***Original Research Article***

**Integrated Nutrient Management Impact Evaluation on French Bean (*Phaseolus vulgaris* L*.*) Progression and Productivity ~~for~~ in Gangetic Plain, Uttar Pradesh**

**Abstract**

A field experiment of fertilizers and vermicompost was conducted to study the INM effect on different genotypes of French bean at the research plot of Krishi Vigyan Kindra-1, Kotwa, Azamgarh district, Uttar Pradesh, India during the two continual *Rabi* season of 2022-23 and 2023-24. Treatments were a combination of five different levels of fertilizers and vermicompost viz. 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) to fulfil the requirement of the recommended dose of fertilizers. This treatment was applied on four genotypes of French bean i.e. Kashi Rajhans, Kashi Sampann, HUR-137, and HUR-15. Growth parameters data were recorded and analyzed at weekly intervals. Treatment (T2) and genotype Kashi Sampann observed a significant maximum plant height (44.44 cm) and (42.41 cm) at 77 DAS, number of primary branches (4.08) and (3.78) at 56 DAS, number of secondary branches (8.12) and (7.44) at 63 DAS, number of leaves per plant (51.71) and (46.09) at 77 DAS, leaf area index (4.09) and (3.77) at 70 DAS, respectively. Yield attribute i.e. maximum length of the pod (8.51 cm) and (7.81 cm), the weight of green one pod (6.49 gm) and (6.09 gm), grains number per pod (6.55) and (6.04), the grain weight per pod (1.33 gm) and (1.46 gm), seed yield per plant (20.92 gm) and (20.66 gm), Seed yield (23.04 q ha) and (22.58 q ha) straw yield (32.45 q ha) and (31.21 q ha), seed index (24.72 gm) and (27.19 gm). Maximum harvest index was achieved by T2 (41.46 %), and genotype Kashi sampann (41.93 %). However, the maximum B:C ratio was achieved by T2 (3.30) and genotype Kashi sampan (3.16). This shows T2 is more economically benefit to farmers than other treatments and genotype Kashi Sampann. Treatment (T2) attributed to better nutrient availability, facilitated by the integrated application of fertilizers and vermicompost, improved soil properties and provided sustained nutrient release. In light of the results, it might be concluded that Kashi Sampann has better potential for by means of it as an alternate cultivar/ genotype for the zone of Gangetic plains and could be applied to enhance~~ment~~ French bean productivity and production.

**Keywords:** French bean,Integrated nutrient management, vermicompost, growth, yield. **(rearrange in alphabetical order)**

1. **Introduction**

French bean (*Phaseolus vulgaris* L.; 2n=22) is one of the most important leguminous vegetables, cultivated widely for green pods as well as dry seeds, the latter of which are known as kidney beans. It is grown globally and accounts for approximately 30% of the total production of food pulse (Vasishtha and Srivastava, 2012). In India, primarily cultivated in regions such as the Himalayan foothills, the Indo-Gangetic plain, central India, and the peninsular region. 100 grams of green pods contain nearly protein 1.7 g, carbohydrates 4.5 g, vitamin A 221 I.U., vitamin C 11 mg, and calcium 50 mg (Gopalakrishnan, 2007; Kanwar *et al.,* 2020) making it a well-rounded food source. The optimum soil pH for sustainable yield is between 5.5 and 6.5 (Choudhary, 2015). French beans are responsive to fertilization, they are unable to fix nitrogen efficiently owing to the NOD gene regulator absence, which results in the lack of root nodules.

Fertilizer consumption at the national level was 32.54 million tons during the year 2020-21. By 2030, the total projected demand for fertilizer consumption is expected to reach 57.32 million tons. The findings also suggest a continuous increase in fertilizer demand in the coming years. Therefore, it is essential to boost domestic fertilizer production to meet this growing need, rather than relying on imports (Jadhav and Ramappa, 2021). Overuse of fertilizers could lead to toxic accumulation of heavy metals like arsenic, uranium, and cadmium in the system of soil. Metals absorb and accumulate in crops and enter the food chain, potentially causing serious health issues (Das, et. al., 2023). Soil structure is crucial for agricultural productivity and serves as an indicator of soil health. Industrial emissions, particularly NaNO3, NH4NO3, KCl, K2SO4, and NH4Cl, can deteriorate soil structure, hindering the production of quality crops (Das, et. al., 2023).

