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Organic Fertilizer Potentials of Aqueous Waste Extract of *Vernonia amygdalina* Leaves for Leafy Vegetables Production

Fabunmi, T. O.
Department of Plant Physiology and Crop Production, Federal University of Agriculture, Abeokuta
Corresponding Author E-mail: tomdeji@yahoo.com

Abstract
Efficient means of replenishing soil nutrients without using chemical fertilizers must be continually discovered in organic crop production systems. The potential of aqueous leaf extract of *Vernonia* amygdalina (VA) (which is often discarded as a waste) as organic fertilizer was evaluated using three leafy vegetables: *Corchorus olitorious*, *Amaranthus hybridus* and *Celosia argentea*. There were three trials carried out simultaneously, which consisted of six treatments each arranged in completely randomized design and replicated three times. The treatments in each trial were three rates of VA: 150 ml, 250 ml and 500 ml per pot; 1.55 g and 0.78 g NPK 15:15:15 per pot (75 kg/ha or 37.8 kg/ha of N, P and K) and no fertilizer. Plant height, dry weight and fresh weight (economic yield) across the vegetables were significantly affected by the treatments. The general response was 500ml VA produced plants that were at par with those that received 37.8 kg/ha of N, P and K, but significantly taller, with higher dry and fresh weight relative to other VA treatments. The laboratory analysis of the VA leaf extract use for the trial showed that the concentration of K was 877.21 mg/l; while N and P, Ca and Mg were 122.42, 70.09, 24.22 and 11.89 mg/l, respectively. The VA contained fertilizer nutrients in the ratio approximately 2:1:7. The study concludes that aqueous extract of *V. amygdalina* can be used as a nutrient source in organic cropping systems.

Keywords: *Vernonia amygdalina*, leaf extract, organic fertilizer

Potentiel d'engrais organique de l'extrait aqueux de résidus de feuilles de Vernonia amygdalina pour la production de légumes à feuilles

Abstrait
Des moyens efficaces de reconstituer les éléments nutritifs du sol sans utiliser d'engrais chimiques doivent être continuellement découverts dans les systèmes de production de cultures biologiques. Le potentiel d'extrait aqueux de feuille de Vernonia amygdalina (VA) (souvent rejeté comme déchet) en tant qu'engrais organique a été évalué à l'aide de trois légumes à feuilles: Corchorus olitorious, Amaranthus hybridus et Celosia argentea. Trois essais ont été menés simultanément, chacun consistant en six traitements organisés selon un plan complètement randomisé et répliqués trois fois. Les traitements dans chaque essai ont été trois taux de VA: 150 ml, 250 ml et 500 ml par pot; 1,55 g et 0,78 g de NPK 15:15:15 par pot (75 kg / ha ou 37,8 kg / ha de N, P et K) et aucun engrais. La hauteur, le poids sec et le poids frais (rendement économique) des légumes ont été significativement affectés par les traitements. La réponse générale a été de produire 500 ml de plantes VA équivalentes à celles ayant reçu 37,8 kg / ha de N, P et K, mais significativement plus hautes, avec un poids sec et frais plus élevé par rapport aux autres traitements à la VA. L'analyse en laboratoire de l'extrait de feuille de VA utilisé pour l'essai a montré que la concentration de K était de 877,21 mg / l; tandis que N et P, Ca et Mg étaient respectivement de 122,42, 70,09, 24,22 et 11,89 mg / l. La VA contenait des nutriments fertilisants dans un rapport d'environ 2: 1: 7. L'étude conclut que l'extrait aqueux de V. amygdalina peut être utilisé comme source d'éléments nutritifs dans les systèmes de culture biologiques.

Mots-clés: Vernonia amygdalina, extrait de feuille, engrais organique.

