Effects~~Role~~ of the addition of ~~vermi~~vermi-compost ~~and~~to the inorganic fertilizers on productivity of late sown wheat

ABSTRACT

Globally wheat (*Triticum aestivum* L.) is a major cereal crop grown ~215 mha of the land and produces about 763.93 million tons. Wheat is the major staple food source for a large part of global population. Due to excessive use of inorganic fertilizers the quality and productivity of soil as well as the grains were reduced~~is reducing~~ because ofthe unbalanced fertilization. So, there isa need to apply the balanced fertilizer by mixing the organic as well as inorganic fertilizer to maintain the sustainable yield which help to feed ever-increasing population. The experiment was laid out in RBD with 14 treatments replicated thrice. The treatment is consists of T_1: control, T_2: Vermi-compost (VC) @ 20 t/ha, T_3: VC@? 4.0 t/ha, T_4 : VC@ 6.0 ton/ha , T_5: 100% RDF (please mention the fuul name for the first time then tha abbreviation), T_6: VC@ 2.0 ton/ha + 7. ~~0 t/ha, T_3: VC@ 4.0 t/ha, T_4 : VC@ 6.0 ton/ha , T_5: 100% RDF, T_6: VC@ 2.0 ton/ha + 7~~5%RDF, T_7: VC@ 2.0 ton/ha +100%RDF, T_8: VC@ 2.0 ton/ha + 125%RDF ,T_9: VC@ 4.0 ton/ha+75%RDF ,T_{10} VC@ 4.0 ton/ha + 100%RDF, T_{11}: VC @ 4.0 ton/ha + 125%RDF, T_{12}: VC@ 6.0 ton/ha + 75%RDF, T_{13}: VC @ 6.0 ton/ha +100%RDF, T_{14}: VC@ 6.0 ton/ha +125%RDF. The results revealed that the treatment T_{14} gave the significantly better growth parameters, yield contributing characters with highest grain and straw yield (4.38 t/ha and 7.13 t/ha, respectively) compared to rest of treatments. The minimum grain yield (2.74 t/ha) and straw yield (4.80 t/ha) was recorded under the treatment T1 (control).

Keywords: Vermicompost, inorganic fertilizer, Wheat, Yield

INTRODUCTION

Wheat is one of the most popular and staple food in India among both vegetarians and non-vegetarians. It compares well with other cereal in nutritive value. It has good nutrition profile with 12.1 per cent protein, 1.8 per cent lipids, 1.8 %~~per cent~~ ash, 2.0 %~~per cent~~ educing sugar, 6.7% ~~per cent~~ pentose, 59.2 %~~per cent~~ starch with good source of mineral of vitamin and nicotinic acid (Agam *et al.*, 2017). It processed in different forms like flour, suzi, maida and being eaten by number of consumers in different ways as porridge (Halwa), chapati, bread and biscuits etc. Besides that, wheat straw and wheat bran are also good source of feed for animals (Yadav *et al.,* 2014). Wheat is mainly grown in the *Rabi* season (October-December to March-May) along with Barley, Lentils, Peas, Mustard and Potatoes. The Production of Wheat during 2020-21 is estimated at record 109.52 million tons. It is higher by 9.10 million tons than the average wheat production of 100.42 million tones (Anonymous, 2022). China is the top country by wheat production in the world. As of 2020, wheat production in China was 134,250 thousand tons that accounts for 20.66% of the world's wheat production. The top 5 countries (others are India, Russian Federation, the United States of America, and Canada) account for 63.46% of it. 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 crop so that, it can be exported to other countries and thereby reducing the quality and quantity of wheat and here focusing to boost the economy of a nation by combine application of organic and inorganic fertilizer.

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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 among cereals, which is of great importance in the diet of human societies. 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 by reducing the concentration of these elements in the plant 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 hidden but hidden human health problems 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 will grow well and produce significant amounts of plant biomass. Providing nutrients in the soil determines the status of nutrients in the plant and the most important mission of agriculture in the production of healthy and nutritious food in human societies in order 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).

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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 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 increase the growth and activity of microorganisms and by maintaining the structure of the soil provides a good substrate for growth, 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 minerals ~~salts~~ and on the other hand due to their acidic and alkaline properties cause changes in soil acidity which leads to the deposition or dissolution of trace elements by affecting(is not good all the time) their balance in the soil (Lansdown, 1995). Today, ~~vermi~~vermin-compost is considered as a simple biotechnological process of compost and as an easy technology and a nature-friendly process, so that this process is used to obtain organic fertilizers from waste (Thakur *et al*., 2021). With the increasing application of different levels of ~~vermi~~vermi-compost 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).

