Почвознание агрохимия и екология, **54***, 3/2020*
Bulgarian Journal of Soil Science Agrochemisty and Ecology, 54, 3/2020

Effect of salinity stress on growth, yield and nutritional qualities of two okra varieties

Isiaka Kareem[1*]; Zainab Ayodeji Dauda [1]; Saliu Adeyemi Kareem[2]; Abdulmaliq, S. Y.[3]; Adekola, O. F.[1]; Abdulkareem, K. A.[4]; Olayinka, B. U.[4]; Abdul Aziz Ayinla[5]; Alasinrin Sikiru Yusuf[1]; Usman Magaji[6]; Mahamoud Abdillahi Rabileh[7]

[1]*Department of Agronomy, University of Ilorin, P. M. B. 1515, Ilorin, Nigeria*
[2]*Department of Biology, School of Secondary Education (Science Programme), Federal College of Education (Special), Oyo, Nigeria.*
[3]*Department of Crop Production, Ibrahim Badamasi Babangida Univesity, Lapai, Niger State, Nigeria*
[4]*Department of Plant Biology, University of Ilorin, P. M. B. 1515, Ilorin, Nigeria*
[5]*Department of Biological Sciences, Faculty of Natural and Applied Sciences, Al-Hikmah University, Ilorin, Nigeria*
[6]*Department of Agronomy, Faculty of Agriculture, Federal University of Kashere, Gombe, Nigeria*
[7]*Department of Crop and Soil Science, Eelo University, Borama, Somalia*
E-mail*: abdulkareemishaaq@gmail.com

Abstract

Kareem, I., Dauda, Z., Kareem, S., Abdulmaliq, S. Y., Adekola, O. F., Abdulkareem, K. A., Olayinka, B. U.,Ayinla, a., Yusuf, A., Magaju, U., Rabileh, M. (2020). Effect of salinity stress on growth, yield and nutritional qualities of two okra varieties. *Bulgarian Journal of Soil Science Agrochemisty and Ecology, 54*(3), 52-63.

The objective of this study was to determine the effect of salt stress on the growth yield and nutritional quality of two okra varieties. The experiment was laid out in randomized complete block design (RCBD) with three replications. Clemenson spineless NHA-e varieties of okra were the two varieties tested. The treatments used comprised four salinity levels (0 mM, 25 mM, 50 mM, and 75 mM) using sodium chloride as the salinity source. The varieties were assessed using plant height, number of leaves, leaf area, days to first flowering and fruit weight. Furthermore, moisture, carbohydrate, crude protein, crude fat, ash and crude fiber contents were used to assess the fruit nutritional qualities. The results showed that Clemenson spineless variety had better tolerance to salinity stress in plant height, days to flowering, fruit mass, ash content and crude protein content. However, NHA-e variety was more tolerant in fruit dry matter, crude fibre content, carbohydrate content and ether extract content. It is concluded that Clemenson spineless was more tolerant to salinity stress than NHA-e variety. Therefore, Clemenson spineless variety should be used in saline areas of Ilorin which is the northern guinea savannah zone of Nigeria and places with the same edaphic and climatic attributes.

Key words: salinity stress, okra varieties, proximate analysis, growth and yield of okra.

Introduction

Okra (Abelmosuchus esculentus) is an economically important vegetable crop grown in tropical and subtropical part of the world. It is one of the most utilized species of the family Malvaceae. Okra is a multipurpose crop due to its various uses of the fresh leaves, buds, flowers, pods, stems and seed. It can be serve as a source of carbohydrate, fats, vitamins, and various mineral. Also, okra polysaccharide lowers cholesterol level in blood and may prevent cancer by its ability to bind bile acids. Moreover, Okra seed possess blood glucose normalization and lipid profiles lowering action in diabetic condition (Sabitha et al., 2011).

In spite of having good nutritional value, it's per hectare yield is low. Although the area under okra has progressively increased during the last few years, there is a decreasing trend in its yield per hectare (Anonymous, 2008). This could be as a result of abiotic and biotic stresses like heat, cold, drought and salinity but salinity stress exerts more drastic effects in terms of low productivity (Munns, 2002).

Salinity is defined as the amassment of water-soluble salts in the top layer of the soil to a level that drastically affect crop production (Rengasamy, 2002). Salinity is one of the most serious factors limiting the productivity of agricultural crops, with adverse effect on germination, plant vigour and crop yield (Munns & Tester, 2008).

Salinization of soils is one of the serious problems for irrigated agriculture and the situation is most severe in tropical regions (Khan et al., 2003). Globally, more than 45 million hectares of irrigated land have been damaged by salt and about1.5 million hectares are taken out of production each year as a result of high salinity level in the soil (Munns & Tester, 2008). High salinity affects plants in form of water stress, ion toxicity, nutritional disorder, oxidative stress, alteration of metabolic processes, membrane disorganization, reduction of cell division and expansion, genotoxicity (Hasegawa et al., 2000). Together, these effects reduce plant growth, development and survival.

