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Integrated nutrients on growth and yield of barley (*Hordeum vulgare* L.)

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Abstract

A field experiment was conducted during Rabi *season of 2020-21 at Department of Agriculture, Maharishi Markandeshwar University, Sadopur to study the effect of integrated nutrients on the growth and yield of barley (*Hordeum vulgare *L.). The soil was sandy loam in texture with medium available nitrogen, phosphorous and potassium of experimental field. The experiment was laid out in randomized block design replicated thrice with seven different treatments viz. T_1 (Control), T_2 (100% RDF), T_3 (75% RDF + 25% FYM), T_4 (50% RDF + 50% FYM), T_5 (FYM @ 5 t ha^{-1} +* Azotobacter *+ PSB + 25% RDF), T_6 (Vermicompost @ 2.5 t ha^{-1}), T_7 (Vermicompost @ 2.5 t ha^{-1} +* Azotobacter *+ PSB + 25% RDF). The growth parameters viz. plant height of (31.10, 72.10, 92.96 and 100.63 cm) at 30, 60, 90 and at harvest, fresh weight (36.28 g plant^{-1}), dry weight (21.30 g plant^{-1}) at harvest and yield parameters viz. length of spike (8.43 cm), no. of grains spike^{-1} (43.00), 1000 seed weight 44.50 g), grain , straw and biological yield (48.42, 60.12, 108.44 q ha^{-1}) and harvest index (44.65%) were significantly increased in treatment T_7: Vermicompost @ 2.5 t ha^{-1} +* Azotobacter *+ PSB + 25% RDF along with maximum net returns of Rs. 38967.00 ha^{-1} and benefit cost ratio of 2.25.*

Key words: Integrated nutrients, Vermicompost, growth parameters, net returns, benefit cost ratio

Introduction

Barley (*Hordeum vulgare* L.) is a rapidly growing annual cereal crop that can be used as a fodder or as a cover crop to enhance the soil fertility and its quality. It is an important *Rabi* season cereal crop of Northern plains of India. It is widely grown fourth annual cereal crop after wheat, rice and maize with the production of 132 million tons annually (Patel and Meena, 2018). Barley is also cultivated for industrial use for malt production in southern part of the country like Karnataka. It is quite hardy crop and more tolerant to adverse conditions like drought, salinity and alkalinity than other *Rabi* cereals. It requires annual rainfall of 45 cm and temperature ranging between 25 to 30 C. Barley is cultivated mainly for human food supply and grown as animal feed, for malt production and human food. Barley crop is grown in the area of 49.29 m ha with the production of 147.16 million tons and productivity 2990 kg ha^{-1} in the world. The major growing states of barley in India are Rajasthan, Uttar Pradesh and Punjab, the barley crop is grown in the area of 0.59 million hectares with production of 1.5 million tons and productivity 2550 kg ha^{-1} (Anonymous, 2016). In Haryana, barley crop is grown in the area of 48 thousand ha with the production and productivity 167 thousand tons and 3480kg ha^{-1} respectively (Anonymous, 2014-15). Barley grain contains 8-10% protein (albuminoid), 12.5% moisture, 74-76% carbohydrates, 1.3% fat, 3.9% crude fiber and 1.5% ash (Kumar *et al*., 2018). The most valuable by-product is the straw which is used mostly for bedding purpose and also as a feed for livestock. Barley is used mainly as mixtures in flours for bread purpose due to its cost and nutritional value as compared to wheat (Kumar *et al*., 2017). In some areas, it is more preferred because absence of gluten content in barley grain and straw are more digestible over wheat. Sometimes, the barley grain is mixed with gram or wheat and ground to flour for preparing better quality *chapattis* (Singh and Khippal, 2018). Due to high nutritional and medicinal quality, it is used in Ayurvedic medicines and is used to cure fever, cold, asthma, skin diseases, sore throat,

