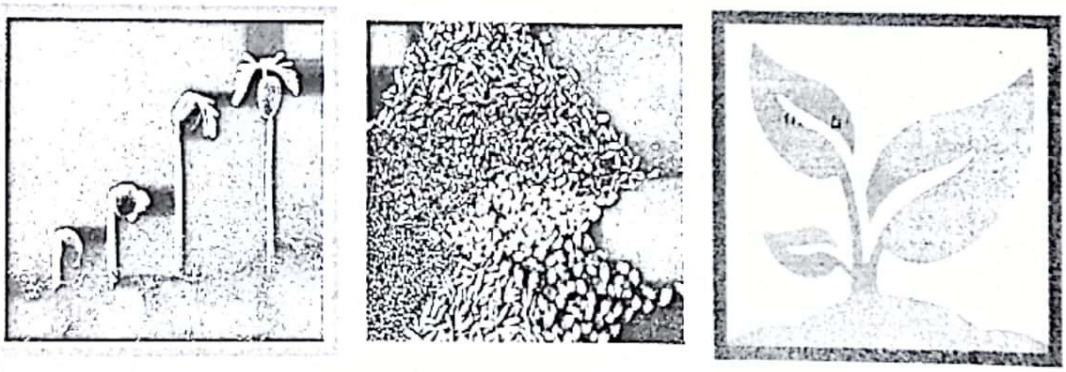
NIGERIAN JOURNAL OF SEED SCIENCE (NJSS)

A Scientific Journal Serving Seed Scientists and Technologists

Volume 2, 2018



PUBLISHED BY
Association of Seed Scientists' of Nigeria (ASSN)

Nigerian Journal of Seed Science

VOL. 2 Content 2018

Nigerian Journal of Seed Science (NJSS) Vol. 2, 42 - 55, 2018

Growth Performance and Yield of Irrigated Tomato (*Lycopersicum esculentum* (l.) H. Karst) as affected by Nitrogen sources and Organic Mulches in Kadawa- Kano, Nigeria

[1]Ainika J.N., [2]Yusuf S.T., [2]Odofin A.J., and [2]Ibrahim H.

[1]*Institute for Agricultural Research, Ahmadu Bello University Zaria*

[2]*School of Agriculture and Agricultural Technology, Federal university of Technology Minna Niger State*

Corresponding author: tayo.yusuf@futminna.edu.ng

Abstract

Two field trials were conducted in the dry season of 2015-2016 and 2016-2017 at the Irrigation Research Farm of Institute for Agricultural Research, Kadawa (11°39' N 080' 027'E, 500 m above sea level) located in the Sudan Savannah ecological zone of Nigeria to evaluate some growth and yield characteristics of irrigated tomato varieties as affected by nitrogen sources and organic mulches. Treatments consisted of two tomato varieties (UC82B and Rio Grande), two organic mulches (rice straw and sugar-cane peel) and a control (No mulch) at recommended rates of 5 t ha^{-1} and 10 t ha,$^{-1}$ respectively and three nitrogen sources (mineral fertilizer, poultry manure, mixture of mineral fertilizer and poultry manure) at recommended rate of 90 kg N ha^{-1} and a control (No application). Variety and nitrogen sources were assigned to the main plots while sugar-cane peel mulch was assigned to the sub plots and replicated three times.

The results showed that the performance (growth) of UC82B was better than Rio-grande in 2015-2016 while the reverse was the case in 2016-2017. However, there was no significant difference between the fruit yield of the varieties. Application of all the applied nitrogen sources especially in 2016-17 which were statistically similar enhanced the growth and yield of tomato varieties but the highest fruit yield was achieved with the mixture of mineral fertilizer and poultry manure. The performance of the two applied organic mulches in enhancing growth and yield of tomato varieties is the same. In conclusion, both varieties could be used in the Sudan savanna but for higher yield Rio-grande is recommended. Application of poultry manure may be recommended as a better source for meeting the nitrogen need of tomato to ensure sustainability in farmer's tomato production in the Sudan savannah ecology. Sugar-cane peel mulch is recommended as a good replacement to rice straw mulch. However, for a higher fruit yield, the application of poultry manure in combination with either rice straw mulch or sugar-cane peel mulch is recommended.