Salinization from irrigation water is also greatly increased by poor drainage and use of saline water for irrigating agricultural crop. It is estimated that up to half of irrigation schemes worldwide are salt affected (Flowers & Yeo, 1995). Salt stress affects plant at both whole plant and cellular levels through osmotic and ionic stress (Murphy & Durako, 2003). It has also been noted that salinity stresses affect plants in two ways: first the high concentrations of salt in soil makes it harder for shoot to extract water (osmotic stress) and secondly high concentrations of salt within the plant can be toxic (ionic stress) (Munns, 2002). Meanwhile, high salt content reduces growth and productivity by affecting physiological processes like modification of ion balance, water status, mineral nutrition, stomatal conductance behavior and photosynthesis efficiency (Munns, 1993). In the same vein, non-absorption of water by plant growing in saline water results in physiological drought or dryness within the plant.

Abiotic factor like salinity stress affects the nutritional values of okra. The nutritional characteristics include fibre, moderate levels of some essential mineral (magnesium and iron) and vitamins (A and K) which are important for body metabolic processes that utilize carbohydrates, protein and fat. It doesn't contain fat or cholesterol but rich in soluble fibre.

During the onset and development of salt stress within plant, all major processes such as photosynthesis, protein synthesis as well as energy and lipid metabolism are affected (Parida & Das, 2005). During the initial exposure to salinity, plant experiences water stress, which in turn reduces leaf expansion. The osmotic effect of salinity stress can be observed immediately after salt applications and are believed to continue for the duration of exposure, resulting in inhibited cell expansion and cell division as well as stomatal closure (Flowers, 2004, Munns, 2002). During the long-term exposure to salinity, plant experience ionic stress which leads to premature senescence of adult leaves and consequently reduction in the photosynthetic area available to support continued growth of plants (Cramer & Nowak, 1992). All these physiological changes can affect the nutritional components of the fruit.

Seeds from Sabz Pari, Punjab-8 of Okra (Albemuscus esculentus) varieties, grown under similar environment, had different nutritional contents-moisture content 7.26, 8.35%; ash 5.18, 6.23%; oil 11.72, 13.42%, protein 20.00, 23.68% and crude fiber 29.60, 27.41%, respectively (Anwar et al., 2011).

Soil salinity is one of the major constrains in the development of irrigated agriculture in humid, arid, and semi-arid regions in the world. Each year, about 40000 ha of land becomes unavailable for agricultural production because of salinization problems throughout the world. In addition to that, report prepared by specialized agencies of the United Nations indicates that about 50% of the irrigated area of the world is either salinized or has been potentially affected by salinity. Furthermore, about 2% of the lands farmed by dry-land agriculture, and more than 45 million hectares of irrigated land (at least 20% of total irrigated acreage) have been already damaged by salt (Lauchli et al., 2008). However, these problems are more severe in arid and sub-arid regions since precipitation is not sufficient and water supplies are also scarce as compare to the needs of cultivable land (Lamsal et al., 1999). Therefore, this research was conducted to determine the effect of salt stress on growth, yield and nutritional qualities of two okra varieties to select a better variety for saline soils.

Materials and Methods

Experimental site

This research was conducted at the Agronomy pavilion, Faculty of Agriculture, University of Ilorin (Lat $8^0$29'N, $4^0$35'E) which falls within the Southern Guinea Savanna ecological zone of Nigeria.

Soil collection and treatment application

The soil used in this experiment was collected from a fallow land located behind the Department of Agronomy pavilion, University of Ilorin at the depth of 0-15cm. Each of the experimental pots was filled with 7kg of the soil. Clemson spineless and NHA-e varieties of okra were used for the trial.

Experimental materials and design

Clemson spineless and NHA-e varieties of okra were used in this experiment. Four concentrations of sodium chloride (0 mM (control), 25 Mm, 50 Mm and 70 Mm sodium chloride) were used as treatments for each variety. Four treatments used for each variety was replicated three times to give a total of 12 of 12 experimental pots/units per variety. Therefore, the sum total of all the experimental pots was 24. All the experimental pots used were perforated at the bottom to allow for drainage of gravitational water. The lay out of the experiment was randomized complete block design with three replications.

Planting and cultural practices

Five seeds of each okra varieties used were planted in pots well-irrigated a day to planting. The resulting seedlings were thinned to 2 per pot 15days after planting. Each pot was irrigated every other day to avoid water logging. Weed control was through hand pulling to keep the plants weed free. DD-force insecticide was used to rid the plants of white flies' invasion.

Data collection

Data were collected on plant height, number of leaves, days to first flowering, number of fruits per pot and fruit mass per pot. Proximate analysis of the harvested fruits was carried out as follows:

Moisture determination

2g of plant material was weighed into empty moisture can of known mass(W_o) and the mass of the two materials was recorded as W_1. The sample was then dried in a hot-air drying oven at 105-110^o C until a constant mass was achieved. The sample was then cooled in a desiccator and the mass of moisture can plus dry plant sample was determined and recorded as W_2. Percentage of moisture was calculated as follows:

$$\%\text{Moisture} = (W1-W2)/(W1-W0)\times 100$$

Preparation of sample for proximate analysis

Dried samples of leaves were ground into fine powder. From the ground samples, crude fat, crude protein, crude fibre and ash contents were determined as follows:

