Journal of Agriculture and Environment Vol. 6 Nos.1&2, 2010: 91-98
ISSN 1595-465X

GROWTH AND YIELD OF TOMATO (*Solanum lycopersicum* Mill.) AS INFLUENCED BY INTER-ROW SPACING AT SOKOTO-RIMA VALLEY, NIGERIA

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ABSTRACT

Field experiments were conducted during 2003/2004 and 2004/2005 dry seasons at the *Fadama* Teaching and Research Farm of the Usmanu Danfodiyo University, Sokoto (latitude 13°9 and longitude 5°13'; 300 m above sea level) to study the effects of inter-row spacing on the growth and yield of two tomato cultivars (Roma VF and UC 82B). Treatments consisted of four inter-row spaces (40, 60, 80 and 100 cm) and two cultivars of tomato (Roma VF and UC 82B) laid out in a randomized complete block design (RCBD) replicated three times. The two cultivars showed marked significant response in leaf area index, days to 50% flowering and dry stover weight, which were more pronounced in Roma VF cultivar than UC 82B cultivar. Results also revealed that increase in economic yield per hectare of tomato was recorded in the closer inter-row spacing (40cm) of tomato in both years. It could be concluded that closest inter-row space of (40 cm) increased the economic yield of tomato under irrigation in the study area.

Keywords: Inter-row spacing; Tomato; Growth and yield

INTRODUCTION

Tomato (*Solanum Iycopersicum*) is a vegetable of immense popularity and acceptance in Nigeria. It is widely cultivated around the Guinea and Sudan savanna ecological zones. It holds industrial promise as a source of raw material. Adams *et al*. (1984), Ariyarathyne (1989) and Bodunde (1993) confirmed that large chunk of total production in Nigeria goes into culinary uses in homes. Baffur (1988) and Donald (2006) as well as Choudhury (2007) reported that the crop gained access into African region since 16th century and West African sub region in the 18th century through the Portuguese and Arab traders. It is now the most widely cultivated vegetable crop in the world, giving growers income, expanding export potential and improving the supply of vitamins and minerals in human nutrition (Zhang, 2005). The edible part represents 94% of the total weight of the fruit. It contains (Per 100g) 93.8g water, 12g protein, 4.8g carbohydrate (including 0.7g cellulose), 7mg calcium, 0.6mg iron, 0.5mg carotene, 0.06mg thiamine,

0.04mg riboflavin, 0.6mg niacin and 23mg vitamin C. The energy value is 83kj (or 20 kcal) 100 g^{-1} (Brown, 1984; Romain, 2001). Tomatoes are rarely eaten fresh (raw); consumers globally prefer to use them as cooked (pastes) in the preparation of sauces (Romain, 2001). In Nigeria, the crop gains popularity and where it holds a promise as source of raw material for puree (canned tins) as tomapep along with culinary utilization in homes (Bodunde, 1993; Kadams *et al.*, 2001; IAR, 2003).

Majority of tomato growers in Nigeria are mostly peasant farmers that do not attach much importance to recommended agronomic practices for tomato production (for examples inter row spacing and use of improved varieties) (Bodunde, 1993). In Nigeria and Sokoto Fadama flood plains in particular, the common spacing often used by farmers is 1m (Anon, 1994a). This produces 6700-10,000 plants per hectare. It may be one of the reasons for the low yield being obtained from tomato farm units in the area. This in no small measure affects the per hectare return (low yield) of the crop in the country (17 t ha^{-1}) when compared with yield obtained in other African countries (South Africa-68.8 t ha^{-1}, Morocco-58.8 t ha^{-1}, Egypt-38.9 t ha^{-1}) (FAOSTAT, 2006). Thus, this research would furnish farmers with the necessary information on the right inter-row spacing to adopt in order to obtain higher yield in tomato.

MATERIALS AND METHODS

The experiment was conducted in the dry seasons of 2003/2004 and 2004/2005 at the Fadama Teaching and Research Farm, Usmanu Danfodiyo University at Kwalkwalawa Village, Sokoto. Sokoto falls in the Sudan savanna agro-ecological zone of Nigeria (Lat. 13°01' N:, Long. 05° 15'E) at an altitude of 350 m above sea level with a mean annual rainfall of about 752 mm (Kowal and Knabe, 2002).

