

## Impact of Integrated Nutrient Management on Growth, Yield, Quality and Economics of Grain Amaranth

### ABSTRACT

The research was conducted during *rabi* seasons of 2022-23 and 2023-24 at College Farm, Navsari Agricultural University, Navsari, India. Nine integrated nutrient management treatments were applied to grain amaranth crop in *rabi* season (mid-November and harvested in April/May) and replicated three times in randomized block design. Almost all the growth attributes, yield attributes, and quality were significantly improved due to combination of organic manures and inorganics. Significantly higher grain yield (1371 kg/ha) and stover yield (2916 kg/ha) were recorded under the application of vermicompost 5 t/ha + 100% RDN through inorganic fertilizer (T<sub>6</sub>). However, this yield was at par with the application of biocompost 5 t/ha + 100% RDN through inorganic fertilizer (T<sub>4</sub>) and application of FYM 5 t/ha + 100% RDN through inorganic fertilizer (T<sub>2</sub>) in pooled analysis of 2022-23 to 2023-24. Application of biocompost 5 t/ha + 100% RDN through inorganic fertilizer (T<sub>4</sub>) gave maximum profitably higher net returns (₹ 65768) and BCR (2.67) among all the treatments.

**KEYWORD:** Grain amaranth, Growth, Yield attributes, Yield, Quality and Economics.

### INTRODUCTION

“*Amaranthus* or pigweed belongs to the family *Amaranthaceae*. The word *Amaranthus* is basically derived from a Greek word “Anthos” which means ever lasting or un-wilting. At present time, it is also called as a third millennium crop. Amaranth varies in flower, leaf, and stem colour with range of striking pigment from the spectrum of maroon to crimson and can grow longitudinally from 1 to 2.5 meter tall with a cylindrical, succulent, fibrous stem. It is believed to have originated from Central and South America, it is an important part of diet in areas of Latin America, Africa, and Asia” (Grubben and Von Sloten, 1981). The genus *Amaranthus* consists of up to 70 species, either as cosmopolitan weeds or cultivated plants, and is widely spread across all tropical and subtropical regions of the world. They are grown as leafy vegetables, grains, or ornamental plants, while others exist as weeds (Srivastva, 2011), *Amaranthus cruentus* Linn and *Amaranthus hypochondriacus* Linn, are the best grain producers. “Amaranth is C<sub>4</sub> plant that germinates quickly when soil temperature reaches 15°C to 18°C. Seedling rate should be increased to compensate for lower emergence rates when soil temperatures are less than 15°C” (Webb *et al.*, 1987). “Grain amaranth can be grown several times a year and it tolerates drought, heat stress, high soil acidity and salinity. It has potential for increased production due to low cost of inputs and its adaptation to a wide range of agro-ecological zones” [18].

“Amaranth is widely distributed throughout the old and new world. In Asia-Pacific regions covering India, China, Manchuria, Nepal, Bhutan, Afghanistan, Indonesia, Japan, Thailand and Israel, this crop is cultivated as a minor crop. In India, grain amaranth was primarily cultivated in hill regions but of late in 1990s, its cultivation gained momentum in Central and Western Plateau regions. Now-a-days, this crop is being promoted globally as a nutritive food crop or potential crop of the future. This crop is still not in the main stream cultivation practices in India and the world. In some of the Indian languages, it is known as rajgira (king of seeds) in Gujarati, ramdana (seed sent by god) in Bihar, Odisha and Uttar Pradesh, chuka in Bengal, kalaghesa, chumera and ganhar in Central India and bathu in Himachal Pradesh. Presently amaranth is grown in Himachal Pradesh and on hills of Uttar Pradesh and Uttaranchal for grain and leafy vegetable purpose. It is mainly grown for grain in Uttarakhand, Maharashtra and in some parts of Gujarat. Being a profitable crop the area under amaranth is increasing day by day where irrigation facilities exist” (Neeraja, 2013).

## **MATERIALS AND METHOD**

The study took place at the Agronomy Instructional Farm, situated at the College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari during the *rabi* season 2022-23 and 2023-24. The soil of south Gujarat is locally known as “Deep Black Soil”. The soils of Navsari campus are classified under the order, ‘*Inceptisols*’. The soil analysis reveal that soil of experimental plot was clay in texture, low in organic carbon (0.49% and 0.43%) and available nitrogen (206.10 kg/ha and 196.23 kg/ha), medium in available phosphorus (36.30 kg/ha and 40.10 kg/ha) and high in available potassium (290.2 kg/ha and 298.36 kg/ha).

