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Effects of Fertilizer Sources on the performance of some Vegetable *Amaranths* in Mubi, Adamawa State, Nigeria

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Abstract

Field experiment were conducted during 2015 and 2016 cropping seasons to study the effect of fertilizer sources on the performance of some Amaranthus spp in Mubi at Dairy Research Farm, Adamawa State University Mubi, Nigeria. The treatments consisted of factorial combinations of 4 levels of fertilizers and three amaranth accessions. The fertilizer levels were F_1 (0 t/ha = control), F_2 (10 t/ha of cow dung), F_3 (10 t/ha of poultry manure) and F_4 (67.5 kg/ha of urea). The three accessions were Amaranthus 12, Amaranthus doodo and Amaranthus cruentus. Data were collected on agronomic parameters: plant height, number of leaves/plant, number of branches/plant, leaf length, leaf area and non- edible shoot weight. For yield parameters; dry shoot weight, fresh leaf weight and fresh shoot yield t/ha. Soil analysis data collected before planting were: available phosphorus, nitrogen, potassium, organic carbon, soil P^H, particle size analysis and water holding capacity. For both agronomic and yield parameter studied, plants grown on 10 t/ha poultry manure performed better than other fertilizer sources and significant interaction effect recorded between the fertilizer sources and the amaranthus varieties revealed that poultry manure in combination with Amaranthus 12 produced the tallest plants, highest number of leaves and branches/plant and highest fresh herbage yield. In conclusion, for amaranths production the study revealed the superiority of poultry manure over cow dung and urea fertilizers.

Keywords: Poultry manure, Cow dung, Urea, Treatment combination and *Amaranthus*.

Introduction

Amaranthus belongs to the family *Amaranthaceae*, collectively known as amaranth, is a cosmopolitan genus of herbs. People around the world value amaranths as leaf vegetables, cereals and ornamentals. *Amaranthus hypochondriacus* and *A. cruentus* are commonly grown for grain and *A. tricolor* is grown for the leaves, *A. caudatus* is a third type of grain species, although it is often grown more as an ornamental. *Amaranthus* is one of the most important annual vegetables in the tropic, which has a short growing period of four to six weeks (Makinde *et al.,* 2010) and it thrives well on the soil with high organic matter. In Africa *Amaranthus cruentus* features predominantly in the vegetable farming system of Nigeria, Republic of Benin, Cote d'voire, Tanzania and Zimbabwe, where it is usually grown in family gardens or in small commercial holdings, around the major urban areas (Jain and Satarno, 1996). In Nigeria the economic value of *Amaranthus* as market vegetable rank high from market survey. The crop appears as one of the main African leafy vegetable, with no statistical data available, since in most cases all leafy vegetables are recorded as one single group (PROTA, 2004). *Amaranthus cruentus* as a leafy vegetable is cultivated for its therapy in people with hypertension and cardiovascular disease (Martirosyan and Miroshnichenko, 2007). Vegetable amaranths are recommended as a good food with medicinal properties for young children, lactating mothers and for patients with constipation, haemorrhage, fever, anaemia and kidney complaints (PROTA, 2004; Costea *et al.,* 2001). There is no clear dividing line between the grain-type and the vegetable-type of *amaranthus.* The grain *amaranthus* can be serve as food source; while the leaves are consumed as vegetable when plant are young (Olaniyi *et al.,* 2008). The seed of grain amaranths like *Amaranthus caudatus*, *Amaranthus cruentus* and *Amaranthus hypochondriacus* can be used to prepare breakfast and confectionary ingredients (National Academy Press, 1983). *Amaranthus* is use as diuretic in Senegal. The roots are also boiled with honey as a laxative for infant (Burkill, 1985). In Ghana, the water of macerated plants is used to treat pain in limbs (Grubben and Solten, 1981) and in Ethiopia, *Amaranthus cruentus* is used as a tape worm expellant, while in Sudan the ash from the stem is used as a wound dressing (Holland *et al.,* 1991).

