International Journal of Environment and Climate Change

Volume 13, Issue 10, Page 2968-2976, 2023; Article no.IJECC.105569
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Effect of Integrated Nutrient Management on Growth and Yield of Barley (*Hordeum vulgare* L.)

Anchal Karol [a*], P. K. Sharma [b], Akarsha Raj [a], Kehokhunu [c], Anjali Rawat [d] and Ashline Shaji [e]

[a] Maharana Pratap University of Agriculture and Technology, Udaipur- 313001, Rajasthan, India.
[b] Vivekananda Global University, Jaipur- 303012, Rajasthan, India.
[c] School of Agricultural Sciences and Rural Development, Medziphema- 797106, Nagaland, India.
[d] Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidalaya, Palampur- 176062, Himachal Pradesh, India.
[e] Kerala Agricultural University, Vellanikkara, Thrissur- 680656, Kerala, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2023/v13i102963

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/105569

Original Research Article

Received: 26/06/2023
Accepted: 02/09/2023
Published: 12/09/2023

ABSTRACT

During the Rabi season of 2018-19, a field experiment was undertaken at Vivekananda Global University's Research Farm in Jaipur to investigate the "Effect of Integrated Nutrient Management on Growth and Yield of Barley (Hordeum vulgare L.)." The experiment followed a randomized block design with three replications. The treatments consisting of nine treatment combinations viz., 100% RDF (T1), 100% RDF + vermicompost 2.5 t ha-1 (T2), 100% RDF + vermicompost 2.5 t ha-1 + Azotobacter (T3), 75% RDF (T4), 75% RDF + vermicompost 2.5 t ha-1 (T5), 75% RDF + vermicompost 2.5 t ha-1 + Azotobacter (T6), 50% RDF (T7), 50% RDF + vermicompost 2.5 t ha-1 (T8) and 50% RDF + vermicompost 2.5 t ha-1 + Azotobacter (T9) were applied to the barley var.

**Corresponding author: E-mail: anchalk863@gmail.com;*

RD-2035. The experimental results demonstrated that several integrated nutrient treatments greatly boosted barley growth, yield characteristics and yield, quality, and economics. With the application of 100% RDF + vermicompost 2.5 t ha-1 + Azotobacter (T3), the maximum plant height at 60 DAS and 90 DAS, total number of tillers at 60 DAS and 90 DAS, effective number of tillers, ear length, number of grains ear-1, grain yield, straw yield, biological yield, and nitrogen content in grain and straw of barley were obtained. However, the application of 100% RDF yielded the significantly largest net returns and B: C ratio of barley (T1).

Keywords: Biofertilizers; integrated nutrient management; nitrogen; vermicompost.

1. INTRODUCTION

Barley, the world's fourth most significant cereal crop, is grown in alkaline soils and in frost or drought-prone areas. It is utilized in the brewing industry to produce malt, and its straw is used as cattle feed. In comparison to wheat, barley grains and straw have 12.5% moisture, 11.5% albuminoids, 74.0% carbohydrate, 1.3% fat, 3.9% crude fiber, and 1.5% ash. Barley is grown in China, Russia, Germany, the United States, Canada, India, Turkey, and Australia. Barley is farmed in the Indian states of Rajasthan, Uttar Pradesh, Madhya Pradesh, Haryana, Punjab, West Bengal, and Bihar. Lower production in dry and semiarid locations, on the other hand, is caused by climate variability, poor irrigation water quality, insufficient fertilization, poor soil physical conditions, nutrient imbalances, and soil permeability. Nitrogen is a universally lacking plant nutrient in most Indian soils, whereas phosphorus is a necessary component of nucleic acid, ADP, and ATP. Nitrogen is a necessary component of many substances, including nucleotides, phospholipids, enzymes, hormones, and vitamins. It has a significant impact on the consumption of carbohydrates, potassium, and other components. Nitrogen, being an essential component of protein nucleic acid and chlorophyll, is important in photosynthesis and chlorophyll synthesis [1]. Nitrogen's reaction is widespread throughout the world.

The availability and type of phosphorus in the soil are determined by native and/or added phosphate fertilizer sources, as well as organic matter content from external sources. Currently, 49.3% of Indian soils are classified as poor, 48.8% as medium, and 1.9% as high in terms of phosphorus. In Indian agriculture, phosphorus is obtained via fertilizers, organic manures, and, to a lesser extent, crop wastes. It is a necessary component of nucleic acid, ADP, and ATP. It promotes root development and growth, as well as accelerates maturation and increases crop yield quality. The availability and type of phosphorus in the soil are determined by the native and/or additional phosphate fertilizer sources, as well as the organic matter content from external sources.