“The treatment consisted of integrated nutrient management *viz.*, T<sub>1</sub>: 25% N through FYM + 75% RDN through inorganic fertilizer, T<sub>2</sub>: FYM 5 t/ha + 100% RDN through inorganic fertilizer, T<sub>3</sub>: 25% N through Biocompost + 75% RDN through inorganic fertilizer, T<sub>4</sub>: Biocompost 5 t/ha + 100% RDN through inorganic fertilizer, T<sub>5</sub>: 25% N through Vermicompost + 75% RDN through inorganic fertilizer, T<sub>6</sub>: Vermicompost 5 t/ha + 100% RDN through inorganic fertilizer, T<sub>7</sub>: FYM 5 t/ha, T<sub>8</sub>: Biocompost 5 t/ha and T<sub>9</sub>: Vermicompost 5 t/ha were applied to grain amaranth crop in *rabi* season and replicated three times in randomized block design. For this experiment, the grain amaranth used was Grain amaranth 2, and it was sown with a spacing of 45 cm × 10 cm”. [18]

## RESULTS AND DISCUSSION

### Effect on growth parameters

According to pooled results of 2 years (Table 1) integrated nitrogen management treatments exhibited significant effect on plant height (except at 30 DAS), stem girth, dry matter per plant and 50% days to flowering. Application of vermicompost 5 t/ha + 100% RDN through inorganic fertilizer (T<sub>4</sub>) recorded significantly higher plant height at 60 DAS and at harvest and dry matter (g/plant) which were remained at par with application of biocompost 5 t/ha + 100% RDN through inorganic fertilizer (T<sub>4</sub>) and FYM 5 t/ha + 100% RDN through inorganic fertilizer (T<sub>2</sub>). Whereas significantly higher stem girth and more number of days to 50% flowering of grain amaranthin pooled study was found at par with all treatments except application of 25% N through FYM + 75 % RDN through inorganic fertilizer (T<sub>1</sub>), vermicompost 5 t/ha (T<sub>9</sub>), biocompost 5 t/ha (T<sub>8</sub>) and FYM 5 t/ha (T<sub>7</sub>). Significantly lower plant height, stem girth, dry matter and 50% days to flowering were observed with application of FYM 5 t/ha (T<sub>7</sub>).

“Significantly higher plant height, stem girth, 50% days to flowering and dry matter were observed by combined application of organic and inorganic sources of nitrogen, it might be due to application of nitrogen and phosphorus through chemical fertilizer which enhanced its availability which resulted in increased photosynthetic activity and translocation of photosynthates from source to sink which helped in achieving higher plant height, stem girth, dry matter (g/plant)”. [18] The physical characteristics of the soil were also improved by the use of organic sources (vermicompost, biocompost, and FYM) as a source of humus and plant nutrients. These sources also increased the soil's ability to absorb and hold water, enhanced aeration, and promoted the growth-promoting microbial activity. The increased growth characteristics are also a result of cell expansion and division, which are reliant on the availability of balanced nutrients, particularly N and P. Similar results were reported by Jangir *et al.* (2019), Srujan *et al.* (2021) and Bartwalet *et al.* (2022).

### Effect on yield parameters

Length of spike, length of spikelet and no. of spikelets/spike were significantly affected by different treatments of integrated nutrient management. Application of vermicompost 5 t/ha + 100% RDN through inorganic fertilizer (T<sub>6</sub>) showed significantly higher spike length and length of spikelet and no. of spikelets/spike of grain amaranth at harvest which was statistically at par with application of biocompost 5 t/ha + 100% RDN through inorganic fertilizer (T<sub>4</sub>) and application of FYM 5 t/ha + 100% RDN through inorganic fertilizer (T<sub>2</sub>) in pooled analysis.

Test weight of grain amaranth (volume basis) was not significantly influenced by different treatments in pooled study. Length of spike, length of spikelets and no. of spikelets/spike were noted significantly lower with the treatment T<sub>7</sub> (FYM 5 t/ha).

It was underlined that the usage of inorganic fertilizer and organic sources significantly improves crop growth by delivering necessary nutrients from the start. Increased macro and micronutrient delivery in a more synchronized manner in the treatment, with an integrated supply of nutrients from organic manure and inorganic fertilizer, resulting in improved photosynthetic efficiency. Thus, greater availability of photosynthates, metabolites and nutrients to develop reproductive structures seems to have resulted in increased length of spikelet, length of spikelet and no. of spikelets/spike in amaranth crop. The results were in agreement with the findings of Kushare *et al.* (2010), Keraliya *et al.* (2017), Jangir (2019) and Patel *et al.* (2022) in grain amaranth.

