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

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Abstract

The present investigation entitled, “Effect of Integrated Nutrient Management on Growth parameters of French Bean (*Phaseolus vulgaris* L.)” conducted at University Research Farm, Departmental of Horticulture, School of Agricultural Sciences, G.H. Raisonni University, Saikheda, Pandhurna, Madhya Pradesh during Rabi 2024. Data pertaining to various criteria used for treatment evaluation were analyzed statistically to test their significance and analysis of variance for these data has been given in appendices at the end. The research trail was carried on French bean crop. The application of organic and inorganic fertilizers like T₁- Control (No fertilizer, no organic manure, no biofertilizer), T₂- 100% Recommended Dose of Fertilizer (RDF) (NPK), T₃- 75% RDF + 25% N through Farmyard Manure (FYM), T₄- 75% RDF + 25% N through Vermicompost, T₅- 75% RDF + Rhizobium inoculation, T₆- 75% RDF + Phosphate Solubilizing Bacteria (PSB), T₇- 75% RDF + 25% N through FYM + Rhizobium, T₈- 75% RDF + 25% N through Vermicompost + Rhizobium, T₉- 75% RDF + 25% N through Vermicompost + Rhizobium + PSB and T₁₀ - 50% RDF + 25% N through FYM + 25% N through Vermicompost + Rhizobium + PSB was used for the experiment for observed the growth parameters, namely Days to Seed Germination, Plant Height (cm), Number of Branches per Plant, Plant Spread (cm), Number of Leaves per Plant, Leaf Area (cm²), Days to First Flowering, Days to 50 Per Cent Flowering and Days to First Pod Picking. The results revealed that the early germination (8.50 days), and maximum Plant Height at 30, 45 and 60 DAS (26.86 cm, 44.46 cm and 60.96 cm), Number of Branches per Plant (7.90), Plant Spread (51.10 cm cm), Number of Leaves per Plant (51.30), Leaf Area (112.40 cm²), early Days to First Flowering (33.18 days), early Days to 50 Per Cent Flowering (37.70 days) and early Days to First Pod Picking (46.19 days) was observed under the treatments T₁₀ while minimum and lowest values was observed under the control.

Keywords: French bean, integrated nutrient management, vermicompost, rhizobium, PSB

Introduction

French bean (*Phaseolus vulgaris* L.), commonly known as common bean, snap bean or green bean, is an important leguminous vegetable crop cultivated across tropical, subtropical and temperate regions. The crop is valued for its tender green pods, which are consumed as a vegetable, as well as for its mature seeds. Its short duration, adaptability to diverse agro-climatic conditions and good market demand make it an economically important vegetable legume. The tender pods provide appreciable amounts of protein, carbohydrates, vitamins and minerals and therefore contribute to dietary nutrition. In addition to its nutritional importance, French bean belongs to the legume family and has the capacity to obtain part of its nitrogen requirement through biological nitrogen fixation, although effective nodulation and nitrogen fixation depend on genotype, soil conditions and the availability of compatible Rhizobium strains.

Nutrient management is one of the major factors determining growth, productivity and quality of French bean. The crop requires an adequate and balanced supply of major nutrients for vigorous vegetative growth, flowering, pod development and yield formation. Excessive reliance on inorganic fertilizers may not adequately address long-term soil fertility, whereas the exclusive use of organic manures may not provide nutrients in sufficient quantities or at the required rate during periods of high crop demand. Consequently, Integrated Nutrient Management (INM), involving the complementary use of inorganic fertilizers, organic manures and biofertilizers, has emerged as an important approach for sustainable production. FYM and vermicompost contribute to nutrient supply and improvement of soil physical and biological properties, while biofertilizers

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such as Rhizobium and phosphate-solubilizing bacteria (PSB) can improve biological nitrogen fixation and phosphorus availability. Field studies in French bean have demonstrated that combining inorganic fertilizers with organic nutrient sources and beneficial microorganisms can improve growth, yield attributes, nutrient uptake and economic returns. Rajput *et al.*, (2011) ^[8] reported significant improvements in plant growth, yield attributes, nutrient uptake and economics through integrated use of NPK, vermicompost and biofertilizers in French bean. Similarly, Poonam *et al.*, (2023) ^[7] observed improved growth, yield and economic performance with combined application of inorganic fertilizers and organic manures.

