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Effect of Various Sources of Nitrogen on Growth, Yield, and Quality in Vegetable Amaranthus (*Amaranthus tricolor* L.)

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ABSTRACT

The present experiment entitled "Effect of Various Sources of Nitrogen on Growth, Yield, and Quality in Vegetable Amaranthus (*Amaranthus tricolor* L.)" was conducted during two consecutive summers of 2020 and 2021 at Horticulture Research Farm, Department of Horticulture and Post-Harvest Technology, Palli Siksha Bhavana, Visva Bharati Sriniketan, West Bengal. The trial was laid down in randomized complete block design (RCBD) with four replications and five treatments *viz*. T_1: 100% N Inorganic + 0% N FYM + 0% N VC, T_2: 75% N Inorganic + 12.5 % N FYM + 12.5% N VC, T_3: 50% N Inorganic + 25% N FYM + 25% N VC, T_4: 25% N Inorganic + 37.5% N FYM + 37.5% N VC, T_5: 0% N Inorganic + 50% N FYM + 50% N VC. Based on the pooled data, results of study revealed that maximum plant height (54.6 cm), number of leaves (16.3), leaf length (17.8 cm), leaf width (7.6cm), leaf area index (8.7), petiole length (7.3 cm), stem diameter (1.4cm), plant weight (53.9g), yield per plot (7.4kg), yield per hectare (213.3 q), chlorophyll a (40.7 mg/100 g), chlorophyll b (21.5 mg /100g), total chlorophyll (62.2 mg/100g), ascorbic acid (331.9 mcg/ 100g), Protein (5.2%), and B: C Ratio (1.55) were found with the application T_4: 25% N Inorganic + 37.5% N FYM + 37.5% N VC. It was evident that inorganic nitrogen replacement with organic nitrogen from 25 to 75% is possible in vegetable amaranth without affecting yield.

Key words: *Amaranthus, FYM, Protein content, and Vermicompost.*

Introduction

Amaranthus is one of the most common and popular leafy vegetables in India. It belongs to the family *Amarantheace*, subfamily *Amaranthoideae*, and genus Amaranthus. Amaranthusis C4 plant. Section

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amaranthus is a dibasic genus with X= 16 and X = 17 (Rastogi and Shukla, 2013). There are 400 species of amaranthus distributed in temperate, tropical, and subtropical parts of the world. Amaranthus may be divided into two groups based on their consumption *viz.* grain and leafy amaranthus. Leafy amaranthus (*Amaranthus tricolor* L.) is believed to be native of India and its maximum diversity is reported in the Himalayan part of the country. There are six spp. which are considered as leafy amaranthus, *Amaranthus tricolor* L., *Amaranthus blitum* L., *Amaranthus dubius* Mart ex L Theil., *Amaranthus virdis* L., *Amaranthus cruentus* L. and *Amaranthus spinosus* L. In India, major leafy amaranthus growing states are Uttar Pradesh, Bihar, Kerala, Karnataka, Maharashtra, West Bengal, Orissa, and Chhattisgarh (Kumar and Gupta, 2018). It contains three times more calcium and vitamin B than spinach as well as twenty times more iron than lettuce.100-gram fresh leaves of leafy amaranthus contain3.9 g protein, 1.8 mg vitamin A, 62 mg of vitamin C, 358 mg calcium, 2.4 mg iron and 0.8 mg Zinc (Achigan Dako *et al*., 2014). Vegetable amaranths have many medicinal properties therefore it is recommended for patients with constipation, fever, haemorrhage, anaemia, and kidney complaints. Grain amaranthus is very popular in Gujarat and Maharashtra and is popularly known as *Rajgirah* "King seed" (Jangir *et al*., 2018).

Nutrient management is one important agronomic practice to improve crop production. As we know nitrogen is one primary nutrient for plants growth and development. Generally, for nitrogen, farmer apply urea in their field due to its cheap cost and easily availability. But continuous use of chemical fertilizer declines the physical, chemical, and biological properties of soil whereas organic manures improve it. Proper integration of organic manures with chemical fertilizers shows great promise in not only sustaining growth and productivity but also in meeting a part of the chemical requirement of the crop (Khan *et al.,* 2019). Organic manures such as vermicompost and FYM are good source of nutrients and organic matter, these sources enhance biodiversity and microbial properties of soil (Albiach *et al.*, 2000). Here the purpose of the study was that up to which level we can replace inorganic N by applying organic manures as vermicompost and FYM. Hence an experiment on "Effect of Various Sources of Nitrogen on Growth, Yield, and Quality in Vegetable Amaranthus (*Amaranthuus tricolor* L.)" was conducted at Horticulture farm, Palli Siksha Bhavana, Visva Bharati, West Bengal in two successive summers of 2020 and 2021, respectively.

