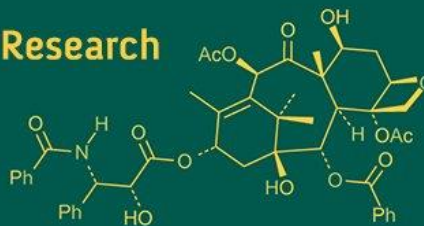


International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2026): 5.29
IJABR 2026; SP-10(6): 90-96
www.biochemjournal.com
Received: 01-05-2026
Accepted: 03-06-2026

Shalu Kumar
Assistant Professor, Arni
University, Kathgarh,
Himachal Pradesh, India

Vidushi Rawat
Research Scholar, Dev Bhoomi
Uttarakhand University,
Dehradun, Uttarakhand, India

Gagan Saini
Assistant Professor, Arni
University, Kathgarh,
Himachal Pradesh, India

Bindiya Barsola
Assistant Professor, Arni
University, Kathgarh,
Himachal Pradesh, India

Nivedita
Assistant Professor, Arni
University, Kathgarh,
Himachal Pradesh, India

Manisha Phaugat
Professor, Dev Bhoomi
Uttarakhand University,
Dehradun, Uttarakhand, India

Amit Singh
Assistant Professor, Faculty of
Agriculture, Shivalik College of
Engineering, Dehradun,
Uttarakhand, India

Corresponding Author:
Amit Singh
Assistant Professor, Faculty of
Agriculture, Shivalik College of
Engineering, Dehradun,
Uttarakhand, India

Influence of integrated nutrient management approaches on growth and yield attributes of barley (*Hordeum vulgare* L.)

Shalu Kumar, Vidushi Rawat, Gagan Saini, Bindiya Barsola, Nivedita, Manisha Phaugat and Amit Singh

DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i6Sb.8559>

Abstract

Barley (*Hordeum vulgare* L.) is a cereal grass primarily cultivated for its grains. The genus *Hordeum* comprises 32 species, all possessing a fundamental chromosome number of $x = 7$. Most species are diploid ($2n = 2x = 14$), while some are tetraploid ($2n = 4x = 28$) or hexaploid ($2n = 6x = 42$) (Tehulie and Eskezia, 2021). During the Rabi season of 2024-2025, a field experiment will be conducted at the Crop Research Centre of Uttaranchal University, Dehradun, Uttarakhand. The experimental site receives an average annual rainfall of approximately 1200 mm, with nearly 70% of the total precipitation occurring between July and October. The mean annual maximum and minimum temperatures are 29.6°C and 16.7°C, respectively. Summers are typically hot and humid, while winters range from mild to severe cold, with average temperatures varying between 6.5°C and 21.7°C. Prior to sowing, the field was carefully prepared using a tractor-driven disc plough and rotavator, followed by planking to level the soil. Stones, pebbles, and crop residues from the previous season were manually removed to ensure proper field conditions. The high-yielding barley variety RD-2552, known for its resilience to harsh environmental conditions, excellent grain quality, and vigorous growth, was selected for the experiment. Seeds were treated with 12% Carbendazim and 63% WP Mancozeb before sowing. The experiment was laid out in a Randomized Block Design (RBD) with three replications and seven treatment combinations involving inorganic fertilizers and organic manures. The treatments included T₁ (Control, no fertilizer or manure), T₂ (100% Recommended Dose of Fertilizers (RDF) @ 80:40:40 kg N:P₂O₅:K₂O ha⁻¹), T₃ (100% Farmyard Manure (FYM) @ 10 t ha⁻¹), T₄ (100% Vermicompost @ 15 t ha⁻¹), T₅ (50% RDF + 50% FYM), T₆ (50% RDF + Vermicompost @ 15 t ha⁻¹), and T₇ (100% RDF + FYM @ 10 t ha⁻¹ + Vermicompost @ 15 t ha⁻¹). Plant height was recorded at 30, 60, and 90 days after sowing (DAS) and at the time of harvest. The tallest plants were observed under treatment T₇, which received the combined application of RDF, FYM, and vermicompost. The results showed that integrated nutrient management had a significant positive effect on plant growth and yield attributes. Grain yield increased in response to higher nutrient inputs, with the maximum grain yield of 3259 kg ha⁻¹ recorded under treatment T₇. Similarly, the highest straw yield was also obtained under T₇, demonstrating the synergistic effect of combining inorganic fertilizers with organic manures in enhancing the growth and productivity of barley.

Keywords: Integrated nutrient management, barley (*Hordeum vulgare* L.), yield attributes, hexaploid, Uttarakhand etc.

