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INFLUENCE OF VELVET BEAN FALLOW AND COMPOST AMENDMENTS ON AMARANTHS (*Amaranthus caudatus*) YIELD AND SOIL PROPERTIES IN AN ORGANIC CROPPING SYSTEM

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ABSTRACT

One of the major problems bedeviling crop production in many parts of the tropics is low soil fertility status. Thus, this report evaluates the effects of soil fertility improvement by velvet bean fallow and compost, on the yields of amaranth, as well as the post-harvest soil fertility. Green amaranth (*Amaranthus caudatus*) was used as the test crop. Six fertilizer treatments namely, Ibadan brewery waste based grade A compost (IBBW1), Ibadan brewery waste based grade B compost (IBBW2), IBBW1 + Velvet residual fertility, IBBW2 + Velvet residual fertility, Velvet residual fertility (Sole) and No fertilizer treatment (as a control) were investigated. The composts were applied at 100 kg N/ha, while treatments having velvet bean fallow had the bean earlier sown on them to rejuvenate the soils. The experiment was laid in a randomized complete block design (RCBD) with four replications. All the data collected were subjected to analysis of variance (ANOVA) and means were separated using Least Significant Difference (LSD) at 0.05 probability level. The result showed that the fertilizer sources had significant effects on the total fresh weight (t/ha) and dry weight (t/ha) at $p < 0.05$. The IBBW1 + Velvet bean produced the best significant ($p<0.05$) total fresh weight of amaranths (31.20 t/ha), it left the soil with better pH, total nitrogen and available phosphorus status. Based on the results of this study, IBBW1 compost + Velvet bean fallow proved better fertilizers in the production of *Amaranthus caudatus*. Thus, these treatments could be useful in organic production system for amaranth.

Key words: Ibadan brewery waste based compost, velvet-fallow, amaranths, soil fertility, residual fertility.

INTRODUCTION

Soil fertility is one of the most important factors limiting organic crop production in many parts of the tropics. This situation often limits crop yields from organic farms. Thus, cost saving alternatives to soil fertility restoration or maintenance is needed by producers in order to improve yield. It is a known fact that soil fertility needs to be enhanced and maintained in order to sustain crop production. The traditional way of improving soil fertility is land fallow system. Although this system is becoming obsolete because of the increasing pressure on agricultural lands, however, land fallow is still one of the ways of improving soil fertility in intensive organic crop production system. Bush fallow practiced by many traditional farmers in many developing countries, which could be up to 10 years or more to allow the replenishment of soil fertility has been drastically shortened or no more practicable in many places. Thus, inadequate means of improvement led to reduced levels of soil organic matter, decline in soil fertility and acidified soils in many developing countries (Manyong *et al.,* 2000).

Supplementing the nutrient requirements of crops through organic fertilizers such as crop residues, manures and compost among others, now play key roles in sustaining soil fertility and crop productivity in the tropics (Soumare *et al.,* 2003; Simon and Czako, 2014). Organic fertilizer applications in form of compost, manure and other forms of organic fertilizers are the most common ways of improving soil fertility in organic crop production systems. Composts are widely used as a soil amendment to improve soil structure, provide plant nutrients and facilitate the re-vegetation of disturbed soils (Sarwar *et al.,* 2005; Kayode *et al.,* 2013). However, cost attached to organic fertilizers like compost often lead to insufficient fertilizer application on many organic farms. Thus, there is a need to investigate other alternatives to organic fertilizer application in organic crop production systems.

Many studies have reported that organic fertilizers are effective nutrient sources for increasing yield and nutrient status of crops such as maize, amaranths, sorghum, flutted pumpkin and pepper (Adeniyan and Ojeniyi, 2005; Iren *et al..,* 2014). It also improves soil fertility and physical properties. Organic fertilizer despite their low nutrient analysis and slow nutrient release (Cooke, 1982), play a significant role in meeting fertilizer needs of crops. Due to environmental awareness and the need to reduce input costs, the use of organic fertilizers is increasing considerably (Pappa *et al.,* 2006). Some conventional farmers also believe that organic fertilizers are more environmentally safe and less expensive; compared to using inorganic mineral fertilizers (Edmeades, 2003).

