Adamawa State University Journal of Scientific Research (ADSUJSR)
Volume 12 Issue 2, 2024
ISSN: 2705-1900 (Online); ISSN: 2251-0702 (Print)
adsujsr.adsu.edu.ng

Influence of Plant Growth Regulators on the Performance of Vegetable Amaranth (*Amaranthus caudatus* L.) in Mubi, Northern Guinea Savannah, Adamawa State Nigeria

Njobdi, M[1]. and Babayola, M[2].
[1]Department of Agricultural Technology, Adamawa State Collage of Agriculture, Ganye, Nigeria
[2]Department of Crop Science, Adamawa State University, Mubi, Nigeria
Contact: *muazubabayola2@gmail.com* ***(07030086018)***

(Received in October 2024; Accepted in November 2024)

Abstract

Low crop productivity is a general problem facing most farming systems in Nigeria and due to the increase in demand in urban areas where people are not involved in the primary production, the demand for vegetable amaranths has increased. Field trial was conducted during the 2022 cropping season, under rain fed condition at Teaching and Research Farm, Food and Agricultural Organization/Tree Crop Program (FAO/TCP) farm, Adamawa State University, Mubi. The treatments consisted of four Plant Growth Regulators (Gibberellins, Cytokinins, Indole butyric acid and Water as control). The Treatments were laid in a Randomized Complete Block Design replicated three times. Data were collected on plant height, stem girth, leaf area, dry matter weight, crop growth rate and fresh vegetable yield. Data collected were subjected to Analysis of Variance and treatments that showed significant differences were separated using Least Significant Differences at 5 % level of probability. The results showed that foliar application of gibberellins recorded the highest men values in all the growth and vegetable yield with 31.23 cm and 105.07 cm plant height, 5.59 mm^2 and 21.97 mm^2 Stem girth, 43.04 cm^2 and 281.03 cm^2 leaf area, 6.23 g and 28.23 g dry matter weight, at 3 and 6 WAS respectively. Similarly, higher crop growth rate of 8.38 g/m^2/ day, and fresh vegetable yield (79.07 tones ha^{-1}) at 6 weeks after sowing was also obtained from the application of gibberellins. For the best yield of vegetable amaranth (Amaranthus caudatus L.), foliar application of gibberellins was found to be promising and farmers are therefore advised to adopt its utilization in order boast amaranth production in the study area.

Keywords: Amaranthus, plant growth regulators, growth and vegetable yield.

Introduction

Vegetables are essential in the diet for humans as they provide plant fibre, mineral elements, vitamins, carbohydrates and proteins, (Hollingsworth, 2017). *Amaranthus caudatus* L. is a leafy vegetable commonly cultivated in Nigeria and other West African countries Olorode (2015). Aphane *et al.* (2016) reported that foods of animal origin which are known was the major source of vitamins and proteins are very expensive for poor households. Fruits and vegetables could alternatively play a major role in alleviating problems associated with malnutrition due to their ability to supply proteins, vitamins, calories and other nutrients needed in a balanced diet (Wehmeyer and Rose, 2018). Laker (2007) observed that of more than 100 different indigenous leafy vegetable species in Africa, amaranth is the most widely consumed. Amaranth, a C4 plant, is one of a few dicots in which the first product of photosynthesis is a four carbon compound. Mabulu and Chalamila (2005) reported that the average leaf yields of amaranths in Sub-Saharan Africa are less than 1.2 t ha^{-1}, against the potential yield of 32 - 40 t ha^{-1}. Most of existing cultivars of amaranth in Africa are generally much smaller, up to 50 cm, strongly branched and prostrate with many flowers and small leaves which creates difficulties during harvest particulary *A. blitum* and *A. graecizans* (Mabulu Chalamila, 2005). Amaranth requires 40 – 50 % less moisture than maize and survives better than most crops under dry and hot conditions because of its extensive root system and use of C4 photosynthesis mechanism (Stallknecht *et al.*, 2018).