Materials and Methods

The present investigation entitled, “Effect of Intergrated Nutrient Management on Growth parameters of French Bean (*Phaseolus vulgaris* L.)” conducted at University Research Farm, Departmental of Horticulture, School of Agricultural Sciences, G.H. Raison University, Saikheda, Pandhurna, Madhya Pradesh during Rabi 2024. Data pertaining to various criteria used for treatment evaluation were analyzed statistically to test their significance and analysis of variance for these data has been given in appendices at the end. The research trail was carried on French bean crop. The application of organic and inorganic fertilizers like T₁- Control (No fertilizer, no organic manure, no biofertilizer), T₂- 100% Recommended Dose of Fertilizer (RDF) (NPK), T₃- 75% RDF + 25% N through Farmyard Manure (FYM), T₄- 75% RDF + 25% N through Vermicompost, T₅- 75% RDF + Rhizobium inoculation, T₆- 75% RDF + Phosphate Solubilizing Bacteria (PSB), T₇- 75% RDF + 25% N through FYM + Rhizobium, T₈- 75% RDF + 25% N through Vermicompost + Rhizobium, T₉- 75% RDF + 25% N through Vermicompost + Rhizobium + PSB and T₁₀ - 50% RDF + 25% N through FYM + 25% N through Vermicompost + Rhizobium + PSB was used for the experiment for observed the growth parameters, namely Days to Seed Germination, Plant Height (cm), Number of Branches per Plant, Plant Spread (cm), Number of Leaves per Plant, Leaf Area (cm²), Days to First Flowering, Days to 50 Per Cent Flowering and Days to First Pod Picking.

Results and Discussion

Days to seed germination

The earliest germination was recorded under treatment T₁₀ (50% RDF + 25% N through FYM + 25% N through Vermicompost + Rhizobium + PSB), which required only 8.50 days for germination. This treatment was closely followed by T₉ (75% RDF + 25% N through Vermicompost + Rhizobium + PSB), T₈ (75% RDF + 25% N through Vermicompost + Rhizobium) and T₇ (75% RDF + 25% N through FYM + Rhizobium), which recorded 8.90, 9.20 and 9.50 days, respectively. The maximum number of days to seed germination (11.80 days) was observed in the control treatment (T₁), where no fertilizer, organic manure or biofertilizer was applied. The earlier germination under T₁₀ may be attributed to the combined and balanced supply of nutrients from inorganic fertilizer, FYM and vermicompost, along with the beneficial activity of Rhizobium and PSB. Organic manures improve soil structure, moisture retention and microbial activity, while biofertilizers enhance nutrient availability, creating favourable conditions for rapid seed imbibition and early seedling establishment. Parween *et al.* (2019) ^[6] reported that integrated nutrient management involving RDF, FYM, vermicompost and Rhizobium + PSB improved the growth performance of French bean.

The superior performance of T₁₀ may also be attributed to the

synergistic action of Rhizobium and PSB, which enhances biological nitrogen fixation and phosphorus availability, respectively, thereby supporting early root development and seedling growth. Rajput *et al.*, reported that integrated application of inorganic fertilizers, vermicompost and biofertilizers improved growth and nutrient uptake in French bean. Similarly, Azad and Tomar (2022) ^[1] reported that integrated use of inorganic fertilizers with FYM and vermicompost improved French bean performance compared with the unfertilized control. More recently, Changkiri *et al.*, (2024) ^[3] found that integrated nutrient management involving inorganic fertilizers and vermicompost significantly improved growth and yield attributes of French bean. Thus, the present findings suggest that the combined application of 50% RDF + FYM + vermicompost + Rhizobium + PSB created favourable nutritional and biological conditions for faster germination and early establishment of French bean.

