Original Research Article

Effect of integrated nutrient management on growth and yield of French bean (*Phaseolus vulgaris* L.)

Abstract

The present investigation entitled **"Effect of integrated nutrient management on growth and yield of French bean (*Phaseolus vulgaris* L.)** was carried out at the Research farm of the School of Agriculture, Abhilashi University, Mandi (H.P.) during the spring season of 2022. The experiment was laid out in a randomized block design with three replications. The treatments consisted of conjoint and sole application of organic (FYM and vermicompost) and inorganic ~~fertilizer~~ fertilizers(urea, SSP and MOP). In terms of soil chemical properties i.e., soil pH (5.6), maximum organic carbon (0.99%) and maximum NPK (260.00:18.00: 336.00 kg/ha) ~~was~~ wereobserved in treatment T_7 (75% RDF of NPK + 12.5% FYM + 12.5% Vermicompost. Out of seven treatments, treatment T_7 was recorded best performing for all the traits i.e. days to 50% germination (14.06), leaf area index at 60 (105.32 cm^2) and (130.65 cm^2) at harvest, fresh weight of plant (189.20 g), dry weight of plant (20.03 g), yield per plot (17.45 kg), yield per hectare (290.84q/ha), biological yield (29.47q/ha) and harvest index (59.19%). The maximum gross return (530375 Rs/ha), net return (431885 Rs/ha) and B:C ratio (1:5.3) was also recorded in T_7 75% RDF of NPK + 12.5% FYM + 12.5% Vermicompost.Thus, application of optimum doses of NPK along with organic manures was found highly beneficial for plant growth, ~~yield~~yield, and economics of French bean.

Keywords: B:C ratio,Integrated Nutrient Management (INM), ~~french~~French bean, yield.

Introduction

French bean (*Phaseolus vulgaris* L) is one of the most popular and widely grown vegetables in India. It belongs to the Fabaceae family and has the chromosome 2n=22. One of the most significant leguminous vegetables is this one. It is a non-traditional, short-season legume with a high production potential that is one of the most prized and loved pulse crops

in north India (Jan et al. 2019). It is a nutrient-rich vegetable that may be cultivated in a variety of soils, from light sandy loam to clay soils with a pH range of 5.3 to 6.0. It has many synonyms ~~like;~~like, common beans, snap ~~bean~~beans, dwarf beans, kidney beans, wax beans, garden beans pole beans and runner beans etc. It is cultivated in Himachal Pradesh as a seasonal and primary crop.

Being a ~~short duration~~short-duration crop French bean can be grown under different cropping patterns of ~~plain~~ plainsand hills of Himachal Pradesh. In India, it is mainly grown in Punjab, Haryana, Uttar Pradesh, Madhya Pradesh, Odisha, Bihar, Gujrat, Andhra Pradesh, Tamilnadu and Himachal Pradesh. The present practices being followed by the farmers for the packaging of French beans are in gunny bags or ~~large size~~large-size polythene bags therefore, the normal shelf life of French ~~bean~~ beansis 2-3 days.

French bean pods are a complete food since they have 1.7 g of protein, 0.1 g of fat, 4.5 g of carbohydrates, and 1.8 g of fiber in addition to being a source of vitamin A, thiamine, riboflavin, and other vitamins (Singh 2006). Besides it has some medicinal ~~values~~ valueand acts as antiaging factors, helps to prevent obesity, lowers the cholesterol content of blood and is therefore recommended for curing heart and ~~kidney related~~kidney-related ailments (Adsule et al. 1998).

French beans are a delicate vegetable crop that cannot withstand frost, extreme heat, or heavy rain. The most advantageous soil temperature for its seed germination is between 18 and 24 °C, and its seeds do not germinate below 15 °C. Since the crop grows best in a temperature range of 15 to 25 °C, it is planted throughout the chilly season in India's plains. Its vegetative growth is not ~~favoured~~ favoredby conditions of extremely high temperatures (Evans, 1974).