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digestive system and to control the cholesterol level of blood (Kumar *et al*., 2020). Barley performs well in poor and low-fertility soil. But in fertile soils, barley yields are more comparable to those of wheat (Malik, 2017). Before sowing, the residues of nitrogen in soil should be maintained to minimize nitrogen application, to increase the malting quality and yield. Excessive use of nitrogen application in barley crop gets accumulated in grain and is unsuitable for malt production. The desirable yield was obtained with balanced use of nitrogen without increase in grain protein (Kumar *et al*., 2020). The organic materials ameliorate the soil condition and fertility. These includes farmyard manure, animal wastes, crop residues, bio - gas slurry and vermicompost preparations. The application of organic fertilizers give better crop growth and supplement plant nutrients including micro - nutrients as well as improves the physical, chemical and biological properties of soil (Dejene and Lemlem, 2012). Dung contains about 50% of the nitrogen, 15% of potash and nearly all of the phosphorous that is excreted by animals (Prasad *et al*., 2019). The organic fertilizer increases the organic matter, improves structure and buffering capacity of the soil and inorganic fertilizer supply readily available nutrients (Godara *et al*., 2012). Combined supplement of organic and inorganic fertilizers, generally entitled as integrated nutrient management is commonly used to increase the yield and improve the soil productivity and crop sustainably. The favourable effect of integrated nutrient management is to decline the deficiency of several macro- and micro - nutrients. Due to the fact of vermicompost, the essential nutrients can be easily uptaken by barley plant. Effective tillering of crop depends on the physical properties of soil that were higher due to addition of vermicompost (Kakraliya *et al*., 2016). Vermicompost is an organic material prepared by earthworms and micro - organisms which improves the germination and yield of crops. Bio - fertilizers are the natural fertilizers in which the micro - organisms like bacteria, fungi and algae have an important role for its preparation. These micro - organisms help in increasing crop productivity by fixing atmospheric nitrogen and solubilizing insoluble phosphate fertilizer to sustain the soil fertility. *Azotobacter* is known to restore the soil fertility through nitrogen fixation to improve the seed germination and crop growth rate. Phosphate solubilizing bacteria (PSB) are the beneficial bacteria which save about 50% of crop requirement of phosphatic fertilizer with the combination of rock phosphate. Seed inoculation with PSB gives crop yield responses equivalent to 30 kg P_2O_5 ha^{-1} or reduce the 50% of the demand for phosphatic fertilizer (Neelam *et al*, 2018). Therefore, the research study was carried out the effect of various combination of fertilizers on growth, soil and yield of barley.

Materials and Methods

The present study was conducted on ñEffect of integrated nutrients on growth and yield of barleyò (*Hordeum vulgare* L.) was under randomized block design (RBD) and with seven treatments replicated thrice, during *Rabi* season (November-April) of 2020-2021 at the Agronomy Department farm of Maharishi Markandeshwar University, Sadopur (Haryana). The research site is located at 3042ô39" N latitude and 7677ô69" E longitude and 264 m ASL in a tropical and semi-arid climate. The soil samples were taken randomly from different site of the experimental area at depth of 0-15 cm before the layout and after the harvesting of crop. The experiment site included seven different treatments viz. T_1 (Control), T_2 (100% RDF), T_3 (75% RDF + 25% FYM), T_4 (50% RDF + 50% FYM), T_5 (FYM @ 5t ha^{-1} + *Azotobacter* + PSB + 25% RDF), T_6 (Vermicompost @ 2.5 t ha^{-1}) and T_7 (Vermicompost @ 2.5 t ha^{-1} + *Azotobacter* + PSB + 25% RDF) and were replicated thrice in a randomized block design. The experimental farm area was sandy loam soil having pH 8.6 with available nitrogen (101.15 kg ha^{-1}), available phosphorous (15.23 kg/ha), available potassium (71.75 kg ha^{-1}) and organic carbon (0.40 %). The planting method for sowing seeds was line sowing. Barley variety BH 902 was sown @ 80 kg seed/ha at the depth of 5 cm with the help of Pora in lines spaced 20 cm apart. The recommended dose of fertilizer for barley crop is 60 kg ha^{-1} N, 30 kg ha^{-1} P_2O_5 and 30 kg ha^{-1} K_2O. The half dose of nitrogen and full dose of P_2O_5 and K_2O were applied as basal dose at the time of sowing and remaining half dose of nitrogen was top dressed applied at the time of first irrigation. The vermicompost and FYM were also applied as a basal dose at the time of sowing of barley crop. The doses of N, P and K nutrients were applied through chemical fertilizer i.e. urea, DAP and murate of potash, respectively and these nutrients also applied through vermicompost and biofertilizers. The observations of ten selected plants from each net plot area were recorded on growth and yield parameters.

The harvest index was calculated as follows:
HI = (Grain yield/Biological yield)* 100

Nutrient uptake of crop was computed on the basis of its dry weight by using the formula:
Nutrient uptake (kg ha^{-1})
= Nutrient content (%)*Yield (kg ha^{-1}) / 100

BCR were calculated as Gross returns from treatment (INR/ha) / Cost of cultivation of the treatment (INR/ha). The experimental data were statistically analyzed as per the procedure given by Gomez and Gomez (1984). The data were subjected to appropriate statistical analysis, significance of F value was taken at 5 % level of significance. The critical difference (CD P=0.05) was used for comparison of different treatments.

