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Effect of integrated nutrient management on growth and yield attributes, yield and nutrients uptake of grain amaranth (*Amaranthus hypochondriacus* L.)

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Abstract
A field experiment was conducted during *rabi* season of 2018-19 at Agronomy Instructional Farm, S. D. Agricultural University, Sardarkrushinagar, Gujarat to study the effect of integrated nutrient management on growth and yield attributes, yield and nutrients uptake of grain amaranth. Growth and yield attributes such as plant height, dry matter accumulation per plant, length of inflorescence, test weight, grain and stalk yield were recorded significantly higher by the application of 100% RDF + vermicompost @ 1 t/ha + seed inoculation with *Azotobacter* and PSB followed by 75% RDF + vermicompost @ 1.5 t/ha + seed inoculation with *Azotobacter* and PSB and 100% RDF + FYM @ 2.5 t/ha + seed inoculation with *Azotobacter* and PSB. It also recorded significantly higher N and P uptake and net returns.

Keywords: *Azotobacter*, economics, farm yard manure, grain amaranth, grain yield, PSB, recommended dose of fertilizer, Vermicompost, Vermiwash

Introduction
Grain amaranth (*Amaranthus hypochondriacus* L.) called a pseudocereal is an under exploited tropical novel crop with a high nutritive value. Amaranth locally known as *Rajagira* and it is grown during *rabi* season. Amaranth is a quick growing, bushy plant with thick stalk. The unique features are lower water and input requirement, tolerance to moisture stress with short growing period.

Imbalance use of fertilizers has been one of the key factors in declining the crop productivity and depleting the soil fertility. Balanced and optimum nutrition required for getting the maximum grain yield and quality. Organic manures are good complementary source of nutrients and improve the efficiency of the applied mineral nutrients on one hand and physical and biological properties of soil on the otherhand (Chaudhary *et al*., 2004) [1]. Application of different organics with *azospirillium* favourably influence the soil physical, chemical and biological environment such as bulk density, water holding capacity, organic carbon and available nitrogen (Kannan *et al*., 2005) [5]. Use of biofertlizer not only fixes the biological nitrogen but also solubilizes the insoluble phosphate in soil by PSB and thus improves fertilizer use efficiency (Gogoi, 2008) [4]. Therefore, any nutrient management practice that can improve organic matter status of soil is important. A judicious and combined use of organic and inorganic sources of plant nutrients is essential to maintain soil health and to augment the efficiency of nutrients. Additionally, such integration of organic manures, biofertilizers and inorganic nutrients source plays an important role in economizing the use of fertilizers under escalating cost which is restricting their use to an optimum level. Integration of cost-effective and eco-friendly biofertilizers with chemical fertilizers and organic manures is the alternate way for saving N fertilizers (Chaudhary *et al*., 2009) [2]. Hence, the present experiment was undertaken to find out the effect of integrated nutrient management on grain yield, quality and uptake of N and P by grain amaranth.

Materials and Methods
A field experiment was carried out during *rabi* season of 2018-19 at Agronomy Instructional Farm, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar. The experiment was conducted on loamy sand soil having low inorganic carbon (0.18%) and

available nitrogen (171 kg/ha), medium in available P_2O_5 (34.2 kg/ha) and potassium (239.5 kg/ha) with soil pH of 7.4. The experiment consisted of ten treatments *viz*., T_1: 100% RDF, T_2: 100% RDF + FYM @ 2.5 t/ha + seed inoculation with *Azotobacter* and PSB, T_3: 75% RDF + FYM @ 5 t/ha + seed inoculation with *Azotobacter* and PSB, T_4: 50% RDF + FYM @ 7.5 t/ha + seed inoculation with *Azotobacter* and PSB, T_5: 100% RDF + vermicompost @ 1 t/ha + seed inoculation with *Azotobacter* and PSB, T_6: 75% RDF + vermicompost @ 1.5 t/ha + seed inoculation with *Azotobacter* and PSB, T_7: 50% RDF + vermicompost @ 2 t/ha + seed inoculation with *Azotobacter* and PSB, T_8: 100% RDF + vermiwash @ 10% foliar spray at 30, 45 and 60 DAS, T_9: 75% RDF + vermiwash @ 10% foliar spray at 30, 45 and 60 DAS and T_{10}: 50% RDF + vermiwash @ 10% foliar spray at 30, 45 and 60 DAS. The experiment was laid out in randomized block design with three replications. The nutrient sources, *viz*. FYM (0.44% N, 0.19% P_2O_5, 0.42% K_2O), vermicompost (0.65% N, 0.77% P_2O_5, 0.40% K_2O) and required quantity of N and P in the form of urea and diammonium phosphate were applied as per treatments, respectively. Foliar spray of vermiwash @ 10% was done at 30, 45 and 60 DAS as per treatments. The seeds of amaranth were treated with *Azotobacter* and phosphorus solubilizing bacteria (PSB) @ 5 ml/kg seed just before sowing of the seeds. Amaranth variety GA-3 was sown @ 2.0 kg/ha seed rate at an inter-row spacing of 45 cm on 26th Oct, 2018. The recommended dose of fertilizer for grain amaranth is 60:40 kg N:P/ha. Full dose of phosphorus and half dose of nitrogen were applied at the time of sowing and remaining half dose of nitrogen was applied in two equal splits at 25 and 45 DAS as per treatments. Five random plants/plot were selected in the net plot area and tagged for recording growth and yield attributes. The crop was manually harvested, threshed and grain yield was recorded. The soil samples were collected from each plot after harvesting of amaranth at 0-15 cm depth and analyzed using standard procedures. The total Ncontent of plants was analyzed by micro-kjeldahl method and P by Olsen's method. The net return was computed using the prevailing market rates and prices for inputs and grain of amaranth.

