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EFFECTS OF SALINITY STRESS ON NPK PARTITIONING, GROWTH, YIELD AND PROXIMATE COMPOSITION OF OKRA (*ABELMOSCHUS ESCULENTUS*)

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ABSTRACT

This experiment was conducted to determine the effects of salinity on growth, yield, NPK partitioning and proximate composition of okra. To achieve this objective, four levels of salinity (0, 50, 75 and 100mM sodium chloride) were tested on 17Lucky19 okra variety in a pot experiment. The experiment was laid out in randomized complete block design (RCBD) with three replications. Parameters used to determine the effects of salinity on the crop were nitrogen, phosphorus and potassium contents of stem and leaves. Also, plant height, number of branches, number of leaves, number of fruits, fresh fruit mass, dry straw mass, chlorophyll content and proximate parameters (crude fat, crude fibre, crude protein and ash contents of the plant leaves) were used. It was found that all the growth and yield parameters tested reduced with increase in salinity levels. Similarly, all proximate parameters decreased with increase in salinity levels with the exception of crude fibre which increased with increase in salinity level. In the same vein, nitrogen and potassium levels decreased with increase in salinity level in both leaves and stems. However, phosphorus levels in stems and leaves decreased with increase in salinity level. It is, therefore, concluded that 17Lucky19 okra variety is susceptible to salinity stress. This implies that salinity tolerant or resistant varieties should be used instead of 17Lucky19 whenever saline soil is to be used for cultivating okra.

KEY WORDS: ***s****alinity stress, okra, NPK partitioning, proximate composition, growth and yield*

INTRODUCTION

Salinity and drought stress are among the most serious challenges to crop production in the world especially developing countries (Sobar et al., 2010). Salinity is a severe abiotic stress caused primarily by abundant sodium chloride from natural accumulations, irrigation and evapotranspiration (Flowers & Flowers, 2005). Saline soils are characterized by having an electrical conductivity higher than $4dSm^{-1}$which could not be tolerated by many crops (Qadir et al., 2000). Consequential ionic imbalance from salinity disturbance of nutrient uptake and accumulation of ions over time are the main causes of toxicity in plants (Verslues et al., 2006). It should be noted that a lot of traits contribute to salinity tolerance and they are species and developmental stages dependent (Jones et al., 2015). Yield is negatively affected by osmotic stress while the intensity of consequential membrane injury depends on the rate of salt absorption and the ability to partition the salt into different tissues (Volkmar et al., 1998).

Salinity of soil or water is of increasing importance to agriculture because it causes a stress condition to crop plants. Several physiological processes like photosynthesis, respiration, nitrogen fixation and carbohydrate metabolism are affected by high salinity (Chen et al., 2008). Salinity applied at the seedling stage frequently induces premature senescence of leaves (Lutts et al., 1996). Salinity can limit growth and plant yield by reducing osmotic potential, creating ion toxicity and causing imbalanced ion uptake as well as disorder in enzyme and metabolic activities in the plant (Murphy et al., 2003). Effects of salinity result in reduced vegetative growth (Rogers et al., 2009), leaf area, chlorophyll content (Saleh & Maftoun, 2008), plant height (Rahman et al., 2008) plant dry mass (Razzaque et al., 2009) and ultimately crop yield (Zeng & Shannon, 2000). It should be understood that reductions in growth rate occur because of toxicity by high salt concentration and inability of plants to absorb enough water as a result of decrease in osmotic component of soil water potential (Tester & Davenport, 2003). It is equally worth noting that prolonged stress causes wilting similar to that of drought with leaves having greenish-blue colour and thick wax (Fraga et al., 2010).

Crop yield loss through salinity stress is too enormous for farmers of any category in crop production to bear. So, crops to be produced in saline soils should be tested for their tolerance of the stressful environmental condition before being cultivated on a large scale. Therefore, this research was conducted to determine the effects of salinity stress on growth, yield, NPK partitioning and proximate composition of okra.

MATERIAL AND METHODS

Experimental site. The experiment was carried out in the glass house of the Faculty of Agriculture, University of Ilorin, Ilorin, Kwara State. The university was located on latitude 8º29'N and Longitude 4º35'E in the southern Guinea savanna Agro ecology of Nigeria

Experimental units and design. A total of sixteen experimental units (pots) were used in the experiment. Each pot was filled with 6kg of soil and the pots were perforated at the base to allow for drainage of gravitational water and prevent water logging at the instance of irrigation. The experiment was laid out in randomized complete block design (RCBD) with four replications.

