

THE EFFECTS OF ORGANIC FERTILIZER ON THE GROWTH, YIELD AND NUTRITIONAL QUALITY OF SPINACH (*Amaranthus hybridus*)

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Abstract

There is a shift towards organic fertilizers as a result of high-priced inorganic fertilizers. The paper evaluates the effects of organic fertilizers on the growth, yield and nutritional status of spinach. The experiment was laid out in a Randomized Complete Block Design (RCBD) with six treatments and three replications. The treatments were T1 (No manure/fertilizer), T2 (cow dung), T3 (goat and sheep manure), T4 (poultry droppings), T5 (rabbits droppings) and T6 (NPK 15:15:15) respectively. Manures application (15t/ha) were done before nursery, after transplanting and two weeks after transplanting. Amongst the various organic manures, poultry manure produced significantly higher ($p < 0.5$) plant growth, yield (18.2t/ha) and proximate composition. Therefore, planting spinach with poultry manure under moderate rainfall enhances the growth and yield of spinach.

Keywords: Organic fertilizer; growth; yield; manures; proximate composition

Introduction

Amaranth growing is one of the major enterprises in Agriculture which is becoming more popular due to the greater appreciation of their food values, vitamins and minerals (Musa 2018). Vegetables contribute an important part of the diet to many people in the tropical Africa more especially in Northern Nigeria. Amaranth is essentially a tropical crop and among the most commonly grown vegetable throughout Nigeria (Musa, 2018). It is cultivated for its fresh leaves and stem in both tropical and sub-tropical countries of the world. The leaves are consumed by man, while the leaves and stems are considered good cattle feed and. The seeds, oil, and leaf are used as food. The entire plant is used to make medicine. Amaranth is used for treatment of ulcer, diarrhea, swelling of the mouth or throat, and reducing high cholesterol in body (Musa, 2018). Amaranth cultivation requires nutrients such as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), sodium (Na) and Sulphur (S) for fertility maintenance and crop production. These nutrients are specific in function and must be supplied to plants at the right time and at the right quantity. Lack of sufficient amounts of these nutrients result in poor performance of the amaranth with growth been affected resulting to low yield (Abubakar, 2018).

Amaranth production in the Northern Nigeria is high yielding. The high yielding experience has been attributed to good soil fertility and high organic matter contents of the soil which are properly mixed with important mineral nutrients (Abubakar, 2018). This fertilizer has become a scarce commodity, even when available, is beyond the reach of the poor resource farmers due to its high costs. For example over 70 % of vegetable farmers in Niger State, have no access to mineral fertilizer due to high cost and scarcity. Hence Animal wastes that result to animal manures is better alternative and a necessary option (Peter, 2019). According to Olatunji *et al.* (2006), the application of organic manure had been found to have higher comparative economic advantage over the use of inorganic fertilizer.

A study conducted by Nwajiuba and Akinsanmi (2017) in Southeastern Nigeria, showed that returns per ha were higher in organic farms though outputs were slightly less in inorganic farms. Asiegbu and Carol (2000) reported that the application of poultry manure is the best way of improving the yield of amaranth and that amaranth requires soil with high organic content and such soils favored the production of leaf numbers which is highly consumed. According to Colling Wood, *et al.*, (1988), proper poultry manure is required for optimum growth and

development of vegetable since excessive nitrogen increases their susceptibility to fungal disease and deterioration of keeping quality. Hence there is need for poultry manure application in cropping system to maximize nutrient recycling and to minimize losses.

Similar results were obtained by Olaniyi, *et al.*, (2008) who reported increased Amaranth plant height at higher organic manure application rate. Olufolaji (2007) reported that Amaranth plants require high nitrogen content for their vegetative growth and poultry manure have high nitrogen than all others. Also, the increase in number of leaves with urea confirmed the role of nitrogen in promoting vigorous vegetative growth in leafy vegetables as reported by Myers, (1998) and Olaniyi, (2007). The higher stem length observed with urea treatment is also supported by Alonge, *et al.*, (2007) who reported that nitrogen caused increase in plant height. The finding also agrees with Pospisil, *et al.*, (2006) who reported that higher levels of nitrogen contents in poultry dropping application produced significantly taller and broader Amaranth plants compare to cow dung, goat and sheep and follow by rabbit manure.

