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Response of tomato (*Lycopersicon lycopersicum* L.) varieties to NPK fertilizer rates in the Sudan savanna agro-ecological zone of Nigeria

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Abstract
Field experiments were conducted during dry and wet seasons of 2016/2017 at the Teaching and Research Farm of Kebbi state University of Science and Technology, to study the response of some tomato varieties to rates of NPK (15:15:15) fertilizer in the study area. Treatments consisted of factorial combination of four (4) tomato varieties (Roma-VF, Tima, UC82B and Rio-grande) and four (4) NPK (15:15:15) rates (0, 300, 600 and 900 kg NPK ha^{-1}), laid out in a completely randomized block design, with three replications. The result showed that variety Roma-VF proved the best in terms of plant height (101.87cm) at 10WAT, number of leaves (103.00), weight of fruits per plant (1.10kg), mean fruits diameter (3.25cm) and fresh fruit yield (55.41t ha^{-1}), and similar to Tima in terms of plant height (92.64cm), number of leaves (83.92) and mean fruit weight (57.87g). Both varieties Tima and Roma-VF produced greater mean fruits weight (57.87 and 50.04g, respectively) than UC82B (38.27) and Rio-grande (30.03g). Plant height, number of leaves and leaf area index throughout the growth period; number and weight of fruits per plant and mean fruit weight were higher with NPK rates of 600 – 900 kg ha^{-1}. Generally, the best growth and yield performance was by Roma-VF and Tima coupled with the NPK rates from 600 - 900 kg NPK ha^{-1}. Based on the result of this study, it could be concluded that the varieties Roma-VF and Tima produced with NPK rates of 600 - 900kg ha^{-1}gave the best tomato growth and yield, hence recommended to tomato farmers in the study area.

Keywords: tomato *Lycopersicon lycopersicum* L. NPK

1. Introduction
Tomato originated from the Central and South America, extending from Mexico, Ecuador through Chile and it is introduced to Europe where it was improved further before reaching the United States and Asia (De Lannoy, 2001) [4]. In Nigeria, tomato is widely grown in Guinea Savanna mostly in the wet season and in Sudan Savanna in the dry season under irrigation (De Lannoy 2001) [4]. The yield of tomato in Nigeria is low; the average in Western part of the country being only about 5 t ha^{-1} and in growing areas of Northern Nigeria is 20 t ha^{-1} (Phimmasone, 2011) [14].

Tomato belongs to the family Solanaceae and is one of the most widely eaten vegetables in the world which can be eaten fresh or in multiple of processed forms. The world production of tomato in 2016 was 145.8 million metric tons with China leading with 41.9 million metric tons. In Africa, Egypt is the leading producer with the production of 39.5 million metric tons and Nigeria is the fourth in Africa and leads in West African sub-region with an estimated output of 1.10 million metric tons and average yield of 10 t ha^{-1} (FAOSTAT, 2016) [6].

Tomato is a popular fruit vegetable in Nigeria and yet its yield is low compared with what is obtainable in the temperate zones, mainly due to differences in climate, use of inferior varieties as well as inadequate application of improved cultural practices such fertilizer application. African soil nutrient balances are often negative due to continuous cropping with low level of fertilizer inputs. This soil nutrient depletion is a major constraint to sustainable crop production and productivity (Mbah, 2006) [8]. For a crop like tomato that has shallow root system and yet requiring early flowering and fruits setting, it becomes necessary to provide adequate level of soil fertility through the use of fertilizers (Olaniyi *et al*, 2011) [12]. More so, the response of crops was found to vary among varieties (Nafiu *et al*., 2011) [10].

In recognition of the increased costs of fertilizers as well as the growing concern for their potential environmental effect, their efficient and judicious use becomes an important aspect in tomato cropping system worth careful study. Since the soil of every environment has its own inherent fertility (Oyinlola and Junaidu (2012) [13], the amount of nutrients needed to support a given crop depends on the local soil characteristics. The aim of the study was to determine the response of selected tomato varieties to different rates of NPK fertilizer.

