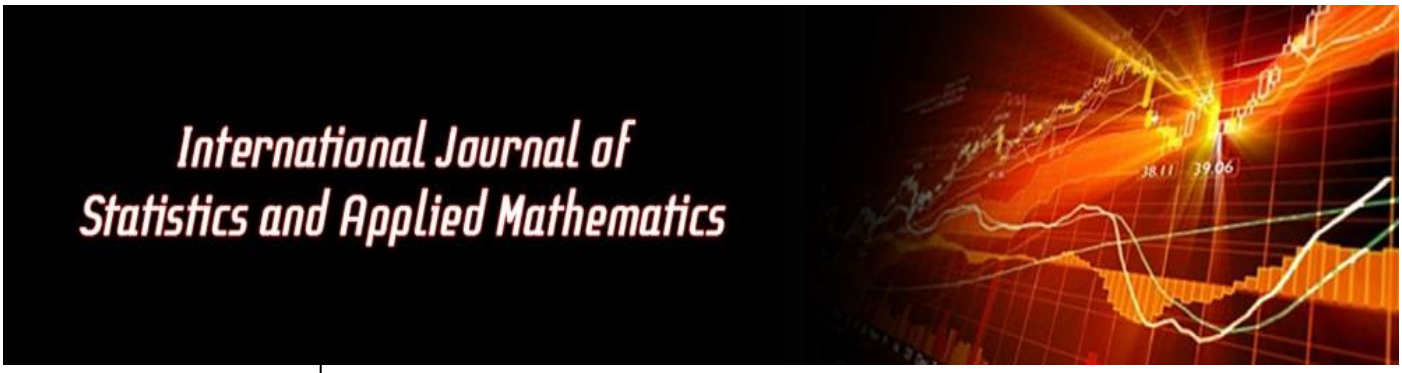

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Effect of FYM, vermicompost, *Azotobacter*, sulphur and Zn with chemical fertilizer on growth, yield and yield attribute in wheat crop

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Abstract
The present experiment was laid out on random block design, with consists of 8 treatments *viz;* where 100% RDF (T_1), 75% RDF (T_2), 75% RDF + $ZnSO_4$ @ 25 kg/ha^{-1} (T_3), 75% RDF + sulphur @ 40 kg/ha^{-1}(T_4), 75% RDF +25% N through FYM + *Azotobacter* (T_5), 75% RDF + $ZnSO_4$ @ 25 kg/ha^{-1} + Sulphur @ 40 kg/ha (T_6), 100% RDF + 25% N through (Vermi compost) + $ZnSO_4$ @ 25 kg/ha^{-1} (T_7) replicate with three times in wheat crop. The results of this experiment indicate the growth parameter *viz*; plant height at 60 and 90 DAS, Dry matter accumulation at 60, 90 and Harvest stage, Leaf area index (LAI) 60 and 90 DAS, number of tillers 60, 90 DAS and harvest and yield attributing character and yield of wheat crop *viz*; number of spikelet's, length of spike, grain per spike and test weight and grain, straw and biological yield of was recorded maximum from 100% RDF +25% N through (vermin compost)+ $ZnSO_4$ @ 25 kg/ha^{-1} which were statistically superior than 75% RDF +25% N through FYM + *Azotobacter*, 75% RDF + $ZnSO_4$ @ 25 kg/ha^{-1} + Sulphur @ 40 kg/ha^{-1} and 100% RDF (Recommended dose of fertilizer) However, the minimum value of these parameter was recorded from control plot. Among economic point of view, the maximum net return and benefit: Cost ratio was documented from 100% RDF +25% N through (vermin compost) + $ZnSO_4$ @ 25 kg/ha^{-1} which were statistically more than with 75% RDF + 25% N through FYM + *Azotobacter* and 75% RDF +25% N through FYM + *Azotobacter*. However, the minimum net return was recorded from control plot.