Results and Discussion

Growth parameters

Plant height

Analysis of relevant data of plant height and number of tillers per plant revealed that the various organic, inorganic and biofertilizers influenced the plant height of barley recorded at 30, 60, 90 DAS and at harvest are shown in table 1. The plant height was maximum in the treatment T_7 - Vermicompost @ 2.5 t ha^{-1} + *Azotobacter* + PSB + 25% RDF which was statistically at par with T_5 - FYM @ 5 t ha^{-1} + *Azotobacter* + PSB + 25% RDF. The minimum results was recorded in plots where no fertilizer was used. Kumar *et al.* (2020) also suggested that in barley where application of 100% RDN, vermicompost @ 5 t ha^{-1} and *Azotobacter* resulted in taller plants. Whereas, Mitiku *et al*. (2014) found that the combined application of organic and inorganic fertilizers of 5 t ha^{-1} FYM + 75% of recommended NP and 5 t ha^{-1} vermicompost increased the plant height of barley.

Fresh and Dry weight

The data related to fresh weight and dry weight (g $plant^{-1}$) in table 1 recorded at harvest showed that every treatments increased significantly fresh and dry weight of barley except control plots. The more fresh weight and dry weight with respective values of 36.28 and 21.39 g $plant^{-1}$ was obtained in treatment T_7 (vermicompost @ 2.5 t ha^{-1} + *Azotobacter* + PSB + 25% RDF) closely followed by T_5 (FYM @ 5 t ha^{-1} + *Azotobacter*+ PSB + 25% RDF). Kumar *et al*. (2017) recorded similar results of fresh weight and dry weight in barley (37.27 and 22.40 g $plant^{-1}$) in barley with application of 100% NPK and PSB.Yield and yield attributes

Spike length

The data of spike length in table 1 indicated that maximum spike length in treatment T_7 of vermicompost @ 2.5 t ha^{-1} + *Azotobacter* + PSB + 25% RDF (8.43 cm) which was at par with T_5 (FYM @ 5 t ha^{-1} + *Azotobacter* + PSB + 25% RDF). Treatments T_3 (75% RDF + 25% FYM), T_4 (50% RDF + 50% FYM) were found to be least effective treatments. Chauhan (2016) reported that the different level of NPK fertilizers with the combined application of 75% NPK, farmyard manure @ 5 t ha^{-1} and biofertilizer improved the spike length. Application of various combined fertilizers results maximum spike length of barley (Misganaw *et al*., 2020).

Number of grains $spike^{-1}$

The number of grains $spike^{-1}$ (Table 1) was maximum noted in treatment T_7 (43.00 cm) with combined fertilizers of vermicompost @ 2.5 t ha^{-1} + *Azotobacter* + PSB + 25% RDF though, it was statistically on par with treatment T_5 (42.46) and T_2 (40.83).

1000 seed weight

The data refer to 1000 seed weight (Table 1) of barley revealed in treatment T_7 of 44.50 cm with vermicompost @ 2.5 t ha^{-1} + *Azotobacter* + PSB + 25% RDF recorded highest 1000 seed weight of barley. Kumar *et al*.(2017) reported that maximum grain $spike^{-1}$ and 1000 seed weight under the treatment wherte combined application of 100% recommended dose of fertilizer and PSB was given.

Grain yield, Straw yield, Biological yield and harvest index

The grain yield, straw yield and biological yield (Table 1) was maximum with respective values of 48.42 q ha^{-1}, 60.12 q ha^{-1} and 108.44 q ha^{-1} with the combined application of vermicompost @ 2.5 t ha^{-1} + *Azotobacter* + PSB + 25% RDF followed by T_5 (FYM @ 5 t ha^{-1} + *Azotobacter* + PSB + 25% RDF) and T_2 (100% RDF). The least effective results was found in control plots. Application of 75% NPK, biofertilizer with vermicompost has earlier also been reported to give higher grain ha^{-1} in barley (Chauhan, 2016). Kumar *et al*. (2017) reported higher biological yield (126.29 q ha^{-1}) under the treatment of 100% RDF and PSB. The harvest index of barley was also highest (44.65%) in treatment T_7 (vermicompost @ 2.5 t/ha + *Azotobacter* + PSB + 25% RDF) followed by T_5

(FYM @ 5 t ha^{-1} + *Azotobacter* + PSB + 25% RDF), T_2 (100% RDF) and T_4 (50% RDF + 50% FYM). The harvest index was minimum in control T_1 (39.92%). In Ethiopia, Abera and Tesfaye (2018) observed higher grain yield of barley from the integration of 50-50% vermicompost and farmyard manure with recommended nitrogen and phosphorous fertilizer application. However, Prasad *et al*. (2019) reported that the both NPK and FYM nutrients alone or in combination had enhanced growth and yield parameters of barley.

