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RESPONSE OF TOMATO (*Lycopersicum* esculentum) VARIETIES TO NPK FERTILIZER AND GREEN MANURE RATES IN THE NIGERIAN AGRO-ECOLOGICAL AREAS

[1]Muazu, Abdu and [2]Abubakar, Auwal Yusuf
[1]Department of Agronomy, Federal University, Gashua Yobe State, Nigeria
[2]Centre for Biotechnology and Genetic Engineering, University of Jos, Nigeria
Corresponding Author's E-mail: muazz44@ yahoo.co.uk **Tel.:** 08055476664

ABSTRACT
Field experiments were conducted in 2017 and 2018 dry seasons at Research Farm of the Institute for Agricultural Research, Samaru and Kadawa to study the response of tomato varieties to NPK fertilizer and green manure rates in the Nigerian Agro- ecological areas. The treatments consisted of two tomato varieties (Roma VF and UC82B), four NPK 15-15-15 fertilizer rates (0, 200, 400 and 600 kg ha^{-1}) and three green manure rates (0, 10 and 20 t ha^{-1}) that were laid out in a split-plot design with three replications. The combination of variety and NPK fertilizer was assigned to the main plot and green manure rate to the subplot. Results revealed that variety UC82B was superior to Roma VF and to some of the measured growth parameters such as number of leaves, number of branches and leaf area index and yield attributes like fruit number per plant and total fresh fruit yield; however, Roma VF had wider fruit diameter. NPK fertilization at 400 kg ha^{-1} significantly increased leaf area index, fruit number per plant and total fresh fruit yield per plant. However, increasing NPK fertilizer rate beyond 400 kg ha^{-1} did not increase yield significantly. Green manure application at 20 t ha^{-1} resulted to significant increase in some growth parameters and yield attributes at both locations. The study concluded that green manure application increased soil N, soil P, soil K contents. It was recommended that for better yield in the study area, variety UC82B with combination of 200 kg ha^{-1} NPK fertilizer and 20 t ha^{-1} green manure should be selected for further study.

Keywords: Agro-ecological areas, Green manure rates, Nigerian, NPK fertilizer, Tomato varieties.

INTRODUCTION

Tomato (*Lycopersicum* esculentum) belongs to the family *Solanaceae* (also known as the night shade family). The family also include other important vegetable crops such as potato (*Solanum tuberosum* L.), pepper (*Capsicum spp.* L.), eggplant (*Solanum melongena* L.) and tobacco (*Nicotiana tabacum*). All related wild species of tomato are native of the Andean region that includes part of Chile, Colombia, Ecuador, Bolivia and Peru (Sims, 1980). Although the ancestral forms of tomato grew in the Peru-Ecuador area, the first extensive domestication seems to have occurred in Mexico (Sims, 1980; Harvey *et al.*, 2002).

The Spaniard introduced tomato into Europe in the early 16th Century (Harvey *et al.*, 2002) and subsequently to Africa through Gibraltar and Morocco. Tomatoes were initially grown only as ornamental plants; fruits were considered to be poisonous because of the closely related and deadly night shade (*Solanum dulcamara*). The cultivated tomato reached its present status after a long period of domestication and it is now grown throughout the temperate and tropical climates (Harvey *et al.*, 2002).

MATERIALS AND METHODS

The study was conducted at two locations in 2017 and 2018 dry seasons in the Institute for Agricultural Research, farm ($11^0$11'N, $07^0$38'E,686m above sea level) Samaru in the Northern Guinea Savanna and Kadawa ($11^0$39',$08^0$02'E 500m above sea level) in the Sudan savanna agro ecological areas of Nigeria. Soil samples from locations at a depth of 0-30 cm were randomly collected from the experimental sites using hand auger. The soil samples in each location were bulked, dried, grounded, sieved and subjected to physico-chemical analyses and green manure fodder also was analyzed using method described by Association of Official Analytical Chemists (AOAC, 2002).

The treatments consisted of two tomato varieties (Roma VF and UC82B), four rates of NPK 15-15-15 fertilizer (0, 200, 400 and 600 kg ha^{-1}) and three rates of green manure (0, 10 and 20 t ha^{-1}). The treatments were arranged in a split-plot design with three replications. A factorial combination of NPK fertilizer and tomato varieties were assigned to the main plot treatment while green manure rates occupied the sub-plots. The plots were prepared as sunken seed beds with gross plot size 7.0 m x 3.0 m ($21m^2$), while 6 m x 2 m ($12m^2$) was net plot size. At Samaru, the land was previously cultivated.

