Tomato fruits yield and soil Properties as affected by Salts application and irrigation schedule at Jega, Sudan Savanna agro-ecological zone.

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Abstract

Tomato (*Lycopersicon esculentum,* Mill.) is the most popular vegetable with great nutritive value and good source of Potassium and Vitamin A & C. No horticultural crop has received more attention and detailed study than tomato. Water deficit decreases tomato growth, yield and quality therefore, proper water management is vital for sustainable crop production.Therefore, this work is aimed at investigating the effect of salts addition especially sodium chloride and potassium chloride and irrigation schedules on some soil properties and performance of tomato in the Sudan Savanna agro-ecological region of Northern Nigeria, under which Jega falls. The experiment consists of six treatments of salt and irrigation interval and applied at two levels and control i.e. no salt (NaCl 5g 10g and 0g) also at two levels (4 and 7 days) combined in factorial arrangement. The treatments were coded as SoI_4, SoI_7, SA_1I_4, SA_2I_4, SA_1I_7 and SA_2I_7, designated as control (without salt with four and seven days irrigation interval), 5g NaCl with 4 days irrigation interval, 10g NaCl with 4 days irrigation interval, 5g NaCl with 7 days irrigation interval and 10g NaCl with 7 days irrigation interval respectively. The treatments were laid down in a Randomized Completely Block Design (RCBD) and replicated three times. The results of this study shows that both salt and irrigation scheduling does not significantly affected the soil pH, whereas soil Organic Carbon was significantly affected by the salt application in which it was observed that the lower the salt concentration, the higher the percentage OC, while the longer the irrigation interval, the higher the percentage OC. No significant effect was also observed in the percentage TN (Total Nitrogen) by salt application as well as irrigation scheduling. Exchangeable bases were also affected by salt application as well as irrigation schedule.

Key words: salt, irrigation, yield, soil, organic carbon, exchangeable bases

Introduction:

Tomato (*Lycopersicon esculentum,* Mill.) is the most popular vegetable with great Nutritive value and good source of Potassium and Vitamins A & C. It is moderately Sensitive to salinity and few cultivars are salt tolerant up to some extent. Tomato fruits absorbed high amounts of K from the soil. With optimum nutrition, nutrient uptake increases rapidly during the fruit growth period. At this time, K is the dominant nutrient. Adequate K supply is important to several plant processes among them enzyme activation, photosynthesis, osmoregulation, phloem transport, determining the final yield. In low K soil it is not possible to obtain high tomato yields without adding K fertilizer. In these soils, diffusion is an important soil mechanism for supplying nutrients to plant roots, and only potassium within the diffusive soil zone contributes to K supply to the root. Potassium diffusion rate depends on several factors, among them soil water in the root zone which is closely associated with the irrigation system. Tomato is a moderate salt-tolerant crop with substantial cultivar differences (Dasgan et al., 2002). Although salt stress has been found to disrupt several physiological processes that leading to reduction in growth and yield (Yurtseven et al., 2005), salinity can improve its fruit quality (Hao et al., 2000).

The crop tolerates fairly acid soil and liming is unnecessary unless the soil pH is below 5. Well drained sandy loam is preferred by the crop. No horticultural crop has received more attention and detailed study than tomato (Lycopersicon esculentum). Water deficit decreases tomato growth, yield and quality (Byari and Al-Sayed, 1999) therefore, proper water management is vital for a sustainable crop production

According to Ismail and Ozawa (2009), in the arid and semi arid as well as tropical regions, water shortage is a normal phenomenon and seriously limits the agricultural potential. Therefore, under irrigation or rain-fed conditions, it is important for the available water to be used in the most efficient way. Proper irrigation interval can play a major role in increasing the water use efficiency and the productivity by applying the required amount of water when it is needed. On the other hand, the poor irrigation interval can lead to the development of crop water deficit and result in a reduced yield due to water and nutrient deficiency.

Early in the season when plants are small, it is beneficial to encourage the roots to explore as much of the soil profile as possible. This maximizes nutrient uptake and stress tolerance later in the season

Irrigation frequencies or different irrigation frequencies or different irrigation schedules have beneficial effects on water balance fruit quality and fruit production. Irrigation also plays important role in maintaining sustainable growth of every crop especially it reduces the wilting which causes 60-80% crop loss but sometimes excessive water or frequent flooding for longer periods of time affect the yield of the crop.