Plant height (cm)

At 30, 45 and 60 DAS, the maximum plant height (26.86 cm, 44.46 cm and 60.96 cm) was recorded under T₁₀ (50% RDF + 25% N through FYM + 25% N through Vermicompost + Rhizobium + PSB), which was significantly superior to all other treatments. This was followed by T₉ (25.16 cm, 41.76 cm and 57.16 cm), and T₈ (23.66 cm, 38.96 cm and 53.36 cm). The minimum plant height (14.56 cm, 23.26 cm) was observed in the control treatment (T₁). The superior growth under T₁₀ may be attributed to the complementary supply of nutrients from RDF, FYM and vermicompost, together with the beneficial effects of Rhizobium and PSB on nutrient availability and uptake. Organic manures also improve soil structure, moisture retention and microbial activity, thereby creating favourable conditions for vigorous vegetative growth. Rajput *et al.*, (2011) ^[8] reported that integration of inorganic fertilizers with vermicompost and biofertilizers significantly improved plant height and other growth characteristics of French bean. The greater plant height under T₁₀ may further be associated with the synergistic action of Rhizobium and PSB, which enhances nitrogen fixation and phosphorus availability, respectively, supporting cell division, cell elongation and overall vegetative development. Parween *et al.*, (2019) ^[6] also reported improved growth attributes of French bean under integrated nutrient management involving RDF, FYM/vermicompost and Rhizobium + PSB. Similarly, Azad and Tomar (2022) ^[1] observed that integrated use of organic and inorganic nutrient sources significantly improved the growth performance of French bean compared with the unfertilized control. More recently, Changkiri *et al.* (2024) ^[3] reported maximum plant height (35.68 cm) with 75% inorganic NPK + 25% N through vermicompost, demonstrating the beneficial effect of combining inorganic and organic nutrient sources on vegetative growth of French bean. Thus, the present findings indicate that the combined application of 50% RDF + FYM + vermicompost + Rhizobium + PSB provided a balanced nutrient supply and favourable soil biological conditions, resulting in superior plant height throughout the crop growth period.

Number of branches per plant

The highest number of branches per plant (7.90) was recorded under T₁₀ (50% RDF + 25% N through FYM + 25% N through Vermicompost + Rhizobium + PSB), which was found to be significantly superior over all other treatments. This was followed by T₉ (7.40), T₈ (6.90) and T₇ (6.50) branches per plant. The lowest number of branches per plant (4.20) was observed under the control treatment (T₁), where no nutrient source was applied. The higher branching under T₁₀ may be attributed to the balanced

and continuous supply of nutrients from inorganic fertilizer and organic sources, together with improved nutrient availability through Rhizobium and PSB. Adequate nitrogen and phosphorus promote vegetative growth, cell division and the development of axillary buds, resulting in greater branching. Rajput *et al.*, (2011) ^[8] reported significant improvement in branches per plant of French bean with integrated application of inorganic fertilizers, vermicompost and biofertilizers.

The superiority of T₁₀ may also be associated with improved soil physical and biological conditions created by FYM and vermicompost. The addition of organic manure enhances nutrient availability and microbial activity, while Rhizobium and PSB improve nitrogen fixation and phosphorus availability, respectively, thereby supporting vigorous vegetative development. Parween *et al.* (2019) ^[6] recorded the highest number of primary branches with integrated application of RDF, vermicompost and Rhizobium + PSB in French bean. Similarly, Dash *et al.* (2019) ^[4] reported significantly higher primary branches under 75% NPK + 25% N through vermicompost compared with other nutrient treatments. Thus, the present findings confirm that the integrated application of FYM + vermicompost + Rhizobium + PSB with RDF provides a favourable nutritional environment for enhanced branching in French bean.

Plant spread (cm)

The maximum plant spread (51.10 cm) was recorded under T₁₀ (50% RDF + 25% N through FYM + 25% N through Vermicompost + Rhizobium + PSB), which was significantly superior to all other treatments, followed by the treatment was T₉ (75% RDF + 25% N through Vermicompost + Rhizobium + PSB), 47.40 cm, T₈ (43.80 cm) and T₇ (41.20 cm). The lowest plant spread (26.10 cm) was observed in the control treatment (T₁), where no nutrient source was applied. The greater plant spread under T₁₀ may be attributed to the balanced and continuous supply of nutrients from inorganic and organic sources, along with improved nutrient availability through Rhizobium and PSB, which promoted vigorous vegetative growth. Similar improvement in growth attributes of French bean under integrated nutrient management was reported by Azad and Tomar (2022) ^[1] and Changkiri *et al.*, (2024) ^[3].