2. Materials and methods
The experiments were conducted at the Teaching and Research Farm of Kebbi State University of Science and Technology, Aliero during 2016/2017 cold and dry season (latitude 12°18.64'N; longitude 4°29.85'E; 262m above sea level) located in the Sudan Savanna ecological zone of Nigeria. The area has a long dry season that is characterized

by cool dry air (harmattan) that prevails from November to February and hot dry air extending from March to May. The locations are mainly used for cultivation of vegetable and cereal crops. The treatments consisted of factorial combination of four tomato varieties (Roma, Tima, UC82B and Rio-grande) and four rates of NPK 15-15-15 fertilizer (0, 300, 600 and 900 kg ha^{-1}), laid out in a randomized complete block design with three replications. The land was ploughed and harrowed accordingly. Four sunken beds of 1.0 x 2m each were constructed and served as seed nursery beds, adjacent to the main field. In the main field, plot of 3.0 x 2.5m ($7.5m^2$) were constructed making a gross plot of 12m x 37.5m ($450m^2$). The four seed beds were fertilized with 300kg NPK 15:15:15 after ploughing and harrowing. Tomato seeds used were Roma VF, Tima, UC82B and Rio-grande, sourced from National Horticultural Research Institute (NIHORT) Bagauda, Kano, Nigeria. The seed was broadcast each on a bed and light sand was spread on it to prevent drying off which thereafter were mulched and watered every day in the morning hours. The seedlings were hardened off by gradual removal of the mulch material and reducing the watering frequency. For the irrigated trial the seeds were sown and transplanted on 8th November, 2016 and 12th December, 2016, respectively; while for the rain-fed trial, the seeds were sown on 28th April 2017 and transplanted on 4th June 2017.Transplanting was done for the two trials after 34 and 37days of sowing, respectively. The nursery beds were watered a day before transplanting which facilitated easy lifting of seedlings during transplanting. The seedlings were transplanted at the spacing of 40 x 50cm for both trials. Stakes of 0.75 - 1.2m height were driven in to the soil about 10cm to the side of the tomato plant. This was done within two weeks of transplanting; a thin white rope was used to secure the tomato to the stake. Plots were irrigated at intervals of 3 - 4 days within 1 - 8 weeks after transplanting, 6-7 days within 9-14 weeks after transplanting for the irrigated trial. Fertilizer was applied according to treatments at 0, 300, 600 and 900 kg ha^{-1}in two splits doses; at 2 and 5WAT, respectively. Manual (hoe) weeding was used to control weeds at 3, 6 and 9WAT. Pesticide (*Cypermerthrin*) formulation was sprayed four times at 6 - 9WAT for both trials. Harvesting was done by hand picking at 4-5 days interval when fruits changed colour from green to pink or yellowish-red orange. Data collected were subjected to analysis of variance procedure using Statistical Analysis System (SAS^R, 2003). Means were separated using Duncan's Multiple Range Test (DMRT).

3. Results

3.1 Plant height (cm)

Plant height at 6, 8 and 10 WAT as influenced by NPK rates and variety for irrigated and rain-fed trials during 2016/2017 growing season is presented in Table 1. For the irrigated trial at 6WAT, application of 600 and 900 kg NPK ha^{-1} produced significantly taller plants than both 300 kg ha^{-1} and the untreated control. But in the rain-fed trial, application of NPK at all rates recorded taller plant than the untreated control. For the irrigated trial at 8WAT, application of 900 kg NPK ha^{-1} resulted to significantly taller plants than only 300 kg ha^{-1} and the untreated control. For the rain-fed trial, taller plants were recorded with 600 kg NPK ha^{-1} than with 300 kg NPK ha^{-1} and the shortest plants were recorded by the untreated control. For the irrigated trial at 10WAT, tallest plants were recorded with the application of NPK at the rates of 600 and 900 kg ha^{-1} than with application of 300 kg ha^{-1} and the untreated control. For the rain-fed trial, taller plants were recorded with application of 600 kg NPK ha^{-1} than with 300 kg ha^{-1} which in turn was higher than the untreated control. On the other hand, results of irrigated trial showed that plant height at 6WAT vary significantly among the varieties where Roma - VF grew taller than Rio-grande. Table 1. For rain-fed trial, Roma-VF was taller than only Tima and UC82B, but not Rio-grande. For irrigated trial at 8WAT, Roma-VF produced significantly taller plant than only Rio-grande. For rain-fed trial, Roma-VF and Rio-grande produced taller plants than UC82B, but Tima was statistically similar with Rio-grande. For irrigated trial at 10WAT, Roma-VF and Tima had the taller plants than UC82B and Rio-grande, while in the Rain-fed trial, Roma-VF and Rio-grande produced taller plants than UC82B, but Tima was statistically similar with Rio-grande. The interaction of NPK and variety on plant height at 8WAT was significant in both irrigated and rain-fed trials as presented in Tables 2 and 3, respectively. Rio-grande produced taller plants with application of 900 kg NPK ha^{-1} 600 kg NPK ha^{-1}; the shortest plant by Roma-VF was with the uncontrolled treatment.

