ISSN: 0976-3376

Available Online at http://www.journalajst.com

ASIAN JOURNAL OF
SCIENCE AND TECHNOLOGY

Asian Journal of Science and Technology
Vol. 08, Issue, 11, pp.6427-6433, November, 2017

RESEARCH ARTICLE

GROWTH AND YIELD OF VEGETABLE AMARANTH (*AMARANTHUSCRUENTUS.*) AS INFLUENCED BY ROW SPACING AND NITROGEN FERTILIZER INNORTHERN GUINEA SAVANNAHOF NIGERIA

***Babayola, M and Toungos, M. D.**

Department of Crop Science Adamawa State University, P M B 25 Mubi, Adamawa State Nigeria

ARTICLE INFO

Article History:
Received 22nd August, 2017
Received in revised form
04th September, 2017
Accepted 26th October, 2017
Published online 30th November, 2017

Key words:

Amaranth, Spacing,
Nitrogen, Fertilizer.

ABSTRACT

The study was conducted to determine the optimum level of fertilizer for maximum yield of *Amaranthus.*A field experiment was conducted atFood and Agricultural Organization/ Tree Crop Programme (FAO/TCP) Teaching and Research Farm, Faculty of Agriculture, Adamawa State University, Mubi, Northern Guinea Savannah zone of Nigeria on sandy loam soil. This was to study the growth and yield of vegetable amaranth (*Amaranathuscruentus* L.) as influenced by row spacing and nitrogen fertilizer in 2015 and 2016rain fed cropping seasons. The experiment involved three levels of row spacing (20, 30, and 40 cm)and five levels of N fertilizer (0, 30, 60, 90, and 120 kg ha^{-1}). These treatments in a factorial combination were laid out in a Randomized Complete Block Design and replicated three times. Data were collected on growth and yield parameters. Data generated were analyzed using Analysis Of Variance (ANOVA). Result show that Plant height, number of leaves, leaf area, absolute crop growth rate ($plant^{-1}$) of vegetable amaranth increased significantly ($P < 0.05$) as row spacing and applied N rate was increased. On a unit of area basis however, fresh yield increased as the applied N increased and row spacing decreased. Application of higher dosage of fertilizer at the rate of 120 kg N ha^{-1} with narrow row spacing of 20 cm produced significantly higher fresh yield of 73.81 t ha^{-1} in 2015, 71.80 t ha^{-1} in 2016 and 72.81 t ha^{-1} combined. The least value of yield (14.7 t ha^{-1}) was obtained in the treatment with wider row spacing and no application of N fertilizer (0 kg N ha^{-1} at 40 cm row spacing). Therefore, the optimum N rate and row spacing for the maximum yield of vegetable amaranth (*Amaranthuscruentus* L.) is 120 kg N ha^{-1} at 20 cm inter row spacing and was adjudged as the best combination for the production of vegetable amaranth in the Northern Guinea Savannah zone of Nigeria.

INTRODUCTION

*Amaranthus*collectively known as *Amaranth* is a cosmopolitan genus of herbs. Approximately, 60 species are recognized with inflorescence and foliage ranging from purple and red to gold (Grubben and Denton, 2004). Amaranth *(Amaranthus spp.*) is one of the important underutilized crop in Central and South America. It is widely cultivated in various regions of the world as well as in Nigeria as food and leafy vegetable (Smitha, 2010). The crop belong to the family *Amaranthacea*and genus Amaranthus. There is no clear dividing line between a vegetable type and grain type (Olaniyi, 2007). The leaves of vegetable amaranth are nutritionally significant source of minerals included vitamin A, vitamin B_6, vitamin C and vitamin K (Grubben and Denton, 2004).

****Corresponding author:*** **Babayola, M.,**
Department of Crop Science Adamawa State University, P M B 25 Mubi, Adamawa State Nigeria.

