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Growth and Yield Response of Tomato to the Application of Fertilizer and Some other Cultural Practices

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Abstract
Investigations were carried out at the Research Farm of the Oyo State College of Agriculture, Igboora to determine the effects of fertilizer application and some cultural practices on the growth and yield of tomato (Solanum lycopersicon L.). Tomato plots were subjected to two levels of NPK (15-15-15) fertilizer at 0 and 250 kg/ha and four cultural practices of Staking, No Staking, Pruning, and No Pruning to give eight treatment combinations. Growth parameters (plant height, girth and total leaf area/plant) of tomato were periodically measured to evaluate its growth performance while its fruit yield was obtained by harvesting the fruits at maturity when the fruits were moderately ripened. Data were subjected to analysis of variance (ANOVA) and means compared using Least Significant Difference (LSD) at probability level of 5%. Results showed that treatments had significant effects on the growth and yield of tomato throughout the periods of experiment. Plant height, girth and total leaf area per plant of tomato were highest in plots Staked/Pruned followed by Staked/Not Pruned and Not Staked/Pruned tomato in that order while the variables/attributes were the least in Not Staked/Not Pruned plots. Growth parameters were also significantly increased with fertilizer application. Fruit yield of tomato similarly followed the same trend of growth parameters with yield occurring in the order of Staked/Pruned> Staked/Not Pruned>Not Staked/Pruned>Not Staked/Not Pruned tomato.

Keywords: *Tomato, growth and yield, staking, pruning, fertilizer.*

Introduction

Tomato (*Solanum lycopersicon* L.) is one of the most important and widely distributed vegetable crops in the world. Tomato is a major contributor of carotenoids (especially lycopene), phenolics and vitamin C in daily diets (Causse *et al.*, 2003). Results from epidemiological studies have shown that tomato and its products may have a positive effect against various forms of cancer, especially prostate cancer and cardiovascular diseases (Ellinger *et al.*, 2006). According to FAO (2013), Nigeria produces 1,233,399 tonnes of tomato per annum. Tomato is usually produced during the dry season period under irrigation and provides employment to a large number of Nigerians.

Growth and yield (in terms of fruit size, quality and weight) of tomatoes are influenced by many factors, including staking and pruning of plant, inorganic and/or organic fertilizer applications among other factors. Pruning refers to selective removal of side shoots to limit excessive plant growth. It has a number of advantages including causing fruit to

mature earlier and grow to greater size and uniformity; improving air circulation within the canopy, which reduces foliar diseases, and facilitates spraying and harvesting (Hanson *et al.*, 2000).

There are conflicting reports on the effects of pruning on tomato yields. Mabako and Du ploy (2009) reported that plants pruned to two stems resulted in a significant increase in total and marketable yield, and concluded that yield and fruit size can be effectively manipulated by stem pruning, while fruit pruning has only a limited effect. However, Kanyomeka and Shivute (2005) reported that pruning does not increase tomato yield, and that the only benefits obtained from tomato pruning were increased quality and plant health, as pruned tomatoes were less prone to pest attack than those which were not pruned. Similarly, Olson (1989) reported that heavy pruning reduced yield over no pruning or light pruning. Further studies showed that fruit size increased as degree of pruning increased; while total yield were reduced by heavy pruning but larger fruit size occurred with heavy pruning and heavy pruning produced the lowest percentage of marketable yield.

Staking tomato plants with bamboo poles, wood stakes, or other staking materials provides support and keeps the fruit and foliage off the ground. Staking can increase fruit yield and size, reduce fruit rot, and make spraying and harvesting easier. Staked plant usually produced higher yields and better fruit quality than unstaked plants (Hanson *et al*., 2000). Saunyama and Knapp (2003) also reported that staked plant usually produced higher yields and better fruit quality than unstaked plants. Similarly, in Zimbabwe, Saunyama and Knapp (2003) also reported that production trends among small holder farmers growing determinate variety indicate distinctness in yield between trellised and untrellised crops.

