International Journal of Agriculture and Environmental Research

ISSN: 2455-6939

Volume: 10, Issue: 01 "January-February 2024"

EFFECTS OF ORGANIC AND INORGANIC FERTILIZERS ON SOIL CHEMICAL PROPERTIES AND THE YIELD OF *Amaranthus species* IN A CONTINUOUSLY CROPPED ULTISOL

Akinmutimi, A.L. and Okoroji¸ M.C.

Department of Soil Science and Land Resources Management, College of Crop and Soil Sciences, Michael Okpara University of Agriculture, Umudike, P.M.B. 7267, Umuahia, Abia State, Nigeria.

DOI: https://doi.org/10.51193/IJAER.2024.10105

Received: 09 Jan. 2024 / Accepted: 05 Feb. 2024 / Published: 21 Feb. 2024

ABSTRACT

Field and laboratory experiments were conducted to evaluate the effects of poultry manure and NPK (20:10:10) fertilizer on soil chemical properties and yield of *Amaranthus species*. The treatments were: T1-Control (no fertilizer), T2-NPK 20:10:10 (200kg/ha), T3-Poultry manure (5 tons/ha), T4-NPK 20:10:10 (100kg/ha) + Poultry manure (2.5 tons/ha), T5-NPK 20:10:10 (100kg/ha)+ Poultry manure (5 tons/ha), T6-NPK 20:10:10 (200kg/ha)+ Poultry manure (5 tons/ha. The experiments were laid out in a randomized complete block design (RCBD). The soil was strongly acidic, having a pH of 5.1 and low in % total Nitrogen (0.10), % organic carbon (1.13) and the exchangeable bases. From the study, the poultry manure 5t/ha + NPK (20:10:10) 100kg/ha gave the best yield of *Amaranthus species*, followed by poultry manure 5t/ha + NPK (20:10:10) 200kg/ha which gave an increase in soil chemical properties. It is recommended that the combination of poultry manure 5t/ha + NPK (20:10:10) 100kg/ha fertilizer could be used for profitable *Amaranthus* production in the study area.

Keywords: Organic fertilizer, Inorganic fertilizer, Soil chemical properties, Yield, *Amaranthus species*

1. INTRODUCTION

Amaranthus is one of the most important annual leaf vegetables in the tropics. It has a growing period of 5 to 6 weeks, thus making it an advantage for the rural and urban farmers to keep cultivating it two or more times on the same piece of land in a year (Adewole and Igberaese, 2011). *Amaranthus* does well on soils with high organic matter; it is a nutritious vegetable and contains relatively high amounts of minerals and vitamins, which are needed for healthy body

ISSN: 2455-6939

Volume: 10, Issue: 01 "January-February 2024"

growth, sustenance and alleviation of problems of hunger and malnutrition mostly experienced amongst children in developing countries (Lucas and Ojeifo, 2000). *Amaranthus* is one of such important vegetables that could be domesticated and cultivated, but information on its fertility requirements is scanty due to resource-poor conditions encountered in most rural settings of the most African countries, especially southern Nigeria, northern Guinea and sudan savannas. *Amaranthus* cultivation has emerged as an important field not only for enhancing nutritional levels especially of Indian diets, but also as a diversified profession for higher earnings. In order to make it competitive and profitable, it is important and necessary to use critical inputs to achieve higher levels of quality and productivity. Vegetable seedlings are one of the most important and costly inputs in the modern vegetable crop production. Precision in the application of this input is vital in realizing the crop potential and returns. The exclusive use of inorganic nitrogenous fertilizer to improve crop production most of the time has a negative effect on semi-arid tropical soils as this increases soil acidity, which has been well reported by several researchers (Makinde *et. al.*, 2010: Modisane *et. al.*, 2009). There is the need therefore, to investigate alternative sources of fertilizers for *Amaranthus* production in order to increase the availability of high quality *Amaranthus* throughout the wet cropping season and at affordable price.

Although the crop responds to organic manure, studies on effect of organic wastes, crop residues and integrated application of organic and inorganic fertilizers on performance of *Amaranthus* are scarce.

The objectives of the study were to:

1. Determine the yield response of *Amaranthus* to different fertilizer sources (organic and inorganic).
2. Determine the effect of the different fertilizer sources on soil chemical properties.

MATERIALS AND METHODS

Location

The field experiment was conducted at Agbama Ibeku in Umuahia Abia State, Nigeria. The field plot lies between latitude 05^0 29. 059' N and longitude 07^0 32.197' E on an elevation of 100 meters above sea level. There had been consistent farming on the land.

