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Correlation Analysis on Growth and Yield Parameters of Tomato Varieties as Influenced by Pinching, Mineral Fertilizers and Mulching in Three Seasons

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Abstract
Tomato, a vegetable crop of immense importance in the diet and economy of Nigeria requires better agronomic practices for optimum performance. Three trials were conducted in Ogbomoso and Mokwa, between 2012 and 2014 cropping seasons to assess the effect of pinching, mineral fertilizers and mulching on growth and fruit yield of tomato. Correlation analysis was done using statistical SAS package to determine one and two tailed differences among growth and yield parameters. In experiment one, the parameters had positive and negative significant relationship with each other. Fruit weight of tomato had positive significant relationship with total fruit yield with the highest (r=0.95) among other parameters at P≤0.01. In experiment two, the highest degree of association was from fruit length which positively correlated with fruit diameter, fruit weight and total fruit yield obtained from (r=0.76) at P≤0.01. Experiment three recorded the highest degree of association from parameters of fruit weight of tomato which was positive and significantly correlated with total fruit yield (r=0.100) at P≤0.01. Therefore, it can be recommended that for better performance of tomato fruit weight and total fruit yield should be positive and significantly correlated with each other at P≤0.01.
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1. Introduction

Tomato (*Lycopersicon lycopersicum* Mill) 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 16th century, and was initially used as ornamental plant. Its cultivation as edible fruit started at the end of the 18th century. Tomato was introduced to West Africa and Nigeria in particular, at the end of the 19th century (Villareal, 1980).

Depending on variety the growth habit of tomato may be determinate or indeterminate. Tomato plants of determinate varieties are relatively compact and grow to a certain height. They flower and set all their fruits within a short time. The main stem and lateral branches terminate in two consecutive inflorescences after a number of nodes, according to variety. In these varieties, the number of inflorescences per stem is not fixed. Determinate varieties can be grown in open fields, spread out over beds or trellised on sticks, if the varieties have a strong growth (George, 2004).

Indeterminate tomato plants grow continuously, producing flowers and fruit over a long period of time until the grower or weather conditions terminate the crop. The main stem and lateral branches continue to grow and the number of leaves between inflorescences is more or less fixed. In these varieties, the inflorescence appears with a set number of leaves between the branches. Indeterminate varieties can be grown on trellises in open fields and greenhouses, and the plant is shaped by pruning the lateral branches (Omar, 2005).

Tomato plants can typically grow to 1.3 m in height and have a weak stem that sprawls. It is perennial in its native habitat, and it is cultivated as an annual crop. Most tomato plants have compound leaves, and are called regular leaf plants, but some cultivars have simple leaves known as potato leaf stay because of their resemblance to their particular relative. The leaves are 10-25 cm long, odd pinnate, with five to nine leaflets on petiole, each leaflet is up to 8 cm long, with a serrated margin, but the stem and the leaves are densely hairy (Acquaah, 2002).

Tomato crop is significant relative to the economy of Nigeria. This sustains both during the rainy season when it is rainfed and dry season when irrigation facilities are employed. The leading producers of tomato in Nigeria are Gombe, Bauchi, Kano, Kebbi and Sokoto States. It is also widely cultivated in the southern part of the country (Sydenham *et al*., 1988; Olaoye *et al.,* 2007). Tomato cultivation in the country has improved from the traditional intercropping system with major staple crops to a much more commercially oriented system. 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). 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). On the average, the consumption of tomato in Nigeria is about 10 grams per person per day considerably. For 160 million

people, the demand would be 1,600 tons per day or 584,000 tons per annum (Balarabe, 2012).

Tomato is a rich source of nutrients, as fresh tomatoes and tomato juices are high in water, low in calories and rich in Vitamin C (Kocchar, 1981). It is a good source of vitamin A, and it is cholesterol free. Similarly, canned tomatoes contain about 3-4 times the vitamin C content of fresh ripe tomatoes. Ripe tomatoes contain 3-4 times the vitamin A as mature green tomatoes, but otherwise tomato varieties are about equal in nutritional value. Tomato puree and plain types of tomato sauce without added ingredients such as meat or mushrooms have about twice the solids content and about double the nutritional value of fresh tomatoes and tomato juice. Tomato paste, which has about four times the solids content of fresh tomatoes, is a concentrated source of nutrients, making it a valuable ingredient when used in preparation of food (Iris and David, 2001). Also the health value of tomato has been revealed by new medical researches which suggest that the consumption of lycopene- the stuff that gives tomato its red colour- may prevent cancer (Balarabe, 2012).

