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Growth, Yield and Economic of Grain Amaranth (*Amaranthus hypochondriacus* L.) as Affected by Integrated Nitrogen Management

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ABSTRACT

A two year field experiment was used to evaluate the effects of integrated nitrogen management on growth, yield and economic of grain amaranth (Amaranthus hypochondriacus L.). The experiment was conducted at College Farm of N. M. College of Agriculture, Navsari Agricultural University, Navsari during rabi seasons of 2016-17 and 2017-18. There were six treatments applied to grain amaranth. Significantly higher plant height, leaf area index, chlorophyll content and straw yield were recorded under treatment T_1 (100% RDN through inorganic fertilizer) and being at par with treatment T_3 (75% RDN through chemical fertilizer + 25% through BC) and T_2 (75% RDN through chemical fertilizer + 25% through FYM). Whereas, significantly higher spike length, no. of lateral spikelets/spike, test weight and grain yield with maximum net returns and B:C ratio were recorded under treatment of 75% RDN through chemical fertilizer + 25% through BC (T_3) and which remained at par with application of 100% RDN through inorganic fertilizer (T_1) and 75% RDN through chemical fertilizer + 25% through FYM (T_2) in pooled analysis. Thus, integration of organic manure and inorganic fertilizer have higher yield potential and performed better as compared to inorganic fertilizer treatment as well as the treatment which receiving organic manure only.

Key words: *Recommended dose of nitrogen (RDN), Leaf area index (LAI), Chlorophyll content, Grain yield, Straw yield, Economic*

INTRODUCTION

Eco-friendly scientific method of crop production emphasizes the use of organics in the soil as source of nutrients[13]. Experiences from long term fertilizer experiments revealed that integrated use of farm yard manures, vermicompost, biocompost *etc*., with graded levels of chemical fertilizers is promising not only in maintaining higher productivity but also in providing maximum stability in crop production. The response of N as chemical fertilizer generally increases when it is used in combination with FYM, vermicompost *etc*. and saves N fertilizer[7].

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Nitrogen availability to crop is one of the big limiting factors in the productivity of crop and increase in the use of nitrogen fertilizers for enhancing the agricultural production has been under consideration. For economic and environmental reasons, nitrogen fertilizers should be utilized more efficiently as much as possible in crop production.

Amaranthus or pigweed belongs to the family Amaranthaceae. It is originated from Central and South America[5]. The genus *Amaranthus* comprise of up to 70 species (in the form of cosmopolitan weed or cultivated plant) and are widely spread in all tropical and subtropical regions of the world and they are cultivated as leafy vegetables, grains or ornamental plants, while, others are weeds[12]. *Amaranthus cruentus* Linn. and *A. hypochondriacus* Linn. are the best grain producers species. In India, presently amaranth is commonly grown in Himachal Pradesh and on hills of Uttar Pradesh and Uttaranchal for both grain and leafy vegetable purpose, however, the Himalayan region is mainly known as 'centre for diversity' of the amaranth for the number of varieties that are been cultivated. While, it is mainly grown for grain especially in Uttarakhand, Maharashtra and in some parts of Gujarat. Grain amaranth commonly called as *Chaulai, Batu, Bhabhri, Ganhar, Harave, Keere, Maarsu, Marsha, Pung-keerai, Rajakeera, Sawal, Sil or Ram Dana*. However, in parts of Maharashtra and Gujarat, it is known as *Rajgirah* "King seed". Amaranth is a quick growing multipurpose crop. Grain amaranth produces significant edible cereals grain but known as "pseudo-cereals" to distinguish it from other cereal producing crops. Compared to staple food crops, the grain amaranth is early maturing, can be grown several times a year and tolerates drought, heat stress, high soil acidity and salinity. Besides amaranth also attribute more efficient C_4 metabolic pathways and low input requirements. Grain amaranth has potential for increased production due to fewer requirements of inputs and its adaptation to a wide range of agro-ecological zones.