3.2 Number of leaves

Number of leaves at 6, 8 and 10 WAT as influenced by NPK rates and variety for irrigated and rain-fed trials is presented in Table 4. For the irrigated trial at 6WAT, application of 600 and 900 kg NPK ha^{-1} produced significantly taller plants than both 300 kg ha^{-1} and the untreated control. But in the rain-fed trial, application of NPK at all rates recorded taller plant than the untreated control. Effect of NPK and Variety on number of leaves per plant of tomato in Irrigated and Rain-fed condition during 2016/2017 growing season. At all sampling period application of NPK at the rate of 900 kg ha^{-1} produce highest number of leaves per plant which was statically comparable to 600 kg ha^{-1} and followed by 300 kg ha^{-1} and the least number of leaves per plant was recorded in the control treatment. On the other hand, higher leaf number was recorded by variety Roma - VF than Tima, UC82B and Rio-grande in both Irrigated and Rain-fed trials at all sampling stages. There was no significant interaction between the treatment factor in all the sampling period in both Irrigated and Rain-fed tomato.

Table 1: Plant height and number of leaves of tomato as Influenced by Variety and NPK rates in Irrigated and Rain-fed conditions in 2016/2017 Growing season

Treatment	Plant Height (cm) 8WAT		Number of leaves 8WAT	
	Irrigated	Rain-fed	Irrigated	Rain-fed
NPK (kg ha^{-1})				
0	70.34c	21.98c	66.67ab	13.92b
300	73.57bc	33.82b	63.83b	23.68b

600	84.52ab	42.29a	82.92ab	38.67a
900	89.33a	39.07ab	85.25a	40.32a
SE±	4.17	2.32	6.33	3.65
Varieties				
Roma – VF	88.36a	40.16a	99.25a	37.35a
Tima	78.03ab	32.44bc	78.08b	24.66b
UC82B	76.82ab	28.33c	68.33bc	27.20ab
Rio-grande	74.55b	36.22ab	53.00c	27.37ab
SE±	4.17	2.32	6.33	3.65
Interaction				
NPK x Var	NS	NS	NS	NS

Means followed by the same letter (s) in a treatment group are not significantly different at 5%

3.3 Number of fruits per plant

Number of fruits per plant as influenced by NPK rates and variety for irrigated and rain-fed trials during 2016/2017 growing season is presented in Table 6. For the irrigated trial, application of 600 and 900 kg NPK ha^{-1} produced significantly higher number of fruits per plant than both 300 kg ha^{-1} and the untreated control. For the rain-fed trial, application of NPK at all rates recorded higher number of fruits per plant than the untreated control. On the other hand, for the irrigated trial Roma-VF and UC82B recorded higher number of fruits compare with Tima and Rio-grande. Similarly in rain-fed trial, Roma-VF and UC82B recorded higher numbers of fruits than Rio-grande which in turn was higher than Tima.

The interaction of NPK and variety on number of fruits per plant was significant in both Irrigated and Rain-fed season as presented in Tables 7 and 8, respectively.

For the irrigated trial, the untreated control recorded significantly the same number of fruits per plant for all the variety tested; for the 300 kg ha^{-1}, UC82B recorded significant higher number of fruits per plant than only Rio-grande; with 600 kg ha^{-1} UC82B recorded significant higher number of fruits than the other three variety tested; and with 900 kg ha^{-1}, all the variety recorded the same number of fruits per plant.

On the other hand, Roma-VF recorded the highest number of fruits per plant with the application of 300 – 900 kg NPK ha^{-1}; for Rio-grande, the highest number of fruits per plant were recorded in the application of 600 and 900 kg NPK ha^{-1}; application of 900 kg NPK ha^{-1} produced the highest number of fruits per plant with Tima variety; and application of 600 kg NPK ha^{-1} with UC82B recorded the highest number of fruits per plant followed by 300 and 900 kg NPK ha^{-1} and the least number of fruits were recorded in the untreated control.

However, UC82B with the application of 600 kg NPK ha^{-1} recorded significantly the highest number of fruits per plant for the irrigated trial and the least number of fruits were also recorded inUC82B with the application rates at the untreated control.

