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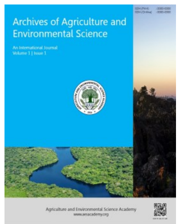

ORIGINAL RESEARCH ARTICLE

Growth and yield of amaranth (*Amaranthus spp.*) as influenced by seed rate and method of planting in Sokoto, Nigeria

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ABSTRACT

Amaranthus cruentus L. is a leafy vegetable commonly cultivated in Nigeria and other West African countries. In Nigeria farmers considered amaranths as a minor crop, they plant amaranths without any consideration of seed rate and this result to suboptimum plant population, similarly broadcasting (which results to wasted of seeds and overcrowding of plants) was predominantly the major method of planting used while planting, Field experiment was conducted to determine the effect of seed rate and method of planting on growth and yield of Amaranths (*Amaranthus spp.*) at Sokoto. The treatments consisted of factorial combination of four (4) seed rates (2.0 kgha^{-1}, 2.5 kgha^{-1}, 3.0 kg ha^{-1} and 3.5 kg ha^{-1}) and two (2) methods of planting (Broadcasting and Drilling). The results revealed that seed rate at 3.0 kg ha^{-1} produced significantly taller plants, followed by seed rate at 2.5 kg ha^{-1} and the shortest plants was from seed rate at 2.0 and 3.5 kg ha^{-1} at 4, 6 and 8 Weeks After Planting (WAP). However, method of planting and interaction between seed rate and method of planting had no significant effect on plant height at 2, 4, 6 and 8 WAP, Seed rate and method of planting and their interaction had no significant effect on number of leaves and Leaf area at harvest. Seed rate at 3kg ha^{-1} produced significantly highest fresh and dry weight. Seed rate at 3kg ha^{-1} and drilling method of planting would be beneficial for the farmers in Sokoto State and areas with similar environmental conditions for optimum yield of amaranths.

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INTRODUCTION

Amaranthus species (*A. blitum, A. caudatus, A. cruentus and A. tricular*) collectively known as amaranths or pigweed, are members of the *Amaranthaceae* family. They have a common name such as African Spinach, India Spinach and Chinese spinach; approximately 60 species are presently recognized with inflorescence and foliage ranging from purple and red to gold. Member of this genus share many characteristics and uses with members of the closely related genus (Juan, 2007). Amaranths, originated from South America where it was widely distributed throughout most tropical regions, where it is used as a protein grain, leafy vegetable and a forage crops (Putnam, 2007). Species grown for vegetables are represented mainly by *A. tricolor, A. dubius, A. lividus, A. creuntus, A. palmeri* and *A. hybridus.* Three principal species considered for grain include, *A. hypochondriacus, A. cruentus* and *A. caudatus* (Mlakar *et al*., 2010). Amaranth leaf can be used as greens in salads, boiled or fried in oil and mixed with meat or fish. This can be used as side dish in soups or as an ingredient in sauce and baby food (Mlakar *et al*., 2010). Amaranth leaves are used similarly as spinach and can be boiled or fried as a tasty side dish. The leaves are high in fiber and contain high concentration of Vitamin A, B6 and C, riboflavin and foliate. Minerals include calcium, iron, magnesium, phosphorus, potassium, zinc, copper and manganese (Putnam, 2007). An Amaranth grain can be ground for use in bread, noodle, pancakes, cereals, granola cookies or other flour baked products. More than 40 products containing amaranths are currently on the market in the U.S.A. (Putnam, 2007). Leafy vegetables of amaranth supply protein, minerals and vitamins in diet. Their lush, green, succulent crisp are eaten raw or cooked as vegetables in soup, they are best when the plant is young and tender. Amaranth grain is high in protein and contains two essential amino acids: lysine and methionine which are frequently found in other cereal grains. It is high in fiber and iron than wheat, and high in calcium than milk, it contain potassium, phosphorus, vitamin A and C. Amaranth contain to cotrienols (a form of vitamin E) which have cholesterol lowering activity in humans. Cooked amaranth is 90% digestible and it has traditionally been given to those recovering from an illness or ending a fasting period. Amaranth contains 6-10% oil, high in linoleic and which is important in human nutrition (Stallknecht and Schulz-Schaeffer, 1993).