MATERIAL AND METHODS

The field experiment was conducted at College Farm of N. M. College of Agriculture, Navsari Agricultural University, Navsari. The study was conducted during *rabi* seasons of 2016-17 and 2017-18. The soil of the experimental field was clayey in texture and low in organic carbon (0.39%), available nitrogen (200.70 kg/ha), moderately high in available phosphorus (37.79 kg/ha), very high in available potassium (311.70 kg/ha) and slightly alkaline in reaction (pH 8.1) with normal electrical conductivity (0.145 dS/m). The materials used in this research are grain amaranth cultivar GC 4, FYM, biocompost, Urea and SSP. This research was conducted by randomized block design with four replications. The field experiment consisted of integrated nitrogen management *viz*., T_1 - 100% RDN through inorganic fertilizer, T_2 - 75% RDN through chemical fertilizer + 25% through FYM, T_3 - 75% RDN through chemical fertilizer + 25% through BC, T_4 - 50% RDN through chemical fertilizer + 50% through FYM, T_5 - 50% RDN through chemical fertilizer + 50% through BC and T_6 - 50% RDN through FYM + 50% through BC to grain amaranth. Recommended dose of fertilization (RDF) for grain amaranth is 60 N + 40 P_2O_5 + 00 K_2O kg/ha. Grain amaranth seed was sown with spacing of 30 cm x 10 cm in November and harvested in March during both the years. The grain amaranth crop was fertilized as per treatments. The nitrogen was applied through FYM, biocompost and urea whereas phosphorus was applied through single superphosphate. The 50% dose of fertilizer nitrogen and full dose of phosphorus were applied at the time of sowing and remaining 50% dose of fertilizer nitrogen was applied at 30 days after sowing. In case of phosphorus fertilizer, the quantity of phosphorus from FYM and bio-compost was counted and deducted from the quantity of recommended dose of phosphorus and remaining phosphorus was applied in the form of SSP. FYM and biocompost was applied as per treatment before sowing and mixed well in soil. The seed of grain amaranth variety GA 2 was treated with biofertilizer *Azotobacter* @ 200 ml, suspended in 400 ml water and used for inoculating 10 kg seed.

Growth and yield attributes were recorded from five plant selected from net plot and leaf area index per plant were recorded from three plant selected from border area, while net plot yield was converted into hectare basis. The stem girth was measured in centimetre and noted from 5 cm above ground level from five tagged plant.

Chlorophyll content was measured by using SPAD (Soil plant analysis development) meter. Three fully opened leaves from the top of plants were randomly selected. Average value was recorded and expressed as SPAD reading per plant.

Leaf area meter (Model L1-COR 3100) was used for recording the area of leaves. Average values for per plant at each stage were recorded accordingly. LAI was calculated by using the formula suggested by Watson[14].

$$LAI = \frac{\text{Leaf area (cm}^2\text{)}}{\text{Land area (cm}^2\text{)}}$$

Test weight of grain amaranth was recorded on volume basis and grains were filled in 5 ml measuring cylinder up to 2 ml and weighed on electronic top pan balance and averaged for 1 ml for each treatment.

Harvest index was computed by using the formula suggested by Donald[4].

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (kg/ha)}}{\text{Total biological yield (kg/ha)}} \times 100$$

Pooled analysis of the grain amaranth analyzed for two years was worked out as per the method described by Panse and Sukhatme[9].

RESULTS AND DISCUSSION

Effect on growth

It is evident from the results that different integrated nitrogen management treatments influenced crop growth from 20 DAS onward upto harvest of grain amaranth.

Application of 100% RDN through inorganic fertilizer (T_1) recorded significantly highest plant height at 40 DAS while, it was at par with 75% RDN through chemical fertilizer + 25% through BC (T_3) at 20 and 60 DAS, but at harvest, it remained at par with 75% RDN through chemical fertilizer + 25% through BC (T_3) and 75% RDN through chemical fertilizer + 25% through FYM (T_2) during pooled analysis.

