Response of Tomato (*Lycopersicon esculentum* Mill.) Varieties to Different Animal Manure

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Summary

High cost of inorganic manure in Nigeria coupled with the problem of product availability justifies an investigation into alternative source of nutrients, which is more readily available and cheaper while the importance of organic manure in improving crop production for food security cannot be overemphasized. Two field experiments were carried out at the Faculty of Agriculture Teaching and Research Farm, University of Benin during the 2016/2017 and 2017/2018 dry cropping seasons of October – March to determine the response of two tomato (*Lycopersicon esculentum* Mill.) varieties to different animal manure. The treatments were three types of animal manure (swine, poultry, cow-dung at 20 t ha^{-1} each and a control) and two tomato varieties (Roma VF and UC82). The experiment was a 2 × 4 factorial laid out in a randomized complete block design (RCBD) in three replications. Data were collected on plant height, number of leaves, number of branches, leaf area, stem diameter, number of flowers, number of days to 50% flowering, number of fruits per plant, fruit fresh weight, fruit diameter and fruit yield t ha^{-1}. Results obtained from the experiment showed that there were significant differences ($p < 0.05$) in some of the reproductive characters as influenced by different animal manure. Swine and poultry manure showed superiority above cow-dung and the control. In both years, significantly similar and the highest fruit yield was produced by swine manure (14.24 and 7.82 t ha^{-1}) and poultry manure (12.15 and 7.64 t ha^{-1}). This study showed that the rate of 20 t ha^{-1} of either swine or poultry manure could be used for production of the two tomato varieties (Roma VF or UC 82) in Edo rain - forest zone of Nigeria.

Key words

cow-dung, stem diameter, yield

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Introduction

Tomato (*Lycopersicon esculentum* Mill.) belongs to the family Solanaceae and is one of the most popular and nutritious vegetables in Nigeria as well as in the world. Tomato is a very important source of vitamins and minerals that forms an essential source of the human diet. It is rich in vitamins A and B complex that helps to prevent eye and skin diseases. Enujeke (2013) reported that tomato is also rich in potassium that is helpful in controlling the rate of heart beat, heart diseases and stroke. It is widely grown all over the world due to its acceptability to many people and adaptability in wide range of soil and climate. In spite of its broad acceptability, there is paucity of information regarding the use of animal manure as a sole source of nutrient in tomato production. The cost of inorganic manure has enormously increased to an extent that they are out of reach of the small and resource poor farmers. In addition to being expensive and scarce, the use of inorganic fertilizer has not been helpful in intensive agriculture because it is often associated with reduced crop yield, soil acidity and nutrient imbalance. (Ano and Agwu, 2005; Agbede et al., 2008). Sustainable agriculture has become a concern, due to the pressures of the "energy crisis" and issues of "environmental protection". The need to use renewable forms of energy and reduce costs of fertilizing crops has revived the use of organic manure worldwide (Ayoola and Adeniyan 2006). Large quantities of organic wastes such as poultry manure are available especially in urban centres and are an effective source of nutrients for vegetables such as tomato (Adediran et al., 2003). Organic manure helps to increase the population of soil micro-organisms that have some influence in protecting plant against pathogens, such as nematodes and soil borne insects and also provide growth hormones, such as auxins (Agbede and Ojeniyi, 2009). It is easily available and cheaper source of nutrient for vegetables production. Aliyu (2001) reported increase in seed and fruit yield in sweet pepper as a result of poultry manure application. In order to increase the productivity of tomato in Nigeria, there is need to use high yielding and disease resistant varieties coupled with the use of appropriate fertilizers applied at the appropriate rate and timing.

Hence, this study was conducted to evaluate the effect of types animal manure on the growth and yield of two varieties of tomato.

Materials and Methods

Soil sampling and analysis

Two field experiments were carried out during the dry cropping seasons (October – March) of 2016/2017 and 2017/2018 at the Research Farm of the Faculty of Agriculture, University of Benin, Benin City, in the rain forest zone of Nigeria. The location lies between latitude 6° 14' N and 7° 34' N and longitude 5° 40' E and 6° 43' E on elevation of 162 m above sea level. The meteorological data during the experimental period was obtained from Nigerian Institute for Oil Palm Research (NIFOR) and is presented in Table 1.

