Yıeld and yıeld components of irrıgated tomato (*Lycopersicon lycopersicon* M.) varıetıes as influenced by intra ro`w spacıng and poultry manure in the savanna ecologıcal zone of Nıgerıa

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Abstract: Two field trials were conducted in the dry season of 2019/2020 at Teaching and Research Farm of the Federal University Dutsin-Ma Badole Katsina State, in the Sudan Savanna Ecological Zone of Nigeria and Mai-Gatari, Kankara Local Government Area located at Northern Guinea Savanna Ecological Zone of Nigeria to study the Effect of variety, intra row spacing and rates of poultry manure application on growth and yield parameters of tomato. The treatment consisted of a factorial combination of two tomato varieties (UC82B and ROMA VF MANSOON-4132), 3 intra row spacing (30, 40, and 50 cm) and 4 rates of poultry manure (0, 2, 4 and 6). The treatments were factorized and laid out in a randomized complete block design (RCBD) with three replications. Result obtained showed that all the tomato growth parameters were significantly enhanced by the application of poultry manure up to 6 t ha^{-1} in both locations. Varying intra row spacing tested had significant effect on fruit yield were intra row spacing of 40 cm apart significantly gave more yield. Among the parameters tested, ROMA FV significantly produced more number of fruits than UC82B. However, UC82B significantly gave heavier fruits. But in the final yield no significant differences observed among the two varieties under investigation in both locations. Based on the results obtained from these experiments, it could be concluded that the application of poultry manure at the rate of 6 t ha^{-1} significantly enhanced the growth and yield of the two tomato varieties evaluated in the study areas. It therefore recommends that any among the two cultivars investigated using 50cm intra row spacing and application of 6 tonnes per hectare is profitable for tomato farmers in the study areas.

Keywords: Tomato Varieties, growth and yield parameters, intra row spacing, poultry manure

INTRODUCTION

The yield of tomatoes is generally low in Nigeria, with an average yield of 20 t ha^{-1} in the northern part, while in the southern and eastern parts average yield is 10 t ha^{-1} and 5 t respectively (FAO, 2016). To meet the increasing demand for tomatoes in Nigeria due to population increase, tomato varieties that are most adapted to the growth or environmental conditions need to be developed for optimum production.

Organic manures such as Poultry manure can be used as an effective source of nitrogen to develop the commonly grown varieties in the savanna where the production of Tomatoes is concentrated (Bassi. & Akanbi 2020).

Poor varietal performance and management practices that include inter and intra row spacing among the major constraints of tomato production and productivity in Nigeria. Ara *et al.,* (2007). Optimum spacing improves the performance of tomatoes. (Lemma, 2002) It has been reported that wider spacing increased mean fruit size, mean fruit weight, and fruit weight per plant. Singh, (2004) reported that an intra raw spacing of 20-40cm was appropriate for maximum fresh tomato yield and quality in

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the Sudan savanna of Nigeria. Inorganic fertilizer application is the fastest way of meeting the nitrogen needs of crop plants like tomatoes but inorganic fertilizers are out of reach of small and medium scale farmers due to increasing cost. The problems associated with the use of inorganic fertilizers are receiving increasing attention worldwide because of the environmental pollution and ecological imbalances they cause. Nitrogen, being the most important primary nutrient needed for the satisfactory growth and development of tomatoes in the savanna, is in limited quantity in the soil. The beneficial effects of inorganic fertilizers have been deemed short of immeasurable significance of the organic sources of nutrients. The shortage, high cost, and negative residual effects of synthetic fertilizers have limited their use for vegetable production amongst peasant farmers in Nigeria. This could in turn result in an imbalance of nutrient content in the soil. However, alternative nutrient sources that are 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 and improving the water conservation of the soil which will ultimately enhance productivity can also be developed. (Bonato & Ridray, 2007). The application of organic fertilizers has been a traditional practice of maintaining soil fertility because apart from the nutrients that they supply, they also improve soil's physical and chemical properties. However, Most organic manure recommendations for tomatoes that are based on rates do not take into consideration the type and nitrogen content of the manure before making recommendations to farmers.This has led to variations in organic manure recommendations even within the same ecological zone.

Commercial production of tomatoes relies mostly on exotic varieties and production is essentially restricted to the northern Guinea savanna and the Sudan savanna ecologies due to favorable climatic conditions, particularly high insulation and low relative humidity.

Therefore, there is a need to standardize production technology under local climatic and edaphic conditions so that farmers of the area can get the maximum benefit from tomatoes as well as increase production and maintain a safe environment under dry season conditions.

The study was therefore designed to evaluate the effect of different intra row spacing and poultry manure rates on growth and yield of tomato varieties in the study areas.