1. Introduction

Barley (*Hordeum vulgare* L.) is one of the world's most important cereal crops, ranking fourth in global production after wheat, maize, and rice. It possesses an extensive genome, containing approximately 39,000 genes in its haploid genome. Although its genetic structure is complex, the availability of comprehensive genomic resources, including a high-quality reference genome sequence, has significantly advanced research in barley genetics. These resources support crop improvement efforts, enhancing the resilience and productivity of barley, and thereby contributing to global agriculture and food security (Mascher *et al.*, 2017) [11]. Barley plays a vital role not only in human consumption but also in animal feed and industrial uses, particularly in brewing, distilling, and the production of beer. Nutritionally, 100 grams of barley contain 10.6 mg of iron, 31.0 mg of vitamin B1, 0.1 mg of vitamin B2, and 50.0 µg of folate. It is well adapted to cool climates, grows rapidly,

improves soil health, and serves as an important component of sustainable farming systems (Kumari *et al.*, 2024). Globally, barley is cultivated on a large scale due to its adaptability and economic significance. In 2016-17, barley was planted on 49.29 million hectares, producing 147.16 million tons with an average yield of 2,990 kg ha⁻¹. Approximately one-fifth of this production is used for human consumption, another fifth for malting, and the remainder for animal feed. Barley straw is also widely utilized for producing silage and hay. In India, during 2015-16, barley was grown on 589.4 thousand hectares, yielding 1,437.5 thousand tons with an average productivity of 24.39 q ha⁻¹, underscoring its crucial role in both food and fodder production systems (Anonymous, 2018). In 2023-24, India's barley production was estimated at 1.913 million metric tons over an area of 628,000 hectares, with an average yield of 3.05 metric tons per hectare. Rajasthan accounted for more than 50% of total production, followed by Uttar Pradesh and Madhya Pradesh. In Punjab, barley occupied 5.5 thousand hectares with a production of 21.3 thousand tonnes and an average productivity of 38.66 q ha⁻¹. In Dehradun district of Uttarakhand, barley covered 966 ha, producing 2,234 tonnes with an average yield of 2.31 t ha⁻¹ in 2022-23 (DEC, 2023; Kaur *et al.*, 2025) ^[9].

Integrated Nutrient Management (INM) plays a crucial role in enhancing barley production while conserving soil resources. INM integrates the use of organic manures, such as farmyard manure (FYM), vermicompost, and agricultural by-products, with chemical fertilizers and other sustainable practices like green manuring, cover cropping, intercropping, crop rotation, quality tillage, and efficient irrigation and drainage systems. This approach synchronizes nutrient supply with crop demand, stabilizes water reserves, improves nutrient availability, and enhances nutrient use efficiency, ultimately optimizing crop yields and sustaining soil health (Jena *et al.*, 2019). Vermicompost, with its porous texture, high moisture retention, and beneficial microbial activity, improves nutrient absorption, while other organic inputs like chicken manure and barnyard manure serve as cost-effective soil conditioners that enhance plant growth and disease resistance (Akkaya and Kara, 2018). Integrated Nutrient Management (INM) is a versatile strategy aimed at enhancing both crop yield and quality by reducing dependence on chemical fertilizers while improving their efficiency and profitability for farmers. INM emphasizes maintaining optimal soil fertility and supplying essential nutrients to meet crop requirements. This approach combines the use of chemical fertilizers, organic manures, and bio-fertilizers to sustain crop productivity, preserve soil health and biodiversity, reduce fertilizer costs, and increase nutrient-use efficiency. Research has shown that integrating organic and inorganic nutrient sources under INM consistently outperforms the use of either source alone, significantly improving barley growth, yield components, and overall productivity (Dinka *et al.*, 2018). Fertilizer application has been a major factor contributing to the 50-75% increase in global crop yields, demonstrating a strong correlation between nutrient input and productivity. However, excessive or unregulated use of chemical fertilizers can reduce soil organic matter, disrupt soil microbial activity, and pose potential risks to human health. In contrast, the use of organic fertilizers enhances soil organic carbon, improves fertility, and often results in higher sustainable yields compared to balanced chemical

fertilizers alone (Potal, 2020). Proper fertilization not only provides essential nutrients for plant growth but also shortens crop development cycles, enables earlier harvests, improves soil structure, and promotes long-term agricultural sustainability (Demirsoy *et al.*, 2020). INM is a versatile and sustainable strategy that minimizes dependence on chemical fertilizers, improves their efficiency, and increases farmers' profitability while maintaining soil fertility and biodiversity. By combining fertilizers, organic manures, and bio-fertilizers, INM enhances crop productivity, soil fertility, and resource-use efficiency. Research consistently demonstrates that integrated nutrient application outperforms the use of either organic or inorganic sources alone, leading to significant improvements in barley growth, yield components, and overall productivity (Dinka *et al.*, 2018). Fertilizer use has contributed to 50-75% of the global increase in crop yields; however, the excessive and unregulated application of chemical fertilizers has led to a decline in soil organic matter, degradation of soil biological activity, and potential risks to human health. Conversely, organic fertilizers enhance soil organic carbon, improve soil fertility, and often result in more sustainable yield trends (Potal, 2020). Proper fertilization practices not only improve nutrient availability and crop quality but also reduce crop duration, enable earlier harvesting, improve soil structure, and promote long-term agricultural sustainability (Demirsoy *et al.*, 2020) ^[15].

