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Comparative effect of organic and inorganic fertilizers on the growth, yield and mineral content of tomato (*Lycopersicum Lycopersicum* Mill*)* fruit

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Abstract

A field experiment was carried out at the experimental plot of the Institute of Agricultural Research and Training (I.A.R&T), Moor Plantation, Ibadan (latitude 7°22'N and longitude 3°50'SE) to evaluate the effect of fertilizer sources on the growth, yield and nutritional content of tomato. The experiment was carried out during the rainy season of 2014, between May and July. Effectiveness of organic and inorganic fertilizers on growth, yield and nutrient composition of tomato were compared in a Randomized Complete Block Design (RCBD) with four treatments which include sole application each of NPK and organic fertilizer, applied at 100 kg N/ha, 50 kg N/ha Organic fertilizer + 50 kg N/ha of NPK fertilizer and the control replicated three times. The soil samples were collected and tested in the laboratory to know the physical and chemical properties. Tomato premier (variety UC-82-B) was planted at 50 cm × 50 cm at 1 seedling per stand. The Aleshinloye Compost (Grade B) organic fertilizer was applied two weeks before transplanting at 100kg N/ha at the appropriate plots while NPK 15:15:15 was applied 2 weeks after transplanting at 100kg N/ha. Parameters assessed were plant height (cm), number of leaves, and number of branches, stem girth (mm), days to 50 % flowering, number of flowers/plot, number of fruits/plot and fruit weight (g). Nutrient component determined in the laboratory were vitamin A and vitamin C. The fertilizer sources did not affect the growth of tomato. The result also showed that NPK 15:15:15 at 100kg N/ha significantly gave the highest fruit yield of 18.60 t/ha than the lowest yield (4.07 t/ha) obtained from the control plots while other sources are similar with NPK. Vitamin A content was best enhanced by NPK 15:15:15 + organic fertilizer while vitamin C content in tomato fruit was not affected by fertilizer source.

Keywords: Tomato; fertilizer; growth; yield; vitamins.

Introduction

Tomato (*Lycopersicon esculentum Mill*) which belongs to the family Solanaceae is one of the three important annual fruit vegetables of the tropical region which originated in South and Central America, around sixteenth century and was introduced into other parts of tropical and sub-tropical America before the middle of seventeenth century and mostly cultivated in Africa (Julel, 2001). Tomato is one of the popular and most consumed vegetables in the world. It is tasty and easily digestible and its bright colour stimulates appetite like other vegetables. Tomato plays a very important role in human diet, it supplies some of the nutrient deficient in other food materials e.g. tomato fruits are rich in minerals and vitamin (Biwasi, 1999). It is also rich in nutrients and calories. It is a rich source of iron and vitamins such as vitamin A, B and C. A 230g of tomato consumption can supply about 60 % of the recommended daily allowance of vitamin C in adults and 85 % in children. Similarly, consumption of 100 ml of tomato juice can supply 20 % of the recommended daily allowance in vitamin A. (Davies, and Hobson, 1981). Mineral composition of tomatoes

depends on the amount and type of nutrients taken from the growth medium. However, adequate supply of nutrients is necessary in tomato production (Barker and Bryson, 2006). Generally, agricultural production depends on factors that can improve the soil fertility, such as fertilizer application (organic and inorganic). Organic manure plays an important role on soil fertility and productivity, and its function is performed through the improvement of the physical condition of the soil structure (Lombin *et al.*, 1991). The various constraints affecting tomato could be averted by the use of appropriate practices such as early sowing, transplanting, mulching, staking, application of fertilizer, pesticides application and other improved crop husbandry practices (Engle's, 2010). Schan, (1992) observed that mineral, protein and vitamins content of crops were improved by soil fertilizer. About 99.5percent of fertilizers used in Nigeria were inorganic fertilizers and this has a negative effect on the plant, the soil and even human who consume the produce obtained from inorganic farming (Williams, 2009). Therefore, there is a compelling need to determine the level of safety and nutritional value ascribable to the consumption of fruit vegetables raised from organic and inorganic fertilizer sources.

The aims of the study were

i) to evaluate effect of fertilizer source on the growth and yield of tomato.

ii) to evaluate effect of fertilizer source on selected vitamins of tomato.

