Australian Journal of Science and Technology

ISSN Number (2208-6404)
Volume 7; Issue 3; September 2023

Original Article

Effects of irrigation water type and poultry manure on the growth and yield of tomato (*Lycopersicum esculentum*) in the Northern Guinea Savanna Zone of Nigeria

Ursulla Ukamaka Emeghara[1]*, Jeremiah Samuel Aluwong[2], Charles Moses Emmanuel[3]

[1]Department of Forestry Technology, Federal College of Forest Resources Management Ishiagu, Ebonyi State, Nigeria, [2]Department of Agricultural-Extension and Management, School of Agricultural Technology, Nuhu Bamali Polytechnic, Zaria, Kaduna State, Nigeria, [3]Department of Crop Production, Ibrahim Badamasi Babangida University, Lapai, Niger State, Nigeria

ABSTRACT

An experiment was conducted to study the effects of organic fertilizer on the growth and yield of tomato irrigated with fish effluent and normal water at the premises of Faculty of Agriculture, University of Abuja, Nigeria. The investigation consisted of two factors which are irrigation water type, fish effluent, and normal water and poultry manure doses, namely 0 tonnes/ha, 10 tonnes/ha, 20 tonnes/ha, and 30 tonnes/ha. The 8 treatments were replicated thrice and the experiment consists of 24 plots in total. The seedlings were raised in the nursery and transplanted at 21 days onto aerated pots containing 15 kg of soil mix of different ratios of poultry manure. The fish effluent showed consistent increase in plant height, number of leafs, leaf area, and number of branches than those irrigated with normal water. The application of 20 tonnes/ha poultry manure had significant effect on the fat content. The result obtained revealed that tomato responded well to the application of poultry manure and it may be recommended as adequate for maximum growth and yield of tomato in the study location.

Keywords: Irrigation water type, Nigeria, Northern Guinea Savanna, poultry manure, tomato

Submitted: 04-08-2023, **Accepted:** 01-09-2023, **Published:** 30-09-2023

INTRODUCTION

The Solanaceae family includes the tomato (*Lycopersicon esculentum*). It is one of the most important vegetables in many tropical and subtropical nations, including Nigeria. Tomato yield output has also remained relatively low due to a number of other factors, including the use of unimproved local varieties with low-yielding capacity that is frequently grown in mixtures and may prevent exploitation of crop productive capacity; other factors are environmental risks such as drought and the prevalence of pests and diseases, plant population decline, including decline in soil fertility, and a variety of other factors. Nigeria often produces little tomatoes since small-scale farmers only get minimal yields.[1] Inorganic fertilizers have not aided intensive agriculture because they exacerbate soil degradation.[2] Loss of natural matter results in the corruption, which causes causticity in the soil and low crop yields.[3] How much organic matter is in the soil depends on the type of organic material that is supplied. Root exudates, sloughed-off root nodules, and roots themselves can all naturally supply organic material to the soil, as can organic fertilizers like chicken dung[2,4] claimed that the nutrients in organic manure have a longer residual effect because they release more gradually and stay in the soil for a longer period of time. Contrarily, inorganic fertilizer is readily available to crops and has a high concentration of nutrients, but its widespread usage in impoverished countries such as Nigeria is limited by its exorbitant cost.[5] There are approximately 4 million hectares of tomato cultivation worldwide, of which 63,482 are thought to be cultivated. According to FAO,[6] Nigeria produces about 1.7 million tonnes annually. However, despite the growing demand for human consumption, this was still far below demand. Be that as it may, the majority of the shortages were balanced by importation. Nevertheless, despite efforts to increase tomato production in Nigeria, farmers have not achieved optimal production to meet consumer demand. 170.8 million metric