The experimental field was manually cleared and debris was incorporated into the soil. Prior to soil analysis and before planting soil samples were taken randomly from ten points with a soil auger at a depth of 0 – 30 cm, on the experimental plot. The samples were thoroughly mixed together to form a composite sample and it was air dried and crushed to pass through a 2 mm sieve. Soil pH (H_20) was determined using a pH meter. Organic carbon was determined by wet oxidation method (Walkley and Black, 1962) as modified by Jackson (1969). Total nitrogen was obtained by Kjeldahl method as modified by Jackson (1969). Available P was extracted by Bray I method (Bray and Kurtz, 1945) and P was estimated by the blue colour method of Murphy and Riley (1962). Exchangeable K and Na were determined using flame photometer, and Ca and Mg using the Atomic Absorption Spectrophotometer. Cow dung, poultry and swine manure were sub-sampled, air-dried and analyzed for their chemical composition.

Experimental design

The treatments involved two tomato varieties (Roma VF and UC 82) and three types of animal manure (poultry, swine manure and cow dung) at 20 t ha^{-1} each and a control. The experiment was a 2 × 4 factorial arrangement fitted into a randomized complete block design (RCBD) with eight treatments replicated three times. Each replicate had 8 plots of a total of 24 plots (6 m x 15 m) in this experiment. The land was prepared manually using hoe with the residues incorporated into the soil. Tomato seeds were sown in the nursery and seedlings transplanted to the field when seedlings were three weeks old at a spacing of 60 cm × 90 cm, giving a plant population of 18,518 plants ha^{-1}. Plots were mulched with dry grasses to conserve soil moisture and suppress weeds. The field was weeded manually using hoe. Weeding was done at 3, 6 and 8 weeks after transplanting (WAT).

Data collection

Four plants were randomly tagged per plot for data collection. Data were collected on: vine length (cm), number of leaves, number of branches, leaf area (cm) and stem diameter (cm) starting at 4 WAT and commenced until 7 WAT, while data for number of days to 50% flowering, number of flower, number of fruits, fruit fresh weight (g), fruit diameter (cm) and fruit yield (t ha^{-1}) were taken 8 – 15 WAT.

Statistical analysis

Data obtained were subjected to statistical Analysis of Variance (ANOVA) using Statistical Analysis System (SAS) version 2003, following the model for factorial experiment in a randomized complete block design and differences among treatments means were separated using the Least Significant Difference (LSD) at ($p \leq 0.05$).

Results

Meteorological data

The meteorological data during the period of the experiment showed that the rainfall was scanty with no rains in December and January 2016/17 and January 2017/18 this necessitated supplemental irrigation. The temperature ranged from (24.70°C to 27.48°C) in 2016/17 and (27.90°C to 31.00°C) in 2017/18 cropping seasons and the relative humidity was above 50% in both years (Table 1).

Table 1. Meteorological data at the experimental site during the growing season (2016/17 and 2017/18)

Year	Weather condition	October	November	December	January	February	March
2016/17	Rainfall (mm)	247.80	62.80	0.00	0.00	126.10	80.45
	Temperature (°C)	25.36	27.48	26.75	26.05	25.75	24.70
	Relative humidity (%)	78.95	74.1	63.65	53.35	69.90	72.3
2017/18	Rainfall (mm)	157.70	58.80	31.10	0.00	7.00	155.10
	Temperature (°C)	31.00	28.30	28.40	28.07	28.06	27.90
	Relative humidity (%)	85.25	78.35	69.05	51.30	72.35	74.25

Source: Nigerian Institute for Oil Palm Research (NIFOR)

Soil and manure properties

The results of the soils of the experimental sites revealed the textural class as sandy loam and the soil pH (H_2O) before and after the experiments in both years were strongly acidic (5.26 - 5.30) and (5.30 - 5.11) for 2016/17 and 2017/18, respectively. The major plant nutrients (N and exchangeable K) before the experiments were below recommended critical concentration levels of 0.15% N, and 0.34 c mol kg^{-1} K required for crop production (Table 2). The total P content (14.70 mg kg^{-1}) of the soil was in the range of the recommended critical value of 10 – 16 mg P kg^{-1} and increased above the critical concentration level after both experiments. The results of the chemical analysis of poultry manure, cow dung and swine manure revealed nutrient rich source for the growth and development of tomato plant (Table 3).

