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Original Article

Effects of irrigation water-type and cow dung on the growth and yield of tomato (*Lycopersicum esculentum*) in the Northern Guinea Savanna zone of Nigeria

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ABSTRACT

Agriculture cannot be sustainable without using manure. A field experiment was carried out at the Faculty of Agriculture, University of Abuja, Nigeria to investigate the effect of different levels of cow dung manure and irrigation water types on the growth, fruit yield, and quality of tomatoes. The experiment was laid out in a randomized complete block design with three replications. The treatment composed of four levels of cow dung manure (0, 10, 20 and 30 t/ha) and two irrigation water types (fish effluent and normal water). The treatments were combined factorially to give 8 treatment combinations and replicated thrice to produce a total of 24 plots. The parameters measured were plant height, leaf area, number of leaves, number of branches, number of flowers, number of fruits, fruit weight, and the fruit quality was also determined. The result of this study indicated that application of cow dung manure at 10 and 20 t/ha significantly affected the growth parameters measured. The yield parameters measured were increased with the application rate of 10 and 30 t/ha. However, the application of fish effluent as an irrigation water type significantly increased the performance of tomato with respect to the growth, yield, and quality of tomato fruits.

Keywords: Cow dung, growth and yield tomato, irrigation water type, Northern Guinea Savanna Zone of Nigeria

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INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is an herbaceous crops and belongs to the family *Solanaceae*.[1] Tomato is one of the most important vegetables worldwide, Nigeria inclusive. It is the world's largest vegetable crop after potato and sweet potato, but it tops the list of canned vegetables.[2] Tomato is a relatively short duration crop and gives a high yield, it is economically attractive and the area under cultivation is increasing daily.[1] Moreover, tomatoes contribute to a healthy, well-balanced diet, and rich in minerals, vitamins, essential amino acids, sugars, and dietary fibers. Tomato contains much vitamin B and C, iron, and phosphorus.[3] Organic fertilizers create a healthy environment for the soil over a long period of time, whereas inorganic fertilizers work much more quickly but fail to create a sustainable environment. The use of inorganic fertilizers for crops is hazardous for health because of residual effects, but in the case of organic fertilizers, such problems do not arise rather increases the productivity of soil as well as crop quality and yield. The use of organic inputs such as crop residues, manures, and compost have great potential for improving soil productivity and crop yield through improvement of the physical, chemical, and microbiological properties of the soil as well as nutrient supply.[4] The use of organic sources of nutrients has a great significance effect on the growth, yield, composition of fruits, and in the soil physical attributes.[5,6] Tomato has been reported to contain several nutrient elements that are important for growth, development as well as for metabolic activities of man such nutrient element include calcium, niacin, vitamins, minerals, and antioxidants. Tomato seeds contain 22–29% crude fat, 15–28 crude fibre, 5–10% ash content, and 23–24% crude protein.[7] Tomato has been reported to be rich in essential amino acids and also serves

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as a good source of many minerals. Tomato is also reported to be rich in sugars, dietary fibers, iron, and phosphorus, thus contribute to a well-balanced diet.[1] Tomato is an important condiment in most diets and a very cheap source of vitamins. It also contains a large quantity of water, calcium, and niacin all of which are of great importance in the metabolic activities of man.[3] The problems associated with the use of hazardous chemicals for crop protection, weed control, and soil fertility are receiving increasing attention worldwide since pests, diseases, and weeds become resistant to chemical pesticides and environmental pollution and ecological imbalances may occur. Therefore, this research focuses on the use of organic sources as a means of soil fertilization for crop growth/production to reduce the increasing hazards that occur as a result of inorganic fertilizer usage. According to Sainju *et al*.,[8] tomatoes require at least twelve essential elements (nutrients) (N, P, K, Ca, Mg, S, B, Fe, Mn, Cu, Zn, and Mo) for normal growth and reproduction[8] also noted that, without these nutrients, tomato cannot grow properly or bear fruits[8] deduced that, because the soil cannot supply adequate amounts of N, P, and K for optimum growth and production of tomato, these nutrients are added as amendments in the form of manures and fertilizers to the soil.

Objectives of the Study

The main objective of the study is to determine the effect of fish effluent and cow dung application rates on the growth, fruit yield and quality of tomato. The specific objectives of the study are to:

i. Determine the influence of fish effluent and cow dung on the growth and fruit yield of tomato, and
ii. Determine the effect of fish effluent and cow dung on the nutritional quality of tomato fruits.

