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Growth and yield of grain amaranth as influenced by integrated nutrient management under south Gujarat condition

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Abstract
A field experiment was conducted at College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari during *rabi* seasons of 2017-18 and 2018-19. There were seven treatments applied to grain amaranth. Significantly higher plant height, grain yield and straw yield were recorded under the treatment T_4 (Bio compost 5 t/ha + 100% RDF through inorganic fertilizer) and being at par with the treatments T_6 (Vermi compost 5 t/ha + 100% RDF through inorganic fertilizer) and T_2 (FYM 5 t/ha + 100% RDF through inorganic fertilizer). 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.

Keywords: Grain amaranth, INM, FYM, bio compost, vermi compost, grain and straw yield

Introduction
Amaranthus or pigweed belongs to the family *Amaranthaceae.* It is originated from Central and South America (Grubben and Von Sloten, 1981) [3]. 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 (Srivastva, 2011) [12]. *Amaranthus cruentus* Linn and *Amaranthus hypochondriacus* Linn are the best grain producers species. 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".

At present, India is the largest exported of amaranth seeds. India has the most favourable climate for the growth of amaranth as the crop responds well to high sunlight and warm temperature. In the year 2015-16 India exported amaranth seeds worth USD 1,138,974. India export near to 70% of amaranth every year of the total exports made out of India. 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. 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. Compared to staple food 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 amaranth also attribute more efficient C_4 metabolic pathways and low input requirements. Grain amaranth has potential for increased production due to few requirements of inputs and its adaptation to a wide range of Agro-Ecological Zone.

The basic concept of integrated nutrient management (INM) 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 (Tondon, 1992) [14]. An 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) [13]. Experiences from long term fertilizer experiments revealed that integrated use of farm yard manures, vermi compost, 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. The response of nutrients as chemical fertilizer generally increases when it is used in

combination with FYM, bio compost and vermi compost etc. and saving nutrients (Nambiar and Abrol, 1989) [8]. Although increased level of production can be achieved by increasing use of inorganic fertilizers alone but it may lead to pollution problem and deterioration of soil. This can only be maintained at sustainable level by nutrients via integrated approach including organic manures.

2. Material and Methods

The field experiment was conducted at College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari during *rabi* seasons of 2017-18 and 2018-19. The soil of the experimental field was clayey in texture, low in organic carbon (0.42%) and low in available nitrogen (196.80 kg/ha), medium in available phosphorus (38.30 kg/ha) and high in available potassium (315.43 kg/ha). The soil was alkaline in reaction (pH 8.23) with normal electrical conductivity (0.30 dS/m). The field experiment consisted of integrated nutrient management *viz.*, T_1 : FYM 5 t/ha + 75% RDF through inorganic fertilizer, T_2 : FYM 5 t/ha + 100% RDF through inorganic fertilizer, T_3 : Bio compost 5 t/ha + 75% RDF through inorganic fertilizer, T_4 : Bio compost 5 t/ha + 100% RDF through inorganic fertilizer, T_5 : Vermi compost 1 t/ha + 75% RDF through inorganic fertilizer, T_6 : Vermi compost 1 t/ha + 100% RDF through inorganic fertilizer and T_7 : 100% RDF through inorganic fertilizer, were applied to grain amaranth in *rabi* season and replicated three times in randomized block design. Recommended dose of fertilizer (RDF) for grain amaranth is 60 N + 40 P_2O_5 + 00 K_2O kg/ha.

Grain amaranth variety GA-2 (Gujarat Amaranth 2) was sown with spacing of 45 cm x 10 cm in November and harvested in February during both the years. The grain amaranth crop was fertilized as per treatments. Organic manures (FYM, Bio compost and Vermi compost) were applied to grain amaranth crop as per treatments and evenly spread and mixed in that particular bed during both the years. The nitrogen was applied through urea, whereas phosphorus was applied through single superphosphate. The 50% dose of nitrogen and full dose of phosphorus were applied at the time of sowing and remaining 50% dose of nitrogen was applied at 30 days after sowing.

3. Results and Discussion

3.1 Effect on growth parameters

The data of Table 1 clearly revealed that plant height of grain amaranth among different treatments were significant at all the stages of crop growth in pooled results except at 20 DAS, where in plant height was found non significant due to effect of different treatments. Plant height of grain amaranth increased with the advancement of crop age during both the years and reached maximum at harvest. It was observed that the increase in plant height was found more pronounced during 40 to 60 DAS, moderate increase recorded after 60 DAS till harvest.

