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Influence of integrated nutrient management on growth, yield attributes and yield of grain amaranth (*Amaranthus hypochondriacus* L.) under South Saurashtra condition

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Abstract
A field experiment entitled "Influence of integrated nutrient management on growth, yield attributes and yield of grain amaranth (*Amaranthus hypochondriacus* L.) under South Saurashtra condition" was conducted on medium black calcareous soil at Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh (Gujarat) during *rabi* season of 2022-23. The experiment was laid out in randomized block design with three replications. The experiment comprising 8 integrated nutrient management treatments *viz.*, Control (T_1), 100% RDF through inorganic fertilizer (T_2), Vermicompost 1 t/ha + 50% RDF through inorganic fertilizer (T_3), Vermicompost 1 t/ha + 75% RDF through inorganic fertilizer (T_4), Enriched compost 5 t/ha + 50% RDF through inorganic fertilizer (T_5), Enriched compost 5 t/ha + 75% RDF through inorganic fertilizer (T_6), FYM 5 t/ha + 50% RDF through inorganic fertilizer (T_7) and FYM 5 t/ha + 75% RDF through inorganic fertilizer (T_8). The results of the experiment indicated that application of enriched compost 5 t/ha + 75% RDF through inorganic fertilizer, followed by FYM 5 t/ha + 75% RDF through inorganic fertilizer and 100% RDF through inorganic fertilizer improved growth attributes *viz.*, plant height, stem girth, days to 50% flowering, days to maturity and yield attributes *viz.*, spike length, no. of spikelets/spike, test weight, harvest index which ultimately resulted in higher grain and stover yields of amaranth. On the basis of the results obtained from one year field study, it can be concluded that higher production from *rabi* grain amaranth can be achieved by application of enriched compost 5 t/ha + 75% RDF through inorganic fertilizer or FYM 5 t/ha + 75% RDF through inorganic fertilizer or 100% RDF through inorganic fertilizer.

Keywords: Grain amaranth, organic manure, vermicompost, enriched compost, FYM

Introduction
Amaranth belongs to the family Amaranthaceae and genus Amaranthus. The genus *Amaranthus* has more than 60 species of which some are grown for leaf purpose and seeds of which are black in colour. Three species (*Amaranthus hypochondriacus, Amaranthus caudatus* and *Amaranthus cruentus*) are grown for grain purpose and seeds of which are in golden yellow in colour. The word *Amaranthus* is basically derived from a Greek word "Anthos" (flower) which means everlasting or unwilting. At a present time, grain amaranth is also called as a third millennium crop. It produces significant edible cereals grain but known as "pseudo cereals". Amaranth is a pseudo-cereal because of its flavour and cooking similarities to grains. It is said to be highly nutritious with higher protein and lysine content than almost any other cereals. It also provides a good source of dietary fiber and minerals such as iron, magnesium, phosphorus, copper and especially manganese.
In India, presently amaranth is grown in Himachal Pradesh and on hills of Uttar Pradesh and Uttaranchal for 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 been cultivated. While, it is mainly grown for grain in Uttarakhand, Maharashtra and in some parts of Gujarat. In Gujarat, it is mainly grown in Mehsana, Banaskantha, Sabarkantha, Gandhinagar and Kheda and

some parts of Saurashtra region as a rabi crop in an area about 3425 ha with a productivity of around 1700 kg/ha (Neeraja, 2013) [1].

Growth, yield and quality of Amaranth depends on nutrient availability in soil, which is released to the judicious application of manures and fertilizers. Nutrients may be applied through two sources *viz.* Organic and inorganic sources. Increased use of inorganic fertilizers in crop production deteriorates soil health, cause soil health hazard and creates imbalance to environment by polluting nature. The continuous use of chemicals degrade the soil texture, composition, reduces manure content and kills useful microbes, soil acidification and soil crust, thereby reducing the content of organic matter, humus content, beneficial species, stunting plant growth, altering the pH of the soil, growing pests and even leading to the release of greenhouse gases. Besides, now-a-days gradual deficiencies in soil organic matter and reduced yield of crop are alarming problems in India. The cost of inorganic fertilizers is very high and sometimes it is not available in the market for which the farmers fail to apply the inorganic fertilizers to the crop field in optimum time.

