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RESEARCH ARTICLE

EFFECT OF MINERAL FERTILIZERS ON FRUIT YIELD AND NUTRITIONAL QUALITY OF TOMATO VARIETY (*Lycopersicon lycopersicum* Mill) IN OGBOMOSO AND MOKWA, NIGERIA

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ABSTRACT

Field experiment was conducted at the Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso and Niger State College of Agriculture, Mokwa, in 2013 cropping season to examine the effects of mineral fertilizers on fruit yield and nutritional qualities of tomato variety. The experiment had twenty seven fertilizer treatments namely: nitrogen (0, 30 and 60 in kg N ha^{-1}), phosphorus (0, 25 and 50 kg P_2O_5 ha^{-1}) potassium (0, 16.5 and 33 kg K_2O ha^{-1}) and their combinations, replicated three times. Treatment without fertilizer served as control. The experiment was laid out in Randomized Complete Block Design (RCBD). Data were collected on plant height, number of flowers, number of fruits and total fruit yield. The determination of fruit phytochemical contents at full ripening, 6 fruit samples were randomly selected per plot and analysed for nutritional qualities such as crude Protein, Carotene, Iron, Phosphorus, Potassium, Calcium, Lycopene, Magnesium, Vitamin C contents. Data was analysed using analysis of variance (ANOVA) SAS package and treatment means compared using Duncan multiple range test at 5 % probability level. External input of mineral fertilizer improved tomato yield and nutritional quality of tomato. Application of 60 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} + 33 kg K_2O ha^{-1} gave the highest fruit yield (27.81 t ha^{-1}) while control plot had the least (9.96 t ha^{-1}). Nutritional qualities (Lycopene, phosphorus, potassium) were best at fertilizer rates of 60 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} + 33 kg K_2O ha^{-1}. In conclusion, external input of mineral fertilizer is necessary to improve tomato yield and nutritional quality. Plants fertilized with 60 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} + 33 kg K_2O ha^{-1} responded better than other rates and therefore can be recommended for farmers to increase crop production within the study areas.

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INTRODUCTION

Tomato (*Lycopersicon lycopersicum*) belongs to the solanaceae family. It originated in Peru and Mexico, in the present day Central and South America from where it spread to other parts of the world (Zeidan, 2005). Tomato reached Europe from Mexico in the 16^{th} century, and was initially used as ornamental plant. Its cultivation for edible fruits started at the end of the 18^{th} century. Tomato was introduced to West Africa and Nigeria in particular, at the end of the 19^{th} century (Villareal, 1980). It is currently considered to be one of the main vegetable crops in the world, and constitutes an economic force that influences the income of many growers in the world (Omar, 2005). In Nigeria tomato also finds its way into almost every kitchen. Tomato crop is very important in terms of diet and economy in Nigeria both during the rainy season (rainfed) and dry season using irrigation facilities. It is used as a condiment in stews and soup or eaten raw in salads. Industrially, the crop is made into puree, sauce, paste and powder (Balarabe, 2012). Although the use of improved varieties along with fertilizer application have increased tomato production in the tropics, the full potential of the crop has not been achieved when compared to the temperate countries where fruits yield could be as high as 52.80 t ha^{-1} (FAO, 2000). The low yield of 10 t ha^{-1} obtained in the tropics has been attributed to several factors including high temperatures, high humidity, excessive rainfall (FAO, 2006), lack of appropriate varieties (Olaniyi, 2010) and cultural practices (Znidarcic *et al.*, 2003). Fertilizer recommendation for tomato in Nigeria often appears as straight nitrogen (N), phosphorus (P), or potassium (K) applied as Urea, Single Super Phosphate and Muriate of potash respectively (Anon. 2002). Yet it is much more convenient for the farmers to apply

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fertilizer-nutrient needs in one single formulation. The use of mineral fertilizer has also been very widely adopted by farmers. Infact, over 70% of all fertilizer used in Nigeria today is in the form of NPK 15-15-15. The problem with too much reliance on NPK 15-15-15 is that this fertilizer has low N and P content (Anon, 2002). Nitrogen is the most limiting nutrient in the guinea savanna zones (Enwezor *et al*., 1990; Aduayi *et al*., 2002). The soils of this zone are low in organic matter, poorly buffered and are of low activity clay (LAC) with Kaolinite as dominant clay fraction, therefore cations and water retention capacities are low (Enwezor *et al*., 1990; Odunze, 2006). Application of N as fertilizer to soils in the savanna is therefore essential in order to achieve high crop yields of good quality. The current tomato production systems require high levels of N and irrigation for optimum growth. Nitrogen has a pronounced effect on growth and development of tomato (Upendra *et al*., 2003).

Modern tomato cultivars and hybrids exhibit high relative growth rates and therefore rely on adequate supply of nitrogen and phosphorus for optimal development and high yield. The relative growth rate of tomato increases sharply with increasing plant P concentration when the latter is below the critical level of adequacy (de Groot *et al*., 2002). Tomato fruits absorb high amounts of K from the soil. With optimum nutrition, nutrient uptake increases rapidly during the fruit growth period. Adequate K supply is important to several plant processes among them enzyme activation, photosynthesis, osmoregulation and phloem transport determining the fruit yield. In low K soil it is not possible to obtain high tomato yields without K fertilizer (Huett and Dettmann, 1988). Despite many investigations in the area of nutrition, knowledge on how mineral fertilizers influence physical and phytochemical contents of tomato fruit is insufficient. This study determined plant growth, fruit yield and nutritional qualities of tomato variety in Ogbomoso and Mokwa, Nigeria as affected by mineral fertilizers.

