Ameriolation of vermicompost and inorganic fertilizer on late-sown wheat Productivity

ABSTRACT

Wheat is the major staple food source worldwide. Due to the excessive use of inorganic fertilizer and unbalanced fertilization, the quality and productivity of soil, as well as the grains are reducing. So, there is a need to apply a balanced mix of organic and inorganic fertilizers to maintain a sustainable yield that helps to feed the ever-increasing population. The experiment was laid out in randomized block design (RBD) with 14 treatments of three replicates. The treatments were as follows: T_1; control, T_2; Vermicompost (VC) (2.0 t.ha^{-1}), T_3; VC (4.0 t.ha^{-1}), T_4; VC (6.0 ton.ha^{-1}), T_5; RDF (100%), T_6; VC (2.0 t.ha^{-1} + 75% RDF), T_7; VC (2.0 t.ha^{-1} +100% RDF), T_8; VC (2.0 t.ha^{-1} + 125% RDF), T_9; VC (4.0 t.ha^{-1} +75% RDF), T_{10} VC (4.0 t.ha^{-1} + 100% RDF), T_{11}; VC (4.0 t.ha^{-1} + 125% RDF), T_{12}; VC (6.0 t.ha^{-1} + 75% RDF), T_{13}; VC (6.0 t.ha^{-1} +100% RDF), and T_{14}; VC (6.0 t.ha^{-1} +125% RDF). The results revealed that the treatment T_{14} gave significantly better growth parameters and yield contributing characters with the highest grain and straw yield (4.38 t.ha^{-1} and 7.13 t/ha, respectively) compared to others. The minimum grain yield (2.74 t.ha^{-1}) and straw yield (4.80 t.ha^{-1}) were recorded under treatment T1 (control).

Keywords: inorganic fertilizer, Vermicompost, Wheat, Yield

INTRODUCTION

“Wheat is one of the most popular and staple foods in India among vegetarians and non-vegetarians. It compares well with other cereals in nutritive value. It has a good nutrition profile with 12.1% protein, 1.8% lipids, 1.8% ash, 2.0% reducing sugar, 6.7% pentose, 59.2% starch, and a good source of minerals, vitamins, and nicotinic acid” (Agam *et al*., 2017). It is processed in different forms like flour, Suzi, and maida, and is eaten by consumers in different ways such as porridge (Halwa), chapati, bread, and biscuits. Besides that, wheat straw and wheat bran are good sources of feed for animals (Yadav *et al.*, 2014). Wheat is mainly grown in the Fall season (October-December to March-May) along with Barley, Lentils, Peas, Mustard, and Potatoes. The Production of Wheat during 2020-21 was estimated at 109.52 million tons. It is higher by 9.10 million tons than the average wheat production of 100.42 million tons (Anonymous, 2022). China is the top country in wheat production with 134,250 thousand tons which accounts for 20.66% of the world's wheat production in 2020, while India, the Russian Federation, the United States of America, and Canada account for 63.46%. The world's total wheat production was estimated at 649,759 thousand tons in 2020. India is the second largest producer and consumer of wheat in the world and therefore there is a need to increase the production of wheat and here focusing to boost the economy of the nation by combining the application of organic and inorganic fertilizers.

“Today, chemical fertilizers are used as the most economical tool to achieve maximum production per unit area and compensate for the shortage of resources, which leads to increased production costs along with the destruction of soil, water, and biological resources. Wheat is one of the most strategic crops and is of great importance in the diet of human societies”. [27] “Wheat plays an important role in providing essential minerals, carbohydrates, and protein, and if wheat production increases, many food deficiencies will be addressed" (Akbarabadi *et al*., 2015). "Most crops, including cultivated cereals, are deficient in micronutrients. Deficiency of these elements in the soil not only reduces the yield of the plant but also reduces the absorption of these elements by humans and livestock and this leads to various diseases and endangers public health" (Zirgoli and Kahrizi, 2015).