Materials and Methods

The field experiment was conducted during the summer of 2020 and 2021 at Horticulture Research Farm, Palli Siksha Bhavana, Visva Bharati, West Bengal. The experiment was laid out into Randomized Complete Block Design (RCBD) with 4 replications and consisted 5 treatments *viz.* T_1 = 100% N inorganic + 0% FYM + 0% N VC, T_2 =75% N inorganic + 12.5% FYM + 12.5% VC, T_3 = 50 % N Inorganic + 25 % FYM + 25% VC, T_4 = 25% N Inorganic + 37.5% N FYM +37. 5 % N VC, T_5 = 0% N Inorganic + 50% FYM + 50% VC. The crop was raised at the spacing of 30cm x 30 cm in plot size of 2 x 1.75m. Standard culture practices recommended for amaranthus were followed uniformly in all experimental plots.

Observation recorded

Growth and Yield Parameters

Among the growth and yield parameters following parameters were observed *viz.* Plant height (cm), Number of leaves per plant, Leaf length (cm), Leaf width (cm), Leaf Area (cm^2), Leaf Area Index, Stem diameter (cm), Plant weight (kg), Yield per plot (kg/plot), and Yield per hectare (q/ha).

Biochemical /Quality Parameters

Among the biochemical /quality parameters following parameters were estimated *viz.* chlorophyll content, ascorbic acid (mcg/100 g), and protein content (g/100g).

Economics - The benefit-cost ratio was calculated as to cost of cultivation/ha (Rs.) divided by Gross income/ha (Rs.).

Biometrical Analysis

Experimental data was subjected to biometrical analysis as per the standard procedure given by Gomez and Gomez (1984).

Results and Discussion

Effect of various sources of nitrogen on growth characters

Among the different treatments, the application of

treatment T_4 (25% N Inorganic + 37.5% N FYM + 37.5 %VC) produced maximum plant height (54.3 and 55.0 cm) which was statistically at par with T_3 (52.9 and 53.1 cm) and T_2 (52.8 and 53.0cm) during both years 2020 and 2021 respectively. A similar result was also given by Khadse *et al.,* (2021) in spinach. Statistically, there was a significant difference was noted among various treatments in respect of a number of leaves. However, a maximum number of leaves were found in treatment T_4 (16.3 and 16.4) followed by T_3 (15.1 and 15.4) and T_5 (14.9 and 15.0). Whereas the minimum number of leaves were found in T_1 (14.0 and 15.0). There was significant variation recorded in leaf length among different sources of nitrogen. Maximum leaf length was recorded in T_4 (17.0 and 18.7 cm) followed by T_3 (16.4 and 17.9 cm) and T_2 (16.0 and 16.1 cm) whereas minimum in T_1 (15.5 and 16.4 cm) during both years of experiment 2020 and 2021 respectively. The highest leaf width (7.5 and 7.8 cm) was recorded in treatment T_4 (25% N Inorganic + 37.5% N FYM + 37.5% VC which was noted similar to T_3 (7.4 and 7.7 cm) and T_2 (7.3 and 7.3 cm) 2020 and 2021 respectively. On the other hand, treatment T_1 100 % N Inorganic + 0 % FYM + 0 % N VC showed minimum leaf width. This is found to be similar with findings of Yeshiwas *et al*., (2018) in lettuce. The Leaf area was significantly influenced by the application of different treatments during both years of the experiment. Maximum leaf area was noted in T_4 (127.5 and 128.90 cm^2) followed by T_3 (124.6 and 125. 6 cm cm^2) and T_2 (112.0 and 115.9 cm^2) whereas minimum as in T_1 (94.5 and 95.0 cm^2). As data showed that there was a clear difference among various treatments regarding to leaf area index. However maximum leaf area index was recorded in T_4 (8.4 and 8.9) followed by $T_3$7.7 and 7.8) and T_2(6.4 and 6.6) and minimum in T_1 (4.7 and 4.9). Similar variations were also noticed in pooled data in all observations (Table 1).