Protein content in barley grain

A close look over the data in table 1 indicated that the protein content of grain was highest recorded in the treatment T_7 of vermicompost @ 2.5 t ha^{-1} + *Azotobacter* + PSB + 25% RDF i.e. 9.93 followed by T_2 (100% RDF). However, the minimum percentage of protein content was found in control i.e. 8.93. Chavarekar *et al*. (2013) reported that the combined application of chemical fertilizers and *Azotobacter* recorded higher percentage of protein (10.8%) in barley. The maximum protein content under 90 kg N ha^{-1}followed by 75 and 60 kg N ha^{-1} of barley (Yadav *et al*., 2020).

Effect of integrated nutrients on NPK status in soil

Available Nitrogen

Significantly higher available nitrogen of soil after harvest (Table 2) was found in treatment T_7 (vermicompost @ 2.5 t ha^{-1} + *Azotobacter* + PSB + 25% RDF) i.e. 129.12 kg ha^{-1} which was at par with T_5 (FYM @ 5 t ha^{-1} + *Azotobacter* + PSB + 25% RDF) and followed by T_3 (75% RDF + 25% FYM) in Table 2. Increase in nitrogen might be due to application of vermicompost, as it improved the available nitrogen content of soil (Kumar *et al*., 2018). Whereas, Randhawa *et al*. (2020) observed that the available nitrogen content in soil varied with the application of 100% RDF through inorganic fertilizer.

Available Phosphorous

It is evident that the available phosphorous status of soil was recorded maximum in the treatment T_7 of vermicompost @ 2.5 t ha^{-1} + *Azotobacter* + PSB + 25% RDF i.e. 21.58 kg ha^{-1} at par with by T_5 (vermicompost @ 2.5 t ha^{-1}) followed by T_3 (75% RDF + 50% FYM) and T_4 (50% RDF + 50% FYM) . Control plots recorded the lowest phosphorous value of 14.10 kg ha^{-1}.

Available Potassium

Table 1: Effect of organic, inorganic and biofertilizers on growth parameters, yield and yield parameters and protein content on barley

Treatment	Plant height (cm) 30 DAS	60 DAS	90 DAS	At harvest	Fresh weight (g plant^{-1}) AH	Dry weight (g plant^{-1})AH	Spike length (cm)	No. of grains spike^{-1}	1000 seed weight (g)	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Biological yield(q ha^{-1})	Harvest index	Protein content in grain (%)
T_1	21.00	52.8	75.06	79.13	21.63	12.69	6.60	29.76	29.53	23.33	34.31	56.6	39.92	8.93
T_2	29.36	70.53	92.36	96.10	32.87	18.33	7.93	40.83	38.86	35.55	47.1	82.7	42.98	9.68
T_3	27.10	65.50	90.23	95.33	33.33	19.94	7.60	40.56	36.20	30.72	42.31	72.84	42.17	9.25
T_4	26.66	65.23	90.00	94.80	27.82	16.11	7.50	38.7	36.20	32.41	43.28	75.58	42.87	9.06
T_5	30.90	71.63	91.73	100.36	33.33	19.94	8.36	42.46	43.50	36.18	47.78	83.96	43.09	9.56
T_6	24.03	59.70	85.26	89.30	23.30	14.31	7.73	33.13	34.16	31.68	43.06	76.38	42.43	9.12
T_7	31.10	72.10	92.96	100.63	36.28	21.39	8.43	43.00	44.50	48.42	60.12	108.44	44.65	9.93
SEm ±	0.12	0.14	0.41	0.14	0.72	0.47	0.16	0.98	0.21	0.11	0.10	0.17	0.12	0.02
CV (%)	0.66	0.30	0.65	0.22	3.49	3.84	2.99	3.60	0.80	0.46	0.32	0.30	0.39	0.39
CD (P=0.05)	0.29	0.31	0.93	0.33	1.64	1.06	0.37	2.23	0.48	0.25	0.24	0.39	0.27	0.06