Amaranth has a very high nutritional value, higher grain protein (13 – 19 %) and leaf protein (23 – 25 %) with high lysine and sulphur containing amino acids, which are scarce in other conventional crops (Joshi and Rana, 1995). Amaranth has been used for food by human in a number of ways. Grain is grind in to flour for use in bread, noodles, pancake, cereals, granola, cookies and other flour based product (Putnam, 1990). *Amaranthuscruentus L.* is a tall annual herbs topped with cluster of dark pink flower and can grow up to 2 m in height (Stallknecht and Schaeffer, 1993). It is one of the three amaranths species cultivated as vegetable and grain source. The other two are *Amaranthuscaudatus* L. and *Amaranthushy pochondriacus* L. (Olaniyi, 2007; Olaniyi*et al*., 2008). Fertilizers are soil amendments applied to promote plants growth. They are roughly divided up into organic and inorganic fertilizer with the main difference between the two being sourcing and not necessary differences in the nutrient content. Fertilizers are usually directly applied to soil, and also sprayed on leaves (foliar feeding), (Mergers, 2010). The Main nutrients present in fertilizers are Nitrogen, Phosphorus and Potassium (macro-nutrients) and other nutrients are added in smaller amounts, Calcium, Magnesium and sulfur (micro-nutrients). Nitrogen been the most important nutrient in promoting vegetative growth is paramount in the production of vegetable amaranth. N promote vegetative growth and imparts the characteristics of deep green colour to foliage. It is a component of chlorophyll which is essential for photosynthesis. Where N is over supplied the leaves become dark green, soft and soppy (Yayock and Lombin, 1988; Futuless and Bagale, 2007). The Optimum N amount reported for maximum amaranths growth ranges from 45 kg to 100 kg N ha^{-1} (Olaniyi, 2007).*Amaranthus*response actively to broadcasting application of fertilizer at the rate of 50 kg N and 45 kg of P ha^{-1} and thoroughly mixed in the soil. The recommended rate of N fertilizer for amaranth in the North Eastern sub region of Nigeria is 100 kg N ha^{-1} (BOSADP, 1993). *Amaranthus* has been identified to be an important vegetable crop in Nigeria. The demand for this crop as vegetable has increased especially in urban centers where people are not involved in primary production (Schippers, 2000); this has made the vegetable to become an important commodity in the market and production an important economic activity for rural people. However, yield per hectare of this crop in Nigeria is low (7.6 t ha^{-1}) when compared to that of United State of America (77.27 t ha^{-1}) and world average (14.27 t ha^{-1}) (FAO, 2007). This may be attributed to poor cultural practices such as spacing and fertilizer application. Even though much work has been done on the effects of spacing and fertilizer application on the performance of amaranth, at the moment information on this seems to be preliminary for Mubi. Consequently, the production could not meet up with the demand for food, animal feeds, industrial uses and export. However, planting density and N fertilizer application has been reported to increase growth and yield of vegetable *amaranth*. The right quantity of fertilizer need to be applied to the crops in order to increase its growth and yield potential. This could be achieved through the use of various row spacing at different levels of N fertilizer application.

MATERIALS AND METHODS

The two years field experiments were conducted at the Teaching and Research Farm, Food and Agriculture Organization/Tree Crop Programme (FAO/TCP) farm, Faculty of Agriculture, Adamawa State University, Mubi, Nigeria. It was conducted under rain-fed condition in 2015 and 2016 cropping seasons. Mubi, located in the Northern Guinea Savannah of Nigeria is situated between latitude 10^0 10” and 10^0 30” North of the Equator and between longitude 13^0 10” and 13^0 30’’ E of the Greenwich meridian and at an altitude of 696 m above mean sea level (MSL). The annual mean rainfall of Mubi is 900 mm, and a minimum temperature of 18^0C during harmattan period and 40^0C maximum in April (Adebayo, 1990). The composite soil samplings were collected from 0 – 30 cm depth using soil auger at three different locations before ploughing. Soil samples were air dried, grounded and allowed to pass through 2 mm sieve and were analyzed for routine physical and chemical properties using standard laboratory procedures. The3 x 5 (15 treatment combinations) consisting of three rows spacing (20, 30 and 40 cm) and five levels of N fertilizer (0, 30, 60, 90 and 120 kg ha^1) were replicated three times in factorial combination and laid out in a Randomized Complete Block Design (RCBD). Each gross plot size was 2.4 m x 2.0 m (4.8 m^2) and the net plot size was 1.2 m x 1.6 m (1.92 m^2). Between plots and blocks were 0.5 m and 1 m respectively in order to check the effect of one treatment on the other. The land was prepared using tractor drawn plough once and labeled manually according to the experimental design. Germination test was carried out according to International Seed Testing Association (ISTA) (1985) standard. This was done by randomly counting 25 amaranth seeds from pure seeds.

The 25 pure seeds were placed in a petri dish containing filter paper soaked with distilled water. Germination count was made every day up to the completion of germination. A seed was considered to have germinated when the seed coat rapture, plumes and radical came out up to 2 mm length. The amaranth seed for this research (variety NH 84/445) was obtained from National Institute of Horticultural Research (NIHORT, Ibadan). The seeds were sown by drilling according to the treatments spacing and later thinned to 5 cm between plants at one week after emergence (WAE). Single Super Phosphate (SSP) fertilizer was applied at the rate of 45kg P_2 O_5ha^{-1} to all the experimental plots during land preparation and the amount of N Fertilizer needed for each plot was applied in the form of Urea (46 % N). This was calculated based on the treatment level for the N fertilizer using $Q = \frac{R}{100n} X \frac{A}{1}$ (Avav and Ayuba, 2006). Where Q = amount of fertilizer required, R = recommended rate of nutrient element, n = analysis or grade of fertilizer (%) and A = Area (m^2). Half of the N fertilizer for each treatment was applied at the time of sowing by drilling in small furrows opened manually 10 cm away from the seed line and covered with soil to avoid losses, while the remaining half of the N was applied at 3 weeks after sowing (WAS).

