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Effects of Nitrogen Fertilizer on the Growth of Vegetable Amaranths (*Amaranthus cruensis*. L) in Mubi, Adamawa State Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author MDT designed the study, wrote the first draft of the manuscript managed the analyses of the study. Author MB wrote the protocol and managed the literature searches. Authors HES and YMK performed the statistical analysis. Author NB managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted at Food 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. To study the three levels of row spacing (20, 30, and 40 cm) and five levels of nitrogen (N) fertilizer (0, 30, 60, 90, and 120 kg ha^{-1}) 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). The crop was harvested at 6 weeks after sowing. The result show that stem girth and fresh weight ($plant^{-1}$) of vegetable amaranth increased significantly (P = 0.05) as row spacing and applied N rate was increased and leaves area index increased as the applied N increased and row

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spacing decreased. Application of higher dosage of fertilizer at the rate of 120 kg N ha^{-1} with a broader row spacing of 40 cm produced significantly higher mean fresh plant weight of 127.57g in 2014, 125.78g in 2015 and 126.67g (plant^{-1}) in the combined. The least mean value (19.40g) was obtained in the treatment with narrow row spacing and no application of N fertilizer (0 kg N ha^{-1} at 20 cm row spacing). Therefore, the optimum N rate and row spacing for the maximum fresh weight(plant^{-1}) of vegetable amaranth (*Amaranthus cruentus* L.) is 120 kg N ha^{-1} at 40 cm inter-row spacing and was found as the best combination for the production of vegetable amaranth in the Northern Guinea Savannah zone of Nigeria.

Keywords: Row spacing; nitrogen fertilizer.

1. INTRODUCTION

Amaranthus collectively known as Amaranth is a cosmopolitan genus of herbs. About 60 species are recognized with inflorescence and foliage ranging from purple and red to gold [1]. Amaranth *(Amaranthus spp.*) is one of the important underutilized crop native to Central and South America. It is widely cultivated in various regions of the world as well as in Nigeria as food and leafy vegetable [2]. The crop belongs to the family *Amaranthaceae* and genus *Amaranthus*. There is no clear dividing line between a vegetable type and grain type [3]. The leaves of vegetable amaranth are nutritionally significant source of minerals included vitamin A, vitamin B_6, vitamin C and vitamin K [1]. 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 limited in other conventional crops [4]. Amaranth has been used for food by a 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 [5]. Several studies have shown that like Oats, amaranth is beneficial for people with hypertension and cardiovascular disease. Regular consumption reduces blood pressure and cholesterol level, which improved antioxidant stages and some more immune parameters [3,6,7]. It is also a potential source of forage (9.9 – 12.7 t ha^{-1}) dry matter as well as 74 – 148 t ha^{-1} of silage (80 % moisture) [8].

Amaranthus cruentus L. is a tall annual herb topped with a cluster of dark pink flower and can grow up to 2 m in height [9]. It is one of the three *Amaranthus* species cultivated as a vegetable and grain sources. The other two are *Amaranthus caudatus* L. and *Amaranthus hypochondriacus* L. [3,6]. *Amaranthus* has been identified to be an essential vegetable crop in Nigeria. The demand for this crop as a vegetable has increased especially in urban centers where people are not involved in the primary production [10]. This has made the vegetable an essential commodity in the marketing and production a significant economic activity for rural people. However, yield per hectare of this crop in Nigeria is low (7.6 t ha^{-1}) when compared with that of United State of America (77.27 t ha^{-1}) and world average (14.27 t ha^{-1}) [11]. This may be attributed to poor cultural practices such as spacing and fertilizer application. The production could not meet up with the demand for food, animal feeds, industrial uses, and export. However, nitrogen has been reported to increase growth and yield of vegetable amaranth. This could be achieved through the use of proper dosage. Fertilizers are roughly divided into organic and inorganic fertilizer with the main difference between the two being sourcing and not necessary differences in the nutrient concentration. Fertilizers are usually directly applied to soil, and also sprayed on leaves (foliar feeding) [12]. The main nutrients in fertilizers are N, P and K (macro-nutrients) and other nutrients are added in smaller amounts (micro-nutrients). Nitrogen been the most important nutrient in promoting vegetative growth is paramount in the production of vegetable amaranth. [13] reported that N promote vegetative growth and impart the characteristics of deep green color to foliage because it is a component of chlorophyll which is essential for photosynthesis. Where N is oversupplied through fertilizer application, the leaves become dark green, soft and soppy. *Amaranthus* response actively to broadcasting application of fertilizer at the rate of 50 kg N and 45 kg of P ha^{-1} and the P should be thoroughly worked in the soil during land preparation. The recommended rate of N fertilizer for amaranth in the North Eastern sub region of Nigeria is 100 kg N ha^{-1} [14]. Morphology of a plant plays an important role in crop production and the potential yield of a genotype within the genetic limit are determined by environment. The yield potential can be further exploited through better agronomic practices such as proper planting density (row spacing) and fertilizer application.

