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Eeffects of Planting Density and NPK Fertilizer on Growth and Fruit Yield of Tomato (*Lycospersicon esculentus* Mill)

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Abstract: Effects of planting density and NPK fertilizer application on growth and fruit yield of tomato were carried in 2003 and 2004 at Evboneka, Nigeria was carried to determine the appropriate planting density and fertilizer rate for tomato. This study involved two trials. In the first trial, seven cultivars were evaluated in the field at two levels of NPK fertilizer (0 and 200kg ha^{-1}). In the second trial, effects of three planting densities (33333, 41667 and 55556 plants ha^{-1}) and three levels of NPK fertilizer (0, 200 and 400kg ha^{-1}) on the growth and yield of three cultivars of tomato were determined. The highest yielding and most responsive cultivar to fertilizer application was TI 106 (13.63t ha^{-1}) followed by TI 468 (11.41t ha^{-1}) and local was the least (6.57t ha^{-1}). The planting density and fertilizer application rate increased fruit yield, leaf area index, crop growth rate, relative growth rate and net assimilation rate. The plants grown under high planting density and fertilizer rate achieved this efficiency through higher degree of foliation and higher net assimilation rate than plants grown under lower planting density and fertilizer rate. The higher leaf area index associated with higher planting density and fertilizer rate elicited corresponding effects on crop growth rate and relative growth rate resulting in higher fruit yield in all the cultivars. A combination of 55556 plants ha^{-1} and 400kg NPK fertilizer was the most efficient in terms of fruit yield and growth indices in all the cultivars.

Key words: Fruit yield, NPF fertilizer, planting density and tomato cultivars

INTRODUCTION

Tomato (*Lycospersicon esculentus*) is an essential component of human diet for the supply of vitamins, minerals and certain types of hormone precursors in addition to protein and energy[1]. Large scale tomato production is found in the northern Guinea and Sudan savanna zones of Nigeria, where relatively high yield could be realized by planting between June and December[2]. It is also grown on small scale in the kitchen garden in the rainfall zone and southern Guinea savanna zones.

Total cultivated area in Nigeria for the production of tomato was 127000 hectares and the production quantity was 889000 tonnes giving an average of 7 tonnes per hectare (t ha^{-1})[3]. Tomato productivity in Nigeria is low when compared to other major producer countries like Niger (22.22t ha^{-1}), Southern Asia countries (18.88t ha^{-1}), China (27.01t ha^{-1}), U.S (69.40 t ha^{-1}) and UK (210.28t ha^{-1}). According to FAO[4], tomato productivity in Nigeria is below Africa average which is 20.51t ha^{-1}. Among the factors that accounted for the low productivity in Nigeria and other tropical countries when compared to the temperate countries are the use of obsolete cultural practices which include using unimproved local cultivars for sowing the crop, scanty plant stands, weed control, non-use of fertilizer, organic manures and other improved agricultural inputs in the management of the crop under degraded soil condition[4].

The cultural techniques which greatly influence tomato fruit yield are planting density, fertilizer application and use of improved cultivars. Many improved tomato cultivars had been developed and high yield cultivars had been imported into the country to boost productivity due to the fact that the local cultivars had been associated with low productivity[2].

The spacing for tomato actually depends on many factors which among others include soil condition, soil fertility, climate, cultivar, methods of planting, incidence of diseases and insect pests[5]. The knowledge of plant responses to planting density provides basis for accessing intra-specific competition[6]. Closer spacing resulted in higher yield; less cracked fruit per plant ($plant^{-1}$) and reduced fruit yield $plant^{-1}$.

It has been proven that chemical fertilizers are an essential input in any system in which the aim is to maintained good yield[5]. Adequate fertilizer application

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is require by tomato for growth and for high yield. Fertilizer application can sustain yield under continuous cropping on most soils.

Lack of research information on the effect of these cultural practices on tomato production is one of the factors that prevent farmers in Nigeria and other tropical countries from using the improved techniques. As the use of adequate levels of nutrients, planting density and improved cultivars are essential factors to increasing the production and yield of tomato and in view of little information available on the response of tomato to these cultural practices and made an attempt to provide the physiological basis underlying the better performance of plants grown under these practices, field experiment was carried out to study the response of various tomato cultivars to different planting densities and NPK 15:15:15 fertilizer application.