Optimum nutrients requirement reported for maximum amaranth growth by different researchers are substantially different. According to Akanbi and Togun (2002), the use of inorganic manure is very essential in promoting *amaranthus* growth. Vegetable yield can be increased with proper fertilization with nitrogen and other mineral nutrients (Turan and Sevimli, 2005) and hence increase leaf protein content (Suresh *et al.,* 1996, PROTA, 2004). In addition nitrogen fertilisation increases the beta carotene content of vegetables (Flores *et al.,* 2004 and Mozafar, 1993).

The demand of *amaranthus* as vegetable has increased especially in urban centres where people are not involved in primary production (Schippers, 2000), making the crop to become an important commodity in the market and its production very important economic activity for rural people. However, yield per hectare of this crop in Nigeria is low (7.6t/ha), when compared of that of United

State of America (77.27 t/ha) and world average (12.27 t/ha) (FOA, 2007). This may be attributed to declining soil fertility and nutrient losses through run-off and leaching. These considerations prompted this investigation, with an aim to study the effects of fertilizer sources on the performance of some *amaranths* accessions. The objectives of this study are to:

i. Determine the performance of vegetable Amaranths under different sources of fertilizer.
ii. Determine the best variety that gives a maximum vegetable yield under different sources of fertilizer.

Materials and Methods

The study was conducted during 2015 and 2016 cropping seasons at the Dairy Research Farm of Adamawa State University, Mubi, Nigeria. Mubi is located in the Sudan Savannah of Nigeria which lies between latitude 10^0 10' N and 10^0 30' N of the equator and between longitude 13^0 10' E and $13^0$30' E of the Greenwich meridian and on altitude of 696m above sea level. The mean annual rainfall of Mubi ranges from 700mm to 1,050mm and a mean temperature of 18^0C during hamattan period and 40^0C in April (Adebayo, 2004).

Before planting, soil sample were collected from an uncultivated land of the experimental site at 0-15cm depth using soil auger. The soil samples collected was analysed for pH, organic carbon, available nitrogen, phosphorus, calcium, sodium, potassium, particle size and water holding capacity.

The soils sample was air-dried, crushed using a mortar and pestle and then sieved using a 2mm mesh. From the sieved soil, the following physio-chemical properties were carried out before the experiment was conducted:

1. Particle size analysis was determined by using Bouyocous hydrometer method (Trout, *et al.*, 1987).
2. Soil reaction (pH) was determined by using the pH meter method (soil/water ratio of 1:2:5 (Page *et al.*, 1982).
3. Organic carbon was determined by dichromate digestion (Walkey and Black, 1934). From where organic matter was calculated.
4. Available P was extracted (Bray and Kurtz, 1945).
5. Available K was determined by Flame photometer using routine analytical method (IITA, 1979).
6. The total N was determined by macro-kjeldahl procedure as described by Jackson (1958).
7. Water holding capacity (WHC) was determined by

gravimetric method Trout *et al.*, (1987).

8. Available Ca was determined by extraction with 1m ammonium acetate at pH 7.0 Using a corning flame photometer with appropriate filter (IITA, 1979).

During 2015 and 2016 wet seasons, the experimental site were cleared with cutlass, ploughed and harrowed using a tractor. The field was properly level using a hand hoe in order to obtain a fine soil tilth for easy emergence of amaranths seeds planted. The research field was demarcated into plots using ropes, pegs and tape. Total land area for the experiment measured 17.5m x 8m ($140m^2$) and raised beds (i.e.12 plots per replicate) were constructed (1m x 2m) and used in the field giving a total of 36 plots and each was separated by a pathway of 50cm between each plot and 1m apart between each replicate for easy movement during cultural practices operation. The cow dung and poultry manure each at 10 t/ha was applied at 2 weeks before planting. On the control plots no fertilizer was applied, while at 2 weeks after planting urea fertilizers was applied on the appropriate plots. 10 g each of the three accessions of *amaranthus* were sown by broadcasting on the raised beds. The growth duration of the *amaranthus* was six weeks for each cropping season (5^{th} July to 15^{th} August, 2015 and 5^{th} July to 15^{th} August, 2016). Hand weeding was carried out to control weed competition with the crop for nutrients.