2. Materials and methods

2.1 Source of Materials

The field experiment was conducted during the Rabi season of 2024-2025 at the Crop Research Centre of Uttaranchal University, Dehradun, Uttarakhand. The experimental field was carefully leveled to ensure uniform soil conditions and proper seedbed preparation, which is crucial for reducing variability in field experiments (Piper, 1966; Spark, 1996). The study area receives an average annual rainfall of approximately 1200 mm, with nearly 70% occurring between July and October. The mean annual maximum and minimum temperatures are 29.6 °C and 16.7 °C, respectively. Summers are generally hot and humid, while winters vary from mild to severe cold, with temperatures ranging from 6.5 °C to 21.7 °C. December is the coldest month, with temperatures occasionally dropping to 4 °C, whereas June is the hottest, with maximum temperatures reaching 45 °C. From March onwards, both daily temperatures and the evaporation rate gradually increase. Meteorological data recorded from November 2024 to April 2025 indicated that the average monthly maximum and minimum temperatures ranged from 21.1 °C to 34.4 °C and 3.0 °C to 11.3 °C, respectively, while rainfall and relative humidity varied across the months (ICAR-IISWC, 2025).^[7] Prior to sowing, the field was prepared using a tractor-driven disc plough and rotavator, followed by planking, ensuring good tilth and moisture conservation (Piper, 1966; Gavlak *et al.*, 2005). Stones, pebbles, and residues from the previous crop were manually removed, and the field was irrigated to attain optimal soil moisture levels. The experimental area was divided into three equal parts to accommodate three replications, each further subdivided into seven main plots measuring 3 m × 2 m, with bunds of 20 cm width. Treatments were randomly assigned to the main plots within each replication using a random number table, following the principles of Randomized Block Design

(RBD) to reduce experimental error (Piper, 1966; Spark, 1996). Each main plot was further divided into three subplots to facilitate the application of different fertilizer levels while maintaining adequate irrigation and drainage. The high-yielding barley (*Hordeum vulgare* L.) variety RD-2552 was used in the study. This variety is widely cultivated in India due to its robust growth, superior grain quality, and tolerance to adverse environmental conditions (Anonymous, 2018; Kaur *et al.*, 2025). Seeds were treated with Carbendazim (12%) and Mancozeb (63% WP) prior to sowing to protect against seed-borne pathogens, which is a standard procedure to ensure healthy crop establishment (Gavlak *et al.*, 2005; Zhou, 2009)^[9].

The experiment followed a Randomized Block Design (RBD) with three replications and seven treatments, which included the use of inorganic fertilizers, organic manures, and their combinations. Treatments were as follows, T₁: Control (no fertilizer or manure); T₂: 100% Recommended Dose of Fertilizers (RDF) @ 80:40:40 kg N:P₂O₅:K₂O ha⁻¹; T₃: 100% Farmyard Manure (FYM) @ 10 t/ha; T₄: 100% Vermicompost @ 15 t/ha; T₅: 50% RDF + 50% FYM; T₆: 50% RDF + Vermicompost @ 15 t/ha; T₇: 100% RDF + FYM @ 10 t/ha + Vermicompost @ 15 t/ha. The nutrient doses were determined based on standard fertilizer recommendations for barley (Anonymous, 2018; Muhr *et al.*, 1963; Olsen *et al.*, 1954). The combination of inorganic fertilizers with organic manures is widely recognized as an effective strategy for improving nutrient-use efficiency and sustaining soil fertility under field conditions (Akkaya & Kara, 2018; Dinka *et al.*, 2018; Jena *et al.*, 2019; Kumari *et al.*, 2024; Potal, 2020; Yimer, 2022). Vermicompost improves soil structure, nutrient retention, and microbial activity, whereas FYM enhances soil organic carbon and moisture-holding capacity (Potal, 2020; Yimer, 2022).

Each plot was sown at a depth of 4-5 cm using line sowing with a spacing of 30 cm × 10 cm, as recommended for barley (Anonymous, 2018; Kaur *et al.*, 2025). The total plot size was 126 m² (9 m × 14 m), and the seed rate was 100 kg/ha (approximately 2.5 kg per plot). This experimental setup allowed for precise evaluation of the effects of different fertilizer and manure combinations on barley growth, development, and yield under the specific agro-climatic conditions of Dehradun. The design also ensured uniformity in irrigation, nutrient application, and plot management, thereby minimizing experimental errors and enabling reliable comparisons among treatments (ICAR-IISWC, 2025; Piper, 1966; Spark, 1996)^[9, 1, 15].

