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Effect of integrated nitrogen management treatments on yield of soybean [*Glycine max* (L.) Merrill] and their residual effect on growth, yield, quality, soil parameter and economics on grain Amaranthus

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Abstract
Soybean being an important pulse as well as oil seed needs special mention to overcome crisis in edible oil production in the country. It is also called as "Gold of soil". An experiment was conducted at College of Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand (Gujarat) during *kharif* (Soybean) and *rabi* (Amaranthus) season of the years 2019-20 and 2020-21. An agronomical investigation on effect of integrated nitrogen management in soybean and their residual effect on grain amaranthus under irrigated condition. There were ten integrated nitrogen management treatments arranged in Randomized Block Design with 4 replications. Integrated use of the organic and inorganic sources of plant nutrients on growth and yield attributes is very crucial for the assurance of food securities. Different observation on the crop parameters were carried out during course of investigation. All the growth and yield parameters *viz.*, number of pods/plant, seed yield and straw yield were recorded significantly higher with application of 50% RDN through vermicompost + 50% RDN through inorganic fertilizer (T_3). Residual amaranthus crop, integrated nitrogen managements did not exert any significant response on plant height at 30 DAS. Significantly higher growth parameters *viz*., plant height at harvest, panicle length, spikelet length, grain yield and straw yield were recorded by application of 50% RDN through FYM + 50% RDN through inorganic fertilizer (T_2) during pooled of two years.

Keywords: Nitrogen, soybean, vermicompost, FYM, Amaranthus

1. Introduction
Soybean is finding its place in policy agenda of industrial, medicinal and food sector on India due to wide spectrum of its chemical composition. Soybean [*Glycine max* (L.) Merrill] is one of the major important oilseed crop in the world and belongs to the family *fabaceae*. Soybean is considered as a wonder crop due to its dual qualities *viz*., high protein (40-42%) and oil content (20%). In India, the total area under soybean cultivation is 11.2 million metric hectares with the production and the productivity of 10.5 million metric tonnes and 937 kg/ha respectively (Anon., 2019-20) [1].

The integrated nutrient management plays the way to overcome the problems which involved conjunctive used of chemical fertilizers, organic manures and bio fertilizers to crop production and maintain soil health. The organic manures along with bio fertilizer help in reducing the dose of inorganic fertilizer, which in turn reduced the cost of cultivation and help to improve the soil health. Efficient management of organic and inorganic source is prerequisite. Organic matter forms a very important source of plant nutrients whereas organic manures are used to supply both macro and micronutrients and sustain amount of humic substances particularly humic and fulvic acid that helps to maintain soil pH. Appropriate and conjunctive used of application of suitable nutrients through organic and inorganic solely or in combination can provided the solutions to the problem such as increase price of inorganic fertilizers and deterioration effect of soil fertility and productivity. At present soybean is one of the most important economical crops and having good nutritional response on healthy diet and information of same cropping sequence was not available for farming community so planned study on the application of organic sources of nutrients *viz*., vermicompost, FYM, bio-fertilizers (Rhizobium + PSB) under middle Gujarat conditions.

Soybean – cereal is one of the most prevalent cropping sequence followed in a substantial area of Madhya Pradesh and adjacent areas of Gujarat like Dahod and Panchmahal districts.

Grain amaranthus (*Amaranthus hypochondriacus* L.) is a potential upcoming subsidiary food crop of the future. Being C_4 plant it has more efficiency of nitrogen utilization and photosynthesis along with yield potential more than 50 q/ha.

