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Integrated Nutrient Management of French Bean (*Phaseolus vulgaris* L.) in Subtropical Humid Zone of Nagaland, India

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ABSTRACT

Background: *French bean* is one of the most precious and highly relished widely grown short duration legume vegetable. This investigation is intended to assess the integrated manner of nutrient management for higher productivity of French bean under acidic soil condition in subtropical humid zone of Nagaland.

Methods: The experiment was carried out during three consecutive years (2017-2018, 2018-2019 and 2019-2020) of *rabi* season on French bean at Horticultural Research Farm, School of Agricultural Sciences and Rural Development, Medziphema, Nagaland University with the combination of eight treatments. The experiment was laid out in randomized block design with three replications using the variety Arka Komal.

Result: The pooled results of three years revealed that the highest growth, quality and yield parameters were observed in treatment T_3 (75% NPK through inorganic + 25% N through vermicompost) with maximum plant height (35.68 cm), no. of pods per plant (27.77), no. of seeds per pod (7.01), length of pod (13.96 cm), width of pod (10.58 mm), fresh weight of pod (4.22 g), fresh yield (153.61 q ha^{-1}), crude protein content (28.83%) and benefit cost ratio (4.06) of French bean which was found significantly superior over other treatments.

Key words: Economics, French bean, Integrated nutrient management, Vermicompost, Yield.

INTRODUCTION

French bean (*Phaseolus vulgaris* L.), also commonly known as the common bean or kidney bean or runner bean, belongs to the Fabaceae family with chromosome number 2n= 22. It is self pollinated and is said to be native to southern Mexico and Central America.

French beans are rich in digestible protein (22.9%), vitamins A and C, folic acid and fiber. It is also rich in minerals such as calcium, potassium, iron and phosphorus. It is grown for soft green pods and dried seeds (rajmah). Based on growth habits, it is divided into bush, semi-pole and pole types while based on fiber, string and stringless types. In the plains, it is sown twice, from September to October and January to February and in the hills, it is sown from March to May. It is one of the most popular beans grown in India. Production in India is approximately 1,977 million tonnes, covering an area of 2,228 million hectares and bringing productivity of 10.35 t ha^{-1} (NHB, 2018). In the case of Nagaland, the area of 40,700 ha produces about 562,000 t, with productivity of 11.96 t ha^{-1}, which is higher than the national productivity (Anonymous, 2017). This can be beneficial to the people of the region. The northeastern part of India is blessed with suitable conditions for growing kidney beans. It is also a very profitable crop from an economic point of view, especially in Nagaland, where it has the highest price on the market among legumes and is consumed in large quantities by the people of the region. However, the crop's behavior towards nutritional practices is negligible and less common with this important legume. The goal of integrated nutritional management is to integrate the use of natural and artificial soil nutrients to increase crop productivity and maintain soil productivity for future generations. In long-term crop studies, balanced use of NPK fertilizers cannot maintain higher yields over the years due to lack of secondary and micronutrients and deterioration of soil physical properties. Increased use of fertilizer will undoubtedly increase the production of raw materials significantly, but in the long run it will have a negative impact on soil health. In case of INM approach, careful application of all nutrients can sustainably improve soil fertility and economic yields (Masanta and Biswas, 2009). This current study shows the actual impact of the integrated use of inorganic fertilizers combined with organic fertilizers and biofertilizers on the growth, yield and quality of French bean and soil health.