Address for correspondence: Ursulla Ukamaka Emeghara, Federal College of Forest Resources Management Ishiagu, Ebonyi, Nigeria.
E-mail: amakaopec@yahoo.com

tons of tomatoes were produced worldwide in 2017. Tomatoes contain minerals such as potassium, vitamins, and pro-vitamins (including pro-vitamin A, vitamin C, folate, and carotene), as well as secondary metabolites such as flavonoids, lycopene, polyphenols, and phytosterols[7,8] estimated that 100 g of fresh tomatoes contain more than 46%, 8%, and 3.4% of the recommended daily intakes of vitamin A (900 UE), vitamin C (82.5 mg), and potassium (3500 mg), respectively. Effluent with a higher concentration of nutrients, silt, and hazardous compounds that are discharged into the environment without sufficient treatment may have detrimental impacts on the soil and water quality of the receiving water body. This effluent may change the qualities of the receiving water body and soil.[9] Chemical fertilization is bad for the soil's fertility and characteristics, and it may cause heavy metals to build up in plant tissues, which can hurt the nutritional value and edible quality of fruits.[10,11] Crops affected by chemical fertilizer also have lower carbohydrate quality and lower protein content. The enormous amount of water utilized in the production phases of the fish processing industry results in the production of significant volumes of effluents.[12] This posed a serious challenge as it would lead to environmental pollution. High cost and non-availability of inorganic fertilizer coupled with its attendant effect on soil justifies the use of organic manure and fish effluent.

Objectives of the Study

The main aim of the study is to determine the effects of irrigation water type and poultry manure on the growth and yield of tomato. The specific objectives are to:

i. Determine the effect of fish effluent as source of irrigation water and poultry manure on the nutritional qualities of tomato fruit.
ii. Determine the effect of fish effluent and poultry manure on the growth and yield of tomato plant.

MATERIALS AND METHODS

Experimental Site

The experiment was carried out on the grounds of the Faculty of Agriculture, University of Abuja, Nigeria. The faculty is located in the Northern Guinea Savanna Zone of Nigeria in Latitudes 9°4'20'N and Longitudes 7°29'28'E, where the mean annual temperature fluctuates between 24°C and 32°C. The faculty fish pond's discharge served as the source of the fish waste water employed in the experiment.

Source of Seeds

The seeds (U.C.82-B) are obtained from a reputable seed vendor in Abuja.

Pot Preparation

Before being transferred to the pot, the seeds were grown in the nursery for 21 days. The experimental field was prepared by clearing debris, and then, the seedlings are transplanted into pots containing 15 kg of soil each mixed with different rates of poultry manure.

Experimental Design

The experiment consists of two factors, namely irrigation water type and poultry manure. The treatments are (i) poultry manure of four different rates; 10 tonnes, 20 tonnes, and 30 tonnes and (ii) irrigation water type: fish effluent and normal type. The treatments are replicated thrice giving a total of 24 plots. Each plot consists of three plants, i.e., three pots, and a single plant was taken as an experimental unit from each plot.

Agronomic Practices

All agronomic practices are carried out as at when due. Weeding is done manually by handpicking and occasionally using hoe to keep the field neat and free from weeds.

Data Collection

The data taken on the growth and development of tomatoes are plant height, number of leafs, number of fruits, fruit weight, number of branches, leaf area, moisture content, ash content, crude fiber, crude protein, fat content, carbohydrates, and energy value.

Proximate Analysis

The nutritional quality of the tomato was examined for proximate analysis to determine the ash content, moisture content, fat content, crude fiber, crude protein, carbohydrate content, and energy.

Data Analysis

All data collected will be subjected to Analysis of Variance and significant means will be separated using least significant differences (LSD) at 5% probability level.

RESULTS

Physiochemical Properties of Experimental Soil, Poultry Manure, and Fish Effluent

Table 1 shows the chemical analysis of fish effluent, poultry manure, and physiochemical properties of soil before the experiment.

Effect of Irrigation Water Type and Poultry Manure on the Plant Height (cm) of Tomato

The result in Table 2 shows the effect of different irrigation water and poultry manure rates on the plant height of tomato. The result indicated that there were no significant differences between the application of fish effluent and normal water at 4 and 12 at 5% probability level. 10 tonnes/ha application of poultry manure produced significantly taller tomato plants compared to other applications. Application of 30 tonnes/ha produced the shortest tomato plants at 5% probability

