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Yield of Tomato as Influenced by Training and Pruning in the Sudan Savanna of Nigeria

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Abstract: Replicated field trials were carried out at the Usmanu Danfodiyo University Fadama Teaching and Research Farm, Sokoto, during 2004/05 and 2005/06 dry seasons, to examine the effects of training and pruning on growth and yield of tomato (*Lycopersicon lycopersicum* Mill.) variety Roma VFN. Treatments consisted of factorial combination of two levels of training (staked and unstaked) and three levels pruning (three-stem, two-stem and unpruned) and three levels of intra-row spacing (20, 40 and 60 cm) laid out in a split-plot design replicated three times, with training allocated to the main plots and pruning intra-row spacing to the sub-plots. Results of training and pruning are presented in this paper. Results revealed that mean fruit length and diameter in the first trial, fruit weight in both trials and the two trials combined, total fresh fruit yield in the first trial and combined and percentage marketable yield in the first trial and the combined were significantly ($p<0.05$) higher in the tomato plants that were staked. Results on pruning showed that mean fruit length, diameter and weight in both trials were significantly higher in three-stem and two-stem pruned plants than unpruned plants. Similarly, three-stem pruned plant produced the highest total fresh fruit yield in both trials. Significant training x pruning interactions recorded, showed that the highest percentage marketable yield was at staked and pruned (both three and two-stem) plants; while two-stem with staking or no staking produced the highest mean fruit weight.

Key words: Tomato (*Lycopersicon lycopersicum* Mill), training, pruning, Sudan savanna, Nigeria

INTRODUCTION

Tomato originated from the tropics of Central and South America, extending from Mexico, Ecuador through Chile. It was transported to Europe and improved further before reaching the United States and Asia (Kalloo, 1993). It was now the most widely grown vegetable crop in the world, giving 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.

Yield of tomatoes in the tropics is generally low when compared with the temperate regions. In 1994, the average yield was 9.9 t ha^{-1} in Thailand, 15.6 in India, 25.3 in China, 8.8 in Philippines, 4.5

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in Malaysia, 52.8 in Japan and 63.6 t ha^{-1} in the U.S.A. (Anonymous, 1994). 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).

Inadequate application of improved cultural practices may be some of the factors that limit tomato production, farmers in Nigeria obtained very low yield compared with global yield. 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). Ahmad and Singh (2005) reported a significant yield increase by staking tomato. 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. Wuster and Nganga (1970) stressed that, properly supported and pruned plants that are appropriately spaced produce larger, earlier and relatively reasonable fruit yield than non-pruned and non-stated plants of the same variety. Therefore, determining effects of staking and pruning on the performance of tomato was the objective of the study presented in this research.

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, Sokoto (latitude 13°9'N and longitude 5°15'E) (Kowal and Knabe, 1972). 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 14-41°C was recorded between 2003-2006. The soil of the study area was clay loam (pH 5.7) and seasonally flooded (during rainy season). The physico-chemical analysis of the soil at the experimental site revealed that the soils were low in total N, available P and organic carbon and was slightly acidic in nature (pH = 5.61-6.35). The soil at the experimental site was loamy in 2004/05 and clay loam in 2005/06 cropping season (Table 1).

The treatments consisted of factorial combination of two training (staked and unstaked), three pruning levels (Three-stem, two-stem and unpruned) and three intra-row spacing (20, 40 and 60 cm)

Table 1: Physico-chemical properties of the soil at the experimental site in 2004/05 and 2005/06 cropping season

Physico-chemical characteristics	2004/05	2005/06
Chemical properties		
pH (Water)	6.35	5.61
pH ($CaCl_2$)	5.92	5.56
Organic carbon (g kg^{-1})	0.27	0.74
Total N (g kg^{-1})	0.056	0.77
Available P (ppm)	0.025	0.024
CEC (Cmol kg^{-1})	3.16	3.16
Exchangeable bases (Cmol kg^{-1})		
Ca	0.095	0.040
Mg	0.065	0.040
K	1.025	1.0505
Na	1.080	0.113
Physical properties		
Sand (g kg^{-1} soil)	442	338
Silt (g kg^{-1} soil)	444	350
Clay (g kg^{-1} soil)	114	312
Textural class	Loamy	Clay loam

laid out in a split plot design replicated three times with staking allocated to the main plots and pruning and intra-row spacing allocated to the sub-plots. Results of training and pruning are presented in this research.