Maximum petiole length was noted in T_4 (7.5 and 7.2 cm) followed by T_5 (6.9 and 7.0 cm) and T_3 (5.9 and 6.0 cm) whereas minimum as in T(5.0 and 5.1 cm). The effect of different treatments on stem diameter was recorded highest (1.4 and 1.5 cm) in treatment T_2, *i.e.* 75% N inorganic + 12.5% N FYM + 12.5% NVC which was significantly at par with T_4(1.3 and 1.7 cm) and T_3 (1.3 and 1.8 cm). This result may be continuous nutrient availability by the use of combined manuring. On the other hand, minimum stem diameter was reported in treatment T_1 *i.e.* 100 % N inorganic + 0% FYM + N VC. This result is close to the findings of Kumar and Gupta (2018) and Jangir *et al.,* (2018). The soil application with 25% N inorganic + 37.5% N FYM + 37.5% VC (T_4) recorded maximum plant weight (53.9 and 54.0 g) which is statistically at par with treatment T_3 (52.3 and 52.5 g) and T_2(51.8 and 51.7 g). Minimum plant weight was recorded with the application of treatment T_1 (33.7 and 33.6 g). A similar result was recorded by Kavitha *et al.,* (2013) in amaranthus and Jhakhro *et al.,* (2017) in spinach (Table 2).

Effect of various sources of nitrogen on yield characters

The data with respect to yield per plot indicate that there was significant variation among treatments. Highest yield per plot (7.4 and 7.7 kg /plot) was reported in T_4= 25% N inorganic + 37.5% N FYM + 37.5 % N VC followed by T_2 (7.1 and 7.2 kg/ ha), T_3 (6.7 and 6.8 kg/ha) and T_5 (6.1 and 6.5kg/ha) respectively. Among the various treatments, the application of 25%N inorganic + 37.5% N FYM + 37.5% VC resulted from maximum vegetative yield in T_4 (212.8 and 213.9 q/h) which was statistically at par with T_2 (204.4q/ha) and T_3(193.5 and 195.6 q/ha) respectively. Minimum vegetative yield (169.6 and 170.8 q/ ha) was reported in treatment T_1= 100% N Inorganic + 0% FYM + VC. A similar result was reported by Thongney *et al*., (2020) and Srivastava *et al*., (2020), (Table 2).

Effect of various sources of nitrogen on biochemical/ quality characters

Data indicate that among various treatments, T_4 produced maximum chlorophyll a (40.5 and 41.0 mg/ 100 g), chlorophyll b(21. 4 and 21.5 mg/100 g), and total chlorophyll (61.9 and 62.5 mg/100 g) followed by T_3 and T_2. Data clearly showed that maximum ascorbic acid (831.0 and 832.8 mcg/100 g) was reported in treatment T_4 followed by T_3 (760.4 and 780.0 mcg/100 g) and T_5 (700.5 and 725. 7 mcg/ 100g) whereas minimum content of ascorbic acid was found in T_1. (489.0 and 490. 9 mcg/ 100g). Protein content values ranged from 2.0 to 4.9g/100 and 2.0 to 5.8 g/100 g during the first and second years respectively. The highest protein content was recorded in treatment T_4(4.9 and 5.5g/100g) followed by T_5 (4.0 and 4.4 g/100g) and T_3 (3.7 and 4.0 g/ 100g) during both years of the experiment. Similar trends were also noticed in pooled data in all biochemical and quality parameters. These findings are in accordance with Tejswani *et al., (*2017), (Table 3).

Table 1. Effect of different treatments ongrowth characters.

Treatments	Plant height (cm)			Number of leaves per plant			Leaf length (cm)			Leaf width (cm)			Leaf Area (cm^2)			Leaf Area Index		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
T_1	44.9	45.7	45.3	14.0	15.0	14.5	15.5	16.4	15.9	6.1	6.5	6.3	94.5	95.0	94.7	4.7	4.9	4.8
T_2	52.8	53.0	52.9	14.0	14.3	14.1	16.0	16.1	16.0	7.3	7.2	7.3	112.0	115.9	113.6	6.4	6.6	6.5
T_3	52.9	53.1	53.0	15.8	15.1	15.4	16.4	17.9	17.1	7.4	7.7	7.5	124.6	125.6	125.1	7.7	7.8	7.7
T_4	54.3	55.0	54.6	16.3	‘16.4	16.3	17.0	18.7	17.8	7.5	7.8	7.6	127.5	128.9	128.2	8.4	8.9	8.7
T_5	40.5	42.1	41.3	14.9	15.0	14.9	15.6	16.9	16.2	6.5	6.6	6.5	101.4	101.5	101.4	5.7	5.9	5.8
Mean	49.1	50.1		15.4	15.8		16.4	17.5		7.0	7.2		89.6	115.9		6.6	6.8	
C.D.(0.05 %)	1.7	2.36		0.9	0.7		0.6	0.58		0.3	0.4		7.1	4.43		0.26	0.29	
C. V. (%)	1.8	2.4		3.2	2.4		2.0	1.7		2.3	3.4		3.3	2.04		2.11	2.22	