However, the number and sizes of fruits may be reduced by high salinity. In fact, salinity directly influences plant water relationship, since under osmotic stress, uptake of nutrients such as Ca and K is reduced, as well as water. It is a known fact that increasing EC may improve fruit quality in terms of composition (soluble sugars, acids, and minerals), flavor (aroma) and color, with little or no yield reduction. The fruits will typically show a compact, tough skin and thick cuticle that surrounds the fruit leading to longer shelf life.

Changes in the EC levels can be achieved by increasing macronutrients or by adding NaCl which is less expensive. Any increase in the EC can be substituted by NaCl and Na and Cl concentration up to 12 mM are acceptable. The addition of major nutrients affect vegetative growth adversely at 12 $mScm^{1}$ and reduce the size, dry weight and sugar content of the fruit as compared with NaCl. Moreover, in comparison with raising EC by major nutrients, NaCl induced EC cause lower incidence of blossom end rot. Excessive concentration of Na or Cl in the root environment however, may be detrimental to plant growth and nutrient uptake.

This work is therefore aimed at investigating the effect of salts addition especially sodium chloride and potassium chloride and irrigation schedules on some soil properties and performance of tomato in the Sudan Savanna agro-ecological region of Northern Nigeria.

Materials and Methods:

The research was conducted at the teaching and research farm of the Kebbi State University of Science and Technology, Aliero, located at Jega, Kebbi State, during the cool dry season. Jega is located between Longitude 4°23'E and Latitude 12°11'N in Kebbi State. Jega falls within the

Sudan savanna of the semi-arid zone of Nigeria, the mean rainfall in the study area ranges between 550-650 mm per annum, and average relative humidity of 51-79%. Harmattan period which is the drier and coolest period of the year has a temperature range of 17-22^{O}C experienced in December to February which makes it favorable for the production of tomato. The experiment consists of six treatments of salt and irrigation interval and applied at two levels and control i.e. no salt (NaCl 5g 10g and 0g) also at two levels (4 and 7 days) combined factorially. The treatments were coded as SoI_4, SoI_7, SA_1I_4, SA_2I_4, SA_1I_7 and SA_2I_7, designated as control (without salt with four and seven days irrigation interval), 5g NaCl with 4 days irrigation interval, 10g NaCl with 4 days irrigation interval, 5g NaCl with 7 days irrigation interval and 10g NaCl with 7 days irrigation interval respectively. The treatments were laid down in a Randomized Completely Block Design (RCBD) and replicated three times.

A total land area of 17.8x14.6m was marked out for the experiment and subdivided into gross plots measuring 3.2 x 3.2m. An area of 1.5m wide was left between blocks. A space of 1 m was also left between gross plots within block. Tomato (cv. Roma VF) seedlings were raised in a nursery and transplanted at the six leaf stage (5 weeks after sowing). A week before transplanting, the experimental site was ploughed and harrowed to depths of 25 cm. Basal application of fertilizers (15 : 15 : 15) at the rate of 300 kg/ha was worked in the soil. All the beds were irrigated and allowed to drain to field capacity. After 24 h, the seedlings were transplanted at spacing of 45x45 cm. It was followed by a light irrigation to ensure seedling establishment. The treatments were imposed 2 weeks after transplanting. Water was applied by irrigation in accordance to the scheduling treatment. The plots were manually weeded three times in the season. The plants were sprayed against white flies, aphids, fruit worms and other pests with Karate EC at the rate of 0.75 l/ha 4 weeks after transplanting, and at the 6th and 8th weeks with Perfeckthion at the rate of 0.8 l/ha.

Agronomic data pertaining plant biomass yield, flowering percentage, number of fruit per plant, total yield and marketable fruit yield will be collected at the appropriate time of the plant growth.Prior to commencement of the research work, soil samples were collected at the experimentalsite at the depth of 15cm, and to establish the status of available soil nutrients. A tot al number of 24 samples were obtained, they samples were air dried, crushed and sieved and wer e analyzed for particle size, pH, Organic carbon (O.C) Total N, available phosphorus (AP), exch angeable Calcium (Ca) Magnesium (Mg) Potassium (K), and Sodium (Na) and Cation Exchange Capacity (C.E.C). The same parameters were also monitored after harvest to monitor any change due to treatments. Standard procedures for soil analysis were followed in all the soil analysis conducted.