2.2 Analysis of Soil: The physicochemical properties of the experimental soil were analyzed to characterize the site prior to sowing. The soil's physical properties, including sand, silt, and clay content, were determined using the hydrometer method as described by Gavlak *et al.* (2005), and the overall soil texture was classified using a triangular diagram based on the pipette method (Piper, 1966). Chemical properties of the soil were also evaluated. Soil pH was measured in a 1:2.5 soil-to-water suspension using a glass electrode pH meter, and electrical conductivity (EC) was determined using the conductivity method (Spark, 1996). Organic carbon content was estimated using the wet chromic acid digestion method according to Walkley *et al.* (1934). Available nitrogen in the soil was measured by the alkaline permanganate method (Subbiah *et al.*, 1956), while available phosphorus was determined using Olsen's method

(Olsen *et al.*, 1954).^[13] Available potassium was extracted with ammonium acetate and quantified using a flame photometer (Muhr *et al.*, 1963).^[12] These analyses provided essential baseline information regarding the fertility status and nutrient availability of the experimental site.

2.3 Observations Recorded

2.3.1 Growth Parameters

Plant growth was assessed through measurements of plant height and dry matter accumulation, following established agronomic procedures (Piper, 1966; Gavlak *et al.*, 2005; Spark, 1996)^[14, 6, 16]. Plant height (cm) was recorded as the average measurement at the point of maximum growth, typically when the plants had matured and turned brown. Individual plant heights were measured from the ground level to the top of the plant canopy using a meter rod, and the average height was subsequently computed for each plot (Anonymous, 2018; Kaur *et al.*, 2025)^[2, 9]. Dry matter accumulation was determined by harvesting plant samples from a continuous one-meter row, specifically from the second and third rows starting from the west, at different growth stages 30, 60, and 90 days after sowing (DAS), as well as at harvest. This method of sequential destructive sampling at fixed intervals is standard for assessing biomass dynamics in cereals (Piper, 1966; Zhou, 2009)^[14, 20]. Plants were cut at ground level, and fresh weight was recorded in grams per meter after sun-drying to remove surface moisture. Subsequently, the samples were oven-dried at 65 ± 5 °C until a constant weight was achieved, and the dry matter content was calculated, following the procedures outlined by Gavlak *et al.* (2005), ICAR-IISWC (2025)^[6, 7, 9].

2.3.2 Yield and Yield Attributes

To evaluate the effects of different treatments on barley growth, yield attributes, nutrient content, and overall productivity, systematic observations were recorded for each parameter, following standard agronomic methodologies (Anonymous, 2018; Piper, 1966; Gavlak *et al.*, 2005)^[2, 14, 6]. The number of grains per spike was determined by manually threshing spikes that were selected for spike length measurement. The grains were counted manually, and the mean number of grains per spike was calculated for statistical analysis (Anonymous, 2018; Zhou, 2009)^[2, 20]. Spike length (cm) was measured at physiological maturity by randomly selecting five productive ears from each plot and replication. Each ear was measured from the base of the spikelet to the tip of the uppermost spikelet, including awns, using a centimeter scale, and the average spike length was computed for each treatment (Kaur *et al.*, 2025; Dinka *et al.*, 2018)^[9, 5]. The 1000-grain weight, or test weight, was estimated by taking three random samples of 100 seeds each from the total seed yield of selected plants. The seeds were weighed using an electric balance, and the average weight was calculated and expressed in grams (Piper, 1966; Gavlak *et al.*, 2005; Spark, 1996)^[14, 6, 16]. Biological yield (q ha⁻¹) was determined by sun-drying the harvested crop for one week, followed by recording the weight of all produce collected from the net plot area and converting it to quintals per hectare. This method ensures accurate estimation of total biomass under field conditions (Potal, 2020; Yimer, 2022)^[15, 19]. Grain yield (q ha⁻¹) was measured by threshing the harvested produce from each net plot. The grains were sun-dried to

maintain a standard 12% moisture content, weighed, and converted to $q\ ha^{-1}$, which aligns with recommended protocols for cereals (Anonymous, 2018; Zhou, 2009; Piper, 1966) [2, 14, 6]. Straw yield ($q\ ha^{-1}$) was obtained by recording the total weight of the crop before threshing and calculating the contribution of straw from the net plot area, expressed in quintals per hectare. This parameter represents the non-grain biomass and is crucial for understanding nutrient recycling and total productivity (Jena *et al.*, 2019; Kumari *et al.*, 2024; Dinka *et al.*, 2018) [8, 10, 5].

These observations provided comprehensive data on the productivity and yield components of barley under different fertilizer and manure treatments, enabling precise evaluation of the effects of integrated nutrient management on both growth and yield performance (Akkaya & Kara, 2018; Dinka *et al.*, 2018; Potal, 2020) [1, 5, 15].