MATERIALS AND METHODS

The experiment was conducted at two locations; Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso (8^o10^1N; 4^o10^1E) and Niger State College of Agriculture, Mokwa (9^o 18^1N and 5^o 04^1E), during 2013 cropping season. The experimental plot was ploughed and harrowed after which lining out was carried out. There were 81 plots with three replications. Each replicate consisted of 27 plots. Each treatment was in a plot size of 2.5 m x 2.0 m (5.0 m^2). A plot contained 30 plants. The total experimental area was 850.50 m^2 (0.085 ha^{-1}). The alley way between replicates was 1.0 m and within replicates was 1.0 m. Tomato seedlings were transplanted at a spacing of 50 cm x 50 cm. UC82B which was the best variety from the previous experiments was used. Three mineral fertilizer types at 3 rates each and their combinations were used. The treatments were laid out in a Randomized Complete Block Design, replicated three times. The seeds were sourced from the Department of Crop Production and Soil Science, Ladoke Akintola University of Technology, Ogbomoso and from the Department of Agricultural Technology, Niger State College of Agriculture, Mokwa. The tomato seeds were sown on nursery beds containing pulverized soil and the seedlings were raised for four weeks before transplanting to the field at the two locations. Watering in the nursery was done as at when needed. Healthy and vigorous seedlings were transplanted into the field in order to ensure uniformity. Watering was done using watering - can to supplement rainfall. Pesticide in form of cypermethrin was applied at the dosage of 25 ml per 15 litres of knapsack sprayer fortnightly to check caterpillars, worms and grasshoppers. Manual weeding was also carried out using hoe at three weeks interval starting from 2 WAT to reduce competition between weeds and plants. Data were collected on plant height, number of flowers, number of fruits and total fruit yield. The determination of fruit phytochemical contents at full ripening, 6 fruit samples were randomly selected per plot and analysed for nutritional qualities such as crude Protein, Carotene, Iron, Phosphorus, Potassium, Calcium, Lycopene, Magnesium, Vitamin C contents. In order to assess these, 6 fruit samples were collected and dried in an oven at 85^OC for 72 hours. The dried fruit samples were separately ground with a Wiley mill, and passed through a 0.5 mm sieve for tissue analysis. Total P was determined by the Vanadomolybdate method, K and Ca was determined by the flame photometry and Mg and Fe were determined by atomic absorption spectrophotometer (IITA, 1989). Total N was analyzed by the micro-Kjeldahl procedure as described by IITA (1989) and crude protein was obtained by multiplying the total N by a factor of 6.25. Data collected were subjected to Analysis of Variance (ANOVA) using SAS statistical package. Treatment means were separated using Duncan multiple range test (DMRT) at 5% probability level.

RESULTS

Plants height

The mean plants height of tomato plant is presented in Table 1. The plant height was significantly ($P \leq 0.05$) different at 2, 4 and 6 WAT. At 2 WAT, the highest plant height of 16.1 cm was obtained from the plants treated with 60 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} + 33 kg K_2O ha^{-1} which was significantly taller than that of 30 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} + 33 kg K_2O ha^{-1} (14.8 cm) which was also taller than other treatments. While the least mean value (11.8 cm) was observed from un-fertilized plot. At 4 WAT, tomato grown on soil amended with 33 kg K_2O ha^{-1} produced the tallest height (35.8 cm) which was significantly taller than that of 30 kg N ha^{-1} + 25 kg P_2O_5 ha^{-1} + 33 kg K_2O ha^{-1} which had mean value (34.0 cm). The tomato plants treated with fertilizer of 60 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} + 33 kg K_2O ha^{-1} (33.5 cm) and 25 kg P_2O_5 ha^{-1} (33.3 cm) had similar height while the least mean value (22.4 cm) was obtained from un-fertilized plot. Likewise, plant height of tomato was significantly ($P \leq 0.05$) influenced by combined fertilizer application rates at 6 WAT. The tallest plant height with the mean value (71.2 cm) was obtained from 60 kg N ha-1 + 50 kg P_2O_5 ha-1 + 33 kg K_2O ha-1. This was followed with the mean value (68.5 cm) received from 50 kg P_2O_5 ha-1 + 16.5 kg K_2O ha-1and the least mean value (47.6 cm) was obtained from un-fertilized plot.

Number of flowers

The number of flowers of tomato plant was significantly ($P \leq 0.05$) increased by combined fertilizer application rate (Table 2). The tomato plants fertilized with 60 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} + 33 kg K_2O ha-1 (39.8) was significantly higher than that of 60 kg N ha^{-1} + 50 kg P_2O_5 ha-1 (32.6) which was not significantly different from the mean values of (31.4) received from the plants treated with 33 kg K_2O ha^{-1}, 60 kg N ha^{-1} + 33 kg K_2O ha^{-1} (31.1) and 50 kg P_2O_5 ha^{-1} + 33 kg K_2O ha^{-1} (31.0).

