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Effect of doses and sources of nutrients on growth, yield and nutrient uptake in paddy (*Oryza sativa* L.)

Akshay Ujjwal, Vivek, BP Dhyani, Mukesh Kumar and Adesh Singh

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 doses and source of nutrients and also to find out the economic viability of this cultivar for soil quality. The treatments comprised of Control (T_1), NPK- (150:60:40 kg ha^{-1}) (T_2), 100% NPK + Nano Zn Spray (25 DAT) (T_3), 100% NPK + Bio-stimulant Spray (25 DAT) (T_4), 75% NPK + NPK Consortia (T_5), 75% NPK + NPK spray (25 DAT) (T_6), 75% NPK + NPK Consortia + Nano N spray (25 DAT) (T_7), 75% NPK + NPK Consortia + NPK spray (25 DAT) (T_8), 75% NPK + NPK Consortia + NPK spray (25 DAT) + Bio-stimulant Spray (25 DAT) (T_9), 75% NPK + NPK Consortia + NPK spray (25 DAT) + Bio-stimulant Spray (25 DAT) + Nano Zn spray (25 DAT) (T_{10}), 75% NPK + NPK Consortia + Nano Zn spray (25 DAT) (T_{11}) and 75% NPK + NPK Consortia + Nano N spray (25 DAT) + Nano Zn spray (25 DAT) (T_{12}). Results revealed that treatment T_{10} (75% NPK + NPK Consortia + NPK spray (25 DAT) + Bio-stimulant Spray (25 DAT) + Nano Zn spray (25 DAT) and T_3 (100% NPK + Nano Zn Spray (25 DAT) exhibited significant influence on yield attributes and yields of rice as compared to the application of 100% NPK alone. The maximum gross return was obtained in T_3 followed by $T_{10.}$ The highest net return was obtained in T_3 followed by T_{10}, while minimum gross return and net return was obtained in T_1 during both the years. Application of 100% NPK + Nano Zn Spray (25 DAT) (T_3) and 75% NPK + NPK Consortia + NPK spray (25 DAT) + Bio-stimulant Spray (25 DAT) + Nano Zn spray (25 DAT) (T_{10}) recorded higher gross return, net return and B:C ratio due to higher cost of zinc and iron. Higher values of B: C ratio (2.48 & 2.64) was obtained in T_3 during 2021 and 2022.

Keywords: Rice, zinc, iron, production potential, profitability

Introduction

Rice [*Oryza sativa* (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 43.42 million ha produced 105.25 million tonnes of rice during 2020-21. Total world consumption of wheat is around 216 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. Rice straw is an important source of fodder for a large animal population in India. In India, rice is the second most important cereal crop after wheat covering an area of 30.79 million hectares. Total annual production of rice in India is 129.66 million tonnes with the productivity of 2390 kg per hectare during 2021-22**.** 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 90% of rice is produced in six states *viz*. Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, Rajasthan and Bihar. Uttar Pradesh with 116.20 lakh tonnes production holds first position.

Uttar Pradesh being the most important rice producing state of the country, it can play an important role in increasing the total wheat production in the country. Average productivity of rice 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.

Doses and sources 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 percent of nitrogen, 60 to 70 percent of phosphorus and 70 percent of potassium are available to the first crop, while remaining amount of nutrients will be available to succeeding crop. Zinc and iron 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**.**

Micronutrients not only enhances the rate of decomposition but also improves the nutrient status. Application of Zn with Fe increased the Diethylene Triamine Penta Acetic Acid (DTPA)-Zn content in soils. Zinc 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 zinc and iron 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.

Zinc and iron 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 zinc and iron 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.

Nano-fertilizers have high surface area, sorption capacity, and controlled-release kinetics to targeted sites, and have been considered as smart delivery system. The application of nano fertilizer encourages the efficient translocation of nutrients to the desired parts of plant. In rice plants nano particles were present in phloem tissues which mean that nano particles were taken up and transported through phloem route from leaves to stem down to roots, which was documented with transmission electron microscope**.**

Foliar application of micronutrients results in quick absorption by leaf epidermis of plant and attainable to other plant parts through xylem and phloem. Application of micronutrients alone (Fe, Mn, Zn and Cu) or along with 1% urea on growth and yield of rice caused significant increases in rice grain protein content, yield and quality of rice. Three foliar nutrient solution sprays at tillering, jointing and booting stages along with half of the recommended doses of N and P helped in enhancing yield and yield components of rice**.** Foliar application of Zn and Fe increases seed yield, straw yield, seed quality, test weight as well as Zn concentration in flag leaves and grains. The effect of foliar application of micronutrient solution on rice yield and quality of rice grains application of these nutrients.