Table 2. Effect of different treatments ongrowth and yield characters

Treatments	Petiole length (cm)			Stem diameter (cm)			Plant Weight (g)			Vegetative Yield per plot (kg)			Vegetative Yield (q/ha)		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
T_1	5.0	5.1	5.1	1.1	1.4	1.2	33.6	33.7	33.6	5.9	6.0	5.9	169.6	170.8	170.2
T_2	5.3	5.6	5.4	1.4	1.5	1.4	52.2	52.3	52.2	7.1	7.2	7.1	204.7	205.8	205.2
T_3	5.9	6.0	5.9	1.3	1.8	1.5	51.7	51.8	51.7	6.7	6.8	6.7	193.5	195.6	194.5
T_4	7.5	7.2	7.3	1.3	1. 7	1.4	53.9	54.0	53.9	7.4	7.7	7.5	212.8	213.9	213.3
T_5	6.9	7.0	6.9	1.0	1.8	1.5	34.0	35.0	34.5	6.1	6.5	6.3	175.2	176.3	175.7
Mean	6.43	6.55		1.0	1.3		45.0	20.1		6.6	6.7		191.1	192.4	
C.D. (0.05 %)	0.34	0.20		0.07	0.06		1.7	1.3		0.3	0.4		110.80	11.30	
C. V. (%)	2.9	1.69		3.01	2.65		2.0	1.4		2.9	3.5		3.23	3.073	

Table 3. Effect of various sources of nitrogen on biochemical/ quality characters

Treatments	Chlorophyll A(mg/ 100g)			Chlorophyll B(mg/ 100g)			Total Chlorophyll (mg/ 100g)			Ascorbic Acid (mcg/100g)			Protein Content (g/100g)			B: C Ratio		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
T_1	20. 4	20.8	20.6	11.1	11.5	11.3	31.5	31.9	31.7	489.0	490.9	489.9	2.0	2.5	2.2	1.0	1.1	1.1
T_2	28.3	28.8	28.5	15. 3	15.7	15.7	43.6	44.0	43.87	560.4	565.0	562.7	2.3	2.7	2.5	1.2	1.2	1.2
T_3	30.2	30.3	30.2	16. 1	16.5	16.5	46.4	46.8	46.6	760.4	780.0	770.2	3.7	4.0	3.9	1.2	1.3	1.2
T_4	40.5	41.0	40.7	21. 4	21.5	21.5	61.9	62.5	62.2	831.0	832.8	831.9	4.9	5.5	5.2	1.5	1.6	1.5
T_5	25.1	25.5	25.3	15.7	16.6	16.1	40.8	42.1	41.4	700.5	725.7	713.1	4.0	4.4	4.2	1.1	1.2	1.2
Mean	31.0	29.1		13.4	16.3		44.9	45.4		668.3	678.9		3.4	3.6		1.2	1.2	
CD (0.05 %)	1.38	1.09		0.72	0.16		2.54	1.51		20.65	18.05		0.09	0.20				
CV %	2.51	1.96		2.20	2.20		2.96	1.73		1.62	1.39		1.44	2.97				

Effect of various sources of nitrogen on Economics

B: C ratio

It is clear from the data that the maximum B: C ratio was observed in T_4 (1.5 and 1.6) followed by T_3 (1.2 and 1.3) and T_5 (1.1 and 1.2) during both years of trial whereas the minimum in T_1 (1.0 and 1.1). A similar trend was also noticed in pooled data (Table 3).

Conclusion

Based on this result it may be concluded that the application of organic sources of nitrogen as FYM and vermicompost (each 37.5% N) along with inorganic sources of nitrogen as urea (25%) is useful to obtain the maximum yield in vegetable amaranth. However, inorganic nitrogen replacement with organic nitrogen from 25% to 75% is possible in vegetable amaranth without comprising yield. Therefore, local growers should be encouraged to use integrated sources of organic and inorganic nutrients for commercial cultivation of vegetable amaranth under the red and laterite zone of West Bengal.

Conflicts of Interest – The Authors declares no conflicts of interest.

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