In Brazil, pruning and staking, as well as staking without pruning resulted in significantly higher yields than unprunned and pruned control. Differences between staked and pruned, and staked and unpruned were not significant (Ledo *et al*., 1998; Saunyama and Knapp, 2003). Davis and Etes (1993) reported that staked but unpruned plant produced lower yield of large fruits, though total yields was greater for staked and pruned plants (Saunyama and Knapp, 2003).

In studies involving the effects of staking and pruning on yield of tomato Mangal *et al*. (1981) reported higher marketable and total yields, respectively, when plants were staked and pruned, rather than left lying on the ground. In contrast, Voinea and Bunescu (1957) reported lower total yields in staked and pruned plants. (Ozminkowski *et al.*, 1990). This suggests that for different varieties, their growth pattern among other factor determine the effects of staking and pruning on growth and yield of tomatoes.

Bryan and Dalton (1974) reported that incorporating the fertilizer in the bed under mulch in commercial fields resulted in higher yields of large, US No. 1 and marketable tomatoes, in the sandy loam and sand phases of Rockdale soil but not in the marl phase. Geraldson (1963) suggested that most growers apply fertilizer in bands on top of flat beds before mulch application. It has been shown that fertilizer applied in bands gives a better yield response when bands are located below the soil surface.

Realising the importance of N, P and K nutrient elements in the promotion of high yield of tomato, Hanson *et al.* (2000) established a fertilizer model to provide these elements in adequate supply for the uptake of tomato. They calculated the amount of nutrient elements for application to tomato by multiplying the targeted yield of tomato by some yield factors which were 2.4 for N, 0.35 for P_2O_5 and 1.45 for K_2O. For a targeted yield of 20 t/ha of tomato, the amount of N to be applied would be 48 kg N/ha, P_2O_5 16.8 Kg P/ha and K_2O would be 69.6 Kg/ha.

There are still conflicting reports on the effects of the cultural practices on growth and yield of tomato (Mabako and Du ploy, 2009). Again, most of the previous studies on the use of cultural practices have been on one practice at a time rather than two or more practices combined. The objective of the study was to evaluate the effect of a combination of these cultural practices on the growth and yield of tomato under fertilizer application.

Materials and Methods

Tomato seeds (var. Roma Extra) obtained from the Institute of Agricultural Research and Training (I.A.R & T), Moore Plantation, Ibadan were raised in the nursery under shade for a period of four weeks before transplanting to the field in the two years of experimentation. The seedlings were raised in seed trays filled with top soil and were maintained by regular watering and removal of weed seeds and weeds from the trays.

The main field was prepared by removing the weeds through hoeing after which the soil samples were taken from soil dept of 0- 15 cm to determine the nutrient status of the site. Planting beds of dimensions 2.4 × 18.4 m and of 15 cm thickness were made on the main field. An avenue or in-between space was created between the beds to allow for operational movements. Each bed was divided into plot size of 1.80 × 2.40 m with 0.5 m space in-between plots. The experimental design used was Randomized Complete Block Design (RCBD) and the treatments consisted of four cultural practices of Staked/Pruned, Staked/Not Pruned, Not Staked/Pruned, and Not Staked/Not Pruned tomato combined with two NPK (15-15-15) fertilizer levels of 0, and 250 kg/ha to give eight treatment combinations and which were replicated four times. The treatment combinations include Staked/Pruned/Unfertilized, Staked/Pruned/Fertilized, Staked/Not Pruned/Not Fertilized, Staked/Not Pruned/Fertilized, Not Staked/Pruned/Not Fertilized, Not Staked/Not Pruned, Fertilized, and Not Staked/ Not Pruned/Not Fertilized.