The major role of nano 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 micro nutrients on productivity and profitability of rice in Randomized Block Design with 12 treatments (Table 1), replicated three times. The maximum and minimum temperatures recorded were 41.3 °C and 15.8 °C during the crop growth period. Relative humidity ranges between 44.1-95.8% 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 Pusa Basmati-1was sown on December 19 & 21, 2021 & 2022 and harvested on 17 & 18 October, 2021 & 2022. The seed rate was 25 kg ha^{-1}. The recommended dose of nitrogen (150 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. 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, panicle length, filled grains per panicle, 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*., Panicle length; filled grains per panicle, unfilled grains per panicle and weight of 1000 grains of rice were affected significantly by various treatments involving different micro nutrients (Table 1 and Fig 1).

Table 1: Effect of nutrients doses and sources on yield attributes of rice

	Treatments	Yield attributes							
		Panicle length (cm)		Filled grains panicle^{-1}		Unfilled grains panicle^{-1}		1000 grains weight (g)	
		2021	2022	2021	2022	2021	2022	2021	2022
T_1	Control	20.9	21.5	66.3	68.3	27.3	28.7	19.7	20.7
T_2	NPK- (150:60:40 kg ha^{-1})	24.3	25.0	86.0	88.6	32.7	34.3	20.1	21.1
T_3	100% NPK + Nano Zn Spray (25 DAT)	26.7	27.5	92.6	95.4	36.5	38.3	20.3	21.3
T_4	100% NPK + Bio-stimulant Spray (25 DAT)	24.8	25.5	88.2	90.8	33.7	35.4	20.2	21.2
T_5	75% NPK + NPK Consortia	22.1	22.8	78.2	80.6	29.3	30.8	19.8	20.8
T_6	75% NPK + NPK spray (25 DAT)	22.3	23.0	78.6	81.0	29.9	31.4	19.8	20.8
T_7	75% NPK + NPK Consortia + Nano N spray (25 DAT)	22.9	23.6	80.5	82.9	32.3	33.9	19.9	20.9
T_8	75% NPK + NPK Consortia + NPK spray (25 DAT)	22.8	23.5	80.0	82.4	31.0	32.6	19.9	20.9
T_9	75% NPK + NPK Consortia + NPK spray (25 DAT) + Bio-stimulant Spray (25 DAT)	24.3	25.0	84.4	87.0	32.7	34.3	20.1	21.1
T_{10}	75% NPK + NPK Consortia + NPK spray (25 DAT) + Bio-stimulant Spray (25 DAT) + Nano Zn spray (25 DAT)	24.9	25.6	88.7	91.4	34.6	36.3	20.3	21.3
T_{11}	75% NPK + NPK Consortia + Nano Zn spray (25 DAT)	23.0	23.7	80.6	83.0	32.4	34.0	19.9	20.9
T_{12}	75% NPK + NPK Consortia + Nano N spray (25 DAT) + Nano Zn spray (25 DAT)	24.7	25.4	87.8	90.5	32.8	34.4	20.2	21.2
		0.9	1.1	2.8	3.0	1.3	1.4	0.7	0.8
		2.5	3.0	8.2	9.0	3.8	4.1	NS	NS

From the given data (Table 1) it can be inferred that the maximum spike length (26.7 & 27.5 cm) were produced in the treatment T_3 (100% NPK + Nano Zn Spray (25 DAT)) which was found to be on par with 75% NPK + NPK Consortia + NPK spray (25 DAT) + Bio-stimulant Spray (25 DAT) + Nano Zn spray (25 DAT), 100% NPK + Bio-stimulant Spray (25 DAT), 75% NPK + NPK Consortia + Nano N spray (25 DAT) + Nano Zn spray (25 DAT), NPK- (150:60:40 kg ha^{-1}) and 75% NPK + NPK Consortia + NPK spray (25 DAT) + Bio-stimulant Spray (25 DAT) during both the years. However, the lowest panicle length (20.9 & 21.5 cm) 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 Leghari *et al.* (2016) [6] and Singh *et al.* (2016) [11].