Overuse of chemical fertilizers degrades soil biological power, which must be avoided because soil microflora negotiate all nutrient transformations. Organic matter is a source of energy for soil microflora and organic carbon content, and it is regarded as an indicator of soil health. Organic components are an intrinsic and necessary component of all soils, transforming the soil into a living dynamic system. Organic matter acts as a reservoir for nutrients necessary for plant growth. It decomposes to produce organic acids and CO_2, which help to dissolve minerals and make them more available to growing plants. Organic manures are possible micronutrient sources, improve soil structure by providing binding action to soil aggregates, and boost soil water retention and buffering ability. It also improves nitrogen utilization by chelating the chemical fertilizer. Organic supplementation is more than just a source of nutrients. Vermicompost is now being promoted as a good manure for use in field-based integrated nutrient management strategies [2]. Earthworm processed organic west, also known as vermicompost, is a final divided peat-like material with great porosity, aeration, drainability, and water holding capacity. Vermicomposting is high in macro and micronutrients, vitamins, enzymes, antibiotics, and growth hormones. Apart from providing a balanced nutrient supply, it enhances fertilizer and water use efficiency even more than FYM [3].

Bio-fertilizers supplement chemical fertilizers by meeting integrated nutrient demands through biological nitrogen fixation (BNF), nutrient solubilization, and plant residue decomposition. Bio-fertilizers promote mineral and water intake, root development, and vegetative growth., and nitrogen fixation. Azotobacter, a non-leguminous agricultural free-living bacteria, enhances seed germination and early plant vigour by generating growth-promoting chemicals. To close the gap between nitrogen fertilizer output and use, a focus on mixing chemical fertilizers with renewable, less expensive sources such as biofertilizers and organics is required. An integrated approach has the potential to boost crop productivity and stability. A well-balanced mix of organic and inorganic fertilizers can ensure long-term fertility and crop productivity. Nutrient management approaches that are standardized are critical.

2. MATERIALS AND METHODS

The experiment was carried out at Vivekananda Global University's Research Farm in Jaipur during Rabi 2018-19. The research area is located at 075o 88'99" E longitude and 26o 81'17" N latitude, and it is part of Rajasthan's agro-climatic zone III A (Semi-arid Eastern Plain Zone). This zone's climate is typically semi-arid, characterized by aridity of the atmosphere and extreme temperature extremes in both summer (45.5C) and winter (4C), with annual rainfall of 500-700 mm. The soil at the experiment site was loamy sand with a pH of 8.2. The experimental site's available nitrogen, phosphorus, and potassium were 139.66, 14.43, and 241.12 kg/ha, respectively. The experiment followed a randomized block design with three replications. The treatments consisting of nine treatment combinations viz., 100% RDF (T1), 100% RDF + vermicompost 2.5 t ha^{-1} (T2), 100% RDF + vermicompost 2.5 t ha^{-1}+ Azotobacter (T3), 75% RDF (T4), 75% RDF + vermicompost 2.5 t ha^{-1} (T5), 75% RDF + vermicompost 2.5 t ha^{-1} + Azotobacter (T6), 50% RDF (T7), 50% RDF + vermicompost 2.5 t ha^{-1} (T8) and 50% RDF + vermicompost 2.5 t ha^{-1} + Azotobacter (T9) were applied to the barley var. RD-2035. On November 10, 2018, the crop was sowed at a seed rate of 100 kg/ha. Prior to sowing, a full dose of phosphorus and half dose of nitrogen were applied as a basal dose via urea and DAP. At 25 and 40 DAS, the remaining half dose of nitrogen was top dressed with urea in two equal splits. The nitrogen in DAP was corrected with urea. Potassium was administered through MOP in accordance with the protocols. Vermicompost (1.67% N, 1.20% P, and 0.89% K) was applied in the field according to treatments and properly mixed before sowing. Inoculation of biofertilizer: 30 g of jaggery was cooked in half a liter of water and then cooled; 50 g of culture was mixed in the jaggery solution. The needed amount of seed was thoroughly mixed with the culture paste to inoculate them with Azotobacter, and the seeds were then left to dry in the shade. Four irrigations were applied using the sprinkler irrigation method as needed for the crop, and the crop was harvested on March 25, 2019. The harvested produce from each plot was weighed after drying to determine the biological yield plot-1. Threshing was originally done by beating with wooden sticks and winnowing. Deducting the weight of seed yield from total biological yield yielded the straw yield. All of the data in plot-1 were then converted to kg ha-1. Plant height was measured from the base of the plant to the top of the main branch of five randomly selected plants in each plot on a metre scale. The number of ear bearing tillers in each plot was counted by placing a metre scale along the crop row at three randomly selected sites, and the average was used to calculate the number of effective tillers per plant. Five ears were selected at random from each plot and measured on a metre scale, with the mean recorded and displayed in cm. Five ears were threshed from each plot, the grains were counted, and the average number of grains ear-1 was calculated. The N concentration in grains and straw of wheat was measured with three replications depending on the crop stage, following the kjeldahl procedure. To determine the most profitable treatment, the economics of various treatments were calculated in terms of net returns (ha-1) using current market rates, so that the most profitable therapy could be recommended. The benefit:cost ratio for each treatment was computed using the following formula to determine its economic viability:

$$\text{B:C ratio} = \frac{\text{Gross returns (₹}ha^{-1})}{\text{Cost of cultivation (₹}ha^{-1})}$$

2.1 Data Analysis

Various observations were statistically analysed with the help of Fisher's analysis of variance technique [4]. The critical difference (CD) for the treatment comparisons were worked out wherever the variance ratio (F test) was found significant at 5% level of significance

3. RESULT AND DISCUSSION

Plant height, Total number of tillers plant^{-1}, Effective number of tillers plant^{-1}, Ear length (cm):

Several integrated nutrition management treatments significantly increased barley plant height at 60 and 90 DAS. The application of 100% RDF + vermicompost @ 2.5 t ha-1+

Azotobacter (T3) produced the highest plant height and outperformed 75% RDF (T4), 50% RDF (T7), 50% RDF + vermicompost @ 2.5 t ha-1 (T8), and 50% RDF + vermicompost @ 2.5 t ha-1+ Azotobacter (T9) at 60 and 90 DAS. The application of 100% RDF + vermicompost @ 2.5 t ha-1+ Azotobacter (T3) resulted in a significant increase in barley plant height of 19.82, 54.98, 24.88, and 21.42% at 60 DAS and 18.91, 50.14, 21.18, and 19.78% at 90 DAS over T4, T7, T8, and T9, respectively, over T4, T7, T8, and T9 The experimental results demonstrated that the total number of tillers plant-1 differed significantly between integrated nutrition treatments at 60 and 90 DAS of barley. T3 (100% RDF + vermicompost 2.5 t ha-1 + Azotobacter) had the largest total number of tillers plant-1 at 60 and 90 DAS of barley, followed by T1, T2, T5, and T6, but found superior to T4, T7, T8, and T9.

The effective number of tillers plant-1 at harvest of barley rose considerably when different integrated nutrition treatments were used. Significantly highest effective number of tillers plant^{-1} at harvest of barley was recorded with the application of 100% RDF + vermicompost 2.5 t ha^{-1} + Azotobacter (T3) which was closely followed by T1, T2, T5, and T6 but found superior to T4, T7, T8 and T9. The application of 100% RDF + vermicompost 2.5 t ha-1+ Azotobacter (T3) resulted in a considerable increase in the maximum effective number of tillers plant-1, which were 20.16, 51.96, 22.33, and 21.44% higher than treatments T4, T7, T8, and T9, respectively, while the remaining treatments were on par with treatment T3.

The data show that the ear length of barley was considerably impacted by the application of different integrated nutrient treatments. The treatment significantly increased the ear length of barley. 100% RDF + vermicompost 2.5 t ha-1 + Azotobacter (T3) outperformed 75% RDF (T4), 50% RDF (T7), 50% RDF + vermicompost @ 2.5 t ha-1 (T8), and 50% RDF + vermicompost @ 2.5 t ha-1 (T9). The use of 100% RDF + vermicompost 2.5 t ha-1 + Azotobacter (T3) significantly enhanced ear length, with increases of 17.10, 19.82, 18.82, and 18.12% over treatments T4, T7, T8, and T9.