African indigenous vegetables play significant role in the food security of the under-privileged in both

urban and rural settings (Schippers, 1997). Many communities use vegetables as source of energy and micro nutrients in their diets. Vegetables are usually picked fresh, used as greens in salads or blanched, steamed, boiled, fried in oil, and mixed with meat, fish, cucurbit seeds, groundnut or palm oil. Cooked greens can be used as a side dish, in soups or as an ingredient in sauce and baby food etc. (Grubben and Denton, 2004). The carbohydrates in Amaranth grain consist primarily of starch made up of both glutinous and non-glutinous fractions. The unique aspect of Amaranth grain starch is that the size of the starch granules is much smaller than found in other cereal grains. The unique size and composition of Amaranth starch suggested that the starch may possess unique gelatinization and freeze/thaw characteristics which could be of benefit to the food industry. Several considerations for the use of Amaranth starch in food preparation of custards, pastes, and salad dressing have been reported by Singhal and Kulkarni (1990 a, b, c). The crop can therefore support farmer's income, In Sub-Saharan Africa about 20 - 25 % of the population is under-nourished due to poor energy and protein intake. In addition, 40 % of women in childbearing age are anemic, while a similar proportion of children under-five years lack enough nutrients for normal physical development (IFPRI, 2019). Research indicated that the vast majority of yield growth in African agriculture to date has been due to improved seed varieties and appropriate seed rate, as opposed to technological improvements in cultivation practices or other inputs (Evenson, 2013). Improved vegetable productivity and resources use efficiency could only be achieved, when appropriate planting technique and seed density, adequate application of fertilizers and use of Plant Growth Regulators (PGRs) are available.

For sustainable food production to meet the increasing population in Nigeria, the production of vegetable amaranths need to be increase through proper application of plant growth regulators that can give maximum output because most vegetable amaranth growers in Nigeria do not apply PGRs. Vegetables can be grown all year round and can be produced even on marginal soils. Most of the important indigenous vegetables including amaranth have been identified as having potential for commercial exploitation and production for human consumption (Taylor and Moss, 2020). Most indigenous plants can adapt to the prevailing conditions and require few agricultural inputs to perform well in areas unsuitable to introduced vegetables (Aphane *et al*., 2016).

Amaranth is considered as underutilized crop (NRC, 1984) and has, until recently, received little research attention. Low crop productivity is a general problem facing most farming systems in Nigeria. Due to the increase in demand in urban areas where people are not involved in the primary production, the demand for this vegetable crop has increased (Schippers, 1997); this has made the vegetable amaranths to become an important commodity in the market and its production an important economic activity for the rural people. However, yield per hectare of this crop is low (7.6 t/ha^{-1}) when compared to that of United States of America (77.6 t/ha^{-1}) and world average (14.27 t/ha^{-1}) (FAO, 2014). This may be to poor cultural practices such as fertilizer application, timely planting, pests and disease control and non-use of plant growth regulators that can give maximum growth and yield. Even though much work has been done on the performance of vegetable amaranth, but at the moment not much work has been done on the effect of plant growth regulators on the performance of vegetable Amaranth in Mubi environment. Therefore, the right plant growth regulators that can give maximum growth and vegetable yield of amaranths needed to be identified, and this could be achieved through the use of different plant growth regulators.

The objectives of this study are to evaluate the effect of plant growth regulators on the performance of vegetable amaranth and to identify the best plant growth regulators that can give maximum yield of vegetable amaranth in the study Area.

This research will facilitate understanding of the plant growth regulators and its effect on vegetable amaranths. Furthermore, the finding of this study will also be of great importance to researchers, farmers and policy makers as a guide to help in solving the issue of low yield among vegetable farmers in Nigeria.

Materials and Methods

Experimental Site

Field experiment was conducted at the Department of Crop Science, Food and Agricultural Organization/Tree Crop Program (FAO/TCP); Teaching and Research Farm, Adamawa State University, Mubi, under rain fed condition in 2023 cropping season. Mubi is located in the Northern Guinea Savannah zone of Nigeria, situated between latitude 10° 11' and 10° 30' North of the Equator and between longitude 13^0 10' and 13° 30' East of the Greenwich meridian and at altitude of 969 m above mean sea level (MSL). The mean rainfall of Mubi is 969 mm and a minimum temperature of 18°C during harmattan period and 40°C as maximum in April (Adebayo, 2020).

Treatments and Experimental Design

The treatments consisted four (4) different plant growth regulators viz; Gibberellins, Cytokinins, Indole butyric acid (IBA) and Water. The experiment was laid out in a Randomized Complete Block Design (RCBD) replicated three times. The gross plot size was 2 m × 2 m (4 m^2) and the net plot size 1.5 m x 1 m (1.5 m^2), two meters was left between replicates and 1 m between plots to check the effects of one treatment on the other.

Land Preparation

The land was sprayed with herbicide (paraquat) to control the weed before ploughing, which was done by tractor and the field was later levelled manually using hoe to pulverize the soil before sowing.

Source of Seed and its Description

The seed of Amaranths used in the research was obtained at Mubi main market. Seed of are small, around 0.9 to 1.7 mm in diameter. The mass of 1000 seeds is around 0.6 to 1.0 g. Grains are lenticular, with a color that varies from white to gold and brown to black. The coat of the seed is smooth and thin.

