***Original Research Article***

**Effects of Integrated nutrient management and vermicompost on genotypes of French Bean in Phenology and Yield under Gangetic Plain**

**Abstract**

The field experiment trial was carried out at the research plot of Krishi Vigyan Kindra-1, Kotwa, Azamgarh, Uttar Pradesh India during the winterseason of 2022-23 and 2023-24. The Split Plot Design was laid out for experimental research plot for 20 treatments with three replications of five combinations of fertilizers and vermicompost, T1 (100% NPKS + 0% VC), T2 (75% NPKS + 25% VC), T3 (50% NPKS + 50% VC), T4 (25% NPKS + 75% VC) T5 (0% NPKS + 100% VC), and four genotypes of French bean i.e. Kashi Rajhans, Kashi Sampann, HUR-15, and HUR-137. The study's primary goal was to evaluate the effects of varying fertilizer and vermicompost levels on various French bean genotypes (*Phaseolus vulgaris* L.).In this investigation, treatment (T2) 75% NPKS through fertilizers + 25% vermicompost, and cultivars Kashi Sampann the results were non-significantly on phenology but growth and yield parameters achieve significantly more plant height (44.44 cm), number of primary branches (4.08), secondary branches (8.12), leaves per plant (51.71), leaf area (2966.17 cm2), leaf area index (4.37), Yield and same important yield attributing variables i.e. pod length (8.51 cm), the weight of one pod (6.49 g), and green pod productivity (yield 169.09 q ha-1), straw yield (32.45 q ha-1), seed index (24.72 gm), were significantly higher than other treatments. Harvest index (41.46 %) and B:C ratio (3.30) of treatment (T2) and cultivar Kashi Sampann showed that French beans might be beneficiary for farmers and soil healthier. Treatment (T2) attributed to better nutrient availability, facilitated by the combination of fertilizers and vermicompost, enhanced soil properties and provided a sustained nutrient release. Kashi Sampann has good potential for adoption as an alternative genotype for the Gangetic Plains region and could be utilized to increase French bean production, according to the results collected.

**Keywords:** French bean,growth, Integrated nutrient management, vermicompost, yield.

1. **Introduction**

A vital leguminous vegetable crop, the French bean (*Phaseolus vulgaris* L.; 2n=22) is widely cultivated for its dry seed and green pod. Kidney beans are dry seeds. According to Vasishtha and Srivastava (2012), it may be grown anywhere in the world and accounts for around 30% of the global production of edible legumes. It is one of the most significant crops in the world, yielding 18.95 million tonnes a year on 28.2 million hectares of land. In terms of both area and production, Brazil is the top producer of French beans. The United States, Canada, Mexico, Colombia, Turkey, and China are also significant producers of French beans. In India, it is mainly grown in range Himalayan region, Indo-Gangetic plain, central India, and peninsular region. According to Gopalakrishnan (2007) and Kanwar *et al*. (2020), 100 grams of green pods are a complete food since they provide roughly 1.7 g of protein, 4.5 g of carbs, 221 I.U. of vitamin A, 11 mg of vitamin C, and 50 mg of calcium. French beans, also called "haricot verts," They are prized for their high nutritional value, especially their protein and fiber content, which makes them a staple in many cuisines and a major vegetarian food source. Their main purpose is to produce fresh, edible green pods that can be cooked in a variety of ways, adding vitamins, minerals, and dietary fiber to a balanced meal. to use effective growing techniques in order to produce, optimize output, and increase market value French beans are a sensitive vegetable crop, unable to tolerate frost, extreme heat, or heavy rain. Optimal seed germination occurs at soil temperatures between 18 and 24 °C, with no germination below 15 °C. The crop thrives in a temperature range of 15 to 25 °C and is cultivated during the cooler season in India's plains. High temperatures hinder its vegetative growth (Evans, 1974). Its optimum Soils with a pH between 5.5 and 6.5 can produce yield (Choudhary, 2015). A dependable crop that reacts favorably to fertilizer is the French bean. Despite being a legume, it is ineffective at fixing nitrogen because it lacks nodules since the NOD gene regulator is absent. It is widely accepted that relying exclusively on chemical input-based agriculture is unsuitable in the long term and that the only way to maintain crop production and protect soil health and biodiversity is through integrated nutrient management (INM), which combines fertilizer, organic manure, and bio-fertilizers. Furthermore, organic manures increase the effectiveness of inorganic fertilizer applications.

