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INFLUENCE OF SODIUM AND POTASSIUM FERTILIZERS ON GROWTH AND NUTRIENT CONTENTS OF TOMATO PLANT IN SOUTH WESTERN NIGERIA

Idowu, M. K.

Department of Soil Science and Land Resources Management, Faculty of Agriculture Obafemi Awolowo University, Ile-Ife, Nigeria.

E-mail: midowu@oauife.edu.ng, Phone No.: +234 803 827 2331

ABSTRACT

The influence of sodium (Na) and potassium (K) on growth and nutrient content of tomato was investigated on the field between 2003 and 2004 at the Teaching and Research Farm, Obafemi Awolowo University. The experiment was a 4 x 3 factorial arranged in Randomized Complete Block Design (RCBD) with three replications. The factors and levels were 0, 4, 16 and 32 mg Na kg^{-1} soil and 0, 64 and 128 mg K kg^{-1} soil applied as NaCl (analytical grade) and KCl (muriate of potash), respectively. Nitrogen and phosphorus at the rate of 30 kg N ha^{-1} and 90 kg P_2O_5 ha^{-1} as urea and single super phosphate, respectively, were applied as basal treatments at four weeks after transplanting. Soil properties were determined prior to experimentation. The nutrient contents of the shoot and root were also determined. The nutrient deficiency and toxicity symptoms were recorded. The number of leaves, branches and flowers were also recorded. Nitrogen, phosphorus, calcium, magnesium and sodium content of shoot and roots were determined after fresh fruits have been harvested at 5 months after transplanting. The results showed scorching and curling of leaves at 32 mg Na kg^{-1} soil. Bigger, brightly coloured and firmer fruits were obtained at Na and K combination of 16 mg kg^{-1} and 64 mg kg^{-1} soil at ratio of 1:4, which gave shoot content of 2.24, 2.32, 16.84, 9.57, 2.33 and 0.17 mg g^{-1} dry weight for N, P, K, Ca, Mg and Na, respectively. A significant decrease of N content and increase in Ca content at the application of 16 to 32 mg Na kg^{-1} and 64 to 128 mg K kg^{-1} soil resulted in imbalance in nutrient composition and an adverse effect in growth, fruit yields and quality. Tomato plant roots contained higher Na content than the shoot. Fruit yield correlated strongly with number of leaves (r = 0.88***), number of flowers (r = 0.58*) and number of branches (r = 0.55*). Shoot-N (r = 0.62**) and root-P were positively correlated with all growth parameters and fruit yield. It was concluded that application of Na and K at ratio 1:4 promoted balanced nutrient content in the tomato plant, and hence recommended for improved tomato plant growth yield and quality.

Keywords: Sodium, potassium, tomato, growth and nutrient content.

INTRODUCTION

The influence of sodium (Na) on potassium (K) nutrition in crop plants is increasingly attracting the attention of plant nutritionists. Different influences of sodium on crops have been observed. Brownell (1979), reported sodium as an essential nutrient for some C_4

species. Other authors maintained that when K is in low supply, Na is known to substitute partially for K in Rhodes grass *(Chloris gayana Kunth)* (Smith, 1974). The substitution was also reported in tomato *(Lycopersicon esculentum* Mill.*)* (Figdore *et al*., 1987), cotton (*Gossypium* spp.) (Balaguru and Khanna, 1982) and sugar beet (*Beet vulgaris*) (Moragban, 1985). More recent report by Aduayi and Olowoyo (2003), in okra showed an independent positive role of Na, at 8 mg Na kg^{-1}. It enhanced water stored in plant, N and K content, leaf area and number of leaves significantly. In Amaranth, Ivahupa *et al.* (2006), maintained that the substitution of Na for K has implications for the diagnosis of plant K status if it causes a shift in the tissue K concentration, which is associated with optimal growth. Idowu and Aduayi (2006), observed an independent positive influence of Na as well as synergistic influence between Na and K on tomato growth and fruit yield, even at sufficiency K levels. The shelf-life of the tomato fruits and flavour were improved (Idowu and Aduayi, 2007). Increase in Na content of plants increased the soil-water potential gradient, thereby serving as a positive function in water and ion transport (Aduayi and Olowoyo, 2003).