Seed rate, which is the amount of seed sown per unit area, is an important factor for forage production, because it affects plant density. The highest plant density is always obtained at the highest seed rate. The influence of plant density on growth and yield of crops is through its influence on competition for light, nutrients in soil and available moisture that affects leaf area index and dry matter yield (Gisink and Eforn (1986). Patel *et al.* (2011) reported that there was significant interaction amongst the genotype, row spacing and seed rate on growth and yield of amaranth fodder.

Lack of access to food influences food intake and consequently impacts the health and nutritional status of households. Food and nutrition security are the fundamental challenges to human welfare and economic growth. Attending the nutritional needs of people is an equally important aspect of improving health and survival (Schippers, 2000). Foods of animal origin, which are known to be the major source of vitamins and proteins, are in most cases, too expensive for poor households (Aphane *et al.,* 2003). Low crop productivity is a general problem facing most farming systems in sub-Saharan Africa (SSA). Low leaf yields of less than 1.2 tons per hectare (Mabulu and Chalamila, 2005) are normally realized against the potential of 32-40 tons per hectare in amaranth (Oluoch *et al*., 2009; Republic of South Africa (RSA) (2010).

Amaranths exhibits a large degree of variability depending on such factors as soil seed density, planting methods, chemical and physical properties, climate, planting time, variety, and level of fertilization (Stallknecht and Schulz-Schaeffer, 1993); the authors reported that these factors affect or determine the growth and yield of crop, that is, growth characters of crops such as plant height, leaf area, number of leaves or branches, and seed production. Improved vegetable productivity and resources use efficiency could be achieved, when appropriate planting methods and seed rates for vegetables are adopted. Amaranths are a source of rich vegetable supply proteins, minerals and essential vitamins (vitamin C) in the diet. Therefore, increasing productivity of amaranths will increase the nutrient and health status of consumers, thereby improving health status as a result of replacement of animal protein which is high in cholesterol and too cost. Improved vegetable productivity and resources use efficiency could only be achieved, when appropriate planting technologies and seed density for the vegetables are available. Production of good quality vegetables would promote national, regional and international market opportunities for indigenous vegetables of Nigeria. The objectives of the research was to determine: the optimum seed rate that gives maximum yield under Sokoto condition and the appropriate planting method for Amaranth that gives maximum yield under Sokoto condition.

MATERIALS AND METHODS

Field experiment was conducted at the Usmanu Danfodiyo University Teaching and Research Vegetable Garden Sokoto, Sokoto is located on latitude 13°.1'N: longitude 5°.15'E and altitude of about 350m above the sea level in Sudan Savannah Agro ecological Zone of Nigeria. The climate of the area is semi-arid with mean annual rainfall of 645mm and the temperature ranges from 15°-40°C (SERC, 2016). Before planting composite sample of soil was collected from 20 randomly selected points within the experimental site at a depth of 0-30 cm using auger. The sample was bulked, air-dried and sieved by using 2mm sieve. The bulked sample was used for physico-chemical analysis of the soil. Treatment consisted of factorial combination of four seed rates (2.0 kg ha^{-1}, 2.5kg ha^{-1}, 3.0 kg ha^{-1} and 3.5kg ha^{-1}) and two methods of planting (Broadcasting and Drilling), laid out in randomized complete block design (RCBD) replicated three times.

The experimental site was ploughed and then harrowed. Seed rates and planting of amaranths (*Amaranthus spp.*) was as per the treatments, at broadcasting the seeds was mixed with fine sand in the ratio 1: 2 and at drilling the seeds was spaced at 40cm between rows. Recommended fertilizer rate of 70 kg N, 34 kg P and 26 kg K ha^{-1} was applied in two applications, basal and top dressing at three weeks after planting. Weeding was done using hoe. First weeding was carried out at two weeks after sowing and second weeding at 4 weeks after sowing. Harvesting was done by uprooting the whole plant at 8 weeks after planting (WAP).

Data collection: Data was collected on growth and yield parameters of amaranths (*Amaranthus spp.*) following methods adopted by Omary (2013); Abubakar (2015).

Plant height (cm): A meter rule was used to take the height of four (4) tagged plants of amaranths (*Amaranthus spp.*) in each experimental unit at 2, 4, 6 and 8 weeks after planting, and the mean was calculated and recorded. The height was measured from the ground level to the tip of the plant.

Number of leaves per plant: Leaves of four (4) tagged plants were counted in each experimental unit at 2, 4, 6 and 8 weeks after planting, and the mean was determined and recorded. Only fully opened leaves were counted.

