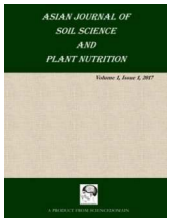

Asian Journal of Soil Science and Plant Nutrition

1(3): 1-9, 2017; Article no.AJSSPN.35268

Impact of Irrigation and Mulching on Tomato Yield and Soil Nutrient Status on Soils Treated with KCl and NaCl

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Authors' contributions

This work was carried out in collaboration between all authors. Author ARS initiated the work, wrote the first draft of the manuscript. Authors AI and MAA supervised the data collection and organization. Author YD collected the data and irrigates the crops. Author AM designed the experiment and performed the data analysis. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJSSPN/2017/35268
Editor(s):
(1) Artemi Cerda, Department of Geography, University of Valencia, Spain.
Reviewers:
(1) Vlado Kovacevic, University J. J. Strossmayer in Osijek, Croatia.
(2) M. M. Buri, CSIR – Soil Research Institute, Ghana.
(3) Ulas Senyigit, Suleyman Demirel University, Turkey.
Complete Peer review History: http://www.sciencedomain.org/review-history/20511

Original Research Article

Received 3rd July 2017
Accepted 29th July 2017
Published 16th August 2017

ABSTRACT

An experiment was conducted at the Teaching and Research Farm of Kebbi State University of Science and Technology at Jega to evaluate tomato fruit yield and nutrient availability as influenced by mulching and irrigation schedule on salt treated soil. The experiment consists of fractional combinations of two irrigation intervals (four (I_4) days irrigation and seven (I_7) days irrigation intervals), and two mulching levels (with mulch and without mulch). The treatments were coded as MI_4, MI_7, UMI_4, and UMI_7: assigned as Mulch with 4 days irrigation interval, Mulch with 7 days interval, without mulch with four days irrigation interval, without mulch with seven days irrigation interval, respectively. The treatments were laid down in a randomized complete block design (RCBD), and replicated three times. Total tomato fruit yield as measured at the end of the

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experiment shows that I_4 (4 days irrigation interval) has the highest total yield of 31.65 t ha^{-1} as against 21.9 t ha^{-1} recorded for I_7 (7 days irrigation interval). Mulch application also yielded higher total fruit yield of 29.9 t ha^{-1} which is higher than no mulch plot which is 23.63 tha^{-1}. However, marketable fruits also keep the same trend that is I_4 is superior over I_7 with the values of 55.77% and 50.79% respectively, Mulch treatment also yielded the highest percentage marketable fruit yield of 56.15% higher than no mulch plot with 50.41%. After harvest the soil properties indicated that pH was not significantly affected by irrigation intervals at both level, but Mulch treatment have 5.13 and no Mulch have 5.03. Organic Carbon percentage indicates that I_4 is lower than I_7 with the value of 0.43% and 0.49% respectively, also mulch treatments has higher percentage O.C. I_7 is higher than I_4 in terms of Total N content with the value of 0.062% and 0.055% respectively, the trend for Mulch is similar as Mulch plots is higher than no Mulch plots in Total N content. Available P content indicated that I_7 has 5.28 mg kg^{-1}, while I_4 has 2.60 mg kg^{-1} and Mulch plots is also superior to no Mulch plots in terms available P. Cation Exchange Capacity (CEC) was also affected by irrigation interval as I_7 has 6.9 cmol (+) kg, which is higher than I_4 which has the value of 5.82 cmol (+) kg, but Mulch and no Mulch plots indicates similar values of CEC.

Keywords: Salts; nutrients; mulch; irrigation; fruit; marketable.

1. INTRODUCTION

Tomato (*Lycopersicon esculentum,* Mill.) is the most popular vegetable with great Nutritive value and good source of Potassium and Vitamin A & C. It is moderately sensitive to salinity and few cultivars are salt tolerant up to some extent. Tomato fruits absorb 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 [1]. Although salt stress has been found to disrupt several physiological processes that leading to reduction in growth and yield [2], salinity can improve its fruit quality [3].

Surface mulching either by synthetic plastic sheets (or films) or natural organic waste material is now a days being used to protect plants from root borne diseases and for water conservation. Organic mulches containing sawdust, dry grass (lawn clippings), maize cobs, rice and wheat straw, water hyacinth etc., have been very effective for vegetable growth and yield through improving water content of soil, heat energy and add some of the organic nitrogen and other mineral to improve nutrient status of the soil.

