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Effect of Zinc enriched and organic sources on Productivity and Profitability of Wheat (*Triticum aestivum* L.)

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Abstract
A field experiment was conducted at Crop Research Center, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, with a view to compare the production potential under different zinc enriched and organic sources and also to find out the economic viability of this cultivar for soil quality. The treatments comprised of Control (T_1), 100% NPK (T_2), 100% NPK + Zn @ 5.0 Kg ha^{-1} (T_3), 100% NPK + FYM @ 5.0 t ha^{-1} (T_4), 100% NPK + FYM @ 5.0 t ha^{-1} enriched with Zn @ 0.1% (T_5), 100% NPK + V.C @ 1.5 t ha^{-1} (T_6), 100% NPK + V.C. @ 1.5 t ha^{-1} enriched with Zn @ 0.33% (T_7) and 100% NPK + Zn @ 2.5 Kg ha^{-1} application twice at basal and max. tillering stage (T_8). Results revealed that treatment T_7 (100% NPK + V.C. @ 1.5 t ha^{-1} enriched with Zn @ 0.33%) and T_8 (100% NPK + Zn @ 2.5 Kg ha^{-1} application twice at basal and max. tillering stage) exhibited significant influence on yield attributes and yields of wheat as compared to the application of 100% NPK alone. The maximum gross return was obtained in T_8 followed by T_7. The highest net return was obtained in T_8 followed by T_7 and T_5, while minimum gross return and net return was obtained in T_1 during both the years. Application of 100% NPK + Zn @ 2.5 Kg ha^{-1} application twice at basal and max. tillering stage (T_8) and 100% NPK + V.C. @ 1.5 t ha^{-1} enriched with Zn @ 0.33% (T_7) recorded higher gross return, net return and B:C ratio due to higher cost of zinc and vermicompost. Higher values of B: C ratio (2.77 & 2.85) was obtained in T_8 during 2019-20 and 2020-21.

Keywords: Wheat, zinc enriched, production potential, profitability

Introduction
Wheat [*Triticum aestivum* (L.)] is the most important staple food crop of the world and emerged as the backbone of India's food security. Globally it is grown in 122 countries and occupies an area of 215 million ha produced 765.55 million tonnes of wheat during 2018-19. Total world consumption of wheat is around 759 million tonnes per year and this is expected to continue grow over the coming years. It is grown all over the world for its wider adaptability and high nutritive value. It is an important winter cereal contributing about 38% of the total food grain production in India. Wheat straw is an important source of fodder for a large animal population in India. In India, wheat is the second most important cereal crop after rice covering an area of 30.79 million hectares. Total annual production of wheat in India is 98.51 million tonnes with the productivity of 3.20 tonnes per hectare during 2018. India is the second largest wheat producer (approximately 12%) and consumer after China. Wheat is an integral part of human diet, lacks the mechanism of zinc absorption as compared legume thus realized deficiency of zinc in plants meanwhile in human as well as in soils also.

In India, about 91% of wheat is produced in six states *viz.* Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, Rajasthan and Bihar. Uttar Pradesh with 31.28 million tonnes production holds first position.

Uttar Pradesh being the most important wheat producing state of the country, it can play an important role in increasing the total wheat production in the country. Average productivity of wheat in U.P. is lower than average productivity of country. Even though in some western districts of Uttar Pradesh like Meerut, Muzaffarnagar, Baghpat and Bulandshahr are comparable to that of Haryana, where as the productivity in central, eastern and Bundelkhand region is much lower than state average. It is mainly due to limited resources of irrigation water. FYM, the principle source of organic matter in our country is a source of primary, secondary and micronutrients to the plant growth.

It is a constant source of energy for heterotrophic microorganisms, help in increasing the availability of nutrient quality and quality of crop produce. The entire amount of nutrients present in farmyard manure is not available immediately but about 30 per cent of nitrogen, 60 to 70 per cent of phosphorus and 70 per cent of potassium are available to the first crop, while remaining amount of nutrients will be available to succeeding crop. Farmyard manure it improve the chemical and biological conditions of soil increasing cation exchange capacity and providing various, vitamins, harmones and organic acids which are very important for soil aggregation and beneficial micro-organism which involved in bio-chemical process and release of nutrients**.**

Farmyard manure with micronutrients not only enhances the rate of decomposition but also improves the nutrient status. Application of FYM with $ZnSO_4$ increased the Diethylene Triamine Penta Acetic Acid (DTPA)-Zn content in soils. Zinc enriched organic manures improves the availability of zinc in soil by preventing their fixation and precipitation thereby enhancing the use efficiency of applied zinc thus saving the cost on fertilizer. The effect of combined application of FYM and zinc on soil parameters and plant factors was well documented. The Zn application through enriched organics could be a better way for management of micronutrient stress to increase crop yields as well as to reduce chemical load thereby helping in improving soil quality.