Hand weeding was carried out at two weekly intervals from 2 WAS. Incidence of corn ear worm, *Heliothiszea* and cowpea weevil,*Aphidscraceavora* was controlled using cypermetrin 10 EC insecticide at the rate of 800 ml ha^{-1}. The chemical persistence of the insecticide is 72 hrs. A sample consisting of ten plants was selected and tagged at random from each net plots for recording various biometric observations. Data were collected every two weeks on plant height (cm), number of leaves, leave area (cm^2), absolute crop growth rate (g wk^3) and harvestable fresh yield (t ha^1). The crop was harvested treatment wise at 6 WAS when all the vegetative parts have reached their maximum, because vegetable amaranth losses quality when aged (Futuless and Bagale, 2007). Vegetable yield was determined by weighing the plants from each net plot and converted to yield per hectare. Analysis of variance was carried out on each of the observation recorded for each year of study, followed by combined analysis over two years using SAS system 2008 (version 9.2). Mean values were subjected to Duncan’s Multiple Range Test (DMRT) at 5 % level of probability.

RESULTS

Physical and Chemical Properties of soil of the Experimental Site: The experimental site was sandy loam with pH (6.40 in 2015 and 6.50 in 2016), low available nitrogen of 0.18 g N kg^{-1} (2015) and 0.17 g N kg^{-1}(2016), medium available phosphorus of 6.67 g kg^{-1} (2015) 6.80 g kg^{-1} (2016) and high available potassium of 0.45 C mol kg^{-1} (2015) and 0.46 C mol kg^{-1} (2016) as presented in Table 1.

Table 1. Soil physical and chemical properties of the experimental site, 0-30 cm depth

Particular		*2015*	*2016*
I.	**Physical properties**		
A.	Particles size distribution (%)		
	Clay	14.2	14.1
	Silt	31.6	32.8
	Sand	54.2	53.1
B.	Textual class	*Sandy Loam*	*Sandy Loam*
II.	**Chemical Properties**		
pH (1:2 soil : water solution)		6.40	6.50
Organic carbon (kg^{-1})		3.7	3.8
Cation exchange capacity [c mol (+) kg^{-1}]		3.25	3.40
Available nitrogen (g N kg^{-1})		0.18	0.17
Available phosphorus (mg P kg^{-1})		6.67	6.82
Available potassium [c mol (+) kg^{-1}]		0.45	0.46
Available magnesium [c mol (+) kg^{-1}]		0.43	0.41
Available sodium [c mol (+) kg^{-1}]		0.36	0.35
Available calcium [c mol (+) kg^{-1}]		1.90	1.92

Crop growth, vegetative yield and Plant Height (cm): Nitrogen fertilizer application had significant effects ($P < 0.05$) on all the growth and yield parameters measured. The result on plant height at 3 and 6 WAS is presented in Table 2. At all the growth stages, in both the two seasons and the combined, height of *Amaranthus* increased as the applied N fertilizer increased up to 120 kg N ha^{-1}. Application of 120 kg N ha^{-1} recorded significantly higher than all other treatments, followed by 90 kg N $ha^{-1}$with a plant height of ///////. Plants treated with 0 kg N $^{-1}$ha recorded the lowest plant height.Similarly, the result showed that the height of amaranthus increase as inter row spacing increased. The highest plant was recorded in 40 cm inter row spacing, followed by 30 and 20 cm, respectively.

Number of Leaves: Application of 120 kg N ha^{-1} recorded more number of leaves than the remaining treatments at all the growth stages in both seasons (Table 4). This was followed by 90 kg N ha^{-1}. And the Least mean values was obtained in 0 kg N ha^{-1}.

The number of leaves differed significantly with response to inter row spacing. Plant sown at 40 cm inter row spacing recorded more number of leaves than 30 and 20 cm row spacing. This was followed by 30 cm inter row spacing which is higher than 20 cm row spacing. The interaction effect was significantly higher in treatment combinations at all the growth stage and in both seasons (Table 4). Application of 120 kg N ha^{-1} with 40 cm row spacing gave more number of leaves than the remaining treatment combinations. This was followed by 120 kg N ha^{-1} with 30 cm row spacing. The least value was obtained in the treatment combination of 0 kg N ha^{-1} with 20 cm row spacing.