Surface mulching has shown to reduce evaporation and decrease salinity hazards to improve wheat production in China [4]. Mulch keeps the surface layer wetter and helps to increase root growth in maize. Ground nut mulch has been found to reduce day time temperature and conserve moisture, increase growth and yield attributes of lettuce. Mulching has been used to obtain good vegetable growth and yield in crops like sweet potato, potato, tomato and pepper [5]. [6] also shown that mulching can minimize salinity hazards.

Increasing EC to over 7 mSm^1 can reduce the dry weight of lots of crops, but it has little effect on dry matter partitioning into fruit, shoot and root. 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, minerals), flavor (aroma) and color, with little or no yield reduction. The fruit 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 mSm^1 are acceptable. The addition of major nutrients affect vegetative growth adversely at 12 mSm^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 may be detrimental to plant growth and nutrient uptake.

In today's world market, fruit flavor is of paramount importance to guarantee consumer satisfaction. Increasing EC levels is a key factor in improving tomato fruit quality. The aim of this paper is to evaluate tomato fruit yield and nutrient availability as influenced by mulching and irrigation schedule on salt treated soil.

2. 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℃ experienced on December to February which makes it favorable for the production of tomato. The experiment consists of fractional combinations of two irrigation intervals (four (I_4) days irrigation and seven (I_7) days irrigation intervals), and two mulching levels (with mulch and with no mulch). The treatments were coded as MI_4, MI_7, UMI_4, and UMI_7: designated as Mulched with 4 days irrigation interval, Mulched with 7 days interval, without mulch with four days irrigation interval, without mulch with seven days irrigation interval, respectively. The treatments were laid down in a randomized complete block design (RCBD), and replicated three times. A total land area of 17.8x14.6 m was marked out for the experiment and subdivided into gross plots measuring 3.2 x 3.2 m. 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 with the scheduling treatment. All 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 experimental site using an auger to establish the status of available soil nutrients. A total number of 24 samples were obtained, they samples were air dried, crushed and sieved and were analyzed for particle size, pH, Organic carbon (O.C) Total N, available phosphorus (AP), exchangeable 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.

3. RESULTS AND DISCUSSIONS

3.1 Plant Biomass

The results of the influence of treatment on the biomass of tomato as shown in Table 1, reveals that the treatment with four day irrigation interval (I_4) had produced more plant biomass (7.83 g), relative to the one placed on seven days irrigation interval (I_7) which recorded (6.35 g) as its biomass weight, this is in agreement with the finding of [7] that shows similar biomass accumulation with similar soil condition, but contrary to the finding of [8], that shows higher biomass accumulation with an increase in the number of days to irrigation intervals at Kadawa. This signifies that water supply to crop in adequate amount has a potential for increasing vegetative growth and consequently biomass production probably due to the influence of water on, dissolution, transport and uptake of nutrients, photosynthesis, transpiration and in addition cooling the environment around the crop thus

enhancing the biochemical process in the crop, but this depends on the nature of the soil texture. A heavy soil will surely be negatively affected by the frequency of irrigation.

However, mulch application on soil in this study for tomato production did not show any significant effect on the plant biomass production. But it was clear from the results (Table 1) that the control treatment (Mo), which had not received any mulch application, gave relatively higher value of biomass (8.52 g) than the treatment that had mulch application (M_1). The treatment had lower value of plant biomass (5.62 g). This suggests that application of mulch on soil for production of tomato impacted negatively on its biomass production as the action was associated with a reduction in plant biomass. This was possible probably due to shading effect of mulch on the lower leaves. It could be attributed to low soil temperature induced by mulch application which resulted in low biochemical activity translated to low biomass production, but this may not be the case always considering the finding of [7], that shows superiority in all the parameters that were measured on the agronomic data on tomato at Danbatta.

3.2 Flowering Percentage %

The results presented in Table 1, reflecting the influence of irrigation interval and mulch application on the flowering percentage of tomato at 5 WAT. No significant effect was observed as a result of application of irrigation scheduling on the plant. And the number of plants which had produced flowers was the same (15.83) for both the treatment that was irrigated at four days intervals (I_4) and the one with seven days irrigation interval (I_7).