Planting, treatment application and cultural practices. In each experimental pot, four seeds of 17Lucky 19 variety of okra were planted and the resulting seedlings were later thinned to two per pot. There was regular irrigation on daily basis in all the experimental pots for five weeks after which imposition of salinity stress was embarked upon. Salinity treatments used the were control (salinity stress-free), 50mM NaCl, 70mM NaCl and 100mM NaCl. The treatments lasted for two weeks after which normal irrigation (like that of the control pots) was resumed. Weed control was by hand pulling which was done as required from the beginning of the experiment to the end to keep the plants free of weeds.

Data collection. Data were collected on plant height, number of branches, number of leaves, dry straw mass, number of fruits per pot and fruit fresh mass. Amounts of nitrogen, phosphorus, potassium, crude fat, crude protein, crude fibre, ash and chlorophyll present in targeted plant parts were determined as follows:

Nitrogen determination. This was done using Kjeldahl method described by Chang (2003). 0.5g 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 100ml using distilled water and kept in a volumetric flask. 10ml of the digest was mixed with equal volume (10ml) of 45% sodium hydroxide solution in Kjeldahl distillation apparatus. The mixture was distilled into 10ml of 40% boric acid containing three drops of mixed indicators (bromocresol 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. Percentage of nitrogen was then calculated using equation 1.

$$\%\text{Nitrogen} = \frac{100xNx14xVt}{Wx1000\ X\ Va} xTxB \quad \text{.....Equation 1.}$$

W= Mass of sample (0.5g)
N= Normality of titrant (0.02N H_2SO_4)
Vt= Total digest volume (100ml)
Va= Volume of analyzed digest (10ml)

T= Sample titre value
B=Blank titre value
Note:1ml of 1N H_2SO_4 =14mg

Phosphorus determination. One gram of plant sample was weighed into 20ml of acid mixture and then boiled for 10 minutes to digest. The digest was then cooled down and filtered. Phosphorus content of the filtrate was then determined using spectrophotometer. Filtrate absorbance was then measured at 650 nm with a spectrophotometer and phosphorus concentration was determined from the standard curve. The standard curve was obtained by plotting the absorbance values of standards against the corresponding phosphorus concentrations on linear graph paper. Phosphorus concentration values of the samples were obtained directly from prepared standard curve and the values were recorded in mg/L.

Potassium determination. One gram of plant sample was weighed into 20ml of acid mixture and then boiled for 10 minutes to digest. The digest was cooled down and filtered. Potassium content of the filtrate was then determined using flame photometer. Percentage of potassium was calculated using equation 2.

$$\% \text{ Potassium} = \frac{(a-b)\ X\ V\ X\ F\ X\ 100}{1000\ X\ W\ x\ 1000} \quad \ldots\ldots\ldots\ldots\ldots\ldots\text{Equation 2.}$$

Chlorophyll determination. Leaf chlorophyll content was determined homogenizing 1g of a leaf sample in 15ml of ethanol. The mixture was then filtered and the filtrate was covered aluminum foil to prevent it from being broken down by sunlight. The concentration of chlorophyll was then measured as a function of intensity of absorbed light in a spectrophotometer. Absorbance was measured at 647 and 664 nm wavelengths with UV spectrophotometer. Total and actual chlorophyll were calculated using the following formulae:

Chlorophyll a = $(13.19 \times A_{664})-(2.57 \times A_{647})$……Equation 3
Chlorophyll b = $(22.1 \times A_{647})-(5.26 \times A_{664})$……..Equation 4
Total chlorophyll = Chlorophyll a + chlorophyll b…….Equation 5
A_{664} and A_{647} are absorbances at wavelengths 647 and 664nm respectively.

Determination of proximate composition of okra.

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 using the methods described by Kirk and Sawyer (1980), AOAC (1990) and James (1995).

Crude Protein Determination. Nitrogen content was first determined using Kjeldahl method described by Chang (2003) as stated above under nitrogen

determination. Crude protein was then determined from the amount of nitrogen got using equation 6.

%Crude Protein= %N x 6.25……..Equation 6.