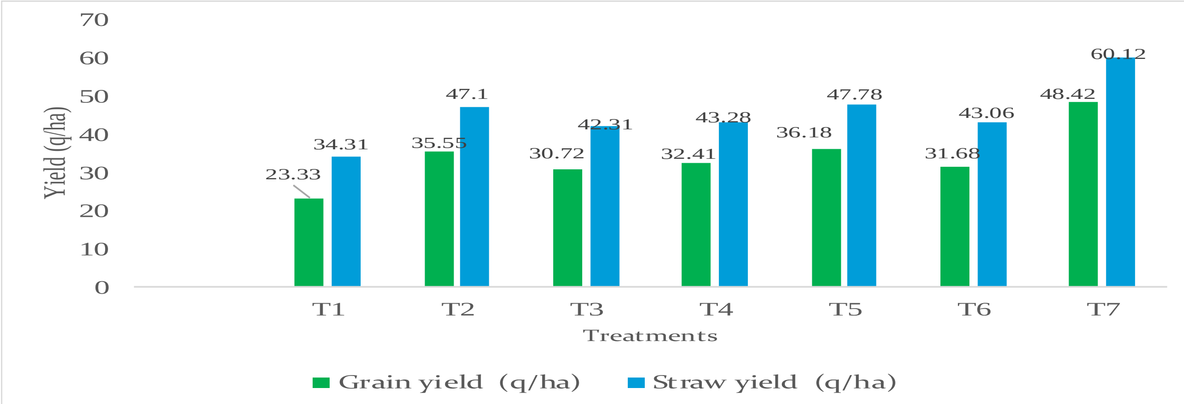

Fig. 1: Effect of integrated nutrient management on yield of barley

Like N and P, available K in soil was also observed maximum with the combined application of vermicompost @ 2.5 t ha^{-1} + *Azotobacter* + PSB + 25% RDF that is 93.25 kg ha^{-1} followed by T_5 (FYM @ 5 t ha^{-1} + *Azotobacter* + PSB+ 25% RDF). Control plots had the minimum available K i.e. 71.74 kg ha^{-1}.

Effect of INM treatments on nutrient content in grain and straw and grain of barley

Nitrogen content in barley grain and straw

The data of nitrogen content in barley grain and straw clearly in table 2 indicated that the nitrogen content (1.59 %) in grain of barley was maximum in treatment T_7 with combined application of vermicompost @ 2.5 t ha---$^{-1}$ + *Azotobacter* + PSB + 25% RDF followed by T_2 (100% RDF) and T_5 (FYM @ 5 t ha^{-1} + *Azotobacter* + PSB + 25% RDF). Similarly, the maximum N content in straw of barley recorded in treatment T_7 (0.41%) and T_5 (0.40%) followed by T_2 (0.36%). The minimum values of nitrogen content in grain and straw was 1.43% and 0.30% respectively in T_1 control. Taleb *et al* (2015) concluded that the maximum values of nitrogen concentration in barley grains were obtained with 100 kg N/ac and the lowest value was obtained under 70 kg N/ac. Whereas, Malik (2017) reported that farmyard manure with 75% dose of NPK and 20 kg Zn SO_4 ha^{-1} was found superior to 100% NPK alone in barley.

Phosphorous content in barley grain and straw

From the data in table 2 recorded that maximum P content in grain and straw of barley was observed in the treatment T_7 (0.40 %) with the combined application of vermicompost @ 2.5 t ha^{-1} + *Azotobacter* + PSB + 25% RDF which was found at par with treatment T_5 (0.39 %) with the application of FYM @ 5 t ha^{-1} + *Azotobacter* + PSB + 25% RDF. Similarly, the application of treatment T_7 (0.30 %) also resulted in the highest P uptake by straw and at par with T_5 (0.28

Table 2: Effect of organic, inorganic and biofertilizers on nutrient status of soil and nutrient uptake by barley