Climate

Agbama area is a humid tropical climate area with marked wet and dry season. The rainy season distributions are two forms with peaks in July and September. Rainfall is heavy more in October.

ISSN: 2455-6939

Volume: 10, Issue: 01 "January-February 2024"

The temperature of the area range from about 28^{o}C during wet season to about over 35^{o}C in dry season, with a mean temperature of 12.1^{o}C and relative humidity ranging from 58-90% according to Meteorology Station of National Root Crops Research Institute Umudike Abia State (National Root Crops Research Institute Umudike, 2001).

Vegetation

The vegetation of the area is distributed with crops, grasses, shrub and other medicinal or herbaceous plants can be seen around. There are also cultivated crops in the area by farmer or individuals for personal interest Example are plantain, maize, vegetables, cassava etc for economical usage.

Collection and preparation of soil samples

Before the experiment, Soil samples were randomly collected at the depth of 0-20cm, bulked together and a composite soil sample was collected for determination of soil physical and chemical properties. At the end of the experiment, soil samples were randomly collected per plot at the same depth for determination of some chemical properties. The composite soil samples were air-dried, sieved to pass through a 2mm sieve and kept for routine laboratory analysis.

LABORATORY ANALYSIS

The particle size distribution

Mechanical analysis was determined using Bouyoucos hydrometer method (Sheldrick and Wang, 1993).

Soil pH determination

Soil pH determination was carried out using a ratio of 1:2.5 soil to water and 1N KCl, and read with a digital pH meter (Ibitoye, 2006).

Total nitrogen

Total Nitrogen was determined by the micro-kjeldahl method (Bremner, 1996).

Organic carbon determination

Organic carbon content was determined by Walkley and Black dichromate oxidation method as modified by (Nelson and Sommers, 1996).

Available phosphorus

ISSN: 2455-6939

Volume: 10, Issue: 01 "January-February 2024"

Available phosphorus was extracted using Bray 2 solution and determined using the procedure proposed by the Bray and Kurtz (1945).

Exchangeable bases

Exchangeable bases; Ca, K, Mg and Na were extracted with 1N NH_4OA_c using a soil: solution volume ratio of 1:10. The K and Na in the extract were read using flame photometer; while Ca and Mg were determined by EDTA titration method (IITA, 1989).

Exchangeable acidity

Exchangeable acidity; H^+ and Al^{3+} were determined from 1N KCl extract and titrated with 1N HCl (Hendershot and Lalande, 1993).

Land preparation

The land was cleared of its initial vegetation of grasses and beds were made at the measurement of 1x1 meter; a total of 18 beds with spacing of 1meter between each bed with each bed having 3 stands of *Amaranthus* plant and a total of 54 stands.

MATERIALS USED FOR THE STUDY

Amaranthus species

They seeds were obtained from the National Seeds Council domiciled at the National Root Crops Research Institute, Umudike, Abia State.

Poultry manure

Poultry manure was obtained from the poultry unit of the University. This was to have an increase amount in quantity and quality of poultry manure.

N.P.K Fertilizer

The fertilizer N.P.K 20:10:10 was used for this study as well

Treatment application rate

There were six (6) treatments which were:

T1-Control (no fertilizer)

T2-NPK 20:10:10 (200kg/ha), application rate 20g

ISSN: 2455-6939

Volume: 10, Issue: 01 "January-February 2024"

T3-Poultry manure (5 tons/ha)

T4-NPK 20:10:10 (100kg/ha), application rate 10g + Poultry manure (2.5 tons/ha)

T5-NPK 20:10:10 (100kg/ha), application rate 10g+ Poultry manure (5 tons/ha)

T6-NPK 20:10:10 (200kg/ha), application rate 20g+ Poultry manure (5 tons/ha)

Field experiment

The farm site was slashed, ploughed, harrowed and marked out. The experiment was laid out in a Randomized Complete Block Design (RCBD), replicating three times with 6 treatments. The S plot size was 1m x 1m. A planting distance of 20cm x 20cm intra spacing, and inter row spacing of 50cm between experimental plot was used and the distance between blocks was 1m.

RESULTS AND DISCUSSION

Physical and chemical properties of the soil for the experiment

Table 1 shows the physical and chemical properties of the soil for the experiment, the soil was loamy sand and low in pH (water) 5.1 and 4.0 in KCl. This simply indicates strong acidity (Chude *et al.*, 2004).

