in various ways.

Thus it is reasonable to believe that two or more of these processes may be occurring at the same time, but whether they ultimately affect crop yield or quality depends upon the salinity level, composition of salts, the crop species and a number of environmental factors.

IV. Conclusion and Recommendation

It was observed that excess salt causes significant yield losses with apparent toxicity symptoms on *C. spineless*. Increased salt concentrations lead to hormonal and nutrition imbalances, leaf expansion is impaired and their anatomical properties altered. Salinity problem must therefore be given rapt attention in other to overcome its obstructive impact by improving salt tolerance cultivars, valuable data and analysis from this study is therefore a way forward that can enhance the understanding of the mechanisms by which salinity affects photosynthesis and other physiological processes in other to improve conditions for growing vegetables with high yield and quality, and would also be a useful tool for future genetic engineering.

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