Key word: Tomato, Growth parameters, Nitrogen sources, Organic mulches.

Introduction

The climatic condition of Nigeria especially the Savannah agro-ecology offers the most suitable condition for the growth and development of heat tolerant tomato varieties especially during the dry season characterized by relatively low temperature, relative humidity and less pest and diseases infestation. The minimum temperature is around 10°C with the maximum being 34°C. The optimum growing temperatures for tomato are 21°C to 24°C. Temperature variation might result in poor fruit quality or reduced yields. At these temperatures good quality seeds will take about seven days to emerge.

Temperature affects flowering and pollination. The hot and dry weather leads to drying of the flowers and stops pollination. If temperatures are below 15°C or above 29°C, pollen release is restricted resulting in incomplete fertilization of ovules. This causes collapsed fruit walls and formation of deep indentation in the fruit, a phenomenon called catface (Peirce, 1987; Bok *et al.*, 2006).

It has been shown that humidity is a very important factor in terms of growth, incidence of disease and product quality. Both high and low humidity have adverse effects. However, the occurrence of long periods of high humidity is normally considered to be most serious. According to report by Walker and Duncan (1956) that high relative humidity conditions however, do favours overall plant growth which normally relates to a reduction in plant water stress. On the other hand low relative humidity is associated with reduced yield and growth as well as other problems such as fruit maladies (radial cracking of tomatoes) which generally increases when low humidity conditions occur. Relative humidity of 70 % is optimal for pollination, fruit set and development. Very high humidity keeps the pollen too damp and sticky, reducing the chance of sufficient pollen transfer from anthers to stigma (Mariam, 2017).

Inorganic fertilizers' application is the fastest way of meeting the nitrogen need of crop plant like tomato but are out of reach of small and medium scale farmers due to increasing cost. The problems associated with the use of synthetic fertilizers for soil fertility are receiving increasing attention worldwide because of the environmental pollution and ecological imbalances they cause . However, other possible measures that are economical and environmentally friendly for improved yield and quality such as the use of organic manure which is capable of changing the structure of the soil over time to improve the water conservation of the soil which will intimately enhance productivity are being adopted. Sustainability in agro-ecosystems involves environmentally friendly techniques based on biological and non- chemical methods (Bonato and Ridray, 2007).

Application of organic fertilizers has been a traditional practice of maintaining soil health and fertility because apart from the nutrient it supplies it also improves the soil physical and chemical properties as well. However, most organic manure recommendations for tomato that are based on rates do not take into consideration the type and nitrogen content of the manure before making recommendation to farmers and has led to variations in organic manure recommendation such as poultry manure even within the same ecological zone.

Tomato production during dry season takes the largest percentage of the total production of the crop tomato in Nigeria. Moisture conservation is an important agronomic practice for increase production of tomato. Inorganic mulching material such as black polythene has been recommended as the most effective way of conserving soil moisture but have some detrimental effects on soil condition. However, organic mulching material such

as rice straw with little or no detrimental effect on soil condition has been recommended for farmers in the Sudan ecology due to its availability but its use as livestock feed has made it scarce for the farmer to afford due to high cost. Sugar-cane peel or trash which has been an environmental threat around human dwellings and also an important contributor to climate change when burnt can be used alternatively as an option to conserve moisture for the plants and maintain a save environment for agricultural sustainability.

The aim of this research is, therefore, to study some growth and yield characters of irrigated tomato varieties as affected by nitrogen sources and organic mulches in Kadawa, Kano Nigeria.

Materials and Methods

Experimental Site

Field trials were conducted in the dry season of 2015-16 and 2016-17 at the Irrigation Research Farm of Institute for Agricultural Research, Kadawa (11°39' N 080' 027'E, 500 m above sea level) located in the Sudan Savannah ecological zone of Nigeria to study some growth and yield characters of irrigated tomato varieties as affected by nitrogen sources and organic mulches in Kadawa, Kano, Nigeria.

