

Original Research Article

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Effect of Biofertilizers and Split Application of Vermicompost on Productivity and Profitability of Wheat (*Triticum aestivum* L.) Crop in Clay Loam Soils

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ABSTRACT

A field experiment was conducted for two consecutive *rabi* (winter) seasons during 2017-18 and 2018-19 at the Instructional Farm of RCA, Udaipur, Rajasthan to study the effect of biofertilizers and split application of vermicompost on productivity and profitability of wheat (*Triticum aestivum* L.). Two years pooled data indicate that growth attributes (plant height), yield attributing traits (total tillers, effective tillers and test weight), yields *viz.*, grain, straw and biological in wheat differ significantly in both biofertilizers and vermicompost treatments and were maximum with the B₅ (*Azotobacter*+PSB+KMB+ZnSB) and V₃ (50% at sowing+50% at tillering) as compared to control. The highest net return and B:C ratio was obtained with B₅ (*Azotobacter*+PSB+KMB+ZnSB) and vermicompost with V₃ (50% at sowing+50% at tillering) of wheat. Interaction effect of biofertilizers and vermicompost on yield and economy of wheat were found significant.

Keywords

Biofertilizers,
Vermicompost,
Yield, Wheat, Split
application

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Introduction

Wheat is the most important cereal crop of the family Poaceae. Wheat is the second most important food grain crop in India ranking next to rice contributing about 35% of the food grain production in India. The rising population and reduction in available land and other productive units are placing

unprecedented pressure on the current agriculture and natural resources to meet the increasing food demand. Adoption of intensive system will meet the food demand of growing population. The manufacturing of synthetic fertilizers is highly cost effective and depended on non-renewable fossils fuel that is in acute shortage. Efforts have been devoted to reduce chemical fertilizers

application in wheat production, organic manure and biofertilizers amendments are considered to be feasible ways to realize this goal without decreasing grain yields (Uribe *et al.*, 2010).

Indigenous sources like FYM, vermicompost and biofertilizers should be encourage as it supply plant nutrient, improve the soil biodiversity and thereby increase the productivity and fertility of the soil.

Bio-fertilizers being essential components of organic farming play vital role in maintaining long term soil fertility and sustainability by fixing atmospheric nitrogen. Keep the soil environment rich in all kinds of micro- and macro-nutrients via nitrogen fixation, phosphate and potassium solubalization or mineralization, release of plant growth regulating substances, production of antibiotics and biodegradation of organic matter in the soil (Sinha *et al.*, 2014).

It is evident the biofertilizers like *Azotobacter* in combination have great prospect for increasing productivity of wheat. When seeds are inoculated with biofertilizers, they multiply and participate in nutrient cycling and improved crop productivity (Singh *et al.*, 2011).

Vermicompost is the microbial composting of organic wastes through earthworm activity to form organic fertilizers which contain higher level of organic matter, organic carbon, total and available N, P, K and micronutrients, microbial and enzyme activities (Parthasarathi *et al.*, 2007).

Split application of vermicompost resulted in higher yield parameters such as panicles, filled grains per panicle and total spikelets per panicle, grain yield and NUE in rice but only if vermicompost was applied at two or three doses (Bejbaruah *et al.*, 2013). The objective

behind this experimentation was to increase the yield attributes and yield of wheat along with use of biofertilizers and vermicompost.

Materials and Methods

Experimental Location and Design

A field experiment was laid at Instructional Farm, Rajasthan College of Agriculture, Udaipur. The site is situated at 24°35' North Latitude and 74°42' East Longitude with the altitude of 579.5 m above mean sea level. The region comes under agro-climatic zone IVA (Sub-Humid Southern Plain and Aravalli Hills) of Rajasthan. The wheat crop experienced maximum and minimum temperature ranged between 23.43 to 37.85 °C and 5.21 to 19.83°C during *rabi* 2017-18, respectively.