With maize in 2015 and Sorghum in 2016 rainy seasons at Kadawa, the land was cropped with rice in rainy seasons in both years of the study. The common weeds found at both locations during the research were mostly annual broad leaf and grasses which include *Digitaria horizontalis, Ageratum conizoides,* various *Cyperus spp., Axonopus compressors* and *Portulaca oleracea* while common insect pests found were white flies (*Bamisia tabacci*), Spider mites (*Tetranychus urticae*), tomato fruit worm (*Helicoverpa armegera*) and the common diseases during the experiments include bacteria wilt caused by *Ralstonia solanacearum* and Buckeyed rot of fruits.

RESULTS AND DISCUSSION

Result of the experiments revealed that the number of leaves per plant only differed significantly on varieties at 9 WAT in both seasons at both locations and also at 7 WAT at Kadawa in 2018 (Table 1). The number of leaves was more with UC82B than Roma VF. Application of NPK fertilizer significantly increased number of leaves per plant at all the sampling stages at Samaru and only at 9 WAT at Kadawa 2017. In 2018, only number of leaves $plant^{-1}$ was only significant at 9 WAT at Samaru and significant at 7 and 9 at Kadawa. At Samaru in 2017, and at 5 WAT, the application of 200 kg ha^{-1} resulted in more number of leaves per plant which was similar to other rates but significantly higher than the control. At 7 and 9 WAT, the application of 600 kg of NPK fertilizer resulted in significant more number of leaves than the lower rates applied, while at Kadawa in 2017, increase in the rate of NPK applied resulted in significant increase in number of leaves at 9 WAT. Similarly at Samaru in 2018, the application of 600 kg NPK produced significantly more of leaves than the lower rates, however 200 and 400 kg were similar at 9 WAT. At Kadawa in 2018 at 7 and 9 WAT the application of 600 kg NPK had produced significantly more leaves than the control, but similar to other rates applied.

The application of green manure resulted in significant increase in the number of leaves per plant at 9 WAT in both seasons at Samaru while at Kadawa differences were significant at 9 WAT in 2017 and 5 WAT in 2018. At Samaru in 2017, the number of leaves were similar at all rates of green manure applied but significantly higher than the control treatment while at Kadawa in 2017, application of 20 t of green manure resulted in significantly more number of leaves than the lower rate and the control. In 2018 at Samaru and at 9 WAT, number of leaves per plant significantly increased with increase rates of green manure while at Kadawa application of 10 t of green manure significantly produced more leaves which was similar to 20 t ha^{-1} of green manure. Interaction between the factors on number of leaves during the study periods was not significant at both locations. The number of branches per plant between the varieties differed significantly at 9 WAT at Samaru in 2017 and 2018 (Table 2) where UC82B produced more branches than Roma VF.

The number of branches per plant significantly increased with increase in fertilizer application at Samaru at 5 and 9 WAT; and 7 and 9 WAT at Kadawa in 2017 and also at 7 and 9 WAT for both sites in 2018 (Table 2). At Samaru in 2017 at 5 WAT, applying 200 kg NPK fertilizer significantly increased number of branches but further increase did not significantly produce more branches. At 9 WAT, application of 400 kg NPK fertilizer resulted in more branches than the lower rates but similar to 600 kg NPK fertilizer. A similar trend was observed at Kadawa at 7 and 9 WAT in 2017. At both locations at 7 and 9 WAT application of 400 kg NPK fertilizer resulted in more number of branches per plant which was statistically similar to application of 600 kg ha^{-1}. Application of 400 kg ha^{-1} NPK fertilizer differed significantly from lower rate at all sampling period except at 9 WAT at Kadawa in 2018 application of 200 and 400 kg ha^{-1} NPK fertilizer were statistically similar.

Green manure application resulted in significant increase in number of branches per plant at 7 and 9 WAT in Samaru 2017 and all the sampling period at both locations and seasons. In all the sampling periods at both seasons and locations, application of 20 t ha^{-1} green manure resulted in significant more branches per plant than the lower rate applied. At all the sampling period 20 t ha^{-1} green manure had significantly increased number of branches than the control except at 5 and 9 WAT in Kadawa in 2017 where similarity was observed in the control. The interaction between factors on number of branches during the study periods was not significant at both locations.