Results and Discussion:

Number of fruits per plant:

As shownin Table 2. The influence of salt and irrigation scheduling on number of fruits per plant produce by tomato plant at 6 and 8 WAT was not significant. However, the control which is the treatment that do not received salt application, had consistently obtained the highest number of fruits per plant (9.88 and 9.96) at 6 and 8 WAT respectively. Although (SA_1) the treatments which received 5 g of NaCl and (SA_2) recorded similar number of fruits per plant (2.79) at 6 WAT. During the second sampling at 8 WAT, the case was different. Because SA_2 treatment out yielded SA_1. The treatments SA_1 and SA_2, recorded 8.58 and 8.12 fruits per plant respectively. No clear trend was observed on number of fruits per plant with the various levels of salts applied during the sampling period.

Irrigation scheduling (I_4) and (I_7) produced 3.44 fruits per plant and 6.86 fruits per plant thus I_4 was found to bear the lowest number of fruits and I_7 the highest fruit producer at 6 WAT, but they were not significantly different ($P<0.05$) (Table 2). However, at 8 WAAT the case was not the same because the former irrigation scheduling (I_4) obtained the highest number of fruits per plant (8.91 fruits) while the later (I_7) had the least (8.19 fruits). The insignificant effect of NaCl and irrigation on number of fruits per plant as observed here signifies that the salt treatments and irrigation scheduling used in this study are incapable of increasing or decreasing the number of fruits per plant in the crop while maintaining the same management practices, observed that the number of fruits per plant was not increased significantly with irrigation and is in harmony with the findings contained herein.

Biomass yield:

Both NaCl and irrigation scheduling did not affect the production of biomass of tomato plant at significant level at 3 WAT (Table 2). However, it is evident from the result that the treatment

SA_2 which had highest quantity (10 g) of NaCl produced the highest amount of plant biomass (8.48 g), while the control (S_0) obtained the second highest biomass (6.85 g) and the treatment SA_1 that received 5 g NaCl had the least (5.78 g) biomass production.

Conversely, irrigation scheduling designated as I_4 produced plant biomass of 8.52 g while the other irrigation treatment I_7 gave 5.56 g as its biomass. However, the biomass observed on the two irrigation scheduling did not differ significantly. But with the highest biomass production obtained with the I_4 treatment, it appears that irrigating tomato at four days interval is more favorable for biomass production in the plant. The findings is compatible with the report of Cano *et al*. (2003) who reported increase in tomato plant biomass as a result of shorter irrigation intervals of four days.

Total yield:

NaCl salt treatment and irrigation scheduling affected the total yield of tomato but not at a significant level (Table 2). As per salt (NaCl) treatment the total yield recorded was in the following order; NaCl (SA_1) > NaCl (SA_2) >Control (S0), corresponding to 27.46, 28.89 and 29.96 t ha^{-1} yield output respectively.

The four days irrigation scheduling (I_4) in which irrigation water was added at four days interval produced higher total yield (32.44 t ha^{-1}) than the other irrigation scheduling (I_7) in which water was applied at seven days interval as it had recorded 25.09 t ha^{-1} as its total output. This indicates that the water applied was not limiting to the plant yield under the same conditions of management and the same thing goes with salt (NaCl) treatment. Rhayyat *et.,al* (2007) has reported that the increase of fruit yield per plant in comparison with their respective non saline or saline control.

Initial Physico-Chemical Properties of the soil in the experimental site:

Table 2 shows result on the Physico-chemical properties of the experimental site before planting and application of treatment. The result reveals that the textural class of the soil was sandy loam. Particle size distribution of clay was low (13%) silt also low (10%) and 77% sandand the dominant particle. The sandy loam texture indicates that the soil was suitable for tomato production (CTA 2005). Soil organic carbon in the site was high (0.21%), total Nitrogen was high (0.35%) available phosphorus was medium (14.00mg kg^{-1}). Exchangeable calcium (Ca) and Mg were 4.55 (medium) and 0.65 cmol (+) kg^{-1}, respectively. Exchangeable potassium (K) and sodium (Na) were low at 0.140 and 0.18 cmol (+) kg^{-1}, respectively. Cation exchange capacity status (CEC) was rated medium (8.20 cmol (+) kg^{-1}), the soil reaction was tested strongly acidic (4.50). Except for the pH, generally the soil at the experimental site had good physic-chemical properties for production of most crops.