For rain-fed trial, with the untreated control all the variety recorded significantly the same number of fruits per plant; with 300 kg NPK ha^{-1}, UC82B recorded the highest number of fruits per plant than all other variety except Tima which is statically similar; with 600 kg ha^{-1} Roma-VF and UC82B produced the highest number of fruits than Rio-grande and Tima; and with 900 kg ha^{-1}, UC82B and Roma produced the highest number of fruits per plant followed by Rio-grande and the least was Tima.

On the other hand, Rio-grande and Roma-VF recorded the highest number of fruits per plant with the application of 600 and 900 kg NPK ha^{-1}; Tima recorded the highest number of fruits per plant at the application of 600 and 900 kg NPK ha^{-1} although 300 and 900 kg NPK ha^{-1} had the same number of fruits per plant significantly and the least number of fruits by Tima was with the untreated control; and UC82B recorded higher number of fruits per plant with the application of 600 and 900 kg NPK ha^{-1} than 300 kg NPK ha^{-} and the least number of fruits per plant by UC82B was with the untreated control.

However, UC82B and Roma-VF with the application of 600 and 900 kg NPK ha^{-1} recorded significantly the highest number of fruits per plant and all the variety with the untreated control and 300 kg NPK ha^{-1} except UC82B at 300 kg NPK ha^{-1} recorded the least number of fruits per plants.

3.4 Weight of fruits per plant

Weight of fruits per plant as influenced by NPK rates and variety for irrigated and rain-fed trials during 2016/2017 growing season is presented in Table 6. For both irrigated and rain-fed trial, weight of fruits per plant was consistently heavier with the application of NPK at the rate of 600 and 900 kg ha^{-1} than 300 kg ha^{-1} and the untreated control.On the other hand, for both irrigated and rain-fed trial, variety Roma-VF, UC82B and Tima produced significantly heavier fruits per plant than Rio-grande.

Table 2: Number and Weight of Fruits per Plant of tomato as influenced by variety and NPK rates in irrigated and rain-fed conditions in 2016/2017 growing season

Treatment	Number of Fruits per Plant		Weight of Fruits per Plant (kg)	
	Irrigated	Rain-fed	Irrigated	Rain-fed
NPK(kgha^{-1})				
0	13.58b	13.50b	0.43b	0.33b
300	14.96b	17.99a	0.50b	0.54ab
600	20.51a	16.98a	0.98a	0.64a
900	22.33a	17.61a	0.99a	0.69a
SE±	2.090	1.530	0.211	0.130
Varieties				
Roma-VF	22.15a	24.58a	1.10a	0.79a
Tima	15.73b	13.58c	0.85a	0.78a
UC82B	24.20a	25.33a	0.92a	0.76a
Rio-grande	14.00b	19.88b	0.42b	0.31b
SE±	2.090	1.530	0.211	0.130
Interaction				
NPK x Var	*	*	NS	NS

Means followed by the same letter (s) in a treatment group are not significantly different at 5% using DMRT

Table 3: Interaction of variety and NPK on Numbers of Fruits per Plants for Irrigated season

Variety	NPK (kg ha^{-1})			
	0	300	600	900
Roma-VF	86.00gh	180.00cde	154.33def	200.66bcd
Tima	71.00hij	57.66ij	74.33gh	127.33ef
UC82B	104.00f	101.66fg	223.66a	145.33de
Rio-grande	41.33jf	56.50ij	61.66hij	56.00ij
SE±	4.330			

Means followed by the same letter (s) are not significantly different at 5% using DMRT

Table 4: Interaction of variety and NPK on Numbers of Fruits per Plant for Rain-fed season

Variety	NPK (kg ha^{-1})			
	0	300	600	900
Roma – VF	1.02def	13.53bc	17.26bc	16.79bc
Tima	1.00def	3.00def	5.71cde	13.22bc
UC82B	10.71cde	9.91cde	23.15a	25.27a
Rio-grande	1.27def	5.52cde	6.05cde	10.89cde
SE±	2.458			

Means followed by the same letter (s) are not significantly different at 5% using DMRT

3.5 Mean fruits weight

Mean fruits weight as influenced by NPK rates and variety for irrigated and rain-fed trials during 2016/2017 growing season is presented in Table 9. For the irrigated trial, mean fruits weight was higher with the application of 600 and 900 kg NPK ha^{-1} than 300 kg ha^{-1} and the untreated control. For the rain-fed trial, application of 600 and 900 kg NPK ha^{-1} recorded the highest mean fruits weight followed by 300 kg ha^{-1} and the least was with the untreated control.