Optimum performance of the crop must be desirable through changes in cultural practices [15]. Such cultural practice includes higher planting density and fertilizer application for improving growth and yield of the crop. The outcome of this research, therefore, will equip farmers with information on how to maximize the yield of vegetable amaranth through the use of proper planting density (row spacing) and application of N fertilizer.

The objectives of this study are to:

i. Evaluates the performance of vegetable amaranth (*Amaranthus cruentus* L.) as influenced by different row spacing.
ii. Evaluate the effects of different level of N fertilizer on the performance of vegetable amaranth and
iii. The interaction between row spacing and N fertilizer levels on the performance of vegetable amaranth.

2. MATERIALS AND METHODS

The two years' field experiments were conducted at the Food and Agriculture Organization/Tree Crop Programme (FAO/TCP) Teaching and Research Farm, Faculty of Agriculture, Adamawa State University, Mubi, Nigeria in 2014 and 2015 cropping seasons. Mubi, the Northern Guinea Savannah Zone of Nigeria between latitude $10^{\circ}10$" and $10^{\circ}30$" and between longitude $13^{\circ}10$'' and $13^{\circ}30$'' E and altitude of 696 m above sea level. The annual mean rainfall of Mubi 900 mm, and a minimum temperature of 18°C during a dusty period and 40°C as a maximum in April [16]; [17]. The treatment 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 factorial in a Randomized Complete Block Design, replicated three times. The composite soil samples were collected from 0 – 30 cm depth using soil auger at three different locations before ploughing. Soil samples were air dried, ground and allowed to pass through 2 mm sieve and were analyzed for routine physical and chemical properties using standard laboratory procedures. 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 treatment for row spacing and later thinned to 5 cm between plants one week after emergence (WAE). Germination test was carried out according to International Seed Testing Association [18] standard. Single Super Phosphate (SSP) fertilizer was applied at the concentration of 45 kg P_2 O_5 ha to all the treatments during land preparation, and the N Fertilizer was applied in the form of Urea (46). The urea needed for each plot was calculated based on each treatment using Q = R/100n X A/1 [19].

Where Q = amount of fertilizer required,
R = recommended rate of nutrient element,
A = area (m^2) and
n =analysis or grade of fertilizer (%).

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, remaining half of the N was applied at 3 weeks after sowing (WAS). In this research, hand weeding was carried out at two weekly intervals from 2 WAS. The incidence of corn ear worm, *Heliothis zea* and cowpea weevil *Aphids craceavora* was controlled using cypermetrin 10 EC insecticide at the rate of 700 ml ha^{-1}. The plants were harvested at 6 WAS when all the vegetative parts had reached their maximum because of vegetable amaranth losses quality when aged [20].

2.1 Collection of Data and Plant Sampling

A sample consisting of ten plants was selected and tagged at random from each plot for recording various biometric observation at 3, and 6 WAS. The growth and yield parameters measured: stem girth, leaf area index, fresh plant weight, and dry matter weight.

