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Integrated Nutrient Management through Organic Manures, Inorganic Fertilizers and Biofertilizers for Enhancing Growth, Yield and Profitability of Barley (*Hordeum vulgare* L.)

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Abstract

A field experiment was conducted to evaluate the effect of integrated nutrient management practices on growth, yield attributes, yield and economics of barley (*Hordeum vulgare* L.). The experiment comprised nine treatments involving different combinations of recommended dose of fertilizers (RDF), farmyard manures (FYM), vermicompost (VC) and biofertilizers. The treatments were arranged in a randomized block design with three replications. The results revealed that integrated application of inorganic fertilizers, organic manures and biofertilizers significantly improved plant growth, dry matter accumulation; yield attributes and yield over absolute control. Among the treatments, T7 (50% RDF + FYM-N (25%) + VC-N (25%) + Biofertilizers) recorded the maximum plant height at harvest (92.62 cm), dry matter accumulation at harvest (1117.13 g m^{-2}), effective tillers (342.14 m^{-2}), grains $spike^{-1}$ (49.94), spike length (9.54 cm), test weight (48.44 g), grain yield (4301.03 kg ha^{-1}), straw yield (6318.56 kg ha^{-1}) and biological yield (10619.59 kg ha^{-1}). Economic analysis indicated that T7 produced the highest net returns (Rs. 74,847 ha^{-1}), whereas the highest benefit: cost ratio (3.00) was observed under 100% RDF. The study concluded that integrated use of inorganic fertilizers, vermicompost and biofertilizers substantially enhanced productivity and profitability of barley under semi-arid conditions.

Keywords: Barley, Integrated nutrient management, Vermicompost, Biofertilizers, Yield, Economics

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Introduction

Barley (*Hordeum vulgare* L.) is one of the oldest cereal crops cultivated worldwide and ranks fourth among cereal crops after wheat, rice and maize. It is widely cultivated under diverse agro-climatic conditions because of its adaptability to marginal soils and drought-prone environments. In India, barley is grown mainly for feed, food, malt and fodder purposes. Sustainable barley production largely depends upon balanced nutrient management practices that ensure optimum nutrient availability and improved soil health.

Continuous use of chemical fertilizers alone often leads to deterioration of soil physical, chemical and biological properties, ultimately reducing crop productivity and nutrient use efficiency. Integrated nutrient management (INM), which combines inorganic fertilizers with organic manures and biofertilizers, has emerged as a sustainable approach for maintaining soil fertility and enhancing crop productivity. Organic manures such as farmyard manure and vermicompost improve soil structure, microbial activity, water holding capacity and nutrient availability, while biofertilizers enhance nutrient mobilization and biological nitrogen fixation.

Recent studies have demonstrated that integrated application of organic and inorganic nutrient sources improves growth, yield attributes and nutrient uptake in barley and other cereal crops [1, 2]. Vermicompost has been reported to enhance enzymatic activity and microbial population in soil, leading to better root growth and nutrient absorption [3]. Similarly, biofertilizers improve nutrient availability and crop performance by increasing rhizospheric microbial activity [4].

Considering the importance of integrated nutrient management for sustainable barley production, the present investigation was undertaken to evaluate the effect of different combinations of inorganic fertilizers, organic manures and biofertilizers on growth, yield and economics of barley.

Material and Methods

A field experiment entitled was conducted during the Rabi season of 2025–26 at the Research Farm of Vivekananda Global University, Jaipur, Rajasthan, India. The experimental site is geographically situated at 26°51′ N latitude and 75°47′ E longitude. longitude and falls under the Semi-Arid Eastern Plain Zone of Rajasthan. The climate of the experimental region is semi-arid with hot summers and cold winters. During the crop season, the maximum and minimum temperatures ranged from 20.1°C to 33.3°C and −0.5°C to 15.6°C, respectively. A total rainfall of 39.5 mm was received during the experimental period.

The soil of the experimental field was loamy sand in texture with low fertility status. Composite soil samples (0–15 cm depth) collected before sowing were analyzed for physico-chemical properties. The soil contained 84.1% sand, 9.3% silt, and 6.6% clay with pH 8.21 and EC 0.33 dS m^{-1}. The soil was low in organic carbon (0.23%) and available nitrogen (130.23 kg ha^{-1}), medium in available phosphorus (20.56 kg ha^{-1}), and potassium (220.56 kg ha^{-1}).