So that use organic manure like vermicompost, FYM and enriched compost acts as a store house of several macro, micro nutrients and plant growth regulators are released during the process of mineralization to release plant nutrients present in the soil which increases the fertilizer use efficiency. On the other hand, the organic manure is easily available to the farmers and its cost is low compared to that of inorganic fertilizers. The crop production cost is more or less similar to organic and inorganic fertilizer, the use of readily available organic sources of nutrients should be used to maximize the economic return.

Taking note of the facts highlighted above, a field experiment was conducted to study the Influence of integrated nutrient management on growth, yield attributes and yield of grain amaranth (*Amaranthus hypochondriacus* L.) under South Saurashtra condition.

Materials and Methods

A field experiment was conducted at Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh (Gujarat) in *rabi* season of 2022-23. Geographically, Junagadh is situated at 21.5° N latitude and 70.5° E longitude with an altitude of 60 m above the mean sea level. The experiment took place on medium black calcareous soil with $pH_{2.5}$ 8.00 and $EC_{2.5}$ 0.34 dS/m, low in available nitrogen (242 kg/ha) and medium in available phosphorus (40.10 kg/ha) and potassium (235 kg/ha). The mean maximum and minimum temperature during the crop period ranged from 25.7 to 37.7 °C and 9.4 to 18.6 °C, respectively. During the crop period, the relative humidity was in the range of 39 to 78%. Bright sun shine hours, wind velocity and daily evaporation were 4.2 to 9.5 h/day, 2.3 to 7.6 km/h and 3.6 to 6.6 mm/ day, respectively.

The study focused on "Influence of integrated nutrient management on growth, yield attributes and yield of grain amaranth (*Amaranthus hypochondriacus* L.)". Employing a randomized block design (RBD), the experiment comprised eight treatments replicated thrice. The treatments included various combinations of organic manures and inorganic fertilizers: T_1 -Control (No fertilizer), T_2 -100% RDF (60:40:00 kg NPK /ha) through inorganic fertilizer, T_3 -Vermicompost 1 t/ha + 50% RDF through inorganic fertilizer, T_4 -Vermicompost 1 t/ha + 75% RDF through inorganic fertilizer, T_5 - Enriched compost 5 t/ha + 50% RDF through inorganic fertilizer, T_6 - Enriched compost 5 t/ha + 75% RDF through inorganic fertilizer, T_7 -FYM 5 t/ha + 50% RDF through inorganic fertilizer, T_8 -FYM 5 t/ha + 75% RDF through inorganic fertilizer. Nitrogen and phosphorus were applied through Urea and DAP respectively as per treatments. The total quantity of phosphorus and half dose of nitrogen were applied in furrows just before sowing of amaranth as per treatments. The remaining half dose of nitrogen was applied as top dressing at 30 days after sowing. Vermicompost, enriched compost and FYM as per treatments were applied as basal dose in ploughed furrows before sowing.

The required quantity of clean seeds of grain amaranth variety GA 6 was mixed with soil for uniform sowing of seeds. The sowing was done manually in previously opened furrows at a depth of 2cm on November 23, 2022. Seed rate @ 2 kg/ha was used. The crop was raised as per the recommended package of practices. The crop was harvested at physiological maturity on 01st March 2023. The growth parameters and yield attributes were recorded from the five tagged plants in each plot. Grain and stover yield were recorded from the net plot area and converted into kilogram per hectare base. The data were subjected to statistical analysis by adopting appropriate analysis of variance as described by Gomez and Gomez (1984) [2]. Wherever the F values found significant at 5% level of probability, the critical difference (CD) values were computed for making comparison among the treatment means.