Nitrogen stimulates photosynthetic rate and hence increases glucose supply to plant, which may have resulted in higher dry matter production in barley plant. Similarly, increasing availability of phosphorus has long been regarded as an essential ingredient of all living organisms, playing a key role in energy conservation and transfer in metabolic activities of living cells, including biological energy transformations. Phosphorus is the second most important nutrient for plant growth and development, and it plays a significant role in energy conservation and transfer in living cell metabolic activities, including biological energy transformation. It is the primary component of the co-enzyme of ATP and ADP, which serves as the plant's energy currency. Thus, phosphorus administration influences photosynthesis, protein, phospholipid, and nucleic acid formation, membrane transport, and 39 cytoplasmic streaming. Increased phosphorus availability due to its application in low phosphorus soils may have improved phosphate availability, resulting in more uptakes and, as a result, increased all plant development qualities. It is well known that exchangeable potassium aids in protein synthesis, chlorophyll creation, and stress resistance, which may have benefited plant growth and development. The increased plant height and number of tillers caused by the use of vermicompost could be attributed to increased photo synthetically active leaf area for a longer period of time during the vegetative and reproductive phases More radiant energy absorption and use resulted in increased dry matter accumulation and a considerable rise in plant height. It is well known that organic manures improve the physical, chemical, and biological properties of soil and provide almost all of the essential plant nutrients for growth and development of plants, as well as growth hormones and beneficial microbes [5], which may have resulted in increased plant height, new shoots, and increased dry matter accumulation. Organic matter works as a chelate for nutrients, and soluble chelates likely boost their availability and uptake by plants, as well as their mobility in soils Thus, higher crop development metrics may be due to increased availability of macro and micro nutrients. Furthermore, biofertilizers had a positive effect on growth qualities due to certain growth stimulating chemicals released by microbial inoculants, which enhanced nutrient availability. The addition of biofertilizers in addition to N and P fertilization is beneficial in boosting growth properties at all levels of plant growth. The beneficial effect of bacterial inoculation could be linked to an increase in N supply in inoculated plots due to these bacteria's N-fixation capabilities. Aside from nitrogen fixation, seed inoculation with Azotobacter benefits host plant drought tolerance and disease resistance. The faster availability of nutrients from an adequate supply of inorganic fertilizers with organic manure and biofertilizers throughout the cropping period increases the crop's nutrient requirement and production of a greater number of photo-synthetically 40 active leaves, which may have resulted in higher carbohydrate and phytohormone production, resulting in increased dry matter accumulation and number of tillers. The results of the present investigation are in close conformity with those of Choudhary [6], Kumawat [7] Dhiman and Dubey [8], Limanpure *et al*. [9], Singh [10], Jat *et al*. [11] and Singh *et al*. [12] in barley crop.

Table 1. Effect of integrated nutrient management on plant height of barley

Treatments	Plant height (cm)			Total number of tillers m^{-1} row length		Ear length (cm)
	At 30 DAS	At 60 DAS	At 90 DAS	At 60 DAS	At 90 DAS	
100% RDF	21.28	70.86	126.10	94.25	95.41	9.78
100% RDF + VC 2.5 t ha^{-1}	21.76	71.42	127.30	95.13	96.46	9.91
100% RDF + VC 2.5 t ha^{-1} + *Azotobacter*	21.98	71.59	128.11	95.40	96.97	9.95
75% RDF	20.81	59.75	107.74	79.62	81.21	8.50
75% RDF + VC 2.5 t ha^{-1}	21.07	70.47	125.52	93.74	94.67	9.74
75% RDF + VC 2.5 t ha^{-1} + *Azotobacter*	21.50	71.20	126.80	94.70	96.02	9.86
50% RDF	20.17	46.19	85.33	63.91	65.28	8.31
50% RDF + VC 2.5 t ha^{-1}	20.30	57.32	105.72	78.37	79.73	8.38
50% RDF + VC 2.5 t ha^{-1} + *Azotobacter*	20.66	58.96	106.95	78.84	80.48	8.43
SEm±	1.10	3.02	5.25	4.05	4.20	0.38
CD (P = 0.05)	NS	9.05	15.73	12.16	12.58	1.13
CV	9.02	8.14	7.87	8.17	8.32	7.12