Table 1: Physiochemical analysis of soil and chemical analysis of poultry manure 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 Na (Cmol/Kg)	K (Cmol/Kg)	Ca (Cmol/Kg)	Mg (Cmol/Kg)	E.A (Cmol/Kg)	CEC (Cmol/Kg)	Soil particle sizes 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	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)					
Poultry	6.30	1120	25.29	74.708	0.246	0.953	2.12	2.33	1.36	0.42					
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 poultry manure 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	12.94[a]	61.25[a]	25.69[a]	268.50[a]
Water	10.79[a]	60.19[a]	20.44[a]	203.51[b]
Poultry manure (tonnes/ha) (P)				
C	12.10[b]	57.75[a]	19.75[b]	187.11[b]
10	15.78[a]	53.31[a]	34.92[a]	228.59[ab]
20	10.92[bc]	60.65[a]	21.64[b]	254.99[ab]
30	8.77[c]	61.18[a]	15.96[b]	273.34[a]
Interaction				
I×P	NS	NS	NS	NS

According to Least Significant Difference (LSD), values in a column that are immediately followed by the same letter (s) are not statistically different at the 5% probability level, WAT: Week after transplanting

level. Application rates for poultry manure at 4WAT differ significantly while poultry manure application rate is not significantly at 12WAT at 5% probability level.

Effect of Irrigation Water Type and Poultry Manure on the Number of Leafs of Tomato

Table 2 shows the effect of irrigation water type and rate of application of chicken manure on number of tomato leafs. The results revealed that the number of tomato leafs at 4WAT was not significantly affected by the use of fish effluent and regular water as irrigation water because the number of leaves of the plant irrigated with fish effluent and regular water was equal. However, fish effluent produced higher number of leaves of tomato at 12WAT with the mean value of 268.50 at 5% probability level ($P \leq 0.05$). The effect of poultry manure application rate on the number of leaves of tomato was also significant. The result showed that the application of 10 tonnes/ha of poultry manure produced significantly higher number of leaves compared to other rates at 4WAT, while there were no significant differences among other rates at the same period. Application of 30 tonnes/ha produced a significantly higher number of tomato plant leafs at 12WAT, with mean value of 273.34 at the 5% probability level. However, at the 5% probability level, the application of 0 tonnes/ha produced lower leafs of tomato plants.

Effect of Irrigation Water Type and Poultry Manure on the Leaf Area (cm^2) of Tomato

Table 3 shows the effect of irrigation water type and poultry manure application rate on the leaf area of tomato. The result showed that there was significant difference between pots irrigated with fish effluent and those irrigated with normal water as fish effluent produced plants with wider leaves at 4 and 12WAT compared to normal water with the mean area of 19.46 cm^2 and 68.89 cm^2 at 5% probability level ($P \leq 0.05$). However, there were no significant differences between the application rates of 10 and 20 tonnes/ha at 12WAT, and similarly, there were no significant differences among the application rates at 4WAT as they were all equal at the 5% probability level. On the other hand, the application of poultry manure at a rate of 10 tonnes/ha resulted in significantly wider tomato leaves in comparison to other application rates at 4 and 12WAT with mean areas of 25.15 cm^2 and 73.20 cm^2, respectively.

Effect of Irrigation Water Type and Poultry Manure on the Number of Branches of Tomato

The number of tomato plant branches was affected by irrigation water and poultry manure rates, as shown in Table 3. At 4WAT, the number of branches was not significantly affected by the irrigation water or poultry manure at 5% probability level. However, tomato plants irrigated with fish effluent produced significantly higher number of branch at 12WAT but poultry manure application rate was not significant.

Table 3: Effect of irrigation water type and poultry manure 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	19.46^{a}	68.89^{a}	3.70^{a}	11.33^{a}
Water	12.75^{b}	49.62^{b}	2.81^{a}	9.28^{b}
Poultry manure (tonnes/ha) (P)				
0	13.71^{b}	39.00^{b}	3.22^{a}	10.89^{a}
10	25.15^{a}	73.20^{a}	5.03^{a}	9.22^{a}
20	14.61^{b}	68.25^{a}	3.00^{a}	9.69^{a}
30	11.10^{b}	56.17^{ab}	2.77^{a}	11.50^{a}
Interaction				
I×P	NS	NS	NS	NS

According to Least Significant Difference (LSD), values in a column that are immediately followed by the same letter (s) are not statistically different at the 5% probability level, WAT: Week after transplanting

Effect of Irrigation Water Type and Poultry Manure on the Number of Fruits of Tomato per Plant

The number of fruits of tomato as affected by the application of different irrigation water and poultry manure rates is shown in Table 4. The result revealed that the application of fish effluent water significantly affects the number of fruit of tomato per plant at 10WAT only, as plants irrigated with fish effluent significantly produced more number of fruits with the mean value of 2.42 at 5% probability level ($P \leq 0.05$). The effect of application of poultry manure was significant only at 10 and 12 WAT. While application of poultry manure at 10 tonnes/ha significantly produced higher number of fruits at 10WAT, 30 tonnes/ha, on the other hand, produced significantly lowest number of fruits. Application of 0 and 20 tonnes/ha was statistically similar.