On the other hand, for the rain-fed trial, Roma-VF and Tima recorded statically similar mean fruits weight which was higher than UC82B. The least mean fruis weight was by Rio-grande. For the rain-fed trial, Tima recorded higher mean fruit weight than Roma followed by UC82B with the least by Rio-grande.

3.6 Mean fruits diameter

Mean fruits diameter as influenced by NPK rates and variety for irrigated and rain-fed trials during 2016/2017 growing season is presented in Table 9. For the irrigated trial, NPK fertilizer did not affects mean fruits diameter in both rain-fed and irrigated trials.

On the other hand, for the rain-fed trial, variety UC82B recorded the least mean fruits diameter compare with all other variety. Tima had larger mean fruit diameter than only Roma-VF and Rio-grande.

3.7 Fresh fruits yield

Fresh fruits yield as influenced by NPK rates and variety for irrigated and rain-fed trials during 2016/2017 growing season is presented in Table 9. For the irrigated trial, application of 600 and 900 kg NPK ha^{-1} produced significantly more fresh fruits yield than 300 kg ha^{-1} and the untreated control. For the rain-fed trial, application of 600 and 900 kg NPK ha^{-1} resulted in more fresh fruits yield than 300 kg ha^{-1} and the untreated control resulted in the smallest fresh fruit yield. On the other hand, for the rain-fed trial, Roma-VF and Tima recorded statically similar mean fruits weight which was higher than UC82B. The least mean fruis weight was by Rio-grande. For the rain-fed trial, Tima recorded higher mean fruit weight than Roma-VF followed by UC82B with the least by Rio-grande.

Table 5: Mean fruit weight (g), mean fruit diameter (cm) and fresh fruit yield (t ha^{-1}) of tomato as influenced by variety and NPK rates in irrigated and rain-fed conditions in 2016/2017 growing season

Treatment	Mean Fruit Weight (g)		Mean Fruit Diameter (cm)		Yield (t ha^{-1})	
	Irrigated	Rain-fed	Irrigated	Rain-fed	Irrigated	Rain-fed
NPK(Kgha^{-1})						
0	32.09b	25.03c	2.86	2.92	21.78b	16.89c
300	33.95b	30.25b	2.72	3.07	25.39b	27.20b
600	47.96a	38.16a	2.75	2.96	49.18a	32.39ab
900	44.64a	39.28a	2.74	3.15	49.84a	34.58a
SE±	2.030	2.203	0.080	0.130	3.313	3.432
Varieties						
Roma – VF	52.28a	50.04a	2.83a	3.07ab	45.95a	55.41a
Tima	57.87a	54.15a	2.94a	3.25a	39.29ab	42.58b
UC82B	28.41c	38.27b	2.40b	2.87b	35.98b	46.30b
Rio-grande	20.09d	30.03c	2.90a	2.92b	19.96c	21.02c
SE±	2.030	2.203	0.080	0.130	3.313	3.432
Interaction						
NPK x Var	*	*	*	NS	*	*

Means followed by the same letter (s) in a treatment group are not significantly different at 5% using DMRT

The interaction of NPK and variety on mean fruits weight was significant in both Irrigated and Rain-fed season as presented in Tables 10 and 11, respectively.

For the irrigated trial, the untreated control recorded the highest mean fruit weight with Rio-grande and the least mean fruits weight was with Tima although Rio-grande recorded the same mean fruit weight significantly with Roma-VF; for the 300 kg ha^{-1}, Rio-grande recorded significant higher mean fruits weight than only UC82B which in turn was higher than Tima; for 600 kg ha^{-1} all the variety recorded significantly the same mean fruits weight except UC82B; for the 900 kg ha^{-1}, Rio-grande recorded the highest mean fruits weight followed by Tima and the least mean fruits weight was recorded by UC82B.

