# Evaluation of Integrated Nutrient Management Approaches on Phenological Development and Yield Components of Wheat *(Triticum aestivum* L.*)*

**Abstract:** A field experiment was conducted to evaluate the effects of integrated nutrient management on growth and yield performance of wheat (*Triticum aestivum* L.). The study comprised eight treatments combining different rates of chemical fertilizers (RDF), farm yard manure (FYM), and bio-fertilizers (PSB) in a randomized block design. Morphological characteristics, including plant height, number of tillers, leaf area index, and dry matter accumulation, were significantly influenced by the integrated application of nutrients. The treatment $T_6$ 100% RDF + farm yard manure@1t/ha + PSB showed superior performance in growth parameters and yield attributes. This integrated approach enhanced nutrient availability, improved soil physical properties, and increased biological activity, resulting in better crop performance. Economic analysis revealed higher net returns and benefit-cost ratio under integrated nutrient management compared to sole application of chemical fertilizers. The study demonstrates that judicious integration of organic, inorganic, and bio-fertilizers can optimize wheat productivity while maintaining soil health and ensuring economic viability.

**Keywords:** Integrated Nutrient Management; Farm Yard Manure, Bio-fertilizers, Growth Parameters, Yield Components, Economic Analysis, Sustainable Agriculture, Soil Health, Resource Use Efficiency



**Introduction:**

"Wheat (*Triticum aestivum* L.) is very important staple and remunerative *Rabi* crops, cultivated in almost all the countries of the world. Among major wheat producing countries, India ranked second next to China with regards to its production in world (Agriculture Sectors National Portal). It is the second most important cereal crop after rice in India, and grown under diverse agro climatic conditions. In India wheat is grown in an area of about 29.58 million hectares with the production of 99.70 million tones and the productivity of 33.71 q ha-1" (Anonyms, 2018). In Madhya Pradesh, it is grown in 5.56 million ha area with the production of 15.9

million tones and share in all India production 15.96%. The five major wheat growing states of Uttar Pradesh, Punjab, Madhya Pradesh, Haryana and Rajasthan contributed nearly 86.0 per cent to the total production in the country. Punjab has the highest average productivity of 4.7 t ha-1 followed by Haryana 4.4 t ha-1, Rajasthan 3.1 t ha-1, Gujarat 3.0 t ha-1, Uttar Pradesh 2.8 t ha-1, Madhya Pradesh 2.6 t ha-1 and Bihar 2.2 t ha-1 Kumar (2021) and Mishra (2009).

"Organic farming is a system which avoids or largely excludes the use of synthetic inputs (such as fertilizers, pesticides, hormones, feed additives etc.) and to the maximum extent feasible rely upon crop rotations, crop residues, animal manures, off-farm organic waste, mineral grade rock additives and biological system of nutrient mobilization and plant protection" (Panwar,2008). "Biofertilizers are not chemical fertilizers rather these are carrier-based preparations containing beneficial microorganisms and when incorporated in soil, enhance specific microbial growth in rhizosphere, play vital role in nutrient mineralization, increase nutrient accumulation ultimately increase crop yield without any deterioration of nature" (Patra, 2009). Biofertilizers represent an environmentally sustainable and cost-effective approach to agricultural production, offering a viable alternative to conventional chemical fertilizers while promoting soil health and fertility. These microbial inoculants, particularly Rhizobium species, play a crucial role in enhancing nutrient availability and uptake in wheat cultivation systems. The application of biofertilizers not only reduces dependency on synthetic chemical fertilizers but also contributes to the restoration and maintenance of soil biological properties, leading to improved soil structure and fertility.

The process of seed inoculation with Rhizobium has demonstrated remarkable efficacy in promoting various aspects of wheat growth and development. When wheat seeds are treated with Rhizobium inoculants, they exhibit enhanced nodulation capacity, which significantly improves the plant's ability to fix atmospheric nitrogen. This biological nitrogen fixation process naturally enriches the soil with essential nutrients, creating a more favorable environment for plant growth. The increased nodulation activity results in better root development, leading to improved nutrient absorption and water uptake efficiency.

Furthermore, the implementation of biofertilizer technology offers multiple economic advantages to farmers. By reducing the requirement for chemical fertilizers, it substantially lowers production costs while maintaining or even improving crop yields.