The corresponding temperature fluctuations during second year (2018- 19) of experimentation were 21.58 to 39.40 °C and 4.07 to 20.10 °C, respectively. Total rainfall received during the crop season was 6.60 mm during 2017-18 and 1.9 mm in 2018-19, respectively. The weather data during experimental period was collected from the meteorological observatory of agronomy. The soil is an vertisols with a clay loam texture (sand 38.57%, silt 26.66% and clay 34.37%) neutral alkaline in reaction, medium in available nitrogen (251 kg ha⁻¹) and phosphorus (18 kg ha⁻¹) and high in available potassium (443 kg ha⁻¹).

To ascertain physico-chemical characteristics of the experimental field, soil samples up to 0-15 cm depth were drawn from different spots of field and a representative composite sample was prepared by mixing and physico-chemical and biological analysis using standard methods. The study was designated with different biofertilizers and vermicompost treatments.

We selected five levels of biofertilizers [Control (B₁), *Azotobacter* (B₂), *Azotobacter*+PSB (B₃), *Azotobacter*+ PSB+KMB (B₄) and *Azotobacter*+PSB+ KMB+ ZnSB(B₅)] and four levels of vermicompost [Control (V₁), 100% at sowing (V₂), 50% at sowing+50% at tillering (V₃) and 50% at sowing+50% at tillering (V₄)], making twenty treatment combinations. These treatments were replicated thrice in Factorial Randomized Block Design.

Treatment application and crop management

The experiment field was disposed of for two years to confirm the same soil properties. After harvesting of *Kharif* season crop, the experimental field was prepared by ploughing (0-15 cm) with tractor drawn disc plough followed by cross harrowing and planking to bring the soil in to good tilth. Before sowing, all the biofertilizers viz. *Azotobacter*, PSB, KMB and Zn solublizer will be used as seed treatment @ 5 ml kg⁻¹ of each biofertilizers. The application of vermicompost @ 4 t ha⁻¹ will be applied in the field as per treatments mixed at the time of sowing and tillering stage.

The details nutrient content present in the vermicompost is given in Table 1. Necessary intercultural operations were regularly monitored for maintaining optimum plant growth condition.

The crop was intermitted irrigation, crop weeded were done at 30 and 45 days after sowing, respectively for weed control in the wheat crop, use of pesticides for pest control were carried out following the farmers practices.

Crop was manually harvested, after the crop harvested, the straw and yield were air dried and weight. Soil samples from the top soil (0-

15 cm) were taken at four different points of each replicated plots were thoroughly mixed to make homogeneous composite sample of each replication, air dried and transferred in clean polythene bags.

Plant sampling and analysis

Plant samples were taken from each plot for the recorded the observation and analysis. Plant height at harvest should be measured randomly with the help of scale meter, total number of tillers at 60 DAS and number of effective tillers (ear bearing tillers) at physiological maturity were recorded non-destructively from two randomly selected one meter row length in each plot.

The total biomass harvested from each net plot was threshed; winnowed, cleaned and dried grains of wheat thus obtained were weighed in terms of kg plot⁻¹. Straw yield of wheat was calculated by subtracting grain yield from respective biological yield of each treatment and expressed in terms of kg ha⁻¹.

The ratio of economic yield (grain yield) to biological yield was worked out to estimate harvest index and expressed as percentage as suggested by Donald and Hablin (1976). For the test weight 1000 grains were counted and weighed and expressed in gram.

Statistical analysis

All the recorded data were subjected to statistical analysis using analysis of variance (ANOVA) techniques as applicable to random block design. The two years plant data is presented so after carrying out F- test of homogeneity of variance, the yield data from two years were pooled and statistically analyzed and least significant difference (LSD) at P = 0.05 was used to test the differences between means of individual treatments (Gomez and Gomez, 1984).

Results and Discussion

Growth

Plant height pertaining to different biofertilizers recorded at harvest has been presented in table 2.