MATERIALS AND METHODS

In the first experiment, seven cultivars were evaluated at two levels of NPK fertilizer. The experiment was carried at Evboneka. The site had been under grass fallow for two years. Soil particle analysis revealed that it had 780g kg^{-1} sand, 110g kg^{-1} clay and 110g kg^{-1} silt. The textural class was loam sand. The pre-planting soil chemical analysis showed that it had N 16.2 g kg^{-1}; organic C 1.80 g kg^{-1}; P 7.30 mg kg^{-1}; pH (1:25 and not "had 16.2 g kg^{-1}; 1.80 g kg^{-1}; 7.30mg kg^{-1}; pH (1:2.5" soil : water) 5.70; exchangeable calcium 7.80 Cmol kg^{-1}; exchangeable magnesium 0.60 Cmol kg^{-1} and Exchangeable potassium 0.60 Cmol kg^{-1}.

Seven cultivars used were TI 106, TI 468, TI 539, SAMTOM 7, TI 204, TI 208 and Local. A compound fertilizer, NPK 15:15:15 was applied at two rates, 0 and 200kg ha^{-1} was done in two equal parts, ten days after transplanting (DAT) as basal and the remaining part applied at 50 DAT as top dressing.

The experimental layout was a 7 x 2 factorial design with four replicates. The crop was sown in large tray filled with top forest soil on 26/10/03. After three weeks, the seedlings were transplanted to a well prepared bed in the field and spaced 50 x 60 cm to achieve a planting population of 33333 plants per hectare (pph). Mulching, weeding, irrigation, insecticidal spray, staking and other horticultural operations were done when necessary.

Matured fruits were harvested at weekly interval for assessment of average yield per plants. Fruit yield ha^{-1} was obtained through conversion of the net plot yield.

In the second experiment, TI 106 and 468 cultivars which produced the highest yield and next to it, respectively together with the local cultivar were used. Seeds of these cultivars were first sown in the nursery on 23/10/04 and were transplanted to the field at three weeks after sowing on 23/10/04. The seedlings were spaced at 30 x60, 40 x 60 and 50 x 60cm to achieved plant population of 55556, 41667 and 33333 pph respectively, according to the treatment, NPK 15:15:15 compound fertilizer was applied at three levels, 0, 200 and 400kg ha^{-1} in two equal parts at 10 DAT and at 50 DAT as top dressing. Other cultural practices such as weed, pest and disease control measures were adequately carried out and when necessary.

Three sampling were taken fortnightly starting from 3 weeks after transplanting (DAT). At each sampling, two plants were uprooted at random from their inner rows for determination of leaf area index (LAI) and total dry weight. The samples were separated into leaves, stem and root. The total dry weight was determined using ISTA[7] procedure. From the leaf area and total dry weight, crop growth rate (CGR), relative growth rate (RGR) and net assimilation rate (NAR) was computed according to the methods of Remison[8].

Matured fruits were harvested at weekly intervals. For the assessment of number of fruits per plant and average fruit weight, three randomly selected plants were used. Days to 50% flowering, fruit number $plant^{-1}$ and fruit weight $plant^{-1}$ were recorded on plot basis. Fruit yield ha^{-1} was obtained through conversion of the net plot yield.

Data collected were subjected to analysis of variance using COSTAT programme and significant differences among treatment means were separated using least significant difference (LSD).

RESULTS AND DISCUSSION

Results: In the first experiment, cultivars differed significantly in yield, with the highest yielding cultivars being TI 106 (13.63t ha^{-1}) and TI 468 (11.41t ha^{-1}) in that order (Table 1). The introduced cultivars performed better than the developed cultivar (SAMTOM 7) and the local cultivar. The local cultivar (6.57t ha^{-1}) was the least yielding followed by SAMTOM 7 (6.86t ha^{-1}) (Table 1).

In planting density and fertilizer application trial, leaf area index (LAI) increased as planting density and fertilizer application increased up to 7 WAT in all the cultivars without declining (Table 2). A treatment combination of 55556 pph and 400kg NPK ha^{-1} had the best LAI among the cultivars (Table 2).