Determination of crude fat. The determination was through gravimetric method described by Krick and Sawyer (1980). 5g 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 200ml 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^{o}C for 30minutes to remove any residual solvent. The flask was then cooled in a desiccator and weighed (W_2). The percentage of oil (fat) extract was then determined using equation 7.

$$\%Fat = \frac{W2-W1}{\text{Mass of plant sample}} x100 \quad \text{.....Equation 7.}$$

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). 5.0g of prepared plant sample was weighed into a porcelain crucible of mass W_1. The sample was burnt to ashes at 550^{o}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 using equation 8.

$$\%Ash = \frac{W2-W1}{\text{Mass of plant sample}} x100 \quad \text{.....Equation 8.}$$

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). 5.0g of the prepared plant sample was weighed and boiled in 150ml of 1.25% H_2SO_4 solution for 30minutes 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 150ml 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^{o}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 using equation 9.

$$\%\text{Crude Fibre} = \frac{W2-W3}{\text{Mass of plant sample}} x100 \quad \text{.....Equation 9.}$$

Where:

W_2=Mass of crucible + sample after washing, boiling and drying

W_3=Mass of crucible + Sample of ash

Statistical analysis. All the data collected were subjected to analysis of variance (ANOVA) and significant means were separated using least significant difference (LSD).

RESULTS AND DISCUSSION

Effect of salinity stress on plant height

The tallest plants were from the control pots. The shortest plants were from pots treated with 100mM NaCl (Table 1). Decrease in plant height with increase in salinity level showed clearly that they were affected by salinity stress. In the work of Al-Zubaidi (2018), decrease in plant height with increase in salinity stress level was also observed and recorded. The depressed growth might be attributed to toxic effect of sodium and chloride 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 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 reduced the capability of roots in extracting water or it resulted in toxicity which caused inhibition of many

physiological and biochemical processes like nutrient uptake and assimilation (Hasegawa *et al*, 2000; Munns, 2002).

Effect of salinity stress on number of branches

The number of branches significantly decreased with increase in salinity stress. The highest number of branches was found in the control plants and the lowest number was from the plants stressed with 100mM NaCl (Table 1). Branches can predict plant biomass yield. To some extent, economic yield can also be predicted by them. This is because the number of branches determines the number of leaves to be produced and the number of leaves produced determines the amount of photosynthate that will be produced provided mutual shading is eliminated. Decrease in number of branches with increase in salinity level was also recorded by Al-Zubaidi (2018) when he subjected two varieties of eggplant to salinity stress. Therefore, if photosynthate produced is judiciously partitioned, economic yield will increase. The reduction in the number of branches produced under salinity stress in this work might be because of the fact that plants could not produce enough assimilates as a result of inhibited photosynthesis under water stress. It could also be attributed to inhibition of cell division and enlargement in the meristematic tissue as well as having less amount of water uptake to prepare sufficient food needed for growth (Zubarer et al., 2007).

TABLE 1: Effect of salinity stress on plant height and number of branches

Treatment	Plant Height(cm)	Number of Branches
Control	41.25[a]	7.00[a]
50mMNaCl	36.25[c]	4.00[b]
70mM NaCl	38.25[b]	3.00[c]
100 mM NaCl	26.75[d]	2.00[d]

Means with the same letter(s) in the same column are not significantly different at 5% probability level.

Effect of salinity stress on number of leaves

The number of leaves decreased with increase in salinity level. The highest number of leaves was from the control plants while the lowest number was from the plants stressed with 100Mm sodium chloride (Table 2). There was an inverse relationship between salinity levels and number of leaves. This implies that increase in the concentration of salts led to decrease in the number of leaves. This might be because plants that suffered from salinity stress 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 retention of toxic ions in the roots (Munns and Tester, 2008).

Effect of salinity stress on number of fruits

The highest number of fruits was also found in the control plants while the lowest number of fruits was from plants stressed with 100mM sodium chloride (Table 2). This yield reduction under salinity stress may be attributed to low cell expansion, less photosynthetic rate and leaf senescence (Wahid et al., 1997). Furthermore, the growth of salinity 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 (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 result could still 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). Finally, it should also be noted that salinity stress can cause decreased seed germination, seed growth, and dry matter production (Nautiyal et al., 1989).

TABLE 2: Effect of salinity stress on number of leaves and number of fruits

Treatment	Number of Leaves	Number of Fruits
Control	8.00[a]	8.00[a]
50 Mm NaCl	5.00[b]	3.00[b]
70 mM NaCl	2.00[c]	2.00[d]
100 Mm NaCl	1.00[c]	1.00[d]

Means with the same letter(s) in the same column are not significantly different at 5% probability level.