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Introduction

Land degradation and reduction in soil fertility have been identified as the greatest challenge for sustainable crop production in the tropics where nutrients are lost through crop removal (Agegnehu and Amede, 2017). Use of chemical fertilizers was associated with the challenges of scarcity, high prices and pollution of ground water (Savci, 2012). The use of more eco-friendly practices for sustainable crop production, like crop rotation, animal manure, green manure, alley cropping have re-emerged in recent years (Kumari, *et al*., 2014).

Vernonia amygdalina popularly referred to as bitter leaf is a shrub that is popular in many parts of the tropics. Although some nutritional, medicinal and antioxidant values of this plant have been documented (Kadiri and Olawoye, 2016, Hamman *et al*; 2016, Offor, 2014), it seems there are other usefulness of the plant yet to be discovered. When used as vegetable the leaves are macerated and washed repeatedly with water to extract, remove or reduce the bitter taste to an acceptable minimum level cooking it. Even after the process of maceration and several washing, both the leaves and the extract remain green after series of washing. Greenness in plant is associated with the pigment chlorophyll which is rich in nitrogen and magnesium that are essential mineral nutrients required for plant growth, development and yield.

Celosia argentea, Amaranthus spp and *Cochorus spp* are common leafy vegetables consumed in many tropical areas of the world of which Nigeria is among. These crops are rich in proteins, vitamins and minerals essential for human healthy living (Alegbejo, 2013; Ebert *et al*., 2011, Choudhary *et al*., 2014, Adeyeye et al., 2013 and Olawuyi et al., 2014). The leaf of *Celosia argentea* has also been reported to have some medicinal properties as it contain phenols, flavonoids, saponins, alkaloids, tannin, carbohydrate, glycosides, protein, gum, mucilage and vitamins (kanu *et al*., 2017). Similarly, leaves of *Corchorus* spp have long been used in many cultures as laxatives, for skin care and treatment of wide range of diseases and it contains Vitamins A, C and E (Islam, 2013). Amaranthus leaves also contain some vitamins like thiamine, niacin, riboflavin, vitamin B6, folate, vitamin C, vitamin E, and minerals like calcium, iron, magnesium, manganese, phosphorus, potassium and zinc; as well as carbohydrates, fat and protein (http://www.diarystore.com). However, sustainable production of these vegetables is hinged on, among other factors, adequate nutrient supply. This study was therefore conceptualized to evaluate the fertilizer potential of aqueous extract of *Vernonia amygdalina* (VA) using *Celosia argentea, Amaranthus hybridus and Cochorus olitorious*. Successful utilization of the leaf aqueous extract of VA will therefore translate to conversion of what hitherto has been considered as waste to wealth.

The objectives of this study are to ascertain the nutrient content of the aqueous leaf extract of *Vernonia amygdalina* and to evaluate its influence on growth performance of the test crops.

Materials and Methods

Experimental site treatments and design

The trial was a pot experiment carried out at College of Plant Science and Crop Production of the Federal University of Agriculture Abeokuta, Ogun State Nigeria between the month of October and November, 2017.Three leafy vegetables: *Amaranthus hybridus, Cochorus olitorius* and *Celosia argentea* were evaluated simultaneously for their growth response to three rates of VAaqueous leaf extract (150, 250 and 500 ml per pot) and three controls: two rates of NPK 15:15:15(0.78g and 1.55g per pot) and no fertilizer application. Thus given a total of six treatments arranged in completely randomized design and replicated three times per vegetable.

Routine soil analysis and chemical analysis of aqueous leaf extract of *Vernonia amygdalina* leaf

Routine soil laboratory analysis of the soil used for the study, as well as chemical analysis of the aqueous leaf extract of *Vernonia amygdalina* was carried out. The pH of the soil was measured using the pH meter while the particle size analysis was done using the Bouyocous hydrometer method. The total nitrogen was determined using the micro Kjeldhal method, total carbon was determined by the Walkey- Black method, P content was determined using the Bray-1 method, while the Na, K, Ca and Mg content were determined using the Ammonium acetate method.