Keywords: NPK, FYM, Vermicompost, wheat, grain and stover yield

Introduction
Wheat (*Triticum aestivum* L.) is the world's most widely cultivated food crop. Wheat grain contains about 12% protein which is more than that in other cereals and is of special significance to maintain the good bread making quality, due to the presence of a characteristic substance called 'gluten'. It has also a relatively high content of niacin and thiamine. Wheat is the second most important grain crop after rice in India. India has ever growing population, it has been projected that to feed 1.3 billion population and for diversified uses, India will have to produce at least 109 million tons of wheat by 2021 AD which might be only possible through elevating the national productivity up to 40.0 q ha^{-1} (Nagarajan and Rana, 2002) [10]. Wheat is the most widely cultivated crop which provides food and nutrition to two-third population of the world. India ranks second in wheat production in the world next to China. Wheat is the second staple food crop of India after rice and consumed by nearly 65 percent of the population (Mishra *et al*., 2005) [8] and ranks first in dietary shares of northern India (Joshi *et al.*, 2007) [7]. India ranks second in wheat production in the world next to China. India has 30.22 M ha area under wheat cultivation with production of 93.50 Mt (Anonymous, 2020a) [1]. In Punjab, area under wheat production is 3.46 M ha with production of 17.63 M T (Anonymous, 2021b) [2].

Integrated Nutrient management helps to restore, sustain and increase soil fertility and crop productivity also. It may also help to check the emerging deficiency of other nutrients than NPK. Integrated management of the nutrient is essential for proper plant growth, together with effective crop, water, soil, and land management. To compensate the continue supply and recent price hike in inorganic fertilizers, use of indigenous sources of nutrients like manure

should be encouraged as it supplies plant nutrient, improve the physical, chemical and biological properties of the soil and thereby increase the fertility and sustain productivity of the soil. The application of Farm Yard Manure (FYM) in the soil helps in increasing the fertility of the soil as physical and biological condition including its water& nutrient holding capacity, microbial activity in soil. Organic manures, which were perhaps the main sources of plant nutrients in traditional agriculture, receive less priority with the advent of high analysis chemical fertilizers. The decision on the optimum and balanced use of fertilizer required awareness of crop response to applied fertilizer, inherent nutrients by soil and its short or long-term fate effects. The macronutrient sulphur also known as plays an important role in protein formation and nitrogen assimilation in wheat. Sulphur is an essential mineral nutrient for plant growth and development. It is the fourth major nutrient after nitrogen, phosphorus, and potassium. Ninety % of the sulphur in the plant body is used to synthesize sulphur-containing amino acids and protein, which are the major component of proteins. Sulphur insane essential component of nitrogen metabolism enzymes such as nitrate reductase (NR). A sulphur deficiency in plant will reduce the absorption of nitrogen, affecting the content of protein and the proportions of gluten in and gliadin in total protein, all of which affect the quality of flour. Zinc a necessary element for the normal growth and development of plants. It has plays important rolein enzyme activation and also involved in the biosynthesis of some enzymes and growth hormones. Zinc deficiency is a very important nutrient problem in the Indian soils especially in northern India. Total Zn concentration is adequate in many agricultural areas, but available Zinc concentration is deficient because of different soil and climatic condition. Soil pH, lime content, organic matter, amount and type of clay and also amount of applied phosphorus fertilizer that affects the available Zn concentration in soil. *Azotobacter* is among one of the very promising futures of biofertilizer. Which are non- symbiotic heterotrophic bacteria capable of fixing an average 20 kg N ha^{-1} $year^{-1}$.

As a result of concerted and persistent effort several high yielding strains of wheat have been developed. Newer high yielding varieties being relatively, thermos-sensitive, perform better even under variable climatic conditions. The varieties HD-2285, NW-1067, Kundan and Unnat Halna have been found promising under irrigated conditions.

Materials and Methods

The experiment was conducted during Rabi season 2022-23 at Agronomy Research Farm of Dolphin (PG) college of Science and Agriculture, Chunni Kalan; a campus of Punjabi University, Patiala, Punjab. Geographically, it is situated on the Fatehgarh Sahib Chandigarh road, Chunni Kalan it is located at 30^0 09 N latitude and 76^0 33 E longitude at an altitude of 281 meters above the mean sea level. The experiment was laid out in a randomized block design (RBD) with 3 replication. T_1) 100% RDF (Recommended dose of fertilizer), (T_2) 75% RDF, (T_3) 75% RDF + $ZnSO_4$ @25kg/ha^{-1}, (T_4) 75% RDF + sulphur @40kg/ha^{-1}, (T_5) 75%RDF +25% N through FYM + *Azotobacter*, (T_6) 75% RDF + $ZnSO_4$ @25kg/ha^{-1} + Sulphur @40kg/ha^{-1}, (T_7) 100% RDF +25% N through (vermicompost)+ $ZnSO_4$ @25kg/ha^{-1}, (T_8) Control. Application of Azotobacter: Inoculation was done @ 1 packet Azotobacter with 10 kg seed of Wheat by making the pest with the help of 500ml water and 50g gur heated and cools down and mix with seed. After that dry the seeds in shade and sown. Application of poultry manure and FYM: Vermicompost and FYM applied 20 days before sowing for getting good result in required plot. Application of fertilizers: Half amount of Nitrogen together with full amount of Phosphorus, Potash, Zn (30 kg/ha) and S (20 kg/ha) and were applied as basal at the time of sowing in the form of Urea, DAP and MOP, respectively. Remaining half dose of nitrogen was top dressed into two split doses at 32 and 56 days after sowing (DAS).