**Material and Method:**

The experiment was conducted in the experimental block, Vikrant University, Gwalior, M.P. during *Rabi* 2024. In RBD with the 8 treatments T1 control, T2 100% RDF, T3 100% RDF + farm yard manure@1t/ha, T4 75% RDF + farm yard manure@1t/ha, T5 50% RDF + farm yard manure@1t/ha, T6 100% RDF + farm yard manure@1t/ha + PSB, T7 75% RDF + farm yard manure@1t/ha + PSB, T8 50% RDF + farm yard manure@1t/ha +PSB in 3 replications by following all the cultural practices of the crop. The characters of growth attributes such as Days required 50% flowering, plant height, dry matter plant, number of tillers per plant, number of leaves per plant are observed in the interval of 30,60 and 90 DAS and the characters of yield attributes such as Effective tillers $m^{-2}$, numbers of grains per ear head, 1000-Grain Weight, Biological yield, Grain yield, Straw yield, Harvest index are observed. The data collected during the course of present investigation were statistically analyzed by adopting standard methods known as 'Analysis of Variance' (Panse and Sukhatme, 1967).

**Result and Discussion:**

The experimental findings demonstrate the significant advantages of an integrated nutrient management approach in wheat cultivation, particularly through the combination of 100% recommended dose of fertilizer (RDF), farm yard manure (FYM), and Phosphate Solubilizing Bacteria (PSB). The superior performance of treatment T6 in terms of growth parameters and yield components can be attributed to several interconnected factors (Fig.1). The inclusion of FYM likely improved soil physical properties, enhanced water holding capacity, and provided a steady supply of nutrients through gradual mineralization. This organic component, when combined with inorganic fertilizers, creates an optimal nutrient release pattern that matches the crop's requirements throughout its growth stages. The addition of PSB plays a crucial role in increasing phosphorus availability by solubilizing fixed soil phosphorus, thereby enhancing its uptake by plants. This biological component also contributes to improved soil biological activity and the production of growth-promoting substance, similar studies were cited by Astaneh (2018), Gomaa (2018), Gopinath (2016), Zhao (2009) and Kloepper (2004). The synergistic effect of these three components (RDF, FYM, and PSB) is evident in the enhanced plant height, increased tiller numbers, and improved dry matter accumulation. The superior economic performance of T6, as reflected in higher gross and net monetary returns and benefit-cost ratio, suggests that this integrated approach not only optimizes plant growth and yield but also provides better financial returns to farmers Alam, Kaur and Singh (2024) focuses on assessing the effectiveness of various organic fertilizers, including vermicompost, in rehabilitating degraded soils. This study aims to provide insights into how these fertilizers can improve soil properties and support plant growth in compromised environments. The poor performance of the control treatment (T1) underscores the importance of proper nutrient management in wheat cultivation. Rajput (2022) and Rawte (2022). These findings align with the principles of sustainable agriculture, where the goal is to maintain high productivity while ensuring soil health and economic viability (Fig. 2-4). The results suggest that integrated nutrient management could be a key strategy for achieving sustainable intensification in wheat production systems, particularly in regions where soil fertility is a limiting factor. This approach not only addresses the immediate nutrient requirements of the crop but also contributes to long-term soil health and sustainable agricultural practices Joshi (2013) and Kannoj (2022).