While many farmers might not be willing to leave their farm lands to fallow just for fertility rejuvenation, they are willing to do planted fallow, using legumes. Velvet bean (*Mucuna pruriens*) is one of the promising legumes that could be efficient as low-cost sources of soil nitrogen. The bean has been reported to be gaining popularity over the last few years in the production of some natural products. Velvet bean has been reported to increase testosterone and stimulate growth hormone (thereby increasing muscle mass) (Mesko, 2002). It is also showing up as an ingredient in various weight loss, libido, brain/memory, anti-aging, and body builder formulas. Moreover, the bean has been reported to have a considerable potential of improving soil fertility in an intensified cropping systems (Buckles *et al.,* 1998). Earlier reports have indicated that yield responses to previous legume crops are in the range of 50-80% more than yields in cereal-cereal rotations (Oikeh *et al.,* 1998). Thus, incorporation of the bean in planted fallow system is promising.

The test crop *Amaranthus caudatus* L. is a fast growing and common vegetable in Nigerian dishes, especially, the Southwestern part. It has been reported that most Nigerian leaf - vegetables are good, relatively cheap and rich source of nutrients such as vitamin, minerals, sugar, water, protein, calcium, thiamine, riboflavin, nicontinamide and fiber needed for healthy body growth and sustenance (Mnkeni *et al.,* 2006). However, one major constraint to growing this crop is the demand for heavy dosage of nitrogen fertilizer (Adeoye *et al.,* 2005). Several efforts have been made to investigate the effect of organic fertilizers and organomineral fertilizers on some leafy vegetables (Makinde *et al.,* 2010; Akinyele *et al.*, 2012; Olowoake, 2014) but the legume fallow augmented with compost has not been investigated in Amaranthus production.

Therefore, the objective of this report is to evaluate the effects of velvet bean fallow and compost on the yields of amaranth as well as the post-harvest soil fertility.

MATERIALS AND METHODS

A field experiment was conducted between January and March 2014 on the field of the Organic Vegetable Garden at the Teaching and Research Farm, University of Ibadan, Ibadan, Nigeria. The experimental site is located in the derived savannah of South West Nigeria. The treatments consisted Ibadan brewery waste based grade A (IBBW1), Ibadan brewery waste based grade B(IBBW2), IBBW1 + Velvet bean fallow, IBBW2 +Velvet bean fallow, Velvet bean fallow alone, and a control treatment (no fertilizer). The composts were obtained from an experimental demonstration site of brewery spent grain composting lot at the organic section of the Teaching and Research Farm, University of Ibadan, Nigeria. Each treatment was replicated four times in a Randomized Complete Block Design. Each experiment plot consisted of 2 m x 1.5 m bed, with a total land area of 456.8 m^2 (24 m x 19.8 m). The amaranth seed was sown in line of 3 cm inter-row and 0.5 m inter-bed spacing making a planting density of 1.8 million plants per hectare.

Surface soil samples (0-15 cm depth) were collected for laboratory analysis from the experimental plots, before and after planting. The soil samples were air dried and sieved (<2 mm). A portion of each sample was processed for laboratory analysis. Particle size analysis was determined by the hydrometer method of Bouyocus (1951). Soil pH in water was determined potentiometrically using glass electrode in a 1:1 soil: water slurry. Organic matter was determined by the chromic acid oxidation procedure (Walkey and Black, 1934). Total nitrogen was determined by the Kjeldahl procedure. Available phosphorus was extracted using Bray I extractant, and P in the extract was determined calorimetrically using the molybdenum blue method. Exchangeable bases and micronutrient were extracted using Mehlich III method and read with an Atomic Absorption Spectrophotometer. The Na^+ was determined using the flame photometer. Exchangeable acidity of the soil was extracted with 1N KCl solution and determined by titrating with 0.025N NaOH solution.