Crude Protein Determination

This was done using Kjeldahl method described by Chang (2003). In this method, total nitrogen was determined and multiplied by 6.25 to obtain crude protein content of plant samples. 0.5 g of each plant sample was mixed with 10ml of H_2SO_4 in a digestion flask. A tablet of selenium was then added to the mixture and the resulting mixture was heated under a fume cupboard until the mixture turned to a clear solution (sample digest). The digest was made up to 100 ml using distilled water and kept in a volumetric flask. 10ml of the digest was mixed with equal volume (10 ml) of 45% sodium hydroxide solution of Kjeldahl distillation apparatus. The mixture was distilled into 10 ml of 40% boric acid containing three drops of mixed indicators (bromo cresol green and methyl red). A total of 50ml distillate was collected and titrated against 0.02N EDTA until the colour turned from green to deep red (the end point). Reagent without plant sample (blank) was also distilled and titrated. The nitrogen and crude protein contents were then calculated using the following formula:

$$\%\text{Nitrogen} = \frac{100xNx14xVt}{Wx1000 \text{ x } Va} xTxB$$

%Crude Protein= %N x6.25
W= Mass of sample (0.5 g)
N= Normality of titrant (0.02N H_2SO_4)
Vt= Total digest volume (100 ml)
Va= Volume of analyzed digest (10 ml)
T= Sample titre value
B=Blank titre value
Note: 1ml of 1N H_2SO_4 =14 mg

Determination of crude fat

The determination was through gravimetric method described by Krick and Sawyer (1980). 5 g of plant sample was wrapped in a porous paper (whatman filter paper) and put in a thimble. The thimble was put in a soxlet reflux flask and mounted on weighed extraction flask (W_1) containing 200 ml of petroleum ether. The upper part of the reflux flask was connected to a water condenser. The solvent (petroleum ether) was heated to boil, vapourize and condense into soxlet reflux flask. Through this process the sample in the thimble was shortly covered with the solvent after it was put there until soxlet reflux flask was filled and then siphoned. The oil extract was carried down to the boiling flask. This process was allowed to go on repeatedly for four hours before the defatted sample was removed. The solvent was recovered and the oil extract was left in the flask. The flask containing the oil extract was dried in an oven at 60°C for 30 minutes to remove any remove any residual solvent. The flask was then cooled in a desiccator and weighed (W_2). The mass of oil (fat) extract was determined as follows:

$$\%\text{Fat} = \frac{W2-W1}{\text{Mass of plant sample}} x100$$

Where:
W_1=Mass of empty extraction flask
W_2=Mass of flask + Oil (fat) extract

Determination of Total Ash Content

This was determined through furnace incineration gravimetric as described by James (1995) and AOAC (1984). 5.0 g of prepared plant sample was weighed into a porcelain crucible of mass W1. The sample was burnt to ashes at 550°C in a muffle furnace. After it has completely burnt into ashes, it was cooled in a desiccator and the mass of the crucible and ash was determined and recorded as W_2. Percentage of ash in the sample was determined as follows:

$$\%\text{Ash} = \frac{W2-W1}{\text{Mass of plant sample}} x100$$

Where:
W_1=Mass of empty extraction flask
W_2=Mass of crucible + Ash

Determination of crude fibre

This was determined by the procedure described by James (1995). 5.0 g of the prepared plant sample was weighed and boiled in 150 ml of 1.25% H_2SO_4 solution for 30 minutes under reflux. The boiled sample was washed in several portions of hot water using a two-fold cloth to

trap plant particles. The sample was returned to the flask and boiled again in 150 ml of 1.25% sodium hydroxide for 30 minutes under the same condition. After the sample was washed in several portions of hot water, the sample was allowed to drain and dry before being transferred into a weighed crucible where it was dried to a constant mass at 105°C using an oven. The mass of crucible + the dry sample was recorded as W_2. The dried sample was then transferred into a muffle furnace and burned into ashes. Percentage of crude fibre was determined as follows:

$$\%\text{Crude Fibre} = \frac{W2-W3}{\text{Mass of plant sample}} x100$$

Where:
W_2=Mass of crucible + sample after washing, boiling and drying
W_3=Mass of crucible + Sample of ash

Carbohydrate determination (Using Nitrogen Free Extraction (NFE) Method)

The nitrogen free extraction (NFE) refers to soluble carbohydrate which is not determined directly but obtained as a difference between crude protein and the sum of ash, protein, crude fat and crude fiber. NFE is calculated as follows:

NFE = 100- (%Ash+ % Crude fiber+ %Crude protein+ % Crude fat).

Statistical analysis

All the data obtained were subjected to analysis of variance (ANOVA) using GENSTAT package. Significant means were separated using least significant difference (LSD) at $P \leq 0.05$.

Results and Discussion

Salinity stress led to progressive decrease in height of Clemenson spineless okra variety from the control plants that had the tallest plants to the plants stressed with application of 75 mM NaCl. The closest plants in height to the control plants were from plants stressed with application of 25 mM NaCl. In variety NHA-e, however, there was progressive increase in height except for plants stressed with application of 50 mM NaCl which had the shortest plants to distort the trend of height increase with increase in salinity stress. So, the tallest plants were from plants stressed with application of 75 mM NaCl while the shortest plants were from the plants stressed with application of 50 mM NaCl (Table 1).