Research Question

The research question guiding this study is: What is the effect of different organic fertilizers (NPK 15:15:15, poultry droppings, rabbits droppings, goat and sheep droppings, and cow dung) on plant growth and development?

Hypothesis: Based on the research question, the following hypothesis is formulated:

Null Hypothesis (H₀): There is no significant difference in the effects of different organic fertilizers (NPK 15:15:15, poultry droppings, rabbits droppings, goat and sheep droppings, and cow dung) on plant growth and development.

Alternative Hypothesis (H₁): There is a significant difference in the effects of different organic fertilizers (NPK 15:15:15, poultry droppings, rabbits droppings, goat and sheep droppings, and cow dung) on plant growth and development.

Rationale for Hypothesis: The alternative hypothesis is based on the assumption that different organic fertilizers have varying levels of nutrients and other beneficial compounds that can impact plant growth and development. NPK 15:15:15 fertilizer, for example, is a balanced fertilizer that contains equal amounts of nitrogen, phosphorus, and potassium, making it a popular choice for plant growth. On the other hand, organic fertilizers like poultry droppings and rabbits droppings are high in nutrients but may have varying levels of other beneficial compounds.

Materials and Method

Area of the study: The research was conducted at the teaching and research farm of Niger State College of Education Minna, 2022 cropping season. Minna is located in the Southern Guinea Savanna. It lies between latitude 9° 37 North and Longitude 6° 32 East (Smith. M. B. 1992).

Sampling and data collection: The *Amaranthus hybridus* seeds and NPK (15:15:15) were bought from Vegetable Market popularly known as Tunga Goro Minna, Niger State. Cow dung, goat and sheep manure, poultry droppings and rabbit manure was collected from COE Minna Teaching and Research farm.

Following the clearance of the field, the soil was tilled using hoe. A measuring tape and a hoe were used to measure a gross plot of 12 by 12 metres square. The gross plot was further divided into twelve equal net plots and each net plot was measured 3 by 2 metres square. The distance between the net plots and the treatments is 0.5m. The five treatments were identified randomly as T1, T2, T3, T4, T5 and T6 for zero fertilizer, cow dung, goat and sheep manure, poultry droppings, rabbit manure, NPK and control respectively.

Sowing of the Seeds: The seeds rate of 0.075kg mixed with 5ml of triazine (insecticide) and sand. The seed was planted by broadcasting. After germination, the seedlings were transplanted

at a space of 0-18cm and a distance of 0.5m between the net plots and the treatments. Application of Fertilizers: All fertilizers used for the study (cow dung, goat and sheep manures, poultry droppings, rabbit manure and NPK) were quantified at 0.3kg (300g) were used for each net plot. Both cow dung, goat and sheep manures, poultry droppings and rabbit manure were thoroughly spread and mixed with the soil before broadcasting the seeds because they gradually incorporate into the soil compared to NPK which takes only 2-4 days, while NPK was applied a week after germination. NPK contains nitrogen, phosphorus and potassium; if applied before planting or less than 6 days after seeds germination, it may burn the seedlings or suppress their growth thereby leading to the death of the plants (Sanchez, 2011).

Watering and Weeding: After sowing the seeds, the experiment was carried out during the raining season. The *A. hybridus* plants neither require too much moisture nor dryness (Onyanga, 2010). According to Onyanga (2010) *A. hybridus* should be watered with sufficient water, water shortage causes early flowering which reduces the yield and the market quality. Onyanga, (2010) also reported that too much of water washes the seeds away from the plots due to their lightness and high dryness also makes the plants to sprout and wilt, thereby causing them to become yellow in colour and finally die off. Normally, *Amaranthus hybridus* seeds have variability in germination. For this reason, some seeds started germinating on the second day after planting while others on the third and fourth days. The weeding was done when the need arise using hands (selective weeding) for the weeds on the beds and hoe for the weeds found in-between the rows/net plots, according to FAO (2008) and known herbicide is reported due to the variability in the seeds germination, the poultry manure and rabbit droppings) and NPK 15: 15: 15 inorganic fertilizer were applied to the soils at the rate equivalent to 5 ton/ha of the organic manure and 60 kg/ha of NPK fertilizer for the plots to be planted with vegetable. The rates amounted to 5 kg and 3.59 g per plot of organic manure and NPK fertilizer respectively. The plots were arranged in a completely randomized design with three replicates. The manures were incorporated into the soils two weeks before broadcasting while the NPK fertilizer was applied at weeks after broadcasting. The control plots were broadcasted without any treatment application.