Effect of biofertilizers

Among the treatments, B₅ (*Azotobacter*+PSB+KMB+ZnSB) had maximum plant height (101.99 cm) at harvest of wheat, which was significantly higher than B₃ (*Azotobacter* + PSB), B₂ (*Azotobacter*) and B₁ (control). But it was at par with B₄ (*Azotobacter* + PSB + KMB). The variation in plant height due to nutrient sources was considered to be the variation in nutrient availability.

Biofertilizers improve growth by increasing the supply or availability of primary nutrients to the host plant. The increased endogenous nitrogen content due to inoculation might have promoted crop growth. These results were supported by Ahemad and Khan, (2009) and Kaushik *et al.*, (2012).

Effect of vermicompost

Data (Table 2) revealed that among the treatments, V₃ (50% at sowing+50% at tillering) had maximum plant height (101.58 cm) at harvest of wheat, which was significantly higher than V₂ (100% at sowing) and V₁ (control). But it was at par with V₄ (75% at sowing+25% at tillering). This clearly indicates that higher level of nutrients helped in the elongation of stem due to development of cells, rapid cell division and cell elongation in meristematic region of plant. The similar results noted by Kheyri *et al.*, (2017).

Yield attributes and yield

The data regarding yield of wheat were summarised in Table 2 and revealed that the

grain and straw yield of wheat were also positively affected by seed inoculation with biofertilizers and spilt application of vermicompost.

Effect of biofertilizers

Biofertilizers had a remarkable influenced on the total number of tillers, effective number of tillers, test weight, grain yield, straw yield, biological yield of wheat. Data (Table 2 and 3) recorded that treatment B₅ (*Azotobacter*+PSB+KMB+ZnSB) had maximum number of total tillers (91.71) and effective tillers (77.88) per meter row length at harvest of wheat, which was significantly higher than B₃ (*Azotobacter*+PSB), B₂ (*Azotobacter*) and B₁ (control) except B₄ (*Azotobacter*+PSB+KMB).

Application of different biofertilizers has significantly affected grain yield, straw yield and biological yield of wheat over the control and single inoculation (Table 3). Treatment B₅ (*Azotobacter*+PSB+KMB+ZnSB) had higher grain yield (4564.75 kg ha⁻¹), straw yield (6606.7 kg ha⁻¹) and biological yield (11171.42 kg ha⁻¹) at harvest of wheat, which was significantly higher than B₃ (*Azotobacter*+PSB), B₂ (*Azotobacter*) and B₁ (control), But it was at par with B₄ (*Azotobacter*+PSB+KMB).

Highest test weight (44.45 g) was recorded with B₅ (*Azotobacter*+PSB+KMB+ZnSB), which was at par with B₄. Treatments B₄, B₃ remained at par with each other. Increase in yield attributes and yield of wheat with biofertilizers seems owing to increased supply of plant hormones by the microorganisms or by roots as results of reaction to microbial colonization (Avivi and Feldman, 1982). Priming with biofertiliser inoculations significantly improves grain yield, straw yield and biological yield of wheat crop Patra and Singh (2018). Harvest index of wheat was not influenced significantly with the application

of biofertilizers. This might be due to variable rate of translocation of assimilate toward grain development, leading to variability in yield and HI value among the applied treatments (Kumawat *et al.*, 2017).

Effect of vermicompost

Vermicompost contains primary, secondary and micronutrients. Thus, significantly influence total number of tillers, effective number of tillers, test weight, grain yield, straw yield, biological yield of wheat. Tillering is an important trait for grain production, application of vermicompost has significantly influence total tillers and effective tillers of wheat (Table 2). Treatment V₃ (50% at sowing+50%at tillering) had maximum number of total tillers (92.29) and effective tillers (76.79) per meter row length at harvest of wheat, which was significantly higher than V₂ (50% at sowing) and V₁ (control).