MATERIALS AND METHODS

Experimental Site

The experiment was conducted at Faculty of Agriculture, University of Abuja, Nigeria lies at a Longitudes of 7°29''28''E and Latitudes 9°4'20''N of the equator. Abuja is located in the Northern Guinea Savannah zone of Nigeria. It experiences an average monthly temperature of 24°C–32°C with a mean annual rainfall range of 1308 mm.

Treatment and Experimental Design

The experiment consisted of two factors, namely, irrigation water type and cow dung. The irrigation water type was made up two levels; fish effluent and normal water, whereas the cow dung in tonnes was made up of four rates (0, 10, 20, and 30). The treatments were factorially combined given rise eight treatment combination, replicated 3 times and laid out in a Randomized Complete Block Design. Cow dung was separately mixed with topsoil at the rates of 10, 20, and 30t/ha before transplanting and irrigation water (fish effluent and normal water) applied approximately. The experiment was made up of 2 irrigation water type, 4 rates of cow dung, and 3 replicates given rise to 24 pots.

Sources of Experimental Materials

The seed of *L. esculentum* (U.C 82-B) variety was obtained in Abuja. Other materials used for the experiments such as polythene bags was obtained from Abuja market, whereas cow dung and fish effluent were sourced from University Teaching and Research Farm, University of Abuja.

Agronomic Practices

U.C 82-B tomato variety was used for this study; seedlings were raised in nursery for 3 weeks before transplanting to the experimental pots. The experimental area was cleared and topsoil was gotten from different location, mixed, and weighed. Each pot was filed with 15 kg of top soil and was prepared for transplanting. Weeds were removed by hand picking.

Data Collection

Three plants were randomly selected for data collection from each pot and the mean score recorded. The data collected on growth and yield parameters were as outlined below

Plant Height/Plant (cm)

Plant height was measured in centimeter with the aid of a meter rule. The plant was measured from base to the top tip of the plant vertically. Plant height was measured at 4 and 12 weeks after planting.

Numbers of Leaves

The number of leaves on the three plants was counted and the mean (average) was taken and recorded. This was measured at 4 and 12 weeks after planting.

Leaf Area

The leaf area was measured using a meter rule. The leaf was measured vertically and then horizontal and was multiplied by a constant value of 0.07. Leaf area was measured in centimeters (cm) and was done at four and 12 weeks after planting.

Number of Fruits

The number of fruits was counted on each pot and was recorded at harvest.

Fruit Weight

The fresh fruit weight was measured at harvest in kilograms using a sensitive scale. The mean weight of the fruits was recorded.

Fruit Nutritional Quality

The fruits of tomato were collected and sent for proximate analysis to examine the moisture content, ash content, crude fiber, crude protein, CHO, and energy value of the tomato fruits.

Data Analysis

Data collected were subjected to analysis of variance and significant means were separated using Least Significance Difference using SAS Statistical tool.

RESULTS

Physiochemical Properties of Experimental Soil, Cow Dung, and Fish Effluent

Table 1 shows the chemical analysis of fish effluent, cow dung, and physiochemical properties of soil before the experiment. From the result of the physiochemical analysis, the soil particles of the soil sample include sand (92.08%), clay (6.24%), and silt (1.68), this implies that the experimental soil is sandy hence coarse in texture. However, the experimental soil had a pH of 6.60 which indicates that the soil is neutral while cow dung and fish effluent had a pH of 8.40 and 7.7, respectively, which indicates alkalinity.

Effect of Irrigation Water-Type and Cow Dung on Plant Height of Tomato

Table 2 showed the effect of fish effluent and cow dung application rates on the plant height of tomato. The result indicates that fish effluent was significantly different from water at 4WAT at 5% probability level ($P \leq 0.05$), fish effluent produced significant taller plants with the mean height of 16.78 cm at 4 WAT but were not statistically different at 12 WAT. Similarly, the results also revealed that application rates of cow dung have a significant difference at 4WAT at 5% probability level ($P \leq 0.05$) on the plant height of tomato as application rate of 10t onnes/ha produced taller plants while application rate of 0tonnes/ha produced shorter plant heights. However, there were no significant differences in the plant heights of tomato as influenced by cow dung application rates at 12WAT.