Mineral deposits from which K fertilizers are manufactured are finite resources, therefore, other elements that are present in the soil and the atmosphere, which have not be fully accredited as plant nutrients should be fully researched (Manning, 2009). The specific influence of application of low levels of Na in relation to K on nutrient accumulation by tomato plants has not been demonstrated under field conditions. There is limited information on the interaction of Na and K on the growth and nutrient composition and its partitioning in tomato plants. This study aimed to examine the influence of Na and K fertilizers on growth, nutrient contents of roots and shoot of tomato in relation to fruit yield under the field condition.

MATERIALS AND METHODS

The study was conducted on soil that was under secondary regrowth for 6 years with no history of previous fertilizer application at the Obafemi Awolowo University Teaching and Research Farm (OAUTRF), Ile-Ife. Ile-Ife lies between latitudes 7° 31' and 7° 33' N and longitudes 4° 33' and 4° 34' E in forest zone of Southwestern Nigeria. The trial was conducted in 2003 dry cropping season (November and March) when irrigation was applied and the second one during early season (April to July) 2004. The pattern of rainfall is bimodal, with the average annual rainfall estimated to be about 1400 mm. The average monthly temperature ranges from 18.9 to 34.6° C and the mean monthly relative humidity is 61 % and 83 % for the early and dry planting seasons, respectively.

Soil sampling, preparation and analysis

Representative soil samples were taken randomly at 0-15 cm depth. Soils at the sampling site were classified as Iwo series and as Typic Paleustult. Soil samples were air dried, crushed, passed through a 2-mm sieve, and kept in air tight polyethylene bags for the analysis. Exchangeable K, Ca, Na and Mg were extracted with a neutral (pH 7) solution of 1 N NH_4OAc. Potassium, Ca and Na were determined using a flame photometer and Mg using the Atomic Absorption Spectrophotometer (AAS).

Particle size distribution was determined by the modified hydrometer method using 0.2 M NaOH solution as the dispersing agent. The field moisture capacity (FMC) was determined according to the method of Hanks *et al.* (1954). Soil pH was determined using a glass electrode pH meter in both distilled water and 0.01 M $CaCl_2$ solution using 1:2 soil: $CaCl_2$ solution. Soil organic carbon was determined using the chromic acid digestion method. The total N concentration was determined using Macro-Kjeldahl method and the available P was determined using Bray-1 method.

Seedling preparation and transplanting

The tomato seeds (*Lycopersicon lycopersicum* (L.) Karst) (cv. DT97 / 74) were obtained from the National Horticultural Research Institute (NIHORT), Ibadan, Nigeria. Tomato seeds were planted on Sept. 9, 2003 in trays using sterilized soil in the nursery for the dry cropping season and transplanted into the field on November 4, 2003. For early season, seeds were sown on February 28, 2004 and seedlings were transplanted eight weeks later on April 24, 2004. Seedlings were hardened by reducing their water supply slightly, and exposing them directly to field conditions for 6-9 days before transplanting into the field. Vigorous seedlings of uniform height were transplanted at 8 leaves and 20cm height.

Field Experiment

The site was cleared, disc ploughed and harrowed. The experiment was a 4 x 3 Randomized Complete Block Design (RCBD) factorial with three replications. The treatments levels were chosen based on the results of the preliminary study conducted in the greenhouse. The factors and levels were 0, 4, 16 and 32 mg Na kg^{-1}soil (corresponding to 0, 9, 36 and 72 kg Na ha^{-1}) and 0, 64 and 128 mg K kg^{-1}soil (i.e. 0, 143 and 287 kg K_2O ha^{-1}) applied as NaCl (analytical grade) and KCl, respectively. Nitrogen and phosphorus at the rate of 30 kg N $ha^{-1}$and 90 kg P_2O_5 ha^{-1}as urea and single super phosphate, respectively, were applied as basal treatments at four weeks after transplanting (WAT). The plots measured 1.5 m x 1.5 m and adjacent plots were separated by 1 m. Each block measured 30 m x 1.5 m and adjacent blocks were separated by a path of 1.5 m. The total experimental area was 30.0 m x 9.5 m or 285.0 m^2, given plant population of 40,000 per ha.