But it was at par with V₄ (75% at sowing+25% at tillering). Application of vermicompost has significantly affected grain yield, straw yield and biological yield of wheat over the control (Table 3). Treatment V₃ (50% at sowing+50%at tillering) had higher grain yield (4587.25 kg ha⁻¹), straw yield (6648.5 kg ha⁻¹) and biological yield (11235.54 kg ha⁻¹) at harvest of wheat, which was significantly higher than V₂ (100% at sowing) and V₁ (control) however, it was at par with V₄ (75% at sowing+25%at tillering). Highest test weight (43.73 g) was recorded with V₃ (*Azotobacter*+PSB+KMB+ZnSB), which was at par with V₄. Harvest index of wheat was not influenced significantly with the split application of vermicompost.

The beneficial effect of vermicompost split doses on these parameters might also be due to its continuous contribution in supplying addition plant nutrients and increasing the

availability of native soil nutrients. It seems that if vermicomposting is applied in three splits, it can boost plant growth and consequently increase grain yield (Kheyri, 2017).

The increase in yield attributes with the application of vermicompost might be due to higher availability of balanced plant nutrients throughout the crop period especially at critical stages of plant (Surendra Rao and Sitaramaya, 2000). Vermicompost applied at 2, 4 and 6 t ha⁻¹ increased grains yield of wheat by 11, 17 and 26% over control respectively (Hadis *et al.*, 2018).

Similar finding of harvest index also reported by (Biri *et al.*, 2016) this might be due to competition for growth resources, i.e. moisture, nutrients and light. These all had played great roles in enhancing the biological, grain and straw yields, in the present experimentation. The similar results noted by Khan *et al.*, (2013).

Economics

The data concerned with economics of wheat were summarized in Table 4. It is envisaged with the figure that cost of cultivation in rupees per hectare. Economics of production is very important aspect to adjudge the efficiency of different production systems based on physical feasibility and its commercial viability, while calculating the economics *viz*; cost of cultivation, gross income, net income and B:C ratio were into consideration. The gross income was influenced significantly by the application of different biofertilizers and vermicompost treatments.

Effect of biofertilizers

Data presented in Table 4 and reported that treatment B₅ (*Azotobacter*+PSB+KMB+

ZnSB) had higher gross return (Rs 99979.1 ha⁻¹), net return (Rs 67529.1 ha⁻¹) and BC ratio (1.50) of wheat, which was significantly higher than B₃ (*Azotobacter*+PSB), B₂ (*Azotobacter*) and B₁ (control), But it was at par with B₄ (*Azotobacter*+PSB+KMB). Use of efficient strains of bio-fertilizers are environment friendly, low cost agricultural inputs that have an important role in improving nutrient supply to crops but also reducing the cost of production (Kumar, 2013).

Effect of vermicompost

Data (Table 4) revealed that treatment V₃ (50% at sowing+50%at tillering) had higher gross return (Rs 100501.5 ha⁻¹), net return (Rs 67451.5 ha⁻¹) and BC ratio (2.04) of wheat, which was significantly higher than V₂ (100% at sowing) and V₁ (control), But it was at par with V₄ (75% at sowing+25%at tillering). These finding also supported by Verma *et al.*, (2014).

Table.1 Chemical characteristics of vermicompost applied in experiment

Nutrient content	N (%)	P (%)	K (%)
2017-18	1.14	0.79	0.71
2018-19	1.16	0.76	0.69

Table.2 Effect of biofertilizers and vermicompost on growth and yield attributes of wheat (Pooled means data)

Treatments	Plant height (cm)	Total tillers m ⁻¹ row length	Effective tillers m ⁻¹ row length	Test weight(g)
Biofertilizers				
B ₁ (control)	85.95	74.97	59.99	38.73
B ₂ (<i>Azotobacter</i>)	91.79	84.32	66.68	41.12
B ₃ (<i>Azot.</i> +PSB)	96.33	88.03	73.54	42.77
B ₄ (<i>Azot.</i> +PSB+KMB)	100.92	89.47	75.84	43.52
B ₅ (<i>Azot.</i> +PSB+KMB+ZnSB)	101.99	91.71	77.88	44.45
SEm±	0.99	0.91	0.91	0.41
C.D. (P=0.05)	2.81	2.58	2.58	1.16
Vermicompost				
V ₁ (Control)	84.82	75.47	60.95	39.06
V ₂ (100% at sowing)	95.36	83.32	68.82	42.07
V ₃ (50% at sowing+50% at tillering)	101.58	92.29	76.79	43.73
V ₄ (75% at sowing+25% at tillering)	99.83	90.13	76.58	43.61
SEm±	0.88	0.81	0.81	0.36
C.D. (P=0.05)	2.51	2.31	2.31	1.03