Experimental details

The experiment was laid out in a Randomized Block Design (RBD) with nine treatments and three replications. The treatments comprised different combinations of recommended dose of fertilizers (RDF), farmyard manure (FYM), vermicompost (VC), and biofertilizers (Azotobacter + phosphate solubilizing bacteria). The treatments were: T_1–Absolute control, T_2–100% RDF, T_3–75% RDF + FYM-N (25%), T_4–75% RDF + VC-N (25%), T_5–50% RDF + FYM-N (25%) + biofertilizers, T_6–50% RDF + VC-N (25%) + biofertilizers, T_7–50% RDF + FYM-N (50%) + biofertilizers, T_8–100% FYM-N + biofertilizers, and T_9–100% VC-N + biofertilizers. Each plot measured 3.0 m × 5.0 m with a net plot area of 2.2 m × 4.0 m.

Barley variety RD 2035 was used as the test crop. Seeds were sown on 17 November 2025 at a spacing of 20 cm using a seed rate of 100 kg ha^{-1} by the "Kera" method. Recommended fertilizer dose of 80:40:40 kg N:P_2O_5:K_2O ha^{-1} was applied through urea, DAP, and MOP. Half nitrogen and full doses of phosphorus and potassium were applied as basal, while the remaining nitrogen was top dressed in two equal splits at irrigations. FYM and vermicompost were incorporated as per treatments before sowing. Biofertilizer inoculation was done by coating seeds with Azotobacter and PSB culture using jaggery solution.

Standard agronomic practices were followed uniformly for all treatments. Four irrigations were applied at critical growth stages using the check basin method. One hand weeding and hoeing operation was performed at 25 days after sowing for effective weed control.

Observations on growth parameters such as plant population, plant height, and dry matter accumulation were recorded at different crop growth stages. Yield attributes including effective tillers, spike length, grains $spike^{-1}$, and test weight were recorded at harvest. Grain, straw, and biological yields were computed and harvest index was calculated.

Economic analysis including net returns and benefit:cost ratio was calculated based on prevailing market prices. Statistical analysis: The recorded experimental data were statistically analyzed using Fisher's analysis of variance (ANOVA) technique applicable to Randomized Block Design. The significance of treatment effects was tested at the 5% level of probability and critical difference (CD) values were calculated wherever the treatment effects were found significant.

Results and Discussion

Effect on Plant Height

Plant height increased progressively with crop growth under all treatments (**Table 1**). At harvest, the highest plant height (92.62 cm) was recorded under T7 (50% RDF + FYM-N (25%) + VC-N (25%) + Biofertilizers), which was significantly superior to the control and most other treatments. However, it remained statistically at par with T6. The increase in plant height under integrated nutrient management treatments might be attributed to improved nutrient availability, enhanced microbial activity and better root development due to combined application of inorganic fertilizers, vermicompost and biofertilizers. The lowest plant height (63.12 cm) was observed under absolute control (T1), indicating poor nutrient availability under unfertilized conditions. Application of vermicompost along with biofertilizers likely enhanced cell elongation and meristematic activity through continuous nutrient supply and production of growth-promoting substances. Similar findings were reported by [1] and [3] in barley.

Effect on Dry Matter Accumulation

Dry matter accumulation increased significantly with advancement in crop age and nutrient management practices. At harvest, T7 recorded the maximum dry matter accumulation (1117.13 g m^{-2}), followed by T6 (1086.38 g m^{-2}) and T5

(1065.63 g m^{-2}). The increase in dry matter production under integrated nutrient management treatments may be due to enhanced photosynthetic efficiency, better nutrient uptake and improved translocation of assimilates.

Table 1 Effect of Nutrient management on plant height and dry matter accumulation of barley