The plants were treated with 30 g Dithane M45 / 5 litre one week after transplanting to prevent damping-off disease. White flies (*Bemisia tabaci)* and grasshopper (*Zonocerus variegatus* L.) were noticed on the plants at three weeks after transplanting. Hence the plants were sprayed with 1.7 g carbaryl per liter. There were four rows per plot with a seedling per stand and data were collected from the two middle rows. The latter treatment was repeated every three weeks, and weeding was carried out weekly by hand picking.

Agronomic characteristics of tomato

The number of leaves, branches and flowers as affected by treatments were recorded. The number of leaves was recorded weekly starting from two weeks after transplanting (WAT) until when plants reached the reproductive stage. The number of branches was recorded weekly from four weeks after transplanting, then once in two weeks till the end of the experiment. Number of flowers was also recorded weekly.

Tomato fruits were harvested as it ripened over a period of six weeks starting from 22 December, 2003 and ended on 30 January, 2004 for dry cropping season and started on 15 May and ended on 11 June, 2004 for the early season. Fruits were harvested two times a week and the total recorded weekly. Tomato fruit weight produced by a plant was estimated in gram per area of land, which was later extrapolated to tonne per hectare.

Chemical analysis of plant tissue

Plant tissue was ground in a Wiley micro-hammer stainless mill to pass through a 1mm sieve. Before chemical analysis of the individual plant part, a portion of each sample was re-dried at 105^0C and then placed in a desiccator and 0.5 g portion of ground plant tissue was ignited in a muffle furnace at 450^0C for two hours (until ash was whitish / grayish white). The ash was dissolved in 5 ml of 4N HCl solution. Concentrations of K, Ca and Na were determined by flame photometer (Model) while Mg was by AAS (Model). Phosphorus was determined by the vanadomolybdate method, and nitrogen content determination was by the micro-Kjeldahl method.

RESULTS AND DISCUSSION

Soil properties

Data summarizing the properties of soil used for the field study are shown in Table 1. The soil was adequate in pH (6.2) and medium in organic carbon (1.51 %), medium in total N (0.12 %) and high in available P (21.05). Exchangeable Ca, Mg, K, and Na concentrations of 2.0, 2.1, 0.36 and 0.23 cmol kg^{-1} soil (510.00, 300.24, 219.85 and 93.17 mg kg^{-1} soil, respectively) were at medium range. The Na and K concentrations were within the medium fertility range, the Na:K ratio of 1:2, confirming the observation by Aduayi *et al.* (1999) and Akintunde *et al*. (2000). However, IFDC (1984), noted that K concentration of 0.1 to 0.45 cmol kg^{-1} soil (39 to 176 mg K kg^{-1} soil) were within the low range, and Liang (1999), also reported Na concentration of 7 me / L (161 mg kg^{-1} soil) as low. Although, the Na requirements for high yield and good quality tomato fruits have not been established for most Nigerian soils.

Table 1: Properties of the Soil Used for the Experiment

Soil Properties	0-15cm
Sand (%)	72
Silt (%)	12
Clay (%)	16
Texture	Loamy sand
pH	6.20
Organic carbon (%)	1.51
Total N (%)	0.12
Available P ($mgkg^{-1}$)	21.05
Exchangeable Ca (mg kg^{-1})	510.00
Exchangeable K (mg kg^{-1})	219.85
Exchangeable Mg (mg kg^{-1})	300.24
Exchangeable Na (mg kg^{-1})	73.17

