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Effects of Incorporated Green Manure and Inorganic Fertilizer on Amaranth (*Amaranthus Caudatus. L*) Vegetable

Adeniji Azeez Adewale, Kumoye Deborah Etooluwa

Department of Science Laboratory Technology, Federal Polytechnic Ilaro, Ogun State, Nigeria

ABSTRACT

Four cowpea varieties (Oloyin, Drum, Zobo and White Mallam), and four levels of nitrogen fertilizer (20, 40, 60 and 80 kg N/ha) were applied at 2 weeks after planting (WAP) to the vegetable Amaranth between October 2018 to April 2019. The cowpea green manure was incorporated into soil 6 WAP and left for a week to decompose before planting the vegetable Amaranth. Growth of cowpea varieties used as green manure in 2018 showed no significant difference. However, in 2019 the canopy height and fresh weight at 3 WAP were significantly ($p<0.05$) different among cowpea varieties. The canopy height of Oloyin, Drum and White Mallam were similar but significantly ($p<0.05$) higher than that of Zobo variety. Similarly, application of 60 and 80 kg N/ha significantly produced more yield relative to 0 and 40 kg N/ha of inorganic fertilizer rates. Generally, higher significant yield ($p<0.05$) was recorded in the second cycle of planting. This study concluded that green manure from Oloyin produced yield of Amaranth us (11.0 - 47.3 t/ha) which was similar to the yield obtained from 80 kg N/ha (12.13 - 37.7t/ha).

KEYWORDS: *Cowpea varieties, Amaranth, Green manure, Biomass yield, Nitrogen fertilizer*

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INTRODUCTION

Vegetable production in Africa is as old as peasant farming though its cultivation is still at the household level with few farmers producing it on a commercial level. This could be due to the fact that crops such as cereals, roots, and tubers and body-building crops like legumes are given much attention. Cereals and tubers form the bulk of food consumed in the tropics but they are deficient in minerals and vitamins compared to the body requirement to guarantee good healthy living, and these cereals, root and tubers are however often consumed with different types of vegetables [1]. Amaranth (*Amaranthus caudatus* L.) is a leafy vegetable in the tropical region of the world. It forms a high percentage of the daily intake of leafy vegetables. *Amaranthus caudatus* growth is grown for its leaves and is among the highly prized leafy vegetables in Nigeria, due to their high nutritional benefits and commercial significance [2]. In Nigeria, Amaranth vegetable is planted throughout the year and harvested for food, it also serves as source of income for small scale farmers during the dry season [3].

There is an increase in awareness of the value of leafy vegetable in contributing to balanced diet, particularly in areas where animal protein is deficient. Leafy vegetables contribute significantly to the amount of carotene, vitamin C, protein, and minerals particularly calcium. The production of Amaranth requires high nitrogen and this is usually sourced from chemical fertilizers which are scarce with several negative residual effects and the use of green manure could be an alternative source of required nitrogen. In other to grow Amaranth, it is necessary to know the effect of nitrogen sources on its yield as nitrogen has been found to be the major primary limiting factors of amaranths production [4].

However, most Nigerian soils have low nitrogen and the low nitrogen status is usually supplemented with nitrogen fertilizer. The sources of this nitrogen have increased over the years. The problem with the usage of chemical fertilizer is that while it can lead to high crop yield at the same time resulted into pollution of ground water after crop harvesting [5]. Another major limitation to the usage of chemical fertilizers is the adverse effects they have sometimes on plant quality and disease susceptibility. A continual dependence on chemical fertilizers may be accompanied by a fall in organic matter content, increased soil acidity, degradation of soil physical properties and increased rate of erosion due to instability of soil aggregates [6].

One of the ways to maintain or improve the soil fertility is by maintaining its organic matter. This is possible through the use of organic sources of fertilizer. The improved performance, yield and quality of amaranth as a result of application of organic fertilizers and organic manure to soils had been reported in previous research [7]. The use of inorganic fertilizer in improving soil fertility had been discussed to have direct and fast effects as nutrients in fertilizers are soluble and immediately available to plants

and only relatively small amounts would be required for the crop growth since they are quite high in nutrient content [8].

