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RESEARCH ARTICLE

Effect of urea fertilizer on the growth and yield of African spinach (*Amaranthus hybridus* L.) in derived- savanna zone of Delta State, Nigeria

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ABSTRACT

A field study was carried during the 2020 cropping season to determine the effect of urea on the growth and yield of *Amarathus hybridus* at the Teaching and Research Farm, University of Delta, Agbor Delta State. The urea fertilizer was applied at 0, 100, 150, 200 and 250 kg ha^{-1}. The amounts of urea fertilizer used were 0, 100, 150, 200, and 250 kg ha^{-1}. The five levels of urea fertilizer were duplicated three times in the experimental design, which was a randomized complete block. Plant height, number of leaves plant^{-1}, leaf area plant^{-1}, stem girth, and fresh yield of the plant were all measured. The data was examined using analysis of variance (ANOVA), and the means were separated using the Duncan Multiple Range Test (DMRT) at a probability level of 5%. Amaranthus growth and yield characteristics were dramatically improved by increasing the rate of urea fertilizer treatment. However, urea administered at a rate of 250 kg ha-^{1} improved growth characteristics more than the lower rate and control. The application of 250 kg ha-^{1} urea resulted in the highest fresh plant production (2.30 t ha^{-1}) and differed substantially from the control (0.90 t ha^{-1}), but not from the other urea levels used.

Key words: *Amaranthus hybridus*, Effect, Urea, Growth characters, Yield

INTRODUCTION

Amaranthus (*Amaranthus* spp.) are seasonal herbaceous plants found in the tropics. They are by far the most popular leafy vegetable in Nigeria, and are grown in many ecological zones (Remison, 2005). Many amaranthus species likely originated in the Adean region of South America or Mexico and now inhabit most tropical environments. Nitrogen is vital in several physiological processes within plants. It develops photosynthetic capacity and extends effective leaf area duration, delaying senescence (Isitekhale and Osemwota, 2010).

Nitrogen (N) is a macro-element necessary for plant growth. According to Oyedeji et al. (2014), plants need enough nitrogen in the soil to grow well. Kayode (2000); Iren et al. (2014) asserted that nitrogen is essential in protein and vitamin structure. Ample N is required for chlorophyll synthesis. Similarly, Russel (1991); Iren et al. (2011) stated that nitrogen promotes biomass above ground in tropical soils. Akanbi et al. (2009) found that crops show a substantial positive reaction to N application.

Most farmers apply nitrogen to the soil because it is needed for plant growth (Okeke and Oti, 1998; Oyedeji et al., 2014). To maximize output, each soil and crop variety's N requirements must be determined (Eke-Okoro, 2000; Iren et al., 2014). Kayode (2000) recommended 60-90kg of nitrogen per acre for the growth and yield of amaranthus.

Plants consume nutrients for active vegetative development or store them (Isitekhale and Osemwota, 2010). The delivery of a nutrient to plants is boosted from a low level to the needed amount (Kayode, 2000; Iren et al., 2011). Organic fertilizers can help maintain high crop yields under intensive farming in Nigeria today (Adediran and Banjoko, 1995; Olatoberu et al., 2019). Chemical fertilizer can sustain crop yield in Nigeria. Zemenchik and Albrecht (2002) noted that crops are fertilized to replenish nutrients deficient in the soil. A good fertilization programme supplies enough fertilizer year after year to maintain optimal crop yield (Olatoberu et al., 2019). Mineral elements are crucial in plant growth and development (Remison, 2005; Babajide et al., 2014). Olatoberu et al. (2019) observed that crop nutrient uptake varies depending on plant type and yield.

The effects of organic fertilizer application on soil parameters have been studied in the growth of African spinach (*Amaranthus hybridus*). Eating vegetables is a great way to save money and acquire a variety of vitamins, minerals, and phytochemicals. Fertilizers must be used properly to boost this crop's productivity. To assess the influence of urea fertilizer on the growth and yield of African spinach (*Amaranthus hybridus*) in Delta state's derived-savanna zone.

MATERIALS AND METHODS

Experimental location

The study was conducted in 2020 at the University of Delta's Teaching and Research Farm in Agbor. The rainfall regime has two peaks separated by a dry phase in August termed August break. The rainy season lasts at least seven months, or 220 - 250 days, with an average of 159 rain days. Temperature is very high during the day and cool night (Iloeji, 2003).

Experimental material

African spinach (*Amaranthus hybridus*) seeds were received from NIHORT in Ibadan, Oyo State. ADP, Agbor, Delta State, supplied the urea fertilizer.