It is commonly known that integrating organic and inorganic nutrition sources in integrated nutrient management (INM) has advantages. INM is a comprehensive strategy aimed at the judicious application of chemical fertilizers alongside crop leftovers, green manures, organic manures, and bio-fertilizers to optimize nutrient availability and improve soil health. INM promotes the balanced and efficient use of nutrient sources to enhance crop yields, improve soil fertility, and reduce environmental impacts, while addressing challenges such as soil degradation and nutrient imbalance (Ghosh *et al*., 2004; Roy *et al*., 2006). Vermicompost is a nutrient-rich organic fertilizer that improves soil aeration, productivity, and moisture retention, while enhancing nutrient availability through microorganisms. It recycles organic waste, reduces environmental pollution, and offers a cost-effective, eco-friendly alternative to conventional fertilizers, making it an ideal solution for rural areas with low capital investment and potential for job creation and additional income. Understanding the extent to which vermicompost can replace nutrient fertilizers is crucial. In light of this, the current study was conducted to assess how Integrated Nutrient Management (INM) affects French bean yield. Thus, assessing its potential in the eastern Uttar Pradesh region is the main goal of this study.

**Materials and Method**

A field study was conducted at Krishi Vigyan Kindra-1, Kotwa, Azamgarh, Uttar Pradesh (26° 34' 56.64" N and 83° 25' 16.32" E) and above mean sea level 84 meters, during Rabi season years 2022-2023 and 2023-24. Azamgarh district falls under the 8th Eastern Plain Argo-climatic zone of India. This region has a semi-arid to sub-humid and subtropical climate, experiencing 1081.5 mm rainfall, and is subjected to harsh weather extremes, including intensely hot summers and frigid winters. During the cropping period, total rainfall in 2022-23 was only 2.0 mm, much lower than the 59.5 mm recorded in 2023-24. However, rainfall distribution was more consistent in 2023-24. The sandy clay loam soil in the experimental field was deep, flat, well-drained, low in organic carbon (0.42%), and had a medium amount of nitrogen (338 kg per hectare), phosphorus (15 kg per hectare), and potassium (189 kg per hectare). Crops respond well to NPKS fertilizers, and the soil's reactivity ranges from neutral to slightly alkaline.

In the field, the experiment comprised 20 treatments combined with four varieties i.e. Kashi Rajhans, Kashi Sampann, HUR-15, and HUR-137 of French beans, and five integrated nutrient management levels of inorganic fertilizer and vermicompost (VC) to supply the recommended dose of nutrients. Three replications of each treatment were included in the split-plot design of the field experiment. The nutrient supply through 100% RDF through fertilizers 75% RDF via fertilizers with 25% from vermicompost 50% RDF from fertilizers and 50% vermicompost 25% RDF through fertilizers with 75% vermicompost; and 100% RDN via vermicompost. Each combination of INM is applied to the respective genotypes. The N, P K and S content vermicompost (1.71%, 1.15% 1.06%). The certified seeds of the French bean variety were brought from the Indian Institute of Vegetable Science, Varanasi, and HUR- 15 and HUR- 137 from Banaras Hindu University, Varanasi. The seeds were seeded by line sowing in a shallow furrow that was marked with a marker at a distance of 45 cm between rows and 15 cm between plants on November 02, 2022, for the first year, and November 03, 2023, for the second. The French bean seeds, with the exception of the absolute control, were treated with 250 grams/10 kg of Rhizobium, PSB, and Trichoderma before being dried in the shade and used for planting.