Given the growing consensus that reliance on chemical fertilizers alone is unsustainable in the long term, INM, which combines fertilizers, organic manures, and bio-fertilizers, has become essential for maintaining crop productivity, soil health, and biodiversity. Organic manures also enhance the efficiency of inorganic fertilizers, contributing to more sustainable agricultural practices. The benefits of integrated approach of organic and inorganic nutrient sources in INM are well-established. INM optimizes nutrient availability and improves soil health by using chemical fertilizers alongside manures, green manures, crop residues, and bio-fertilizers. This approach enhances crop productivity, improves soil health i.e. fertility, and diminishes environmental impacts (Ghosh et al., 2004; Roy et al., 2006). Vermicompost, a nutrient-rich organic fertilizer, improves soil aeration, moisture retention, and nutrient availability, while recycling organic waste and reducing pollution. It offers a cost-effective, eco-friendly alternative to conventional fertilizers, benefiting rural areas through low capital investment and job creation. This study to be evaluates the outcome of INM on the productivity, economics of French beans in eastern Uttar Pradesh.

**2. Method and materials**

 The field experiment was carried out at Krishi Vigyan Kindra-1, Kotwa, Azamgarh, Uttar Pradesh (26° 34' 56.64" N and 83° 25' 16.32" E), 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 subtropical climate between semi-arid and sub-humid type, experiencing 1081.5 mm rainfall (Singh et al., 2012) and subjected to life-threatening extreme weather conditions i.e., temperature (extremely hot summer) and cold winter. Soil of the field trail was sandy clay loam (typical Ustochrepts) in texture, flat, deep, low in organic carbon (0.42%), well-drained, and available nutrient i.e. nitrogen 338 kg ha-1 (medium), phosphorus 15 kg ha-1 (low) and potassium 189 kg ha-1 (medium). Soil reaction varies from neutral to mildly alkaline.

In field 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. The experimental plot layout was designed in a split plot arrange with three replications for all treatments. 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. Applied vermicompost to treatment plots contained 1.71% nitrogen (N), 1.15% phosphorus (P), and 1.06% potassium (K). All certified seeds were brought from the Indian Institute of Vegetable Science, Varanasi and HUR- 15 and HUR- 137 from Banaras Hindu University, Varanasi. The first year, on November 02nd, 2022- and second-year November 03rd, 2023 he seeds were sown using line sowing in a shallow furrow created with a marker, maintaining a row-to-row spacing of 45 cm and a plant-to-plant spacing of 15 cm. Prior to sowing, the French bean seeds were treated with Rhizobium and Trichoderma at a rate of 250 grams per 10 kg of seeds, excluding the absolute control. The treated seeds were then shaded to dry before being used for sowing.

1. **Result and discussions**

**3.1 Plant Height**

The plant height indicator parameters were recorded to assess the impact on growth through the treatments and genotypes (Sitompul and Guritno, 1995). Plant heights among all tested treatments and genotypes were observed at weekly intervals. Data on plant height was observed non-significant between 14 to 21 DAS, but, at 28 to 77 DAS significantly greater than other treatments (Table 1). Maximum plant height was obtained with T2 (44.44 cm) followed by T3, T1, and T4. In genotypes, plant height significantly influenced at weekly interval at 21 to 77 DAS, except 14 DAS. The maximum plant height (42.41 cm) achieved by Kashi Sampann followed by Kashi Rajhans, and HUR-15. The growth pattern among genotypes was different that is related to differences in the genetic characteristic response to the environment (Sitaresmi, 2016).

This outcome also revealed that significant plant height recorded from 28 DAS (P < 0.05) (Table 1). In INM treatment, the highest weekly average growth rate of plant height 7.50 cm was recorded at 42 DAS, while the lowest 2.01 cm observed at 77 DAS and average for all treatments 3.67 cm per week. At 42 DAS, the highest 9.02 cm plant height growth rate was recorded with T2, followed by T3 (8.34 cm), T1 (7.58 cm), and T4 (6.64 cm). The average growth rate of plant height for all genotypes was (4.25 cm) at weekly interval (Table 1) 42 DAS, the maximum plant height was noted in cultivars Kashi Sampann (7.74 cm) followed by Kashi Rajhans, and HUR-15, while the lowest with HUR-137 (7.22 cm). The increase in plant height under T2 is attributed to better nutrient availability, facilitated by the combined application of fertilizers and vermicompost, which improved soil properties and provided sustained nutrient release. Similar conclusions have been stated by Singh (2000), Dhanjal *et al*., (2001), and Ramana *et al*., (2011). The differences in genetic makeup and the physiological response to environmental conditions can explain this outcome (Sugeng 2001).