Presently, there are tomato cultivars and hybrids which can be cultivated in different climatic conditions and could also serve as sources of genes for improvement of adapted varieties. However, commercial cultivation of tomatoes in Nigeria exhibits seasonality with much of the production concentrated in the relatively cool and dry period under irrigation or in the 'fadama'. Furthermore, yields of the varieties of the tropics are generally low compared with yields obtained in the temperate region (McGraw *et al*., 1992; Anon, 1992; Surya, 1993). 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 52.8 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; Opena *et al*., 1989), diseases and insect pests (Ma, 1985), lack of appropriate varieties (Olaniyi, 2010) and cultural practices (Znidarcic *et al*., 2003). Despite these numerous positive effects of pinching, mineral fertilizers and mulching the fruit yield relatively remain low on farmers field as a result of the use of poor varieties and non-application of appropriate type and quantity of fertilizers among many others. Yield is a complex character and selection for yield and yield components deserves considerable attention. Correlation analysis measures the mutual relationship between various plant characters and determines the component characters for yield improvement. Therefore, it has become imperative to increase the yield potentials of the crop, knowledge of the direction and association that exists between growth, yield and yield components. Therefore, the objective of the study was to improve growth and fruit yield of tomato through correlation analysis by means of pinching, mineral fertilizers and mulching in Ogbomoso and Mokwa, Nigeria.

2. Materials and Methods

Three experiments were conducted at two locations: The Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso ($8^{\circ}10^{\prime}$N; $4^{\circ}10^{\prime}$E) and Niger State College of Agriculture, Mokwa ($9^{\circ}18^{\prime}$N and 5° $04^{\prime}$E), between 2012 and 2014 cropping seasons. The experiments were conducted to assess the effect of pinching, mineral fertilizers and mulching on growth and fruit yield of tomato. Correlation analysis was done using statistical SAS package to determine one and two tailed differences among growth and yield parameters. 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.

Experiment 1 examined the appropriate time of pinching to obtain growth and high fruit yield of three tomato varieties. The growth parameters assessed at 2 weeks interval was as follows: Plant height: This was done by measuring the plants from the soil level up to the apical bud of the plants at 2, 4 and 6 WAT and recorded. Number of leaves per plant: This was determined by counting the number of fully expanded leaves per plant at 2, 4 and 6 WAT and recorded. Number of branches per plant: This was done by counting the number of branches per plant at 4, 6 and 8 WAT and recorded. Stem girth: This was determined by using venier caliper to measure the stem diameter (cm) of the plant at 2, 4 and 6 WAT and recorded. The yield and yield components were: Days to 50% flowering: This was by counting the days in which at least 50% of the plants per plot have flowered. Number of flowers per plant: This was determined by counting the number of open flowers on the tagged plants at 2 weeks interval. Number of aborted flowers: This was determined by counting and calculating the number of fruits all over number of flowers. Number of fruits: This was done by counting the number of fruits per plant at harvesting. Fruit length: This was determined by using venier caliper to measure the length of the fruits graduated in centimeters. Fruit diameter: This was done with the use of venier caliper, graduated in centimeters. Total fruit yield: This was done by determining the weight of harvested tomato fruits per treatment in t ha^{-1}.

Experiment 2 determined the type and rate of mineral fertilizers required for optimum performance of tomato. The Nitrogen, Phosphorus and Potassium at 3 rates each and their various combinations were investigated. The tomato variety used was the best performing from the previous experiments. The Nitrogen, Phosphorus, and Potassium application rates were chosen based on the recommendation rates of (Federal Ministry of Agriculture Abuja, 2002). The growth and yield parameters were as stated in experiment 1 Experiment 3 assessed the effects

of mulch materials and mulching rates on tomato performance. The treatments used consisted of: a. Mulch types: Rice husk, Groundnut shell and Dry guinea grass: b. 0, 5, 10, 15 and 20 t ha^{-1}. The growth and yield parameters were as assessed in experiment 1.

3. Results

3.1 Correlation for growth and yield parameters as influenced by variety and pinching time.

The result of correlation between the growth and yield parameters for combined locations in 2012 cropping is shown in Table 1. The plant height was positive and significantly correlated with number of aborted flowers (r=0.47) at P≤0.01. Number of leaves had positive significant relationship with number of branches (r=0.81) and stem girth (r=0.33). The numbers of branches had moderately positive association with stem girth and number of flowers (r=0.34, 0.21) at P≤0.05 (Table 1). The stem girth of tomato plant had moderately positive significant correlation with number of flowers (r=0.25) at P≤0.05.