"Therefore, the availability of nutrients in the soil determines the nutrient status of the plant. Deficiency or lack of sufficient micronutrients in the soil not only reduces crop productivity but also reduces the nutritional quality of agricultural products, thus leading to malnutrition in the human population and causing many hidden but hidden human health problems" (Zuo and Zhang, 2011). "When nutrients are present in the soil crops, plants will grow well and produce significant amounts of biomass. Providing nutrients in the soil determines the status of these nutrients in the plant and the most important mission of agriculture is the production of healthy and nutritious food in human societies to achieve food security" (Mohammadi *et al*., 2015). "The effects of chemical fertilizers have caused contamination in the soil, which is one of the threatening factors of production resources and is one of the most important agricultural concerns today. But bio-organic fertilizers will not cause soil pollution compared to mineral fertilizers" (Savci, 2012; Awan *et al*., 2020; Sarker *et al*., 2020).

"Proper plant nutrition based on the use of organic fertilizers is one of the basic principles of achieving sustainable agriculture and plays an important role in improving the quality and quantity of agricultural products and the availability of nutrients. Chemical fertilizers, environmental protection, and enrichment of agricultural products are effective in food security and the health of human communities" (Jat *et al.*, 2015). "Soil remediation using organic fertilizers can be considered a useful way to improve the sustainability of agricultural systems. The use of organic fertilizers, soil organic matter, and nutrients increases the growth and activity of microorganisms and maintains the structure of the soil, and helps keep the plant healthy. Increasing biological activity improves nutrients from chemicals, organics, sources and decomposition of toxic substances, and nutrient exchange capacity" (Chew *et al*., 2019).

"Reducing the use of chemical fertilizers and replacing them with organic and integrated fertilizers has increased the yield, which is desirable and useful for achieving sustainable agriculture. The use of chemical fertilizers changes the concentration of soil salts and causes changes in soil acidity which leads to the deposition or dissolution of trace elements by affecting their balance in the soil" (Lansdown, 1995). "Today, vermicompost is considered a simple biotechnological process of compost and an eco-friendly process, so this process is used to obtain organic fertilizers from waste" (Thakur *et al*., 2021). "With the increasing application of different levels of vermicompost in the soil, the concentration of zinc and copper in the soil increases" (Thakur *et al*., 2021). "Nitrogen chemical fertilizer has a significant effect on wheat yield and quality" (Liu *et al*., 2021). "Organic fertilizers can reduce phosphorus uptake and increase plant access to phosphorus" (Adnan *et al*., 2020).

"The combined use of organic and inorganic fertilizers is an effective way to maintain nutrient supply, provide the soil microbes with organic carbon, and mobilize soil-bound nutrients on decomposition through the release of organic acids" (Sharma *et al*., 2013). "Integration of inorganic fertilizers with organic manures and bio-fertilizers will not only help sustain crop productivity but also will improve soil health and increase nutrient-use efficiency" (Verma *et al*., 2006). We aimed to evaluate the effectiveness of organic and inorganic fertilizers for improving the growth and yield of wheat crop and their economics.

MATERIAL AND METHODS

Field experiments were conducted during the winter of 2018-19 at the Student Instructional Farm (SIF) of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur

(U.P.), India. The soil was sandy loam having organic carbon of up to 0.45 % with pH 7.3, N 170 $kg.ha^{-1}$, P_20_5 16 kg ha^{-1}, and K_20 180 $kg.ha^{-1}$ at the start of the experiment in 0 to 30 cm soil layer (Table 1).

