

Effect of Algae and Urea on Soil Nutrient Status and Yield of *Amaranthus Cruentus* in an Ultisol of Southeastern Nigeria

ABSTRACT

A pot experiment was carried out in the Green House of Michael Okpara University of Agriculture, Umudike, Abia State of Nigeria to investigate the effects of algae and urea on soil nutrient indices (pH, P, N, OC, and ECEC) and yield of *amaranthus* in a sandy-loam Ultisol of southeastern Nigeria. The layout was a factorial in Complete Randomized Design (CRD) and treatments comprised of five rates of dried algae (0, 1, 2, 3 and 4t/ha) and four rates (0, 40, 80 and 120kg/ha) of urea in three replications giving a total of sixty observational units. Results showed that the treatments both as lone and combined significantly influenced ($P<0.05$) both the soil nutrient properties and the yield of *amaranthus*. Relative to control, the treatments improved the soil fertility indices and the yield parameters of the *amaranthus* measured and these improvements were proportional to the rate of amendments. With the exception of nitrogen, application of algae consistently showed greater improvement on nutrient properties than urea when applied as lone treatments. It was also observed that with the exception of available exchangeable acidity, the interactions between the two amendments were highly significant ($P<0.05$) in influencing the soil chemical properties. The improvement on the soil chemical properties as a result of these amendments led to corresponding response in the yield of *amaranthus*. Fresh weight, plant height, number of leaves per plant and stem girth increased as a result of the amendments and the increase were also proportional to the rate of amendments with the application algae also showing greater improvement than urea when applied as lone treatments. Statistics showed that with the exception of plant height, the amendments as lone treatments significantly ($P<0.05$) improved the other yield parameter. The interaction between the amendments however were only significant in increasing the fresh weight and stem girth at $P<0.05$.

Keywords: Algae, urea, soil nutrient status.

INTRODUCTION

Soil fertility maintenance under intensive cropping has been a major challenge that is still elusive (Kekong *et al.*, 2008). Emphasis has remained centralized on the use of inorganic fertilizers as the major source of soil nutrients with very low significant regard to organic manures. Although, inorganic fertilizers ensure quick release of nutrients to crops, but over dependency on them have made them scarce and expensive to many poor resource farmers. Apart from these, there are reports of environmental pollution associated with consistence use of inorganic fertilizers (Kushwaha and Ochi, 1991). Ojeniyi and Adeniyi (1999) reported that continuous use of mineral fertilizers aggravates soil acidity, nutrient imbalance and loss of organic matter. Consequently, recent studies have focused on the use of organic manures as soil improvers and source of soil nutrients (Awodun, 2007). Long term conservation of the soils health is the key benefit of organic fertilizers, which is vital to sustainable agriculture (Ghabbour and Aivis, 2001).

On this basis, farmers and scientists are now showing renewed interest in proper and effective use of organic manures to improve the nutrient status and to give a high residual effect on soil fertility. Algae, which is one of the biological and organic component of the soil have been found to contain accumulated nutrients through photosynthesis, nitrogen fixation, mineralization of organic compounds as well as their involvement in mineral weathering (Joseph, 2007). The potentials of algae in soil fertility management was discovered early in the history of agriculture in Coastal Asia and Island of Europe (Dawson, 1966). Eneje and Azu (2009) reported that the application of composted algae to soils led to improvement on chemical properties of soils studied. As in the case of other organic materials, the limitation in the use of algae as nutrient source is the difficulty in obtaining adequate quantities for large scale agriculture. Consequently, recent researches are advocating the combined use of organic and inorganic fertilizers in soil fertility management (Azu et al., 2017). Adediran *et al.*, (1999) observed that supplementation of organic and inorganic fertilizers were more superior to the application of either of the amendment alone. Similarly, FAO (1976) reported that combined use of organic and inorganic fertilizers proved a sound soil fertility management strategy in many countries. Vegetable provide excellent means of supplementing mineral and vitamin deficiencies in the diets of Nigerian when properly cooked (Williams, 1993). *Amaranthus*, also called African spinach, produces the highest amount of protein and dry matter per unit area and time among vegetables (Mesiaen, 1992) and therefore could be a very valuable source of combating under nutrition and mal-nutrition in the tropics (Chadha, 2006), but the potential for sustained *amaranthus* production in southeastern Nigeria is very limited in the absence of amendments due to the inherent low soil fertility status of the area. The effect of combined use of algae and urea on soil chemical and nutrient properties and the response of *Amaranthus cruentus* to these amendments have remained under researched in the humid tropics. It is this inadequate information on the potentials of combined use of algae and urea in fertilizing soils of southeastern Nigeria that informed the choice of this study.