The treatments consisted of factorial combinations of 4 levels of fertilizers and three accessions (Table 1). The fertilizer levels were F_1 (0 t/ha = control), F_2 (10 t/ha of cow dung), F_3 (10 t/ha of poultry manure) and F_4 (67.5 kg/ha of urea). The three accessions were *Amaranthus* 12 (V_1) was obtained from Tanzania collection, *Amaranthus* doodo (V_2) from Garkida and *Amaranthus cruentus* (V_3) from Uba; both were obtained from Adamawa State. The treatments were laid out in a Randomized Complete Block Design replicated three times. From the net plot, five sampled plants were used to collect the following parameters: Plant height, number of leaves/plant, number of branches/plant, leaf length, leaf area, non-edible shoot weight, dry shoot weight, fresh leaf weight and fresh shoot yield. Data collected were analyzed using Statistical Application for Sciences (SAS 1998) and mean were separated using Duncan's Multiple Range Test at 5% level of probability.

Results

Soil chemical composition

The soil of the experimental site was a clay loam texture (Table 2) with a pH of 5.5 and 5.6 for 2015 and 2016 cropping seasons respectively. This revealed that the soil was acidic in reaction. The organic carbon was 0.63 % in 2015 and 0.85 % in 2016 cropping season; total nitrogen was low in the two years of trial with 0.20 % and 0.13 % for 2015 and 2016 respectively. The available phosphorus values were also low for the two years (0.43 and 0.61).

Table 1: Treatment combinations between 4 fertilizer levels and 3 accessions of amaranthus.

Accession	Fertilizer sources F_1	F_2	F_3	F_4
V_1	V_1F_1	V_1F_2	V_1F_3	V_1F_4
V_2	V_2F_1	V_2F_2	V_2F_3	V_2F_4
V_3	V_3F_1	V_3F_2	V_3F_3	V_3F_4

Treatment combinations

Key**:** Treatment Combinations between Fertilizer (F) and Accession (V)

V_1 + 0 t/ha (Control) = V_1F_1	V_2 + 0 t/ha (Control) = V_2F_1	V_3 + 0 t/ha (Control) = V_3F_1
V_1 + 10 t/ha (Cowdung) = V_1F_2	V_2 + 10 t/ha of Cow dung = V_2F_2	V_3 + 10 t/ha of Cow dung = V_3F_2
V_1 + 10 t/ha of PM = V_1F_3	V_2 + 10 t/ha of PM = V_2F_3	V_3 + 10 t/ha of PM = V_3F_3
V_1 + 67.5kg/ha of Urea = V_1F_3	V_2 + 67.5kg/ha of Urea = V_2F_4	V_3 + 67.5kg/ha = V_3F_4

Table 2: Some chemical and physical properties of the soil within the depth of 0-15 cm used for the study

Chemical composition	2015	2016
pH in water	5.5	5.6
Organic carbon (%)	0.63	0.85
Available Phosphorus (ppm)	0.43	0.61
Available calcium (c mol/kg)	4.36	4.02
Total nitrogen (%)	0.20	0.13
Available potassium (c mol/kg)	2.03	2.20
Physical composition		
Clay (%)	25.83	23.8
Sand (%)	45.50	47.95
Silt (%)	28.67	28.27
Soil texture	Clay loam	Clay loam
Maximum water holding capacity (%)	60.63	68.89