The leaf area index per plant differed significantly with variety at all the growth stages at both locations and seasons except in Samaru at 9 WAT where the varieties did not differ significantly (Table 3). At both locations and years UC82B had higher leaf area index and significantly differed from Roma VF throughout its growth stages.

At both locations and years of study, NPK fertilization significantly increased LAI in all the growth stages sampled (Table 3). At Samaru 2017, applied NPK fertilizer rate at 600 kg ha^{-1} significantly increased LAI than the lower rates in all the sampling periods while at Kadawa in 2017, application of 600 kg ha^{-1} NPK fertilizer increased LAI but at 7 and 9 WAT 400 kg ha^{-1} NPK fertilizer had similar LAI value to 600 kg ha^{-1}. In 2018 at Samaru, application 400 kg ha^{-1} of NPK fertilizer resulted to increased LAI; further increase of NPK fertilizer to 600 kg ha^{-1} did not increase LAI at 5 WAT. At 7 and 9 WAT, application of 600 kg ha^{-1}NPK fertilizer resulted in larger LAI than the lower rates. While at Kadawa, at 5 WAT LAI was significantly higher at 600 kg ha^{-1} NPK fertilizer. At 7 and 9 WAT, application of 400 kg ha^{-1} NPK fertilizer significantly increased LAI beyond which there was no significant increase in LAI.

Incorporation of green manure significantly affected the leaf area index at both locations and years of study except at 7 and 9 WAT at Samaru and Kadawa in 2017, respectively, also at 7 and 9 WAT in Kadawa 2018. In all cases, application of 20 t ha^{-1} of green manure significantly resulted in higher leaf area index than lower rate and the control. The interaction between factors on Leaf area Index during the periods of study was not significant at both locations.

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Table 1: Number of leaves per plant of tomatoes as affected by varieties, NPK fertilizer and green manure rates at Samaru and Kadawa in 2017 and 2018 dry seasons

	2017						2018					
	Samaru			Kadawa			Samaru			Kadawa		
Treatment	**5WAT**	**7WAT**	**9WAT**	**5WAT**	**7WAT**	**9WAT**	**5WAT**	**7WAT**	**9WAT**	**5WAT**	**7WAT**	**9WAT**
Variety (V)												
Roma VF	12.6	21.6	43.5^{b}	24.3	49.4	55.8^{b}	11.0	20.5	46.2^{b}	19.7	40.6^{b}	60.7^{b}
UC82B	11.9	21.2	59.9^{a}	27.4	52.2	75.4^{a}	12.1	21.6	56.6^{a}	24.6	52.1^{a}	74.0^{a}
SE±	0.39	0.53	0.65	1.66	3.55	1.50	0.56	0.89	1.03	1.67	3.46	3.86
NPK rate kg ha^{-1}(F)												
0	11.1^{b}	16.5^{c}	31.1^{d}	24.6	46.2	49.8^{d}	11.6	20.3	31.7^{c}	20.0	36.9^{b}	55.4^{b}
200	12.8^{a}	18.1^{c}	43.2^{c}	25.3	59.4	62.1^{c}	11.0	20.5	39.8^{b}	19.7	45.3^{ab}	69.1^{ab}
400	13.1^{a}	23.4^{b}	60.2^{b}	27.1	51.1	69.9^{b}	12.3	22.4	38.9^{b}	23.0	48.1^{ab}	69.7^{ab}
600	12.2^{ab}	27.6^{a}	73.4^{a}	27.1	51.9	80.6^{a}	11.5	21.3	56.7^{a}	26.0	55.0^{a}	75.3^{a}
SE±	0.48	0.74	0.92	2.34	5.03	2.12	0.80	1.27	1.45	2.36	4.90	5.46
Green manure rate t ha^{-1} (G)												
0	12.1	20.7	50.3^{b}	24.0	49.3	61.0^{b}	11.8	21.0	48.7^{c}	18.8^{b}	47.5	62.3
10	12.1	21.8	55.9^{a}	26.5	52.2	65.2^{b}	10.9	20.4	52.8^{b}	22.6^{a}	41.3	66.2
20	12.5	21.8	54.9^{a}	27.1	55.0	70.7^{a}	11.9	21.8	57.3^{a}	25.1^{a}	50.3	71.6
SE±	0.39	0.67	0.59	1.63	3.05	1.88	0.58	1.02	1.22	2.01	3.55	3.19
Interaction												
F x V	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
F x G	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
G x V	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
F x G X V	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Means followed by same letter(s) within the same column and treatment group are not significantly different at 5% level of probability. WAT = Weeks after transplanting, ** = significant at 1% level of probability. NS = Not significant.

