International Journal of Organic Agriculture Research & Development
Volume 11 (2015)

Influence of feather meal on growth and yield of *Amaranthus caudatus*

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ABSTRACT

Inherent advantages of organic fertilizers are major factors making many farmers to consider their use in crop production systems. This has led to evaluation of the influence of feather meal on growth and yield of Amaranthus caudatus. The experiment involves both incubation study and field trials in two seasons. Completely Randomized Design was used for incubation study while Randomized Complete Block Design with four replicates was used for field trials. The treatments considered were feather meal, compost, mineral fertilizer (NPK 15-15-15) and control (no soil additive). All the treatments (except control) were applied at 100 kg N/ha. The incubated treated soils were air dried and analysed for N. Data collected from field trials include growth parameters, fresh and dry yield. The data were subjected to Analysis of Variance (ANOVA) and means compared using Duncan Multiple Range Test (DMRT) at 5 % probability level. The incubation study showed that feather meal had a higher release of N across the weeks of incubation than NPK while control had the least. Results from the field trials revealed that feather meal treatment (18 t/ha) at 4 weeks after sowing significantly ($P<0.05$) compared favourably with NPK 15-15-15 (20.21 t/ha) and compost (16.54 t/ha) while it resulted in better performances compared to the control treatment (10.03 t/ha) on the fresh weight of amaranth plants during the dry season, while the rainy season trial followed the same pattern. It could therefore be concluded that Feather meal is a good fertilizer for amaranth production.

Keywords: Feather Meal, Organic fertilizer, N release, Amaranthus caudatus

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INTRODUCTION

The inherent advantages of organic fertilizers are major factors making many farmers to consider their use in crop production systems. Organic fertilizers have several advantages over inorganic types because they are safer to use as they do not readily burn plants. They are also less susceptible to leaching from the soil (Kramer *et al*., 2006; Kundu *et al*., 2007). Although, inorganic fertilizers especially nitrogenous fertilizers release their nutrients faster than the organic alternatives, they do not contribute much to soil physical and biological properties. It is also noteworthy that crop yield response to inorganic amendment follows the law of diminishing returns, and is responsible for decrease in value per unit material with increased application rates (Adeoye *et al*., 1993).

The use of easily available and cheap agro industrial wastes by vegetable farmers in periurban areas ensures sustainability of production, more balance nutrition and environmental sanitation. Works have been done on several organic materials both of plant and animal origin as sources of fertilizers; farm yard manure (Achieng *et al*., 2010; Adeyemo and Agele, 2010), *Gliricidia sepium* (Sridhar *et al*., 2001), cocoa pod husk (Adeoye *et al*., 2001; AdeOluwa and AyanfeOluwa, 2015), Tithonia (Achieng *et al*., 2013) and many others. However, there are still some organic materials of which fertilizer potential has not been explored or at best is currently being given attention, among them is feather meal. Feather meal is an organic material of animal origin which is more or less a waste in our environment. Poultry feather generated annually in Nigeria is estimated at 75, 000 t/year (FAO, 2008).

There is therefore a need to consider the potential of feather meal as a fertilizer due to the fact that it could be easily available to farmers. It is rich in N (12 %) (Peaceful Valley Farm supply, 2004) and 13 % (Andrew *et al*., 2011), thus it could serve as N source of organic fertilizer. However, in soil fertility, it is not the composition that matters but how available the contents are (nutrients) for the plant use. Thus, this study was set up to evaluate the rate

of release of total nitrogen by feather meal under incubation in the laboratory and to assess the potential of the feather meal as organic fertilizer for producing *Amaranthus caudatus*.

MATERIALS AND METHODS

The experimental sites were located at the Department of Agronomy, University of Ibadan, Nigeria. Incubation study was carried out on the feather meal to evaluate the rate of N release. The design used for the incubation study was Completely Randomized Design (CRD) in which there were four (4) treatments with each repeated five (5) times (to be harvested weekly for five (5) weeks) making a total of twenty (20) experimental units. The leached sandy soil used for the incubation study was very low in N (0.03 g / kg), P (7 mg / kg) and K (0.1 cmol / kg). In the field trials, each plot was manually cleared and gently tilled; each experimental unit was a bed of 0.81 m^2 and 0.51 m^2 in the rainy and dry season trials respectively. A total of 16 experimental units therefore made up 19 m^2 and 14 m^2 field area for the rainy and dry seasons respectively. The soil was also low in N (0.8 g / kg), had medium level of P (17 mg / kg) and K (0.2 cmol / kg) (FFD, 2012).