French bean is a fertilizer-responsive crop that benefits from nutrition, but too much nitrogen reduces pod output. It also fixes atmospheric nitrogen and increases soil fertility, just like other legumes (Adsule et al. 1998). According to studies, the lack of nodulation in north Indian planes prevents French ~~bean~~ beansfrom capturing enough atmospheric nitrogen (Kushwaha 1994). It consequently requires a lot of fertilizer high in nitrogen.

Studies clearly ~~indicates~~ indicatethat~~,~~ the combined use of organic and chemical fertilizer not only increase the yield of crop but improve the physical, chemical and biological properties of soil. ~~Use~~ The useof organic manures with the optimum rate of fertilizer under an intensive farming system increased the turnover of nutrients in the soil plant system (Metkari and Dhok, 2011). Keeping this in view, the present experiment is proposed to be undertaken

to find out the effect of integrated nutrient management on the growth and yield of ~~Frenchbean~~French bean.

Material and methods

The present investigation was conducted during 2021-22 during kharif season at Agriculture Research Farm School of Agriculture, Abhilashi university, Mandi (H.P.). The experimental farm is situated at $31^0$33'34" N latitude and $77^0$00'31" E longitudes having an altitude of 1,426 m above mean sea level. The experiment was laid out in randomized block design (RBD) with seven treatments and three replications. The treatments were T_1: Control (Without fertilizer), T_2 :100% Recommended dose of fertilizer NPK (Inorganic), T_3:100% RDF of ~~farm yard~~farmyard manure, T_4:100% RDF of vermicomposting, T_5:50% RDF of NPK +50% RDF of Vermicompost, T_6 :50% RDF of NPK + 25% FYM + 25%Vermicompost, T_7:75% RDF of NPK + 12.5% FYM + 12.5%Vermicompost. The plot size was 3m × 2m and the spacing adopted was 60cm × 45cm. Seeds of French bean Rizwan Charmee imp ~~was~~ weresown on 1 ~~march~~March, 2022 at a spacing of 30 × 10 cm. Seeds were properly covered with a thin layer of soil and the plots were irrigated lightly. Farmyard manure was applied at the time of field preparation. Before the commencement of the experiment, soil samples were collected randomly from different plots of the experiment field from depth of 0-15 cm and the composite sample was prepared by mixing all these samples together. The soil sample after drying was passed through 2.0 mm sieve and was analyzed for soil pH, organic carbon and for available NPK. The result of analysis and methods used are presented in table 3. The recommended dose of N, P_2O_5 and K_2O were applied at the time of sowing in each plot as per the distributed to different treatments. Different growth and yield parameters like plant height, leaf area index, number of pods per plant, number of seeds per pod yield per hectare. The statistical analysis was carried out by using the statistical package OPSTAT.

Result and discussion

Soil properties of experimental field (post-harvest)

Data pertaining to soil pH, OC (%), available NPK are present in (Table-1) showed that application of different level of NPK did not affected pH in the post-harvest soil. The

treatments were found significant effect for organic carbon, available NPK. The result indicated that the combination of NPK significantly increase the organic carbon content in the soil over control and the application of different levels of NPK successively and significantly increased the available NPK content in the soil.

The minimum pH was recorded in T_1 Control without fertilization (5.3) and maximum pH was recorded in $T_7$75% RDF of NPK + 12.5% FYM + 12.5% Vermicompost (5.6). Similar results for soil pH ~~was~~ were observed by Badhulkar et al. (2000) and Selvi et al. (2004). In the case of organic carbon T_4 100% RDF of vermicompost ~~observe~~ observed the highest organic carbon (0.99) and T_1 Control without fertilization ~~observe~~ observed the minimum organic carbon (0.65).