At harvest, the fresh shoot weight of Amaranths (edible part and non-edible part), root and the total fresh weight were determined. Samples were oven dried at 70^0C to constant weights for dry weight of parameters. All weighing operations were done using a top loading digital weighing balance. Data generated were analysed statistically by analysis of variance (ANOVA) using GENSTAT. Least significant difference (LSD) was used to compare treatment means at 0.05 significance level.

RESULTS

Details of nutrient composition of the brewery based waste compost A and B are presented in Table 1. The nutrient composition revealed that total nitrogen ranged from 0.93 % - 0.98%, while the phosphorus ranged from 0.92 % - 0.94 % as well as potassium 0.74% - 1.12%.

Pre-planting chemical properties of the experimental soil

The chemical soil properties are shown in Table 2. The pH of the soil is 6.8, indicating a moderately acidic soil. The total nitrogen is lower than the lower limit of the critical range. The soil is low in organic carbon (2.81 g/kg) , available phosphorus (P) of the soil (13.7mg/kg) and exchangeable potassium (K) were within

Table 1: N, P, K composition of the compost

Fertilizers	N	P	K
		(%)	
IBBW1	0.93	0.92	0.74
IBBW2	0.98	0.94	1.12

IBBW1 = Ibadan brewer-based compost grade A
IBBW1 = Ibadan brewer-based compost grade B

Table 2: Soil chemical properties and particle size distribution before planting

Parameters	pH	OC	N	Av. P	Ca	K	Na	Mn	Fe	Cu	Sand	silt	Clay
		← g/kg →		mg/kg	← cmol/kg →			← mg/kg →			← g/kg →		
Values	6.8	2.8	0.1	14	3.1	0.2	0.5	65	67	11	650	236	114

the critical range (0.2 – 0.4 cmol/kg). The soil was loamy sand in texture. The generally low nutrient status of the soil made it suitable for the fertilizer response experiment.

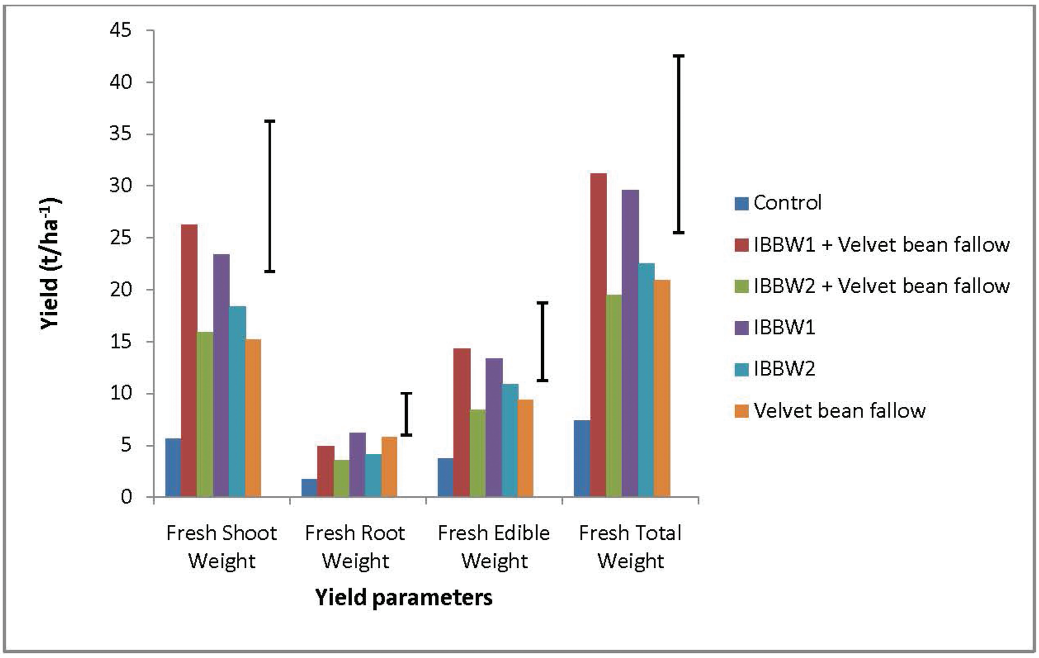
Comparative effects of organic amendments on the fresh yield of Amaranth

