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Effect of Spraying Frequency of Moringa Leaf Extract on Growth and Yield of Amaranth (*Amaranthus cruentus* L.)

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Abstract

Global interest in sustainable agriculture and natural plant extracts to enhance crop yield is growing. This study investigates whether Moringa leaf extract, known for its nutritional value, can improve the growth and yield of Amaranth (*Amaranthus cruentus*). A pot experiment was conducted at Ekiti State University's Teaching and Research Farm in Nigeria. Amaranth seeds were planted thrice in 5-kilogram soil-filled pots, each receiving one, two, or three sprays of 25 ml fresh Moringa leaf extract. Data on plant height, leaf count, leaf area, and yield biomass were collected. Results indicated significant differences ($p \leq 0.5$) between spraying frequencies and the control group. Notably, plants sprayed three times exhibited the tallest height (32.06 cm), highest leaf count (32.78), and most excellent leaf area (996.3 cm2) five weeks after planting. Furthermore, the three-spray regimen yielded the highest biomass, outperforming the control. Overall, spraying Amaranth with Moringa leaf extract improved yield, with increased spraying frequency correlating with enhanced performance. This suggests that local farmers could benefit from applying Moringa leaf extract to boost production due to its affordability and accessibility.

Keywords: *Amaranthus cruentus* L., moringa leaf extract, spraying frequency

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Introduction

Amaranthus cruentus L., popularly known as 'Efo tete' by the Yorubas in Southwest, 'Alaiyaho' by Hausas in North and 'Imne' by Igbos in Southeast Nigeria and 'pigweed' in English. *Amaranthus cruentus* L. is one of about 60-70 species of the Amaranth family, which belongs to the family *Amaranthaceae*. It was mostly considered as grain amaranth but was usually grown as a leaf vegetable. *Amaranthus cruentus* L. is considered to have been domesticated in Central America for over 6000 years (Grubben, 2004) but is now widely cultivated in both temperate and tropical regions of the world (Alegbejo, 2013). They are annual herb, erect or less commonly ascending, growing up to 2 m tall, with often reddish tinted throughout; leaves arranged spirally, simple, without stipules, long-petiolate (Grubben, 2004). It is an important vegetable crop as it is mainly used for stew, sauce or sliced vegetable

dishes in combination with cereal and tuber meals because of its richness in protein. It can be eaten raw or cooked. Amaranth is rich in minerals and vitamins, so it is eaten with other food substances (Alegbejo, 2013). Bradtke (2013) showed that Amaranth has three times more calcium and vitamin B than spinach leaves and twenty times more iron than lettuce. Oil extracted from *Amaranthus cruentus* L. contained 19 % palmitic acid, 3.4 % stearic acid, 34 % oleic acid and 33 % linoleic acid (Yanez *et al*. 1994).

The frequency of spraying moringa leaf extract can significantly impact the growth and yield of Amaranth (Amaranthus cruentus L.). Research has shown that applying moringa leaf extract at specific intervals after emergence can lead to notable improvements in growth parameters such as plant height, shoot length, fresh weight, dry weight of shoot, as well as yield components like grain weight per plant (Biswas et al., 2016). Foliar spraying of moringa leaf extract has been found to contain growth-promoting substances that extend the leaf area duration grain-filling period and delay crop maturity, resulting in increased economic and biological yields in crops like wheat (Bakhtavar et al., 2015). Studies have also explored the optimization of dosages and growth stages for foliar application of moringa leaf extract, indicating its role in delaying leaf senescence and enhancing growth in crops like late-sown wheat (Yasmeen et al., 2012). Furthermore, moringa leaf extract has been linked to improved growth, yield, and nutrient status in crops such as cabbage (Hoque et al., 2020). The effectiveness of moringa leaf extract as a biostimulant has been demonstrated in various plants, with findings showing enhanced growth parameters and yield attributes in crops like pepper (Mehdawe et al., 2023), rocket (Abdalla, 2013), black cumin (Mehmood et al., 2021), and mustard (Reddy et al., 2022).