### **Effect on yield**

The treatment receiving vermicompost 5 t/ha + 100% RDN through inorganic fertilizer (T<sub>6</sub>) recorded significantly higher grain yield and straw yield (1371 and 2916 kg/ha) remained at par with application of biocompost 5 t/ha + 100% RDN through inorganic fertilizer (T<sub>4</sub>) (1341 and 2796 kg/ha) and application of FYM 5 t/ha + 100% RDN through inorganic fertilizer (T<sub>2</sub>) (1280 and 2728 kg/ha) in pooled analysis. Further, results indicated that the treatment T<sub>5</sub> (25% N through vermicompost + 75% RDN through inorganic fertilizer), treatment T<sub>3</sub> (25% N through Biocompost + 75% RDN through inorganic fertilizer) and, treatment T<sub>1</sub> (25% N through FYM + 75% RDN through inorganic fertilizer) found at par with one other in pooled analysis.

Significantly lower grain and straw yields were recorded in treatment T<sub>7</sub> (FYM 5 t/ha) (788 and 1893 kg/ha) in pooled results.

An increase in the grain and straw yield with vermicompost, biocompost and FYM served as reserves of macro and micronutrients which are released during process of mineralization. Among the treatments, the combined use of organic and inorganic fertilizers, as well as solely

inorganic fertilizers, resulted in higher grain yield compared to treatments receiving nutrients only through organic manures. This is likely due to the optimal supply of nutrients at the right time to meet crop requirements. Grain amaranth responds well to fertilizer application, which promotes more extensive root growth. This enhanced root development leads to better absorption of moisture and nutrients from the soil, facilitating effective dry matter production and the translocation of photosynthates from the leaves to the spikelets, resulting in improved grain development. The results were in agreement with the findings of Parmar and Patel (2009), Gunjal (2011), Neeraja and Patel (2015), Keraliya *et al.* (2017), Jangir *et al.* (2019) and Patel *et al.* (2022) in grain amaranth.

### **Effect on Quality**

Significantly higher protein content and protein yield were noted under the application of vermicompost 5 t/ha + 100% RDN through inorganic fertilizer (T<sub>6</sub>) which was statistically at par with application of biocompost 5 t/ha + 100% RDN through inorganic fertilizer (T<sub>4</sub>) and application of FYM 5 t/ha + 100% RDN through inorganic fertilizer (T<sub>2</sub>) in pooled analysis of the experimental results.

The variation in protein yield was observed because uptake of nitrogen associated with its levels of supply as well as plant potential to absorb and utilize for growth as well as accumulation of protein in grain under adequate N supply through inorganic fertilizers or combination of organics and inorganics might be accounted to continuous availability of nitrogen for protein synthesis. The protein yield is correlated with protein content in grain and grain yield of crop. This could be due to the higher grain yield under corresponding treatment. These results are in accordance with the findings of Jangir *et al.* (2021) and Patel (2022) in grain amaranth.

### **Economics**

Maximum net monetary return of ₹ 65768 and BCR of 2.67 was recorded by the treatment of biocompost 5 t/ha + 100% RDN through inorganic (T<sub>4</sub>) followed by treatment of 25% N through biocompost + 75% RDN through inorganic fertilizer (T<sub>3</sub>) with net monetary return of ₹ 51323 and BCR of 2.42 and T<sub>2</sub> (FYM 5 t/ha + 100% RDN through inorganic fertilizer) with ₹ 48815/ha and BCR 1.94. Whereas, the lowest net monetary return of ₹ 1922 with BCR of 1.03 was recorded with the treatment T<sub>9</sub> (Vermicompost 5t/ha).

The highest net monetary return under treatment T<sub>4</sub> (Biocompost 5 t/ha + 100% RDN through inorganic fertilizer) might be due to low cost of biocompost as compared to other organic manure used under study which resulted in low cost of cultivation coupled with higher grain

yield turned in higher net monetary return and BCR. Similar results were also reported by Keraliya *et al.* (2017), Salmankhan *et al.* (2023), Bartwal (2022) and Patel (2022).

## CONCLUSION

Based on two years of experimentation, it can be concluded that the application of biocompost 5 t/ha combined with 100% recommended dose of nitrogen (60 kg N/ha) and Phosphorus (40 kg P<sub>2</sub>O<sub>5</sub>/ha) from inorganic fertilizers enhances the growth parameters, yield attributes, yield, quality, net returns and BCR of grain amaranth.