2.2 Statistical Analysis and Interpretation of Data

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 [21]. Mean values were subjected to Duncan's Multiple Range Test (DMRT) at 5% level of probability.

3. RESULTS

The Soil of the experimental site was sandy loam. The soil had a normal pH (6.40 in 2014 and 6.50 in (2015) with low available nitrogen of 0.18 g N kg^{-1} (2014) and 0.17 g N kg^{-1}(2015), medium available phosphorus of 6.67 g kg^{-1} (2014) 6.80 g kg^{-1} (2015) and high available potassium of 0.45 C mol kg^{-1} (2014) and 0.46 C mol kg^{-1} (2015) as presented in Table 1.

The results on stem girth, leaf area index and fresh plant weight of *Amaranthus cruentus* L. as influenced by row spacing and N fertilizer at 3and 6 WAS in 2014, 2015 and combined are presented in Tables 2, 3 and 4 respectively. N fertilizer has significant effects on the growth components. The stem girth, leaves area index and fresh plant weight per plant at both the growth stages and in all the growing seasons was found to have been increasing as N fertilizer increased from 0 up to 120 kg N ha^{-1}. Application of 120 kg N ha^{-1} gave highest mean values. Follow by 90, 60 and 30 kg N ha^{-1}. The least mean values were obtained in 0 kg N ha^{-1}.

Row spacing also follows the same pattern. A significant effect of row spacing was observed on growth and yield components. Leaf area index increases as row spacing decreased while stem girth and fresh plant weight per plant were found to have been increasing as the row spacing increased up to 40 cm inter-row spacing.

There was no interaction effect between nitrogen fertilizer and row spacing on stem girth at 3 WAS in both years and in combined and at 6 WAS in 2014, respectively. However, in 2015 at 6WAS and the combined, there was an interaction between N fertilizer and row spacing.

However, the interaction effect was observed between N fertilizer and row spacing on leaf area index and fresh plant weight per plant of vegetable amaranth at both the growth stages and in all the growing season's and the combined (Tables 5 and 6) respectively.

4. DISCUSSION

4.1 Effects of N Fertilizer

The study showed that, nitrogen fertilizer rates positively influenced growth and yield parameters of vegetable amaranth. Application of 120 kg recorded significantly higher mean value of all the growth parameters measured. The yield increased in the application of 120 kg N ha^{-1} was mainly due to the considerably higher fresh weight per plant. The increased in plant weight as the applied nitrogen rate increased reconfirm the role of nitrogen fertilizer in promoting vegetative growth. The stem girth, leaf area index and plants were found to have been growing as the applied nitrogen rate increased. The result was in agreement to the findings of [22,23,15,24,14,25,26,3] and [27].

4.2 Effects of Row Spacing

The row spacing of 40 cm recorded significantly higher mean value of all the growth parameters measured. The stem girth and fresh plant weight increased as inter-row spacing increased. However, leaf area index decreases as row spacing increased. This agrees with [5,23,28,29,30,31,32] and [33].

4.3 Interactive Effect of N Fertilizer and Row Spacing

There was a significant interaction between N fertilizer and row spacing on growth parameters and harvestable yield (fresh weight) of *Amaranthus cruentus* L. The significantly higher interaction for harvestable fresh plant weight (126.67g $plant^{-1}$) was recorded in the treatment combination of 120 kg N ha^{-1} with 40 cm row spacing. This was mainly due to significantly higher performance of growth and yield parameters. 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. The finding is also in agreement with [25] on the effects of fertilizer on the performance of vegetables.

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. This was followed by 120 kg N ha^{-1} at 30 cm row spacing. However, at 3 WAS in both the two years of the research and in the combination of 90 kg N ha^{-1} with 40 cm row spacing produced fresh plant weight that were comparable and statistically the same with 120 kg N ha^{-1} in 20 cm row spacing Lowest mean values of fresh plant weight ererecorded in treatment combination of 0 kg Nha^{-1} at 40, 30 and 20 cm row spacing, respectively.