Table 1: Measurement of the Stem Length

Weeks after transplanting	Stem Length (cm)					
	T1	T2	T3	T4	T5	T6
2 WAT	6.4	14.4	15.2	30.3	29.4	35.4
3 WAT	8.4	16.4	16.8	33.3	28.2	45.4
5 WAT	16.7	31.0	32.6	44.5	39.6	64.2

KEY: T1 –No manure/fertilizer; T2- Cow dung; T3- goat and sheep manure; T4- Poultry dropping; T5- rabbits dropping; T6- NPK 15:15:15

Table 2: Measurement of the Stem Width

Weeks after transplanting	Stem Width (cm)					
	T1	T2	T3	T4	T5	T6
2 WAT	2.1	3.6	3.6	5.0	4.8	6.4
3 WAT	2.5	3.8	3.9	5.0	4.8	7.0
5 WAT	3.0	4.4	4.5	5.2	5.0	8.1

KEY: T1 –No manure/fertilizer; T2- Cow dung; T3- goat and sheep manure; T4- Poultry dropping; T5- rabbits dropping; T6- NPK 15:15:15

Table 3: Measurement of the Leaf Length

Weeks after transplanting	Leaf Length (cm)					
	T1	T2	T3	T4	T5	T6
2 WAT	6.3	7.1	7.5	9.3	8.0	12.0
3 WAT	9.0	9.1	9.3	13.0	12.2	16.0
5 WAT	9.2	16.1	16.5	17.1	17.1	19.3

KEY: T1 –No manure/fertilizer; T2- Cow dung; T3- goat and sheep manure; T4- Poultry dropping; T5- rabbits dropping; T6- NPK 15:15:15

Table 4: Measurement of the Leaf Width

Weeks after transplanting	Leaf Width (cm)					
	T1	T2	T3	T4	T5	T6
2 WAT	3.0	5.0	5.5	7.0	6.0	11.2
3 WAT	5.0	5.1	5.8	8.0	6.5	12.4
5 WAT	5.5	8.0	8.4	9.1	8.8	14.2

KEY: T1 –No manure/fertilizer; T2- Cow dung; T3- goat and sheep manure; T4- Poultry dropping; T5- rabbits dropping; T6- NPK 15:15:15

Table 5: Number of Leaves per Plant

Weeks after transplanting	Number of Leaves per Plant					
	T1	T2	T3	T4	T5	T6
2 WAT	10	12	13	14	13	23
3 WAT	13	14	15	18	16	34
5 WAT	13	24	25	30	28	34

KEY: T1 –No manure/fertilizer; T2- Cow dung; T3- goat and sheep manure; T4- Poultry dropping; T5- rabbits dropping; T6- NPK 15:15:15

Figure: 1. Total yield in t/ha.