Leaf Area (mm^2): The effect of nitrogen fertilizer on leaf area per plant was significant ($P < 0.05$) (Table 5). Application of 120 kg N ha^{-1} produced plants with remarkable higher leaf area than the rest of the treatment at all the growth stages in both years of the experiment and the combined. This was followed by 90 kg N ha^{-1}. The least value of //////was recorded in the application of 0 kg N ha^{-1}. The result followed the same pattern in response to row spacing. There was increased in leaf area with increased in row spacing up to 40 cm. The interaction effect was highly significant at $P< 0.05$) on all growth stages in both years of the experiment and the combined. Treatment combination of 120 kg N ha^{-1} with 40 cm row spacing recorded the highest leaf area per plant. Followed by 120 kg N ha^{-1} with 30 cm row spacing (Table 6). Treatment combination of 0 kg N ha^{-1} with 20 cm row spacing give the lowest mean value of ////

Harvestable Fresh Yield (t ha^{-1}): The result of harvestable fresh yield of *Amaranthuscruentus* L is presented in Table 7. In all the two years of the experiment and in the combined, harvestable fresh yield of vegetable amaranth increased significantly as the applied N fertilizer rate increased up to 120 kg N ha^{-1} which recorded more harvestable fresh yield. This were followed by 90 kg N ha^{-1} , 60 kg N ha^{-1} , 30 kg N $ha^{-1}$and the least value was obtained 0 kg N ha^{-1}. The row spacing of 40 cm produced significantly more harvestable fresh yield of ////. These were followed by 30 and 20 cm row spacing, respectively.

Table 2. Mean Plant Height (cm) Per Plant of *A.cruentus* L as Influenced by Row Spacing and N Fertilizer in 2015, 2016 Raining Seasons and Combined

Treatments	3 WAS			6 WAS		
	2015	2016	Combined	2015	2016	Combined
N Fertilizer(kg ha^{-1})						
0	6.45^{e}	6.26^{e}	6.36^{e}	32.43^{e}	33.95^{e}	33.20^{e}
30	13.67^{d}	13.88^{d}	13.77^{d}	35.92^{d}	36.37^{d}	36.14^{d}
60	15.95^{c}	15.96^{c}	15.94^{c}	38.96^{c}	39.40^{c}	39.18^{c}
90	17.92^{b}	17.80^{b}	17.86^{b}	47.97^{b}	49.93^{b}	48.95^{b}
120	22.28^{a}	22.28^{a}	22.28^{a}	66.71^{a}	65.32^{a}	66.02^{a}
SE ±	0.122	0.117	0.030	0.230	0.298	0.189
Level of Significance	*	*	*	*	*	*
Row Spacing (cm)						
20	13.46^{c}	13.44^{c}	13.45^{c}	39.36^{c}	38.74^{c}	39.05^{c}
30	14.99^{b}	14.94^{b}	14.97^{b}	44.04^{b}	45.11^{b}	44.58^{b}
40	17.29^{a}	17.33^{a}	17.31^{a}	49.79^{a}	51.13^{a}	50.46^{a}
SE ±	0.094	0.090	0.023	0.178	0.231	0.146
Level of Significance	*	*	*	*	*	*
Interaction						
N X Spacing	*	*	*	*	*	*

Mean value of with the same letters in each treatment are not statistically significant different at P = 0.05 (DMRT)
WAS = Weeks after sowing
N = Nitrogen
SE± = Standard error

Table 3. Mean Number of Leaves per Plant of *A.cruentus* L as Influenced by Row Spacing and N Fertilizer in 2015, 2016 Raining Seasons and c Combined

TREATMENTS		3 WAS	COMBINED	2015	6 WAS	COMBINED
	2015	2016			2016	
N Fertilizer (kg ha^{-1})						
0	7.79^{e}	7.82^{e}	7.81^{e}	13.28^{e}	14.73^{d}	14.01^{e}
30	9.40^{d}	9.47^{d}	9.43^{d}	16.46^{d}	17.87^{c}	17.16^{d}
60	10.81^{c}	10.54^{c}	10.68^{c}	18.09^{c}	18.05^{c}	18.97^{c}
90	12.38^{b}	12.31^{b}	12.34^{b}	19.09^{b}	18.84^{b}	1897^{b}
120	13.32^{a}	13.23^{a}	13.28^{a}	21.33^{a}	20.31^{a}	20.82^{a}
SE ±	0.131	0.213	0.125	0.192	0.298	0.131
Level of Significance	*	*	*	*	*	*
Row Spacing (cm)						
20	9.77^{c}	9.73^{c}	9.75^{c}	16.53^{c}	16.22^{c}	16.38^{c}
30	10.81^{b}	10.93^{a}	10.87^{b}	17.30^{b}	17.97^{b}	17.64^{b}
40	11.63^{a}	11.36^{a}	11.50^{a}	19.11^{a}	19.69^{a}	19.40^{a}
SE ±	0.101	0.165	0.097	0.149	0.137	0.101
Level of Significance	*	*	*	*	*	*
Interaction						
N X Spacing	*	*	*	*	*	*

Mean value with the same letters in each treatment group are not statistically significantly different at P =O.05 (DMRT).
* = statistically significant difference at 5% level of probability.
WAS = Weeks after sowing
N = Nitrogen
SE± = Standard error

Table 4. Interactive Effect of N Fertilizer and Row Spacing on Mean Numbers of Leaves Per Plant of *A.cruentus* L in 2015, 2016 Raining Seasons and Combined