Moreover, using moringa leaf extract in seed priming has positively affected early crop growth and yield performance in crops like linola (Rehman et al., 2014). The application of moringa leaf extract through foliar spraying has been associated with increased growth and yield in crops like okra (Kanchani & Harris, 2019), snap beans (Emongor, 2015), lettuce (Saleh et al., 2022), black gram (EL-Dekashey et al., 2022), tomato (Shehata, 2018), and pea (El-Sayed et al., 2019). Combining moringa leaf extract with other substances like silicon has enhanced grapevine yield and fruit quality (Bassiony & Ibrahim, 2016). The spraying frequency of moringa leaf extract plays a crucial role in enhancing the growth and yield of various crops. Farmers can harness moringa leaf extract's potential to improve agricultural productivity sustainably by understanding the optimal dosages, growth stages, and application methods.

The moringa tree, known as the 'Miracle tree', is grown mainly in semi-arid, tropical and subtropical areas, with *Moringa oleifera* being the most common species (Fahay, 2005). It is grown mainly for its nutritional and medicinal properties (Foidl *et al.*, 2001). Many African countries use moringa leaf powder as a food supplement to fight malnutrition, as a water purification agent, and to assist people suffering from micronutrient deficiency (Johnson, 2005; Ashfaq *et al.*, 2011). Moringa leaves contain zeatin, a naturally occurring cytokinin and other growth-enhancing components that made the leaf extract to be used as plant growth enhancers (Foidl *et al.*, 2001: Nagar *et al.*, 2006). Zeatin helps to promote cell division and elongation and prevents damage in the cell (Taiz and Zeiger, 2006). Moringa leaves can be used as an effective plant hormone capable of increasing yield by 20 – 35 % for nearly any crop (Fuglie, 1999; Moringa S.A., 2011). Marcu (2005) observed that zeatin promotes plant growth and has anti-ageing potential and protective effects in plants.

The desire for organic products increases as humans become weary of chemical products, leading to better agroecological practices (Silva and Moore, 2017). Hence, moringa leaf extract should be used against organic and inorganic fertilizers. *Amaranthus cruentus* L is a vegetable crop grown and consumed mainly by most households in Southwest Nigeria due to its importance in their meal. Therefore, using moringa leaf extract as a natural enhancer is desirable. Foliar spray of crops with moringa leaf extract has been effective in crop production (Foidl *et al.*, 2001; Moringa S.A., 2011; Aluko, 2013). The spray frequency also needs to be examined for better crop performance. Therefore, this study is aimed to

investigate the number of sprays required for the optimum production of *Amaranthus cruentus* L.

Materials and Methods

Experimental site

The experiment was conducted at Ekiti State University's Teaching and Research Farm in Ado-Ekiti, Nigeria. Ado-Ekiti is located at coordinates 7° 35' and 74° 47' north, and 5° 11' and 5° 16' east of the Greenwich Meridian. It is located in the humid tropical region of Nigeria. Ado-Ekiti receives around 1,500 mm of rainfall every year, and the south-western wind blows for the majority of the year, from December through February. Cooler continental winds from the interior of Ado Ekiti prevail during the rainy season, which runs from March to October each year.

Collection and analysis of soil sample

Soil samples were collected randomly at a cultivated field at the Teaching and Research Farm of Ekiti State University, Ado-Ekiti, with 5 kg measured into five 5-litre plastic containers. Particle-size distribution was determined using the hydrometer method, and soil pH in distilled water was measured using a Kent pH meter (7020). The routine soil analysis was carried out as IITA (1979) described, and the result is shown in Table 1.

Seed viability test and planting

Seeds *Amaranthus cruentus* were purchased from the market in Ado-Ekiti and soaked in water to determine their viability. Floated seeds were discarded, those that dropped at the bottom were regarded as viable, and ten seeds were planted into each pot of 5 kg soil.

Collection and preparation of moringa leaf extract

Moringa leaves were collected at the moringa plantation at the Teaching and Research Farm of Ekiti State University, Ado-Ekiti. Fresh moringa leaves collected were cleaned, blended and sieved to form the extract. 36 ml of the moringa extract was then diluted with 32 ml of distilled water and used as the treatment.