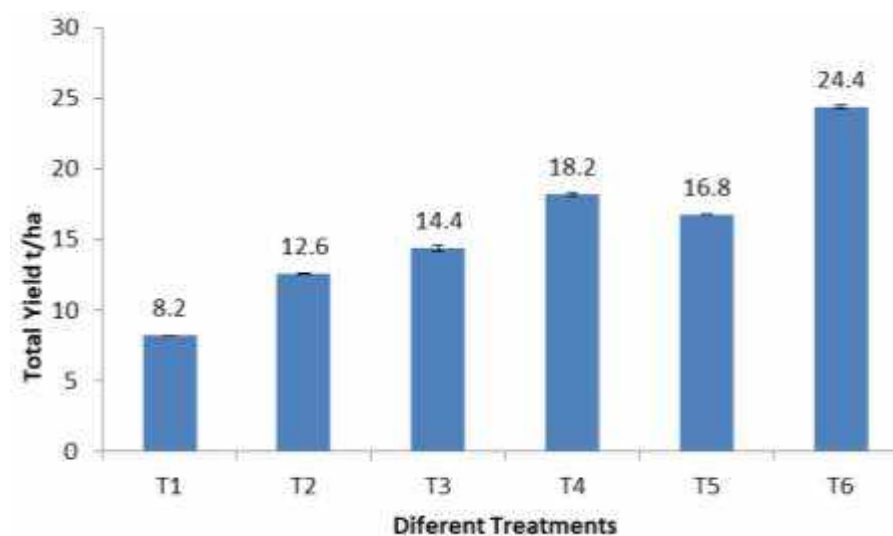


Table 6: Nutritional Quality of spinach

Nutritional parameters	Treatments		
	Control	Poultry droppings	NPK
Starch (g/100g FW)	3.00	3.53	4.00
Protein(g/100g FW)	2.00	2.35	2.50
Fat(g/100g FW)	0.00	0.00	0.00
Fibre (g/100g FW)	2.00	2.35	2.62
β-Carotene (mg/100g FW)	0.20	30.40	32.00
Vitamin C(mg/100g FW)	24.00	28.20	30.00
Flavonoids(QE/g)	7.82	9.86	10.20
Total phenols (GAE/g)	160.00	180.20	182.5

Discussion

There were (6) six treatments; zero manure/fertilizer, cow dung, goat and sheep manure, poultry droppings, rabbits dropping and NPK 15:15:15 which were randomly identified as T1, T2, T3, T4, T5 and T6 respectively. The parameters observed and measured were the stem length, stem width, leaf length, leaf width, number of leaves per plant, total yield and nutritional quality. The data were collected three times; at the second, third and fifth after transplanting.

Measurement of the Stem Length: Table 1 shows the results obtained from the measurement of the stem length. The table indicates NPK 15:15:15 treatment as having the longest stem throughout the weeks with a maximum length of 64.2cm at the fifth week, followed by poultry droppings, rabbit's droppings, goat and sheep manure, cow dung and zero manure/fertilizer having a maximum length of 44.5cm, 39.6cm, 32.6cm, 31.0cm and 16.7cm respectively.

Measurement of the Stem Width: The results obtained from the measurement of the stem width are shown in Table 2. Plants treated with NPK 15:15:15 are found to have the thickest stem throughout the weeks with a maximum width of 8.1cm at the fifth week, followed by those treated with poultry droppings (5.2cm), rabbit dropping (5.0cm), goat and sheep manure (4.5cm), cow dung (4.4cm), and zero manure/fertilizer (3.0cm).

Measurement of the Leaf Length: Table 3 shows the results obtained from the measurement of the leaf length. NPK 15:15:15 treatment has the highest length throughout the period of the study with a maximum value of 19.3cm, followed by poultry droppings, rabbit droppings, goat and sheep manure, cow dung, and zero manure/fertilizer with a maximum height of 17.5cm, 17.1cm, 16.5cm, 16.1cm and 9.2cm respectively.

Measurement of Leaf Width: Table 4 shows NPK 15:15:15 treatment is the treatment which has the highest leaf width throughout the period with a maximum value of 14.2cm, followed by poultry droppings, rabbit droppings, goat and sheep manure, cow dung and zero manure/fertilizer with 9.1cm, 8.8cm, 8.4cm, 8.0cm and 5.5cm as at the seventh week respectively.

Number of Leaves per Plant: The results obtained for the number of leaves per plant are shown in Table 5. Based on the data collected, NPK 15:15:15 treatment have the highest number of leaves with 34 leaves, followed by poultry droppings 30, rabbit droppings 28, goat and sheep manure 25, cow dung 24 and zero manure/fertilizer 13 leaves as at the seventh week of the study respectively.

Total yield in t/ha: NPK 15:15:15 have the highest yield of 24 t/ha follow by poultry droppings 118.2 t/ha, rabbit droppings 16.8 t/ha, goat and sheep manure 14.4 t/ha, cow dung 12.6 t/ha and no manure/fertilizer 8.2 t/ha respectively as shown in figure 1 above.