Treatments and Experimental Design consisted of two tomato varieties:UC82B and Rio Grande; two organic mulches:rice straw and sugar-cane peel at recommended rates of 5 t ha^{-1} and 10 t ha^{-1}, respectively; three nitrogen sources: at recommended rate of 90 kg N ha^{-1}. The first nitrogen source was mineral fertilizer (N.P.K 15:15:15) which was used by split application to supply 45 kg ha^{-1} of nitrogen as first dose in addition to P_2O_5 and K_2O it supplied to meet the P and K requirement of the crop at two weeks after transplanting while urea (46% N) was used to supply the second dose of nitrogen at 45 kg ha^{-1} which gave a total of 90 kg N ha^{-1} supplied to the crop at two week after the first application. Poultry manure was also applied during land preparation as basal at 90 kg N ha^{-1}. This was achieved by analyzing the nitrogen content of the manure in the laboratory and the value obtained was used through extrapolation to determine the quantity of poultry manure that will supply the plant with 90 kg ha^{-1} of nitrogen. A mixture of mineral fertilizer (N.P.K-15:15:15) and poultry manure at 45 kg N ha^{-1} each was applied appropriately to supply a total of 90 N ha^{-1}. The control plots received no fertilizer application throughout the period of experimentation. Variety and nitrogen sources were assigned to the main plots while sugar-cane peel mulch was assigned to the sub plots and replicated three times.

UC82B is a short variety (50-60 cm) with semi determinate growth habit, speedy branches and open pollinated with short maturity period of 70 - 75 days after transplanting. It has high yield potential (30 – 35 t ha^{-1}). It is a processing type with a square shaped red fruit containing many seeds. The fruits are firm and can store for about two weeks when harvested at green stage. It is resistant to *Verticillium dalhiae* and *Fusarium oxysporum sp.* (Anon, 2016).

Rio Grande seeds germinate fast and the fruits form in clusters: the plants seem to do well in weather extremes, both hot and cold. Maturity period is 75-80 days from transplanting with vigorous plant. The fruit is large, 8cm, pear-shaped paste tomato, deep red in colour. It is a cylindrical elongated fruit in shape with a very good shelf life and transportability and with yield potential of 30-40 t ha^{-1} (Royal Seed). It has good disease resistance against leaf roll virus. Rio Grande is a trailing tomato with a determinate growth habit. The fruit weight is 90 – 100 g with a cylindrical elongated very firm flesh and good flavor (Anon, 2016).

Parameters studied

Crop growth rate (CGR)

This is the rate of dry matter production per unit of time. It was calculated using the formula given by Radford (1967). Where, W_1 and W_2 are dry weight in g plant $^{-1}$ at time T_1 and T_2 in weeks and GA is the ground area.

Relative growth rate (RGR)

Relative growth rate (RGR) is the cumulative dry matter increment per unit of time and was computed using the formula as described by Radford (1967).

Wk

Where W_1 and W_2 refer to the total dry matter of plant at times T_1 and T_2 respectively.

Net assimilation rate (NAR)

This was computed with the following formula given by Radford (1967). Where W_1 and W_2 = dry weight in g per plant at time T_1 and T_2 respectively and LA = Leaf area.

Total fruit yield (ha^{-1})

This was determine by weighing the total number of harvested fruits per net plot with the use of a top loader balance and then converted to tones per hectare.

Statistical Analyses

Data collected were subjected to analysis of variance (ANOVA) as described by Steel and Torrie (1987) and treatment means were separated using Duncan multiple range test as described by Duncan *et al.* (1997).

Results

Crop growth rate

The crop growth rate (CGR) of tomato varieties as affected by nitrogen sources and organic mulches in Kadawa in 2015-2016 and 2017-2017 dry seasons are presented on Table 1. Variety UC82B had significantly higher crop growth rate than Rio-grand variety at 5 and 7 WAT in 2015-2016 but at 9 WAT of the same season and at 5 WAT in 2016-2017 variety Rio-grande had higher CGR than UC82B. Variety had no significant effect on CGR at 7 and 9 WAT in 2016-2017 dry season.