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The combined use of organic and inorganic fertilizers is effective ways to maintains nutrient supply, gives organic carbon to soil microbes, and mobilizes 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 the crop productivity but also will be effective in improving soil health and increase the nutrient-use efficiency (Verma *et al*., 2006). Keeping this view in mind, an experiment was planned to know the combined use of organic and inorganic fertilizers for improving growth and yield attributes of wheat crop and their economics.(please mention the aim of the study)

MATERIAL AND METHODS

Field experiments were conducted during winter 2018-19(not the same date that you mentioned above) 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 0.45 % with pH 7.3, available N 170 kg ha^{-1}, available P_20_5 16 kg ha^{-1} and available K_20 180 kg ha^{-1} at the start of the experiment in 0 to 30 cm soil layer during 2018-19 (Table 1).

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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 *viz*, T_1: control, T_2: Vermi-compost (VC) ;@ 2.0 t/ha, T_3: VC@ 4.0 t/ha, T_4: VC@ 6.0 ton/ha , T_5: 100% RDF, T_6: VC@? 2.0 ton/ha + 75%RDF, T_7: VC@ 2.0 ton/ha +100%RDF, T_8: VC@ 2.0 ton/ha + 125%RDF ,T_9: VC@ 4.0 ton/ha+75%RDF ,T_{10}: VC@ 4.0 ton/ha + 100%RDF, T_{11}: VC @ 4.0 ton/ha +125%RDF, T_{12}: VC@ 6.0 ton/ha + 75%RDF, T_{13}: VC@ 6.0 ton/ha +100%RDF, T_{14}: VC@ 6.0 ton/ha +125%RDF (Table 2). The results revealed that the treatment T_{14} gave the significantly better growth parameters, yield contributing characters with highest grains and straw yield (4.38 t /ha and 7.1 t/ha, respectively) compared to rest of treatments.(why you do not registered te grains test weight) The minimum grains yield (2.7 t/ha) and straw yield (4.8 t/ha) was recorded under the treatment T1 (control). The experiment was laid out in randomized block design with three replications. Vermi-compost 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.(the highlighted lines in gray color must be under the results part) 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 content in plant were estimated by standard methods(please mention it and

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their references). Nutrient uptake was estimated by multiplying the dry-matter accumulation at maturity stage in grains and straw of wheat by their respective percentages. Total uptake was calculated by adding uptake of grains, and straw.(how come?) 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@? (not scientific at all)2.0 ton/ha
T_3	VC@4.0 ton/ha
T_4	VC@6.0 ton/ha
T_5	100 % RDF
T_6	VC@2.0 ton/hac.+75% RDF
T_7	VC@2.0 ton/hac.+100% RDF
T_8	VC@2.0 ton/hac.+125% RDF
T_9	VC@4.0 ton/hac.+75% RDF
T_{10}	VC@4.0 ton/hac.+100% RDF
T_{11}	VC@4.0 ton/hac.+125% RDF
T_{12}	VC@6.0 ton/hac.+75% RDF
T_{13}	VC@6.0 ton/hac.+75% RDF
T_{14}	VC@6.0 ton/hac.+75% RDF

RESULTS AND DISCUSSION

Effect on growth parameters

Plant height (cm)

The results of the analysis of variance of data in (Table 3 and Fig. 1) showed that the effect of different manures ? you are not uses manure and fertilizers on the height of the plant had a significant effect on the level of 1% probability. Thus, the studied treatments caused a relative increase in plant height compared to the control(the grains weight is the important weight not all the plant). The maximum and minimum height of the plants were recorded at 30, 60, 90 DAS and maturity stage for the treatment T_{14} and T_1 with values of 14.93, 79.30, 81.69 and 83.09 cm and 9, 35, 49.64, 52.24 and 54.14 cm, respectively. The effect of chemical fertilizers on plant growth is 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, ~~in~~and in general, it improves photosynthesis and thus plants growth. The increase of these traits by chemical fertilizers can be considered by increasing the length of intermediates due to providing water and nutrients required by the plant. Chemical fertilizers increase plant height (Jamir *et al.*, 2017). The reason for increasing plant height is probably affected by the number of spikes per unit area and the control treatment by reducing the number of spikes per unit area, for light and nutrient availability, compared to other fertilizer treatments has a high level of competition between plants.(the grains weight and their yield amounts are the determinants for judging the success of any treatment not the number of spikes nor the total weight of plant) This increases the plant height in the plant (Geravandi *et al.*, 2011). The use of chemicals and ~~manures~~ vermi-compost separately had the highest and lowest plant height. Nitrogen increase leads to an increase in plant height and has a significant 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 is fertile and

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has more flowers, which increases the number of seeds per spike (Sepahvand *et al*., 2021).