Results and Discussion

Growth attributes

The Growth attributes *viz*., plant height at 30 DAS and at harvest (Table 1) and stem girth at 60 DAS and at harvest (Table 1) were found significantly higher with application of enriched compost 5 t/ha + 75% RDF through inorganic fertilizer (T_6), it was found statistically at par with the treatments T_8 (FYM 5 t/ha + 75% RDF through inorganic fertilizer) and T_2 (100% RDF through inorganic fertilizer).While, days to 50% flowering and days to maturity (Table 1) were not significantly influenced by different treatments. The lowest values of growth attributes were recorded under T_1 (Control). Significantly higher plant height and stem girth were observed by combine application of the organic and inorganic sources, it might be due to the application of the nitrogen and phosphorous through the chemical fertilizer which enhanced its availability which resulted in increased photosynthetic activity and translocation of the photosynthates from sources to sink which help toward higher plant height and stem girth. At the same time, effect of organic sources like FYM, enriched compost and vermicompost as source of the plant nutrient and humus improved the soil 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 Ainika *et al*. (2011) [3], Gunjal (2011) [4], Neeraja and Patel (2015) [5], Chowdhury *et al*. (2017) [6], Mahata and Sinha (2018) [7] and Yadav *et al*. (2022) [8].

Yield attributes

An assessment of data presented in Table 2 indicated that different integrated nutrient management treatments did not cause any significant effect on test weight of amaranth seed and harvest index. The spike length and number of spikelets/spike were significantly higher under the treatment of enriched compost 5 t/ha + 75% RDF through inorganic fertilizer (T_6), which remained statistically equivalent to the treatments T_8 (FYM 5 t/ha + 75% RDF through inorganic fertilizer) and T_2 (100% RDF through inorganic fertilizer). Spike length and number of spikelets per spike were recorded significantly the lowest with the treatment T_1 (Control). This may be due to the increase in the supply of the major plant nutrients. nitrogen accelerates growth, reproductive phases and protein synthesis, thus promoting length of spike besides that better length of spike depends on optimum dry matter partitioning during reproductive stage of plant. Nutrient elements from organic and inorganic sources ensure long term and optimum nutrient supply to the plant which ensure maximize accumulation of photosynthates to the spike consequently increase the length of spike. 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. Similar results were also reported by the finding of Chaudhary and Gautum (2007) [9], Pratap and Dutta (2010) [10], Roy *et al*. (2018) [11], Harika *et al*. (2019) [12], Jangir *et al*. (2019) [13] and Zala *et al*. (2022) [14].

Yield

A critical examination of data (Table 2) indicated that grain yield and stover yield were significantly influenced by different treatments. Significantly higher grain yield (1734 kg/ha) and stover yield (3432 kg/ha) was registered under the treatment T_6 (Enriched compost 5 t/ha + 75% RDF through inorganic fertilizer) and it was found statistically equivalent to the treatments T_8 (FYM 5 t/ha + 75% RDF through inorganic fertilizer) and T_2 (100% RDF through inorganic fertilizer) having grain yield of 1653 and 1498 kg/ha, respectively and stover yield of 3374 and 3339 kg/ha, respectively. Conversely, the treatment T_1 (Control) recorded significantly the lowest in grain yield (1169 kg/ha) and stover yield (2446 kg/ha). 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 superiority of these treatments could be explained on the basis of better growth and higher uptake of nutrients under these treatments might have better partitioning and migration of the total available photosynthates to economic yield. Second probable reason may be the better expression of yield attributes *viz*., Spike length and number of spikelets/spike (Table 2) under this treatment, which cumulatively altogether increased the grain yield of amaranth. The higher stover yield under above treatments might be due to increase in vegetative growth through in terms of plant height and stem girth (Table 1). 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 stover yield. The results are in close agreement with those of Sepat *et al*. (2010) [15], Devi *et al.* (2011) [6], More *et al.* (2013) [17], Deshmukh *et al.* (2014) [18], Jagathjothi and Ramamoorthy (2015) [19], Thumar *et al*. (2016) [20] and Patel *et al*. (2022) [21].