The result showed that yield responded positively to planting density (row spacing) and N fertilizer application as they both increased yield. Fresh yield was least with plants without the application of N fertilizer. This reconfirmed the finding of [34].

.Table 1. Soil physical and chemical properties of the experimental site, 0-15 cm and 15-30 cm depth

Particular	**2014**	**2015**
1. Physical properties 0 – 15 cm depth	Light yellowish brown Dark brown	Yellowish brown Dark brown.
A. Particle size distribution.		
% Clay	14.2	14.1
%Silt	31.6	32.8
%Sand	54.2	53.1
B. Textural class	Sandy Loam	Sandy Loam
2. Chemical properties		
P^H (1:2 soil water: soluble)	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

Table 2. Mean stem girth (mm^2) per plant of *Amaranthus cruentus* L. as influenced by row spacing and n fertilizer in 2014, 2015 raining seasons and combined

Treatments	3 WAS			6 WAS		
	2014	2015	Combined	2014	2015	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 3. Mean leaf area index per plant of *Amaranthus cruentus* L. as influenced by row spacing and n fertilizer in 2014, 2015 raining seasons and combined

Treatments	3 WAS			6 WAS		
	2014	2015	Combined	2014	2015	Combined
N fertilizer (kg ha^{-1})						
0	0.48^{e}	0.52^{e}	0.50^{e}	3.92^{e}	4.82^{d}	4.37^{e}
30	0.85^{d}	0.92^{d}	0.89^{d}	7.68^{d}	8.53^{c}	8.10^{d}
60	1.60^{c}	1.76^{c}	1.68^{c}	10.21^{c}	8.53^{c}	9.37^{c}
90	2.65^{b}	2.76^{b}	2.71^{b}	12.44^{b}	10.49^{b}	11.47^{b}
120	4.35^{a}	4.62^{a}	4.49^{a}	19.78^{a}	15.12^{a}	17.49^{a}
SE ±	0.033	0.091	0.048	0,204	0.218	0.149
Level of significance	*	*	*	*	*	*
Row spacing (cm)						
20	2.17^{a}	2.27^{a}	2.22^{a}	12.23^{a}	9.82^{a}	11.02^{a}
30	1.82^{c}	2.01^{b}	1.19^{c}	10.17^{b}	8.76^{b}	9.47^{c}
40	1.98^{b}	2.06^{b}	2.02^{b}	10.06^{b}	9.92^{a}	$9{,}97^{b}$
SE ±	0.025	0.070	0.037	0.158	0.169	0.116
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. Mean fresh plant weight (g) per plant of *Amaranthus cruentus* L as influenced by row spacing and n fertilizer in 2014, 2015 raining seasons and combined

Treatments	3WAS			6 WAS		
	2014	**2015**	**Combined**	**2014**	**2015**	**Combined**
N fertilizer (kg ha^{-1})						
0	1.70^{e}	1.96^{e}	1.83^{e}	24.55^{e}	23.70^{e}	22.12^{e}
30	4.67^{d}	4.95^{d}	4.81^{d}	44.46^{d}	43.39^{d}	43.93^{d}
60	10.38^{c}	10.48^{c}	10.43^{c}	54.72^{c}	53.88^{c}	54.30^{c}
90	16.24^{b}	16.37^{b}	16.31^{b}	69.74^{b}	69.02^{b}	69.38^{b}
120	21.61^{a}	22.08^{a}	21.84^{a}	100.02^{a}	98.53^{a}	99.28^{a}
SE ±	0.133	0.180	0.112	0.350	0.217	0.206
Level of significance	*	*	*	*	*	*
Row spacing (cm)						
20	9.00^{c}	9.15^{c}	9.08^{c}	46.39^{c}	45.58^{c}	45.98^{c}
30	10.82^{b}	11.05^{b}	10.94^{b}	57.99^{b}	57.20^{b}	57.59^{b}
40	12.95^{a}	13.30^{a}	13.12^{a}	71.72^{a}	70.34^{a}	71.03^{a}
SE ±	0.103	0.139	0.087	0.271	0.169	0.160
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 5. Interactive effect of N - fertilizer and row spacing on mean leaf area index (mm^2) per plant of *Amaranthus cruentus* L in 2014, 2015 raining seasons and combined