Table 1. Effect of fertilizer types on the plant height of tomato plants in 2013 cropping season

Fertilizer types (Kg ha^{-1})	Plant height (cm)		
	Weeks after transplanting		
	2	4	6
0	11.8f	22.4g	47.6f
30 N	13.2cdef	25.8g	54.5de
60 N	14.0bcd	27.9fg	55.3cde
25 P_2O_5	12.5ef	33.3bc	60.8bc
50 P_2O_5	13.4bcde	29.5def	55.9cde
16.5 K_2O	14.5bc	31.0de	59.8bcd
33K_2O	13.7bcde	35.8a	62.6b
30N + 25 P_2O_5	14.0bcde	29.1ef	54.8de
30N + 50 P_2O_5	14.2bcd	31.1cde	57.6bcde
30N + 16.5 K_2O	12.6ef	32.3bc	47.8f
30N + 33 K_2O	13.1cdef	25.8g	52.5f
60N + 25 P_2O_5	14.1bcd	27.9fg	56.3cde
60N + 50 P_2O_5	12.8def	29.0ef	55.3cde
60N + 16.5 K_2O	13.4bcde	27.7g	56.8cde
60N + 33 K_2O	14.3bcd	29.5def	55.3cde
25 P_2O_5 + 16.5 K_2O	13.9bcde	31.7bcd	58.5bcd
25 P_2O_5 + 33 K_2O	13.7bcde	27.7fg	56.2cde
50 P_2O_5 + 16.5 K_2O	14.7abc	29.6def	68.5a
50 P_2O_5 + 33 K_2O	14.2bcd	28.0fg	54.1cde
30N + 25 P_2O_5 + 16.5 K_2O	12.8def	29.0ef	55.3cde
30N + 25 P_2O_5 + 33 K_2O	14.2bcd	34.0b	59.5bcd
30N + 50 P_2O_5 + 16.5 K_2O	13.3bcde	25.8g	54.5de
30N + 50 P_2O_5 + 33 K_2O	14.8ab	26.7g	57.7bcde
60N + 25 P_2O_5 + 16.5 K_2O	13.7bcde	27.7fg	56.2cde
60N + 25 P_2O_5 + 33 K_2O	14.0bcd	27.9fg	55.3cde
60N + 50 P_2O_5 + 16.5 K_2O	14.3bcd	29.5def	55.3cde
60N + 50 P_2O_5 + 33 K_2O	16.1a	33.5ab	71.2a

Means with the same letter are not significantly different at 5% probability (DMRT)

Table 2. Effect of fertilizer types on flowers and fruit characteristics of tomato in 2013 cropping season

Fertilizer types (Kgha^{-1})	No. of flowers / plant	No. of fruits / plant	Total fruit yield (t/ha)
0	21.9g	19.5j	9.96f
30 N	26.2f	24.0hi	11.24ef
60 N	29.1cde	27.3cdef	12.47bcde
25 P_2O_5	25.3f	23.4i	12.06cde
50 P_2O_5	27.2ef	24.3hi	13.41bc
16.5 K_2O	30.0bcd	27.0defg	13.48bc
33 K_2O	31.4bc	29.4bc	12.82bcd
30N + 25 P_2O_5	26.1f	24.2hi	12.65bcde
30N + 50 P_2O_5	32.6b	30.2b	13.80b
30N + 16.5 K_2O	25.9f	25.0hi	10.70ef
30N + 33 K_2O	26.3f	24.1hi	11.64ef
60N + 25 P_2O_5	29.1cde	27.3cdef	12.47bcde
60N + 50 P_2O_5	25.2f	23.5i	11.53de
60N + 16.5 K_2O	27.7def	26.0efgh	12.17cde
60N + 33 K_2O	31.1bc	25.8bcd	13.26bc
25 P_2O_5 + 16.5 K_2O	25.7f	23.6i	12.86bcd
25 P_2O_5 + 33 K_2O	27.4ef	25.0fghi	9.96f
50 P_2O_5 + 16.5 K_2O	31.0bc	28.3bcde	13.28bc
50 P_2O_5 + 33 K_2O	26.1f	23.7i	11.50de
30N + 25 P_2O_5 + 16.5 K_2O	25.5f	23.5i	11.34def
30N + 25 P_2O_5 + 33 K_2O	26.7ef	24.6ghi	12.76bcde
30N + 50 P_2O_5 + 16.5 K_2O	27.2f	25.8ghi	11.74ef
30N + 50 P_2O_5 + 33 K_2O	27.7def	26.0efgh	12.17cde
60N + 25 P_2O_5 + 16.5 K_2O	27.4ef	24.0hi	12.07cde
60N + 25 P_2O_5 + 33 K_2O	29.1cde	27.3cdef	12.47bcde
60N + 50 P_2O_5 + 16.5 K_2O	31.3bc	28.8bcd	13.20bc
60N + 50 P_2O_5 + 33 K_2O	39.8a	36.4a	27.81a

Means with the same letter are not significantly different at 5% probability (DMRT)

The application of 33 kg K_2O ha^{-1} fertilizer had mean (30.0) which was significantly higher than that of 60 kg N ha^{-1} + 16.5 kg K_2O ha^{-1} and 30 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} + 33 kg K_2O ha^{-1} (27.7). But were not significantly different from the plants treated with 25 kg P_2O_5 ha^{-1} + 16.5 kg K_2O ha^{-1} and 30 kg N ha^{-1} + 25 kg P_2O_5 ha^{-1} + 33 kg K_2O ha^{-1} fertilizers (26.7). Application of 30 kg N ha^{-1} fertilizer was not significantly different from the mean values of 30 kg N ha^{-1} + 16.5 kg K_2O ha^{-1} (25.9), 30 kg N ha^{-1} + 25 kg P_2O_5 ha^{-1} + 33 kg K_2O ha^{-1} (25.5), 25 kg P_2O_5 ha^{-1} (25.3) and 60 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} (25.2) and the least mean value (21.9) was obtained from un-fertilized plot.