### Future line of work

Research should investigate the long-term impacts of integrated nutrient management on soil health, crop productivity, and environmental sustainability. Additionally, studies should explore the potential benefits of combining different organic amendments with inorganic fertilizers across various crops and agro-climatic conditions to optimize nutrient use efficiency and enhance overall agricultural sustainability.

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**Table 1. Effect of integrated nutrient management on plant height, stem girth, 50% days to flowering and dry matter of grain amaranth**

Treatments	Plant height (cm)			Stem girth (cm)	50% days to flowering	Dry matter (g/plant)	
	At 30 DAS	At 60 DAS	At harvest			At 60 DAS	At harvest
<b>T<sub>1</sub></b> : 25% N through FYM + 75% RDN through inorganic fertilizer	19.19	95.88	122.20	3.57	51.83	33.06	40.75
<b>T<sub>2</sub></b> : FYM 5 t/ha + 100% RDN through inorganic fertilizer	20.12	113.50	142.17	3.80	54.17	39.67	47.91
<b>T<sub>3</sub></b> : 25% N through Biocompost + 75% RDN through inorganic fertilizer	19.28	98.87	125.59	3.68	53.17	35.05	42.39
<b>T<sub>4</sub></b> : Biocompost 5 t/ha + 100% RDN through inorganic fertilizer	20.69	118.67	151.88	3.86	55.00	42.55	51.30
<b>T<sub>5</sub></b> : 25% N through Vermicompost + 75% RDN through inorganic fertilizer	19.54	104.04	127.23	3.77	53.50	37.93	43.61
<b>T<sub>6</sub></b> : Vermicompost 5 t/ha + 100% RDN through inorganic fertilizer	21.19	120.25	153.01	4.03	56.50	43.93	52.87
<b>T<sub>7</sub></b> : FYM 5 t/ha	17.89	81.18	100.38	2.93	44.67	27.15	33.28
<b>T<sub>8</sub></b> : Biocompost 5 t/ha	18.39	81.82	101.17	3.08	49.17	28.88	35.32
<b>T<sub>9</sub></b> : Vermicompost 5 t/ha	18.69	83.87	102.70	3.28	50.17	30.51	37.19
<b>SEm ±</b>	0.79	3.94	4.97	0.14	1.51	1.48	1.73
<b>CD (P=0.05)</b>	NS	11.34	14.31	0.41	4.35	4.25	4.98
<b>CV (%)</b>	10.01	9.66	9.72	9.74	7.11	10.21	9.90

<b>Y</b>	<b>SEm ±</b>	0.375	1.856	2.341	0.067	0.712	0.696	0.814
	<b>CD (P=0.05)</b>	NS	NS	NS	NS	NS	NS	NS
<b>Y × T</b>	<b>SEm ±</b>	1.124	5.567	7.024	0.200	2.136	2.088	2.443
	<b>CD (P=0.05)</b>	NS	NS	NS	NS	NS	NS	NS

**Table 2. Effect of integrated nutrient management on length of spike, spikelet, No. of spikelets/spike, grain yield, straw yield, protein content and protein yield of grain amaranth (pooled data 2022-23 & 2023-24)**

<b>Treatments</b>	<b>Length of spike (cm)</b>	<b>Length of spikelet (cm)</b>	<b>No. of spikelets/spike</b>	<b>Test weight (g) (Volume basis 10mL)</b>	<b>Grain yield (kg/ha)</b>	<b>Straw yield (kg/ha)</b>	<b>Protein content</b>	<b>Protein yield</b>
<b>T<sub>1</sub></b> : 25% N through FYM + 75% RDN through inorganic fertilizer	51.36	14.29	56.96	6.133	1078	2333	12.35	133.10
<b>T<sub>2</sub></b> : FYM 5 t/ha + 100% RDN through inorganic fertilizer	57.72	15.89	67.19	6.330	1280	2728	13.47	172.63
<b>T<sub>3</sub></b> : 25% N through Biocompost + 75% RDN through inorganic fertilizer	53.16	14.95	60.10	6.187	1106	2468	12.98	143.85
<b>T<sub>4</sub></b> : Biocompost 5 t/ha + 100% RDN through inorganic fertilizer	61.73	16.15	73.21	6.317	1341	2796	14.07	188.78
<b>T<sub>5</sub></b> : 25% N through Vermicompost + 75% RDN through inorganic fertilizer	53.43	15.19	61.73	6.220	1146	2488	13.15	151.02
<b>T<sub>6</sub></b> : Vermicompost 5 t/ha + 100% RDN through inorganic fertilizer	62.96	17.28	73.62	6.400	1371	2916	14.15	193.89
<b>T<sub>7</sub></b> : FYM 5 t/ha	46.43	12.16	46.12	5.967	788	1893	11.46	90.20
<b>T<sub>8</sub></b> : Biocompost 5 t/ha	50.01	13.96	48.93	6.022	830	1972	11.73	97.71
<b>T<sub>9</sub></b> : Vermicompost 5 t/ha	50.77	14.17	50.85	6.037	924	2073	11.81	109.35
<b>SEm ±</b>	2.12	0.57	2.50	0.102	41.89	94.4	0.24	6.72