Leaf area: The length and width multiplied by a constant (6.6) of the four (4) tagged plants in each experimental unit was used to obtain this parameter, the mean was calculated and recorded (Muhammed, 2012).

$L \times W \times 6.6 = LA$

Fresh weight of the plant (kg ha^{-1}): The whole plant in the net plots after been uprooted and root washed was weighed, and then extrapolated to per hectare.

Dry weight of the plant (kg ha^{-1}): The harvested Amaranths were then sun dried for a week (7 days) and weighed to determine the dry weight of the net plot and then extrapolated to per hectare.

Data analysis: The data collected was subjected to analysis of variance (ANOVA) (Muhammed, 2012; Omary; 2013; Abubakar; 2015), where treatments are significant Duncan's New Multiple Range Test (DNMRT) was used for mean separation.

RESULTS AND DISCUSSION

Physical and chemical properties of soil: The result recorded on soil physical and chemical characters are presented in Table 1. Based on the results of the analysis, the soil is loamy in texture, low in exchangeable cations, nitrogen and organic carbon.

Plant height: Plant height of amaranths (*Amaranthus spp.*) as affected by seed rates and method of planting in 2016 rainy season is presented in Table 2.

Effect of seed rate: The effect of seed rate on plant height of amaranths (*Amaranthus spp.*) from 2 to 8 weeks after planting (WAP) is presented in Table 2. The result showed that seed rate has no significant (P<0.05) effect on number of leaves of amaranths (*Amaranthus spp.*) at 2 WAP. However, at 4, 6 and 8 WAP seed rate significantly affected plant height. At 4, 6 and 8 WAP seed rate of 3kg/ha resulted to significantly taller plants, followed by seed rate of 2.5kgha^{-1}, respectively. Seed rate of 2 kg ha^{-1} recorded the shortest plant height of amaranths (*Amaranthus spp.*) which could be as a result of reduced canopy spread which could affect light interception increasing rate of evapotranspiration and also competition between individual plants for space and resources in Seed rate of 3.5 kgha^{-1} at a higher seed rate which results to higher plant population per unit area. Stallknecht and Schulz-Schaeffer (1993) reported that individual cultivars can vary in height from 91 to 274 cm in height and have stem diameters from 2.54 to 15 cm, dependent upon plant density and available soil moisture. This result is consistent with findings of Gasim (2001), who reported that the effect of seed rate on plant height per plant increased with increase in seed rate of Teff grass.

Effect of method of planting: The effect of method of planting on plant height of amaranths (*Amaranthus spp.*) from 2, 4, 6 and 8 weeks after planting (WAP) is presented in Table 2. The result showed that method of planting had no significant effect on plant height of amaranths (*Amaranthus spp.*) at 2, 4, 6 and 8 WAP. However, drilling produced a higher mean value than broadcasting at 2, 4, 6 and 8 WAP respectively which was statistically similar. The result for the effect of method of planting on plant height indicated that there was minimal competition for both soil and space resources. The result is not in conformity with the result of Patel *et al.* (2011) who indicated that drilling of 45 cm rows apart recorded significantly tall plants (93cm plant^{-1}) than broadcasting owing to the fact that greater spacing provides a more favorable conditions of growth and development, thereby reducing competition between individual plants on soil and aerial resources.

Effect of interaction: The effect of interaction between seed rates and method of planting on plant height of amaranths (*Amaranthus spp.*) from 2 to 8 WAP is presented in Table 2. The result showed that there was no significant (*P<0.05*) effect of interaction between seed rate and method of planting at 2, 4, 6 and 8 WAP.

Number of leaves: Number of leaves of amaranths (*Amaranthus spp.*) as affected by seed rates and method of planting in 2016 rainy season is presented in Table 3. Number of leaves plant^{-1} plays an important role because they manufacture and supply food material synthesized during photosynthesis.

Effect of seed rate: The effect of seed rate on leaf number of amaranths (*Amaranthus spp.*) from 2 to 8 weeks after planting (WAP) is presented in Table 3. The result showed that seed rate has no significant (P<0.05) effect on number of leaves at 2, 4, 6 and 8 WAP. This may be due to number of leaves is controlled by different factors. However, the result is not similar to the findings of Maboko and Du Plooy (2009) and Mwai *et al*. (2009) who reported that total leaf fresh mass increased with an increase in seed rates. Generally, leaf yield per unit area increased due to increased plant density, while leaf yield per plant decreased with increasing plant density. This result is also not consistent with the findings of Gasim (2001), who reported that leaves per plant increased with increase in seed rate of Teff grass.