Number of fruits per plant

Number of tomato fruits per plant was significantly ($P \leq 0.05$) influenced by various fertilizer application rates (Table 2).

Table 3. Effect of fertilizer types on nutritional qualities of tomato in 2013 cropping season

Fertilizer types (Kg ha^{-1})	Protein	Carotene	Fe
	→	mg/100 g	←
0	1.1ab	0.5d	0.6bc
30 N	1.1ab	0.4e	0.5d
60 N	1.1ab	0.8a	0.7ab
25 P_2O_5	1.1ab	0.4e	0.6bc
50 P_2O_5	1.1ab	0.7b	0.4e
16.5 K_2O	1.1ab	0.7b	0.8a
33 K_2O	1.1ab	0.6c	0.7ab
30N + 25 P_2O_5	1.1ab	0.6c	0.5d
30N + 50 P_2O_5	1.1ab	0.7b	0.6bc
30N + 16.5 K_2O	1.1ab	0.6c	0.6bc
30N + 33 K_2O	1.1ab	0.4e	0.5d
60N + 25 P_2O_5	1.1ab	0.8a	0.7ab
60N + 50 P_2O_5	1.1ab	0.7b	0.5d
60N + 16.5 K_2O	1.0b	0.5d	0.5d
60N + 33 K_2O	1.1ab	0.6c	0.7ab
25 P_2O_5 + 16.5 K_2O	1.1ab	0.6c	0.7ab
25 P_2O_5 + 33 K_2O	1.0b	0.6c	0.5d
50 P_2O_5 + 16.5 K_2O	1.1ab	0.6c	0.7ab
50 P_2O_5 + 33 K_2O	1.1ab	0.5d	0.5d
30N + 25 P_2O_5 + 16.5 K_2O	1.1ab	0.7b	0.5d
30N + 25 P_2O_5 + 33 K_2O	1.1ab	0.6c	0.7ab
30N + 50 P_2O_5 + 16.5 K_2O	1.1ab	0.4e	0.5d
30N + 50 P_2O_5 + 33 K_2O	1.0b	0.5d	0.5d
60N + 25 P_2O_5 + 16.5 K_2O	1.0b	0.6c	0.5d
60N + 25 P_2O_5 + 33 K_2O	1.1ab	0.8a	0.7ab
60N + 50 P_2O_5 + 16.5 K_2O	1.1ab	0.6c	0.7ab
60N + 50 P_2O_5 + 33 K_2O	1.2a	0.8a	0.7ab

Means with the same letter are not significantly different at 5% probability (DMRT)

Table 4. Effect of fertilizer types on phosphorus, potassium and calcium contents of tomato in 2013 cropping season

Fertilizer types (Kg ha^{-1})	P	K	Ca
→	mg/100 g	←	
0	4.8h	4.7ef	2.8e
30 N	5.7f	4.2gh	1.9h
60 N	6.5cd	5.4c	2.5f
25 P_2O_5	4.5i	3.8i	2.9de
50 P_2O_5	5.4g	4.1h	1.7i
16.5 K_2O	6.6cd	5.7b	2.4fg
33 K_2O	5.4g	4.3g	3.5b
30N + 25 P_2O_5	6.7c	4.7ef	2.9de
30N + 50 P_2O_5	7.8a	5.4c	3.8a
30N + 16.5 K_2O	6.1e	4.3gh	2.8e
30N + 33 K_2O	5.7f	4.2gh	1.9h
60N + 25 P_2O_5	6.5cd	5.4c	2.5f
60N + 50 P_2O_5	4.6hi	4.2gh	2.3g
60N + 16.5 K_2O	6.1e	4.6f	1.9h
60N + 33 K_2O	7.1b	5.2d	2.0h
25 P_2O_5 + 16.5 K_2O	5.7f	4.8e	3.5b
25 P_2O_5 + 33 K_2O	6.5cd	5.1d	2.8e
50 P_2O_5 + 16.5 K_2O	7.1b	5.8ab	3.3c
50 P_2O_5 + 33 K_2O	4.5i	4.3g	2.5f
30N + 25 P_2O_5 + 16.5 K_2O	4.6hi	4.2gh	2.3g
30N + 25 P_2O_5 + 33 K_2O	5.7f	4.8e	3.5b
30N + 50 P_2O_5 + 16.5 K_2O	6.7cd	4.2gh	1.9h
30N + 50 P_2O_5 + 33 K_2O	6.1e	4.8e	1.9h
60N + 25 P_2O_5 + 16.5 K_2O	6.5cd	5.1d	2.8e
60N + 25 P_2O_5 + 33 K_2O	6.5cd	5.4c	2.5f
60N + 50 P_2O_5 + 16.5 K_2O	7.1b	5.2d	2.0h
60N + 50 P_2O_5 + 33 K_2O	5.9f	6.0a	3.0d

Means with the same letter are not significantly different at 5% probability (DMRT)

