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Effect of nutrient management on growth, yield and economics of grain amaranth (*Amaranthus hypochondriacus* L.) under south Gujarat conditions

Rutul S Patel, RM Pankhaniya, Dhwani Bartwal and Akshay R Katara

Abstract
A field experiment was conducted at the College Farm, Navsari Agricultural University, Navsari (Gujarat) during *rabi* seasons of 2019-20 and 2020-21. There were seven treatments imposed in grain amaranth *viz*., T_1 - FYM 2.5 t /ha + 50% RDF, T_2 - FYM 2.5 t /ha + 75% RDF, T_3 - Bio compost 2.5 t /ha + 50% RDF, T_4 - Bio compost 2.5 t /ha + 75% RDF, T_5 - Vermicompost 2.5 t /ha + 50% RDF, T_6 - Vermicompost 2.5 t /ha + 75% RDF, T_7 - FYM 2.5 t /ha + 100% RDF in *rabi* season and replicated three times in randomized block design. Almost all the growth, yield attributes and yields were significantly improved due to combination of organic manures and inorganics. Significantly higher grain yield and straw yield were observed under application of treatment FYM 2.5 t/ha + 100% RDF (T_7) which were remained at par with Vermicompost 2.5 t/ha + 75% RDF (T_6) and bio compost 2.5 t/ha + 75% RDF (T_4). The highest net return with B:C ratio were recorded under treatment bio compost 2.5 t/ha + 75% RDF (T_4) followed by treatment FYM 2.5 t/ha + 100% RDF (T_7) and Vermicompost 2.5 t/ha + 75% RDF (T_6).

Keywords: Grain amaranth, fertilizer, FYM, Vermicompost, bio compost, economics

1. Introduction
Amaranthus or pigweed belongs to the family Amaranthaceae. It is believed to have originated from Central and South America. The genus Amaranthus consists of up to 70 species (in the form of cosmopolitan weed or cultivated plant) and are widely spread in all tropical and sub-tropical regions of the world and they are cultivated as leaf vegetables, grains or ornamental plants, while, others are weeds (Srivastava, 2011) [8]. *Amaranthus cruentus* Linn. and *Amaranthus hypochondriacus* Linn., are the best grain producers and they are also decorative, yielding giant monochromatic or Bicoloured plumped flower clusters in green, red, burgundy or gold sometimes with purple foliage or leaves that turn brilliant red as the seed matures in early autumn. Grain amaranth produces significant edible cereals grain but known as "pseudo-cereals" to distinguish it from other cereal producing crops. In India, presently amaranth is commonly grown in Himachal Pradesh and on hills of Uttar Pradesh and Uttarakhand for both grain and leafy vegetable purpose, however, the Himalayan region is mainly known as the amaranth 'center for diversity' for the number of varieties that are cultivated. 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 Maharashtra and Gujarat, it is known as *Rajgirah* "King seed".
At present, India is the largest exported of amaranth seeds. India has the most conducive climate for the growth of amaranth as the crop responds well to high sunlight and warm temperatures. In the year 2019-20, India exported amaranth seeds worth 2.68 USD million. India export nearly 70% of amaranth every year of the total exports made out of India.
In Gujarat, it is mainly grown in Mehsana, Banaskantha, Sabarkantha, Gandhinagar and Kheda districts as a mixed crop during *rabi* season with mustard. It is also grown on borders of the field of lucerne or cumin crops or taken as a mixed crop with mustard.
Amaranth is a quick growing multipurpose crop. Amaranth grain has been reported to be more nutritive than the common food grains. The main virtue of the seed lies in the high protein content coupled with easily digestible carbohydrate component. It is the richest source of protein (16%) and amino acids like lysine (5%), cystine (2.9%), methionine (4.4%) and tryptophan (1.4%) in comparison to the cereal crops *viz*., barley, maize, rice and wheat.

It is also a rich source of fat (7.1 g), moisture (9.3%), calcium (0.49 g), phosphorus (0.45 g), iron (22.4 g) and total food energy (391 calories) per 100 grams in comparison to common cereals. Amaranth leaves are also considered to have healing properties. It is also believed to improve the eye-sight. Amaranth seed contains 8-17% of edible oil, useful for both domestic cooking and industrial purposes. The oil contains a special component known as squelene, found only in dogfish liver, whale fish liver oil and shark liver oil. Lysine in grain amaranth is said to be herbal cure for herpes (a common and painful skin disease in HIV/AIDS victims). Additionally, it is claimed that several more diseases are prevented, managed or healed by this grain.