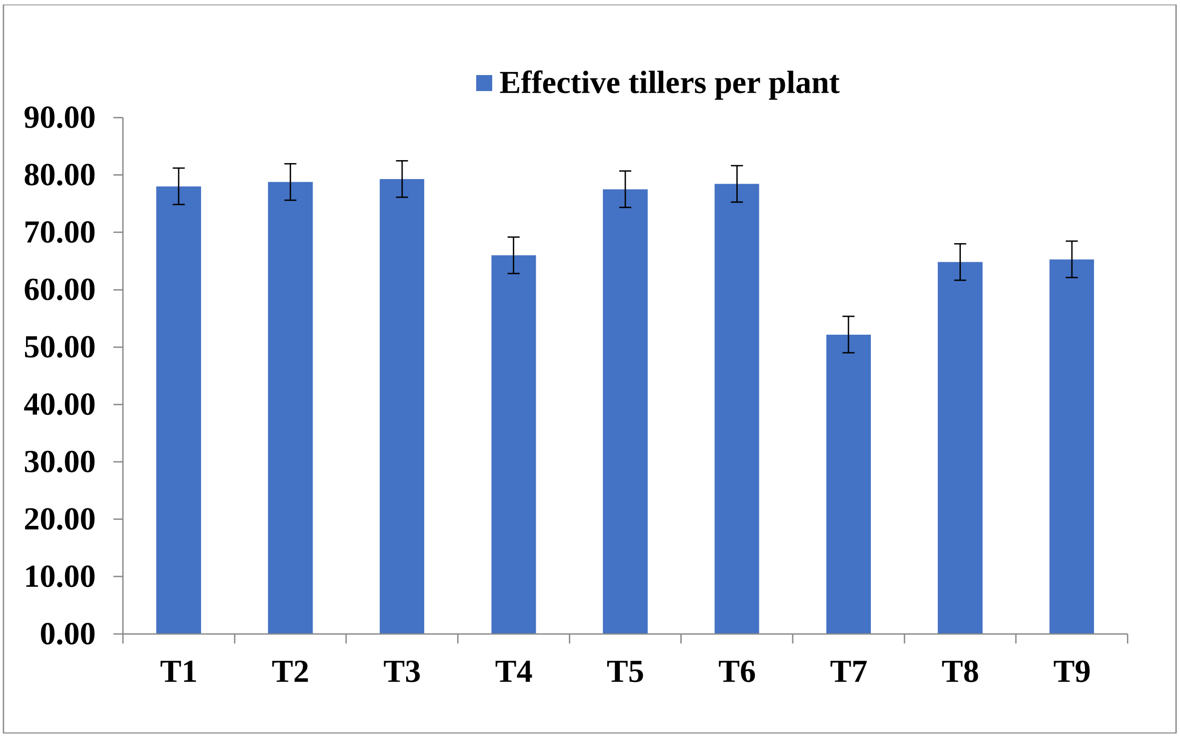

Fig. 1. Effect of integrated nutrient management on effective tillers of barley

Grain yield, Straw yield, Biological yield:

Data (Table 2) show that different integrated nutrition treatments considerably influenced barley grain production. The application of 100% RDF + vermicompost 2.5 t ha-1 + Azotobacter (T3) produced the highest grain yield (4073 kg ha-1) of barley, followed by 100% RDF (T1), 100% RDF + vermicompost @ 2.5 t ha-1 (T2), 75% RDF + vermicompost @ 2.5 t ha-1 (T5), and 75% RDF + vermicompost @ 2.5 t ha-1 + Azotobacter(T9). The grain yield increase due to the application of 100% RDF + vermicompost 2.5 t ha-1 + Azotobacter (T3) was in the range of 17.39, 40.07, 20.77, and 18.93%, respectively, over treatments T4, T7, T8, and T9.

A comprehensive examination of the data in Table 2 demonstrated that various integrated nutrition treatments greatly boosted barley straw production. The highest straw yield (5727 kg ha-1) was obtained by combining 100% RDF + vermicompost 2.5 t ha-1 + Azotobacter (T3) with 100% RDF (T1), 100% RDF + vermicompost @ 2.5 t ha-1 (T2), 75% RDF + vermicompost @ 2.5 t ha-1 (T5), and 75% RDF + vermicompost @ 2.5 t ha-1 + Azotobacter (T6). However, 75% RDF (T4), 50% RDF (T7), 50% RDF + vermicompost @ 2.5 t ha-1 (T8), and 50% RDF + vermicompost @ 2.5 t ha-1 + Azotobacter (T9) were found to be significantly higher. The percentage increase in straw production due to the use of 100% RDF + vermicompost 2.5 t ha-1 + Azotobacter (T3) was in the range of 18.10, 42.11, 20.53, and 19.48%, respectively, when compared to treatments T4, T7, T8, and T9.