Significantly higher filled grains per panicle (92.6 & 95.4) was recorded in treatment T_3 (100% NPK + Nano Zn Spray (25 DAT)), which was statistically found to be on par with, 75% NPK + NPK Consortia + NPK spray (25 DAT) + Bio-stimulant Spray (25 DAT) + Nano Zn spray (25 DAT), 100% NPK + Bio-stimulant Spray (25 DAT), 75% NPK + NPK Consortia + Nano N spray (25 DAT) + Nano Zn spray (25 DAT), NPK- (150:60:40 kg ha^{-1}) and 75% NPK + NPK Consortia + NPK spray (25 DAT) + Bio-stimulant Spray (25 DAT). Treatment T_1 (Control) recorded the lowest filled grains per panicle (66.3 & 68.3) 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 nano zinc, NPK Consortia and Bio-stimulant, which ultimately resulted in rapid cell multiplication and cell elongation under sufficient nutrient supply. The results were in accordance with those reported by Zemichael *et al.* (2017) [15], Kaur *et al.* (2018) [4] and Belete *et al.* (2018) [1].

It is evident from the data that the significantly higher unfilled grains per panicle (36.5 & 38.3) were produced in treatment T_3 (100% NPK + Nano Zn Spray (25 DAT)), which remained on par with, 75% NPK + NPK Consortia + NPK spray (25 DAT) + Bio-stimulant Spray (25 DAT) + Nano Zn spray (25 DAT), 100% NPK + Bio-stimulant Spray (25 DAT), 75% NPK + NPK Consortia + Nano N spray (25 DAT) + Nano Zn spray (25 DAT), NPK- (150:60:40 kg ha^{-1}) and 75% NPK + NPK Consortia + NPK spray (25 DAT) + Bio-stimulant Spray (25 DAT). Treatment T_1 recorded lowest unfilled grains per panicle (27.3 & 28.7) followed by T_2 (100% NPK) during 2021 & 2022. Adequate nutrients availability to the crop as a result of increment in photosynthesis as well as growth led to increase in the unfilled grains per panicle. These findings were almost similar to the results reported by Ullah *et al.* (2018) [14] and Rajicic *et al.* (2019) [8].

Nutrients doses and sources had no any significant difference on the 1000-grains weight of rice during both the years. Maximum 1000- grain weight (20.3 & 21.3 g) was recorded in T_3 (100% NPK + Nano Zn Spray (25 DAT)), whereas the lowest test weight (19.7 & 20.7 g) was recorded in T_1 (Control) during both the years. The different micro nutrients application of nano zinc, NPK Consortia and Bio-stimulant 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 Godebo *et al.* (2021) [2] and Sharma *et al.* (2022) [10].

Effect of nutrients doses and sources on Productivity

Data with regard to the effect of nutrients doses and sources on grain yield, straw yield, biological yield and harvest index of rice crop are mentioned in Table 2 and depicted in Fig 2.

Table 2: Effect of nutrients doses and sources on grain, straw, biological yield (q ha^{-1}) and harvest index (%) of rice crop

	Treatments	Yield (q ha^{-1})							
		Grain		Straw		Biological		Harvest index (%)	
		2021	2022	2021	2022	2021	2022	2021	2022
T_1	Control 107.5 102.8 102.3 67.1	21.3	22.8	44.3	45.9	65.6	68.7	32.5	33.2
T_2	NPK- (150:60:40 kg ha^{-1})	40.2	41.7	57.0	58.7	97.2	100.4	41.4	41.5
T_3	100% NPK + Nano Zn Spray (25 DAT)	46.1	48.4	58.9	61.7	105.0	110.1	43.9	44.0
T_4	100% NPK + Bio-stimulant Spray (25 DAT)	42.1	43.9	58.2	60.4	100.3	104.3	42.0	42.1
T_5	75% NPK + NPK Consortia	31.2	33.8	56.2	57.0	87.4	90.8	35.7	37.2
T_6	75% NPK + NPK spray (25 DAT)	32.8	34.2	56.6	57.3	89.4	91.5	36.7	37.4
T_7	75% NPK + NPK Consortia + Nano N spray (25 DAT)	35.9	37.6	56.8	57.7	92.7	95.3	38.7	39.5
T_8	75% NPK + NPK Consortia + NPK spray (25 DAT)	33.5	35.8	56.7	57.6	90.2	93.4	37.1	38.3
T_9	75% NPK + NPK Consortia + NPK spray (25 DAT) + Bio-stimulant Spray (25 DAT)	37.8	39.5	56.9	58.1	94.7	97.6	39.9	40.5
T_{10}	75% NPK + NPK Consortia + NPK spray (25 DAT) + Bio-stimulant Spray (25 DAT) + Nano Zn spray (25 DAT)	42.3	44.3	58.3	60.8	100.6	105.1	42.0	42.2
T_{11}	75% NPK + NPK Consortia + Nano Zn spray (25 DAT)	37.0	38.7	56.8	57.9	93.8	96.6	39.4	40.1
T_{12}	75% NPK + NPK Consortia + Nano N spray (25 DAT) + Nano Zn spray (25 DAT)	39.9	40.6	57.7	59.6	97.6	100.2	40.8	40.5
		1.5	1.6	2.0	2.1	3.4	3.5	1.3	1.4
		4.4	4.7	5.8	6.0	9.7	10.1	3.9	4.2