**3.2 Leaves number per plant**

 The leaves number per plantwas observed significantly at weekly interval from 14 to 77 DAS, except at 14 DAS recorded non-significant (Table 2). Treatment (T2) observed the maximum leaves number 51.71 followed by T3, T1, and T4. In case of genotype maximum leaves number per plant (50.42) was recorded significantly higher in Kashi Sampann from 21 to 77 DAS except at 14 DAS with a 95% confidence level followed by Kashi Rajhans, and HUR-15, while the lowest with HUR-137 (46.09). Treatment T2 provided nitrogen and vermicompost increased nitrogen uptake, promoting protein synthesis, cell division, and enlargement, which resulted in increased leaves. This is consistent with findings by Shekhar et al. (1992) and Zagonel et al. (2002). The improved nitrogen and vermicompost supply also enhanced growth-promoting substances, The differences in genetic makeup and the physiological response to environmental conditions can explain this outcome (Sitaresmi, 2016).

In INM treatment, the highest average weekly leaves number per plant was observed at 35 DAS (8.51), while the lowest was observed at 77 DAS (0.88). At 35 DAS, the highest leave number was recorded in Treatment T2 (9.30), followed by T3 (8.94), T1 (8.47), and T4 (8.35). This growth rate was notably higher compared to other weekly observations. In cultivars, the highest average weekly leave number per plant was recorded at 35 DAS (8.51), while the lowest was observed at 77 DAS (0.88) (Table no.2). The maximum plant height was observed in cultivars Kashi Sampann (9.20) followed by Kashi Rajhans, and HUR-15, while the lowest with HUR-137 (8.18).

**3.3 Leaf area index**

Leaf Area Index of French bean was measured recorded days after sowing (DAS) 14 to 77 and showed significant variation at all weekly intervals, except between 14 and 21 DAS (Table 3). Treatment T2 exhibited the highest LAI (4.37), followed by T3, T1, and T4. Among the genotypes, Kashi Sampann consistently recorded the highest LAI at most weekly stages, with the exception of the 14 to 21 DAS period where the differences were not significant. The final LAI of Kashi Sampann was the highest (3.99), followed by Kashi Rajhans and HUR-15. The growth patterns observed across varieties varied, which can be attributed to the genetic variances in their responses to various factors of environment (Sitaresmi, 2016).

In INM treatment, the average highest growth rate (0.77) of LAI was recorded at 42 DAS and while the lowest was observed at 70 DAS (0.12). In case of treatment, the highest LAI was recorded (0.92) with T2 at 42 DAS, followed by T3 (0.86), T1 (0.77), and T4 (0.69). In genotype, the overall average maximum weekly LAI was recorded at 42 DAS (0.77), while the lowest (0.12) observed at 70 DAS. The genotype Kashi Sampann recorded highest LAI (0.80), followed by Kashi Rajhans, and HUR-15, while the lowest with HUR-137 (0.75). LAI is influenced by the moisture and air content in the soil, as well as the soil's temperature. The higher LAI in T2 is owing 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).

**3.4. Primary branch**

 The primary branch per plant among all tested treatments and genotypes was observed significantly at all weekly intervals 21 to 56 DAS except 14 DAS (Table 4). Treatment T2 observed the maximum primary branch per plant from 21 to 56 DAS followed by T3, T1, and T4 while the minimum with T5, (3.26). In the case of genotypes was recorded significantly higher between 28 to 56 DAS at a 95% confidence level except at 21 DAS non-significant. Kashi Sampann genotype recorded the maximum primary branch per plant in all weekly interval observations, 28 to 56 DAS. So, the maximum final primary branch per plant (3.78) was observed with Kashi Sampann followed by Kashi Rajhans, and HUR-15, while the lowest with HUR-137 (3.60). The growth pattern among cultivars was different. That is related to differences in the genetic characteristic response for environment and farming practices, as noted by Pandey *et al*., (2011). Sitaresmi, (2016).

