

## Research Article



# Effect of Vermicompost and Microbial Inoculants on Yield, Soil Fertility and Economics of Wheat under Rainfed Conditions

Muhammad Arsaln<sup>1</sup>, Sair Sarwar<sup>2\*</sup>, Rizwan Latif<sup>1</sup>, Junaid Nawaz Chaudhary<sup>3</sup>, Munazza Youstra<sup>2</sup> and Shahbaz Ahmad<sup>2</sup>

<sup>1</sup>Barani Agricultural Research Institute, Chakwal, Pakistan; <sup>2</sup>Land Resources Research Institute, Pakistan; <sup>3</sup>Water Management Research Centre, University of Agriculture Faisalabad, Pakistan.

**Abstract** | Integrated application of mineral fertilizers, organic amendments and microbial inoculants not only maximize the crop production and economic returns but also improve the soil health. A two years field study was conducted in the farm of Barani Agricultural Research Institute, Chakwal (32°55'33"N, 72°43'30"E) to evaluate the integrated impact of vermicompost (VC) and microbial inoculants on wheat yield and economics. Eight treatments i.e., control; recommended dose of fertilizers (160:150:50) NPK in kg ha<sup>-1</sup>; VC @ 4t ha<sup>-1</sup>; PSB; Recommended fertilizers + VC @ 4t ha<sup>-1</sup>; Recommended fertilizers + PSB; VC @ 4t ha<sup>-1</sup> + PSB; Recommended fertilizers + VC @ 4t ha<sup>-1</sup> + PSB were tested in the experiment using various combinations of vermicompost (VC) @ 4t ha<sup>-1</sup> and phosphorus solubilizing bacterial (PSB) as microbial inoculants along with recommended dose of NPK fertilizers (RDF) were applied at the time of sowing. The combined application of VC, PSB and RDF increased the wheat yield 2684 kg ha<sup>-1</sup> and 3179 kg ha<sup>-1</sup> while the yield recorded in control was 572 and 887 kg ha<sup>-1</sup> for two consecutive years. Same trend was observed in other yield attributes i.e. no. of tillers m<sup>-2</sup> (T8; 348, 352 vs control; 240, 238), spike length (T8; 12cm, 14cm vs control; 9.10, 10.9), no. of grains spike<sup>-1</sup> (T8; 63, 65 vs control; 34, 28) during both years, respectively. It has also mended the soil health by improving the soil OM status (0.58%), NO<sub>3</sub>-N (13ppm) and phosphorus (9.4ppm) contents. The economic analysis revealed that maximum net returns were found in integrated nutrient application (RDF, VC and microbial inoculants) i.e., Rs. 67,044 ha<sup>-1</sup> for 2017-18 and Rs. 1,03,202 ha<sup>-1</sup> for 2nd year and minimum returns in control.

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\***Correspondence** | Sair Sarwar, Land Resources Research Institute, Pakistan; **Email:** sardarsair@hotmail.com

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**Keywords** | Soil fertility, Wheat yield, Recommended dose of fertilizers (RDF), Vermicompost, Phosphorus solubilizing bacteria (PSB)

## Introduction

Wheat (*Triticum aestivum* L.) is considered energetic dietary food among the cereal crops of Pakistan and occupies a major position in farming system (Anon, 2016). Wheat yield is being affected due to many factors like low rainfall, frost and heat hazards, imbalanced use of fertilizers, poor soil fertility and unaffordable cost of chemical fertilizers

in barani areas. However, rust and water shortage are the major factors which are reducing wheat yield each year (Rahman *et al.*, 2012; Ahmad *et al.*, 2010; Shad *et al.*, 1999).

Due to world energy crisis and highest prices of inorganic fertilizers, the application of organic sources as plant nutrients is gaining importance. Under such conditions, proper blending of both

organic and inorganic materials is essential which improve yield and enhance soil fertility and health (Pullicino *et al.*, 2009; Weber *et al.*, 2007). Pakistan is facing many challenges like food and energy crisis, therefore to feed the growing population that is increasing @ 2.6% every year, latest technologies of cultivation have to be explored to improve the yield (Qazilbash, 2002). Mineral fertilizers are powerful and immediate sources to meet the requirement, but the prices of inorganic chemical source are very high, non environment friendly and also unaffordable for poor farmers.