Results and Discussion

Growth and yield attributes

Application of 100% RDF along with vermicompost @ 1.0 t/ha + seed inoculation with *Azotobacter* and PSB resulted in significantly taller plants. However, the plant height in the plots treated with 75% RDF + vermicompost @ 1.5 t/ha + seed inoculation with *azotobacter* and PSB and 100% RDF + FYM @ 2.5 t/ha along with seed inoculation of *azotobacter* and PSB was similar (Table 1).This may be owing to adequate and continuous supply of N and P_2O_5 through inorganic fertilizers along with vermicompost as well as seed inoculation with biofertilizers in combination which enhanced cell division and cell enlargement resulted in faster growth in term of taller plants. These results are in close vicinity with the findings of Chaudhary *et al*. (2009) [2] and Neerja (2013) [7]. Number of leaves per plant was marginally increased with integration of 100% or 75% RDF with vermicompost and biofertilizers but failed to show any significant improvement over rest of the treatments. These findings are in conformity with the results obtained by Patel *et al*. (2018) [8].

Higher length of inflorescence and dry matter accumulation was recorded with 100% RDF + vermicompost @ 1.0 t/ha + seed inoculation with *azotobacter* and PSB followed by 75% RDF + vermicompost @ 1.5 t/ha + seed inoculation with *azotobacter* and PSB as well as plot received 100% RDF + FYM @ 2.5 t/ha + seed inoculation with *azotobacter* and PSB. In present study, better nutrition of the plants owing to integration of either vermicompost or FYM with inorganic fertilizers and biofertilizers (*Azotobacter* and PSB) might have resulted in improvement in the length of inflorescence. In association with soil microorganisms, organic manures are known to help in synthesis of certain phytohormones and vitamins which promote growth and development of crops. The slow release of nutrients associated with vermicompost / FYM and adequate supply of N and P through inorganic fertilizers might have resulted in higher concentration of nutrients in plant cells resulting in higher dry matter accumulation. The highest dry matter accumulation per plant at harvest was recorded with 100% RDF + vermicompost @ 1.0 t/ha + seed inoculation with *azotobacter* and PSB followed by 75% RDF + vermicompost @ 1.5 t/ha + seed inoculation with *azotobacter* and PSB. These results are in accordance with the findings of Deshmukh *et al*. (2013) [3] and Yadav *et al*. (2017) [11].

Significantly higher test weight was recorded with application of 100% RDF + vermicompost @ 1 t/ha + seed inoculation with *azotobacter* and PSB being at par with treatments 75% RDF + vermicompost @ 1.5 t/ha + seed inoculation with *azotobacter* and PSB, 100% RDF + FYM @ 2.5 t/ha + seed inoculation with *azotobacter* and PSB and 50% RDF + vermicompost @ 2.0 t/ha + seed inoculation with *azotobacter* and PSB. Further, higher assimilating surface at reproductive development stage resulted in more production of metabolites and their translocation towards seed as evident from nutrient concentration and their uptake might have increased weight of individual grain of amaranth. Similar findings were also reported by Singh and Chauhan (2016) [10].