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 (Thinning out and hardening off was carried out before transplanting). Seedlings were transplanted at about 30-35 day after sowing (i.e., 4-5 leaf stage). Stakes of about 1m length were driven at 10 cm 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 at field capacity. Fertilizer was split-applied at transplanting and 4 weeks after transplanting at the rate of 300 kg NPK (15:15:15) ha^{-1} and 140 kg Urea ha^{-1}, respectively.

Pruning was done starting from 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 using Karate® (Lambdacyhalothrin) at the rate of 4 mL $liter^{-1}$. Fruits were harvested at regular intervals at physiological maturity (skin turned yellowish-orange).

Data was collected on mean fruit length and diameter, mean fruit weight, total fresh fruit yield and percentage marketable yield. Data collected were subjected to Analysis of Variance (ANOVA) procedure and significant differences were further analyzed using Least Significant Difference (LSD) test.

RESULTS AND DISCUSSION

Mean Fruit Length and Diameter

Training showed a significant ($p<0.05$) effect on mean fruit length and mean fruit diameter only in the first trial (Table 1). The highest fruit length (6.30 cm) and diameter (4.35 cm) were recorded in staked tomato plants compared with the unstaked plants with 5.81 and 4.01 cm, respectively. Ahmad and Singh (2005) and Ariyarathne (1999) reported similar result for fruit length and fruit diameter, respectively. Both authors attributed the result to higher insolution (less mutual shading) advantage exhibited by the staked plants which result to higher photosynthetic rate.

Significantly higher mean fruit length was produced by three-stem (6.25 cm) and two-stem (6.37 cm) plants compared with unpruned (5.54 cm). Similarly, in terms of fruit diameter, higher mean fruit diameter was recorded in three-stem (4.47 cm) and two-stem (4.34 cm) compared with the unpruned (3.73 cm). This agrees with the findings of Hernandez and Sanchez (1992), Zhang (1999) and Myanmar (1999). However, the higher fruit size produced by the pruned plants could be because, pruned plants had a reduced vegetative sink (shoots) compared to unpruned plants. In that case, larger portion of the photosynthate would be partitioned to the reproductive sink (fruits) in the pruned plants while in unpruned, most of the photosynthate would be used by the shoots for respiration (Brown, 1984).

Mean Fruit Weight

Mean fruit weight in both trials and the combined (Table 2) was significantly ($p<0.05$) higher (48.74 g) in staked plants than in unstaked (45.52 g) plants. Ariyarathne (1999) and Ahmad and Singh (2005) reported similar results. However, the higher mean fruit weight by staked plants cold be because staking facilities good insolation (minimal shading effect) of leaves and enhances proper air circulation, which ultimately leads to more photosynthetic rate (Mckeen, 1984; Konsler, 1999).

In both trials significantly higher mean fruit weight was recorded in three-stem and two-stem compared with the unpruned. In the combined, two-stem plants produced the highest (52.19 g),

Table 2: Mean fruit length and diameter of tomato as influenced by training and pruning in 2004/05 and 2005/06 cropping seasons and the two years combined

	Mean fruit length (cm)			Mean fruit diameter (cm)		
Treatments	2004/05	2005/06	Combined	2005/06	2004/05	Combined
Training						
Staked	6.30a	5.97	5.84	4.35a	3.94	3.93
Unstaked	5.81b	5.16	5.78	4.01b	3.36	3.90
SE of mean	0.05	0.46	0.30	0.03	0.53	0.34
Significance	S	NS	NS	S	NS	NS
Pruning						
Three-stem	6.26a	5.64ab	5.95a	4.47a	3.81a	4.08a
Two-stem	6.37a	5.67a	6.02a	4.34a	3.84a	4.04a
Unpruned	5.54b	5.39b	5.96b	3.73b	3.30b	3.62b
SE of mean	0.07	0.09	0.05	0.06	0.10	0.06
Significance	S	S	S	S	S	S
Interaction						
Training×Pruning	S	NS	NS	NS	NS	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 3: Mean fruit weight and total fresh fruit yield (t ha^{-1}) as influenced by training and pruning in 2004/05 and 2005/06 cropping seasons and the two years combined

