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Effect of Nitrogen, Zinc and Iron Fertilization on the Economic Yield of Wheat (*Triticum aestivum*. L)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The experiment was carried out entitled "Effect of nitrogen fertilizer and Ferti-fortification through zinc and iron on yield and economics of wheat (*Triticum aestivum*)" at the Crop Research Centre of Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, (U.P.) during *rabi* season

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of 2021-22 and 2022-23. The soil of the experimental area was sandy clay loam with low organic matter, available nitrogen, medium in available phosphorus, potassium, zinc, iron and slightly alkaline in reaction. The result of the experiment revealed that the maximum grain yield (52.83 q ha^{-1} and 51.44 q ha^{-1}), straw yield (66.06 q ha^{-1} and 65.40 q ha^{-1}), net returns (₹ 106,008 ha^{-1} and ₹ 112,155 ha^{-1}) and B:C ratio (3.27 & 3.26) was recorded with recommended nitrogen (150 kg N ha^{-1}) + foliar zinc (0.5%) + foliar iron (0.5 %) treatments during 2021-22 and 2022-23, respectively.

Keywords: Fertilization; nutrients; yield; wheat; zinc; iron.

1. INTRODUCTION

Wheat (*Triticum aestivum* L.), which is the most important food crop in the world, is cultivated in 122 countries on 217 million hectares of land and produces 781.7 million tons of grain annually. Global wheat consumption is estimated to be 777 million tons per year, and this figure is expected to increase in the future [1]. In India, 31.6 million hectares area is under wheat cultivation, which would produce 109.53 million tones with a productivity of 3464.5 kg ha^{-1} in 2021–2022 [1]. About 91% of the wheat consumed in India is grown in just six states: Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, Rajasthan, and Bihar. Uttar Pradesh holds first position with 31.28 million tons of wheat. Uttar Pradesh is the state that produces the most wheat in the nation; it can have a significant impact on the country's overall wheat production. The average productivity of wheat in the U.P. is lower than the national average. It is primarily caused by a lack of resources and inadequate nutrient management techniques [2,3].

Although the country's agricultural productivity has increased considerably because of Green Revolution technologies, several kinds of problems remain that pose a threat to sustainability. The high extent of adoption of common blanket fertilizer recommendations and dependence on high analysis fertilizers have led to multiple deficiencies of secondary and micro nutrients resulting in low fertilizer and input use efficiencies. Zinc deficiency appeared initially followed by iron and manganese. WHO reports regarding mineral deficiencies particularly Zn and Fe in the human population have also become a concern and biofortification of agricultural produce is now a priority on the agenda. Fragmentation of agricultural holdings further aggravated the issues with variable nutrient supply capacity both at the spatial and temporal scale. Crop nutrition present in small concentration play a crucial role in the growth and development, quality and yield formation of crops. Nitrogen is a crucial component of proteins, amino acids, nucleic acids, nucleotides, phospholipids, chlorophyll, enzymes, hormones, vitamins, and other substances. It gives plants their dark green color and enhances the quality of wheat crops. Phosphorus governs root growth and reproductive function as a constituent of nucleic acid, phytin, phospholipids, ATP etc. Potassium promotes disease resistance, regulates water balance, strengthens stalks, builds proteins, regulates respiration, stretches water, and acts as a disease retarder, but it is ineffective without co-nutrients like nitrogen and phosphorus. Zinc, as a constituent of amino acids and vitamins, helps in chlorophyll formation, involved in forming and stabilizing the tertiary structure of enzyme and other proteins.