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MATERIALS AND METHODS

The investigation was conducted at Horticultural Research Farm, School of Agricultural Sciences and Rural Development, Medziphema, Nagaland University during three consecutive *rabi* seasons of 2017-2018, 2018-2019 and 2019-2020. The field is located at an altitude of 304.8 m above the mean sea level and is positioned geographically at latitude of 20° 45′ 43″ N and a Longitude of 93° 53′ 04″ E. The initial status of the soil was highly acidic with a pH of 4.4, 1.25% of OC and available NPK of 232.1 kg ha^{-1}, 17.81 kg ha^{-1} and 209.7 kg ha^{-1} respectively. The experiment comprised of 08 treatments *viz*., T_1 (100% NPK through inorganic source), T_2 (75% NPK through inorganic source + 25% FYM), T_3 (75% NPK through inorganic source + 25% vermicompost), T_4 (50% NPK through inorganic source + 50% FYM), T_5 (50% NPK through inorganic source + 50% vermicompost), T_6 (25% NPK through inorganic source + 75% FYM), T_7 (25% NPK through inorganic source + 75% vermicompost), T_8 (Control) which were designed in RBD and replicated three times. Seeds were sown singly at 2-3 cm depth, @ 60-70 kg ha^{-1}, maintaining a spacing of 15 cm plant to plant and 50 cm row to row. Recommended dose of N, P, K in the ratio 50:75:75 kg ha^{-1} respectively were applied through Urea, SSP and MOP. Full dose of manures, P, K and half dose of N were applied at the final land preparation. The other half dose of N was applied 30 days after sowing. Biofertilizer (*Azotobacter*) was drenched @ 20 g l^{-1} of water 15 days after sowing. To raise the crop, other recommended package of practices was followed. The treatments were evaluated on the basis of growth, yield and yield attributes, quality, soil nutrients and economics. The mean of each treatment was replicated thrice and each parameter was worked out statistically by the method of analysis of variance using RBD. The data obtained during the period of investigation were analyzed by the variance method (Panse and Sukhatme, 1989) and the significance sources of variation were tested by error mean square using Fisher Shedecor 'F' test of probability at 5% level.

RESULTS AND DISCUSSION

Growth parameters

The NPK fertilizers with organic manures along with biofertilizers alone or in combination were found to have significant effect on growth characters as compared to control. It is evident from Table 1 and 2 that among all the eight treatments, T_3 (75% NPK through inorganic source + 25% vermicompost) recorded the highest plant height of 35.68cm, no. of pods per plant (25.37), no. of seeds per pod (7.01), length of pod (13.96 cm) and width of pod (10.58 mm) which was statistically at par with T_5 (50% NPK through organic + 50% N through vermicompost). The reason might be due to higher availability of nutrients as a result of integration of organic and inorganic sources. This is in line with the findings of researchers Longmatula *et al*., (2021); Kumar *et al*., (2009);

Table 1: Effect of integrated nutrient management on French bean.

Treatment	Plant height (cm)			Pooled	No. of Pod/plant			Pooled	No. of seeds/pod			Pooled
	2017-18	2018-19	2019-20	mean	2017-18	2018-19	2019-20	mean	2017-18	2018-19	2019-20	mean
T_1: 100% NPK through inorganic source	31.36	29.54	29.07	29.99	19.10	22.40	22.35	21.28	5.73	6.50	5.83	6.02
T_2: 75% NPK through inorganic+25% N through FYM	35.52	31.64	30.97	32.71	19.30	24.87	24.51	22.89	5.77	6.75	6.17	6.23
T_3: 75% NPK through inorganic+25% N through vermicompost	39.20	34.31	33.52	35.68	20.31	28.04	27.77	25.37	6.87	7.17	7.00	7.01
T_4: 50% NPK through inorganic+50% N through FYM	35.00	33.94	32.94	33.96	17.91	21.95	22.28	20.71	5.71	6.03	6.17	5.97
T_5: 50% NPK through inorganic+50% N through vermicompost	36.45	34.35	33.64	34.81	19.64	26.40	26.54	24.19	6.34	7.10	7.00	6.81
T_6: 25% NPK through inorganic+75% N through FYM	34.04	27.58	27.25	29.62	17.65	21.62	21.95	20.41	5.76	6.00	5.83	5.86
T_7: 25% NPK through inorganic+75% N through vermicompost	35.68	31.92	31.25	32.95	19.60	26.48	26.38	24.15	6.11	7.03	6.50	6.55
T_8: Control	29.28	23.17	23.16	25.20	13.53	16.13	15.31	14.99	5.04	6.00	5.33	5.46
SEm±	0.60	2.30	1.90	0.64	0.38	1.08	0.60	0.65	0.31	0.06	0.20	0.11
CD (5%)	1.81	6.97	5.72	1.94	1.14	3.26	1.81	1.97	0.95	0.19	0.61	0.35

Band *et al*., (2007); Shwetha *et al*., (2012); Zahida *et al*., (2016) in French bean and Verma *et al*. (2017) in soybean.