Maximum available N (260.00) was recorded in $T_7$75% RDF of NPK + 12.5% FYM + 12.5% Vermicompost and minimum N (164.00) in treatment T_1 Control without fertilization. Nitrogen will be mineralized slowly and supplied required quantity of useable nitrogen during a progressive growth period but the initial requirement of nitrogen would be met from inorganic source ~~but~~ nitrogen combined with vermicompost as well as farm yard manure results in better soil fertility which improves the yield according to Jagdale et al. (2005), Kalange (2006), Band et al. (2007), Kamble et al. (2016) and Mohanty et al. (2017).Maximum available P (18.00) was recorded in $T_7$75% RDF of NPK + 12.5% FYM + 12.5% Vermicompost and minimum P (10.00) in treatment T_1 Control without fertilization.The increase in the available P content due to incorporation of organic manures as well as solublization of native P through release of various organic acids, but better availability of phosphorus is under chemical fertilizer treatment and integrated nutrient management due to more mineralization owing to addition of chemical fertilizers. Similar improvement in available P due to integrated use of manures and chemical fertilizer has been observed by Sharma et al. (2009). And maximum available K (336.00) was recorded in $T_7$75% RDF of NPK + 12.5% FYM + 12.5% Vermicompost and minimum K (145.00) in treatment T_1 Control without fertilization.Increase in K availability due to application of organic manures might have been due to direct addition of K to the available K pool of the soil besides the reduction of K fixation due to interaction of organic matter with clay (Bharadwaj and Omanwar, 1994).

Table:1-Effect of NPK on soil properties

Treatments	Soil pH	Organic carbon (%)	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})
~~Control(~~Control (without fertilization).	5.3	0.65	164.00	20.00	145.00
100% recommended dose of fertilizer NPK (Inorganic).	5.5	0.80	192.00	32.00	280.00
100% RDF of Farm yard manure.	5.4	0.70	205.00	29.00	162.00
100% RDF of Vermicompost.	5.4	0.99	240.00	33.00	179.00
50% RDF of FYM + 50% RDF of Vermicompost.	5.5	0.70	216.00	42.00	302.00
50% RDF of NPK + 25% FYM +25% Vermicompost.	5.5	0.90	244.00	47.00	205.00
75% RDF of NPK + 12.5% FYM + 12.5% Vermicompost.	5.6	0.95	260.00	51.00	336.00
SE (m) ±	0.05	0.01	2.17	0.24	2.05
CD at 5%	NS	0.02	6.14	0.68	5.78

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Plant growth attributes

The earliest germination count is observed in T_7 (8.28) under 75% RDF of NPK + 12.5% FYM +12.5% Vermicompost. And the lowest germination count is observed in T_1 14.06 (Control without fertilizer) followed by T_2 (10.91) under 100% recommended dose of fertilizer NPK (Inorganic). As we know that inorganic fertilizers such as N promotes seed germination through function as signaling molecule and vermicompost help seeds germinate faster so application of organic fertilizers along with inorganic has great effect on the germination percentage of French bean. Similar data was observed by Meena et al. (2018), Sharma et al. (2014), Singh and Chauhan (2009).

At 60 DAS maximum leaf area index of (105.32) cm^2 was recorded in T_7 (75% RDF of NPK + 12.5% FYM + 12.5% Vermicompost). And the lowest leaf area index was recorded in T_1 (Control without fertilizer) 53.02 cm^2. And at the time of harvest, the maximum leaf area index i.e. 130.65 cm^2 was observed in treatment T_7 (75% RDF of NPK + 12.5% FYM + 12.5% Vermicompost). And the lowest leaf area index 81.74 cm^2 was recorded in T_1 (Control

without fertilizer). Nitrogen will be mineralized slowly but steadily and supplied required quantity of useable nitrogen during progressive growth period but initial requirement of nitrogen would be met from inorganic source as it would be available instantly to the plants according to Jagdale et al. (2005), Kalange (2006), Band (2016) and Mohanty (2017).

. Among different treatments, T7 (75% RDF of NPK + 12.5% FYM + 12.5% Vermicompost) recorded significantly higher number of leaves from 30 DAS till maturity whereas, minimum number of leaves was recorded in T1 control without fertilization). In T6 maximum number of leaves were recorded followed by T5 50% RDF of NPK + 25% FYM +25% Vermicompost, T4 100% RDF of Vermicompost, T3 100% RDF of Farm yard manure.