	2015 3WAS			2016 3WAS			COMBINED		
Treatments	Inter Row Spacing (cm)			Inter Row Spacing (cm)			Inter Row Spacing (cm)		
N-Fertilizer	20	30	40	20	30	40	20	30	40
(*kg ha^{-1}*)									
0	6.20^{m}	8.33^{kl}	8.83^{jk}	6.47^{n}	8.63^{j-l}	8.37^{j-m}	6.33^{k}	8.48^{ij}	8.60^{i}
30	8.60^{j-l}	9.30^{ij}	10.30^{h}	8.43^{j-m}	9.53^{ij}	10.43^{g-i}	8.52^{ij}	9.42^{h}	10.37^{g}
60	9.60^{hi}	11.10^{g}	11.73^{d-g}	9.07^{jk}	11.37^{c-g}	11.20^{c-h}	9.33^{h}	11.23^{f}	11.47^{f}
90	12.10^{c-f}	12.30^{b-e}	12.73^{bc}	12.30^{b-e}	12.20^{b-f}	12.43^{bc}	12.20^{c-e}	12.25^{b-e}	12.58^{bc}
120	12.36^{b-d}	13.03^{b}	14.57^{a}	12.40^{b-d}	12.93^{b}	14.37^{a}	12.38^{b-d}	12.98^{b}	14.47^{a}
SE±		0.227			0.369			0.217	
2012			2013			COMBINED			
6 WAS			6 WAS						
0	11.97^{n}	13.23^{m}	14.63^{l}	12.13^{n}	15.17^{m}	16.90^{i-l}	12.05^{m}	14.20^{l}	15.77^{k}
30	15.53^{kl}	16.43^{i-k}	17.40^{g-i}	16.50^{kl}	18.27^{c-g}	18.83^{bf}	16.02^{k}	17.35^{h-j}	18.12^{fg}
60	17.37^{g-j}	17.80^{gh}	19.10^{b-e}	17.03^{i-k}	18.17^{d-h}	18.97^{d-e}	17.20^{ij}	17.98^{gh}	19.03^{c-e}
90	18.03^{e-g}	19.07^{b-f}	20.17^{b}	17.57^{g-j}	19.30^{bc}	19.67^{b}	17.80^{gh-i}	19.18^{cd}	19.92^{b}
120	19.77^{c-d}	19.97^{bc}	24.27^{a}	17.87^{f-i}	18.97^{b-d}	24.10^{a}	18.82^{c-f}	19.47^{bc}	24.18^{a}
SE ±		0.333			0.307			0.226	

Mean value with the same letters in each treatment group are not statistically significantly different at P =O.05 (DMRT).
* = statistically significant difference at 5% level of probability.
WAS = Weeks after sowing
N = Nitrogen
SE± = Standard error

Table 5. Mean Leaf Area (mm^{2}) Per Plant of *A.cruentus* L as Influenced by Row Spacing and N Fertilizer in 2015, 2016 Raining Seasons and Combined

TREATMENTS		3 WAS			6 WAS	
	2015	2016	COMBINED	2015	2016	COMBINED
N Fertilizer (kg ha^{-1})						
0	73.06^{e}	79.88^{e}	76.47^{e}	593.51^{e}	755.51^{d}	674.51^{e}
30	126.61^{d}	137.12^{d}	131.87^{d}	1112.14^{d}	1250.84^{c}	1181.49^{d}
60	236.51^{c}	257.74^{c}	247.13^{c}	1464.24^{c}	1233.96^{c}	1349.10^{c}
90	387.84^{b}	401.22^{b}	394.53^{b}	1802.03^{b}	1528.91^{b}	1665.47^{b}
120	653.73^{a}	677.45^{a}	665.59^{a}	2944.26^{a}	2362.47^{a}	2653.37^{a}
SE ±	4.807	9.821	5.494	30.854	41.717	25.944
Level of Significance	*	*	*	*	*	*
Row Spacing (cm)						
20	217.69^{c}	227.48^{c}	222.58^{c}	1222.55^{c}	981.07^{c}	11o1.81^{c}
30	272.33^{b}	291.88^{b}	282.10^{b}	1526.01^{b}	1313.84^{b}	1419.93^{b}
40	396.64^{a}	412.69^{a}	404.66^{a}	2001.14^{a}	1984.10^{a}	1992.62^{a}
SE ±	3.724	7.608	0.057	23.900	32.314	20.096
Level of Significance	*	*	*	*	*	*
Interaction						
N X Spacing	*	*	*	*	*	*

Mean value with the same letters in each treatment group are not statistically significantly different at P =O.05 (DMRT).
* = statistically significant difference at 5% level of probability.
WAS = Weeks after sowing
N = Nitrogen
SE± = Standard error