The number of fruits increased as the fertilizer rates increased and declined thereafter. The number of fruits increased from the plants treated with 60 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} + 33 kg K_2O ha^{-1} (36.4) which was significantly higher than that of 30 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} (30.2) and this was not higher than that of 33 kg K_2O ha^{-1} (29.4), 60 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} + 16.5 kg K_2O ha^{-1} (28.5) and 50 kg P_2O_5 ha^{-1} + 16.5 kg K_2O ha^{-1} (28.3). The tomato grown with soil amended of 60 kg N ha^{-1}, 60 kg N ha^{-1} + 25 kg P_2O_5 ha^{-1}, 60 kg N ha^{-1} + 25 kg P_2O_5 ha^{-1} + 33 kg K_2O ha^{-1} (27.3), 16.5 kg K_2O ha^{-1} (27.0) and 30 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} + 33 kg K_2O ha^{-1} (26.0) were not significantly different from each other while the least mean value (19.5) was received from un-fertilized plot.

Table 5. Effect of fertilizer types on lycopene, magnesium and vitamin C contents of tomato in 2013 cropping season

Fertilizer types (Kg ha^{-1})	Lycopene	Mg	Vit. C
→	mg/100 g	←	
0	2.7c	1.4d	28.2cde
30 N	2.2h	1.9c	27.0ef
60 N	3.0a	1.9c	29.2cd
25 P_2O_5	2.4f	1.2d	29.7bc
50 P_2O_5	2.3g	1.3d	27.8de
16.5 K_2O	2.5e	1.9c	28.8cd
33 K_2O	2.5e	1.9c	31.8a
30N + 25 P_2O_5	2.0j	1.3d	26.2f
30N + 50 P_2O_5	3.0a	1.8c	26.0f
30N + 16.5 K_2O	2.8c	1.7c	28.9cde
30N + 33 K_2O	2.2h	1.9c	27.0ef
60N + 25 P_2O_5	3.0a	1.9c	29.2cd
60N + 50 P_2O_5	2.2h	1.4d	28.7cd
60N + 16.5 K_2O	2.6d	1.4d	28.5cde
60N + 33 K_2O	3.0a	1.9c	29.7bc
25 P_2O_5 + 16.5 K_2O	2.9b	2.2a	28.3cde
25 P_2O_5 + 33 K_2O	1.9k	1.4d	27.0ef
50 P_2O_5 + 16.5 K_2O	2.1i	2.2a	28.2cde
50 P_2O_5 + 33 K_2O	2.7c	1.7c	28.3cde
30N + 25 P_2O_5 + 16.5 K_2O	2.2h	1.4d	26.0f
30N + 25 P_2O_5 + 33 K_2O	2.9b	2.2a	28.3cde
30N + 50 P_2O_5 + 16.5 K_2O	2.5d	1.9c	27.0ef
30N + 50 P_2O_5 + 33 K_2O	2.6d	1.4d	28.5cde
60N + 25 P_2O_5 + 16.5 K_2O	1.9k	1.4d	27.0ef
60N + 25 P_2O_5 + 33 K_2O	3.0a	1.9c	29.2cd
60N + 50 P_2O_5 + 16.5 K_2O	3.0a	1.8c	29.7bc
60N + 50 P_2O_5 + 33 K_2O	3.0a	2.0bc	31.0ab

Means with the same letter are not significantly different at 5% probability (DMRT)

Total fruit yield

The fertilizer application rates was found to significantly ($P \leq 0.05$) influence total fruit yield of tomato with the highest yield (27.81 t ha^{-1}) obtained from the plants treated with 60 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} + 33 kg K_2O ha^{-1} (Table 2). The yield obtained was significantly higher than the yields received from all other treatments. More so, the plots treated with 60 kg N ha^{-1} + 25 kg P_2O_5 ha^{-1} + 16.5 kg K_2O ha^{-1}which had the ranged mean values of 12.07 t ha^{-1} to 13.48 t ha^{-1} were not significantly different from each other. But were significantly different from the plants treated with 30 kg N ha^{-1} (11.24 t ha^{-1}) and 60 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} (11.53 t ha^{-1}) while the least mean value (9.96 t ha^{-1}) was received from un-fertilized plants.

Crude protein, Carotene and Iron contents

The fertilizer application had significant ($P \leq 0.05$) influence on the fruit nutritional qualities of tomato plants (Table 3). The protein content was significantly increased by fertilizer application rates with the highest mean value of 1.2 mg/100 g observed from the plants treated with 60 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} + 33 kg K_2O ha^{-1}. The treatments which had the mean values of 1.1 mg/100 g were significantly higher than the treatments with the mean values of 1.0 mg/100 g. The fruit carotene content was significantly ($P \leq 0.05$) influenced by fertilizer application. The highest mean values of 0.8 mg/100 g were obtained from the plants treated with 60 kg N ha^{-1}, 60 kg N ha^{-1} + 16.5 kg K_2O ha^{-1}, 60 kg N ha^{-1} + 25 kg P_2O_5 ha^{-1} + 33 kg K_2O ha and 60 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} + 33 kg K_2O ha^{-1} which were significantly better than the ranged values obtained from other treatments (0.4 mg/100 g to 0.6 mg/100 g). The iron content of tomato fruit was significantly ($P \leq 0.05$) influenced by various fertilizer application rates. The highest mean value of 0.8 mg/100 g was obtained from the plants fertilized with 16.5 kg K_2O ha^{-1} which was significantly higher than the treatments with the mean values of 0.7 mg/100 g. The treatments with the mean values of 0.6 mg/100 g was significantly higher than the treatments which gave the mean values of 0.5 mg/100 g while the least mean value of 0.4 mg/100 g was obtained from 50 kg P_2O_5 ha^{-1}. The potassium content of tomato fruit was significantly (P≤0.05) influenced by various fertilizer application rates. The highest mean value of 6.0 mg/100 g was received from the plant treated with 60 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} + 33 kg K_2O ha^{-1}. This was followed with the mean value of 5.7 mg/100 g obtained from 33 kg K_2O ha^{-1} and the least mean value of 3.8 mg/100 g was received from the plants fertilized with 50 kg P_2O_5 ha^{-1}.