Similarly, the effect of mulch on the flowering percentage of tomato at 5 WAT was also not significant. But more plants (16.33%) produced flowers in the treatment that was without mulch (Mo). It was observed that fewer plants (15.33%) produced flowers in the treatment which received mulch application (M_1); this may be due to higher moisture conserved in the soil in the treatment which received mulch which perhaps favored plant vegetative growth than reproductive developmental processes. Interaction between irrigation and mulch was also not significant.

The non-significant effect of irrigation and mulch treatment on the plant flowering suggests that the irrigation intervals and mulch application considered in the study did not subject the plants to great moisture stress. Probably because tomato plant has low demand for soil moisture or it could be due to the position of water table at the study area at that period of the season which may favor capillary rise of water upwards, which may help to meet up the water demand by the plant. The interaction effect between irrigation and mulch was also not significant. However, non-significant effect of irrigation on flowering percentage of the plant contradicts with the finding of [9,10] who indicated that mulch does not have an impact on flowering percentage.

3.3 Number of Fruits per Plant

Results of the effect of irrigation interval and mulch application on number of fruits produced per plant as presented in Table 1, like all other

Table 1. Influence of irrigation and much treatments on yield attribution of tomato

	Yield attributes					
Treatments	**Flowering %**	**Biomass (g)**	**No. of fruits/plant**		**Total yield tha^{-1}**	**Marketable yield tha^{-1}**
			6WAT	**8WAT**		
Irrigation						
I_4	15.83	7.83	4.92	9.96	55.77	31.63
I_7	15.83	6.35	3.00	6.00	50.79	21.96
Significant	ns	Ns	ns	ns	ns	Ns
LSD (0.05)	8.67	6.46	2.09	5.03	17.89	12.95
Mulch						
M_0	16.33	8.52	3.92	7.00	50.41	23.63
M_1	15.33	5.62	4.00	8.96	56.15	29.96
Significant	ns	Ns	ns	ns	ns	Ns
LSD (0.05)	8.67	2.45	5.03	5.03	17.89	12.95
Interaction						
Irri. Vs Mulch	ns	Ns	ns	Ns	Ns	Ns

parameters reported so far, number of fruits produced per plant was not significantly influenced by irrigation interval during the sampling periods. It was observed that at both 6 and 8 WAT, plants that were irrigated at four days interval (I_4) produced 4.92 and 9.96 fruits per plant, respectively, which were greater compared to the treatment that was irrigated at seven days interval (I_7) which produced 3.00 and 6.00 fruits per plant, respectively in a similar passion. The production of greater number of fruits per plant as observed here, following irrigation at four days interval, (that is more frequent irrigation) is at variance with the findings of [11] that observed that organic mulch showed the general desirable impact on tomato growth and yield performance.

Similarly, mulch application to soil did not produced significant effect on number of fruits per tomato plant at 6 and 8 WAT. However, plants that received mulch (M_1) had more fruits per plant during the sampling period. The treatment M_1, recorded 4.00 and 8.96 fruits per plant when the plants were sampled at 6 and 8 WAT, respectively. Therefore, the results demonstrated clearly the positive impact of mulch application on soil for tomato production and also it's potential for increasing tomato yield in the area. Increased number of fruits per plant with mulch application on soil was attributed to the to the role of mulch of conserving of soil moisture, cooling of soil surface and decreased soil temperature, thus providing more favorable condition for growth and fruit production for the plant. The finding on positive effect of mulch on fruit number per plant as contained here contradicts the findings of [12,13] who worked with mulch as a treatment on and tomato reported a significant difference in yield of the crop between mulch and unmulched treatments.