The crop growth rate (CGR) generally increased progressively throughout the sampling period. CGR increased as planting density and fertilizer application rate among the cultivars (Table 3).

The influence of planting density and fertilizer application rate on relative growth rate (RGR) is presented in Table 4. The RGR increased as planting

Table 1: Average yield per plant and total yield per hectare tomato as affected by different cultivars and NPK fertilizer application rates.

Cultivars	Average yield plant-1 Fertilizer rate (kg ha-1)			Total yield (t ha-1) Fertilizer rate (kg ha-1)		
	0	200	Mean	0	200	Mean
TI 106	0.37	0.45	0.41	12.30	14.95	13.63
TI 468	0.31	0.37	0.34	10.50	12.32	11.41
TI 539	0.30	0.35	0.33	10.10	11.75	10.93
TI 204	0.24	0.28	0.26	7.89	9.40	8.65
TI 208	0.19	0.26	0.23	6.80	8.75	7.53
SAMTOM 7	0.17	0.24	0.21	5.82	7.90	6.86
Local	0.16	0.23	0.20	5.54	7.60	6.57
Mean	0.25	0.31	0.28	8.49	10.38	9.44
LSD (0.05) Fertilizer rate			0.055			2.021
LSD (0.05) Cultivar			0.055			2.021
LSD (0.05) Fertilizer rate x Cultivar			ns			ns

ns-not significant at 5% level of probability.

Table 2: Leaf area index in three tomato cultivars, three planting densities and three fertilizer application rate at different sampling periods.

Cultivar	Planting density (pph)	3 WAT Fertilizer rate (kg ha^{-1})				5 WAT Fertilizer rate (kg ha^{-1})				7 WAT Fertilizer rate (kg ha^{-1})			
		0	200	400	Mean	0	200	400	Mean	0	200	400	Mean
TI 106	33333	0.03	0.08	0.12	0.08	2.00	2.50	2.81	2.44	3.01	4.15	4.71	3.96
	41667	0.05	0.10	0.15	0.10	2.20	2.71	3.01	2.57	3.50	4.65	5.12	4.42
	55556	0.07	0.15	0.19	0.14	2.30	2.98	3.26	2.85	3.81	4.86	5.65	4.77
Mean		0.05	0.11	0.46	0.21	2.17	2.73	3.03	2.64	3.44	4.55	5.16	4.38
LSD(0.05) Planting density					0.031				0.353				0.521
LSD(0.05) Fertilizer rate					0.031				0.353				0.521
LSD(0.05) Planting density x Fertilizer rate					ns				ns				ns
TI 468	33333	0.02	0.06	0.11	0.06	1.88	2.41	2.68	2.32	2.91	3.82	4.44	3.72
	41667	0.04	0.09	0.13	0.07	2.01	2.53	2.87	2.47	3.21	4.50	4.68	4.13
	55556	0.06	0.11	0.16	0.11	2.17	2.67	2.97	2.60	3.44	4.63	5.01	4.36
Mean		0.04	0.09	0.13	0.09	2.02	2.54	2.84	2.47	3.19	4.32	4.71	4.07
LSD(0.05) Planting density					0.021				0.372				0.531
LSD(0.05) Fertilizer rate					0.021				0.372				0.531
LSD(0.05) Planting density x Fertilizer rate					ns				ns				ns
Local	33333	0.01	0.03	0.08	0.04	1.53	2.00	2.12	1.88	1.21	2.01	2.37	2.20
	41667	0.02	0.07	0.10	0.06	1.60	2.11	2.27	1.99	1.38	2.22	2.46	2.35
	55556	0.04	0.08	0.12	0.08	1.71	2.27	2.37	2.08	1.91	2.48	2.68	2.36
Mean		0.02	0.06	0.10	0.06	1.61	2.13	2.25	1.98	1.50	2.27	2.50	2.09
LSD(0.05) Planting density					ns				0.138				0.138
LSD(0.05) Fertilizer rate					ns				0.138				0.138
LSD(0.05) Planting density x Fertilizer rate					ns				ns				ns

ns- not significant at 5% level of probability

density and fertilizer application rate increase for TI 106 and TI 468 plants only. There were significant changes in RGR with different planting densities and fertilizer rates and increased up to 7 WAT for TI 106 and TI 468 plants only in that order. The local cultivars performed poorly; there were no significant changes in RGR with different planting densities or fertilizer application rates. RGR decreased with plant age in the local plants (Table 4).