Consumption of food and nutrients is the basis of life, and a lack of proper nutrition is the primary cause of the widespread deaths of people. In 2003, about 30 million people died as a result of this issue in developing countries with limited resources. According to Graham, one person passes away from a disease related to diet every second. Additionally, one in three people worldwide suffers from Fe insufficiency, whereas 10% of Americans and Canadians and 30% of those in underdeveloped nations are Zn deficient. However, common cereals like wheat frequently have insufficient levels of micronutrients, particularly iron (Fe) and zinc (Zn), and milling removes the majority of this content. In countries where grains constitute the majority of the human diet, this results in micronutrient shortages. It was also asserted that additional Zn and Fe applications by soil or foliar applications could promote the increased activity of Zn and Fe in the source (flag leaf and stem) during grain filling. Soil fertilization with Zn, which is typically applied as $ZnSO_4$ $7H_2O$, appears to be important for ensuring the success of biofortification [4].

2. MATERIALS AND METHODS

The field experiment was conducted at the Crop Research Center of the Sardar Vallabhbhai Patel

University of Agriculture and Technology in Meerut (U.P.), which is located in the North Western Plains of the wheat growing zone and, in the Indo, -Gangetic plains of Western Uttar Pradesh. Geographically, the farm is situated at 290 05' 19" North latitude, 770 41' 50" East longitudes, and 237 meters above mean sea level. Meerut is situated on Delhi-Dehradun National Highway. This area has a semi-arid, subtropical climate with rich alluvial soil. The average annual rainfall in the area is 890 mm. Most of the rain falls between mid-June and the end of September. The last week of December through the middle of January sees periodic rain and frost, and the winter months are colder overall. The temperature can reach 44–47°C or higher in May and June than and as low as 2-3° C in the winter. Since July until the end of March, the mean relative humidity (7 AM) has been roughly steady at 80–90%, and following March, it steadily declines to 40–50% by the end of April before returning to 80% in May. The weekly distribution of maximum and minimum temperature (^{0}C), relative humidity (%), wind velocity (km hr^{-1}), evaporation rate (mm day^{-1}) and total rainfall (mm) recorded during the crop growth period (2021-22 and 2022-23). Before pursuance of the experiment, representative samples (15 cm depth) were collected from the experimental field to determine the initial physico-chemical status of the soil. Those were then subjected to mechanical and chemical analysis and results for the physical and chemical properties of the soil. The soil of the experimental area was sandy clay loam with low organic matter, available nitrogen, medium in available phosphorus, potassium, zinc, iron and slightly alkaline in reaction.

The field was irrigated to have the optimum moisture level for field preparation and germination. After irrigation, the field was ploughed once, followed by harrowing twice and planking. Each time, the operations were done by tractor drawn implements. After that, the plots were marked according to the layout plan and dressed properly with spades. Every plot of the experimental crop was treated with an equal amount of nutrients, which were 150, 60, 60 and 5 kg of N, P, K and Zn per hectare respectively. Urea, single super phosphate, muriate of potash and zinc sulphate were used to apply the N, P, K and Zn, respectively. The experiment comprises twelve treatments *viz.* Control, No nitrogen + soil zinc without nitrogen + foliar iron (0.5%) without nitrogen + foliar zinc (0.5 %), No nitrogen + soil zinc + foliar zinc (0.5%), Recommended nitrogen (150 kg N ha^{-1}), Recommended nitrogen + soil zinc, Recommended nitrogen + foliar zinc (0.5%), Recommended nitrogen +foliar iron (0.5%), Recommended nitrogen +foliar iron (1.0%), Recommended nitrogen + soil zinc + foliar iron (0.5%) and Recommended nitrogen + foliar zinc (0.5%) + foliar iron (0.5%) were tested in randomized block design with three replications. At the time of sowing, a full dose of phosphorus, potash, zinc and one-third of nitrogen were applied in the field. Following the initial irrigation, the rest of the nitrogen was top dressed in two equal splits at the first & second irrigation in order to ensure the crop would grow well. The foliar spray of iron was applied as per treatment.

3. RESULTS AND DISCUSSION

3.1 Grain Yield (q ha^{-1})

The data related to yield are presented in Table 1 and depicted in Fig. 1a and 1b. The yield of the crop was significantly influenced by nutrient enrichment practices during both the years 2021-22 & 2022-23.