Yield

Application of 100% RDF + vermicompost @ 1 t/ha + seed inoculation with *azotobacter* and PSB resulted in significantly higher grain and stalk yield followed by 75% RDF + vermicompost @ 1.5 t/ha + seed inoculation with *azotobacter* and PSB and 100% RDF + FYM @ 2.5 t/ha + seed inoculation with *azotobacter* and PSB. Increase in grain yield with 100% RDF + vermicompost @ 1 t/ha + seed inoculation with *azotobacter* and PSB, 75% RDF + vermicompost @ 1.5 t/ha + seed inoculation with *azotobacter* and PSB and 100% RDF + FYM @ 2.5 t/ha + seed inoculation with *azotobacter* and PSB was 57.98, 47.64 and 46.29%, respectively over application of RDF only. Kushare *et al*. (2010) [6] reported that significantly higher length of main inflorescence and seed yield per plant lead to higher seed yield of amaranth. It is obvious that phosphate solubilizing bacteria produced higher quantity of organic acids which dissolved insoluble phosphate and made it available to plants. These findings indicated that combined use of organic sources (vermicompost/FYM and biofertilizers) and inorganic fertilizers proved more superior over application of chemical fertilizer (RDF) only (Singh *et al*., 2015) [9].

Quality

The protein content in grain was significantly influenced by different nutrient management practices. Higher protein content was registered with application of 100% RDF + vermicompost @ 1 t/ha + seed inoculation with *azotobacter* and PSB followed by 75% RDF + vermicompost @ 1.5 t/ha + seed inoculation with *azotobacter* and PSB and 100% RDF

+FYM @ 2.5 t/ha + seed inoculation with *azotobacter* and PSB. As N is a basic constituent of protein and with the increase rate of N application from organic manures and inorganic fertilizers the N availability increased which resulted in enhanced protein content in seeds. Singh *et al*. (2015) [9] claimed that integrated nutrient management i.e. 75% RDN through inorganic sources + 25% through vermicompost + biofertilizers registered higher protein content in sorghum.

Nutrients uptake

Significantly higher total uptake of N and P was recorded with the application of 100% RDF + vermicompost @ 1 t/ha + seed inoculation with *azotobacter* and PSB followed by 75% RDF + vermicompost @ 1.5 t/ha + seed inoculation with *azotobacter* and PSB and 100% RDF + FYM @ 2.5 t/ha + seed inoculation with *azotobacter* and PSB (Table 2). The uptake of nitrogen and phosphorus was more in vermicompost treated plots than in FYM treated plots, owing to better availability of phosphorus in crop root zone resulting from its solubilization caused by the organic acids, produced from decaying organic matter. The increase in N uptake might be attributed to enhanced activity of nitrogenase and nitrate reductase enzyme in soil. Chaudhary *et al*. (2009) [2] and Neerja (2013) [7] also recorded the highest uptake of N and P by grain amaranth with integrated nutrient management.

Soil fertility

Integrated nutrient management treatments had no significant effect on available N and P_2O_5 in the soil (Table 2). However, slight improvement was recorded due to application of organic manure (VC/FYM) along with biofertilizers than the inorganic treatment (100% RDF) and treatments recieved 100 %, 75 % and 50 % RDF through inorganic fertilizers + foliar spray of vermiwash @ 10 % at 30, 45 and 60 DAS. Fertility status of major nutrients (N and P) was improved by application of vermicompost and FYM in combination with 100 % RDF or 75 % RDF + *azotobacter* and PSB over the initial values.

Table 1: Effect of integrated nutrient management on growth and yield attributes, protein content and yield of grain amaranth

Treatments	Plant height (cm)	Number of leaves /plant	Length of inflorescence (cm)	Dry matter accumulation at harvest (g/plant)	1000 grain weight (g)	Protein content (%)	Grain yield (kg/ha)	Stalk yield (kg/ha)
T_1 : 100% RDF	118.1	27.5	47.9	37.5	0.67	12.15	1335	4651
T_2 : 100% RDF + FYM @ 2.5 t/ha + *Azotobacter* and PSB	132.3	31.3	54.1	44.8	0.79	12.77	1953	5785
T_3 : 75% RDF + FYM @ 5.0 t/ha + *Azotobacter* and PSB	124.2	28.8	48.8	41.8	0.69	12.35	1597	4926
T_4 : 50% RDF + FYM @ 7.5 t/ha + *Azotobacter* and PSB	127.2	29.9	48.9	41.9	0.70	12.46	1656	5384
T_5 : 100% RDF + VC @ 1.0 t/ha + *Azotobacter* and PSB	153.8	32.9	56.4	48.5	0.81	13.46	2109	6421
T_6 : 75% RDF + VCt @ 1.5 t/ha + *Azotobacter* and PSB	144.5	32.0	56.1	47.4	0.80	13.15	1971	6013
T_7 : 50% RDF + VC @ 2.0 t/ha + *Azotobacter* and PSB	127.5	30.3	52.6	42.1	0.76	12.71	1670	5719
T_8 : 100% RDF + vermiwash @ 10% at 30, 45 and 60 DAS	121.8	28.5	48.3	40.1	0.68	12.23	1368	4685
T_9 : 75% RDF + vermiwash @ 10% at 30, 45 and 60 DAS	108.3	26.5	46.4	34.0	0.66	11.75	1268	4550
T_{10}: 50% RDF + vermiwash @ 10% at 30, 45 and 60 DAS	105.6	26.2	45.4	32.7	0.64	11.66	1192	4245
S.Em.±	8.66	1.54	2.36	2.15	0.03	0.33	121.17	342.44
C.D.(P = 0.05)	25.7	NS	7.0	6.4	0.10	0.97	359	1017
C.V. (%)	11.87	9.06	8.09	9.08	8.06	4.55	13.02	11.32