MATERIALS AND METHOD

Sampling Site and Sample Preparation

The study was carried out under Green House condition in Michael Okpara University of Agriculture Umudike, Abia State Nigeria, latitude 5°29'N and longitude 7°35'E, elevation is about 122m above sea level with mean annual rainfall of about 2163mm, mean daily temperature range of 35°C to 20°C and a relative humidity of about 72% (Odurukwe *et al.*, 1995). The soil used for the study was an ultisol from the teaching and research farm of the university and has been classified as Haplic Herisol (FAO/UNESCO, 1958). Soil samples were collected with the soil auger from 0-20cm depth, air dried, sieved with 2mm sieve, after which sub-samples of 5kg each were weighed into 12L capacity plastic buckets perforated at the bottom to allow for air and water movement.

Amendment Collection and Preparation

The algae used in the study were collected from the irrigation path around the university research and farm and other fresh water habitats around the study area and these were air dried, ground and weighed out for application.

The urea was obtained from the Abia State Ministry of Agriculture, Umuahia, while the *amaranthus* was obtained from National Agricultural Seed Service, NRCRI, Umudike.

Pot Experiment

Appropriate weights of algae and urea were taken and mixed thoroughly with the soils. The treatments comprised five rates (0, 1, 2, 3 and 4t/ha) algae and four rates (0, 40, 80 and 120kg/ha) urea arranged factorially in a completely randomized design (CRD) in three replications. The amended soils were incubated for four weeks with adequate watering at field capacity to keep the soils moist for microbial decomposition of the algae to release its nutrient content.

The amaranthus seeds were sown in drills using river sands after the incubation period and thinned to one seedling per bucket after three days of germination. The buckets were kept at about field moisture capacity throughout the green house study according to the method described by Whitehead and Hood (1965). The entire plants were harvested by uprooting after five weeks of planting as described by Shippers (2000) and the following agronomic and yield parameters measured: plant height, number of leaves per plant, fresh weight and stem girth.

Laboratory Analysis

Pre-treatment and post harvest soil samples were subjected to the following chemical analysis: pH (Maclean, 1965) as modified by Eno *et al.*, (2009), organic carbon (Walkley and Black, 1934) total N (Jackson, 1962), available P (Bray and Kurtz, 1945) and ECEC (Kamprath, 1967) as modified by Eno *et al.*, (2009).

Statistical Analysis

Data collected from both yield parameters and soil analysis were subjected to analysis of variance (ANOVA) as outlined by Steel and Torrie (1980) and means were separated using (FLSD_{0.05}).

RESULTS AND DISCUSSION

Physical and Chemical Properties of the Soil Used for the Study.

Results showed that the soil used for the study was loamy sand (Table 1). The soil was acidic with mean values of 5.01 and 4.12 in water and CaCl₂ respectively which are below the pH range of 5.5-7.5 reported by Raemaeker (2001) as optimum for amaranthus production. The low value of pH (Udo *et al.*, 2009) indicated soil acidity and therefore suggested the need for liming in order to ensure the release of essential elements for plant growth (Onwuka *et al.*, 2009; Eneje and Azu, 2009). Organic carbon was low (13%) indicating a low soil fertility status (Woomer and Ingram, 1990). Total N was low with value of 0.103% which is less than the critical level of 0.15% reported by Adeoye and Agbola, (1984) for soils of humid tropical region. The low N level could be attributed to the high rate of mineralization and subsequent high rate of leaching that accompany the heavy rains associated with the forest zone of southeastern Nigeria (Osodeke, 1996). The soil also indicated a medium level of phosphorus with value 15.12mg/kg which is slightly higher than the critical level of 15mg/kg for most tropical crops (Osodeke and Uba, 2005). Generally, the soil was low in exchangeable cations, consequently, the ECEC was low (4.76) and B.S was

69.33%. The result of the physical and chemical properties of the soil used for the study generally showed that the soil was inherently low in fertility and therefore requires external fertilizer input for optimum and sustainable amaranthus production.

Table 1: Physicochemical Characteristics of the Soils Used for the Study

Characteristics	Value
Sand (%)	82.80
Silt (%)	8.80
Clay (5)	8.40
Textural class	Loamy sand
pH (H ₂ O)	5.01
pH (CaCl ₂)	4.12
Organic carbon (%)	1.13
Organic matter (%)	1.95
Total nitrogen	0.103
Av. P (mg/kg)	15.12
Ca (Cmol/kg)	2.00
Mg (Cmol/kg)	0.10
K (Cmo/kg)	0.11
Na (Cmol/kg)	0.09
E.A (Cmol/kg)	1.46
ECEC (Cmol/kg)	4.76
B.S (%)	69.33

Chemical Properties of the Algae used for the study.