Materials and methods

The field experiment was carried out behind the Recreational Centre of the Institute of Agricultural Research and Training, Moor Plantation, Ibadan with Latitude 7º 22 N and longitude 3º 50 E. The experiment was done during the early rainy season of 2014 between May and July in the rainforest zone of Nigeria. The soil of the experimental site was a strongly-leached, and belongs to Alfisol, classified as Typic Kanhaplustalf (Soil Survey Staff, 2006). The average annual minimum temperature was 24.3℃ and the maximum temperature was 34.8℃ for the period of 10 years with the average annual rainfall of 1440 mm (NIMET, 2007). The mean rainfall during the experimental period was 167 mm with average maximum temperature of 31℃ and average minimum temperature of 23℃. It was a rain-fed experiment without irrigation. The experimental design was a Randomized Complete Block Design (RCBD) comprising of 3 fertilizer sources: 100 Kg N/ha of NPK (15:15:15) at 133.33g/plot, Commercial organic manure (1.52% N, 3% P and 2% K) at 1315.79g/plot, NPK (50 kg N/ha)+ Organic(50 kg N/ha) and the control plot replicated three times. Plot size was 2 x 1 m with 1 m margin between plots and 2 m margin between replicates. Seedlings of tomato variety,UC-82-B, from IAR&T seed store were raised in the nursery for 5 weeks after which transplanting of the most vigorous seedlings was done to the field already ploughed and harrowed. The seedlings were planted at 50 cm x 50 cm, 1 seedling per stand (15 stands/plot). Being a slow releasing fertilizer, the organic fertilizer was applied two weeks before transplanting at the appropriate plots while NPK 15:15:15 was applied 2 weeks after transplanting. Data collection commenced two weeks after transplanting from randomly selected four plants per plot. Growth parameters collected at the peak of vegetative growth at seven weeks after transplanting included: plant height (cm), number of leaves, number of branches, and stem girth (mm) while the yield parameter included: days to 50 % of flowering, number of fruits/plot, fruits weight (g) plot taken from eight weeks after transplanting. Fruit analysis was done at eleven weeks after transplanting in the laboratory to determine the effects of fertilizer source on vitamin A and vitamin C.

Determination of vitamin A

Ten ml of distilled water was added to 2 g of the sample in a beaker and carefully shaken to form a blend; 25 ml of alcoholic KOH solution was added and heated for 1hr with frequent shaking in a water bath. The mixture was cooled rapidly then 30 ml of water was added. The mixture was transferred into a separating funnel; 250 ml of chloroform was used for the extraction (3 times). 2 g of anhydrous Na_2S0_4 was added to the extract, to remove any trace of water. The mixture was then filtered into 100 ml volumetric flask and made up to mark with water (if the sample is still high, pipette 1 ml into another 100 ml flask and made up to mark. Finally, the absorbance at 328 nm was read according to the procedure of AOAC, (1990).

Determination of vitamin C

Tomato fruit sample (red ripe) at 11 weeks after transplanting, 0.5 g of the sample was weighed into little quantity 0.5 ml of distilled water and filtered. 1 ml from the filtrate was pipette into a 100 ml flask and 1ml from the solution was taken into a 50 ml flask. 0.8 ml of 10 ppm $K_2Cr_2O_7$ solution was added followed by addition of 1M H_2SO_4. After 10 mins, 1mL of 0.25 % DPC and was made up with distilled water for

titration to determine the vitamin (Mohammed and Hazim, 2016).

Data analyses

Data were analyzed using analysis of variance and the means were separated using Duncan's Multiple Range Test (DMRT) at 5 % level of probability

Results and discussion

Physico chemical properties of the soil before planting

The properties of the experimental soil presented in Table 1 indicated that the soil was loamy sand in texture; with slightly acidic pH (5.9). According to soil fertility rating reported by (FMARD, 2012); organic carbon, available phosphorus and total nitrogen contents of the soil were low, exchangeable cations ranged from low to moderately low while the cation exchangeable capacity of the soil was low. This implies that the soil is of low capacity status and thereby suitable for the experiment.

Effects of fertilizer sources on the growth of tomato at 7 weeks after transplanting

It was observed that growth of tomato in terms of number of branches, number of leaves, and plant height were significantly enhanced by different fertilizer sources while growth was significantly hampered in unfertilized plots (Table 2). One of the methods through which plants would display their potential genetic capacity is by supplying the plants with adequate amount of fertilizer at the right time (Olaniyi, 2006). The similarity observed in the stem girth of treated and untreated plots may be due to aggressive vine extension at the expense of vine thickness or nutrient imbalance in the tomato crop and a reduction in the uptake of certain nutrients, which may be responsible for poor response of tomato to fertilizer (Ewulo *et al.,* 2008).