MATERIALS AND METHODS

Field experiments were conducted during the dry seasons of 2019 and 2020 at Teaching and Research Farm of the Federal University Dutsin-Ma, Badole Katsina State, located in the Sudan savanna ecological Zone of Nigeria ($11^0$58`N, 80 26`E and 475) above sea level and a Farm site at Mai-Gatari, Kankara Local Government Area located in Northern Guinea Savanna Ecological Zone of Nigeria (Latitude $11^0$55`52.76”N Longitude $7^0$24’49.68”E, and 595m above sea level.

Soil samples from the two locations were collected diagonally across the field at a depth of 0 – 15 cm and 15 – 30 cm from the experimental sites using soil auger. The soil

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samples from each locations were bulked, dried, ground, sieved, and subjected to physicochemical analysis.

Poultry manure used was analyzed to determine the nutrient contents such as N, P, and K as well as some exchangeable bases such as calcium, magnesium, and sodium at the Department of Soil Science laboratory of Ahmadu Bello University, Zaria.

Meteorological data including daily temperature, sunshine hours, and relative humidity during the 2019 and 2020 experiments were obtained from the Nigerian Metrological Agency Katsina (NIMET).The weather was characterized by daily temperatures ranging from 12^0 to 45^0C (December 2019 to April 2020).

Treatments consisted of a factorial combination of two tomato varieties (UC82B and ROMA VF MANSOON – 4132, three intra – row spacing of 30, 40 and 4 different rates of poultry manure (0, 2,4, and 6 t ha^{-1}). The treatments were factorized and laid out in a Randomized Complete Block Design (RCBD) with three replications.

The gross plot size was 3m×2m = $6m^2$. The marked plots were separated by a 0.5m path while replications were separated by a 1.5m path and were used as borders to ease management. After the seedbed preparation, irrigation was applied to field capacity two times before transplanting of seedlings.

Agronomic Practices

Agronomic practices were carried out according to the recommended agronomic practices from nursery practice to harvesting. The poultry manure was applied according to treatments two weeks before transplanting and the field was irrigated to field capacity twice a week.

Observations and Data Collection

Plant height (cm)

This was measured with a meter rule from the base of the plant to the apex (terminal bud) of each of five randomly tagged plants per plot at 4, 6, and 8 WAT.

Number of productive branches

The total number of productive branches from the five randomly tagged plants was counted at 4, 6, and 8 WAT.

Number of leaves per plant

The number of functional leaves from each of the five randomly tagged plants was counted, the mean was calculated and recorded at 4, 6, and 8 WAT.

Plant dry weight (g)

Three plants were uprooted at 4, 6, and 8 WAT from outside the net plots and then oven-dried at 75°C to a constant weight to obtain the dry weight (Bok et al. 2006).

Leaf area index (LAI)

Three plants were removed from each net plot and leaves were detached from each which were inserted inside the leaf area machine (LT-3100C area meter) in the laboratory to determine the leaf area and the mean was determined and recorded. The leaf area index was determined by modified Watson's method (Watson, 1958) and calculated as shown below:

$$LAI = \frac{\text{Total leaf Area per plot}}{\text{The area of ground covered}}$$

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Number of days to 50% flowering

This is the Number of days from planting to when 50% of plants in each plot produce flowers, were counted, averaged and recorded.

Fresh fruit yield (t ha^{-1})

The weight of harvested matured fruits from the net plots was calculated using a balance (Metler Toledo model SB 16001) at five different harvest times at Badole location and seven times at Kankara location. The cummulative yield from each net plot was recorded and values obtained were extrapolated to tonnes per hectare (ton/ha $^{-1}$).

Data Analysis

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.,* (1955).

RESULTS

Fruit Diameter (cm)

The Influence of variety, intra row spacing and poultry manure on the fruit diameter of tomatoes during the 2019 and 2020 dry seasons is presented in Table 1. Variety did not have any significant (P>0.05) effect on fruit diameter at both locations.

The response of intra row spacing of 40 cm had indicated a significant influence on the fruit diameter of tomato (p<0.05) but the difference was not statistically significant with other treatments in Kankara. The rate of application of poultry manure had a significant (P<0.05) effect on the fruit diameter of tomatoes at both locations. Application of 6 t ha^{-1} recorded the highest value at both locations.

The interaction had shown no significant difference in all the two locations of the experimentation.

Table 1: Influence of variety, intra row spacing, and rates of application of poultry manure on fruits diameter in Badole and Kankara during the 2019 and 2020 dry seasons.