Farmyard manure is a organic source of nutrients that also have been shown to increase soil organic matter and enhance soil quality**.** It is well known that organic amendments like farm yard manures have a number of benefits in soil physical and chemical properties. The poor recovery of zinc by crops necessitates the adoption of improved techniques like use of synthetic chelates. Zinc chelates, though more effective in maintaining Zn in soil solution, their use on large scale under field condition is prohibitive due to high cost. In such situation enrichment of Zn with organic manures which acts as natural chelates seems to be economically viable.

Vermicomposting is one of the best processes of recycling of different types of wastes available on farm, rural areas and urban settlements and may become most important component. Vermicompost is the conversion of biodegradable organic waste materials into granular compost through earthworms consisting of worms casts rich in nutrients and micro flora than conventional compost. Some of the secretion of worms and associated microbes act as growth promoter along with other nutrient. It has attracted the attention not only of scientists but also of farmers worldwide. Since it is a natural organic product which is eco-friendly, it does not leave any adverse effects either in the soil or in the environment. Much interest in vermicompost has been noticed due to the fact that earthworms play an important role in soil improvement, organic matter decomposition and enhancing plant growth. The C:N ratio of vermicompost is much lower (16:1) than that of FYM (30:1). The effect of earthworms on plant growth may be due to several reasons apart from the presence of macro and micronutrient in their secretion and vermicast in considerable quantities. Certain metabolites produced by earthworms may also be responsible to stimulate the plant growth. Vermicompost also help in preventing plant disease. The mucus associated with the cast being hygroscopic absorbed water holding capacity.

The major role of zinc in crop production is carbohydrate metabolism, both in photosynthesis and in the conversion of sugars to starch, protein metabolism, auxin (growth regulator) metabolism, pollen formation, the maintenance of the integrity of biological membranes, the resistance to infection by certain pathogens**.**

Material and Methods

The experiment was carried out at Crop Research Centre, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.) to study the influence of different zinc enriched and organic sources on productivity and profitability of wheat in Randomized Block Design with 08 treatments (Table 1), replicated three times. The maximum and minimum temperatures recorded were 40.0 ^{0}C and 4.6 ^{0}C during the crop growth period. Relative humidity ranges between 37-83% during crop growth period. The area receives mean annual rainfall between 650-805 mm. The soil of the experimental field was sandy loam in texture, low in available nitrogen (180.4 kg ha^{-1}) and organic carbon (0.45%), medium in available phosphorous (15.7 kg ha^{-1}) and potassium (280.0 kg ha^{-1}), available zinc (0.75) and slightly alkaline (pH 7.8) in reaction with electrical conductivity of 0.25 dS m^{-1}. The crop variety DBW-71 was sown on December 9 & 5, 2019 & 2020 and harvested on 22 & 18 April 2021. The seed rate was 120 kg ha^{-1}. The recommended dose of nitrogen (80 kg ha^{-1}) was applied in two equal split, the half as basal and the remaining half was top dressed 2 times at the time of first and second irrigation. The whole quantity of potassium (40 kg ha^{-1}) was applied as basal dose through Murate of Potash at 8-10 cm depth along with half dose of nitrogen prior to sowing. Phosphorous was applied as basal dose (60 kg ha^{-1}) through DAP. Vermicompost (1.5 t ha^{-1}) and FYM (5.0 t ha^{-1}) were applied in the field as per treatments and was thoroughly mixed at the time of sowing. Zinc was applied at the time of sowing in the form of Zinc sulphate. The seed was treated with Azotobacter @200g / 10 kg seed which was applied as per treatments before the sowing. One thinning was done after 30 days of sowing to maintain a plant to plant distance of about 15 cm. Weeding and hoeing operation were performed manually after first and second irrigation at proper soil moisture condition of the soil. At the harvest, grains $spike^{-1}$, 1000 grains weight, seed yield and straw yield were calculated. Economics of treatments were computed on the basis of prevailing market price of inputs and outputs under each treatment. The total cost of cultivation of crop was calculated on the basis of different operations performed and materials used for raising the crop including the cost of fertilizers and seeds. The cost of labour incurred in performing different operation was also included. Statistical analysis of the data was done as per the standard analysis of variance technique for the experimental designs following SPSS software based programme, and the treatment means were compared at $P<0.05$ level of probability using t-test and calculating CD values.