A significant primary branch per plant occurred from 28 to 56 DAS (P < 0.05) (Table 3). In INM treatment, the maximum average weekly primary branch per plant was recorded at 28 DAS (1.08), while the lowest was observed at 56 DAS (0.02) and average growth rate (0.44) per week for all treatments. At 28 DAS, primary branch per plant, the maximum increasing rate was recorded in Treatment T2 (1.21), followed by T3 (1.16), T1 (1.08), and T4 (1.01). In cultivars, the maximum increasing rate of primary branch per plant was recorded at 28 DAS (1.08), while the lowest at 56 DAS (0.02). The highest primary branch per plant was recorded in cultivars Kashi Sampann (1.11) followed by Kashi Rajhans, and HUR-15. The higher nitrogen levels and vermicompost triggered nitrogen availability and uptake, which in turn promoted protein synthesis, cell division, and cell enlargement. This ultimately led to a noticeable increase in primary branch. Comparable findings were reported by Shekhar et al. (1992) and Zagonel et al. (2002). The improved nitrogen supply facilitated the synthesis of growth-promoting substances in the plant, leading to a greater number of branches per plant The variances in genetic makeup and the plant physiological response to environmental conditions might explain this result (Sugeng 2001).

**3.5 Secondary branch**

Secondary branches enhance both the productivity and adaptability of French beans, making them an important feature in yield. Treatment (T2) observed the maximum secondary branch from 28 to 63 DAS, and the maximum final secondary branch (8.12) per plant followed by T3, T1, and T4. In genotypes recorded significantly higher from 28 to 63 DAS at a 95% confidence level. So, the highest final secondary branch per plant of Kashi Sampann (7.44) followed by Kashi Rajhans, and HUR-15, while the lowest with HUR-137 (7.23). This study also showed that a significant secondary branch per plant occurred from 28 DAS (Table 3).

In INM treatment, maximum weekly average secondary branch per plant rate was recorded at 42 DAS (1.70), while the lowest was observed at 63 DAS (0.07). Treatment T2 recorded the highest secondary branch per plant (1.76) at 42 DAS, followed by T3 (1.72), T1 (1.70), and T4 (1.67). In genotypes recorded at 42 DAS (1.70), while the lowest at 63 DAS (0.05) and average (0.98) per week (Table 5). At 42 DAS, observation recorded the highest secondary branch per plant in cultivars Kashi Sampann (1.74) followed by Kashi Rajhans, and HUR-15, while the lowest with HUR-137 (1.67). The higher nitrogen levels and vermicompost give rise to nitrogen availability and its uptake, which in turn promotes protein synthesis, cell division, and cell enlargement. This ultimately led to a noticeable increase in the secondary branch. The improved nitrogen supply facilitated the synthesis of growth-promoting substances in the plant, leading to a greater number of branches per plant, The variances in genetic makeup and the plant physiological response to environmental conditions might be explained this outcome (Sugeng 2001), (Sitaresmi, 2016).

**3.6 Yield attributing and yield**

Characters of yield attributing such as pod length, weight of green pod per pod, grains per pod, grain weight per pod, seed yield (per plant and quantal par ha), straw yield (French bean crop), and seed index were significantly affected by INM of fertilizers and vermicompost in Table 6. The maximum yield and yield-contributing traits were observed with the T2 (75% NPKS + 25% VC), followed by T3 (50% NPKS + 50% VC), T1 (100% NPKS + 0% VC), T4 (25% NPKS + 75% VC), and T5 (0% NPKS + 100% VC). In genotypes, cultivars Kashi sampan recorded the highest followed by Kashi Rajhans, HUR-15, and HUR-137. T2 improved yield attributes can be attributed to better nutrient availability from combined fertilizers and vermicompost, which enhanced nitrogen supply to the growing plants. This may have resulted from early root development, boosting leaf production, photosynthesis, and the transfer of nutrients to yield-related traits. Organic amendments improve soil quality by boosting microorganisms, organic matter, and nutrient capacity, leading to higher yields (Bulluck et al., 2002). Comparable outcomes were described by Singh (2000), Dhanjal *et al*., (2001), Manjunath (2010), and Ramana *et al*., (2011). The yield and yield-contributing traits cultivars was different which related to variances in the genetic characteristic to response accordingly the environment (Sitaresmi, 2016).