Organic fertilizer on the other hand, had more balanced nutrient supply, create better soil structure thereby enhancing root growth while the slow release of the nutrients would contribute to the residual pool of organic nitrogen and phosphorus in the soil. Although, organic fertilizer being low in nutrient contents would make larger quantity to be needed to provide enough nutrients for crop growth. Green manure has been reported to have increased the yield and economic returns of other crops like maize grain yield [9]. The previous research on comparative study of inorganic and organic manure effects on soils properties and production of Amaranth had mostly been the use of NPK, organo-mineral, compost, poultry manure, goat manure, or farmyard manure alone [10]. To grow Amaranth, it is necessary to know the effect of sources of nitrogen fertilizer on its yield because nitrogen was found to be the primary limiting factors of Amaranths production. [4], [11]. This present study focuses to investigate green manure and Nitrogen fertilizer on the productivity of Amaranth vegetable, as well as to evaluate the potential of green manure on four local cowpea varieties.

MATERIALS AND METHODS

Description of the experiment site

The experiment was conducted at the Teaching and Research Farm of Federal University of Agriculture Abeokuta, Ogun State, Nigeria. Situated in the tropical rainforest zone of southern Nigeria on Latitude 7°21'N, Longitude 3°23'E and on elevation 76 m above sea level. The location is in Forest Savannah Transition Agro-ecological zones of Southwest Nigeria. The area has humid climate. Long term rainfall average for this location is above 1300 mm and bimodally distributed. It is also characterized by distinct wet and dry seasons.

Soil sample collections

Prior to the commencement of the study soil samples were collected randomly from 0 to 15 cm depth in the site using soil auger, thoroughly mixed and the bulk sample was taken to the laboratory, air dried and sieved to pass through a 2 mm sieve for soil physico-chemical test.

Experimental treatments description and cultural practices

The experiment comprised of nine treatments arranged in Randomized Completely Block Design (RCBD) and replicated three times. The land was cleared and beds were made manually using cutlass and hoe. Each bed measured as 2 m by 2 m (4 m^2) and the total plots size was 11 by 27 m with 1 m pathway.

The Amaranthus seed and four cowpea varieties were obtained from International Institute of Tropical Agriculture, (IITA), Ibadan. The cowpea varieties were planted on 5th of October 2018, (late season) and 5th of April, 2019 (early season) at 3 seeds per hole and later thinned to two plants per stand at one week after planting. The cowpea used as green manure was planted using 25 by 50 cm and maintained on the plots and incorporated in-situ at 6 weeks after planting and allowed to decompose for two weeks before the planting of the Amaranth vegetable in October 2018 and November 2019 respectively.

Amaranthus seed were planted two weeks after the cowpea was incorporated. While Amaranth was planted once on the 5th of December, 2018 and two cycles of Amaranthus were again planted on 5th of June 2019, early season trial using 2 x 2 m plant spacing. The land was as much as possible kept weed free, two weeks interval during the conduct of the experiment.

Plant height, canopy height, fresh weight, biomass weight and dry weight were recorded every two weeks till the end of the experiment. The leaf was determined based on length-width method as described by [13].

Data analysis

Data collected were subjected to analysis of variance (ANOVA) and significant means were separated using Duncan multiple range test (DMRT) and Least significant difference (LSD) at 5% level of probability. The statistical package used was GenStat (v11).

RESULTS AND DISCUSSION

Agronomics growth table as shown in Table 1 below reveals that the textural class of the soil in late and early season trial was sandy and loamy. The soil pH in both trials was slightly acidic with organic carbon content of 0.44 and 1.52 % in the late and early trial, respectively. The nitrogen level at both late and early season (0.04 and 0.17 %) was very low and medium in content. The average P (1.49 mg/kg) at late and early season, Exchangeable K and Ca were low with values of (0.35 and 2.00) cmol/kg and (1.49, 0.27 and 0.29) cmol/kg, respectively while the Mg contents of the soil was at medium level 0.62cmol/kg for both season trial.

Table 1: Analysis of pre-planting physico-chemical properties of the soil used for the studies (0-15 cm depth)

Parameter	Sand	Silt	Clay	Textural Class	pH	Na	K	Ca	Mg	CEC	Av. P	N	OC
Soil	%					(c mol/ kg)					(mg/kg)	%	
Early Season	88	4	8	Sandy soil	5.5	0.39	0.37	2.0	0.62	3.41	1.49	0.04	0.44
Late Season	78	15	7	Sandy soil	5.3	0.39	0.27	0.29	0.62	3.41	1.49	0.17	1.52

The climatic data during the experiment were obtained from the Metrological department of Federal University of Agriculture, Abeokuta. Highest rainfall was recorded in July (202.6 mm) for early season and the lowest in November (1.65 mm) for late season. Figure 1, It was observed that as the rainfall increased, humidity also increases, while there was reduction in sunshine hours and evaporation rate in late and early season trials. The mean soil temperatures recorded were shown in Figure 2 with highest temperature recorded 50 cm and lowest at 10 cm. The Agro-meteorological weather report during the trial showed that the highest rainfall was recorded in July (202.6 mm) for early season and the lowest in November (1.65 mm) for late season Furthermore, it was observed that as the rainfall increased, humidity also increases, while there was reduction in sunshine hours and evaporation rate in late and early season trials.