Initial plant population: Initial plant population was recorded after 15 days of sowing, when the germination was completed. The plant population per square meter were counted at three places in each plot by taking row in the length of one meter taking with 5 rows of 20 cm a part and were averaged over to find out initial plant population per square meter. Final plant population: Final Plant population recorded at the maximum tillering stage. Five rows considered up to a length of one meter from three places in each plot and averaged over to find out final plant population per square meter. Total tillers: The total tillers productive tillers and unproductive tillers/m^2 the help of the following formula.

Total tillers = Plant population at maximum tiller - Initial plant population.

Productive tiller = Ear head - Initial plant population.

Unproductive tiller = Total tillers - productive tillers.

Plant Height at maturity: Three randomly selected plants in net area were tagged and the height of the main shoot was measured in cm from ground level to the tip of main shoot 120 days after sowing of crop and average height of main shoot was calculated Fresh Weight per plant at dough stage: In this case three plants from each plot were taken randomly at dough stage of crop. The plants were cut from ground level and fresh Weight is recorded then average fresh weight per plant is calculated In this case three plants of each plot were randomly selected at dough stage of crop. These three samples were kept for sun drying for 8 days and then dried in oven at 70 °C. The dry weight was averaged to get per plant dry weight.

Yield Attributing Characters

- **Number of spikes per square meter**
  For recording the final stand of the crop, the number of spikes per square meter were counted at the same three places. In each net plot area where germination counts were taken from this and average number of spikes per square meter was calculated. Spike length: The length of spike was measured from the base of the spike to the end of the terminal spike-lets in centimetre.
- **Weight of spike (g):** Five spikes were selected and weighted with the help of electrical balance and average value was calculated. Number of grains per spike: After threshing of 5 spikes grain were cleaned and counted then mean value is recorded. Grain weight per spike: After threshing of 5 selected spikes the grain are separate and weighed and recorded in gram per Spike. 1000 Grain Weight: One thousand grain from a composite sample of each plot was taken. The three samples in each plot are taken and weighted separately and recorded in grams.

- **Yield Studies:** Grain Yield The grain yield obtained after threshing of crop produce of each net plot and was recorded in kilogram per plot and later on converted into quintal per hectare. Straw Yield: The straw yield worked out by subtracting the grain yield from the weight of harvested material (Biological Yield) per plot in kilograms. It was timber converted into quintal per hectare. Harvest Index (HI) The harvest index was computed with the help of formula as suggested by Singh and Staskofif (1971).

$$Harvest\ \ Index = \frac{Economic\ yield(q/ha)}{Biological\ yield(q/ha)} x100$$

The experimental data obtained during the course of study were subjected to statistical analysis using analysis of variance technique (ANOVA) for split plot design as prescribed by Gomez & Gomez, (1984) [5].

Results and Discussion

- **Initial plant population:** The data related to the initial plant population per running meter row length of wheat crop as influenced by integrated source of nutrient have been presented in Table -1. and demonstrated. It is clearly evident from data that initial plant population per running meter row length of wheat crop does not show significant results due to Integrated Nutrient Management (INM) of wheat crop.

- **Plant height**: The data related to the plant height of wheat crop as influenced by integrated source of nutrient have been presented in Table - 1 and demonstrated. It is clearly evident from data that plant height at 30 DAS of wheat crop does not show significant results due to integrated source of nutrient on wheat crop. However, plant height of wheat crop at 60 and 90 DAS stage of crop growth was significantly influenced due to integrated source of nutrient on wheat crop. The maximum plant height at 60and 90 DAS stage was documented from 100% RDF +25% N through (vermicompost)+ $ZnSO_4$ @25kg/ha^{-1}which were statistically highest when 75%RDF +25% N through FYM + *Azotobacter*. However, the minimum plant height at 60, 90 DAS and harvest stage was recorded from control plot.