The experimental site is a low-lying flat land, located along the Sokoto River valley. Soil samples from the site were collected at the depth of 0-30cm for physical and chemical analysis. Results of the soil analysis indicated the soils as slightly acidic (pH 4.9), loose in texture (silt = 214 gm kg^{-1}) with a moderate water holding capacity (EC 19.4c mg kg^{-1}). The soil is further endowed with an appreciable concentration of potassium (2.75 g kg^{-1}), nitrogen (0.043 g kg^{-1}), phosphorus (0.025 ppm) and magnesium (1.04 g kg^{-1}) with C.E.C of 19.6 Cmol kg^{-1}. The treatments consisted of four inter-row distances (40, 60, 80 and 100 cm) and two tomato cultivars (UC 82B and Roma VF), which were factorially combined, laid out in randomized complete block design (RCBD) and replicated three times. Other cultural operations were carried out as and when necessary. Five plants were randomly ear-marked for the measurement of agronomic parameters which included stand establishment count, plant height, leaf area index, stem diameter, days to 50% flowering, mean weight of fruit, Mean fruit diameter, total fruit yield and haulm weight at harvest. Data generated from the experiments were subjected to the analysis of variance (ANOVA) procedure for Randomized Complete Block Design (RCBD) (Gomez and Gomez, 1984), using Statistical Analysis System (SAS 2003). Means separation was carried out using the Least Significant Difference (LSD) test.

RESULTS AND DISCUSSION

Stand Establishment Count

Results in Table 1 indicated that there was no significant difference ($P>0.05$) between Roma VF and UC 82B in the two cropping seasons sequel to varied inter-row spacing. The same trend was reported by Frabbel (2004), who attributed this to their botanical affinities.

There was significant effect ($P<0.05$) of inter-row spacing on stand count of tomato. This was expected because of the variation in the row spacing as prescribed by the treatments, i.e., 40 cm produced significantly the highest number of stands followed by 60 cm, 80 cm and 100, respectively. This could be as a result of closer spacing, hence higher yield was recorded where higher numbers of stands were obtained and vice versa. The same result was obtained by (Adetayo and Fawusi, 1988). The trend was the same in 2004/2005 trial.

Plant Height

There was no significant difference in the plant height of the cultivars in both seasons. Similar results have been reported by Ariyaratne (1989) and Wassermann (2005).

Inter-row spacing had significant effect ($P<0.01$) on plant height in both seasons (Table 1). The highest plant height was obtained in the closest inter-row spacing of 40 cm, followed by 60 cm, 80 cm and 100 cm, respectively. The tendency of the crop to have increase in height was influenced by the plant population (density) otherwise referred to as etiolation, as opined by Brown (1984). Hernandez (1992) and Wassermann (2005), who stated that planting density influences competition for resources such as sunlight, carbon dioxide, soil moisture and nutrients in an attempt by the plant to spread and to avoid mutual shading from the neighbouring plants hence the upward growth continues competitively and therefore height increases. This therefore explains why plants of dense stands tend to be taller than the widely-spaced plants (Romain, 2001).

Stem Diameter

The results (Table 3) indicated the effect of cultivar on mean stem diameter in all the cropping seasons was not significant. Also, the effect of inter-row spacing to the mean stem diameter was not significant in the two cropping seasons.

Leaf Area Index

The results (Table 3) showed that the effect of cultivar on Leaf Area Index was not significant in both seasons. The effect of inter-row spacing on Leaf Area Index was also not significant.

Days to 50% Flowering

The result (Table 3) indicated that the effect of cultivar on days to 50% flowering was not significant ($P<0.05$) in the two cropping seasons. Variety UC 82B took lesser number of days to attain 50% flowering than Roma VF, because UC 82B showed more adaptive tendency to Sokoto environment than Roma VF. The same opinion was reported by Muhammed and Singh (2007).

Table 1: Effect of inter-row spacing on growth and days to 50% flowering of tomato

Inter-row spacing	ESt. count (Plants ha^{-1})	Plant height (cm)	Stem diameter (cm)	Leaf area index	Days to 50% flowering
			2004		
40	54509^{a}	62.7^{a}	1.73	2.54	54.5^{a}
60	41675^{b}	58.8^{b}	1.79	2.34	48.0^{b}
80	27354^{a}	55.9^{c}	1.85	2.28	43.2^{c}
100	20936^{a}	54.6^{d}	1.85	2.13	41.7^{d}
SE ±	599.6	0.34	0.027	0.031	0.52
			2005		
40	54111^{a}	62.7^{a}	1.72	2.47	53.8^{a}
60	40786^{b}	58.8^{b}	1.79	2.34	47.7^{b}
80	27029^{a}	55.9^{c}	1.80	2.26	43.3^{c}
100	20526^{a}	54.6^{d}	1.82	2.13	44.0^{c}
SE ±	624.5	0.34	0.020	0.032	0.63