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

The observed data of dry matter accumulation are shown in (Table 3 and Fig. 2)). The significant mass increases in dry matter from 30 to 90 DAS due to faster growth and further increase in dry matter till maturity is very slow because of diminishing growth rate of crop. The result shows that there was significant difference between the treatments at 30, 60, 90 DAS and harvest stage. At 30 DAS the treatment T_{13} was recorded highest dry matter accumulation (2.80g) while the lowest dry matter accumulation was recorded in treatment T_1(1.67g). Dry matter accumulation at 60 DAS recorded highest in T_{14} (7.72g) compared to rest of the treatment. At 90 DAS, the treatment T_{14} observed the highest dry matter accumulation (18.30g) which is on par with treatments T_{11}, T_{12} and T_{13} and lowest dry weight was recorded under the treatments T_1(13.15). At harvest stage, treatment T_{14} recorded the highest dry matter accumulation per plant (23.43g) compared to rest of the treatments. The increase in dry matter accumulation due to the balanced application of nutrients which were supplied through both the sources (organic and inorganic). Plant uptake adequate amount of nutrients from the soil and increases its photosynthetic areas and finally led to more dry matter accumulation. Similar findings were observed by (Kakraliya *et al*., 2017).

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Table 3: Effects of vermivermin-compost and inorganic fertilizers on growth parameters of late sown wheat

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 @? 2.0ton/ha	11.30	60.00	61.81	63.07	1.84	6.12	14.51	18.59
T3: VC @ 4.0ton/ha	11.40	60.56	62.35	63.63	1.84	6.13	14.54	18.63
T4: VC @ 6.0ton/ha	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 @ 2.0ton/ha+75%RDF	12.69	67.44	69.38	70.80	1.90	6.55	15.61	20.00
T7: VC@2.0ton/ha+100%RDF	13.03	69.26	71.18	72.65	2.06	6.87	16.28	20.86
T8: VC @2.0ton/ha+125%RDF	13.27	70.52	72.45	73.60	2.11	7.03	16.67	21.36
T9: VC @ 4.0ton/ha+75%RDF	13.38	71.06	72.70	73.90	2.15	7.15	16.96 33	21.74
T10: VC @4.0ton/ha+100%RDF	13.53	71.86	73.66	75.12	2.17	7.21	17.08	21.88
T11: VC @4.0ton/ha+125%RDF	13.89	73.79	75.88	77.36	2.20	7.31	17.32	22.19
T12: VC@ 6.0ton/ha+75%RDF	14.40	76.50	78.63	80.30	2.22	7.40	17.51	22.43
T13:VC @6.0ton/ha+100%RDF	14.62	77.67	79.97	81.50	2.80	7.57	17.95	23.00
T14: VC@6.0ton/ha+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

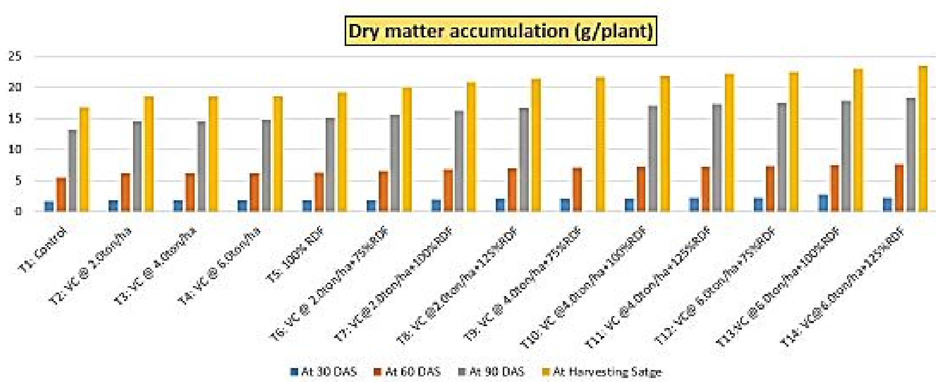

Figure 2: Effects of ~~vermi~~vermin-compost and inorganic fertilizer on growth parameters of late sown wheat

Effect on yield attributes

Integrated use of fertilizers with ~~vermi~~vermi-compost increased the dry matter accumulation, number of effective tillers, grains spike^{-1} 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 stimulated vegetative growth of wheat on account of adequate and prolonged supply of essential nutrients. Similarly, the number of effective tillers, grain/spike and test weight produced by the application Vermi-compost @? 6.0 ton/ha+125% RDF were found to be significantly higher than the other treatments and the lowest from the control. These results are in line with the findings of those of Dey, S.R *et al.* (1999) who reportedthat the significant increase in number of plants per meter row by combine application of manure and fertilizers.