Effect of Irrigation Water Type and Poultry Manure on the Fruit Weight (Kg) of Tomato

Table 4 shows the effect of irrigation water type and poultry manure application on the weight of tomato fruit. The result showed that the effect was significant only at 12 WAT with fish effluent consistently and significantly produced heavier fruits. Similarly, the application of 20 tonnes/ha of poultry manure significantly produced heavier tomato fruits (0.43 kg) at 10WAT while the application of 30 tonnes/ha produced the lightest fruits (0.21kg) but statistically similar to 0 and 10 tonnes. Application of 10 and 30 tonnes/ha was at par at 12WAT and significantly produced heavier fruits with the mean weight of 0.46 kg and 0.59 kg, respectively, while application of 20 tonnes/ha produced the least weight of tomato fruits (0.41 kg)

Table 4: Effect of irrigation water type and poultry manure on the number of fruits and fruit weight of tomato

Treatment	Number of fruit			Fruit weight (kg)		
	10WAT	12WAT	14WAT	10WAT	12WAT	14WAT
Irrigation water (I)						
Fish effluent	2.42^{a}	2.42^{a}	2.58^{a}	0.41^{a}	0.60^{a}	0.45^{a}
Water	1.69^{b}	2.25^{a}	2.33^{a}	0.35^{a}	0.340^{b}	0.51^{a}
Poultry manure (tonnes/ha) (P)						
0	2.17^{ab}	2.33^{ab}	2.83^{a}	0.38^{ab}	0.57^{ab}	0.53^{ab}
10	2.39^{a}	1.83^{b}	1.67^{a}	0.49^{ab}	0.46^{a}	0.24^{b}
20	2.17^{ab}	2.00^{ab}	3.17^{a}	0.43^{a}	0.41^{b}	0.73^{a}
30	1.50^{b}	3.17^{a}	2.17^{a}	0.21^{b}	0.59^{a}	0.38^{ab}
Interaction						
I×P	NS	NS	NS	NS	NS	NS

According to Least Significant Difference (LSD), values in a column that are immediately followed by the same letter (s) are not statistically different at the 5% probability level, WAT: Week after transplanting at 5% probability level. On the other hand, the application of 20 tonnes/ha significantly produced heavier tomato fruits (0.73 kg) at 14WAT while there were no significant differences between application of 0 and 30 tonnes/ha while 10 tonnes/ha had the least weight of tomato fruits at 5% probability level ($P \leq 0.05$).

Effect of Irrigation Water Type and Poultry Manure on the Fruit Characteristics of Tomato

Table 5 shows the effect of irrigation water type and poultry manure application on the nutritional qualities of tomato fruit. The result revealed that there were no significant differences in the moisture content and crude fiber of plant irrigated with fish effluent and normal water, while there were significant differences in the ash content, crude protein, fat content, CHO, and energy value of plants irrigated with fish effluent compared to normal water with the mean value of 0.27%, 0.16%, 0.13% 7.06 kg/g, and 31.89 kj/kg, respectively, at 5% probability level. However, there were no appreciable differences between tomato plants treated with various rates of poultry manure application in terms of crude fiber, crude protein, fat content, or CHO. In contrast, plants treated with 20 tons/ha of poultry manure produced tomato fruits with a higher energy value of 31.23 kj/kg than plants treated with other poultry manure application rates. Different rates of applying poultry manure had a substantial impact on the ash content of tomato plants. At the 5% probability level, the application of 10 tonnes/ha resulted in tomato fruits with a higher ash content (0.29%), which was statistically equal to 0 tonnes/ha but considerably higher than 20 and 30 tonnes/ha ($P \leq 0.05$).