Result and Discussion

Effect of different zinc enriched and organic sources on yield attributes of Wheat

Yield attributes *viz*., Spike length, Spikelet $spike^{-1}$, Number of grains $spike^{-1}$ and weight of 1000 grains of wheat were affected significantly by various treatments involving different zinc enriched and organic sources (Table 1 and Fig 1).

Table 1: Effect of Zinc enriched organic sources on yield attributes of wheat

	Treatments	Yield attributes							
		Spike length (cm)		Spikelet/spike		No. of grains/spike		1000-grain weight (g)	
		2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
T_1	Control	3.92	4.60	6.98	7.54	25.51	26.04	30.78	31.34
T_2	100% NPK	6.87	7.54	10.86	11.22	35.38	35.80	33.33	33.91
T_3	100% NPK + Zn @ 5.0 Kg ha^{-1}	9.31	10.00	15.04	15.49	41.26	41.72	37.34	37.40
T_4	100% NPK + FYM @ 5.0 t ha^{-1}	7.54	8.22	12.83	13.26	37.31	37.83	34.76	35.26
T_5	100% NPK + FYM @ 5.0 t ha^{-1} enriched with Zn @ 0.1%	10.47	11.19	15.74	16.27	43.05	43.98	38.51	39.00
T_6	100% NPK + V.C @ 1.5 t ha^{-1}	8.27	8.87	13.68	14.23	39.69	40.15	35.98	36.36
T_7	100% NPK + V.C. @ 1.5 t ha^{-1} enriched with Zn @ 0.33%	11.09	11.65	15.91	16.39	44.00	44.46	39.38	39.87
T_8	100% NPK + Zn @ 2.5 Kg ha^{-1} application twice at basal and max. tillering stage	11.76	12.49	16.85	17.30	45.18	45.70	40.46	40.91
	S.Em±	0.28	0.30	0.44	0.46	1.26	1.28	1.18	1.19
	CD at 5%	0.82	0.88	1.29	1.33	3.69	3.74	3.44	3.48

From the given data (Table 1) it can be inferred that the maximum spike length (11.75 & 12.49 cm) were produced in the treatment T_8 (100% NPK + Zn @ 2.5 Kg ha^{-1} application twice at basal and max. tillering stage) which was found to be on par with T_7 (100% NPK + V.C. @ 1.5 t ha^{-1} enriched with Zn @ 0.33%). However, the lowest spike length (3.92 & 4.60) was recorded in treatment T_1 (Control), which was significantly lower than rest of the other treatments. The results were in accordance with those reported by Nataraja *et al*. (2005) [12], Khan *et al*. (2009) [10] and Mouriya *et al*. (2013) [11]. Significantly higher spikelet spike^{-1} (16.85 & 17.30) was recorded in treatment T_8 (100% NPK + Zn @ 2.5 Kg ha^{-1} application twice at basal and max. tillering stage), which was statistically found to be on par with, T_7 (100% NPK + V.C. @ 1.5 t ha^{-1} enriched with Zn @ 0.33%) and T_5 (100% NPK + FYM @ 5.0 t ha^{-1} enriched with Zn @ 0.1%). Treatment T_1 (Control) recorded the lowest spikelet spike^{-1} (6.98 & 7.54) and next in order was treatment T_2 (100% NPK). It might be due to increased and prolonged availability of nutrients from integrated use of vermicompost, zinc and FYM, which ultimately resulted in rapid cell multiplication and cell elongation under sufficient nutrient supply. The results were in accordance with those reported by (Hotz and Braun, 2004), Dahshouri *et al*. (2017) and Jat *et al*. (2018) [6, 4, 8].