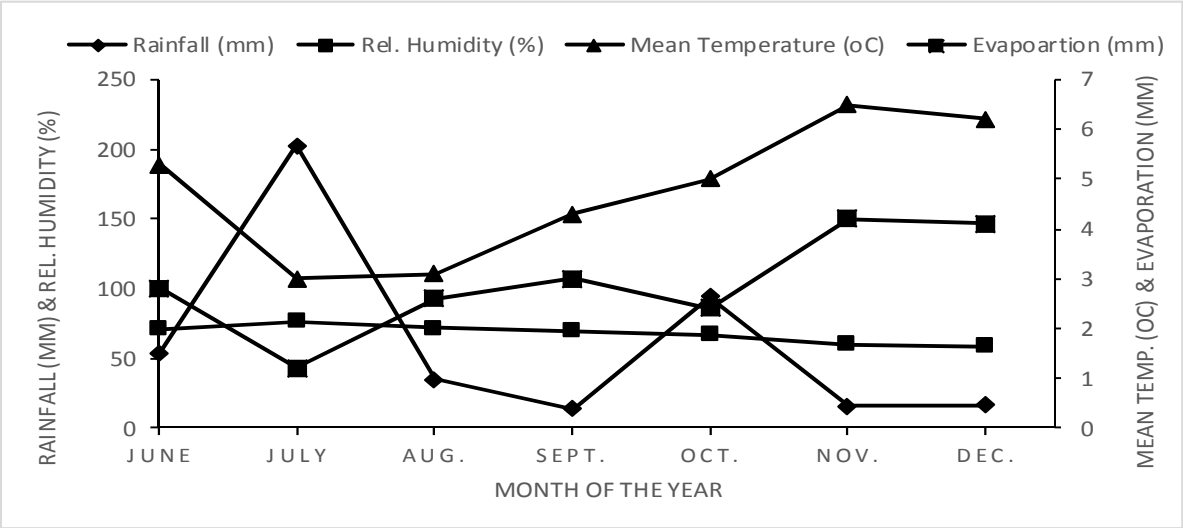

Figure 1: Mean climatic variables during the crop growing season

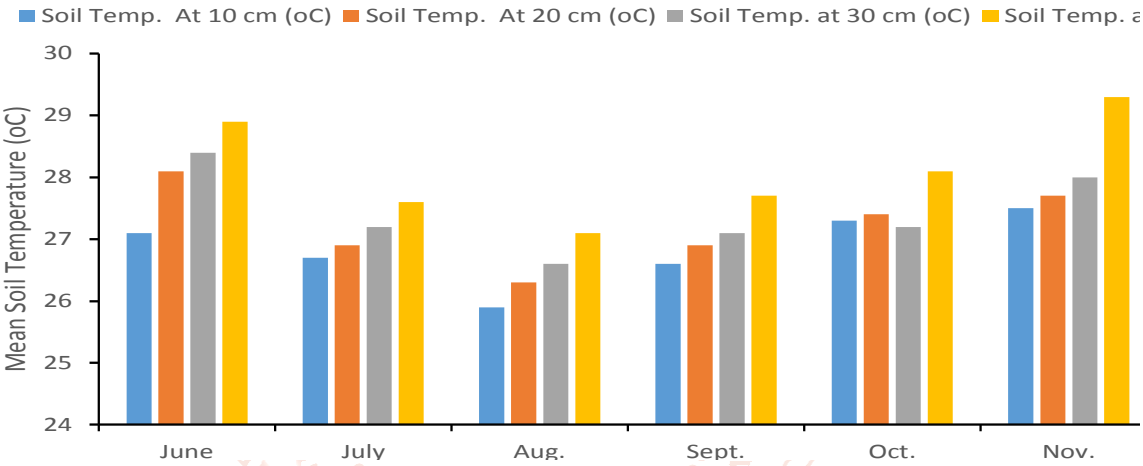

Figure 2: Mean soil temperature during the crop growing season

Table 2, presented cowpea variety of Oloyin produce significantly higher (P<0.05) canopy height among the cowpea incorporated varieties as green manure at 3 WAP. However, there was no significant difference among the varieties of cowpea green manure on canopy width at 3 and 6 WAP.