Table 6. Interactive Effect Of N Fertilizer and Row Spacing on Mean Leaf Area (mm^2) Per Plant of *A.cruentus* L in 2015, 2016 Raining Seasons and Combined

	2015 3WAS			2016 3WAS			COMBINED		
Treatments	Inter Row Spacing (cm)			Inter Row Spacing (cm)			Inter Row Spacing (cm)		
N-Fertilizer (*kg ha^{-1}*)	20	30	40	20	30	40	20	30	40
0	40.86^{k}	77.63^{ij}	100.69^{hi}	45.41^{k}	86.91^{h-k}	107.34^{hi}	43.14^{k}	82.27^{ij}	104.01^{hi}
30	96.32^{h-j}	116.70^{h}	166.82^{g}	99.76^{h-j}	127.58^{h}	184.02^{g}	98.04^{h-j}	122.14^{h}	175.42^{g}
60	175.14^{g}	239.59^{f}	294.79^{e}	190.99^{g}	278.03^{ef}	304.22^{ef}	183.07^{g}	258.81^{f}	299.50^{e}
90	305.36^{e}	371.35^{d}	486.82^{c}	321.08^{e}	390.62^{d}	491.96^{c}	313.022^{e}	380.99^{d}	489.38^{c}
120	470.74^{c}	556.38^{b}	924.08^{a}	480.16^{c}	576.26^{b}	975.93^{a}	475.45^{c}	566.32^{b}	955.00^{a}
SE ±		8.326			17.011			9.517	
	2015			2016		6WAS			
			6 WAS			COMBINED			
0	346.47^{k}	625.22^{j}	808.84^{i}	365.16^{n}	781.61^{lm}	1119.76^{h-k}	355.81^{l}	703.42^{k}	964.30^{j}
30	901.94^{i}	1108.59^{h}	1325.90^{e-g}	920.92^{k-m}	1331.41^{d-g}	1500.21^{c-e}	911.43^{j}	1220.00^{g-i}	1413.05^{f}
60	1270.36^{f-h}	1393.96^{ef}	1728.39^{d}	1013.22^{i-l}	1208.11^{g-i}	1480.54^{d-f}	1141.79^{i}	1306.04^{f-h}	1604.46^{e}
90	1468.41^{e}	1773.06^{d}	2164.62^{c}	1200.27^{g-j}	1522.32^{cd}	1864.14^{b}	1334.33^{fg}	1647.69^{e}	2014.38^{c}
120	2125.59^{c}	2729.24^{b}	3977.96^{a}	1405.81^{d-g}	1725.76^{c}	3955.85^{a}	1765.70^{d}	2227.50^{b}	3966.90^{a}
SE ±		53.439			72.255			44.936	

Mean value with the same letters in each treatment group are not statistically significantly different at P =O.05 (DMRT).
* = statistically significant difference at 5% level of probability.
WAS = Weeks after sowing
N = Nitrogen
SE±= Standard error

Table 7. Mean Harvestable Fresh Yield (t ha^{-1}) of *A.cruentus* L as Influenced by Row Spacing and N Fertilizer at 6 WAS in 2015, 2015 Raining Seasons and Combined

TREATMENTS	2015	2016	COMBINED
N Fertilizer (kg ha^{-1})			
0	16.44^{e}	15.11^{e}	16.11^{e}
30	30.11^{d}	29.33^{d}	29.72^{d}
60	37.89^{c}	37.11^{c}	37.50^{c}
90	47.56^{b}	47.22^{b}	49.39^{b}
120	67.33^{a}	66.22^{a}	66.78^{a}
SE ±	0.354	0.222	0.209
Level of Significance	*	*	*
Row Spacing (cm)			
20	45.39^{a}	45.00^{a}	45.47^{a}
30	38.13^{b}	37.73^{b}	37.93^{b}
40	35.53^{c}	34.67^{c}	35.10^{c}
SE ±	0.274	0.172	0.162
Level of Significance	*	*	*
Interaction			
N X Spacing	*	*	*

Mean value with the same letters in each treatment group are not statistically significantly different at P =O.05 (DMRT).
* = statistically significant difference at 5% level of probability.
WAS = Weeks after sowing
N = Nitrogen
SE± = Standard error

The highest yield of 73.81 t ha^{-1} (2015), 71.80 t ha^{-1} (2016) and 72.81 t ha^{-1} (combined) were obtained in the treatment combination of 120 kg N ha^{-1} at 20 cm row spacing. This were followed by 120 kg N ha^{-1} at 30 and 40 cm row spacing, respectively. However, the result indicated that the increased in harvestable fresh yield was more associated with decreased in row spacing. The lowest yield values were obtained in the treatment combination of 0 kg N ha^{-1} at 40 cm row spacing.