Treatments	Plant height (cm)				Dry matter accumulation (g m^{-2})			
	At 30 DAS	At 60 DAS	At 90 DAS	At harvest	At 30 DAS	At 60 DAS	At 90 DAS	At harvest
T_1- Absolute control	18.22	37.42	58.52	63.12	106.38	271.63	588.13	711.13
T_2 – 100% RDF	24.62	50.82	74.42	83.32	141.88	381.13	796.38	979.38
T_3 – 75% RDF + FYM-N (25%)	25.42	52.52	76.22	85.12	147.88	395.63	816.13	1005.88
T_4 – 75% RDF + VC-N (25%)	26.02	53.32	77.02	86.42	150.88	403.88	832.38	1027.13
T_5 – 50% RDF + FYM-N (25%) + Biofertilizers	27.32	55.72	79.72	89.02	159.63	421.13	864.38	1065.63
T_6 – 50% RDF + VC-N (25%) + Biofertilizers	28.02	56.62	81.12	90.42	162.88	432.13	884.13	1086.38
T_7 – 50% RDF + FYM-N (25%) + VC-N (25%) + Biofertilizers	29.22	58.32	83.52	92.62	169.88	446.63	913.63	1117.13
T_8 – 100% FYM-N + Biofertilizers	24.22	48.42	72.52	80.22	135.63	364.38	763.38	947.88
T_9 – 100% VC-N + Biofertilizers	25.02	49.72	73.32	81.82	139.13	373.13	781.88	966.38
SEm±	0.7	1.2	2.4	2.7	4.25	11.50	20.50	24.00
CD (P = 0.05)	NS	NS	7.1	7.9	12.75	33.75	60.50	71.00

Organic manures improve soil aeration and moisture retention, while biofertilizers stimulate microbial activity and nutrient mobilization. Consequently, plants maintained better vegetative growth and biomass production throughout the crop growth period. The minimum dry matter accumulation (711.13 g m^{-2}) was observed under control treatment. Similar observations were also reported by [2].

Effect on Yield Attributes

Integrated nutrient management significantly influenced yield attributes of barley (**Table 2**). Treatment T7 recorded the highest number of effective tillers (342.14 m^{-2}), grains $spike^{-1}$ (49.94), spike length (9.54 cm) and test weight (48.44 g). The improvement in yield attributes may be attributed to balanced nutrient availability throughout crop growth stages and improved soil biological activity. The combined use of vermicompost and biofertilizers enhanced nutrient uptake efficiency and supported better reproductive growth. Increased availability of nitrogen and micronutrients likely improved spike development and grain filling. Similar results were reported by [4] and [5].

Lower yield attributes under control treatment were mainly due to nutrient deficiency, reduced photosynthetic activity and poor assimilate translocation.

Table 2 Effect of nutrient management on yield attributes and yields of barley

Treatments	Yield attributes				Yield (kg/ha)			
	Number of effective tillers m^{-2}	Number of grains $spike^{-1}$	Spike length (cm)	Test weight (g)	Grain	Straw	Biological	Harvest index (%)
T_1- Absolute control	223.14	36.34	7.24	38.74	2448.45	4145.36	6593.81	38.25
T_2 – 100% RDF	302.14	44.64	8.54	44.04	3740.21	5827.84	9568.04	40.31
T_3 – 75% RDF + FYM-N (25%)	312.14	45.84	8.74	44.64	3861.86	5950.52	9812.37	40.52
T_4 – 75% RDF + VC-N (25%)	318.14	46.44	8.94	45.24	3936.08	6021.65	9957.73	40.72
T_5 – 50% RDF + FYM-N (25%) + Biofertilizers	328.14	48.04	9.14	46.44	4087.63	6137.11	10224.74	41.24
T_6 – 50% RDF + VC-N (25%) + Biofertilizers	333.14	48.74	9.34	47.24	4168.04	6221.65	10389.69	41.34
T_7 – 50% RDF + FYM-N (25%) + VC-N (25%) + Biofertilizers	342.14	49.94	9.54	48.44	4301.03	6318.56	10619.59	41.75
T_8 – 100% FYM-N + Biofertilizers	296.14	43.74	8.34	43.24	3620.62	5672.16	9292.78	40.10
T_9 – 100% VC-N + Biofertilizers	299.14	44.34	8.44	43.74	3690.72	5740.21	9430.93	40.31
SEm±	5.9	1.1	0.2	0.8	82	116	139	0.7
CD (P = 0.05)	17.6	3.3	0.6	2.4	145.87	347.67	416.72	2.09