Compared to staple cereal crops, the grain amaranth is early maturing (less than three months), can be grown several times a year and tolerates drought, heat stress, high soil acidity and salinity. Besides this, amaranth also possess more efficient C_4 metabolic pathways and low input requirements. Grain amaranth has potential for increased production due to low cost of inputs and its adaptation to a wide range of agro-ecological zones.

The basic concept of nutrient management is maintenance or adjustment of soil fertility and supply plant nutrients to an optimum level for sustaining the desired crop productivity through optimization of benefits from all possible sources of plant nutrients in an integrated manner. The appropriate combination of mineral fertilizers, organic manures and crop residues varies according to the system; land use, ecological, social and economic conditions. Eco-friendly scientific method of crop production envisages the use of organics in the soil as source of nutrients (Tayade *et al*., 2012) [9]. In spite of increased use of chemical fertilizers, there is a gap between the nutrients applied and nutrients harvested, which is likely to widen further with the achievement of targets, leading to mining of soil. Experiences from long term fertilizer experiments revealed that integrated use of FYM, vermicompost, bio compost, *etc*., with graded levels of chemical fertilizers is promising not only in maintaining higher productivity but also in providing maximum stability in crop production (Nambiar and Abrol, 1989) [5].

2. Material and Methods

The present investigation was conducted during the *rabi* seasons of 2019-20 and 2020-21 at College Farm, Navsari Agricultural University, Navsari. It is situated in the South Gujarat Agro-climatic Zone. The soil of research farm was clay in texture, low in organic carbon (0.41%) and available nitrogen (198.40 kg/ha), medium in available phosphorus (37.98 kg/ha) and high in available potassium (313.83 kg/ha). The soil was found slightly alkaline (pH 8.2) with normal electric conductivity (0.30 dS/m). The experiment comprising of seven treatments *viz*., T_1 - FYM 2.5 t /ha + 50% RDF, T_2 - FYM 2.5 t /ha + 75% RDF, T_3 - Bio compost 2.5 t /ha + 50% RDF, T_4 - Bio compost 2.5 t /ha + 75% RDF, T_5 - Vermicompost 2.5 t /ha + 50% RDF, T_6 - Vermicompost 2.5 t /ha + 75% RDF, T_7 - FYM 2.5 t /ha + 100% RDF to grain amaranth in *rabi* season. The treatments were evaluated under randomized block design with three replications. Recommended dose of fertilizer (RDF) for *rabi* grain amaranth is 60 N + 40 P2O5 + 00 K2O kg/ha.

Grain amaranth *Cv*. GA 2 was sown with spacing of 45 X 10 cm in November and harvested in March during both the years. The Grain amaranth crop was fertilized as per treatment. The nitrogen was applied through urea (46% N) whereas phosphorus was applied through DAP (18% N & 46% P_2O_5). Organic manures (FYM, bio compost and vermicompost) were applied to grain amaranth crop as per treatments and evenly spread and mixed in that particular bed. The grain amaranth variety, GA-2 seeds treated with Thirum @ 3.0 g/kg of seeds to protect the crop against fungal diseases was used for this experiment in *rabi* season in both the years before sowing. The treated seeds were sown as per the treatments.

The data recorded during the course of investigation were subjected to statistical analysis as per method of analysis of variance (Panse and Sukhatme, 1978) [7].

3. Results and Discussion

Data presented in (Table 1 & 2) indicated that the plant height (at 60 DAS and harvest), stem girth, spike length, no. of lateral spikelets/spike, test weight, dry matter accumulation per plant, grain and straw yield of grain amaranth were significantly influenced by different treatments tried in the experiment on the basis of pooled analysis.