Nursery practices

Seeds of the amaranthus were first sown on a prepared bed from a standing secondary forest near the experimental field on 29th September, 2019 at the Teaching and Research Farm, University of Delta, Agbor. The seeds were broadcast and mulched to reduce evaporation. The nursery was watered as the need arose.

Experimental design

The five levels of urea fertilizer (0, 100, 150, 200 and 250 kg ha^{-1}) were laid out in a randomized complete blocks design (RCBD) with three replicates.

Land preparation

Before transplanting, the location was carefully prepared and plotted. Individual plots were 1.35 x 1.2 m with 0.5 m alleys between plots and replicates. The seedlings were transplanted three per stand into a minimally prepared bed, then trimmed to one per stand in a 45 x 30 cm space. Each plot had 20 plants, giving a total population of 300 plants, or 83,333 plants/ha. The land used was 24.30 m^2, or 0.003 ha. Two weeks after transplantation, urea was administered. Weed management was done manually with a hoe at 3 and 5 weeks (WAT).

Soil analysis

Before planting, soil augers were used to gather composite soil samples from 0 to 15 cm deep from the experimental location. In the laboratory, samples were bulked, air dried, and sieved with a 2 mm mesh sieve. The bulked samples were treated and tested

for physicochemical parameters Okalebo et al. (2002).

Data collection: Data were collected on vegetative and yield parameters.

Vegetative characters: Collection of vegetative parameters commenced at three weeks after transplanting (WAT) and were obtained every two weeks till the 7th week after transplanting. Four plants were tagged in the net plot for data collection. The vegetative characters collected included:
plant height (cm), number of leaves per plant, leaf area/plant, stem girth (cm), and fresh plant yield.

Table 1. Pre-planting soil physico-chemical parameters of the experimental site

Parameters	Values
Sand (gkg^{-1})	820
Silt (gkg^{-1})	70
Clay (gkg^{-1})	110
Textural Class	Sandy loam
pH (H_2O 1:1)	5.75
Organic carbon (gkg^{-1})	8.30
Total nitrogen (gkg^{-1})	0.45
Available phosphorus ($mgkg^{-1}$)	10.00
Exchangeable calcium ($cmolkg^{-1}$)	1.03
Exchangeable magnesium ($cmolkg^{-1}$)	0.46
Exchangeable potassium ($cmolkg^{-1}$)	1.02
Exchangeable sodium ($cmolkg^{-1}$)	0.08
Total Exchangeable Bases ($cmolkg^{-1}$) $[Ca^{2+} + Mg^{2+} + K^{+} + Na^{+}]$	2.59
Total Exchangeable Acidity ($cmolkg^{-1}$) $[Al^{3+} + H^{+}]$	0.10
Effective cation exchange capacity ($cmolkg^{-1}$)	2.69
Base saturation %	96.28

Statistical analysis
All data collected were analysed using analysis of variance (ANOVA) at 5% level of probability and the means separated using Duncan's Multiple Range Test (DMRT), when F – ratio proved significant (Steel and Torie, 1980).

RESULTS

Soil analysis
The soil used for the experiment was sandy loam, slightly acidic, with moderate organic carbon, low in nitrogen, marginal in available phosphorus, and exchangeable bases (**Table 1**).

Plant height (cm)

The plant height of African spinach as influenced by urea fertilizer application is presented in Table 2. The height of amaranthus increased throughout the period of sampling among the treatments. At 7WAT, the height varied from 5.38-7.13cm. The crops fertilized at 250 kg/ha had the highest (7.13cm) while the control had the least (5.38cm).

Number of leaves plant^{-1}

The fertilizer applied did not significantly influence the amount of leaves plant^{-1} of amaranthus except at 7 WAT (**Table 2**). At 7WAT, the value ranged from 24.00-40.00. The highest number of leaves plant^{-1} (40.00) was obtained from crops fertilizer at 250 kg ha^{-1}, while the untreated crops gave the least (24.00).

Table 2. Effect of urea fertilizer on the growth parameters of African spinach

Treatment (kg/ha)/ parameters	Weeks after transplanting		
	3	5	7
Plant height (cm)			
0	4.00^{ns}	4.35^{c}	5.38^{bc}
100	5.38	5.40^{ab}	6.00^{ab}
150	5.38	5.40^{ab}	6.13^{ab}
200	6.00	6.23^{a}	6.38^{ab}
250	6.13	6.40^{a}	7.13^{a}
mean	5.41	5.50	6.20
No. of leaves/plant			
0	16.00^{ns}	21.00^{ns}	24.00^{c}
100	18.00	24.00	28.00^{b}
150	17.00	25.00	32.00^{b}
200	18.00	25.00	38.00^{ab}
250	18.00	29.00	40.00^{a}
mean	17.00	24.00	32.00
Leaf area/plant (cm^2)			
0	7.20^{b}	11.10^{b}	11.40^{bc}