Number of leaves per plant

The highest number of leaves per plant (51.30) was recorded under T₁₀ (50% RDF + 25% N through FYM + 25% N through Vermicompost + Rhizobium + PSB), which was significantly superior to all other treatments. This treatment was followed by T₉ (46.70 leaves), T₈ (42.90 leaves) and T₇ (39.40 leaves per plant). The minimum number of leaves per plant (21.90) was observed in the control treatment (T₁), where no fertilizer, organic manure or biofertilizer was applied. The increased leaf production under T₁₀ may be attributed to the balanced supply of nutrients from inorganic and organic sources, together with improved nutrient availability through biofertilizers, which promoted vigorous vegetative growth and leaf initiation. Singh and Chaturvedi (2025) ^[9] similarly reported higher numbers of leaves per plant in French bean under integrated application of fertilizers and vermicompost.

Leaf area (cm²)

The maximum leaf area (112.40 cm²) was recorded under T₁₀ (50% RDF + 25% N through FYM + 25% N through Vermicompost + Rhizobium + PSB), which was significantly superior to all other treatments. This was followed by T₉ (104.00

cm²), T₈ (96.30 cm²) and T₇ (90.20 cm²). The minimum leaf area (56.20 cm²) was observed under the control treatment (T₁), where no fertilizer, organic manure or biofertilizer was applied. The superior leaf area under T₁₀ may be attributed to the balanced and continuous supply of nutrients from inorganic and organic sources, along with improved nutrient availability through Rhizobium and PSB, which enhanced vegetative growth and leaf expansion. Rajput *et al.* (2011) ^[8] reported significant improvement in growth characters of French bean with integrated application of inorganic fertilizers, vermicompost and biofertilizers. Similarly, Poonam *et al.* (2023) ^[7] observed higher leaf area under integrated application of RDF with FYM and vermicompost in French bean. More recently, Singh and Chaturvedi (2025) ^[9] reported increased leaf area and leaf area index with integrated nutrient management and vermicompost.

Days to first flowering

The earliest flowering was recorded under T₁₀ (50% RDF + 25% N through FYM + 25% N through Vermicompost + Rhizobium + PSB), which required only 33.18 days for the appearance of the first flower. This treatment was found to be significantly superior to all other treatments. It was followed by T₉ (34.28 days), T₈ (35.48 days) and T₇ (36.28 days). The maximum number of days to first flowering (42.58 days) was observed under the control treatment (T₁), where no fertilizer, organic manure or biofertilizer was applied. The earlier flowering under T₁₀ may be attributed to the balanced and continuous supply of nutrients from inorganic and organic sources, along with improved nutrient availability through Rhizobium and PSB. Adequate nutrition promotes vigorous vegetative growth and facilitates the transition from vegetative to reproductive development. Similar beneficial effects of integrated nutrient management on flowering and growth of French bean have been reported by Barcchiya and Kushwah (2017) ^[2].

The superiority of T₁₀ may also be associated with the complementary effects of FYM, vermicompost and biofertilizers in improving soil fertility, nutrient uptake and plant growth. Parween (2019) ^[6] reported improved growth and yield performance of French bean under integrated application of RDF, organic manures and Rhizobium + PSB. Similarly, Azad and Tomar (2022) ^[1] observed improved crop performance with integrated use of inorganic fertilizers and organic nutrient sources compared with the unfertilized control. Thus, the earlier flowering in T₁₀ indicates that the integrated nutrient combination created favourable nutritional and biological conditions for timely reproductive development in French bean.

Days to 50 per cent flowering

The minimum number of days to 50 per cent flowering (37.70 days) was recorded under T₁₀ (50% RDF + 25% N through FYM + 25% N through Vermicompost + Rhizobium + PSB), which was significantly superior to all other treatments. This treatment was followed by T₉ (38.89 days), T₈ (40.28 days) and T₇ (41.19 days). The maximum number of days required to attain 50 per cent flowering (48.89 days) was observed under the control treatment (T₁). The favourable response of T₁₀ may also be associated with improved nutrient uptake and soil biological activity resulting from the combined use of FYM, vermicompost and biofertilizers. Rajput *et al.*, (2011) ^[8] reported that integrated application of organic, inorganic and biofertilizer sources significantly improved growth and nutrient uptake in French bean. Similarly, Changkiri *et al.*, (2024) ^[3] demonstrated that integrated nutrient management improved crop growth and productivity of French bean. Thus, the present results suggest that the combined

application of 50% RDF + FYM + vermicompost + Rhizobium + PSB provided favourable nutritional and biological conditions for earlier attainment of 50 per cent flowering.