The maximum grain yield was recorded with recommended nitrogen + foliar zinc (0.5%) + foliar iron (0.5%), which remained statistically *at par* with recommended nitrogen + soil zinc + foliar iron (0.5%), but was significantly higher than the rest of the treatment during both years. The grain yield was increased by 80.89 and 89.81 percent with the recommended nitrogen + foliar zinc (0.5%) + foliar iron (0.5%) than control treatment during 2021-22 and 2022-23, respectively. The lowest grain yield was observed in the control treatment during both years of the experiment. These results are in close conformity with the findings of Hasan et al. [5], Sultana et al. [6] and Malav et al. [7].

3.2 Straw Yield (q ha^{-1})

The maximum straw yield was observed in recommended nitrogen + foliar zinc (0.5%) + foliar iron (0.5%) treatment, which remained statistically *at par* with recommended nitrogen + soil zinc + foliar iron (0.5%), recommended nitrogen + foliar iron (1.0%), recommended nitrogen + foliar iron (0.5%), recommended nitrogen + foliar zinc (0.5%) and recommended nitrogen + soil zinc, but significantly higher than rest of the treatments during both years. The lowest straw yield was observed in the control treatment during both the years of the experiment. Similar findings have been reported by Malav et al. [7].

Table 1. Effect of nutrient enrichment practices on grain yield, straw yield (q ha^{-1}) and harvest index (%)

Treatments	Grain Yield		Straw Yield		Harvest Index	
	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23
Control	28.10	27.10	39.22	36.95	41.74	42.31
No Nitrogen + Soil Zinc (5 kg ha^{-1})	29.16	28.41	40.17	37.45	42.06	43.13
No Nitrogen + Foliar Iron (0.5 %)	29.30	28.52	40.54	37.67	41.95	43.09
No Nitrogen + Foliar Zinc (0.5 %)	29.58	28.88	39.53	38.44	42.80	42.90
No Nitrogen + Soil Zinc (5 kg ha^{-1}) + Foliar Zinc (0.5 %)	29.79	29.33	40.32	39.37	42.49	42.69
Recommended Nitrogen (150 kg N ha^{-1})	48.10	47.29	63.61	62.48	43.19	43.08
Recommended Nitrogen + Soil Zinc (5 kg ha^{-1})	49.14	48.27	65.15	63.42	43.00	43.22
Recommended Nitrogen + Foliar Zinc (0.5%)	50.50	49.86	65.20	64.37	43.65	43.65
Recommended Nitrogen +Foliar Iron (0.5 %)	49.59	48.58	64.49	64.23	43.47	43.07
Recommended Nitrogen +Foliar Iron (1.0 %)	50.76	49.71	64.78	64.72	43.80	43.44
Recommended Nitrogen + Soil Zinc (5 kg ha^{-1}) + Foliar Iron (0.5 %)	51.52	50.28	65.02	64.20	44.31	43.92
Recommended Nitrogen + Foliar Zinc (0.5 %) + Foliar Iron (0.5 %)	52.83	51.44	66.06	65.40	44.44	44.03
SEm±	*0.54*	*0.48*	*0.59*	*0.71*	*0.52*	*0.38*
CD (P= 5%)	*1.60*	*1.42*	*1.75*	*2.10*	*1.54*	*1.11*