Seed Treatment and Sowing

The seed was treated with a seed dressing chemical (apron star) at a rate of 1 sachet (10 g) to 1.5 kg of seed to control the effects of soil pathogen on the germination and early growth of seedlings. The seed was sown by drilling method (25 cm) between drills and later thinned to 5 cm between plants at two weeks after sowing (WAS).

Fertilizer Application

Nitrogen (N) fertilizer was applied at the rate of 120 kg N ha^{-1}, while phosphorus and potassium were applied at the rate of 30 kg P_2O_5 and MOP ha^{-1} respectively. Half of the N together with P and K were applied at land preparation using NPK 20:10:10; while the remaining half of the N was applied at 3 WAS using urea (46 % N).

Application of Plant Growth Regulators (PGRs)

The plant growth regulators were foliage applied at 20 and 30 days after sowing. Gibberellins (5 %) was sprayed at the rate of 600 ml per ha (60 ml was diluted in clean water per knapsack), Cytokinins (0.4 %) was sprayed at the rate of 300 ml per ha (30 ml was diluted in clean water per knapsack), Indole butyric acid (IBA 0.6 %) was sprayed at the rate of 300 ml per ha (30 ml was diluted in clean water per knapsack). The clean water used in the dilution of the PGRs was sprayed to the control plots.

Pest Control

Incidence of weed was controlled manually using hoe after every two weeks during the period of the experimental while **i**nsect pest control was done using cypermetrin (0.5 % EC) at the rate of 750 ml ha^{-1}.

Harvesting

Vegetable amaranth was harvested at 6 weeks after sowing when all the vegetative parts have reached their maximum to serve as green vegetable. The *Amaranthus caudatus* L. was harvested just before flowering in order to maintains quality.

Data Collection

Ten (10) sampled plants were tagged in each plot and data were collected on the following parameters.

1. ***Plant height*:** plant height was measured from the ground level up to the end of terminal bud using meter rule and their mean was calculated and recorded (cm).
2. ***Stem girth:*** Stem girth of the ten tagged plants from each plot were determined

using venire caliper and their mean was calculated and recorded (mm).

3. ***Leaf area:*** Leaf area of the ten sampled plants were determined by measuring the leaf length and width using meter rule and multiply by its factors (0.645) as suggested by Babayola and Toungos (2017) and their mean was calculated and recorded (cm^2).
4. ***Dry matter weight:*** Five (5) destructive sampled plants from each plot were oven dry to a constant weight and the dry matter weight of leaves and stems was determined. The weight obtained was recorded in grams (g) per plant.
5. ***Crop growth rate:*** *(CGR) (g/m2/day)* This is the rate of growth of crop per unit area. The CGR was determined as $CGR = \frac{W2-W1}{T2-T1} \times \frac{1}{P}$ where; W_1 and W_2 are shoots dry weight which was taken at two consecutive harvests over time interval T1 and T2, while P is the ground area covered by the plant (Reddy and Reddy, 2010).
6. ***Fresh vegetable Yield:*** Final vegetable yield was determined by harvesting the whole net plot of each treatment and weighing using sensitive scale and the weight was converted to fresh vegetable yield in tons per ha. That is; $\frac{\text{weight of net plot}}{\text{area of net plot}}$ x 10,000 m^2.

Data Analysis

Data obtained were subjected to analysis of variance (ANOVA) using SAS (2008) version 9.2. and treatment means were separated using Least Significance Difference (LSD) at 5 % level of probability.

Results

Effects of Plant Growth Regulators on the Growth and Vegetable Yield of Amaranth (Amaranthus caudatus L.) in Mubi During 2022 Growing Season

The result of effect of plant growth regulators on plant height, stem girth, leave area, dry matter weight at 3 and 6 WAS, and crop growth rate and fresh vegetable yield of *Amaranthus caudatus* at 6 WAS in 2022 growing season are presented in Table 1. The result showed a highly significant (P<0.001) difference between the treatments in all the parameters measured, at both 3 and 6 WAS during the period of the study. At 3 WAS, foliar application of gibberellins recorded the highest values on plant height (31.23 cm/plant), followed by cytokinins (24.20 cm/plant) which is statistically the same with Indole butyric acid (21.87 cm/plant), while the least value was recorded from control (13.60 cm/plant). Similarly, at 6 WAS, gibberellins recorded the tallest plants (105.07 cm/plant), followed by cytokinins (90.57 cm/plant) and control recorded the shortest plants (50.93 cm).