Table 1: Chemical analysis of the soil of the experimental field

SN	**Soil characteristics**	**Value**	**Method of determination**
1	Organic carbon (%)	0.45	Walkley and Black rapid titration method (Walkey and Black, 1934).
2	Soil PH	7.3	Glass electrode pH meter (Piper, 1950)
3	E.C. (mmhos/cm at 25^0C	0.22	Electrical conductivity bridge method (Jackson, 1973)
4	Available nitrogen (kg/ha)	170	Alkaline potassium permanganate method (Subbiah and Asija (1956))
5	Available phosphorus (kg/ha)	16	Olsen's method (Olson, 1960)
6	Available potash (kg/ha	180	Flame photometric method (Hanway and Heidal (1952))

The experiment consists of fourteen treatments as follows T_1; control, T_2; Vermicompost (VC) (2.0 $t.ha^{-1}$), T_3; VC (4.0 $t.ha^{-1}$), T_4; VC (6.0 $ton.ha^{-1}$), T_5; RDF (100%), T_6; VC (2.0 $t.ha^{-1}$ + 75% RDF), T_7; VC (2.0 $t.ha^{-1}$ +100% RDF), T_8; VC (2.0 $t.ha^{-1}$ + 125% RDF), T_9; VC (4.0 $t.ha^{-1}$ +75% RDF), T_{10} VC (4.0 $t.ha^{-1}$ + 100% RDF), T_{11}; VC (4.0 $t.ha^{-1}$ + 125% RDF), T_{12}; VC (6.0 $t.ha^{-1}$ + 75% RDF), T_{13}; VC (6.0 $t.ha^{-1}$ +100% RDF), and T_{14}; VC (6.0 $t.ha^{-1}$ +125% RDF) (Table 2). The results illustrated that treatment T14 provided the highest grain and straw yields(4.38 $t.ha^{-1}$ and 7.1 $t.ha^{-1}$, respectively) were compared to the other treatments. It also provided substantially enhanced growth traits and yield-contributing features. Under treatment T1 (control) . The the least grain yield (2.7 $t.ha^{-1}$) and straw output (4.8 $t.ha^{-1}$) were obtained.

The experiment was laid out in randomized block design with three replications. Vermicompost was applied 15 days before sowing as per treatment. Wheat cultivar Unnat

Halna (K-9423) was sown in rows 22.50 cm apart on 25 December, 2018 and harvested on 22 April, 2019. Half of nitrogen and full dose of phosphorus and potash were applied at the time of sowing as per treatment combination. The remaining nitrogen as per treatment was top dressed after first irrigation. N, P and K were applied through urea, single super phosphate, and murate of potash respectively. The crop received three uniform irrigations at crown root initiation, flowering, and milking stages. Organic carbon, pH, available N, P, K of soil and N, P, K contents in plants were estimated. Nutrient uptake was estimated by multiplying the dry-matter accumulation at maturity in grain and straw of wheat by their respective percentages. Total uptake was calculated by adding uptake of grain and straw. The yield parameters and yields were recorded and analyzed as per Gomez and Gomez (1984). The treatment comparisons were made using t-test at 5% level of significance. The economics was calculated on the basis of prevailing local market price of wheat grains and cost of inputs**.**

Table 2: Treatment Combination

Symbol	**Treatments**
T_1	Control
T_2	VC at a rate of 2.0 $t.ha^{-1}$
T_3	VC at a rate of 4.0 $t.ha^{-1}$
T_4	VC at a rate of 6.0 $t.ha^{-1}$
T_5	100% RDF
T_6	VC at a rate of 2.0 $t.ha^{-1}$+75% RDF
T_7	VC at a rate of 2.0 $t.ha^{-1}$+100% RDF
T_8	VC at a rate of 2.0 $t.ha^{-1}$+125% RDF
T_9	VCat a rate of 4.0 $t.ha^{-1}$+75% RDF
T_{10}	VC at a rate of 4.0 $t.ha^{-1}$+100% RDF

T_{11}	VC at a rate of 4.0 $t.ha^{-1}$+125% RDF
T_{12}	VC at a rate of 6.0 $t.ha^{-1}$+75% RDF
T_{13}	VC at a rate of 6.0 $t.ha^{-1}$+75% RDF
T_{14}	VC at a rate of 6.0 $t.ha^{-1}$+75% RDF

