Growth and Yield of three Varieties of Tomato as Influenced by Staking and Spacing

***Ajayi, E. O., Tairu, F. M. and Akinleye, O. C.**

National Horticultural Research Institute, P.M.B 5432, Idi-Ishin, Jericho. Ibadan
**Corresponding author: oluwakayodefunmi@gmail.com*

Abstract
A field experiment was conducted between May and August, 2016 at the National Horticultural Research Institute (NIHORT), Ibadan to determine varietal performance of staked and unstaked tomato at different spacing. The study was a 3x2x3 split-split-plot experiment fitted into randomized complete block design (RCBD) with four replications. Three varieties of tomato (UC82B, Tropimech and Ibadan Local) were the main-plot, staking (staking and no staking) served as the sub-plot and the sub-sub-plots were three different spacing (60cm x 30cm, 60cm x 45cm and 60cm x 60cm). Growth and yield data collected were subjected to analysis of variance (ANOVA) and significant means were compared using the least significant difference (LSD). The results indicated that Ibadan local was significantly shorter compared to UC82B and Tropimech but produced significantly higher number of leaves and branches. Unstaked tomato produced significantly higher number of leaves compared to staked tomato but average fruit weight and marketable fruit weight of staked tomato was significantly higher than unstaked tomato. Tomato planted at 60cm x 60cm produced fruits with significantly higher average weight of 49 g than those planted at 60cm x 45cm (43.7g) and 60cm x 30cm (43. 6g). On the other hand, fruit weight and fruit yield of tomato planted at 60cm x 30cm was significantly higher than those planted at 60cm x 45cm and 60cm x 30cm. It could therefore be concluded that Ibadan local produced the highest fruit yield, likewise staked tomato produced more fruit yield and tomato planted at 60cm x 30cm produced more fruit yield.
Keywords: *fruit yield, Spacing, Staking, Tomato, varieties.*

INTRODUCTION

Tomato (*Solanum lycopersicum* L. Miller) is an economically important crop worldwide. It belongs to the family *Solanaceae* and it's a native of Peru Ecuador region (Jenkins, 1948). It is normally a self-pollinated crop. It ranks 16th among vegetables in relative concentration of vitamins and minerals and most highly priced and consumed widely. Tomatoes are rich sources of vitamins A and C, potassium and fiber. They are rich in lycopene (Dimascio *et al.,* 1989; Trinklein, 2010). Yield and quality of tomato could be improved through the use of improved crop cultural practices. Trinklein (2010) showed that proper spacing and staking are essential for healthy plants and good fruit production. Tomato variety is classified according to growth type (determinate and indeterminate), determinate varieties do not require stake as the indeterminate varieties because they continue to grow and produce fruit year round except they are killed by the harsh weather (Hanson *et al.,* 2000). It is necessary for indeterminate

variety to be supported with local material such as woods or bamboo that can be afforded by both small and large scale farmers. Staking is a means of providing supports to ensure clean and unblemished fruits which kept fruits off from the ground, minimizing diseases and rotting of fruits thereby increasing marketable yield. Staking improves marketable yield, fruit set and fruit quality and also makes harvesting easier, staked plants are less likely than unstaked plants to get diseases. Akoroda *et al.* (1990) and Trenbath (1976) supported the idea of staking because it facilitates harvesting of vegetable and pods and also exposes the leaves for effective light reception. Spacing affects growth, yield and quality of tomatoes

ISSN 978-978-54729-6-7
THEME: "Horticulture for Improved Food Security, Sustainable Environment and National Economic Growth
18th – 22nd November, 2018

as well as pest and disease prevalence. Spacing is among the management practices which greatly influence tomato fruit yield (Lemma *et al.,* 1992; Mehla *et al.,* 2000; Abdel-Mawgoud *et al.,* 2007). Appropriate spacing can help to mitigate attack from disease and to obtain early or delayed harvest depending on the demand and market price. Appropriate spacing can also help to obtain early or delayed harvest depending on the demand and market price, wider spacing (60 cm X 50 cm) gave higher marketable yield (82.39 t/ha) than closer spacing of 60 cm x 40 cm (Ara *et al.,* 2007). Wider spacing minimizes competition for nutrients, water and radiation (Wasserman, 1985; Cochlar and Joseph, 1986). Muhammad and Singh (2007) further showed that greater circulation of air and interception of light by plants resulting in lower incidence of diseases and pests at wider spacing. Appropriate spacing is however in relation to variety, soil fertilization and other cultural practices, including season of production. Proper spacing is also crucial to allow light penetration to the lower leaves of the plants. The aim of this experiment was therefore to determine the varietal performance of staked and unstaked tomato at different spacing.