Table 2: Varietal differences of cowpea manure materials as shown in canopy height and canopy width in 2018

Sources of Green manure (Cowpea varieties)	Canopy height (cm)		Canopy width (cm)	
	3WAP	6WAP	3WAP	6WAP
Oloyin	23.70	24.80	14.90	32.50
Drum	19.90	23.30	17.80	28.40
Mallam	22.87	25.70	19.00	31.60
Zobo	14.93	21.53	12.10	27.40
LSD (p<0.05)	6.32*	NS	NS	NS

NS – Not significant. LSD –Least significant different at 5% level of probability WAP – Week after planting

Table 3 shows the effect of varietal difference on fresh weight of Oloyin and Mallam which were similar (p<0.05) but significantly higher than that of drum and Zobo which were equally similar. The fresh weight at 6 WAP, dry weight and total biomass were not significantly different.

Table 3: Varietal differences of cowpea manure materials as shown in fresh and dry weight in 2018

Sources of green manures (Cowpea varieties)	Fresh weight (g/plant)	Dry weight (g/plant)	Total Biomass (t/ha)
	6WAP		
Oloyin	34.2	2.28	21.1
Drum	22.2	2,58	19.5
Mallam	18.0	2.11	18.6
Zobo	17.6	1.63	14.7
LSD (P<0.05)	NS	NS	NS

NS – Not significant. LSD – Least significant different at 50% level of probability

Table 4 showed that fresh weight of Amaranthus grown on Oloyin green manure plot was significantly higher than those of Mallam and Zobo and those of 0 to 60 kgN/ha inorganic fertilizer rates at 2 WAP. Oloyin variety of green manure significantly ($p<0.05$) enhance the fresh weight of Amaranthus compared with control (0 Kg/ha). Nonetheless there was no significant difference among the treatments on dry weight and total yield of amaranth at 2 and 4 WAP.

Table 4: Varietal differences of cowpea manure materials as shown in canopy height and canopy width in 2019

Sources of green manures (Cowpea varieties)	Canopy height (cm)		Canopy width (cm)	
	3WAP	6WAP	3WAP	6WAP
Oloyin	23.70	24.80	14.90	32.50
Drum	19.90	23.30	17.80	28.40
Mallam	22.87	25.70	19.00	31.60
Zobo	14.93	21.53	12.10	27.40
LSD ($p<0.05$)	6.32*	NS	NS	NS

NS – Not significant. LSD – Least significant difference at 50% level of probability.WAP – Weeks after planting

However, incorporation of Oloyin and inorganic fertilizer rate at 80 kgN/ha produced higher values of vegetable amaranth in terms of total biomass at 4 WAP. Table 5, showed the chlorophyll content of vegetable amaranth showed significant difference only at 2 WAP of the first cycle, where all fertilizer and manure treatments where significantly higher than the control.

Table 5: Varietal differences of cowpea manure materials as shown in fresh weight, dry weight and total biomass in 2019

Sources of green manures (Cowpea varieties)	Fresh weight (g/plant)		Dry weight (g/plant)		Total biomass (t/ha)
	3WAP	6WAP	3WAP	6WAP	6WAP
Oloyin	23.87	66.30	1.21	7.10	30.00
Drum	14.01	69.30	1.53	8.00	25.00
Mallam	24.82	53.70	1.04	6.30	29.30
Zobo	14.01	38.70	0.92	3.90	23.70
LSD ($p<0.05$)	5.139**	18.98	0.43	2.81	9.22

LSD-Least significant difference at 1% level of probability. WAP- Weeks after planting

Table 6, showed that fresh weight of amaranthus grown on oloyin green manure plot was significantly higher than those of mallam and zobo and those of 0 to 60 kg N/ha inorganic fertilizer rates at 2 WAP. Oloyin variety of green manure significantly ($p<0.05$) enhance the fresh weight of Amaranthus compared with control (0 Kg/ha). Nonetheless, there was no significant difference among the treatments on dry weight and total yield of amaranth at 2 and 4 WAP. However, incorporation of oloyin and inorganic fertilizer rate at 80 kg N/ha produced higher values of vegetable amaranth in terms of total biomass at 4 WAP.