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Table 2: Number of branches per plant of tomatoes as affected by varieties, NPK fertilizer and green manure rates at Samaru and Kadawa in 2017 and 2018 dry seasons

	2017						**2018**					
	Samaru			**Kadawa**			**Samaru**			**Kadawa**		
Treatment	**5WAT**	**7WAT**	**9WAT**	**5WAT**	**7WAT**	**9WAT**	**5WAT**	**7WAT**	**9WAT**	**5WAT**	**7WAT**	**9WAT**
Variety (V)												
Roma VF	2.9	6.5	8.9^{b}	3.5	7.2	8.4	3.8	7.3	7.9^{b}	3.4	7.1	8.9
UC82B	3.1	6.5	10.1^{a}	3.3	7.6	8.8	4.0	8.0	9.1^{a}	3.5	8.0	9.4
SE±	0.17	0.24	0.25	0.15	0.23	0.42	0.20	0.28	0.25	0.21	0.18	0.30
NPK rate kg ha^{-1}(F)												
0	1.2^{b}	6.0	7.7^{c}	3.4	6.2^{b}	7.2^{b}	3.8	6.8^{b}	7.2^{c}	3.3	5.8^{c}	7.9^{c}
200	3.8^{a}	6.9	8.8^{b}	3.4	6.8^{b}	7.8^{b}	3.8	6.5^{b}	7.9^{b}	3.6	6.6^{b}	8.9^{bc}
400	3.6^{a}	6.6	10.4^{a}	3.4	8.0^{a}	9.5^{a}	3.9	8.3^{a}	9.8^{a}	3.6	8.4^{a}	9.4^{ab}
600	3.5^{a}	6.5	11.1^{a}	3.4	8.6^{a}	9.8^{a}	3.9	9.2^{a}	10.0^{a}	3.4	9.2^{a}	10.4^{a}
SE±	0.23	0.33	0.35	0.22	0.32	0.60	0.28	0.37	0.35	0.30	0.25	0.42
Green manure rate t ha^{-1} (G)												
0	2.8	5.5^{c}	8.3^{c}	3.2^{b}	6.2^{c}	7.8^{b}	3.6^{b}	6.6^{b}	7.0^{c}	2.4^{b}	5.4^{c}	7.4^{c}
10	2.9	6.5^{b}	9.7^{b}	3.3^{b}	7.6^{b}	8.3^{b}	3.6^{b}	8.1^{a}	8.7^{b}	2.9^{b}	8.1^{b}	9.4^{b}
20	3.3	7.7^{a}	10.7^{a}	3.7^{a}	8.4^{a}	9.8^{a}	4.2^{a}	8.4^{a}	9.9^{a}	3.8^{a}	9.0^{a}	19.8^{a}
SE±	0.25	0.29	0.33	0.13	0.26	0.31	0.14	0.24	0.33	0.18	0.19	0.31
Interaction												
F x V	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
F x G	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
G x V	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
F x G X V	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Means followed by same letter(s) within the same column and treatment group are not significantly different at 5% level of probability. WAT = Weeks after transplanting, *= significant at 5% level of probability. NS = Not significant.

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Table 3: Leaf area index per plant of tomatoes as affected by varieties, NPK fertilizer and green manure rates at Samaru and Kadawa in 2017and 2018 dry seasons