On the basis of pooled results at 40 DAS and at harvest, application of Bio compost 5 t/ha + 100% RDF through inorganic fertilizer (T_4) recorded significantly higher plant height but it remained at par with the treatment T_6 (Vermi compost 1 t/ha + 100% RDF through inorganic fertilizer) and T_2 (FYM 5 t/ha + 100% RDF through inorganic fertilizer) except 60 DAS. At 60 DAS, it remained at par with the treatment T_6 (Vermi compost 1 t/ha + 100% RDF through inorganic fertilizer) only.

Significantly higher plant height was observed by combine application of the organic and inorganic sources, it might be due to the application of the nitrogen and phosphorus through the chemical fertilizer which enhanced its availability which resulted in increased photosynthetic activity and translocation of the photosynthates from source to sink which help toward higher plant height. At the same time, effect of organic sources like FYM, Bio compost and Vermi compost as source of the plant nutrient and humus improved the physiological condition by increasing its capacity to absorb and store water, improving aeration and favouring the beneficial microbial activity which helps in improving the plant height. The increase in plant height is also a function of cell division and cell enlargement, which depends upon availability of nutrients in balanced form especially N and P. Similar results were reported by Akanbi and Togun (2002) [1] as well as Gunjal (2011) [4].

On the basis of pooled results, stem girth was significantly influenced by different treatments tried in experiment at 60 DAS and at harvest except at 20 and 40 DAS. Application of Bio compost 5 t/ha + 100% RDF through inorganic fertilizer (T_4) recorded significantly higher stem girth and it remained at par with the treatment T_6 (Vermi compost 1 t/ha + 100% RDF through inorganic fertilizer) and T_2 (FYM 5 t/ha + 100% RDF through inorganic fertilizer) at 60 DAS and at harvest. 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. Similarly, this findings tally with that of Neeraja and Patel (2015) [9], Chaudhary *et al.* (2018) [2] and Jangir *et al.* (2021) [5].

Days to 50% flowering and days to maturity of grain amaranth were fond non significant due to effect of various INM treatments at course of investigation in pooled results.

3.2 Effect on yield of grain amaranth

The treatment receiving of Bio compost 5 t/ha + 100% RDF through inorganic fertilizer (T_4) recorded significantly higher grain yield and which remained at par with application of Vermi compost 1 t/ha + 100% RDF through inorganic fertilizer (T_6) and FYM 5 t/ha + 100% RDF through inorganic fertilizer (T_2) in pooled results. This might be due to adequate supply of nutrient element at the right time from combined application of organic and inorganic sources which helped optimum dry matter partitioning from the source to sink during reproductive stage of plant and its effect on improved vegetative growth which ultimately lead to increase in photosynthetic activity of plant and root system and thus enabled plant to extract more water and nutrients from the soil depth, resulting into better development of plant growth and ultimately the higher grain yield. The results are in close agreement with those of Parmar and Patel (2009) [10], Kushare *et al.* (2010) [7], Keraliya *et al.* (2017) [6] and Jangir *et al.* (2021) [5].

Similarly, significantly higher straw yield was recorded with the application of Bio compost 5 t/ha + 100% RDF through inorganic fertilizer (T_4) and it remained at par with the application of Vermi compost 1 t/ha + 100% RDF through inorganic fertilizer (T_6) in pooled results. The higher straw yield under above treatments might be due to increase in vegetative growth through in terms of plant height. It might also be due to slow and steady supply of nutrients through combinations of organic and inorganic fertilizer throughout the crop growth period improved suitable biomass production

which resulted into higher straw 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 straw yield of the crop significantly. The increase in straw yield is also a resultant effect of improved vegetative growth and better expression of growth attributes like plant height and stem girth. Similar results were also obtained by Keraliya *et al.* (2017), Patel *et al*. (2019) [11] and Jangir *et al*. (2021) [5].

Table 1: Plant height and stem girth of grain amaranth as influenced periodically by different treatments.

Treatments	Plant height (cm)				Stem girth (cm)			
	At 20 DAS	At 40 DAS	At 60 DAS	At Harvest	At 20 DAS	At 40 DAS	At 60 DAS	At Harvest
T_1	8.60	41.07	112.85	148.37	0.87	3.10	3.40	3.42
T_2	9.27	46.00	126.83	166.95	0.91	3.23	3.85	3.84
T_3	8.92	43.39	122.17	160.52	0.90	3.20	3.69	3.67
T_4	9.45	47.36	136.89	175.20	0.93	3.27	3.98	4.04
T_5	9.04	44.30	119.59	157.36	0.90	3.17	3.61	3.59
T_6	9.32	46.38	127.84	169.80	0.92	3.24	3.89	3.87
T_7	8.23	32.23	90.05	130.80	0.85	2.85	3.41	3.41
S.Em±	0.29	0.94	3.15	3.92	0.02	0.09	0.08	0.08
C.D. at 5%	NS	2.72	9.09	11.33	NS	NS	0.24	0.23
C.V.%	8.89	5.94	7.17	6.70	5.43	8.04	5.99	5.74
Interaction (Y x T)					Interaction (Y x T)			
S.Em±	0.16	0.50	1.68	2.09	0.01	0.05	0.04	0.042
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS

T_1: FYM 5 t/ha + 75% RDF through inorganic fertilizer, **T_2:** FYM 5 t/ha + 100% RDF through inorganic fertilizer, **T_3:** Bio compost 5 t/ha + 75% RDF through inorganic fertilizer, **T_4:** Bio compost 5 t/ha + 100% RDF through inorganic fertilizer, **T_5:** Vermi compost 1 t/ha + 75% RDF through inorganic fertilizer, **T_6:** Vermi compost 1 t/ha + 100% RDF through inorganic fertilizer, **T_7:** 100% RDF through inorganic fertilizer

Table 2: Days to 50% flowering, days to maturity, grain and straw yield of grain amaranth as influenced by different treatments.

Treatments	Days to 50% flowering	Days to maturity	Grain yield	Straw yield
T_1	56.29	100.60	1283	3535
T_2	54.56	96.40	1667	4314
T_3	55.08	97.68	1395	3966
T_4	50.95	91.98	1802	4870
T_5	56.07	100.07	1332	3897
T_6	53.22	93.16	1735	4511
T_7	56.86	102.01	1221	3086
S.Em±	1.39	2.54	70.10	168.85
C.D. at 5%	NS	NS	202.45	487.67
C.V.%	6.84	7.04	12.65	11.30
	Interaction (Y x T)		Interaction (Y x T)	
S.Em±	0.74	1.36	37.47	90.25
C.D. at 5%	NS	NS	NS	NS

T_1: FYM 5 t/ha + 75% RDF through inorganic fertilizer, **T_2:** FYM 5 t/ha + 100% RDF through inorganic fertilizer, **T_3:** Bio compost 5 t/ha + 75% RDF through inorganic fertilizer, **T_4:** Bio compost 5 t/ha + 100% RDF through inorganic fertilizer, **T_5:** Vermi compost 1 t/ha + 75% RDF through inorganic fertilizer, **T_6:** Vermi compost 1 t/ha + 100% RDF through inorganic fertilizer, **T_7:** 100% RDF through inorganic fertilizer

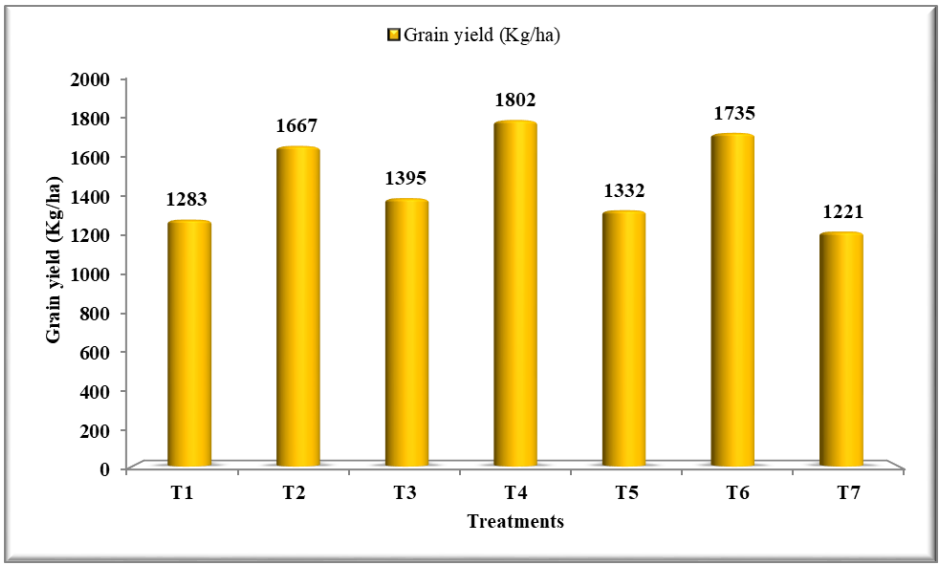

Fig 1: Grain yield of grain amaranth as affected by different treatments

Conclusion

In the view of the results obtained from the present investigation, it can be concluded that for getting higher growth and yield of grain amaranth under south Gujarat condition, *rabi* grain amaranth crop should be fertilized with Bio compost 5 t/ha + 100% RDF through inorganic fertilizer.

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