Treatments	**2014 3WAS**			**2015 3WAS**			**Combined**		
	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	0.43^{ij}	0.52^{i}	0.50^{ij}	0.45^{h-k}	0.58^{h-j}	0.54^{h-k}	0.44^{jk}	0.55^{ij}	0.52^{jk}
30	0.94^{g}	0.78^{gh}	0.83^{gh}	1.00^{gh}	0.85^{hi}	0.92^{h}	0.97^{g}	0.81^{hi}	0.88^{gh}
60	1.74^{e}	1.60^{ef}	1.46^{f}	1.91^{e}	1.85^{ef}	1.52^{e-g}	1.83^{e}	1.73^{ef}	1.49^{f}
90	3.05^{c}	2.47^{d}	2.43^{d}	3.21^{c}	2.61^{d}	2.46^{d}	3.13^{c}	2.54^{d}	2.45^{d}
120	4.68^{a}	3.71^{b}	4.67^{a}	4.80^{a}	4.18^{b}	4.88^{a}	4.74^{a}	3.84^{b}	4.77^{a}
SE±		0.056			0.157			0.084	
2014 6 WAS			**2015 6 WAS**				**Combined**		
0	3.50^{jk}	4.17^{j}	4.09^{jk}	3.65^{l}	5.21^{k}	5.60^{k}	3.58^{l}	4.69^{k}	4.85^{k}
30	9.02^{gh}	7.39^{i}	6.63^{i}	9.21^{d-g}	8.88^{d-h}	7.50^{ij}	9.11^{g}	8.13^{hi}	7.07^{j}
60	12.70^{e}	9.29^{g}	8.64^{gh}	10.13^{d-e}	8.05^{g-i}	7.40^{ij}	11.42^{e}	8.67^{gh}	8.02^{hi}
90	14.68^{d}	11.82^{ef}	10.82^{f}	12.00^{c}	10.15^{d}	9.32^{d-f}	13.34^{d}	10.94^{e}	10.07^{f}
120	21.26^{a}	18.19^{c}	19.89^{b}	14.17^{b}	11.51^{c}	19.78^{a}	17.66^{b}	14.85^{c}	19.83^{a}
SE ±		0.354			0.377			0.259	

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 fresh plant weight (g) per plant of *Amaranthus cruentus* L in 2014, 2015 raining seasons and combined

Treatments	**2014 3WAS**			**2015 3WAS**			**Combined**		
	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	0.77^{m}	1.93^{l}	2.41^{kl}	0.99^{m}	2.09^{kl}	2.81^{kl}	0.88^{m}	2.01^{l}	2.61^{k}
30	2.81^{k}	4.40^{j}	6.79^{i}	3.05^{k}	4.78^{j}	7.01^{i}	2.93^{k}	4.59^{j}	6.90^{i}
60	8.76^{h}	10.29^{g}	12.11^{f}	8.38^{h}	10.44^{g}	12.63^{f}	8.57^{h}	10.37^{g}	12.37^{f}
90	13.95^{e}	16.19^{d}	18.58^{c}	14.55^{e}	16.13^{d}	18.44^{c}	14.25^{e}	16.16^{d}	18.51^{c}
120	18.72^{c}	21.27^{b}	24.84^{a}	18.78^{c}	21.83^{b}	25.63^{a}	18.75^{c}	21.55^{b}	25.23^{a}
SE ±		**0.231**			**0.311**			**0.194**	
	2014 6 WAS			**2015 6 WAS**			**Combined**		
0	19.88^{m}	24.30^{l}	29.46^{k}	18.92^{o}	23.01^{n}	29.17^{m}	19.40^{o}	23.65^{n}	29.32^{m}
30	35.58^{j}	45.22^{i}	52.59^{h}	34.37^{l}	44.67^{k}	51.14^{i}	34.78^{l}	44.94^{k}	51.87^{i}
60	46.45^{i}	55.44^{g}	62.28^{f}	46.33^{j}	54.57^{h}	60.74^{f}	46.40^{j}	55.00^{h}	61.51^{f}
90	56.23^{g}	66.29^{e}	86.71^{c}	56.46^{g}	65.72^{e}	84.88^{c}	56.35^{g}	66.01^{e}	85.79^{c}
120	73.81^{d}	98.69^{b}	127.57^{a}	$71,80^{d}$	98.01^{b}	125.78^{a}	72.81^{d}	98.35^{b}	126.67^{a}
SE ±		0.606			0.375			0.357	