Table 3: Crop growth rate in three tomato cultivars, three planting densities and three fertilizer application rates at different age

		3-5 WAT Fertilizer rate (kg ha^{-1})				5-7 WAT Fertilizer rate (kg ha^{-1})			
Cultivars	Planting density (pph)	0	200	400	Mean	0	200	400	Mean
TI 106	33333	0.76	1.86	1.89	1.50	15.59	18.13	18.60	17.44
	41667	0.95	2.33	2.36	1.88	16.80	20.67	21.70	19.72
	55556	1.06	3.10	3.15	2.43	16.96	22.19	21.90	20.35
Mean		0.92	2.43	2.47	1.94	16.45	20.33	20.73	19.17
LSD (0.05) Planting density					0.502				0.723
LSD (0.05) fertilizer rate					0.052				0.723
LSD (0.05) Planting density x Fertilizer rate					ns				ns
TI 468	33333	0.53	1.43	1.76	1.23	12.35	16.16	16.30	15.27
	41667	0.41	2.05	1.93	2.15	13.50	19.17	18.73	17.13
	55556	0.67	2.62	2.53	1.94	13.89	21.68	20.37	18.65
Mean		0.54	2.03	2.06	1.54	13.25	14.94	18.47	15.55
LSD (0.05) Planting density					0.493				2.321
LSD (0.05) fertilizer rate					0.493				2.321
LSD (0.05) Planting density x Fertilizer rate					ns				ns
Local	33333	0.31	0.63	1.10	0.68	4.32	6.85	7.15	6.11
	41667	0.33	0.73	1.22	0.77	4.85	6.93	7.60	6.46
	55556	0.43	0.56	1.53	0.85	4.93	7.43	7.40	6.59
Mean		0.36	0.64	1.28	0.76	4.70	7.07	7.38	6.38
LSD (0.05) Planting density					0.200				0.254
LSD (0.05) fertilizer rate					0.200				0.254
LSD (0.05) Planting density x Fertilizer rate					ns				ns

ns-not significant at 5% level of probability

Table 4: Relative growth rate in three tomato cultivars, three planting densities and three fertilizer application rates at different age

		3-5 WAT Fertilizer rate (kg ha^{-1})				5-7 WAT Fertilizer rate (kg ha^{-1})			
Cultivars	Planting density (pph)	0	200	300	Mean	0	200	400	Mean
TI 106	33333	0.25	0.62	0.63	0.50	0.41	0.72	0.87	0.67
	41667	0.32	0.78	0.79	0.63	0.44	0.78	0.92	0.71
	55556	0.35	0.35	1.05	0.81	0.48	0.83	0.96	0.76
Mean		0.31	0.78	0.82	0.65	0.44	0.78	0.92	0.71
LSD (0.05) Planting density					0.163				ns
LSD (0.05) fertilizer rate					0.163				0.301
LSD (0.05) Planting density x Fertilizer rate					ns				ns
TI 468	33333	0.13	0.32	0.43	0.30	0.31	0.42	0.68	0.47
	41667	0.17	0.32	0.46	0.32	0.33	0.48	0.73	0.51
	55556	0.20	0.43	0.50	0.38	0.38	0.51	0.79	0.56
Mean		0.17	0.36	0.46	0.33	0.34	0.47	0.73	0.51
LSD (0.05) Planting density					ns				ns
LSD (0.05) fertilizer rate					0.463				0.442
LSD (0.05) Planting density x Fertilizer rate					ns				ns
Local	33333	0.02	0.06	0.08	0.05	0.01	0.06	0.04	0.04
	41667	0.04	0.07	0.09	0.07	0.02	0.06	0.06	0.05
	55556	0.06	0.09	0.09	0.08	0.04	0.08	0.05	0.06
Mean		0.04	0.07	0.09	0.07	0.02	0.07	0.05	0.05
LSD (0.05) Planting density					ns				ns
LSD (0.05) fertilizer rate					ns				ns
LSD (0.05) Planting density x Fertilizer rate					ns				ns

ns-not significant at 5% level of probability

Table 5: Net assimilation rate in three tomato cultivars, three planting densities and three fertilizer application rates at different age