Phosphorus, Potassium and Calcium contents

The phosphorus content of tomato fruit was significantly (P≤0.05) increased by fertilizer application rates (Table 4). Phosphorus content increased as the fertilizer rates increased and declined thereafter. The highest mean value of 7.8 mg/100 g was obtained from the plants treated with 30 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} which was significantly higher than the mean values of 7.1 mg/100 g received from the plants fertilized with 60 kg N ha^{-1} + 33 kg K_2O ha^{-1}, 50 kg P_2O_5 ha^{-1} + 16.5 kg K_2O ha^{-1} and 60 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} + 16.5 kg K_2O ha^{-1}. The plants treated with 30 kg N ha^{-1} + 25 kg P_2O_5 ha^{-1} (6.7 mg/100 g) significantly produced better phosphorus content than that of 60 kg N ha^{-1}, 60 kg N ha^{-1} + 25 kg P_2O_5 ha^{-1}, 25 kg P_2O_5 ha^{-1} + 33 kg K_2O ha^{-1}, 60 kg N ha^{-1} + 25 kg P_2O_5 ha^{-1} + 16.5 kg K_2O ha^{-1} and 60 kg N ha^{-1} + 25 kg P_2O_5 ha^{-1} + 33 kg K_2O ha^{-1} (6.5 mg/100 g) and the least mean value of 4.6 mg/100 g was obtained from 25 kg P_2O_5 ha^{-1} and 50 kg P_2O_5 ha^{-1} + 33 kg K_2O ha^{-1}. The potassium content of tomato fruit was significantly (P≤0.05) influenced by fertilizer application rates. Potassium content increased as the fertilizer rates increased and declined thereafter. The highest mean value (6.0 mg/100 g) was obtained from the plants treated with 60 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} + 33 kg K_2O ha^{-1} which was followed by the plants fertilized with 50 kg P_2O_5 ha^{-1} + 16.5 kg K_2O ha^{-1} (5.5 mg/100 g). But the value obtained from this treatment was not significantly higher than the plants applied with 16.5 kg K_2O ha^{-1} (5.7 mg/100 g). The plants treated with 60 kg N ha^{-1}, 30 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1}, 60 kg N ha^{-1} + 25 kg P_2O_5 ha^{-1} and 60 kg N ha^{-1} + 25 kg P_2O_5 ha^{-1} + 33 kg K_2O ha^{-1} (5.4 mg/100 g) were significantly higher than the plants fertilized with 60 kg N ha^{-1} + 33 kg K_2O ha^{-1} and 60 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} + 16.5 kg K_2O ha^{-1} (5.2 mg/100 g). While the least mean value (3.8 mg/100 g) was obtained from the plants fertilized with 25 kg P_2O_5 ha^{-1}. The calcium content of tomato fruit was significantly (P≤0.05) increased by various fertilizer application rates (Table 4). Calcium content increased as the fertilizer rate increased and declined thereafter. The highest mean value of 3.8 mg/100 g obtained from 30 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} was significantly higher than the values of 3.5 mg/100 g obtained from the plants treated with 33 kg K_2O ha^{-1}, 25 kg P_2O_5 ha^{-1} + 16.5 kg K_2O ha^{-1} and 30 kg N ha^{-1} + 25 kg P_2O_5 ha^{-1} + 33 kg K_2O ha^{-1}. The plants treated with 50 kg P_2O_5 ha^{-1} + 16.5 kg K_2O ha^{-1} (3.3 mg/100 g) was significantly higher than the plots fertilized with 60 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} + 33 kg K_2O ha^{-1} (3.0 mg/100 g) which was also significantly higher than the treatments that gave the mean values of 2.8 mg/100 g. This was significantly higher than the treatments with the mean values of 2.0 mg/100 g and 2.5 mg/100 g while the least mean value of 1.7 mg/100 g was obtained from the plants fertilized with 50 kg P_2O_5 ha^{-1}.