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

5. CONCLUSION

In Northern Guinea Savannah zone of Nigeria, significantly higher harvestable fresh yield (weight per plant) of *Amaranthus cruentus* L. (126.67 g) can be obtained in the application 120 kg N ha^{-1} with 40 cm row spacing.

COMPETING INTERESTS

Authors declared that no competing interests exist.

REFERENCES

1. Grubben GJH, Denton OA. Plant resources of tropical Africa. Vegetable PROTA Foundation, Wagenigen, Back Huys, Leida CTA. Wageningen; 2004.
2. Smitha PA. Fordder productivity and quality of amaranth genotypes under different row spacing and seed rate. M. Sc. (Agri.) Thesis, Uni. Agric. Sci. Bangalore, Karkanata, India; 2010.
3. Olaniyi JO. Evaluation of yield and quality performance of grain amaranth varieties in the Southwestern Nigeria. Res. J. Agron. 2007;1(2):42–45.
4. Joshi BD, Rana RS. Genetic divergence in grain amaranth (*Amaranthus hypochondriacus*). Indian J. Agric. Sci. 1995;65(8):605–607.
5. Putnam DH. Agronomic practices for grain amaranth. In: Stallknech GF, Schulz-Schaeffer JR. Amaranth Rediscovered Jamic and Simon JE. (eds.), New crops. Wiley, New York. 1993;211–218.
6. Olaniyi JO, Adelasoye KA, Jegede CO. Influence of nitrogen fertilizer on the growth, yield and quality of grain amaranth varieties. World Journal of Agricultural Science. 2008;4(4):506-513.
7. Kolawole EL, Sarah OA. Growth and yield performance of *Amaranthus cruentus* influenced by planting density and poultry manure application. Not. Bot. Hort. Agrobot Cluj. 2009;37(1):195-199.
8. Putnam DH, Doll JD, Oplinger ES, Schulte EM. Amaranth. Alternative field crop manual; 1989.
9. Sterrett SB, Savange GP. Culinary herbs are alternative crops. The vegetable growers news. 1989;42(1):3-4.
10. Schippers RR. African indigenous vegetables. An overview of the cultivated species. Natural Resources Institute/ACP-EU Technical Centre for Agricultural and Rural Cooperation. Chaltham. UK. 2000; 214.
11. FAO. Food and Agriculture Organization. 2007 FAOSTAT. FAO Statistic Division; 2007. Rome. In: Kolawole EL, Sarah OA. Growth and yield performance of *Amaranthus cruentus* influenced by planting density and poultry manure application. Not. Bot. Hort. Agrobot Cluj. 2009;37(1):195–199.
12. “Mergers in the fertilizer industry”, The economist. 2010.
    Retrieved 21st February, 2010
    Available:http://www.economic.com/businessfiance/displaystory.cfm?storyid=15549105.
13. Yayock JY, Lombin JE. Crop science and production in warm climate. McMillan Publishers Ltd. London; 1988.
14. Borno State Agricultural Development Programme (BOSADP). Package of Cropping Recommendation for Borno State. 1993;55.
15. Subhan B. Effect of dosage and application time of nitrogen fertilizer on growth and yield of amaranth (*Amaranthus tricolor* L.) Indonesian English summary. Penelitian Horticultura. 1989;17:31-40.
16. Adamawa State University, Mubi. Weather Station Report. Meteorological Data 2014 and 2015 Raining Seasons; 2015.
17. Adebayo AA. Climate II. Rainfall. In: Adamawa State in Maps. Adebayo AA, Tukur AL. (eds.) Paraclete Publishers Yola. 1990;23–26.
18. ISTA. International seed testing association. International Rules for Seed Testing Science and Technology. 1985; 13:142-145.
19. Avav T, Ayuba SA. Fertilizers and Pesticides calculation and application techniques. 2006;10-11.
20. Futuless KN, Bagale HW. (2007). Effects of different levels of nitrogen fertilizer on the growth and yield of *amaranthus* (*Amaranthus cruentus* 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.
21. SAS, Statisticl Analysis Software. SAS system version 9.2; 2008.
22. Keskar BG, Bhore DP, Patil AV, Sonone HN, Maslekar SR. Comparative efficacy of soil and foliage application of nitrogen