Cultivars	Planting density (pph)	3-5 WAT Fertilizer rate (kg ha^{-1}) 0	200	400	Mean	5-7 WAT Fertilizer rate (kg ha^{-1}) 0	200	400	Mean
TI 106	33333	5.15	8.76	9.06	7.66	3.72	5.77	6.76	5.42
	41667	5.78	8.88	9.18	7.95	3.87	5.68	6.83	5.46
	55556	5.89	8.97	9.58	8.15	3.95	5.87	6.97	5.60
Mean		5.16	8.87	9.27	7.92	3.85	5.77	6.85	5.49
LSD (0.05) Planting density					0.821				0.162
LSD (0.05) fertilizer rate					0.821				0.162
LSD (0.05) Planting density x Fertilizer rate					ns				ns
TI 468	33333	2.45	4.72	7.55	4.91	1.16	1.66	1.77	1.53
	41667	2.73	4.88	7.83	5.15	1.73	1.87	1.98	1.86
	55556	2.97	4.97	8.15	5.36	2.15	1.78	2.01	1.31
Mean		2.72	4.86	7.84	5.14	1.68	1.77	1.92	1.79
LSD (0.05) Planting density					0.435				0.231
LSD (0.05) fertilizer rate					0.435				0.231
LSD (0.05) Planting density x Fertilizer rate					ns				ns
Local	33333	0.02	0.17	0.52	0.24	0.01	0.04	0.08	0.04
	41667	0.01	0.15	0.37	0.18	0.04	0.07	0.09	0.07
	55556	0.04	0.11	0.39	0.18	0.06	0.03	0.05	0.05
Mean		0.02	0.14	0.43	0.20	0.04	0.05	0.07	0.05
LSD (0.05) Planting density					ns				ns
LSD (0.05) fertilizer rate					0.172				ns
LSD (0.05) Planting density x Fertilizer rate					ns				ns

ns-not significant at 5% level of probability

Table 6: Days to flowering, average fruit yield weight and fruit yield plant^{-1} area index in three tomato cultivars, three planting densities and three fertilizer application rates.

Cultivar	Planting density (pph)	Days to flowering Fertilizer rate (kg ha^{-1}) 0	200	400	Mean	Average fruit weight (g) Fertilizer rate (kg ha^{-1}) 0	200	400	Mean	Fruit yield plant^{-1} (kg) Fertilizer rate (kg ha^{-1}) 0	200	400	Mean
TI 106	33333	29.30	29.50	28.20	29.00	16.20	24.10	30.10	23.47	0.52	0.60	0.88	0.67
	41667	35.00	34.00	33.70	34.30	13.00	23.20	28.70	21.63	0.45	0.50	0.80	0.58
	55556	35.20	37.50	40.30	37.67	16.00	20.10	26.40	20.83	0.40	0.48	0.70	0.53
Mean		33.17	33.67	34.07	33.66	15.07	22.47	28.40	21.98	0.46	0.53	0.79	0.59
LSD(0.05) Planting density					ns				4.321				0.253
LSD(0.05) Fertilizer rate					ns				4.321				0.253
LSD(0.05) Planting density x Fertilizer rate									ns				ns
TI 468	33333	27.50	27.50	26.40	27.13	15.30	23.60	29.20	22.70	0.49	0.55	0.78	0.61
	41667	34.30	32.10	31.20	32.53	12.00	21.90	26.90	20.27	0.40	0.46	0.70	0.52
	55556	34.60	32.30	40.00	35.63	15.00	19.10	26.90	20.33	0.34	0.42	0.63	0.46
Mean		32.13	30.63	32.53	31.76	14.10	21.53	27.67	21.10	0.41	0.48	0.70	0.53
LSD(0.05) Planting density					ns				4.135				0.242
LSD(0.05) Fertilizer rate					ns				4.135				0.242
LSD(0.05) Planting density x Fertilizer rate					ns				ns				ns
Local	33333	40.30	43.40	47.50	43.73	10.12	16.13	18.23	14.83	0.18	0.23	0.27	0.23
	41667	42.20	47.30	49.50	46.33	8.42	16.04	16.50	13.65	0.18	0.23	0.26	0.23
	55556	44.20	49.30	49.30	47.27	8.30	13.25	15.37	12.39	0.14	0.19	0.20	0.18
Mean		42.24	46.67	48.77	45.89	8.45	15.14	16.70	13.60	0.17	0.22	0.24	0.21
LSD(0.05) Planting density					ns				0.615				0.051
LSD(0.05) Fertilizer rate					ns				0.615				0.051
LSD(0.05) Planting density x Fertilizer rate					ns				ns				ns