Table 1: Effects of Plant Growth Regulators on the Growth and Vegetable Yield of Amaranth (*Amaranthus caudatus* L.) in Mubi During 2022 growing season

Treatment	Plant height (cm)		Stem girth (mm)		Leaf area (cm^2)		Dry mater weight (g)		Crop growth rate ($g/m^2/d$)	Fresh vegetable yield ($t\ h^{-1}$)
	3WAS	6WAS	3WAS	6WAS	3WAS	6WAS	3WAS	6WAS		
Gibberellins	31.23	105.07	5.59	21.97	43.04	281.03	6.23	28.23	8.380	79.07
Cytokinins	24.20	90.57	4.46	18.00	34.77	214.70	4.87	19.50	5.593	71.30
Indole butyric acid	21.87	79.70	4.04	17.67	29.78	181.30	4.33	17.50	5.053	70.87
Water (control)	13.6	50.93	3.33	9.07	18.31	102.63	3.27	10.60	2.807	26.20
P of F	0.001	0.001	0.001	0.001	0.003	0.001	0.001	0.001	0.001	0.001
LSD	3.3479	6.804	0.4034	2.329	10.112	31.892	0.5011	2.6716	0.9935	3.4410

WAS = Weeks After Sowing.

The result of stem girth also showed that application of gibberellins recorded the highest values of 5.59 mm^2 and 21.967 mm^2/plant at 3 and 6 WAS, followed by cytokinins (4.46 mm^2 and 18.00 mm^2), while control recorded the least value of 3.330 mm^2 and 9.067 mm^2/plant) at 3 and 6 WAS respectively.

In a similarly vein, foliar application of gibberellins recorded the highest leaf area (43.04 cm^2 and 281.03 cm^2), followed by cytokinins (34.77 cm^2 and 214.70 cm^2), the least value was recorded from control (18.31 cm^2 and 102.63 cm^2/plant) at 3 and 6 WAS.

The result further showed that application of gibberellins recorded the highest value on dry matter weight (6.23 g and 28.23 g), followed by cytokinins (4.87 g and 19.50 g), the least value was recorded from control (3.27 g and 10.60 g/plant) at 3 and 6 WAS.
Similar pattern was observed on crop growth rate, as the foliar application of gibberellins recorded the highest mean value of 8.380 g/m^2/day, followed by cytokinins (5.593 g/m^2/day) which was statistically the same with indole butyric acid (5.053 g/m^2/day), but control recorded the least value (2.807 g/m^2/day) at 6 WAS.

The result of effect of plant growth regulators on fresh vegetable yield of *Amaranthus caudatus* at 6 WAS also indicated that foliar application of gibberellins recorded the highest value (79.07 tons/ha), followed by cytokinins (71.30 tons/ha) which was statistically similar with indole butyric acid (70.87 tons/ha) and the least value was recorded from control (26.20 tons /ha).

Discussion

The highest values recorded in the application of gibberellins in all the growth characters (plant height, stem girth, leaf area, dry matter weight, crop growth rate and fresh vegetable yield) measured could be due to the positive influence of gibberellins in cell division and elongation of the plants. This result is in line with the findings of Mc (2009); who reported that, application of gibberellins enhances the growth and yield of vegetable crops. Similarly, Mandava (1979), reported that gibberellins are important in seed germination, which affect enzyme production that mobilizes food production used for growth of new cells and they also promote flowering and cellular division. This was also in agreement with the findings of Surendra *et al*. (2006) who reported that application of gibberellins in different concentrations (25 and 50 ppm) significant increase plant heights of amaranthus. Singh *et al*. (2005) also reported that as gibberellins rates increased plant height, stem girth, leaf area, weight per plant and yield per hectare in amaranthus also increased. Furthermore, Babayola (2021) also reported an increase in leaf area, plant height and early flowering with the application of gibberellins in cowpea plants.

Conclusion

Based on the findings from this study, it can be concluded that foliar application of plant growth regulators significantly influenced the growth and vegetable yield of amaranths with gibberellins recorded the highest vegetable yield (79.07 $t\ ha^{-1}$)). Based on the findings of this trial, farmers can be advised to adopt the use of gibberellins growth regulators to boast the production of vegetable amaranths.

References

Adebayo, A. A. (2020). *Adamawa State in Maps. Climate ii. Rainfall:* Adebayo, A.A and Tukur, A.L.(eds). Paraclete publishers, Yola. Pp 23 - 26.

Aphane, J., Chadha, M. L. and Oluoch, M. O. (2016). Increasing the consumption of micronutrient-rich foods through production of indigenous foods. *In: FAO/AVRDC International Workshop Proceedings*, 5 - 8 March 2002, Arusha, Tanzania. AVRDC - The World Vegetable Centre Shanua, Taiwan: AVRDC Publication. No. 03 - 561: pp: 1-77.

