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Utsav Gour
M.Sc. (Ag.) Soil Science
Department of Natural Resource Management, M.G.C.G.V.V. Chitrakoot Satna, Madhya Pradesh, India

Uma Shanker Mishra
Head Department of Natural Resource Management, M.G.C.G.V.V. Chitrakoot Satna, Madhya Pradesh, India

Pawan Sirothia
Associate Professor Department of Natural Resource Management, M.G.C.G.V.V. Chitrakoot Satna, Madhya Pradesh, India

Corresponding Author:
Utsav Gour
M.Sc. (Ag.) Soil Science
Department of Natural Resource Management, M.G.C.G.V.V. Chitrakoot Satna, Madhya Pradesh, India

Effect of different level of fertilizer and various organic manure on growth and yield of barley (*Hordeum vulgare* L.)

Utsav Gour, Uma Shanker Mishra and Pawan Sirothia

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Abstract
The present study was conducted to evaluate the effect of different levels of inorganic fertilizers and various organic manures on the growth and yield of barley. The experiment was carried out at the Rajaula Agriculture farm, Madhya Pradesh, using a factorial randomized block design with eight treatments and three replications. The treatments included combinations of recommended dose fertilizers (RDF), FYM, vermicompost, and poultry manure. Growth parameters like plant height, number of tillers, and yield attributes such as number of spikes, spike length, grains per spike, and test weight were recorded. The results indicated that the treatment combination of 50% RDF with 50% poultry manure (T_8) produced the highest plant height (92.35 cm at 90 DAS), the maximum number of tillers (52.47 at 30 DAS), and the highest grain yield (40.19 q ha^{-1}). Treatment T_8 also recorded the maximum spike length (8.19 cm), grains per spike (41.6), and test weight (45.37 g). The combined use of organic manures and inorganic fertilizers significantly enhanced the physical and chemical properties of the soil, promoting better growth and higher yield compared to the control and sole RDF treatments. Thus, the integrated use of organic and inorganic fertilizers is recommended for sustainable barley production.

Keywords: Barley, yield, tillers, FYM, vermicompost, poultry manure

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 has immense potential as quality cereal especially for nutritional and medicinal point of view; hence, it is used in Ayurvedic medicines. Barley is also used to cure fever, common cold, asthma, skin diseases, sore throat, urinary disorders and digestive system. In developed countries barley is considered as a functional food and used in many bakery products and recipes. In western countries, porridges and soups are prepared from dehusked barley grains. It is preferably used in breweries. However, vinegar, cider and sugar syrups are other modes of utilizing barley.
The production volume of barley across India during financial year 2023 was about 1.91 million metric tons, an increase from about 1.37 million metric tons in the previous year. The production volume of barley was estimated to be about 2.22 million tons in fiscal year 2024 (Statista, 2024) [13].
Rajasthan ranks first in barley production (840.52 thousand tonnes), followed by Uttar Pradesh (460 thousand tonnes) and Madhya Pradesh (116 thousand tonnes). These three states altogether accounted for 83 per cent of total national barley production. Madhya Pradesh had the maximum area under barley (2.41 lakh hectares) and contributed a share of 43 per cent to the total area and 54 per cent to the total production. The average crop production and productivity in barley were 39 thousand ton and1.61ton ha^{-1}in Madhya Pradesh in the year 2022-23 (Directorate of Economic and Statistics, 2024) [1].
Nitrogen is the key element in achieving consistently high yields in cereals. Nitrogen is a constituent of many fundamental cell components such as nucleic acids, amino acids, enzymes, and photosynthetic pigments. The rate of uptake and partition of N is largely determined by supply and demand during various stages of plant growth.

Vermicompost, which are stabilized organic materials produced by earthworms and microorganisms, have been reported to improve plant growth and yields in greenhouse crops (Edwards *et al*., 2004) [3].

The combined use of organic fertilizer, and inorganic fertilizer improve the physical properties of soil as well as the soil structure (Katyal, 2020) [8].

Nitrogen (N), phosphorous (P) and potassium (K) are considered as the most important macronutrients for plant growth**.** P influences root growth, allows plants to enhance nutrients utilization, and consequently improves flower production, fertilization and yield. It plays also an important role in photosynthesis, in macromolecules structure such as nucleic acids and energy transfer**.** Plants that receive an adequate amount of P at an early stage will grow more vigorously due to the promotion of root growth, and they will reach maturity more rapidly than plants with an inadequate P supply (Teng *et al.*, 2013) [17]. According to Warraich *et al.* (2022) [19], barley plants will produce more fertile tillers/m^2 and more biological yield in response to P fertilization.