It is evident from the data that the significantly higher number of grains spike^{-1} (45.18 & 45.70) were produced in treatment T_8 (100% NPK + Zn @ 2.5 Kg ha^{-1} application twice at basal and max. tillering stage), which remained on par with, T_7 (100% NPK + V.C. @ 1.5 t ha^{-1} enriched with Zn @ 0.33%) and T_5 (100% NPK + FYM @ 5.0 t ha^{-1} enriched with Zn @ 0.1%). Treatment T_1 recorded lowest number of number of grains spike^{-1} (25.51 & 26.04) followed by T_2 (100% NPK) during 2019-20 & 2020-21. Adequate nutrients availability to the crop as a result of increment in photosynthesis as well as growth led to increase in the number of grains spike^{-1}. These findings were almost similar to the results reported by Kanwar *et al*. (2005) [9] and Channabasanagowda *et al*. (2008) [2]. Maximum 1000- grain weight (40.46 & 40.91 g) was recorded in T_8 (100% NPK + Zn @ 2.5 Kg ha^{-1} application twice at basal and max. tillering stage), which was on par to T_7 (100% NPK + V.C. @ 1.5 t ha^{-1} enriched with Zn @ 0.33%) and T_5 (100% NPK + FYM @ 5.0 t ha^{-1} enriched with Zn @ 0.1%), whereas the lowest test weight (30.78 & 31.34 g) was recorded in T_1 (Control) during both the years. The integrated application of zinc, vermicompost and FYM might increase availability of plant nutrients which result into better nourishment of plants and the formation of bold seeds, ultimately increased weight of grain. The results were similar to the findings reported by Khan *et al*. (2009) [10] and Mouriya *et al*. (2013) [11].

Effect of different zinc enriched and organic sources on Productivity

Data with regard to the effect of zinc enriched and organic sources on grain yield, straw yield, biological yield and harvest index of wheat crop are mentioned in Table 2 and depicted in Fig 2.

Table 2: Effect of Zinc enriched organic sources on biological, grain, straw yield (q ha^{-1}) and harvest index (%) of wheat

	Treatments	Yield (q ha^{-1})							
		Grain		Straw		Biological		Harvest index (%)	
		2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
T_1	Control	25.65	26.88	37.45	39.29	63.1	66.17	40.65	40.62
T_2	100% NPK	35.19	37.23	51.77	54.83	86.96	92.06	40.47	40.44
T_3	100% NPK + Zn @ 5.0 kg ha^{-1}	39.35	41.06	58.01	59.54	97.36	100.6	40.42	40.82
T_4	100% NPK + FYM @ 5.0 t ha^{-1}	37.86	39.37	55.29	56.54	93.15	95.91	40.64	41.04
T_5	100% NPK + FYM @ 5.0 t ha^{-1} enriched with Zn @ 0.1%	41.26	43.39	60.86	62.03	102.12	105.42	40.40	41.16
T_6	100% NPK + V.C @ 1.5 t ha^{-1}	38.54	39.94	56.78	57.89	95.32	97.83	40.43	40.82
T_7	100% NPK + V.C. @ 1.5 t ha^{-1} enriched with Zn @ 0.33%	42.50	44.78	62.73	64.46	105.23	109.24	40.39	40.99
T_8	100% NPK + Zn @ 2.5 kg ha^{-1} application twice at basal and max. tillering stage	44.06	46.72	64.06	66.54	108.12	113.26	40.75	41.25
	S.Em±	1.23	1.29	1.82	1.88	3.05	3.17	1.31	1.32
	CD at 5%	3.60	3.78	5.33	5.50	8.93	9.27	NS	NS

