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Growth of Tomato (*Lycopersicon lycopersicum* Mill.) as Influenced by Training and Pruning at Sokoto Fadama, Nigeria

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Abstract
Field experiments were conducted during 2004/05 and 2005/06 dry seasons at the Usmanu Danfodiyo University Fadama Teaching and Research Farm, Sokoto, to study the effects of training, intra-row spacing and pruning on the growth of tomato (*Lycopersicon lycopersicum* var. Roma VFN) in the semi-arid zone of Nigeria. Treatments consisted of a factorial combination of two levels of training (staked and unstaked) and three pruning levels (three-stem, two-stem and unpruned) laid out in a split-plot design replicated three times. Training was allocated to the main plots while pruning was allocated to the sub-plots. Results revealed that Plant Height, Leaf Area Index (LAI) and Days to 50% flowering were favored by unstaking. Unpruned plants produced higher LAI, Shoot Dry Weight (SDW) and took longer Days to 50% flowering. Thus, pruning and staking (Training) may reduce growth of tomato. Higher growth in unstaked and unpruned plants may translate to higher total fruit yield (marketable +unmarketable). Pruning and training resulted is early flowering of tomato.
Keywords: Tomato (*Solanum lycopersicum* Mill.), training, pruning, Nigeria

1.0 introduction

Tomato originated from the tropics of Central and South America. It is now the most widely grown vegetable crop in the world, giving its growers income, expanding export potential, and improving the supply of vitamins and minerals in human nutrition (Rawshan, 1996). Commercially, almost 70 million tones of tomato are grown in the world in more than 2 million hectares of land, but less than 20% of the yield comes from the tropics (Phene, 1989). The versatility of the tomato crop contributes greatly to its popularity as a food product; tomatoes can be processed and canned easily as a whole or as paste; Juice, sauce or powder, or eaten raw, alone or in combination with other foods. In Africa average yield of 8-25 t ha^{-1} was recorded, with the highest yield from South Africa and the least from Benin and Nigeria (De Lannoy, 2001). In Nigeria, tomato is widely cultivated around Guinea Savanna mostly in the wet season and Sudan Savanna in the dry season through irrigation scheme (Adelana, 1977).

Tomato yield could be increased substantially through improved agronomic techniques like staking (a practice of supporting plant to prevent fruit clusters from touching the ground) and pruning (removal of side shoots and lower shoots). A significant yield increase was reported by staking tomato (Ahmad and Singh, 2005). A number of researchers (Rafi, 1996), (Chen and Lal, 1999) and (Abdel-Al *et al*., 1962) also recommended pruning as a cultural practice that improves the yield and quality of tomato. However, the benefits of staking and pruning according to (Chen and Lal, 1999) include; while staking improves fruit quality by keeping plants and fruits off the ground thus reduces rotting, incidence of soil borne diseases and providing a better spray coverage, pruning diverts nutrients to flower clusters and fruits on the main stem, and allows more efficient air circulation.

Plant growth analysis is considered to be a standard approach to plant productivity. Growth and yield are functions of a large number of metabolic processes, which are affected by environmental and genetic factors. Studies of growth pattern and its understanding not only tell us how plant accumulates dry matter, but also reveals the events which can make a plant more or less productive singly or in population (Brown, 1984). Therefore, determining effects of staking and pruning on growth performance of tomato is the objective of the study presented in this paper.

2.0 Materials and Methods

Two experiments were conducted during the 2004/05 and 2005/06 dry seasons at the Usmanu Danfodiyo University, Fadama Teaching and Research Farm, (latitude $13^{0}9$'N and longitude $5^{0}15$'E). The climate of the area is semi-arid with rainfall range of 550-660 mm per annum, spread over a period of 4-5 months (May-September). A mean monthly temperature range of between $14^{0}C$ – $41^{0}C$ was recorded from 2003-2006 (Sokoto Energy Research Center, 2006). The soil of the study area was clay loam (pH 5.7) and seasonally flooded (during rainy season).