**Result and discussions**

**1.0 Effect of INM on crop phenology**

**1.1 Days to germination.**

Treatment levels showed a non-significant positive effect on days to germination minimum days were observed in treatment T2 (6.98 DAS), followed by T5, T1, T4, and maximum days of germination T3 (7.28 DAS). In genotype also, data non-significant differences among various cultivars to days to germination cultivars minimum days of germination was observed, HUR-137 (6.93 DAS), followed by Kashi Rajhans, Kashi sampann, maximum days of germination HUR-15 (7.44 DAS). The bold-seeded character of some of the genotypes may be the cause of this outcome. Mal *et al*. (2024) and Kalauni *et al*. (2019) reported a similar finding.

**1.2 Seed germination (%)**

Treatment levels showed a non-significantly favorable impact on germination, with the highest germination observed in T3 (92.42%), followed by T2, T4, and T1, and the lowest in T5 (92.00%). Among cultivars, Kashi Sampann showed the highest germination (92.43%), followed by Kashi Rajhans, HUR-137, and the lowest in HUR-15 (92.03%). The bold-seeded character of some of the genotypes may be the cause of this outcome. Mal *et al*. (2024) and Kalauni *et al*. (2019) reported a similar finding.

**1.3 First branch appearance (DAS)**

Treatment levels showed a non-significantly favorable impact on the first branch appearance, with the fewest days observed in T1 (20.18), followed by T4, T3, T2, and the most in T5 (20.52). Among cultivars, Kashi Sampann took the least time (20.12), followed by HUR-137, HUR-15, and Kashi Rajhans (20.47). Das *et al*. (2018) and Pandey *et al*. (2011) reported similar results.

**1.4 First flower appearance (DAS)**

Initial flower appearance was positively impacted by treatment levels; however, this effect was not statistically significant. Treatment T2 had the fewest days to take the first blossom (42.71), followed by T1, T3, and T4, and treatment T5 had the most days to take the first flower (42.96). Showed data non-significant differences among various cultivars minimum days to take first flower was observed, Kashi Sampann (42.14) followed by, Kashi Rajhans, HUR-15, maximum days to take first flower HUR-137 (43.62). The findings of Das *et al*. (2018) and Mal *et al*. (2024) supported the hypothesis that genetic disparity may be the cause of the variations in flowering time.

**1.5 Days taken to 50 % flowering**

The average number of days needed to reach 50% flowering varied greatly. with different nutrient doses from inorganic fertilizers and vermicompost for French beans (Table 1). The tiniest days to 50% flowering were observed in T2 (75% NPKS + 25% VC) at 48.64 days, followed by T3 (50% NPKS + 50% VC) at 49.78 days, and T1 (100% NPKS + 0% VC) at 51.04 days. In contrast, T4 (25% NPKS + 75% VC) and T5 (0% NPKS + 100% VC) required more days. Among cultivars, Kashi Sampann had the least days (33.13), followed by Kashi Rajhans (33.72) and HUR-15 (34.55), with HUR-137 requiring the most (45.60). This variation is likely due to season, photoperiod, and temperature, as reported by White and Laing (1989), and aligns with findings by Pandey *et al*., (2011), Das *et al*., (2018), and Mal *et al*., (2024).

**1.6 First pod appearance**

Treatment levels showed a non-significant but positive effect on the first pod minimum days to take the first pod was observed in treatment T4 (44.89), followed by T2, T1, T5, and maximum days to take the first pod T3 (45.13). Showed data significant differences among various cultivars minimum days to take first pod was observed, Kashi sampann (43.89) followed by, Kashi Rajhans, HUR-15, maximum days to take first pod HUR-137 (45.78). These results were supported by Das *et al*. (2018), who suggested that genetic disparity could be the cause of the variations in pod duration.

**Physical maturity (DAS)**

The mean number of days required for physical maturity significantly differed among the recommended nutrient doses through different fertilizers and vermicompost levels for the French bean crop (Table 1). The data revealed a lesser mean number of days required for physical maturity was noticed in T1 (102.72 days). T2 (103.06 days) is closely followed by T3 (103.95 days) and T4 (105.65 days) the higher number of days required for physical maturity was noticed in T5 (106.87 days). The mean number of days required for physical maturity significantly differed among the cultivars of French beans (Table 1). The data revealed that a lesser mean number of days required for physical maturity was noticed in Kashi Sampann (102.57 days) closely followed by Kashi Rajhans (103.48 days) and HUR-15 (105.66 days). while, a higher number of days was noticed in HUR-137 (106.09 days). Moreover, genetic diversity within varieties can lead to variations in yield and adaptability to management practices (Ceccarelli., 1994).