The growth of Clemson spineless variety decreased as salinity level decreased showed clearly that they were affected by salinity stress. The depressed growth might be attributed to toxic effect of Na^+ and Cl^- ions on plant metabolism and plant-water relation (Nahed et al., 2017). Furthermore, reduction in vegetative growth by salinity stress could be linked to alteration of water potential, increase in ion toxicity, obstruction of cell division and expansion as well as ion imbalance (Arshi et al., 2005). Moreover, growth reduction could be the result of inhibition of apical growth and endogenous hormonal imbalance caused by salinity stress (Younis et al., 2010). Similarly, reduced plant height caused by salinity stress might be caused by reduced cell division resulting from osmotic stress of saline soil solution. It might equally be the result of inability of getting sufficient water and nutrient needed for cell elongation and enlargement as a result of physiological dryness experienced by the plants. This might have had consequential effect on photosynthate production because water and some nutrients like potassium and chlorine are needed for successful photosynthetic activities. With less photosynthate production, translocation to the growing areas becomes a great difficulty and, therefore, growth is checked. This was manifested in reduced plant height found in this work. Moreover, salinity might have disturbed the capacity of roots to extract water or salinity resulted in toxicity which caused inhibition of many physiological and biochemical processes like as nutrient uptake and assimilation (Hasegawa et al, 2000; Munns, 2002). All these effects reduce plant growth, development and survival.

However, NHA-e variety still displayed its tolerance to the imposed salinity stress. This might be attributed to cell membrane stability and lower

osmotic potential of the cells which led to influx of water from the surrounding soil into the roots for biochemical and physiological use. In addition to that, it could equally be a result of the ability of the cultivar to sequester salt in its body. Therefore, the plants grew without being affected.

Number of leaves per plant was not affected by salinity stress except at the highest level of salinity stress (75 mM NaCl) in both varieties tested. For both Clemson spineless and NHA-e varieties, leaves produced per plant increased from the control plants to the plants stressed with 50 mM NaCl and then a decline in plants stressed with 75 mM NaCl. Salinity stress with 50 mM NaCl induced production of highest number of leaves in both varieties used (Table 1).

There was a direct relationship between salinity and number of leaves. This implies that increase in the concentration of salts led to increase in the number of leaves. However, an interesting decrease in the number of leaves in both varieties was recorded at 75 mM. This might be because plants faced with the problem of salinity experienced a change in cell wall properties, leaf turgor and photosynthetic rates which then led to reduction in number of leaves produced. In the same vein, reduction in number of leaves could have resulted from reduced turgor or reduction in extensibility of cell walls (Neumann, 1993). The problem could still be due to water stress in the short run and ion toxicity in the long run (Yeo et al., 1991). This reduction in number of leaves can be seen as an avoidance mechanism which occurs so as to reduce water loss by transpiration. This reduction in water loss by transpiration is also capable of limiting accumulation of the salt ions in the shoot by favouring the retention of toxic ions in the roots (Munns & Tester, 2008). Finally, it can be said that salinity stress up 50 mM NaCl induced better leaf production and only at 75mM that salinity effect started hampering leaf production. This might be attributed to cell membrane stability and lower osmotic potential of the cells which led to influx of water from the surrounding soil into the roots for biochemical and physiological use. In addition to that, it could equally be a result of the ability of the cultivar to sequester salt in its body. It might equally be suggested that there was higher water uptake in the plants when they were stressed with 25 and 50 mM NaCl. Consequentially, increase in water uptake capacity allowed the ion dilution to prevent toxic level in cytosol (Chelli-Chaabouni et al., 2010). Therefore, the plants grew without being affected.

Table 1. Effect salinity stress on height and number of leaves of two okra varieties

Treatment	Plant Height(cm)		Number of Leaves(no/plant)	
	Clemenson spineless	NHA-e	Clemenson spineless	NHA-e
Control	33.7	22.0	5.33	5.33
25 mM NaCl	33.0	22.7	6.00	6.33
50 mM NaCl	24.7	16.0	6.33	6.67
75 mM NaCl	24.7	26.3	5.00	4.00
LSD (0.05)	ns	ns	ns	ns

Salinity stress delayed flower production in the two okra varieties tested. The duration of delay in NHA-e variety was more than that of Clemson spineless variety when compared to the control. The NHA-e flowered earlier than Clemson spineless. Despite that, the plants from NHA-e were more affected by salinity stress in terms of delay in flower production than Clemson spineless variety which flowered late. The duration of delay between the control plants and the plants stressed with highest level of salinity stress was 5 days in Clemson spineless variety and 14 days in NHA-e (Table 2).

This might have been caused by delay in growth and development occasioned by salinity stress. It, therefore, took longer days for the plants to transit from vegetative to reproductive stage. The delay in growth and transition to the reproductive stage could be attributed to a decrease in carbon assimilation due to stomatal limitation and/or metabolic impairment (Hajiboland et al. 2014). Moreover, the reduction in plant growth under saline conditions might be the result of direct inhibition of cell division and expansion (Zhu, 2001; Munns, 2002). The number of fruits produced by all the varieties used was generally affected by the level of salinity imposed. All the varieties produced the same number of fruits with the control at all levels of salinity stress imposed with the exception of salinity through 75 mM NaCl for Clemson spineless variety and 50mM NaCl for NHA-e variety. These occurrences could be by chance. The most amazing result was that of the control that equally had the same number of fruits with the stressed plants (Table 2).