The treatments consisted of two training (staked and un-staked) and three pruning levels (Three-stem, two-stem

and unpruned). The treatments, in factorial combination, were laid out in a split plot design replicated three times. Staking was allocated to the main plots while pruning was allocated to the sub plots. The plot size was 3.0m x 2.5m (7.5m^2). Certified seed of tomato cultivar (*Roma VFN*) was obtained from Kebbi State Agricultural Supply Company (KASCOM) Birnin Kebbi. Seedlings were raised in nursery bed using nursery management techniques. Seedlings were transplanted at about 30-35 day after sowing (i.e. 4-5 leaf stage). Stakes of about 1m length were driven at 10cm to the side of the plants in the staked treatments. A strong but soft thread was used to tie the plants to the stake at intervals as the plant grows. Irrigation was done at an interval of between 4-7 days, depending on the need of the crop. Fertilizer was applied in two split doses, at planting, 300 kg ha^{-1} using NPK (15:15:15) followed by 140 kg urea as top dressing at 4 weeks after transplanting (WAT).
Pruning treatment was applied at 4 WAT and continued 2-weekly up to 10WAT. Depending on the pruning level, one or two shoots just below the first flower cluster was left to grow as the second and third shoots respectively, while the rest were removed. Weeds were controlled manually by weeding three times at 4 weeks interval. The plots were sprayed against insect pests at an interval of 3 weeks. Data were collected on plant height, leaf length, leaf width and days to 50% flowering. Models for the estimation of total leaf area (LA), shoot fresh weight (SFW) and shoot dry weight (SDW) (Son and Cholakov, 2002) were employed. The models use plant height (H) leaf length (L) and leaf width (W) as follows:

1. Leaf area (LA) = 452 – 19.8 x H – 23.7 x W + 1.56 x HW (R^2 = 0.958)
2. Shoot fresh weight (SFW) = 39.06 – 0.891 x H – 3.083xW+0.092xHW (R^2 = 0.939)
3. Shoot Dry Weight (SDW) = 4.937 + 0.178 x H – 0.766 x L + 0.007 x HL (R^2 = 0.821)

Where H=Plant height, L=leaf Length and W= leaf width

Leaf area index (LAI) was calculated by dividing the total leaf area (LA) by the total land area covered by the plant (La). LAI was expressed by (Brown, 1984) and (Harper, 1999) as follows:

$$\text{Leaf area index (LAI)} = \frac{\text{Total leaf area of the plant (LA)}}{\text{Total land area covered by plant (La)}}$$

Data were subjected to analysis of variance (ANOVA) procedure using (SAS, 2003) and the mean were separated using least significant difference (LSD) test.

3.0 Results and Discussion

3.1 Plant height

Plant height at 8, 10 and 12 WAT showed significant response to training in both seasons (Table 1). Un-staked plants produced the tallest plants at virtually all stages of growth. Un-staked plants produced 42.56, 50.48 and 53.30 cm at 8, 10 and 12WAT, respectively against 38.44, 46.96 and50.85 cm for the staked plants in the 2004/05 season. The result was similar for 2005/06 where un-staked plants produced 48.74, 55.26 and 56.89 cm against 43.74, 52.78 and 54.22 cm of staked plant, respectively. The taller plant recorded in un-staked treatments could be attributed to creeping nature of the tomato stem. According to Frank (2003), once a creeping stem is allowed to grow undisturbed, it has the tendency to grow faster and longer than the plant trained to grow against its natural course.
Pruning had a significant ($P<0.05$) effect on plant height at 8, 10 and 12 WAT in both trials (Table 1). Two-stem pruning produced the tallest plants at 8, 10 and 12WAT compared to the three-stem and unpruned plants that were statistically similar. Taller plants recorded in two-stem pruning could be due to reduced competition for photosynthate among the branches (Frank, 2000). In two-stem pruning, photosynthate is diverted to two branches and in three stem, it is diverted to three, while in unpruned, the photosynthate is diverted to many branches. This result agrees with the findings of (Rafi, 1996) and (Myanmar,1999) who reported a significant plant height response to pruning, and that one-stem pruning produced the tallest plants compared to no pruning treatment.