The maximum number of leaves was observed in the treatment T7 35.20 (75% RDF of NPK + 12.5% FYM + 12.5% Vermicompost)whereas, the minimum number of leaves was recorded in T9 (Control without fertilization) and its value was 27.48. According to Shwetha et al. (2012) maximum no of leaves in french bean crop is due to the application of organic and inorganic fertilizers combines.

The maximum value of french bean fresh weight of plant is recorded in treatment T_7 i.e. 189.20 (75% RDF of NPK + 12.5% FYM + 12.5% Vermicompost) and the minimum value of fresh weight of plant is recorded in T_1 (145.30) control without fertilization. Fresh weight of the plant is directly influenced by the application of inorganic manures but has better results are seen along with organic fertilizers. The result is in consonance with the reports of Singh et al. (2011).

The highest plant weight (dry) was recorded 20.03 in $T_6$50% RDF of NPK + 25% FYM +25% Vermicompost) and the minimum value was recorded 13.83 in T_1 (control without fertilization). Dry weight of the plant is directly influenced by the application of inorganic manures along with organic fertilizers. The result is in consonance with the reports of Ramana et al. (2011), Singh et al. (2011).

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

Treatments	Day to 50 per cent germination	Leaf area index (cm^2)	No of leaves	Fresh weight of plants	Dry weight of plants

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		At 60	At harvest			
Control(without fertilization).	14.06	53.02	81.74	27.48	145.30	13.83
100% recommended dose of fertilizer NPK (Inorganic).	10.91	99.76	118.60	30.60	162.90	16.96
100% RDF of Farm yard manure.	12.79	75.74	98.65	27.78	160.60	14.93
100% RDF of Vermicompost.	12.56	78.07	103.63	28.04	162.86	16.16
50% RDF of FYM + 50% RDF of Vermicompost.	11.37	87.23	111.88	26.44	163.06	18.83
50% RDF of NPK + 25% FYM +25% Vermicompost.	8.28	88.15	126.20	30.60	176.70	20.03
75% RDF of NPK + 12.5% FYM + 12.5% Vermicompost.	7.77	105.32	130.65	35.20	189.20	17.83
SE (m) ±	0.59	0.59	0.59	0.51	6.31	0.37
CD at 5%	1.84	1.84	1.84	1.59	19.68	1.17

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Yield attributes

Maximum seeds per pod were recorded (7.20) and maximum number of pods per plant (29.80) in treatment T_7 (75% RDF of NPK + 12.5% FYM + 12.5% Vermicompost) and the minimum number of seeds per pod (6.33) and the lowest number of pods per plants (23.20) was observed intreatment T_1Control (without fertilization).

Maximum yield per plant (250.25g), yield per plot (17.45kg), yield per hectare (290.84q), biological yield (27.39q/ha) and highest harvesting index (59.19%) was observed in T_7 (75% RDF of NPK + 12.5% FYM + 12.5% Vermicompost). Application of vermicompost, FYM and bio fertilizers combine helped in improving soil health as well as facilitates slow and continuous supply of nutrients to the plant. The increase in yield is due to better performance of yield attributes according to Singh (2000), Dhanjal et al. (2001), Manjunath (2010), Ramana et al. (2011).

Table:3- Effect of integrated nutrient management on yield of French bean

Treatments	Seed/Pod	Pods/ plants	Yield per plant	Yield per plot	Yield/hectare	Biological yield (q/ha)	Harvest index			
Control(without fertilization).	6.33	23.20	147.27	9.77	162.91	21.04	46.45			
100% recommended dose of fertilizer NPK (Inorganic).	7.00	28.26	202.57	13.55	225.81	23.97	56.35			
100% RDF of Farm yard manure.	6.43	25.93	172.82	11.49	191.55	21.22	53.97			
100% RDF of Vermicompost.	6.46	26.76	189.39	12.23	203.84	22.19	54.91			
50% RDF of FYM + 50% RDF of Vermicompost.	6.73	27.83	200.54	13.02	217.06	23.14	56.1			
50% RDF of NPK + 25% FYM +25% Vermicompost.	7.06	29.50	240.19	15.91	265.30	27.39	58.02			
75% RDF of NPK + 12.5% FYM + 12.5% Vermicompost.	7.20	29.80	250.25	17.45	290.84	29.47	59.19			