DISCUSSION

Effect of Nitrogen Fertilizer

Result of the study showed that, growth and yield parameters of vegetable amaranth were positively influenced by nitrogen fertilizer rates. The yield increased in the application of 120 kg N ha^{-1} was mainly due to the significantly higher fresh weight per plant. The plant height, number of leaves, leaf area and absolute crop growth rate was found to have been increasing as the applied nitrogen rate increased. The result was in conformity with the findings of (Keskar *et al*., 1981; Ramachandra and Thimmaraju, 1983; Subhan, 1989; Ehigiator, 1990; BOSADP, 1993; Singh and Whitehead, 1996; Egharevba and Ogbe, 2002; Olaniyi, 2007 and Jombo *et al*., 2012).

Interactive Effect of N Fertilizer and Row Spacing

There was significant interaction between N fertilizer and row spacing on growth parameters and harvestable fresh yield of *Amaranthuscruentus* L. The significantly higher interaction for harvestable fresh yield (72.33 t ha^{-1}) was recorded in the treatment combination of 120 kg N ha^{-1} with 20 cm row spacing. This was mainly due to significantly higher performance of growth and yield parameters viz. plant height, (85.85 cm), number of leaves (14.47), leaf area (3,966.90

cm^2) and absolute crop growth rate (0.46g). These growth and yield parameters increased as the applied N fertilizer and row spacing increased up to 120 kg N ha^{-1} with 40 cm row spacing.This indicates that plant growth and biomass production was optimum in the application of 120 kg N ha^{-1} at 40 cm row spacing leading to significantly higher mean values. However, yield increased was mainly due to decreased in row spacing as the application of higher N fertilizer (120 kg N ha^{-}) with narrow row spacing (20 cm) gave the highest harvestable fresh yield per hectare. The second best significant higher interaction for harvestable fresh yield (65.17 t ha^{-1}) was recorded with the application of 120 kg N ha^{-1} with 30 cm row spacing than the application of 120 kg N ha^{-1} with 40 cm row spacing. The result showed that yield responded positively to planting density (row spacing) and N fertilizer application as they both increased yield. However, on a unit area basis, yield of vegetable amaranth increased with increased in N fertilizer and decreased in planting density (narrower row spacing). This agreed with the finding of Singh and Whitehead (1993) and Oluwaseun (2012) who observed that, on a unit area basis, green yield of amaranthus increased quadratically as inter row spacing decreases. Fresh yield was least with plants without the application of N fertilizer. This reconfirmed the finding of Adediran and Banjoke (2003).

Conclusion

In Northern Guinea Savannah zone of Nigeria, significantly higher harvestable fresh yield (72.33 t ha^{-1}) of *Amaranthuscruentus* L. can be obtained with the application of 120 kg N ha^{-1} at 20 x 5 cm inter and intra row spacing.

Recommendations

From the result, the following recommendations are made:

- Application of 120 kg N ha^{-1} provided highest growth and development of vegetable amaranth and should be adopted.
- Farmers should use 20 cm inter row spacing for its higher planting density.
- Farmers to be encouraged to use inorganic fertilizer (urea) in theproduction of vegetable amaranth. This is because urea has faster rate of nutrient release.
- for highest yield of vegetable amaranth (*Amaranthuscruentus* L.), application of 120 kg N ha^{-1} at 20 x 5 cm spacing be adopted by farmers in Mubi the Northern Guinea Savannah zone of Nigeria.
- More researches should be carried out in this direction by increasing row spacing and increasing the rate of N fertilizer; and by decreasing row spacing and increasing N fertilizer rate in same crop and other leafy and fruit vegetables.

REFERENCES

"Mergers in the fertilizer industry", The economist. 18th February, 2010. http://www.economic.com/businessfiance/displaystory.cfm?storyid=15549105. Retrieved 21st February, 2010.

Adebayo, A. A. 1990. Climate II. Rainfall. In: Adamawa State in Maps. Adebayo, A. A. and A. L. *Tukur, (eds.) Paraclete Publishers Yola.* Pp 23 – 26.

Adediran, J. A. and V. A. Banjoke, 2003. Comparative effectiveness of some compost formulation for maize in Nigeria. *Nigeria Journal of Soil Science.* 13:42-48.

Avav, T. and S. A. Ayuba, 2006. Fertilizers and Pesticides calculation and application techniques. Pp 10-11.

Borno State Agricultural Development Programme (BOSADP) 1993. Package of Cropping Recommendation for Borno State. P 55.

Bruce Gelina and Philippe Seguin 2008. Evaluation of Management Practices for grain amaranth production in Eastern Canada. *Agro J.*, 100 (2). 344 – 351.

Chaudhari, J.H., Raj, V.C., Rajeev, K., Srivastava, N and Ahir, M.P. *(*2009). Effect of varying of sowing date and row spacing on yield attributes ofRabi grain amaranthus under south Gujarat conditions. *Agric. Science Digest, 29 (2). 66 – 68.*

Egharevba, R. K. A. and F. M. Ogbe 2002. The effects of different levels of organic and mineral fertilizers on the yield performance of two Amaranthus (*Amaranthuscruentus* L.) cultivars. *The plant Scientists* 3: 62 – 72.