The experimental results (Table 2) show that using different integrated nutrient management treatments increased barley biological yield considerably. The application of 100% RDF + vermicompost 2.5 t ha-1 + Azotobacter (T3) gave significantly highest biological yield of barley (9800 kg ha-1) over 75% RDF (T4), 50% RDF (T7), 50% RDF + vermicompost @ 2.5 t ha-1 (T8) and 50% RDF + vermicompost @ 2.5 t ha-1 + Azotobacter (T9) but remained at par with application of 100% RDF (T1), 100% RDF + vermicompost @ 2.5 t ha-1 (T2), 75% RDF + vermicompost @ 2.5 t ha-1 (T5), and 75% RDF + vermicompost @ 2.5 t ha-1 + Azotobacter (T6). The increase in biological yield of barley caused by the use of 100% RDF + vermicompost 2.5 t ha-1 + Azotobacter (T3). 17.80, 41.26, 20.63 and 19.25% as compared to T_4, T_7, T_8 and T_9, respectively.

The beneficial response of inorganic nutrient sources with organic manure and biofertilizers on yield attributes and yield of barley could be attributed to the availability of adequate amounts of plant nutrients throughout the crop's growth period, resulting in better nutrient uptake, plant vigour, and improved yield. The beneficial effect of chemical fertilizer application in conjunction with vermicompost and biofertilizer on yield attributing characteristics of barley appears to be owing to a cumulative influence on plant development and vigour. enhanced fertilizer application may have resulted in a large rise in dry matter production due to an enhanced availability of metabolites. Increased fertilizer levels may have provided stability in a larger supply of photosynthates towards the sink (seeds ear^{-1}). Increased plant height, dry matter accumulation, and the number of tillers plant-1 may have offered better sites for pod formation and grain development. As a result, practically all crop output metrics improved significantly as a result of fertilizer treatment. Organic matter is also a source of energy for soil micro-flora, which causes the organic form of nutrients in soil to be converted into accessible form. The increase in yield attributes with the application of vermicompost can be attributed to the direct addition of plant nutrients and growth regulators, as well as an increase in soil microbial population, which has accelerated the process of humification, removal of obnoxious odor, and detoxification of soil pollutants. The increase in grain and straw yields with the application of chemical fertilizers may be due to a better nutritional environment in low nitrogen and phosphorus soil, as evidenced by their uptake in the plant, and the increased supply of N, P, and K and their higher uptake by plants may have stimulated the rate of various physiological processes in the plant, leading to increased growth and yield parameters, resulting in increased grain and straw yield of the plant. Furthermore, biofertilizers (Azotobacter) may have played an essential role in converting inaccessible forms of nutrients into available forms, resulting in improved nutrient uptake and subsequent production increases. The increase in yield caused by Azotobacter inoculation could be attributed to its direct role in nitrogen fixation, synthesis of phytohormone-like compounds, and higher uptake of nutrients such as nitrogen. The increase in production may possibly be attributable to improved soil nutrient uptake, which may have contributed to increased dry matter buildup and the number of tillers plant-1, resulting in increased grain and straw yield of barley. The plant that emerged from biofertilizer inoculated seeds produced considerably more grain than the plant that emerged from biofertilizer uninoculated seeds. The results of the present study are in close conformity with findings of Hariram and Dhaliwal [13], Chavarekar *et al.* [14], Kumawat [7], Singh and Chauhan [15], Dhiman and Dubey [8], Jat *et al.* [11] and Singh *et al.* [12] in barley crop.

Effect on Nitrogen content in grain and straw:

Data on the nitrogen content of barley grain and straw demonstrated that several integrated nutrient management treatments significantly improved the nitrogen content of barley seed and straw. The application of 100% RDF + vermicompost 2.5 t ha-1 + Azotobacter (T3) resulted in the highest nitrogen content in grain and straw, which was comparable to T1, T2, and T6, but superior to T4, T5, T7, T8, and T9. The percentage increase in nitrogen content in grain and straw caused by the use of 100% RDF + vermicompost 2.5 t ha-1 + Azotobacter (T3) was calculated. 15.02, 13.25, 34.29, 17.93 and 16.06% in grain and 15.77, 13.82, 35.21, 19.28 and 17.69% in straw of barley, respectively as compared to T4, T7, T8 and T9.

