International Journal of Environment, Agriculture and Biotechnology
Vol-9, Issue-6; Nov-Dec, 2024
Peer-Reviewed International Journal
Journal Home Page Available: https://ijeab.com/
Journal DOI: 10.22161/ijeab

Effect of Spacing and Fertilizer Levels on Growth, Yield and Economics of Grain Amaranth (*Amaranthus hypochondriacus* L.)

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Received: 30 Sep 2024; Received in revised form: 01 Nov 2024; Accepted: 06 Nov 2024; Available online: 12 Nov 2024

Abstract— *The present investigation was conducted to estimate the Impact of spacing and fertilizer levels on growth, yield and economics of grain amaranth during rabi season of 2022 at Experimental farm, Agronomy Department, College of Agriculture, Parbhani. The experiment was laid out in split plotdesign with three replication. Main plots were assigned to the different spacingviz S1: 45cm x 15cm, S2 : 45cm x 20cm and S3 : 30cm x 20cm and subplot comprises of fourfertilizer levels viz. F1 : 30:20:10 NPK kg ha^{-1}, F2 :45:30:15 NPK kg ha^{-1}, F3 :60:40:20 NPK kg ha^{-1} and F4 :75:50:25 NPK kg ha^{-1}. The experimental gross plot size was 5.4 x 4.8 m^2 and net plot size varied as per treatment. On 21st November, 2022, sowing was carried out by dibbling the seed @ 2 kg ha^{-1}. The result of experiment revealed that sowingof amaranth at spacing of 45cm ×15cm and application of 75:50:25 NPK Kg ha^{-1} were found more productive and profitable.*

Keywords— ***Amaranth, Spacing, Fertilizer levels, Growth, Yield, Economics***

I. INTRODUCTION

Amaranth is one of the important and popular plant for grain and leafy vegetable purpose. Amaranth is popularly known as ‘Chaulai’ and Grain Amaranth is called as pseudocereal It belongs to the family Amaranthaceae. In addition to protein, carbohydrates, dietary fiber and dietary fiber and lipids, grain amaranth also contains high levels of calcium, iron, magnesium, phosphorous, copper, maganese, cobalt, chromium, iodine, selenium, zinc, molybdenum and sodium like other cereals which are also required by the human body in very small quantities.

Amaranth has C_4 metabolism as well as deep root system, results in increased efficiency to use CO_2 under wide range of both temperature and moisture stress environment. The crop can be grown in any type of soil. Amaranth grows best under hot and humid climate although, it tolerates drought, low fertility and adverse climate condition. Amaranth has a short growing period, grain amaranth can be harvested at 90 days. In India, Amaranth is cultivated both in hills as well as plains covering states of Madhya Pradesh, Uttar Pradesh, Uttarakhand, Maharashtra, Gujarat, Orissa, Karnataka, Bihar. The exact information about area, production and productivity of grain amaranth at national level is lacking.

Plant spacing is a non-monetary input, but it plays a vital role by changing the magnitude of competition. Uniform distribution of crop plants over an area results in efficient use of nutrients, moisture, and suppression of weeds leading to high yield. Higher plant population may compensate the lower individual plant yield. Hence, it is necessary to maintain optimum plant population to get high productivity. The balanced use of fertilizer plays a vital role in enhancing the productivity of crop. Nitrogen, phosphorus and potassium are the essential plant nutrients required for healthy growth of plants. Availability of low concentration of these nutrients in plants rigorously limits the yield and produces more or less distinct deficiency symptoms. In one of the study, it has been observed that the grain amaranth respond good up to fertilizer dose of 60:40:20 NPK kg ha^{-1} (Raiger *et al.*,2009). There is limited and preliminary information available on the plant spacing and fertilizer requirements of amaranth (Olaniyi *et al*., 2008). Keeping this in view, the present investigation entitled 'Effect of spacing and fertilizer levels on growth, yield and economics of grain amaranth (*Amaranthus hypochondriacus* L.)

II. MATERIAL AND METHODS

The experiment was conducted during rabi season of 2022 at Research Farm, Department of Agronomy, College of Agriculture Parbhani, Maharashtra. The experimental site featured a clay-like soil texture with a slightly alkaline reaction (pH 7.67). Prior to sowing, the soil's nutrient profile revealed moderate levels of available nitrogen (276.5 kg ha^{-1}), moderate levels of available phosphorus (11.9 kg ha^{-1}) and very highlevels of available potassium (428.2 kg ha^{-1}). The site is well-drained nature facilitated to optimal growth of amaranth.