Table 2. Effect of nutrient enrichment practices on economics of wheat

Treatments	Cost of cultivation (₹ ha^{-1})		Gross returns (₹ ha^{-1})		Net returns (₹ ha^{-1})		B:C ratio	
	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23
Control	43,509	46,253	84,076	87,148	40,567	40,895	1.93	1.88
No Nitrogen + Soil Zinc	44,649	47,573	86,876	90,331	42,227	42,758	1.95	1.90
No Nitrogen + Foliar Iron (0.5 %)	44,134	46,881	87,418	90,741	43,284	43,860	1.98	1.94
No Nitrogen + Foliar Zinc (0.5 %)	44,317	47,103	87,275	92,122	42,958	45,019	1.97	1.96
No Nitrogen + Soil Zinc + Foliar Zinc (0.5 %)	45,457	48,423	88,251	93,822	42,794	45,399	1.94	1.94
Recommended Nitrogen	45,253	47,997	141,449	150,475	96,196	102,478	3.13	3.14
Recommended Nitrogen + Soil Zinc	46,393	49,317	144,622	153,310	98,229	103,993	3.12	3.11
Rencommended Nitrogen + Foliar Zinc (0.5%)	46,061	48,847	147,398	157,449	101,337	108,602	3.20	3.22
Recommended Nitrogen +Foliar Iron (0.5 %)	45,878	48,625	145,067	154,617	99,189	105,992	3.16	3.18
Recommended Nitrogen +Foliar Iron (1.0 %)	45,923	48,673	147,627	157,410	101,704	108,737	3.21	3.23
Recommended Nitrogen + Soil Zinc + Foliar Iron (0.5 %)	47,018	49,945	149,327	158,205	102,309	108,260	3.18	3.17
Recommended Nitrogen + Foliar Zinc (0.5 %) + Foliar Iron (0.5 %)	46,686	49,475	152,694	161,630	106,008	112,155	3.27	3.26
SEm±	-	-	*1031*	*1068*	*1167*	*1199*	*0.02*	*0.02*
CD (P= 5%)	-	-	*3101*	*3209*	*3497*	*3598*	*0.08*	*0.08*

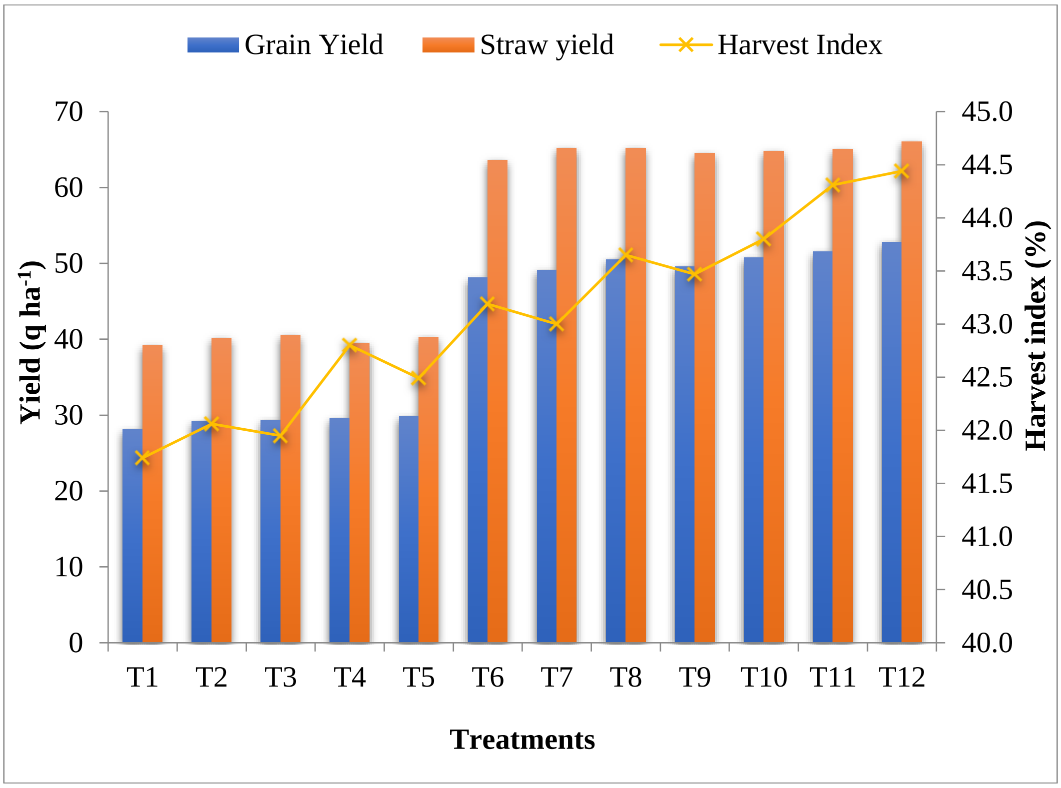

Fig. 1a. Effect of nutrient enrichment practices on grain, straw, biological yield (q ha-1) and harvest index (%)