The data gathered were subjected to Statistical Analysis and were analyzed using One-way Analysis of Variance (ANOVA) and the results were expressed as percentage differences, the differences between the mean values were determined at 95% confidence. NPK 15:15:15 treatment was found to have a significant difference at ($p < 0.05$) on the vegetative growth of *Amaranthus hybridus* when compared with the other organic manures. From this research, NPK 15:15:15 treatment is found to produce plant with the highest height of 64.2cm, followed by poultry droppings, rabbit dropping, goat and sheep manure, cow dung and zero manure/fertilizer with 44.5cm, 39.6cm, 32.6cm, 31.0cm and 16.7cm respectively. Similar results were obtained by Paul, *et al.*, (2018) who reported increased *Amaranthus* plant height at higher nitrogen application rate. The research is also in agreement with the report of Olufolaji (2020) who reported that *Amaranthus* plants require high nitrogen content for their vegetative growth.

Conclusion

The study investigated the effects of different organic fertilizers on plant growth and development. The results showed that NPK 15:15:15 fertilizer recorded the highest parameter observed, followed by poultry droppings, rabbits droppings, goat and sheep droppings, and cow dung. This indicates that NPK 15:15:15 fertilizer is the most effective in promoting plant growth, but the use of organic fertilizers such as poultry droppings and rabbits droppings can be a suitable alternative.

Recommendation

But it would be highly recommended for farmers to use the organic fertilizers despite their lesser effect because this research was conducted within a short period of time which would not allow the full effects of the organic fertilizers to manifest as their incorporation to the soil takes much time than the inorganic which takes only 2-4 days. It is also less hazardous to the soil quality and health of the consumers.

Based on the findings of this study, the following recommendations are made:

1. Farmers and gardeners should consider using NPK 15:15:15 fertilizer for optimal plant growth and development.

2. Organic fertilizers such as poultry droppings and rabbits droppings can be used as a suitable alternative to inorganic fertilizers.
3. Further research should be conducted to investigate the long-term effects of using organic fertilizers on plant growth and development.
4. The use of organic fertilizers should be promoted through extension services and education to reduce the environmental pollution associated with the use of inorganic fertilizers.

References

- Abdulrazzaq, A (2019). Effects of Chicken Manure, Sheep Manure and Inorganic Fertilizer on Yield and Nutrients Uptake by Onion. *Pak. Biol. Sci.*, 266-268.
- Abubakar, B. (2018): Evaluating the influence of varied NPK fertilization on yielding and microelement contents at amaranth (*Amaranthus cruentus* L.) depending on its cultivar and plant spacing. – *Acta Scientiarum Polonorum Hortorum Cultus* 10: 245-261.
- Adekayode, F. O., (2004). The Use of Manure to Increase the Yield and Quality of *Amaranthus* to Feed Rabbit in a Humid Tropical Region. *Journal of Animal Veterinary Advance.*,3, 758-762.
- Alonge, S. O., Alonge, F. O., Bako, J. D., Olarewaju, O. B., & Adeniyi, S. P., (2007). The Effects of Rates and Split Application of Compound NPK Fertilizer on the Growth and Yield of three *Amaranthus* Species in Nigeria Guinea Savanna. *Asian Journal Plant Science*, 6, 906-912.
- Alonge, S.O., Alonge, F. O., Bako, S. P., Olarewaju, J. D., & Adeniyi, O. B., (2017). The Effects of Rates and Split Application of Compound NPK Fertilizer on the Growth and Yield of three *Amaranthus* Species in Nigeria Guinea Savanna. *Asian Journal of Plant Science.*, 6, 906-912.
- Asiegh, O. N., & Carol, S. O., (2000). Effect of poultry manure and NPK 15- 15-15. and combination of their reduced levels on amaranth growth and soil chemical properties. *Nigerian Journal of Soil Science*, 15, 34-41.
- Babatola, L. A., & Olaniyi, J. O., (2013). Performance of *Amaranthus caudatus* at Diff. Levels of NPK Fertiliz. & Under Diff. Storage Methods, *Proceeds. 16th Ann. Conf. of Hort. Soc. of Nig.*, UNAAB, Abeokuta, pp. 36-40.
- Bodey, E., Hardcastle, J., & Shah, N. J., (2019). Cousin and Cousine Islands Status and Management of Alien Invasive Species.
- Coolong, T. W., Kopsell, D. A., Kopell, D. E., & Randle, W. M., (2015). Nitrogen and Sulfur Influence Nutrient Usage and Accumulation in Onion. *Journal of. Plant Nutrition.*, 27, 1667-1686.
- Fatima, A. M. S., Rizk, A., & Singer, S. M., (2017). Growing Onion Plants without Chemical Fertilizer. *Res. Journal of Agricultural Biology Science*, 3, 95-104.
- Food and Agriculture Organization of the United Nations. (2008). *Traditional Food Plants*. FAO, Food and Nutrition, p. 2.
- Hardey, O. J., (2018) Soil fertility management for the production of fruits and vegetables in South Western Nigeria. *Acta Hort.* 128:237-242.
- Muake, W., (2019). Organic Manures-No Alternative to Mineral Fertilizers for Developing Countries. *BASF Agriculture News*, 2:90, pp. 8- 20.
- Musa, E., (2018). Environmental Effects of Chemical Fertilizers. http://www.ehow.com/facts_envt-effects_fert.html.
- Myers, R. L., (1998). Nitrogen Fertilizer Effect on Grain Amaranth. *Agron. Journal.*, 90, 5. 597-602.
- Nwajiuba, I. N., & Akinsanmi, m., (2017) Response of maize (*Zea mays*) to nitrogen and phosphorus fertilization under agro-climatic condition of Rawalokot Azad Jammu and Kashmir. *Pak. Journal of Biological Science* 4, 53-55

