Evaluating the effects of fertilizers and bio-stimulants on field performance of *Amaranthus dubius*

Abstract

Aims: The continuous increase in human population warrants more food production. Amaranthus spp. is one of the most consumed leafy vegetables globally. A field experiment was conducted at the Teaching and Research Farm of Ekiti State University, Ado-Ekit Nigeria to assess the effects of fertilizers and bio-stimulants on the growth and performance of *Amaranthus dubius*. **Methodology**: The experiment was laid out in a randomized complete block design (RCBD) with three replicates. The *Amaranthus dubius* seeds were sown under open field conditions and the treatments included aqueous moringa leaf extract (AMLE), NPK 15:15:15, poultry manure, grand humus, and super gro which were applied at 2, 4, and 6 weeks after sowing WAS. Data were collected 7 days after each application on on leaf area (cm^3), plant height (cm), stem girth (cm), and total fresh biomass (g). The collected data were analysed using IRRI STAR 2.0. **Results:** The result revealed that all the treatments were significantly different (P>0.05) for all the parameters studied. AMLE recorded the highest value for all the parameters studied while control had the lowest values. For the total fresh biomass, AMLE recorded the highest mean value (1981.33) followed by NPK 15:15:15 (1535.00) and poultry manure (140.67) respectively while control had the least mean value (640.33). **Conclusion**: *Amaranthus dubius* was a short live plant response to AMLE and NPK 15:15:15 than the other treatment applied. It is therefore recommended that AMLE should be applied to boost the performance of *Amaranthus dubius*.

Keywords:*Amaranthus dubius*, Leaf extract, Bio-stimulants, Fertilizers, Grand humus.

INTRODUCTION

The world's global human population tends to increase by 3.5 billion in the next 50 years [1]. The rate of the global food supply is far below its demand due to the rapidly increasing human population. Hence, meeting global food requirements will necessitate an increase in production by 50% [2]. According to the Food and Agricultural Organization (FAO), there are about 795 million undernourished people globally in 2015 [3]. Amaranth is a leafy vegetable having high nutritional value and essential micronutrients [4]. Amaranth is rich in lysine, an essential amino acid that is lacking in cereals and tubers. It is the most consumed leafy vegetables [5]. Amaranth an ephemeral crop with high nutrient levels is a cheap source of protein and minerals for humans. The crop can be produced several times a year, which makes it to be more readily available and affordable.

Deterioration in soil fertility due to continuous farming, leaching, and erosion has limited its production of amaranth. Excessive use of chemical fertilizers to supplement the diminishing soil nutrients has resulted in soil acidity and poses environmental problems [6]. The use of organic matter is one of the major

approaches to increase soil fertility. The use of plant extracts such as seaweed, and Moringa has helped to improve crop performance and soil properties. Fresh leaves of *Moringa oleifera contain* zeatin [7]. The zeatin concentration in moringa various parts varied between 5 µg and 200 µg/g [8]. Fugile[7] reported that AMLE increases the yields of onion, soybean, melon, and maize. The cytokinin-related hormone called zeatin shows that Moringa plant extract has the potential benefit of enhancing crop growth, development, and yield. However, Moringa is relatively available and eco-friendly [9]. Supergro is a liquid organic fertilizer that is made from organic matter, poultry droppings, and sea guano for the improvement of agricultural development. It is a natural wetting agent, penetrable, and sticker that contains no chemicals. Supergro has been reported to increase crop productivity [10]. Humic acid (HA) are naturally occurring substance that is are soluble in water under alkaline conditions. Humic acid fertilizers do not only enhance fertility and improve the physicochemical properties of the soil [11]. HA improves the water-holding capacity of the soil and makes soil nutrients to be readily available for plant uptake. HA helps in binding insoluble metal ions, oxides, and hydroxides which are steadily made available for plant uptake [12]. Therefore, the objective of this experiment is to assess the effect of different organic fertilizers and bio-stimulants on fresh leaf yield and yield-related traits in amaranthus spp**.**

MATERIALS AND METHOD

Study site

The research work was carried out at the Teaching and Research farm, Ekiti State University, Ado Ekiti Nigeria. Ado-Ekiti climate is tropical humid characterized by two distinct seasons (Rainy and dry season). The rainy season spans from April to October while the dry season spans from November to March. However, a 15-day rain break is usually observed in August. The experimental site have been left to fallow for a year before the commencement of the experiment. The vegetation existing at the experimental site included *Tithonia diversifolia*, *Ageratum conyzoides*, and *Euphorbia heterophylla*. The experimental site has been previously used for the cultivation of maize. The soil in the experimental site is well-drained and sandy loam in nature.

Soil Sample Preparation and Analysis

The topsoil of the experimental site was randomly taken at 15 spots across the site to form a compost sample at a depth of 0-15cm with a sterilized soil auger before field preparation. The soil samples were packed in a well-labeled envelope for physio-chemical analysis at the Environmental Toxicology Laboratory of Elizade University, Ilara-Mokin, Nigeria.