Effect of varieties and fertilizer sources on agronomic parameters

Table 3 shows the effect of varieties and fertilizers on growth parameters of amaranths during 2015 and 2016 seasons. The plots treated with 10 t/ha of poultry manure produced the tallest plants having 50.43 cm and 53.58 cm for 2015 and 2016 respectively and the highest number of leaves per plant (22) and branches per plant (5) in each season. Poultry manure treated plot recorded the longest leaf length (15.92 cm) in 2015 and 14.96 cm in 2016 cropping seasons. Amaranths on 10 t/ha poultry manure also recorded average leaf area of 1502.62 cm^2 and 1707.73 cm^2 for 2015 and 2016 seasons respectively. This was followed by plants treated with 10 t/ha of cow dung and the lowest plant height, leaves and branches per plant and other agronomic parameters was recorded by plants on the control plots. Amaranthus 12 (V_1) gave the highest plant height (38.84 cm) in 2015 and 37.20 cm in 2016, number of leaves per plant (20) in 2015 and 18 leaves per plant in 2016 wet season. Similarly, Amaranthus 12 recorded highest leaf length, leaf area and non- edible shoot weight in 2015 and 2016 cropping seasons. This was followed by *Amaranthus cruentus* (V_3), which recorded 15 and 17 leaves per plant in 2015 and 2016 respectively; with 5 branches per plant in both seasons. Although, there was no significant difference between accession 3 and accession 2 statistically for most of this parameters except for branches per plant. Furthermore, the interaction effects of varieties and fertilizer sources were highly significant for plant height, number of leaves and branches per plant in 2015 and 2016 seasons.

Effect of varieties and fertilizer sources on amaranths yield parameters

The influence of leaf yield and its components due to varietal and fertilizer sources is shown in Table 4. Similarly as revealed in the growth parameters, the 10 t/ha of poultry manure plots recorded the highest dry shoot weight (31.45 g and32.63 g), highest fresh leaf weight (8.23 g and 8.20 g) and fresh shoot yield (45.42 t/ha and 49.48 t/ha) in 2015 and 2016 planting seasons respectively. This was followed by plants with 10 t/ha cow dung treatment and the least dry shoot weight, fresh leaf weight and fresh shoot yield was obtained on the control plots. *Amaranthus* 12 (V_1) outperformed *Amaranthus* dodo (V_2) and *Amaranthus cruentus* (V_3), with respect to the yield parameters studied. The interaction effect was only significant ($P<0.05$) for fresh shoot yield during 2016 cropping season.

Table 3: Effect of varieties and fertilizer sources on growth parameters of amaranths during 2015 and 2016 seasons

Treatments	Plant height (cm) 2015	2016	Combined	No. of leaves /plant 2015	2016	Combined	No. of branches /plant 2015	2016	Combined	Leaf length (cm) 2015	2016	Combined	Leaf Area (cm^2) 2015	2016	Combined	Non-edible shoot weight (g) 2015	2016	Combined
Fertilizer source (F)																		
0kg/ha (control)	16.21^{d}	16.66^{d}	16.44^{d}	11.04^{d}	12.61^{d}	11.83^{c}	3.20^{c}	3.38^{d}	3.29^{d}	6.52^{c}	7.57^{d}	7.05^{d}	248.03^{d}	250.83^{d}	249.43^{d}	10.04^{d}	8.72^{d}	9.38^{d}
10t/ha cow dung	40.30^{b}	38.53^{b}	39.42^{b}	17.24^{b}	18.24^{b}	17.74^{b}	4.52^{a}	4.56^{b}	4.54^{b}	9.73^{b}	11.74^{b}	10.74^{b}	890.61^{b}	977.30^{b}	933.96^{b}	33.24^{b}	35.22^{b}	34.23^{b}
10t/ha P M	50.43^{a}	53.58^{a}	52.01^{a}	22.01^{a}	21.73^{a}	21.87^{d}	4.60^{a}	4.91^{a}	4.76^{a}	15.92^{a}	14.96^{a}	15.44^{a}	1502.62^{a}	1707.73^{a}	1605.18^{a}	42.05^{a}	46.46^{a}	44.26^{a}
67.5kg/N (Urea)	23.10^{c}	24.08^{c}	23.59^{c}	14.02^{c}	14.53^{c}	14.29^{d}	3.40^{b}	3.71^{c}	3.56^{c}	9.64^{b}	8.50^{c}	9.05^{c}	425.40^{c}	437.44^{c}	431.14^{c}	15.82^{c}	18.79^{c}	17.30^{c}
SE±	0.70	0.93	80.17	0.45	0.53	0.43	0.10	0.09	0.16	0.24	0.30	0.27	32.19	41.89	36.95	2.14	1.15	1.65
Variety (V)																		
V1	38.84^{a}	37.20^{a}	38.02^{a}	19.56^{a}	17.70^{a}	18.63^{a}	3.62^{b}	3.77^{b}	3.70^{a}	10.71^{a}	11.83^{a}	11.27^{a}	962.52^{a}	978.66^{a}	970.59^{a}	40.17^{a}	31.52^{a}	35.85^{a}
V2	31.29^{b}	31.39^{b}	31.34^{b}	15.30^{b}	15.71^{b}	15.51^{b}	3.50^{b}	3.65^{b}	3.58^{b}	10.51^{b}	10.48^{b}	10.50^{b}	763.71^{b}	794.78^{b}	779.25^{b}	24.32^{b}	25.53^{b}	24.92^{b}
V3	30.30^{b}	30.92^{b}	30.61^{b}	15.38^{b}	16.93^{ab}	16.16^{b}	4.56^{a}	5.00^{a}	4.78^{a}	10.41^{b}	9.77^{b}	10.09^{b}	753.21^{b}	756.53^{b}	754.87^{b}	24.59^{b}	24.83^{b}	24.71^{b}
SE±	0.68	0.80	0.71	0.57	0.46	0.32	0.12	0.07	0.10	0.21	0.26	0.20	26.4	36.28	31.34	0.07	0.10	0.07
Interaction																		
F x V	**	**	**	**	**	**	**	**	**	NS	NS	NS	NS	NS	NS	NS	NS	NS