Application of the different nitrogen sources resulted in no significant increase in CGR in 2015-2016. In 2016-2017 combined application of mineral fertilizer and poultry manure resulted in significantly greater CGR than that of the control at 5-9 WAT. There were no significant differences among the CGR

Table 1: Crop growth rate (g wk^{-1} plant^{-1}) of irrigated tomato as affected by varieties, nitrogen sources, organic mulches and interactions during 2015-16, 2016-17, 2017-18 inKadawa Kano Nigeria

	2015-2016			2016-2017		
Factor level/interaction	**5WAT**	**7WAT**	**9WAT**	**5WAT**	**7WAT**	**9WAT**
Variety (V)						
UCS2B	1.34a	8.80a	12.00b	1.28b	4.95	26.01
RIO-GRANDE	0.61b	5.32b	15.47a	1.90a	6.53	29.05
SE±	0.224	0.654	0.799	0.076	0.646	4.360
Nitrogen source (N)						
No application	0.70	5.74	11.92	1.43b	4.16b	15.49b
Mineral fertilizer	1.64	7.73	13.74	1.56ab	5.02b	30.56ab
Poultry manure (PM)	0.76	7.79	13.95	1.56ab	4.15b	24.59ab
Mineral fertilizer + PM	0.81	6.98	15.34	1.83a	9.63a	39.58a
SE±	0.317	0.924	1.129	0.107	0.913	6.166
Organic mulches(M)						
No mulch	1.30	6.93	11.92b	1.34b	6.26	16.47b
Rice straw	0.73	6.79	14.51ab	1.80a	5.52	36.13a
Sugar-cane peel	0.89	7.46	14.78a	1.64ab	5.46	29.98a
SE±	0.311	0.996	0.931	0.124	0.622	4.537
Interaction						
N×V	NS	NS	NS	NS	NS	NS
N×M	NS	NS	NS	NS	*	NS
V×M	NS	NS	NS	NS	NS	NS
N×V×M	NS	NS	NS	NS	NS	NS

All means within a column and under each factor followed by same letters are not different at 5% level of significance using Duncan Multiple range test DMRT; NS=Not significant.
*= significant at 5%. WAT=Weeks after transplanting.

values of the control, mineral fertilizer and poultry manure. Also, at 5 and 9 WAT, the CGR values of mineral fertilizer, poultry manure and mineral fertilizer plus poultry manure were similar. At 7 WAT CGR of the plants to which mineral and poultry manure were combined in application was significantly greater than those of the other fertilizer treatments.Only nitrogen source x organic manure interaction effect was significant at 7 WAT in 2016-2017. Table 2 shows the interaction effect of nitrogen sources and organic mulches at 7 WAT in 2016-17.The application of the mixture of mineral fertilizer and poultry manure in combinations with either rice straw or sugar-cane peel mulch resulted in the highest CGR values (12.80 and 10.60 g $wk^{-1}plant^{-1}$ respectively) but significantly greater than those of all the other possible combinations.

Relative growth rate (RGR)

The relative growth rate (RGR) of tomato varieties as affected by nitrogen sources and organic mulches in Kadawa in 2015-2016 and 2017-2017 dry seasons are presented on Table 3. Variety UC82B had significantly(?) higher crop growth rate than Rio-grand variety at 5 and 7 WAT in 2015-2016 but at 9 WAT and at 5 WAT in 2016-2017 variety Rio-grande had higher RGR than UC82B. However, no significant varietal effect on RGR was recorded at 7 and 9 WAT in 2016-2017 dry season

It was only at 5 WAT in 2015-2016 that application of nitrogen sources significantly affected RGR of tomato with mineral fertilizer and poultry manure which were statistically the same showed superiority over the mixture of mineral fertilizer and poultry manure although the difference between poultry manure and the mixture as well as the control was also not significant. However, in 2016-2017 at 5 WAT, application of poultry manure and the mixture of mineral fertilizer and poultry manure had tomato plants with higher RGR compared to application of mineral fertilizer and the control which was also at par statistically but at 7 WAT the mixture of mineral fertilizer and poultry manure produced tomato plants with the highest RGR while all the applied nitrogen sources, which were statistically the same, had higher RGR then the control plots.

Application of organic mulches was only significant at 9 WAT in 2016-17 with both organic mulches showing superiority and statistically similar effect on RGR than the control.

No significant interaction effects were recorded except that between nitrogen sources and organic mulches at 7 WAT in 2016-2017.