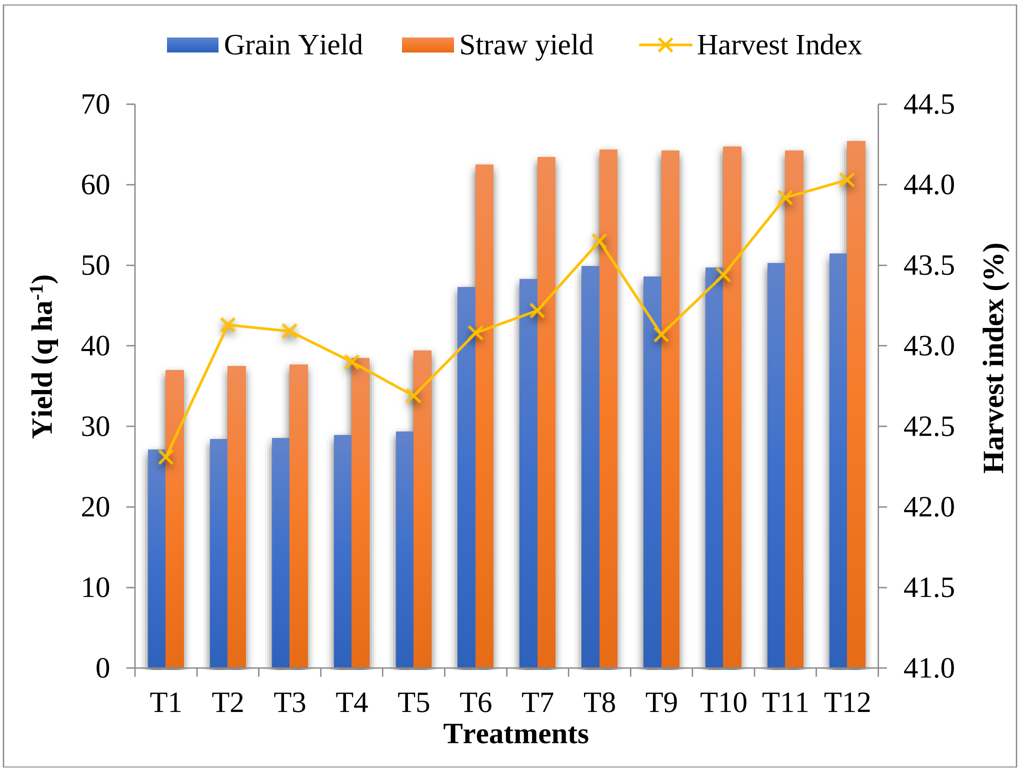

Fig. 1b. Effect of nutrient enrichment practices on grain, straw, biological yield (q ha^{-1}) and harvest index (%)

