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Improvement in growth and productivity of barley through integrated nutrient management strategies established under Himalayan conditions

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Abstract

The goal of field experiment was to assess the effects of eight different combinations of inorganic fertilizers and biofertilizers on the nutritional quality and organic matter status of Barley crop. The purpose of the experiment was to find out how different inorganic and biofertilizers affected the growth and development of Barley crop.

The study was carried out at the experimental field of Department of Agronomy, Doon (PG) College of Agriculture Science & Technology, Selaqui, Dehradun, Uttarakhand, during the winter (*Rabi*) season of 2024-2025. There were eight treatments in the experiment, including the one with 100% inorganic treatment and one without NPK or biofertilizers in a Randomised Block Design with three replications. Eight distinct inorganic and organic combinations were used to test these treatments.

On December 15, 2024, Barley crop was sown in rows 22 cm apart, with a gap of 5 cm between each plant and harvested in April 2025. The sandy loam soil used for the experiment had medium amounts of accessible total nitrogen (151.36 kg/ha) and organic carbon (0.40%). The soil had a slightly alkaline pH (7.49) and low levels of accessible total potassium (153.30 kg/ha) and phosphorus (10.83 kg/ha).

T₈ (75% NPK + FYM@10t/ha + biofertilizer) had the highest response over growth parameters, including plant population, plant height (cm), and dry matter accumulation (g). In comparison to the other treatments, this treatment also produced higher yields of components like seeds per spike and spikes per plant.

It is crucial to remember that these conclusions are based on data from a single crop season; before offering suggestions to the farming community, additional research and validation in at least one more season are required.

Keywords: INM, biofertilizers, barley growth & productivity

Introduction

Barley (*Hordeum vulgare* L.) is the world's fourth most important cereal after Wheat, Rice and Maize. Barley ranks next to Wheat both in acreage and production among *rabi* cereals in India. Barley is believed to be originated in Abyssinia and South East Asia. However, Barley is preferred by farmers under low rainfall conditions. The Barley crop comparatively needs less water and is more tolerant to salinity and alkalinity condition than other winter cereals.

In recent years, about two-third of Barley crop have been used for feed, one-third for malting and about two per cent directly for food (Baik and Ullrich, 2008) ^[1]. The major use of Barley is in brewing industries for manufacturing malt. Both Barley grains and straw are highly digestible compared to Wheat because it lacks gluten.

The microbes play an important role in the plant's life cycle through decomposition, solubilization, and fixation and help in supply of nutrients to the plants. Biofertilizers improve mineralization of Carbon and Nitrogen by promoting soil microbial activities and narrowing down C: N ratio.

Bio mix, a low-cost input technology that contributed to pollution free atmosphere contains a combination of Nitrogen fixers, Phosphorus solubilizers and PGPR to enhance the growth of cereals, oil seeds and legumes and save about 20-25% inorganic fertilizers such as nitrogenous and phosphatic in case of Rice, Cotton, Chili, Groundnut, Soybean and pulses. Use of both organic manure and chemical fertilizer in appropriate proportions assumes complementary and supplementary response to each other in crop production. It has also been recommended that the

response of plant growth may be attributed to the hormone production by microbes or due to enhanced nutrient uptake from inoculated roots. Due to prolonged cultivation of crops with recommended dose of inorganic fertilizers alone, the productivity of soils has decreased and now the time has come to figure out the right and well-matched level of fertilizers with these inoculations in case of Barley production.

Malik (2017) ^[4] reported that various levels of fertilizer (50, 75 and 100% RDF) didn't affect the days taken to emergence of Barley significantly. Similar results for days to emergence as affected by varying levels of nitrogen and phosphorus application have been reported by Khan *et al.* (2014).

Kumar *et al.* (2017) ^[2] showed that grain yield in Barley increased significantly with increased nitrogen doses up to 150 kg N ha⁻¹ during 2010-11 and 2011-12. The grain yield at 150 and 200 kg N ha⁻¹ were statistically similar. Minimum grain yield was recorded in control (0 kg N ha⁻¹).