ns- not significant at 5% level of probability

Table 7: Total fruit yield and % marketable yield in three tomato cultivars, three planting densities and three fertilizer application rates.

Cultivars	Planting density (pph)	Total fruit yield (t ha^{-1}) Fertilizer rate (kg ha^{-1}) 0	200	300	Mean	% Marketable yield Fertilizer rate (kg ha^{-1}) 0	200	400	Mean
TI 106	33333	17.30	20.00	29.30	22.20	45.10	69.20	83.30	65.87
	41667	18.80	27.80	33.30	26.63	39.40	63.20	80.10	60.90
	55556	22.20	26.70	38.90	29.27	37.40	60.10	84.30	60.60
Mean		19.43	24.83	33.83	26.03	40.63	64.17	82.57	62.46
LSD (0.05) Planting density					2.342				28.45
LSD (0.05) fertilizer rate					2.342				28.452
LSD (0.05) Planting density x Fertilizer rate					ns				ns
TI 468	33333	16.33	18.33	25.00	19.89	46.30	68.30	84.50	66.37
	41667	16.67	19.17	29.17	21.67	38.30	64.40	79.43	60.71
	55556	18.89	23.33	35.00	25.74	58.00	70.00	85.00	71.00
Mean		17.30	20.28	29.72	22.43	47.63	67.57	82.98	66.03
LSD (0.05) Planting density					2.432				29.32
LSD (0.05) fertilizer rate					2.432				29.32
LSD (0.05) Planting density x Fertilizer rate					ns				ns
Local	33333	6.13	7.53	9.48	7.71	70.55	60.00	58.56	63.04
	41667	7.70	9.68	10.79	9.39	78.37	78.27	67.33	74.66
	55556	7.94	10.44	11.72	10.03	86.43	82.76	79.76	82.98
Mean		7.26	9.22	10.53	9.00	78.45	73.68	68.55	73.56
LSD (0.05) Planting density					1.322				9.567
LSD (0.05) fertilizer rate					1.322				9.567
LSD (0.05) Planting density x Fertilizer rate					ns				ns

ns-not significant at 5% level of probability

The net assimilation rate (NAR) increased as the rate of fertilizer application and planting density but decreased with plant age in all the cultivars. TI 106 and TI 468 plants performed better than the local plants throughout the sampling periods (Table 5). There were significant differences in respect of NAR for TI 106 and TI 468 plants but not for local plants.

Days to 50% flowering increased as planting density and fertilizer application rate increased among the cultivars and the local plants tend to have higher number of days to 50% flowering than the introduced lines (TI 106 and TI 468) but not significantly (Table 6). Increasing the planting density reduced average fruit weight and fruit yield plant^{-1}in all the cultivars (Table 6). Increasing fertilizer application rate average fruit weight and fruit yield plant^{-1} (Table 6) Fruit yield ha^{-1} increased with increasing planting density from 33333 to 55556 pph coupled with fertilizer application rate from 0 to 400kg ha^{-1} in all the cultivars (Table 7). % Marketable yield increased with increasing planting density and fertilizer rate. The local plants better than TI 106 and TI 468 in terms of % marketable yield (Table7).

The optimum planting density and fertilizer application rate for tomato cultivars in this trial were 55556 pph and 400kg NPK. The best cultivar was TI 106.