Table.3 Effect of biofertilizers and vermicompost on yield (grain, straw and biological) and harvest index of wheat (Pooled data)

Treatments	Grain yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)	Biological yield (kg ha ⁻¹)	Harvest index (%)
Biofertilizers				
B ₁ (control)	3611.19	5304.7	8915.88	40.44
B ₂ (Azotobacter)	3949.16	5713.1	9637.30	41.02
B ₃ (Azot.+PSB)	4285.47	6223.3	10508.78	40.43
B ₄ (Azot.+PSB+KMB)	4479.24	6543.5	11047.71	40.91
B ₅ (Azot.+PSB+KMB+ZnSB)	4564.75	6606.7	11171.42	40.82
SEm±	33.73	49.5	70.840	0.243
C.D. (P=0.05)	95.55	140.2	200.691	NS
Vermicompost				
V ₁ (Control)	3631.03	5329.0	8960.03	40.51
V ₂ (100% at sowing)	3969.92	5797.2	9767.09	40.66
V ₃ (50% at sowing+50% at tillering)	4587.25	6648.5	11235.74	40.84
V ₄ (75% at sowing+25% at tillering)	4523.67	6538.3	11062.01	40.88
SEm±	30.17	44.3	63.362	0.217
C.D. (P=0.05)	85.46	125.4	179.504	NS

Table.4 Effect of biofertilizers and vermicompost on gross, net return and BC ratio of wheat (pooled data)

Treatments	Gross return (Rs ha ⁻¹)	Net return (Rs ha ⁻¹)	BC ratio
Biofertilizers			
B ₁ (control)	79312.1	47662.1	1.50
B ₂ (Azotobacter)	86421.0	54571.0	1.71
B ₃ (Azot.+PSB)	94199.1	62149.1	1.94
B ₄ (Azot.+PSB+KMB)	98068.7	65818.7	2.04
B ₅ (Azot.+PSB+KMB+ZnSB)	99979.1	67529.1	2.08
SEm±	650.6	652.6	0.02
C.D. at 0.05	1843.1	1823.9	0.06
Vermicompost			
V ₁ (Control)	79734.6	50684.6	1.74
V ₂ (100% at sowing)	87095.0	54045.0	1.63
V ₃ (50% at sowing+50% at tillering)	100501.5	67451.5	2.04
V ₄ (75% at sowing+25% at tillering)	99052.7	66002.7	2.00
SEm±	581.9	585.3	0.02
C.D. at 0.05	1648.6	1618.4	0.05

