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Integrated nutrient management studies on French bean (*Phaseolus vulgaris* L.) quality attributes in Vertisols of Chhattisgarh plain

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Abstract
The experiment was comprised of with eight treatments i.e. T_1: 75% RDF + 2.5 t FYM ha^{-1}, T_2: 50% RDF + 5.0 t FYM, T_3: 25% RDF + 7.5 t FYM, T_4: 75% RDF + 1 t vermicompost, T_5: 50% RDF + 2 t vermicompost, T_6: 25% RDF + 3 t vermicompost, T_7: Recommended doses of fertilizer and T_8: Control (without application) which were laid out in randomize block design with three replications. The present study revealed that the quality parameters *viz.* total soluble solids (TSS%), sugar content (%), protein content (%) of green pods, moisture content (%) of green pods, ascorbic acid content (mg/100 g) of green pods and dry matter content (%) was also recorded maximum under 75% RDF + 1 t vermicompost.

Keywords: Nutrient management, French bean (*Phaseolus vulgaris* L.), attributes in vertisols

Introduction
French bean (*Phaseolus vulgaris* L.), is one of the most important and widely cultivated legume crops on the globe. It is commonly known by different names such as snap bean, string bean, kidney bean, haricot bean, fresh bean, navy bean etc. The crop thrives well in diverse environments of the world ranging from tropical to temperate regions (Mongi *et al.*, 2016) [11]. It is a short duration and highly relished vegetables in North India. Its pods are used as a green vegetable, green shelled, or dry as pulses according to stage of harvest. French bean is an excellent source of protein. The pods are cooked fresh or processed as frozen. Hundred grams of green pods contain 1.7 g protein, 4.5 g carbohydrates, 221 I.U. vitamin A, 11 mg vitamin C, 50 mg Calcium (Gopalakrishnan, 2007) [5].

India is the second largest producer of vegetables next to China in the world. In India, it is grown in an area of 9.575 million hectares with the productivity of 17.7 MT/ha which contributes around 14% of the total world production (Anonymous, 2017) [2].

Over the decades, the pressure on legume production has increased significantly, which leading to the extensive use of chemical fertilizers. The use of chemical fertilizers not only affects on the human health but it also deteriorates the field soil health (Kanwar *et al.*, 2020) [7]. There is a worldwide consensus that sole dependence on chemical input based agriculture. Chemical fertilizer is not suitable in long run due to increase in cost and reduction in soil health and the solution of such a problem lies in the use of organic manures either solely or in combination with the chemical fertilizers (Sachan and Krishna, 2020) [14] to sustain crop production, to preserve soil health as well as biodiversity.

Organic manure is one of the major organic nutrient components in integrated nutrient management. Organic manures increase the fertility of land by increasing the NPK content, water holding capacity and productivity of soil (Parween *et al.*, 2019) [12]. Organic manures have been the traditional means of maintaining soil fertility as it provides a balanced source of nutrient for crops and accelerate the biological activity.

French bean crop is especially characterized by lack of nodules due to absence of NOD gene regulator. It is not efficient in nitrogen fixation (Kushwaha, 1994) [9]. Being a fertilizer responsive crop, French bean responds well to nutrition. Like other legumes it also fixes atmospheric nitrogen and improves soil fertility and therefore, it requires large quantity of nitrogenous fertilizer, where application of excessive of chemical fertilizer in French bean increases the residual toxicity in the harvested produce which affects human and soil health(Sachan and Krishna, 2020) [14]. The modern day intensive crop cultivation requires the use of chemical fertilizers. But, the price of inorganic fertilizers has gone up considerably which in turn has increased the cost of production. Use of inorganic fertilizers not only

increased the cost of production but also decreased over all soil fertility causing health problems (Ramana *et al.*, 2010) [13]. Vermicompost and FYM are highly efficient organic manures, which can increase production and improve the quality of vegetables. These organic manures increase the fertility of land by increasing the NPK content, water holding capacity and productivity of soil. Organic manures have been the traditional means of maintaining soil fertility as it provides a balanced source of nutrient for crops and accelerate the biological activity.