**3.7 Harvest Index**

The harvest index is an important measure to indicate the efficiency of the plant in converting biomass into marketable yield. The harvest index was highest in T2 (41.46 %), followed by T2 (41.29 %), T3 (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 %). A higher harvest index reflects better yield potential and improved overall productivity. Fertilizers and vermicompost enhance nutrient availability and promote nitrogen fixation, improving growth, yield (productivity), and harvest index (Krouma and Abdelly 2003).

**3.8 Economics**

Economics is crucial for understanding the cost-effectiveness and profitability that serving farmers to make informed decisions on resource allocation, maximize returns and balance production costs with the environment. The benefit-cost (B:C) ratio reflects the practical utility of integrated nutrient management treatments. It was significantly influenced by fertilizer and vermicompost combinations (Table 6). The maximum B: C ratio was calculated 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). These variations reflect genetic potential and farming practices, consistent with results by Pandey *et al*., (2011).

**Conclusion**

The two-year field experiment might have concluded the positive INM on French bean growth, yield attributing and yield. Treatment T2 (75% NPKS + 25% VC) and genotype Kashi Sampann showed significant enhancements in many growth parameters, i.e. plant height, leaf area index, number of branches, as well as yield attributes parameters including pod length, weight, and seed yield. T2 also resulted in the highest B:C ratio, indicating its economic benefit. A high B: C ratio show the positive attraction to adopt by farmers. The combined application of fertilizers and vermicompost not only enhanced nutrient availability but also improved soil quality, leading to better plant growth and higher productivity. Based on these findings, Kashi Sampann appears to be a promising genotype for boosting French bean production in the region of Gangetic plains.

**Table 1: Response of plant height to integrated nutrient management at weekly intervals (Pooled data of two years).**

|  |  |
| --- | --- |
|  | **Days after sowing (DAS)** |
| INM treatments | 14  | 21  | 28  | 35  | 42  | 49  | 56  | 63  | 70  | 77  |
| T1 (100% NPKS + 0% VC) | 3.96 | 5.60 | 10.41 | 16.58 | 24.15 | 30.40 | 34.51 | 38.14 | 41.20 | 43.32 |
| T2 (75% NPKS + 25% VC) | 4.08 | 5.74 | 11.13 | 17.61 | 26.65 | 32.41 | 36.70 | 40.13 | 42.65 | 44.44 |
| T3 (50% NPKS + 50% VC) | 3.93 | 5.64 | 10.77 | 17.21 | 25.55 | 31.27 | 35.72 | 39.16 | 41.96 | 43.84 |
| T4 (25% NPKS +75% VC) | 4.12 | 5.62 | 10.05 | 16.10 | 22.74 | 29.22 | 33.36 | 36.99 | 40.55 | 42.74 |
| T5 (0% NPKS + 100% VC) | 3.75 | 5.25 | 8.92 | 14.48 | 20.36 | 25.66 | 29.28 | 32.56 | 34.74 | 36.78 |
| SEm± | 0.10 | 0.06 | 0.08 | 0.07 | 0.13 | 0.15 | 0.28 | 0.13 | 0.12 | 0.11 |
| CD (P=0.05) | NS | NS | 0.26 | 0.22 | 0.43 | 0.49 | 0.91 | 0.43 | 0.40 | 0.37 |
| Cultivars | 14 DAS | 21 DAS | 28 DAS | 35 DAS | 42 DAS | 49 DAS | 56 DAS | 63 DAS | 70 DAS | 77 DAS |
| V1 (Kashi Rajhans) | 4.03 | 5.56 | 10.31 | 16.48 | 24.07 | 29.95 | 33.98 | 37.56 | 40.36 | 42.30 |
| V2 (Kashi Sampann) | 4.01 | 5.60 | 10.37 | 16.61 | 24.34 | 30.15 | 34.33 | 37.68 | 40.51 | 42.41 |
| V3 (HUR- 137) | 3.92 | 5.55 | 10.12 | 16.19 | 23.42 | 29.39 | 33.56 | 37.04 | 39.93 | 42.01 |
| V4 (HUR -15) | 3.91 | 5.57 | 10.22 | 16.31 | 23.75 | 29.68 | 33.78 | 37.30 | 40.09 | 42.17 |
|  SEm± | 0.09 | 0.04 | 0.03 | 0.04 | 0.06 | 0.07 | 0.09 | 0.06 | 0.03 | 0.03 |
| CD (P=0.05) | NS | NS | 0.08 | 0.11 | 0.18 | 0.19 | 0.26 | 0.17 | 0.10 | 0.08 |