Effect of method of planting: The effect of method of planting on leaf number of amaranths (*Amaranthus spp.*) from 2, 4, 6 and 8 weeks after planting (WAP) is presented in Table 3. The result showed that method of planting has no significant (P<0.05) effect on number of leaves at 2, 4, 6 and 8 WAP. This result indicated that both drilling and broadcasting offered optimum niche for germination, later nutrient uptake and consequent vegetative growth and development, indicating that even at closer spacing plants performance was not affected. The result for the effect of method of planting is not in conformity with the results of Patel *et al.* (2011) who indicated that drilling recorded significantly higher number of leaves than broadcasting owing to the fact that greater spacing provides a more favorable conditions of growth and development, thereby reducing competition between individual plants on soil and aerial resources.

Effect of interaction: The effect of interaction between seed rates and method of planting on number of leaf from 2 to 8 WAP is presented in Table 3. The result showed that there was no significant (P<0.05) effect on interaction between seed rate and method of planting. This result is not similar to the work of Gisink and Eforn (1986) who concluded that the influence of plant density and sowing methods on growth and yield of crops is through its influence on competition for light, nutrients in soil and available moisture that affects number of leaves, leaf area index and dry matter yield.

Leaf area at harvest: Leaf area of amaranths (*Amaranthus spp.*) as affected by seed rates and method of planting 2016 rainy season is presented in Table 4. Leaf area is an important variable for most eco physiological studies in terrestrial ecosystems concerning light interception, evapotranspiration, photosynthetic efficiency, fertilizers, and irrigation response and plant growth (Blanco and Folegatti, 2005).

Effect of seed rate: The effect of seed rate on leaf area of amaranths (*Amaranthus spp.*) at harvest is presented in Table 4. The result showed that seed rate has no significant (P<0.05) effect on leaf area at harvest. The result is not in similar to the result of Patel *et al.* (2011), in which seed rate of 2.5 kg ha^{-1} produced significantly higher green forage yield (36. 30 t ha^{-1}). This yield was mainly due to significantly higher performance of growth parameters *viz*., plant height (94.22 cm), number of leaves (40.56 $plant^{-1}$), and leaf area (65.64 cm^2 $plant^{-1}$) and total fresh weight (212.67 g $plant^{-1}$).

Effect of method of planting: The effect of method of planting on leaf area at harvest is presented in Table 4. The result indicated that method of planting has no significant ($P<0.05$) effect on leaf area at harvest. This result is not similar to the work of Badi *et al.* (2004) on lettuce, where the closer spacing produced significant increase in leaf area and result of Patel *et al.* (2011) on amaranths, where wider spacing produced significant increase in leaf area.

Effect of interaction: The effect of interaction between seed rates and method of planting on leaf area at harvest is presented in Table 5. The result showed that there was no significant ($P<0.05$) effect of interaction between seed rate and method of planting on leaf area at harvest. This result is not similar to the work of (Gisink and Eforn (1986), who concluded that the influence of plant density and sowing methods on growth and yield of crops is through its influence on competition for light, nutrients in soil and available moisture that affects number of leaves, leaf area and dry matter yield.

Fresh weight: Fresh weight of amaranths as affected by seed rates and method of planting in 2016 rainy season is presented in Table 4.

Effect of seed rate: The effect of seed rate on fresh weight of amaranths at harvest is presented in Table 4. The result showed that seed rate has significant effect on fresh weight of amaranths at harvest. Seed rate of 3 kg ha^{-1} resulted to significantly higher yield followed by seed rate of 2 kg/ha, seed rate of 3.5 kg ha^{-1} and seed rate of 2.5 kg ha^{-1}.

This indicates that seed rate affected fresh weight significantly; this may be due to low seed rate resulted in lower fresh yield compared to the higher seed rate. This may be attributed to fact that low seed rate produced low number of plants per unit area. The result is in agreement with the results reported by Maboko and Du Plooy (2009) and Mwai *et al*. (2009) that Amaranths total leaf fresh and dry mass increased with an increase in plant densities. Generally, leaf yield per unit area increased due to increased plant density, while leaf yield per plant decreased with increasing plant density.