The comparative effects of different organic amendments on fresh yield of amaranth at harvesting are shown on figure 1. The result revealed significant differences attributable to the applied fertilizer treatments on the parameters such as fresh edible weight, fresh shoot weight, fresh root weight and the total fresh weight. At harvest, the result showed that treatment IBBW1 + Velvet bean fallow gave the highest mean edible fresh weight (14.31 t/ha^{-1}) which was significantly higher (P< 0.05) than IBBW2 + Velvet bean fallow (8.46 t/ha^{-1}) and the control (3.74 t/ha^{-1}). However, this was not significantly different from IBBW1 (13.37 t/ha^{-1}), IBBW2 (10.94 t/ha^{-1}) and Velvet bean fallow (9.36 t/ha^{-1}) yields. Equally for the mean fresh shoot, treatment IBBW1 + Velvet bean fallow produced the highest (26.24 t/ha^{-1}) value, which was significantly higher than Velvet bean fallow alone (16.97 t/ha^{-1}), IBBW2 + Velvet bean fallow (15.93 t/ha^{-1}) and the control. This effect was not significantly different from IBBW1 (23.40 t/ha^{-1}), and IBBW2 (18.36 t/ha^{-1}) influenced yields. In the fresh root weight, treatment IBBW1 produced the highest (6.23 t/ha^{-1}) value, which was significantly different from IBBW2 + Velvet fallow (3.58 t/ha^{-1}) and control (1.74 t/ha^{-1}). This was not significantly different from Velvet bean fallow alone (5.78 t/ha^{-1}), IBBW1 + Velvet bean fallow (4.96 t/ha^{-1}) and IBBW2 + Velvet bean fallow (4.15t/ha^{-1}). In the fresh total weight, the treatment IBBW1 + Velvet fallow resulted in the highest value (31.20 t/ha^{-1}), which was significantly higher than IBBW2 + Velvet bean fallow (19.49 t/ha^{-1}) and control (7.38 t/ha^{-1}), but not significantly different from IBBW1 (29.61 t/ha^{-1}), IBBW2 (22.50 t/ha^{-1}) and Velvet (20.39 t/ha^{-1}).

Comparative effects of compost amendment on the dry yield of Amaranth

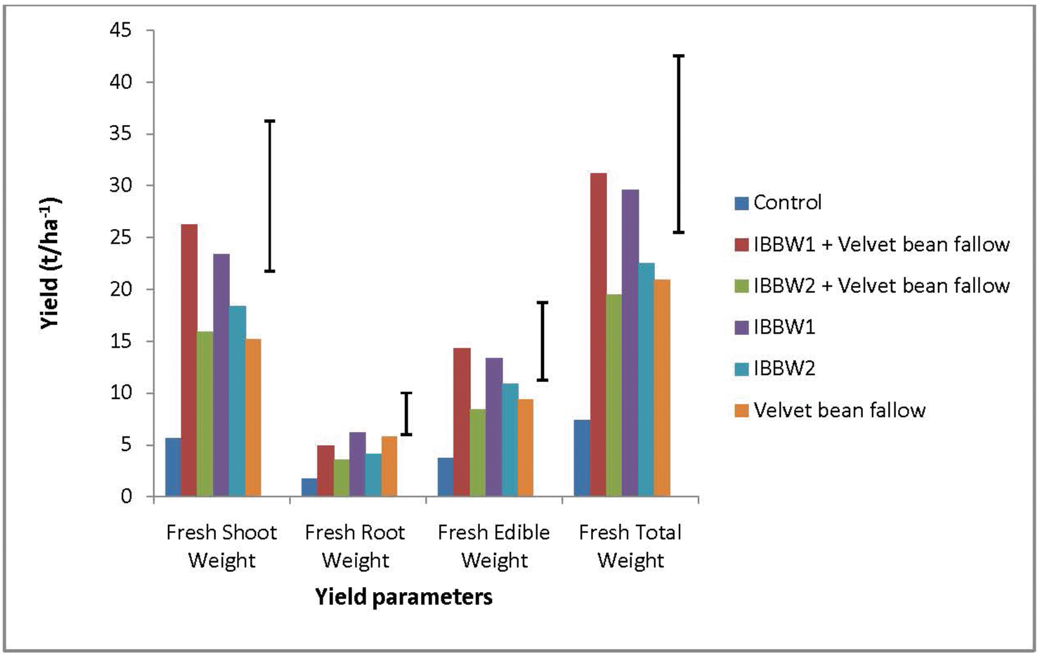
The comparative effects of different organic amendments on dry yield are shown on Figure