	2017						**2018**					
	Samaru			**Kadawa**			**Samaru**			**Kadawa**		
Treatment	**5WAT**	**7WAT**	**9WAT**	**5WAT**	**7WAT**	**9WAT**	**5WAT**	**7WAT**	**9WAT**	**5WAT**	**7WAT**	**9WAT**
Variety (V)												
Roma VF	0.44^{b}	1.06^{b}	1.87	0.94^{b}	1.09^{b}	1.65^{b}	0.89^{b}	1.44^{b}	1.75^{b}	0.90^{b}	1.41^{b}	1.87^{b}
UC82B	0.48^{a}	1.26^{a}	1.94	1.11^{a}	1.52^{a}	2.15^{a}	1.05^{a}	1.77^{a}	2.11^{a}	0.98^{a}	1.56^{a}	2.12^{a}
SE±	0.010	0.039	0.034	0.020	0.044	0.165	0.020	0.038	0.042	0.008	0.031	0.043
NPK rate kg ha^{-1}(F)												
0	0.35^{b}	0.68^{c}	1.39^{d}	0.84^{c}	0.93^{b}	1.42^{b}	0.79^{b}	1.21^{c}	1.49^{c}	0.83^{c}	1.21^{b}	1.59^{b}
200	0.48^{a}	1.18^{b}	1.82^{c}	0.89^{c}	0.96^{b}	1.50^{b}	0.84^{b}	1.23^{c}	1.52^{c}	0.84^{c}	1.26^{b}	1.69^{b}
400	0.49^{a}	1.42^{a}	2.03^{b}	1.14^{b}	1.61^{a}	2.23^{a}	1.14^{a}	1.88^{b}	2.17^{b}	1.01^{b}	1.67^{a}	2.17^{a}
600	0.49^{a}	1.32^{a}	2.37^{a}	1.23^{a}	1.73^{a}	2.40^{a}	1.12^{a}	2.11^{a}	2.56^{a}	1.11^{a}	1.78^{a}	2.31^{a}
SE±	0.014	0.056	0.048	0.028	0.063	0.234	0.028	0.054	0.060	0.011	0.044	0.062
Green manure rate t ha^{-1} (G)												
0	0.44^{b}	1.15	1.75^{b}	0.99^{b}	1.26^{b}	1.94	0.92^{b}	1.53^{c}	1.82^{c}	0.92^{b}	1.47	1.97
10	0.45^{b}	1.15	1.95^{b}	1.04^{a}	1.33^{ab}	1.90	0.99^{a}	1.61^{b}	1.94^{b}	0.92^{b}	1.48	1.99
20	0.49^{a}	1.21	2.01^{a}	1.05^{a}	1.35^{a}	1.84	0.99^{a}	1.68^{a}	2.04^{a}	0.96^{a}	1.49	2.00
SE±	0.011	0.062	0.060	0.015	0.063	0.035	0.018	0.017	0.031	0.007	0.019	0.024
Interaction												
F x V	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
F x G	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
G x V	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
F x G X V	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Means followed by same letter(s) within the same column and treatment group are not significantly different at 5% level of probability. WAT = Weeks after transplanting,* = significant at 5%, ** = significant at 1% level of probability; NS = Not significant.

Response of variety, NPK fertilizer and green manure rates on fruit diameter at Samaru and Kadawa are presented in (Table 4). Tomato varieties did not differ significant on fruit diameter in all the year of study in Samaru while in Kadawa variety differed significantly, Roma VF produced significantly wider fruit diameter than UC82B in all the years and the combined data at Kadawa. At both locations, years and their combined data, fruit diameter was significantly influenced by NPK fertilizer application. In all cases, application of 400 kg ha^{-1} gave wider fruit diameter which was similar to application of 600 kg ha^{-1}.

Table 4: Fruit diameter (cm) of tomatoes as affected by varieties, NPK fertilizer and green manure rates at Samaru and Kadawa in 2017 and 2018 dry seasons

	Fruit diameter (cm)					
	Samaru			Kadawa		
Treatment	**2017**	**2018**	**Mean**	**2017**	**2018**	**Mean**
Variety (V)						
Roma VF	6.3	6.2	6.3	6.5^{a}	6.0^{a}	6.3^{a}
UC82B	5.9	6.1	6.0	5.9^{b}	5.7^{b}	5.9^{b}
SE±	0.19	0.15	0.12	0.22	0.10	0.08
NPK rate kg ha^{-1}(F)						
0	5.6^{b}	5.4^{b}	5.5^{b}	5.5^{b}	5.6^{b}	5.6^{b}
200	5.9^{b}	5.8^{b}	5.8^{b}	5.9^{b}	5.7^{b}	5.8^{b}
400	6.2^{ab}	6.7^{a}	6.5^{a}	6.6^{a}	6.0^{ab}	6.3^{a}
600	6.7^{a}	6.6^{a}	6.6^{a}	6.7^{a}	6.2^{a}	6.5^{a}
SE±	0.26	0.06	0.16	0.31	0.14	0.11
Green manure rate t ha^{-1} (G)						
0	5.8	5.7^{b}	5.6^{b}	5.4^{b}	5.5^{b}	5.5^{b}
10	6.0	6.3^{a}	6.1^{a}	6.4^{a}	5.9^{ab}	6.2^{a}
20	6.4	6.4^{a}	6.4^{a}	6.8^{a}	6.4^{a}	6.5^{a}
SE±	0.26	0.18	0.16	0.23	0.21	0.15
Interaction						
F x V	NS	NS	NS	NS	NS	NS
F x G	NS	NS	NS	NS	NS	NS
G x V	NS	NS	NS	NS	NS	NS
F x G X V	NS	NS	NS	NS	NS	NS

