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Effects of Phosphorus Fertilizer and Intra Row Spacing on the Growth and Yield of Grain Amaranth (*Amaranthus cruentus*)

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Abstract: Grain amaranth (*Amaranthus cruentus*) is an ancient unpopular crop that is now gaining fresh attention and interest all over the world. This has led to a demand for crop management information like that on phosphorus fertilization and spacing. This study evaluates the effects of phosphorus fertilizer and spacing on grain amaranth growth and yield components. The study was carried out at the experimental field of National Horticultural Research Institute (NIHORT), Ibadan, Western region of Nigeria in the year, 2009. Three levels of phosphorus fertilizer (0, 50 and 100 kg P_2O_5 ha^{-1}) and three spacing (30×50, 40×50 and 50×50 cm) were tested under factorial fitted into Randomized complete block design with three replicates, respectively. Amaranth growth and yield was responsive to phosphorus fertilization. Plant spacing of 30×50 cm and fertilizer application of 100 kg P_2O_5 ha^{-1} resulted to the highest plant height, number of leaves, dry matter yield, biological yield and grain yield which was higher than that of the other treatment combinations.

Key words: Amaranth, phosphorus, spacing, grain yield, *Amaranthus cruentus*, Nigeria

INTRODUCTION

Grain amaranth (*Amaranths cruentus*) is a plant with an upright growth habit, cultivated for its seed which is used as grain. It is a C_4 plant and one of a few dicots in which the 1st product of photosynthesis is a four carbon compound (along with such plants as corn and sorghum). It is a high protein pseudo-cereal which originated in central South America.

Amaranth grain is considered to have a unique composition of protein, carbohydrate and lipid. It has high protein (12-18%) than other cereals grain. It has significantly higher lysine content (De Macvean and Poll, 1997) and contains high fiber, calcium, iron, magnesium, phosphorus copper and manganese. While the grain amaranth were the principle species used on the South American continent, amaranth have been cultivated as vegetable crop by early civilization over 2000 years ago and continue to be used essentially world-wide even at the present day.

Various species of grain and vegetable amaranth types can be distinguished, often both the leaves and grains are utilized as human and animal food (Saunders and Becker, 1984). To assure a small annual supply for this specialty crop, traditional farmers have continued to grow small plots of the grain each year. Grain amaranth is often referred to as the crop of the future. It has been proposed as an inexpensive native crop that could be cultivated by indigenous farmers in the rural areas because it is easily harvested, produced lots of seeds used as grain and highly tolerant of arid environment. The distinctly beautiful appearance of grain amaranth has helped to prevent the crop from slipping into obscurity.

Aside from grain amaranth being such an attractive plant, it is extremely adaptable to adverse growing conditions like high heat and drought. It has no major disease problems and it is among the easiest of plants to grow.

MATERIALS AND METHODS

The field experiment was conducted at Ibadan (7°10' N; 3°52' E) a hot humid region with temperature 26-35°C and rainfall from 1100-1250 mm $year^{-1}$ between August and November, 2009. Experimental design of this study was a factorial fitted into Randomized complete block design, consisting of three fertilizer rates and three spacing. The total treatment combination was tested with three replicates. Soil samples were taking on the experimental plots and analyzed before planting which showed that the available soil P was low. Three phosphorus fertilizer levels (0, 50 and 100 kg P_2O_5 ha^{-1}) and three spacing (30×50, 40×50 and 50×50 cm) were

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evaluated in the study. The seeds were planted directly to the experimental plots of size (2×2 m) and phosphorus fertilizer rates were applied 2 weeks after planting. Data were collected on the growth and yield parameter and these were subjected to statistical analysis using SAS procedures and standard error was used to separate the treatment means.

RESULTS AND DISCUSSION

In Table 1, application of 100 kg P_2O_5 ha^{-1} and spacing of 30×50 cm gave the highest plant height which was significantly higher than the other rates of P application and spacing. Application of 0 kg P_2O_5 ha and spacing of 30×50 cm gave the lowest plant height which was significantly lower than the other rates of application and spacing.