3.4 Total Yield

Irrigation interval and mulch effect on total yield of tomato is shown in Table 1. The results revealed that irrigation regimes does not significantly affect total tomato yield. Although, the result showed clearly, that the treatment placed on four days interval (I_4) produced relatively higher total yield of 55.77 t ha^{-1} fresh tomato fruits. The treatment that was irrigated at seven days interval (I_7) has 50.79 tha^{-1}. Increased yield of tomato with subsequent increase in the frequency of irrigation as observed in the case of the I_4 treatment suggests that careful planning of irrigation schedule could adequately supply the water requirement of crops and hence consequently increase tomato yield. Also increased tomato yield as a result of increase irrigation frequency compares favorably well with the report of [14] which shows that greater fruit yield of tomato was observed with shorter irrigation interval, but this finding contradict with the findings of [15] that shows an increase in tomato yield with the longer irrigation intervals at Kadawa. Probably this may be due to variance in the soil type within the two locations (Kadawa and Jega).

Effect of mulch application on soil was not significant (Table 1) on the total yield of tomato. Even though results on mulch treatment shows that tomato plant in the treatment which had mulch (M_1) produced higher yield 56.15 tha^{-1} while the control plot (Mo) that had not received mulch produced relatively lower yield 50.41 tha^{-1}, this suggest that mulch application on soil for tomato production could offer great potential for increasing tomato yield in the study area. Greater increase in the yield of tomato as recorded here was attributed to the positive influence of mulch on soil which include improvement of soil structure, supply of N, P and S nutrient upon decay, conservation and cooling of the soil. These roles of mulch in the soil are necessary for optimum plant growth.

3.5 Marketable Yield Percentage

The results effects of irrigation interval and mulch on marketable yield of tomato fruits are shown in shown in Table 1. The result indicated that both irrigation intervals and mulch treatments did not produce significant effect on marketable yield of tomato. Notwithstanding, it was observed that the irrigation treatment I_4 of which irrigation was carried out at 4 days interval had greater marketable yield of 31.63 tha^{-1} expressed as the percentage of the total fruit yield. The other irrigation treatment (I_7), in which water was added at seven at seven days interval recorded lower marketable yield 21.96 tha^{-1}. Increased marketable fruit yield of tomato was recorded here with the treatment I_4 is in line with the observation on the fruit quality of tomato by [16] who advanced that moisture stress affects the quality of tomato by causing desiccation, sunburn on the fruit as well as reducing vitamin C content in the fruit.

The mulch treatment (M_1) had greater marketable fruits 29.96 tha^{-1} relative to the control (Mo) which had no mulch application, the treatment recorded percentage marketable fruits of 22.63 tha^{-1}, but not at significant level Higher

percentage of marketable yield recorded with the treatment that had mulch application was attributed to increased availability of moisture on the treatment and tallies with findings of [17,7].

3.6 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% sand and the dominant particle. The sandy loam texture indicates that the soil was suitable for tomato production [18]. Soil organic carbon in the site was high (0.21%), total Nitrogen was high (0.35%) available phosphorus was medium (14.00 mg 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.

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

Parameters	Values
Particle size distribution (%)	
Clay	13
Silt	10
Sand	77
Textural class	Sandy Loam
Organic Carbon (%)	0.21
Total Nitrogen (%)	0.35
Available Phosphorous	14.00
Exchangeable bases (cmol(+) kg^{-1}	
Ca	4.55
Mg	0.65
K	0.140
Na	0.18
CEC	8.20
pH in $CaCl_2$ (1:2.5)	4.40

3.7 Chemical Analysis of Soil after the Application of Treatments

3.7.1 Organic carbon (OC)

Results on the effect of irrigation intervals and mulch treatment on chemical properties of the soil at post-harvest of tomato is presented in Table 3. The result shows that organic carbon (OC) was significantly ($P<0.05$) as affected by irrigation treatment. The seven days irrigation interval recorded higher OC (0.49%) that had differed significantly relative to the OC value of 0.43% observed on the four days irrigation interval. The low value of OC in the I_4 treatment might be due to higher biological activities as a result of higher moisture content. [19] states that moisture supply is one of the factors affecting the activities of soil microbes which include oxidation of organic matter.

Also, mulch treatment had significant effect on OC content of the soil. Higher OC value (0.48%) was found on the treatment that had received mulch application (M_1) relative to the control (Mo) which had no mulch. The values for OC had differed significantly between Mo and M_1 treatments. The higher OC observed with (M_1) that had received mulch application was attributed to the nutrient enrichment effect of mulch to the soil (Aquaah, 2006).