Among the various zinc enriched and organic sources, the treatment T_8 (100% NPK + Zn @ 2.5 kg ha^{-1} application twice at basal and max. tillering stage) exhibited significantly higher grain yield (44.06 & 46.72 q ha^{-1}), which was statistically on par to T_7 (100% NPK + V.C. @ 1.5 t ha^{-1} enriched with Zn @ 0.33%) and T_5 (100% NPK + FYM @ 5.0 t ha^{-1} enriched with Zn @ 0.1%). Treatment T_1 (Control) with no application of any fertilizer recorded lowest grain yield of 25.65 & 26.88 q ha^{-1}. About 71.7 & 73.8%, 65.6 & 66.5%, 60.8 & 61.4% and 53.4 & 52.7% increase in seed yield was recorded by T_8 (100% NPK + Zn @ 2.5 kg ha^{-1} application twice at basal and max. tillering stage), T_7 (100% NPK + V.C. @ 1.5 t ha^{-1} enriched with Zn @ 0.33%), T_5 (100% NPK + FYM @ 5.0 t ha^{-1} enriched with Zn @ 0.1%) and T_3 (100% NPK + Zn @ 5.0 kg ha^{-1}) respectively over treatment T_1 (Control) during 2019-20 & 2020-21. The maximum grain yield was recorded due to integrated application of vermicompost and FYM, chemical fertilizers and biofertilizers. This might be due to slow release of nutrient from vermicompost and FYM leading to reduced loss of nitrogen and efficient use of Macro and micronutrients. The production of growth promoting and antifungal substances by Azotobacter and nitrogen fixation was possibly the reason for higher yields.

In the same way, straw yield of wheat (Table 2) was significantly influenced by different zinc enriched and organic sources. Results revealed that the differences in straw yield were found significant due to different treatments. Though significantly higher straw yield 64.06 & 66.54 q ha^{-1} was recorded under T_8, it was statistically on par with T_7 and T_5. The lowest straw yield (37.45 & 39.29 q ha^{-1}) was recorded in T_1 (control) during both the years. Similar trend was observed in Biological yield, whereas maximum harvest index (40.75 & 41.25%) was recorded in T_8. The lowest harvest index recorded with T_1 (Control) plot. The increase in straw yield was mainly due to increased growth attributing characters like plant height and grains $spike^{-1}$. The use of organic manure like vermicompost, FYM and biofertilizers in conjunction with macro and micronutrients had profound effect on vegetative growth due to improved nutrients availability in the soil for longer time with progressive decompositions of FYM. These findings are in conformity with the results of Singh and Singh (2005) [15], Seilsepour (2006) [13], Dayanand *et al.* (2013) [5], Chauhan *et al.* (2014) [3] and Biswas *et al.* (2015) [1].

Economics

From Table 3 it can be seen that among the various nutrient levels, the cost of cultivation (Rs. ha^{-1}) varied from 34258 to 42960 & 35309 to 44011 Rs. ha^{-1}. The highest cost of cultivation was registered with the application of 100% NPK + Zn @ 2.5 Kg ha^{-1} application twice at basal and max. tillering stage (T_8) followed by 100% NPK + V.C. @ 1.5 t ha^{-1} enriched with Zn @ 0.33% (T_7) and 100% NPK + FYM @ 5.0 t ha^{-1} enriched with Zn @ 0.1% (T_5) while the application of no fertilizer (Control) registered the lowest cost of cultivation. Maximum gross returns (116846 & 125542 Rs. ha^{-1}) was obtained by the application of 100% NPK + Zn @ 2.5 Kg ha^{-1} application twice at basal and max. tillering stage (T_8) followed by 100% NPK + V.C. @ 1.5 t ha^{-1} enriched with Zn @ 0.33% (T_7) and 100% NPK + FYM @ 5.0 t ha^{-1} enriched with Zn @ 0.1% (T_5).

Table 3: Effect of Zinc enriched organic sources on economics of wheat

Treatments		Cost of cultivation (Rs ha^{-1})		Gross return (Rs ha^{-1})		Net return (Rs ha^{-1})		B:C ratio	
		2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
T_1	Control	34258	35309	68101	72733	33843	37424	1.99	2.06
T_2	100% NPK	36580	37731	93626	100944	57046	63213	2.56	2.68
T_3	100% NPK + Zn @ 5.0 Kg ha^{-1}	41880	42931	104754	110864	62874	67933	2.50	2.58
T_4	100% NPK + FYM @ 5.0 t ha^{-1}	36800	37951	100526	106026	63726	68075	2.72	2.79
T_5	100% NPK + FYM @ 5.0 t ha^{-1} enriched with Zn @ 0.1%	42350	43290	109856	116710	67506	73420	2.59	2.70
T_6	100% NPK + V.C @ 1.5 t ha^{-1}	38580	39740	102580	107827	64000	68087	2.66	2.71
T_7	100% NPK + V.C. @ 1.5 t ha^{-1} enriched with Zn @ 0.33%	42510	43561	113178	120671	70668	77110	2.66	2.77
T_8	100% NPK + Zn @ 2.5 Kg ha^{-1} application twice at basal and max. tillering stage	42960	44011	116846	125542	73886	81531	2.73	2.85
	S.Em±	-	-	3302	3510	2037	2209	0.08	0.09
	CD at 5%	-	-	9662	10269	5960	6463	0.24	0.27

