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Effect of nitrogen and spacing on growth parameters of vegetable amaranth (*Amaranthus spp.* L.)

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Abstract
The present trial was performed to study the effect of nitrogen and spacing on growth parameters of vegetable amaranth (*Amaranthus spp.* L.) at Govind Ballabh Pant university of Agriculture and Technology during summer season of 2021-22. The experiment was set out in factorial randomized block design along with three replications. The experiment comprised of four variable nitrogen levels which includes N_1 (N@ 0 Kg/ha), N_2 (N @30Kg/ha), N_3 (N@60Kg/ha) and N_4 (N@90Kg/ha) along with three spacing viz., S_1 (45 cm×15cm), S_2 (45 cm×30 cm) and S_3 (45 cm × 45cm). Data on growth parameters were collected and analysed using analysis of variance (ANOVA). Results indicated significant increase in plant height and number of branches per plant was observed with the increased levels of applied nitrogen. However, the plant height was significantly higher in closer spacing. Among the variable nitrogen levels, maximum plant height was recorded in N4 (N@90kg/ha) and with respect to spacing it was recorded maximum in S_1. Among the interactions, N4S1 (N@ 90kg/ha + 45×15 cm) found best for plant height. On the hand, N4S3 (N@ 90kg/ha + 45×15 cm) found superior in terms of number of branches per plant.

Keywords: Amaranthus, growth, nitrogen, spacing

Introduction

Amaranth (*Amaranthus spp*. L.) is indeed a versatile and ancient green leafy vegetable. It belongs to the genus Amaranthus of family Amaranthaceae. In India, primarily grown during the summer and rainy season. In India, it is often referred to as chaulai, marsa, khada saag, and laal saag. Due to its short lifetime and high edible matter per unit area, highly suitable for crop rotation. It is believed that leaf amaranth originated in India whereas, grain type is originated from Central and South America.

Both type of amaranth including leaf type as well as grain type of amaranth grown in the world. Leafy types are usually grown in the kitchen and market gardens. The crop is gaining popularity because of its dual purpose utility as grain and as green leaves. Amaranth is widely distributed in temperate, tropical and subtropical parts of the world. Due to its wider adaptability to environmental condition which makes it hardy crop and can be cultivated round the year. It is a warm season crop, require optimum temperature of 20°-30 °C temperature for cultivation. it thrives well in fertile loam to sandy loam soils having pH of 5.5-7.5.

Amaranth plants are tall, soft-wooded annuals that grow quickly and are quite varied, growth habit from erect to spreading with branched taproot. The colour of the leaves is green, red, or a combination of the these two. The Leaves of vegetable amaranth are simple, alternate, long and petiolate. At maturity, plants generally attain a height which ranges from 0.3 m to 2.5 m, depending on species, growth patterns, and habitat. Terminal and auxiliary inflorescences were observed in amaranth. Most of them are monoecious and wind-pollinated. However, bees occasionally visit grain species with colourful flowers which promotes the cross pollination.

Amaranth being a highly nutritious vegetable crop, rich in ascorbic acid, vitamin A and it also contains appreciable amounts of iron, calcium, phosphorous, riboflavin, thiamine, niacin and iron (Thompson and Kelly, 1988) [4]. The amaranth leaves are rich in protein, minerals, and vitamin A and C. it contains 4 g protein, 397 mg calcium, 83 mg phosphorus, 25.5 mg iron, 341 mg potassium, 247 mg magnesium, 99 mg vitamin C per 100g and 9200 IU vitamin A. Amaranth leaves are nutritionally significant source of minerals, including vitamin A, B_6, C and K (Grubben and Denton, 2004) [2].

Materials and Methods

The field experiment was conducted to assess the effect of nitrogen and plant spacing on vegetative parameters of vegetable amaranth (*Amaranthus spp*. L.) at Vegetable Research Centre, G. B. Pant University of Agriculture and Technology Pantnagar, during summer season of 2021-22. Pantnagar lies in the humid sub-tropical zone and situated in the *Tarai* region at the foothills of Shivalik range of Himalayas. The climate is humid sub-tropical with maximum temperature ranging from 32^0 C to 43^0 C in summers and minimum temperature ranging from 0^0 C to 9^0 C in winters. The summers are hot and dry, winter is too cold and frost can be expected from last week of December to last week of January. It is located at an altitude of 243.84 meters above mean sea level and geographically, it falls in 29^0 N latitude and 79.30^0 E longitude.

The experiment was designed in factorial randomized block design with three replications. The experiment comprised of four levels of nitrogen viz. N1 (N@ 0Kg/ha), N2 (N @30Kg/ha), N3 (N@60Kg/ha) and N4 (N@90Kg/ha) along with three plant spacing which includes S1 (45 cm×15cm), S2 (45 cm×15cm) and S3 (45 cm × 15cm). The observations were made on vegetative parameters and these observations were taken from five randomly selected plants of each treatment and in each replication.