Effect of method of planting: The effect of method of planting on fresh weight of amaranths at harvest is presented in Table 4. The result indicated that method of planting has significant ($P<0.05$) effect on fresh weight at harvest. Drilling produced significantly higher fresh weight of 31000 kg than broadcasting which produced 24000 kg ha^{-1}. This indicated that the distance among plants was more uniform, therefore, each plant had enough space for light interception, whereas, at broadcast planting, the distance between two plants may be very close or very far due to uneven distribution of the plants. Thus, some of the plants had extra space to intercept light and absorb moisture and nutrition while others suffer for those required growth factors, therefore, phenotypic appearance of the plants were highly variable at broadcast planting. The result for the effect of method of planting is similar with the results of Patel *et al.* (2011) on amaranths, which indicated that drilling of Amaranths in row spacing of 45 cm recorded significantly higher green forage yield.

Effect of interaction: The effect of interaction between seed rate and method of planting on fresh weight of amaranths at harvest is presented in Table 5. The result indicated that the interaction between seed rate and method of planting have significant effect on fresh weight of Amaranths at harvest. Interaction between seed rate at 3kg ha^{-1} and drilling had the highest fresh weight for Amaranths of 37900 kg ha^{-1}, while interaction between seed rate of 2.0 kg ha^{-1} and drilling produced the lowest yield of 17500kg ha^{-1}. The result for the interaction is in conformity with the results Patel *et al.* (2011) on amaranths, that there was significant interaction amongst the genotype, method of planting and seed rate on growth and yield of amaranth fodder.

Table 1. Physico-chemical characteristics of the soil used in the cultivation of Amaranthus.

Particle distribution (g/kg)	Value
Sand (%)	45.63
Clay (%)	9.53
Silt (%)	44.83
Texture	Loamy
Chemical properties	
Soil pH	5.51
Organic Carbon (%)	0.41
Total Nitrogen (%)	0.70
Available Phosphorus mg/kg	0.50
Cation Exchange Capacity (CEC)	2.22
Exchangeable Bases (Cmol/kg)	
Calcium (Ca^{2+})	0.40
Potassium (K^+)	0.21
Magnesium (Mg^{2+})	0.14
Sodium (Na^+)	0.52

Table 2. Effect of seed rate, method of planting and their interaction on plant height of Amaranths at Sokoto during the rainy season in the year 2016 at Sokoto.

Treatment Seed rate	Plant height Weeks after planting (WAP)			
	2	4	6	8
2kg ha^{-1}	10.27	31.71^{c}	68.94^{c}	114.50^{b}
2.5kg ha^{-1}	11.64	34.17^{b}	75.13^{b}	118.71^{b}
3kg ha^{-1}	12.87	39.17^{a}	83.93^{a}	121.21^{a}
3.5kg ha^{-1}	9.92	28.09^{c}	61.05^{c}	100.05^{c}
SE±	0.81	2.57	3.49	3.64
Significance	Ns	*	*	*
Method of planting				
Broadcasting	10.34	32.26	72.99	112.25
Drilling	12.25	35.24	73.44	116.75
SE±	0.247	0.573	0.951	0.641
Significance	Ns	Ns	Ns	Ns
Interaction				
SR × MP	Ns	Ns	Ns	Ns

Mean with the same superscript letter in a column are not significantly different (p<0.05) according to Duncan's new multiples range test; Ns = not significant, * = significant at 5%. SR= Seed Rate, MP= Method of Planting.

Table 3. Effect of seed rate, method of planting and their interaction on number of leaves of Amaranths at Sokoto during the rainy season in the year 2016 at Sokoto.

Treatment Seed rate	Number of leaves Weeks after planting (WAP)			
	2	4	6	8
2 kg ha^{-1}	9.33	15.00	29.50	42.17
2.5 kg ha^{-1}	10.83	15.67	28.50	38.67
3 kg ha^{-1}	10.29	15.00	29.71	42.29
3.5 kg ha^{-1}	9.60	14.40	27.00	32.80
SE±	0.45	0.43	0.83	1.62
Significance	Ns	Ns	Ns	Ns
Method of planting				
Broadcasting	9.42	14.08	28.52	38.17
Drilling	10.67	15.00	28.67	40.00
SE±	0.172	0.962	0.884	0.517
Significance	NS	NS	NS	NS
Interaction				
SE × MP	Ns	Ns	Ns	Ns

Mean with the same superscript letter in a column are not significantly different (p<0.05) according to Duncan's new multiples range test; Ns = not significant, * = significant at 5%. SR= Seed Rate, MP= Method of Planting.