Increasing the quantities of K in the nutrient solution did not limit the uptake and accumulation of sodium but resulted in excessive potassium uptake (Zid, 2017) [23]. Also, potassium is considered a major osmotically active solute of plant cell (Mengel and Arneke, 2015) [11]

However, the use of organic manures, such as FYM, Vermicompost and Poultry manure alone as a substitute to inorganic fertilizers is not sufficient to maintain the present levels of crop productivity of high yielding improved varieties due to their low nutrient content and slow release. Therefore, integrated nutrient management in which both organic and inorganic fertilizers are used simultaneously is the most effective method to maintain a healthy and sustainably productive soil. Waseem *et al.* (2013) [20].

To absorb moisture in poultry houses, bedding materials such as straw, sawdust, or wood chips may be used. The carbonaceous bedding mixed into the manure is subsequently a part of the manure and may affect nutritional transformations application to the field. The influence of bedding during storage may relate to both a modifying effect on the physical conditions as regards to air and water transport in a pile and by causing N immobilization due to the high C:N ratios of the bedding. Mixed increasing amounts of cereal straw into poultry manure and found that crop N uptake depended on the C:N ratio obtained (Zaman *et al*., 2017) [22].

Methods and Materials

Experimental Sites

The experiment was carried out at Rajaula Agriculture farm, Mahatma Gandhi Chitrakoot Gramoday Vishwavidyalaya Chitrakoot, Satna (M.P.) which lies in the semi- arid and sub-tropical region of Madhya Pradesh between 25.148° North latitude and 80.855° East longitude. The altitude of town is about 190-210 meter above mean sea level.

Soil Characteristics

Table 1: Chemical properties of the Experimental Soil

S. No.	Parameters	Results	Method Employed
1	pH (1:2 soil water suspension ratio)	7.31	Glass electrode, pH meter
2.	EC (1:2.5 soil water suspension ratio)	0.34	Conductivity bridge (Jackson, 1973) [7]
3.	Organic Carbon (%)	0.34	Wet Oxidation Method (Walkley and Black's method 1934) [18]
4.	Total Nitrogen (kgha^{-1})	96.5	Kjeldahl Method (Subbaih and Asija, 1956) [16]
5.	Available Phosphorus (kg ha^{-1})	18.34	Colorimetric method (Olsen *et al.* 1954) [12]
6.	Available Potash (kg ha^{-1})	215.94	Flame photometer Ammonium acetate extract (Hanwey and Heidel, 1952) [6]

Crop Husbandry

The field was prepared by ploughing with a tractor drawn disc plough by cross harrowing and planking. After preparation of land, the experiment was laid out as per treatment combinations, there were 24 plots and the gross size of each plot was 5.0 m x 3.0 m and the net plot size was 4.0 m x 2.5 m. FYM @ 12 t ha^{-1}and vermicompost @ 4 t ha^{-1} were applied as basal dose as per treatment. After the layout of experimental plot, the fertilizers were weighed and applied in the plots and thoroughly mixed with soil. As per the experimental recommended doses of Nitrogen, Phosphorus and Potassium were applied to all the plots. Recommended dose of Nitrogen, Phosphorus and Potassium were applied through Urea, DAP and MOP (80:40:40 kg ha^{-1}). The seed sowing was done on 10th Nov. 2023. The seed was sown in line after making a narrow furrow with the help of pointed wooden stick at different row spacing. The pre-sowing irrigation was given to entire experimental field. Apart for pre sowing irrigation, two irrigation were given. The Barley crop was harvested when grains were fully matured and straw turned yellow. The borderlines and plants were removed first to eliminate border effect. The crop from net plot was cut close to the ground and kept in respective plots for sun drying. Threshing was done plot wise. Barley grain and straw yield was recorded by weighing as per the treatment.

Detail of treatments and design

The 8 treatments combination of nutrient management practices. Experiment was laid out in Factorial Randomized Block Design with three replications.

Table 2: Treatment combination

Symbol	Details of Treatment
T_1	Control
T_2	100% R.D.F.
T_3	75% RDF + 25% N by FYM
T_4	75% RDF + 25% N by Vermicompost
T_5	75% RDF + 25% N by Poultry Manure
T_6	50% RDF + 50% N by FYM
T_7	50% RDF + 50% N by Vermicompost
T_8	50% RDF + 50% N by Poultry Manure

Statistical analysis: The growth parameters and yields were recorded and analyzed as per Gomez and Gomez (1984) [4] the tested at 5% level of significance to interpret the significant differences.

Results and Discussion

Growth parameters

The data of plant height was recorded at after 30, 60 and 90 days after sowing of the crop. The results revealed that the plant

height of barley varied in between 27.30 to 32.47 cm, 39.85 to 51.98 cm and 84.12 to 92.35 cm at 30, 60 and 90 days after sowing of the crop respectively. The treatment combination T_8 [50% RDF + 50% N by Poultry Manure] observed the maximum plant height (32.47 cm at 30 days, 51.98 cm at 60 days and 92.35 cm at 90 days) followed by the treatment T_7 [50% RDF + 50% N by Vermicompost]. Similar findings were reported by Singh *et al*. (2018) [15] and Prasad *et al.*, (2019) [4].