Effect of salinity stress on fruit fresh mass

Fruit fresh mass decreased with increase in salinity stress. So, the heaviest fruits were from the control plants while the lightest fruits were from plants stressed with 100mM NaCl (Table 3). Reduction in fruit mass could be linked to action of salinity in inducing Fe^{2+}, K^{+}, and Ca^{2+} deficiencies (Singh *et al.*, 2004) which resulted in yield losses (Hunshal et al., 1991). In addition to this effect of salinity stress, it 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 crop production. 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)

Effect of salinity stress on plant dry matter

The heaviest straw was harvested from the control plants while the lightest straw was from plants stressed with 100Mm NaCl (Table 3). From this study, dry mass

was observed to have decreased with increase in salinity stress. This could have resulted from reduction in the number and size of leaves, senescence and total abscission which reduced photosynthate 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 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; Ghanem et al., 2008). The combined effects of reductions in number of leaves, plant height and number of branches led to a drastic reduction in the production and distribution of photosynthate which ultimately caused a reduction the final yield.

TABLE 3: Effect of salinity stress on fruits fresh mass and plant dry matter

Treatment	Fruit Fresh Mass(%)	Dry Straw Mass(%)
Control	12.54[a]	2.25[a]
50 Mm NaCl	5.88[b]	1.51[b]
70 Mm NaCl	4.87[c]	2.34[a]
100 Mm NaCl	3.45[d]	1.24[b]

Means with the same letter(s) in the same column are not significantly different at 5% probability level.

Effect of salinity stress on leaf ether extract (crude fat) content

Crude fat content decreased with increase in salinity level. The highest crude fat content was from the control plants while the lowest level of crude fat was from plants stressed with 100mM NaCl (Table 4). Ether extract (crude fat) is an indicator of energy production (twice that of carbohydrate). It is a means of absorption of fat soluble vitamins, protector of delicate organs in the body as well as insulator against cold. Decrease in ether extract with increase in salinity stress implies that this variety will not be useful whenever crude fat is the target 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.

Effect of salinity stress on crude protein

Crude protein content decreased with increase in salinity level. The highest crude protein content was from the control plants while the lowest crude protein content was found in plants treated with 100mM NaCl (Table 4). Decrease in crude protein with increase in salinity 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 and 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.

Effect of salinity stress on crude fibre content

Crude fibre content increased with increase in salinity level. So, the lowest level of crude fibre was from the control plants while the highest level was from plants treated with highest salinity level (100mM NaCl) (Table 4). 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). Increase in crude fibre implies that the fruits produced would be of low usefulness as either food or feed. 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). 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.

TABLE 4: Effect of salinity stress on crude fat, crude fibre and crude protein

Treatment	Crude Fat(%)	Crude Fat(%)	Crude Protein(%)
Control	7.25[a]	1.75[b]	10.77[a]
50 Mm NaCl	5.75[b]	1.85[b]	9.93[b]
70Mm NaCl	4.25[c]	1.98[b]	8.60[c]
100Mm NaCl	4.00[c]	2.90[a]	7.92[d]

Means with the same letter(s) in the same column are not significantly different at 5% probability level.

Effect of salinity stress on chlorophyll content

The leaf chlorophyll content decreased with increase in salinity. So, the highest chlorophyll content was found in the leaves of control plants while the lowest l was found in plants treated with 100Mm sodium chloride (Table 5). Chlorophyll content is an indication of nitrogen status of the plant and it is significantly decreased by exposure to moisture stress especially chlorophyll-a and chlorophyll-b (Ranjbarfordoei et al., 2000) as well salinity stress. Chlorophyll is very important because it indicates the status of leaf nitrogen and nitrogen content is an indicator of the plant source strength (Gauthami et al., 2013).Total chlorophyll content was recorded to have decreased with increasing salinity. This decrease could be as a result of salt induced weakening of protein-pigment lipid complex and increased chlorophyllase activity (Ambede et al., 2012). In the same vein, the reduction in chlorophyll content together with reduced potassium uptake which results in K/Na antagonism resulted in impaired photosynthesis which consequently led to low yield as found in this work. Furthermore, the decline in chlorophyll content might be the result of the damage done to the chloroplast by reactive oxygen species which are normally produced as a result of salinity or other environmental stresses (Smirnoff, 1995).

However, the degradation of chlorophyll (light harvesting pigment) could still be beneficial because the production of reactive oxygen hinges on the absorption of excess energy by photosynthetic apparatus (Herbinger et al., 2002). Therefore, production and accumulation of reactive oxygen might be checked to make the stressed plants healthier. It should be noted that high chlorophyll content correlates with higher yield (Sengupta & Majumder, 2009) and it was confirmed in this work.