Taalab *et al.*, (2015) ^[8] also reported that straw and grain Nitrogen uptake was significantly affected by N fertilizer rate and Nitrogen uptake by grain and straw of Barley with 100 kg N/acre was higher than 70 kg N/acre.

Malik in 2017 ^[4] at Hisar reported that application of 100% RDF recorded significantly higher N content and N, P and K uptake in grain and straw than the lower fertilizer levels (50 and 75% RDF). Yousefi and Sadeghi (2014) ^[12] investigated that combined application of Urea fertilizer; organic fertilizer like Vermicompost had significant effects on grain yield and grain weight of Wheat crop. The maximum yield in Wheat was obtained with treatments 100% of the recommended urea with 10 and 15 t ha⁻¹ vermicompost and 75% urea + 15 t ha⁻¹ vermicompost, respectively. They concluded that the application of Vermicompost and organic fertilizer can be reduced the dose of chemical fertilizer (urea) up to 25%.

Materials and Methods

The experiment was conducted at experimental field of Department of Agronomy, Doon (PG) College of Agriculture Science & Technology, Selaqui, Dehradun, Uttarakhand. The geographical situation of the farm surrounded by the foothills of Himalayas. The experimental site is located at 29°58 N and 31°2 N Latitude and 77°34 E and 78°18 E Longitudes with the elevation of 450 meter from sea level. The site falls in the sub-temperate mid hill Zone of Uttarakhand. The weekly minimum and maximum temperature during the crop season ranged from 2.0 °C to 31.5 °C respectively.

Soil, as a medium of plant supports the rate of growth as well as development and eventually the final and economic yield of crop. All the possible technical precautions as prescribed for standard soil sampling were also taken. Then samples were brought to the laboratory, air-dried and ground, thereafter sieved through 20 mm mesh.

Treatment Details

Symbols	Details (Kg/ha)
T ₁	Control
T ₂	100% Recommended Dose of NPK
T ₃	75% RDF of NPK + FYM@5t/ha
T ₄	50% NPK + FYM@5t/ha
T ₅	75% NPK + FYM@5t/ha + biofertilizer
T ₆	100% NPK + FYM@10t/ha + biofertilizer
T ₇	100% NPK + FYM@5t/ha + biofertilizer
T ₈	75% NPK + FYM@10t/ha + biofertilizer

Experimental Design

Design	Randomized Block Design
Replications	3
No. of plots	(24)
Plot size	[5 m × 3 m]
Spacing	Row-to-Row: 22.5 cm
Variety	VT ₁₀

Considering the nature of factors under study and the convenience of agricultural operation and efficiency, the experiment was laid out in Randomized block design (RBD) comprising eight treatment combinations along with the three replications.

The plant growth studies carried out at 25, 50 and 75 days after sowing (DAS) and finally at harvest. In each plot three spots were selected randomly, for counting the number of plants per meter & row length at 20 days after sowing. Means were taken for statistical analysis. Three plants were selected randomly from each plot and tagged. The height was measured in cm with the help of scale from base to the top of the plant. Plants in 0.5 m row length from the second row on either side in each plot, were cut close to the ground at 30, 60, 90 DAS and at harvest to record dry matter accumulation per meter row length. Total produce of each net plot was allowed to sun drying in the field after harvest and weighted. From the individual plot, net plot area was harvested, sun dried and the produce was threshed and cleaned. The final weight was recorded in kg per plot and converted into kg ha⁻¹. Stover yield was computed by deducting the seed yield from the total dry matter yield and expressed in kg ha⁻¹. 1000-seeds were selected randomly and weighted on electronic balance. The weight was reported in gram. The ratio of economic yield (seed) to the total biological yield (seed plus stover) was computed and presented in per cent by using formula given below:

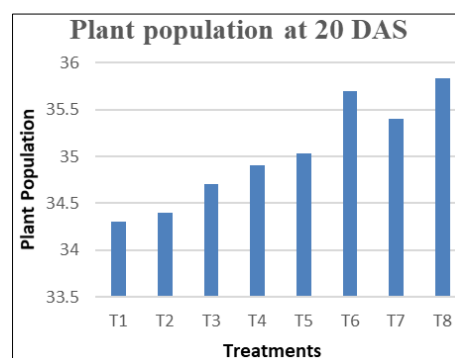
$$\text{Harvest index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Experimental Findings

Plant Population

The observations revealed slight variations in plant population of Barley at 20 DAS was observed due various combinations of NPK fertilizer, biofertilizer and FYM.

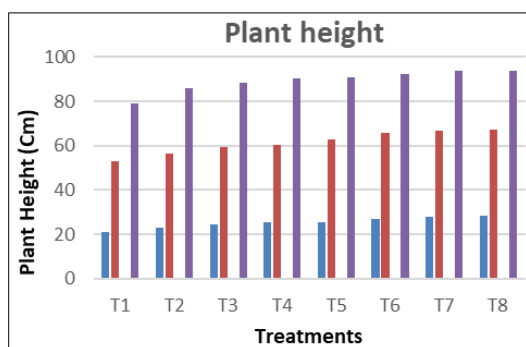
Highest Plant population at 20 DAS in Barley 35.83 in T₈ (75% NPK + FYM @ 10t/ha + biofertilizer) during the experimentation.



Plant height

Perusals of data indicated that the plant height was maximum between 30 to 60 DAS and minimum between 90 DAS and maturity stage 28.44, 67.36, 91.72 and 93.99 cm respectively. Significantly taller plants were recorded in treatment T₈ at all stages of crop growth. However, the difference in plant height of

Barley in treatment T₇, T₆ and T₅ at 30 DAS, T₇ and T₅ at 60 DAS and T₆ to T₇ at 90 DAS were not significant. Similarly, plant height at maturity in treatment T₅, T₆, T₇ and T₈ were recorded at par with each other. The plant height at maturity was 117.80cm, 111.90cm and 113.70cm more in treatment T₈, T₇ and T₆ as compared to the control treatment, respectively.



Number of tillers

Effect of various combinations of NPK fertilizers, bio-fertilizers and FYM on number of tillers per meter row length at different stages of crop growth data indicate that irrespective of the treatments, number of tillers in Barley increased slightly up to 90 DAS and thereafter marginally decreased at maturity. Among various combinations of NPK fertilizers, bio-fertilizers and FYM treatment T₈ at all the stages of crop growth resulted in highest number of tillers/m⁻¹. The difference in number of tillers per meter row length at 30 DAS in treatment T₆ to T₈ were not significant. Similarly, the difference in number of tillers/m⁻¹ of Barley at 60 DAS in treatment T₃ to T₈ were also not significant. At 90 DAS number of tillers/m⁻¹ in treatment T₄ to T₈ were at par with each other. Similarly, at maturity also number of tillers/m⁻¹ in treatment T₈ being at par with T₅ to T₈ was significantly higher than treatment T₁ to T₄.

Dry matter accumulation (g/m²)

Effect of various combinations of NPK fertilizers, biofertilizers and FYM on dry matter accumulation (g/m²) at different stages of crop growth indicated that irrespective of the treatments, dry matter accumulation at various growth stages of Barley increased progressively from vegetative to harvest stage. The rate of dry matter accumulation (g/m²) was slow up to initial 30 days and highest between 30 to 60 DAS and thereafter the increase was at a decreasing rate up to maturity. Among various combinations of NPK fertilizers, biofertilizers and FYM treatment T₈ at all the stages of crop growth resulted in highest dry matter accumulation. The difference in dry matter accumulation at 30 DAS in treatment T₇ to T₈ was not significant. Similarly, the difference in dry matter accumulation at 60 DAS in treatment T₆ to T₈ was also not significant but 90 DAS dry matter accumulation in treatment T₄ to T₈ were at par with each other. Similarly, at maturity, dry matter accumulation in treatment T₈ being at par with T₃ to T₇ was significantly higher than treatment T₁ and T₂.