There are some other but little approaches available that can be adapted for the production of quality food. Maximum cultivated area is utilized for production of wheat in Pakistan than other crops therefor, wheat is considered the most important crop for Pakistani agriculture. Efficient organic resources should be focused in cereals especially in wheat to improve quality and production (Anon, 2007). The reduction of crop yield and soil fertility is due to the less application of bio-sources to soil (Shibu *et al.*, 2010). Organic nutrient sources are caused by the carbon inputs (Lal, 2004), that has significant impact on various soil properties (Kumar and Goh, 1999). The application of composts and vermicompost (VC) as organic sources, except inorganic fertilizer and raw manure, enhance macro and micro nutrients, thereby ultimately improve soil health (Jack and Thies, 2006). Vermicomposting is aerobic, biological technique to convert organic wastes into fine form of organic substances. Application of organic compost and vermicompost boost the multiplication of microbes (nitrogen fixing bacteria and actinomycetes) and hence improve soil nitrogen and phosphorus (Chanda *et al.*, 2011). Arslan *et al.* (2016) stated that the plant yield and nutrient uptake was enhanced by the application of vermicompost and full dose of phosphorus on mung bean. Livleen *et al.* (2013) while investigating the role of vermicompost and microbial inoculant on wheat also reported substantial increase in wheat yield in those treatments where organic and bio-sources were applied combinedly. The use of manures @10 tons ha<sup>-1</sup> and vermicompost @ 5 tons ha<sup>-1</sup> along with 60 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>, PSB and 40 kg S ha<sup>-1</sup> gave maximum yield of grain and straw (Patel *et al.* 2014). Kumar *et al.*, (2017) also reported positive effect of vermicompost @ 5 tons ha<sup>-1</sup> and phosphorus solubilizing bacteria on wheat yield and yield attributes. In view of the above facts, the experiment was designed to assess the

consequence of organic and biological sources in the form of vermicompost and microbial inoculants along with inorganic nutrients on soil health and wheat yield under rainfed conditions.