Lycopene, Magnesium and Vitamin C contents

Fertilizer application rates had significant (P≤0.05) influence on lycopene content of tomato fruits (Table 5). The highest mean values of 3.0 mg/100 g were received from the plants treated with 60 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} + 33 kg K_2O ha^{-1}, 60 kg N ha^{-1}, 30 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1}, 60 kg N ha^{-1} + 25 kg P_2O_5 ha^{-1}, 60 kg N ha^{-1} + 33 kg K_2O ha^{-1}, 60 kg N ha^{-1} + 25 kg P_2O_5 ha^{-1} + 33 kg K_2O ha^{-1} and 60 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} + 16.5 kg K_2O ha^{-1}. This was followed with the mean value of 2.9 mg/100 g obtained from 25 kg P_2O_5 ha + 16.5 kg K_2O ha^{-1} and 30 kg N ha^{-1} + 25 kg P_2O_5 ha^{-1} + 33 kg K_2O ha^{-1} and the least mean value of 1.9 mg/100 g was observed from 25 kg P_2O_5 ha^{-1} + 33 kg K_2O ha^{-1} and 60 kg N ha^{-1} + 25 kg P_2O_5 ha^{-1} + 16.5 kg K_2O ha^{-1}. More so, fertilizer application rates had significant effect on magnesium content with the optimum values (2.0 mg/100 g) obtained from 60 kg N ha^{-1}, 60 kg N ha^{-1} + 25 kg P_2O_5 ha^{-1}, 25 kg P_2O_5 ha^{-1} + 16.5 kg K_2O ha^{-1}, 30 kg N ha^{-1} + 25 kg P_2O_5 ha^{-1} + 16.5 kg K_2O ha-1. The values obtained from these treatments were significantly higher than the plants fertilized with 30 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} and 50 kg P_2O_5 ha^{-1} + 16.5 kg K_2O ha^{-1} (1.8 mg/100 g). Also, magnesium content obtained from the tomato grown on soil amended with 30 kg N ha^{-1} + 25 kg P_2O_5 ha^{-1}, 60 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} and 30 kg N ha^{-1} + 25 kg P_2O_5 ha^{-1} + 16.5 kg K_2O ha^{-1} (1.6 mg/100 g) were not significantly different from the mean value of 1.5 mg/100 g obtained from 50 kg P_2O_5 ha^{-1}, 16.5 kg K_2O ha^{-1} and 33 kg K_2O ha^{-1} while the least mean value of 1.2 mg/100 g were received from 30 kg N ha^{-1}, 50 kg P_2O_5 ha^{-1}, 33 kg K_2O ha^{-1} and 30 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} + 16.5 kg K_2O ha^{-1}. The vitamin C content of tomato fruit was significantly (P≤0.05) increased by fertilizer application rates. The vitamin C content increased as the fertilizer rates increased and declined thereafter. The highest mean value of 31.8 mg/100 g was received from 33 kg K_2O ha^{-1} closely followed with the mean value of 31.0 mg/100 g obtained from 60 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} + 33 kg K_2O ha^{-1}. Other treatments which gave the ranged mean values between 28.2 mg/100 g and 29.7 mg/100 g were not significantly different from each other while the least mean value of 26.0 mg/100 g was obtained from 30 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1}.

DISCUSSION

The significant response of growth parameters, yield and yield component to increase N rates in this study demonstrated the high demand of tomato for this element. This result agrees with the findings of Upendra *et al*. (2003); Elizabeth and John (2003); Oyinlola and Jinadu (2012) who observed that tomato responded significantly to applied N rates. The increase in the parameter measured; plant height as the N rates increased confirmed the importance and contribution of N to the growth of the vegetative crop plants. Maximum growth parameter was obtained at the highest rate of 60 kg N ha^{-1}. This might be due largely to the low level of mineralizable N of the native soils as a result of the low organic matter content. Therefore, it is imperative that nitrogen be adequately supplied to promote both vegetative and productive growth and impacts the characteristic deep green colour of leaves as also observed by Tisdale *et al*. (2003). The measured parameters of yield components responded significantly to N rates and a rate of 60 kg N ha^{-1} appeared optimum for tomato crop. Yield components and fruit yield at 30 kg N ha^{-1} was not significantly higher than the rate of 60 kg N ha^{-1} appeared optimum but with yield rate still significantly greater than what was obtained from the control plot. Therefore, tomato fruit yield responded to increasing N fertilizers until a peak (60 kg N ha^{-1}) was achieved. The result obtained from this current study was at a lower range obtained by Oyinlola and Jinadu

(2012). Samaila *et al*. (2011) reported that the highest mean fruit weight, fruit yield and dry matter yield were obtained at 90 kg N ha^{-1}. From this result, the optimum N rate for better yield performance of tomato is 60 kg N ha^{-1}. This means that, the increase in growth parameter at 60 kg N ha^{-1} led to increase in total fruit yield. This result is in conformity with those obtained by Olaoye *et al*. (2007) who reported that Roma variety recorded a relatively better fruit yield under nitrogen treatment and different growing seasons under moisture regimes.

The significant response of growth parameter, yield and yield components to increase P rates in this study demonstrated the need of tomato for this element which is in accordance with the findings of Tiequan *et al*. (2005) who reported that tomato significantly responded to the applied P rates. The increase in the growth parameters measured, plant height increased as the P rate increased. Although, significantly the contributions of P to variation were minor compared to N effects. Despite this, phosphorus accounted for only a small percentage of total increase growth rates of tomato as reported by Regina and Robert (1991). Findings from this study indicated that maximum growth parameter was obtained at the highest rate of 50 kg P_2O_5 ha^{-1}. Findings from the present study showed that P increased yield by increasing the number of flowers per pant, number of fruits per plant and total fruit yield. The positive contribution of yield components to the fruit yield may be attributed to the improved growth parameter caused by the increased plant height could have increased the number of flowers in applied plots. Results from this study indicated that yield components responded significantly to P rates and a rate of 50 kg P_2O_5 ha^{-1} appeared optimum for tomato plant. Yield components and fruit yield at 25 kg P_2O_5 ha^{-1} was not significantly higher than the rate of 50 kg P_2O_5 ha^{-1} which appeared optimum but was significantly higher than that obtained from non-applied plot. Therefore, tomato fruit yield responded to increasing P fertilizers until a peak of 50 kg P_2O_5 ha^{-1} was reached. This is line with the findings of Tiequan *et al*. (2005) who reported that optimum yields and quality of pepper and tomato depend on adequate N and P nutrition. From this result, the optimum P rate for better yield performance of tomato is 50 kg P_2O_5 ha^{-1}. This proved that, the increase in growth parameter at 50 kg P_2O_5 ha^{-1} led to increase in total fruit yield recorded from this study. This result is in agreement with the findings of de Groot *et al*. (2002) who stated that, modern tomato cultivars and hybrids exhibit relative growth rates and thereby rely on adequate supply of phosphorus for optimal development and high yields.