Significantly higher plant height (at 60 DAS and at harvest) was recorded under treatment FYM 2.5 t/ha + 100% RDF (T_7) being remained at par with treatment vermicompost 2.5 t/ha + 75% RDF (T_6) and bio compost 2.5 t/ha + 75% RDF (T_4). Significantly higher plant height was observed by combine application of the organic and inorganic sources. These findings are in close agreement with those reported by Keraliya *et al*. (2017) [2] and Jangir *et al*. (2021) [1]. Application of FYM 2.5 t/ha + 100% RDF (T_7) recorded significantly higher values of growth and yield attributes *viz*., stem girth, spike length, number of lateral spikelets per spike, test weight, dry matter accumulation per plant, grain yield and straw yield of grain amaranth which remained at par with treatment vermicompost 2.5 t/ha + 75% RDF (T_6) and bio compost 2.5 t/ha + 75% RDF (T_4). Significantly lower values regarding growth and yield attributes observed in treatment FYM 2.5 t/ha + 50% RDF (T_1). In case of days to 50% flowering and maturity, application of FYM 2.5 t/ha + 100% RDF (T_7) recorded the lowest values on the basis of pooled analysis. It might be due to improvement in soil conditions under organic matter addition. Conjunctive use of organic manure and inorganic fertilizers increases the availability of nutrients over a longer period of crop duration owing to their slow release. Thus, better availability of nutrients from an early stage was reflected in improved growth of crop. It was also emphasized that use of inorganic fertilizer and organic source provide needed nutrients from initial stage resulted in increased photosynthetic efficiency. Thus, greater availability of photosynthates, metabolites and nutrients to develop reproductive structures seems to have resulted in higher number of spikelets/spike. The integrated application of organic and inorganic fertilizer in adequate amount leads to improve the root growth and development, thereby higher uptake of nutrients provided better condition for cell division and cell enlargement resulting in increases in the photosynthetic efficiency and thus increased the production of photosynthates reflected in better growth and ultimately in higher dry matter accumulation. It might also be due to the adequate supply of nutrient element at the right time from organic and inorganic sources which helped optimum dry matter partitioning from the source to sink during reproductive stage of plant and its resultant effect on improved vegetative growth and better expression of yield attributes which ultimately turn in to higher grain yield of amaranth. It might also be due to slow and steady supply of nutrients through combination of organic and inorganic fertilizer throughout the crop growth period improved suitable biomass production which resulted into higher yield. Further, organic manures might have increased the efficiency of added chemical fertilizer in soil and increased rate of humification. Humic acid might have enhanced the availability of both native and added nutrients in soil and as a result improved growth and yield attributes and yield of the crop significantly. Similar results were also reported by the finding of Kushare *et al*. (2010) [3], Tayade *et al.* (2012) [9], Neeraja and Patel (2015) [6], Keraliya *et al*. (2017) [2] and Jangir *et al*. (2021) [1].

On the basis of two year's average (2019-20 and 2020-21), maximum net returns of ₹ 70813/ha and BCR of 2.81 were recorded under treatment bio compost 2.5 t/ha + 75% RDF (T_4), followed by treatment FYM 2.5 t/ha + 100% RDF (T_7) (₹ 69735/ha) with BCR of 2.25 and treatment vermicompost 2.5 t/ha + 50% RDF (T_6) (₹ 60429/ha) and BCR of 1.60, while lowest net return of ₹ 44780/ha was observed in treatment vermicompost 2.5 t/ha + 50% RDF (T_5) with BCR of 1.21 (Table 3). The highest net returns and BCR under treatment T_4 (bio compost 2.5 t/ha + 75% RDF) might be due to less cost of bio compost as compared to other organic manures used under study which resulted in low cost of cultivation coupled with higher grain yield turned in higher net returns and BCR. Similar results were also reported by Keraliya *et al.* (2017) [2], Mahata and Sinha (2018) [4] and Jangir *et al.* (2021) [1].

Table 1: Plant height, stem girth, spike length, no. of lateral spikelets/spike, days to 50% flowering and maturity of grain amaranth as influenced by different treatments (Pooled results)

Treatment	Plant height (cm)			Stem girth (cm)	Spike length (cm)	No. of lateral spikelets/spike	Days to 50% flowering	Days to maturity
	30 DAS	60 DAS	At harvest					
T_1	18.70	97.47	136.53	3.06	59.95	56.88	55.11	98.89
T_2	20.16	102.86	140.00	3.48	63.40	63.82	53.28	93.79
T_3	18.97	99.30	136.98	3.28	61.87	59.73	54.16	97.05
T_4	20.55	104.68	150.14	3.76	70.11	65.93	53.08	93.05
T_5	19.95	100.91	140.09	3.45	63.54	62.51	53.98	96.00
T_6	21.03	106.63	163.42	4.04	74.74	75.00	52.55	92.70
T_7	21.72	110.87	171.40	4.16	74.98	75.47	51.82	92.29
S.Em+	0.69	2.91	3.83	0.12	2.11	2.13	0.72	1.65
CD (P=0.05)	NS	8.49	11.18	0.34	6.15	6.21	NS	NS
CV (%)	9.41	7.69	7.04	8.85	8.60	8.79	3.63	4.69
General mean	20.15	103.25	148.37	3.60	66.94	65.62	53.43	94.82
Interaction (Y x T)								
S.Em+	1.10	4.58	6.03	0.18	3.32	3.33	1.12	2.57
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Table 2: Dry matter accumulation, test weight, grain yield, straw yield and harvest index of grain amaranth as influenced by different treatments (Pooled results)