RDF: Recommended dose of fertilizer, FYM: Farm yard manure, VC: Vermicompost, PSB: Phosphate solubilizing bacteria

Economics

Higher net return of ₹92399/ha was obtained with application of 100% RDF + vermicompost @ 1 t/ha seed inoculation with *azotobacter* + PSB followed by 100% RDF + FYM @ 2.5 t/ha + seed inoculation with *azotobacter* and PSB. Higher BCR was observed with 100% RDF + FYM @ 2.5 t/ha + seed inoculation with *azotobacter* and PSB.Integration of organic manure (FYM/vermicompost), biofertilizers along with chemical fertilizers were found more remunerative with respect to net return which attributed due to higher grainyield. These findings are in accordance with those reported by Neerja (2013) [7].

Conclusion

Based on the above mentioned findings, it is concluded that application of 100% RDF (60-40-00 kg N-P-K/ha) + vermicompost @ 1 t/ha + seed inoculation with *Azotobacter* and PSB or 75% RDF (45-30-00 kg N-P-K/ha) + vermicompost @ 1.5 t/ha + seed inoculation with *Azotobacter* + PSB for obtaining higher grain yield, nutrients uptake and net returns from grain amaranth.

Table 2: Effect of integrated nutrient management on quality, nutrients uptake and economics of grain amaranth

Treatments	Total N uptake (kg/ha)	Total P uptake (kg/ha)	Available nutrients (kg/ha)		Cost of cultivation (₹/ha)	Net returns (₹/ha)	B : C ratio
			N	P_2O_5			
T_1 : 100% RDF	66.5	13.6	169.2	33.8	25687	53401	3.08
T_2 : 100% RDF + FYM @ 2.5 t/ha + *Azotobacter* and PSB	95.2	19.8	175.8	36.3	28839	86351	3.99
T_3 : 75% RDF + FYM @ 5.0 t/ha + *Azotobacter* and PSB	76.2	17.0	171.1	34.6	31263	63028	3.02
T_4 : 50% RDF + FYM @ 7.5 t/ha + *Azotobacter* and PSB	82.5	15.8	172.3	34.7	33687	64225	2.91
T_5 : 100% RDF + VC @ 1.0 t/ha + *Azotobacter* and PSB	110.3	22.1	177.1	37.1	32079	92399	3.88
T_6 : 75% RDF + VCt @ 1.5 t/ha + *Azotobacter* and PSB	100.8	20.4	176.4	36.8	34613	81726	3.36
T_7 : 50% RDF + VC @ 2.0 t/ha + *Azotobacter* and PSB	87.5	17.9	173.3	35.1	37147	61738	2.66
T_8 : 100% RDF + vermiwash @ 10% at 30, 45 and 60 DAS	68.5	14.1	170.5	34.3	26399	54604	3.06
T_9 : 75% RDF + vermiwash @ 10% at 30, 45 and 60 DAS	62.9	12.9	168.9	33.5	25802	49383	2.91

T_{10}: 50% RDF + vermiwash @ 10% at 30, 45 and 60 DAS	58.1	12.0	167.0	33.1	25207	45456	2.80
Initial status (kg/ha)	-	-	171.0	34.2	-	-	-
S.Em.±	4.42	1.0	4.21	0.89			
C.D.(P = 0.05)	13.1	3.1	NS	NS			
C.V. (%)	9.47	10.89	4.23	4.43			

RDF: Recommended dose of fertilizer, FYM: Farm yard manure, VC: Vermicompost, PSB: Phosphate solubilizing bacteria

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