The total Nitrogen was low (0.10%). The organic carbon value (1.13%) was also low. These could be as a result of high rainfall which is common to the southeastern Nigeria (Enwezor *et al.*, 1990). Available phosphorus value was moderate (15.20 mg/kg), the exchangeable bases calcium, sodium, magnesium, and potassium has the following value respectively (3.80, 0.17, 1.00, and 0.21) cmol/kg, the values were low. The Ultisol of South Eastern Nigeria reportedly low in exchangeable bases (Nwite *et al.*, 2009).

The organic carbon content of the soil was also low (1.13%), the exchangeable acidity value of (1.12) cmol/kg was due to acidic nature of the soil which might be because of continuous cultivation and excessive nature of rainfall in the south east.

ISSN: 2455-6939

Volume: 10, Issue: 01 "January-February 2024"

Table 1: Physical and chemical properties of the soil for the experiment

Parameters	Values
% Sand	80.40
% Silt	8.30
% Clay	11.30
Texture	Loamy Sand
pH (H_2O)	5.10
pH (KCl)	4.00
Available Phosphorus	15.20
% Total Nitrogen	0.10
% Organic Carbon	1.13
% Organic Matter	1.94
Exchangeable Calcium (cmol/kg)	3.80
Exchangeable Magnesium (cmol/kg)	1.00
Exchangeable Potassium (cmol/kg)	0.21
Exchangeable Sodium (cmol/kg)	0.17
Exchangeable Acidity (cmol/kg)	1.12
Total Exchangeable Bases (cmol/kg)	5.18
Effective Cation Exchange Capacity(cmol/kg)	6.31
% Base Saturation	82.25

Chemical properties of the poultry manure used for the experiment

Table 2 shows the chemical properties of the poultry manure used for the experiment. The pH was close to neutral (6.80). The organic matter content, potassium, nitrogen, phosphorus and organic carbon were 0.92%, 2.61%, 2.14%, and 17.10% respectively. This indicates the high potential for the poultry manure to improve the soil chemical properties (Adeoluwa and Adeogun, 2010).

ISSN: 2455-6939

Volume: 10, Issue: 01 "January-February 2024"

Table 2: Chemical properties of poultry manure used for the experiment

Parameters	Values
pH	6.80
Nitrogen (%)	2.48
Phosphorus (%)	2.14
Potassium (%)	2.61
Calcium (%)	0.92
Organic carbon (%)	17.10
Organic matter (%)	29.48

Effect of poultry manure and npk 20:10:10 on the yield of *Amaranthus species* in the field experiment

Table 3 shows effect of poultry manure and NPK 20:10:10 on the yield of *Amaranthus species* in the field. At harvest, application of NPK (20:10:10) 100kg/ha fertilizer + poultry manure 5t/ha gave the highest plant height. Poultry manure has been reported to increase soil fertility which promotes healthy plant (Ojeniyi and Adejobi, 2002).

On the stem girth of *Amaranthus species*, application of 100kg/ha NPK (20:10:10) + 5t/ha poultry manure gave the highest value followed by 5t/ha poultry manure.

Poultry manure at the rate of 5t/ha + NPK 20:10:10 at the rate of 100kg/ha recorded the highest number of leaves which is due to the complementary effect of poultry manure and NPK 20:10:10 fertilizer (Nweke and Nsoanya, 2013).

Fresh weight of *Amaranthus species* at harvest was improved mostly by 5t/ha poultry manure + 100kg/ha NPK (20:10:10) fertilizer, followed by 5t/ha poultry, then 5t/ha poultry manure + 200kg/ha NPK (20:10:10) fertilizer. The fresh weight yield was actually in this order: 5t/ha poultry manure + 100kg/ha NPK (20:10:10) > 5t/ha poultry manure> 5t/ha poultry manure + 200kg/ha NPK (20:10:10)> 2.5t/ha poultry manure + 100kg/ha NPK (20:10:10)>200kg/ha NPK (20:10:10). The control gave the least fresh weight. This is not surprise because poultry manure is a good source of nitrogen. Combine application of organic and inorganic nutrients has also been reported to give better yield than sole application of each (Omar, 2013).