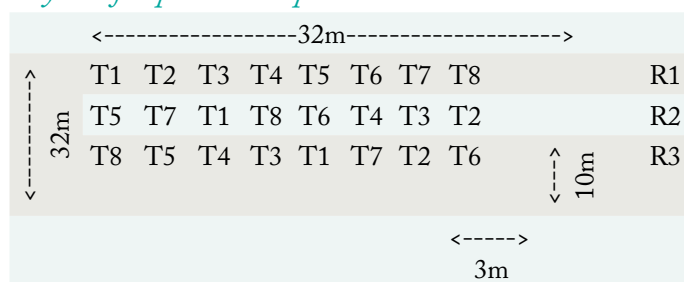
## Materials and Methods

A two years field study was conducted to assess the integrated effect of vermicompost, microbial inoculation and mineral fertilization on growth and yield of wheat cultivar Barani-17 at Barani Agricultural Research Institute (BARI), Chakwal (32°55'33"N, 72 °43'30"E) during 2017-18 to 2018-19 with the mean rain fall during monsoon season for 2017-18 and 2018-19 was 210mm and 140mm respectively. Soil samples were collected prior to sowing at two depths of 0-15cm and 15-30cm using soil sampler and analyzed for soil texture (Hydrometer method) pH/EC (US Salinity lab staff, 1954), Organic matter (Walkley, 1947), available Nitrogen (Bremner *et al.*, 1965), available phosphorus (Olsen *et al.*, 1954) and available potassium (flame photometer method) in soil science lab of BARI, Chakwal. Soil pH was neutral to slightly alkaline as 7.6, non-saline EC 0.78 dSm<sup>-1</sup>, low in organic matter 0.31%, poor available nitrogen (3mg kg<sup>-1</sup>) and low available phosphorus (2.5mg kg<sup>-1</sup>) and medium in available potassium (110mg kg<sup>-1</sup>). The texture of soil was clay loam with low moisture contents 3% (Gravimetric method) in upper layer (0-6 inch) and 7.2% in lower layer (6-12 inch). Well prepared vermicompost was obtained from vermiculture unit existing at BARI that was analyzed for mineral composition given in Table 1 and PSB inoculants were collected from Land Resources Research Institute, NARC Islamabad to evaluate the efficiency under rainfed condition of Chakwal. Fertilizer, vermicompost was applied at the time of sowing and wheat seed was inoculated with PSB prior to sowing. The experiment was laid out in RCBD factorial design using eight treatments e.g. T<sub>1</sub>: control where fertilizer, vermicompost (VC) and PSB was not applied, T<sub>2</sub>: Recommended fertilizers (RF) of NPK (120:85:60) in kg ha<sup>-1</sup> was applied (Department of Agriculture Govt. of Punjab), T<sub>3</sub>: Vermicompost (VC) @ 4t ha<sup>-1</sup>, T<sub>4</sub>: Phosphorus Solubilizing Bacteria (PSB), T<sub>5</sub>: Recommended fertilizers (RF) + VC @ 4t ha<sup>-1</sup>, T<sub>6</sub>: Recommended fertilizers (RF) + PSB, T<sub>7</sub>: VC @ 4t ha<sup>-1</sup> + PSB, T<sub>8</sub>: Recommended fertilizers (RF) + VC @ 4t ha<sup>-1</sup> + PSB. and three replications. The crop was

sown with a single hand drill method maintaining row to row distance as 22.8cm keeping each plot size of 3mx10m. As 2<sup>nd</sup> year study was conducted on the same experimental site where 1<sup>st</sup> year was conducted hence, the residual effect of previously applied vermicompost on soil and crop yield was also assessed after two years study. Agronomic data on no. of tillers per square meter by counting no. of tillers, plant height (cm) using meter rod, thousand grain weight (g) by weighing balance, spike length (cm) by measuring scale and final yield (kg ha<sup>-1</sup>) using weighing balance after harvest was recorded and analyzed statistically (stat 8.1) using Least Significant Difference (LSD) multiple range test P≤0.05 (Steel, 1997). The benefit cost ratio (BC) was also determined for each treatment by calculating amount of total income and total cost of production.

$$B:C = \frac{\text{Total Income (Rs.)}}{\text{Cost of Production (Rs)}}$$

#### Layout of experimental plot



**Table 1: Composition of vermicompost.**

Parameters	Unit	Vermicompost
Organic carbon	%	30
Nitrogen	%	2
Phosphorus	%	0.3
Potassium	%	1.8
Magnesium	mg kg <sup>-1</sup>	450
Zinc	mg kg <sup>-1</sup>	150
Copper	mg kg <sup>-1</sup>	45
Iron	mg kg <sup>-1</sup>	1600
CN ratio		16
pH		6.8
Moisture	%	27

## Results and Discussion

### Plant height

Results exhibited that all the parameter concerning wheat growth and yield were significantly affected by

integrated application of vermicompost and microbial inoculants in combination with inorganic fertilizers (Table 2). For grain crops although plant height is not a yield constituent but it showed the impact of diverse nutrients on plant metabolism. Results indicated that when vermicompost and microbial inoculants in combination with inorganic fertilizers were applied it significantly increased in plant height over control. Maximum plant height (95cm, 96cm) during 2017-18 and 2018-19, was observed in plots where integrated organic, inorganic and biological sources (T<sub>8</sub>) were applied. Minimum plant height (81cm; 81cm) in both years was recorded in control. The plant height increases in response to integrated application might be mainly due supplementary contribution of nitrogen from different sources (Awan *et al.*, 2011; Meena *et al.*, 2003).

### No of tillers/m<sup>2</sup>

The integrated application of vermicompost, PSB and RF significantly increased number of tillers m<sup>-2</sup>. The Highest number of tillers m<sup>-2</sup> (348; 352) were found in T<sub>8</sub> during 2017-18 and 2018-19, respectively. Control treatment (T<sub>1</sub>) showed minimum tillers m<sup>-2</sup> (240; 238) during both consecutive years. Optimum accessibility of the required nutrients may increase number of tillers (Brahmachari *et al.*, 2011). The results also indicated that no. of tillers increased where appropriate amount of NPK and vermicompost was applied. This kind of trend may be due to the effect of VC and NPK that ultimately improve soil fertility during the two years, respectively. Maqsood *et al.* (2001) revealed that adequate application of NPK increased in number of tillers.