Organic manures are eco-friendly, cheap source of nutrients and are potentially sound for supplying nutrients which can reduce dependence on chemical fertilizers. Organic resources are largely biological in origin and they have several nutrients in their composition, which on decomposition are released into soil (Kumar *et al.*, 2014) [8]. Organic sources of the plant nutrients have been reported to improve nutritional quality, protein content and mineral content in crops as compared to those with inorganic sources (Bhadoria *et al.*, 2002) [3].

French bean, being a fertilizer responsive crop, responds well to nutrition, while excess nitrogen results in poor pod yield. Like other legumes it also fixes atmospheric nitrogen and improves soil fertility. Application of higher doses of nitrogen especially for seed crop of French bean is imperative for realising its potential yield (Sardana *et al.*, 2006) [15].

Material and Methods

The experiment was conducted to study integrated nutrient management in French bean quality attributes in vertisols of Chhattisgarh plain. The investigation was performed at Horticultural Research cum Instructional Farm, IGKV, Raipur, Chhattisgarh during rabi 2020-21 and 2021-22. The design used to analyze and perform experiment was Randomized Block Design with three replications and eight treatment combination containing varying nutrient concentrations *viz.*, T_1 – 75% RDF + 2.5 t FYM ha^{-1}, T_2- 50% RDF + 5.0 t FYM, T_3- 25% RDF + 7.5 t FYM, T_4- 75% RDF + 1 t vermicompost, T_5- 50% RDF + 2 t vermicompost, T_6- 25% RDF + 3 t vermicompost, T_7- Recommended doses of fertilizer, T_8- Control (without application. Plot size was 3.0 m x 4.0 m with spacing of 45 cm x 30 cm between row and plant, respectively. Fertilizer was applied as a recommended dose of 80: 60:30 kg ha^{-1} NPK. First irrigation was applied just after sowing while subsequent five irrigations were provided as crop needed and on critical stages. The observations were recorded for quality attributing characters like total soluble solids (TSS%), sugar content (%), protein content (%) of green pods, moisture content (%) of green pods, ascorbic acid content (mg/100 g) of green pods and dry matter content (%).

Result and Discussion

Quality Parameters

Total soluble solids (%): Among the treatments, maximum total soluble solids (%) (6.68 and 6.82%) was recorded in T_4 - 75% RDF + 1 t vermicompost during 2020-21,2021-22 and in mean data, respectively. However, minimum total soluble solids (%) (5.02, 5.30 and 5.16%) was recorded in T_5 - 50% RDF + 2 t vermicompost during 2020-21, 2021-22 and in mean data, respectively.

Protein content (%) of green pods: Among the treatments, maximum protein content (%) (6.24, 5.96 and 5.91%) was recorded in T_5 - 50% RDF + 2 t vermicompost, T_2 - 50% RDF + 5.0 t FYM and T_4 - 75% RDF + 1 t vermicompost during 2020-21, 2021-22 and in data, respectively. However, minimum protein content (%) (4.66, 5.23 and 4.95%) was recorded in T_7 - Recommended doses of fertilizer and during 2020-21, 2021-22 and in mean data, respectively.

This might have been due to the increased nitrogen availability and uptake in case of heavy fertilization and nitrogen being an essential component of seed protein. These results are in harmony with Gupta *et al*. (1996) [6] and Abdel-Mawgoud *et al*. (2005) [1].

Sugar content (%): Among the treatments, maximum sugar content (%) (0.89%) in T_5 - 50% RDF + 2 t vermicompost during 2020-21, (0.88 and 0.87%) were recorded in T_6 - 25% RDF + 3 t vermicompost during 2021-22 and in mean data, respectively. However, minimum sugar content (%) (0.80, 0.78 and 0.81%) was recorded in T_8 - Control (without application), T_7 - Recommended doses of fertilizer and T_1 - 75% RDF + 2.5 t FYM during 2020-21, 2021-22 and in mean data, respectively.

Moisture content (%) of Green pods: Among the treatments, maximum moisture content (%) (87.57, 85.40 and 85.48%) was recorded in T_2 - 50% RDF + 5.0 t FYM, T_4 - 75% RDF + 1 t vermicompost and T_2 - 50% RDF + 5.0 t FYM during 2020-21, 2021-22 and in mean data, respectively. However, minimum moisture content (%) (83.53, 83.10 and 83.89%) was recorded in T_4 - 75% RDF + 1 t vermicompost, T_1 - 75% RDF + 2.5 t FYM and T_3 - 25% RDF + 7.5 t FYM during 2020-21, 2021-22 and in mean data, respectively.