Effects of fertilizer sources on number of fruit of tomato

The effect of fertilizer sources on number of fruit is shown in Table 3. Except for harvesting done at 56 days after transplanting (DAT) and 81DAT, treated plots significantly produced more fruits than the untreated plot which is evident in the work of (Baker, 2005). The number of fruits per plot was comparable at the onset until 61 DAT and 66 DAT harvests where NPK treated plot gave better result than other treatments (Agbede, 2008). The complementary application of fertilizer also gave higher number of fruits per plot at 71 DAT and 81 DAT harvest periods while the organic fertilizer treated plot gave better result at 76 DAT harvest even though the result was not significantly different from other treated plots. However, the control plot produced cumulatively the least number (141.0) of fruit per plot which was significantly lower than the treated plots. NPK treated plot gave the highest value of 341.33 which was comparable with other treated plots. These results confirmed the report of Awodun, (2007) that there was a significant influence on the growth and yield of *Telfaria* by the application of fertilizers.

Effect of fertilizer sources on days to 50% flowering and fruit yield of tomato

The effect of fertilizer source on days to 50 % flowering and fruit yield are shown in Table 4. There was no significant difference in the number of days to 50 % flowering in both the treated plots and the untreated plot, even though flower initiation was fastest (80 days) under the plot treated with NPK fertilizer while it was mostly delayed (90 days) in the organic treated plot which may be due to slow release of nutrient (Agboola and Odeyemi, 2009). There was significant difference in fruit yield of tomato between the treated and untreated plot from the 56 days after transplanting (DAT) harvest period. Except at 61 DAT and 81 DAT harvests, NPK treated plots produced higher yield of tomato than other treated plots even though the results was comparable. Meanwhile, at 81 DAT harvest, complementary application of fertilizer gave higher fruit yield which was not significantly different from the other treated plots. The total cumulative fruit yield was highest (3719.69g/plot) under the NPK treatment and least (814.75g/plot) under the control plot. The yield values from the treated plots were not significantly different from each other. In other words, according to Ehigiator, (1998), organic manure alone or in combination with mineral fertilizer exerts more beneficial effect on fruit yield when compared to crops exposed to only fertilizer.

T**able 1: Physico Chemical properties of Pre-planting soil**

Parameters	Unit	Value
pH		5.9
Total N	g kg^{-1}	0.9
Available P	mg kg^{-1}	5
Organic C	g kg^{-1}	8.6
Exchangeable cations	c mol kg^{-1}	
Ca^{2+}	,,	2.2
Mg^{2+}	,,	0.8
Na^{+}	,,	0.4
K^{+}	,,	0.3
H^{+}	,,	0.1
ECEC	,,	3.8
Particle Size	g kg^{-1}	
Sand	,,	860
Silt	,,	76
Clay	,,	104
Textural Class		Loamy sand

Table 2: Effects of fertilizer sources on the growth of tomato at 7 weeks after transplanting

Treatment	No. of Branches	No of leaves	Plant height (cm)	Stem diameter (mm)
Control	15.67b	36.75b	21.13b	8.18
NPK	25.75a	60.42a	34.54 a	11.01
Organic	24.58a	63.58a	39.96a	12.39
NPK + Organic	22.50a	85.42a	39.27a	9.93

Values followed by the same letter in a column are not significantly different at 5% level of probability according to Duncan's Multiple Range Test

Table 3: Effects of fertilizer sources on number of fruits per plot of tomato

Treatment							Cumulative number of fruits /plot
	56 DAT	61 DAT	66 DAT	71 DAT	76DAT	81 DAT	
Control	23.33	48.00c	40.00b	10.00b	8.67b	11.00b	141.00b
NPK	33.67	118.33a	106.67a	30.00a	28.00a	24.67ab	341.33a
Organic	25.33	85.00b	85.33a	31.33a	30.67a	27.00a	284.67a
NPK + Organic	23.00	98.67ab	95.67a	36.33a	28.00a	38.67a	320.33a

Values followed by the same letter in a column are not significantly different at 5% level of probability according to Duncan's Multiple Range Test, DAT: days after transplanting.

Table 4: Effect of Fertilizer Source on day to 50 % flowering and fruit yield of tomato (g/plot)

Treatment	Days to 50 % flowering	56 DAT	61 DAT	66 DAT	71 DAT	76 DAT	81 DAT	Cumulative fruit yield (g/plot)
Control	86.00	77.69c	348.89a	227.28b	64.91b	27.22c	68.76b	814.75b
NPK	80.00	348.87a	224.15b	963.65a	689.59a	691.45a	801.98a	3,719.69a
Organic	90.33	219.27b	160.33b	734.92a	503.97a	514.98b	743.31a	2,876.78a
NPK + Organic	85.00	324.37a	199.00b	610.11a	558.58a	505.60b	939.37a	3,137.03a

DAT: days after transplanting, Means with the same letter in a column are not significantly different according to Duncan's Multiple Range Test at 5% level of probability