Table 4 shows the interaction of nitrogen sources and organic mulches on RGR at 7 WAT in 2016-17. Application of the mixture of mineral fertilizer and poultry manure under sugar peel mulch as well as only poultry manure in combinations under sugar-cane peel mulch which (were statistically the same) produced significantly higher RGR than all the other possible combinations.

Net assimilation rate (NAR)

Variety has no significant effect on NAR at 5 and 7 WAT in 2015-2016 and 2016-

Table 2:Interaction effect of nitrogen sources and organic mulches on CGR (g wk^{-1} $plant^{-1}$) of tomato at 7 and WAT during 2016-17 dry in Kadawa Kano State Nigeria.

	Organic mulch		
Nitrogen source	No mulch	Rice straw	Sugar-cane peel
No application	2.55d	5.95bc	3.99b-d
Mineral fertilizer	5.08b-d	6.64b	3.34cd
Poultry manure (PM)	4.58b-d	3.99b-d	3.89b-d
Mineral fertilizer + PM	5.49bc	12.80a	10.60a
SE±		1.245	

Means followed by the same letter are not significantly different at 5% level of probability using DMRT.

2017, respectively but at 7 WAT, UC82B was better than Rio-grande while at 9 WAT Rio-grande was better than UC82B in 2015-2016. However, in 2016-2017 Rio-grande was better at 5WAT while at 9 WAT UC82B was better (Table 5).

Nitrogen source had no significant effect on NAR in 2015-2016 but in 2016-2017, in all the experimental period, application of all the applied nitrogen sources which were statistically similar have higher NAR of tomato plants than the control although the difference between the control and poultry manure was statistically at par.

Organic mulches have no significant effect on NAR throughout the period of experimentation.

Interaction effect was not significant throughout the period of experimentation.

Fresh fruit yield

Table 6 shows the effects of nitrogen sources and organic mulches on tomato varieties in 2015-2016, 2016-2017 and the combined results in Kadawa, Kano Nigeria.

Variety UC82B had significantly higher fruit yield than Rio-grande in 2015-2016 while the reverse was the case in 2016-2017. No significant difference was observed when the fresh fruit yield data were combined for analysis.

Application of all the applied nitrogen sources which were statistically the same significantly produced higher fresh fruit yield than the control in both years and the combined results although the difference between the control as well as mineral fertilizer and poultry manure was also statistically at par.

Organic mulch application did not significantly affect tomato fresh fruit yield in 2015-2016. In 2016-2017, in the combined results both organic mulches resulted in statistically similar yields but only the yield obtained from the use of rice mulch was significantly higher than the control. However, when data for both years were combined and analysed, the yield from the control plot was significantly

Table 4: Interaction effect of nitrogen sources and organic mulches on relative growth rate (g.g.wk^{-1}) of tomato at 7 WAT during 2016-17 dry season in Kadawa Kano State Nigeria.

	Organic mulch		
Nitrogen source	No mulch	Rice straw	Sugar-cane peel
No application	0.45d	0.63bc	0.51b-d
Mineral fertilizer	0.62b-d	0.65b	0.50b-d
Poultry manure (PM)	0.53b-d	0.47cd	0.93a
Mineral fertilizer + PM	0.53e	0.58b-d	0.83a
SE±		0.075	

Means followed by the same letter are not significantly different at 5% level of probability using DMRT.

lower than those of the two mulches.

Nitrogen and organic mulches interaction effect was significant in both years and highly significant in the combined results. Also, the three-way interaction between nitrogen sources, variety and organic mulches was significant in the combined result.

Table 7 shows interaction effect of nitrogen sources and organic mulches on fresh fruit yield of irrigated tomato in 2015-16, 2016-17 and the combined results. Application of a mixture of mineral fertilizer and poultry manure combined with sugarcane peel mulch was found to produce a fruit yield of 20 t ha^{-1} which was significantly higher than all other possible combinations including the control in 2015-16. In 2016-17, the mixture of mineral fertilizer and poultry manure combined with both rice straw mulch and sugarcane peel mulch and that between poultry manure combined with both rice straw mulch and sugarcane peel mulch which was statistically at par was found to have produced the highest fruit yield than all other possible combinations including the control. However, in the combined data, all the applied nitrogen sources in combination with rice straw mulch and sugarcane peel mulch, which were found to be statistically the same, produced the highest fruit yield than all other possible combinations including the control.