	Mean fruit weight (g)			Total fresh fruit yield (t ha^{-1})		
Treatments	2004/05	2005/06	Combined	2004/05	2005/06	Combined
Training						
Staked	49.60a	47.89a	48.74a	56.37a	55.55	55.05a
Unstaked	47.19b	42.85b	45.52b	50.43b	48.74	49.49b
SE of mean	0.45	1.42	0.98	1.19	4.45	1.02
Significance	S	S	S	S	NS	S
Pruning						
Three-stem	52.00a	46.67a	48.83b	56.62a	55.89a	54.56a
Two-stem	42.28b	48.11a	52.19a	50.99b	51.54b	52.02ab
Unpruned	40.89c	39.83b	38.86c	52.60ab	50.88b	51.74b
SE of mean	0.32	1.06	0.52	1.44	1.09	0.85
Significance	S	S	S	S	S	S
Interaction						
Training×Pruning	S	NS	S	NS	NS	S

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

followed by three-stem (48.83 g) and the least was unpruned (38.86 g) plants. Rafi (1996), Zhang (1999) and Myanmar (1999) independently reported that mean fruit weights produced by three-stem and two-stem pruned plants are the same, but was significantly higher than that produced by unpruned plants. The reason for higher mean fruit weight in pruned plants than unpruned could be because of former had less photosynthate-demanding shoots which results to more dry matter partitioning to its fruits. The least mean fruit weight in the training×pruning interaction in the first trial was obtained in unstaked and unpruned plants (Fig. 1).

Total Fresh Fruit Yield

Total fruit yield (Table 3) was significantly ($p<0.05$) affected by training in the first trial and in the combined. Staked plants produced higher (56.33) (55.06) fruit yield in (t ha^{-1}) than unstaked (50.43) (49.49) plants for the first trial and the combined respectively. This result is in line with the findings of Ahmad and Singh (2004) and Ariyarathne (1999). The high fruit yield obtained in staked plants could be reflected to the higher mean fruit weights recorded by staking in Table 3.

For pruning, two-stem and unpruned plants produce lower fresh fruit yield while three-stem plants produced the highest. The total fresh fruit yield in tow-stem plants was not significantly higher than in the unpruned, probably because the plants (two-stem) were heavily pruned such that the

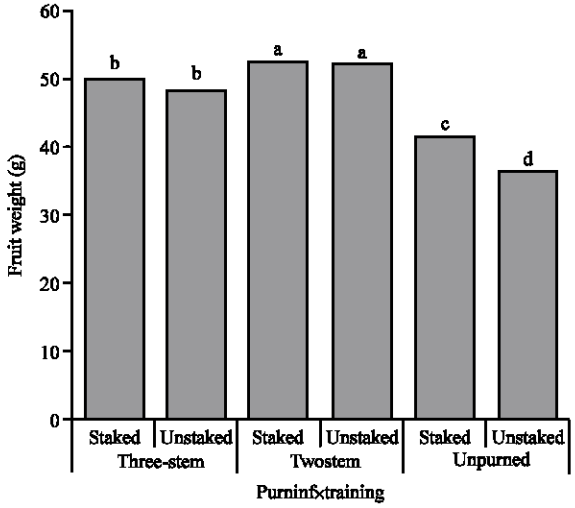

Fig. 1: Mean fruit weight of tomato as influenced by pruning×training interaction in the two years combined. Bars with same letter(s) are not significantly different at 5% level using DMRT