AGRONOMIC CHARACTERISTICS OF THE TOMATO PLANT

Number of leaves, branches and flowers

The effects of Na and K on the number of leaves, branches and flowers are shown in Table 2. The number of leaves, branches and flowers was slightly increased at 4 mg Na kg^{-1} soil which also gave highest values. The parameters decreased at 32 mg Na kg^{-1} soil. The application of K at 64 and 128 mg kg^{-1} soil had no significant effects on number of leaves and branches but the number of flowers was significantly depressed. The interaction of Na and K on number of branches, leaves and flowers are shown in Table 3. The number of leaves, branches and flowers decreased significantly upon the addition of 16 mg Na kg^{-1} soil with 128 mg K kg^{-1} soil, and at 32 mg Na kg^{-1} soil to 64 and 128 mg K kg^{-1} soil. The reduction in plant growth and floral formation could be due to cation-anion imbalance induced by high Na and K application, confirming the observation of Marschner (1998). An improved number of leaves, branches and flowers observed at 16 mg Na kg^{-1} soil to 64 mg K kg^{-1} soil was similar to the results obtained for fruit weight (Idowu, 2009).

Table 2: Effects of Na and K on number of leaves, branches and flowers of tomato in the field

Treatments Na ($mgkg^{-1}$)	Leaves	Number Branches	Flowers
	←	No/plant	→
0	7.96ab	90.55ab	7.28a
4	8.53a	102.89	6.7ab
16	6.69ab	83.64ab	4.90b
32	5.61b	72.38b	4.65b
Lsd	2.71	28.79	2.25

Treatments K ($mgkg^{-1}$)	Leaves	Number Branches	Flowers
	←	No/Plant	→
0	7.59a	93.91a	6.26a
64	7.35a	80.18a	5.71a
128	6.65a	88.00a	5.73a
Lsd	2.34	24.93	1.95

In this, and the following tables Original soil content of
exchangeable Na = 73.17 mg / kg
K = 219.85 mg / kg

Table 3: Effects of Na and K interactions on number of leaves, branches and flowers of tomato in the field.

Treatments Na	K ($mg\ kg^{-1}$)	No of Leaves /plant	No. of Flowers /plant	No. of Branches /Plant
0	0	7.23	7.04	91.19
0	64	8.46*	6.88	70.83*
0	128	8.17	7.91	109.63*
4	0	11.04*	8.52*	129.04*
4	64	7.50	6.07*	92.09
4	128	7.04	5.68*	87.54
16	0	6.71	5.12*	89.96
16	64	7.65	5.20*	92.09
16	128	5.71	4.34*	68.88*
32	0	5.35*	4.24*	65.46*
32	64	5.80*	4.67*	65.71*
32	128	5.67*	4.97	85.96
Mean		7.19	5.90	85.37
CV%		56.05	70.59	34.93
SE 0.05		0.48	0.40	5.09

* Means significantly different at $P < 0.05$.

Nutrient composition of shoot and root of the tomato plant

Shoot

The effects of Na on N, P, K, Ca, Mg and Na content of the shoot of the tomato plants are shown in Table 4. Nitrogen, P, Ca and Mg content was not significantly ($p < 0.05$) different from the control treatments at increasing levels of Na. Potassium content in the shoot decreased with increasing Na levels while sodium content in the shoot increased significantly ($p < 0.05$) at 16 mg Na kg^{-1} soil, which produced no significant ($p < 0.05$) adverse effects on N, P, Ca and Mg content in the shoot. The observed highest relative water content of leaf at 16 mg Na kg^{-1} soil confirmed the positive effects of Na accumulation in the shoot on plant water relation (data not shown). This result agrees with the observation by Marschner (1998), that Na could replace K in the vacuoles for maintenance of the cell turgor. The effects of single application of K on N, P, K, Ca, Mg and Na content in the shoot are also presented in Table 5. Nitrogen, P, K, Ca, Mg and Na content was not significantly ($p < 0.05$) different at increasing levels of K.