Table 2. Physical and chemical properties of the experimental soils preplant and post harvest

Soil properties	Experimental sites			
	Exp 1		Exp 2	
	Pre	Post	Pre	Post
pH (H_2O)	5.26	5.33	5.30	5.11
Organic matter (g kg^{-1})	0.73	0.79	0.80	2.08
Total N (g kg^{-1})	0.04	0.03	0.05	0.07
Total P (g kg^{-1})	14.70	20.69	2.10	18.21
K (cmol kg^{-1})	0.12	0.16	0.20	0.28
Ca (cmol kg^{-1})	0.81	1.20	1.40	1.70
Mg (cmol kg^{-1})	0.51	0.63	0.62	0.80
Sand (%)	66.43	66.87	64.80	65.40
Clay (%)	25.57	25.01	27.20	26.56
Silt (%)	8.00	8.12	8.00	8.04
Textural class	Sandy loam		Sandy loam	

Vegetative characters

In both years, there were no varietal differences observed in the vegetative character of tomato (Table 4). However, animal manure significantly ($p < 0.05$) influenced all the vegetative characters measured except for number of branches and stem diameter. In 2016/17, swine and poultry manure increased plant height above cow dung and the control, and this was similar to the result obtained in 2017/18 where plants that received manure significantly increased in plant height compared to the control that received no manure. The increase in the number of leaves and branches in 2016/17 followed the same trend. Plants that received poultry or swine manure produced significantly higher number of leaves (259.04 and 236.00), branches (36.20 and 36.40) and stem diameter (1.23 cm and 0.99 cm), respectively, compared with cow dung that produced: number of leaves - 137.96, number of branches - 17.58 and stem diameter - 0.41 cm. The leaf area (128.48 cm^2 and 82.48 cm^2) was lowest in the control that received no manure in 2016/17 and 2017/18, respectively (Table 4).

Table 3. Chemical analysis of poultry, swine and cow-dung manure

Nutrients	Poultry manure	Swine manure	Cow-dung
pH (1:1)	6.20	6.90	6.80
Total N (g kg^{-1})	2.23	2.12	2.21
Organic matter (%)	26.07	22.40	20.20
Available P (g kg^{-1})	0.94	0.90	0.43
K (cmol kg^{-1})	1.98	0.72	0.96
Ca (cmol kg^{-1})	0.88	2.14	1.72
Mg (cmol kg^{-1})	0.11	0.62	0.61
Na (cmol kg^{-1})	0.33	0.32	0.30

Table 4. Effects of different types of animal manure on some vegetative characters of two tomato varieties during the 2016/2017 and 2017/2018 dry cropping seasons

Treatment	2016/2017 Cropping season					2017/2018 Cropping season				
	Plant height (cm)	Number of leaves	Number of branches	Leaf area (cm^3)	Stem diameter (cm)	Plant height (cm)	Number of leaves	Number of branches	Leaf area (cm^3)	Stem diameter (cm)
Varieties										
Roman VF	60.92^a	194.02^a	26.92^a	131.34^a	0.76^a	32.35^a	57.28^a	9.52^a	90.33^a	0.33^a
UC 82	58.81^a	189.59^a	27.40^a	130.59^a	0.84^a	34.11^a	52.29^a	9.71^a	87.86^a	0.27^a
Significance	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns
Lsd	4.74	40.27	5.87	7.00	0.17	3.78	9.47	1.36	2.79	0.06
Animal manure (20 t ha^{-1})										
Swine	69.69^a	259.04^a	36.20^a	132.41^a	1.23^a	34.75^a	56.82^a	9.98^a	91.37^a	0.33^a
Poultry	64.03^a	236.00^a	36.40^a	136.73^a	0.99^a	34.21^a	55.84^a	9.92^a	88.65^a	0.29^a
Cow dung	54.41^b	137.96^b	18.47^b	136.25^a	0.57^b	35.67^a	59.29^a	10.15^a	88.88^a	0.33^a
Control (0 t ha^{-1})	51.33^b	134.22^b	17.58^b	128.48^b	0.41^b	28.27^b	47.21^b	8.42^a	82.48^b	0.26^a
Significance	*	*	*	*	*	*	*	Ns	*	Ns
Lsd	6.70	56.96	8.30	8.90	0.24	5.35	5.35	13.40	3.05	0.09
Interaction										
V*P	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	ns