Results and Discussion

1. Effects of nitrogen fertilizer on plant height

The results presented in table-1 showed that application of different level of nitrogen significantly influenced the plant height of amaranth at 30, 60 and 90 DAS. At 30DAS, tallest plant height (42.48cm) recorded with N_4 (N@90kg/ha) followed by (39.26cm) N3 (N@90kg/ha. Whereas, shortest plant height (30.37cm) was noted from N1 (N@0 Kg/ha). At 60DAS, data indicated that tallest plant height (81.43 cm) observed in N_4 (N@90kg/ha) followed by (77.39 cm) N3 (N@60kg/ha). Whereas, shortest plant height (62.24 cm) was recorded from N1 (N@0 Kg/ha). Similarly, at 90 DAS, tallest plant height (121.07 cm) recorded in N_4 (N@90kg/ha) followed by (124.19 cm) N3 (N@60kg/ha) which was statistically *at par* with each other. Whereas, shortest plant height (95.43 cm) was recorded from N1 (N@0 Kg/ha). It may be due to the fact that nitrogen being a constituent of protoplasm, proteins, enzymes and chlorophyll, which helps in stimulating the vegetative growth of plants. Scientists like Mathai (1978) [6] Keshar, *et al.* (1981) [3]; Subhan (1989) [12]; and Rahore *et al*. (2004) [10] also found same results for this parameter.

Significant differences were recorded among the variable spacing with respect to plant height at 30, 60 and 90 DAS. At 30DAS, tallest plant height (37.26 cm) was recorded in S1 (45×15 cm) which was statistically at par (37.22 cm) with S2 (45×30cm). While, the shortest plant height (35.52 cm) was recorded in S3 (45×45cm). At 60 DAS, tallest plant height (74.27 cm) was recorded in S1 (45×15 cm) which was statistically at par (73.08 cm) with S2 (45×30cm). While, the shortest plant height (70.63 cm) was recorded in S3 (45×45cm). At 90DAS, tallest plant height (116.13 cm) was recorded in S1 (45×15 cm) followed by (109.79cm) with S2 (45×30cm) which was statistically at par (108.31 cm) with S3 (45×45cm) having the shortest plant height. These results indicated that plant height was increased in the closer spacing compared to the wider spacing. It may be due to the fact that increased plant population per unit area which may compete for light, temperature, water and nutrients. Therefore, plant height would be higher in closer plant spacing. These results are similar with the findings of Jhon (1992) [5] and Diaz-Oretega *et al*., (2004) [1].

Significant variation was reported due to collective effect of nitrogen and plant spacing with respect to plant height. At 30 DAS the tallest plant height was recorded in tallest plant height (46.53cm) was recorded in N4S1 (N@90kg/ha + 45×15cm) followed by (43.97 cm) N3S2 (N@60kg/ha + 45×30cm). Whereas, shortest plant height (26.90 cm) was recorded in N1S3 (N@0kg/ha + 45×45cm). At 60 DAS, tallest plant height was recorded in N4S1 (87.13 cm) which was statistically at par with N3S2 (83.90 cm). Whereas, minimum plant height was recorded in N1S3 (53.77 cm). Similarly, at 90 DAS, tallest (138.97 cm) plant height was recorded in N3S2 (N@60 Kg/ha + 45×30 cm) which was followed by (138.97 cm) N4S2 (127.07 cm). Whereas, minimum (79.63 cm) plant height was recorded in N1S3 (N@0 Kg/ha + 45 × 45 cm).

2. Number of branches per plant

The analysis of variance presented in table-2 showed that application of variable levels of nitrogen significantly affected the number of branches per plant of amaranth at 30, 60 and 90 DAS. The data indicated that at 30 DAS, more number of branches (7.67) recorded with N_4 (N@90kg/ha) followed by (5.67) in N3 (N@60kg/ha). Whereas, less number of branches (2.22) was recorded from N1 (N@0 Kg/ha). At 60 DAS, more number of branches (18.56) recorded with N_4 (N@90kg/ha) which was statistically at par (17.89) with N3 (N@60kg/ha). Whereas, less number of branches (12.11) was recorded from N1 (N@0 Kg/ha). Similarly, at 90 DAS, more number of branches (29.67) recorded with N_4 (N@90kg/ha) followed by (23.78) in N3 (N@60kg/ha). Whereas, less number of branches (15.44) was recorded from N1 (N@0 Kg/ha). It was evident from the results, that number of branches per plant was increase with the increased application of nitrogen levels. This might be due to the fact that as nitrogen helps in enhancing the initiation of branches and therefore, more levels of applied nitrogen increases the production of branches. These results are similar to that of Mathai (1978) [6], Keshar, *et al*. (1981) [3]; Subhan (1989) [12] and Rahore *et al*. (2004) [10].