Chemical Properties of the Surface Soil (0-15cm) after Harvest of Tomato:

Table 4 shows results on soil pH at the study site, at post-harvest of tomato as affected by application of salt and irrigation scheduling. The result shows that salt treatments on the soil did not affect pH of the soil at significant level. But it was observed that soil pH on the SA_1 (5g NaCl) was high (5.15) relative to SA_2 (10g NaCl) and S0 (Control) which recorded 5.00 and S0 respectively.

Similarly, irrigation scheduling effect on the pH was also not significant. Result shows that the irrigation scheduling of seven days (I_7) had higher pH, with a value of 5.40 which greater than the pH of (5.05) on the irrigation scheduling of four days (I_4). In significant effect of irrigation on the pH indicates the irrigation scheduling used in the study cannot increase pH under the same management practice. The finding on the pH in this study tallied with the report by Adepetu (2000) pH from 5.2 to 6.1 was moderately acidic.

A result on the influence of salt (NaCl) and irrigation treatments on soil organic carbon (OC) is presented in table 4. As can be seen in the result, application of the salt had produced significant effect on OC. Highest value of OC (0.42%) was observed on the control (S0), this was closely followed by the SA_1 (5g NaCl) treatment that obtained 0.40%. The SA_2 (10g NaCl) treatment recorded the least and lowest OC value (0.38%) that had differed with those on SA_1 and the control (S0).

In a similar manner, irrigation scheduling was obtained to produce significant effect on OC. Higher OC (0.45%) that was significantly different was recorded on the irrigation scheduling of seven days (I_7). Low OC value (0.35%) was observed on the irrigation treatment (I_4). The significant effect of both salt (NaCl) applications on soil and irrigation as observed in this study is an indication the salt (NaCl) and irrigation can alter the content of OC in the soil. This implies that regulation of water application through irrigation and management of oc. With the highest OC value observed on the treatment that had seven days irrigation scheduling (I_7), it suggested that the irrigation scheduling is more suitable for maintaining better levels of OC in the soil. The high level of observed with the I_7 treatment as recorded in this finding is consistent with the report of Senjobi (2007). The OC fluctuates irregularly with depth for most of the pedon and this is an indication of continuous deposition of organic material.

Results in Table 4 indicates that the salt (NaCl) applied on soil did not affect total N (TN) content in the soil at the study site at significant level. Although, the values obtained shows that TN content was higher (0.18%) in SA_2treatment that was applied 10g NaCl. The SA_1 treatment in which 5g NaCl was added to low value of TN (0.13%).

In a similar way, TN content of the soil was not significantly affected by the irrigation scheduling imposed in this study. However, the irrigation scheduling (I_4) in which water was applied after every four days had more TN content of 0.67% than the I_7 irrigation scheduling which recorded low TN (0.11%). The result also indicated that TN content of the soil had decreased as the irrigation scheduling was decreased to four days as could be seen on the I_4 treatment. And this may be connected to increased activity of the soil organisms due to higher water supply in the I_4 treatment relative to I_7 irrigation treatment. Although, the irrigation treatments was not significant but the higher TN values observed on the I_4 falls in the high category rating for TN classification (Esu, 1991). Brady and Weil (1999) noted that moisture state of soil and temperature are among the factor affecting the decomposition of organic matter that lead to the supply of TN in the soil.

The exchangeable bases (Ca, Mg, K, Na) were significantly affected ($p<0.05$) by soil treatment of the salt (NaCl) applied. Highest values of Ca and Mg were observed on salt treatment SA_1 that had obtained 3.77 and 0.88cmolkg^{-1} respectively. The values for the exchangeable base (Ca and Mg) recorded on the SA_1 treatment differed significant by compared to those observed on other treatments. The SA_1 and the control recorded Ca values that were statistically similar, but Mg values obtained on the treatments had differed with the control recording the least Mg value (0.47cmol kg^{-1}). As per exchangeable K the values were significant and they could be arranged in the following order SA_2>SA_1>So. Also, exchangeable Na was affected significantly by the NaCl salt applied on the soil. The highest effect was obtained on SA_2 treatment that obtained

0.37cmol kg^{-1} and the highest value for Na differed significantly with those observed on the other treatment and the control.