Within a year, means in a column followed by same letter (s) in superscript are not significantly different (P>0.05); Ns=Not significant

Table 2: Effect of inter-row spacing on yield and yield components of tomato at Sokoto fadama

Inter-row spacing	No of fruits per plant	Mean fruit diameter (cm)	Mean fruit weight (kg)	Dry stover weight (kg ha^{-1})	Fruit yield (kg ha^{-1})
			2004		
40	22.67^{d}	3.93^{b}	0.143^{d}	5426^{a}	53550^{a}
60	26.00^{c}	4.40^{c}	0.162^{c}	5159^{b}	45008^{b}
80	28.42^{b}	4.77^{b}	0.170^{b}	4225^{c}	36542^{c}
100	33.00^{a}	5.42^{a}	0.185^{a}	4099^{d}	31988^{d}
SE ±	0.458	0.039	0.0014	22.4	415.4
			2005		
40	20.25^{d}	3.79^{d}	0.134^{c}	5342^{a}	52599^{a}
60	22.83^{c}	4.33^{c}	0.149^{b}	5134^{b}	44798^{b}
80	24.67^{b}	4.63^{b}	0.157^{a}	4218^{c}	36508^{c}
100	27.08^{a}	5.33^{a}	0.166^{a}	4099^{d}	31833^{d}
SE ±	0.467	0.069	0.0034	25.2	462.7

For each year, means in a column followed by same letter (s) in superscript are not significantly different (P>0.05)

The effect of inter-row spacing on days to 50% flowering was highly significant (P<0.01) in the two cropping seasons. Performance of the two cultivars as influenced by inter-row spacing was found to be statistically different during the two seasons except 80 cm and 100 cm in 2004/2005, which were statistically similar. It was noticed that, the wider the inter-row spacing (100 cm) the lesser the days to 50% flowering while the closer the spacing thehigher the number of days to 50% flowering. This trend may not be unconnected with availability of nutrients, sunlight and moisture in the wider spacing because of less competition in contrast to what was obtained in closer distances of 40, 60 and 80 cm, respectively. This finding was further supported by workers such as Baffaur (1988), Komolafe, (1985) and Romain, (2001).

Number of Fruits per Plant

The effect of variety on the number of fruits produced per plant was not statistically significant during the 2003/2004 and 2004/2005 seasons (Table 4). However, the effect of inter-row spacing on the number of fruits per plant was highly significant (P<0.01) during the two cropping seasons (Table 2). The highest number of fruits per plant was obtained in the 100 cm inter-row spacing, followed by 80, 60 and 40 cm, respectively in both seasons. The widest inter-row spacing of 100 cm significantly out-yielded (33 fruits/ plant) the closest spacing of 40 cm (22 fruits/ plants) in 2003/2004. This trend was often determined by the level of competition for resources existing between these two contrasting spaces. On per plant basis, the widest spaced (100 cm) yielded better than closely spaced (40 cm) tomato, however, on per hectare basis, closer spacing (40 cm) yielded higher (53550 kg ha^{-1}). This assertion was supported by workers such as Komolafe (1985); Baffour (1988); Myanmar (1999) and Romain (2001), who unanimously agree that for economic yield derivation closer spacing is employed.

Table 3: Effect of variety on growth and days to 50% flowering of tomato

Variety	Est. count ($pltha^{-1}$)	Plant height (cm)	Stem diameter (cm)	Leaf area index	Days to 50% flowering
			2004		
Roma VF	36163	57.7	1.79	2.29	46.6^{b}
UC82B	36069	58.2	1.83	2.36	47.1^{a}
SE ±	424.0	0.24	0.019	0.022	0.36
			2005		
Roma VF	35801	57.7	1.78	2.27	47.1
UC82B	35425	58.2	1.78	2.24	47.3
SE ±	441.0	0.24	0.014	0.023	0.44

Within a year, means in a column followed by same letter (s) in superscript are not significantly different (P>0.05)

Fruit Diameter

The effect of variety on fruit diameter per plant was not significant during the two cropping seasons (Table 4). Despite the non-significant effect exhibited by the varietal class on the fruit diameter because of their botanical affinity, there existed some difference in the performance of the two varieties, whereby Roma VF displayed greater fruit diameter than UC 82B.