RESULTS AND DISCUSSION

Effect on growth parameters

Plant height (cm)

The results in (Table 3 and Fig. 1) showed that different manures and fertilizers had a significant ($P < 0.05$) effect on the plant height. The maximum and minimum heights were recorded at 30, 60, and 90 DAS and maturity stages for the treatment T_{14} and T_1. The effect of chemical fertilizers on plant growth was due to the increased availability of nutrients, especially nitrogen, and phosphorus. Nitrogen increases the growth of aerial organs, phosphorus increases the energy transfer for the growth of plant vegetative organs, and improves photosynthesis. The increase of these traits by chemical fertilizers can be considered by increasing the length of intermediates attributed to the availability of water and nutrients required (Jamir *et al.,* 2017). The increase in plant height is probably a consequence of the increased number of spikes per unit area and the control treatment, and light and nutrient availability (Geravandi *et al*., 2011). The use of chemicals and manures separately had the highest and lowest plant height. Nitrogen increase leads to an increase in plant height and has a significant ($P < 0.05$) effect on plant aerial height. Consumption of organic fertilizers along with chemical fertilizers increased the length of the spike compared to the control. Increasing the height of the plant contributed to higher fertility and more flowers, which increases the number of seeds per spike (Sepahvand *et al*., 2021).

Dry matter accumulation (g.plant^{-1})

The results in Table 3 and Fig. 2 revealed a significant ($P < 0.05$) mass increase in dry matter from 30 to 90 DAS due to faster growth and a further increase in dry matter until maturity was very slow because of the diminishing growth rate of crop. The results showed that there was a significant ($P < 0.05$) difference between the treatments at 30, 60, and 90 DAS and harvest stages. At 30 DAS, treatment T_{13} recorded the highest dry matter accumulation, while the lowest dry matter was recorded in treatment T_1. Dry matter accumulation at 60 DAS revealed the highest in T_{14}. At 90 DAS, treatment T_{14} showed the highest dry matter accumulation which is on par with treatments T_{11}, T_{12}, and T_{13}, and the lowest dry weight was recorded in T_1. At the harvest stage, treatment T_{14} showed the highest dry matter accumulation per plant. The increase in dry matter accumulation was due to the balanced application of nutrients that were supplied through organic and inorganic sources. Plants utilize adequate amounts of soil nutrients which increases their photosynthetic areas and led to more dry matter accumulation. Similar findings were observed by (Kakraliya *et al.*, 2017).

Table 3: Effects of vermicompost and inorganic fertilizer on growth parameters of late sown

Treatment	**Plant height (cm)**				**Dry matter accumulation (g/plant)**			
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
T1: Control	9.35	49.64	52.24	54.14	1.67	5.55	13.15	16.85

T2: VC (2.0 $ton.ha^{-1}$)	11.30	60.00	61.81	63.07	1.84	6.12	14.51	18.59
T3: VC (4.0 $ton.ha^{-1}$)	11.40	60.56	62.35	63.63	1.84	6.13	14.54	18.63
T4: VC (6.0 $ton.ha^{-1}$)	11.72	62.23	64.05	65.33	1.88	6.24	14.80	18.57
T5: 100% RDF	12.04	63.95	65.79	67.11	1.90	6.34	15.04	19.27
T6: VC 2.0 $ton.ha^{-1}$+75% RDF	12.69	67.44	69.38	70.80	1.90	6.55	15.61	20.00
T7: VC 2.0 $ton.ha^{-1}$+100% RDF	13.03	69.26	71.18	72.65	2.06	6.87	16.28	20.86
T8: VC 2.0 $ton.ha^{-1}$+125% RDF	13.27	70.52	72.45	73.60	2.11	7.03	16.67	21.36
T9: VC 4.0 $ton.ha^{-1}$+75% RDF	13.38	71.06	72.70	73.90	2.15	7.15	16.96 33	21.74
T10: VC 4.0 $ton.ha^{-1}$+100% RDF	13.53	71.86	73.66	75.12	2.17	7.21	17.08	21.88
T11: VC 4.0 $ton.ha^{-1}$+125% RDF	13.89	73.79	75.88	77.36	2.20	7.31	17.32	22.19
T12: VC 6.0 $ton.ha^{-1}$ +75% RDF	14.40	76.50	78.63	80.30	2.22	7.40	17.51	22.43
T13:VC 6.0 $ton.ha^{-1}$+100% RDF	14.62	77.67	79.97	81.50	2.80	7.57	17.95	23.00
T14: VC 6.0 $ton.ha^{-1}$+125% RDF	14.93	79.30	81.69	83.09	2.32	7.72	18.30	23.43
SEm (±)	0.57	1.68	1.64	1.56	0.04	0.37	0.47	0.67
CD at 5%	1.17	3.46	3.38	3.21	0.09	0.76	0.97	1.39