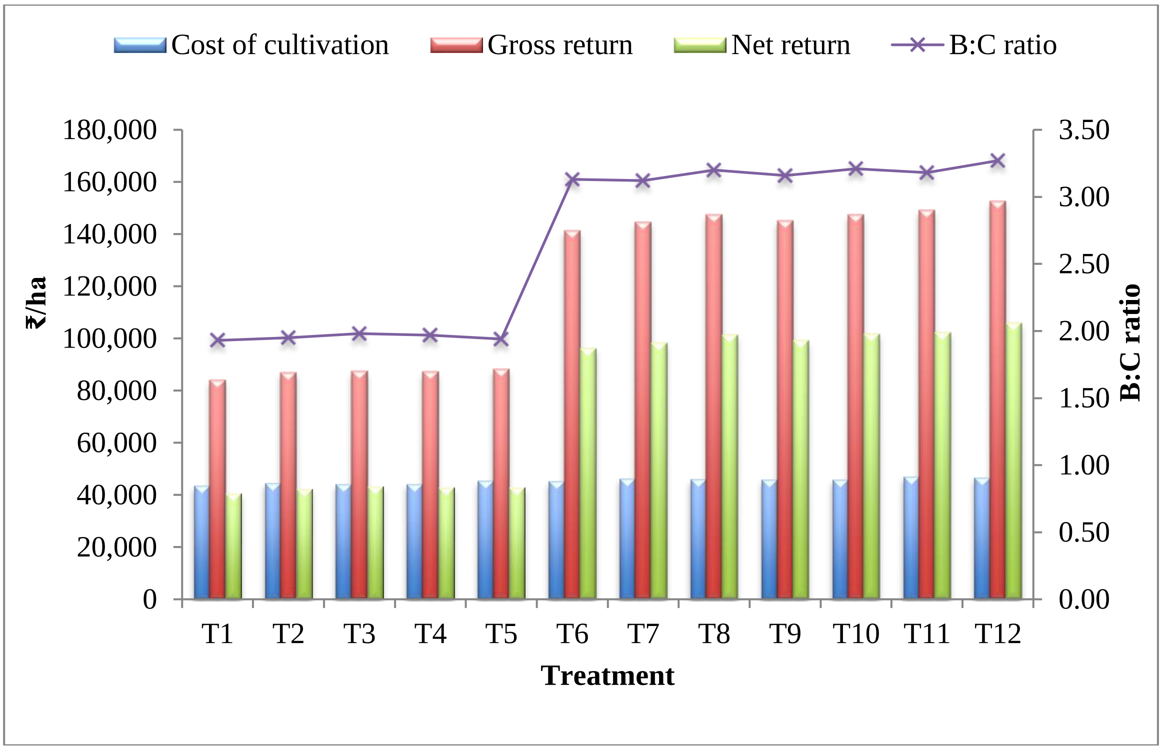

Fig. 2a. Effect of nutrient enrichment practices on economics of wheat cultivation