Table 4. Effect of seed rate, method of planting and their interaction on leaf area and fresh weight of Amaranths at Sokoto during the rainy season in the year 2016 at Sokoto.

Treatments Seed rate	Leaf area at harvest	Fresh weight of Amaranths (kgha^{-1})
2.0 kg/ha	0.08	27250.17^{b}
2.5 kg/ha	0.08	25722.17^{b}
3.0 kg/ha	0.08	32738.00^{a}
3.5 kg/ha	0.06	26266.80^{b}
SE±	0.04	1812.12
Significance	Ns	*
Method of planting		
Broadcasting	0.08	24916.67
Drilling	0.08	31027.83
SE±	0.02	0.026
Significance	NS	*
Interaction		
SR x MP	Ns	Ns

Mean with the same superscript letter in a column are not significantly different (p<0.05) according to Duncan's new multiples range test; Ns = not significant, * = significant at 5%. SR= Seed Rate, MP= Method of Planting.

Table 5. Effect of interaction between seed rate and method of planting on fresh weight of Amaranths at Sokoto during the rainy season in the year 2016.

Seed rate	Method of Planting	
	Broadcasting	Drilling
2.0kg/ha	31000.00^{b}	17500.33^{c}
2.5kg/ha	25333.33^{b}	26111.00^{b}
3.0kg/ha	26333.33^{b}	37944.33^{a}
3.5kg/ha	25000.00^{b}	25555.66^{b}
SE±	1812.12	1812.12
Significance	*	*

Mean with the same superscript letter in a column are not significantly different (p<0.05) according to Duncan's New multiples range test; Ns = not significant, * = significant at 5%.

Table 6. Effect of seed rate and method of planting on dry weight of Amaranths at Sokoto during the rainy season in the year 2016.

Treatment Seed rate	Dry weight of plants (kgha^{-1})
2.0 kg/ha	8041.67^{b}
2.5 kg/ha	8500.00^{b}
3.0 kg/ha	9159.43^{a}
3.5 kg/ha	7900.00^{b}
SE±	518.72
Significance	*
Method of planting	7416.67
Broadcasting	7416.67
Drilling	9430.50
SE±	0.053
Significance	*

Mean with the same superscript letter in a column are not significantly different (p<0.05) according to Duncan's New Multiples Range Test; Ns = not significant, * = significant at 5%.

Table 7. Effect of interaction between seed rate and method of planting on dry weight of Amaranths at Sokoto during the rainy season in the year 2016.

Seed rate	Method of planting	
	Broadcasting	Drilling
2.0kg/ha	8666.66^{b}	5416.67^{c}
2.5kg/ha	8666.67^{b}	8333.33^{b}
3.0kg/ha	8333.33^{b}	10194.33^{a}
3.5kg/ha	8500.00^{b}	7777.67^{b}
SE±	518.72	518.72
Significance	*	*

Mean with the same superscript letter in a column are not significantly different (p<0.05) according to Duncan's New Multiples Range Test; Ns = not significant, * = significant at 5%.

The significantly higher interaction for green forage yield (43.53 t ha $^{-1}$) and dry matter yield (3.01 t ha^{-1}) was recorded in S2G2P2 *viz*., 45 cm row spacing, genotype GA^{-1} with seed rate of 2.5 kg ha^{-1}. Reports have shown that herbage yield of cowpea is consistent with the cumulative effect of higher plant height, number of leaves, number of branches, and leaf area, which indicates the greater allocation of the assimilate to produce vegetative matter (Musah and Yusuf, 1992).

Conclusions

The present study concluded that seed rates and method of planting significantly increased growth and yield of amaranths. It is thereby recommended that seed rate of 3 kg ha^{-1} and drilling method of planting should be adopted for optimum yield of Amaranths.

REFERENCES

Abubakar, M.J.D. (2015). Effect of different soil amendment rates (chicken manure and NPK fertilizer 15-15-15) on the growth and yield of vegetable amaranth (*Amaranthus hybridus*) University for development studies, tamale. Dissertation submitted to the Department of Horticulture, Faculty of Agriculture, University for development studies, in partial fulfillment of the requirements for the award of masters of philosophy degree in horticulture. pp: 139.

