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Effects of Salts Concentration on Emergence and Growth of Tomato (Lycopersicon Esculentum) in Tropical Areas

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Abstract:- Irrigation water quality could have a significant impact on the growth and yield and hence the productivity of crops. All irrigation water contains some dissolves salts, but the concentration and composition of the salts vary with the source of the irrigation water. Water saving in irrigation was identified as a major subject in northern Nigeria. Therefore, the use of treated municipal wastewater and saline water as a complementary source for water irrigation has been encouraged to increase the efficient use of water irrigation in crop production. Thus, the present study was carried out to examine the effect of two salts (NaCl and KCl) in irrigation water at varying concentrations on the emergence and growth of tomato in a semi-arid environment. Potassium chloride was found to be more detrimental on the sustainable production of tomato, NaCl concentration up to 1.5 g/l however was be safely used to boost tomato production. The results show that the treated wastewater, brackish and saline waters and other unconventional sources of water can be safely used in improving agricultural programs under arid and semiarid regions.

I. INTRODUCTION

There has been a wide understanding of the negative impacts of salinity on growth and agricultural yield of plants [1]. The plant response to salinity consists of numerous processes because salinity decreases the rate of photosynthesis and plant growth to various degrees. Movement of salt into roots and to shoots is a product of the transpiration flux required to maintain the water status of the plant [3]. Unregulated, transpiration can result in toxic levels of ion accumulation in the aerial parts of the plant. An immediate response to salinity, which mitigates ion flux to the shoot, is closure of stomata. In general, plants absorb essential nutrients in the form of soluble salts and excessive accumulation of these salts in the soil suppresses plants growth. The US salinity laboratory staff [4] defined a saline soil as the one having an electrical conductivity (EC) of greater than 4 mmhos/cm, and exchangeable sodium percentage (ESP) of less than 15 as well as pH value of less than 8.5 at 25°C. The specific symptoms of sodium toxicity include high tissue sodium concentration and low K:Na ratios, inhibition of root elongation, and shoot calcium deficiency [5]. Despite decades of research into the effects of salinity on crop plants, the causes of sodium toxicity remain controversial. Plants are stressed in two ways by the increase in osmotic potential of the rooting medium as a result of high solute content, and by the toxic effect of high concentration of ions [6]. The United Nations Environment Program estimates that approximately 20% of agricultural land and 50% of cropland in the world is salt-stressed [7] It poses a serious problem in both soils and water management in arid and semi-arid regions where evapotranspiration plays an important role in the pedogenesis of saline and sodic soil. In these regions, the annual rainfall received is less than 500mm with annual evapotranspiration of about 200mm which leads to salinization [3,5]. In addition, both the nutritional and the caloric potential of agricultural production are most acute in areas of the world where food production and distribution is a problematic due to insufficient infrastructure or political instability. Accumulation of soluble salts has influence on soil - plant - water relationships and the level of soluble salts within which plant growth is affected depend upon, plant species, ionic composition, texture and water holding capacity of the soil [1]. Salinity induced reduction in crop growth have been associated with reduction in water used [5]. Sodium chloride had also been shown to reduce shoot water potential thereby resulting in stomata closure and reduced transpiration [1]. The cations and anions associated with salinity are Na^+, Ca^{2+} and Mg^{2+}, and $C1^-$, SO_4^{2-} and HCO_3^-. However, Na^+ and Cl^- ions are considered the most important as they have effect on both soil (physical structure) and plants [1] The purposes of this study were to determine sodium chloride (NaCl) and potassium chloride (KCl) salts effect on seed emergence and growth of tomato.