3.2 Leaf area index (LAI)

Leaf Area Index (LAI) defined as the ratio of the total leaf area to the soil area occupied per plant was significantly ($P<0.05$) influenced by training and pruning at all growth stages in 2004/05 cropping season. However, in 2005/06 only pruning had significant effect on LAI at 8, 10 and 12 WAT (Table 2).Un-staked treatments recorded the highest LAIs of 0.7, 0.94 and 0.95 at 8, 10 and 12 WAT, respectively against staked treatment which had LAIs of 0.40, 0.63 and 0.68 respectively. According to Evans (1984), changes in LAI depend on the relative rate of two processes, growth in leaf area and senescence. Since un-staked plants were found to be taller than staked, the number of leaf as well as the total leaf area of the former would be higher, and consequently, the LAI.
Pruning significantly ($P<0.05$) affected LAI at 8, 10 and 12 WAT in both seasons except at 8 WAT in 2005/06 which had similar trend but not significant (Table 2). Unpruned plants had the highest LAIs compared to the three-stem and two-stem plants which are statistically the same. In the 2004/05 season, the range of LAIs from 8 – 12 WAT were 0.70 - 0.94 for unpruned; 0.5 - 0.80 for three-stem; and 0.5 - 0.7 for two-stem plants. Similarly, the 2005/06 results revealed that the ranges of LAIs from 8 – 12 WAT were 0.6 - 1.04; 0.5 - 0.85 and 0.5 - 0.7

for unpruned, three-stem and two-stem, respectively.

Since LAI depends on growth in leaf area (Brown, 1984), the LAI in unpruned plants would, at any time during growth of the plant, be higher than the plants that were pruned. However, the similarity in LAIs of three-stem and two-stem plants could be explained as, although the three-stem plants had higher number of leaves than the two-stem plants, the two-stem plants might have larger single leaf area. This is because the photosynthate that would have been used in growth of the third shoot in the three-stem plant would be used for leaf expansion in the two-stem. In that case, the larger number of leaves in the three-stem plants was counteracted by the larger sized leaves in the two-stem plants, making the difference in LAIs of the two treatments statistically the same. The interaction of training and pruning shown in Figure1 revealed that un-staked and unpruned plants at 10 WAT produced the highest

3.3 Shoot dry weight (g plant^{-1})

Shoot dry weight (SDW) per plant at 8, 10, and 12 WAT were not significantly affected by training, but higher values were recorded with un-staked plants than staked plants at all growth stages (Table 3). Pruning had a significant ($P<0.05$) effect on SDW at 8, 10, and 12 WAT in both seasons except at 8WAT in 2004/05, where there was no significant effect. Unpruned plants recorded higher shoot dry weight than two-stem and the three-stem plants. Both two-stem and three-stem pruned plants recorded similar shoot dry weight (Table 3). Higher shoot dry weights in the unpruned plants was because the secondary shoots were not removed from the plants. It has been reported that (Evans, 1975) the rate at which a crop increases in dry weight depends at any instant on the product of the area of the photosynthetic system (leaf) and rate of assimilation per unit of that area. Based on this therefore, since more number of leaves (indicating high LAI) as shown in Table 2 were found in unpruned plants, the tendency is that high dry matter would also be expected.

3.4 Days to 50% flowering

Training had significant ($p<0.05$) effect on days to 50% flowering only in 2004/05 (Table 4). Un-staked plants took more days to flower compared to staked plants, probably due to little stress enforced in handling the plants during staking which may likely induced early flowering (Summerfield *et al*., 1983). Similarly, it took more days to flower in unpruned plant than pruned plants. Early flowering in pruned plants might be a result of diversion of photosynthate that would have been used for growth of new shoots and leaves to flower production (Frank, 2003).