3. Results and discussion: The experiment, titled “Influence of Integrated Nutrient Management Approaches on Growth and Yield Attributes of Barley (*Hordeum vulgare* L.)”, was conducted at the Crop Research Centre of Uttarakhand University, Dehradun, Uttarakhand, during the Rabi season of 2024-25. The study comprised seven treatments: T₁ - Control, T₂ - 100% RDF (80:40:40 N:P₂O₅:K₂O kg/ha), T₃ - 100% FYM (10 t/ha), T₄ - 100% Vermicompost (15 t/ha), T₅ - 50% RDF + 50% FYM, T₆ - 50% RDF + Vermicompost (15 t/ha), and T₇ - 100% RDF + FYM (10 t/ha) + Vermicompost (15 t/ha). Observations on growth parameters, yield attributes, and yield were systematically recorded and analyzed using tables and relevant figures.

3.1 Growth Parameters

3.1.1 Plant Height

Plant height varied significantly among treatments at 30, 60, and 90 days after sowing (DAS) as well as at harvest. Treatment T₇, which received the combined application of 100% RDF, FYM, and vermicompost, produced the tallest plants, with heights of 24.48 cm at 30 DAS, 63.42 cm at 60 DAS, 87.14 cm at 90 DAS, and 91.36 cm at harvest. In contrast, the control treatment T₁ resulted in the shortest plants. These findings indicate that the integrated application of organic and inorganic nutrient sources in T₇ significantly enhanced vegetative growth compared to sole applications or control, highlighting the positive role of Integrated Nutrient Management (INM) in promoting plant height (Jena *et al.*, 2019; Dinka *et al.*, 2018) [8, 5].

Compared to other treatments, plants under T₇ consistently exhibited greater height at all growth stages measuring 24.48 cm at 30 DAS, 63.42 cm at 60 DAS, 87.14 cm at 90 DAS, and 91.36 cm at 120 DAS. The application of RDF along with FYM and vermicompost supported similar growth patterns throughout the stages. In contrast, the shortest plants were observed in treatment T₁. The notable increase in height under T₇ can be attributed to the combined use of organic inputs and inorganic fertilizers, where FYM (10 t/ha) and vermicompost (15 t/ha) supply essential macro- and micronutrients and growth-promoting substances gradually over time, enhancing root development and overall vegetative growth (Akkaya & Kara, 2018; Yimer, 2022; Potal, 2020) [1, 19, 15].

Table 3.1 Mean Plant Height (cm) as affected by INM at different phases of growth.

Symbol	Plant Height (cm)			
	30 DAS	60 DAS	90 DAS	Harvest
T ₁	18.32	48.34	71.16	75.14
T ₂	20.23	55.18	81.29	86.2
T ₃	19.37	52.23	78.32	81.04
T ₄	21.53	56.58	82.75	88.05
T ₅	21.63	58.65	83.71	87.24
T ₆	23.46	61.45	86.28	89.24
T ₇	24.48	62.42	87.14	91.36
C.D at 5%	0.093	0.1	0.09	0.99
SE(m)	0.03	0.032	0.029	0.31
SE(d)	0.042	0.045	0.041	0.45

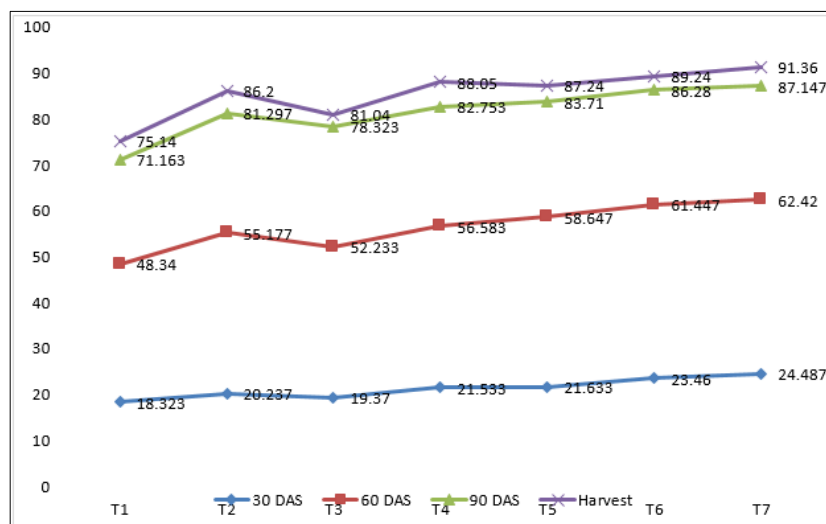


Fig 3.1: Average plant Height (cm) at various growth phases as affected by INM.