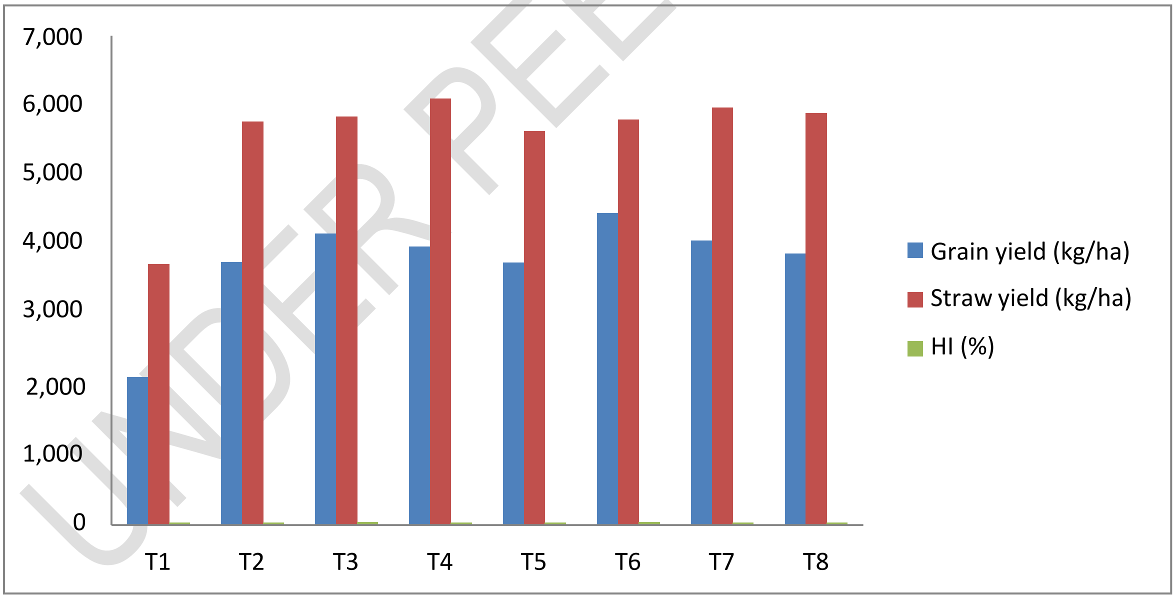



**Fig. 1 Effect of integrated nutrient management on grain, straw yield $ha^{-1}$,harvest index of**

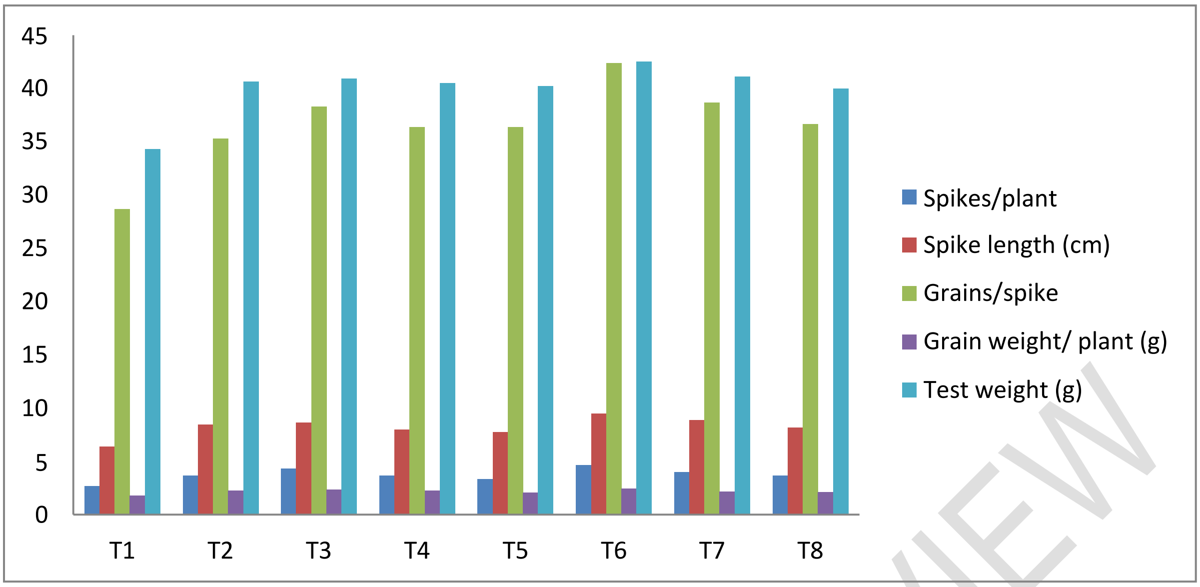



**Fig. 2 Effect of integrated nutrient management on spike length number ofgrains spike$^{-1}$, grains weight plant$^{-1}$, and test weight of wheat**