Different plant spacing showed significant variation in respect of number of branches at 30, 60 and 90 DAS. At 30DAS, more number of branches (5.25) was recorded in S3 (45×45 cm) which was followed by (4.92) with S2 (45×30cm). While, less branches (4.33) was recorded in S1 (45×45cm). At 60 DAS, more number of branches (16.42) was recorded in S3 (45×45 cm) which was statistically at par (16.33) with S2 (45×30cm). While, less number of branches (15.08) was recorded in S1 (45×45cm). At 90 DAS, more number of branches (23.17) was recorded in S3 (45×45cm) which was followed by (21.92) in S2 (45×30cm) which was statistically at par (21.50) with S1 (45×45cm) having the minimum number of branches. These results showed that more number of branches per plant was recorded in the widest spacing as compared to the closer spacing. It might be due to the fact that due to the more plant population as well as more competition for light, air, water and nutrients which results in less number of branches per plant. These results are in accordance with the findings of Rahman *et al*., (2007) [9] and Verma *et al*., (2022)

[13].

Significant differences were observed due to integrated effect of nitrogen and spacing in terms of number of branches per plant. At 30 DAS, more number of branches per plant (8.33) was recorded in N4S3 ((N@90kg/ha +45×45 cm) which was statistically at par with N4S2 N4S2 (8.00) and N3S2 (7.00). Whereas, less number of branches was recorded in N1S1 (0.67). At 60 DAS, more number of branches per plant was observed in N4S3 (20.67) which was statistically at par with N4S2 (19.00) and N3S2 (21.00). Whereas, minimum value was recorded in N1S1 (9.33). At 90 DAS, more branches per plant (32.00) was found in N4S3 (N@90kg/ha+45×45cm) followed by N4S2 (29.67) with N@ 90kg/ha+45×30cm and N4S1 (27.33) in which nitrogen was applied @ 90kg/ha along with 45×15cm. Whereas, less number of branches per plant (12.33) was noted in N1S1 (N@0kg/ha + 45×15 cm). It was observed from the results that there was an increase in the number of branches per plant with the increase in the nitrogen levels and plant spacing.

Table 1: Effect of nitrogen, plant spacing and their interactions on plant height (cm) of vegetable amaranth at 30, 60 and 90 DAS.

Nitrogen levels (kg/ha)	30 DAS Spacing(cm) S1 (45×15)	S2 (45×30)	S3 (45×45)	Mean	60 DAS Spacing(cm) S1 (45×15)	S2 (45×30)	S3 (45×45)	Mean	90 DAS Spacing(cm) S1 (45×15)	S2 (45×30)	S3 (45×45)	Mean
N_0	34.17	30.16	26.90	30.37	70.233	62.73	53.77	62.24	112.67	94.000	79.63	95.43
N_{30}	33.93	30.98	38.77	34.56	68.167	63.97	76.53	69.55	113.60	87.300	113.83	104.91
N_{60}	34.40	43.97	39.40	39.26	71.533	83.90	76.73	77.38	111.20	138.96	122.40	124.18
N_{90}	46.53	43.90	37.00	42.48	87.133	81.70	75.46	81.43	127.07	118.76	117.37	121.06
Mean	37.26	37.22	35.52	36.68	74.27	73.08	70.63	72.65	116.13	109.75	108.31	111.40
Factors	A	B	Interactions (AXB)		A	B	Interactions (AXB)		A	B	Interactions (AXB)	
C.D.	1.69	1.46	2.92		3.15	2.73	5.46		4.56	4.56	7.90	
SE(m)±	0.57	0.49	0.12		1.07	0.93	1.85		1.55	1.34	2.68	

Table 2: Effect of nitrogen, plant spacing and their interactions on number of branches of vegetable amaranth at 30, 60 and 90 DAS.

Nitrogen levels (kg/ha)	30 DAS Spacing(cm) S1 (45×15)	S2 (45×30)	S3 (45×45)	Mean	60 DAS Spacing(cm) S1 (45×15)	S2 (45×30)	S3 (45×45)	Mean	90 DAS Spacing(cm) S1 (45×15)	S2 (45×30)	S3 (45×45)	Mean
N_0	0.67	2.33	3.67	2.22	9.33	12.33	14.67	12.11	12.33	14.33	19.67	15.44
N_{30}	4.00	2.33	5.00	3.78	18.00	13.00	14.67	15.22	22.33	17.33	20.00	19.89
N_{60}	6.00	7.00	4.00	5.67	17.00	21.00	15.67	17.89	24.00	26.33	21.00	23.78
N_{90}	6.67	8.00	8.33	7.67	16.00	19.00	20.67	18.56	27.33	29.67	32.00	29.67
Mean	4.33	4.92	5.25	4.83	15.08	16.33	16.42	15.94	21.50	21.92	23.17	22.19
Factors	A	B	Interactions (A X B)		A	B	Interactions (A X B)		A	B	Interactions (A X B)	
C.D.	0.84	0.73	1.45		1.18	1.02	2.04		1.11	0.96	1.92	
SE(m)±	0.28	0.25	0.49		0.4	0.35	0.69		0.38	0.33	0.65	

Conclusion

On the basis of this investigation, it was concluded that among the four nitrogen levels, N@90kg/ha found best for plant height and number of branches per plant and with respect to plant spacing, more number of branches was recorded in widest spacing. Therefore, nitrogen @90kg/ha along with 45cm ×15 cm was found suitable for cultivation of vegetable amaranth under *Tarai* conditions.

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