

EFFECTS OF UREA AND WOOD ASH ON SOIL CHEMICAL PROPERTIES, GROWTH AND DRY MATTER YIELD OF AMARANTHUS

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ABSTRACT

Apot experiment was carried out in Michael Okpara University of Agriculture, Umudikein 2017 to compare the effects of wood ash and urea on the growth and dry matter yield of *Amaranthuscruentus*, as well as the soil chemical properties after harvest. It was a greenhouse experiment that involved five treatmentsviz: T1- control, T2- wood ash (5tons/ha), T3- urea fertilizer (500kg/ha), T4- wood ash (2.5tons//ha) + urea (250kg/ha) and T5-urea (250kg/ha). Eightkilograms of the soil sample was weighed into 15 different perforated 10-litre capacity plastic pots and the treatments were applied in three replicates, arranged in a completely randomized design. The soil of the study area was acidic, having a pH of 4.60 and 5.70 in salt and water respectively. It was also low in organic carbon (1.38%), total nitrogen (0.90%) and the exchangeable bases. The results of the stem girth (3.43 cm at harvest), plant height (37.70 cm at harvest), number of leaves (24.33), percentage plant dry matter, and soil chemical properties after the harvest of *Amaranthus* in the green house revealed that T2 (wood ash 5tons/ha) and T4 (wood ash 2.5tons/ha + urea 250kg/ha) gave the highest values in plant height, stem girth, number of leaves and soil chemical properties, while T3 (500 kg/ha of urea) gave the highest value for dry matter yield of *Amarathuscruentus*. It was therefore concluded from the results that wood ash and urea fertilizer application either solely or combined gave the best growth in *Amarathuscruentus*. It also improved the soil chemical properties of the study area.

Key words: Urea, Wood ash, Amaranthus, Dry-matter, Nutrient availability

INTRODUCTION

*Amaranthuscruentus*L. commonly known as Amaranth belongs to the family *Amaranthaceae*. It is a leafy vegetable commonly cultivated in Nigeria and other West African countries (Olorode, 1984). It has a growing period of 5 to 6 weeks, thus making it an advantage for the rural and peri-urban farmers in Nigeria to keep cultivating it two or more times on the same piece of land in a year (Adewole and Igberaese, 2011). Till date, the bulk of vegetables consumed in Nigeria are supplied by subsistence farmers. Apart from *A. cruentus* used as a vegetable, its grains can also be cooked as a cereal, popped like popcorn, toasted or even ground into flour for baking (Railey, 1999). Vegetable supply to areas of high demand has remained low and seasonal as most of the subsistence farmers continue to rely on natural rainfall. Most developing countries depend on starch-based foods as the main staple food for the supply of both energy and protein. This accounts in part for protein deficiency which prevails among the populace as recognized by food and agricultural organization (Ladejiet *al*, 1995); vegetable fats and oils are known to lower blood lipids thereby reducing the occurrences

of diseases associated with the damage of the coronary artery (Adenipenkun and Oyetunji 2010).

Urea, a white crystalline solid containing 46% nitrogen is widely used in the agricultural industry as an animal feed, additive and fertilizer. Its breakdown begins as soon as it is applied to the soil, if the soil is totally dry, no reaction happens but within the enzyme urease, plus any small amount of soil moisture, urea normally hydrolyzes and converts to ammonium and carbondioxide. Excessive concentration of urea is likewise toxic to the tissues; it has to be diluted with enough water and excreted (Maynard *et al.*, 1979)

Wood ash results from burning or gasifying wood and consists mainly of minerals that the trees have absorbed over their lifetime (Kofman, 1987).A good wood ash is light grey; if the ash is black, it means that the fuel has not completely combusted (Owens and Cooley, 2013).Some of the problems encountered by amaranth growers in Nigeria are the low soil fertility and lack of capital to buy chemical fertilizers for optimum crop productivity (Olufolajiet *al.*, 1990; Adeyemiet *al.*, 1987). Most African soils are

inherently low in organic carbon, slightly acidic and relatively sandy.

Though several works reporting compositional evaluation and functional properties of various edible wild plants in use in the developing countries abound in literature, much still need to be done. Many workers (Locke et al., 2000; Akindahunsi and Salawu, 2005; Edeoga et al., 2006; Hassan and Umar, 2006; Ekop, 2007) have reported the compositional evaluation and functional properties of various types of edible wild plants in used in the developing countries. Not

MATERIALS AND METHODS

Description of the Experimental Site

Site Location

The experiment was conducted at Michael Okpara University of Agriculture, Umudike. Umudike lies within the latitude 05° 29' N and longitude 07° 33' E at an elevation of 122mm above the sea level.