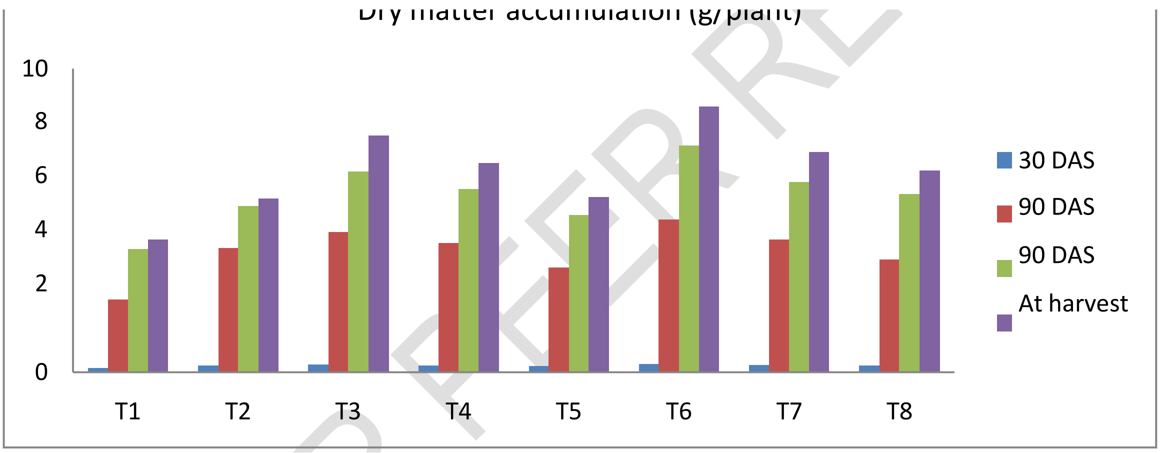
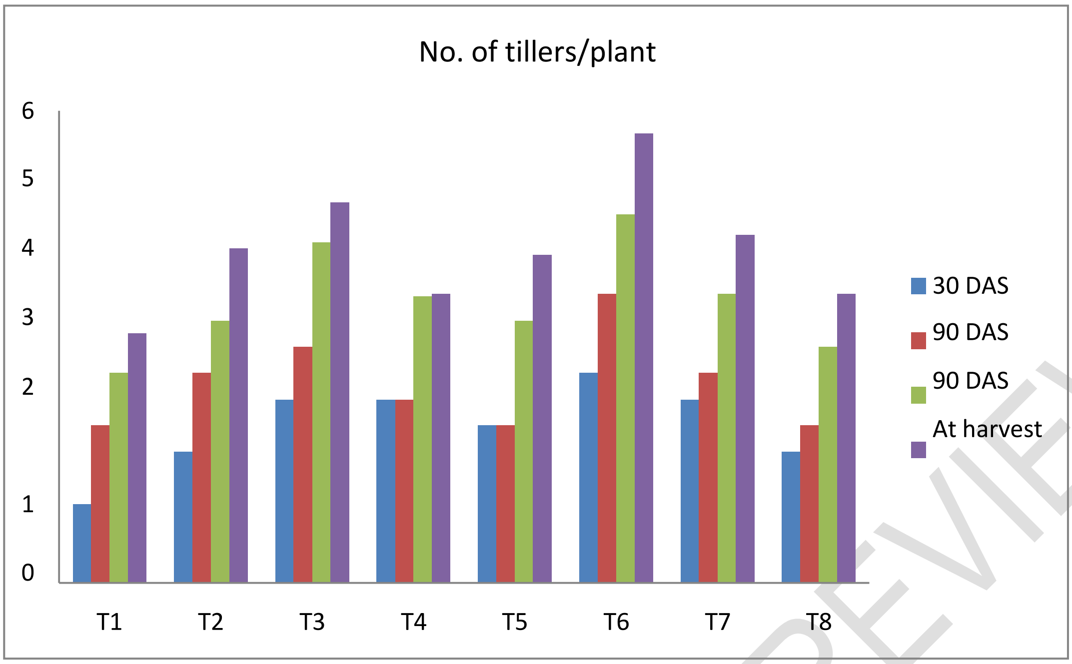