	Fruit diameter (cm)	
Treatment	**Badole**	**Kankara**
Variety		
UC82B	5.42	5.81
ROMA VF	5.14	5.94
SE (±)	0.26	0.25
Intra -row spacing (cm)		
30	3.29_b	4.00_b
40	5.08_a	5.64^a
50	5.46_a	6.00^a
SE (±)	0.31	0.31
Poultry manure (t ha-^{1})		
0	3.61^c	4.50^b
2	5.33^b	5.00^b
4	5.72^a	6.83^a
6	6.44^a	7.17^a
SE (±)	1.26	1.41
Interaction		
P x S	NS	NS
P x V	NS	NS
S x V	NS	NS
P x S x V	NS	NS

Means followed by the same letter(s) within the same column are not significantly different at 5% level of probability using DMRT.

Number of Fruits per Plant

The Influence of variety, intra row spacing and poultry manure on the number of fruits per plant of tomato during the 2019 and 2020

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dry seasons is presented in Table 2. Roma VF significantly (P<0.05) produced more number of fruits per plant than UC82B at both locations but was not significant (P>0.05). The highest number of fruits per plant was recorded by Roma VF at both locations of the experiment. The response of intra row spacing had shown a significant influence on the number of fruit of tomato in all the two locations of the experiments were an intra row spacing of 40 cm significantly gave the highest number of fruit in all the two locations (p<0.05). The number of fruits per plant was significantly (P<0.05) affected by the rate of application of poultry manure at both locations of these experiments. The highest number of tomato fruits per plant was recorded when poultry manure was applied at the rate of 6 t ha^{-1} at both locations. The difference was significant (P<0.05) between the application rate of 6 t ha^{-1} and the control.

Interaction among all the factors tested was not significant with regard to the number of fruit at all the two locations.

Table 2: Influence of variety, intra row spacing, and rates of application of poultry manure on number of fruits per plant in Badole and Kankara during the 2019 and 2020 dry season.

	Number of fruit per plant	
Treatment	**Badole**	**Kankara**
Variety		
UC82B	54.28	62.75b
ROMA VF	58.39	78.03a
SE (±)	3.86	5.10
Intra -row spacing (cm)		
30	45.88[b]	60.75[c]
40	47.83[b]	66.88[b]
50	57.29[a]	74.17[a]
SE (±)	4.73	4.89
Poultry manure (t ha^{-1})		
0	25.78[c]	28.39d
2	37.89[b]	49.67c
4	61.39[a]	70.83b
6	66.28[a]	94.67[a]
SE (±)	5.46	3.21
Interaction		
P x S	NS	NS
P x V	NS	NS
S x V	NS	NS
P x S x V	NS	NS

Means followed by the same letter(s) within the same column are not significantly different at 5% level of probability using DMRT.

Fruit Weight (g)

The Influence of Variety, intra row spacing and poultry manure on the fruit weight (g) of tomatoes during the 2019 and 2020 dry seasons is presented in Table 3. UC82B recorded the heaviest fruit weight in the study areas (P<0.05). Results have shown that the Kankara location of the experiment produced the heavier fruit weight of tomato compared to Badole experimental site. Intra row spacing at 30 cm signicanly recorded the highest fruit weight compared to other spacing in the study areas. Application of poultry manure at 4 tones per hectare recorded the heaviest fruit of tomato per plant at Badole. Wereas at Kankara location 6 tones produces the heaviest. Interaction among the factors tested was not significant with regard to the fruit weight of tomato in all the two locations.

Table 3: Influence of variety, intra row spacing, and rates of application of poultry manure on fruit weight of tomato (g) in

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Badole and Kankarad during 2019 and 2020 dry season.

	Fruit weight of Tomato (g)	
Treatment	**Badole**	**Kankara**
Variety		
UC82B	72.11	84.58[a]
ROMA VF	69.11	78.36[b]
SE (±)	1.57	1.48
Intra -row spacing (cm)		
30	70.92	84.21[a]
40	71.33	81.42[b]
50	69.63	78.79[b]
SE (±)	1.92	2.0
Poultry manure (t ha-[1])		
0	61.22d	75.78[c]
2	66.61c	79.50[b]
4	77.28a	82.50[b]
6	70.33b	88.11[a]
SE (±)	2.22	1.44
Interaction		
P x S	NS	NS
P x V	NS	NS
S x V	NS	NS
P x S x V	NS	NS

Means followed by the same letter(s) within the same column are not significantly different at 5% level of probability using DMRT.

Fruit yield

The results on the fresh fruit yield of tomatoes presented in Table 4 shows that intra row spacing had significant effects (P<0.05) on the fruit yield of tomatoes on the two varieties tested at both locations. Intra row spacing of 40 cm recorded the highest mean value in all the two locations of the experiments eventhogh it was statiscally at par with intra row spacing of 50 cm Application of poultry manure at 6 t ha^{-1} significantly provides the highest yield at both locations of the experiment (P<0.05). The interactions were not significant at the two locations tested.