Means followed by the same letter in a column are not significantly different at 5% level of probability. * Significant at 5% level of probability

Reproductive characters

There was no significant varietal effect on the reproductive characters of tomato plants except for fruit diameter of Roma VF, which increased above UC 82 in both years (Table 5). In 2015/16, days to 50% flowering was the earliest with the application of swine manure (28.47) followed by poultry (30.46) manure and then cow dung (31.01), while for the control the highest number of days to 50% flowering was recorded (32.74). The number of flowers per plant increased above the control with the application of manure in both years. In 2017/18 plants that received swine and poultry manure application produced statistically similar number of fruits per plant (5.33 and 5.00, respectively) and were significantly higher than that produced by cow dung (4.21) and the control (3.07). Fruit weight plant $^{-1}$ (g) and fruit yield (t ha^{-1}) followed almost the same trend in both years and were enhanced by the application of animal manure compared with the control. In 2016/17 cropping season, with application of swine manure plants production of fruit fresh weight plant^{-1} was 64.11g and fruit yield ws 14.24 t ha^{-1}, which was statistically similar to that produced by application of poultry manure (59.41 g and 12.15 t ha^{-1}) and these were significantly higher than the production with application of cow dung (46.47 g and 7.99 t ha^{-1}). The lowest fresh fruit weight plant $^{-1}$ (40.34 g) and fruit yield (4.90 t ha^{-1}) was produced by the control plants. In 2017/18, all the plants that received animal manure significantly ($p < 0.05$) improved in fruit yield above the control (Table 6).

Table 5. Effects of different types of animal manure on some reproductive characters of two tomato varieties during the 2016/2017 and 2017/2018 dry cropping seasons

Treatment	2016/2017 Cropping season			2017/2018 Cropping season		
	No of days to 50% flowering	Number of flowers/plant	Number of fruits/plant	No of days to 50% flowering	Number of flowers/plant	Number of fruits/plant
Varieties						
Roman VF	31.95[a]	8.32[a]	8.01[a]	33.12[a]	4.79[a]	4.40[a]
UC 82	32.48[a]	8.71[a]	8.54[a]	35.97[a]	5.15[a]	4.38[a]
Significance	Ns	Ns	Ns	Ns	Ns	Ns
Lsd	1.28	1.07	3.84	1.10	2.45	0.47
Animal manure (20 t ha^{-1})						
Swine	28.47[c]	10.71[a]	10.07[a]	33.01[a]	5.54[a]	5.33[a]
Poultry	30.46[b]	9.21[a]	8.82[a]	33.46[a]	5.46[a]	5.00[a]
Cow dung	31.01[b]	7.79[b]	7.77[a]	33.74[a]	4.83[a]	4.21[b]
Control (0 t ha^{-1})	32.74[a]	6.26[c]	6.04[a]	34.07[a]	3.10[b]	3.07[c]
Significance	*	*	Ns	Ns	*	*
Lsd	1.02	1.51	5.43	1.13	2.05	0.67
Interaction						
V*P	Ns	Ns	Ns	Ns	Ns	Ns

WAT = Weeks After Transplanting Means followed by the same letter in a column are not significantly different at 5% level of probability. * Significant at 5% level of probability

Table 6. Effects of different types of animal manure on some reproductive characters of two tomato varieties during the 2016/2017 and 2017/2018 dry cropping seasons