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SE (m) ±	0.16	0.39	11.69	0.85	14.29	1.06	1.46			
CD at 5%	0.50	1.23	36.42	0.67	44.53	3.31	4.56			

Economics

The economics of the various treatment combinations have been presented in Table 4 A perusal of data revealed that highest cost of production ₹ /hectare (₹ 1,37,235), maximum gross income ₹ /hectare amounting to (₹ 5,30,375), highest net return ₹ /hectare (₹ 4,31,886), maximum net return/rupee invested (1: 5.3) was incurred in treatment T_7 (75% RDF of NPK + 12.5% FYM + 12.5% Vermicompost)whereas lowest cost of cultivation ₹ /hectare (₹ 87,235), minimum gross income ₹ /hectare (₹ 3,08,650), lowest net return ₹ /hectare (₹ 221415), net return per rupee invested (1:3.5) was observed in treatment T_1 control without fertilization.

Table4. Effect of integrated nutrient management on economics

Treatments	**Cost of cultivation (₹ /ha)**	**Gross Return (₹ /ha)**	**Net Return (₹ /ha)**	**Net return per rupee invested**
Control(without fertilization).	87235	308650	221415	3.5
100% recommended dose of fertilizer NPK (Inorganic).	91595	445125	353530	4.8
100% RDF of Farm yard manure.	107253	373025	265772	3.4
100% RDF of Vermicompost.	137235	393225	255972	2.8
50% RDF of FYM + 50% RDF of Vermicompost.	122235	419700	297447	3.4
50% RDF of NPK + 25% FYM +25% Vermicompost.	111915	467350	355417	4.1
75% RDF of NPK + 12.5% FYM + 12.5% Vermicompost.	98471	530375	431886	5.3

The manuscript lacks a scientific discussion comparing published research; therefore, I suggest incorporating the following paragraphs that would improve the scientific quality of the manuscript.

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Studying the effect of integrated nutrient management (INM) on the growth and yield of French beans (Phaseolus vulgaris L.) in Abhilashi University, Mandi, Himachal Pradesh (H.P.) holds significant relevance both at a local and global scale. At the local level, Himachal Pradesh is known for its diverse agricultural practices, and beans are a vital crop in the region. Investigating how INM can optimize French bean production in the specific agro-climatic conditions of H.P. can directly benefit local farmers by enhancing crop yields, increasing economic returns, and improving food security in the region.

Furthermore, comparing the findings of this research with other studies on soil quality in tropical crops in Latin America allows for the exchange of valuable insights and knowledge between regions with distinct agricultural contexts. Latin America is a major player in global agriculture (Campos, 2023) and its diverse climates (Parra et al. 2012; Rodriguez et al. 2013; Zingaretti et al. 2016) and cropping systems can offer unique perspectives on sustainable farming practices (Hernandez et al. 2020; Hernandez and Olivares, 2020). By drawing comparisons, researchers can identify universal principles of INM and soil management that transcend geographical boundaries (Hernandez and Olivares, 2019), facilitating the dissemination of best practices and the development of innovative strategies to address the challenges faced by farmers worldwide (Hernandez et al. 2018a; 2018b).

Moreover, as agriculture faces increasing pressures from climate change (Viloria et al. 2023), understanding how INM influences crop growth and soil quality in both temperate (Guevara et al. 2013; Casana and Olivares, 2020) and tropical regions becomes crucial for global food security (Olivares et al. 2021). The research conducted in Abhilashi University can serve as a case study that contributes to the broader discourse on sustainable agriculture. It can provide valuable data and insights to inform agricultural policies (Pitti et al. 2021; Olivares et al. 2020), practices (Guevara et al. 2012; Araya-Alman et al. 2020), and adaptation strategies in both Himachal Pradesh and Latin American countries (Montenegro et al. 2021), ultimately benefiting farmers (Olivares et al. 2018), ecosystems (Olivares et al. 2022), and food production on a global scale.

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