**2.0 Effect of INM on French Bean Growth**

**2.1 Plant height**

Data in Table 2 clearly shows significant differences in plant height among the various nutrient doses, fertilizers, and vermicompost levels for the French bean crop. The tallest plant measured was found in T2 (44.44 cm), followed by T3 (43.84 cm), T1 (43.32 cm), and T4 (42.74 cm), while the lowest was in T5 (36.78 cm). Among the cultivars, Kashi Sampann showed the tallest plants (42.41 cm), followed by Kashi Rajhans (42.30 cm), HUR-15 (42.17 cm), and HUR-137 (42.01 cm).T2 is due to improved nutrient availability from the combined fertilizers and vermicompost and the genetic differences between the cultivars, which were produced in identical environmental conditions, could be the cause of these discrepancies in plant height. Pandey *et al*. (2011). Singh (2000), Dhanjal *et al.* (2001), Manjunath (2010), and Ramana *et al.* (2011) all reported similar results.

**2.2 Number of branches**

Fertilizer and vermicompost combinations had a substantial impact on the number of primary and secondary branches per plant in French beans (Table 2). T2 showed the highest number of branches (4.08 primary, 8.12 secondary), followed by T3 (3.91, 7.77), T1 (3.73, 7.44), and T4 (3.47, 7.10). T5 had the lowest (3.26 primary, 6.23 secondary). Among cultivars, Kashi Sampann had the highest branch count (3.78 primary, 7.44 secondary), while HUR-137 had the lowest (3.60 primary, 7.23 secondary). T2 is due to improved nutrient availability from the combined fertilizers and vermicompost Similar results were found by Singh (2000), Dhanjal *et al*. (2001) and differences are likely due to genetic factors and farming practices, as noted by Pandey *et al*. (2011).

**2.3 Leaf characters**

The number of leaves per plant, area of leaves, and index of leaf area in French beans were significantly influenced by fertilizer and vermicompost combinations (Table 2). T2 recorded the highest values (51.71) leaves, (2966.169 cm²) area of leaves, and (4.09) index of leaf area, followed by T3, T1, and T4. T5 had the lowest. Among cultivars, Kashi Sampann had the highest number of leaves (50.42), leaf area (2717.288 cm²), and leaf area index (3.77), while HUR-137 had the lowest. The higher leaf count in T2 is due to improved nutrient availability from the combined fertilizers and vermicompost. Similar results were found by Singh (2000), Dhanjal *et al*. (2001), Manjunath (2010), and Ramana *et al*., (2011).

**3.0 Effect of INM on French bean yield attributes and yield**

**3.1 Length and weight of the pod**

The pod length was significantly affected. Maximum pod length was noted in T2 (8.51cm), tracked by T3 (8.08 cm), T1 (7.39 cm), then T4 (6.89 cm), and lowest in T5 (6.44 cm). Among cultivars, the length of the pod significantly differed in Table 3, maximum pod length recorded in Kashi Sampann (7.81 cm) followed by Kashi Rajhans (7.49 cm), HUR-15 (7.33 cm) and minimum pod length recorded in HUR-137 (7.22 cm) in Table 3. The treatments had a considerable impact on green pod weight, with T2 recording the maximum weight (6.49 gm), followed by T3 (6.29 gm), T1 (6.06 gm), and T4 (5.86 gm). The lowest was in T5 (5.36 gm). Among cultivars, Kashi Sampann had the highest green pod weight (6.09 gm), followed by Kashi Rajhans (6.04 gm), HUR-15 (5.98 gm), and the lowest in HUR-137 (5.94 gm). The improved length of the pod and green pod weight in T2 is attributed to better nutrient availability from the combined fertilizers and vermicompost. Singh (2000), Dhanjal *et al.* (2001), Manjunath (2010), and Ramana *et al*. (2011) all observed similar findings.