Table 6: Effect of green manure incorporated and inorganic Nitrogen fertilizer rates on yield of vegetable amaranth in 2019

Treatments	Fresh weight	(g/plant)	Dry weight (g/plant)		Total biomass (t/ha)
	2WAP	4WAP	2WAP	4WAP	4WAP
Oloyin	3.47a	54.4a	0.77a	3.28a	11.0a
Drum	2.79ab	53.8a	0.76a	2.56a	9.50a
Malam	2.03b	49.8a	0.73a	2.67a	8.67a
Zobo	1.58b	37.1a	0.59a	2.72a	8.50a
0 kg/ha	1.57b	23.9a	0.52a	1.90a	3.83a
20 kgN/ha	1.76b	29.4a	0.66a	2.39a	4.17a
40 kgN/ha	1.75b	31.4a	0.40a	3.60a	5.00a
60 kgN/ha	1.95b	31.2a	0.72a	2.20a	6.17a
80 kgN/ha	2.44ab	50.7a	0.70a	2.69a	12.1a
SE (±)	0.57*	NS	NS	NS	NS

Means that have the same alphabet along a column are not significant. WAP- weeks after planting. NS- Not significant. SE- Standard error

From the result of this study, cowpea varieties Oloyin, drum and Mallam in 2018 and 2019 were more consistent in the production of herbage used for green manure. This could be due to their genetic make-up. This is in agreement with [9], who tested the different varieties of cowpea on economic yield of maize production where cowpea varieties Oloyin and drum were used with Oloyin showing greater potential for use as green manure.

The result of 2019 also indicates that cowpea varieties Oloyin and Mallam had higher canopy height, canopy width, fresh weight, dry weight and total biomass relative to drum and Zobo variety. The effect of different cowpea varieties used as green manure and control (native fertility) on growth of amaranth showed no positive response to the incorporation of green manure, however the control (no fertilizer application) plot performed poorest compared to the other treatments.

The productivity level of green manure and control in 2018, also showed no significant response though the varieties was superior to each other where Oloyin variety produced the

highest yield compared to different rates of inorganic fertilizer applied in 2018. Application of 80 kg N/ha produces higher canopy width, fresh weight and dry weight is relative to the yield observed in response to the incorporation of cowpea green manure. The largest biomass of vegetable amaranth produced from cowpea Oloyin and drums over N-fertilizer rates of 80 kg N/ha throughout the growing period in 2019, could be attributed to the gradual release of nutrients from the former over the latter. Oloyin cowpea green manure produced a positive response of vegetable amaranth when compared with application of 80 kg N/ha in the second cycle of planting.

However, the response of inorganic Nitrogen fertilizer indicates that all rates applied were found to increase the plant height of vegetable amaranth and significantly different from the control plot of Amaranth. This could be due to fast release of nutrient into the soil at the second cycle of production. Thus, there was consistent trend on the growth and yield of Amaranth.

Effect of incorporated green manure on the yield of Amaranthus in 2019, can be attributed to the fact that Oloyin cowpea produce significantly higher dry weight per plant at 4 WAP. Although, total biomass was not significant between the treatments produced from Oloyin compared with other cowpea varieties of Drum and Mallam. Also, vegetable Amaranthus yield from 60 and 80 kg N/ha was similar and higher than other fertilizer rates at the second cycle of production in 2019. This result is in agreement with N-recommendation made by [14]; [15], who observed an increase in growth and yield of Amaranthus up to N-fertilization of 90 kg N/ha. They also reported that optimum levels of Nitrogen needed to maximize yield in leafy amaranth was in the range of 50-200 kg N/ha. Generally, the result of the incorporated green manure and inorganic fertilizer application of 2018 and 2019 indicates that Oloyin green manure produces better yield in the residual effect due to their slow release of nutrients to the soil than application of chemical fertilizer rate of 80 kg N/ha in the second cycle of planting of vegetable amaranth.

The profitability result indicates that vegetable production under green manure of Oloyin green manure of Oloyin and drum had the highest net profit and benefit cost ratio in 2012, while the application of 80kg N/ha of inorganic fertilizer also had the highest net profit and benefit cost ratio throughout the growing period in 2018, the increase could be attributed to the gradual release of nutrients from the former over the latter (IITA 2009).

Research has shown almost universal beneficial effects on green manuring on rice yields and green manure is reported to be able to substitute for up to 60-100kg N/ha [16].

CONCLUSION

Green manure from Oloyin cowpea produced an average yield of Amaranthus (11,000 - 47,700 kg/ha) which was similar to the yield obtained from 80 kg N/ha (12,130 - 37,700 kg /ha) during the period of the study. Amaranthus yield was enhanced significantly with Oloyin green manure. This had a positive effect on the profitability of the succeeding crops which was estimated at 400% yield in amaranth production and 300% increase in drum green manure. This was comparable to the yield obtained by application of 80 kg N/ha inorganic fertilizer in-terms of the economic return on investment (ROI) in the production of the vegetable Amaranthus.

COMPETING INTEREST

Authors have declared that no competing interests exist.

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