The interactions of Na and K on N, P, K, Ca, Mg and Na content in the shoot are shown in Table 5. Application of Na and K decreased N shoot content, except at 4 mg Na kg soil that gave a significant increase in N content. Hylton *et al.* (1967), noted the importance of Na in the N nutrition of plants, which confirm some of the observations reported in this study. The results suggested a balanced nutrient composition in the tomato plant at this level of application. Calcium content of the shoot increased but K depressed significantly ($p < 0.05$) at 4 to 16 mg Na kg^{-1} soil and 64 to 128 mg K kg^{-1} soil. The interaction of Na and K decreased P and Mg content whereas it resulted in an erratic trend in Na content in the shoot. Although the application of Na and K decreased K content of shoot, the values are still within the sufficient range given by Marschner (1998), who reported a range of 1.5% as deficient and 5.5% as toxicity level for adequate level for soybean using upper leaves. Bigger, brightly coloured and firmer fruits were obtained at the Na and K combination of 16 mg kg^{-1} and 64 mg kg^{-1} soil at ratio of 1:4. The value of 2.24, 2.32, 16.84, 9.57, 2.33 and 0.17 mg g^{-1} dry weight was obtained for N, P, K, Ca, Mg and Na, respectively. A significant decrease of N content and increase in Ca content at the application of 16 to 32 mg Na kg^{-1} and 64 to 128 mg K kg^{-1} soil resulted in imbalance in nutrient composition and an adverse effect on fruit yields and quality.

Root

Table 6 shows the effects of Na on N, P, K, Ca, Mg and Na content of the root. At 4 to 32 mg Na kg^{-1} soil, N, P, K, Ca, Mg and Na content of the root was not significantly ($p < 0.05$) different from the control treatment. Sodium content in the root increased significantly at 64 to 128 mg K kg^{-1} soil, compared to the control treatments. There was a marginal increase in K content in the root at the same treatment levels. Accumulation of 1.26 mg g^{-1} Na in the root at 128 mg K kg^{-1} soil, had no depressing effect on the dry matter yield and plant water content, but fruit yields were reduced significantly, compared to the control treatment. The application of 32 mg Na kg^{-1} soil decreased Mg content. It was interesting to note that Na content of tomato roots increased with the increase in applied K. This result was contrary to an earlier report that Na was not taken up when there was sufficient K concentration in the growth medium (Marschner, 1998; Schroeder *et al.*, 2002). It could be inferred that the ability of tomato for Na uptake by tomato roots increased with the increase in K content in the soil but transportation to the shoot was reduced. Nitrogen, P and Ca contents were not

significantly affected.

The effect of Na and K interactions on N, P, K, Ca, Mg and Na content of the root is shown in Table 8. Sodium at 0 to 16 mg kg soil with 64 mg kg soil significantly increased roots N content while further addition of Na decreased it. The addition of 16 mg Na kg^{-1} soil to 64 mg K kg^{-1} soil significantly increased N, P, K, Mg and Na content of the root. The interaction of Na and K at these levels were synergistic. Potassium, N, P and Na content of the root increased significantly ($p < 0.05$) at 4 to 32 mg Na kg^{-1} soil and 128 mg K kg^{-1} soil. Conversely, it may be inferred from the results of this study that when K concentration may be high in soil, the application of Na may be necessary to provide balanced nutritional formulation for the tomato plant. However, at 16 mg Na kg^{-1} soil to 64 mg K kg^{-1}soil, cation-anion balance was partly corrected by increasing P and Mg contents of the root, confirming Marschner (1998) that adequate supply of Na increased the P content of epidermal cells by improving the root hydraulic conductivity. In all Na rates, the application of 64 to 128 mg K kg^{-1} soil resulted in significant increase in Na concentration in roots. The application of K alone or in combination with Na significantly increased root Na content. That uptake of Na was increased when K was at sufficient level, implies that Na has an independent function in the tomato nutrition. This is a unique mechanism that qualifies tomato as a moderate salt tolerant plant, because it demonstrated an exclusion mechanism by avoiding accumulation of Na in the shoot. The results of the current study showed that although Na application rate is far below the salinity level, tomato plant roots contained higher Na content than the shoot. Potassium has been reported as a carrier, which enhanced nutrient transportation via the barrier, plasmalemma through the active entry.