**3.2 Green pod yield**

The yield of the green pod was significantly affected, the maximum green pod yield was noted under T2 (169.09 q ha-1) followed by T3 (162.81 q ha-1), T1 (157.61 q ha-1), and T4 (156.89 q ha-1), while least green pod yield with T5 (141.24 q ha-1). Among cultivars, the maximum output of green pods was noted. in Kashi Sampann (171.81 q ha-1), followed by Kashi Rajhans (163.71 q ha-1), HUR-15 (151.92 q ha-1), and while the least with HUR-137 (142.62 q ha-1). The high nutrient availability, facilitated by the combined use of fertilizers and vermicompost, better-quality soil properties and provided a sustained nutrient release to crop roots reported that Similar findings had been reported by Muthuramu *et al*. (2015), Singh (2000), Dhanjal *et al*., (2001), Manjunath (2010), and Ramana *et al*., (2011), Zeliang *et al*., (2018).

**3.3** **Straw yield**

The yield of straw was significantly higher found in treatment (T2) (32.45 q ha-1) followed by T3, T1, and T4 and the Kashi Sampann cultivar obtained (31.21 q ha-1) highest straw yield than Kashi Rajhans, HUR-15. Farhad *et al.* (2009), and Kushwaha *et al.* (2021), reported similar findings. Vermicompost also enhances essential nutrients such as macro and micronutrients and improves soil physical conditions (Edwards and Bohlen, 1996, Kumar *et al*., 2019).

**3.4** **Seed and Harvest Index**

The seed index in French beans was suggestively partial by fertilizer and vermicompost combinations (Table 3), with the highest seed index recorded in T2 (24.72 gm), followed by T3, T1, and T4. Among cultivars, Kashi Sampann had the highest seed index (27.19 gm), followed by HUR-137 (24.43 gm), HUR-15 (24.27 gm), and the lowest in Kashi Rajhans (19.76 gm). The harvest index was highest in T2 (41.46%), followed by T3 (41.29 %), T1 (40.65 %), and T4 (40.57 %), with the lowest in T5 (39.12 %). In cultivars, Kashi Sampann had the highest harvest index (41.93%), followed by Kashi Rajhans (41.16 %), HUR-15 (40.05 %), and HUR-137 (39.32 %). Fertilizers and vermicompost enhance nutrient availability and promote nitrogen fixation, improving growth, yield, and harvest index (Krouma and Abdelly 2003).

**3.5** **Economics**

The benefit-cost (B: C) ratio reflects the practical utility of integrated nutrient management treatments. It was suggestively partial by fertilizer and vermicompost combinations (Table 3). The highest B: C ratio was recorded in T2 (3.30), followed by T1 (3.27), T3 (2.90), and T4 (2.56), with the lowest in T5 (100% nutrient supply from vermicompost). The higher ratio in T2 is attributed to optimal nutrient supply. Among cultivars, Kashi Sampann had the highest B: C ratio (3.16), followed by Kashi Rajhans (2.96), HUR-15 (2.67), and HUR-137 (2.45). The high nutrient availability, facilitated by the combined use of fertilizers and vermicompost, better-quality soil properties, and provided a sustained nutrient release to crop roots reported that Ramana *et al*., (2011), these variations reflect genetic potential and farming practices, consistent with findings by Pandey *et al*., (2011).

**Conclusions**

As per the results derived from the current study, better growth was obtained with the application of integrated fertilizers and vermicompost manures and the yield of French beans in the Gangetic Plain zone. Application of Treatment (T2) resulted in the maximum green pod yield and the highest benefit-cost ratio. It might be determined that genotype Kashi Sampann among all of the genotypes of French bean was found the finest genotype corresponding to the characters viz., percentage of germination, plant height, number of leaves, branches at weekly and final harvesting stage, pod length, pod diameter, the weight of individual pod per plant, green pod yield per plant and green pod yield per hectare. Based on the results concluded that Kashi Sampann has the potential to be used as an alternative genotype for the Gangetic Plains region and could be used to boost French bean production. However, before giving any recommendation, additional verification through multi-locational trails and farmer’s field experiments would be crucial.