MATERIALS AND METHODS

The study was conducted between May and August, 2016 at the Vegetable Research field of National Horticultural Research Institute (NIHORT), Ibadan, Nigeria ($7^{0}23^{1}$N and $3^{0}54^{1}$E 168 m a.s.l.), located in the forest agro-ecological zone of Nigeria with bi-modal rainfall pattern. The study was a 3 x 2 x 3 split-split-plot experiment fitted into randomized complete block design (RCBD) with four replications. Three varieties of tomato (UC82B, Tropimech and Ibadan Local) were the main-plot while staking (staking and no staking) served as the sub-plot and the sub-sub-plots were three different spacings which included 60 cm x 30 cm, 60 cm x 45 cm and 60 cm x 60 cm corresponding to 55,555, 37,037 and 27,777 plants per hectare respectively.

Land preparation was done mechanically by ploughing, harrowing and bedding. Seeds of tomato obtained from NIHORT and commercial seed store were sown in the nursery on 7th April, 2016 and transplanted on 5th May, 2016 at different spacing based on the treatment. The plot size was 5 m x 0.6 m (3 m^2). Hand weeding was done three times using hoe at 3, 6 and 9 weeks after transplanting (WAT). NPK 15-15-15 was applied at the rate of 120 kgN/ha, this was applied 3 WAT. Data collected on plant height, number of leaves, number of branches, leaf length, number of fruit/plant, fruit weight/plant, and fruit yield/ha were subjected to analysis of variance (ANOVA) using the SAS programme (SAS, 1990). Significant means were compared using the least significant difference (LSD) at 5% probability level

RESULTS AND DISCUSSION

Tomato production is difficult in an open field under rain fed condition, employing appropriate field and disease management practices such as the use of spacing, pruning, staking, ridging, fertilization along with tolerant varieties can however help to produce tomatoes under rain fed (Dessie and Dejen, 2015). Yield and quality of tomato could be improved through the use of improved crop cultural practices. Trinklein (2010) showed that proper spacing and staking are essential for healthy plants and good fruit production. Results from this study indicated that no significant difference existed between UC82B and Tropimech varieties of tomato in terms of plant height and leaf length while Ibadan local was significantly shorter in terms of height and

ISSN 978-978-54729-6-7
THEME: "Horticulture for Improved Food Security, Sustainable Environment and National Economic Growth
18th – 22nd November, 2018

leaf length (Table 1). This may be attributed to the fact the varieties used were determinate type which cease growth at the onset of reproductive phase. This finding corroborated that of Hanson *et al.,* 2000 who opined that determinate varieties do not require stake as the indeterminate varieties because they continue to grow and produce fruit year round except they are killed by the harsh weather. Ibadan local produced significantly higher number of leaves compared to branches than UC82B and Tropimech while the later were comparable with each other in terms of number of leaves but UC82B produced significantly higher number of branches compared to Tropimech (Table 1).

Staking had no significant effect on plant height and number of branches of tomato, whereas unstaked tomato produced significantly higher number of leaves and longer leaves compared to staked tomato (Table 1). This could be due to the fact that the tomato varieties planted were determinate plant which stopped growing upon reaching reproductive stage and this made the staked plant not to be significantly taller than unstaked ones. Spacing significantly affected plant height, number of leaves and leaf length of tomato. Tomato planted at 60 cm x 30 cm produced significantly taller plants with significantly higher number of leaves and longer leaves while tomato planted at 60 cm x 45 cm and 60 cm x 60 cm were comparable with each other in terms of plant height, number of leaves, number of branches and leaf length (Table 1). This could probably be due to the fact that inter plant competition among tomato planted at closer spacing was high to the extent that they struggled to reach for sunlight there by making the plants to grow taller than those planted at wider spacing.

From this study, Ibadan local produced significantly higher average fruit weight (48.75 g), marketable (5.71 t/ha) and unmarketable (2.41 t/ha) and total fruit yield (8.12 t/ha) but unmarketable fruit weight produced by UC82B (1.98 t/ha) was comparable with that of Ibadan local (Table 2). This study also revealed that staking significantly affected average fruit weight and marketable fruit weight of tomato, average fruit weight and marketable fruit weight of staked tomato was significantly higher than unstaked tomato while unmarketable fruit weight and total fruit yield were not significantly affected by staking (Table 2). This may be due to the fact that staked tomato were properly exposed to sunlight for photosynthesis unlike the unstaked plants that intra-plant competition may restrict access to sunlight thereby reducing the amount of sunlight intercepted by the plants. This is in accordance with the work of Dessie and Dejen (2015) that staking improves marketable yield, fruit set and fruit quality and also makes harvesting easier. Staked plants are less likely than unstaked plants to get diseases.