Discussion: The tomato cultivars TI 106 and TI 468, which are currently recommended to farmers in Nigeria, were outstanding among the available cultivars in the country. These cultivars respond well to fertilizer application in this trial. These cultivars yielded 13.63 and 11.41t ha^{-1} for TI 106 and TI 468, respectively as compared to 6.86 and 6.57t ha^{-1} for SAMTOM 7 and local, respectively. This clearly showed the superiority of introduced lines over the local line as earlier reported by Bodunde *et al.*[2]. All the tomato cultivars used for the trial showed the huge potential of fertilizer usage as the fruit yield was reduced when fertilizer was not applied at all. This may be related to insufficient nutrient uptake as the plants have to rely on the native fertilizer of the soil which has been shown to be deficient in the primary nutrients (N, P and K). The significant fruit yield increase was obtained by the application of fertilizer clearly demonstrated the benefit of the application of NPK fertilizer to tomato plants.

Increasing planting density increased yield ha^{-1}, and this effect was more pronounced when it was combined with fertilizer application. The LAI, CGR and RGR in this trial increased in the course of the plant growth up to 7 WAT while NAR declined as the plant ages, this might probably be due to abscission of the lower leaves as reported by Tayo[9]. The LAI of any plant is a measure of the capacity of photosynthetic system and translocation. Increasing planting density increased the LAI through the production of additional number of stnds with nodes and leaves per unit area while increasing fertilizer application rate made it more pronounced through increase in leaf size (leading to greater leaf area per stand), number of leaves and the length of the vegetative growth phase (crop growth duration).

Increasing LAI resulting from higher planting densities and fertilizer application rates led to higher dry matter production and fruit yield, because of better utilization of solar radiation which favoured photosynthetic capacity[10].

Planting density and fertilizer application enhanced NAR, CGR and RGR. These parameters influenced fruit yield as they are measured of the efficiency of photosynthesis and growth. Planting density and NPK fertilizer application influenced these parameters through their effects on LAI and dry matter production.

Too low a plant density is a common cause of poor fertilizer response[11]. Where soil fertilizer status is low, farmers tend to have fewer plants ha^{-1} so that each plant gets a better share of the scarce nutrients in the soil. However, low planting densities with added nutrients through fertilizer application may not result in a commensurate increase in yield owing to suboptimal utilization of added nutrients by the relative low number of plants. As a result of this, there is need to increase planting density for efficient utilization of added nutrients when fertilizer is introduced in order to maximize yield. However, too high a planting density even with abundant nutrients resulting from insufficient light interception due to shading of some leaves may encourage etiolation or use up of the limited soil moisture in drought-prone area.

The higher number of days to 50% flowering as fertilizer application rate increases was attributed to lengthen of the crop growth duration at the expense of the flowering and fruiting. This delay does not depressed yield instead it led to increase in fruit yield and average fruit weight on final analysis.

The fruit yield plant-1 decreased as planting density increase, this might be due to the effect of competition. This arisen due to the fact that competition is less in low planting density than at high planting density. The competition might be for nutrients, physical spaces and water. The progressive increase in fruit yield ha^{-1} as planting density increases was an indication of the fact that at higher planting density, individual plant performance is decreased but the higher number of plants per unit area compensate for lower individual performance, consequently, yielding more fruits than the other planting densities[12].

% Marketable yield increased as planting density increased. This could be attributed to the effect of sunburn, sunscald and fruit rot[6], resulting from the fruits being exposed to direct sunlight under low planting densities. The reverse is the case under higher planting densities as most of the fruits are shaded up and hence well protected against direct imparted of sunlight on the fruits.

There was no significant interaction in any of the parameters recorded in this study, suggesting that planting density, cultivar and fertilizer rates independently affected the parameters studied. The combined effect of cultivar, planting density and fertilizer rate had proved in this trial that it can increased fruit yield drastically above African average and all other tropical countries including China. With continuous improvement in screening of introduced lines, selection of locally available lines (cultivars) for disease resistant and crossing them with superior introduced lines coupled with good management, fruit yield can further be increased to a level comparable with that of the temperate countries.

TI 106 cultivar yielded more than others and the optimum planting density and fertilizer application rate for the three cultivars should be maintained at 55556 pph and 400kg 15:15:15 ha^{-1}.

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