Effect of Irrigation Water type and Cow Dung on the Number of Leafs of Tomato

The effect of irrigation water type and cow dung application rate on the number of leaves of tomato is shown in Table 2. The result showed a significant difference in the number of leaves of tomato at 4, and 12WAT. Fish effluent significantly produced higher number of leaves at 4 and 12 WAT compared to normal water with the mean value of 31.78 and 236.97, respectively, at 5% probability level ($P \leq 0.05$). However, the application rate of cow dung had a significant effect on the number of leaves of tomato at 4WAT only. Application rate of 20 tonnes/ha produced higher number of leaves at 4WAT with a mean value of 27.56 but was not statistically different from the application of cow dung at 30 tonnes/ha, whereas 0 tonnes/ha produced the least number of leaves of tomato, whereas application rate of cow dung at 10tonnes/ha significantly produced the highest number of leaves at 4 WAT with the mean value of 30.39 at 5% probability level ($P \leq 0.05$).

Table 1: Physiochemical properties of experimental soil, cow dung, and fish effluent

Sample	pH	Elec-cond (ppm)	O.C (g/kg)	O.M (g/kg)	Aval. P (mg/kg)	Total N (g/kg)	Exchangeable cations				E.A (Cmol/kg)	CEC (Cmol/kg)	Soil particle sizes		
							Na (Cmol/kg)	K (Cmol/kg)	Ca (Cmol/kg)	Mg (Cmol/kg)			Sand (%)	Clay (%)	Silt (%)
Soil	6.60	80.0	11.97	20.64	43.25	0.42	1.04	0.39	2.44	12.61	0.0	16.55	92.08	6.24	1.68
		Elec. Cond	O.C	O.M	Total P	Total N	Na	K	Ca	Mg					
		PPM	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)					
Cow dung	8.40	11780	29.88	70.119	0.125	0.688	2.35	1.96	0.64	0.174					
Fish Effluent	7.72	330			11.42 (mg/l)	0.012	0.052	0.034	0.12	0.31					

Table 2: Effect of irrigation water-type and cow dung on the plant height (cm) and number of leafs of tomato

Treatment	Plant height (cm)		Number of leafs	
	4WAT	12WAT	4WAT	12WAT
Irrigation water (I)				
Fish effluent	16.78[a]	61.53[a]	31.78[a]	236.97[a]
Water	11.24[b]	57.26[a]	19.65[b]	172.25[b]
SE±	0.729	1.634	2.011	20.315
Cow dung (tonnes/ha) (C)				
0	11.99[b]	57.75[a]	19.75[b]	187.11[a]
10	16.10[a]	56.75[a]	30.39[a]	177.02[a]
20	14.53[ab]	61.33[a]	27.56[ab]	211.80[a]
30	13.33[ab]	61.75[a]	25.17[ab]	242.52[a]
SE±	1.031	2.311	2.971	28.730
Interaction				
I × C	NS	NS	NS	NS

Values followed by the same letter (s) in a column are not significantly different at 5% probability level ($P<0.05$) according to Least significant difference (LSD), WAT: Weeks after transplanting, SE: Standard error

Table 3: Effect of irrigation water type and cow dung on the leaf area (cm^2) and number of branches of tomato

Treatment	Leaf area (cm^2)		Number of branches	
	4WAT	12WAT	4WAT	12WAT
Irrigation Water (I)				
Fish Effluent	27.82[a]	55.83[a]	3.67[a]	11.61[a]
Water	10.07[b]	32.53[b]	3.27[b]	9.60[a]
SE±	1.692	5.169	0.314	0.773
Cow Dung (tonnes/ha) (C)				
0	13.71[b]	39.00[a]	3.22[a`]	10.89[a]
10	23.11[a]	42.67[a]	4.38[a]	10.09[a]
20	21.31[a]	53.33[a]	3.10[a]	11.44[a]
30	17.69[ab]	42.67[a]	3.22[a]	10.00[a]
SE±	2.392	7.309	0.444	1.093
Interaction				
I × C	NS	NS	NS	NS

Values followed by the same letter (s) in a column are not significantly different at 5% probability level ($P<0.05$) according to Least significant difference (LSD), WAT: Weeks after transplanting, SE: Standard error

Effect of Irrigation Water Type and Cow Dung on Leaf Area (cm^2) of Tomato

The result from the experiment showed that fish effluent produced significantly wider leaves of tomato at 4 and 12WAT. Meanwhile, the effect of irrigation water type and cow dung on the leaf area was significant [Table 3]. The effect of fish effluent was significantly and consistently better than normal water during the growing period. However, the effect of cow dung was significant only at 4WAT. The least leaf area was produced at 0 tonnes/ha which was statistically similar to 30t/ha at 4WAT.