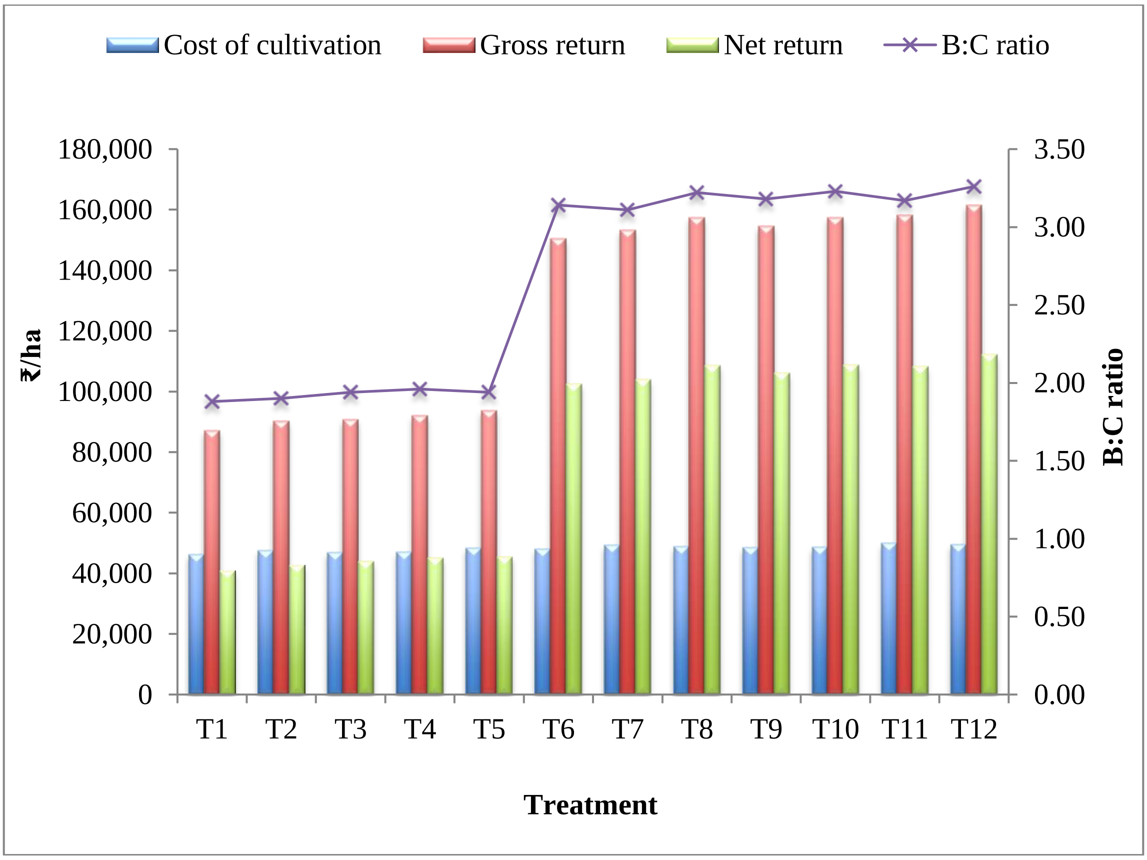

Fig. 2b. Effect of nutrient enrichment practices on economics of wheat cultivation

3.3 Harvest Index (%)

The maximum harvest index was observed in recommended nitrogen + foliar zinc (0.5%) + foliar iron (0.5%) treatment, which remained statistically *at par* with recommended nitrogen+ soil zinc + foliar iron (0.5%), recommended nitrogen + foliar iron (1.0%), recommended nitrogen + foliar iron (0.5%), recommended nitrogen + foliar zinc (0.5%), recommended nitrogen + soil zinc (5 kg ha^{-1}), and recommended nitrogen (150 kg ha^{-1}) but significantly higher than the rest of the treatments during both years. The lowest harvest index was observed in the control treatment during both years of the experiment. Similar findings have been reported by Hasan et al. [5] and Sultana et al. [6].

3.4 Economics of Wheat

The data related to economics are presented in Table 2 and depicted in Fig. 2a & 2b. The economic analyses were significantly influenced by nutrient enrichment practices during both the years 2021-22 & 2022-23.

3.5 Cost of Cultivation (₹ ha^{-1})

Among the nutrient enrichment practices, the maximum cost of cultivation was observed in recommended nitrogen + soil zinc + foliar iron (0.5%) treatment, whereas, lowest cost of cultivation was observed in the control treatment during both years. These results are in close conformity with the findings of Yadav et al. [8] and Choudhary et al. [9].

3.6 Gross Returns (₹ ha^{-1})

Among the nutrient enrichment practices, the maximum gross returns was observed with the application of recommended nitrogen + foliar zinc (0.5%) + foliar iron (0.5%) treatment, whereas, lowest gross return was observed in the control treatment during both years.

3.7 Net Returns (₹ ha^{-1})

Among the nutrient enrichment practices, the maximum net returns was observed with the application of recommended nitrogen + foliar zinc (0.5%) + foliar iron (0.5%) treatment, whereas, lowest net returns were observed in the control treatment during both years. These results are in close conformity with the findings of Chauhan et al. [10], Hasan et al. [5] and Choudhary et al. [9].

3.8 B:C ratio

Among the nutrient enrichment practices, the maximum Benefit: Cost ratio was observed with the application of recommended nitrogen + foliar zinc (0.5%) + foliar iron (0.5%) treatment, whereas, lowest Benefit: Cost ratio was observed in control treatment during both years. Similar findings have been reported by Yadav et al. [8] and Choudhary et al. [9].

4. CONCLUSION

According to the results of the current study, application of the recommended nitrogen dose (150 kg N ha^{-1}) along with soil or foliar Zn + Fe resulted in the maximum grain yield, straw yield, harvest index and higher economics of the wheat crop.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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