Soil Sampling/Sample Preparation

Soil sampling was carried out at the Eastern farm of Michael Okpara University of Agriculture, Umudike. Samples were collected at the depth of 0-15cm at various points of the field and bulked together. The samples were air-dried and sieved through a 2mm mesh to remove roots and stones.

Physical and chemical properties of the soil

Particle Size Analysis

The particle size analysis was carried out using Bouyoucos hydrometer method (Jackson, 1964).

Soil Reaction (pH)

Soil pH was determined using glass electrode pH meter in a soil to water ratio of 1:2.5 (Black, 1965).

Exchangeable Acidity (Al^{3+} and H^+)

Soil exchangeable acidity (Al^{3+} and H^+) was determined by titration method (McLean, 1982).

Organic Carbon

Soil organic carbon was determined by Walkley and Black (1934) method

Total Nitrogen

Soil percentage total nitrogen was determined using the micro Kjeldahl digestion and distillation method (Jackson 1964).

Available Phosphorus

Available phosphorus was extracted using Bray and Kurtz (1945) number two extractant.

The Exchangeable bases

much work has been done on the effect of wood ash and urea on the growth and nutrient content of *Amaranthus* spp in Umudike Ultisols in the recent past.

OBJECTIVES OF THE STUDY

The objectives of the study were:

1. To compare the effects of wood ash and urea on the growth and dry matter yield of *Amaranthus* spp.
2. To compare the effects of wood ash and urea fertilizer on the soil chemical properties after harvest.

The soil was leached with 1N NH_4OAc (ammonium acetate) at pH 7; calcium and magnesium was determined using EDTA titration method while potassium and sodium were determined by flame photometry

Effective Cation Exchange Capacity

Effective cation exchange was calculated as the sum of exchangeable bases (Ca^{2+} , Mg^{2+} , Na^+ and K^+) and exchangeable acidity (H^+ and Al^{3+}).

Base Saturation

The percentage base saturation was determined using equation.

$$\text{Base saturation} = \frac{\text{Total exchangeable bases} \times 100}{\text{Effective cation exchange capacity}} \quad 1$$

Treatments

Five treatments were used namely:

- T_1 -Control
- T_2 - Wood ash-5tons/ha
- T_3 - Urea fertilizer- 500kg/ha
- T_4 - Wood ash-(2.5tons/ha) + Urea 250kg/ha
- T_5 -Urea-250kg/ha

Wood ash analysis

The wood ash used for the greenhouse experiment was collected from the University students' canteen kitchen, MOUAU. It was sieved with 2mm mesh and analyzed for Phosphorus, Calcium, Magnesium, Sodium and Nitrogen using standard laboratory procedures.

Greenhouse Experiment

Amaranthus seeds were pre germinated for about three weeks before transplanting to the greenhouse. 8kg of the soil sample was weighed into 15 different perforated 10-litre capacity plastic buckets and the treatments were applied in three replicates. The buckets were arranged in a Completely Randomized Design (CRD). Data were collected on the *Amaranthus* spp at weekly intervals for six weeks. They were plant height (cm), stem

girth (cm) and number of leaves every week for six weeks.

Plant Dry Matter Determinations

At 6 weeks after transplanting in the greenhouse, the *Amaranthus* plant was harvested and weighed. It was oven-dried to obtain a constant weight for the determination of the dry matter yield.

The dry matter yield was calculated thus:

$$\text{Initial weight of sample} = x$$

$$\text{Final weight of sample} = y$$

$$\therefore \% \text{ dry matter} = \frac{y}{x} \times \frac{100}{1} \quad (\text{Eteng, 2011})$$

Soil Chemical properties after harvest

RESULTS AND DISCUSSION

Physical and Chemical properties of the soil used for the experiment

The physical and chemical properties of the soil used for the experiment results are as shown in Table 1. The values of sand, silt and clay were 758.00, 84.00 and 158.00 g/kg respectively. The textural class of the soil was sandy loam. The soil texture indicated that the soil was vulnerable to nutrient leaching (Beegle and Lingerfelth 1996). The pH value

At harvest, soil samples were collected and analyzed for the following chemical properties: Soil Reaction (pH), Exchangeable Acidity (Al^{3+} and H^+), Organic Carbon, Total Nitrogen, Available Phosphorus, the Exchangeable Bases, Effective Cation Exchange Capacity and Base Saturation.