**Fig.3 Effect of integrated nutrient management on dry matteraccumulation (DMA) of wheat**

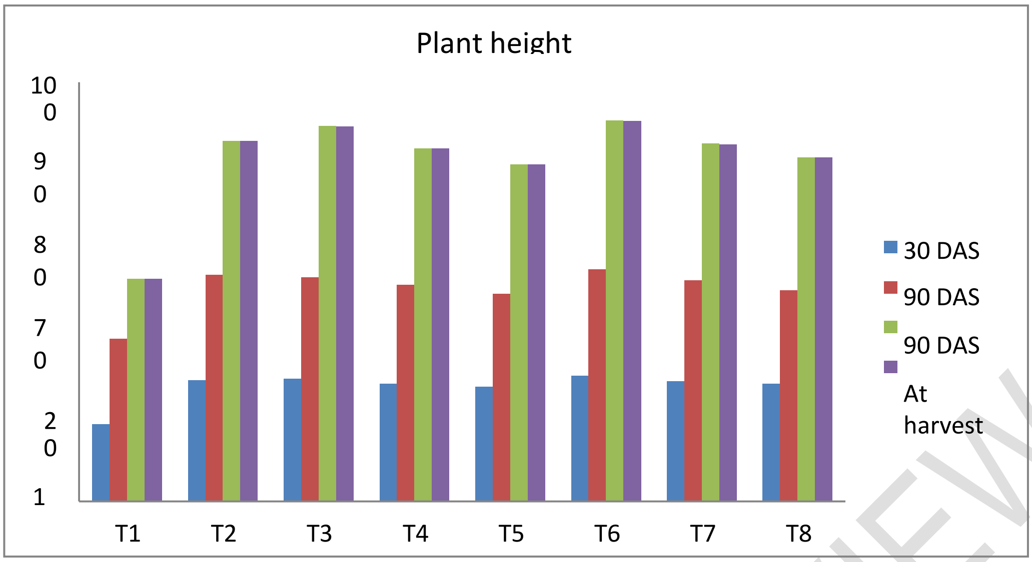
The economic analysis further strengthens the case for integrated nutrient management, as the higher initial investment in T6 is justified by the significantly improved returns Yadav (2009). This has important implications for agricultural policy and extension services, suggesting that farmers should be encouraged to adopt integrated nutrient management practices rather than relying solely on inorganic fertilizers. The findings also indicate that such an approach could help in reducing the environmental impact of intensive agriculture while maintaining or improving productivity levels (Fig.5). This is particularly relevant in the context of climate change and the growing need for sustainable agricultural practices that can ensure food security while preserving natural resources. Similar findings were done by Bodruzzaman *et. al.*, (2010), Bagri (2022), Essam and Lattief (2016), Chen (2006) and Audit (2007)

**Fig.4 Effect of integrated nutrient management on dry matteraccumulation (DMA) of wheat**




- These results contribute to the growing body of evidence supporting the effectiveness of integrated nutrient management in cereal crops. Similar findings were observed how vermicompost can improve soil fertility, stimulate plant growth, and protect crops from various stresses without negatively impacting the environment by Patyal (2022) and Ahmed (2024). The study demonstrates that combining organic, inorganic, and biological fertilizers can create a more balanced and efficient nutrient supply system, leading to improved crop performance and economic returns. This approach represents a viable strategy for sustainable wheat production, offering a pathway to optimize resource use efficiency while maintaining soil health and crop productivity Kumar and Verma (2023) also focused on sustainable fertilizer use and its role in maintaining soil health and agricultural productivity, emphasizing integrated approaches.

**Fig. 5 Effect of integrated nutrient management on plant height of wheatNumber of Tillers/Plant**




## Conclusion

Study demonstrates the significant advantages of an integrated nutrient management approach in wheat cultivation. The combination of 100% recommended dose of fertilizer (RDF), farm yard manure (FYM), and Phosphate Solubilising Bacteria (PSB) (treatment $T_6$) resulted in superior plant growth, yield components, and economic performance compared to other treatments. The inclusion of FYM improved soil physical properties and provided a steady nutrient supply, while the addition of PSB enhanced phosphorus availability and soil biological activity. The synergistic effect of these three components led to increased plant height, tiller numbers, and dry matter accumulation, ultimately translating into higher gross and net monetary returns and a better benefit-cost ratio.

Integrated nutrient management could be a key strategy for achieving sustainable intensification in wheat production systems, particularly in regions where soil fertility is a limiting factor. This approach not only addresses the immediate nutrient requirements of the crop but also contributes to long-term soil health and sustainable agricultural practices, with potential implications for reducing the environmental impact of intensive agriculture while maintaining productivity levels.