### Spike length

A significant increase in spike length was found over control and maximum spike length (12.3cm and 14cm) was found in T<sub>8</sub> treatment (RF + VC + PSB) whereas in control the spike length was only 9.1cm and 11.9cm during the years 2017-18 and 2018-19, respectively. However, only slight difference in spike length was observed in all other treatments. These results may be due to the addition RF and vermicompost which improved nutrient status of soil. Dahiya *et al.* (2008) and Rather and Sharma (2010) also reported the similar findings in wheat. Increase in spike length in the treatment where organic and inorganic fertilizers were used collectively might be due to high availability of nutrients (Awan *et al.*, 2011; Babu *et al.*, 2001).



**Table 2:** Effect of vermicompost, microbial inoculants and RF on agronomic parameters of wheat.

Trt.	Plant height (cm)		No. of tillers (m <sup>-2</sup> )		Spike length (cm)		1000 Grain weight (g)		No. of grains (spike <sup>-1</sup> )		Grain yield (Kg ha <sup>-1</sup> )	
	17-18	18-19	17-18	18-19	17-18	18-19	17-18	18-19	17-18	18-19	17-18	18-19
T <sub>1</sub>	81e	81e	240e	238f	9.10e	10.9e	29d	24c	34e	28e	572e	887f
T <sub>2</sub>	88cd	91abc	287c	287d	10.7c	12.7cd	37c	37b	51cd	51bcd	1963bc	1863bcd
T <sub>3</sub>	88cd	88cd	248e	250f	10.4cd	12.4d	37c	42ab	47d	46d	1233d	1450de
T <sub>4</sub>	90bc	93ab	266d	270e	10d	12.0d	38bc	37b	51cd	49d	1383d	1333ef
T <sub>5</sub>	91abc	90bcd	319b	319c	11.3b	13.3bc	41ab	42ab	55bc	55bc	2033b	2311b
T <sub>6</sub>	93ab	94ab	328b	336b	11.7b	13.6b	40abc	40ab	59ab	57b	1878bc	2057bc
T <sub>7</sub>	84de	85de	299c	307c	10.1d	12.0d	38bc	39b	50d	50cd	1594cd	1628cde
T <sub>8</sub>	95a	96a	348a	352a	12.3a	14.0a	44a	46a	63a	65a	2484a	3179a
CV	3.17	3.10	3.13	3.22	3.01	3.21	5.94	9.19	5.5	6.94	13	14
LSD <sup>(0.05)</sup>	5	5	16	17	0.56	0.71	4	6	5	6	372	463

T<sub>1</sub>: control; T<sub>2</sub>: Recommended fertilizers (RF) of NPK (120:85:60) in kg ha<sup>-1</sup>; T<sub>3</sub>: Vermicompost (VC) @ 4t ha<sup>-1</sup>; T<sub>4</sub>: Phosphorus Solubilizing Bacteria (PSB); T<sub>5</sub>: Recommended fertilizers (RF) + VC @ 4t ha<sup>-1</sup>; T<sub>6</sub>: Recommended fertilizers (RF) + PSB; T<sub>7</sub>: VC @ 4t ha<sup>-1</sup> + PSB; T<sub>8</sub>: Recommended fertilizers (RF) + VC @ 4t ha<sup>-1</sup> + PSB.

### 1000 Grain weight

Another main yield contributing parameter is the grain weight. The results showed that maximum thousand grain weight (44g during 1<sup>st</sup> year and 46g during 2<sup>nd</sup> year) was found in the treatment T<sub>8</sub> (RF + VC + PSB) which was about 51% higher over control treatment that was only 29g and 24g in the two years study. However, the treatments T<sub>5</sub> (Recommended fertilizer + vermicompost @ 4t ha<sup>-1</sup>) also performed better than control showing 41g during 1<sup>st</sup> year and 42 during 2<sup>nd</sup> year. This difference is due to the combined application of organic and inorganic fertilizers in the soil which provide maximum nutrient to the grain. Tahir *et al.* (2011) also observed increase in growth, yield and grain weight of wheat when applied nutrients through different organic sources.