Ehigiator, J. O. 1990. Farm yard manure: Need for its adoption as an alternative to chemical fertilizer uses in Nigeria. *Nigeria Journal of Horticultural Science.* 3: 1 – 9.

Elbehri, A., D. Putnam and M. Schmitt 1993. Nitrogen fertilizer and cultivars effects on yield efficiency of grain amaranth. *Agro J.* 85: (1) 120 – 128.

FAO, 2007. Food and Agriculture Organization. 2007 FAOSTAT. FAO Statistic Division. Rome. In: Kolawole, E. L. and O. A. Sarah 2009. Growth and Yield Performance of Amaranthuscruentus influenced by Planting Density and Poultry Manure Application. *Not. Bot. Hort. AgrobotCluj*37 (1) 2009. 195 – 199.

Futuless, K. N. and H. W. Bagale 2007. Effects of different levels of nitrogen fertilizer on the growth and yield of amaranthus (*Amaranthuscruentus* L.) in Mubi, Adamawa State, Nigeria. In: proceeding of *Horticultural Society of Nigeria (HORTSON)*, held at Adamawa State University, Mubi, Nigeria. 26th – 30th Oct. 2008.

Grubben, G. J. H. and O. A. Denton 2004. Plant Resources of Tropical Africa. Vegetable PROTA Foundation, Wagenigen, Back Huys, Leida CTA. Wagenigen.

Henderson, T. L., B. L. Johnson and A. A. Schneiter 2000. Row spacing, planting population and cultivar effect on grain amaranth in the North Great Plains. *Agro. J.*, 92: 829 – 838.

ISTA, 1985. International Seed Testing Association. *International rules for seed testing science and technology* 13: 142 -145.

Jombo, E. O., S. U. Remison, K. E. Law Ogbomo and A. U. Asaigbovo 2012. Effects of Pome and N P K on the vegetative growth and total yield of Amaranthuscruentus on ultisols of Benin City, Nigeria. *Nig. Jour. Agric.; Food and Envr.* 8 (3): 14 – 20.

Joshi, B. D. and R. S. Rana 1995. Genetic divergence in grain amaranth (*Amaranthushypochondriacus*). *Indian J. Agric. Sci*., 65 (8): 605 – 607.

Keskar, B. G., D. P. Bhore, A. V. Patil, H. N. Sonone and S. R. Maslekar. 1981. Comparative efficacy of soil and foliage application of nitrogen through urea on yield of leafy vegetable Chaulai (*Amaranthusblitum* L.) at various seed rates. *J. Maharashtra Agric. Univ*. 6: 68 – 69.

Malligawad, L. H. and V. C. Patil 2001). Effect of planting density on growth and yield of grain amaranth. *Karnataka J. Agric. Sci.,*14 (1): 11 – 17.

Oluwaseun, O. O. 2012. Effect of variety and spacing on growth and yield of amaranthus. *NatulaeBatanicaeHorti*. Agrobotanici Cluj-Napoca. 6 (2): 65 -73.

Putnam, D. H., J. D. Doll, E. S. Oplinger and E. M. Schulte 1989. Amaranth. Alternative field crop manual. Nov., 1989.

Ramachandra, H. A. and K. R. Thimmaraju 1983. Effect of different levels of nitrogen and phosphorous on growth components and yield of amaranthus (*Amaranthusgangeticus* L.) In: Singh, B. P. and Whitehead W. F. 1996. Management Methods for producing vegetable amaranth. Pp 511 – 515. J. Janick (ed.), Progress in new crops. ASHS Press Arlington.

SAS, 2008). Statistical Analysis Software system .Version 9.2.

Schippers, R. R. 2000. African indigenous vegetables. An overview of the cultivated species. Natural Resources Institute/ACP-EU Technical Centre for Agricultural and Rural Cooperation. Chatham. UK p. 214.

Singh B. P. and W. F. Whitehead, 1996. Management methods for producing vegetable amaranth. Janick, J. (eds.) Progress in New crops ASHS Press, Arlington. Pp. 511 – 515.

Singh, B. P. and W. F. Whitehead 1993. Population density and soil pH effects on vegetable amaranth production In: Janick, J. and J. E. Simon (eds.). New crops Wiley, New York. P. 562 – 564.

Smitha, P. A. 2010. Fodder Productivity and Quality of amaranth genotypes under different row spacing and seed rate. M. Sc. (Agri.) Thesis, Uni. Agric. Sci., Bangalore, Karkanata, India.

Subhan, B. 1989. Effect of dosage and application time of nitrogen fertilizer on growth and yield of amaranth (*Amaranthus tricolor* L.) Indonesian English summary. *PenelitianHorticultural* 17:31 -40.

Yayock, J. Y. and J. E. Lombin, 1988. Crop Science and Production in warm climate. McMillan Publishers Ltd. London.

****