The nutrient composition of the algae used for the study is presented on Table 2. The algae contained high amount of N, P, Ca, Mg and OC, but moderately low in K and Na. Eneje and Azu (2009) reported a low Na content in algae which was responsible for increased aggregate stability of soils treated with algae. The high pH observed in the algae which is in agreement with the findings of Eneje and Azu (2009) and Azu *et al.*(2017) indicated the ability of algae in reducing acidity in soils. Thus, it is expected that, this high nutrient content in algae will have the potentials of establishing greater improvement on the chemical conditions of the soil under study as well as improve the nutrients and yield of Amaranthus..

Table 2: Characteristics of the Algae used for the Study

Properties	Values
pH (H ₂ O)	8.86
pH (CaCl ₂)	7.92
Av.P (%)	19.04
Nitrogen (%)	2.28
Calcium (%)	6.66
Magnesium (%)	2.81
Potassium (%)	0.53
Sodium (%)	0.04
Organic carbon (%)	2.03

Effect of Algae and Urea on Soil Chemical Properties:

The soil chemical and nutrient properties were all positively influenced by the application of algae and urea (Table 3). Significant differences ($P < 0.05$) due to the treatments were observed. Generally, treatments either as lone or combined gave more favourable soil chemical properties relative to control, and the improvements were proportional to the amendment rates. Soil pH, organic C, available P, total N, exchangeable cations and ECEC were all significantly higher in the algae treated soil irrespective of the rate of amendment compared to urea as lone treatments. This could be attributed to the fact that algae are principally organic soil component which is rich in

Table 3: Mean effect of Algae and Urea on Soil Chemical Properties.

	Algae + Urea (t/ha) (kg/ha)	pH ← H ₂ O CaCl ₂ →		Avail.P (mg/kg)	Org.C (%)	Total N (%)	Exc. Bases (Cmol/kg)	Exc Acidity (Cmol/kg)	ECEC (Cmol/kg)
Control		4.95	4.44	21.80	1.33	0.12	5.49	1.32	6.81
0 + 40		5.07	4.93	28.80	1.37	0.14	4.49	1.33	6.82
0 + 80		5.05	4.61	32.47	1.40	0.15	5.42	1.34	6.76
0 + 120		4.98	4.38	43.60	1.42	0.16	5.05	1.36	6.41
1 + 0		5.24	5.16	39.93	1.41	0.14	6.65	0.86	7.51
1 + 40		5.32	5.19	27.93	1.42	0.15	7.96	0.59	8.54
1 + 80		5.14	4.92	29.80	1.41	0.16	9.38	0.43	9.51
1 + 120		5.09	4.84	52.73	1.40	0.16	8.09	0.53	8.63
2 + 0		5.65	5.28	39.60	1.52	0.15	9.69	0.44	10.12
2 + 40		5.65	5.30	28.13	1.52	0.16	9.73	0.43	10.16
2 + 80		5.06	4.96	29.90	1.52	0.16	10.93	0.54	11.49
2 + 120		5.25	4.94	53.33	1.52	0.16	10.31	0.55	10.85
3 + 0		5.90	5.41	42.20	1.71	0.17	11.49	0.32	11.81
3 + 40		5.94	5.43	46.20	1.74	0.17	11.64	0.40	12.04
3 + 80		5.97	5.00	32.00	1.77	0.17	12.16	0.43	12.58
3 + 120		5.78	4.97	54.74	1.77	0.17	11.15	0.53	11.68
4 + 0		6.03	5.53	48.33	1.80	0.17	12.69	0.31	12.99
4 + 40		6.06	5.56	59.33	1.81	0.17	12.74	0.37	13.12
4 + 80		5.98	5.01	56.60	1.82	0.18	12.80	0.51	13.31
4 + 120		5.84	4.97	65.00	1.83	0.19	12.52	0.57	13.09
Mean		5.84	5.04	43.61	1.57	0.19	9.57	0.66	10.21
FLSD _(0.05) A		0.054	0.078	12.005	0.091	0.038	0.2996	0.086	0.561
FLSD _(0.05) U		0.048	0.070	10.737	0.081	0.034	0.268	NS	0.503
F-LSD _(0.05) AxU		0.11	0.157	24.009	0.181	0.076	0.599	0.173	1.122

organic matter and when dead and decomposed, releases substantial amount of organic matter and basic cations which help to moderate pH (FAO, 1967). Also the higher improvement on total N due to algae application can be as a result of the role of algae in soil, N-fixation, a natural process of enriching the soil with N (Brady and Weil, 2006). The exchangeable acidity was significantly higher in urea treated soils compared to algae amended soils. This could be explained with the report of Ojeniyi and Adeniyi (1999) that inorganic fertilizers aggravate soil acidity. The more significant (P<0.05) improvement on the interactions between the two amendments for all the nutrients indices tested relative to individual treatments is in agreement with the findings of Adediran *et al.*, (1999) that the

supplementation of organic and inorganic fertilizers were more superior to the application of either of the amendment alone.