Table 4: Effects of single applied Na and K on elemental composition of shoot of the tomato plant in the field

Treatments K(mgkg^{-1})	**N**	**P**	**K**	**Ca**	**Mg**	**Na**
	←			**(mgg^{-1} dry weight)**		→
0	2.11a	2.33a	18.44ab	6.58a	2.71ab	0.36b
4	2.28a	1.67a	17.22ab	9.35a	2.51ab	0.48ab
16	2.22a	1.92a	16.55ab	11.47a	4.70a	0.66a
12	1.95a	1.95a	15.92b	8.41a	2.92b	0.56ab
Lsd	0.68	0.67	2.63	3.23	3.85	0.25

Treatments Na (mgkg^{-1})	**N**	**P**	**K**	**Ca**	**Mg**	**Na**
	←			**(mgg^{-1} dry weight)**		→
0	2.43a	1.93a	17.85a	8.34a	3.03a	0.52a
64	1.99a	2.27a	16.39a	8.34a	2.82a	0.49a
128	2.12a	1.88a	16.85a	10.18a	3.79a	0.53a
Lsd	0.68	0.07	5.36	2.79	3.34	0.22

Table 5: Effects of Na and K interactions on nutrient composition of the shoot of the tomato plants in the field

Treatments		N	P	K	Ca	Mg	Na
Na	K	←			(mgg^{-1} dry weight)		→
(mg kg^{-1})							
0	0	2.28	2.76	23.93	6.03	3.47	0.46
0	64	1.84*	2.79	15.63*	6.75	2.63	0.30*
0	128	2.21	1.43*	15.75*	6.96	2.02*	0.32
4	0	3.09*	1.59*	14.65*	9.49*	3.07	0.36*
4	64	2.02*	1.21*	19.05*	8.59*	2.47*	0.47
4	128	1.73*	1.90*	17.95*	9.97*	1.99*	0.61*
16	0	2.32	1.87*	15.75*	9.45*	3.34	0.56*
16	64	2.24	2.32*	16.84*	9.57*	2.33*	0.71*
16	128	2.10	1.58*	17.05*	15.40*	8.43*	0.72*
32	0	2.02*	1.50*	17.05*	8.39*	2.22*	0.71*
32	64	1.84*	2.75	14.05*	4.46*	3.83	0.49
32	128	1.99*	2.59	16.65*	8.37*	2.71	0.47
Mean		2.14	2.02	17.03	8.95	3.21	0.52
CV%		16.50	28.95	15.08	26.50	54.40	28.99
SE	0.05	0.10	0.17	0.74	0.69	0.50	0.04

* Means significantly different at $p < 0.05$.

Table 6: Effects of single applied Na and K on elemental composition of root of the tomato plant in the field

Treatments	N	P	K	Ca	Mg	Na
Na (mgkg^{-1})	←			(mgg^{-1} dry weight)		→
0	2.07a	2.44a	11.66ab	21.40a	4.04ab	0.88a
4	2.01a	2.60a	10.09b	28.00a	4.62ab	0.86a
16	2.15a	2.62a	11.14ab	24.51a	5.91a	0.81a
32	2.14a	2.49a	13.00a	28.11a	2.79b	0.86a
Lsd	0.34	0.67	2.63	10.48	2.53	0.21

Treatments	N	P	K	Ca	Mg	Na
K(mgkg^{-1})	←			(mgg^{-1} dry weight)		→
0	2.02a	2.54a	10.97a	26.16a	4.06a	0.39c
64	2.14a	2.46a	11.13a	26.81a	5.20a	0.89b
128	2.12a	2.62a	12.39a	23.54a	3.77	1.26a
Lsd	0.29	0.58	2.28	9.08	2.19	0.18

Table 7: Effects of Na and K interactions on nutrient composition of roots of the tomato plant in the field

Treatments		N	P	K	Ca	Mg	Na
Na	K	←			(mgg^{-1} dry weight)		→
(mg kg^{-1})							
0	0	2.02	2.30	9.60	26.99	2.69	0.48
0	64	2.13*	2.59	11.21*	26.36	6.16*	1.00*
0	128	2.06	2.44	14.16*	10.86*	3.27	1.16*
4	0	1.95	2.79*	9.56	28.73	4.79*	0.44
4	64	2.10*	2.26	9.35	25.53	6.39*	0.89*
4	128	1.99	2.75*	11.35*	29.74	2.69	1.22*
16	0	2.10*	2.77*	12.25*	23.16*	5.71*	0.30
16	64	2.35*	2.79*	10.56*	25.16	5.93*	0.77*
16	128	2.01	2.31	10.91*	15.21*	6.09*	1.35*
32	0	2.01	2.28	12.47*	25.71	3.03	0.34
32	64	1.99	2.20	13.41*	30.20*	2.32	0.91*
32	128	2.43*	2.98*	13.12*	28.35	3.02	1.32*
Mean		2.10	2.54	11.50	25.51	4.34	0.85
CV%		7.09	10.63	13.92	09.84	37.61	45.04
SE	0.05	0.04	0.08	0.46	1.46	0.47	0.11