Table 8 shows interaction effect of nitrogen sources, varieties and organic mulches as affected by fruit yield of tomato in the combined dry season in Kadawa Kano State Nigeria. Application of mineral fertilizer in combination with the two organic mulches and also the mixture of mineral fertilizer with poultry manure on UC82B as well as the application of the mixture of mineral fertilizer and poultry manure in combination with only sugar-cane peel mulch as well as only poultry manure in combination with rice straw mulch, which were statistically similar, produced the highest fruit yield of tomato than any other possible combinations.

Table 3: Main effect and interactions of relative growth rate (g g wk^{-1}) of irrigated tomato as affected by varieties, nitrogen sources and organic mulches during 2015-16, 2016-17, 2017-18 and the combined results in Kadawa Kano Nigeria

	2015-2016			2016-2017		
Factor level/interaction	**5WAT**	**7WAT**	**9WAT**	**5WAT**	**7WAT**	**9WAT**
Variety (V)						
UC82B	0.27a	0.79a	0.79b	0.31b	0.57	0.93
RIO-GRANDE	0.12b	.0.65b	0.92a	0.50a	0.63	0.96
SE±	0.023	0.023	0.020	0.022	0.037	0.033
Nitrogen source (N)						
No application	0.16b	0.67	0.80	0.35bc	0.53b	0.78b
Mineral fertilizer	0.28a	0.74	0.86	0.33c	0.59b	1.00a
Poultry manure (PM)	0.18ab	0.74	0.86	0.44ab	0.51b	0.95a
Mineral fert.+ PM	0.17b	0.73	0.89	0.50a	0.78a	1.07a
SE±	0.032	0.033	0.02	0.081	0.052	0.046
Organic mulches(M)						
No mulch	0.23	0.70	0.82	0.35	0.63	0.85b
Rice straw	0.16	0.75	0.86	0.43	0.58	1.03a
Sugar-cane peel	0.19	0.71	0.89	0.43	0.59	0.97ab
SE±	0.036	0.047	0.027	0.041	0.038	0.045
Interaction						
N×V	NS	NS	NS	NS	NS	NS
N×M	NS	NS	NS	NS	*	NS
V×M	NS	NS	NS	NS	NS	NS
N×V×M	NS	NS	NS	NS	NS	NS

All means within a column and under each factor followed by same letters are not different at 5% level
of significance using Duncan Multiple range test DMRT; NS=Not significant.
*= significant at 5%. WAT=Weeks after transplanting.

Table 5: Net assimilate rate (g cm^{-2} wk^{-1}) of irrigated tomato as affected by varieties, nitrogen sources, organic mulches and interaction during 2015-16, 2016-17, 2017-18 and the combined results in Kadawa Kano Nigeria

	2015-2016			2016-2017		
Factor level/interaction	5WAT	7WAT	9WAT	5WAT	7WAT	9WAT
Variety (V)						
UC82B	0.09	0.13a	0.09b	0.27b	4.59	5.15a
RIO-GRANDE	0.04	0.09b	0.13a	0.40a	5.09	4.12b
SE±	0.015	0.011	0.010	0.019	0.531	0.310
Nitrogen source (N)						
No application	0.05	0.82	0.10	0.18b	3.30b	3.62b
Mineral fertilizer	0.10	0.12	0.10	0.37a	5.45ab	5.26a
Poultry manure (PM)	0.05	0.13	0.12	0.37a	4.76ab	4.19ab
Mineral fertilizer + PM	0.06	0.10	0.13	0.43a	5.85a	5.46a
SE±	0.021	0.016	0.015	0.027	0.751	0.438
Organic mulches(M)						
No mulch	0.09	0.11	0.10	0.28b	4.16	4.57
Rice straw	0.05	0.11	0.11	0.39a	5.14	4.53
Sugar-cane peel	0.60	0.11	0.11	0.33ab	5.22	4.79
SE±	0.020	0.015	0.013	0.033	0.482	0.434
Interaction						
N×V	NS	NS	NS	NS	NS	NS
N×M	NS	NS	NS	NS	NS	NS
V×M	NS	NS	NS	NS	NS	NS
N×V×M	NS	NS	NS	NS	NS	NS

All means within a column and under each factor followed by same letters are not different at 5% level of significance using Duncan Multiple range test DMRT; NS=Not significant.
*= significant at 5%. WAT=Weeks after transplanting.