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**Table 1 Effect of integrated nutrient management on plant height of wheat**

| T. No. | Treatments | Plant height (cm) | | | |
|---|---|---|---|---|---|
| | | 30 DAS | 60 DAS | 90 DAS | At Harvest |
| $T_1$ | Control | 18.40 | 38.74 | 53.06 | 53.03 |
| $T_2$ | 100% RDF | 28.86 | 53.98 | 85.99 | 85.95 |
| $T_3$ | 100% RDF + farm yard manure @ 1t/ha | 29.27 | 53.36 | 89.43 | 89.38 |
| $T_4$ | 75% RDF + farm yard manure @ 1t/ha | 28.08 | 51.64 | 84.17 | 84.14 |
| $T_5$ | 50% RDF + farm yard manure @ 1t/ha | 27.35 | 49.53 | 80.26 | 80.26 |
| $T_6$ | 100% RDF + farm yard manure @ 1t/ha + PSB | 29.93 | 55.30 | 90.80 | 90.72 |
| $T_7$ | 75% RDF + farm yard manure @ 1t/ha + PSB | 28.68 | 52.73 | 85.33 | 85.07 |
| $T_8$ | 50% RDF + farm yard manure @ 1t/ha + PSB | 28.05 | 50.29 | 82.02 | 82.00 |
| | **SEm±** | **0.64** | **0.86** | **1.00** | **1.00** |
| | **CD (P=0.05)** | **1.97** | **2.62** | **3.05** | **3.05** |

**Table 2 Effect of integrated nutrient management on tillers of wheat**

| T. No. | Treatments | No. of tillers/plant | | | |
|---|---|---|---|---|---|
| | | 30 DAS | 60 DAS | 90 DAS | At Harvest |
| $T_1$ | Control | 1.00 | 2.00 | 2.67 | 3.17 |
| $T_2$ | 100% RDF | 1.67 | 2.67 | 3.33 | 4.25 |
| $T_3$ | 100% RDF + farm yard manure @ 1t/ha | 2.33 | 3.00 | 3.67 | 4.17 |
| $T_4$ | 75% RDF + farm yard manure @1t/ha | 2.33 | 2.33 | 3.33 | 3.67 |
| $T_5$ | 50% RDF + farm yard manure @1t/ha | 2.00 | 2.00 | 4.47 | 4.83 |
| $T_6$ | 100% RDF + farm yard manure @1t/ha + PSB | 2.67 | 3.67 | 4.33 | 5.00 |
| $T_7$ | 75% RDF + farm yard manure @1t/ha + PSB | 2.33 | 2.67 | 3.67 | 4.25 |
| $T_8$ | 50% RDF + farm yard manure @1t/ha + PSB | 1.67 | 2.00 | 3.00 | 3.67 |
| | **SEm±** | **0.30** | **0.22** | **0.33** | **0.42** |
| | **CD (P=0.05)** | **0.92** | **0.68** | **1.01** | **1.26** |

**Table 3 Effect of integrated nutrient management on dry matter accumulation (DMA) of wheat**

| T. No. | Treatments | Dry matter accumulation (g/plant) | | | |
|---|---|---|---|---|---|
| | | **30 DAS** | **60 DAS** | **90 DAS** | **At harvest** |
| $T_1$ | Control | 0.15 | 2.39 | 4.06 | 4.38 |
| $T_2$ | 100% RDF | 0.23 | 4.10 | 5.47 | 5.71 |
| $T_3$ | 100% RDF + farm yard manure @1t/ha | 0.26 | 4.62 | 6.60 | 7.79 |
| $T_4$ | 75% RDF + farm yard manure @1t/ha | 0.23 | 4.26 | 6.03 | 6.89 |
| $T_5$ | 50% RDF + farm yard manure @1t/ha | 0.21 | 3.45 | 5.17 | 5.78 |
| $T_6$ | 100% RDF + farm yard manure @1t/ha + PSB | 0.28 | 5.03 | 7.46 | 8.75 |
| $T_7$ | 75% RDF + farm yard manure @1t/ha + PSB | 0.24 | 4.37 | 6.26 | 7.24 |
| $T_8$ | 50% RDF + farm yard manure @ 1t/ha + PSB | 0.22 | 3.72 | 5.87 | 6.64 |
| | **SEm±** | **0.01** | **0.06** | **0.18** | **0.26** |
| | **CD (P=0.05)** | **0.02** | **0.19** | **0.54** | **0.78** |

**Table 4 Effect of integrated nutrient management on days to initiation of germination of wheat**

| T. No. | Treatments | Days to initiation of germination |
|---|---|---|
| $T_1$ | Control | 6.00 |
| $T_2$ | 100% RDF | 5.67 |
| $T_3$ | 100% RDF + farm yard manure @ 1t/ha | 4.33 |
| $T_4$ | 75% RDF + farm yard manure @ 1t/ha | 5.67 |
| $T_5$ | 50% RDF + farm yard manure @ 1t/ha | 5.67 |
| $T_6$ | 100% RDF+ farm yard manure @ 1t/ha + PSB | 4.67 |
| $T_7$ | 75% RDF + farm yard manure @ 1t/ha + PSB | 5.67 |
| $T_8$ | 50% RDF+ farm yard manure @ 1t/ha + PSB | 5.67 |
| | **SEm±** | **0.28** |
| | **CD (P=0.05)** | **0.86** |