Mean followed by the same letter(s) within a treatment group are not significantly different at $P < 0.05$ using DMRT,** = Highly significant at $P < 0.01$ probability level, NS = Not significant.

Discussion

The soils of the experimental site were moderately acidic and low in organic carbon, nitrogen and available phosphorus. Therefore, the soil was generally poor in major essential nutrients required for plant growth. For Mubi soils, Tekwa *et al.* (2011) earlier reported low organic matter and nitrogen content between the range of 0.21 to 1.90% and 0.11 to 0.24 respectively. A good soil has an organic matter value above 3% (Alam *et al.*, 2007). This implies that the variable response of amaranthus accessions to applied fertilizers observed in the study was expected and the application of fertilizer sources to increase soil fertility for amaranths production was justified. Law–Omogbomo *et al.* (2009) reported that application of organic fertilizers among other cultural practices increase vegetable yield in poor tropical soils.

Effect of varieties and fertilizer sources on agronomic parameters

The taller plants with higher number of leaves and branches in plots with poultry manure could be as a result of the improvement of soil fertility which in turn increased the plant height, number of leaves and branches per plant of amaranths. In this study, *amaranthus* accessions exhibited better response to poultry manure than to cow dung and the inorganic fertilizer. This implies that mineralization of poultry manure also has higher N content than that found in cow dung. It has organic matter which also gives it advantage over inorganic fertilizer. The increase in plant height and number of leaves per plant was earlier reported by Vincent *et al.* (2005); Yadav *et al.* (2006); Premesekhar and Rajashree (2009) in okra and Saidu *et al.*, (2011) in tomato. Consequently, poultry manure releases more plant nutrient which increases *amaranthus* growth and herbage yield (Akande *et al.,* 2003). The *amaranthus* accessions also exhibited significant difference for other growth parameters such as leaf length, leaf area and non-edible shoot weight during the trial. Makinde (2013) further reported that the addition of fertilizer to soils increases plant height, leaf number, fresh and dry shoot weight of *amaranths*. Also, Abidin and Yasdar (1986) earlier reported that application of fertilizers encourages plants vegetative growth, net assimilation rate and leaf area index. The poultry manure treated plot had the longest leaf length, largest leaf area and greater quantity of non-edible shoot weight, with *Amaranthus* 12 performing better than *Amaranthus* dodo and *Amaranthus cruentus* with respect to these parameters. Mbwambo *et al.* (2015) reported differences among genotypes in leaf length and width of amaranthus in both grain and leafy vegetable. Akande *et al.* (2010) also reported that leaf area of okra were 90 cm^2 for NPK treatment as against 95.5cm^2 for poultry droppings treatment.