3.7.2 Total N

Table 3, shows that total N was affected at significant level by irrigation intervals at post-harvest. The treatment with seven days irrigation interval (I_7) had recorded higher total N (0.062%) than the four days irrigation intervals (I_4) that obtained total N value of 0.055%. Higher content of total N in the soil found on the I_7 treatment could be related to better aeration in the soil which favors the activities of aerobic soil microorganisms that decompose organic matter and eventual release of soil N Conversely, the application of mulch on soil affected soil total N content at significant ($P \leq 0.05$) level. Greater value of total N (0.062%) was observed, the treatment which did not receive mulch (Mo) than the M_1. The control had a high total N (0.062) that was significantly different relative to M_1 treatment. Higher total N as observed with the treatment that had no mulch application (Mo) could be attributed to nitrogen immobilization due to may be high C: N of the organic matter.

3.7.3 Available phosphorus

Table 3 shows that Available P was significantly ($P<0.05$) higher in the treatment with seven days irrigation interval (I_7) in comparison to the four days irrigation interval (I_4). The I_7 and I_4 treatments obtained Available P values of 5.28 and 2.60 mg kg^{-1}, respectively.

Table 3. Available soil nutrients after application of treatments, at post- harvest of tomato

	Parameters								
				Exch. Bases (cmol(+)kg^{-1})					
Treatments	**OC (%)**	**TN (%)**	**Av. P (mgkg^{1})**	**Ca**	**Mg**	**K**	**Na**	**CEC (cmol(+)kg^{-1})**	**pH ($CaCl_2$)**
Irrigation									
I_4	0.43b	0.055b	2.60b	3.67b	0.55b	0.16b	0.22	5.82b	5.07
I_7	0.49a	0.062a	5.28a	4.60a	0.68a	0.21a	0.21	6.90a	5.08
Significant	*	*	*	*	*	*	Ns	*	Ns
LSD (0.05)	0.018	0.001	0.082	0.094	0.009	0.094	0.039	0.188	0.094
Mulch									
M_0	0.44b	0.06a	2.59b	4.10a	0.62a	0.14b	0.21	6.28b	5.02b
M_1	0.48a	0.05b	5.28a	4.17a	0.60b	0.23a	0.22	6.48a	5.13a
Significant	*	*	*	ns	ns	*	Ns	*	*
LSD (0.05)	0.018	0.001	0.082	0.094	0.009	0.094	0.039	0.188	0.094
Interactions Irrigation vs Mulch	ns	Ns	ns	ns	ns	ns	Ns	ns	Ns

Means followed by same letter (s) within a treatment group are not significantly different at 5% using LSD.
**= Significant at 5% using LSD*

The higher Available P obtained on I_7 treatment was attributed to better aeration and high biological activity and release of soil nutrient in the treatment as the treatment received less water application than I_4 treatment.

Similarly, mulch treatment exerted significant ($P<0.05$) influence on Available P. Greater influence on AP was observed on the treatment that received mulch application (M_1) with an AP value of 5.28 mg kg^{-1} which differed significantly with the value of 2.5 g mg kg^{-1} obtained in the control (Mo). This suggests that the mulch material used had great potential in the management of Available P in the soil. This could be connected to the role of mulch of supplying N, P and S nutrients in the soil.

3.7.4 Effects of irrigation Interval and mulch treatment on exchangeable basic cations

Higher Ca, Mg and K values of 60, 68 and 0.21 cmol (+) kg^{-1} respectively were observed on the treatment with seven days irrigation interval (I_7) (Table 3). The values for the cations were not only higher but also differed significantly compared with the Ca, Mg and K values of 3.67, 0.55, and 0.16 cmol (+) kg^{-1}, respectively, recorded in the treatment with four days irrigation interval (I_4). The other basic cation, Na on the contrary was not affected by irrigation interval at a significant level. Nevertheless, exchangeable Na ion was found to decrease with longer irrigation interval of seven days (I_7) as the treatment had obtained 0.21 cmol (+) kg^{-1} observed on the I_4 treatment. Higher values of Ca, Mg and K resulting from the I_7 irrigation treatment that had received more water application is consistent with the report of [19] that soil that have good aeration is a conducive environment for the activities of aerobic microbes that decompose, solubilize and release nutrients into the soil.