3.2 Yield Attributes

Analysis of yield attributes revealed that different combinations of RDF, FYM, and vermicompost significantly influenced barley productivity. The number of grains per spike and spike length were highest in T₇, reflecting the benefits of combined nutrient application in enhancing reproductive growth (Jena *et al.*, 2019; Dinka *et al.*, 2018) [8, 5].

3.2.1 Grain Yield: Grain yield was markedly affected by the treatments. The highest grain yield of 3259 kg/ha was recorded in T₇, which received 100% RDF along with FYM at 10 t/ha and vermicompost at 15 t/ha. Although this yield was statistically similar to treatments T₄, T₅, and T₆, it was substantially higher than other treatments. The lowest grain yield of 1940 kg/ha was recorded in the control (T₁). These results demonstrate that integrated application of chemical and organic fertilizers positively influences grain production, while the use of fertilizers alone or organic sources alone produces comparatively lower yields (Potal,

2020; Yimer, 2022) [15, 19]. The greatest yield under T₇ can be attributed to the adequate nitrogen supply, which promoted higher dry matter accumulation and enhanced reproductive development (Mascher *et al.*, 2017; Kumari *et al.*, 2024) [11, 10].

3.2.2 Straw Yield

Straw yield was also significantly influenced by the nutrient management practices. Treatment T₇ recorded the highest straw yield, whereas the lowest yield was observed in the control (T₁), indicating that integrated nutrient management enhances not only grain but also vegetative biomass. Enhanced vegetative growth and improved yield components contributed to increased straw and grain yields (3524 kg/ha and 3259 kg/ha, respectively) in T₇. This was due to the better availability of both macro- and micronutrients, along with growth-promoting substances present in vermicompost and FYM (Akkaya & Kara, 2018; Dinka *et al.*, 2018) [1, 5]. In contrast, treatments with lower nutrient input produced the minimum yields.

Table 3.2: Impact INM on Grain and Straw Yield of barley

Symbol	Grain Yield (kg/ha)	Straw Yield (kg/ha)
T ₁	1,940	2,487
T ₂	2,665	2,922
T ₃	2,340	2,802
T ₄	2,792	3,285
T ₅	2,935	3,319
T ₆	3,055	3,477
T ₇	3,259	3,524
C.D.	2.31	1.64
SE(m)	7.421	0.527
SE(d)	10.49	0.745