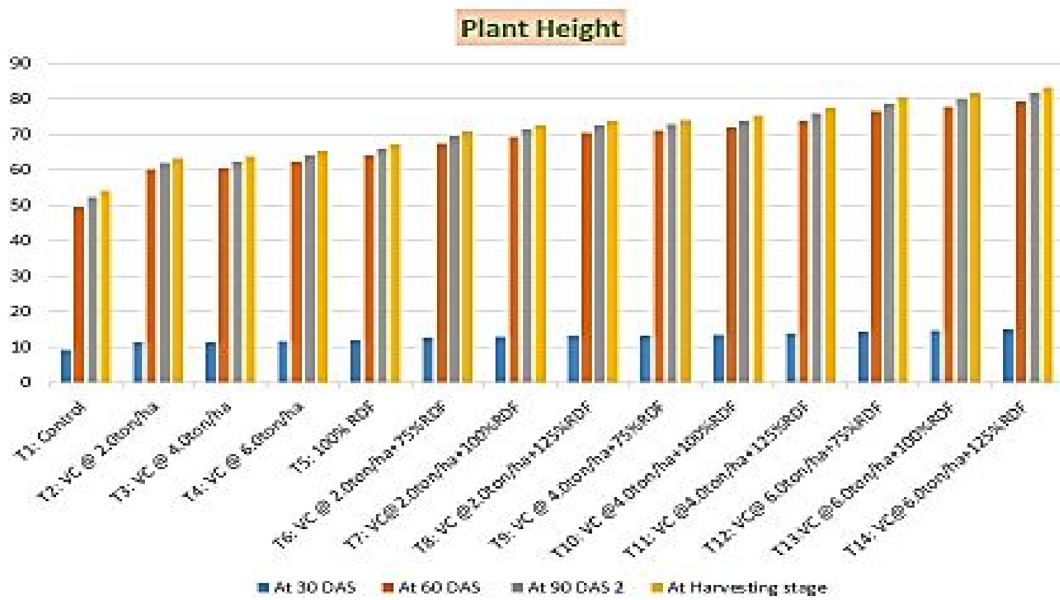

Figure 1: Effects of vermicompost and inorganic fertilizer on growth parameters of late-sown wheat