**Acknowledgments**

We appreciate Krishi Vigyan Kendra-1 at Kotawa, Azamgarh, Uttar Pradesh, for supplying field experiment plots equipped with all the tools required to carry out our research.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

Option 2:

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology

Details of the AI usage are given below:

1.

2.

3.

**References**

Ceccarelli, S. (1994). Specific adaptation and breeding for marginal conditions. Euphytica, 77(3), 205-219. https://doi.org/10.1007/BF02262633

Choudhary, B. R. (2015). French bean. In: Vegetables. Kalyani Publishers, New Delhi, p. 162.

Das, K., Datta, S., and Sikhdar, S. (2018). Performance of bush-type French bean varieties (*Phaseolus vulgaris* L.) with or without rhizobium inoculation. *Indian Journal of Agricultural Research*, 52(3), 284-289.

Dhanjal, R., Om Prakash, and Ahlawat, L. P. S. (2001). Response of French bean (*Phaseolus vulgaris*) varieties to plant density and nitrogen application. *Indian Journal of Agronomy*, 46, 277-281.

Edwards, C. A., and Bohlen, P. J. (1996). Biology and ecology of earthworms (Vol. 3). Springer Science and Business Media.

Evans, A. M. (1974). Research on the evolution and genetic improvement of grain legumes. University of Cambridge, *Department of Applied Physiology, Memoirs*, 46(5-11).

Ghosh, P. K. (2004). Comparative effectiveness of cattle manure, poultry manure, phosphocompost, and fertilizer-NPK on three cropping systems in vertisols of semi-arid tropics. *Bioresource Technology*, 95(1), 77-83.

Gopalakrishnan, T.R. (2007). Vegetable Crops. New India Publishing Agency, New Delhi (India)

Jan, R., Ali, T., Mushtaq, N., Ahmad Bhat, S., Nabi, B. B., & Farooq, K. (2020). Effect of integrated nitrogen management on growth performance of French bean (Phaseolus vulgaris L.) var. Contendor under temperate conditions of Kashmir Valley. *Current Journal of Applied Science and Technology*, *38*(6), 1-9. https://doi.org/10.9734/cjast/2020/v38i6302406

Kalauni, S., Pant, S., Luitel, B. P., and Bhandari, B. (2019). Evaluation of pole-type French bean (Phaseolus vulgaris L.) genotypes for agro-morphological variability and yield in the mid-hills of Nepal. *International Journal of Horticulture*, *9*.

Krouma, A., and Abdelly, C. (2003). Importance of iron use efficiency of nodules in common bean (*Phaseolus vulgaris* L.) for iron deficiency chlorosis resistance. *Journal of Plant Nutrition and Soil Science*, 166(4), 525–528.

Kumar, V., Singh, R., and M. S. (2019). Impact of vermicompost on soil health and crop productivity. *Journal of Applied and Natural Science*, 11(2), 554-558.

Kanwar, R., Mehta, D.K., Sharma, R. and Dogra, R.K. (2020). Studies on genetic diversity of French bean (*Phaseolus* *vulgaris* L.) landraces of Himachal Pradesh based on morphological traits and molecular markers. *Legume Research-An International Journal*. 43: 470-479.

Manjunath, M. N., Patil, P. L., and Gali, S. K. (2010). Effect of organics amended rock phosphate and P solubilizer on P use efficiency of French bean in a Vertisol of Malaprabha Right Bank command of Karnataka. Karnataka *Journal of Agricultural Sciences*, 19(1), 30-35.

Mal, D., Goutam, E., and Kumar, L. (2024). Performance of French bean (*Phaseolus vulgaris* L.) Genotypes under Trans-Gangetic Plains Region. *Indian Journal of Agricultural Research*, *58*(1).

Muthuramu, S., Paulpandi, V. K., Sakthivel, S., Ramakrishna, K., and Karthik, K. (2015). Assessing the performance of French bean (*Phaseolus vulgaris* L.) in district Virudhunagar of Tamil Nadu. *Journal of Krishi Vigyan*, 3(2), 5-6.