The treatments used were feather meal, compost, mineral fertilizer (NPK 15-15-15) and control (no soil additive). The feather meal was very high in N (13 %) although with negligible P and K (Table 1). In both the incubation study and field trial, all the treatments (except control) were randomly applied on dry matter basis at the rate of 100 kg N / ha per experimental unit. In the incubation study, application of the treatments was done the same day and it involved thorough mixing of the various treatments with the sand. The mixture was thereby moistened and each cup covered. In the field trial, while the organic fertilizers were applied a week before sowing, the inorganic was applied one week after sowing (WAS). *Amaranthus caudatus* seeds were drilled in the field trials and thinned to the rate of 1.8 Million plants/ha.

Table 1: Nutrient composition of feather meal used for this study

Elements	Value (%)
Nitrogen	13
Phosphorus	0
Potassium	0

Source: Pacific Calcium, Inc., WA, United States

The incubated soils were air dried at their respective weeks after treatment application and analysed to assess the rate of N released for each treatment. The result was presented using a line graph. In the field trial, plant growth parameters were measured weekly from 2 - 4 WAS while fresh and dry yield was determined once at 4 WAS. The data obtained were subjected to Analysis of Variance (ANOVA) and means compared using Duncan Multiple range Test at 5 % probability level.

RESULTS

Comparative rate of release of N across six (6) weeks of incubation is shown in Fig.1. It was observed that throughout the 6 weeks period, mineral fertilizer had the highest value of 0.7 g/kg at 3 weeks of incubation (WOI) followed by feather meal having 0.67 g/kg at 2 WOI while the control (no soil additive soil) had the lowest value of 0.2 g/kg at 4 and 6 WOI. It showed that both feather meal and NPK had a rise in the release of N and attained a peak at around 4 WOI after which they started decreasing. Thus, the feather meal and NPK followed similar trend in the release of Nitrogen. However, feather meal had a higher release of N across the weeks of incubation than NPK while control had the least. The release of N by compost initially was lower than that of feather meal and NPK but picked up at 3 WOI and started increasing at an increasing rate while the curve showed that it had the potential to maintain that for more weeks.

Field trials

Comparative effects of treatments on plant height (cm) of *A. caudatus*

at 2, 3, and 4 WAS in two seasons of trials are shown in Table 2. The result showed that there was significant difference ($P<0.05$) in the height of the *A. caudatus* across the treatments in the two seasons, and the height increased across the weeks. In the rainy season, at 2 WAS, compost had the highest mean plant height (4.0 cm) and was significantly better than others, followed by feather meal (3.3 cm) which was also significantly better than mineral fertilizer (NPK 15-15-15) (2.6 cm). The control had a value (2.1 cm) which was significantly lower than all other treatments. At 3 WAS, Feather meal resulted in the highest mean plant height (9.6 cm) but was not significantly different from plants that received compost (9.2 cm) and mineral fertilizer (7.2 cm) though significantly higher than the control (4.9 cm). At 4 WAS, mineral fertilizer had the highest mean (14.4 cm) which was similar to the performance of feather meal (13.2 cm) and compost (12.3 cm) but significantly higher than the control (6.7 cm).

In the dry season, at 2 WAS, Amaranths treated with mineral fertilizer had the highest mean plant height (6.1 cm) and was significantly taller than others, followed by feather meal (5.0 cm) which was also significantly taller than compost (4.2 cm) which was again also significantly better than the control (2.8 cm). At 3 WAS, Amaranths plants that received mineral fertilizer had the highest mean plant height of 6.1 cm which was not significantly different from feather meal (16.4 cm) but significantly taller than compost amended plants (12.4 cm), which was not significantly different from the control (11.0 cm). At 4 WAS, mineral fertilizer had the highest mean plant height of 31.5 cm which was not significantly different from that of feather meal (30.5 cm) and compost (22.0 cm) but significantly taller than the control (18.8 cm).