Table 4: Influence of variety, intra row spacing, and rates of application of poultry manure on fruit yield (t ha^{-1}) of tomato in Badole and Kankara 2019/2020 dry season.

Treatment	**Badole**	**Kankara**
Variety		
UC82B	10.4	16
Roma VF	11	18.4
SE	0.47	1.16
Intra -row spacing		
30	9b	16b
40	14.2a	20a
50	14a	22.4a
SE	0.58	1.42
Poultry manure (t ha-[1])		
0	7.0c	14d
2	11.97b	16c
4	12.22b	20b
6	22.0a	36.2a
SE	0.67	2.89
Interaction		
Pm * S	NS	NS
Pm * V	NS	NS
S * V	NS	NS
PM * S * V	NS	NS

Means followed by the same letter(s) within the same column are not significantly different at 5% level of probability using DMRT.

DISCUSION

Influence of Variety on the Growth and Yield of Tomato

The yield parameters tested such as fruit weight and fresh fruit yield was not affected

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by varietal differences in both locations. However, intra row spacing and poultry manure application has significantly influence the fruit weight and fresh yield of the two varieties tested. It was recorded that intra row spacing of 50 cm and applications of 50 tonnes per hectare gave higher yield in both locations. The significant weight observed in UC82B over Roma VF could be attributed to differences in genetic make up. This agrees with the finding of Isah *et al.,* (2014) who reported that Tomato variety UC82B yielded more than Roma VF. However in contrast, Oluwagbenga *et al.,* (2016) reported that there was no significant differences recorded among the varieties in terms of plant height, number of leaves, and fruit weight evaluated.

Influence of Intra row Spacing on Growth and Yield of Tomato

From the results obtained, it was observed that varying intra row spacing in tomatoes did not affect fruit diameter. However, the number of fruit, fruit weight, and fresh fruit weight were enhanced due to variations in intra row spacing with 50 cm showing superiority over the other spacing regimes on the number of fruits and fresh fruit yield in both locations, although 30 and 40 cm intra-raw spacing showed a comparable effect on fresh fruit yield. This is evidence of the fact that reduced intra row spacing leads to more plant population which subsequently increases fruit yield of tomato. Appropriate inter and intra row spacing with variety selection could be practiced to increase the yield and quality of tomatoes. The result of this work is comfirm with Ara *et al.* (2007). Who reported that the highest marketable fruit was recorded at wider spacing than at narrow spacing. Gezu Degefa *et al.* (2019) reported that the highest fruit weight was obtained by the application of 39 kg ha^{-1} N at intra row spacing of 40 cm while fruit yield was at 69 kg ha^{-1} N and 40 cm intra row spacing. This result also disagrees with Zhang and Shuangxi (1999) who reported that spacing had no significant effect on both the number of marketable fruit per plant and the total fruit per plant.

Influence of Poultry Manure on the Growth and Yield of Tomato

Tomato yield attributes such as the number of fruits and fruit diameter as well as fruit yield were significantly enhanced by the application of poultry manure up to 6 t ha^{-1} at both locations. This observation may be due to the improvement of the physical and chemical properties of the soil (improved aeration, water holding capacity, soil organic matter, microbial activities, and increased micronutrient content) as a result of the application of poultry manure. This has manifested the multiple roles played by poultry manure in promoting the yield component of tomato which also conforms with the finding of Akanni *et al.,* (2007) that application of 6 t ha^{-1} poultry manure gave the higher fruit yield attributes among all poultry manure levels, although leaf N increase with the amount of poultry manure This agrees with the work of Ewulo *et al.* (2008) who stated that excess N in the soil and acidity could cause a nutrient imbalance in the tomato crop and a reduction in the uptake of certain nutrients. Isah and Aderemi (2019) have reported that the application of poultry manure significantly ($P<0.05$) increased the number of fruit and fruit yield in Badole Sudan Savanna of Nigeria. Bassi *et al.,* (2020), reported that

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poultry manure promotes higher fruit yield of tomatoes and is easier and cheapest in cost of production compared to inorganic fertilizers. Ilodibia and Chukwuma (2015) reported significant differences in tomato fruit and seed yield among the different rates of poultry manure used in their study. This finding is in line with Mahmud *et al.* (2014) who reported that tomatoes responded well to the application of poultry manure and sowing date of 5th February, compared to other sources of organic manures and sowing date in the study.

CONCLUSİON

Based on the results obtained from these experiments, it could be concluded that the application of poultry manure at the rate of 6 t ha^{-1}significantly enhanced the growth and yield of the two tomato varieties evaluated in the study areas.

It is therefore recommended that any among the two cultivars investigated, using 50cm intra row spacing and application of 6 tonnes per hectare could be used for profitable tomato production in the study areas.

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