The experiment was laid out in split plotdesign with three replication. Main plots were assigned to the different spacing viz S1: 45cm x 15cm, S2: 45cm x 20cm and S3: 30cm x 20cm and subplot comprises of three fertilizer levels viz.F1 : 30:20:10 NPK kg ha^{-1}, F2 :45:30:15 NPK kg ha^{-1}, F3 :60:40:20 NPK kg ha^{-1} and F4:75:50:25 NPK kg ha^{-1}. The experimental gross plot size was 5.4 x 4.8 m^2 and net plot size varied as per treatment. Sowing was done by dibbling seeds @ 2 kg ha^{-1} on 21st November, 2022. The harvest took place on April 05, 2023.

III. RESULTS AND DISCUSSION

Growth attributes:

The data pertaining to various growth parameter of amaranth were significantly influenced by different spacing and fertilizer levels are presented in Table 1. The result revealed that sowing of amaranth seed at spacing of 45 x20 cm recorded maximum number of branches $plant^{-1}$ (41.58), number of functional leaves $plant^{-1}$ (121.1), leaf area $plant^{-1}$ (41.17), drymatter accumulation $plant^{-1}$ (49.16 g) which was significantly superior over rest of the spacings. The maximum growth was recorded in wider spacing as compared to close spacing. The higher growth might be due to sufficientspace, moisture and nutrients in wider spacing, which accelerated the growth and development of the crop. Similar findings were observed by Rahman *et al*. (2007), Patel *et al*. (2011), Chaudhari *et al*. (2022)

In case of fertilizer levels, application of 75:50:25 NPK kg ha^{-1} (F4) recorded significantly higher growth attributes like plant height (157.2 cm), number of branches $plant^{-1}$(42.60), number of leaves $plant^{-1}$ (120.9), leaf area $plant^{-1}$(42.00 dm^2), total dry matter accumulation $plant^{-1}$ (48.25 g). The higher growth of plant might be due to beneficial effect of nutrients which resulted in higher growth of crop. The results were in line with the findings of Kushare *et al*. (2010), Nawlakhe *et al*. (2011), Dehariya *et al*. (2019), Srujan *et al*. (2021)

Table 1: Effect of different treatments on growth- related attributes of amaranth.

Treatments	Plant height (cm)	No. of branches $plant^{-1}$	No. of functional leaves $plant^{-1}$	Leaf area $plant^{-1}$ (dm^2)	Dry matter accumulation $plant^{-1}$ (g)
Spacing (S)					
S1 : 45 cm × 15 cm	148.7	37.41	115.5	37.76	40.76
S2 : 45 cm × 20 cm	140.3	41.58	121.1	41.17	49.16
S3: 30 cm × 20 cm	158.6	36.53	107.4	35.65	37.16
SE (m) ±	3.1	0.89	2.6	0.96	0.86
C.D. at 5 %	12.0	3.50	10.1	3.77	3.36
Fertilizer levels (F)					
F1 : 30:20:10 NPK kg ha^{-1}	138.7	33.58	106.3	33.87	35.27
F2 : 45:30:15 NPK Kg ha^{-1}	146.8	36.34	113.1	35.78	39.39
F3 : 60:40:20 NPK Kg ha^{-1}	154.1	41.49	118.3	41.12	46.54
F4 : 75:50:25 NPK Kg ha^{-1}	157.2	42.60	120.9	42.00	48.25

SE (m) ±	1.3	0.45	1.8	0.57	0.97
C.D. at 5 %	3.9	1.33	5.2	1.69	2.89
SxF					
SE (m) ±	2.2	0.78	3.1	0.98	1.68
C.D. at 5 %	NS	NS	NS	NS	NS
GM	**149.2**	**38.50**	**114.7**	**38.19**	**42.36**

Yield:

The yield parameters including grain yield (kg ha^{-1}), straw yield (kg ha^{-1}) and biological yield (kg ha^{-1}) was influenced significantly due to spacing. The result presented in Table 2 inferred that the effect of spacing and fertilizer levels was found significant on yield. The grain yield (1419 kg ha^{-1}), straw yield (4245 kg ha^{-1}), biological yield (5664 kg ha^{-1}), harvest index (25.06 %) were recorded maximum with the spacing 45 cm x 15 cm (S_1) and was significantly superior over 45cm x 20 cm (S_2), however, it was at par with 30 cm x 20 cm (S_3). Thus it can be concluded that spacing 45 cm x 15 cm and 30 cm x20 cm were found comparable for getting higher yield of amaranth. This might be due to higher plant population under closer spacing that resulted in higher photosynthetic activity along with proper grain filling and thus contributed to higher yield. The similar observations also recorded by Vaghela *et al*. (2018), Verma *et al*. (2022).

The result revealed that application of 75:50:25 NPK kg ha^{-1} (F_4) recorded the higher yield like grain yield (1544 kg ha^{-1}), straw yield (4463 kg ha^{-1}), biological yield (6007 kg ha^{-1}), harvest index (25.70 %) as compared to 30:20:10 NPK kg ha^{-1}(F_1) and 45:30:15 NPK kg ha^{-1}(F_2) but it was found at par with 60:40:20 NPK kg ha^{-1}(F_3). This might be due to balanced application of nutrients which enhanced growth and development of the crop and resulted higher yield. The results corroborated the findings of Parmar *et al*. (2009), Solanki *et al*. (2016), Keraliya *et al*. (2017), Jangir *et al*. (2019), Srujan *et al*. (2021), Rana *et al*. (2022).