Aphane, J., Chadha, M.L. and Oluoch, M.O. (2003). *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.

Badi, H. N., Yazdani, D., Ali, S.M. and Nazari, F. (2004). Effect of spacing and harvesting time on herbage yield and quality/ quantity of oil thyme, *Thymus vulgaris* L. industrial Crops and Products pp: 231-236.

Blanco, F.F. and Folegatti, M.V. (2005). Estimation of leaf area for greenhouse cucumber by linear measurements under salinity and grafting.*Agricultural Science*, 62: (4):305 –309.

Gasim, S.A. (2001). Effect of nitrogen, phosphorus and seed rate on growth, yield and quality of forage maize (*Zea mays*). M.Sc. Thesis, Faculty of Agriculture, University of Khartoum.

Gisink, J. and Eforn, Y.(1986). Planting date and foliar fertilization of corn grown for silage and grain under limited moisture. *Agronomy Journal*, 78: 426-429.

Juan, C.K. (2007). Electrophoretic characteristics of *Amaranthus* L, seed proteins and its systematic implication. *Botanical Journal of the Linnean Society*, 2:57-63.

Maboko, M.M. and Du Plooy, C.P. (2009). Effect of plant spacing on growth and yield of lettuce (*Lactuca sativa* L.) in a soilless production system. *South African Journal of Plant and Soil*, 26:199 -201.

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 1539-1554.

Mlakar, S.G., Turinek, M., Jakop, M., Bavec, M. and Bavec, F. (2010). Grain Amaranth as an alternative and Perspective crop in temperate climate. *Journal for Geography*, 5(1): 135-145.

Muhammed, J. (2012). Productivity of amaranth zz (*Amaranthusspp*) as influenced by water stress and pot size in Sokoto Sudan Savannah Nigeria. B. Agriculture project, Crop Science Department, Usmanu Danfodiyo University, Sokoto, pp: 14.

Musah, U.T. and Yusuf, Y. (1992). Effect of P fertilization on growth, yield and crude protein (CP) content of two cowpea lines in Samaru, Nigeria.Nationally Coordinated Research Project on Cowpea.Workshop, Usmanu Danfodiyo University, Sokoto, pp: 10.

Mwai, G.N., Onyango, M.O.A., Onyango, J.C., Chadha, M.L. and Oluoch, M.O. (2009). Effect of plant density on yield components of nightshade.*Acta Horticulture,* 806: 733-739.

Oluoch, M.O., Mwai, G.N., Onyango, M.O.A., Onyango, J.C. and Chadha, M.L. (2009). Effect of plant density on yield components of nightshade. *Acta Horticulture*. 806:733-739.

Omaryi, M. (2013). Morphological characteristics, growth and yield of elite grain and leaf amaranth in northern Tanzania.A dissertation submitted in partial fulfillment of the requirements for the degree of Master of Science in research methods in the Jomo Kenyatta University of Agriculture and Technology Jomo Kenyata University of Agriculture and Technology pp: 84.

Patel, S.A., Alagundagi, S.C., Mansur, C.P., Kubsad, V.S., Hosamani, S.V. and Megeri, S.N. (2011). Effect of row spacing and seed rate on growth, fodder productivity and economics of amaranth genotypes. *Karnataka Journal of Agricultural Science,* 24(5):651-653.

Putnam, D.H. (2007). Center for Alternative plant and Animal Products Minnesota Extension Services. University of Minnesota. St Paul Mn 55108, pp: 1-5.

Republic of South Africa (RSA) (2010). Amaranthus: Production guideline. Department of Agriculture, Forestry and Fisheries. Pretoria.

Schippers, R.R. (2000). African indigenous vegetables: An Overview of the cultivated species. Chatham UK. Natural Resource Institute/ACP-EU Technical Centre for Agricultural Resources and Rural Cooperation, pp: 54.

Stallknecht, G.F. and Schulz-Schaeffer, J.R. (1993). Amaranths rediscovered. In: J. Janick and J.E. Simon (eds.). *New crops*. Wiley, New York, pp: 211- 218.

SERC, Sokoto Energy Research Center (2016). Meteorological data: Usmanu Danfodiyo University, Sokoto, Nigeria.