Experiment design

The pots were arranged in a completely randomized design (CRD) in three replications. A foliar spray of moringa leaf extract was administered to the *Amaranthus cruentus* two, three and four weeks after planting (WAP). 25 ml of the moringa leaf extract was sprayed each time.

Data collection and analysis

Data were collected on the plant height, number of leaves per plant, total yield biomass (total weight of the harvested product including root, stem, leaves and shoot), above-ground biomass (this includes stem, leaves and shoot), consumable harvest (the part of harvested parts used as soup and salad) and the root weight (the part of the plant below the soil level). All data collected were subjected to analysis of variance (ANOVA) and mean separated using Duncan's Multiple Range Test at 5 % probability.

Result

Physical and chemical analysis of soil used

The particle sizes of the soil used for the work showed that the soil was sandy loam that was slightly acidic at pH 6.3 (Table 1). The soil has a total N of 0.02 %, available P 6.19 mg/kg and organic matter of 2.50 %. The exchangeable bases include potassium (K) at 0.42 cmol/kg, sodium (Na) at 0.21 cmol/kg, calcium (Ca) at 4.13 cmol/kg and magnesium (Mg) at 1.48 cmol/kg, exchangeable acidity of 0.17 and CEC 6.44 (Table 1).

Table 1: Physical and chemical properties of soil used.

Soil properties	Value
pH	6.3
Organic matter (%)	2.50
Total N (%)	0.02
Available P (mg/kg)	6.19
Exchangeable bases (cmol/kg)	
K	0.42
Na	0.21
Ca	4.13
Mg	1.48
Exchangeable acidity	0.17
CEC	6.44
Particle sizes	
Sand (gkg^{-1})	737
Silt (gkg^{-1})	136
Clay (gkg^{-1})	127
Textural class	Sandy loam

Effect of spraying frequency on Amaranth plant height

The plant height of Amaranth indicated increases as the growth period increases (Fig. 1). The plant shows the highest plant height at 5 WAP with the highest spraying frequency (Sp3) of moringa leaf extract gave the tallest plant at 32.06 cm. This was a 54.6 % relative increase to control. The frequency of spraying was significant at a 5 % probability of control. The higher the spraying frequency, the taller the plant, except in 4 WAP, double and triple spray show no significant difference.