DISCUSSION

It is possible that the availability of some nutrients in the fish effluent made available to plants, in the required form for rapid uptake by the plant roots, is the cause of the consistent increase in plant height, number of leaves, leaf area, and number of branches in plants irrigated with fish effluent. When tomatoes are mulched, irrigation greatly improves performance.[13] The presence of nitrogen, phosphorus, and potassium in fish effluent may be responsible for how well plants perform (growth, yield, and fruit quality), as well as their crucial roles in physiological processes such as photosynthetic activity, carbohydrate transport, protein synthesis, control of ionic balance, stomata size regulation, and enzyme activation. Similar results were also reported by El-Dissoky,[14] who suggested that this outcome may be related to the high phosphorus concentration of fish effluent, which is a crucial component of the nucleic acid co-enzyme for cell division. The results are consistent with earlier reports that organic manure increased soil nitrogen fertilization as N and P, which play important roles in promoting the vegetative growth of plants by enhancing cell division and elongation and also had a significant increase in the morphological characteristics.[15] The results are in line with those of Musara and Chitamba[16] who found that cucumbers grown in 20 t/ha manure had more branches per vine. They attributed this to the manure's improved moisture availability, which enhanced the nutrients released during bud initiation and branch growth. This finding is in line with that of Moez *et al*.[17] who discovered that tomato plants grew more quickly when exposed to poultry manure than when not. However, the lack of variation in the number of fruits produced at 14WAT in the application rates of poultry manure can be explained by the fact that the amount of applied organic manure has little influence on these features. This finding is consistent with the findings of Abdulmaliq *et al*.[18] who found that soil amendment had no appreciable impact on the Okra plant's days till first blooming. In addition, Blumenthal *et al*.[19] revealed that there is a bad link between the protein and fat levels. Low nitrogen application enhanced protein and decreased fat.

Table 5: Effect of irrigation water type and poultry manure 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 (I)							
Fish Effluent	92.67^{a}	0.27^{a}	0.11^{a}	0.16^{a}	0.13^{a}	7.06^{a}	31.89^{a}
Water	92.56^{a}	0.24^{b}	0.10^{a}	0.14^{b}	0.10^{b}	5.97^{b}	26.03^{b}
Poultry manure rates (tonnes/ha) (P)							
0	93.37^{a}	0.28^{ab}	0.11^{a}	0.15^{a}	0.11^{a}	6.34^{a}	27.87^{b}
10	93.59^{a}	0.29^{a}	0.13^{a}	0.15^{a}	0.12^{a}	6.25^{a}	28.19^{b}
20	91.22c	0.24^{b}c	0.12^{a}	0.15^{a}	0.11^{a}	6.98^{a}	31.23^{a}
30	92.30^{a}	0.22c	0.07^{b}	0.15^{a}	0.12^{a}	6.49^{a}	28.55^{b}
Interaction							
I×P	NS	NS	NS	NS	NS	NS	NS

According to Least Significant Difference (LSD), values in a column that are immediately followed by the same letter (s) are not statistically different at the 5% probability level

CONCLUSION

In general, this study demonstrated the responsiveness of tomato to different rates of poultry manure and different irrigation water types. From the above results, we concluded that irrigation with fish effluent increases the plant height, number of leaves, leaf area, and number of branches of tomato fruit compare to the use of normal water for irrigation. It can be concluded that irrigation with fish effluent is promising for enhancing the growth, development, and quality of tomato. The amount of fat changed significantly after 20 t/poultry manure application. The findings showed that tomato responded favorably to the addition of poultry manure. Based on the results of this study, it may be suggested that 20t/ha of poultry manure is sufficient for a tomato crop to grow and yield as much as possible in the study area.

RECOMMENDATIONS

It would be unnecessary to pay for fertilizer if nutrient-rich fish farm wastewater was used in place of inorganic fertilizers. Tomato production ought to become more affordable as a result. However, due to issues with inorganic fertilizer, such as high purchasing costs, scarcity, leaching, volatilization, and environmental unfriendliness, it is generally not advised as opposed to organic fertilizer, which is more environmentally friendly. More so, since there is no distinct significance difference between the normal water and fish effluent on irrigation, the use of fish effluent is recommended to reduce the environmental impact of releasing the effluent although, more research should be charged toward the analysis of the effluent before using it to authenticate the result of this research.