Effect of Irrigation Water Type and Cow Dung on the Number of Branches of Tomato

Table 3 shows the effect of cow dung application and irrigation water type on the number of branches of tomato. The result showed that there were significant differences in the number of branches of tomato plants treated with fish effluent and normal water as fish effluent significantly supported higher number of branches of tomato at 4 WAT with the mean value of 3.67 at 5% probability level ($P \leq 0.05$). Meanwhile, there were no significant differences in the number of branches produced by different cow dung application rates at 5% probability level ($P \leq 0.05$).

Effect of Irrigation Water-type and Cow Dung on Number of Fruits of Tomato

The result of application of cow dung as soil amendment and fish effluent as irrigation water is shown in Table 4. The result showed that the application of fish effluent as an irrigation water was significantly different from application of normal water as irrigation water on the number of fruits of tomato. Fish effluent significantly produced higher number of fruits during the growing period except at 14WAT. There were no significant differences between cow dung application rates on the number of fruit of tomato at 5% probability level ($P < 0.05$).

Effect of Irrigation Water type and Cow Dung on the Fruit Weight of Tomato

Table 4 shows the effect of cow dung application rates and irrigation water type on the fruit weight of tomato. The result revealed that there were significant differences in the fruit weight of tomato as irrigated with different irrigation water. The result shows that pots irrigated with fish effluent produced significantly heavier tomato fruits compared to pots irrigated with normal water at 10 and 12, with a mean weight of 0.36 kg and 0.58 kg, respectively, at 5% probability level ($P < 0.05$) but were at par at 14WAT. Similarly, the result also showed a significant difference in the application of cow dung. At 10 WAT, pots amended with 0 tonnes/ha of cow dung significantly produced heavier tomato fruits, while the application of 20 tonnes/ha produced the lightest tomato fruits. At 12WAT, there were no significant differences between the application of 0 tonnes/had and 20 tonnes/ha as it significantly produced heavier fruits compared to other application rates, whereas the application of 10 tonnes/ha produced the lightest fruits. However, there were no significant differences between the application rates at 14WAT as all the application rates were at par at 5% probability level ($P < 0.05$).

Effect of Irrigation Water-Type and Cow Dung on the Nutritional Quality of Tomato Fruit

The tomato fruits nutritional quality as affected by irrigation water type and different cow dung application rate is shown in Table 5. The result revealed that, there were no significant

Table 4: Effect of fish effluent and cow dung on the number of flowers and number of fruits of tomato

Treatment	Number of fruits			Fruit weight (kg)		
	10WAT	12WAT	14WAT	10WAT	12WAT	14WAT
Irrigation water (I)						
Fish Effluent	2.17[a]	2.33[a]	3.33[a]	0.36[a]	0.58[a]	0.62[a]
Water	1.42[b]	1.92[b]	3.00[a]	0.23[b]	0.33[b]	0.55[a]
SE±	0.194	0.253	0.674	0.25	0.027	0.122
Cow dung (tonnes/ha) (C)						
0	2.17[a]	2.33[a]	2.83[a]	0.38[a]	0.56[a]	0.53[a]
10	1.67[a]	1.50[a]	2.50[a]	0.34[ab]	0.27[c]	0.48[a]
20	1.83[a]	2.33[a]	5.00[a]	0.22[c]	0.0.56[a]	0.90[a]
30	1.50[a]	2.33[a]	2.33[a]	0.26[bc]	0.45[b]	0.44[a]
SE±	0.275	0.358	0.953	0.035	0.038	0.173
Interaction						
I × C	NS	NS				

Values followed by the same letter (s) in a column are not significantly different at 5% probability level ($P<0.05$) according to Least Significant Difference (LSD), WAT: Weeks after transplanting, SE: Standard error

Table 5: Effect of irrigation water type and cow dung on the fruit characteristics of tomato

Treatment	Proximate analysis						
	Moisture content (%)	Ash content (%)	Crude fiber (%)	Crude protein (%)	Fat content (%)	CHO (kg/g)	Energy value (kj/Kg)
Irrigation water							
Water	93.06[a]	0.33[a]	0.12[a]	0.15[a]	0.14[a]	7.09[a]	31.04[a]
Fish Effluent	89.74[a]	0.24[b]	0.11[a]	0.14[a]	0.12[b]	6.01[b]	25.18[b]
SE±	1.186	0.010	0.003	0.003	0.003	0.141	0.510
Cow dung (tonnes/ha)							
0	93.37[a]	0.28[bc]	0.11[b]	0.14[b]	0.11[b]	6.34[b]	27.87[a]
10	86.92[b]	0.24[c]	0.11[b]	0.15[a]	0.14[a]	6.32[b]	28.28[a]
20	91.27[ab]	0.28[b]	0.11[b]	0.15[a]	0.12[b]	6.57[ab]	29.13[a]
30	94.50[a]	0.34[a]	0.13[a]	0.16[a]	0.14[a]	6.99[a]	27.16[a]
SE±	1.678	0.014	0.005	0.005	0.005	0.198	0.706
Interaction							
I × C	NS	NS	NS	NS	NS	NS	NS