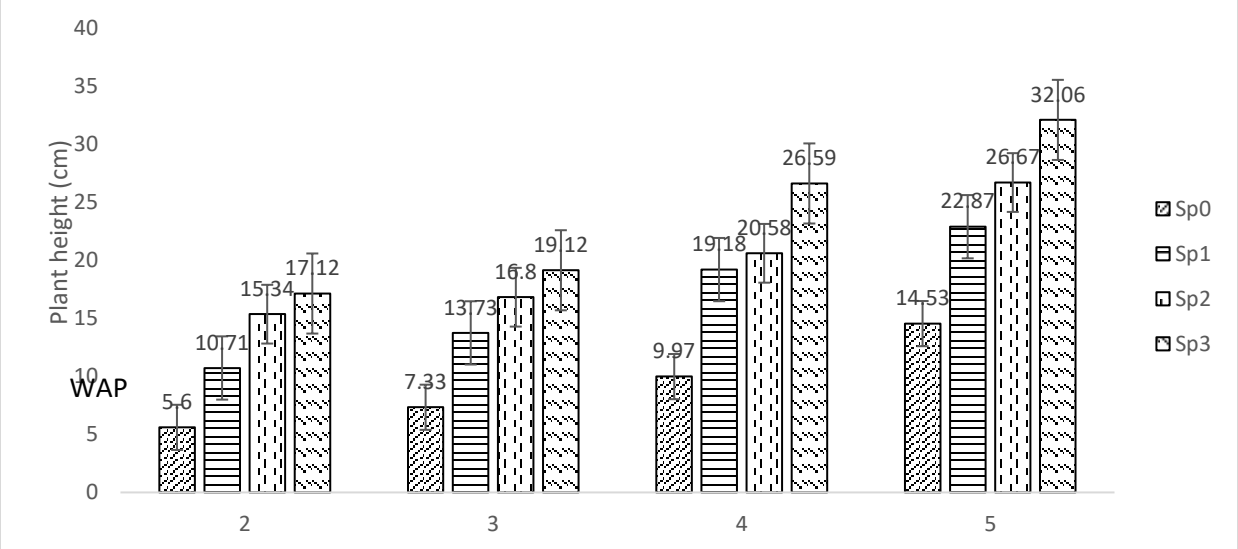

Fig. 1: Effect of spray frequency of Moringa leaf extract on plant height of *Amaranthus cruentus* (Sp0=Control, Sp1=Single spray, Sp2=Double spray, Sp3=Triple spray, WAP= week after planting; means with different letters in the same column are significantly different at 5% probability by Duncan's Multiple Range Test)

Effect of spraying frequency on the number of leaves of Amaranth

Figure 2 shows the effect of spraying frequency on the number of leaves of *Amaranthus cruentus*. The spraying frequency was significantly different from that of the control, at a probability of 5 %. The number of leaves is highest in 5 WAP, indicating that the number of leaves increases as the growth period increases, but spraying frequency are not

significantly different. The spraying of Amaranth three times with moringa leaf extract gave the highest number of leaves (32.78) at 5 WAP.

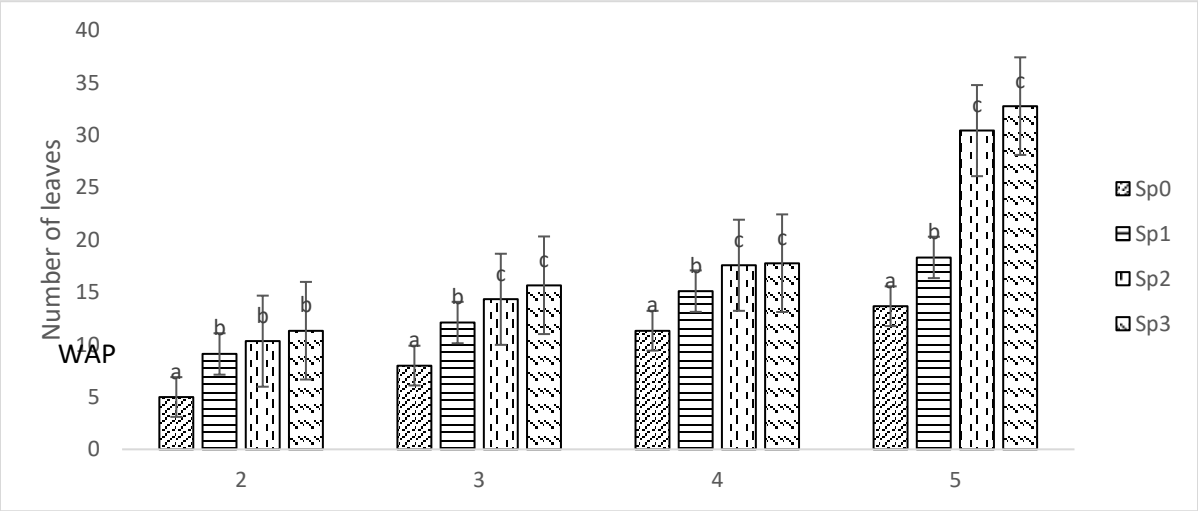

Fig. 2: Effect of spray frequency of Moringa leaf extract on the number of leaves of *Amaranthus cruentus*

(Sp0=Control, Sp1=Single spray, Sp2=Double spray, Sp3=Triple spray, WAP= week after planting; means with different letters in the same column are significantly different at 5% probability by Duncan's Multiple Range Test)

Effect of spraying frequency on leaf area of Amaranth

The leaf area index showed relative significance to control in all the spraying frequencies applied (Fig. 3). Spraying of Amaranth with moringa leaf extract was effective in crop production. The higher the spray frequency, the better the performance of the Amaranth plant, but not significantly different at p=0.05. At 5WAP, three times the spray frequency gave the highest leaf area of 996.3 cm2, an 80.7% relative increase to control