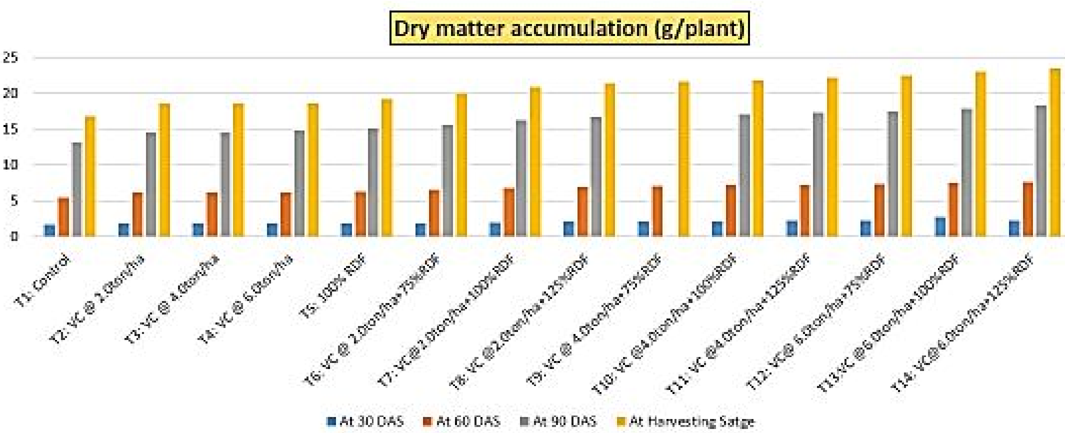

Figure 2: Effects of vermicompost and inorganic fertilizer on growth parameters of late-sown wheat

Effect on yield attributes

Integrated use of fertilizers with vermicompost increased the dry matter accumulation, number of effective tillers, grains/spike, and the test weight (Fig. 3). The enhanced early vegetative growth in terms of higher leaf area, dry matter accumulation, and vigorous root system resulted in more spikes which consequently increased the number of spike bearing tillers significantly. It might be due to the stimulated vegetative growth of wheat on account of an adequate and prolonged supply of essential nutrients. The number of effective tillers, grain/spike, and test weight produced by the application of T_{14} were found to be significantly ($P < 0.05$) higher than the other treatments and the lowest from the control. These results are in line with Dey, S.R *et al*. (1999) who reported a significant increase in the number of plants per meter row by combined application of manure and fertilizers.

Grain yield (ton.ha^{-1})

The addition of vermicompost with different fertilizer levels produced significantly ($p < 0.05$) higher grain and biological yields than the application of fertilizers alone maximum grain yield and biological yield were obtained with the application of T_{14}. The lowest grain yield and biological yield were recorded from the control (Table 4). The increase in grain and biological yield might be due to adequate quantities and balanced proportions of plant nutrients supplied as per need during the growth period resulting in a favorable increase in yield attributing characters which ultimately led towards an increase in economic yield. Improved physicochemical properties of the soil through the application of organic manure might be the other possible reason for higher productivity. Rao *et al*., (1996) reported that the combination of organic and inorganic N sources resulted in comparable rice yield to the application of only inorganic nitrogen. Patil *et al*. (2000) reported that the combination of organic manure and fertilizer significantly improved the grain and biological yield of wheat.

All vermicompost and fertilizer rates produced significantly ($P < 0.05$) higher grain yield of wheat than the control. But the highest values were obtained with T_{14} followed by T_{13} and T_{12}. This is in agreement with Yousefi and Sadeghi (2014) who reported that application of vermicompost to soil significantly increases the yield of wheat. Grain yield is a result of numerous factors such as dry matter, effective tillers, and the number of filled grains. The higher the grain yield, the higher the dry matter accumulation and the greater number of filled grains per spike. This was due to the efficient utilization of nutrients giving vegetative growth and efficient partitioning of photosynthates.

Arancon and Edwards, (2005) demonstrated the beneficial effect of the application of vermicompost at different rates on the yields of other crops such as tomatoes. However, in addition to being a source of different nutrients, vermicompost is supposed to contain growth-promoting hormones (Edwards *et al*., 2004) which might facilitate higher nutrient uptake by plants and this could be an additional factor for the positive effect of vermicompost on crops. The positive effects of vermicompost and NPK fertilizers application on wheat in the current study suggested that the soils are low in nutrient contents, particularly of nitrogen potash. The result of initial soil analysis data also proves (Table 1) this claim.