Values followed by the same letter (s) in a column are not significantly different at 5% probability level ($P<0.05$) according to Least Significant Difference (LSD), SE: Standard error

differences in the moisture content, crude fiber, and crude protein as affected by the different irrigation water type. However, there were significant differences in the ash content, fat content, CHO, and energy value of tomato fruits as fish effluent significantly produced higher values compared to normal water which include 0.33%, 0.14% 7.09 kg/g, and 31.04 kj/kg, respectively, at 5% probability level. On the other hand, cow dung application rate of 30 tonnes/ha produced significantly higher values compared to other application rates in all fruit qualities measured. There were no significant differences in the moisture content of fruits from plots treated with 0 and 30 tonnes/ha and the application rate of 10tonnes/ha produced significantly the least moisture content of 86.92%. There were no differences among the cow dung application rates of 0, 10, and 20 tonnes/ha on the crude fiber of tomato fruits, similarly application rates of cow dung does not significantly affect the energy value of tomato fruits at 5% probability level. The fat content of tomato fruits from plots treated with 10 and 30 tonnes/ha were at par with the mean percentage of 0.14% and 0.14%, respectively, and likewise application rate of 0 and 20tonnes/ha. Cow dung application rates of 0 and 10tonnes/ha significantly produced lower ash content of tomato fruits.

DISCUSSION

From the result of the experiment, it was observed that fish effluent produced significantly taller tomato plants, higher number of leaves, higher number of branches, and wider leaves of tomato. This can be attributed to the fact that fish effluent contained nutrients which might have improved the fertility status of the soil compared to normal water. This result is similar to results obtained when garden egg was used as a test crop[9] as fish effluent treatments supported significantly the highest yields of the crop compared to other treatments. The result also agrees with the findings of Firew *et al*.[10] who studied fishpond wastewater and chemical fertilizer on tomato productivity.[10] deduced that fish effluent can be used in organic farming, because it promotes and enhances the productivity by releasing nutrients, improves the structure of the soil, and increases its ability to hold water and nutrients. Furthermore,[11] carried out a study on the utilization of effluent fish in tomato cultivation and reported that consumption of tomato produce from fish effluent as a source of nutrient is safe for human consumption as it is regarded as an organic manure.

The performance of crop is totally dependent on the rate and nature of manure used as a soil amendment. Influence of different rates of cow dung manure on the growth of tomato revealed that the performance of tomato increased with the cow dung manure application of 10 and 20 tonnes/ha. This agrees with the findings of Gudugi[12] who reported that the application of cow dung at 20t/ha produced tallest plants of okra in both 2011 and 2012 cropping season.

From the result of the experiment, the application of fish effluent as an irrigation water type has shown evidently good quality of tomato fruits compared to the use of normal water as an irrigation type. This can be attributed to the presence of mineral nutrients in the fish effluent which are available for absorption by the soil and also uptake by plants or better performance.

The cow dung might have improved the availability of nutrients to the crop by enhancing the mineralization and supply of readily available nutrients to the soil.[13] The addition of cow dung to the soil boosted the nitrogen content, which in turn caused the tomato fruit to absorb more nitrogen and produce more protein. This explains the reasons for increase in crude protein values between cow dung amendment and control treatment.

CONCLUSION

Fish effluent promotes and enhances the productivity by adding nutrients to the soil, improving the structure of the soil, and increasing its ability to hold water and nutrients. Therefore, from this study, it can be concluded that the fish effluent is a suitable irrigation water for growing tomatoes, since its application as an irrigation water would add the nutrient status of an agricultural land make more environmentally friendly and economically beneficial than the application of artificial fertilizers. It is also a viable source to supplement irrigation water to vegetable growth, and as well, it has bridged the gap existing in chemical fertilizer requirements. It would then be an efficient way of managing waste coming from fish farms. Therefore, application of fish effluent would improve the nutritional qualities of tomato fruits thereby improving the health status of the consumers.

RECOMMENDATIONS

From the findings of the study, it is hereby recommended that the use of fish effluent water as a source of irrigation water for tomato production in the southern guinea savannah ecological zone of Nigeria. Furthermore, further studies should be conducted comparing cow dung and fish effluent as source of soil nutrient for growth and development of crops.

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