Comparative effect of treatments on the stem girth (cm) of *A. caudatus* at 3 and 4 WAS in two seasons of the field trials are shown in Table 3. The result showed that there was significant difference ($P<0.05$) in the stem girth of the *A. caudatus* among the treatments in the two seasons, and the stem girth increased across the weeks. In the rainy season, at 3 WAS, plants

grown with mineral fertilizer resulted in the highest mean stem girth (1.1 cm) which was not significantly different from feather meal (1.0 cm) and compost (1.0 cm) but significantly better than the control (0.6 cm). At 4 WAS, there was no significant difference among the feather meal (1.2 cm), compost (1.2 cm) and mineral fertilizer (1.2 cm) but they were all significantly better than the control (0.7 cm). In the dry season, the mineral fertilizer (1.6 cm) gave the highest stem girth of 1.6 cm which was not significantly different from that of feather meal while they were both significantly better than that of the compost (1.0 cm) and control (1.0 cm). The same trend of result was obtained at 4 WAS.

Comparative effects of treatments on the mean number of leaves of *A. caudatus* at 2, 3, and 4 WAS in the two seasons of trials are shown in Table 4. The result showed that there were significant differences ($P<0.05$) in the number of leaves of the *A. caudatus* across the treatments in the two seasons except at 4 WAS in the dry season. The number of leaves increased across the weeks in the two seasons. In the rainy season, at 2 WAS, there was no significant difference among the compost (8.3), feather meal (7.8) and mineral fertilizer (7.5) while they were all significantly better than the control (6.5). The result followed the same trend at 3 and 4 WAS.

In the dry season, at 2 WAS, mineral fertilizer had the highest mean number of leaves (9.8) and was not significantly different from feather meal (9.3) but higher than compost (8.3) and the control (8.0). At 3 WAS, feather meal (14.3) had the highest significant mean number of leaves followed by the control (12.8) and compost (12.5) while mineral fertilizer resulted in significantly lowest mean number of leaves (11.8).

The comparative effects of treatments on fresh weight and dry weight of *A. caudatus* at 4 weeks in two seasons of trials are shown in Fig. 2. The result showed that there were significant differences ($P<0.05$) in the fresh weight and dry weight of *A. caudatus* across the treatments in the two seasons of trials.

In the rainy season, feather meal had similar performance of 4.98 t/ha with mineral fertilizer (NPK 15-15-15) having 5.53 t/ha and compost having 5.35 t/ha, but performed better than the control with 1.74 t/ha on yield of fresh weight of amaranth plants at 4 WAS. The result of the yield of dry weight of the amaranth followed the same trend. In the dry season, feather meal still had similar performance of 18 t/ha with mineral fertilizer (NPK 15-15-15) having 20.21 t/ha and compost having 16.54 t/ha but performed better than the control with 10.03 t/ha on yield of fresh weight of amaranth plants at 4 WAS. The result of the yield of dry weight of Amaranth also followed the same trend.

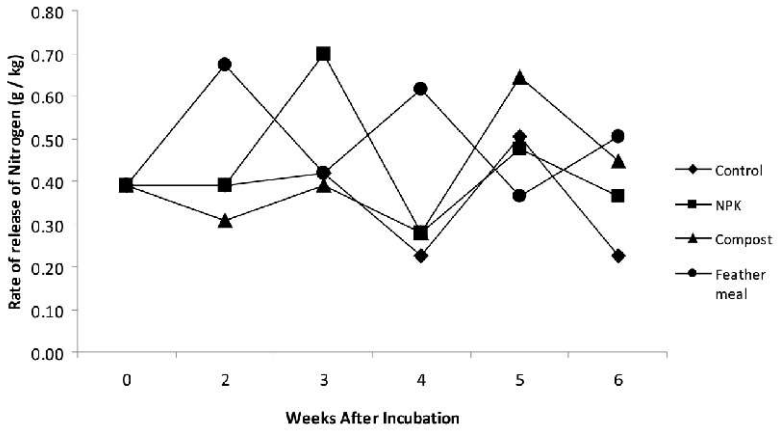


Fig. 1: Comparative rate of release of N by the various treatments across weeks of incubation

Table 2: Comparative effects of treatments on the plant height (cm) of A. caudatus at on weekly basis for two seasons of trials