Yield and yield attributes

Integrated use of fertilizers and organic manures significantly increased yield and yield attributing characters of French bean compared to control (Table 3). Maximum width of pod (10.58 mm), fresh weight of pod (4.22 g) and fresh yield (153.61 q ha^{-1}) of French bean were observed in T_3 (75% NPK through inorganic source + 25% vermicompost) which was statistically at par with T_5 (50% NPK through organic + 50% N through vermicompost). The integrated use of chemical fertilizers, bio fertilizers and vermicompost increased the physical properties of soil (water and nutrient holding capacity). Availability of nutrient helps the plant to bear more number of flowers and reduce the chance of flower and fruit drop; as a result, more number of pods per plant. This is in conformity with Longmatula *et al*. (2021).

The increased growth with substitution of 25% RDF by vermicompost might be due to the fact that organic manures release nutrients slowly, increases nutrient use efficiency, biological fixation and availability of micro-nutrients. Similar results were documented by Gupta *et al*. (2017).

Table 2: Effect of integrated nutrient management on French bean.

Treatment	Length of pod (cm)			Pooled	Width of pod (mm)			Pooled
	2017-18	2018-19	2019-20	mean	2017-18	2018-19	2019-20	mean
T_1: 100% NPK through inorganic source	12.30	12.24	11.91	12.15	10.31	10.03	10.09	10.14
T_2: 75% NPK through inorganic+25% N through FYM	12.67	12.67	12.33	12.56	10.69	10.04	10.11	10.28
T_3: 75% NPK through inorganic+25% N through vermicompost	13.45	14.39	14.05	13.96	11.04	10.32	10.38	10.58
T_4: 50% NPK through inorganic+50% N through FYM	12.23	12.55	11.88	12.22	10.39	10.03	10.10	10.17
T_5: 50% NPK through inorganic+50% N through vermicompost	12.94	14.93	13.66	13.84	11.01	10.23	10.30	10.51
T_6: 25% NPK through inorganic+75% N through FYM	12.32	12.44	11.84	12.20	10.41	9.96	10.02	10.13
T_7: 25% NPK through inorganic+75% N through vermicompost	12.86	13.58	12.31	12.92	10.87	10.10	10.17	10.38
T_8: Control	10.83	12.02	10.58	11.14	9.98	9.60	9.60	9.73
SEm±	0.52	0.55	0.29	0.23	0.36	0.29	0.25	0.06
CD (5%)	1.57	1.67	0.89	0.70	1.08	0.89	0.78	0.20

Table 3: Effect of integrated nutrient management on French bean.

Treatment	Fresh weight of pods (g)			Pooled	Fresh yield (q ha^{-1})			Pooled
	2017-18	2018-19	2019-20	mean	2017-18	2018-19	2019-20	mean
T_1: 100% NPK through inorganic source	5.56	3.31	3.38	4.08	159.43	109.66	111.34	126.81
T_2: 75% NPK through inorganic+25% N through FYM	5.56	3.34	3.51	4.14	160.93	122.74	128.12	137.26
T_3: 75% NPK through inorganic+25% N through vermicompost	5.57	3.43	3.67	4.22	169.63	141.37	149.82	153.61
T_4: 50% NPK through inorganic+50% N through FYM	5.40	3.41	3.43	4.08	150.77	109.83	113.55	124.72
T_5: 50% NPK through inorganic+50% N through vermicompost	5.56	3.45	3.55	4.19	163.53	134.20	139.23	145.65
T_6: 25% NPK through inorganic+75% N through FYM	5.23	3.31	3.57	4.04	138.37	105.08	115.44	119.63
T_7: 25% NPK through inorganic+75% N through vermicompost	5.50	3.43	3.36	4.10	161.67	133.79	131.01	142.16
T_8: Control	4.35	3.11	2.71	3.39	90.83	74.13	60.82	75.26
SEm±	0.19	0.16	0.29	0.11	5.30	5.01	9.66	3.67
CD (5%)	0.57	0.49	0.88	0.31	16.06	15.19	29.02	11.01

Quality parameter

Highest crude protein content (28.83%) was recorded with treatment T_3 (Table 4). The protein improvement could be due to enhancement of nitrogen concentration in seeds with INM. The result is in agreement with the findings of Longmatula *et al*. (2021).