Note: Means followed by same letter(s) within the same column and treatment group are not significantly different at 5% level of probability. NS = Not significant.

Although, the control and 2000 kg ha-^{1} NPK fertilizer did not differ significantly throughout and at both locations except at Samaru 2017 and Kadawa 2018 where applied 400 kg ha^{-1} was statistically similar to lower rate and the control treatment. Incorporation of green manure rate significantly increased fruit diameter at Samaru in 2018 and the combined, and all the years and mean at Kadawa. At Samaru 2018 and the combined, fruit diameter did not differ significantly with application of 10 and 20 t ha^{-1} of green manure but produced wider fruits than the control. At Kadawa applied 10 t ha^{-1} gave significantly wider fruit diameter but a further addition of green manure rate had no significant effect on fruit diameter. The interaction between the factors on fruits diameter during the periods of study was not significant at both locations.

Varieties differed significantly on number of fruits per plant at Samaru only in 2018 and Kadawa in 2018 and in the combined data (Table 5). At both locations, UC82B significantly produced higher number of fruits per plant than Roma VF. The number of fruits per plant increased with increase in NPK fertilizer applied rate at both locations and years of study. At Samaru in 2017 and the combined, applied 400 kg ha^{-1} NPK fertilizer significantly resulted to more number of fruits per plant than the lower rates but a further application beyond 400 kg ha^{-1} did not produce any significant increase in fruit number. However, there was a decrease in number of fruits with addition of fertilizer rate beyond 400 kg in 2018. At Kadawa in 2017 application of 600 kg ha^{-1} NPK fertilizer significantly gave more number of fruits per plant than the lower rates applied. In 2018 and the combined, application of 200 kg ha^{-1} significantly increased number of fruit per plant but a further increase of NPK rate had no influence on number of fruits per plant.

Varying green manure rate significantly increased number of fruits per plant in the mean at Samaru and 2018 only at Kadawa. At both locations, application of 20 t ha^{-1} of green manure resulted in significant more number of fruits per plant than the control, although at Kadawa there was no significant difference between application rate of 10 and 20 t ha^{-1} of green manure. Interaction between the factors on number of fruits during the periods of study was not significant at both locations.

At both locations, the variety differs significantly on total fresh yield per ha^{-1} in 2018and the combined mean (Table 6)**.** At Samaru, UC82B produced significantly higher total fruit yield ha^{-1} than Roma VF where it had more fruits in 2018 and the combined. Similarly at Kadawa, total fruit yield ha^{-1} was higher in variety UC82B than Roma VF in 2018 and combined.

Applied NPK fertilizer significantly influenced total fruit yield ha^{-1} in all the years of study and the combined data at both locations.

At Samaru 2017, application of NPK fertilizer at 400 kg ha^{-1} produced significantly higher total fruit yield ha^{-1} than 200 kg ha^{-1} and the control but further addition of fertilizer did not significantly produce more fruit ha^{-1}. In 2018 and combined data, applied 400 kg ha^{-1} NPK fertilizer significantly increased total fruit yield ha^{-1}, however further NPK fertilizer application to 600 kg ha^{-1} significantly decreased total fruit yield ha^{-1}. At Kadawa in both years of study, application of 400 kg ha^{-1} produced significantly more total yield than the lower rate and control. Green manure application significantly influenced total fruit yield ha^{-1} at both years of study and the combined analysis at both locations. Application of 20 t ha^{-1} produced significantly higher total fruit yield ha^{-1} than 10 t ha^{-1} and the control in all the years of experimentation. The interaction between factors on total fresh fruit yield during the study periods at both locations was not significant.