Pandey, Y. R., Gautam, D. M., Thapa, R. B., Sharma, M. D., and Paudyal, K. P. (2011). Variability of French bean in the western mid-hills of Nepal. *Journal of Natural Science*, 45, 780-792.

Ramana, V., Ramakrishna, M., Purushotham, K., and Reddy, K. B. (2011). Effect of bio-fertilizers on growth, yield, and quality of French bean (*Phaseolus vulgaris* L.). *Vegetable Science*, 38(1), 35-38.

Roy, R. N., Finck, A., Blair, G. J., and Tandon, H. L. S. (2006). Plant nutrition for food security: A guide for integrated nutrient management. *FAO Fertilizer and Plant Nutrition Bulletin*, 16(368), 201-214.

Singh, A. K., and Singh, S. S. (2000). Effect of planting dates, nitrogen, and phosphorus levels on yield-contributing characters in French bean. *Legume Research*, 23, 33-36.

Vasishtha, H., and Srivastava, R. P. (2012). Genotypic variations in protein, dietary fiber, saponins, and lectins in Rajmash beans (*Phaseolus vulgaris* L.). *Indian Journal of Agricultural Biochemistry,* 25(2), 150-153.

Zelaing, P. K., Kumar, M., Kumar, R., Meena, K. L., and Rajkowa, D. J. (2018). Varietal evaluation of French beans for higher productivity and nutritional security under the foothill ecosystem of Nagaland. *Indian Journal of Hill Farming*, 31(2), 206-2

**Table:1 Combined effect of fertilizers and vermicompost on the phenology of French bean genotypes, (polled data two years).**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| INM treatments | Germination (DAS) | Seed germination  (%) | First branch appearance (DAS) | First  flowering  (DAS) | 50% flowering (DAS) | 1st pod appearance (DAS) | Physical maturity (DAS) |
| T1 (100% NPKS + 0% VC) | 7.15 | 92.13 | 20.18 | 42.80 | 51.04 | 44.99 | 102.72 |
| T2 (75% NPKS + 25% VC) | 6.98 | 92.29 | 20.32 | 42.71 | 48.64 | 44.98 | 103.06 |
| T3 (50% NPKS + 50% VC) | 7.28 | 92.42 | 20.33 | 42.88 | 49.78 | 45.13 | 103.95 |
| T4 (25% NPKS +75% VC) | 7.19 | 92.21 | 20.22 | 42.88 | 51.93 | 44.89 | 105.65 |
| T5 (0% NPKS + 100% VC) | 7.10 | 92.00 | 20.52 | 42.96 | 53.03 | 45.14 | 106.87 |
| SEm± | 0.12 | 0.26 | 0.12 | 0.09 | 0.18 | 0.22 | 0.24 |
| CD (P=0.05) | NS | NS | NS | NS | 0.58 | NS | 0.79 |
| Cultivars |  |  |  |  |  |  |  |
| V1(KashiRajhas) | 7.09 | 92.23 | 20.47 | 42.21 | 50.45 | 44.77 | 103.48 |
| V2(KashiSampann) | 7.11 | 92.43 | 20.12 | 42.14 | 50.12 | 43.89 | 102.57 |
| V3 (HUR- 137) | 6.93 | 92.13 | 20.29 | 43.62 | 51.55 | 45.78 | 106.09 |
| V4 (HUR -15) | 7.44 | 92.03 | 20.37 | 43.42 | 51.42 | 45.67 | 105.66 |
| SEm± | 0.19 | 0.23 | 0.12 | 0.10 | 0.08 | 0.15 | 0.11 |
| CD (P=0.05) | NS | NS | NS | 0.28 | 0.23 | 0.43 | 0.31 |