Preparation of aqueous extract of *Vernonia amygdalina*

Fresh leaves of *Vernonia amygdalina (*2.225 kg) were harvested from a farm was pounded in a mortar, the macerated leaves were rinsed repeatedly with a total of 9000 ml of tap water and sieved to obtain the extract (1 g of leaves to 4 ml of water). The moisture content of the leaves was 14.7%. The extract was stored in plastic bottles for 7 days under room temperature before application. The aqueous extract was analysed in the laboratory for N, P, K, Ca and Mg content.

Planting of vegetables and application of treatments

Seven (7) kg of homogenized sandy loam soil each was put in 54 plastic pots and watered to field capacity. The three leafy vegetables were planted in18 pots each. The seed rate for each was 0.5g/pot, 0.3g/pot and 0.2 g/pot for cochorus, celosia and amaranthus respectively. The seeds of the vegetables were sown on the 13th of October, 2017. The liquid extract was applied at the rate of 50, 150 or 250 ml (equivalent to 6.12, 18.36 and 30.61 mg N) per pot one week after sowing of seeds, while chemical fertilizer was applied 2 weeks after planting at the rate of 0.78g and 1.55g per pot representing, 37.8 kg/ha and 75 kg/ha respectively of N, P_2O_5 and K_2O/ha using NPK 15:15:15. The quantity applied per pot was arrived at by using the weight of soil per hectare furrow slice ($2.26 X10^6$).

Data collection and statistical analysis

Data were collected on the plant height, fresh and dry weight of the vegetables. Plant height was taken using a meter rule, while fresh and dry weight per plant were determined by weighing with a sensitive scale before and after oven drying to stable weight. The value for each parameter was average measured from two plants per pot. The data collected were analyzed using analysis of variance; significant means were separated using least significant difference (LSD). Genstat statistical package was used for the analysis.

Results

Chemical analysis of the soil and *Vernonia amygdalina* leaf extract used for the trial

The results of the pre planting physical and chemical analysis of the soil used for the study showed that the soil was sandy (914 g/kg, 38 g/kg and 48 g/kg for sand silt and clay respectively). Percentage nitrogen was 0.7 g/kg available P was 7 mg/g, pH 6.7, Na, K, Ca and Mg were 0.26, 0.43, 2.04 and 0.54 respectively in $cmolkg^{-1}$ (Table 1).

The results of the laboratory analysis of the VA leaf extract used for the trial (Table 2) on the other hand showed that the concentration of potassium was the highest in the extract: 877.2 mg/l; while nitrogen and phosphorus, calcium and magnesium were 122.4, 70.1, 24.2 and 11.9 mg/l respectively.

Table 1: Some physical and chemical properties of the soil before planting

Parameters determined	Quantity/Value
pH	6.7
Na ($cmolkg^{-1}$)	0.26
K ($cmolkg^{-1}$)	0.43
Ca ($cmolkg^{-1}$)	2.04
Mg ($cmolkg^{-1}$)	0.54
Al+H ($cmol\ kg^{-1}$)	0.1
Total Organic Carbon (%)	0.59
Total Nitrogen (g/kg)	0.7
Sand (g/kg)	914
Silt (g/kg)	38
Clay (g/kg)	48
Available P (mg/kg)	7
Textural Class	Sandy

Table 2: Laboratory analysis of aqueous extract of leaves of *Vernonia amygdalina*

Nutrient	Value(mg/l)
Nitrogen	122.42
Phosphorus	70.09
Potassium	877.21
Calcium	24.22
Magnesium	11.89

Table 3: Growth of vegetable amaranth as influenced by rates of aqueous extract of leaves of *Vernonia amygdalina* and NPK fertilizer at 3,4, 5 and 6 weeks after planting (WAP)