Yield attributes and yield

Spike length (cm)

A close perusal of the data relating to spike length revealed that various combinations of NPK fertilizers, biofertilizers and FYM significantly affected the spike length of Barley. The data indicated that spike length was highest in treatment T₈ (6.23 cm), being significantly higher than other treatments but statically at par with treatment T₅ (5.45 cm), T₆ (5.81 cm) and T₇ (5.63 cm). Among various combinations of NPK fertilizers, bio-fertilizers

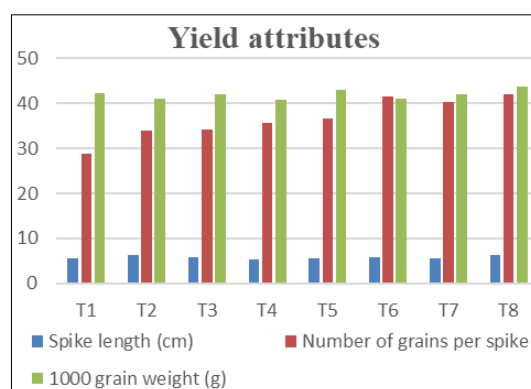
and FYM treatment T₁ (5.63 cm) recorded significantly lowest spike length than rest of the treatments.

Number of grains/spikes

The data pertaining to number of grains per spike under various combinations of NPK fertilizers, bio-fertilizers and FYM significantly influenced the number of grains per spike of Barley. Number of grains/spikes was recorded highest in treatment T₈ (41.87), being significantly higher than other treatments but statically at par with treatment T₆ to T₇. Difference in number of grains / spikes in treatment T₂, T₃ and T₄ were also not significant. The range of number of grains/spikes of Barley varied from 28.68 to 41.87. Least number of grains/spikes was recorded in treatment T₁ (29.68).

Test weight

A perusal of data relating to test weight of Barley revealed that various combinations of NPK fertilizers, bio-fertilizers and FYM did not differ markedly with each other in respect of test weight. However, it was numerically higher in treatment T₈ followed by T₇. The range of test weight was between 40.82 to 43.65 g.



Yield

Grain yield

Response of Barley to various combinations of NPK fertilizers, biofertilizers and FYM is presented in data indicated that grain yield of Barley was significantly affected due to various treatments. There was significant increase in grain yield of Barley with the increasing Nitrogen fertilizer, however, treatment T₈ (75% NPK + FYM @ 10t/ha + biofertilizer) being at par with treatment T₅, T₆ and T₇ resulted in significantly higher grain yield of Barley (3,962 kg ha⁻¹). Least value for grain yield was recorded in treatment T₁ (2,215 kg ha⁻¹). However, the difference in grain yield of Barley in treatment T₁ (Control) and treatment T₂ (100% recommended dose of NPK) were not significant.

Straw yield

The straw yield of any crop is an important criterion for evaluating efficiency of various treatments as it reflects the crop growth. Straw yield of Barley as influenced by various treatments revealed that straw yield of Barley was significantly affected due to various combinations of NPK fertilizers, biofertilizers and FYM. Significant increase in straw yield was obtained with the application of FYM.

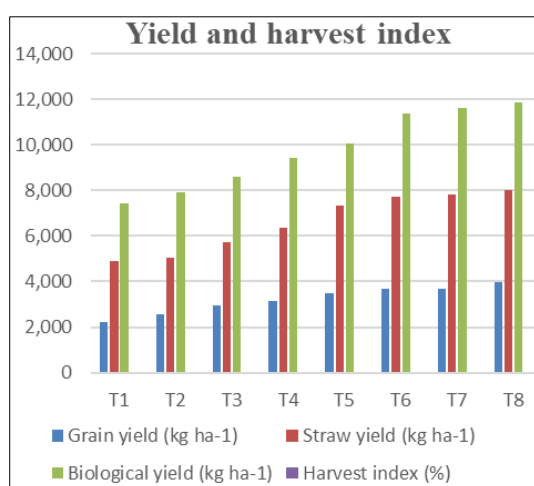
Among various combinations of NPK fertilizers, biofertilizers and FYM straw yield was maximum in treatment T₈, being significantly higher than treatment T₁, T₂, T₃ and T₄, but statically at par with treatment T₅, T₆ and T₇. Treatment T₁ (Control) being at par with treatment T₂ produced straw yield significantly lower than rest of the treatments.