Babayola, M. (2021). Influence of Plant Growth Regulators, Varieties and Phosphorus Levels on the Growth and Flowering of Cowpea (*Vigna unguiculata* L.) in Yola, Adamawa State Nigeria. *Adamawa State Journal of Scientific Research*. 9 (2) 2021. www.adsursr.com

Babayola, M. and Toungos, M. D. (2017). Growth and yield of vegetable amaranth

(Amaranthus cruentus L.) as influenced by row spacing and nitrogen fertilizer in Northern Guinea Savannah of Nigeria. *Asian Journal of Science and Tech*nology. 08 (11): pp. 6427-6433.

Evenson, R. E. (2013*). Making science and technology work for the poor*. In: Baidu-Forson, J.J (Ed) Green and Gene Revolution in Africa. Annual Lectures 2016 sponsored by UNU-INRA and UN ECA, October 2016, pp: 203.

F.A. O. (2014). *Traditional food plants*. FAO food and nutrition pa*per* 42.

Grubben, G. J. H. and Denton, O. A. (2014). *Plant resources of tropical Africa*. *Vegetable PROTA.*

Hollingsworth, D. F. (2017). *The place of potatoes and other vegetables in the diet in vegetable produc*tion. Spedding, C.R.W. (ed) Macmillan London. Pp 154.

IFPRI. (2019). *IFPRI key facts series: Poverty. W*ashington, DC: International Food Policy Research Institute (IFPRI). http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/133271

Laker, M. C. (2007). Introduction to the special edition of Water SA on indigenous crops, water and human nutrition. *Water SA*, 33 (3): 311-315.

Mabulu, R. B. and Chalamila, B. N. (2005). Organic vegetable production an alternative income generating activity to the disease effected coconut farming system in Mkuranga District in Tanzania. *African crop science conference proceedings, Vol. 7. pp*: 1539-1544.

Mandava. N. B. (1979). Natural products in plant growth regulators and plant growth substances, ACS symposium series 111, Washington (DC): *American chemical society, Pp*.137 – 143.

Mc, S. (2009). *Asymmetrical placement of cut tips on coleoptiles.* Gibberellins for treatment of bakanae disease. Pp. 89 – 93.

NRC. (1984). *Amaranth: modern prospects for an ancient crop.* National Research Council. National Academy Press, Washington, D.C.

Olorode, O. (2015). *Taxonomy of West African Flowing Plants.* Longman Group Ltd., London, UK. Pp 158.

Reddy, T. Y. and Reddy, G. H. S. (2010). *Principles of Agronomy*. Fourth revised edition, Kalyani Publishers, New Delhi. Pp 89 - 93.

SAS. (2008). *Statistical Analysis Software systems*. User's guide version 9.2, SAS Institute Inc. Raleigh, New York. U.S.A.

Schippers, R. (1997). Domestication of indigenous vegetables for Sub-Saharan Africa: A strategy paper. African indigenous vegetables, *Workshop Proceedings,* January 13-18, 1997, Limbe, Cameroon. Pp. 125 - 135.

Singh, U. O., Wadhwani, A. M. O. and Johri, B. M. (2005). *Dictionary of economic plants of India.; (ed.2).*

Singhal, R. S. and Kulkarni, P. R. (1990a). Some properties of *Amaranthus paniculatas* (Rajgeera) starch pastes. *Starch/ Starke,* 42: 5-7.

Singhal, R. S. and Kulkarni, P. R. (1990b*).* Utilization of *Amaranthus paniculatas* (Rajgeera) starch in salad dressing. *Starch / Starke* 42: 52-53.

Singhal, R. S. and Kulkarni, P. R. (1990c). Studies on applicability of *Amaranthus paniculatas* (Rajgeeraa) starch for custard preparation. *Starch/Starke* 42: 102- 03. SERC,

Stallknecht, G. F., Gilberstone, K. M. and Ekohff, J. L. (2018) Food crop for people and animals. *New Crops.* 1: 231-234.

Surendra, W., Bin, A. and Petty, I. (2006) *GA3 used in different concentrations (25 and 50 ppm) a significant increase in plant heights was observed on Amaranthus*

Taylor, F. K. and Moss, H. (2020). *The potential for commercial utilization of veld products in Botswana.*Veld Products Institute, Gaborone.

Wehmeyer, A. S. and Rose, E. F. (2018). Important indigenous plants in the Transkei as food supplements. *Bothalia,* 14: 613 – 615