REFERENCES

1. Adekiya AO, Ojeniyi SO. Poultry manure effects on soil properties, leaf nutrient status, growth and yield of cocoyam in a tropical Alfisol. Niger J Soil Sci 2012;22:30-9.
2. Sharma M. In: Egene EA, editor. Effect of Organic and Inorganic Fertilizer on the Growth, Development and yield of Okra (*Abelmoschus esculentus* l. Moench) in Kogi state. B. Agric Project Submitted to the Department of Crop Production. Anyigba: Kogi State University; 2011. p. 37.
3. Ojeniyi SO. Integrated application of poultry manure and NPK fertilizer on performance of tomato in derived savannah transition zone of Southwest Nigeria. J Am Sci 2010;8:50-4.
4. Agboola AA, Omueti JA. Soil Fertility Problem and Its Management in the Africa. Paper Presented at the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. 2012. p. 25.
5. Webber B, Weber K, Clark P, Moffet C, Ames D, Taylor J, *et al*. Movements of domestic sheep in the presence of livestock guardian dogs. Sheep Goat Res J 2015;30:30-8.
6. FAO. The Wealth of Waste: The Economics of Wastewater Use in Agriculture. In: FAO Water Report No. 35. Rome, Italy: Water Development and Management Unit, Food and Agriculture Organization of the United Nations; 2010.
7. Luthria DL, Sudarsan M, Krizek DT. Content of total phenolics and phenolic acids in tomato (*Lycopersicon esculentum* Mill.) fruits as influenced by cultivar and solar UV radiation. J Food Composit Anal 2006;19:771-7.
8. Canene-Adams K, Campbell JK, Zaripheh S, Jeffery EH, Erdman JW Jr. The tomato as a functional food. J Nutr 2005;135:1226-30.
9. Roy K, Chari MS, Gaur SR, Thakur A. Ecological dynamics and hydrobiological correlations in freshwater ponds-recent researches and application. Int J Environ Biol 2014;4:112-8.
10. Islam MS, Ahmed MK, Habibullah-Al-Mamun M, Raknuzzaman M, Ali MM, Eaton DW. Health risk assessment due to heavy metal exposure from commonly consumed fish and vegetables. Environ Syst Decis 2020;36:253-65.
11. Uddin D, Hussain M, Shahadat S, Ahmad H, Roni MZ. Effect of *Trichoderma* concentrations on growth and yield of tomato. Bangladesh Res Publ J 2015;11:228-32.
12. De Melo Ribeiro FH, Naval LP. Reuse alternatives for effluents from the fish processing industry through multi-criteria analysis. J Clean Prod 2019;227:336-45.
13. Gudugi IA, Odofin AJ, Adeboye MK, Oladiran JA. Agronomic characteristics of tomato as influenced by irrigation and mulching. Adv Appl Sci Res 2012;3:2539-43.
14. El-Dissoky R. Agro-economic assessment of added fertilizers to tomato yield grown at Fayoum Governorate, Egypt. J Soil Sci Agric Eng 2018;9:771-80.
15. Qamar-uz-Zaman C, Sarwar S, Ahmad F, Hamid FS. Effect of nitrogenous fertilizer on the growth and yield of tea (*Camellia sinensis* L.) pruned in curved vs flat shape. J Agric Res 2011;49:415-27.
16. Musara C, Chitamba J. Evaluation of cattle manure application rate on the growth rate and fruit yield of cucumber (*Cucumis sativas* L.). Int Res J Agric Sci Soil Sci 2014;4:167-17.
17. Moez B, Sair S, Fayaz A, Hamid FS. Effect of poultry manure on the growth and yield of tomato (*Lycopersicon esculentum* L.) pruned in curved vs flat shape. J Agric Res 2017;49:727-34.
18. Abdulmaliq SY, Abayomi YA, Aduloju MO, Olugbemi O. Effects of curing period of livestock droppings on the growth and yield of okra (*Abelmoschus esculentus* L.) varieties. Int J Agron 2015;2016:3513954. https://dx.doi.org/10.1155/2016/3513954
19. Blumenthal JM, Baltensperger DD, Cassman KG, Mason SC, Pavlista AD. Importance and effect of nitrogen on crop quality and health. In: Hatfield JL, Follet R., editors. Nitrogen in the Environment: Sources, Problems, and Management. 2nd ed. Amsterdam: Elsevier Inc.; 2008.