The number of flowers of tomato had positive significant relationship with fruit length, fruit diameter, fruit weight and total fruit yield (r=0.37, 0.49, 0.47, 0.49). At P≤0.01 significant levels, fruit length of tomato was positive and significantly correlated with fruit diameter, fruit weight and total fruit yield (r=0.70, 0.58, 0.59). The fruit diameter was positive and significantly correlated with fruit weight and total fruit yield (r=0.57, 0.61) at P≤0.01. Expectedly, fruit weight of tomato had positive significant relationship with total fruit yield (r=0.95) at P≤0.01 (Table 1).

Plant height of tomato was negative and significantly correlated with number of flowers, fruit length, fruit diameter, fruit weight and total fruit yield (r=-0.25, -0.49, -0.38 -0.45 -0.43). Also, number of branches negatively correlated with days to 50% flowering (r=-0.26) at P≤0.05. The correlation of number of leaves, numbers of branches, stem girth, days to 50% flowering, number of aborted flowers, fruit length, fruit diameter, fruit weight and total fruit yield were either positive or negatively related with no significant differences.

Table 1: Correlation analysis for growth and yield parameters as influenced by pinching times in 2012 cropping season

	PH	NL	NB	SG	DFF	NF	NAF	FL	FD	FW	TFY
PH	1	-0.03	-0.07	0.12	0.00	-0.25*	0.47**	-049**	-0.38**	-0.45**	-0.43**
NL		1	0.81**	0.33*	-0.18	0.11	-0.07	0.02	0.08	0.06	0.07
NB			1	0.34*	-0.26*	0.21*	-0.13	0.09	0.15	0.11	0.10
SG				1	-0.11	0.25*	-0.13	-0.21*	0.03	0.03	0.05
DFF					1	0.04	-0.01	0.07	0.03	0.00	0.03
NF						1	-0.35*	0.37*	0.49**	0.47**	0.49**
NAF							1	-0.44**	-0.48**	-0.46**	-0.39**
FL								1	0.70**	0.58**	0.59**
FD									1	0.57**	0.61**
FW										1	0.95**
TFY											1

PH= plant height, NL= number of leaves, NB= number of branches, SG= stem girth, DFF= days to 50% flowering, NF= number of flowers, NAF= number of aborted flowers, FL= fruit length, FD= fruit diameter, FW= fruit weight, TFY= total fruit yield

** Correlation is significant at 0.01 levels (2-tailed)

* Correlation is significant at 0.05 levels (2-tailed)

3.2 Correlation for growth and yield parameters as influenced by fertilizer types.

The result of correlation between growth and yield parameters is shown in (Table 2). Plant height had positive significant correlation with stem girth, number of flowers, number of fruits, fruit length and fruit diameter. The highest correlation was obtained from fruit diameter (r=0.82) followed by number of fruits (r=0.65) at P≤0.01. Plant height had positive low correlation with fruit weight and total fruit yield at P≤0.05. Number of leaves was positive and significantly correlated with stem girth, number of branches number of flowers, number of fruits, fruit length, fruit diameter, fruit weight and total fruit yield. The highest correlation was received from number of branches (r=0.60) at P≤0.01. Stem girth of tomato plant had positive significant relationship with number of branches, number of flowers, number of fruits, fruit length, fruit diameter, fruit weight and total fruit weight. The highest correlation was obtained from fruit length (r=0.74) followed by number of flowers (r=0.68) at P≤0.01. Number of branches positively correlated with the number of flowers, number of fruits, fruit length, fruit diameter and the highest correlation obtained from fruit weight and total fruit yield (r=0.81) at P≤0.01 (Table 2).

Days to 50% flowering and number of aborted flowers had low positive significant relationship (r=0.16) at P≤0.05. The number of flowers was positive and significantly correlated with number of fruits, fruit length, fruit

diameter, fruit weight and total fruit yield. The highest correlation was obtained from number of fruits (r=0.97) followed by fruit length and fruit diameter (r=0.75), respectively. At P≤0.01 significant levels, number of tomato fruits had positive significant relationship with fruit length, fruit diameter, fruit weight and total fruit yield with the highest correlation received from fruit diameter (r=0.76) followed by fruit length (r=0.75). Fruit length positively correlated with fruit diameter, fruit weight and total fruit yield with the highest correlation obtained from (r=0.76) at P≤0.01. The fruit diameter of tomato was positive and significantly correlated with fruit weight and total fruit yield (r=0.46). The fruit weight had positive significant relationship with total fruit yield (r=0.100) at P≤0.01.