This reduction of yield and yield components under salt stress may be attributed to low cell expansion, less photosynthetic rate and leaf senescence (Wahid et al. 1997). Furthermore, the growth of salt-stressed plants is mostly limited by the osmotic effect of salinity irrespective of their capacity to exclude salt and it results in reduced growth rate and low stomatal conductance (Fricke et al. 2004; James et al., 2008). As the concentrations increase, the yields move towards zero because most plants (glycophytes) will not grow in high salinity condition and are severely inhibited or even killed at very high salinity level because they have evolved under low salinity conditions and cannot tolerate high salinity stress (Munns et al., 1986).

The mass of individual fruits was negatively affected with progressive increase in salinity level. There was progressive decrease in fruit mass from the control plants to the plants stressed with 50 mM NaCl after which there was a surge in fruit mass for both varieties when the highest level of salinity (75 mM NaCl) was imposed (Table 2). Reduction in yield could be attributed to reduction in the parameters discussed earlier. This could be linked to action of salinity to induce Fe^{2+}, K^{+}, and Ca^{2+} deficiencies (Singh et al., 2004) which resulted in yield losses (Hunshal et al., 1991). Also, salinity stress can cause decreased seed germination, seed growth, and dry matter production (Nautiyal et al., 1989).

It is general that salt stress lead to reduction of crop yield which is the most noticeable effect in agriculture. This is also noticeable in almost all plant species with the exception of some halophytes. For instance, application of 250 mM NaCl decreased yield by 77, 73 and 66% in BARI mung-2, BARI mung-5 and BARI mung-6 respectively compared to the control (Nahar & Hasanuzzaman (2009)).

The ash content of Clemenson spineless variety increased with increase in salinity level until the peak of salinity stress (75 mM NaCl) when there was a sudden drop in ash content. In NHA-e variety, however, there was progressive decrease in the ash content from the control to the highest level of salinity stress (75 mM NaCl) (Table 3).

The ash content signifies the level of minerals in the fruits. The improvement in the mineral nutrient resulting from salinity stress of variety Clemenson spineless could be attributed to balance in soil nutrients which guaranteed even absorption of nutrients without antagonism as the case may be in NHA-e variety is involved. Furthermore, increase in salinity stress in NHA-e variety led progressive inhibition of mineral uptake by the plants. This then resulted in having low ash content which is an indicator of the amount of minerals absorbed by the plants.

Table 2. Effect salinity stress on days to first flowering, number of fruits per pot and fruit mass per pot of two okra varieties

Treatment	Days to First Flowering(days)		Number of Fruits/Pot		Fruit Mass(g/pot)	
	Clemenson		Clemenson		Clemenson	
	spineless	NHA-e	spineless	NHA-e	spineless	NHA-e
Control	45	41	1	1	16.0	14.1
25 mM NaCl	47	50	1	1	14.4	8.9
50 mM NaCl	47	52	1	2	8.3	8.3
75 mM NaCl	50	55	2	1	13.0	13.0
LSD(0.05)	Ns	ns	ns	ns	ns	ns

Table 3. Effect salinity stress on ash, carbohydrate and crude fibre contents of two okra varieties

Treatment	Ash Content (%) Crude		Carbohydrate Content (%)		Fibre Content (%)	
	Clemenson		Clemenson		Clemenson	
	spineless	NHA-e	spineless	NHA-e	spineless	NHA-e
Control	1.57	1.50	57.8	50.95	24.4	20.0
25 mM NaCl	1.86	1.90	38.1	52.56	21.2	26.2
50 mM NaCl	3.18	1.42	54.7	69.34	26.5	14.0
75 mM NaCl	1.10	1.23	61.6	55.85	22.0	28.3
LSD(0.05)	0.639	1.02	ns	4.438	ns	3.85

The carbohydrate content of Clemenson spineless variety was decreased by stressing the plants with the 25 and 50 mM NaCl. However, the carbohydrate content of plants stressed with 75 mM NaCl had a surge which made it the carbohydrate content above the content of the control plants. In summary, the highest carbohydrate content was from the plants stressed with 70 mM NaCl followed by the control while the lowest level was from the plants stressed with 25 mM NaCl. (Table 3).

For NHA-e variety, there was progressive increase in carbohydrate content from the control plants to the plants stressed with 50 mM NaCl after which there was a decline in the plants stressed with 75 mM NaCl. Despite the decline, the carbohydrate content of the plants stressed with 75 mM NaCl was still above that of the control plants. The highest carbohydrate level was from the plants stressed with 50 mM NaCl followed by plants stressed with 25 mM NaCl while the lowest carbohydrate content was found in the control plants (Table 3).

The crude fibre content of Clemenson spineless declined with imposition of salinity stress using 25 mM NaCl then it rose with imposition of 50 mM NaCl and it finally declined when salinity stress was imposed using 75 mM NaCl. The lowest crude fibre content was from plants stressed with 75 mM NaCl followed by the control plants

while the lowest crude fibre level was from plants stressed with 50 mM NaCl (Table 3).