On the other hand, Rio-grande and Roma-VF recorded the highest mean fruits weight with the application of 600 – 900 kg NPK ha^{-1} followed by the application of 300 kg NPK ha^{-1} and the least mean fruits weight were recorded in the untreated control for Rio-grande, Roma and Tima; for Tima, the highest mean fruits weight were recorded in the application of 600kgNPKha^{-1} followed by the application of 900 kg NPK ha^{-1} and the least mean fruits weight were recorded in the untreated control; and for UC82B application of 900 kg NPK ha^{-1} were significantly higher than the application of 300 kg NPK ha^{-1} which was statically equal to the same mean fruits weight with 600 kg NPK ha^{-1} and the untreated control.

However, Rio-grande, Roma-VF and Tima with the application of 600 kg NPK ha^{-1} recorded significantly the highest mean fruits weight for the irrigated trial and the least mean fruits weight were recorded in Tima with the untreated control.

For rain-fed trial, with the untreated control all the variety recorded significantly the same mean fruits weight for all the variety tested except for Roma-VF which recorded the highest mean fruits weight; with 300 kg NPK ha^{-1}, UC82B and Rio-grande recorded the highest mean fruits weight and the least mean fruits weight was recorded with Tima which is statically the same with Roma-VF; with 600 kg ha^{-1} Roma-VF recorded the highest mean fruits weight followed by Rio-grande and UC82B recorded the least mean fruits weight; and with 900 kg ha^{-1}, Roma-VF which was statically the same with Rio-grande recorded the highest mean fruits weight than Tima and UC82B.

On the other hand, Roma-VF recorded the highest mean fruits weight with the application of 600 kg NPK ha^{-1}; Tima recorded the highest mean fruits weight at the application of 600 and 900 kg NPK ha^{-1}; UC82B recorded the highest mean fruits weight with the application of 300 kg NPK ha^{-1}; and for Rio-grande highest mean fruits weight were recorded with the application of 600 and 900 kg NPK ha^{-1}; In all the varieties tested, the untreated control recorded the least mean fruits weight.

However, Roma-VF with the application of 600 kg NPK ha^{-1} recorded significantly the highest mean fruits weight and the least was recorded in Tima, UC82B and Rio-grande with the untreated control.

Table 6: Interaction of variety and NPK on Mean Fruits Weight (g) for Rain-fed season

Variety	NPK (kg ha^{-1})			
	0	300	600	900
Roma – VF	26.73f	38.50de	58.93a	51.93b
Tima	20.30g	32.95e	41.63cd	40.74cd
UC82B	23.02g	40.46cd	33.04e	38.94de
Rio-grande	20.28g	40.90cd	46.23b	45.94bc
SE±	3.003			

Means followed by the same letter (s) are not significantly different at 5% using DMRT

Table 7: Interaction of variety and NPK on Fruit Yield for irrigated season

Variety	NPK (kg ha^{-1})			
	0	300	600	900
Roma – VF	20.53g	26.57de	51.66a	42.58b
Tima	22.50ef	26.38de	46.36b	50.30a
UC82B	25.89de	23.33ef	28.71d	46.02b
Rio-grande	18.00g	21.90ef	35.27c	21.41f
SE±	2.220			

Means followed by the same letter (s) are not significantly different at 5% using DMRT

Table 8: Interaction of variety and NPK on Fruit Yield for Rain-fed season

Variety	NPK (kg ha^{-1})			
	0	300	600	900
Roma – VF	2.53ef	26.57cd	61.66a	44.92bc
Tima	2.50cd	6.38ef	16.36cde	34.48bc
Uc82b	25.89cd	23.33cd	23.71cd	31.36bc
Rio-grande	1.80ef	11.90cde	15.27cde	17.51cde
SE±	2.220			

Means followed by the same letter (s) are not significantly different at 5% using DMRT

Table 9: Interaction of variety and NPK on Fruit Yield for Rain-fed season

Variety	NPK (kg ha^{-1})			
	0	300	600	900
Roma – VF	2.53ef	26.57cd	61.66a	44.92bc
Tima	2.50cd	6.38ef	16.36cde	34.48bc
Uc82b	25.89cd	23.33cd	23.71cd	31.36bc
Rio-grande	1.80ef	11.90cde	15.27cde	17.51cde
SE±	2.220			

Means followed by the same letter (s) across row or column are not significantly different at 5% using DMRT

The interaction of NPK and variety on fruits yield was significant in both Irrigated and Rain-fed season as presented in Tables 12 and 13, respectively.