4.0 Conclusion

The growth parameters studied in this paper indicated a negative response to the staking and pruning treatments. The yield depression due to negative response to growth is often compensated by training and pruning through their ability to enhance fruit quality and marketable yield (see Muhammad & Singh, 2007 for yield components). Thus, pruning and staking (Training) may reduce growth of tomato and higher growth in unstaked and unpruned plants may translate to higher total fruit yield (marketable +unmarketable). Pruning and training resulted is early flowering of tomato.

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Table 1: Plant height of tomato at 8, 10 and 12 WAT as influenced by training and pruning in 2004/05 and 2005/06 cropping seasons.

Treatment	Plant height at 8 WAT (cm)		Plant height at 10 WAT (cm)		Plant height at 12 WAT (cm)	
	2004/05	2005/06	2004/05	2005/06	2004/05	2005/06
TRAINING						
Staked	38.44b	43.74 b	46.96 b	52.78 b	50.85 b	54.22 b
Unstaked	42.56 a	48.74 a	50.48 a	55.26 a	53.30 a	56.89 a
SE +	0.43	0.42	0.44	0.35	0.39	0.43
Significance	S	S	S	S	S	S
PRUNING						
Three-stem	39.89 b	45.61 b	46.22 b	51.39 c	49.61 b	52.83 c
Two-stem	42.50 a	47.61 a	53.17 a	57.28 a	55.89 a	59.11 a
Unpruned	39.11 b	45.50 b	46.78 b	53.39 b	50.72 b	54.72 b
SE +	0.37	0.41	0.65	0.57	0.78	0.41
Significance	S	S	S	S	S	S
INTERACTIONS						
Training x Pruning	Ns	Ns	Ns	Ns	Ns	Ns

Within a treatment group, means in a column followed by same letter(s) are not significantly different at 5% level using LSD. Ns = not significant; S = significant at 5% level of significance.

Table 2: Leaf area index (LAI) of tomato at 8, 10 and 12 WAT as influenced by training and pruning in 2004/05 and 2005/06 cropping seasons.

Treatment	Leaf area index at 8 WAT		Leaf area index at 10 WAT		Leaf area index at 12 WAT	
	2004/05	2005/06	2004/05	2005/06	2004/05	2005/06
TRAINING						
Staked	0.40 b	0.48	0.68 b	0.67	0.68 b	0.81
Unstaked	0.70 a	0.64	0.94 a	0.81	0.95 a	0.94
SE +	0.017	0.43	0.022	0.56	0.03	0.65
Significance	S	Ns	S	Ns	S	Ns
PRUNING						
Three-stem	0.57 b	0.55	0.76 b	0.67 b	0.80 b	0.85 b
Two-stem	0.51 b	0.50	0.66 c	0.66 b	0.71 b	0.72 b
Unpruned	0.71 a	0.63	0.93 a	0.88 a	0.94 a	1.04 a
SE +	0.026	0.049	0.033	0.066	0.04	0.07
Significance	S	Ns	S	S	S	S
INTERACTIONS						
Training x Pruning	Ns	Ns	S	Ns	Ns	Ns

Within a treatment group, means in a column followed by same letter(s) are not significantly different at 5% level using LSD. Ns = not significant; S = significant at 5% level of significance.

