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Response of Vegetable Amaranth (*Amaranthus Cruentus* L.) To Gibberellic Acid Concentrations in Sudan Savannah Zone Of Nigeria

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Abstract: Two field experiments were conducted during the 2015 rainy season at the teaching and research farm of Bayero University Kano new campus (Latitude 12^0 58 'N and Longitude 8^0 25'E) and at the National Horticultural Research Institute Bagauda, Kano (11^0 33'N and 8^0 23'E), both located in the Sudan savanna ecological zone of Nigeria to evaluate the response of vegetable Amaranth (*Amaranthus cruentus* L.) to Gibberellic acid concentrations. The treatment consists of four levels of Gibberellic acid (GA_3) (0, 200, 400, 600ppm) that were laid using out in a Randomized complete block design with four replications, the net plot was 2m X 1.5m making ($3m^2$) with 0.5m between 1m between replicates. Application of GA_3 400ppm and 600ppm significantly increased plant height, number of leaves, leaf area, fresh weight, dry weight at both locations in addition application of Gibberellic acid at 400ppm and 600ppm significantly increased the fresh and dry weight of amaranth at Bagauda. Hence these treatments are recommended for amaranth farmers in the study area in order to boost their economic status.

Keywords: Amaranth, Gibberellic acid, growth, fresh weight and dry weight.

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I. INTRODUCTION

Vegetable Amaranth *(Amaranthus cruentus* L.) is a member of the family Amaranthacea. It is also called *Alayyahu* in Nigeria (Vorster *et.al*, 2002). Amaranth is usually green in color, but a purple one is also grown in some part of the country. The plant can grow up to 2m tall, seed are black in the wild plant and white in the domesticated farm and are eaten as a cereal grain. In Nigeria, amaranths (*Amaranthus* sp.) is grown basically on rotted dung, dilapidated place or on irrigated fields and fallow lands with no deliberate or with just little cultivation performances. Seeds are usually broadcasted on beds or flat land. To avoid overcrowding the plant is thinned at some certain stage of growth and thus removed from the first harvest. They are grounded in to flour, popped like popcorn, cooked in to porridge, and used in to confectionery foods. The leaves can be cooked like spinach, (Gruben and Denton, 2004).

The constraints facing vegetable crop production apart from few pest and diseases is how to improve vegetative part, in this respect the need of plant growth regulators is very important for rapid vegetative growth and nutritional improvement. In addition to that not much work has been done on this crop especially in Northern Nigeria. Gibberellic acid (GA_3) regulates important function such as elongation of stems and synthesis of proteins. Faten *et al.,* (2008) reported that application of GA_3 enhanced plant height, number of shoots per plant, number of leaves per plant as well as fresh and dry weight per plant in potato. The significant increase in plant fresh weight, plant dry weight, with application of GA_3 at varying concentration could be attributed to the positive influence of that growth regulator (GA_3) on cell division, cell elongation and cell expansion. Gibberellic acid on has also been reported to have increased plant height, leaf area index and total dry matter in common beans (Ngatia *et al.* 2004).

Basically, plant height is a genetically controlled character, but several studies have indicated that plant height can be increased by the application of plant growth regulators. It was observed that there was a substantial improvement in the growth and development due to the application of various agro-chemicals, fertilizers, micronutrients and the effect was more pronounced with the foliar application of GA_3 (Ganapathi, 2006).

The efficiency of 400ppm in plants height, numbers of leaves, number of branches and leaf area were significantly higher as compared with other treatments. In a related development Fagge, (2009); Abbas, (2010) and Davis and Namez, (2000) reported that foliar application of growth regulators especially GA_3 increases plant height, leaf area index and fresh weight of some leafy vegetables. The objective of this research was to investigate the effectiveness of Gibberellic acid on growth and yield components of vegetable Amaranth.

II. MATERIAL AND METHODS

The research was conducted in 2015 rainy season at two different locations; teaching research farm of the faculty of Agriculture, Bayero University Kano New site, Ungogo local Government area of Kano State, (lat. 12° 58′ N and long. 8^o 25´E) Olofin, (2007) and at the National Horticultural Research Institute, Bagauda, Bebeji local Government area Kano State (11o 33' N, 8^o 23' E) in the Sudan savannah ecological Zones of Nigeria. The field was prepared through the use of plough, harrowing and a 75cm ridges were made. The field was later marked out into 36 plots, the gross plot was 2m X 4.5m ($9m^2$) while the net plot was 2m X 1.5m ($3m^2$) with 0.5m and 1m discard between plot and replication respectively.