Days to 50% flowering was negative and significantly correlated with number of flowers, number of fruits, fruit length and fruit diameter (r=-0.56, -0.56, -0.40, -0.69). Also, number of flowers with number of aborted flowers (r=-0.41) were negatively correlated at P≤0.01. Similarly, number of aborted flowers was negative and significantly correlated with number of fruits, fruit length, fruit diameter, fruit weight and total fruit yield (r=-0.53, -0.42, -0.36, -026, -0.26). The correlation between days to 50% flowering and fruit weight and total fruit yield were negatively related with no significant differences (Table 2).

Table 2: Correlation analysis for growth and yield parameters as influenced by fertilizer types in 2013 cropping season

	PH	NL	SG	NB	DFF	NF	NAF	NFR	FL	FD	FW	TFY
PH	1	0.23*	0.36**	0.14*	-0.85**	0.65**	-O.24*	0.67**	0.52**	0.82**	0.18*	0.19*
NL		1	0.56**	0.60**	-0.14*	0.48**	-0.20*	0.44**	0.50**	0.44**	0.44**	0.44**
SG			1	0.65**	-0.24*	0.68**	-0.36**	0.67**	0.74**	0.60**	0.66**	0.65**
NB				1	-0.09	0.54**	-0.40**	0.53**	0.66**	0.44**	0.81**	0.81**
DFF					1	-0.56**	0.16*	-0.56**	-0.40**	0.69**	-0.11	0.12
NF						1	-0.41**	0.97**	0.75**	0.75**	0.52**	0.51**
NAF							1	-0.53**	-0.42**	-0.36**	-0.26*	-0.26*
NFR								1	0.75**	0.76**	0.51**	0.50**
FL									1	0.76**	0.62**	0.62**
FD										1	0.45**	0.46**
FW											1	0.100**
TFY												1

PH= plant height, NL= number of leaves, NB= number of branches, SG= stem girth, DFF= days to 50% flowering, NF= number of flowers, NAF= number of aborted flowers, FL= fruit length, FD= fruit diameter, FW= fruit weight, TFY= total fruit yield

** Correlation is significant at 0.01 levels (2-tailed)

* Correlation is significant at 0.05 levels (2-tailed)

3.3 Correlation for growth and yield parameters as influenced by mulch material and mulching rate.

The result of correlation between growth and yield parameters for combined locations in 2014 cropping season is presented in (Table 3). Plant height of tomato had positive significant association with number of leaves, number of branches, and days to 50% flowering, number of fruits, fruit weight and total fruit yield. The highest correlation was obtained from number of fruits (r=0.55) followed by fruit weight and total fruit yield (r=0.49). Number of leaves had positive significant relationship with number of branches, days to 50% flowering, number of flowers, number of fruits, fruit weight and total fruit yield. The highest correlation was recorded from days to 50% flowering (r=0.90) followed by fruit weight (r=0.84) at P≤0.01.

At P≤0.01 significant levels, number of branches had positive significant correlation with days to 50% flowering, number of flowers, number of fruits, fruit weight and total fruit yield. The highest correlation was recorded from days to 50% flowering (r=0.85) followed by fruit weight (r=0.68). Stem girth had a positive significant relationship with fruit length and fruit diameter with the highest correlation received from the fruit diameter (r=0.91) at P≤0.01. Days to 50% flowering had positive significant relationship with number of flowers, number of fruits, fruit weight and total fruit yield with the highest correlation obtained from fruit weight (r=0.74) followed by total fruit yield (r=0.73) at P≤0.01. Number of flowers was positive and significantly correlated with number of aborted flowers, number of fruits, fruit weight and total fruit yield. The highest correlation was obtained from fruit weight and total fruit yield (r=0.72), respectively. Number of aborted flowers had moderately positive significant relationship with fruit weight and total fruit yield with the highest correlation received from total fruit yield (r=0.39) at P≤0.05. More so, number of fruits was positive and significantly correlated with fruit weight and total fruit yield (r=0.67), respectively. Fruit length had positive significant correlation only with fruit diameter (r=0.77) at P≤0.01. Fruit weight of tomato was positive and significantly correlated with total fruit yield (r=0.100) at P≤0.01 (Table 3).