Table 4: Effect of varieties and fertilizer sources on yield parameters of *Amaranthus* during 2015 and 2016 seasons

Treatments	Dry shoot weight (g)			Fresh leaf weight (g)			Fresh shoot yield (t/ha)		
	2015	2016	Combined	2015	2016	Combined	2015	2016	Combined
Fertilizer source (F)									
0kg/ha (control)	6.15[d]	6.30[d]	6.23[d]	4.03[d]	4.08[d]	4.06[d]	5.04[d]	5.53[d]	5.29[d]
10t/ha cow dung	22.62[b]	24.74[b]	23.68[b]	6.22[b]	7.09[b]	6.66[b]	20.27[b]	23.37[b]	21.82[b]
10t/ha poultry manure	31.45[a]	32.63[a]	32.04[a]	8.23[a]	8.20[a]	8.22[a]	45.42[a]	49.48[a]	47.45[a]
67kg N (Urea)	14.07[c]	13.06[c]	13.57[c]	6.09[b]	5.95[c]	6.02[c]	12.08[c]	13.01[c]	12.55[c]
SE±	0.52	0.54	0.58	0.04	0.07	0.05	0.50	0.63	0.56
Variety (V)									
V1	19.08[a]	21.19[a]	20.14[a]	6.85[a]	6.61[a]	6.73[a]	24.5[a]	24.05[a]	24.28[a]
V2	16.35[b]	17.30[c]	16.83[c]	6.03[c]	6.09[c]	6.06[c]	23.83[a]	23.16[a]	23.50[a]
V3	16.98[b]	19.05[b]	18.02[b]	6.19[b]	6.29[b]	6.24[b]	22.65[a]	19.83[b]	21.24[b]
SE±	0.40	0.47	0.44	0.68	0.60	0.66	0.45	0.55	0.50
Interaction									
F x V	NS	NS	NS	NS	NS	NS	NS	*	*

Mean followed by the same letter(s) within a treatment group are not significantly different at $P<0.05$ using DMRT, * = Significant at $P < 0.05$ probability level, NS = Not significant

Significant interaction effects recorded between fertilizer sources and varieties revealed that poultry manure supply to Accession 1 (Amaranthus 12) leads to the highest plant height, number of leaves and branches per plant resulting in high herbage production. This confirms to the basic knowledge in plant physiology that vigorous vegetable growth enhances leaf and grain yield as earlier reported by Mitchell (1970).

Effect of varieties and fertilizer sources on amaranths yield parameters

In this study, *Amaranthus* accession exhibited better response to poultry manure than the other fertilizer sources. In situation where both leaf and stem fractions are combined as fresh herbage, yield was substantially higher as observed in the fresh shoot yield and other yield components due to application of poultry manure when compared with the other fertilizer sources. This result agrees with the findings of Ogedegbe *et al.* (2013). The better response of *amaranthus* to poultry manure than the other fertilizers implies that the mineralization of poultry manure was faster than that of cow dung and the Urea fertilizers. Consequently, the poultry manure released more plant nutrients which increased the yield components of *amaranthus*. This work is also in line with reports by previous workers such as Sanwal *et al.,* (2007) in turmeric, Premesekhar and Rajashree (2009) in okra and Ogedegbe *et al.,* (2013) in amaranths. Accession 1 outperformed accessions 2 and 3 with respect to the yield parameters studied. The fresh shoot yield of amaranths obtained in this trial agrees with the findings of Svirskis (2003) and Oluoch *et al.,* (2009), who reported fresh leaf yield of 10 to 70 t/ha and 17.8 to 32 t/ha respectively. The significant interaction effect of fertilizer and variety for fresh shoot yield revealed that poultry manure is an efficient fertilizer for amaranth herbage production. It also confirms the assertion that poultry manure contains high amount of nutrients than the cow dung and the urea fertilizer.

Conclusion

Fertilizers supply essential nutrient to depleted soils thereby improving soil fertility and enhances crop growth and herbage yield. From this study, 10 t/ha poultry manure showed superiority over the other fertilizer sources and the control plots. Amaranthus 12 recorded better performance in both agronomic and yield parameters than than Amaranthus doodo and *Amaranthus cruentus.*

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