II. MATERIALS AND METHODS

Study site and sample preparation The study was carried out in the Agricultural and Environmental Resources Engineering laboratory at the University of Maiduguri. Maiduguri is located at 130°5′E and 11 0°5′E, and 345m above mean sea level with the mean annual rainfall of about 625mm and annual temperature of 28 - 32°C. University of Maiduguri is situated in the State capital of Borno State, Nigeria. The State occupies the greater part of the Chad formation in Nigeria. The soil of the study area is sandy loam, classified as Typic uptisament based on USDA classification system [8] The soil samples used for this study were collected from the research farm faculty of Agriculture University of Maiduguri. Soil sample was collected at a depth of 0 - 15 cm after the surface litter was scrapped and removed. The sample was packed in a polythene bags and transferred to laboratory. It was air-dried mixed thoroughly and then passed through 2mm sieve to obtain fine earth particles. For the purpose of this study, the soil was divided into two parts: one for pot experiment (seed planting) and the second portion for physico-chemical analysis. An improved tomato variety commonly available to farmers called *ROMA* was grown using pot experiment for forty two (42) days in the laboratory.

III. EXPERIMENTAL DESIGN AND SOIL ANALYSIS

The experimental design consisted of twenty - one pots (bottom perforated 9.5 cm radius and 18 cm height) replicated 3 times. The treatments consisted of a control (plain water) and two different salts: sodium chloride (NaCI) and potassium chloride (KCI) each replicated three times at different concentrations. Table 1:

Table 1: Description of the treatments

Salt	Sodium chloride (B) NaCl			Potassium Chloride (P) KCl			Control (Soil)
Treatment	B_1(g)	B_2(g)	B_3(g)	P_1(g)	P_2(g)	P_3(g)	S_0
1	0.5	1.0	1.5	0.5	1.0	1.5	S_o
2	0.5	1.0	1.5	0.5	1.0	1.5	S_o
3	0.5	1.0	1.5	0.5	1.0	1.5	S_o
Mean							

A 10 kg soil was mixed with one liter of water and transferred into designated pots and left for seven (7) days to equilibrate. Ten (10) viable tomato seeds were evenly planted into each pot and a litre of clean water was applied daily, subsequently each pot was treated as given in Table 1.The parameters measured were seed emergence (count), length and stem thickness (cm). Growth length was measured by a meter rule from plant base to apex. Stem thickness was initially measured using micro meter screw gauge at initial stage and at later stage by the use of vernier caliper. Seed emergence was counted at every 5 day intervals whereas length and stem thickness were recorded after every seven (7) days. Tomato plants were thinned down to 5 stands per pot at 15 days after planting (DAP). Soil chemical and physical analysis was conducted using standard procedures as detailed by Richards [9] and Haluschak [10]

IV. RESULTS AND DISCUSSION

Soil characteristics:- The characteristics of soil in the study site is shown in Table 2, it is slightly acid in reaction, and poor in Na, K, Ca, Mg and nitrogen contents. Such results may have an attribute to the specific site where the sample was collected. Soil collected from experimental plots may not necessarily represent farm condition where farmers perform several agronomic practices for higher yield. Soils in arid and semi - arid areas are relatively poor in organic matter, cation exchange capacities and the essential macronutrients such as nitrogen, phosphates and potassium [11]. Mustapha [12] and Yakubu [13] have reported on the properties of soil where tomato is grown in semi - arid Nigeria.

A. Seed germination

Table 3 shows tomato crop emergence days after application at varying salts treatments. Evidence of tomato seed germination has been experienced within 5 days in all the pots. Compared to control (S_o), seeds exposed to KCl showed the best germination rates. At 1.5g/l the highest concentration of KCl nine out of ten seeds germinated, 15 days after application (Table 3). Seeds exposed to NaCl showed slow germination rates, because at 1.0 and 1.5 g/l of NaCl concentration only 8 and 7 seeds out of 10 germinated at 10 days after application. The result indicates that, KCl has the least effect on plant germination.