Mulch treatment on soil also produced significant influence on all the exchangeable basic cations except Na. The treatment that had received mulch application (M_1) recorded greater Ca, Mg and K with values of 4.10, 0.62, and 0.14 cmol (+) kg^{-1}, respectively, from the treatment. The values differed at significant level with the values for the same cations observed on the control (Mo).

However, exchangeable Na had increase only apparently. The treatment which had mulch application (M_1) obtained a higher (0.22 cmol (+) kg^{-1}, Na) than the control (Mo) in which the value recorded for exchangeable Na was 0.21 cmol (+) kg^{-1}. The Ca value obtained on the mulch treatment (M_1) was rated medium based on the Ca category rating provided by [20]. However, Mg and K were low based on the category rating. The study demonstrated that mulch could improve Ca, Mg and K basic cations which are important as essential nutrient elements of plants and contributes in the regulation of soil acidity.

3.7.5 Cation exchange capacity (CEC)

Table 3 shows that the CEC value was significantly greater (6.90 cmol (+) kg^{-1}) in the

seven days irrigation treatment (I_7) at post-harvest than the four days irrigation interval (I_4) which had recorded CEC value of 5.82 cmol (+) kg^{-1}. Higher CEC in the seven days irrigation interval that was subjected to relatively less moisture and better aerated soil, hence higher biological activity that lead to accumulation of humus with high CEC. High CEC may also be as a result of minimal loss of clay minerals by leaching when soil receives less water supply indicated that clay mineral has CEC cmol (+) kg^{-1}.

Mulch application to soil produced significant effect on CEC, at post-harvest. Table 3 shows that CEC had increased on the treatment that received mulch application (M_1) over the control (Mo), which did not receive mulch. CEC values recorded on the M_1 and Mo treatments were 6.43 and 6.28 cmol (+) kg^{-1}, respectively, and differed significantly. Significant effect with mulch treatment was linked to its role of supplying organic matter that could be decomposed to release soil nutrients and supply humus which is known to exhibit high CEC [19] also reported that soil CEC has improved due to application of mulch treatment on the soil. CEC is one of the important soil parameter influencing soil fertility. It helps the soil to attract and retain cations in the soil and release them as at when due to the plant. Hence it performs a vital function that prevents loss of nutrients by percolating rain or irrigation water. The results on CEC obtained with the mulch in the improvement and management of soil fertility in the study area.

3.7.6 pH

Results on soil pH (Table 3) indicated that pH level had increased due to varied irrigation intervals at post-harvest of tomato. However, the increase was not at significant level. Level of pH was found to be higher (5.08) on the I_7 treatment which was subjected to seven days irrigation interval. The four days irrigation interval (I_4) obtained a pH value of 5.07 which was a marginal increase.

Similarly, soil pH was significantly affected by the mulch applied to the soil. A higher pH value of 5.13 was observed on M_1 treatment which was the treatment in which mulch was applied. The other treatment Mo, the control had a low pH value of 5.02 that was significantly different, compared to the M_1 treatment. The significant influence of mulch on soil pH could be linked to the supply of basic cations which have the ability to raise the pH when it decomposed. It may also be due to mineralization of the basic cations.

4. CONCLUSIONS

Finally, we conclude that in a potassium chloride and sodium chloride treated soil irrigation interval of either 4 or 7 days interval show little or no effect on total tomato yield, however mulching significantly affected yield of tomato. However, based on the findings of this study irrigation interval of seven day (I_7) produced significant effect on most of the soil parameters including organic carbon (OC), total nitrogen (TN), available phosphorus (AP), exchangeable calcium (Ca), magnesium (Mg), potassium (K) and soil cation exchange capacity (CEC), also it had greater positive impact on plant growth and yield attributes.

Similarly, the treatment that was applied mulch had obtained significantly increased OC, AP, exchangeable Mg, and K, CEC and pH. Therefore, appears that the irrigation interval of seven days (I_7) and mulch application on the soil are better practices for maintaining soil fertility in the study area for maintaining good level of soil nutrients.

ACKNOWLEDGEMENTS

We would like acknowledge the assistance given to us financially by the TETFund to carry out this work and to as well thank the management of Kebbi State University of Science and Technology Aliero for given us the approval to use some of the University's resources in this work. We remain indebted.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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