Grain yield (t/ha)

Addition of ~~vermi~~vermi-compost with different fertilizer levels produced significantly higher grain and biological yields than the application of fertilizers alone maximum grain yield and biological yield were obtained with the application of 125% RDF + ~~vermi~~vermi-compost @ 6.0 t ha^{-1}. The lowest grain yield (2.74 t ha^{-1}) and biological yield (4.81 t ha^{-1}) were recorded from control (Table 4). The increase in grain and biological yield might be due to adequate quantities and balanced proportions of plant nutrients supplied to the crop as per need during the growth period resulting in favorable increase in yield attributing characters which ultimately led towards an increase in economic yield. Improved physi~~c~~o-chemical properties of the soil through the application of organic ~~manure~~ fertilizer might be the other possible reason for higher productivity. Our results are also in harmony with Rao *et al.*, (1996) ~~also~~ who reported that the combination of organic and inorganic N sources resulted in comparable rice yield to the application of inorganic nitrogen alone. Patil *et al*. (2000) also reported that combination of organic manure and fertilizer significantly improved grain and biological yield of wheat.

All vermivermi-compost and fertilizer rates produced significantly higher grain yield (4.38 t/ha) of wheat than the control (2.74 t/ha). But the highest values of this parameter were obtained with T_{14} followed by T_{13} and T_{12} in that order. This isOur findings were in agreement with findings those of Yousefi and Sadeghi (2014) who reported that the application of vermivermi-compost to soil significantly increases the yield of wheat. Grains yield is a result of various factor such as dry matter, effective tillers and number of filled grains. The higher grains yield was due to higher dry matter accumulation and a greater number of filled grain per spike. This was due to the efficient utilization of nutrients results more vegetative growth and efficient partitioning of photosynthatesphotosynthesis. Besides, different studies have also demonstrated the beneficial effect of application of vermivermi-compost at different rates on the yields of other crops such as tomato (Arancon and Edwards, 2005). As vermivermi-compompost is a source of different essential plant nutrients, its application in soil with low nutrient content especially in NPK will definitely increases the growth, yield and yield components of crops including wheat. However, in addition to being sources of different nutrients, vermivermi-compost is also supposed to contain growth promoting hormones (Edwards *et al*., 2004) which might facilitate higher nutrient uptake by plants and this could be an addition factor for the positive effect of vermivermi-compost on crops.

The positive effects of vermivermi-compost and NPK fertilizers application on wheat seen in this experiment suggest that the study soils are low in its nutrient contents particularly of the nitrogen potash. The result of initial soils analyses data also proves (Table 1) this claim.

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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 @? 2.0ton/ha	297.17	40.53	36.35	3.34	5.6	37.15
T3: VC @ 4.0ton/ha	299.65	40.87	37.48	3.34	5.63	37.23
T4: VC @ 6.0ton/ha	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 @ 2.0ton/ha+75%RDF	319.68	43.60	37.38	3.72	6.21	37.48
T7: VC@2.0ton/ha+100%RDF	333.41	45.46	37.56	3.82	6.35	37.56
T8: VC @2.0ton/ha+125%RDF	341.16	46.52	37.71	3.89	6.45	37.65
T9: VC @ 4.0ton/ha+75%RDF	347.59	47.39	37.86	3.95	6.47	37.75
T10: VC @4.0ton/ha+100%RDF	349.96	47.72	37.98	3.96	6.52	37.81
T11: VC @4.0ton/ha+125%RDF	354.84	48.41	37.68	4.75	6.68	37.87
T12: VC@ 6.0ton/ha+75%RDF	358.77	48.93	37.75	4.22	6.91	37.93
T13:VC @6.0ton/ha+100%RDF	367.74	50.15	38.18	4.29	7.00	37.98
T14: VC@6.0ton/ha+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