The experiment consist of four levels of Gibberellic acid (GA_3) concentration (0, 200, 400, and 400ppm) laid out in a Randomized complete block design and replicated four times. Vegetable Amaranth NHAR 493-1 variety were raised in the nursery beds for three weeks and then transplanted to the field. Transplanting was done on 16^{th} and 22^{nd} August for BUK and Bagauda respectively, at a depth of 2cm with a spacing of 75 X 25cm inter and intra row spacing. Fertilizer were applied by side placement at 3WAT using NPK (15:15:15) at a rate of 30kg N 30kg P_20_5 30kg K_2O /ha, while the second dose of 20kg N/ha nitrogen were applied at 2 weeks after first applications using Urea. Hoe weeding was done at 2WAS intervals. Soil samples were collected randomly from the experimental site at the depth of 0-30cm using an auger and analyzed for physical and chemical properties using standard procedures as described by Black (1965). Data on crop growth and development were collected using agronomic procedures that included plant height, number of leaves, number of branches and leaf area at 3, 6, and 9WAS while fresh and dry weight were recorded at 6, 8 and 10WAT.The data were subjected to statistical analysis of variance using Gen stat 16^{th} edition treatment means were compared using Student Newman-Keuls (SNK).

III. RESULT AND DISCUSSION

The results of the physico-chemical analysis of the soil samples are shown in Table 1 which indicated that the soils were sandy-loam. It also showed that the soil were acidic (pH 6.9 - 7.24) in both locations the soils recorded low organic carbon (0.22 - 0.37), low total nitrogen (0.10 - 0.07), and moderate available phosphorous at BUK (9.41) while that of Bagauda appeared very low (0.18). The concentrations of (Ca, Mg) increased with soil depths at BUK and Bagauda except (Na, and K). The soils of the experimental sites were sandy in nature.
Plant height of amaranth was significantly different at 3 and 6WAS sampling stage at BUK (Table 3). In all cases significantly taller plants were recorded with application of GA_3 at 200ppm, 400ppm and 600ppm that were statistically different with the zero application of GA_3 (0ppm) (Table 2). These supported the findings of (Davis and Namez, 2009; and Abbas 2010) that variations in plant height are largely due to GA_3 concentration as it has the ability to increase shoot system when applied by foliar application to plants. However, Khan and Tewari, (2003), revealed an increase in height on the stems at different concentrations.

Table 1 Physio-chemical properties of the soil (0-30cm) at the experimental sites in 2015 rainy season.

Character	BUK	BAGAUDA
Particle size distribution		
Sand	74	72
Clay	9.4	9.6
Silt	16.6	18.4
Texture	Sandy-loam	Sandy-loam
Chemical Composition		
pH (H_2O)	6.9	7.24
Organic carbon (g/kg)	0.22	0.37
Total nitrogen (g/kg)	0.10	0.07
Available phosphorus (mg/kg)	9.41	0.18
Total phosphorus (mg/kg)	148	98.67
Exchangeable Bases (cmol/Kg)		
Ca	4.4	3.70
Mg	0.80	1.25
K	0.31	0.51
Na	0.47	0.11

Plant height of amaranth was significantly different at 3 and 6WAS sampling stage at BUK (Table 3). In all cases significantly taller plants were recorded with application of GA_3 at 200ppm and 400ppm that were statistically different with the zero application of GA_3 (0ppm) (Table 2). These supported the findings of (Davis and Namez, 2009; and Abbas 2010) that variations in plant height are largely due to GA_3 concentration as it has the ability to increase shoot system when applied by foliar application to plants. However, Khan and Tewari, (2003), revealed an increase in height on the stems at different concentrations.

Number of leave of amaranth were significantly different at 6 and 9WAT at BUK, with application of 400ppm recoding more number of leaves that are statistically similar with application of 200ppm GA_3 compared with control plots zero (0ppm) GA_3 (Table 2). The result is in agreement with finding of Tan and Marbach (2000). That plant growth regulators are organic substances with important functions in regulating growth of the plants. In a similar development Anika and Amans, (2011) reported that, GA_3 has been used to increase the length, height and number of leaves of plants, it also increase the number of flowers and induced flowering.

Table 2 Effects of Gibberellic acid on plant height and Number of leaves of Amaranthus at BUK and Bagauda in 2015 Rainy Season.

Treatment	Plant Height						Number of Leaves					
	BUK (WAT)			BGD (WAT)			BUK (WAT)			BGD (WAT)		
GA_3 (Ppm)	3	6	9	3	6	9	3	6	9	3	6	9
0	37.5b	107.6c	119.7	22.8	60.4	69.4	20.18	46.3c	65.2c	11.5	33.3	50.3
200	51.2a	129.6a	116.0	39.1	58.1	79.3	19.93	76.8ab	89.1ab	15.4	59.2	69.6
400	52.0a	132.1a	128.8	27.4	76.6	76.0	24.81	93.9a	96.6a	12.6	45.8	82.9
600	48.3a	117.6ab	121.9	25.3	58.5	66.4	21.00	64.0b	87.6b	12.1	47.2	64.8
S.E±	2.99	4.68	5.32	3.82	7.70	6.94	1.41	5.15	7.30	2.11	9.88	10.8
Signifiance	**	*	NS	NS	NS	NS	NS	**	*	NS	NS	NS

Means with the same letter(s) in the same column are not significantly different (P < 0.05%) using SNK = Student Newman-Keuls test, BUK = Bayero University Kano, BGD = Bagauda and WAT = Weeks after Transplanting.