through urea on yield of leafy vegetable Chaulai (*Amaranthus blitum* L.) at various seed rates. J. Maharashtra Agr. Univ. 1981;6:68–69.
23. Ramachandra HA, Thimmaraju KR. Effect of different levels of nitrogen and phosphorous on growth components and yield of *amaranthus* (*Amaranthus gangeticus* L.) In: Singh BP, Whitehead WF; 1996. Management Methods for producing vegetable amaranth. Janick J. (ed.), Progress in new crops. ASHS Press Arlington. 1983;511–515.
24. Ehigiator JO. Farm yard manure: Need for its adoption as an alternative to chemical fertilizer uses in Nigeria. Nigeria Journal of Horticultural Science. 1990;3:1–9.
25. Stallknecht GF, Schulz-Schaeffer JR. Amaranth rediscovered. In: Janick J, Simon JE. (eds). New crops Wiley, New York. 1993;24-218.
26. Egharevba RKA, Ogbe FM. The effects of different levels of organic and mineral fertilizers on the yield performance of two *Amaranthus* (*Amaranthus cruentus* L.) cultivars. The plant Scientists. 2002;3:62–72.
27. Jombo EO, Remison SU, Law Ogbomo KE, Asaigbovo AU. Effects of Pome and N P K on the vegetative growth and total yield of *Amaranthus* cruentus on ultisols of Benin City, Nigeria. Nig. Jour. Agri; Food and Env. 2012;8(3):14–20.
28. Elbehri A, Putnam D, Schmitt M. Nitrogen fertilizer and cultivars effects on yield efficiency of grain amaranth. Agron J. 1993;5:(1):120–128.
29. Henderson TL, Johnson BL, Schneiter AA. Row spacing, planting population and cultivar effect on grain amaranth in the North Great Plains. Agron. J. 2000;92: 829–838.
30. Malligawad LH, Patil VC. Effect of planting density on growth and yield of grain amaranth. Karnataka J. Agric. Sci. 2001; 14(1):11–17.
31. Bruce Gelina and Philippe Seguin. Evaluation of management practices for grain amaranth production in Eastern Canada. Agron J. 2008;100(2):344–351.
32. Chaudhari JH, Raj VC, Rajeev K, Srivastava, Ahir MP. Effect of varying of sowing date and row spacing on yield attributes of rabi grain *Amaranthus* under South Gujarat conditions. Agric. Science Digest. 2009;29(2):66–68.
33. Singh BP, Whitehead WF. Management methods for producing vegetable amaranth. Janick J. (eds.) Progress in New crops ASHS Press, Arlington. 1996;511–515.
34. Adediran JA, Banjoke VA. Comparative effectiveness of some compost formulation for maize in Nigeria. Nigeria Journal of Soil Science. 2003;13:42-48.

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