The effect of irrigation intervals on the exchangeable bases, on the other hand was also significant (Table 4). Results on Ca indicate that the irrigation scheduling of seven days (I_7) had higher Ca (0.68cmol (+) k^{-1}) that differed with the Ca observed on the four days irrigation scheduling (I_4) treatment. The effect of the irrigation treatment on exchangeable Mg, K and was similar pattern between the I_4 and I_7 treatments as it was observed that exchangeable Mg, K, and Na were higher with values of 0.69, 0.26, and 0.94cmol k^{-1} respectively on the I_4 treatment. The values obtained on the I_4 treatment for the basic cot-ions were low and differed significantly with those on the I_4 treatment.

Conclusions and Recommendations:

In this study it was observed that lower salt concentrations favors the accumulations of Total Nitrogen and most of the basic cations that plays a significant roles in Tomato production, Shorter irrigation schedule also favors tomato fruit yield on this kind of soil under the prevailing soil and climatic conditions, Therefore, it can be rightly concluded that under a sandy clay loam soil, salts concentrations should be kept as low as possible and irrigation scheduling should also be as close as possible to meet up the water requirements of the crop especially at the period of the year. Finally we recommend a four day irrigation intervals as well as the lowest salt concentrations, and we also recommend the use of potassium chloride to farmers if available so as to boost yield and quality of tomato fruits.

Table 1: Yield attribute of tomato plant as influenced by irrigation interval and salt application

	No. of Fruits/Plant		Biomass Yield (g)	Total Yield t/ha
Treatments	6WAT	8WAT	3WAT	
Salt				
SA_1	2.79	8.12	5.78	27.46
SA_2	2.79	8.58	8.48	28.89
Control (So)	9.88	8.96	6.85	29.96
Sign.	ns	ns	ns	ns
L.S.D $_{(0.05)}$	11.67	4.91	6.27	10.33
Irrigation				

I_4	3.44	8.91	8.52	32.44
I_7	6.86	8.19	5.56	25.09
Sign.	ns	ns	ns	ns
L.S.D $_{(0.05)}$	9.52	4.01	5.12	8.43
Interaction				
Slt × Irr.	ns	ns	ns	ns

Within treatment group means followed by similar letter(s) are not significantly different at 5% level, *=significant at 5% level.

Table 2. Physico-chemical properties of surface soil (0-15cm) at the experimental site before planting and application of treatments.

Parameters	Values
Particle size distribution (%)	
Clay	13
Silt	10
Sand	77
Texturalclass	Sandy Loam.
O.C (%)	0.21
TN (%)	0.35
Avail. P mg kg^{-1}	14.00
Exch. bases (cmol (+) kg^{-1})	
Ca	4.55
Mg	0.65

K	0.140
Na	0.18
C.E.C (cmol (+) kg^{-1})	8.20
pH in $CaCl_2$ (1:2.5)	4.40

Table 4: Physico-chemical properties of the soil after cultivation at the depth of 0-15cm.

		Percentage (%)			**Exchangeable bases (cmol/kg)**						
Parameters		**pH**	**OC**	**TN**	**Ca**	**Mg**	**K**	**Na**	**CEC**	**ESP**	**SAR**
Treatments											
Salt											
SA_1	5.15	0.40b	0.13a	3.77a	0.88a	0.25b	0.37a	6.50b	5.35b	0.13b	
SA_2	5.00	0.38c	0.18a	3.55b	0.57b	0.28a	1.32b	6.65a	7.67a	0.69a	
So (control)		5.13	0.42a	0.07a	3.50b	0.47c	0.23c	0.27c	5.75c	4.65c	0.56b
Sig.		ns	*	ns	*	*	*	*	*	*	*
LSD $_{(0.05)}$		0.161	0.010	0.144	0.154	0.009	0.012	0.052	0.111	0.744	0.368
Irrigation											
I_4		5.05	0.35b	0.67	3.53b	0.69a	0.26a	0.94a	6.58a	5.94	0.39
I_7		5.40	0.45a	0.11	3.68a	0.59b	0.24b	0.37b	6.02b	5.79	0.13

Sig.	ns	*	ns	*	*	*	*	*	ns	ns
LSD $_{(0.05)}$	0.131	0.008	0.117	0.126	0.008	0.009	0.042	0.091	0.608	0.300
Salt x Irrigation	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

Means bearing the same letter (s) within treatment group in a column are not significant at 5 %, using LSD.

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