B. Length and stem diameter of plants

Table 4 shows the length and stem diameter of tomato plant at 7^{th} until 42^{nd} days after application. From the results all the plants irrespective of their treatment showed some growth development ranging from 1.30 - 1.63 cm under control conditions at one week after planting. Compared to control having 1.63 - 7.27 cm, the seeds exposed to KCl showed a better growth length of 1.37 - 4.20 cm whereas the seeds exposed to NaCl are 1.33 - 3.80 cm at 1.5 g/l in both cases. It is clear that the length of the crop for all the treatments increases with time (days) and decreases with salt concentration. Crop diameter recorded at 7^{th} and 14^{th} days after application was between 0.05 to 0.07 cm including the control, this may be due to imbalance of osmolarity at the initial days of the experiment. Azaizeh et al [14] and Tyerman et al [15] have shown that for maize roots high salinity caused a considerable reduction in water permeability in the cortex, reducing the osmotic water permeability by as much as fivefold. Changes in the osmotic water permeability were reflected in changes in root hydraulic conductivity due to the fact that most of the water was flowing around cells [14]. At 21^{st} days after application the diameter of 0.08 cm was observed for all the treatments including control. However, a significant

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variation in tomato diameter of 0.18, 0.23 and 0.32 cm was noticed during 28th, 35th and 42nd days after application under controlled samples respectively. In general from this study, the crop diameter decreases with increase in salt concentration and KCl has been found with least effect compared to NaCl salt even at varying concentrations.

Table 3: Tomato crop emergence days after planting at varying salts treatments

Salt Treatment	Sodium chloride (B) NaCl			Potassium Chloride (P) KCl			Control (Soil)
DAP	0.5 (g/l)	1.0 (g/l)	1.5 (g/l)	0.5 (g/l)	1.0 (g/l)	1.5 (g/l)	H_2O
5	5	4	3	6	5	5	6
10	8	8	7	8	8	8	9
15	9	8	7	9	9	9	9

Values are mean of 3 readings

Fig 1 a.

Fig. 1 a and b. Tomato shoots

V. CONCLUSION

As a conclusion, these results indicate that the use of sodium chloride and potassium chloride salts hampers normal germination, growth and development of tomato plant. This suggested a negative effect of the salts on plants. According to our experiment the use of varying concentrations in general and applying KCl appear to be less detrimental. Based on the result obtained the study suggest more test using other salt concentrations in the same environment. There is also the need to perform such experiment under real farm condition or using soil samples directly from farmer's plot to ascertain its physical environment. Salt may also affect other growth parameters such as root development, and biomass produced by the plants which is removed during a harvest operation or at the end experiment.

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APPENDIX

Table 2: Characteristics of Soil in the study site

Soil physico-chemical properties	pH 1:2.5 (H_2O)	EC dsm^{-1}	Total N (%)	Mg meq/100g soil	K meq/100g soil	Ca meq/100g soil	Na meq/100g soil	P meq/kg	Organic carbon (%)	Sand %	Silt %	Clay %	Soil texture
Obtained values	6.65	0.10	0.03	0.07	0.21	0.14	0.18	7.0	0.24	68.4	15.2	15.4	Sandy loam

Table 4: Tomato shoot (length, L and diameter, D) measured in (cm) from 7th to 42nd DAP

Salt treatment	Sodium chloride (B) NaCl			Potassium Chloride (P) KCl			Control (Soil)
Shoot length (L) and diameter (D)	0.5 (g)	1.0 (g)	1.5 (g)	0.5 (g)	1.0 (g)	1.5 (g)	S_0
L_7	1.57	1.30	1.33	1.57	1.47	1.37	1.63
D_7	0.05	0.05	0.05	0.06	0.05	0.05	0.06
L_{14}	2.70	2.00	1.93	2.73	2.53	2.03	3.57
D_{14}	0.06	0.06	0.06	0.07	0.07	0.06	0.07
L_{21}	3.80	2.77	2.53	3.83	3.63	2.73	4.77
D_{21}	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**
L_{28}	4.33	3.27	3.13	4.60	4.33	3.27	5.77
D_{28}	0.17	0.15	0.14	0.18	0.17	0.15	0.18
L_{35}	5.03	3.67	3.63	5.60	4.70	3.67	6.68
D_{35}	0.23	0.21	0.19	0.23	0.21	0.21	0.23
L_{42}	5.10	4.10	3.87	6.37	4.80	4.20	7.27
D_{42}	0.29	0.25	0.24	0.30	0.25	0.26	0.32

Values are mean of 3 readings