Statistical Analysis

Data collected from the laboratory analysis and green house experiment were subjected to Analysis of Variance (ANOVA) and significant means was separated using Fisher's Least Significant Difference (FLSD) at 5% probability level.

of the soil was 5.70 and 4.60 in water and salt respectively, which was an indication of strong acidity (Chudeet *al.*, 2005). The soil total nitrogen was 0.10%, which was lower than the critical level reported by Adeoye and Adegbola (1984) for most soils of southern Nigeria. The low level of nitrogen could be a result of losses through crop removal, erosional and leaching losses, and high rate of mineralization (Agbede, 2009). The available phosphorus was 19.60 mg/kg, which was higher than the critical value of 12-15 mg/kg for most crops (Enwezor, 1997).

Table 1: Physical and Chemical Properties of the Soil Used for the Experiment

Parameters	Values
Soil pH (H_2O)	5.70
pH (salt)	4.60
Organic Carbon (%)	1.38
Organic Matter (%)	2.37
Available Phosphorus (mg/Kg)	19.60
Nitrogen (g/kg)	0.10
Exchangeable K (cmol/kg)	0.24
Exchangeable Na (cmol/kg)	0.18
Exchangeable Ca (cmol/kg)	3.07
Exchangeable Mg (cmol/kg)	2.00
Exchangeable acidity (cmol/kg)	1.34
ECEC (cmol/kg)	6.83
Base Saturation (%)	80.38
Sand (g/kg)	758.00
Silt (g/kg)	84.00
Clay (g/kg)	158.00
Soil Texture	Sandy Loam

The chemical properties of the ash used for the experiment

The chemical properties of the ash used for the experiment are as shown on Table

2, the ash was high in pH (9.15), indicating an alkaline nature. It was also high in most soil chemical properties: Calcium (4.60), Phosphorus (39.90), Al (0.52), Organic

Carbon (9.91), Organic matter (17.08), Magnesium (4.60), Potassium (1.20), sodium (0.65). The high organic matter content of the ash showed its potential ability to improve the soil chemical properties including the

pH. Akinmutimi and Ihejirika (2016) reported a similar result when they evaluated the effect of ash and poultry manure on growth and dry matter yield of maize.

Table 2: Chemical Properties of the Ash Used For Experiment

Parameters	Values
Ash pH (H ₂ O)	9.15
Organic Carbon (%)	9.91
Organic Matter (%)	17.08
Phosphorus (%)	39.90
Nitrogen (%)	0.52
Potassium (%)	1.20
Sodium (%)	0.65
Calcium (%)	10.80
Magnesium (%)	4.60

Effects of the sole and combined application of urea and wood ash on the height and stem girth of *Amaranthus cruentus* in the green house

Table 3 shows the effect of sole and combined application of urea and wood ash on the height and stem girth of *Amaranthus cruentus* in the greenhouse. The height increased from the beginning to the end of experiment (week 1 to week 6). However, there were no significant differences among the treatment means except at weeks 4, 5 and 6 where T2 (5 tons/ha wood ash) gave the highest significant values in weeks 4, 5 and 6. This could be as a result of the liming effect of ash on the soil which was obvious from 4 weeks after transplanting and made all the essential nutrients to become available (Agbede, 2009); wood ash will

release basic cations as it neutralizes soil acidity (Ohno and Erich, 1994), which could have resulted into an increase in plant height.

These stem girth increase steadily from the first to the sixth week after transplanting. T2 (5 tonnes/ha) of wood ash gave the highest at the third, fourth and sixth week after transplanting but the increase was not significant from the time of planting except at the sixth week. It could be that the mineralization of the ash was delayed till about sixth week after transplanting. Wood ash had been reported to be useful in enriching agricultural soil nutrition, it serves as a source of potassium and calcium carbonate which could have contributed to the increase in stem girth brought about by wood ash (Lerner, 2008)

Table 3: Effects of the Sole and Combined Application of Urea And Wood Ash on the Height and Stem Girth of *Amaranthus cruentus* (Cm) in the Green House

WAT= Weeks after transplanting; PH= Plant height; SG= Stem girth

Treatments	1 WAT		2 WAT		3 WAT		4 WAT		5 WAT		6 WAT	
	PH	SG	PH	SG	PH	SG	PH	SG	PH	SG	PH	SG
T1	5.50	0.77	8.23	0.97	10.30	1.17	13.00	1.33	16.50	1.83	21.20	1.77
T2	6.00	1.43	11.03	1.70	15.60	1.77	22.80	2.37	29.80	2.03	37.70	3.43
T3	7.10	2.73	9.73	1.20	10.10	1.13	11.80	1.13	12.80	1.13	15.20	1.13
T4	7.27	1.13	11.27	1.40	16.00	1.53	21.10	2.07	27.20	2.37	37.00	2.80
T5	5.27	0.90	7.37	1.00	9.20	1.07	11.80	1.33	14.80	1.47	19.00	1.53
LSD (0.05)	NS	NS	NS	NS	NS	NS	8.35	NS	8.42	NS	10.85	1.04