Treatment	Dry matter accumulation (g/plant)		Test weight (GM)	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest index (%)
	60 DAS	At harvest				
T_1	31.40	35.19	0.724	1234.73	3596.06	25.57
T_2	34.71	40.35	0.766	1330.28	3970.25	25.09
T_3	33.49	37.92	0.738	1265.49	3694.14	25.53
T_4	38.22	45.32	0.783	1559.63	4491.65	25.79
T_5	34.52	40.55	0.764	1319.70	3963.51	24.98
T_6	40.28	47.05	0.835	1591.58	4625.78	25.60
T_7	40.99	47.73	0.841	1627.54	4834.78	25.21
S.Em+	1.07	1.19	0.013	51.04	133.59	0.48
CD (P=0.05)	3.13	3.47	0.037	147.40	385.83	NS
CV (%)	7.95	7.72	4.36	9.82	8.49	4.69
General mean	36.23	42.02	0.779	1418.42	4168.02	25.40
Interaction (Y x T)						
S.Em+	1.66	1.87	0.019	80.40	204.38	0.69
CD (P=0.05)	NS	NS	NS	NS	NS	NS

Table 3: Economics of grain amaranth as influenced by different treatments (Average of 2019-20 and 2020-21)

Treatment	Yield (kg/ha)		Cost of cultivation (₹/ha)			Gross returns (₹/ha)	Net returns (₹/ha)	BCR
	Seed	Straw	Fixed	Variable	Total			
T_1	1234.73	3596.06	20689	8988	29677	76168	46491	1.57
T_2	1330.28	3970.25	20689	9670	30359	82409	52051	1.71
T_3	1265.49	3694.14	20689	3863	24552	78097	53545	2.18
T_4	1559.63	4491.65	20689	4545	25234	96047	70813	2.81
T_5	1319.70	3963.51	20689	16363	37052	81832	44780	1.21
T_6	1591.58	4625.78	20689	17045	37734	98163	60429	1.60
T_7	1627.54	4834.78	20689	10351	31040	100776	69735	2.25
Selling price of grain (₹ 50 & 53/kg) and straw (₹ 3.00 & 3.50/kg) in 2019-20 and 2020-21, respectively								

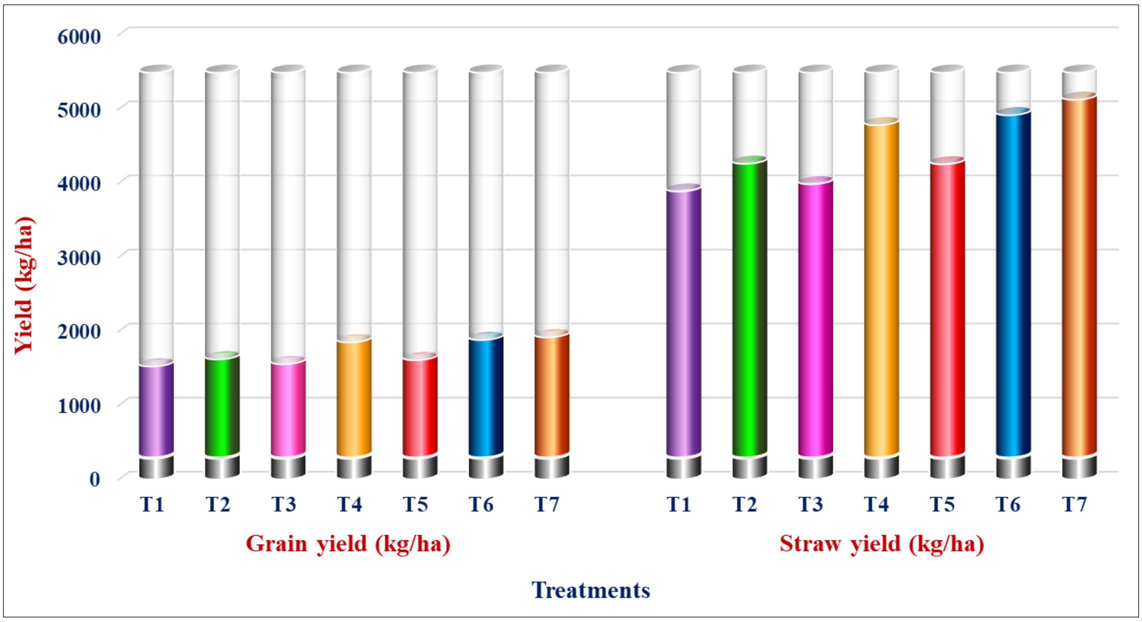

Fig 1: Grain yield and straw yield of grain amaranth as affected by different treatments

4. Conclusions

In the view of the results obtained from the present investigation, it can be concluded that the application of Bio compost 2.5 t/ha + 75% RDF (45-30-00 N-P_2O_5-K_2O kg/ha) was found to be beneficial for getting higher growth, yield and economic returns from grain amaranth.

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