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Table 5: Number of fruits per plant of tomatoes as affected by varieties, NPK fertilizer and green manure rates at Samaru and Kadawa in 2017 and 2018 dry seasons

	Number of fruits plant^{-1}					
	Samaru					Kadawa
Treatment	**2017**	**2018**	**Mean**	**2017**	**2018**	**Mean**
Variety (V)						
Roma VF	23.2	16.0^{b}	19.6	15.2	41.2^{b}	28.2^{b}
UC82B	22.8	18.0^{a}	20.4	15.2	48.7^{a}	31.9^{a}
SE±	0.62	0.23	0.26	0.19	1.61	0.82
NPK rate kg ha^{-1}(F)						
0	18.7^{c}	15.5^{b}	17.1^{c}	14.3^{b}	38.1^{b}	26.2^{b}
200	21.7^{b}	16.5^{b}	19.1^{b}	14.3^{b}	44.1^{ab}	29.4^{ab}
400	26.8^{a}	19.6^{a}	22.2^{a}	15.0^{b}	49.4^{a}	32.2^{a}
600	24.8^{a}	16.4^{b}	21.6^{a}	16.4^{a}	48.2^{a}	32.2^{a}
SE±	0.87	0.32	0.40	0.27	2.28	1.16
Green manure rate t ha^{-1} (G)						
0	16.5	14.5	15.5b	14.5	40.5b	27.8
10	16.7	15.2	15.9b	15.2	44.7ab	29.6
20	19.5	17.5	18.8a	15.5	49.7a	32.6
SE±	0.88	0.36	0.54	0.35	2.18	1.68
Interaction						
F x V	NS	NS	NS	NS	NS	NS
F x G	NS	NS	NS	NS	NS	NS
G x V	NS	NS	NS	NS	NS	NS
F x G X V	NS	NS	NS	NS	NS	NS

Note: Means followed by same letter(s) within the same column and treatment group are not significantly different at 5% level of probability. **= significant at 1% level of probability. NS = Not significant.

In this research generally as presented in Table 6, growth attributes such as number of leaves, number of branches and leaf area index and yield attributes such as number of fruits and total fresh fruit yield at different sampling periods were found higher in UC82B than Roma VF. The superiority of UC82B to Roma VF on the above mentioned growth and yield characters might be attributed to genetic difference between them. It could be the variety UC82B has better photosynthetic efficiency due to higher leaf area index, higher solar harvesting which resulted to good growth and yield. These findings are in line with earlier reports by Miras *et al.* (2011). Differential performance of variety could be attributed to genetic variability and adaptability during the crop growth period. The reports by Olaniyi *et al*. (2010) indicated that UC82B was higher in the growth attributes of tomato than other varieties evaluated.

The yield components such as number of fruits per plant and total fresh fruit yield ha^{-1} was significant where UC82B proved superior to Roma VF in both locations. This could be attributed to genetic factor as influenced by the favorable environmental factors that allowed the crop to grow vigorously resulting to early fruit setting. These results are not in agreement with the findings of (Law-Ogbomo and Eghavevba, 2008) who reported that UC82B yielded low when compared with other varieties evaluated. In this study, application of 400 kg ha^{-1} NPK fertilizer enhanced growth of two tomato varieties. Tomato growth increased as expressed by the increases observed in LAI. This increased in this growth parameter confirmed the importance of N, P and K as a major plant nutrients required for growth processes and development. It has been proven that chemical fertilizer are an essential input in any system in which the aim is to maintain good growth and yield (Rafi, 1996). Ewulo *et al*. (2007) reported that NPK fertilizer increased growth parameters of pepper such as leaf area and number of branches.

NPK fertilizer application resulted to increase in growth parameters and yield of tomato. The significant yield increase could be attributed to the fact that plant biomass increased with increase in applied nutrient resulting in optimum assimilate production and translocation leading to more flower and fruit production. This result was in conformity with the reports by Nafiu *et al.* (2011) whose reports indicated the wider leaf area was obtained with application of 200 kg NPK ha^{-1} in all the growth stages of eggplant. The result of this present experiment higher leaf area index obtained with increase NPK fertilization showed that adequate supply of nutrient could lead to the production of assimilates and their transportation be enhanced. Similar findings was obtained from Law-Ogbomo and Eghaveuba (2008) and Babajide and Salami (2012). Also increasing LAI resulting from higher fertilizer rate led to higher dry matter production and fruit yield, because of better utilization of solar radiation which favoured photosynthetic capacity (Gurnah, 1984).