**Table 5 Effect of integrated nutrient management on days to 50%flowering of wheat**

| T. No. | Treatments | Days to 50 % flowering |
|---|---|---|
| $T_1$ | Control | 72.00 |
| $T_2$ | 100% RDF | 68.33 |
| $T_3$ | 100% RDF + farm yard manure @ 1t/ha | 69.00 |
| $T_4$ | 75% RDF + farm yard manure @ 1t/ha | 71.33 |
| $T_5$ | 50% RDF + farm yard manure @ 1t/ha | 72.67 |
| $T_6$ | 100% RDF + farm yard manure @ 1t/ha +PSB | 66.67 |
| $T_7$ | 75% RDF + farm yard manure @ 1t/ha +PSB | 72.33 |
| $T_8$ | 50% RDF+ farm yard manure @ 1t/ha + PSB | 74.00 |
| | **SEm±** | **0.64** |
| | **CD (P=0.05)** | **1.96** |

**Table 6 Effect of integrated nutrient management on spike length number of grains spike$^{-1}$, grains weightplant$^{-1}$, and test weight of wheat**

| T. No. | Treatments | Spikes /plant | Spike length (cm) | Grains/ spike | Grain weight/ plant (g) | Test weight (g) |
|---|---|---|---|---|---|---|
| $T_1$ | Control | 2.67 | 6.40 | 28.67 | 1.80 | 34.33 |
| $T_2$ | 100% RDF | 3.67 | 8.47 | 35.33 | 2.30 | 40.66 |
| $T_3$ | 100% RDF + farm yard manure @ 1t/ha | 4.33 | 8.64 | 38.33 | 2.37 | 40.92 |
| $T_4$ | 75% RDF + farm yard manure @ 1t/ha | 3.67 | 7.98 | 36.33 | 2.30 | 40.48 |
| $T_5$ | 50% RDF + farm yard manure @ 1t/ha | 3.33 | 7.74 | 36.33 | 2.07 | 40.22 |
| $T_6$ | 100% RDF + farm yard manure @ 1t/ha + PSB | 4.67 | 9.54 | 42.33 | 2.47 | 42.53 |
| $T_7$ | 75% RDF + farm yard manure @ 1t/ha + PSB | 4.00 | 8.87 | 38.67 | 2.20 | 41.12 |
| $T_8$ | 50% RDF + farm yard manure @ 1t/ha + PSB | 3.67 | 8.16 | 36.67 | 2.13 | 40.01 |
| | **SEm±** | **0.33** | **0.18** | **0.72** | **0.05** | **0.54** |
| | **CD (P=0.05)** | **1.02** | **0.55** | **2.20** | **0.17** | **1.66** |

**Table 7 Effect of integrated nutrient management on grain, straw yield ha$^{-1}$ and harvest index of wheat**

| T. No. | Treatments | Grain yield (kg/ha) | Straw yield (kg/ha) | HI (%) |
|---|---|---|---|---|
| $T_1$ | Control | 2,122 | 3,735 | 36.23 |
| $T_2$ | 100% RDF | 3,766 | 5,776 | 39.49 |
| $T_3$ | 100% RDF + farm yard manure @ 1t/ha | 4,172 | 5,841 | 41.67 |
| $T_4$ | 75% RDF + farm yard manure @ 1t/ha | 3,986 | 6,099 | 39.53 |
| $T_5$ | 50% RDF + farm yard manure @ 1t/ha | 3,757 | 5,635 | 40.00 |
| $T_6$ | 100% RDF + farm yard manure @ 1t/ha + PSB | 4,463 | 5,802 | 43.48 |
| $T_7$ | 75% RDF + farm yard manure @ 1t/ha + PSB | 4,073 | 5,973 | 40.56 |
| $T_8$ | 50% RDF+ farm yard manure @ 1t/ha + PSB | 3,884 | 5,890 | 39.74 |
| | **SEm±** | **34** | **89** | **0.27** |
| | **CD (P=0.05)** | **105** | **273** | **0.84** |