The seedlings were transplanted from the nursery at the age of four weeks after sowing (WAS) on September 28, 2009 and October 6, 2010. Staking and fertilizer application were carried out immediately after transplanting. Fertilizer application was carried out by spot application at the rate of 9 grams per stand of tomato while at a spacing of 60 × 60 cm to give 12 plants per plot and 27,777 plants per hectare. Staking was done by implanting hard wood sticks of 1.2 m height into the soil close to each tomato plant. The stakes were sharpened at the lower end to allow easy penetration of pegs into the soil. The tomato plants were each tied to the stakes with strong short twines to form a noose. Pruning was carried out in pruning plots with sharp knives or scissors by removing the excessive branches/leaves from tomato particularly the lower ones that touched the ground. Watering was occasionally carried out through the use of Jerry cans in latter November/December of each year of experimentation.

Growth parameters (height, girth and leaf area) of tomato were measured periodically at 2 weeks intervals. Plant height of tomato was measured with the metre rule while the girth was taken through the use of linen tape rule and leaf area was measured through the use of leaf area meter (LICOR 300) model to measure three leaves that were taken as sample. This was multiplied with the number of leaves per plant.

Harvesting commenced 8 weeks after transplanting (WATP) and continued until 12 WATP when all fruits had completely ripened. Harvesting was done at weekly intervals. Harvested tomatoes were weighed per plot or per treatment. Total weights of tomatoes per plot were converted to weights per hectare.

Data collected were subjected to analysis of variance (ANOVA) and means separated using Least Significant Difference (LSD) at 5% level of probability.

Results

The result of precropping soil physico-chemical properties is shown in Table 1.

Table 1: Physico-chemical properties of soil in which tomato plants were grown

Properties	Values
pH (1:2 soil/$CaCl_2$ solution)	6.85
Organic Carbon %	28.80
Available P (Bray 1)	19.00
Sand (%)	73.5
Silt (%)	14.00
Clay (%)	12.50
K^+ (cmol/kg)	0.51
Ca^+ (cmol/kg)	0.46
Mg^+ (cmol/kg)	6.50

Plant height was highest in Staked /Pruned tomatoes followed by Staked/Not Pruned, Not Staked/Pruned in that order, and least in Not Staked/Not Pruned plots in all the growth stages and two years of experimentation. The tomato plants in fertilized soil were significantly taller than those grown in plots fertilizer was not applied. Girth and total leaf area per plant of tomato (Tables 2 and 3) followed the same trend with height of tomato in response to both cultural practices and fertilizer application.

Table 2: Height (cm) of tomato subjected to fertilizer application and other cultural practices in 2009 and 2010

Plant Stage	Cultural Practice	NPK Fertilizer Level (Kg/ha)					
		2009			2010		
		0	250	Mean	0	250	Mean
2 WATP	Staked/Pruned	38.00	54.00	46.00	42.00	57.00	49.50
	Staked/Not Pruned	34.00	50.00	42.00	37.00	53.00	45.00
	Not Staked/Pruned	29.00	46.00	37.50	32.00	49.00	40.50
	Not Staked/Not Pruned	25.00	43.00	34.00	28.00	44.00	36.00
	Mean	31.50	48.25		34.75	50.75	
	CV%			6.93			7.27
	LSD			2.42			2.75
4 WATP	Staked/Pruned	64.00	91.00	77.50	67.00	94.00	80.50
	Staked/Not Pruned	59.00	80.00	69.50	61.00	82.00	71.50
	Not Staked/Pruned	55.00	72.00	63.50	55.00	72.00	63.50
	Not Staked/Not Pruned	34.00	67.00	50.50	34.00	67.00	50.50
	Mean	53.00	77.50		54.25	78.75	
	CV%			4.48			4.35
	LSD			2.56			2.53
6 WATP	Staked/Pruned	72.00	125.00	98.50	75.00	150.00	112.50
	Staked/Not Pruned	67.00	95.00	81.00	71.00	100.00	85.50
	Not Staked/Pruned	60.00	87.00	73.50	63.00	93.00	78.00
	Not Staked/Not Pruned	44.00	86.00	65.00	49.00	80.00	64.50
	Mean	60.75	98.25		64.50	105.75	
	CV%			4.51			4.20
	LSD			3.19			3.04