**Table: 2 Response of the number of leaves per plant to integrated nutrient management at weekly intervals (Pooled data of two years)**

|  |  |
| --- | --- |
|  | **Days after sowing (DAS)** |
| INM treatments | 14 | 21 | 28 | 35 | 42 | 49 | 56 | 63 | 70 | 77 |
| T1 (100% NPKS + 0% VC) | 3.04 | 7.00 | 12.43 | 20.90 | 28.83 | 35.29 | 40.73 | 45.70 | 48.64 | 49.46 |
| T2 (75% NPKS + 25% VC) | 3.03 | 7.02 | 12.78 | 22.08 | 30.16 | 36.87 | 43.10 | 47.87 | 50.73 | 51.71 |
| T3 (50% NPKS + 50% VC) | 3.03 | 7.02 | 12.58 | 21.52 | 29.49 | 36.12 | 41.75 | 46.74 | 49.74 | 50.61 |
| T4 (25% NPKS +75% VC) | 3.04 | 7.02 | 12.21 | 20.55 | 28.21 | 34.61 | 39.62 | 44.39 | 47.25 | 48.32 |
| T5 (0% NPKS + 100% VC) | 2.99 | 6.87 | 11.68 | 19.16 | 26.27 | 31.62 | 35.85 | 39.56 | 41.52 | 42.20 |
| SEm± | 0.01 | 0.01 | 0.06 | 0.12 | 0.11 | 0.16 | 0.19 | 0.23 | 0.15 | 0.18 |
| CD (P=0.05) | NS | 0.05 | 0.21 | 0.40 | 0.37 | 0.53 | 0.61 | 0.75 | 0.48 | 0.60 |
| Cultivars | 14 | 21 | 28 | 35 | 42 | 49 | 56 | 63 | 70 | 77 |
| V1 (Kashi Rajhans) | 3.024 | 7.02 | 12.39 | 21.52 | 29.49 | 35.99 | 41.52 | 46.37 | 49.17 | 50.03 |
| V2 (Kashi Sampann) | 3.026 | 7.01 | 12.44 | 21.64 | 29.63 | 36.16 | 41.87 | 46.66 | 49.47 | 50.42 |
| V3 (HUR- 137) | 3.031 | 6.93 | 12.21 | 19.75 | 27.25 | 33.32 | 38.17 | 42.54 | 45.21 | 46.09 |
| V4 (HUR -15) | 3.027 | 6.98 | 12.29 | 20.47 | 28.00 | 34.15 | 39.28 | 43.84 | 46.46 | 47.29 |
|  SEm± | 0.01 | 0.01 | 0.02 | 0.03 | 0.03 | 0.05 | 0.06 | 0.09 | 0.06 | 0.06 |
| CD (P=0.05) | NS | 0.03 | 0.05 | 0.09 | 0.10 | 0.14 | 0.17 | 0.26 | 0.17 | 0.17 |