	Rainy season			Dry season		
Treatments	2 WAS	3 WAS	4 WAS	2 WAS	3 WAS	4 WAS
Control	2.1d	4.9b	6.7b	2.8d	11.0b	18.8b
NPK	2.6c	7.2ab	14.4a	6.1a	18.3a	31.5a
Compost	4.0a	9.2a	12.3a	4.2c	12.4b	22.0ab
Feather meal	3.3b	9.6a	13.2a	5.0b	16.4a	30.5a

Means with same letter in a column are not significantly different at 5 %

level of probability by Duncan Multiple Range Test (DMRT)

Table 3: Comparative effects of treatments on the stem girth (cm) of *A. caudatus* at 3 and 4 WAS in two seasons of trial

	Rainy season		Dry season	
Treatments	3 WAS	4 WAS	3 WAS	4 WAS
Control	0.6b	0.7b	1.0b	1.4b
NPK	1.1a	1.2a	1.6a	2.1a
Compost	1.0a	1.2a	1.0b	1.6b
Feather meal	1.0a	1.2a	1.5a	2.2a

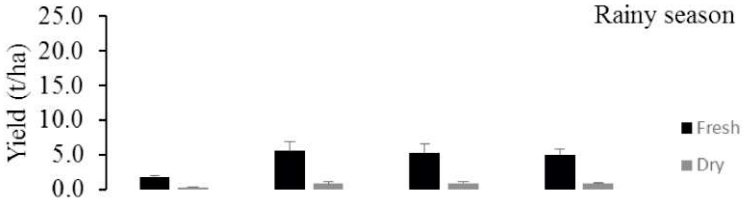
Means with same letter in a column are not significantly different at 5 % level of probability by Duncan Multiple Range Test (DMRT)

Table 4: Comparative effects of treatments on the number of leaves of *A. caudatus* at 2, 3 and 4 WAS in two seasons of trials

	Rainy season			Dry season		
Treatments	2 WAS	3 WAS	4 WAS	2 WAS	3 WAS	4 WAS
Control	6.5b	9.0b	8.3b	8.0b	12.8b	12.3
NPK	7.5a	10.8a	11.0a	9.8a	11.8c	15.5
Compost	8.3a	10.5a	10.0a	8.3b	12.5b	14.0
Feather meal	7.8a	10.8a	9.5a	9.3a	14.3a	15.0
						NS

NS: not significant

Means with same letter in a column are not significantly different at 5 % level of probability by Duncan Multiple Range Test (DMRT)



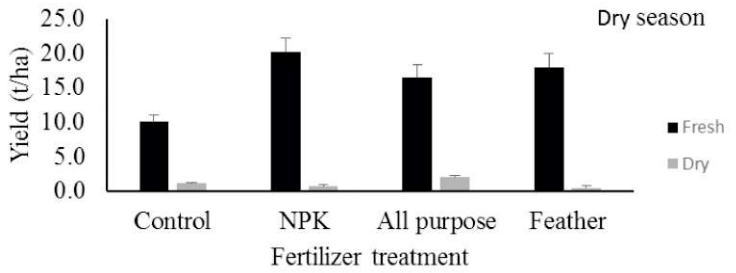


Fig. 2: Effects of the fertilizer treatments on the fresh and dry weight (g) of *A. caudatus* at 4 weeks after sowing for two seasons of trials

DISCUSSION

The focus of this report is to evaluate the rate of release of total nitrogen by feather meal under incubation in the laboratory and to assess the potential of the feather meal as organic fertilizer for producing *Amaranthus caudatus*. In the incubation study, the feather meal showing similar pattern of release of N with that of NPK mineral fertilizer revealed that it is a fast nutrient releasing organic fertilizer material and can be suitable for producing amaranth and other short season crops especially the ones that have similar nutrient requirement with amaranths. The results showed that the feather meal reached its peak of N release at around 4 weeks after incubation (WOI) i.e. 28 days. This is in line with the report of (Gale *et al*., 2006) and (Garret, 2009) who reported that the N from specialty organic fertilizer materials, such as feather meal, has been shown to mineralize rapidly with a large fraction of the amendment N becoming plant-available in the first 28 days after application. However compared with rate of mineralization in some other organic fertilizers; fish meal, blood meal and Guano according to (Hartz and Johnstone, 2006), feather meal mineralized faster as they all reached their peak of N release at 8 WOI.