The significant response of growth parameter, yield and yield components to increase K rates in this study demonstrated the high demand of tomato for this element required. This result is in agreement with the findings of Chapagain and Wiesman (2004) who reported that the K requirements of tomato are extraordinarily high due to the rapid growth of the plant in combination with the heavy fruit load. The increase in the parameter measured; plant height increased as the K rate increased confirmed the need of K to several plant processes. From the result of this study, maximum growth parameter was obtained at the highest rate of 33 kg K_2O ha^{-1}. It is therefore, imperical that potassium be adequately supplied for enzymes activation, photosynthesis, osmoregulation and phloem transport as also observed by Chen and Gabelman (2000). The influence of K on tomato variety proved that K increased yield by increasing the number of flowers per plant, number of fruits and total fruit yield. The positive contribution of yield components to the fruit yield might be due to the improved growth parameter caused by the increased plant height would have amount to increased number of flowers in fertilized plots. Findings from the current study showed that yield component parameters significantly responded to K rates and a rate of 33 kg K_2O ha^{-1} appeared optimum for the tomato plants. Yield components and fruit yield at 16.5 kg K_2O ha^{-1} was not significantly higher than the rate of 33 kg K_2O ha^{-1} appeared optimum but was significantly greater than that obtained from the control plot. Therefore, tomato fruit yield responded to increasing K fertilizer until it reaches a peak of 33 kg K_2O ha^{-1}. The result obtained from this present study is in conformity with Martin and Liebhardt (1994) who reported that total tomato yield increased up to 112 kg ha^{-1} in soil high in plant available K. From this study, the optimum K rate for better yield performance of tomato is 33 kg K_2O ha^{-1}.

The significant response in the growth and yield parameters of tomato combined with the application of N, P and K rates showed the high need of tomato for these elements. The result of this current study is in agreement with the findings of Balemi (2008) who reported that there was significant main effect on applied N, P and K fertilizer rates. The increase in all the parameters due to combined N, P and K application confirmed the valuable contribution of these fertilizers on the vegetative growth of the crop plants. The maximum growth parameter was obtained at the highest rates of 60 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} + 33 kg K_2O ha^{-1}. The result obtained in this study is not surprising; this might be attributed to decreased nutrient use efficiency, following the exclusion of the NPK fertilizer rates. Therefore, there is need for nitrogen, phosphorus, and potassium to be adequately supplied to promote both the vegetative and productive growth of tomato plants as also revealed by Akanni (2005). The influence of N, P and K on tomato cultivar indicated that these fertilizers increased yield by increasing the number of flowers per plant, number of fruits per plant and total fruit yield. The positive contribution of yield components on the total fruit yield might be attributed to the improved growth parameter caused by plant height which amount to increased number of flowers in fertilized plots that led to fruit yield. The measured parameters of yield components in this present study responded significantly to combined N, P and K rates, with the highest yield of 27.81 t ha^{-1} obtained at 60 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} + 33 kg K_2O ha^{-1} supported the report of Qian and Schoenau (2002), and Okwugwu and Alleh (2003) who reported that high and sustained crop yield of tomato could be achieved with a judicious and balanced NPK fertilizer treatment combined with organic matter amendments. Therefore, tomato total fruit yield response was highest at 60 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} + 33 kg K_2O ha^{-1}. From this result, the optimum N, P and K fertilizer for better yield performance of tomato is at 60 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} + 33 kg K_2O ha^{-1}. The significant increase in the fruit nutritional qualities parameters which fertilizer treatment was imposed showed the potentials involved in tomato variety. The nutritional composition increased as the fertilizer application rates increased. The result obtained from this present study is in agreement with the findings of Olaniyi *et al*. (2010) which stated that there was inconsistence in the nutritional qualities obtained in their study for the tomato varieties used. The plants fertilized with 60 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} + 33 kg K_2O ha^{-1} significantly recorded higher nutritional qualities than the other fertilizer application rates. Ara *et al*. (2007) supported the result obtained in this study that tomato is a dependable source of Vitamin A, B, C and D, minerals, Ca, P and Fe. Result of the nutritional qualities revealed that tomato fruits are rich in phosphorus, potassium, calcium and vitamin C. This might be the reason of their intensive use for stew in meals.

Conclusion: Based on the research findings, it could be concluded that external input of mineral fertilizer is necessary to improve tomato yield and nutritional quality. Plants fertilized with 60 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} + 33 kg K_2O ha^{-1} responded better than other rates. Therefore, farmers should be encouraged to apply the fertilizer on their crops in order to boost food production.

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