Plant height was negative and significantly correlated with the stem girth and fruit diameter (r=-0.32, -0.24). Number of leaves was negatively correlated with stem girth and fruit length (r=-0.93, -0.58). Also, number of branches of tomato plant had negative significant association with stem girth, number of aborted flowers, fruit length and fruit diameter (r=-0.87, -0.21, -0.65, -0.79). Stem girth was negative and significantly correlated with days to 50% flowering, number of flowers, number of aborted flowers, number of fruits, fruit weight and total fruit yield (r=-0.97, -0.49, -0.25, -0.42, -0.73, -0.72). Days to 50% flowering had negative significant relationship with number of aborted flowers, fruit length, and fruit diameter (r=-0.29, -0.61, -0.81). The number of flowers was negative and significantly correlated with fruit diameter (r=-0.49) while number of fruits negatively correlated with fruit diameter (r=-0.34) at P≤0.05.

More so, fruit length had negative significant correlation with fruit weight and total fruit yield (r=-0.26, -0.26) at P≤0.05. Similarly, fruit diameter was negative and significantly correlated with fruit weight and total fruit yield (r=-0.67, -0.67) at P≤0.01. The correlation between plant heights and number of aborted flowers and fruit length, number of leaves and number of aborted flowers, numbers of flowers and fruit length, number of aborted flowers and number of fruits and fruit length were either positive or negatively related with no significant differences.

Table 3: Correlation analysis for growth and yield parameters as influenced by mulch material and mulching rate in 2014 cropping season

	PH	NL	NB	SG	DFF	NF	NAF	NFR	FL	FD	FW	TFY
PH	1	0.41*	0.25*	-0.32*	0.37*	0.42**	0.17	0.55**	0.06	-0.24*	0.49**	0.49**
NL		1	0.84**	-0.93**	0.90**	0.52**	0.16	0.54**	-0.58**	-0.85**	0.79**	0.78**
NB			1	-0.87**	0.85**	0.48**	-0.21*	0.45**	-0.65**	-0.79**	0.68**	0.67**
SG				1	-0.97**	-0.49**	-0.25*	-0.42**	0.71**	0.91**	-0.73**	-0.72**
DFF					1	0.57**	-0.29*	0.45**	-0.61**	-0.81**	0.74**	0.73**
NF						1	0.38*	0.71**	-0.08	-0.49**	0.72**	0.72**
NAF							1	-0.01	0.02	-0.15	0.38*	0.39*
NFR								1	0.07	-0.34*	0.67**	0.67**
FL									1	0.77**	-0.26*	-0.26*
FD										1	-0.67**	-0.67**
FW											1	0.100**
TFY												1

PH= plant height, NL= number of leaves, NB= number of branches, SG= stem girth, DFF= days to 50% flowering, NF= number of flowers, NAF= number of aborted flowers, FL= fruit length, FD= fruit diameter, FW= fruit weight, TFY= total fruit yield

** Correlation is significant at 0.01 levels (2-tailed)

* Correlation is significant at 0.05 levels (2-tailed)

4. Discussion

Correlation is a measure of the degree of association between variables. Result obtained from experiment one showed strong correlation between the yield variables that can be explored directly or indirectly for crop improvement of tomato plants. The results were confirmed with the findings of (Haydar *et al*., 2007, Shiferawet *et al*. 2002; Ramana *et al*. 2007) who reported that fruit weight of tomato exerted high positive and direct effect on fruit yield per plant. In experiment two, the result showed that there was strong positive association between growth and yield parameters. This is in conformity with (Tasisa *et al*. 2012; Meseret *et al.* 2012) who observed that positive and significant correlation existed between average fruit yield with fruit clusters and fruits per plant. Also, (Haydar *et al*. 2007; Prashanth *et al*. 2008) observed a significant correlation between fruit yield and the number of fruits per plant. Findings from the result of correlation analysis in experiment three revealed that plant height, number of leaves, fruit diameter and fruit weight had positive relationship with total fruit yield. This agrees with the report of (Tiwari and Upadhyay 2011; Dharminder *et al*. 2013) who reported that plant height, fruit diameter and fruit length were directly responsible for the determination of fruit yield in tomato.

5. Conclusion and Recommendation

Based on research findings of the three experiments from the three different seasons it can be concluded that for optimum tomato yield; number of flowers, number of fruits, fruit weight and total fruit yield parameters should be positively correlated with each other. Also, from the findings it became evident that for maximum growth of tomato; plant height, number of leaves and number of productive branches should be positively correlated with each other. Therefore, it can be recommended that for good tomato production growth and yield parameters has to be positively correlated with each other so that farmers within the study area can gain maximum benefit of tomato

production.

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