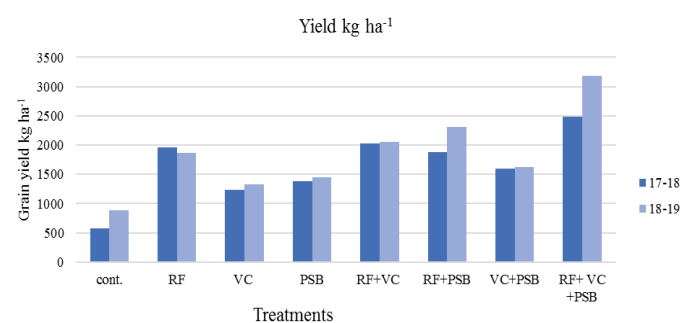
### Number of grains spike<sup>-1</sup>

Data on no. of grains spike<sup>-1</sup> indicated significant difference in the treatment T<sub>8</sub> (RF + VC + PSB) over treatment T<sub>1</sub> (control). Maximum no. of grains spike<sup>-1</sup> were 63 and 65 for the year 2017-18 and 2018-19, respectively whereas minimum grains spike<sup>-1</sup> were recorded in treatment T<sub>1</sub> (34 and 28 for both year) where no organic and inorganic input was applied. However, grains spike<sup>-1</sup> also improved in other treatments where individual or combined organic and inorganic source was used. These results are similar to the findings of Khan and Hussain (2001), who found that the farm yard manure and different levels of nitrogen and phosphorous significantly increased the number of grains.

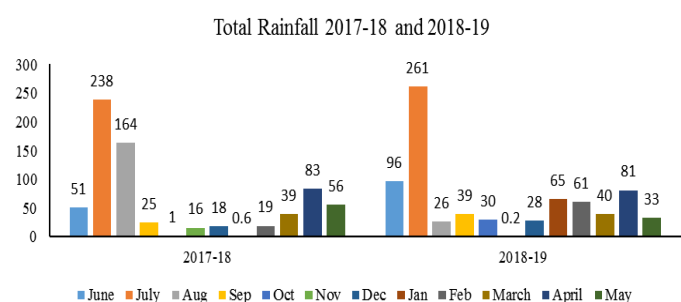
### Grain yield (kg ha<sup>-1</sup>)

In this study, highest grain yield (2784 kg ha<sup>-1</sup> and 3179 kg ha<sup>-1</sup>) was recorded in the T<sub>8</sub> treatment which was followed by T<sub>5</sub> and T<sub>6</sub> (572 kg ha<sup>-1</sup> and 887 kg ha<sup>-1</sup>). During the year 2017-18 and 2018-19, the treatment T<sub>7</sub> where vermicompost and PSB was applied depicted better grain yield (1594 kg ha<sup>-1</sup>, 1628 kg ha<sup>-1</sup>) than control (Figure 1). This increase in grain yield may be due to the collective application of organic, inorganic and biological sources that enhanced nutrient status in soil. Davari *et al.* (2012) revealed that combined use of biofertilizers and organic material increased the wheat yield. Same consequences were also stated by Moe *et al.* (2019) that the combined nutrient application through organic and mineral sources improved the rice grain yield significantly over control. As yield and yield attributes mainly depends on efficient source but Barani Agricultural Research Institute (BARI), Chakwal located in the region where rainfall is mostly uneven and 70% rainfall occurs during moonsoon season (July to September). Wheat yield is generally low due to such climatic constraints and insufficient use of inputs. (Punjab Development Statistics, 2013). Rainfall data was recorded from meteorological system installed in the Institute. It can be observed from the graph that rainfall pattern was different for both the year 2017-18 and 2018-19. During the first monsoon season maximum rainfall occur during July (238 mm) and August (164 mm) whereas during 2018-19 maximum rainfall occur in June-July (96mm and 261mm) that left less moisture at the time of sowing but a continuous spell of rain

from January 2019 to April 2019 occurred during the growing season of wheat that influence plant growth (Figure 2).