	Plant height (cm)			Fresh weight (g/plant)				Dry weight (g/plant)			
Treatment	4	5	6	3	4	5	6	3	4	5	6
500ml VA	9.0	14.6	21.7	0.34	1.00	1.44	2.62	0.05	0.13	0.18	0.52
250ml VA	10.0	9.3	12.0	0.27	0.79	1.01	1.46	0.06	0.08	0.27	0.40
150ml VA	5.7	9.3	10.3	0.27	0.66	0.77	0.79	0.06	0.09	0.16	0.43
No Fert.	5.7	6.7	7.67	0.26	0.41	0.62	0.48	0.07	0.06	0.15	0.25
0.78g NPK15:15:15	14.7	18.7	20.0	0.51	1.35	2.32	2.62	0.07	0.23	0.52	0.58
1.55g NPK15:15:15	11.0	24.3	27.7	0.57	2.16	3.34	4.11	0.10	0.27	1.35	1.16
LSD (p=0.05)	4.36	4.42	2.22	0.18	0.28	0.48	0.86	0.03	0.05	0.24	0.19

500ml VA = 500ml of Vernonia amygdalina leaf extract per pot, No fert.= No fertilizer

Table 4: Growth of *Celosia argentea* as influenced by rates of aqueous extract of leaves of *Vernonia amygdalina* and NPK fertilizer at 3,4, 5 and 6 weeks after planting (WAP)

	Plant height (cm)			Fresh weight (g/plant)				Dry weight (g/plant)			
Treatment	4	5	6	3	4	5	6	3	4	5	6
500ml VA	12.3	20.0	22.0	0.42	0.67	3.91	4.22	0.06	0.16	0.26	0.69
250ml VA	13.0	13.7	20.3	0.38	0.63	1.47	1.71	0.07	0.10	0.22	0.36
150ml VA	10.3	12.3	16.7	0.37	0.59	1.45	1.92	0.07	0.14	0.23	0.33
No Fert.	9.0	11.3	14.0	0.33	0.44	0.80	1.49	0.06	0.11	0.15	0.23
0.78g NPK15:15:15	15.0	19.3	26.7	0.72	1.77	3.21	3.09	0.09	0.29	0.46	0.36
1.55g NPK15:15:15	16.0	24.7	37.3	0.78	1.91	5.67	5.52	0.43	0.28	0.71	0.54
LSD (p=0.05)	3.82	4.46	2.65	0.13	0.80	1.18	0.98	Ns	0.08	0.09	0.17

500ml VA = 500ml of *Vernonia amygdalina* leaf extract per pot, No fert.= No fertilizer

Table 5: Growth of *Cochorusolitorius* as influenced by rates of aqueous extract of leaves of *Vernonia amygdalina* and NPK fertilizer at 3,4, 5 and 6 weeks after planting (WAP)

	Plant height (cm)			Fresh weight (g/plant)				Dry weight (g/plant)			
Treatment	4	5	6	3	4	5	6	3	4	5	6
500ml VA	19.7	26.3	31.67	0.67	1.05	2.05	2.20	0.09	0.08	0.33	0.41
250ml VA	19.0	23.7	28.3	0.49	0.67	0.99	2.02	0.08	0.05*	0.30	0.33
150ml VA	16.0	22.3	27.7	0.41	0.41	0.90	1.19	0.04	0.05	0.27	0.25
No Fert.	15.7	20.3	26.0	0.34	0.34	0.87	0.74	0.01	0.01	0.20	0.21
0.78g NPK15:15:15	28.3	36.7	41.3	0.76	0.76	2.27	2.42	0.09	0.12	0.54	0.48
1.55g NPK15:15:15	32.0	43.0	48.7	0.93	0.93	3.32	4.11	0.10	0.19	0.66	0.81
LSD (p=0.05)	8.31	4.51	2.97	0.12	0.12	0.42	0.78	0.02	0.05	0.11	0.12

500ml VA = 500ml of *Vernonia amygdalina* leaf extract per pot, No fert.= No fertilizer