Table 2: Effect of different treatments on yield of amaranth.

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest Index
Spacing (S)				
S_1 : 45 cm × 15 cm	1419	4245	5664	25.06
S_2 : 45 cm × 20 cm	1206	3737	4943	24.39
S_3: 30 cm × 20 cm	1318	4019	5337	24.69
SE (m) ±	38	90	109	-
C.D. at 5 %	150	355	429	-
Fertilizer levels (F)				
F_1 : 30:20:10 NPK kg ha^{-1}	1026	3387	4413	23.25
F_2 : 45:30:15 NPK Kg ha^{-1}	1187	3776	4964	23.92
F_3 : 60:40:20 NPK Kg ha^{-1}	1500	4375	5876	25.53
F_4 : 75:50:25 NPK Kg ha^{-1}	1544	4463	6007	25.70
SE (m) ±	29	40	45	-
C.D. at 5 %	85	118	132	-
SxF				
SE (m) ±	50	69	77	-
C.D. at 5 %	NS	NS	NS	-
GM	**1314**	**4000**	**5315**	**24.73**

Table 3: Effect of different treatments on economics of amaranth.

Treatments	Cost of cultivation (₹ ha^{-1})	Gross Monetary Returns (₹ ha^{-1})	Net Monetary Returns (₹ ha^{-1})	B : C ratio
Spacing (S)				
S_1 : 45 cm × 15 cm	35691	99359	63668	2.77
S_2 : 45 cm × 20 cm	35306	84414	49108	2.38
S_3: 30 cm × 20 cm	35993	92225	56232	2.56
SE (m) ±	-	2682	2664	-
C.D. at 5 %	-	10530	10460	-
Fertilizer levels (F)				
F_1 : 30:20:10 NPK kg ha^{-1}	34217	71820	37603	2.10
F_2 : 45:30:15 NPK Kg ha^{-1}	35157	83106	47948	2.36
F_3 : 60:40:20 NPK Kg ha^{-1}	36155	105008	68853	2.90
F_4 : 75:50:25 NPK Kg ha^{-1}	37124	108064	70940	2.91
SE (m) ±	-	2007	1994	-
C.D. at 5 %	-	5963	5924	-
SxF				
SE (m) ±	-	3476	3453	-
C.D. at 5 %	-	NS	NS	-
GM	**35663**	**91999**	**56336**	**2.57**

Economics:

The data furnished in Table 3 revealed that economics like GMR (99359 ₹ ha^{-1}), NMR (63668 ₹ ha^{-1}) were recorded maximum with the spacing 45 cm x 15 cm (S_1) and was found at par with spacing 30 cm x20 cm (S_3). This might be due to higher grain yield was obtained with 45 cm ×15 cm (S_1) and 30 cm × 20 cm (S_3) which reflected in achieving returns. The result of experiment revealed that the spacing of 45cm×15cm (S_1) recorded higher benefit-cost ratio (2.77) followed by 30 cm ×20 cm (S_3) (2.56). This might be due to higher gross monetary return and less cost of cultivation in spacing 45cm×15cm (S_1). These results are inconformity with those reported by Chaudhari *et al.*(2009), Vaghela *et al*. (2018), Palanjiya *et al*. (2019) in grain amaranth.

The economic analysis of the data revealed that application of 75:50:25 NPK kg ha^{-1} (F_4) recorded the higher economics like GMR (108064 ₹ ha^{-1}), NMR (70940 ₹ ha^{-1}) and it was found at par with 60:40:20 NPK kg ha^{-1} (F_3). It might be due to a higher grain yield achieved due to better nutrition which eventually resulted in higher GMR and NMR. The application of 75:50:25 NPK kg ha^{-1} recorded higher B: C ratio (2.91), which was closely followed by application of 60:40:20 NPK kg ha^{-1}(2.90). The higher B:C ratio might be due to higher gross monetary return obtained under fertilizer level 75:50:25 NPK kg ha^{-1} and 60:40:20 NPK kg ha^{-1}. These findings are in line with the earlier findings of Patel *et al*. (2011), Keraliya *et al.* (2017), Srujan *et al.* (2021), Rana *et al.* (2022).

IV. CONCLUSION

The findings of the experimentation indicated that dibbling of amaranth at spacing of 45 x15 cm was found more productive and profitable. application of 75:50:25 NPK kg ha^{-1} recorded significantly higher growth, yield attributes and economics of amaranth. However, it was comparable with 60:40:20 NPK kg ha^{-1}.

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