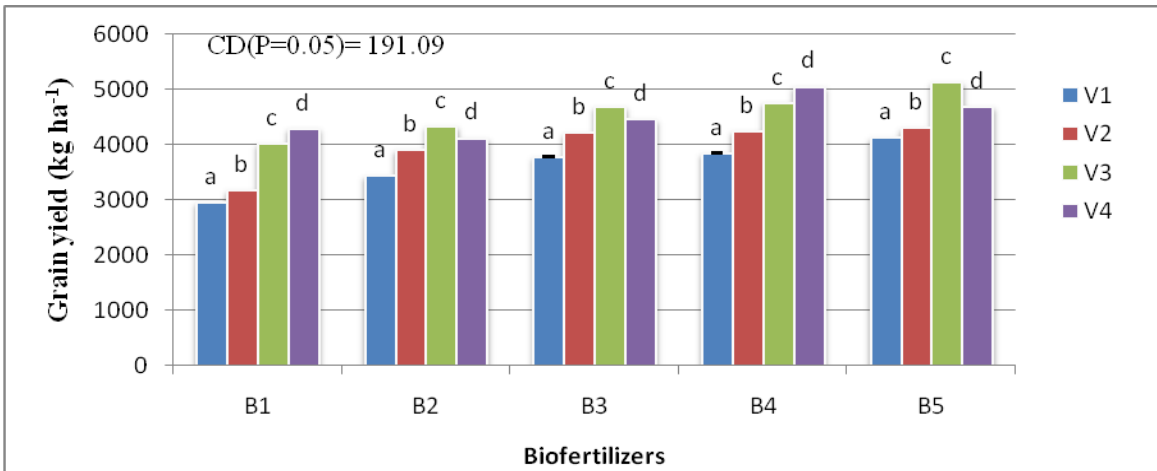


Fig.1 Interactive effect of biofertilizers and vermicompost on grain yield (kg ha^{-1}) of wheat in pooled basis. The error bars shows the LSD ($p=0.05$) values

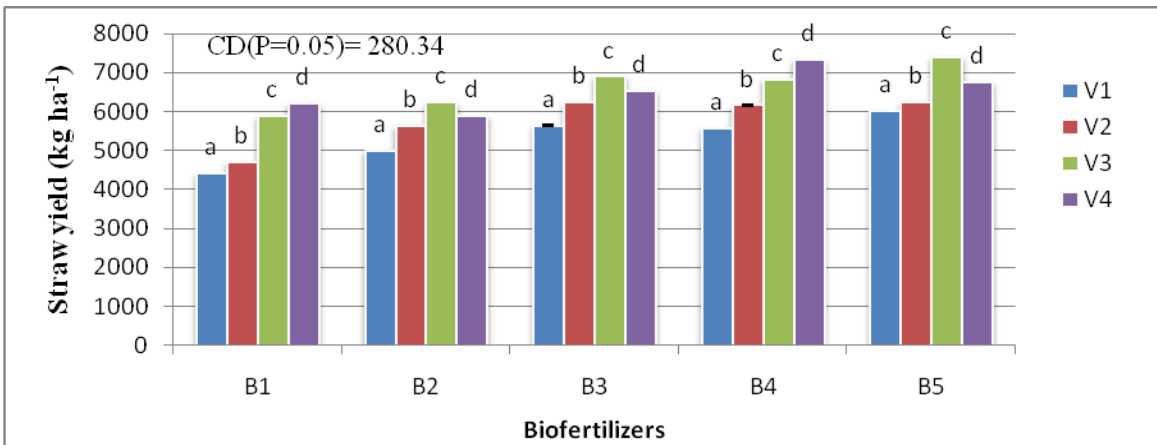


Fig.2 Interactive effect of biofertilizers and vermicompost on straw yield (kg ha^{-1}) of wheat in pooled basis. The error bars shows the LSD ($p=0.05$) values