The nitrogen content of grain and straw, as well as their uptake, were greatly improved as a result of the use of various integrated nutrient management treatments. The use of 100% RDF + vermicompost 2.5 t ha-1+ Azotobacter (T3) greatly increased the nitrogen content of grain and straw. The significant increase in nitrogen content in barley grain and straw in this treatment could be attributed to improved inherent nutrient supplying capacity of nutrients, complexing of nutrients, flushing of available nutrients on autolysis of microbial cells (Shuman and Hargrover 1985), as well as improvements in soil biochemical parameters. When vermicompost is put to soil, complex nitrogenous compounds slowly breakdown and provide consistent nitrogen supply throughout the crop's growth period, which may be ascribed to increased nitrogen availability. The rise in nitrogen content in barley grain and straw with fertilizer treatment might be attributed to an improved nutritional environment in the rhizosphere as well as in the plant system, resulting in higher translocation of N, P, and K in plant parts. Choudhary [6], Kumawat [7], Singh [10], and Jat et al. [11] all reported similar findings in barley.

Effect on economics:

Returns on capital and the BC ratio Table 3 summarizes the statistics on net returns and the B: C ratio of barley. A careful evaluation of the data revealed that all integrated nutrient management treatments had a substantial difference in net returns and barley B: C ratio. The significantly maximum net returns (Rs. 45074 ha-1) was obtained with the application of 100% RDF which were remained at par with application of 100% RDF + vermicompost @ 2.5 t ha-1 (41404 ha-1), 100% RDF + vermicompost 2.5 t ha-1 + Azotobacter (41531 ha-1), 75% RDF + vermicompost @ 2.5 t ha-1 (40338 ha-1), and 75% RDF + vermicompost @ 2.5 t ha-1+ Azotobacter (40913 ha-1). In compared to 75% RDF (T4), 50% RDF (T7), 50% RDF + vermicompost @ 2.5 t ha-1 (T8), and 50% RDF + vermicompost @ 2.5 t ha-1 + Azotobacter (T9),

Table 2. Effect of integrated nutrient management on yield of barley and nitrogen content in grain and straw

Treatments	Yield (kg ha^{-1})			Nitrogen content (%)	
	Grain	Straw	Biological	Grain	Straw
100% of RDF	3951	5632	9583	1.66	0.457
100% RDF + VC 2.5 t ha^{-1}	4035	5692	9727	1.69	0.468
100% RDF + VC 2.5 t ha^{-1} + *AZB*	4073	5727	9800	1.71	0.472
75% of RDF	3470	4849	8319	1.49	0.408
75% RDF + VC 2.5 t ha^{-1}	3926	5565	9491	1.51	0.415
75% RDF + VC 2.5 t ha^{-1} + *AZB*	3986	5666	9652	1.67	0.462
50% of RDF	2908	4030	6938	1.27	0.349
50% RDF + VC 2.5 t ha^{-1}	3373	4751	8124	1.45	0.396
50% RDF + VC 2.5 t ha^{-1} + *AZB*	3425	4793	8218	1.47	0.401
SEm$\pm$	144	217	267	0.04	0.01
CD (P = 0.05)	433	651	801	0.13	0.03
CV	6.79	7.25	5.21	4.86	4.72

NS = Non-significant

Table 3. Effect of integrated nutrient management on economics of various treatments

Treatment	COC (Rs.)	Treatment Cost (Rs.)	Total cost (Rs.)	Gross return (Rs.)	Net return (Rs.)	B:C ratio
T_1	20050	3029	23079	68154	45074	2.95
T_2	20050	8029	28079	69483	41404	2.47
T_3	20050	8529	28579	70110	41531	2.45
T_4	20050	2272	22322	59667	37345	2.67
T_5	20050	7272	27322	67660	40338	2.48
T_6	20050	7772	27822	68735	40913	2.47
T_7	20050	1515	21565	49935	28370	2.32
T_8	20050	6515	26565	58069	31504	2.19
T_9	20050	7015	27065	58907	31842	2.18

***Barley grain = ₹ 14.4 kg^{-1}, straw = ₹ 2.0 kg^{-1}, Urea = ₹13 kg^{-1}, DAP = ₹ 52 kg^{-1}, MOP = ₹ 18 kg^{-1}, Vermicompost = ₹ 2 kg^{-1} and Biofertilizer = ₹ 250 packet^{-1}.*

100% RDF generated increased net yields of 7730, 16704, 13570, and 13232 ha-1, respectively. While the application of 100% RDF yielded the greatest B: C ratio (2.95), it was much greater than all other treatments.