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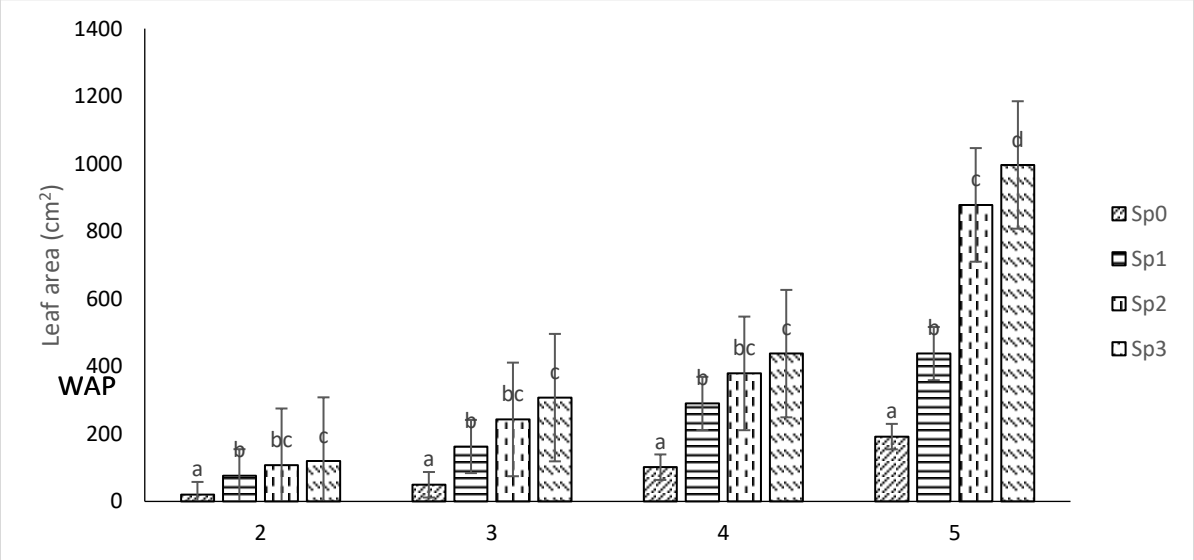

Fig. 3: Effect of spray frequency of Moringa leaf extract on leaf area of *Amaranthus cruentus*

(Sp0=Control, Sp1=Single spray, Sp2=Double spray, Sp3=Triple spray, WAP= week after planting; means with different letters in same column are significantly different at 5% probability by Duncan's Multiple Range Test)

Effect of spraying frequency on yield component of Amaranth

The yield component of Amaranth (*Amaranthus cruentus*) as showed in figure 4 indicated significant at 5 % probability. The spraying of Amaranth thrice gave a total yield (T.B.) of 172.67 g which was 53.67 % higher than control (80.00 g). Spraying frequency also have significant effects on above ground biomass (AGB), consumable harvest (C.H.) and root fresh weight (RFW). Triple spray gave 125.89 g AGB, 81.89 g C.H. which were the highest but double spray was highest in RFW (46.56 g) higher than triple spray (43.89 g) but are not significantly different. Spraying thrice gave the highest yield component at 5 WAP giving the highest in all the spraying frequency applied.