The lowest Gross return of 68101 & 72733 Rs. ha^{-1} was obtained in treatment T_1 (Control). Maximum net return of 73886 & 81531 Rs ha^{-1} was recorded by the application of 100% NPK + Zn @ 2.5 Kg ha^{-1} application twice at basal and max. tillering stage (T_8) followed by 100% NPK + V.C. @ 1.5 t ha^{-1} enriched with Zn @ 0.33% (T_7) and 100% NPK + FYM @ 5.0 t ha^{-1} enriched with Zn @ 0.1% (T_5). However, the maximum Benefit cost ratio of 2.73 & 2.85 was obtained by the application of 100% NPK + Zn @ 2.5 Kg ha^{-1} application twice at basal and max. tillering stage (T_8) followed by T_4, T_7 and T_6 during both the years. The higher net returns and BCR was mainly due to increase in grain yield. Similar results recorded by Jat *et al.* (2013) [7], Chauhan *et al.* (2014) [3] and Singh *et al.* (2015) [16].

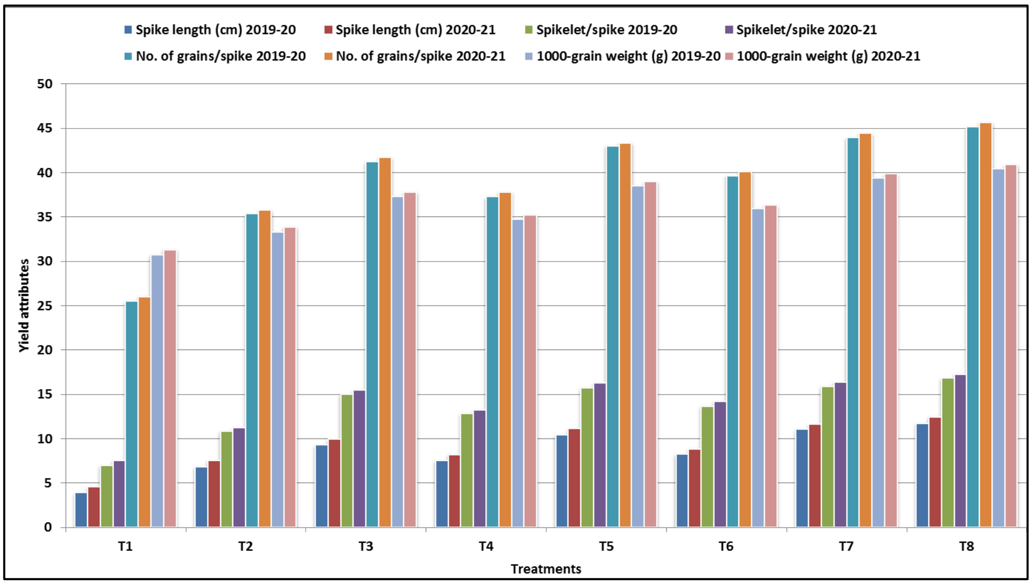

Fig 1: Effect of Zinc enriched organic sources on yield attributes of wheat

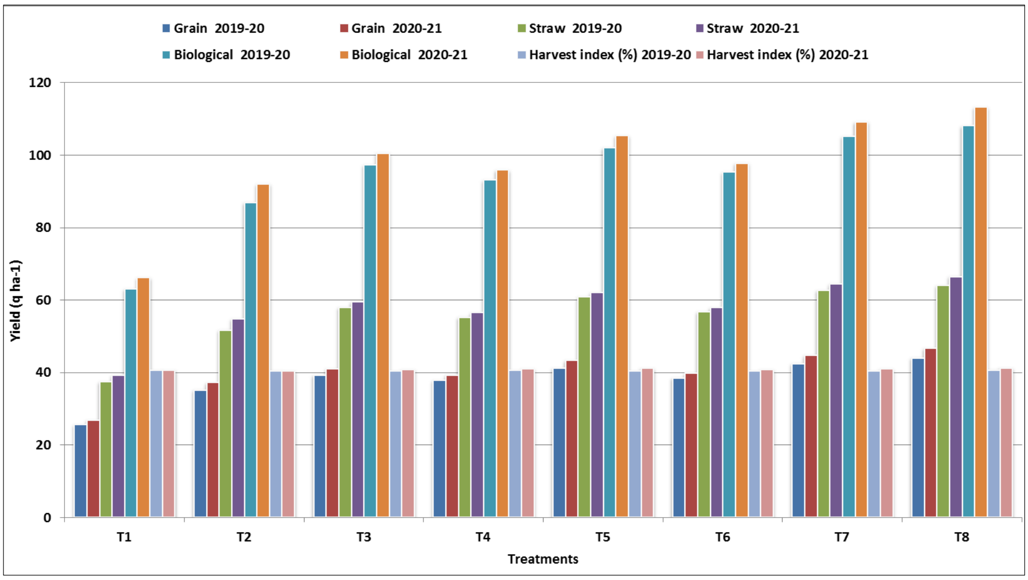

Fig 2: Effect of Zinc enriched organic sources on biological, grain, straw yield (q ha^{-1}) and harvest index (%) of wheat