Application of 0 kg P_2O_5 ha^{-1} gave the lowest number of leaves in all the spacing combination while the application of 100 kg P_2O_5 ha^{-1} and 30×50 cm spacing gave the highest number of leaves which was significantly higher than that of 0 kg P_2O_5 ha^{-1} application. Application of 0 kg P_2O_5 ha^{-1} and spacing of 30×50 cm gave to the lowest number of branches which was significantly lower than that of the other spacing and fertilizer combinations. Application of 100 kg P_2O_5 ha^{-1} and spacing of 50×50 cm gave the highest number of branches, this may be due to wider spacing and highest fertilizer application. Spacing of 50×50 cm and fertilizer application of 100 kg P_2O_5 ha^{-1} gave the highest stem diameter at 45 days after planting which was significantly higher than other spacing and fertilizer combination.

Application of 0 kg P_2O_5 ha^{-1} and 30×50 cm spacing gave the lowest stem diameter which was significantly lower than the others fertilizer application rates and spacing.

In Table 2, application of 0 kg P_2O_5 ha^{-1} and 30×50 cm spacing gave the lowest dry matter yield at 45 days after planting while the application of 100 kg P_2O_5 ha^{-1} and 30×50 cm spacing gave the highest dry matter yield which was significantly higher than the others.

Application of 0 kg P_2O_5 ha^{-1} with spacing of 30×50 cm gave the lowest biological yield which was significantly lower than the other P application rates. Application of 100 kg P_2O_5 ha^{-1} and spacing of 30×50 cm gave the highest biological yield which was significantly higher than that of the other rates of application and spacing.

Spacing of 30×50 cm and application rate of 100 kg P_2O_5 ha^{-1} gave the highest overall grain yield which was significantly higher than the others. Application of 100 kg P_2O_5 ha^{-1} and 50×50 cm spacing gave the highest Harvest index which was significantly higher than others.

Table 1: Effects of spacing and phosphorous fertilizer on the growth parameters

Treatments					
Plant spacing (cm)	Phosphorus (kg ha^{-1})	Plant height 45 DAS (cm)	No. of leaves at 45 DAS	No. of branches at 45 DAS	Stem diameter at 45 DAS (cm)
30×50	0	112.00	39.00	7.00	1.52
30×50	50	115.00	45.00	8.00	1.72
30×50	100	139.67	54.00	9.00	1.98
40×50	0	118.67	43.00	9.00	1.82
40×50	50	119.67	52.00	10.00	1.84
40×50	100	130.33	45.00	11.00	1.87
50×50	0	113.33	41.00	10.00	1.82
50×50	50	118.00	45.00	11.00	1.87
50×50	100	130.67	52.00	12.00	2.05
SE		5.74	3.27	1.51	0.19

Table 2: Effects of spacing and phosphorus fertilizer on the yield parameters

Treatments					
Plant spacing (cm)	Phosphorus (kg ha^{-1})	Dry matter yield at 45 DAP (kg)	Biological yield (kg)	Grain yield (kg)	Harvest index
30×50	0	0.08	19.97	0.60	2.96
30×50	50	0.10	20.00	0.65	3.30
30×50	100	0.18	22.03	0.80	3.67
40×50	0	0.10	19.10	0.57	2.80
40×50	50	0.11	20.80	0.59	3.03
40×50	100	0.12	20.87	0.65	3.13
50×50	0	0.10	20.33	0.54	2.87
50×50	150	0.11	20.39	0.68	3.43
50×50	100	0.12	21.43	0.70	3.83
SE		0.01	1.27	0.07	0.24

CONCLUSION

Based on the findings of this study, it can be said that planting grain amaranth at a spacing of 30×50 cm with the application of 100 kg P_2O_5 ha^{-1} is the best for optimum growth and grain yield of grain amaranth.

The result of this study is not in accordance with the findings of Elbehri *et al.* (1993) who obtained no yield response to P and Henderson *et al.* (2000) who suggested that the plasticity of grain amaranth morphology may limit its response to seeding rate and row spacing. Aufhammer *et al.* (1995), Myers and Putnam (1988) and Gimplinger *et al.* (2007) also all failed to observe a yield response to row spacing. On the other hand, Malligawad and Patil (2001) reported grain yield increases with increase in plant population. A Missouri study at Thomas Jefferson Agricultural Institute comparing different row spacing, found that the wider rows gave the highest yield. It was suggested that amaranth plants seem to compete excessively with each other when planted in the narrow spacing, leading to shorter, less vigorous plants and smaller grain heads. This statement was not true in this present study because it was the closer spacing (30×50 cm) that resulted to the highest seed yield.

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