In the field trials, generally, the result of this experiment showed that the performance of the *A. caudatus* for both the growth and yield parameters was better in the dry season than in the rainy season trial. A major reason is

the heavy downpour of rain which probably was too much for Amaranths and could have also slowed down the rate of mineralization of the applied organic fertilizer treatments (Bot and Benites, 2005).

In terms of plant height, it was observed that the mean plant height of Amaranth that received the mineral fertilizer treatment was lower than that of the organic sources at 2 and 3 WAS in the rainy season. This probably could be due to the leaching and volatilization of the highly soluble N from mineral fertilizer as a result of the heavy downpour of rain (Ojeniyi, 2010; Kotschi, 2013). It was observed at 4 WAS (which is the average maturity period for leafy amaranth on the field) that mineral fertilizer treated plants had the highest mean height; however it was not significantly different from both feather meal and the compost though they were all significantly better than the control in both seasons.

In terms of stem girth and number of leaves, it was observed that at 4 WAS although mineral fertilizer produced amaranths with the highest mean stem girth, it was not significantly different from the feather meal in both seasons. In terms of yield which is the major parameter of economic importance to the farmer, the yield was generally low in the rainy season while it was better in the dry season. However, in the two seasons it was still lower than average yield of 24 t/ha for *A. caudatus* at 4 WAS reported by Cofie *et al*. (2010) and of 25.5 t/ha by Omolayo *et al*. (2011) (although at 5 WAS). This could be due to the heavy down pour of rain experienced during the rainy season which could have lowered the soil temperatures there by slowing down the rate of mineralization of the applied fertilizer treatments. This is in line with Omolayo *et al*. (2011) where the rate of mineralization of different organic fertilizers (feather meal, fish meal, blood meal, and Guano) increased with increase in temperature from 10 ^{o}C to 25 ^{o}C.

In the rainy season, feather meal compared favourably (4.98 t/ha) with mineral fertilizer (NPK 15-15-15) (5.53 t/ha) and compost (5.35 t/ha) but better than the control (1.74 t/ha) as revealed by the fresh yield of *A. caudatus* plants at 4 WAS. This was against the result obtained by AdeOluwa

and Adeogun (2011) in a screen house experiment where mineral fertilizer performed significantly better than both feather meal and the compost. This better performance obtained in the field trial might be due to the loamy soil used (as against the pure sand soil used in the screen house by AdeOluwa and Adeogun (2011)) which might have enhanced the rate of decomposition of the organic sources. Also the mineral fertilizer is more prone to leaching, and nutrient like N easily volatilized on the field (Kotschi, 2013) unlike in the screen house experiment where such could be conserved.

The result of the dry season followed the same trend with that of the rainy season, but with a higher yield in general. It could thus be inferred that the rate of mineralization of fertilizer treatments were higher in the dry season (due to higher level of soil temperatures) which is in accordance with the result of Hartz and Johnstone (2006). Also, Watts and Torbert III (2004) reported that dairy compost greatly influenced N mineralization by season with the summer months mineralizing the most N.

This performance of the feather meal on yield of fresh weight of *A. caudatus* plants at 4 WAS concurs with Gale *et al*. (2006) who reported that the N from special organic fertilizer materials, such as fish and feather meal, has been shown to mineralize rapidly with a large fraction of the amendment N becoming plant-available in the first 28 days (4 WAS) after application. The result therefore showed that feather meal could be a suitable organic fertilizer for Amaranth production as well as for other short season crops with similar nutrient requirement. It also showed that feather meal application would be more beneficial in the dry season than in the rainy season.

CONCLUSION

The results of this experiment revealed the ability of feather meal to compare favourably with mineral fertilizer (NPK 15- 15- 15) in the production of *Amaranthus caudatus* as shown by the result of the incubation study where feather meal had a similar pattern (and even a higher level) of

release of N with mineral fertilizer (NPK 15-15-15). This was confirmed by the field trials in which the results showed that feather meal compared favourably with the NPK in both rainy and dry seasons' trials as revealed by the yield of the *Amaranthus caudatus*. Thus, feather meal is recommended for production of amaranths in organic crop production systems, especially in ecologies similar to the area of this study.

ACKNOWLEDGEMENT

Nature's Intent feather meal was supplied free by Pacific Calcium, Inc., WA, USA and management of the University of Ibadan provided a conducive environment and facilities to carry out the experiment.

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