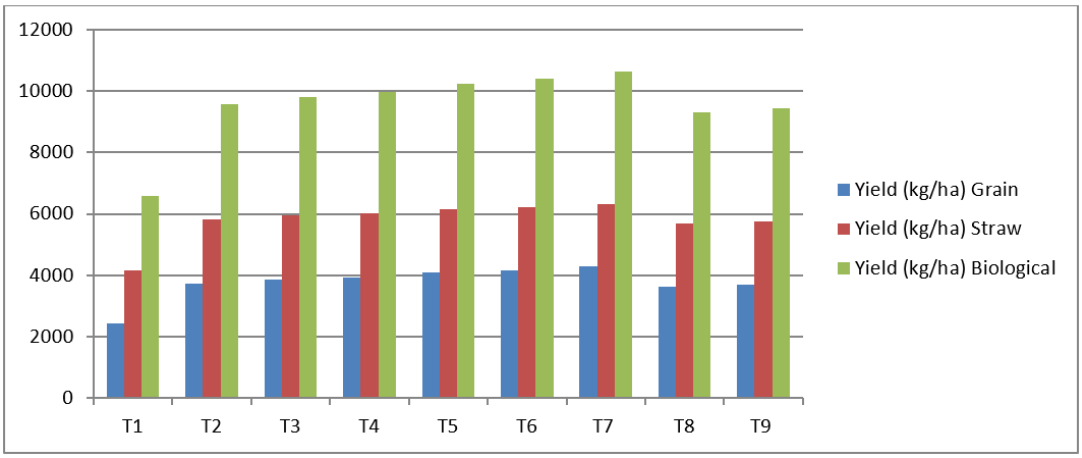

Figure 1 Effect of nutrient management on yields and harvest index of barley

Effect on Grain and Straw Yield

Grain and straw yields were significantly affected by nutrient management treatments. The maximum grain yield (4301.03 kg ha^{-1}), straw yield (6318.56 kg ha^{-1}) and biological yield (10619.59 kg ha^{-1}) were recorded under T7, which was significantly superior to the control and other treatments. The substantial increase in grain yield under integrated nutrient management may be attributed to improved vegetative growth, enhanced yield attributes and greater dry matter accumulation. Combined application of inorganic fertilizers, vermicompost and biofertilizers ensured continuous nutrient supply and improved nutrient use efficiency, ultimately resulting in higher productivity. Harvest index was also highest under T7 (41.75%), indicating efficient partitioning of assimilates towards economic yield. The lowest grain yield (2448.45 kg ha^{-1}) was recorded under absolute control. Similar findings have been documented by [6] and [3].

Effect on Economics

Economic analysis revealed substantial variation among treatments (**Table 3**). Treatment T7 produced the highest gross returns (Rs. 115,347 ha^{-1}) and net returns (Rs. 74,847 ha^{-1}). However, the highest B: C ratio (3.00) was recorded under T2 (100% RDF), mainly because of lower cultivation cost compared to integrated nutrient management treatments.

Higher profitability under T7 was mainly associated with increased grain and straw yields. The integrated use of vermicompost and biofertilizers improved crop productivity sufficiently to compensate for the additional cost incurred on organic inputs. Similar results were reported by [1] and [2].

Table 3 Effect of nutrient management on economics of barley

Treatments	**Economics**			
	Total cost of Cultivation (₹ ha^{-1})	**Gross returns (₹ ha^{-1})**	**Net returns (₹ ha^{-1})**	**B: C ratio**
T_1- Absolute control	26,000	62,173	36,173	2.39
T_2 – 100% RDF	34,500	103,466	68,966	3.00
T_3 – 75% RDF + FYM-N (25%)	36,000	106,188	70,188	2.95
T_4 – 75% RDF + VC-N (25%)	37,500	107,925	70,425	2.88
T_5 – 50% RDF + FYM-N (25%) + Biofertilizers	38,000	110,684	72,684	2.91
T_6 – 50% RDF + VC-N (25%) + Biofertilizers	39,000	112,880	73,880	2.89
T_7 – 50% RDF + FYM-N (25%) + VC-N (25%) + Biofertilizers	40,500	115,347	74,847	2.85
T_8 – 100% FYM-N + Biofertilizers	36,500	99,428	62,928	2.72
T_9 – 100% VC-N + Biofertilizers	37,000	101,058	64,058	2.73
SEm±	—	1,852	1,460	—
CD (P = 0.05)	—	5,412	4,270	—

Conclusion

The present investigation clearly demonstrated that integrated nutrient management significantly improved growth, yield attributes, yield and economics of barley. Among the treatments, T7 (50% RDF + FYM-N (25%) + VC-N (25%) + Biofertilizers) proved most effective in enhancing plant height, dry matter accumulation, yield attributes and grain yield. The treatment also recorded the highest net returns, indicating its suitability for sustainable barley production under semi-arid conditions. Therefore, integrated application of inorganic fertilizers, vermicompost and biofertilizers may be recommended for improving productivity and maintaining soil health in barley cultivation.

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