ISSN: 2455-6939

Volume: 10, Issue: 01 "January-February 2024"

Table 3: Effect of poultry manure and NPK (20:10:10) on the yield of *Amaranthus species* in the field experiment

Treatments	Plant height (cm)	No of leaves (cm)	Stem girth (cm)	Fresh weight (g)
Control	22	30	3.10	227
PM 5t/ha	65.0	101	7.22	2586
NPK 200kg/ha	28	48	4.11	334
PM 5t/ha+NPK 200kg/ha	60	82	6.99	2268
PM 5t/ha+NPK 100kg/ha	80	131	8.76	2958
PM 2.5t/ha+NPK 100kg/ha	63	91	6.78	2025
Mean	52.7	80.6	6.16	17.53
CV	12.6	11.5	13.2	9.3
SE	6.66	9.23	0.81	161.4
LSD (0.05)	19.27	42.99	2.56	2204.2

PM = Poultry manure

T/ha = Tons per hectare

Effect of different rates of poultry manure and npk (20:10:10) fertilizer on soil chemical properties after the harvest of *Amaranthus sp.*

Table 4 shows effects of different rates of poultry manure and NPK (20:10:10) fertilizer on soil chemical properties after the harvest of *Amaranthus sp.* in the field. At the rate of 5t/ha of poultry manure + 200kg/ha NPK (20:20:10) fertilizer, soil chemical properties were most improved. This treatment among others, gave the highest values for soil pH (H_2O) (6.27); and pH (KCl) (5.80). These values were significantly higher ($p<0.05$) than what was obtained from all other treatment followed by 5t/ha of poultry manure + 100kg/ha NPK (20:10:10) fertilizer which was also significantly higher than the other treatments. The control gave the least value for soil pH (H_2O) (4.54) and pH (KCl) (3.83). All other parameters also followed the same pattern, except for the soil exchangeable acidity where 5t/ha of poultry manure +100kg/ha NPK (20:10:10) fertilizer gave the least value (0.35 cmol/kg), followed by 5t/ha of poultry manure + 200kg/ha NPK (20:10:10) fertilizer. The ability of the manure to increase the soil pH can be aligned with the supply of K, Ca, Mg and Na. The increase in the pH of the soil after harvest could be due to the buffering from the carbonates and organic acids in the amendments (Sanni*et al.*, 2013).

Table 4: Effect of Different Rates of Poultry Manure and NPK (20:10:10) Fertilizer on Soil Chemical Properties after the harvest *Amaranthus sp.*

Treatment	pH($H_2$0)	pH(KCl)	Av.Pmg/kg	TN %	OC %	OM %	Ca	Mg	K	Na	EA	AL^{3+}	ECEC	BS
							←		Cmol/kg	→				
Control	4.54	3.83	13.23	0.10	0.91	1.57	2.87	0.67	0.18	0.15	1.36	0.35	5.22	73.92
PM 5t/ha	5.80	4.97	19.20	0.41	2.34	4.03	5.77	3.00	0.48	0.32	0.44	0.09	10.01	95.53
NPK 200kg/ha	5.04	4.13	19.57	0.32	1.28	2.21	4.97	2.67	0.40	0.33	0.99	0.23	9.35	89.44
PM 5t/ha+NPK 200kg/ha	6.57	5.80	28.20	0.57	2.34	4.06	10.37	5.40	0.70	0.51	0.45	0.17	17.43	97.39
PM 5t/ha+NPK 100kg/ha	6.03	5.30	23.53	0.48	2.33	4.02	8.40	4.27	0.58	0.41	0.35	0.11	14.02	97.47
PM 2.5t/ha+NPK 100kg/ha	5.50	4.63	21.27	0.38	1.76	3.02	6.73	3.20	0.53	0.40	0.49	0.15	11.34	95.70
Mean	5.58	4.78	28.83	0.37	1.83	3.15	6.52	3.20	0.48	0.35	0.68	0.18	11.23	91.58
CV	1.10	1.60	0.30	1.40	1.30	1.30	0.30	2.80	0.51	0.90	2.50	0.90	0.50	0.40
SE	0.060	0.079	0.060	0.005	0.023	0.042	0.016	0.088	0.003	0.003	0.016	0.002	0.053	0.357
LSD (0.05)	0.18	0.20	0.87	0.035	0.08	0.14	0.14	0.58	0.009	0.009	0.04	0.02	0.69	0.99

CONCLUSION

The result of the study shows that the soil of the area is acidic, which results in low organic carbon, low exchangeable bases for example calcium, magnesium, sodium, and potassium. The use of poultry manure 5t/ha + NPK (20:10:10) 100kg/ha gave the best yield result followed by poultry manure 5t/ha + NPK (20:10:10) 200kg/ha which gave an increase in soil chemical properties. It is recommended that the combination of poultry manure and NPK (20:10:10) fertilizer is better for profitable production of *Amaranthus species* in the study area.