Table 6: Fruit yield (t ha^{-1}) of irrigated tomato as affected by varieties, nitrogen sources, organic mulches and interaction during 2015-16 and 2016-17 dry season and the combined result in Kadawa, Kano State Nigeria.

Factor level/interaction	2015-16	2016-17	Combined
Variety (V)			
UC82B	16.03a	18.80b	22.14
RIO-GRANDE	6.75b	22.99a	21.20
SE±	0.659	0.999	0.666
Nitrogen source (N)			
No application	9.60b	16.43b	18.05b
Mineral fertilizer	10.67ab	21.41a	22.45a
Poultry manure (PM)	12.30ab	21.34a	22.09a
Mineral fert. + PM	13.00a	24.40a	24.09a
SE±	0.932	1.413	0.942
Organic mulches (M)			
No mulch	10.46	18.27b	19.25b
Rice straw	10.49	24.13a	23.34a
Sugar-cane peel	13.22	20.28ab	22.43a
SE±	1.191	1.361	0.753
Interaction			
N×V	NS	NS	NS
N×M	*	*	**
V×M	NS	NS	NS
N×V×M	NS	NS	*

All means within a column and under the same factor followed by same letters are not different at 5% level of significance using Duncan Multiple range test DMRT. NS=Not significant. *= significant at 5%. WAT=Weeks after transplanting.

Table 7: Interaction effect of nitrogen sources and mulches on fruit yield (t ha^{-1}) of tomato during 2015-16, 2016-17 dry season and the combined results in Kadawa Kano State Nigeria.

	Organic mulch		
Nitrogen source	No mulch	Rice straw	Sugar-cane peel
2015-16			
No application	6.9e	12.6b-d	9.3b-e
Mineral fertilizer	10.9b-e	7.0e	14.2bc
Poultry manure (PM)	12.8b-d	14.8b	9.2c-e
Mineral fertilizer + PM	11.2b-e	7.6de	20.2a
SE±		2.42	
2016-17			
No application	12.27f	21.61b-d	15.42ef
Mineral fertilizer	18.42de	19.31de	20.03c-e
Poultry manure (PM)	19.86c-e	25.69ab	24.88a-c
Mineral fertilizer + PM	16.09d-f	29.92a	27.21a
SE±		2.448	
Combined			
No application	12.30d	19.67bc	17.94c
Mineral fertilizer	20.01bc	23.72a-c	23.64a-c
Poultry manure (PM)	21.46bc	25.14ab	23.91a-c
Mineral fertilizer + PM	19.50bc	24.28ab	28.48a
SE±		1.506	

Means followed by the same letter are not significantly different at 5% level of probability using DMRT.

Discussion

Variety UC82B had better performance with respect to all the growth parameters evaluated in 2015-2016 but in 2016-2017 the reverse was the case with Rio-grande exhibiting better performance. However, variety did not affect the final fresh fruit yield at all. The poor performance of Rio-grande in 2015-2016 may be due to delay in planting and outbreak of *Tuta absoluta* (tomato ebola) which was experienced during crop establishment and fruiting stage, respectively. If this was not the case Rio-grande would have shown similar trend in the first year. The better performance of Rio-grande over UC82B may be attributed to genetic makeup because Rio-grande is known to be bigger and heavier in size as reported by Anon (2012). Therefore, the differences observed in the parameters evaluated between the varieties may not be attributed to treatment differences but rather to genetic characteristic so the varieties may be generally considered similar in their response to treatment factors.

Table 8: Interaction effect of nitrogen sources, varieties and organic mulches on fruit yield of tomato in the combined dry season in Kadawa Kano State Nigeria.