Experimental Materials

The *Amaranthus dubius* seeds, Grand humus, Super gro, and NPK 15:15:15 fertilizer were obtained from Ekiti State Ministry of Agriculture and Food Security Agro-Input Store, Ado-Ekiti. The *Moringa oleifera* leaves were collected from the Teaching and Research Farm, Ekiti State University, Ado Ekiti

Nigeria, and identified at the Herbarium Centre of the Department of Biosciences and Biotechnology of University of Medical Science, Ondo City Nigeria.

Land preparation and experimental design

A total land area of 10m by 10m was prepared by constructing a bed measuring 1m by 3m with a spacing of 0.46m between beds. The vegetation at the experimental site was manually slashed with cutlass and the slashed vegetation residues were hand-packed. The beds were thoroughly tilled and prepared with hoe. The experiment was laid out in a randomized complete block design (RCBD) with three replicates.

Sowing of seed

The *Amaranthus dubius*seeds were sown using the broadcast method, where the seeds were evenly scattered over the prepared bed. This method allows for uniform distribution of seeds across the planting area.

Preparation of extract and treatment application (Organic fertilizer and bio-stimulants)

Fresh plants of *Moringa oleifera* leaves were harvested into a clean polythene bag. The plant leaves were blended with 10 grams to 10 ml of distilled water to form extract concentrate. 1 ml of the concentrate was mixed with 1 liter of water before application [13]. After three weeks of sowing, the first application of the treatments was carried out with foliar spray at 1ml of concentrate to 1 liter of water at two-week intervals. However, NPK fertilizer was applied using the broadcasting method at 150kgha-1. The extract was applied at 6:00 hours of the day when the stomata and lenticel of the plant were still open to ensure the absorption by the plant [14]. The HA was applied by side placement at the rate of 10mg per plant while poultry manure was applied at the rate of 3 tons per hectare.

Data collection and analysis.

Data were collected 7 days after each treatment application. Data were collected on plant height (cm) and stem girth (cm) using measuring tape and Vernier caliper respectively. The leaf length and width were also measured using the measuring tape and coefficient (0.997). All data collected were subjected to analysis of variance using IRRI STAR 2.0 and means separated using the Duncan Multiple Range Test at 5% probability. Proximate analysis and mineral contents of the harvested plant were carried out at the Biochemistry Laboratory of Elizade University, Ilara-Mokin Nigeria.

Harvest and weighing

After a total duration of seven weeks, all the plants were harvested. The harvested plants were weighed to determine their biomass.

RESULTS AND DISCUSSION

Soil Properties of Experimental Sites

The physicochemical properties of the soil at the experimental site used for the experiment are shown in Table 1. The soil pH value at the experimental site is 5.69. The pH level revealed that the soil is slightly acidic in nature. The pH level will still allow the uptake of plant nutrients [15]. The textural class of the sandy loam. The total N and organic matter content values in the experimental site are low compared to the 1.5-2.0 g kg-1 and 25-30 g kg-1 critical ranges of total N and organic matter respectively as established for soils in Nigeria. Soil available phosphorus was below the soil nutrient critical level of 10-15 mg kg-1 established for soils in Nigeria [16].

Table 1: The soil physiochemical properties of the experimental sites.

Properties	Ado-Ekiti
Sand (%)	66.3
Clay (%)	17.4
Silt (%)	17.3
Textural Class	Sandy loam
pH (H20)	5.69
Carbon (%)	0.83
Organic Matter (%)	1.41
Nitrogen (%)	0.08
Phosphorus ($mgkg^{-1}$)	7.13
Ca^{2+} ($cmolkg^{-1}$)	1.64
Mg^{2+} ($cmolkg^{-1}$)	0.62

Effects of organic fertilizer and bio-stimulants

The effects of organic fertilizer and bio-stimulants on leaf area (cm^3), plant height (cm), and stem girth (cm) on *Amaranthus dubius*are present in Tables 2, 3, and 4 respectively. AMLE had the highest values for leaf area throughout the experiment followed by Super Gro and NPK 15:15:15 respectively while control recorded the least leaf area value (48.84) at 7 WAS followed by HA (49.31). However, it was recorded that grand humus had the least value at week 3 after sowing followed by control. This could be a result of incomplete mineralization of HA at this stage. For plant height, poultry manure recorded the highest plant height values throughout the experiment. In the seventh week of the experiment, poultry manure (43.33) recorded the highest value for AMLE (37.00), Supergro (35.67), and NPK 15:15:15 (33.17) respectively. Control (22.00) recorded the lowest value. AMLE recorded the highest stem girth throughout the experiment. All the values recorded for all the treatments throughout the experiment for the leaf area, plant height, and stem girth were significant ($P<0.05$) except for stem girth at 7 WAS. The effects of organic fertilizer and bio-stimulants on (aerial parts) yield (g) of *Amaranthus dubius* is shown in

Table 5. There were significant differences (P<0.05) among the treatments applied to the *Amaranthus dubius* on the total fresh yield. AMLE (1981.33) recorded the highest total fresh yield (g) followed by NPK 15:15:15 (1535.00) while the plants that received no treatment (control) recorded the least value (640.33).