Among the various nutrients doses and sources, the treatment T_3 (100% NPK + Nano Zn Spray (25 DAT)) exhibited significantly higher grain yield (46.1 & 48.4 q ha^{-1}), which was statistically on par with 75% NPK + NPK Consortia + NPK spray (25 DAT) + Bio-stimulant Spray (25 DAT) + Nano Zn spray (25 DAT) and 100% NPK + Bio-stimulant Spray (25 DAT). Treatment T_1 (Control) with no application of any fertilizer recorded lowest grain yield of 21.3 & 22.8 q ha^{-1}. Mean increasing yield with 100% NPK + Nano Zn Spray (25 DAT), 75% NPK + NPK Consortia + NPK spray (25 DAT) + Bio-stimulant Spray (25 DAT) + Nano Zn spray (25 DAT) and 100% NPK + Bio-stimulant Spray (25 DAT) was 114.2, 96.3 and 95.0 percent over control plot during 2021 & 2022. The maximum grain yield was recorded due to 100% NPK and nano zinc. This might be due to slow release of nutrient from zinc and iron 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 rice (Table 2) was significantly influenced by different nutrients doses and sources. Results revealed that the differences in straw yield were found significant due to different treatments. Though significantly higher straw yield 58.9 & 61.7 q ha^{-1} was recorded under T_3 (100% NPK + Nano Zn Spray (25 DAT)), followed by 75% NPK + NPK Consortia + NPK spray (25 DAT) + Bio-stimulant Spray (25 DAT) + Nano Zn spray (25 DAT) and 100% NPK + Bio-stimulant Spray (25 DAT). The lowest straw yield (44.3 & 45.9 q ha^{-1}) was recorded in T_1 (control) during both the years. Similar trend was observed in Biological yield, whereas maximum harvest index (43.9 & 44.0%) was recorded in T_3 (100% NPK + Nano Zn Spray (25 DAT)). 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 filled grains per paincle. The use of nano zinc, NPK Consortia and Bio-stimulant in conjunction with micronutrients had profound effect on vegetative growth due to improved nutrients availability in the soil. These findings are in conformity with the results of Hasan *et al.* (2020) [3], Meena *et al.* (2021) [7].

Economics

From Table 3 it can be seen that among the various nutrient levels, the cost of cultivation (Rs. ha^{-1}) varied from 25482 to 34443 and 26247 to 34860 Rs. ha^{-1}. The highest cost of cultivation was registered with the application of 100% NPK + Nano Zn Spray (25 DAT) (T_3) followed by 75% NPK + NPK Consortia + NPK spray (25 DAT) + Bio-stimulant Spray (25 DAT) + Nano Zn spray (25 DAT) (T_{10}) while the application of no fertilizer (Control) registered the lowest cost of cultivation. Maximum gross returns (129335 & 138215 Rs. ha^{-1}) was obtained by the application of 100% NPK + Nano Zn Spray (25 DAT) (T_3) followed by 75% NPK + NPK Consortia + NPK spray (25 DAT) + Bio-stimulant Spray (25 DAT) + Nano Zn spray (25 DAT) (T_{10}).

The lowest Gross return of 63175 & 69378 Rs. ha^{-1} was obtained in treatment T_1 (Control). Maximum net return of 94892 & 103355 Rs ha^{-1} was recorded by the application of 100% NPK + Nano Zn Spray (25 DAT) (T_3) followed by 75% NPK + NPK Consortia + NPK spray (25 DAT) + Bio-stimulant Spray (25 DAT) + Nano Zn spray (25 DAT) (T_{10}). However, the maximum Benefit cost ratio of 2.76 & 2.96 was obtained by the application of 100% NPK + Nano Zn Spray (25 DAT) (T_3) followed by 75% NPK + NPK Consortia + NPK spray (25 DAT) + Bio-stimulant Spray (25 DAT) + Nano Zn spray (25 DAT) during both the years. The higher net returns and BCR was mainly due to increase in grain yield. Similar results recorded by Kumar *et al.* (2014) [5], Tarafdar *et al.* (2015) [13] and Singh *et al*. (2020) [12].