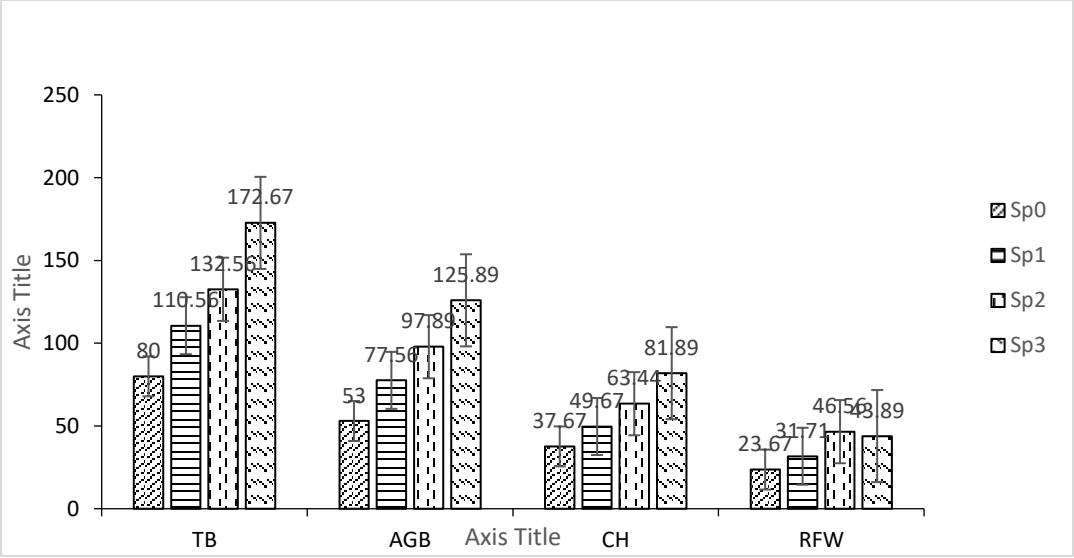

Fig. 4: Effect of spray Frequency of Moringa leaf extract on yield of *Amaranthus cruentus*
(Sp0=Control, Sp1=Single spray, Sp2=Double spray, Sp3=Triple spray, TB=Total yield biomass, AGB=Above ground biomass, CH=Consumable harvest, RFW=Root fresh weight; means with different letters in same column are significantly different at 5% probability by Duncan's Multiple Range Test)

Discussion

The nutrients available in the soil used for this experiment suggested the need for enrichment as some of the soil nutrients are below soil nutrients critical level for Southwest Nigeria. Agboola and Ayodele (1985) as reported by Ayodele and Omotoso (2008) observed that soils with organic matter range of 0-2.0%, Total N of 0-0.15%, available P of 0-8.5 mg/kg, exchangeable K of 0-0.16 cmol/kg and Ca of 0-1.5 cmol/kg are of low fertility. Therefore this soil used can be considered of low quality as most of it nutrients are below the critical level except for exchangeable K and Mg. The need to enhance the productivity of this crop is therefore inevitable in order to achieve optimum production. It has been demonstrated through research that the application of moringa leaf extract at predetermined intervals following the emergence of the plant can result in significant enhancements to growth parameters such as plant height, shoot length, fresh weight, and dry weight of shoot, as well as yield components such as grain weight per plant (Biswas et al., 2016).

The results from this research showed appreciable increase in growth and yield of *Amaranthus cruentus* spray with moringa leaf extract. Treatments applied from single to triple spray showed significant increase in growth and yield of *Amaranthus cruentus* compare to the control. This result was in contrast to the finding of Okeke *et al.* (2015) that *Moringa oleifera* had negative effect on the growth of *Amaranthus spinosus* and *Amaranthus hybridus* by inhibiting growth and yield. But it support the general

observation of Foidl *et al.* (2001) that moringa leaf extract increases the growth and yield of crops. The observation of Aluko (2016), on capsicum pepper spray with moringa leaf extract also confirmed the general observations. Foliar spray with *Moringa* oleifera leaf extract has been observed to increase crop yield to between 20-35% (Moringa S.A., 2011), which was confirmed by the results of this study. However, Bakhtavar et al., (2015) discovered that the use of moringa leaf extract as a foliar spray include growth-promoting compounds which lengthen the leaf area duration grain-filling period and delay crop maturity, which ultimately results in improved economic and biological yields in crops such as wheat. The yielded result indicated 27.64, 39.65 and 53.67 % increases for once, twice and thrice spraying, which verified this claim.

Conclusion

The study has confirmed the positive effect of moringa leaf extract as a plant growth enhancer. The frequency of spaying was also effective, as the more sprays there were, the better the crop performance. There was a significant increase in plant stem height, number of leaves, leaf area and plant biomass. Moringa leaf extract can, therefore, be used to increase *Amaranthus cruentus* production.

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