Treatment	Nitrogen (kg ha^{-1})	Phosphorous (kg ha^{-1})	Potassium (kg ha^{-1})	N uptake		P uptake		K uptake	
				Grain	Straw	Grain	Straw	Grain	Straw
T_1	101.12	14.10	71.24	23.58	34.68	3.55	5.22	16.62	24.43
T_2	111.30	17.00	87.21	39.56	52.41	6.04	8.00	31.00	41.27
T_3	124.10	20.76	85.29	38.12	52.50	5.83	8.03	26.19	36.08
T_4	121.41	20.74	84.45	39.34	52.54	6.74	7.75	27.36	36.54
T_5	126.10	21.53	90.63	45.62	60.24	7.82	10.33	32.78	43.30
T_6	107.90	16.86	80.46	34.17	46.45	5.51	7.50	25.48	31.60
T_7	129.12	21.58	93.25	62.51	77.62	11.25	13.96	45.14	52.43
SE (m)±	0.85	0.09	0.08	0.24	0.34	0.36	0.02	0.06	1.81
CV (%)	1.01	7.01	0.13	0.85	0.88	7.67	0.48	0.31	4.11
CD (P=0.05)	1.92	0.21	0.18	0.55	0.77	0.82	0.06	0.14	6.71

%). The minimum values of phosphorous content in grain and straw was noticed in T_1 control with the respective values of 0.34% and 0.20%.

Like N and P, maximum K content in grain of barley (1.61%) was recorded in plots having application of vermicompost @ 2.5 t ha^{-1} + *Azotobacter* + PSB + 25% RDF which was statistically at par with treatment T_3 (75% RDF + 25% FYM), T_4 (50% RDF + 50% FYM) and T_5 (FYM @ 5 t ha^{-1} + *Azotobacter* + PSB + 25% RDF) and T_3 (75% RDF + 25% FYM). Similarly, the potassium uptake by straw of barley was highest in T_7 (0.43%). But, it was statistically at par with T_2 (0.41%) and T_4 (0.40%). The minimum content in potassium by grain and straw was found in control i.e. 1.53% and 0.36%, respectively. Gottipati and Menon (2020) suggested that the organic amendments and inorganic source of nutrients improved the soil fertility and productivity.

Economic Analysis

Cost of cultivation

The highest cost of cultivation of barley was found in treatment T_7 of vermicompost @ 2.5 t ha^{-1} + *Azotobacter* + PSB + 25% RDF (Rs. 31161.00 ha^{-1}) and lowest cost of cultivation (Rs. 17805.00 ha^{-1}) was found in control plots (Table 3).

Gross return

The gross return of barley (Rs. 70128.00 ha^{-1}) was in table 3 significantly higher in T_7 of vermicompost @ 2.5 t ha^{-1} + *Azotobacter* + PSB + 25% RDF and the lowest gross return (Rs. 33982.00 ha^{-1}) was found in control plots.

Net return

The highest net return was recorded (Table 3) in treatment T_7 (Vermicompost @ 2.5 t ha^{-1} + *Azotobacter* + PSB + 25% RDF (Rs. 38967.00 ha^{-1}) followed by T_5 (FYM @ 5 t ha^{-1} + *Azotobacter* + PSB + 25% RDF) over control. Jai *et al*. (2015) evaluated that in barley, 100% RDF (60:30:30), biofertilizers (*Azotobacter* + PSB) and vermicompost @ 2.5 t ha^{-1} attaining higher net returns (Rs. 35358 ha^{-1}). Additionally, in dry climatic condition, the use of recommended dose of fertilizer NPK (60:30:30), biofertilizer (*Azotobacter* + PSB) and farmyard manure were beneficial for attaining higher net profit.

Benefit cost ratio

The highest BCR (2.25) was found (Table 3) in treatment T_7 (vermicompost @ 2.5 ha^{-1} + *Azotobacter* + PSB + 25% RDF followed by T_5 (FYM @ 5 t ha^{-1} + Azotobacter + PSB + 25% RDF). The lowest value of benefit cost ratio was observed in (1.90). Yadav *et al*. (2014) recorded that the integrated treatments of 40 kg N ha^{-1} + FYM + biofertilizers increased the gross as well as net income that treatment of 120 kg N ha^{-1} alone. Subsequently, Kumar *et al*. (2017) revealed that the cost of cultivation (30230 Rs./ha), BCR (2.13), straw and biomass yield of barley were maximum with the application of 100% NPK and PSB.

Table 3: Effect of organic, inorganic and biofertilizer on economics of different treatments

Treatment	Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	BCR
T_1	17805.00	33982.00	16177.00	1.90
T_2	24716.76	52080.00	27363.24	2.10
T_3	23145.07	45326.00	22180.93	1.95
T_4	27510.88	48448.00	20937.12	1.76
T_5	32890.39	52028.00	19137.61	1.58
T_6	30305.00	46628.00	16323.00	1.53
T_7	31161.00	70128.00	38967.00	2.25

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