Table 1: Effect of different treatments on growth attributes of grain amaranth

Tr. No.	Treatments	Plant height (cm)		Stem girth (cm)		Days to 50% flowering	Days to maturity
		At 60 DAS	At harvest	At 60 DAS	At harvest		
T_1	Control	58.53	114.20	3.04	4.04	45.50	91.73
T_2	100% RDF through inorganic fertilizer	69.43	128.47	5.00	5.92	52.23	94.37
T_3	Vermicompost 1 t/ha + 50% RDF through inorganic fertilizer	58.60	117.67	3.19	4.19	46.76	91.93
T_4	Vermicompost 1 t/ha + 75% RDF through inorganic fertilizer	64.13	123.47	3.98	4.94	52.07	94.02
T_5	Enriched compost 5 t/ha + 50% RDF through inorganic fertilizer	62.87	118.87	3.28	4.28	48.80	92.86
T_6	Enriched compost 5 t/ha + 75% RDF through inorganic fertilizer	75.67	134.53	5.48	6.00	53.30	95.03
T_7	FYM 5 t/ha + 50% RDF through inorganic fertilizer	64.07	119.27	3.91	4.87	49.50	93.77
T_8	FYM 5 t/ha + 75% RDF through inorganic fertilizer	74.47	130.33	5.26	5.93	53.00	94.57
S.Em.±		3.07	3.30	0.21	0.34	3.37	5.55
C.D. at 5%		9.31	10.01	0.65	1.02	NS	NS
C.V.%		8.06	4.63	8.92	11.60	11.65	10.27

Table 2: Effect of different treatments on yield attributes and yield of grain amaranth

Tr. No.	Treatments	Spike length (cm)	Number of spikelets/ spike	Test weight (gm)	Grain yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)
T_1	Control	32.33	40.67	0.72	1169	2446	32.32
T_2	100% RDF through inorganic fertilizer	42.33	50.67	0.80	1498	3339	31.03
T_3	Vermicompost 1 t/ha + 50% RDF through inorganic fertilizer	36.00	41.67	0.75	1334	2799	32.27
T_4	Vermicompost 1 t/ha + 75% RDF through inorganic fertilizer	38.00	48.00	0.79	1424	2906	32.85
T_5	Enriched compost 5 t/ha + 50% RDF through inorganic fertilizer	36.33	41.87	0.75	1394	2841	33.19
T_6	Enriched compost 5 t/ha + 75% RDF through inorganic fertilizer	44.67	52.00	0.82	1734	3432	33.56
T_7	FYM 5 t/ha + 50% RDF through inorganic fertilizer	37.00	44.33	0.78	1404	2893	32.69
T_8	FYM 5 t/ha + 75% RDF through inorganic fertilizer	43.00	51.33	0.81	1653	3374	33.06
S.Em.±		1.93	2.20	0.03	78.62	160.01	1.94
C.D. at 5%		5.87	6.68	NS	238.46	485.35	NS
C.V.%		8.65	8.24	5.81	9.38	9.23	10.32

Conclusion

On the basis of one year experimental field study, it can be concluded that *rabi* grain amaranth (cv. GA-6) crop should be fertilized with enriched compost 5 t/ha + 75% RDF (60:40:00 N:P_2O_5:K_2O kg/ha) through inorganic fertilizer *or* FYM 5 t/ha + 75% RDF through inorganic fertilizer *or* 100% RDF through inorganic fertilizer for getting higher yield & yield attributes and growth attributes under medium black calcareous soil of South Saurashtra Agro-climatic Zone of Gujarat.

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