- **Number of tillers:** The data related to the number of tillers of wheat crop as influenced by integrated source of nutrient have been presented in Table-1. and demonstrated in It is clearly evident from data that number of tillers at 30 DAS of wheat crop does not show significant results due to Integrated Nutrient Management (INM) of wheat crop. The maximum number of tillers at 60 DAS stage was documented from 100% RDF +25% N through (vermicompost) + $ZnSO_4$ @ 25 kg/ha^{-1} which were statistically at par with 75% RDF +25% N through FYM + *Azotobacter* and 100% RDF (Recommended dose of fertilizer). However, the minimum number of tillers at 60 DAS stage was recorded from control plot. The maximum number of tillers at 90 DAS stage was documented from 100% RDF +25% N through (vermicompost)+ $ZnSO_4$ @ 25 kg/ha^{-1} which were statistically superior than 75% RDF +25% N through FYM + *Azotobacter*, 75% RDF + $ZnSO_4$ @25 kg/ha^{-1} + Sulphur @ 40 kg/ha^{-1} and 100% RDF (Recommended dose of fertilizer) However, the minimum number of tillers at 90 DAS was recorded from control plot. The maximum number of tillers at harvest stage was documented from 100% RDF +25% N through (vermicompost) + $ZnSO_4$ @ 25 kg/ha^{-1}which were statistically superior than 75% RDF +25% N through FYM + Azotobacter, 75% RDF + $ZnSO_4$ @25kg/ha^{-1} + Sulphur @ 40 kg/ha^{-1} and 75% RDF + ZnSO4 @25kg/ha^{-1} + Sulphur @40kg/ha^{-1}. However, the minimum number of tillers at 90 DAS was recorded from control plot. The integrated source of nutrient on wheat crop have been increase the dry matter production. Similar finding have been reported by Jat *et al.*, (2013) [6] and S. M. Shirazi *et al.*, (2014) [12].

Table 1.1: Effect of Integrated Nutrient Management (INM) on plant population, plant height and number of tillers

S. N	Treatments	Initial plant population (per meter row length)	Plant height			Number of tillers			
			30 DAS	60 DAS	90DAS	30 DAS	60 DAS	90DAS	Harvest
1	100% RDF (Recommended dose of fertilizer)	28.480	28.400	51.400	88.750	45.100	90.150	89.140	85.130
2	75% RDF	28.980	28.410	49.120	88.100	45.120	86.420	85.120	84.130
3	75% RDF + $ZnSO_4$ @25kg/ha^{-1}	28.000	28.310	50.490	88.500	45.120	89.500	88.410	82.610
4	75% RDF + sulphur @40kg/ha^{-1}	28.100	28.130	50.150	88.100	45.140	82.140	82.130	81.120
5	75%RDF +25% N through FYM + *Azotobacter*	28.520	28.140	53.150	90.470	46.410	92.160	91.140	91.130
6	75% RDF + $ZnSO_4$ @25kg/ha^{-1} + Sulphur @40kg/ha^{-1}	28.420	28.320	50.460	89.120	46.310	90.450	90.140	89.100
7	100% RDF +25% N through (vermicompost)+ $ZnSO_4$ @25kg/ha^{-1}	28.500	28.420	54.410	92.250	47.500	93.520	92.430	91.530
8	Control	28.400	28.500	49.000	87.150	41.470	85.160	84.100	83.120
	C.D at 5 % SEm ± SEm ±	N/A 0.769	N/A 0.767	2.89 1.365	3.15 1.395	N/A 1.214	3.35 2.361	3.45 2.339	3.67 2.316

Yield attributes

The data related to the Yield attributes *viz*; number of spikelet's, length of spike, grain per spike and test weight of wheat crop as influenced by integrated source of nutrient have been presented in Table-2. and demonstrated It is clearly evident from data that number of spikelets of wheat crop were show significant results due to Integrated Nutrient Management (INM) of wheat crop. The maximum number of spikelet's was documented from 100% RDF +25% N through (vermicompost) + $ZnSO_4$ @ 25 kg/ha^{-1} which were statistically superior with 75% RDF +25% N through FYM + *Azotobacter* and 75% RDF +25% N through FYM + *Azotobacter*. However, the minimum number of spikelet's was recorded from control plot.