Significant difference existed in stem girth as a consequence of different integrated nitrogen management practices at all the stages of crop growth except at 20 DAS. Application of 75% RDN through chemical fertilizer + 25% through BC (T_3) recorded significantly higher stem girth and remained at par with T_2 (75% RDN through chemical fertilizer + 25% through FYM), T_1 (100% RDN through inorganic fertilizer), T_4 (50% RDN through chemical fertilizer + 50% through FYM) and T_5 (50% RDN through chemical fertilizer + 50% through BC) randomly at different growth stages in pooled results. Maximum leaf area index was recorded with application of 100% RDN through inorganic fertilizer (T_1) at early stage (40 DAS) but at latter stages (60 DAS and harvest) it remained at par with 75% RDN through chemical fertilizer + 25% through BC (T_3). However, significantly higher chlorophyll content was recorded under the treatments T_1 (100% RDN through inorganic fertilizer) which was at par with treatments T_3 (75% RDN through chemical fertilizer + 25% through BC) and T_2 (75% RDN through chemical fertilizer + 25% through FYM) at different periodical intervals. Higher values of plant growth attributes were attained with the application of inorganic fertilizers as well as combination of inorganic and organic fertilizers might be due to the fact that more quantity of nitrogen absorbed by grain amaranth plants was synthesized into protein by combining with sugars formed by the leaves. Protein synthesized in protoplasm and is the essential constituent of a cell resulting in cells grow larger and increases in number due to faster cell division. Application of nitrogen has accelerated the synthesis of chlorophyll and amino acids which associated with major photosynthetic process of plants. Availability of more photosynthates resulted in higher plant height, stem girth, leaf area index and chlorophyll content. Similar results were reported by Akanbi and Togun[1], Parmar and Patel[10], Gunjal[6] as well as Chowdhury *et al*.[3].

Effect on yield and yield attributes

Significantly higher spike length, number of lateral spikelets per spike and test weight (volume basis) were recorded under the treatment of 75% RDN through chemical fertilizer + 25% through BC (T_3) and remained at par with treatments T_1 (100% RDN through inorganic fertilizer), T_2 (75% RDN through chemical fertilizer + 25% through FYM), while in case of test weight it remained at par with treatments T_1 (100% RDN through inorganic fertilizer), T_5 (50% RDN through chemical fertilizer + 50% through BC) and T_2 (75% RDN through chemical fertilizer + 25% through FYM). It was emphasized that use of chemical fertilizer and organic source bring about significant improvement in overall growth of the crop by providing needed nutrient from initial stage. Increased supply of macro as well as micro nutrient in more synchronize way in the treatment receiving integrated supply of nutrient from organic manure along with inorganic fertilizer resulting in increased photosynthetic efficiency. Similar results were reported by Parmar and Patel[10]. and Gunjal[6].

On the basis of pooled data analysis, the treatment which receiving 75% RDN through chemical fertilizer + 25% through BC (T_3) recorded significantly higher grain yield (1773.91 kg/ha) and which remained at par with application of 100% RDN through inorganic fertilizer (T_1) (1669.73 kg/ha) and 75% RDN through chemical fertilizer + 25% through FYM (T_2) (1611.12 kg/ha). While significantly higher straw yield (4801.30 kg/ha) was recorded with the application of 100% RDN through inorganic fertilizer (T_1) and remained at par with application of 75% RDN through chemical fertilizer + 25% through BC (T_3) (4653.22 kg/ha) and 75% RDN through chemical fertilizer + 25% through FYM (T_2) (4582.13 kg/ha) in pooled analysis. Grain and straw yields are ultimate result of various interacting growth factors interdependence of growth, development and yield contributing characters increased consistently and significantly with combined application nitrogen through organic and inorganic fertilizer. It may also be due to adequate availability of major nutrients which are required in larger quantity thus directly help the plants to register higher yield. The results were in agreement with the findings of Parmar and Patel[10], Gunjal[6] as well as Olofintoye *et al*.[8].

In case of harvest index (%) of grain amaranth, different treatments did not exert any significant effect.

Effect on economic

Maximum net monetary returns and B:C ratio were recorded with application of 75% RDN through chemical fertilizer + 25% through BC (T_3) followed by treatments T_1 (100% RDN through inorganic fertilizer) and T_2 (75% RDN through chemical fertilizer + 25% through FYM). It might be due to that the less cost of biocompost ultimately low cost of cultivation and also gave higher grain yield of grain amaranth resulted in maximum net returns. Similar results were reported by Basavaraju[2] in maize and Rathore[11]. in sorghum.