- Oladotun, A. O., (2002). Managing manure as a fertilizer; Saskatchewan, Agriculture, Food and Rural Revitalization, pp. 5.
- Olaniyi T. D., Adegbola, P. I. & Adetutu, A., (2008): Antioxidant activity of Amaranthus species from the Amaranthaceae family - a review. – *South African Journal of Botany* 133, 111-117.
- Olaniyi, J. O., (2017). Organo-mineral and inorganic fertilizers on the growth, fruit yield, quality and chemical compositions of Okra. *Journal of Animal & Plant Science. 1*, 1135–1140.
- Olatunji, S. O., Akanni, D. I., & Awodun, M. A., (2006). Effect of goat manure on some soil properties and growth yield and nutrient status of tomato. University of Khartoum *Journal of Agricultural Science. 15*, 396-405.
- Olufolaji, M. T., (2007). Organic residue management, soil nutrient changes and amaranth yield in humid Utisol. *Nutrient Recycling Agro Ecosyst.*, 47, 189-195.
- Olufolaji, S. M., (2020). Growing Onion Plants without Chemical Fertilizer. *Res. Journal. Agric. Biology. Science, 3*, 95-104.
- Onyanga, C. M., (2010). Preharvest & Postharvest Factors Affecting Yield and Nutrient Content of Vegetable Amaranth (Var. Amaranthus hypochondriacus).
- Paul, R. L., Nurse, R.E., Obied, K., & Pag, E. R., (2018). Optimal Planting Date. Row width & Critic. Weed-free Period for Grain Amaranth & Quinoa Grown in Ontario, Canada. *Canada. Journal. of Plant Science.*
- Peter, A. A., (2019). Influence of organic, mineral and organomineral fertilizers on growth, yield, and soil properties in grain amaranth (Amaranthus cruentus L.). *Journal of Organic mineral. 1(1)*, 39–47
- Pospisil, A., Pospisil, M., Varga, B. & Svecjak, Z., (2006). Grain Yield of Protein Concentration of Two Amaranth Species (Amaranthus spp.) as Influenced by the Nitrogen Fertilization. *European Journal of Agronomy. 25*, 250-253.
- Qhureshi, Z., (2007). Breeding Investigation in Bhendi (Abelmoschus esculentus (L.) Moench). Master Thesis, University of Agriculture Sciences, GKVK, Bangalore.
- Rober, A. and Peter, P. (2019). Research and development of organic crop production in Nigeria. FAO Expert Group Workshop on Preparation of Technical Guidelines on Organic Cultivation of Tropical and Subtropical Fruits.
- Sanchez, P. A., (2011). Organic matter and soil fertility management in acid soils of the tropics. *Transactions of the XIII Congress of International Soil Science Society*, p. 5.
- Sanni, A. A., & Adesina, G. O., (2012). Influence of differently composted organic residues on the yield of maize and its residual effects on the fertility of an Alfisol in Ibadan, Nigeria. *International Journal of Agric Environment Biotech; 6(1)*, 79 - 84.
- Smith. M. B. (1992). North farms alone: A study of rural livelihoods in the middle belt of Nigeria. DARE ASLD working paper 38.