Table 4: Effects of vermicompost and inorganic fertilizer on yield attribute

Treatment	**Effective tiller (m^{-2})**	**No of grains/ear**	**Test weight(g)**	**Grain yield (tons/ha)**	**Straw yield (tons/ha)**	**Harvest index (%)**

T1: Control	268.70	36.65	36.0	2.74	4.81	36.35
T2: VC (2.0 ton.ha^{-1})	297.17	40.53	36.35	3.34	5.6	37.15
T3: VC (4.0 ton.ha^{-1})	299.65	40.87	37.48	3.34	5.63	37.23
T4: VC (6.0 ton.ha^{-1})	303.21	41.33	37.21	3.43	5.77	37.33
T5: 100% RDF	308.04	42.02	37.26	3.53	5.94	37.41
T6: VC 2.0 ton.ha^{-1}+75% RDF	319.68	43.60	37.38	3.72	6.21	37.48
T7: VC 2.0 ton.ha^{-1}+100% RDF	333.41	45.46	37.56	3.82	6.35	37.56
T8: VC 2.0 ton.ha^{-1}+125% RDF	341.16	46.52	37.71	3.89	6.45	37.65
T9: VC 4.0 ton.ha^{-1}+75% RDF	347.59	47.39	37.86	3.95	6.47	37.75
T10: VC 4.0 ton.ha^{-1}+100% RDF	349.96	47.72	37.98	3.96	6.52	37.81
T11: VC 4.0 ton.ha^{-1}+125% RDF	354.84	48.41	37.68	4.75	6.68	37.87
T12: VC 6.0 ton.ha^{-1} +75% RDF	358.77	48.93	37.75	4.22	6.91	37.93
T13:VC 6.0 ton.ha^{-1}+100% RDF	367.74	50.15	38.18	4.29	7.00	37.98
T14: VC 6.0 ton.ha^{-1}+125% RDF	374.71	51.10	38.32	4.38	7.13	38.05
SEm (±)	5.68	0.75	0.28	1.67	2.54	0.23
CD at 5%	11.68	1.54	0.58	3.45	6.05	0.48

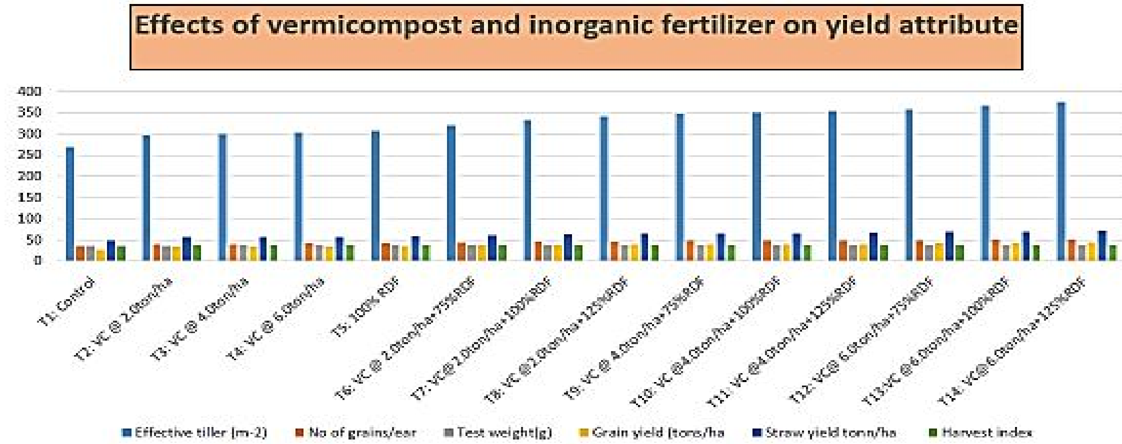

Figure 3: Effects of vermicompost and inorganic fertilizer on yield attribute

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Economics

Net Return and Benefit: The cost ratio increased with the supplementation of the recommended dose of fertilizer. Highest net return (Rs.77450.ha^{-1}) and B: C ratio (2.50) were obtained with the application of T_{14} (Table 5 and Fig. 4). Suthar (2006) reported that integrated application of NPK fertilizers with vermicompost in field crops not only influences growth and production of the plant but also reduces the production budget.