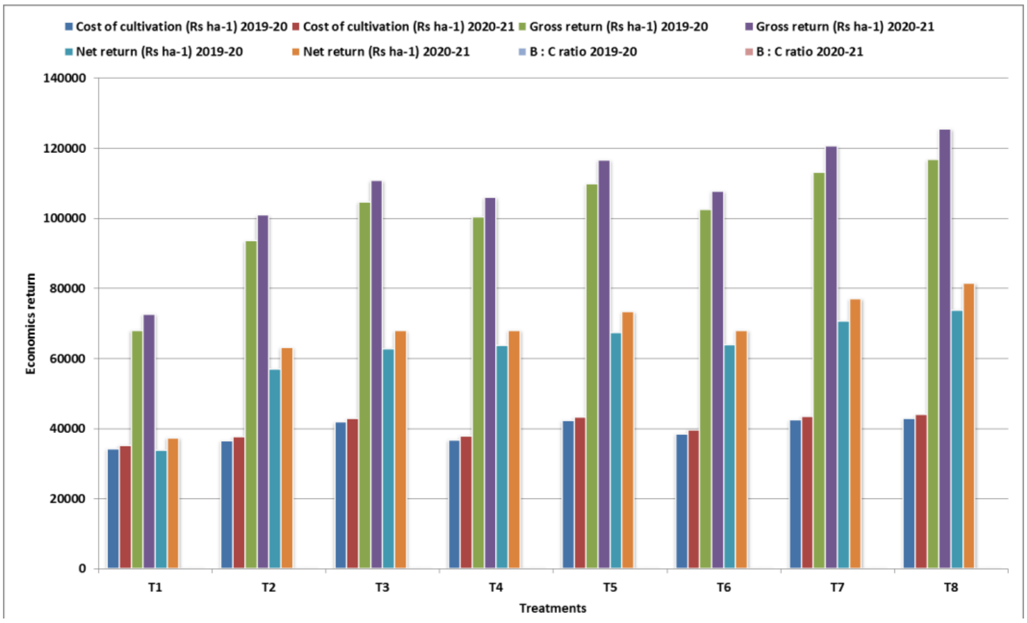

Fig 3: Effect of Zinc enriched organic sources on economics of wheat

Conclusion

All the growth, yield attributes and yield of wheat improved with the application of organic and inorganic fertilizers and achieved maximum value with 100% NPK + Zn @ 2.5 Kg ha^{-1} application twice at basal and max tillering stage. Application of micronutrients not only improves the content of Zn in grain and straw but also improve the content of N, P and K. A common fertilizer dose of NPK with micronutrients able to maintain the soil fertility while improving the micronutrients availability in soil. It is obvious that cost of cultivation increased by the additional input of micronutrients but the ultimate net return and B:C ratio was maximum with application 100% NPK + Zn @ 2.5 Kg ha^{-1} application twice at basal and max tillering stage followed by 100% NPK + V.C. @ 1.5 t ha^{-1} enriched with Zn @ 0.33% and 100% NPK + FYM @ 5.0 t ha^{-1} enriched with Zn @ 0.1% during both years.

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