Effects of the sole and combined application of urea and wood ash on the number of leaves of *Amaranthus cruentus* in the greenhouse and dry matter yield after harvest

Table 4 shows the effects of the sole and combined application of urea and wood ash on the number of leaves of *Amaranthus cruentus* in the greenhouse and

dry matter yield after harvest. The number of leaves increased from the first week to the sixth week after transplanting, T2 (5 tons/ha wood ash) and T4 (2.5 tons/ha urea+wood ash) gave the highest increase at one time or the other during the planting period in the green house. However, that increase was not significant from the beginning of the experiment until the 6th week after

transplanting. Ash contains some essential nutrients which could have led to the increase in the number of leaves, in this experiment (Table 2). Akinmutimiet *al.* (2013) also reported that wood ash contained some essential nutrients that enhance crop growth. Concerning the dry matter yield of

Amaranthuscruentus after harvest, there were no significant differences ($p > 0.05$) among the treatment means. Although, T3 (500 kg/ha of urea) gave the highest value of plant dry matter yield. Akanbiet *al.* (2009) reported higher yield of *Amaranthus* with higher levels of urea application

Table 4: Effects of the Sole And Combined Application of Urea And Wood Ash on the Number of Leaves of *Amaranthuscruentus* in the Greenhouse and Dry Matter Yield After Harvest

	1WAT	2WAT	3WAT	4WAT	5WAT	6WAT	Dry matter yield after harvest (%)
T1	5.67	8.33	10.67	12.33	16.00	18.67	8.35
T2	6.00	9.67	13.00	15.67	19.33	24.33	8.25
T3	6.67	9.00	12.67	14.00	16.00	18.67	13.00
T4	7.33	9.67	11.67	15.67	18.67	23.00	8.15
T5	6.00	7.67	9.67	11.67	14.00	17.33	10.50
LSD _(0.05)	N.S	N.S	N.S	N.S	N.S	5.04	NS

WAT= Weeks after transplanting

Effects of the sole and combined application of urea and wood ash on the soil chemical properties of in the greenhouse.

Table 5 shows the effect of sole and combine application of urea and wood ash on the soil chemical properties after harvest. The applied treatments significantly ($P < 0.05$) increased soil pH above the control. Treatments containing wood ash had the highest pH values (T2- 6.80 and T4- 6.67) when compared to other treatments. This was not unusual because wood ash had been reported to have a neutralizing effect on acid soils (Wiklund, 2017; Ohno, 1992). Other soil

chemical properties (Ca, Av.P, T.N, OC, Mg, K, Na, EA, ECEC, BS,) being significantly increased by treatments containing wood ash was in order; the addition of wood ash had previously been shown to provide a significant amount of plant nutrients (Bougnomet *al.*, 2011), especially base cations (Nkanaet *al.*, 1998). This result is in line with the findings of (Nwachukwu and Chukwu, 2012) who reported an increase in some soil chemical properties after the application of ash and organic manure in an Ultisol of Southeast Nigeria.

Table 5: Effects of the sole and combined application of urea and wood ash on the chemical properties of the soil after harvest

-	pH		Av.P	%TN	%	Ca	Mg	K	Na	EA	ECEC	%BS
	Water	Salt	(mg/kg)		OC							
T1	5.30	4.27	17.47	0.08	0.99	3.07	1.47	0.19	0.17	1.48	6.18	76.04
T2	6.80	5.88	26.80	0.19	1.77	7.33	3.03	0.41	0.23	0.12	11.15	98.85
T3	6.40	5.30	21.63	0.22	1.32	5.53	2.40	0.28	0.19	1.00	9.39	89.33
T4	6.67	5.63	24.60	0.23	1.51	6.73	3.07	0.38	0.20	0.57	10.76	94.76
T5	6.00	5.07	20.60	0.17	1.14	5.13	2.07	0.25	0.19	1.23	8.87	86.10
LSD _(0.05)	0.20	0.22	1.70	0.01	0.10	0.88	0.26	0.06	0.02	0.09	0.99	1.29

Conclusion

Results from this study have shown that the soil of the study area was acidic, low in most of the soil nutrients and that wood ash had the potential to increase most of the nutrients. Going by the results of plant height, number of leaves and stem girth, wood ash either solely applied (5 tons/ha) or in

combination with urea (2.5 tons/ha wood ash + 250 kg/ha urea) gave better growth of *Amaranthuscruetus* and increase in soil chemical properties, while 500 kg/ha urea sole application gave the highest dry matter yield. Further research could be carried out as a field experiment using the same treatment levels in the study area.

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