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Effect of spacing and fertilizer levels on yield and economics of amaranth (*Amaranthus hypochondriacus* L.)

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Abstract
A field experiment was conducted at Experimental Farm, Agronomy Department, College of Agriculture, Parbhani to study the effect of spacing and fertilizer levels on yield and economics of amaranth during rabi 2022-23. The experiment was designed in split plot design and was replicated thrice. Main plots were assigned to the different spacing viz S1: 45 cm x 15 cm, S2:45 cm x 20 cm and S3: 30 cm x 20 cm and subplot comprised of four 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}. Sowing was done by dibbling seeds @ 2 kg ha^{-1} on 21st November, 2022. The result of experiment revealed that significantly higher grain yield, gross monetary return and net monetary return of amaranth was observed in spacing 45 cm ×15 cm, however it was comparable with spacing 30 cm ×15 cm. As regards to fertilizer level, the application of 75:50:25 NPK Kg ha^{-1} and 60:40:20 NPK kg ha^{-1} recorded comparable grain yield, gross monetary return and net monetary return.

Keywords: Amaranth, spacing, fertilizer levels, yield, economics

Introduction
Amaranth is a high nutritive value crop which belongs to the family Amaranthaceae, subfamily Amaranthoideae and genus Amaranthus and grows in wide range of climatic conditions and has high yield potential with low water requirement. The grain amaranth contains 16% protein, 62% carbohydrates, 8.0% lipids and 3% minerals. It has balanced composition of essential amino acids such as lysine 5% and methionine 4.0%. It is rich source of iron, beta carotene, calcium, potassium, phosphorous, vitamin-A and Vitamin-C. It can be used as grain as well as vegetable form. It is cultivated in hills as well as in plains. Grain amaranth assumes special significance because of its C4 metabolism indicating high productivity. It seems ideally suited to hot and humid climate where the crop can be with stand i both drought and low temperature during its later stages.

Performance of crop can be explored by manipulating the various agronomic practices. Among these spacing and nutrient are the most important production factors that plays a vital role in augmenting the productivity of crop. Plant spacing is one of the most important factors in increasing crop yield. Uniform distribution of crop plants over an area results in efficient use of nutrients, moisture, and suppression of weeds leading to high yield. Among various other agronomic factors known to augment crop yield, fertilizer management play a vital role in increasing crop productivity. Nitrogen, phosphorus and potassium are the essential plant nutrients required for healthy growth of plants. Out of the three major plant nutrients used as fertilizers, nitrogen ranks first practically all over the world. Significant increase in amaranth grain yield with fertilizer application. In this scenario adoption of modern agronomic practices like spacing and fertilizer levels is the need of hour to augment the efficient use of seeds and fertilizer and enhance the yield of amaranth. But information regarding to spacing and fertilizer requirement of grain amaranth is scanty (Bansal *et al*., 1995 and Misra *et al*., 1985) [1, 5]. Taking into consideration these points the present field investigation was conducted at Experimental Farm, Agronomy Department, College of Agriculture, Parbhani during rabi season of the year 2022-23 to find out the effect of spacing and fertilizer levels on yield and economics of amaranth.

Materials and Methods
A field experiment was conducted at Experimental Farm, Agronomy Department, College of Agriculture, Parbhani to find out the effect of spacing and fertilizer levels on yield and economics of amaranth during rabi season of the year 2022-23.

The soil of the experimental plot was clayey in texture, low in organic carbon, medium in available nitrogen and phosphorus, but very high in available potassium and slightly alkaline in reaction.

The experiment was designed using Split Plot Design. The experiment consists of twelve treatment combinations comprised of three spacings and four fertilizer levels. Main plots were assigned to the different spacing viz S1: 45 cm x 15 cm, S2: 45 cm x 20 cm and S3: 30 cm x 20 cm and subplot comprises of four 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 m2 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.

Results and Discussion

Yield

The data presented in Table 1 revealed that grain yield (kg ha^{-1}), straw yield (kg ha^{-1}) and biological yield (kg ha^{-1}) of amaranth were significantly influenced by different spacing and fertilizer levels. Amaranth sown at the spacing of 45 x 15 cm recorded significantly higher grain yield (1419 kg ha^{-1}), straw yield (4245 kg ha^{-1}), biological yield (5664 kg ha^{-1}), harvest index (25.06) however, it was found at par with the spacing 30 x 10 cm. The higher yield 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. These findings are parallel with the earlier findings reported by Vaghela *et al*. (2018) [13], Verma *et al*. (2022) [14].