Ascorbic acid content (mg/100 g) of green pods: Among the treatments, maximum ascorbic acid content (mg/100 g) (15.90, 16.03 and 15.79 mg/100 g) was recorded in T_7 - Recommended doses of fertilizer, T_8 - Control (without application) and T_7 - Recommended doses of fertilizer during 2020-21, 2021-22 and in mean data, respectively. However, minimum ascorbic acid content (mg/100 g) (14.47, 14.87 and 15.19 mg/100 g) was recorded in T_1 - 75% RDF + 2.5 t FYM, T_2 - 50% RDF + 5.0 t FYM and T_1 - 75% RDF + 2.5 t FYM during 2020-21, 2021-22 and in mean data, respectively.

Dry matter content (%): Among the treatments, maximum dry matter content (%) (11.40, 11.61 and 11.51%) was recorded in T_4 - 75% RDF + 1 t vermicompost during 2020-21, 2021-22 and in mean data, respectively. However, minimum dry matter content (%) was recorded (10.50, 10.49 and 10.49%) in T_8 - Control (without application) during 2020-21, 2021-22 and in mean data, respectively.

Table 1: Effect of integrated nutrient management on TSS%, sugar content and protein content of French bean

Treatment	TSS (%)			Protein content (%)			Sugar content (%)		
	2020-21	2021-22	Mean	2020-21	2021-22	Mean	2020-21	2021-22	Mean
T_1	6.00	6.12	6.06	5.38	5.45	5.42	0.81	0.80	0.81
T_2	5.86	6.06	5.96	5.64	5.96	5.80	0.85	0.82	0.84
T_3	5.54	5.66	5.60	6.05	5.75	5.90	0.83	0.86	0.84
T_4	6.66	6.98	6.82	6.04	5.77	5.91	0.81	0.83	0.82
T_5	5.96	6.10	6.03	6.24	5.38	5.81	0.89	0.79	0.84

T_6	5.60	5.82	5.71	5.45	5.74	5.60	0.86	0.88	0.87
T_7	6.60	6.14	6.37	4.66	5.23	4.95	0.88	0.78	0.83
T_8	5.02	5.30	5.16	5.18	5.81	5.50	0.80	0.82	0.81
S.Em ±	0.70	0.56	0.63	0.36	0.51	0.44	0.08	0.05	0.07
CV (%)	20.52	16.00	18.35	11.03	15.77	13.63	17.37	11.10	14.65
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 2: Effect of integrated nutrient management on ascorbic acid, moisture content and dry matter content of French bean

Treatment	Moisture content (%)			Ascorbic acid (mg/100 g)			Dry matter content (%)		
	2020-21	2020-21	Mean	2020-21	2021-22	Mean	2021-22	2021-22	Mean
T_1	87.20	14.47	15.92	14.47	15.92	14.47	15.92	0.80	0.81
T_2	87.57	15.65	14.87	15.65	14.87	15.65	14.87	0.82	0.84
T_3	84.57	15.56	15.08	15.56	15.08	15.56	15.08	0.86	0.84
T_4	83.53	15.52	15.92	15.52	15.92	15.52	15.92	0.83	0.82
T_5	83.93	15.50	15.67	15.50	15.67	15.50	15.67	0.79	0.84
T_6	86.10	15.10	15.60	15.10	15.60	15.10	15.60	0.88	0.87
T_7	85.27	15.90	15.68	15.90	15.68	15.90	15.68	0.78	0.83
T_8	83.63	15.27	16.03	15.27	16.03	15.27	16.03	0.82	0.81
S.Em ±	2.52	1.58	1.53	1.58	1.53	1.58	1.53	0.05	0.07
CV (%)	5.13	17.79	16.99	17.79	16.99	17.79	16.99	11.10	14.65
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Conclusion

This study revealed that performance of treatment T_4 (75% RDF + 1 t vermicompost) found superior in maximum quality attributing characters. However, the result did not perform significantly different for all quality characters.

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