Nutrient status of soil

The treatment (T_3) produced highest available nitrogen (287.84 kg ha^{-1}), potassium (126.80 kg ha^{-1}) and organic carbon (1.68%) while, treatment T_1 produced the highest available phosphorus (26.85 kg ha^{-1}) (Table 5). The slight increase might be due to the addition of NPK through application of organic and inorganic fertilizers. As for the soil pH, all the treatments were in the range of 4.03-4.23 and there was no significant difference. These findings are in line with the report of Kemal *et al*. (2018).

Economics

It is evident from the Table 6, the maximum expenditure was incurred in treatment T_7 (Rs.1,20,13,250/-) followed by T_5 (Rs.1,05,598/-) while for BCR, the highest value was obtained from T_2 (4.35) followed by T_3 (4.06). The high expenditure in treatment T_7 might be due to the high cost of

Table 4: Effect of INM on crude protein content (%) in French bean.

Treatment	Crude protein content (%)
T_1: 100% NPK through inorganic source	28.33
T_2: 75% NPK through inorganic source+25% FYM	27.81
T_3: 75% NPK through inorganic source+25% vermicompost	28.83
T_4: 50% NPK through inorganic source+50% FYM	27.17
T_5: 50% NPK through inorganic source+50% vermicompost	27.38
T_6: 25% NPK through inorganic source+75% FYM	26.25
T_7: 25% NPK through inorganic source+75% vermicompost	26.94
T_8: Control	25.35
S.Em±	0.54
CD (5%)	1.60

Table 5: Effect of INM on nutrient status of soil after harvest of French bean.

Treatments	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})	Organic carbon (%)	Soil pH
T_1	287.68	26.85	126.60	1.63	4.23
T_2	287.14	26.00	126.25	1.62	4.17
T_3	287.84	26.11	126.80	1.68	4.20
T_4	285.57	24.83	122.91	1.57	4.07
T_5	286.14	25.91	123.02	1.57	4.10
T_6	285.19	24.25	121.41	1.61	4.13
T_7	285.60	24.77	121.84	1.56	4.17
T_8	277.15	21.52	103.55	1.47	4.03
Initial	283.59	23.03	106.00	1.41	4.20
S.Em±	1.36	0.49	0.89	0.03	0.04
CD (5%)	4.01	1.46	2.62	0.10	0.11

Table 6: Effect of integrated nutrient management on economics of French bean.

Treatment	Fresh yield (kg ha^{-1})	Gross income (Rs. 30 kg^{-1})	Cost of cultivation	Net income (Rs.)	B:C ratio
T_1: 100% NPK through inorganic source	126.81	380430	76530.00	303900.00	3.98
T_2: 75% NPK through inorganic+25% N through FYM	137.26	411780	76897.50	334882.50	4.35
T_3: 75% NPK through inorganic+25% N through vermicompost	153.61	460830	91064.50	369765.50	4.06
T_4: 50% NPK through inorganic+50% N through FYM	124.72	374160	77265.00	296895.00	3.84
T_5: 50% NPK through inorganic+50% N through vermicompost	145.65	436950	105598.00	331352.00	3.14
T_6: 25% NPK through inorganic+75% N through FYM	119.63	358890	77632.00	281257.50	3.62
T_7: 25% NPK through inorganic+75% N through vermicompost	142.16	426480	120132.50	306347.50	2.55
T_8: Control	75.26	225780	68000.00	157780.00	2.32

vermicompost. This is in line with other researchers (Longmatula *et al*., 2021; Reddy *et al.,* 2011; Mukherjee, 2016).

CONCLUSION

It can be concluded from the study that the variety, Arka Komal as well as application of inorganic fertilizers when combined with organic sources of compost/manures resulted in better growth and yield of French bean in acidic soil of subtropical plain zone of Nagaland, India. It is noted that the application of T_3 (75% NPK through inorganic + 25% N through vermicompost) resulted in best yield. However, it was observed that the integrated treatment of T_2 (75% NPK through inorganic + 25% N through FYM) is best with highest benefit cost ratio followed by T_3 (75% NPK through inorganic + 25% N through vermicompost). Therefore, from a sustainable agricultural approach, treatment T_2 (75% NPK through inorganic + 25% N through FYM) gives optimal yield and B:C in French bean under Nagaland condition. Thus, as per availability of the source *i.e.,* vermicompost and FYM in a given area or location, T_3 and T_2 may be recommended to the farmers of Nagaland.

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Conflict of interest

On behalf of all authors, I am declaring that there is no conflict of interest for the publication of this paper.

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