Table 3: Effect of nutrients doses and sources on economics of rice

	Treatments	Cost of cultivation (Rs ha^{-1})		Gross return (Rs ha^{-1})		Net return (Rs ha^{-1})		B: C ratio	
		2021	2022	2021	2022	2021	2022	2021	2022
T_1	Control	25482	26247	63175	69378	37693	43131	1.48	1.64
T_2	NPK- (150:60:40 kg ha^{-1})	32526	33523	113910	121334	81384	87811	2.50	2.62
T_3	100% NPK + Nano Zn Spray (25 DAT)	34443	34860	129335	138215	94892	103355	2.76	2.96
T_4	100% NPK + Bio-stimulant Spray (25 DAT)	33723	34345	118995	127428	85272	93083	2.53	2.71
T_5	75% NPK + NPK Consortia	30280	30578	90800	100420	60520	69842	2.00	2.28
T_6	75% NPK + NPK spray (25 DAT)	30558	30852	94960	101526	64402	70674	2.11	2.29
T_7	75% NPK + NPK Consortia + Nano N spray (25 DAT)	31096	31661	102905	110454	71809	78793	2.31	2.49
T_8	75% NPK + NPK Consortia + NPK spray (25 DAT)	30758	31223	96765	105752	66007	74529	2.15	2.39
T_9	75% NPK + NPK Consortia + NPK spray (25 DAT) + Bio-stimulant Spray (25 DAT)	31723	32358	107770	115482	76047	83124	2.40	2.57
T_{10}	75% NPK + NPK Consortia + NPK spray (25 DAT) + Bio-stimulant Spray (25 DAT) + Nano Zn spray (25 DAT)	33963	34562	119525	128556	85562	93994	2.52	2.72
T_{11}	75% NPK + NPK Consortia + Nano Zn spray (25 DAT)	31475	31985	105710	113358	74235	81373	2.36	2.54
T_{12}	75% NPK + NPK Consortia + Nano N spray (25 DAT) + Nano Zn spray (25 DAT)	32780	33190	113285	118672	80505	85482	2.46	2.58
	SEm±	-	-	3919	4199	2748	2982	0.08	0.09
	CD at 5%	-	-	11253	12058	7896	8563	0.23	0.26