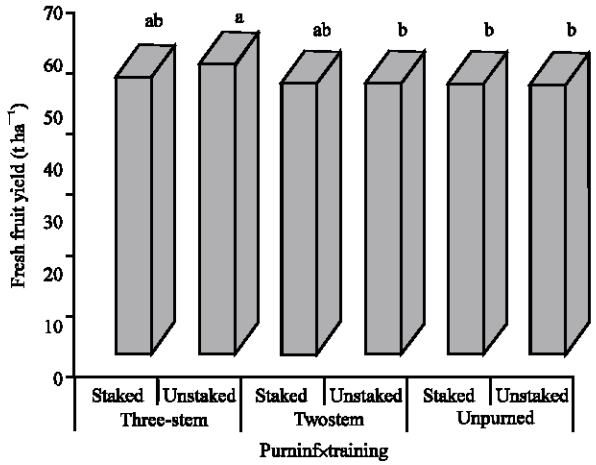

Fig. 2: Total fruit fresh weight as influenced by training and interaction in the two years combined. Boxes with same letter(s) are not significantly different using DMRT at 5%

pruning advantages-i.e., increase fruit size and mean fruit weight (Maynard, 2000) could not outweigh the unpruned advantage-i.e., high number of fruits per plant. But the moderately pruned (three-stem) plants had higher fruit size, mean fruit weight and relatively comparable number of fruit to the unpruned, as a result, the three-stem plants out yielded both unpruned and two-stem plants significantly (Fig. 2). Rafi (1996) and Myanmar (1999) reported the same.

Percentage Marketable Yield

Significantly larger percentage of marketable fruits in the first trial (Table 4) were produced in staked (72.73%) plants compared with the unstaked (67.68%). More so, in the combined analysed result, staked treatment yield 77.17% fruits that were marketable compared with only 66.20% produced by the unstaked plants. This result is in line with the recommendation of the advisory

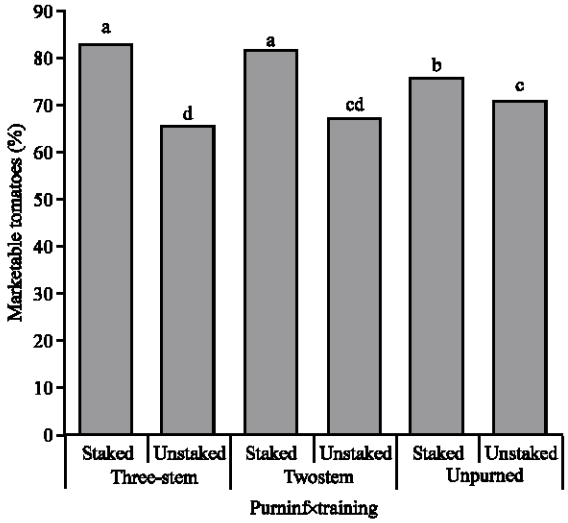

Fig. 3: Percentage marketable yield of tomato as influenced by training and pruning interaction in 2004/05 cropping season Bars with same letter (s) are not significantly different at 5% level using DMRT

Table 4: Percentage marketable yield as influenced by training and pruning in 2004/05 and 2005/06 cropping seasons and the two years combined

	Percentage marketable yield (%)		
Treatments	2004/05	2005/06	Combined
Training			
Staked	79.73	73.42	77.17
Unstaked	67.68	66.67	66.20
SE of mean	1.13	4.64	3.06
Significance	S	NS	S
Pruning			
Three-stem	74.00	71.41	72.15
Two-stem	74.12	69.21	71.67
Unpruned	72.99	69.52	71.25
SE of mean	1.04	2.85	1.38
Significance	NS	NS	NS
Interaction			
Training×Pruning	S	NS	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

committee on vegetable crops of the United States (Ahmad and Singh, 2005) which stressed that one of the advantages of staking tomato plant is to increase the percentage of marketable fruits, by preventing fruits from touching the soil and thus reduces rotting and incidence of soil-borne diseases (Chen and Lal, 1999).

Pruning did not have significant effect on the percentage marketable yield in both trials and the combined. This result confirmed the report by Rafi (1996) and Rawshan (1996), but contradicts Zhang (1999) who reported that unpruned plants produced the highest percentage marketable yield than pruned plants. The interaction between training and pruning (Fig. 3) in the first trial, showed that highest percentage marketable yield was obtained in staked and pruned (both three and two-stem) plants (Fig. 3).

CONCLUSIONS

From the findings of this study particularly on yield (total fresh fruit yield) and yield components (fruit size and mean fruit weight), it could be concluded that staking, coupled with three-stem pruning increases tomato yield and quality.

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