For the irrigated trial, the untreated control recorded the highest fruit yeild with UC82B and the least fruits yield was with Rio-grande although Rio-grande recorded the same fruit yield significantly with Roma-VF; for the 300 kg ha^{-1}, the four varieties recorded significantly the same fruit yield; for 600 kg ha^{-1} Roma-VF recorded the highest fruits yield followed by Tima and the least fruits yield was recorded by UC82B; for the 900 kg ha^{-1}, Tima recorded the highest fruits yield and the least fruits yield was recorded with Rio-grande although Roma-VF recorded the same fruits yield significantly with UC82B.

On the other hand, Roma-VF recorded the highest fruits yield with the application of 600kg NPK ha^{-1} followed by the application of 900 kg NPK ha^{-1} and the least fruits yield were recorded in the untreated control; for Tima, the highest fruits yield were recorded in the application of 900kgNPKha^{-1} followed by the application of 600 kg NPK ha^{-1} and the least fruits yield were recorded in the app untreated control; and for UC82B application of 900 kg NPK ha^{-1} were significantly higher than the application of 300 kg NPK ha^{-1} which was statically equal to the same mean fruits weight with 600 kg NPK ha^{-1} and the untreated control.

However, Roma-VF with the application of 600 kg NPK ha^{-1} and Tima with the application of 900 kg NPK ha^{-1} recorded significantly the highest fruits yield for the irrigated trial and the least fruits yield were recorded in Rio-grande with the untreated control.

For rain-fed trial, with the untreated control, variety Tima and UC82B recorded highest and significantly the same fruits yield and the least was with Roma-VF and Rio-grande which were statistically the same; with 300 kg NPK ha^{-1}, Roma-VF,UC82B and Rio-grande recorded the highest fruits yield and the least fruits yield was recorded with Tima; with 600 kg ha^{-1} Roma-VF recorded a higher fruits yield than Tima, UC82B and Rio-grande; and with 900 kg ha^{-1}, Roma-VF, Tima and UC82B recorded the highest fruit yield and the least was with Rio-grande.

On the other hand, Roma-VF recorded the highest fruits yield with the application of 600 kg NPK ha^{-1}; Tima recorded the highest fruits yield at the application of 600 and 900 kg NPK ha^{-1}; UC82B recorded the highest fruits yield with the application of 900 kg NPK ha^{-1}; and for Rio-grande all the application rates recorded significantly the same fruits yield; In all the varieties tested, the untreated control recorded the

least fruits yield. However, Roma-VF with the application of 600 kg NPK ha^{-1} recorded significantly the highest fruits yield and the least was recorded in Roma-VF and Rio-grande with the untreated control

4. Discussion

Variety Roma VF proved the best in terms of plant height, number of leaves, number and weight of fruits per plant, mean fruits diameter and fresh fruit yield, and with Tima in terms of plant height, number of leaves and mean fruit weight. The greater vegetativeness of variety Roma-VF could be due to its peculiar leaf arrangement, having more erect architecture which enables it display more leaves for effective photosynthesis. This is in harmony with the findings of Enujeke (2013) [5] that attributed the differences in growth characters of crop varieties to differences in distribution of leaf surface and crop canopy, leaf arrangement, differences in chlorophyll content and photosynthetic activities and activity of photosynthetic enzymes.

The greater performance of variety UC82B in terms of leaf area index and number of fruits per plant could be attributed to larger individual leaf area it produced. This also explained the similarity in LAI and number and weight of fruits per plant between variety Roma-VF and UC82B. The differences in growth and yield performance observed among the four varieties could be attributed to the genetic make-up of the varieties. Such genetically controlled variation among tomato varieties in term of growth and yield was reported by, Olaniyi *et al.* (2010) [11] and Samaila *et al.* (2011) [16] who independently reported that genetic constitution of crop varieties influences growth and yield characters which they express. It is also similar to the findings of Muhammad and Singh (2007) [9] that attributed the growth and yield differences of crop varieties to right season and suitable agro-ecology.

Both variety Tima and Roma VF produced greater mean fruits weight than UC82B and Rio-grande. This could be due to the ability of Tima and Roma VF to partition photosynthetic materials to economic yield. This is similar to the findings of Akanni (2005) [3], Akanbi *et al*., (2003) [2] who attributed the yield differences in crop cultivars to differences in partitioning of photosynthetic materials towards economic yield. It is also in harmony with the findings of Olaniyi *et al.*, (2010) [11] who attributed the differences in yield and its components between crop genotypes to variations in genetic structure, mineral concentration and potentials to transport photosynthetic materials within plants.