2. Materials and Methods

A field experiment was conducted at College Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand, (Gujarat) during *kharif* (Soybean) and *rabi* (Amaranthus) season of the years 2019-20 and 2020-21. The soil of experimental field was loamy sand in texture having good drainage. The pH was alkaline and low in soluble salts. The experimental site was deficient in organic carbon, low available nitrogen, medium in available phosphorus and available potassium. The experiment was laid out in Randomized Block Design with 4 replications. The ten integrated nitrogen management treatments *viz.*, RDN (45 kg ha^{-1}) through inorganic fertilizer (T_1), 50% RDN through FYM + 50% RDN through inorganic fertilizer (T_2), 50% RDN through vermicompost + 50% RDN through inorganic fertilizer (T_3), 50% RDN through castor cake + 50% RDN through inorganic fertilizer (T_4), Bio NP (*Rhizobium* + PSB) + 50% RDN through inorganic fertilizer (T_5), 25% RDN through FYM + 75% RDN through inorganic fertilizer (T_6), 25% RDN through vermicompost + 75% RDN through inorganic fertilizer (T_7), 25% RDN through castor cake + 75% RDN through inorganic fertilizer (T_8), Bio NP (*Rhizobium* + PSB) + 75% RDN through inorganic fertilizer (T_9) and 25% RDN through FYM + Bio NP (*Rhizobium* + PSB) seed treatment + Soil drenching at 20 DAS (T_{10}) were studied.

Five plants from each net plot were selected and used for the recording biometric observations at importance critical growth stages. The statistical analysis was carried out on pooled basis.

3. Results and Discussion

3.1 Effect of integrated nitrogen management treatments on yield of soybean

Number of pods/plant (55.25) was higher in treatment T_3 (50% RDN through vermicompost + 50% RDN through inorganic fertilizer) than rest treatments except treatment T_2 (50% RDN through FYM + 50% RDN through inorganic fertilizer). Application of organic manure/Vermicompost application through delayed leaf senescence and this might be the reason for increased seed weight. Secondly, better growth and development of crop plants due to nitrogen supply might have increased the supply of assimilates to seed, which ultimately gained more weight.

The results of data revealed that seed yield and stover yield of soybean significantly escalated with integrated nutrient management treatments (Table 1 and Fig. 1). Application of 50% RDN through vermicompost + 50% RDN through inorganic fertilizer (T_3) reported higher seed (2205 kg/ha) and stover yield (2811 kg/ha). Treatment T_3 did not differed significantly with treatments T_1, T_2 and T_4 in seed yield while in case of stover yield treatment T_3 was closely related to treatments T_2 and T_4. The seed yield was higher with application of 50% RDN through vermicompost + 50% RDN through inorganic fertilizer due to the higher availability of nutrients as well as amino acids, vitamins and growth promoting substance throughout the crop growth; it led to the increased number of pods/plant resulting in higher seed yield. Other reason might be due to increasing yield might be due to the increased growth and yield attributes i.e., plant height and number of branches/plant resulting in favourable environment for vegetatively as well as reproductively crop growth from initial growth stage to harvest, thus enabling the crop for maximum utilization of nutrients, moisture, light, and space which consequently caused significant increase in photosynthesis and dry matter accumulation, which resulted in higher stover yield of soybean.

3.2 Residual effect of integrated nitrogen management on Amaranthus crop

Effect of integrated nitrogen management treatment on plant height at 30 DAS did not exert any significantly differences during the pooled analysis. Significantly higher plant height of Amaranthus at harvest (125.7 cm) was recorded under application of 50% RDN through FYM + 50% RDN through inorganic fertilizer (T_2), which was closely related to the treatments T_3 and T_4. The highest plant height may be due to the positive effects of application of FYM which had accelerated various metabolic processes and resulted in increasing vegetative growth. These result corroborated the earlier findings obtain by Jaybhay *et al*. (2015) [3] and Singh and Kushwaha (2018) [2].

Significantly higher panicle length of Amaranthus (61.2 cm) recorded under application of 50% RDN through FYM + 50% RDN through inorganic fertilizer (T_2). But, it was very closely followed by treatment T_3 and recorded 60.1 cm panicle length. It might be due to that integrated use of chemical fertilizers with organics *viz.*, FYM, vermicompost might have added huge quantity of organic matter in soil that resulted in higher yield attributes and yield. These result similar with obtain by Sharma *et.al*. (2001) [4] and Jaybhay *et al*. (2015) [3].