Table 4.1. Mean Plant height, stem girth and leaf area index (LAI) of grain amaranth as affected periodically by different treatments

Treatment	Plant height (cm)				Stem girth (cm)				Leaf area index (LAI)			
	20 DAS	40 DAS	60 DAS	At harvest	20 DAS	40 DAS	60 DAS	At harvest	20 DAS	40 DAS	60 DAS	At harvest
T_1	9.53	50.50	126.97	167.10	0.92	3.21	3.78	3.80	1.08	2.67	6.54	4.72
T_2	8.56	41.32	112.92	157.86	0.91	3.27	3.91	3.86	0.99	1.97	5.58	3.94
T_3	9.28	41.46	118.65	163.38	0.93	3.49	4.26	4.04	1.01	2.13	6.05	4.29
T_4	8.43	37.84	105.03	142.72	0.87	2.95	3.76	3.55	0.97	1.64	4.13	3.46
T_5	8.37	39.86	108.13	145.51	0.90	3.11	3.72	3.64	0.99	1.67	4.54	3.66
T_6	7.67	32.93	91.07	130.67	0.83	2.60	3.26	3.16	0.95	1.47	3.97	3.22
SEm$\pm$	0.31	1.79	4.19	5.39	0.03	0.11	0.12	0.12	0.04	0.07	0.18	0.17
CD (P=0.05)	0.89	5.17	12.09	15.56	NS	0.32	0.34	0.34	NS	0.21	0.52	0.50
CV (%)	10.14	12.45	10.72	10.08	10.25	10.00	8.77	9.16	10.12	10.61	9.89	12.67
General mean	8.64	40.65	110.46	151.21	0.89	3.11	3.78	3.68	1.00	1.93	5.13	3.88

T_1 : 100% RDN through inorganic fertilizer, T_2 : 75% RDN through chemical fertilizer + 25% through FYM, T_3 : 75% RDN through chemical fertilizer + 25% through BC, T_4 : 50% RDN through chemical fertilizer + 50% through FYM, T_5 : 50% RDN through chemical fertilizer + 50% through BC and T_6 : 50% RDN through FYM + 50% through BC

Table 4.2. Mean chlorophyll content (SPAD meter reading), spike length (cm), number of lateral spikelets/spike, test weight (volume basis), grain yield, straw yield, harvest index and economic of grain amaranth as affected by different treatments

Treatment	Chlorophyll content (SPAD meter reading)				SL (cm)	LS/S	TW	GY (kg/ha)	SY (kg/ha)	HI	NMR (₹/ha)	BC
	20 DAS	40 DAS	60 DAS	At harvest	At harvest							
T_1	32.43	40.69	38.14	22.12	70.66	70.03	0.79	1669.73	4801.30	25.77	95110	3.99
T_2	31.41	37.95	35.48	20.03	67.55	67.25	0.78	1611.12	4582.13	25.98	86502	3.07
T_3	32.41	39.31	36.52	21.29	71.82	73.00	0.81	1773.91	4653.22	27.63	101217	4.21
T_4	28.12	33.30	33.11	18.38	60.65	62.50	0.77	1373.92	4065.24	25.45	65675	2.02
T_5	29.08	34.73	34.28	18.70	63.37	64.68	0.78	1404.16	4095.58	25.65	75904	3.13
T_6	26.22	31.16	29.80	16.54	58.20	58.45	0.74	1258.11	3606.18	25.99	56691	1.72
SEm$\pm$	0.91	1.20	0.99	0.74	2.03	2.04	0.01	68.03	143.95	1.01	-	-
CD (P=0.05)	2.62	3.47	2.87	2.12	5.86	5.89	0.03	196.49	415.77	NS	-	-
CV (%)	8.58	9.40	8.13	10.66	8.77	8.75	3.23	12.70	9.47	10.95	-	-
General mean	29.94	36.19	34.56	19.51	65.37	65.98	0.78	1515.16	4300.61	26.08	-	-

SL= spike length, LS/S = number of lateral spikelets/spike, TW = test weight, GY = grain yield, SY = straw yield, HI = harvest index, NMR = net monetary returns and BC = Benefit cost ratio

T_1 : 100% RDN through inorganic fertilizer, T_2 : 75% RDN through chemical fertilizer + 25% through FYM, T_3 : 75% RDN through chemical fertilizer + 25% through BC, T_4 : 50% RDN through chemical fertilizer + 50% through FYM, T_5 : 50% RDN through chemical fertilizer + 50% through BC and T_6 : 50% RDN through FYM + 50% through BC

CONCLUSION

On the basis of experimental results, concluded from the present investigation that for getting better growth as well as higher yield and net returns, grain amaranth crop should be nourished with 60 kg nitrogen (75% RDN through chemical fertilizer + 25% through BC) along with recommended dose of 40 kg P_2O_5 (considering the phosphorus content in biocompost) through inorganic fertilizer.

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