**Table:3 Response of leaf area index to integrated nutrient management at weekly intervals (Pooled data of two years)**

|  |  |
| --- | --- |
|  | **Days after sowing (DAS)** |
| INM | 14 | 21 | 28 | 35 | 42 | 49 | 56 | 63 | 70 | 77 |
| T1 | 0.071 | 0.200 | 0.420 | 1.19 | 1.97 | 2.69 | 3.28 | 3.79 | 3.96 | 3.73 |
| T2 | 0.071 | 0.200 | 0.428 | 1.35 | 2.27 | 2.99 | 3.73 | 4.17 | 4.37 | 4.09 |
| T3 | 0.071 | 0.200 | 0.424 | 1.28 | 2.14 | 2.85 | 3.46 | 4.00 | 4.17 | 3.88 |
| T4 | 0.071 | 0.201 | 0.416 | 1.10 | 1.79 | 2.52 | 3.10 | 3.63 | 3.74 | 3.52 |
| T5 | 0.071 | 0.201 | 0.410 | 1.02 | 1.65 | 2.38 | 2.93 | 3.35 | 3.41 | 3.31 |
| SEm± | 0.000 | 0.001 | 0.001 | 0.02 | 0.03 | 0.04 | 0.06 | 0.04 | 0.04 | 0.04 |
| CD (P=0.05) | NS | NS | 0.002 | 0.06 | 0.10 | 0.11 | 0.20 | 0.14 | 0.11 | 0.14 |
| Cultivars | 14 | 21 | 28 | 35 | 42 | 49 | 56 | 63 | 70 | 77 |
| Kashi Rajhans | 0.07 | 0.20 | 0.420 | 1.20 | 1.98 | 2.71 | 3.31 | 3.81 | 3.95 | 3.72 |
| Kashi Sampann | 0.07 | 0.20 | 0.422 | 1.22 | 2.02 | 2.75 | 3.39 | 3.88 | 3.99 | 3.77 |
| HUR- 137 | 0.07 | 0.20 | 0.418 | 1.16 | 1.91 | 2.61 | 3.23 | 3.74 | 3.84 | 3.64 |
| HUR- 15 | 0.07 | 0.20 | 0.419 | 1.17 | 1.95 | 2.68 | 3.27 | 3.77 | 3.90 | 3.68 |
| SEm± | 0.00 | 0.00 | 0.000 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 |
| CD (P=0.05) | NS | NS | 0.001 | 0.02 | 0.02 | 0.03 | 0.04 | 0.05 | 0.03 | 0.03 |

**Table: 4 Response of primary branch to integrated nutrient management at weekly intervals (Pooled data of two years)**

|  |  |
| --- | --- |
|  | **Days after sowing (DAS)** |
| INM treatments | 21  | 28  | 35  | 42  | 49  | 56  |
| T1 (100% NPKS + 0% VC) | 1.09 | 2.18 | 3.05 | 3.47 | 3.71 | 3.73 |
| T2 (75% NPKS + 25% VC) | 1.08 | 2.29 | 3.26 | 3.71 | 4.04 | 4.08 |
| T3 (50% NPKS + 50% VC) | 1.08 | 2.24 | 3.17 | 3.60 | 3.90 | 3.91 |
| T4 (25% NPKS +75% VC) | 1.09 | 2.10 | 2.89 | 3.37 | 3.45 | 3.47 |
| T5 (0% NPKS + 100% VC) | 1.08 | 2.02 | 2.71 | 3.15 | 3.25 | 3.26 |
| SEm± | 0.01 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 |
| CD (P=0.05) | NS | 0.06 | 0.11 | 0.09 | 0.08 | 0.10 |
| Cultivars |  |
| V1 (Kashi Rajhans) | 1.09 | 2.17 | 3.03 | 3.48 | 3.69 | 3.72 |
| V2 (Kashi Sampann) | 1.09 | 2.20 | 3.06 | 3.50 | 3.74 | 3.78 |
| V3 (HUR- 137) | 1.08 | 2.14 | 2.97 | 3.42 | 3.60 | 3.60 |
| V4 (HUR -15) | 1.08 | 2.15 | 3.01 | 3.44 | 3.66 | 3.67 |
|  SEm± | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 |
| CD (P=0.05) | NS | 0.02 | 0.02 | 0.02 | 0.03 | 0.06 |

**Table: 5 Response of secondary branch** to **integrated nutrient management at weekly intervals (Pooled data of two years)**