	Variety						
	UC82B			RIO-			GRAND
	Organic mulch						
Nitrogen source	No mulch	Rice straw	Sugar-cane peel	No mulch	Rice straw	Sugar-cane peel	
No application	11.89i	19.01f-h	17.13h	12.72i	21.95d-g	18.76f-h	
Mineral fertilizer	22.85d-f	25.88a-d	27.91ab	24.59b-e	21.00e-h	19.37f-h	
Poultry manure (PM)	24.08b-e	24.09b-e	18.89f-h	18.83f-h	26.20a-d	20.46e-h	
Mineral fert.+ PM	21.27e-h	22.96c-f	29.78a	17.74gh	25.61b-d	27.18a-c	
SE±							

All means within a row or column followed by same letters are not different at 5% level of significance using Duncan Multiple Range test DMRT.

In 2016-2017 at 5 and 9 WAT all the applied nitrogen sources significantly enhanced CGR and RGR while net assimilations rate also was similarly affected in all sampling periods although the difference between all the applied nitrogen sources were statistically the same compared to the control. Also, the fresh fruit yield was also enhanced with the application of all the applied nitrogen sources but was statistically the same in all the experimental period and the combined result. However, nitrogen sources did not show any significant effects on CGR and NAR in 2015-2016 and this may be attributed to inability of tomato plants to accumulate enough dry matter early enough for further assimilation. In all the growth characters tested including the fresh fruit yield, the mixture of mineral fertilizer with poultry manure gave the highest contribution but was statistically at par to other nitrogen sources. The result of this work is not unexpected because all the nitrogen sources have been reported earlier over the years by different workers to have positive impact on growth and development of tomato plant. The response observed from all the nitrogen sources is due to the role played by nitrogen as an essential element of all

amino acids in plant structures which are the building blocks of plant proteins important in growth and development of vital plant tissues and cells like cell membranes and the chlorophyll.

In all the parameters evaluated, the application of both organic mulches showed that they are statistically similar in their ability to enhance the growth and development of tomato compared to the control throughout the period of experimentation. This response observed was due to the role played by organic mulches as a means of not only conserving moisture but also as a means of regulating soil temperature, protection of soil from erosion, reduction of compaction of soil due to impact of heavy rainfall, and prevention of weed growth to check loss of soil nutrients.

An interaction between nitrogen and organic mulches was more pronounced followed by that between nitrogen sources, variety and organic mulches. CGR was better enhanced by interaction between the mixture of mineral fertilizer with poultry manure in combination with both organic mulches while RGR was better enhanced by the interaction between the mixture of mineral fertilizer and poultry manure as well as poultry manure in combinations with sugar-cane peel mulch. However, the result from interaction effects has shown that the crop fresh fruit yield was better enhanced with the combinations of all the nitrogen sources when combined with any of the organic mulches.

Results from this work suggest that the application of poultry manure and any of the organic mulches was a better source of meeting the nitrogen need of tomato to ensure sustainability in farmers tomato production in the Sudan savannah ecology. However, for a higher yield, the application of poultry manure in combination with either rice straw mulch or sugar-cane peel mulch is recommended for better production of tomato.

References

Anonymous, (2016). Vegetable Seed-Premier Seed Nigeria Limited. *http://www.premier-seeds.com/services/production/vegetable-seeds.html).*

Bok, I M., Madisa, D. Machcha, M. Moamogwe & K. More. (2006). Manual for vegetable production in Botswana (ed). Department of Agricultural Research, Gaborone, Botswana.

Bonato O, Ridray G. 2007. Effect of tomato deleafing on mirids, the natural predators of whiteflies, *Agron. Sustain. Dev. 27, 167–170.*

Duncan D. B. (1955). "Multiple Range and multiple" *F-test Biometrics" 11; 1 - 42.*

Mariam, K. (2017). Pollination and fruit development in tomatoes. Cooperative extension service. University of Alaska Fairbanks. *www.uaf.edu/ces or 1-877-520-5211*

Peirce, L.C. (1987). Vegetables characteristics, production and marketing. John Wiley and Sons. Inc. Toronto. Canada.

Radford, P. J. (1967). Growth analysis formula, their use and abuse. *Crop Science* 7:171-175.