**Table: 2 Combined effect of fertilizers and vermicompost on growth of various genotypes, French bean, polled (data two years).**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| INM treatments | Plant height (cm) | Primary branch (No.) | Secondary branch (No.) | Leaf Number per plant | Leaf area.(cm2) | Leaf area index |
| Treatments | (77 DAS) | (56DAS) | (63 DAS) | (77DAS) | (77DAS) | (70DAS) |
| T1 (100% NPKS + 0%VC) | 43.32 | 3.73 | 7.44 | 49.46 | 2705.58 | 3.96 |
| T2 (75% NPKS + 25%VC) | 44.44 | 4.08 | 8.12 | 51.71 | 2966.17 | 4.37 |
| T3 (50% NPKS + 50%VC) | 43.84 | 3.91 | 7.77 | 50.61 | 2851.14 | 4.17 |
| T4 (25% NPKS +75% VC) | 42.74 | 3.47 | 7.10 | 48.32 | 2543.92 | 3.74 |
| T5 (0% NPKS + 100%VC) | 36.78 | 3.26 | 6.23 | 42.20 | 2248.01 | 3.41 |
| SEm± | 0.11 | 0.03 | 0.05 | 0.18 | 13.93 | 0.04 |
| CD (P=0.05) | 0.37 | 0.10 | 0.17 | 0.60 | 45.435 | 0.11 |
| Cultivars |  |  |  |  |  |  |
| V1 (Kashi Rajhans) | 42.30 | 3.72 | 7.36 | 50.03 | 24.07 | 3.95 |
| V2 (Kashi Sampann) | 42.41 | 3.78 | 7.44 | 50.42 | 24.34 | 3.99 |
| V3 (HUR- 137) | 42.01 | 3.60 | 7.23 | 46.09 | 23.42 | 3.84 |
| V4 (HUR -15) | 42.17 | 3.67 | 7.30 | 47.29 | 23.75 | 3.90 |
| SEm± | 0.03 | 0.02 | 0.02 | 0.06 | 0.06 | 0.01 |
| CD (P=0.05) | 0.08 | 0.06 | 0.05 | 0.17 | 0.18 | 0.03 |

**Table:3 Combined effect of fertilizers and vermicompost on yield attributes and yield of various genotypes, French bean, (polled data two years).**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| INM treatments | Length of pod (cm) | Weight of one pod(gm) | Green pod yield(q/ha) | Straw yield(q/ha) | Seed index (gm) | Harvest index (%) | B:C ratio |
| T1 (100% NPKS + 0%VC) | 7.39 | 6.06 | 157.61 | 30.35 | 23.73 | 40.65 | 3.27 |
| T2 (75% NPKS + 25%VC) | 8.51 | 6.49 | 169.09 | 32.45 | 24.72 | 41.46 | 3.30 |
| T3 (50% NPKS + 50%VC) | 8.08 | 6.29 | 162.81 | 30.75 | 23.82 | 41.29 | 2.90 |
| T4 (25% NPKS +75% VC) | 6.89 | 5.86 | 156.89 | 28.15 | 23.72 | 40.57 | 2.56 |
| T5 (0% NPKS + 100%VC) | 6.44 | 5.36 | 141.24 | 26.80 | 23.57 | 39.12 | 2.04 |
| SEm± | 0.12 | 0.04 | 0.88 | 0.45 | 0.23 | 0.47 | 0.02 |
| CD (P=0.05) | 0.38 | 0.12 | 2.86 | 1.47 | 0.76 | 1.53 | 0.07 |
| Cultivars |  |  |  |  |  |  |  |
| V1 (Kashi Rajhans) | 7.49 | 6.04 | 163.71 | 29.86 | 19.76 | 41.16 | 2.96 |
| V2 (Kashi Sampann) | 7.81 | 6.09 | 171.86 | 31.21 | 27.19 | 41.93 | 3.16 |
| V3 (HUR- 137) | 7.22 | 5.94 | 142.62 | 28.61 | 24.43 | 39.32 | 2.45 |
| V4 (HUR -15) | 7.33 | 5.98 | 151.92 | 29.12 | 24.27 | 40.05 | 2.67 |
| SEm± | 0.06 | 0.01 | 0.95 | 0.19 | 0.27 | 0.32 | 0.03 |
| CD (P=0.05) | 0.17 | 0.04 | 2.75 | 0.55 | 0.77 | 0.93 | 0.07 |