The crude fibre contents of variety NHA-e rose in plants stressed with 25 mM NaCl after which it fell in plants stressed with 50 mM NaCl and finally rose again in plants stressed with highest level of NaCl (75 mM). The lowest crude fibre content was found in plants stressed with 50 mM NaCl followed by the control plants while the highest was from plants stressed with 75 mM NaCl.

Crude fibre is the part of an organic material (food or feed) that contains cellulose and other carbohydrates which are insoluble in either weak acid or alkali solution. High content of crude fibre implies low digestibility of the food or feed material as well as low energy and total digestible nutrient (TDN). The increase in crude fibre in NHA-e variety implies that the fruits produced would be of low usefulness as either food or feed. It should be noted that fruit bulking is through increase in fibre content and water which are both disadvantages because they result in low shelf life, low dry matter content and low digestibility. However, variety Clemenson spineless was better because salinity stress led to decrease in crude fibre production except when stressed with 50 mM NaCl which could have resulted from chance. Therefore, fruit of variety Clemenson spineless would better as food or feed when stressed with salinity. However, high fibre content in okra is useful in stabilizing blood sugar by slowing down or regulating the rate at which sugar is absorbed from the intestinal tract and, therefore, useful for managing diabetes (Ngoc et al., 2008).

Crude protein in the variety Clemenson spineless rose with decrease in salinity stress with exception of the control plants. The lowest crude protein content was found in the control plants followed by plants stressed with the highest concentration of NaCl (75 mM) while the highest was found in the plants stressed with 25 mM NaCl (Table 4).

In NHA-e variety, crude protein content increased with decrease in salinity stress. So, the lowest crude protein content was found in the plants stressed with the highest level NaCl (75 mM) followed by plants stressed with 50 mM NaCl while the highest crude protein content was from the control (Table 4).

Increase in crude protein Clemenson spineless variety might be the result of better nitrogen supply to the fruits resulting from salinity stress at the root zone. Salinity stress might have elicited protein synthesis and prevented accumulation of amino acids. This observation could still result from decrease in the activities of hydrolyzing enzymes which might have led to accumulation of amino acids at the expense of protein synthesis (Pessarakli &Tucker, 1988). Furthermore, high protein content could have resulted from high nitrate reduction activity which led to increase in plant. However, the results from NHA-e variety indicated a decrease in crude protein with increasing salinity. This might have resulted from decreased synthesis of protein as well as increased activities of protein hydrolysing enzymes which led to accumulation of amino acids at the expense of protein (Pessarakli & Tucker, 1988). Furthermore, it is well known that higher ratio of Na^+ to K^+ and accumulation of salts at high salinity level inactivate enzymes and inhibit synthesis of protein. Finally, reduction in protein content might be attributed to low nitrate reduction activity (NR) which could have accounted for decline in plant growth.

The ether extract in the variety Clemenson spineless increased with decrease in salinity stress. So, the lowest ether extract content was from plants stressed with the highest level of NaCl (75 mM) followed by plants stressed with 50 mM NaCl while the highest was found in the control plants (Table 4).

In NHA-e variety, there was a rise and fall trend. There was increase above the control in 25 mM NaCl stressed plants after which there was a drop in plants stressed with 50 mM NaCl and there was final rise in the plants stressed with 75 mM NaCl. The highest content was from plants stressed with 25 mM NaCl followed by 75 mM NaCl while lowest was from the control. All in all, salinity stress led to increase in ether extract content above the control. The control was opposite that of variety Clemenson spineless (Table 4).

Ether extract (crude fat) is an indicator of energy production (twice that of carbohydrate), means

of absorption of fat soluble vitamins, protector of delicate organs in the body as well as insulator against cold. Variety Clemenson spineless had an inverse relationship with salinity stress. This implies that this variety will not be useful whenever crude fat is needed in okra fruits. Increase in salinity level might have triggered lipase production which was responsible for breaking down of fat. Therefore, increase in salinity stress resulted in decrease in crude fat content. However, the case is opposite in NHA-e variety. As salinity increased, crude fat also increased. This might be attributed to triggering effect of root zone salinity stress on fat synthesis and prevention of more of lipase that would have led to degradation of fat to fatty acid and glycerol.

The dry matter of variety Clemenson spineless increased with increase in salinity stress with the exception of the plants with highest level of salinity (75 mM NaCl). So, the lowest fruit dry matter was from plants stressed with 75 mM NaCl followed by the control plants while the highest fruit dry matter was from plants stressed with 75 mM NaCl (Table 4).

In NHA-e variety, fruit ash content followed the pattern of ether extract content of this variety. At the beginning, there was increase in the value of fruit dry matter in plants stressed with 25 mM NaCl over that of control after which there was a drop in value in plants stressed with 50 mM NaCl and finally there was a surge again in plants stressed with 75 mM NaCl. The highest fruit dry matter was from plants stressed with 75 mM NaCl followed by the control while the lowest dry matter was from plants stressed with 50 mM NaCl (Table 4).