Growth of vegetable amaranth as influenced by rates of aqueous *Vernonia amygdalina* leaf extract and NPK fertilizer

Plant height of vegetable amaranth was significantly increased by application of aqueous leaf extract of bitter leaf in this study. At 4 WAS applications of 500ml and 250 ml per pot produced plants with similar plant height which were significantly taller than plants with 150 ml which was similar to the control (no fertilizer treatment). Application of 1.55g of NPK 15:15:15 resulted in the tallest plants which were similar to application of 0.78g/pot of the same fertilizer (Table 3). At 5 and 6 WAP plants grown with 250ml and 150 ml of the extract had similar height and were significantly taller than the no fertilizer treatment at 6 WAP. At 5 and 6 WAP, application of 500ml of the extract produced plants that were as tall ($p>0.05$)as those that received 0.78g/pot of NPK 15:15:15, but were shorter than plants that received 1.55g/pot of NPK 15:15:15 (Table3).

The results of the fresh and dry weight of vegetable amaranth as influnced by aqueous extract of Vernonia leaves as presented in Table3 revealed that the plant extract significantly increased the fresh weight of vegetable amaranth at 4 and 6 WAP. Plants grown with 500 ml of the extract had

significantly higher fresh weight compared with those that received 150ml of the extract as well as the control (no fertilizer) at 4WAP. At 6 WAP however, application of 500ml Vernonia extract produced plants with fresh weight similar ($p>0.05$) to those treated with 0.78g NPK 15:15:15 per pot and were significantly higher than the fresh weight from 250 and 150ml extract, as well as the control (no fertilizer). Highest fresh weight ($p<0.05$) was from the treatment that received 1.55g NPK 15:15:15 per pot (75kg N, P_2O_5, K_2O hectare).

There was no significant difference between the dry weights of vegetable amaranth from the different rates of Vernonia leaf extract, 0.78g NPK 15:15:15 and no fertilizer control at 5 and 6 WAP; however at 6 WAP, application of 500ml of the extract and 0.78g NPK 15:15:15 produced plants with similar dry weight which were higher than values obtained from plants that received 150 or 250ml of extract which were equally similar and slightly higher than that of the no fertilizer (control) ($p>0.05$).

Growth of *Celosia argentea* as influenced by rates of aqueous *Vernonia amygdalina leaf* extract and NPK fertilizer

At 4WAP all the rates of the aqueous leaf extract of Vernonia produced plants with similar height ($p>0.05$), which were similar to treatment that received 0.78 g/pot of NPK 15:15:15, and significantly taller than the no fertilizer treatment. At 6 WAP, application of 500ml and 250ml of Vernonia leaf extract produced plant with similar plant height, which were significantly taller than when 150ml was applied and the no fertilizer plot that produced the shortest plant ($p<0.05$). The tallest plants were however produced by application of 1.55g/pot NPK 15:15:15 at 4, 5 and 6 WAP.

Fresh and dry weight of Celosia as influenced by application rates of bitter leaf extract is presented in Table 4. At 4 WAP, all rates of VA extract and control produced plants with similar fresh weight ($p>0.05$) which were significantly lower than the fresh weight produced by the two rates of NPK 15:15:15, which were equally similar. At 6 WAP however, application of VA led to significant increase in fresh weight of *Celosia argentea* such that 500 ml extract > 0.78g NPK 15:15:15 > 250 ml extract = 150 ml extract = control.

Results of the dry weight of Celosia in this study showed that application of 500 ml of VA extract produced plants with dry weight that were similar to the dry weight obtained with application of 1.55g of NPK 15:15:15 but significantly higher than weight obtained by the application of all other VA rates and no fertilizer control at 6WAP.