100	11.00[a]	14.00[a]	14.20[ab]
150	11.00[a]	14.40[a]	14.60[ab]
200	11.80[a]	14.60[a]	14.80[ab]
250	11.90[a]	15.20[a]	15.30[a]
mean	10.00	13.90	14.20
Stem girth (cm)			
0	4.50[c]	5.00[c]	6.70[b]
100	5.10[bc]	5.50[c]	7.70[b]
150	6.70[b]	7.00[b]	8.70[a]
200	7.70[a]	8.40[a]	9.20[a]
250	8.10[a]	9.20[a]	10.00[a]
mean	6.50	7.00	8.50

Values with same letter(s) superscript indicated in columns are not significantly differently different; using DMRT at 5% level of probability; ns: not significant

Leaf area plant^{-1}

The applied fertilizer significantly affected the leaf area/plant of the crop throughout the period of sampling (**Table 2**). At 7WAT, the mean varied from 11.40-15.30 cm^2. Crops fertilized at 250 kg/ha had the highest at 3 weeks after planting leaf area/plant was highest in treatment which received 250kg/ha and the unfertilized crops gave the highest and least leaf area/plant values of 15.30 cm^2 and 11.40cm^2, respectively.

Stem girth

The stem girth of African spinach is presented in Table 2. There were significant differences among the treatments from 3-7WAT. The stem girth increased from 3-7WAT. At 7WAT, the valued ranged from 6.70-10.00cm. Crops fertilized at 250kg ha^{-1} gave the highest stem girth (9.20cm) while unfertilized crops gave the least (6.70cm).

Table 3. Effect of urea fertilizer on the fresh plant yield (t ha^{-1}) of African spinach

Treatment (kg ha^{-1})	Fresh plant yield (t ha^{-1})
0	0.90[c]
100	1.30[b]
150	1.40[b]
200	2.10[a]
250	2.30[a]
mean	1.60

Values with same letter(s) superscript indicated in column are not significantly differently different; using DMRT at 5% level of probability.

Fresh Yield

Table 3 showed that the four rates of urea fertilizer applied yielded significantly more herbage than the unfertilized plants. The fresh plant yield varied from 0.90-2.30 t/ha. Crops treated at 250 kg ha^{-1} yielded more fresh plants (2.30 t ha^{-1}) than other rates including the control (0.90 t^{-1} ha).

DISCUSSION

The nitrogen released from the urea fertiliser applied was attributed to the highest plant height seen in the fertilised crops. Olaniyi et al. (2008) and Ademola et stem girth observed with higher rates of urea treatment is supported by Alonge et al. (2007); Otobong et al. (2016) who reported that higher levels of nitrogen applied increased the stem girth of amaranthus above the control.

al. (2009) found similar results. They discovered that amaranthus plants require a lot of urea to develop vegetatively. Higher rates of treatment (200 and 250 kg ha^{-1}) resulted in significantly more leaves per plant than lower rates and the control. Olatoberu et al. (2019) found that urea increased the number of leaves in plants, confirming the importance of nitrogen in supporting rapid vegetative development.

The significant increase in the leaf area from the fertilized crops above the untreated crops is an indication that the crops utilized the applied nutrients for growth and development. Olaniyi (2007); Tongos (2016); Ademola et al. (2019) reported higher leaf area of amaranthus with higher levels of urea application. The higher

Generally, treatments with higher vegetative characters gave higher fresh plant yield. Although growth characters are attribute of genetic make-up, but nitrogen fertilizer promotes vegetative growth of crops. Crops treated with urea at 250 kg ha^{-1} with the highest plant height, number of leaves plant^{-1}, leaf area plant^{-1} and stem girth, significantly, had the

highest fresh plant yield. This result is in conformity with the reports of Fatima et al. (2007); Olaniyi (2007); Otobong et al. (2016); Olatoberu et al. (2019) who observed significant higher fresh leaf of amaranthus from fertilized crops than the control.

CONCLUSION

From the present study, crops treated with urea fertilizer at 250kg/ha performed best in terms of growth and yield. However, the applied 250kg/ha urea fertilizer is recommended for the growth and yield of African spinach in Agbor, Delta State.

COMPETING INTERESTS

The authors declare that they have no competing interests

DATA AVAILABILITY STATEMENT

The raw data used to support the findings of this study are available from the corresponding author upon request.

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