Table 3: Plant girth (cm) of tomato subjected to fertilizer application and other practices in 2009 and 2010

Plant Stage	Cultural Practice	NPK Fertilizer Level (Kg/ha)					
		2009			2010		
		0	250	Mean	0	250	Mean
2 WATP	Staked/Pruned	0.39	0.53	0.46	0.43	0.56	0.50
	Staked/Not Pruned	0.37	0.46	0.42	0.41	0.53	0.47
	Not Staked/Pruned	0.34	0.43	0.39	0.38	0.51	0.45
	Not Staked/Not Pruned	0.29	0.41	0.35	0.33	0.48	0.41
	Mean	0.35	0.46		0.39	0.52	
	CV%			8.51			8.14
	LSD			0.03			0.03
4 WATP	Staked/Pruned	0.55	1.43	0.99	0.61	1.59	1.10
	Staked/Not Pruned	0.56	1.04	0.80	0.57	1.11	0.84
	Not Staked/Pruned	0.47	0.80	0.64	0.54	0.88	0.71
	Not Staked/Not Pruned	0.34	0.65	0.50	0.41	0.72	0.56
	Mean	0.48	0.98		0.53	1.08	
	CV%			12.19			9.87
	LSD			0.08			0.07
6 WATP	Staked/Pruned	0.60	1.76	1.18	0.84	2.07	1.35
	Staked/Not Pruned	0.57	1.18	0.88	0.64	1.35	0.98
	Not Staked/Pruned	0.57	0.96	0.77	0.61	1.04	0.83
	Not Staked/Not Pruned	0.40	0.81	0.61	0.45	0.84	0.63
	Mean	0.54	1.81		0.63	1.33	
	CV%			11.81			13.72
	LSD			0.09			0.11

Consequently, girth and leaf area of tomato were highest in plots Staked/ Pruned followed by tomato plants Staked/Not pruned, Not Staked/Pruned, and Not Staked/ Not Pruned in that decreasing order. All variables under investigation increased with fertilizer application. Yield of tomatoes (Table 4) similarly took the order of Staked/Pruned> Staked/Not Pruned> Not Staked Pruned>Not Staked Not Pruned. Fruit yield of tomato was higher in fertilizer applied plot than where fertilizer was not applied.

Table 4: Total leaf Area (cm^2/plant) of tomato subjected to fertilizer application and other cultural practices in 2009 and 2010

Plant Stage	Cultural Practice	NPK Fertilizer Level (Kg/ha)					
		2009			2010		
		0	250	Mean	0	250	Mean
	Staked/Pruned	290.00	730.00	510.00	294.33	735.33	514.83
	Staked/Not Pruned	305.00	355.33	330.00	314.67	364.33	339.50
2 WATP	Not Staked/Pruned	250.76	470.67	360.67	314.67	364.33	339.50
	Not Staked/Not Pruned	167.33	430.00	298.67	256.00	475.67	365.84
	Mean	253.25	496.50		179.00	503.25	308.34
	CV%			3.79	261.00		2.42
	LSD			12.44			8.10
	Staked/Pruned	775.50	2089.00	1432.25	784.00	2096.33	1441.17
	Staked/Not Pruned	540.67	1470.00	1005.34	549.00	1476.00	1010.00
4 WATP	Not Staked/Pruned	489.33	1259.33	873.33	493.00	1267.50	880.25
	Not Staked/Not Pruned	236.67	1015.67	626.17	243.33	1021.00	632.17
	Mean	510.54	1458.50		517.33	1465.21	
	CV%			2.28			0.82
	LSD			19.62			7.14
	Staked/Pruned	1025.67	3795.00	2410.34	1135.00	3809.00	2472.00
	Staked/Not Pruned	750.00	2020.67	1385.34	776.00	776.80	776.40
	Not Staked/Pruned	610.33	1690.67	1150.50	620.00	1701.00	1160.50
6 WATP	Not Staked/Not Pruned	399.00	1359.00	879.00	421.00	1368.00	894.50
	Mean	2196.25	1966.34		738.00	1913.70	
	CV%						0.47
	LSD						6.16