The greater mean diameter of variety Roma VF over Tima and Rio-grande was due to the fruits shape and size. The fruits of Roma-VF are morphologically pear shaped and relatively bigger than other three varieties. This could also be linked to genotype characteristics.

Plant height, number of leaves and leaf area index throughout the growth period were highest with fertilizer rate of 600 - 900 kg NPK ha^{-1}. The response of LAI to higher fertilizer rates of 900 kg NPK ha^{-1} as the crop ages could be attributed to nutrient supply, irrespective of fertilizer rate and also to the nature of the fertilizer. The half dose applied as basal, together with the inherent soil nutrient was able to nourish the crop for early growth. More so, the second fertilizer dose maintained the growth trend up to about fruiting stage. That could be the reason why higher fertilizer rates of 900 kg NPK ha^{-1} were needed for maximum growth at a later period of the crop's life cycle. Oyinlola and Junaidu (2012) [13] and Samaila *et al.*, (2011) [16] suggested application of half of N at planting to ensure a uniform establishment, and then using frequent light application of N for the rest of the season in order to maintain vegetative growth and rapid fruit setting. Number and weight of fruits per plant and mean fruit weight were highest with NPK rates of 600 – 900 kg ha^{-1}. The similar response trend of number and weight of fruits per plant; mean fruit weight and yield to NPK rates was due to the highly significant correlations of these characters to the final fresh fruit yield.

Nitrogen was largely known to enhance vegetativeness but production, deposition and translocation of dry matter are believed to be collective functions of N, P and K. Since N content of fertilizer in these trials doubles the quantity of both P and K, application of 600 kg NPK ha^{-1} may supply adequate N for maximum leaf area, but inadequate for maximum dry matter production. Therefore, application of the highest fertilizer rate of 900 kg NPK ha^{-1} supplies reasonably adequate quantities of P and K for optimum dry matter production. This is in agreement with Isah *et al*. (2015) [7] who attributed the growth and yield parameters of tomato to the level of plant nutrient availability. Nafiu *et al*. (2011) [10] and Shuka *et al*. (1993) [17] reported that tomato requires N, P, K, Mg, Ca and Na for good production and stressed that these nutrients are specific in function and must be supplied to the plant at the right time and in the right quantity. Uzo (1971) [22] also emphasized on the satisfactory balance of N, P, and K nutrient elements for good production of tomato.

It was also observed that there were significant response of plant height, number of leaves, LAI, shoot dry weight, weight of fruits per plant, mean fruit weight and fresh fruit yield to the interaction of NPK rate and variety have clearly indicated the dependence of tomato genotypes to its edaphic environment for manifestation of their full potentials in terms of growth, development and yield as reported by Nafiu *et al*. (2011) [10].

Varieties Roma-VF, Tima and Rio-grande attained maximum plant height at NPK rates of 900 kg ha^{-1} while UC82B reach maximum plant height at NPK rates of 300 kg ha^{-1} for the irrigated while Tima, UC82B and Rio-grande reach maximum plant height at NPK fertilizer rates of 600 kg ha^{-1} for the rain-fed trial. Roma-VF, Tima and UC82B attained maximum leaf area index at NPK rate of 600 kg ha^{-1}, while variety Rio-grande attained similar performance at higher rate of 900 kg ha^{-1}. The similarity between Roma-VF, Tima and UC82B in attainment of maximum leaf area index was due to the profuse nature of the varieties in terms of leaf production.

Number of fruits and mean fruit weight were significantly influenced by fertilizer interactions. All the varieties produced maximum number and weight of fruits at NPK rate of 600 – 900 kg ha^{-1}. The trend could be attributed to the rate at which fertilizer dissolved and absorbed by the plant hence limiting its availability for crop uptake (Muhammad and Singh, 2007) [9].

Roma-VF and Tima attained maximum yield at fertilizer rate of 600kg NPK ha^{-1} while UC82B and Rio-grande attained maximum yield at fertilizer rate of 900kg NPK ha^{-1} though

Rio-grande also attained maximum yield at fertilizer rate of 600kg NPK ha^{-1} at par Roma-VF and Tima. The rate of interaction of all the varieties with the rate of fertilizer application with the level of availability and assimilation determine the yield of each variety.

5. Conclusion

Based on the result of this study, it could be concluded that the varieties Roma-VF and Tima coupled with NPK rates of 600-900 kg ha^{-1} produced the best growth and yield in the study area.

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