	<b>CD (P=0.05)</b>	6.12	1.63	7.21	NS	120.68	272.0	0.70	19.35
	<b>CV (%)</b>	9.60	9.31	10.24	4.029	9.36	9.6	4.65	11.56
<b>Y</b>	<b>SEm ±</b>	1.001	0.267	1.180	0.048	19.748	44.503	0.115	3.166
	<b>CD (P=0.05)</b>	NS	NS	NS	NS	NS	NS	NS	NS
<b>Y × T</b>	<b>SEm ±</b>	3.004	0.801	3.539	0.144	59.245	133.510	0.344	9.497
	<b>CD (P=0.05)</b>	NS	NS	NS	NS	NS	NS	NS	NS

**Table 3: Economics of grain amaranth as influenced by different treatments of integrated nutrient management (Average of 2022-23 and 2023-24)**

Treatments	Yield (kg/ha)		Cost of cultivation (₹ /ha)			Gross returns (₹ /ha)	Net returns (₹ /ha)	BCR
	grain	Straw	Fixed Cost	Treatment Cost	Total			
<b>T<sub>1</sub></b> : 25 % N through FYM + 75% RDN through inorganic fertilizer	1078	2333	31160	17099	48259	84849	36590	1.76
<b>T<sub>2</sub></b> : FYM 5 t/ha + 100% RDN through inorganic fertilizer	1280	2728	31160	20635	51795	100610	48815	1.94
<b>T<sub>3</sub></b> : 25 % N through Biocompost +75% RDN through inorganic fertilizer	1106	2468	31160	4927	36087	87410	51323	2.42
<b>T<sub>4</sub></b> : Biocompost 5 t/ha + 100% RDN through inorganic fertilizer	1341	2796	31160	8135	39295	105064	65768	2.67
<b>T<sub>5</sub></b> : 25 % N through Vermicompost + 75% RDN through inorganic fertilizer	1146	2488	31160	16071	47231	90276	43045	1.91
<b>T<sub>6</sub></b> : Vermicompost 5 t/ha + 100% RDN through inorganic fertilizer	1371	2916	31160	43135	74295	107667	33372	1.45
<b>T<sub>7</sub></b> : FYM 5 t/ha	788	1893	31160	17500	48660	62853	14193	1.29
<b>T<sub>8</sub></b> : Bio compost 5 t/ha	830	1972	31160	5000	36160	66164	30004	1.83
<b>T<sub>9</sub></b> : Vermi compost 5 t/ha	924	2073	31160	40000	71160	73082	1922	1.03

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Note: Selling price of grain (₹ 68 and ₹ 70 /kg) and straw (₹ 4.5 /kg) in 2022-23 and 2023-24, respectively.