Number of branches was significant only at 3WAS at BUK with 400ppm and 200ppm GA_3 concentration recording more number of branches compared with 200ppm and 0ppm GA_3 concentration (Table 3). Sarkar *et al.* (2002) reported that GA_3 and IAA sprayed separately on soybean hand enhanced number of branches per plant, and plant dry weight per plant. In another contrarily development Kamuro (2005) reported that plants sprayed with GA_3 at 50ppm and Abscisic acid at 10ppm showed increased photosynthetic rate and dry weight of shoot and root per plants compared to those plots sprayed with either GA_3 or Abscisic acid at higher levels.

Leaf area of amaranth was significant at 9WAS across both locations with application of 400ppm GA_3 concentration resulting in wider leaf area that were statistically at par with other treatments while zero (0ppm) GA_3 resulting in narrower leaf area (Table 3). Medina and Saavedra, (2005) reported that, GA_3 has been used to increase leaf are, length, height of plants, increase the number of flowers and induced flowering in vegetables crops.

Table 3 Effects of Gibberellic acid Concentration on Number of Branches and Leaf Area (cm^2) of Amaranth at 3, 6, and 9WAT during 2015 rainy season.

Treatment	Number of Branch						Leaf Area					
	BUK (WAT)			BGD (WAT)			BUK (WAT)			BGD (WAT)		
GA_3 (ppm)	3	6	9	3	6	9	3	6	9	3	6	9
0	4.9b	5.5	7.1	2.5	5.2	6.1	68.0	81.5	131.3c	27.9	48.9	31.5c
200	7.3a	7.2	8.5	4.8	5.2	8.0	68.7	78.8	148.5b	24.1	44.3	148.4b
400	7.6a	8.3	9.5	4.4	4.3	7.0	73.6	82.5	162.7a	28.1	50.2	162.6a
600	6.3b	7.5	8.5	4.6	4.2	5.3	67.0	76.5	146.1b	23.7	41.9	146.1b
S.E±	0.64	0.71	0.71	1.29	0.8	1.16	7.50	6.65	5.50	2.50	4.38	7.51
Signifiance	**	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means with the same letter(s) in the same column are not significantly different (P < 0.05%) using SNK = Student Newman-Keuls test, BUK = Bayero University Kano, BGD = Bagauda and WAT = Weeks after Transplanting.

The fresh weight of Amaranthus was highly significant by the application of all levels of GA_3 for both the location except at all sampling periods except at 3 at Bagauda application of 400ppm GA_3 produced statistically higher fresh weight than the control (0ppm) (Table 4). The report was similarly to the finding of Ganapathi, (2006) reported that there is an improvement in growth and development due to the application of various agro-chemicals, fertilizers, micronutrients and the effect was more pronounced with the foliar application of GA_3 which leads to production of more vegetable plants.

The dry weight of Amaranthus was significantly significant by the application of GA_3 across both locations except at 6WAT at Bagauda location. The results indicated that BUK application of 400ppm and 200ppm GA_3 recorded statistically heavier dry weight across both locations (Table 4). The result is in consonance with finding of Ngatia *et al*., (2004). That GA_3 has been reported increased plant height, leaf area index and total dry matter in common beans. In another related development Ganapathi, (2006) and Fagge, (2009) reported that there is an improvement in growth and development due to the application of various agro-chemicals, fertilizers, micronutrients and the effect was more pronounced with the foliar application of GA_3 which leads to production of more vegetable plants.

Table 4 Effects of Gibberellic acid Concentration on Fresh and Dry Weight of Amaranth at 6, 8, and 10WAT during 2015 rainy season.

Treatment	Fresh Weight						Dry Weight					
	BUK (WAT)			BGD (WAT)			BUK (WAT)			BGD (WAT)		
GA_3 (ppm)	6	8	10	6	8	10	6	8	10	6	8	10
0	16.0e	14.0d	19.0b	21.7	20.8c	12.9b	3.0b	1.6b	5.5b	3.83	6.2c	4.4c
200	127.0b	168ab	183a	25.5	71.7b	94.1a	31.4a	27.4a	47.4a	5.63	23.9ab	24.4ab
400	171.0a	124ab	217a	39.6	102.8a	94.2a	45.3a	40.6a	64.1a	7.58	30.5a	30.2a
600	66.0cd	61.0cd	77.0b	18.6	26.0c	46.2ab	4.3b	12.1b	24.5b	4.06	7.8c	12.4c
S.E±	25.2	25.0	25.1	8.36	19.2	16.7	5.32	5.09	6.68	1.46	5.98	4.48
Signifiance	**	**	*	NS	*	*	**	**	**	NS	*	**

Means with the same letter(s) in the same column are not significantly different (P < 0.05%) using SNK = Student Newman-Keuls test, BUK = Bayero University Kano, BGD = Bagauda and WAT = Weeks after Transplanting.

IV. CONCLUSION

Based on the results obtained it can be concluded that the application of GA_3 at 400ppm and can be more beneficial to farmers and resulted in better growth and development, The increase in fresh and dry weight might be due to the increase in growth parameters such as plant height, number of leaves leaf area and number per plant. It has been suggested that farmers in the Sudan Savanna zone should adopt the use of GA3 application at 400ppm or 200ppm for maximum yield of Amaranth.

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