Treatment	2016/2017 Cropping season			2017/2018 Cropping season		
	Fruit diameter (cm)	Fruit fresh weight (g)	Fruit yield (t ha^{-1})	Fruit diameter (cm)	Fruit fresh weight (g)	Fruit yield (t ha^{-1})
Varieties						
Roman VF	4.88[a]	54.15[a]	9.92[a]	3.45[a]	38.28[a]	7.60[a]
UC 82	5.14[b]	53.01[a]	10.22[a]	4.67[b]	40.81[a]	8.70[a]
Significance	*	Ns	Ns	*	Ns	Ns
Lsd	0.48	4.16	1.81	0.56	9.58	2.38
Animal manure (20 t ha^{-1})						
Swine	6.00[a]	64.11[a]	14.24[a]	3.35[a]	43.19[a]	7.82[a]
Poultry	5.78[a]	59.41[a]	12.15[a]	3.29[a]	43.12[a]	7.64[a]
Cow dung	4.29[b]	46.47[b]	7.99[b]	3.03[a]	41.78[a]	6.22[a]
Control (0 t ha^{-1})	3.98[b]	40.34[c]	4.90[c]	2.29[b]	30.18[b]	3.33[b]
Significance	*	*	*	*	*	*
Lsd	0.69	5.80	2.56	0.71	7.20	2.48
Interaction						
V*P	Ns	Ns	Ns	Ns	Ns	Ns

WAT = Weeks After Transplanting Means followed by the same letter in a column are not significantly different at 5% level of probability. * Significant at 5% level of probability

Discussion

The laboratory analysis of the sampled animal manure revealed varying levels of N, P and K (Table 3). These elements (N, P and K) are important plant nutrients required for plant growth and yield. Generally, the increase in some vegetative growth could be attributable to the amounts of useful plant nutrients in animal manure that were limited in the unfertilized control plots. The lowest values of some vegetative and yield parameters obtained under the control treatment compared to other treatments could be a result of initial low soil nutrients status that often characterize continuous cultivation of land without fertilizer application. The application of fertilizers, especially animal manure, enhance both soil and crop productivity in the tropics. Previous observations have shown beneficial effects of animal manure on soil nutrient composition, structural aggregates, infiltration rate, microbial and other biological activities of the soil (Omueti et al., 2000). The application of animal manure improved tomato growth and better plant performance compared to the control. The significant effect in the fruit diameter of the tomato varieties studied could probably be influenced by genetic characteristics of these tomato varieties as reported by Bitala (2001).

The increase in some of the reproductive characters especially in the fruit fresh weight and fruit yield in 2016/17 by swine and poultry manure could probably be due to more readily available nutrients in swine and poultry manure then in cow dung. Similarly, poultry manure has a higher total solid content than most other types of animal manure from animal species such as cattle and is considered a rich source of organic fertilizer for crop production (Nguyen, 2010). Mineralization of animal manure such as cow dung is slower than of other animal manure, whereas poultry manure is known to be one of the fastest animal manure to mineralize (Ewulo et al., 2007). The earliness of flowering of plants that received manure compared with the control is an indication that manure is beneficial for attaining higher fruit yield of tomato. Ewulo et al. (2008) reported a significant increase in plant height, root length, numbers of branches, numbers of fruits and fruit lengths as a result of application of poultry manure to the soil. Manure application has been found to encourage early maturity, uniformity in ripening and fruit size and yield increase of tomato. Aliyu (2001) reported increase in seed and fruit yield in sweet pepper as a result of poultry manure application. Application of animal manure (solely or as mixtures) to soils with low fertility status enhanced favorable yield and growth parameters of crops probably due to their rich nutrient concentrations. This finding agreed with the work of Moyin-Jesu and Ojeniyi (2006) that reported a rapid response in the yield and growth of okra with the application of organic fertilizers.

Conclusions

In Nigeria, farmers have limited financial resource and can rarely afford to purchase sufficient mineral fertilizers that can produce optimum yield of crops. The use of animal manure in increasing crop growth and yield has become eminent because it is cheap and easily sourced. In this study, cow dung enhanced some of the vegetative and yield attributes over the control that received no organic fertilizer. However, in 2016/17 cropping season, poultry and swine manure produced the best ($p \leq 0.05$) result in most of the vegetative and yield attributes studied and should be recommended to farmers in this locality

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