2. The result revealed significant differences in dry edible weight, dry shoot weight, dry root weight and the total dry weight. The treatment IBBW1 + Velvet bean fallow gave the highest ($P < 0.05$) dry edible weight, dry shoot weight and the total dry weight (2.66; 4.16; 5.09) t/ha^{-1} respectively. This was significantly higher than that of the control treatment, but not other treat-



Error bar = Least significant difference (**p<0.05**)

Fig.1. Comparative effects of organic amendments on the fresh yield of amaranth (t/ha) at harvest



Error bar = Least significant difference (**p<0.05**)

Fig.1. Comparative effects of organic amendments on the fresh yield of amaranth (t/ha) at harvest

Table 3: Influence of fertilizer treatments on postharvest soils

Treatments	pH	O C	N	Av. P	Ca	K	Na	Mn	Fe	Cu
		◄ g/kg ►		mg/kg	◄cmol/kg ►			◄ mg/kg►		
Control	6.7	3.2	0.1	9	3.1	0.2	0.5	627	66	3
IBBW1 + Velvet bean fallow	6.6	3.8	0.4	30	4.1	0.5	0.7	679	124	28
IBBW2 + Velvet bean fallow	6.9	3.7	0.3	23	3.7	0.3	0.7	689	117	16
IBBW1 Compost	6.8	3.2	0.3	21	5.8	0.3	0.8	777	99	16
IBBW2 Compost	6.7	3.1	0.2	15	4.1	0.3	0.3	752	78	11
Velvet bean fallow	6.7	4.4	0.2	16	3.3	0.2	0.5	654	80	61
Mean	6.7	3.6	0.3	19	4.0	0.3	0.6	696	94	23
SD								48.	19.	17.
	0.1	0.4	0.1	6.1	0.8	0.1	0.2	6	6	4

SD- Standard derivation

ments. The treatment Velvet bean fallow produced the highest dry root weight (0.95 t/ha^{-1}).

Influence of fertilizer treatments on post planting chemical properties of experimental soils

Table 3 shows the chemical composition of the soil as influenced by the soil amendments. The pH of the plots treated with organic amendments improved slightly above the control. Organic amended plot had higher soil organic carbon when compared with the control. Organic amendments improve total N in the soil compared with the control.

DISCUSSION

The use of organic fertilizers has often been reported to be beneficial to crop production, especially in soils of low fertility status. In this study, the effects of velvet bean fallow and compost were evaluated. Fertilizer from plant sources (e.g. Velvet) has been reported as a substitute for commercial N fertilizers in cropping systems (Follett *et al.* 1991). It was obvious that IBBW1 + Velvet bean fallow had a better effect on growth of *A. caudatus* when compared to other treatments, especially no soil additive treatment (control) with respect to fresh weight and dry weight yield at harvesting. This treatment produced highest yield (fresh and dry) at harvesting (31.20 t/ha, 13.43 t/ha respectively). This could be as a result of N fixed from the atmosphere through their root nodules of velvet beans (Ahmad *et al.,* 2001) coupled with a better interaction with the applied compost. This could have increased the nutrient uptake efficiency and crop yields (Cherr *et al.*, 2006). Although the yield obtained from this study was lower than 34 t/ha reported by AdeOluwa *et al.* 2009, but it is greater than 20 t/ha reported by Norman (1992) and Grubben and Vanslotten (1978) who reported optimum yield of 30 t/ha fresh weight.