From this study, dry mass was observed to have decreased with salinity in all tested varieties. This could have resulted from reduction in the number and size of leaves, senescence and total abscission which reduced photsynthate production and consequently the dry matter accumulation. Furthermore, it might be that there was build-up of chlorine in the leaves of salt stressed plants and that triggered the synthesis of some forms of carboxylic acids which are converted to ethylene (a hormone) which triggered abscission in plants (Dodd, 2005). Finally, it should be noted that senescence may occur prior to accumulation of toxic ions and, therefore, osmotic phase is characterized by accumulation of abscisic acid (ABA) and a decrease in indole-3-acetic acid (IAA) (Albacete et al., 2008 and Ghanem et al., 2008). Final yield for all cultivars reduced with increasing salinity. The combined effects of reductions in root size, number of leaves and leaf area led to a drastic reduction in the production and distribution of photosynthate which ultimately caused a reduction the final yield.

Table 4. Effect salinity stress on crude protein, dry matter and ether extract contents of two okra varieties

Treatment	Crude Protein Content (%))		Fruit Dry Matter (%		Ether Extract Content (%)	
	Clemenson		Clemenson		Clemenson	
	spineless	NHA-e	spineless	NHA-e	spineless	NHA-e
Control	6.68	10.51	75.2	77.9	9.40	8.50
25 mM NaCl	8.97	10.39	79.0	85.2	8.54	10.50
50 mM NaCl	7.22	6.13	83.0	76.1	8.50	9.30
75 Mm NaCl	6.75	5.25	72.0	89.0	8.40	10.17
$LSD_{(0.05)}$	ns	1.32	ns	ns	ns	ns

Conclusion

From this work, it was found that Clemenson spineless variety had better tolerance to salinity stress in plant height, days to flowering, fruit mass, ash content and crude protein content. However, NHA-e variety was more tolerant in fruit dry matter, crude fibre content, carbohydrate content and ether extract content. It is concluded that Clemenson spineless was more tolerant to salinity stress than NHA-e variety. It is, therefore, recommended that Clemenson spineless variety should be used in saline areas of Ilorin which is the northern guinea savannah zone of Nigeria and places with the same edaphic and climatic attributes.

Reference

Albacete, A., Ghanem, M. E., Martínez-Andújar, C., Acosta, M., Sánchez-Bravo, J., Martínez, V., ... & Pérez-Alfocea, F. (2008). Hormonal changes in relation to biomass partitioning and shoot growth impairment in salinized tomato (Solanum lycopersicum L.) plants. *Journal of Experimental Botany, 59*(15), 4119-4131.

Anonymous (2008). Fruits, Vegetable and Condiments Statistics 2006-07. Islamabad, Pakistan: MINFAL

Anwar, F., Rashid, U., Mahmood, Z., Iqbal, T., & Sherazi, T. H. (2011). Inter-varietal variation in the composition of okra (Hibiscus esculentus L.) seed oil. *Pak. J. Bot, 43*(1), 271-280.

Arshi, A., Abdin, M. Z., & Iqbal, M. (2005). Ameliorative effects of CaCl2 on growth, ionic relations, and proline content of senna under salinity stress. *Journal of plant nutrition, 28*(1), 101-125.

Chang, S. K. C. (2003). Protein Analysis: Food Analysis, Nielson, S.S. (Ed.). *Kluwer Academic Plenum Publisher*, New York.

Chelli-Chaabouni, A., Mosbah, A. B., Maalej, M., Gargouri, K., Gargouri-Bouzid, R., & Drira, N. (2010). In vitro salinity tolerance of two pistachio rootstocks: Pistacia vera L. and P. atlantica Desf. *Environmental and Experimental Botany, 69*(3), 302-312.

Cramer, G. R., & Nowak, R. S. (1992). Supplemental manganese improves the relative growth, net assimilation and photosynthetic rates of salt-stressed barley. *Physiologia plantarum, 84*(4), 600-605.

Dodd, I. C. (2005). Root-to-shoot signalling: assessing the roles of 'up' in the up and down world of long-distance signalling in planta. *Plant and soil, 274*(1-2), 251-270.

Flowers, T. J. (2004). Improving crop salt tolerance. *Journal of Experimental botany, 55*(396), 307-319.

Flowers TJ , Yeo AR. (1995).Breeding for salinity resistance in crop plants—where next? *Australian Journal of Plant Physiology, 22*, 875–884.

Fricke, W., Akhiyarova, G., Veselov, D., & Kudoyarova, G. (2004). Rapid and tissue-specific changes in ABA and in growth rate in response to salinity in barley leaves. *Journal of experimental botany, 55*(399), 1115-1123.

Ghanem, M. E., Albacete, A., Martínez-Andújar, C., Acosta, M., Romero-Aranda, R., Dodd, I. C., ... & Pérez-Alfocea, F. (2008). Hormonal changes during salinity-induced leaf senescence in tomato (Solanum lycopersicum L.). *Journal of Experimental Botany, 59*(11), 3039-3050.

Hajiboland, R., Norouzi, F., & Poschenrieder, C. (2014). Growth, physiological, biochemical and ionic responses of pistachio seedlings to mild and high salinity. *Trees, 28*(4), 1065-1078.

Hasegawa, P. M., Bressan, R. A., Zhu, J. K., & Bohnert, H. J. (2000). Plant cellular and molecular responses to high salinity. *Annual review of plant biology, 51*(1), 463-499.