**Figure 1:** Effect of vermicompost and microbial inoculants and RDF on grain yield (kg ha<sup>-1</sup>) for 1<sup>st</sup> year 2017-18 and 2<sup>nd</sup> year 2018-19 respectively.



**Figure 2:** Total rainfall pattern in Barani agricultural research institute, Chakwal.

### Effect on soil fertility

Post-harvest soil analysis was done and it was observed that soil fertility improved where organic sources fertilizers were applied. Application of VC @ 4t ha<sup>-1</sup> and microbial inoculant along with RF significantly increased OM, available nitrogen, phosphorus and potash in soil over control. However, soil fertility improvement was observed in all treatments where organic and inorganic sources were applied except control. This improvement in soil health might be a factor that increase wheat yield. Pandey *et al.* (2009) also found improvement in soil fertility when FYM applied along with chemical fertilizers in wheat.

### Economic analysis

For economic analysis, total production cost and total income were calculated separately. The total production included cost of POL for tillage practices, seed, Fertilizers, weedicides, vermicompost preparation cost, PSB and Threshing via combine harvester. These costs were calculated on the basis of inputs applied and then converted into per hectare area. Similarly output cost for grain and straw yield was calculated for all the treatments (Table 4).

**Table 3:** Post Harvest soil analysis.

Treatments	OM (%)	NO <sub>3</sub> -N (mg kg <sup>-1</sup> )	P (mg kg <sup>-1</sup> )	K (mg kg <sup>-1</sup> )
Control	0.28	4	3.32	104.67
RF	0.35	8	7.11	117.67
VC	0.44	10	8.14	120.00
PSB	0.30	6	6.11	101.00
RF+VC	0.48	11	8.34	121.67
RF+PSB	0.39	8	7.74	116.67
VC+PSB	0.46	10	8.48	109.67
RF+ VC+PSB	0.58	13	9.4	128.33
CV	3.46	10.94	9.58	3.55
LSD <sub>(0.05)</sub>	0.03	1.7	1.23	7.15

**Table 4:** Total input/ income cost and Output/production cost (Rs.).

Input/Management practices	Cost ha <sup>-1</sup> (Rs.)	
	2017-18	2018-19
Seed (Certified seed)	6500	6875
Fertilizer (Urea, DAP, SOP)	19250	21250
Vermicompost	12500	12500
PSB inoculants (NARC)	1500	1500
Harvest (Rs. 1500 Acre <sup>-1</sup> )	3750	3750
Weedicide (Buctral Super; 3L ha <sup>-1</sup> )	5000	5000
POL (Sowing, 03 tillages)	10000	12500
Total input cost	58500	63375
Total Output/Income Rs. ha <sup>-1</sup>	2017-18	2018-19
Grain Yield market Rate (Rs./40kg)	1200	1250
Straw market rate (Rs./40kg)	450	450

The economic analysis is the only tool, which compels the farmers to decide what to grow and what not to grow (Khan *et al.*, 2009). Therefore, the economic analysis of agroecosystems is necessary for good management. Input cost of wheat in the first year varied from Rs. 25250 ha<sup>-1</sup> for the control to Rs. 72500 ha<sup>-1</sup> for T<sub>8</sub> (RF+VC+PSB), and for 2<sup>nd</sup> year from Rs. 28125 ha<sup>-1</sup> for the control to Rs. 63375 with treatment T<sub>8</sub>. The combined application of RF+VC and microbial inoculants given in different treatments no doubt increased cost of production for 1<sup>st</sup> year and for 2<sup>nd</sup> year, but also increased net return as Rs. 50781 ha<sup>-1</sup> and Rs. 83669 ha<sup>-1</sup> (T<sub>8</sub>) for 1<sup>st</sup> and 2<sup>nd</sup> year over control i.e Rs. -97 ha<sup>-1</sup> and Rs. 12914 ha<sup>-1</sup> (Tables 5 and 6). The economic value of wheat cultivation was improved with integrated nutrient application of organic, inorganic and biological sources as reported by Sharma *et al.* (2000) and Singh and Prasad (2011).