Effect of salinity stress on ash content

Ash content decreased with increase in salinity. The highest ash content was from the control plants followed by 70Mm while the lowest ash content was found in plants stressed with 100Mm sodium chloride. (Table 5). The ash content signifies the level of minerals in the fruits. Increase in salinity stress led to progressive inhibition of mineral uptake by the plants which resulted in having low ash content which is an indicator of the amount of minerals absorbed by the plants. This might be attributed to imbalance in soil nutrients caused by salinity stress. It might also be a result of nutrient antagonism which led to inhibition in mineral absorption and consequently low ash content. This is evident in mineral absorption and partition as shown in Table 6.

TABLE 5: Effect of salinity stress on chlorophyll and ash content

Treatment	Chlorophyll Content (µmolcm^{-2})	Ash Content (%)
Control	0.13^{a}	3.80^{a}
50 Mm NaCl	0.05^{b}	1.36^{c}
70mM NaCl	0.04^{b}	2.21^{b}
100 Mm NaCl	0.03^{b}	1.28^{c}

Means with the same letter(s) in the same column are not significantly different at 5% probability level.

Effect of salinity stress on NPK partitioning in stems and leaves

Leaf and stem nitrogen decreased with increase in salinity level. The highest levels of leaf and stem nitrogen content were from the control plants while the lowest nitrogen content in both leaf and stem was from plants stressed with 100Mm sodium chloride (Table 6). However, leaf and stem phosphorus content increased with increase in salinity stress. So, the highest levels of leaf and stem phosphorus content were from plants stressed with 100mM NaCl while the lowest leaf and stem phosphorus were from plants stressed with 50mM NaCl. It should be noted that the control plants had leaf and stem phosphorus levels above those of plants stressed with 50mM NaCl which had the lowest level of leaf and stem phosphorus content (Table 6).

Stem potassium content decreased with increase in salinity. The highest stem potassium content was from the control plants while the lowest level of potassium was from plants stressed with the highest salinity level (100Mm NaCl) (Table 6). Leaf potassium content also decreased with increase in salinity stress though potassium content of the control leaves was less than that of plants stressed with 50mM NaCl. So, the highest leaf potassium content was from plants stressed with 50Mm NaCl followed

by the control plants while the lowest potassium level was found in plants stressed with 100Mm NaCl (Table 6)

TABLE 6: Effect of salinity stress on NPK content of stems and leaves

Treatment	Stem Nitrogen(%)	Leaf Nitrogen(%)	Stem Phosphorus(mg/L)	Leaf Phosphorus(mg/L)	Stem Potassium(%)	Leaf Potassium(%)
Control	1.62[a]	2.71[a]	0.85[b]	1.61[c]	11.11[a]	9.07[b]
50 mM NaCl	1.51[b]	2.25[b]	0.64[c]	1.37[d]	10.40[b]	10.93[a]
70 mM NaCl	1.30[c]	2.06[c]	0.86[b]	1.88[b]	5.28[c]	6.80[c]
100mM NaCl	1.16[d]	1.84[d]	0.94[a]	1.92[a]	4.96[d]	6.67[c]

Means with the same letter(s) in the same column are not significantly different at 5% probability level.

Apart from protein and starch, some micro- and macro-mineral nutrients such as Zn, Fe, Cu, N, K, P, and Mg are essential for human nutrition in rice grain (Heinemann et al., 2005) and other fruits. However, their absorption and uptake are altered under environmental factors including salinity stress (Turan, Turkmen, & Taban, 2007). The uptake and distribution of minerals in various parts of rice including other grains is a complicated process and gets affected by environmental constraints such as soil organic matter, fertilizers and climate changes. However, the aerial parts are usually more sensitive to the cation disturbances than the roots. Also, the ability of various plant species to tolerate salt stress greatly varies. Different minerals react differently under varying concentration of salt.

CONCLUSION

From this work, it was found that all the growth and yield parameters tested decreased with increase in salinity level. Similarly, all proximate parameters decreased with increase salinity levels with the exception of crude fibre which increased with increase in salinity level. In the same vein, nitrogen and potassium levels decreased with increase in salinity level in both leaves and stems. However, phosphorus levels in stems and leaves decreased with increase in salinity level. It is, therefore, concluded that 17Lucky19 okra variety is susceptible to salinity stress and this variety should not be used whenever saline soil is to be used for cultivating okra.

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