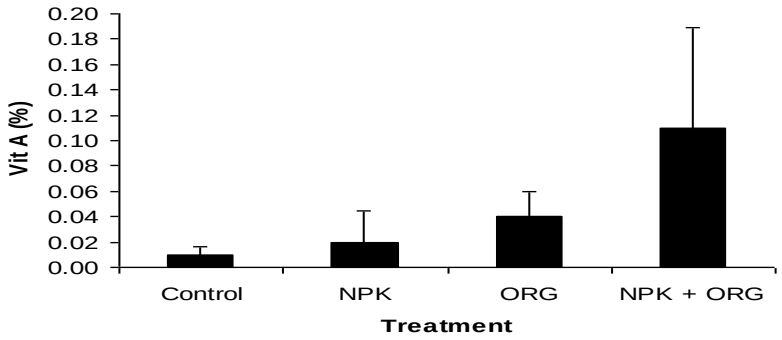

Fig 1: Effects of fertilizer source on vitamin A content of tomato fruits

NPK= 15:15:15
ORG= Organic fertilizer
NPK+ORG= NPK 15:15:15 + Organic fertilizer

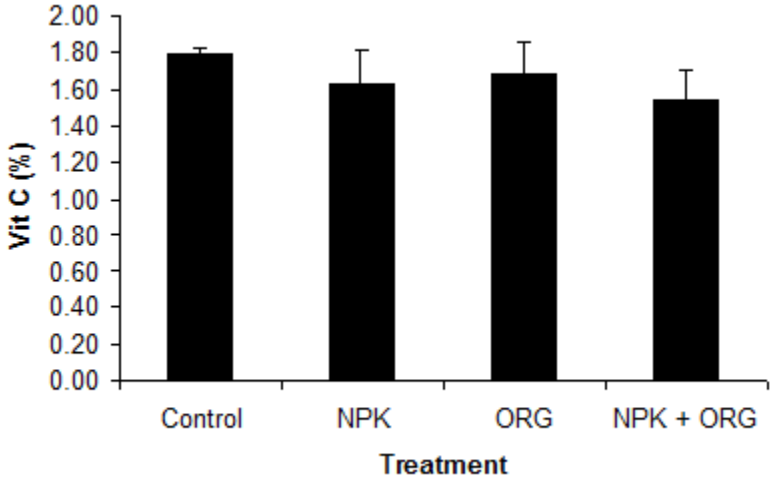

Fig 2: Effects of fertilizer source on vitamin C content of tomato fruits

NPK= 15:15:15
ORG= Organic fertilizer
NPK+ORG= NPK 15:15:15 + Organic fertilizer

Effect of Fertilizer Source on Vitamin A Content of Tomato fruit

The effect of fertilizer source on vitamin A content of tomato (Figure 1) indicated that vitamin A content of tomato was significantly supported best by the application of organic and inorganic fertilizer with 0.11 %, followed by organic fertilizer which is similar with NPK while the lowest percentage was from untreated plot with 0.01 %. Tomato being a good source of Fe and vitamin A, B and C (Davies and Hobson 1981), can be enhanced by the combination of organic and mineral fertilizers in order to achieve a resource saving and balanced nutrient supply and a high quality tomato yield (Heeb, 2005). Apart from nutrient supply, yield and product quality of tomato may also be affected by environmental conditions as sunlight and temperature that are beyond the growers control (Heeb, 2005).

Effect of fertilizer source on Vitamin C content of Tomato fruit

The effects of fertilizer sources on vitamin C content of tomato were summarized in Figure 2. The untreated plants had the highest percentage of vitamin C content of 1.79 % which is similar with the treated plants, complementary fertilizer application giving the least value of 1.54 %. The low response observed might have been due to accumulation of chemical fertilizers, which compromised fruit quality (Shimbo *et al.*, 2001). Also, according to (Mozafar, 1993), elevated vitamin C contents have been measured in relation to poor yields or high light intensity, whereas high N applications decreased vitamin C contents. The latter might be an indirect effect as an increased plant growth causes self-shading of the fruits (Dumas *et al.*, 2003)

Conclusion

Growth responses of tomato to different sources of fertilizers were similar but this does not completely translate into the fruit yield of tomato. NPK 15:15:15 treated plants flowered earlier than the other treatments which might be responsible for earlier fruiting and productivity of the crop as it gave the highest fruit yield, even though it is comparable with other fertilizer sources but it is significantly different from control plants. Application of NPK 15:15:15 fertilizer to the soil improved nutrient availability to the crop and enhanced good growth and yield of the crop. However, vitamin A content was best enhanced by NPK 15:15:15 + organic fertilizer while fertilizer source did not affect the composition of vitamin C in tomato fruit. This result is an indication that low income farmers working on moderately fertile soil could still benefit, nutritionally from tomato, when scarcely available inorganic fertilizer is supplemented with organic sources.

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