Hunshal, C. S., Viswanath, D. P., Chimmad, V. P., & Gali, S. K. (1991). Performance of groundnut genotypes under saline water irrigation. J*OURNAL-MAHARASHTRA AGRICULTURAL UNIVERSITIES, 16*, 116-116.

James, C. S. (1995). Analytical Chemistry of Foods. Chap. 6, General Food Studies, Firsted.

James, R. A., von Caemmerer, S., Condon, A. T., Zwart, A. B., & Munns, R. (2008). Genetic variation in tolerance to the osmotic stress componentof salinity stress in durum wheat. *Functional Plant Biology, 35*(2), 111-123.

Khan, A. A., Rao, S. A., & McNeilly, T. (2003). Assessment of salinity tolerance based upon seedling root growth response functions in maize (*Zea mays* L.). *Euphytica, 131*(1), 81-89.

Kirk, R. S., & Sawyer, S. (1980). Pearson's Food Composition and Analysis.

Lamsal, K., Paudyal, G. N., & Saeed, M. (1999). Model for assessing impact of salinity on soil water availability and crop yield. *Agricultural Water Management, 41*(1), 57-70.

LÄUCHLI, A., James, R. A., Huang, C. X., McCULLY, M. A. R. G. A. R. E. T., & Munns, R. (2008). Cell-specific localization of Na+ in roots of durum wheat and possible control points for salt exclusion. *Plant, Cell & Environment, 31*(11), 1565-1574.

Munns, R., & Fisher, D. B. (1986). Na^+ and Cl^- transport in the phloem from leaves of NaCl-treated barley. *Functional plant biology, 13*(6), 757-766.

Munns, R. (1993). Physiological processes limiting plant growth in saline soils: some dogmas and hypotheses. *Plant, Cell & Environment, 16*(1), 15-24.

Munns, R. (2002). Comparative physiology of salt and water stress. Plant, cell & environment, 25(2), 239-250.

Munns, R., & Tester, M. (2008). Mechanisms of salinity tolerance. *Annu. Rev. Plant Biol., 59*, 651-681.

Murphy, L. R., Kinsey, S. T., & Durako, M. J. (2003).

Physiological effects of short-term salinity changes on Ruppia maritima. *Aquatic Botany, 75*(4), 293-309.

Nahar, K., & Hasanuzzaman, M. (2009). Germination, growth, nodulation and yield performance of three mungbean varieties under different levels of salinity stress. *Green Farming, 2*(12), 825-829.

Rashed, N., Shala, A., & Mahmoud, M. A. (2017). Alleviation of Salt Stress in Nigella Sativa L. By Gibberellic Acid and Rhizobacteria. *Alexandria Science Exchange Journal, 38(October-December)*, 785-799.

Nautiyal P. C, Ravindra, V., Joshi, Y. C. (1989). Germination and early seedling growth of some groundnut (Arachis hypogaea L.) cultivars under salt stress. *Indian J Plant Physiol., 32*, 251–253.

Neumann, P. M. (1993). Wall extensibility and the growth of salt stressed leaves. In Interacting Stresses on Plants in a Changing Climate (pp. 603-615). *Springer, Berlin, Heidelberg.*

Ngoc, T., & Ngo, N. (2008). Van T and Phung V. Hypolipidemic effect of extracts from Abelmoschus esculentus L.(Malvaceae) on Tyloxapol-induced hyperlipidemia in mice. *Warasan Phesatchasat, 35*, 42-46.

Parida, A. K., & Das, A. B. (2005). Salt tolerance and salinity effects on plants: a review. *Ecotoxicology and environmental safety, 60*(3), 324-349.

Pessarakli, M., & Tucker, T. C. (1988). Dry matter yield and nitrogen-15 uptake by tomatoes under sodium chloride stress. *Soil Science Society of America Journal, 52*(3), 698-700.

Rengasamy, P. (2002). Transient salinity and subsoil constraints to dryland farming in Australian sodic soils: an overview. *Australian Journal of Experimental Agriculture, 42*(3), 351-361.

Sabitha, V., Ramachandran, S., Naveen, K. R., & Panneerselvam, K. (2011). Antidiabetic and antihyperlipidemic potential of Abelmoschus esculentus (L.) Moench. in streptozotocin-induced diabetic rats. J*ournal of pharmacy and bioallied sciences, 3*(3), 397.

Singh A.I., Basu, M.S.& Singh, M.B. (2004). Mineral Disorders of Okra.National Research Center for Fruits and Vegetables. (ICAR), Junagadh, India, pp. 85-114

Wahid, A., & Rasul, E. (1997). Identification of salt tolerance traits in sugarcane lines. *Field Crops Research, 54*(1), 9-17.

Yeo, A. R., Lee, Λ. S., Izard, P., Boursier, P. J., & Flowers, T. J. (1991). Short-and long-term effects of salinity on leaf growth in rice (Oryza sativa L.). *Journal of Experimental Botany, 42*(7), 881-889.

Younis, M. E., Hasaneen, M. N., & Kazamel, A. M. (2010). Exogenously applied ascorbic acid ameliorates detrimental effects of NaCl and mannitol stress in Vicia faba seedlings. *Protoplasma, 239*(1-4), 39-48.

Zhu, J. K. (2001). Plant salt tolerance. *Trends in plant science*, 6(2), 66-71.