Effect of Algae and Urea on Yield of Amaranthus

Considering the yield of *amaranthus*, there were noticeable changes between treatments (Table 4). There were significant ($P<0.05$) increases on yield parameters as a result of the amendments on the soils both as lone and combined applications over the control treatment.

Table 4: Mean effect of Algae and Urea on Yield of *Amaranthus* (*Amaranthus cruentus*)

Algae + Urea (t/ha) (kg/ha)	Fresh Weight (g)	Plant Height (cm)	Number of leaves	Stem Girth (cm)
Control	17.43	19.27	16.00	2.47
0 + 40	23.57	24.20	23.67	3.03
0 + 80	25.27	25.37	24.33	2.90
0 + 120	30.13	29.70	26.67	3.43
1 + 0	46.17	52.93	51.67	4.20
1 + 40	52.43	50.13	50.67	4.27
1 + 80	52.17	54.33	53.00	4.56
1 + 120	44.43	47.43	47.67	3.67
2 + 0	62.67	57.33	61.67	4.90
2 + 40	63.40	56.47	62.00	4.73
2 + 80	65.07	59.90	63.33	5.10
2 + 120	48.07	47.60	47.00	4.33
3 + 0	76.37	61.13	66.33	5.47
3 + 40	79.53	61.63	66.33	5.63
3 + 80	81.33	64.09	67.67	6.43
3 + 120	57.77	51.87	53.00	4.33
4 + 0	89.87	64.80	68.67	6.57
4 + 40	92.37	63.80	68.67	6.53
4 + 80	97.13	65.17	70.33	6.93
4 + 120	62.50	51.73	57.67	5.20
Mean	58.398	50.96	52.32	4.74
FLSD _(0.05) A	6.309	0.907	6.892	0.410
FLSD _(0.05) U	6.643	NS	6.160	0.367
F-LSD _(0.05) AxU	12.617	18.142	13.767	0.821

Fresh weight, plant height, number of leaves and stem girth were consistently higher in the algae treated soils than urea amendment soils when applied as lone treatments. This observation justifies the higher improvement on soil fertility properties in algae treated soils than urea treated soils as lone treatments as observed earlier in this study. There were significant ($P<0.05$) interactions in improving the yield parameters and the highest increase were obtained when the two amendments were combined and these increases were directly proportional to the rates of amendment. Other research work (Ano and Asumugha, 2000) also observed a greater yield by the integrated use of inorganic and organic fertilizers compared to either of them. It was also observed that relative to the other rates of application, soils amended with 120kg/ha urea either as lone or combined with algae, showed consistent reduction on the yield parameters. This could be due to the fact that at 120kg/ha, urea became toxic to plants and hence, adversely affected the yield. This observed reduction in the yield of *amaranthus* in the pot that had 120kg/ha urea could also be attributed to increased soil acidification due to increased urea use. Treatment combination of 4t/ha algae and 80kg/ha urea gave the highest increase for all yield parameters measured and it is therefore recommended for optimum and large scale production of *amaranthus* in southeastern Nigeria.

CONCLUSION

Potentials for sustained *amaranthus* production in southeastern Nigeria are very limited in the absence of amendments due to the inherent low soil fertility status of the zone. This study has led to the conclusion that soils amended with algae and urea as lone treatments and interactively gave appreciable higher improvements on soil fertility properties and yield of *amaranthus*. The observations therefore emphasize the importance of algae especially when combined with urea or other mineral fertilizers as soil amendment for maintaining the fertility status of tropical soils. Comparable soil chemical properties and yields obtained indicates that detrimental effects on soil and crops associated with consistent and prolonged use of large amount of mineral fertilizers could be reduced by supplementation with algae as an organic manure. It is therefore recommended that to reduce or avoid the residual adverse effects resulting from the over-use of mineral fertilizers, soil fertility management strategy of combining algae with appropriate amount of inorganic fertilizers should be adopted. This will help farmers develop interest on the potentials of algae as a farm resource which when effectively and properly used, has direct positive effect on soil nutrient properties and yield of crops.

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