Table 5: Fruit yield (t/ha) of tomato subjected to fertilizer application and other cultural practices in 2009 and 2010

Plant Stage	Cultural Practice	NPK Fertilizer Level (Kg/ha)					
		2009			2010		
		0	250	Mean	0	250	Mean
	Staked/Pruned	7.00	18.60	12.83	9.10	22.33	15.72
	Staked/Not Pruned	5.50	15.33	10.42	7.20	18.50	12.85
Harvest	Not Staked/Pruned	3.90	12.30	8.10	5.16	15.33	10.25
	Not Staked/Not Pruned	2.50	10.00	6.25	3.50	13.50	8.50
	Mean	4.73	14.06		6.24	17.42	
	CV%			10.03			10.09
	LSD			0.83			1.13

Discussion

Tomato in staked and pruned plots in this study performed best in terms of growth parameters and fruit yield because of the great support received from staking as a result of which tomato foliage and fruits were kept off the ground. By this, all sections (stem, leaves and fruits) of tomato were exposed to growth factors such as light, air and copious rain water, the effect of which must have resulted in the tallest height, largest stem girth and leaf size, and highest fruit yield. Since manufacturing and distribution of photosynthates in plants are functions of good photosynthesis exposure of leaves to sufficient sunlight (Photosynthetic Active Radiation) (Salisbury and Ross, 1978) and must have contributed immensely to the good performance of tomatoes in staked/pruned plots. Air circulation also has been found to be more improved in the canopy of tomato and thus reduce foliar diseases in the pruned tomato than the unpruned tomato (Hanson *et al.*, 2000). The improvement of the environment received in this study has made tomato in staked/pruned to have good growth and yield better than any combinations. The results support the findings of Hanson *et al.* (2000) and Saunyama and Knapp (2003) who in separate studies found that staking of tomato gave higher yield and better fruit quality than the unstaked tomato. Similarly, Mabako and Du ploy (2009) reported that fruit and yield size of tomato can be manipulated to greater advantage by stem pruning. Tomato yield was also considerably increased through staking and pruning because fruit size was increased and fruit rot drastically reduced. Thus the performance of tomato was always best when the two cultural practices were effectively carried out in the study followed by any treatment consisting of staking alone, pruning alone, in that order and finally by where no staking or no pruning was carried out, implying that staking was more potent than pruning.

Tomato growth and fruit yield were also effectively influenced by fertilizer application in this study because of the major nutrient elements including N, P, K in the soil that must have been improved through the application of NPK (15-15-15) fertilizer. Plant height, stem girth and total leaf area per plant of tomato increased with the application of fertilizer and consequently fruit yield of tomato also followed the pattern of growth parameters in response to fertilizer application because the fruit yield is a product of dry matter accumulated by the growth parameters. Adeyemi (2009) got similar results in maize

where the grain yield followed the pattern of growth parameters of maize as influenced by NPK (15-15-15). Hanson *et al.* (2000) has also emphasised the high need of NPK fertilizer application to obtain good growth performance and high fruit yield of tomato, using a fertilizer model. For better results to be obtained in the production of tomato, regardless of cultural practices growers engage in, they must endeavour to include fertilizer application at the rate not less than 250 kg/ha NPK (15-15-15).

Conclusion/Recommendation

Staking and pruning operations in tomato are good cultural practices that can enhance good growth, development and high fruit yield of the plant more than where the practices are not carried out. Addition of NPK fertilizer to the cultural practices in the production of tomato can further improve the performance of tomato in terms of good growth and high fruit yield.

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