Days to first pod picking

The earliest first pod picking was recorded under T₁₀ (50% RDF + 25% N through FYM + 25% N through Vermicompost + Rhizobium + PSB), which required only 46.19 days. This treatment was found to be significantly superior to all other treatments. It was followed by T₉ (47.39 days), T₈ (48.80 days) and T₇ (49.89 days). The maximum number of days to first pod picking (57.69 days) was observed under the control treatment (T₁), where no fertilizer, organic manure or biofertilizer was applied. The earlier pod picking under T₁₀ may be attributed to improved nutrient synchronization and greater nutrient-use efficiency resulting from the combined use of inorganic and organic nitrogen sources. FYM and vermicompost provide nutrients progressively during crop growth, while RDF supplies readily available nutrients during the early growth phase. This

balanced nutrient supply promotes rapid canopy development and efficient photosynthesis, enabling plants to reach reproductive maturity earlier. Similar effects of integrated nutrient management on earliness and productivity of French bean have been reported by Kumar *et al.*, (2020) ^[5] and Changkiri *et al.*, (2024) ^[3].

The delayed pod picking in the control may be due to nutrient deficiency and reduced photosynthetic capacity, which can slow vegetative development and postpone the transition to reproductive growth. The presence of Rhizobium and PSB in T₁₀ may have further contributed by improving nitrogen fixation and phosphorus availability, supporting reproductive development and pod formation. Barcchiya and Kushwah (2017) ^[2] reported that integrated nutrient management significantly improved flowering and reproductive development in French bean. Thus, the present results suggest that the integrated nutrient treatment T₁₀ created a favourable nutritional environment for earlier pod maturity and first harvesting.

Table 1: Effect of integrated nutrient management on growth parameters of french bean crop

Treat.	Days to Seed Germination	Plant Height (cm)			No. of Branches per Plant 60 DAS	Plant Spread (cm)	No. of Leaves per Plant	Leaf Area (cm ²)	Days to First Flowering	Days to 50% Flowering	Days to First Pod Picking
		30 DAS	45 DAS	60 DAS							
T ₁	11.80	14.56	23.26	32.94	4.20	26.10	21.90	56.20	42.58	48.89	57.69
T ₂	10.60	17.96	29.06	40.34	5.10	32.30	28.20	70.10	39.88	45.29	54.19
T ₃	10.20	19.26	31.26	43.14	5.60	34.80	31.40	76.00	38.78	44.09	52.89
T ₄	9.90	20.46	33.46	45.86	6.00	37.10	34.30	81.50	37.68	42.98	51.49
T ₅	10.00	19.86	32.46	44.66	5.80	35.90	32.70	78.80	38.08	43.39	51.98
T ₆	10.10	19.56	31.86	44.06	5.70	35.40	32.10	77.40	38.38	43.79	52.29
T ₇	9.50	22.36	36.56	50.26	6.50	41.20	39.40	90.20	36.28	41.19	49.89
T ₈	9.20	23.66	38.96	53.36	6.90	43.80	42.90	96.30	35.48	40.28	48.8
T ₉	8.90	25.16	41.76	57.16	7.40	47.40	46.70	104.00	34.28	38.89	47.39
T ₁₀	8.50	26.86	44.46	60.96	7.90	51.10	51.30	112.40	33.18	37.7	46.19
S.Em±	0.027	0.105	0.181	0.240	0.032	0.215	0.258	0.481	0.080	0.094	0.098
CD at 5%	0.080	0.311	0.538	0.712	0.094	0.638	0.766	1.430	0.237	0.281	0.290

Conclusion

On the basis of our research the treatment T₁₀ was the best-performing treatment for all recorded growth parameters, including plant height, branching, plant spread, leaf number and leaf area. It also resulted in the earliest flowering, 50% flowering and first pod picking. This indicates that combining inorganic fertilizer with FYM, vermicompost and biofertilizers produced a favourable nutritional environment for French bean growth and development.

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