* Means significantly different at $p < 0.05$.

Relationship among soil properties, fruit yields and some growth parameters as influenced by the application of Na and K in the field

Table 8 presents the correlation between number of leaves, flowers and branches, fruit yields and nutrient composition of shoot and roots as influenced by the application of Na and K in the field. Fruit yield correlated strongly with number of leaves (r = 0.88***), number of flowers (r = 0.58*) and number of branches (r = 0.55*). Shoot-N (r = 0.62**) and root-P were positively correlated with all growth parameters and fruit yield. The result confirmed the earlier report by Aduayi and Olowoyo (2003) and Idowu (2006), that applied Na with K indirectly improved fruit yield due to its effects on N assimilation. The results of this study supported the earlier observation by Jones (2008), that N markedly affects growth as well as fruit yield of tomato. Both K and Na contents in shoot and roots of tomato correlated negatively to fruit yield. It implied that Na and K contents in the tomato plant after fruit harvest stage was not directly correlated with tomato fruit yield. Shoot-Ca, root-N and -Ca were not significant.

Table 8: Relationship between number of leaves, flowers and branches, and components of yield as influenced by the application of Na and K in the field

Sources of Comparison	Correlation Coefficient (r)			
	No. of Leaves	**No. of Flowers**	**No. of Branches**	**Fruit Yield**
Shoot N	0.69**	0.57**	0.76**	0.62**
Shoot P	-01.15^{ns}	-0.09^{ns}	-0.34*	-0.26*
Shoot K	-0.14^{ns}	0.07^{ns}	-0.02^{ns}	-0.24*
Shoot Ca	-0.24*	-0.47*	-0.18*	-0.10^{ns}
Shoot Mg	-0.29*	-0.34*	-0.32*	-0.33*
Shoot Na	-0.61**	-0.80***	-0.46*	-0.19*
Root N	-0.91*	0.25*	-0.04^{ns}	-0.15^{ns}
Root P	0.30*	0.14^{ns}	0.42*	0.25*
Root K	-0.47*	0.26*	0.28*	-0.51**
Root Ca	0.03$_{ns}$	0.12^{ns}	-0.11^{ns}	0.14^{ns}
Root Mg	0.30*	0.02^{ns}	0.06^{ns}	0.46*
Root Na	-0.23*	-0.13^{ns}	-0.20*	-0.26*
No of Leaves	1.00	0.89***	0.80***	0.83***
No of Flowers	0.89***	1.00	1.79**	0.58**
No of Branches	0.80***	0.79*	1.00	1.55**

CONCLUSION

The effect of Na and K application on growth and nutrient accumulation in the shoot and roots of tomato was investigated under the field condition. The results showed scorching and curling of leaves at 32 mg Na kg soil. Bigger, brightly coloured and firmer fruits were obtained at Na and K combination of 16 mg kg^{-1} and 64 mg kg^{-1} soil at ratio of 1:4, which gave shoot content of 2.24, 2.32, 16.84, 9.57, 2.33 and 0.17 mg g^{-1} dry weight for N, P, K, Ca, Mg and Na, respectively. A significant decrease of N content and increase in Ca content at the application of 16 to 32 mg Na kg^{-1} and 64 to 128 mg K kg^{-1} soil resulted in imbalance in nutrient composition and an adverse effect in growth, fruit yields and quality. Tomato plant roots contained higher Na content than the shoot. It was concluded that application of Na and K at ratio 1:4 promoted balanced nutrient content in the tomato plant, and hence recommended for improved growth, yield and quality of the tomato.

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