The effect of inter-row spacing on the fruits diameter per plant was highly significant ($P<0.01$) during the 2003/2004 and 2004/2005 cropping seasons (Table 2). The results also revealed that higher mean fruit diameter was obtained in widest spacing (100 cm) than in closely spaced crop (40 cm). This might not be unconnected with low level of competition for resources in wider spacing of 100 cm than was obtained in closer spacing. This view was further supported by workers such as Romain (2001) and Wassermann (2005).

Fruit Weight at Harvest

The effect of variety on mean weight of fruit at harvest was not significant during the cropping seasons of 2003/2004 and 2004/2005 (Table 4).

Inter-row spacing had significant ($P<0.01$) effect on fruit weight at harvest in both seasons (Table 2). The highest mean fruit weight at harvest was obtained in the widest spacing of 100 cm followed by 80, 60 and 40 cm, respectively during the two cropping seasons. This observation might not be unconnected with the available spaces prevalent in wider spacing than in closer spacing which favoured competitive survival and hence heavier fruits than was obtained in closer inter-row spacing. This assertion was supported by Philips (1977); Komolafe (1985); Baffaur (1988); Valadex (1992) and Romain (2001).

Dry Stover Weight

The effect of variety on dry stover weight was highly significant ($P<0.01$) during both seasons (Table 3). Higher dry stover weight per hectare was recorded in UC 82B cultivars compared to Roma VF during the 2003/2004 and 2004/2005 cropping seasons. This may be attributed to higher dry matter accumulation in UC 82B cultivar as reported by Romain (2001), alongside favourable adaptational features of the cultivar to the experimental area (Anon., 1994b).

Effect of inter-row spacing was highly significant on the dry stover weight in both seasons (Table 2). The highest dry stover weight per hectare was obtained from 40 cm inter-row spacing followed by 60 cm, 80 cm and 100 cm inter-row spacing. This may not be unconnected with the plant density, which tends to be highest in closer spacing than wider spacing as reported by Messain (1994), Arnold (2002) and Frabbel (2004).

Fresh Fruit Yield

The effect of variety on the yield performance of tomato cultivars per hectare was significant ($P<0.01$) during the two seasons (Table 4). Variety Roma VF gave higher yield in both seasons. Yielding potential of the two cultivars during the two cropping seasons conformed with the botanical rhythm of the two cultivars as was supported by the findings of Kochhar and Joseph (1985) and Anon. (1994b). The effect of inter-row spacing on fresh fruit yield per hectare was highly significant ($P<0.01$) during the two cropping seasons (Table 1). The results showed that the closest inter-row spacing of 40 cm yielded highest

(53, 550 kg ha^{-1}) followed by 60 cm (45,008 kg ha^{-1}) 80 cm (36,542.3 kg ha^{-1}) and 100 cm (31,988.0 kg ha^{-1}) respectively. Higher yield obtained in the closer spacing on the per hectare basis confirmed the findings of many workers notably Komolafe (1985), Baffour (1988) and Romain (2001).

Table 4: Effect of variety on growth and yield of tomato at Sokoto fadama

Variety	No of fruits per plant	Mean fruit diameter (cm)	Mean fruit weight (kg)	Dry stover weight (kg ha^{-1})	Fruit yield (kg ha^{-1})
			2004		
Roma VF	27.83	4.68	0.167	4671^{b}	42381^{a}
UC82B	27.21	4.58	0.630	4784^{a}	41164^{b}
SE ±	0.820	0.028	0.0010	15.8	293.8
			2005		
Roma VF	23.96	4.56	0.154	4630^{b}	41877^{a}
UC82B	23.46	4.47	0.149	4767^{a}	40992^{b}
SE	0.330	0.048	0.0024	17.8	327.2

For each year, means in a column followed by same letter (s) in superscript are not significantly different (P>0.05)

CONCLUSIONS

From the findings of this study it could be concluded that inter-row spacing and variety play a significant role in determining the performance of tomato. Furthermore, for higher economic yield, tomato cultivar Roma VF at inter-row spacing of 40 cm is recommended under irrigation in the Sudan Savannah agro-ecological zone of Nigeria.

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