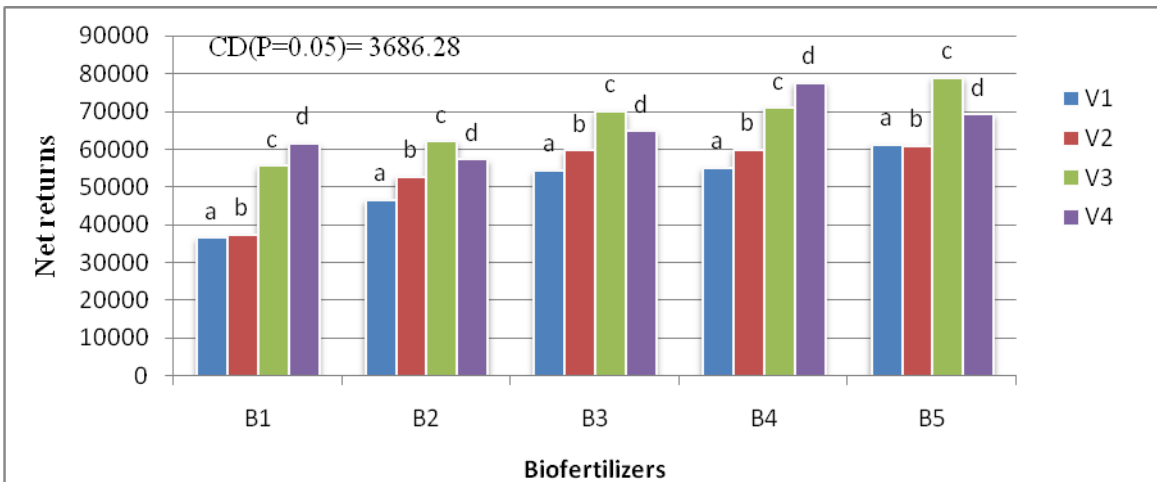


Fig. 3 Interactive effect of biofertilizers and vermicompost on net returns (Rs ha^{-1}) in pooled basis. The error bars shows the LSD ($p=0.05$) values

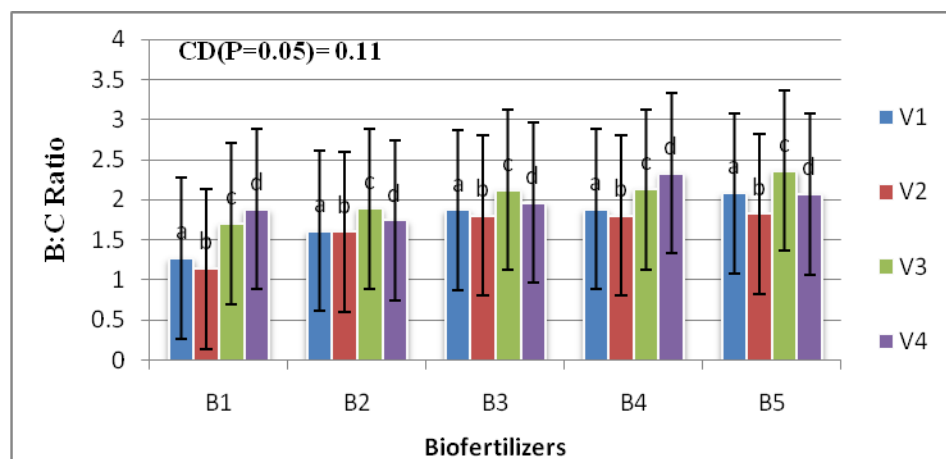


Fig.4 Interactive effect of biofertilizers and vermicompost on B:C ratio of wheat in pooled basis. The error bars shows the LSD ($p=0.05$) values

Interaction effect of biofertilizer and vermicompost on yield and economics

Interaction effect of biofertilizers and vermicompost on grain yield and straw yield was significant (Fig. 1 and 2). Results showed that the highest grain yield and straw yield ($5132.56 \text{ kg ha}^{-1}$ and $7396.02 \text{ kg ha}^{-1}$) was recorded from B_5V_3 treatment, which was at par B_4V_4 . On the other hand, the lowest grain and straw yield ($2956.58 \text{ kg ha}^{-1}$ and $4419.24 \text{ kg ha}^{-1}$) was recorded from B_1V_1 treatment. Similar results were recorded by Azarpour *et al.*, (2012) and Arancon and Edwards (2005). Further revealed that (Fig. 3 and 4) Comparison of mean between interaction effect levels of biofertilizers and vermicompost showed that, the highest net return and BC ratio ($\text{Rs } 78884.23 \text{ ha}^{-1}$ and 2.33) was recorded from B_5V_5 treatment which was at par B_4V_4 , respectively. Similar findings also reported by Sharma *et al.*, (2009).

Based on the finding of the present investigation, it can be referred that application of bifertilizers along with vermicompost proved in significance on growth dynamics, productivity of wheat. From the present study it was observed that biofertilizers (Azotobacter + PSB + KMB +

ZnSB) + vermicompost as (50% at sowing+ 50% at tillering) gave the best result. Our results revealed that, biofertilizers with organic manure can be a better supplement of inorganic fertilizers to produced better growth and production of wheat.

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