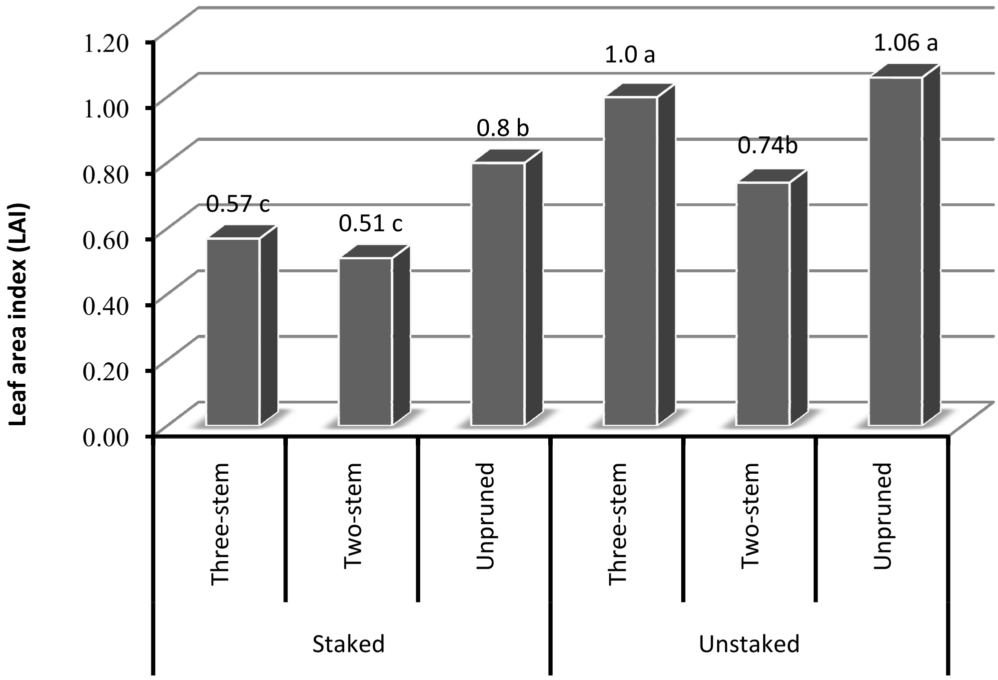

Figure 1: Leaf Area Index (LAI) at 10 WAT as influenced by 'Training x Pruning' interaction in 2004/05 cropping season. Bars with the same letter are not significantly different using LSD at 5% level.

Table 3: Shoot dry weight per plant at 8, 10 and 12 WAT as influenced by training, spacing and pruning in 2004/05 and 2005/06 cropping seasons.

Treatment	Shoot dry weight at 8WAT (g plant^{-1})		Shoot dry weight at 10 WAT (g plant^{-1})		Shoot dry weigh at 12 WAT (g plant^{-1})	
	2004/05	2005/06	2004/05	2005/06	2004/05	2005/06
TRAINING						
Staked	2.75	1.70	5.47	3.76	5.79	4.37
Un-staked	3.47	1.80	5.79	4.27	6.31	4.83
SE +	0.12	0.12	0.09	0.14	0.12	0.12
Significance	Ns	Ns	Ns	Ns	Ns	Ns
PRUNING						
Three-stem	3.26	1.49 b	4.97 b	3.42 b	5.40 b	4.10 b
Two-stem	2.91	1.50 b	5.37 b	3.40 b	5.63 b	3.99 b
Unpruned	3.40	2.27 a	6.55 a	5.22 a	7.13 a	5.73 a
SE +	0.20	0.18	0.24	0.28	0.24	0.31
Significance	Ns	S	S	S	S	S
INTERACTIONS						
Training x Pruning	Ns	S	NS	Ns	S	Ns

Within a treatment group, means in a column followed by same letter(s) in superscript are not significantly different at 5% level using LSD. Ns = not significant; S = significant at 5% level of significance.

Table 4: Days to50% flowering as influenced by training and pruning in 2004/05 and 2005/06 cropping season

Treatments	Days to 50% flowering	
	2004/05	2005/06
TRAINING		
Staked	47.78b	53.15
Un-staked	50.60a	51.60
SE	0.13	0.53
Significance	S	Ns
PRUNING		
Three-stem	49.61b	49.22b
Two-stem	49.22b	50.61b
Unpruned	51.72a	57.28a
SE	0.42	1.02
Significance	S	S
INTERACTIONS		
Training x pruning	Ns	Ns

Within a treatment group, means in a column followed by same letter(s) are not significantly different at 5% level using LSD. Ns = not significant; S = significant at 5% level of significance.