It is clearly evident from data that length of spike of wheat crop were show significant results due to Integrated Nutrient Management (INM) of wheat crop. The maximum length of spike was documented from 100% RDF +25% N through (vermicompost)+ $ZnSO_4$ @ 25 kg/ha^{-1}which were statistically superior with 75% RDF + 25% N through FYM + *Azotobacter* and 75% RDF +25% N through FYM + *Azotobacter*. However, the minimum length of spike was recorded from control plot. It is clearly evident from data that number of grains per spike of wheat crop were show significant results due to Integrated Nutrient Management (INM) of wheat crop. The maximum number of grains per spike was documented from 100% RDF +25% N through (vermicompost) + $ZnSO_4$ @ 25 kg/ha^{-1}which were statistically at par with 75% RDF + 25% N through FYM + *Azotobacter* and 75% RDF +25% N through FYM + *Azotobacter*. However, the minimum number of grains per spike was recorded from control plot. It is clearly evident from data that test weight of wheat crop were show significant results due to Integrated Nutrient Management (INM) of wheat crop. The maximum test weight was documented from 100% RDF +25% N through (vermicompost) + $ZnSO_4$ @ 25 kg/ha^{-1}which were statistically at par with 75% RDF + 25% N through FYM + *Azotobacter* and 75%RDF +25% N through FYM + *Azotobacter*. However, the minimum number of grains per spike was recorded from control plot.

Yield

Grain yield

The data related to the grain yield of wheat crop as influenced by integrated source of nutrient have been presented in Table-2. and demonstrated. It is clearly evident from data that grain yield of wheat crop were show significant results due to Integrated Nutrient Management (INM) of wheat crop. The maximum grain yield was documented from 100% RDF +25% N through (vermicompost)+ $ZnSO_4$ @ 25 kg/ha^{-1} which were statistically more than with 75% RDF + 25% N through FYM + *Azotobacter* and 75% RDF +25% N through FYM + *Azotobacter*. However, the minimum grain yield was recorded from control plot. Straw yield-The data related to the straw yield of wheat crop as influenced by integrated source of nutrient have been presented in Table-2. and demonstrated. It is clearly evident from data that straw yield of wheat crop was show significant results due to Integrated Nutrient Management (INM) of wheat crop. The maximum straw yield was documented from 100% RDF +25% N through (vermicompost) + $ZnSO_4$ @ 25 kg/ha^{-1} which were statistically more than with 75% RDF + 25% N through FYM + *Azotobacter* and 75% RDF +25% N through FYM + *Azotobacter*. However, the minimum straw yield was recorded from control plot.

Biological yield

The data related to the biological yield of wheat crop as influenced by integrated source of nutrient have been presented in Table-2. and demonstrated. It is clearly evident from data that biological yield of wheat crop were show significant results due to Integrated Nutrient Management (INM) of wheat crop. The maximum biological yield was documented from 100% RDF +25% N through (vermicompost) + $ZnSO_4$ @ 25 kg/ha^{-1} which were statistically more than with 75% RDF + 25% N through FYM + *Azotobacter* and 75% RDF +25% N through FYM + *Azotobacter*. However, the minimum biological yield was recorded from control plot Harvesting index (%) The data related to the harvesting index of wheat crop as influenced by integrated source of nutrient have been presented in Table-2. and demonstrated. It is clearly evident from data that harvesting index of wheat crop were show significant results due to Integrated Nutrient Management (INM) of wheat crop. The maximum harvesting index was documented from 100% RDF +25% N through (vermicompost) + $ZnSO_4$ @ 25 kg/ha^{-1} which were statistically more than with 75% RDF + 25% N through FYM + *Azotobacter* and 75% RDF +25% N through FYM + *Azotobacter*. However, the minimum harvesting index was recorded from control plot Reported that Yadav *et al.*, (2018) [13].