REFERENCES

[1] Adeoluwa, O. and Adeogun, O. O. (2010) "Evaluation of feather as organic fertilizers on Amaranthus (Amaranthuscaudatus)," in Proceedings of the 1st Technical Workshop on Organic Agriculture Conference, pp. 16–19, Ladoke Akintola University of Technology, Ogbomoso, Nigeria, 2010.

[2] Adewole, M. B., Igberaese, S. O. (2011). Growth, yield of organically produced *Amaranthus*.

[3] Bray, R. H. and Kurtz, N. T. (1945). Determination of total organic and available forms of phosphorus in soil. Soil Science 59: 39-45

[4] Bremner, J.M. (1996) Nitrogen-total. In: Method soil analysis. Chemical methods, sparkers, D.L. (Ed). American society of agronomy and soil science society of America, Madison, USA., pp1085-1121.

[5] Chude V. O, Jayeoba J.O and Oyebanji O. O (2005).Soil reaction and its effect on nutrients availability. Handbook on Soil Acidity and Use of Agricultural Lime in the Crop Production.24 pages.

[6] Enwezor, W, O., Udo, E.J., Ayotade, K.A., Adeputa, J.A. and Chude, V.O. (1990).A review of soil and fertility use in Nigeria. In FPDD.Literature review on soil fertility investigation in Nigeria. (volume 5 North West 2004). Federal ministry of Agriculture and Natural Resource, Lagos Pp;241-281.

[7] Hendershot, W. H. and Lalande, H. (1993). Ion exchange and exchangeable cation. In: soil sampling and method of analysis, pp:197:206.

[8] Ibitoye, A. A. (2006). Laboratory Manual on Basic Soil Analysis. Foladave publishers Akure Nigeria. International Institute of Tropical Agriculture (1989).Automated and semi-automated methods for soil analysis. IITA, Ibadan Nigeria.

[9] Lucas, E.O., and Ojeifo, I.M. (2000).Partitioning of dry matter and nutrients in two varieties of *Amaranths*. African Journal of Agricultural Science 12(1/2):39-48.

[10] Makinde, E.A., L.S. Ayeni, S.O. Ojeniyi and J.N. Odedina. (2010). Effect of organic, organ mineral and NPK fertilizer on nutritional quality of *Amaranthus* in Lagos, Nigeria. Researcher, 2: 91-96

[11] Modisane, P.C., Beletse, Y. and Du Plooy, C.P. (2009). Yield response of *Amaranthus* and fertilizer application. Africa Crop Science Conference Proceedings, 9: 213-216

[12] National Root Crops Research Institute Umudike, Agro-climatology, (2001)

[13] Nelson, D. W. and Sommers, L. E. (1996).Total carbon, organic carbon and organic matter. In: method of soil analysis, part 3: chemical methods, American society of Agronomy/Soil science society of American, Madison, pp: 961-1010.

[14] Nweke, I. A. and Nsoanya, L. N. (2013).Effect of poultry manure and inorganic fertilizer on the performance of maize and selected physical properties of soils of Igboriam southeast, Nigeria. *International of journal of Agriculture and Rural development* 16:1348-1353

[15] Nwite, J. C., Essien J. B and Igwe, C. A. (2009). Maize yield and chemical properties in Ultisol amend with ash from different sources in Souyh Eastern Nigeria. The Nigeria journal 40, no 1 (2009), pp. 65-72.

[16] Ojeniyi.S.O. and Adejobi, K.B. (2002).Effect of manure on leaf nutrient on leaf nutrient composition, growth and yield of Amaranthus. Nigeria Agricultural Journal, 33:46-49.

[17] Omar, G. (2013). Effect of combine application of farmyard manure and inorganic fertilizer on growth and yield of maize (*Zea mays L.*) in Bauchi. Proceeding of the 37th Annual conference of the Soil Science Society of Nigeria. Pp. 62-70.

[18] Sanni, K.O., Ewulo, B.S., and Ojeniyi, S.O. (2013).Effects of Goat and Pig manures on chemical soil properties and yield of egg plant (*Solanummelongena*) in south western

ISSN: 2455-6939

Volume: 10, Issue: 01 "January-February 2024"

Nigeria. Proceedings of the 37th Annual Conference of the Soil Science Society of Nigeria. Pp. 166-171.

[19] Sheldrick and Wang, (1993).Particle – Size Distribution. In: Soil Sampling and Methods of Analysis, Carter, M.R. (Ed). Lowis Publishers Ann Arbor MI., pp495 – 511.