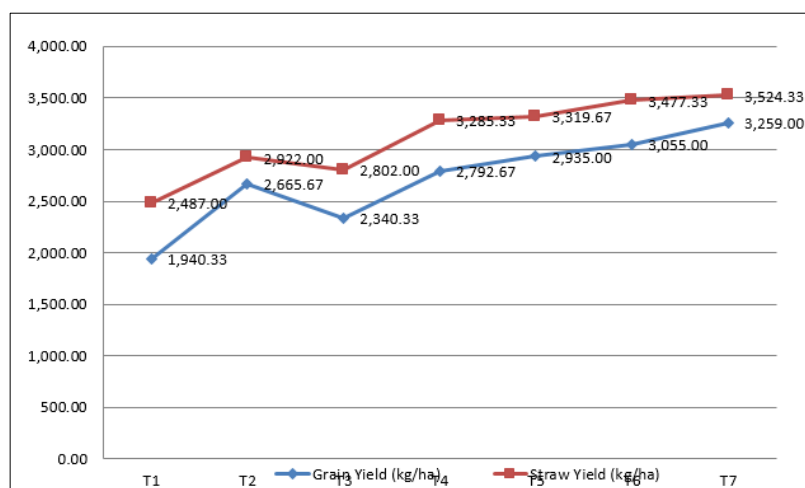


Fig 3.2: Average Grain and straw yields as affected by INM

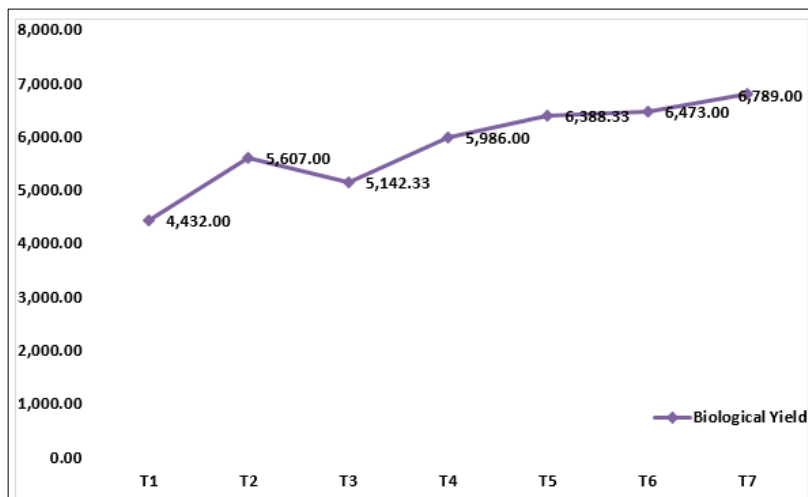
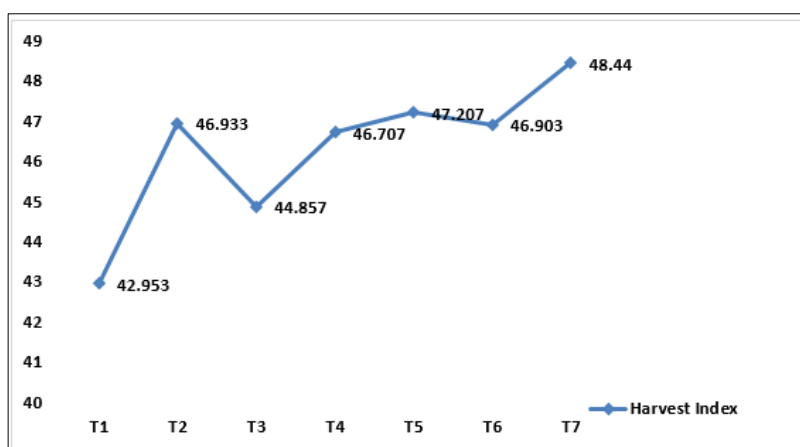
3.3 Biological Yield: Biological yield followed a similar trend to grain and straw yields, with T₇ achieving the highest total biomass production. The combination of 100% RDF, FYM at 10 t/ha, and vermicompost at 15 t/ha significantly enhanced overall crop growth and biomass accumulation. This improvement can be attributed to the synergistic effect of organic and inorganic nutrient sources, which supply essential macro- and micronutrients and improve soil fertility and structure, ultimately promoting greater vegetative and reproductive growth (Jena *et al.*, 2019; Dinka *et al.*, 2018; Yimer, 2022) [8, 5, 19].

3.4 Harvest Index

The harvest index, calculated as the ratio of grain yield to biological yield, ranged from 42.95% to 48.44%, with T₇ showing the highest value. These results indicate that integrated application of chemical fertilizers with FYM and vermicompost not only increased total biomass but also enhanced the proportion of economic yield, reflecting more efficient partitioning of assimilates to the grain (Potal, 2020; Kumari *et al.*, 2024) [15, 10].

Table 3.3: Impact INM on Biological Yield and Harvest Index of barley

Symbol	Biological Yield	Harvest Index (%)
T ₁	4,432	42.95
T ₂	5,607	46.93
T ₃	5,142	44.85
T ₄	5,986	46.70
T ₅	6,388	47.20
T ₆	6,473	46.90
T ₇	6,789	48.44
C.D.	1.39	0.03
SE(m)	0.44	0.012
SE(d)	0.63	0.01

**Fig 3.3:** Average Biological yield as affected by INM.**Fig 3.4:** Average Harvest index (%) at various growth phases as affected by INM

Overall, the results of this study confirm that Integrated Nutrient Management, combining chemical fertilizers with organic sources such as FYM and vermicompost, significantly improves the growth, yield components, grain and straw yield, and harvest index of barley under the agro-climatic conditions of Dehradun, Uttarakhand.

4. Conclusion

The field experiment titled “*Influence of Integrated Nutrient Management Approaches on Growth and Yield Attributes of Barley (Hordeum vulgare L.)*” was conducted at the School of Agriculture, Uttaranchal University, Dehradun, Uttarakhand, during the Rabi season of 2024-2025. The study evaluated the effect of various combinations of inorganic fertilizers, Farm Yard Manure (FYM), and vermicompost on the growth and yield of barley. The

findings revealed that treatments integrating 100% RDF with organic inputs, particularly T₇ (RDF + FYM + Vermicompost) and T₆ (50% RDF + Vermicompost), significantly enhanced plant growth and yield parameters compared to sole applications or control (Dinka *et al.*, 2018; Yimer, 2022) [5, 19].

Among the growth parameters, plant height and dry matter accumulation were markedly higher in T₇ and T₆ across all stages of development, indicating improved vegetative growth due to the synergistic effect of organic and inorganic nutrients (Jena *et al.*, 2019; Potal, 2020) [8, 15]. Similarly, key yield attributes, including spike length, number of grains per spike, 1000-grain weight, grain yield, straw yield, and biological yield, were maximized under integrated nutrient management, with T₇ consistently outperforming other treatments (Mascher *et al.*, 2017; Kumari *et al.*, 2024) [11, 10].