**Table 5:** Total Production cost and B:C for the year 2017-18.

Trt	Seed (RS./ha)	Fertilizers (RS./ha)	Weedicide (RS./ha)	Harvester (RS./ha)	POL (RS./ha)	T. Input (RS./ha)	T. output (RS./ha)	Net (Rs./ha)	BC
T1	6500	0	5000	3750	10000	25250	25153	-97	1.00
T2	6500	33250	5000	3750	10000	58500	86372	41872	1.48
T3	6500	12500	5000	3750	10000	37750	54267	16517	1.44
T4	6500	1500	5000	3750	10000	26750	58100	31350	2.17
T5	6500	45750	5000	3750	10000	71000	89452	32452	1.26
T6	6500	34750	5000	3750	10000	60000	82617	36617	1.38
T7	6500	14000	5000	3750	10000	39250	70151	30901	1.79
T8	6500	47250	5000	3750	10000	72500	109281	50781	1.51

**Table 6:** Total Production cost and B:C for the year 2018-19.

Trt.	Seed (RS./ha)	Fertilizer (RS./ha)	Weedicide (RS./ha)	Harvester (RS./ha)	POL (RS./ha)	T. Income (RS./ha)	T. Output (RS./ha)	Net (Rs./ha)	BC
T1	6875	0	5000	3750	12500	28125	41039	12914	1.46
T2	6875	21250	5000	3750	12500	49375	86148	36773	1.74
T3	6875	12500	5000	3750	12500	40625	61667	21042	1.52
T4	6875	1500	5000	3750	12500	29625	64163	34538	2.17
T5	6875	33750	5000	3750	12500	61875	95136	33261	1.54
T6	6875	22750	5000	3750	12500	50875	106884	56009	2.10
T7	6875	14000	5000	3750	12500	42125	75280	33155	1.79
T8	6875	35250	5000	3750	12500	63375	147044	83669	2.32

T<sub>1</sub>: control; T<sub>2</sub>: Recommended fertilizers (RF) of NPK (120:85:60) in kg ha<sup>-1</sup>; T<sub>3</sub>: Vermicompost (VC) @ 4t ha<sup>-1</sup>; T<sub>4</sub>: Phosphorus Solubilizing Bacteria (PSB); T<sub>5</sub>: Recommended fertilizers (RF) + VC @ 4t ha<sup>-1</sup>; T<sub>6</sub>: Recommended fertilizers (RF) + PSB; T<sub>7</sub>: VC @ 4t ha<sup>-1</sup> + PSB; T<sub>8</sub>: Recommended fertilizers (RF) + VC @ 4t ha<sup>-1</sup> + PSB.

### Conclusions and Recommendations

Number of yield and yield attributes were positively affected with combined application of vermicompost PSB and chemical fertilizers. It is also evident that application of organic sources particularly vermicompost can be an excellent organic fertilizer which improved soil physical and chemical properties that was reflected in wheat growth and production. It can also be concluded that if vermicompost is applied in combination with chemical fertilizers can be an alternative substitute of applying chemical fertilizers alone. As vermicompost is rich source of nutrients but have lower quantities of NPK than chemical fertilizers, it has to be applied in bulk quantity which may become costlier and uneconomical hence it should be applied in combination with PSB and chemical fertilizers which will not only boost plant yield but also be economical.

### Novelty Statement

Integrated application of mineral fertilizers along

with microbial inoculants and vermicompost not only increase the wheat production and economic returns but also improve the soil health

### Author's Contribution

Muhammad Arsaln: Conceived the idea, design and conducting experiment, paper writeup.

Sair Sarwar: Data recording, paper writeup and overall management of the article.

Rizwan Latif: Help in conducting experiment and data recoding.

Junaid Nawaz Chaudhary: Statistical analysis of data and arranging figures and tables.

Munazza Yousra: Data organization and paper review etc.

Shahbaz Ahmad: Technical inputs and provision of biofertilizer and compost for experiment

### Conflict of interest

The authors have declared no conflict of interest.

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