As regards to fertilizer levels, application of 75:50:25 NPK kg ha^{-1} (F4) 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} (F1) and 45:30:15 NPK kg ha^{-1} (F2) but it was found at par with 60:40:20 NPK kg ha^{-1} (F3). The higher yield might be due to balanced application of nutrients which enhanced growth and development of the crop and resulted higher yield. These findings are in line with the earlier findings reported by Parmar *et al*. (2009) [7], Solanki *et al*. (2016) [11], Keraliya *et al*. (2017) [4], Jangir *et al*. (2019) [3], Srujan *et al*. (2021) [10], Rana *et al*. (2022) [9].

Table 1: 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)				
S1: 45 cm × 15 cm	1419	4245	5664	25.06
S2: 45 cm × 20 cm	1206	3737	4943	24.39
S3: 30 cm × 20 cm	1318	4019	5337	24.69
SE (m) ±	38	90	109	-
C.D. at 5%	150	355	429	-
Fertilizer levels (F)				
F1: 30:20:10 NPK kg ha^{-1}	1026	3387	4413	23.25
F2: 45:30:15 NPK Kg ha^{-1}	1187	3776	4964	23.92
F3: 60:40:20 NPK Kg ha^{-1}	1500	4375	5876	25.53
F4: 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

Economics

The data presented in Table 2 revealed that significantly higher like GMR (99359 ₹ ha^{-1}), NMR (63668 ₹ ha^{-1}) were observed in spacing 45 cm x 15 cm (S1) and was found at par with spacing 30 cm x20 cm (S3). The higher economics might be due to higher grain yield obtained in spacing 45 cm ×15 cm (S1) and 30 cm × 20 cm (S3) which reflected in achieving higher returns. Similarly, spacing 45 cm×15 cm (S1) recorded higher benefit-cost ratio (2.77) followed by 30 cm ×20 cm (S3). This might be due to higher gross monetary return and less cost of cultivation in both the spacing 45 cm×15 cm (S1). These findings are in conformity with the earlier findings reported by Chaudhari *et al*. (2009) [2], Vaghela *et al*. (2018) [13], Palanjiya *et al*. (2019) [6].

Application of 75:50:25 NPK kg ha^{-1} (F4) recorded the higher economics like GMR (108064 ₹ ha^{-1}), NMR (70940 ₹ ha^{-1}) and was found at par with 60:40:20 NPK kg ha^{-1} (F3). It might be due to a higher grain yield achieved due to better nutrition which eventually resulted in higher GMR and NMR. Similarly, application of 75:50:25 NPK kg ha^{-1} recorded higher B: C ratio (2.91) 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) [4], Srujan *et al*. (2021) [10], Rana *et al*. (2022) [9].

Table 2: Effect of different treatments on economics of amaranth

Treatments	Gross Monetary Returns (₹ ha^{-1})	Net Monetary Returns (₹ ha^{-1})	B: C ratio
Spacing (S)			
S1: 45 cm × 15 cm	99359	63668	2.77
S2: 45 cm × 20 cm	84414	49108	2.38
S3: 30 cm × 20 cm	92225	56232	2.56
SE (m) ±	2682	2664	-
C.D. at 5%	10530	10460	-
Fertilizer levels (F)			
F1: 30:20:10 NPK kg ha^{-1}	71820	37603	2.10
F2: 45:30:15 NPK Kg ha^{-1}	83106	47948	2.36
F3: 60:40:20 NPK Kg ha^{-1}	105008	68853	2.90
F4: 75:50:25 NPK Kg ha^{-1}	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	91999	56336	2.57

Conclusion
On the basis of the present investigation it may be concluded that dibbling of amaranth at 45 cm ×15 cm and 30 cm × 20 cm were found statistically similar achieving for higher grain yield, GMR and NMR of amaranth, whereas application of 75:50:25 NPK kg ha^{-1} recorded significantly higher GMR, NMR however it was comparable with 60:40:20 NPK kg ha^{-1}.

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