The harvest index also reflected the enhanced efficiency of assimilate partitioning toward grain production under combined nutrient application (Demirsoy *et al.*, 2020).^[4] The results highlight that vermicompost and FYM contribute to soil health by improving structure, moisture retention, and nutrient availability, which in turn promotes robust root development and efficient nutrient uptake (Akkaya & Kara, 2018; Yimer, 2022)^[1, 19]. Consequently, the integration of chemical fertilizers with organic amendments proved superior in optimizing barley growth and yield. These findings emphasize that adopting integrated nutrient management strategies is crucial for enhancing crop productivity, ensuring sustainable soil fertility, and achieving higher agricultural output, thereby offering long-term benefits for barley cultivation under the agro-climatic conditions of Dehradun, Uttarakhand (Jena *et al.*, 2019; Dinka *et al.*, 2018)^[8, 5].

Author's Contribution

All authors contributed substantially to the conception and design of the study, acquisition of data, and analysis and interpretation of results. They participated in drafting the manuscript and critically revising it for important intellectual content. All authors have approved the final version for submission and agree to be accountable for all aspects of the work. Each author meets the eligibility criteria for authorship as per the International Committee of Medical Journal Editors (ICMJE) guidelines.

Conflicts of Interest

The authors declare that they have no financial or other conflicts of interest related to this study.

Ethical Approval

This study did not involve experiments on humans or animals, and therefore, ethical approval was not required.

Data Availability

All data generated or analyzed during this study are available from the corresponding author upon reasonable request.

Publisher's Note: All claims expressed in this article are solely those of the authors and do not necessarily represent those of the publisher, editors, or reviewers. This journal remains neutral with regard to jurisdictional claims in published institutional affiliations.

Use of Artificial Intelligence (AI)-Assisted Technology

The authors declare that no artificial intelligence (AI) tools were used in writing, editing, or preparing the manuscript, and no images were generated or manipulated using AI.

References

1. Akkaya A, Kara C. Effect of organic manure types on soil fertility and crop productivity. *Journal of Agricultural Science*. 2018;10(3):45-53.
2. Anonymous. Barley: Global production and utilization. Food and Agriculture Organization of the United Nations; 2018.
3. DEC. District Economic Census, Dehradun: Agricultural Statistics 2022-2023. Government of Uttarakhand; 2023.
4. Demirsoy L, Kaya Z, Yildirim K. Fertilization effects on growth, yield, and soil fertility of cereals. *Turkish Journal of Agriculture and Forestry*. 2020;44(2):112-123. DOI:10.3906/tar-1907-25.
5. Dinka H, Desta B, Mekonnen K. Integrated nutrient management for improving barley yield and soil fertility in Ethiopia. *International Journal of Agronomy*. 2018;2018:1-10. DOI:10.1155/2018/8245610.
6. Gavlak R, Horneck D, Miller RO. Soil, plant, and water reference methods for the western region. 3rd ed. Western Region Cooperative Extension Publications; 2005.
7. ICAR-Indian Institute of Soil and Water Conservation (ICAR-IISWC), Dehradun, Uttarakhand. Meteorological data from November 2024 to April 2025. Dehradun: ICAR-IISWC; 2025.
8. Jena D, Mohanty M, Panda R. Integrated nutrient management for sustainable crop production. *Indian Journal of Fertilizers*. 2019;15(8):56-63.
9. Kaur S, Singh A, Sharma R. Barley production and productivity trends in India. *Journal of Cereal Research*. 2025;17(1):25-32.
10. Kumari S, Verma P, Singh R. Impact of organic amendments on soil health and barley growth. *Journal of Soil and Crop Science*. 2024;14(2):105-116.
11. Mascher M, Gundlach H, Himmelbach A, Beier S, Twardziok SO, Wicker T, *et al.* A chromosome conformation capture ordered sequence of the barley genome. *Nature*. 2017;544(7651):427-433. DOI:10.1038/nature22043.
12. Muhr G, Thomas G, Jackson M. Determination of available potassium in soils by ammonium acetate extraction. *Soil Science Society of America Journal*. 1963;27(4):5-12.
13. Olsen SR, Cole CV, Watanabe FS, Dean LA. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. *USDA Circular*. 1954;939:1-19.
14. Piper CS. Soil and plant analysis. Adelaide: Hans Publishers; 1966.
15. Potal R. Effects of organic and chemical fertilizers on soil properties and crop yield. *Journal of Agricultural Chemistry*. 2020;14(1):33-42.
16. Spark D. Methods of soil chemical analysis. Englewood Cliffs: Prentice Hall; 1996.
17. Subbiah BV, Asija GL. A rapid procedure for the estimation of available nitrogen in soils. *Current Science*. 1956;25:259-260.
18. Walkley A, Black IA. An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science*. 1934;37:29-38.
19. Yimer F. Role of organic fertilizers in enhancing barley yield and soil fertility. *Advances in Crop Science*. 2022;10(2):75-85.
20. Zhou Q. Nutritional composition and health benefits of barley. *Food Science and Nutrition*. 2009;15(3):201-210.