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## REFERENCES

1. Bartwal, D. (2022). Integrated nutrient management in coriander (*Coriandrum sativum* L.) and its residual effect on succeeding summer sesamum (*Sesamum indicum* L.) under south Gujarat condition. *Thesis Ph.D*; Navsari Agricultural University, Navsari (Gujarat). 168 p.
2. Grubben, G. J. H. and Von Sloten, D. H. (1981). *Genetic resources of amaranth: A global plan of action*. International Board for Plant Genetic Resource. FAO, Rome, Italy. 57 p.
3. Gunjal, G. K. (2011). Studies on integrated nutrient management in grain amaranth (*Amaranthushypochondriacus* L.). *Thesis M.Sc. (Agri.)*, University of Agricultural Sciences, Hebbal, Bengaluru (Karnataka). 121 p.
4. Jangir, R.; Thanki, J. D.; Tajane, D. and Kumar, S. (2019). Growth, yield and economics of grain amaranth (*Amaranthushypochondriacus* L.) as affected by integrated nitrogen management. *Int. J. Pure appl. Biosci.*, **7**(3): 329-334.
5. Keraliya, S. J.; Desai, L. J.; Patel, S. J. and Kanara, D. A. (2017). Effect of integrated nitrogen management on yield, quality and economics of grain amaranth (*Amaranthushypochondriacus* L.). *Int. J. Pure Appl. Biosci.*, **5**(6): 531-534.
6. Kushare, Y.; Shete, P.; Adhav, S. and Baviskar, V. (2010). Effect of FYM and inorganic fertilizer on growth and yield of *rabi* grain amaranth. *Int. J. Agric. Sci.*, **6**(2): 491-493.
7. Neeraja, C. R. (2013). Integrated nutrient management in grain amaranth (*Amaranthushypochondriacus* L.) under middle Gujarat conditions. *Thesis MSc. (Agri)*. Anand Agricultural University, Anand. 73 p.
8. Parmar, J. K. and Patel, J. J. (2009). Effect of nitrogen management on growth and yield of grain amaranth (*Amaranthus hypochondriacus* L.) grown on loamy sand soil. *Asian J. Soil Sci.*, **4**(1): 106-109.
9. Patel, R. S. (2022). Nutrient management in grain amaranth (*Amaranthushypochondriacus* L.) - fodder maize (*Zeamays* L.) sequence under south Gujarat condition. *Thesis Ph.D*; Navsari (Gujarat). 195 p.
10. Salmankhan, R. M.; Sukanya T. S.; Ameer P. B. and Parameshnaik C. (2023). Effect of integrated nutrient management on yield and economics of grain amaranth (*Amaranthushypochondriacus* L.). *Biol Forum.*, **15**(3): 128-132.

11. Srivastava, R. (2011). Nutritional quality of some cultivated and wild species of *Amaranthus*. *Int. J. Pharm. Sci.*, **2**(12): 3152.
12. Surjan, S. C.; Patel H. H.; Madagoudra Y. B.; Lokesh R. and Terin, P. (2021). The effect of irrigation and nitrogen levels on growth, yield and economics of grain amaranth (*Amaranthushypochondriacus* L.) *Pharma Innov*, **10**(9): 1146-1149.
13. Webb, D. M.; Smith, C. W. and Schutz-Schaeffer, J. (1987). Amaranth seedling emergence as affected by seedling date and temperature on a thermogradient plate. *AgronomyJ.*, **79** (1): 23-26.
14. Patel , M. P., B. N. Satodiya, K. V. Patel, Nitesh Baldaniya, and P. M. Parmar. 2024. "Effect of Organic Sources of Nitrogen on Growth, Yield, Quality and Economics of Vegetable Cluster Bean (*CyamopsisTetragonoloba* L.) in Organic Farming". *International Journal of Plant & Soil Science* 36 (1):10-16. <https://doi.org/10.9734/ijpss/2024/v36i14323>.
15. Sallawar , S. C., U. N. Alse, and S. G. Mane. 2023. "Effect of Integrated Nutrient Management on Yield, Economics and Available Soil Nutrient of Kharif Sorghum (*Sorghum Bicolor* L.)". *International Journal of Environment and Climate Change* 13 (8):881-88. <https://doi.org/10.9734/ijecc/2023/v13i82024>.
16. Patel, R., Pankhania, R. M., Bartwal, D., & Patel, A. (2024). Residual, direct and interaction effect of nutrient management on growth, yield, quality, and economics of fodder maize and soil nutrient balance under grain amaranth (*Amaranthus hypochondriacus* L.)–fodder maize [*Zea mays* (L.)] sequence in Inceptisols of Western India. *Cereal Research Communications*, 1-18.
17. Jangir, R., Thanki, J. D., Patil, K. B., & Saini, L. K. (2021). Residual and direct effect of integrated nutrient management on growth, yield, monetary efficiency, nutrient uptake of cowpea and soil properties under grain amaranth (*Amaranthus hypochondriacus* L.)–cowpea [*Vigna unguiculata* (L.) Walp] cropping sequence in Inceptisols of Western India. *Journal of Plant Nutrition*, 44(19), 2928-2948.
18. DhwaniBartwal, MS Dudhat, Rutul S Patel and AM Rathod. Effect of integrated nutrient management on growth, yield and economics of coriander (*Coriandrum sativum*L.) under south Gujarat conditions. *The Pharma Innovation Journal* 2022; 11(9): 730-733

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