The variation in the yield could be as a result of time of cultivation and different types of fertilizer used. The influence of the treatments on amaranths dry weight took the same trend as that of the fresh weight above. Earlier workers like (Ehigiator, 1998; Olowoake, 2015; AdeOluwa *et al.* 2015) identified organic fertilizer as possible alternative sources of nutrients to inorganic fertilizer in crop production especially vegetables. This is apparently because organic fertilizer, are a storehouse of not only primary, but secondary and trace elements (Plaster, 1992).

The nutrients such as N in organic fertilizer are released in synchrony with crop needs throughout the growth season (Havlin *et al.,* 2005) in contrast to block release pattern common with soluble mineral fertilizers. The above attributes of organic fertilizer in addition to their capability to improve soil structure, retain nutrients and water for plant use (Anyanwu *et al.,* 2001, Ndor *et al.* 2013) could partly explain the superiority of the organic fertilizer as N sources in vegetable production over inorganic fertilizer.

The result of this trial showed clearly the potentials of organic materials in improving yield and some soil properties. This is expected because of the increase in soil organic matter and micro-nutrient content of the soil. Improvement in the soil pH of organic amended plots might be due possible enrichment of soil with exchangeable bases from the organic material components of specific treatments. Improved availability of cations might lead to high soil pH. In support of this, Ayeni *et al.* (2008), Iren *et al*. 2011a & b; 2012; John *et al*. 2013, attributed improvement in soil pH of organic amended soil to the supply of basic elements as; K, Ca, and Mg. Post planting soil organic carbon of compost and Velvet bean fallow plots were high, compared with the control. The higher organic matter content level observed in amended plots could be attributed to the fact that organic material had major impact on mineralization rate and increase soil carbon directly. Ayeni *et al.* (2008) attributed the melioration in soil health to the nutrient content and the amount of material applied. Thus, the improvement in soil fertility by the velvet fallow and IBBW composts could have led to increase in photosynthate accumulation.The high soil organic carbon of compost and velvet bean fallow plots agrees with the report of Makinde and Ayoola (2008), that the nutrients contained in organic materials are released more slowly and are stored for a longer time in the soil, thereby ensuring a long residual effect.

Available P showed an increase with respect to treatment IBBW1 + velvet fallow and IBBW2 + velvet fallow with the highest value (30 and 23) mg/kg obtained respectively in the post harvest soil. The slight differences in the soil pH brought about by the organic amendment might have influenced the level of availability of phosphorus since the availability of phosphorus and its solubility is pH dependent.The appreciable increase in exchangeable bases (Ca^{2+}, Mg^{2+}, K^{+} and Na^{+}) and the micronutrients may be due to the influence of velvet and compost mixture to decompose and mineralize into organic matter. This corresponds with the observation of Mbagwu *et al.* (1991) who showed that organic matter contributed to the cation exchange capacity of soil with low activity clays, while Owolabi *et al.* (2003) reported that organic matter tended to buffer soils and cause the release of exchangeable cations. This investigation also buttresses the findings of Abou El – Magd *et al*. (2006), who reported that organic amendment (manures) provides all necessary macro and micro nutrients in their available form, thereby improving the physical, chemical and biological properties of the soil.

CONCLUSION

Amaranth (*Amaranthus caudatus*) yield and soil properties as influenced by velvet bean-fallow (residual fertility) and compost amendments was investigated in this study. The result revealed that the combination of Brewery waste-based grade A compost (IBBW1) and velvet bean fallow improved the yield of amaranth. Post-harvest soil with Velvet bean fallow and compost treatments had better nutrient status compared to the control, in terms of nitrogen, phosphorus and organic matter content. The use of velvet bean fallow is therefore suggested as a viable means of soil fertility improvement in the production of amaranths in an organic production system, especially, where climatic factors could favour growth of velvet beans.

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