In agriculture today, the practicality of any therapy can only be determined by the benefit:cost ratio. The gross returns from barley crop varied significantly as a result of various treatments, which altered the overall net returns and benefit:cost ratio. The use of 100% RDF (T1) yielded the highest gross, net returns, and B: C ratio of barley. The cost of these therapies was lower than the cost of additional income, resulting in higher returns under these treatments when compared to alternative treatments. Hariram and Dhaliwal [13], Choudhary [6], and Kumawat [7] discovered similar results in barley.

4. CONCLUSION

Based on the study's findings, it was found that several integrated nutrition treatments considerably improved the growth qualities and economics of barley. With the application of 100% RDF + vermicompost 2.5 t ha-1 + Azotobacter (T3), the maximum plant height, total number of tillers, effective number of tillers, ear length, nitrogen content in grain and straw of barley were obtained. However, the application of 100% RDF yielded the significantly largest net returns and B: C ratio of barley (T1).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Kanwar. Soil fertility: Theory and practices. Indian Council Agricultural Research, New Delhi; 1976.
2. Shroff VN, Devasthali S. Earthworm farming-scope and limitations. In: Proceedings of National Seminar on Natural Farming. 1992;126-142.
3. Dayal D, Agarwal SK. Response of sunflower (*Helianthus annus)* to organic manure and fertilizers. Indian Journal of Agronomy. 1998;43:469-473.
4. Fisher RA. Statistical methods for research work. Oliver and Boyd Edinburgh and London. 1950;57-63.
5. Lee KE. Earthworms: their ecology and relationships with soils and land use. Academic Press, Sydney, Australia; 1985.
6. Choudhary S. Integrated use of fertilizers and manures with foliar application of iron in Barley (*Hordeum vulgare* L.), Ph.D. Thesis submitted to the Sri Karan Narendra Agriculture University, Jobner; 2013.
7. Kumawat S. Effect of integrated nutrient management on soil properties and performance of barley (*Hordeum vulgare* L.). Ph.D. Thesis submitted to the Sri Karan Narendra Agriculture University, Jobner; 2015.
8. Dhiman S, Dubey YP. Effect of biofertilizers and inorganic fertilizers on yield attributes, yield and quality of *Triticum aestivum* and *Zea mays* in an acid alfisol. International Journal of Current Microbiology and Applied Sciences. 2017;6(7):2594-2603.
9. Limanpure Y, Umrao R, Bijalwan A, Dobriyal MJR. Effect of different levels of

inorganic fertilizers on the growth and yield of Barley (*Hordeum vulgare)* under teak (*Tectona grandis*) based Agrisilviculture system. New York Science Journal. 2017;10(5):34-38.
10. Singh SB. Effect of integrated nutrient management on barley (*Hordeum vulgare* L.) under north western plain zone of Uttar Pradesh. Annals of Plant and Soil Research. 2017;19(1):110-114.
11. Jat MK, Purohit HS, Choudhary SK, Singh B, Dadarwa RS. Influence of INM on yield and nutrient uptake in sorghum-barley cropping sequence. International Journal of Chemical Studies. 2018;6(3): 634-638.
12. Singh T, Singh NB, Kumar P, Singh S. Effect of different irrigation and fertility levels on dynamic growth and yield of late sown wheat (*Triticum aestivum* L.). International Journal of Chemical Studies. 2018;6(1):1523-1528.
13. Hariram and Dhaliwal SS. Effect of varieties and integrated nutrient management techniques on growth, productivity, quality and economics of barley (Hordeum vulgare L.). International Journal of Agricultural Sciences. 2012;8(1):91-97.
14. Chavarekar S, Thakral SK, Meena RK. Effect of organic and inorganic nitrogen fertilizers on quality of barley (*Hordeum vulgare* L.). Annals of Agriculture Research New series. 2013;34(2):134-137.
15. Singh SB, Chauhan SK. Effect of integrated nutrient management on barley (*Hordeum Vulgare* L.) under semi-arid conditions of Western Uttar Pradesh. Technofame - A Journal of Multidisciplinary Advance Research. 2016;5(1):20-23.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/105569