|  |  |
| --- | --- |
|  | **Days after sowing (DAS)** |
| INM treatments | 28  | 35  | 42  | 49  | 56  | 63  |
| T1 (100% NPKS + 0% VC) | 2.43 | 3.76 | 5.48 | 6.99 | 7.36 | 7.44 |
| T2 (75% NPKS + 25% VC) | 2.81 | 4.37 | 6.14 | 7.67 | 8.05 | 8.12 |
| T3 (50% NPKS + 50% VC) | 2.64 | 4.08 | 5.78 | 7.40 | 7.73 | 7.77 |
| T4 (25% NPKS +75% VC) | 2.21 | 3.58 | 5.25 | 6.59 | 7.03 | 7.10 |
| T5 (0% NPKS + 100% VC) | 2.00 | 3.17 | 4.81 | 5.96 | 6.12 | 6.23 |
| SEm± | 0.05 | 0.04 | 0.05 | 0.05 | 0.07 | 0.05 |
| CD (P=0.05) | 0.16 | 0.13 | 0.15 | 0.16 | 0.22 | 0.17 |
| Cultivars |  |
| V1 (Kashi Rajhans) | 2.44 | 3.84 | 5.52 | 6.96 | 7.33 | 7.36 |
| V2 (Kashi Sampann) | 2.49 | 3.89 | 5.57 | 7.08 | 7.40 | 7.44 |
| V3 (HUR- 137) | 2.36 | 3.68 | 5.41 | 6.81 | 7.14 | 7.23 |
| V4 (HUR -15) | 2.38 | 3.76 | 5.47 | 6.86 | 7.25 | 7.30 |
|  SEm± | 0.01 | 0.02 | 0.03 | 0.02 | 0.02 | 0.02 |
| CD (P=0.05) | 0.04 | 0.05 | 0.10 | 0.06 | 0.05 | 0.05 |

**Table: 6** **Response of yield attributes and yield to integrated nutrient management at weekly intervals (Pooled data of two years)**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| INM treatments | Length of pod (cm) | Weight of one pod (gm) | Number of grains per pod  | Weight of grainper pod (gm) | Seed yield per plant (gm) | Seed yield q ha | Straw yield (q/ha) | Seed index(gm) | Harvest index(%) | B:C ratio |
| T1 (100% NPKS + 0% VC) | 7.39 | 6.06 | 5.70 | 1.28 | 18.91 | 20.82 | 30.35 | 23.73 | 40.65 | 3.27 |
| T2 (75% NPKS + 25% VC) | 8.51 | 6.49 | 6.55 | 1.33 | 20.92 | 23.04 | 32.45 | 24.72 | 41.46 | 3.30 |
| T3 (50% NPKS + 50% VC) | 8.08 | 6.29 | 6.14 | 1.29 | 19.68 | 21.67 | 30.75 | 23.82 | 41.29 | 2.90 |
| T4 (25% NPKS +75% VC) | 6.89 | 5.86 | 5.35 | 1.27 | 17.97 | 19.27 | 28.15 | 23.72 | 40.57 | 2.56 |
| T5 (0% NPKS + 100% VC) | 6.44 | 5.36 | 4.95 | 1.23 | 16.65 | 17.27 | 26.80 | 23.57 | 39.12 | 2.04 |
| SEm± | 0.12 | 0.04 | 0.06 | 0.011 | 0.19 | 0.21 | 0.45 | 0.23 | 0.47 | 0.02 |
| CD (P=0.05) | 0.38 | 0.12 | 0.18 | 0.037 | 0.62 | 0.68 | 1.47 | 0.76 | 1.53 | 0.07 |
| Cultivars |  |  |  |  |  |  |  |  |  |  |
| V1 (Kashi Rajhans) | 7.49 | 6.04 | 5.89 | 1.29 | 19.23 | 20.95 | 29.86 | 19.76 | 41.16 | 2.96 |
| V2 (Kashi Sampann) | 7.81 | 6.09 | 6.04 | 1.46 | 20.66 | 22.58 | 31.21 | 27.19 | 41.93 | 3.16 |
| V3 (HUR- 137) | 7.22 | 5.94 | 5.45 | 1.16 | 17.45 | 18.57 | 28.61 | 24.43 | 39.32 | 2.45 |
| V4 (HUR -15) | 7.33 | 5.98 | 5.56 | 1.20 | 17.96 | 19.55 | 29.12 | 24.27 | 40.05 | 2.67 |
|  SEm± | 0.06 | 0.01 | 0.03 | 0.015 | 0.20 | 0.22 | 0.19 | 0.27 | 0.32 | 0.03 |
| CD (P=0.05) | 0.17 | 0.04 | 0.10 | 0.043 | 0.57 | 0.63 | 0.55 | 0.77 | 0.93 | 0.07 |

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