Biological yield

After a close look at the data on biological yield of Barley as influenced by various combinations of NPK fertilizers, biofertilizers and FYM, it was observed that biological yield of Barley was recorded highest with treatment T₈ (11,876 kg ha⁻¹) but, the difference in biological yield of Barley in treatment T₅ to T₈ were not significant. Significantly lower value for biological yield was recorded in treatment T₁ (7,454 kg ha⁻¹) which was statistically at par with treatment T₂.

Harvest index

The data pertaining to harvest index of Barley as influenced by various combinations of NPK fertilizers, biofertilizers and FYM is presented in data revealed that various combinations of NPK fertilizers, biofertilizers and FYM did not affect the harvest index of Barley significantly however, it was numerically higher in treatment T₄ followed by T₃. The range of harvest index was between 29.71 to 34.42%.



The number of plants germinated per meter row length was significantly influenced by treatments. The highest germination was recorded in the T₈ treatment (75% NPK + FYM@10t/ha + biofertilizer), followed by T₇ and T₆. The improvement in germination of these treatments can be attributed to the application of organic manures along with chemical fertilizers, which likely improved soil structure, microbial activity, and moisture retention. These findings are in line with [Patel *et al.* (2018) ^[5]], who reported better germination with organic + inorganic input combinations.

Barley plants in T₈ treatment attained the greatest height at all growth stages. This might be due to better nutrient availability throughout the growing season, supporting cell division and elongation. Increased plant height under higher Nitrogen supply (T₈ and T₇) is consistent with the results reported by [Kumar *et al.* (2017) ^[2]], who noted that nitrogen promotes vegetative growth by enhancing photosynthetic activity.

Dry Matter Accumulation (DMA) also followed a similar pattern, being highest under T₈. The combined effect of balanced fertilization and optimal irrigation created a favorable environment for crop development and dry matter translocation. This confirms earlier findings by [Verma *et al.* (2016)] on nutrient and water synergy for improved physiological traits.

Treatments significantly affected the spike length, number of grains per spike, and 1000-grain weight. The T₈ and T₇ treatments showed the best performance. The enhanced yield attributes can be attributed to efficient source-sink relationships facilitated by better nutrient management and moisture availability. These

findings align with [Rathore *et al.* (2019) ^[6]], who observed that integrated nutrient management improves spikelet fertility and grain filling.

These results confirm the conclusions of [Deshmukh *et al.* (2021)], who stated that INM practices improve overall yield sustainability in cereals. Furthermore, irrigation during key phenological stages (as in T₈) enhances the physiological efficiency of Wheat by supporting grain development and reducing terminal stress.

Conclusion

From the results obtained during the experiment, it can be concluded that:

- Integrated nutrient management (T₈) combining (75% NPK + FYM@10t/ha + biofertilizer) proved to be the most effective treatment in enhancing growth, physiological efficiency, and yield of Wheat.
- T₇ (100% NPK + FYM@10t/ha + biofertilizer) was the second-best treatment, demonstrating the importance of timely irrigation during critical growth stages such as CRI and flowering.
- Without RDF was less effective than integrated approaches, proving that a synergistic combination of nutrients and water is essential.
- The control treatment (T₁), where no fertilizers or irrigation were applied, showed significantly lower performance in all parameters, reinforcing the need for proper agronomic practices in Wheat cultivation.

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