The organic fertilizer takes the place of inorganic fertilizer in sustainable agriculture. The technology of using green manure is one of the most environmental friendly agricultural technologies which could provide better condition of the soil by improving the soil physical and chemical properties, soil fertility and soil micro flora (Seo *et al*., 2000b, Aksoy, 2001, Chowdhury, 2004).

In this study, tomato responded to green manure rates produces a better growth as indicated by leaf area index. Higher crop growth and yield due to organic fertilizer could be attributed to favorable changes in soil condition which might result in loose soil and enable better root growth. Moreover, positive influence of organic fertilizer might be due to slow and steady availability of nutrients throughout the growing season from organic fertilizer (Maftoun *et al.*, 2004; Amanullah *et al.*, 2006; Tejada *et al*., 2006).

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Table 6: Total fresh fruit yield (t ha^{-1}) of tomatoes as affected by varieties, NPK fertilizer and green manure rates at Samaru and Kadawa in 2017 and 2018 dry seasons

	Total fresh fruit yield (t ha^{-1})					
	Samaru			Kadawa		
Treatment	**2017**	**2018**	**Mean**	**2017**	**2018**	**Mean**
Variety (V)						
Roma VF	10.9	11.5^{b}	11.2^{b}	9.5	10.0^{b}	9.8^{b}
UC82B	10.9	13.8^{a}	12.4^{a}	8.9	12.5^{a}	10.7^{a}
SE±	0.40	0.29	0.25	0.28	0.27	0.19
NPK rate kg ha^{-1}(F)						
0	8.0^{c}	11.5^{b}	9.8^{c}	7.1^{b}	9.8^{b}	8.5^{c}
200	10.5^{b}	12.4^{b}	11.5^{b}	7.4^{b}	10.9^{a}	9.2^{b}
400	12.7^{a}	14.2^{a}	13.5^{a}	10.5^{a}	12.2^{a}	11.4^{a}
600	12.5^{a}	12.5^{b}	12.5^{ab}	8.5^{a}	11.9^{a}	10.2^{ab}
SE±	0.57	0.42	0.36	0.40	0.39	0.27
Green manure rate t ha^{-1} (G)						
0	10.3^{b}	12.1^{b}	11.2^{b}	8.8^{b}	10.3^{b}	9.6^{b}
10	10.3^{b}	12.0^{b}	11.4^{b}	9.1^{ab}	10.7^{b}	9.9^{b}
20	12.1^{a}	13.3^{a}	12.7^{a}	10.1^{a}	12.7^{a}	11.4^{a}
SE±	0.48	0.38	0.38	0.42	0.45	0.45
Interaction						
F x V	NS	NS	NS	NS	NS	NS
F x G	NS	NS	NS	NS	NS	NS
G x V	NS	NS	NS	NS	NS	NS
F x G X V	NS	NS	NS	NS	NS	NS

Note: Means followed by same letter(s) within the same column and treatment group are not significantly different at 5% level of probability, *= significant at 5% level of probability, **= significant at 1% level of probability. NS = Not significant.

The growth response of tomato (Table 6) to green manure relative to control in this trial could also be attributed to increased amount of nitrogen content and quality of phosphorus and potassium as well as other nutrients derived from decomposition of the incorporated green manure. This is because the amount of nitrogen available depends amongst other factors, on the amount of the total biomass incorporated as reported by Sullivan (2003), Liu *et al.* (2007) and Tonfack *et al.* (2009). The implication of the results was that incorporation of green manure at 20 t ha^{-1} increased soil nutrients and mineralized N from decomposed incorporated materials. Also this could be attributed to the ability of green manure to supply essential nutrients and micronutrients for fruit quality. Aguyoh *et al.* (2010) reported that green manure serve as source of slow-release nutrients; therefore contribute to greater efficiency of nutrient utilization.

CONCLUSION AND RECOMMENDATIONS

Based on the result obtained from this study, it was concluded that variety UC82B was superior to Roma VF in most growth and yield attributes while Roma VF produced wider fruit diameter. Also, the combined application of 200 kg ha^{-1} NPK fertilizer and 20 t ha^{-1} green manure gave best fruit yield.

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