Higher spikelet length of 12.9 cm recorded with application of 50% RDN through FYM + 50% RDN through inorganic fertilizer (T_2). However, it did not different with treatments *viz.*, T_3 and T_4. This might be due to that impact of residual nitrogen that remained in to soil due to low requirement of soybean as well as higher fixation of atmospheric nitrogen into soil, become available to residual amaranthus crop. The resultant cumulative effect than finally increase spikelets length and yield attributes of amaranthus. These result similar with obtain by Sharma *et.al*. (2001) [4] and Jaybhay *et al*. (2015) [3].

Significantly higher grain yield (2426 kg/ha) recorded under application of 50% RDN through FYM + 50% RDN through inorganic fertilizer (T_2) in pooled analysis. But, it failed to be statistically different with treatments T_1 (2267 kg/ha), T_3 (2385 kg/ha), T_4 (2285 kg/ ha) and T_6 (2312 kg/ha). It confirmed the findings of Sharma *et al*. (2001) [4], Thakur *et al*. (2011) [6], Jaybhay *et al*. (2015) [3], Singh and Kushwaha (2018) [2] and Singh *et al.* (2020) [5].

Significantly higher straw yield of 4575 kg/ha recorded under treatment T_2 (50% RDN through FYM + 50% RDN through inorganic fertilizer). However, treatments T_1, T_3 and T_4 were statistically at par during the pooled analysis. It is close agreement with findings of Singh and Kushwaha (2018) [2] and Singh *et al.* (2020) [5].

Different nitrogen management treatments did not showed their significant influence on harvest index of amaranthus during both the years. Protein content of amaranthus grain was significantly higher under application of 50% RDN through FYM + 50% RDN through inorganic fertilizer (T_2) was significantly higher as compare to other treatments.

However, treatment T_2 and T_3 were statistically at par relation. Significantly higher organic carbon content of soil (0.57%) recorded under application of 50% RDN through vermicompost + 50% RDN through inorganic fertilizer (T_2). However, treatments T_1, T_3 and T_4 remained at par relation. Effect of integrated nitrogen management was did not showed any statistical differences with respect to pH and EC of soil during both the years. Further, significantly higher available nitrogen after harvest of Amaranthus crop (195.2 kg/ha) was recorded under treatment T_2 (50% RDN through FYM + 50% RDN through inorganic fertilizer). But, it was remained at par with treatments T_1, T_3 and T_4 in pooled results. Effect of integrated nitrogen management was did not show any statistical differences with respect to available phosphorus content in soil after harvest of Amaranthus crop during both the years.

Residual effect of application of 50% RDN through FYM + 50% RDN through inorganic fertilizer (T_2) gave higher net realization ₹.104777/ha along with BCR value of 6.56 from Amaranthus crop over rest of the treatments. Thus, the results clearly revealed that application of 50% RDN through FYM + 50% RDN through inorganic fertilizer (T_2) to preceding soybean helped to achieve highest net realization and benefit to cost ratio from Amaranthus. The lowest net returns of ₹.81576/ha were recorded under residual effect of treatment T_5 [Bio NP (*Rhizobium* + PSB) + 50% RDN through inorganic fertilizer] with minimum BCR value of 5.33. It is close agreement with findings of Chitale *et al*. (2016) [7], Prajapati and Vyas (2016) [9] and Mehetre *et al.* (2019) [8].

Table 1: Effect of integrated nitrogen management treatment on yield parameters on Soybean.

Treatment		Number of pods/plant	Seed yield (kg/ha)	Stover yield (kg/ha)
T_1		52.47	2021	2479
T_2		54.34	2162	2690
T_3		55.25	2205	2811
T_4		53.64	2043	2642
T_5		49.13	1643	2172
T_6		51.00	1926	2484
T_7		52.08	1989	2507
T_8		50.12	1909	2399
T_9		50.02	1839	2363
T_{10}		49.51	1744	2315
S.Em ±	Y	29	38	0.07
	T	65	79	0.16
	Y ×T	92	119	0.23
C. D. at 5%	Y	NS	NS	NS
	T	184	239	0.47
	Y ×T	NS	NS	NS
C.V. %		5.05	9.46	9.56

Table 2: Effect of integrated nitrogen management treatment on growth, yield and quality parameters on succeeding Amaranthus crop.