The plant height is a growth character that cannot be underestimated as it is directly associated with the productive potential of plants in terms of fodder and grain yield [17]. The height of a plant was reported to be positively correlated with its productivity in terms of grain, fodder, oil, root, or tuber [18]. The higher values in leaf area, plant height, stem girth, and total aerial fresh weight recorded in this study for the AMLE over other treatments and control could be a result of hormones present in the AMLE such as zeatin [7]. Lestari et al. [19] reported the positive influence of both foliar spray and soil surface application of humic acid on the Amaranthus tricolor L height, number of leaves per plant, and shoot weight. Their report is in agreement with the findings from this report. The positive influence of both foliar spray and soil surface application of humic acid on plants could be linked to its ability to absorb macronutrients and micronutrients. The slow release of nutrients by the poultry manure could be the reason Amaranthus spp. responded to AMLE being an ephemeral crop rather than poultry manure.

The findings from this research are in agreement with the report of [20] that AMLE application increases the girth of sweet corn plants.Foidl et al. [21] also gave a similar report that AMLE increases plant height okra. [10] gave a similar report that Supergro greatly influences the vine length, leaf area, and freshly harvested fluted pumpkin leaves. The sole dependence on the native soil nutrients with amendment could be the reason why the plants that received no treatment (control) recorded the lowest values for the parameter taken at 7 WAS. Moreover, the soil analysis revealed that the soil is deficient in some nutrients [16] though the soil pH will still allow the uptake of the available plant nutrients in the soil [15].

Table 2: The effects of organic fertilizer and bio-stimulants on leaf area (cm^3) of *Amaranthus dubius.*

Treatment	**Week after sowing**		
	3	5	7
Moringa oleifera leaf extract	47.35a	67.09a	103.53a
SuperGro	38.87ab	59.56ab	92.68ab
NPK 15:15:15	32.26ab	54.65ab	81.50ab
Grand humus	16.47b	31.18b	49.31b
Poultry manure	33.56ab	53.88ab	69.69ab
Control	19.53b	29.63b	48.84b

Means with the same letter (s) in each Column are not significantly different (P<0.05) according to Duncan's Multiple Range Test (DMRT)

Table 3: The effects of organic fertilizer and bio-stimulants on plant height (cm) of *Amaranthus dubius.*

Treatment	Week after sowing		
	3	5	7
Moringa oleifera leaf	15.00ab	24.83	37.00ab
SuperGro	15.67ab	23.83ab	35.67ab
NPK 15:15:15	14.50ab	23.33ab	33.17ab
Grand humus	9.83b	15.67b	27.83ab
Poultry manure	19.67a	30.50a	43.33a
Control	10.17b	14.50b	22.00b

Means with the same letter (s) in each Column are not significantly different (P<0.05) according to Duncan's Multiple Range Test (DMRT)

Table 4:The effects of organic fertilizer and bio-stimulants on stem girth (cm^3) of *Amaranthus dubius*

Treatment	Week after sowing		
	3	5	7
Moringa oleifera leaf extract	0.55a	0.74a	0.96a
SuperGro	0.45abc	0.68a	0.91a
NPK 15:15:15	0.47abc	0.65ab	0.74a
Grand humus (20 mg/l)	0.32bc	0.53ab	0.54a
Poultry manure	0.52ab	0.71a	0.95a
Control	0.25c	0.37b	0.58a

Means with the same letter (s) in each Column are not significantly different (P<0.05) according to Duncan's Multiple Range Test (DMRT)

Table 5: The effects of organic fertilizer and bio-stimulants on (aerial parts) yield (g) of *Amaranthus dubius.*

Treatment	Total fresh yield (g)
Moringa oleifera leaf extract	1981.33a
SuperGro	1350.67ab
NPK 15:15:15	1535.00ab
Grand humus	1001.67c
Poultry manure	1408.67b
Control	640.33cd

Means with the same letter (s) in each Column are not significantly different (P<0.05) according to Duncan's Multiple Range Test (DMRT)

CONCLUSION

This study indicated that the organic fertilizers and bio-stimulants used enhance the growth and yield of Amaranthus spp. compare with plants that received no treatment. Amaranthus spp. gave superior responses to aqueous AMLE. As *Moringa oleifera* leaf is readily available and required no extra-reagent or input in its extraction process apart from water that is readily available to all farmers, it is therefore

recommended to all Amaranthus spp. farmer to adopt the use of AMLE being a short growth cycle crop. Moreover, it is cost effective and eco-friendly

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