Growth of *Cochorus olitorius*as influenced by rates of aqueous *Vernonia amygdalina* leaf extract and NPK fertilizer

The plant height, fresh weight and dry weight of *Cochorus olitorius* as affected by rates of leaves extract of *V. amygdalina* is presented in Table 5. Plant height of cochorus was also significantly enhanced by the application of the leaf extract of bitter leaf in this study. At 4WAP, application of 500ml and 250ml of the extract produced plants that were as tall as those produced when 0.78g/pot of NPK 15:15:15 was applied. At 6 WAP, all the rates of the plant extract produced plants with similar height which were significantly taller than plants on the control (no fertilizer) plot; the tallest plant was from those that received 1.55g/pot of NPK 15:15:15 (Table5).

Fresh and dry weight of *Cochorus olitorious* as influenced by application of VA is presented in Table5. Application of 500ml of VA and 0.78g NPK 15:15:15 produced similar ($p>0.05$) fresh weight of Cochorus at 3,4 5 and 6 WAP, this ranked next ($p>0.05$) to the fresh weight produced when 1.55g/pot NPK 15:15:15 was applied during the same period. The lowest ($p<0.05$) fresh weight was produced by the control (no fertilizer plot); this ranked same with application of 150 ml VA at 4, 5 and 6 WAP.

On the other hand, the dry weight value of cochorus plant showed that application of 500, 250 or 150 ml of VA produced similar dry weight value at the 5th and 6th WAP; the least ($p<0.05$) dry weight value recorded was from the control plot, while the highest value ($p<0.05$) was recorded on plots that received 1.55g/pot NPK 15:15:15.

Discussion

Chemical analysis of the VA extract showed that the extract contained the fertilizer nutrients N, P, K in the approximate ratio of 2:1:7 apart from other nutrients. This is very important because any material that is considered as a potential fertilizer must contain and supply the required nutrients for plant growth. The moisture content of the Vernonia amygdalina leaves used for this study is slightly higher than the 10.02 and 10.55% reported from earlier studies as reported by Kadiri and Olawoye (2016); this difference can be as a result of stage of plant at harvesting; and environmental factors (Kadiri and Olawoye, 2016).

Similar response of the plant height, fresh and dry weight of these leafy vegetables to application of VA extract suggests that application of 500 ml of the extract will supply nutrients to the

vegetables that will produce plant performance equivalent to that which can be obtained by applying 37.5 kg/ha each of N, P_2O_5 and K_2O. The analysis of the VA extract showed that it contained plant nutrients in the ratio of 2:1:7: The positive response of the vegetables to the applied extract could be due to additional nutrient elements present in the extract apart from N,P and K. The substantial presence of calcium and magnesium in the extract is also very important as it has been reported that yields of 25 t/ha of vegetable amaranth will extract 125 Kg N, 25 Kg P, 250 Kg K, 75 Kg Ca and 40 Kg Mg from the soil (Ebert et al. 2011). Offor (2014) had reported that the leaves of *Vernonia amygdalina* contains varying concentrations of chemical, elemental and macronutrient components that can serve as a good source of useful elements. Kadiri and Olawoye (2016) also reported that the nutritional analysis of *Vernonia amygdalina* revealed that it is rich in the nutrient P, Fe, Zn, Mn, and calcium. This result is however at variance with the findings of Chukwuka *et al*. (2014) who reported that the extract of VA inhibited the plumule development of maize compared to the control and that of growth, development and yield of maize were not significantly affected by the plant extracts. Growth response of the vegetables to VA extract in this study could be due to the fact that the extract was applied to growing seedlings and not to sown or germinating seeds.

Conclusion

The response of the growth parameters of the three leafy vegetables in this study revealed that aqueous extract of *V. amygdalina* can be used intentionally as a nutrient source in organic cropping systems. This was proven by similar response of growth parameters of the three vegetables.

Further studies will however be needed to ascertain consistence of the results obtained in this study on the field, as well as the economic feasibility of the producing the test crops in large scale with the leaf extract.

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