Yield and fruit size of tomatoes are influenced by many factors, including plant spacing and pruning (Jeanine and Edmund, 1993). Spacing is among the practices to improve yield and quality and critical for disease development and dissemination. Spacing affects growth, yield and quality of tomatoes as well as pest and disease prevalence (Dessie and Dejen, 2015). According to Abdel-Mawgoud *et al* (2007), spacing is among the management practices which greatly influence tomato fruit yield. Lemma *et al* (1992) also reported that plant spacing greatly influenced fruit yield in both fresh market and processed tomatoes. Likewise, Godfrey-Sam-Aggrey *et al* (1985)

ISSN 978-978-54729-6-7
THEME: "Horticulture for Improved Food Security, Sustainable Environment and National Economic Growth
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and Mehla *et al* (2000) reported that yield parameters in tomato have been highly influenced by spacing. Results from this study indicated that spacing significantly affected fruit yield and average fruit weight of tomato, tomato planted at wider spacing (60 cm x 60) cm produced fruits with significantly higher average weight of 49 g than those planted at 60 cm x 45 cm (43.7 g) and 60 cm x 30 cm (43. 6 g) which were comparable with each other (Table 2). This may be due to the fact wider spacing minimizes inter-plant competition for nutrients, water and radiation as reported by Wasserman (1985); Cochlar and Joseph (1986). Muhammad and Singh (2007) further showed that greater circulation of air and interception of light by plants resulting in lower incidence of diseases and pests at wider spacing. On the other hand, fruit weight (i.e. marketable and unmarketable) and fruit yield of tomato planted at 60 cm x 30 cm was significantly higher than those planted at 60 cm x 45 cm and 60 cm x 30 cm which were not significantly different from each other (Table 2). This could be due to higher plant population per plot at closer spacing than at wider spacing as reported by Jia (1992). Moreover, closer spacing, according to Mbinga (1983) might have enabled maximized use of the applied nutrients better than the wider spacing.

CONCLUSION

Among the three varieties of tomato used in this study, Ibadan local produced the highest fruit yield, likewise staked tomato produced more fruit yield than unstaked tomato and tomato planted at closer spacing (60 cm x 30 cm) produced more fruit yield than those planted at other spacing. It could therefore be recommended that for optimum yield, tomato should be staked and planted at spacing of 60 cm x 30 cm.

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18th – 22nd November, 2018

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ISSN 978-978-54729-6-7
THEME: "Horticulture for Improved Food Security, Sustainable Environment and National Economic Growth
18th – 22nd November, 2018

Table 1: Growth Parameter of three tomato varieties as affected by staking and spacing

Treatment	Plant height (cm)	Number of leaves	Number of branches	Leaf length (cm)
Variety				
UC82B	53.89	20.97	4.93	27.94
Tropimech	52.79	21.32	3.83	26.81
Ibadan local	45.00	26.82	5.54	24.57
LSD	2.35	1.94	0.39	1.72
Staking				
Staked	50.41	22.00	4.71	25.90
Unstaked	50.40	24.07	4.81	27.03
LSD	1.92	1.58	0.32	1.40
Spacing				
60 cm x 30 cm	54.32	24.80	4.93	27.71
60 cm x 45 cm	48.62	21.91	4.52	25.70
60 cm x 60 cm	48.72	22.40	4.83	25.93
LSD	2.35	1.94	0.39	1.72
F Sig. ($P \leq 0.05$)				
Variety (V)	**	**	**	**
Staking (St)	ns	*	ns	Ns
Spacing (Sp)	**	**	ns	*
V × St	ns	*	**	Ns
V × Sp	**	**	ns	Ns
St × Sp	ns	ns	*	Ns
V × St × Sp	ns	**	ns	Ns

*,** indicate significance effect of the treatment at 5% and 1% probability level.
ns mean not significant
V means variety, St means Staking while Sp means Spacing

ISSN 978-978-54729-6-7
THEME: "Horticulture for Improved Food Security, Sustainable Environment and National Economic Growth
18th – 22nd November, 2018

Table 2: Fruit weight of three tomato varieties as affected by staking and spacing

Treatment	Average Fruit weight (g)	Marketable fruit weight (t/ha)	Unmarketable fruit weight (t/ha)	Fruit yield (t/ha)
Variety				
UC82B	42.34	3.25	1.98	5.23
Tropimech	45.22	3.93	1.32	5.26
Ibadan local	48.75	5.71	2.41	8.12
LSD	3.34	0.84	0.61	1.16
Staking				
Staked	48.60	4.86	2.07	6.60
Unstaked	42.30	3.74	1.73	5.81
LSD	2.73	0.70	0.50	0.95
Spacing				
60 cm x 30 cm	43.55	5.13	2.52	7.70
60 cm x 45 cm	43.74	3.72	1.50	5.21
60 cm x 60 cm	49.00	4.04	1.70	5.73
LSD	3.34	0.84	0.61	1.16
F Sig. ($P \leq 0.05$)				
Variety (V)	ns	**	**	**
Staking (St)	**	**	ns	Ns
Spacing (Sp)	**	**	**	**
V × St	ns	ns	ns	Ns
V × Sp	**	ns	ns	Ns
St × Sp	**	ns	ns	Ns
V × St × Sp	**	ns	ns	*

*, ** indicate significance effect of the treatment at 5% and 1% probability level.
ns mean not significant
V means variety, St means Staking while Sp means Spacing

ISSN 978-978-54729-6-7
THEME: "Horticulture for Improved Food Security, Sustainable Environment and National Economic Growth
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