Treatment	Organic carbon (%)	Soil EC (ds m^{-1})	Soil pH	Available nitrogen (kg/ha)	Available phosphorus (kg/ha)
T_1	0.55	0.14	8.19	188.6	42.48
T_2	0.57	0.13	8.23	195.2	43.18
T_3	0.56	0.13	8.21	191.6	42.63
T_4	0.55	0.14	8.20	189.8	42.68
T_5	0.52	0.13	8.14	176.7	41.60
T_6	0.53	0.14	8.18	185.0	42.22
T_7	0.54	0.14	8.18	185.7	42.41
T_8	0.53	0.13	8.17	184.3	42.12
T_9	0.52	0.14	8.17	181.8	41.85
T_{10}	0.52	0.13	8.16	181.5	41.81
S.Em. ±	0.003	0.001	0.007	1.11	0.15
	0.007	0.004	0.016	2.33	0.33
	0.010	0.006	0.023	3.54	0.49
C. D. at 5%	NS	NS	NS	NS	NS
	0.019	NS	NS	6.57	NS
	NS	NS	NS	NS	NS
C.V. %	3.72	8.73	0.58	3.80	2.33

Table 3: Soil parameters status after harvest Amaranthus crop as influenced by integrated nitrogen management treatments

Treatment	Organic carbon (%)	Soil EC (ds m^{-1})	Soil pH	Available nitrogen (kg/ha)	Available phosphorus (kg/ha)
T_1	0.55	0.14	8.19	188.6	42.48
T_2	0.57	0.13	8.23	195.2	43.18
T_3	0.56	0.13	8.21	191.6	42.63
T_4	0.55	0.14	8.20	189.8	42.68
T_5	0.52	0.13	8.14	176.7	41.60
T_6	0.53	0.14	8.18	185.0	42.22
T_7	0.54	0.14	8.18	185.7	42.41
T_8	0.53	0.13	8.17	184.3	42.12
T_9	0.52	0.14	8.17	181.8	41.85
T_{10}	0.52	0.13	8.16	181.5	41.81
S.Em. ±	0.003	0.001	0.007	1.11	0.15
	0.007	0.004	0.016	2.33	0.33
	0.010	0.006	0.023	3.54	0.49
C. D. at 5%	NS	NS	NS	NS	NS
	0.019	NS	NS	6.57	NS
	NS	NS	NS	NS	NS
C.V. %	3.72	8.73	0.58	3.80	2.33

Table 4: Economics of Amaranthus as influenced by integrated nitrogen management treatments

Treatment	Yields (kg/ha)		Total cost of cultivation (₹/ha)	Gross realization (₹/ha)	Net realization (₹/ha)	BCR
	Grain	Straw				
T_1	2267	4210	18818	115455	96637	6.13
T_2	2426	4591	18818	123595	104777	6.56
T_3	2385	4408	18818	121454	102636	6.45
T_4	2285	4280	18818	116390	97572	6.18
T_5	1970	3788	18818	100394	81576	5.33
T_6	2312	4169	18818	117684	98866	6.25
T_7	2223	4142	18818	113221	94403	6.01
T_8	2148	4029	18818	109414	90596	5.81
T_9	2121	3952	18818	108026	89208	5.74
T_{10}	2086	3858	18818	106229	87411	5.64

Sale price: Seed: ₹ 50.00/kg, Stover: ₹ 0.5/kg

4. Conclusion

On the basis of results of two years of field experiment, it can be concluded that application of 50% RDN through vermicompost + 50% RDN through inorganic fertilizer produced the maximum yield of soybean crop. In succeeding Amaranthus crop, application of 50% RDN through FYM + 50% RDN through inorganic fertilizer application gave produced higher growth, yield and quality parameters of crop.

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