Table 5. Effect of Treatments on Economics

S.N	Treatment	cost of cultivation (Rs/h)	Gross income	Net income	B.C ratio (Rs/h)

			(Rs/h)	(Rs/h)	
1	Control	42485	83100	40615	1.96
2	VC (2.0 $ton.ha^{-1}$)	45610	99106	53496	2.17
3	VC (4.0 $ton.ha^{-1}$)	45780	99893	54113	2.18
4	VC (6.0 $ton.ha^{-1}$)	46545	102509	55964	2.20
5	100% RDF	46995	105401	58406	2.24
6	VC 2.0 $ton.ha^{-1}$+75% RDF	47213	110778	63508	2.34
7	VC 2.0 $ton.ha^{-1}$+100% RDF	48025	103614	65589	2.37
8	VC 2.0 $ton.ha^{-1}$+125% RDF	48530	115528	66998	2.38
9	VC 4.0 $ton.ha^{-1}$+75% RDF	48650	116230	67580	2.39
10	VC 4.0 $ton.ha^{-1}$+100% RDF	48772	117420	68598	2.41
11	VC 4.0 $ton.ha^{-1}$+125% RDF	49566	120445	70879	2.43
12	VC 6.0 $ton.ha^{-1}$ +75% RDF	50912	124735	73823	2.45
13	VC 6.0 $ton.ha^{-1}$+100% RDF	51028	126550	75522	2.48
14	VC 6.0 $ton.ha^{-1}$+125% RDF	51633	129083	77450	2.50
	SE (d) ±	445.309	872.551	1091.60	0.06
	C.D at 5%		1794.33	1794.33	0.13

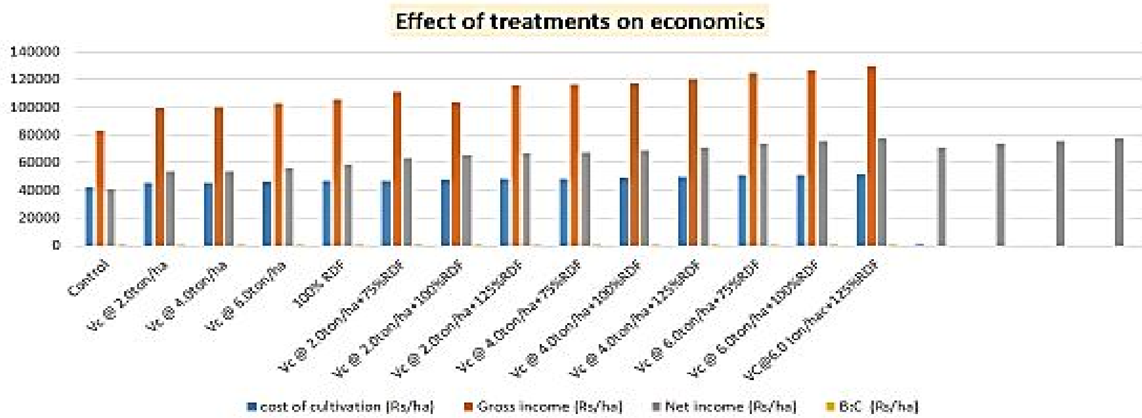

Figure 4: **Effect of treatments on economics**

Conclusion

The study well evaluated the effectiveness of organic and inorganic fertilizers for improving the growth and yield of wheat crop and their economics. The findings revealed that the treatment T_{14} gave significantly better growth parameters and yield contributing characters with the highest grain and straw yield (4.38 $t.ha^{-1}$ and 7.13 t/ha, respectively) compared to others.

Conference disclaimer:

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