The data of number of tillers branches was recorded at after 30 days after sowing of the crop. The results revealed that the number of tillers of barley varied in between 41.56 to 52.47 and 73.42 to 85.64 at 30 and 60 days respectively. The treatment combination T_8 [50% RDF + 50% N by Poultry Manure] recorded the maximum number of tillers (52.47 at 30 days and 85.64 at 60 days) followed by the treatment T_7 [50% RDF + 50% N by Vermicompost] with the value 51.26 and 84.29 respectively. Similar findings were reported by Chala *et al.*, (2020) [2] and Kumari *et al.*, (2024) [10].

Table 3: Effect of different treatment combination on growth parameters

Treatment	Plant height (cm)			No. of tillers	
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS
T_1	27.30	39.85	84.12	41.56	73.42
T_2	28.01	41.87	86.36	41.96	74.63
T_3	28.16	42.29	87.58	43.72	76.98
T_4	29.17	44.23	88.46	47.58	80.40
T_5	29.85	46.51	89.17	48.63	81.75
T_6	30.12	47.76	90.38	49.31	82.34
T_7	31.56	49.58	91.74	51.26	84.29
T_8	32.47	51.98	92.35	52.47	85.64
SEm ±	0.23	0.43	0.56	0.03	0.07
C.D. (P=0.05)	NS	1.33	1.70	NS	0.22

Yield attributes and yield

The results revealed that the no. of spike m^{-2} of barley varied in between 64.25 to 72.69 and all the treatments were significantly superior to T_1 [Control]. The treatment combination T_8 [50% RDF + 50% N by Poultry Manure] gave the maximum no. of spike m^{-2} (72.69) followed by the treatment T_7 [50% RDF + 50% N by Vermicompost] with the value 71.35. Spike length of barley varied in between 6.59 to 8.19 cm and all the treatments were significantly superior to T_1 [Control]. The treatment combination T_8 [50% RDF + 50% N by Poultry Manure] gave the maximum spike length (8.19 cm) followed by the treatment T_7 [50% RDF + 50% N by Vermicompost] with the value 8.02 cm. No. of grain $spike^{-1}$ of barley varied in between 32.2 to 41.6 and all the treatments were significantly superior to T_1 [Control]. The treatment combination T_8 [50% RDF + 50% N by Poultry Manure] gave the maximum no. of grain $spike^{-1}$ (41.6) followed by the treatment T_7 [50% RDF + 50% N by Vermicompost] with the value 40.5. The test weight (g) of barley varied in between 41.44 to 45.37 g. The treatment combination T_8 [50% RDF + 50% N by Poultry Manure] gave the maximum test weight (45.37 g) followed by the treatment T_7 [50% RDF + 50% N by Vermicompost] with the value 44.91 g. Similar findings were reported by Yadav *et al.*, (2016) [21] and Kumar *et al.* (2017) [9].

The results revealed that the grain yield (q ha^{-1}) of barley varied in between 28.53 to 40.19 q ha^{-1}. The treatment combination T_8 [50% RDF + 50% N by Poultry Manure] gave the maximum grain yield (40.19 q ha^{-1}) followed by the treatment T_7 [50% RDF + 50% N by Vermicompost] with the value 39.42q ha^{-1}. Similar findings were reported by Hameso *et al.*, (2022) [5]

Table 4: Effect of different treatment combination on yield attributes and yield

Treatment	No. of spike (m^{-2})	Spike length (cm)	No. of grain $spike^{-1}$	Test weight (g)	Grain yield (q ha^{-1})
T_1	64.25	6.59	32.2	41.44	28.53
T_2	65.36	6.98	34.5	42.91	32.45
T_3	66.97	7.61	35.8	43.11	33.12
T_4	68.92	7.72	37.2	43.46	33.45
T_5	69.71	7.89	38.5	43.89	34.58
T_6	70.13	7.91	39.7	44.25	38.16
T_7	71.35	8.02	40.5	44.91	39.42
T_8	72.69	8.19	41.6	45.37	40.19
SEm ±	2.00	0.24	0.22	0.34	0.08
C.D. (P=0.05)	6.07	0.73	0.67	NS	0.25

Conclusion

The study demonstrated that integrating organic manures with inorganic fertilizers significantly improved the growth and yield of barley. Among the treatments, the combination of 50% RDF and 50% poultry manure (T_8) consistently showed the best results in terms of plant height, number of tillers, spike length, grains per spike, test weight, and overall grain yield. The use of poultry manure and vermicompost, along with reduced RDF, enhanced soil fertility by improving its physical properties and nutrient availability, resulting in better crop performance.

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