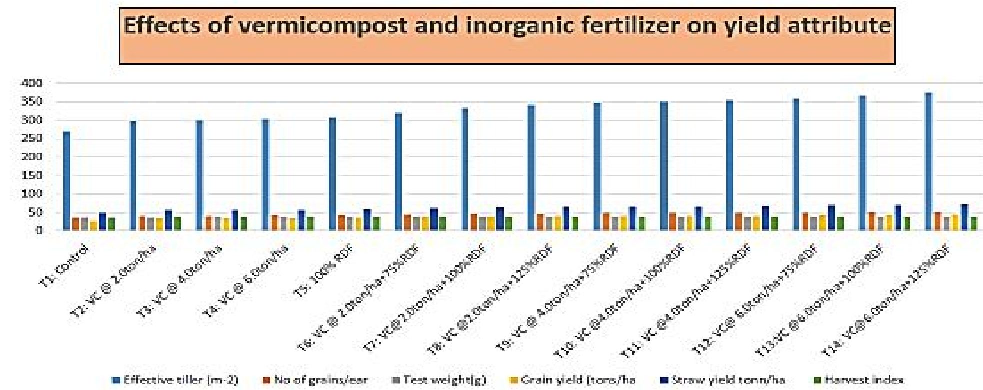

Figure 3: Effects of ~~vermi~~vermi-compost and inorganic fertilizer on yield attribute

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~~Economics~~Economic evaluation of the study:

The study was economically evaluated as the follows:

Net return and Benefit: Cost ratio increased with supplementation of recommended dose of fertilizers. Highest net return (Rs.77450.ha^{-1}) and B: C ratio (2.50) was obtained with the application of 125% RDF +~~vermi~~vermi-compost @ 6.0 t ha^{-1} (Table 5 and Fig. 4). Suthar (2006) reported that integrated application of NPK fertilizers ~~along~~ with vermicompost in field crops not only influences growth and production of plant but ~~at the same time~~ also reduces the production budget.

Table 5. Effect of treatments on economics

S.N	Treatment	cost of cultivation (Rs/h)	Gross income (Rs/h)	Net income (Rs/h)	B.C ratio (Rs/h)
1	Control	42485	83100	40615	1.96
2	Vc @ 2.0ton/ha	45610	99106	53496	2.17
3	Vc @ 4.0ton/ha	45780	99893	54113	2.18
4	Vc @ 6.0ton/ha	46545	102509	55964	2.20
5	100% RDF	46995	105401	58406	2.24
6	Vc @ 2.0ton/ha+75%RDF	47213	110778	63508	2.34
7	Vc @ 2.0ton/ha+100%RDF	48025	103614	65589	2.37
8	Vc @ 2.0ton/ha+125%RDF	48530	115528	66998	2.38
9	Vc @ 4.0ton/ha+75%RDF	48650	116230	67580	2.39
10	Vc @ 4.0ton/ha+100%RDF	48772	117420	68598	2.41
11	Vc @ 4.0ton/ha+125%RDF	49566	120445	70879	2.43
12	Vc @ 6.0ton/ha+75%RDF	50912	124735	73823	2.45
13	Vc @ 6.0ton/ha+100%RDF	51028	126550	75522	2.48
14	VC@6.0 ton/hac+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

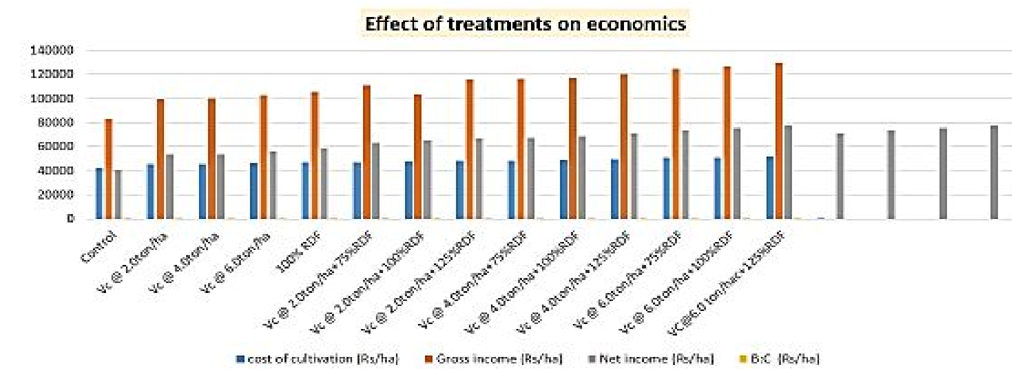

Figure 4: **Effect of treatments on economics**

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