Table 2: Minimum Number of spikelet's, Grain per spike

S. N.	Treatments	Number of spikelet's	Length of spike	Grain per spike	Test weight	Grain yield	Straw yield	Biological yield	Harvesting index
1	100% RDF (Recommended dose of fertilizer)	19.620	11.750	40.730	38.100	49.390	77.730	127.120	38.850
2	75% RDF	19.200	11.510	37.180	37.300	45.700	77.460	123.160	37.100
3	75% RDF + $ZnSO_4$ @25kg/ha^{-1}	19.420	11.700	39.140	37.560	48.350	78.500	126.850	38.110
4	75% RDF + sulphur @40kg/ha^{-1}	19.300	11.600	38.650	36.900	47.850	77.650	125.500	38.120
5	75%RDF +25% N through FYM + *Azotobacter*	20.120	12.100	42.100	39.420	52.450	80.290	132.740	39.510
6	75% RDF + $ZnSO_4$ @25 kg/ha^{-1} + Sulphur @40 kg/ha^{-1}	20.090	11.800	41.650	38.120	50.650	79.200	129.850	39.000
7	100% RDF +25% N through (vermicompost)+ $ZnSO_4$@25kg/ha^{-1}	21.140	12.400	43.100	41.200	55.320	81.140	136.460	40.530
8	Control	19.100	11.420	31.140	35.500	46.100	78.650	124.750	36.950
	C.D at 5 % SEm ± SEm ±	0.14 0.528	0.043 0.316	3.181 1.039	3.105 1.014	4.007 1.308	3.54 2.121	7.34 3.428	2.35 1.032

Conclusion

Initial plant population per running meter row length of wheat crop does not show significant results due to Integrated Nutrient Management (INM) of wheat crop. The maximum plant height at 60 and 90 DAS stage was documented from 100% RDF +25% N through (vermicompost)+ $ZnSO_4$ @ 25 kg/ha^{-1} which were statistically highest when 75% RDF +25% N through FYM + Azotobacter. However, the minimum plant height at 60, 90 DAS and harvest stage were recorded from control plot. The maximum number of tillers at 60 DAS stage was documented from 100% RDF +25% N through (vermicompost)+ $ZnSO_4$ @ 25 kg/ha^{-1} which were statistically at par with 75% RDF +25% N through FYM + Azotobacter and 100% RDF (Recommended dose of fertilizer). The

maximum number of spikelet's was documented from 100% RDF +25% N through (vermicompost)+ $ZnSO_4$ @ 25 kg/ha^{-1} which were statistically superior with 75% RDF + 25% N through FYM + Azotobacter and 75% RDF +25% N through FYM + Azotobacter. The maximum length of spike was documented from 100% RDF +25% N through (vermicompost) + $ZnSO_4$ @ 25 kg/ha^{-1}which were statistically superior with 75% RDF + 25% N through FYM + *Azotobacter* and 75% RDF +25% N through FYM + *Azotobacter*. The maximum number of grains per spike was documented from 100% RDF +25% N through (vermicompost) + $ZnSO_4$ @ 25 kg/ha^{-1} which were statistically at par with 75% RDF + 25% N through FYM + *Azotobacter* and 75% RDF +25% N through FYM + *Azotobacter*. The maximum test weight was documented from 100% RDF +25% N through (vermicompost) + $ZnSO_4$ @ 25 kg/ha^{-1} which were statistically at par with 75% RDF + 25% N through FYM + *Azotobacter* and 75% RDF +25% N through FYM + *Azotobacter*. The maximum grain yield was documented from 100% RDF +25% N through (vermicompost) + $ZnSO_4$ @ 25 kg/ha^{-1} which were statistically more than with 75% RDF + 25% N through FYM + *Azotobacter* and 75% RDF +25% N through FYM + *Azotobacter*. The maximum straw yield was documented from 100% RDF +25% N through (vermicompost) + $ZnSO_4$ @ 25 kg/ha^{-1} which were statistically more than with 75% RDF + 25% N through FYM + *Azotobacter* and 75% RDF +25% N through FYM + *Azotobacter*. The maximum biological yield was documented from 100% RDF +25% N through (vermicompost) + ZnSO4 @ 25 kg/ha^{-1} which were statistically more than with 75% RDF + 25% N through FYM + *Azotobacter* and 75% RDF +25% N through FYM + *Azotobacter*. The maximum harvesting index was documented from 100% RDF +25% N through (vermicompost) + $ZnSO_4$ @ 25 kg/ha^{-1} which were statistically more than with 75% RDF + 25% N through FYM + *Azotobacter* and 75% RDF +25% N through FYM + *Azotobact*.

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