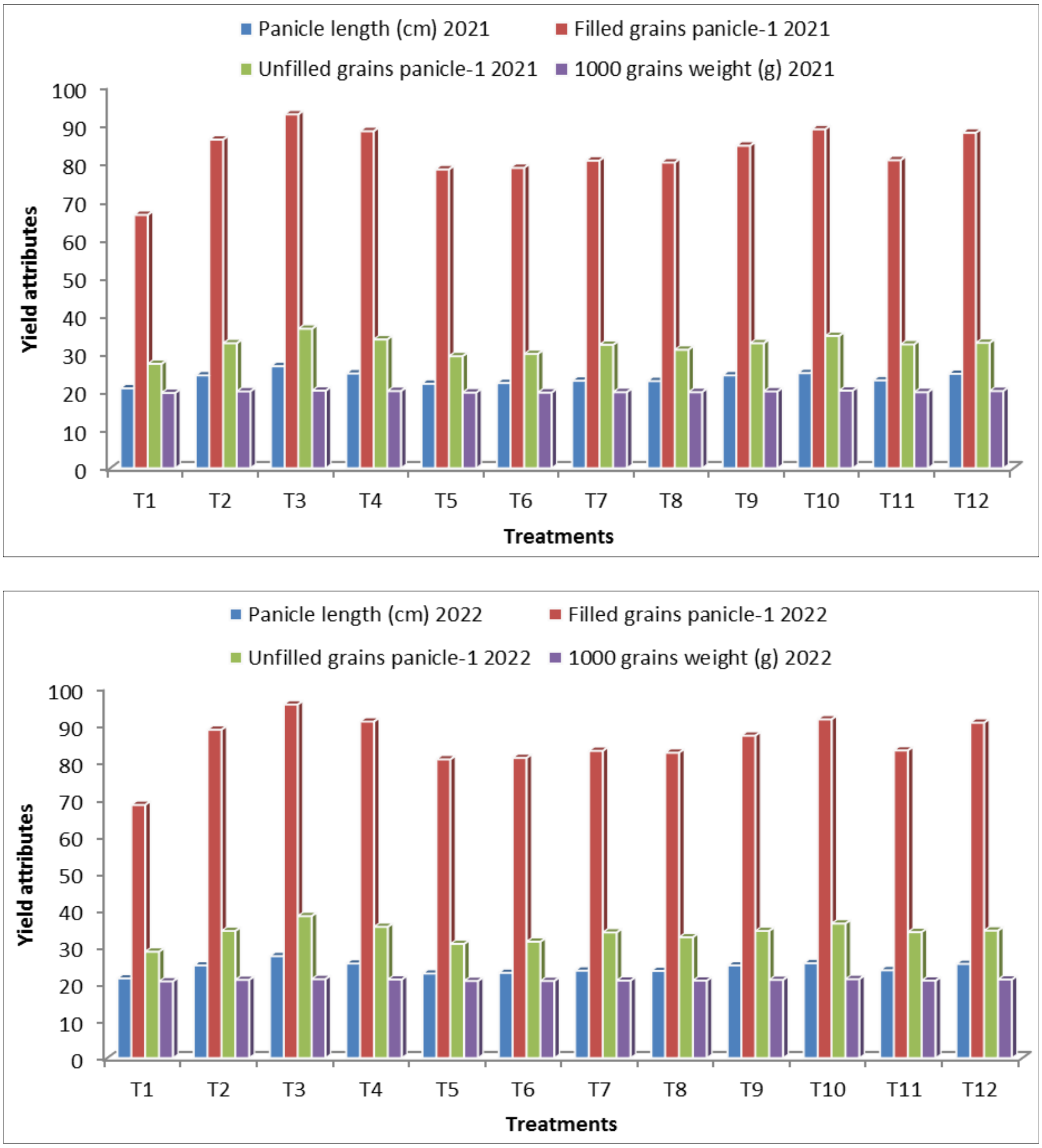
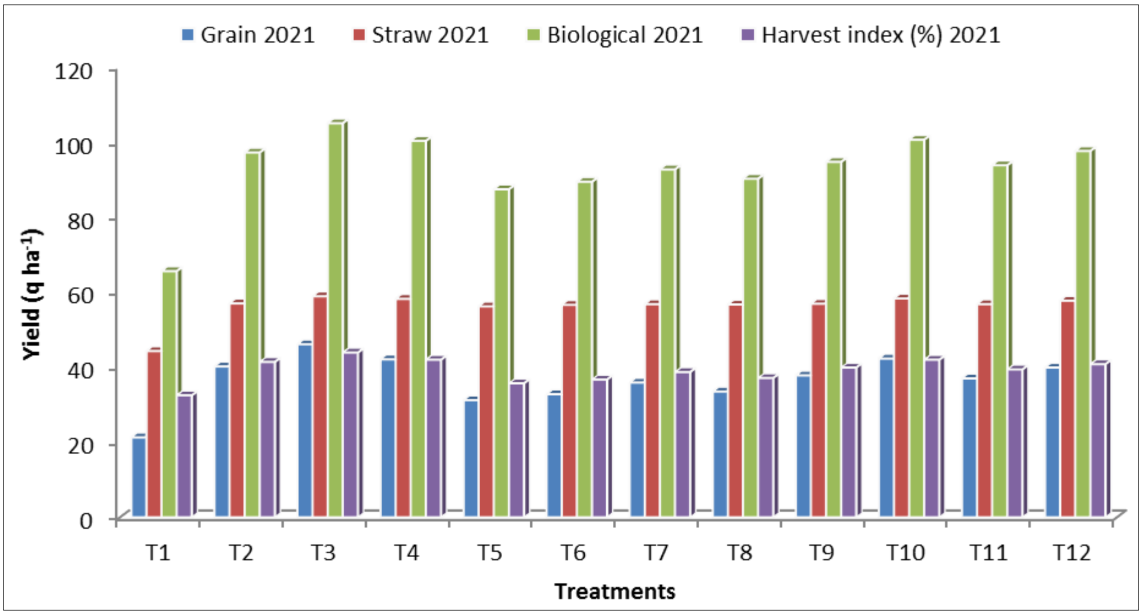


Fig 1: Effect of nutrients doses and sources on yield attributes of rice 2021-22



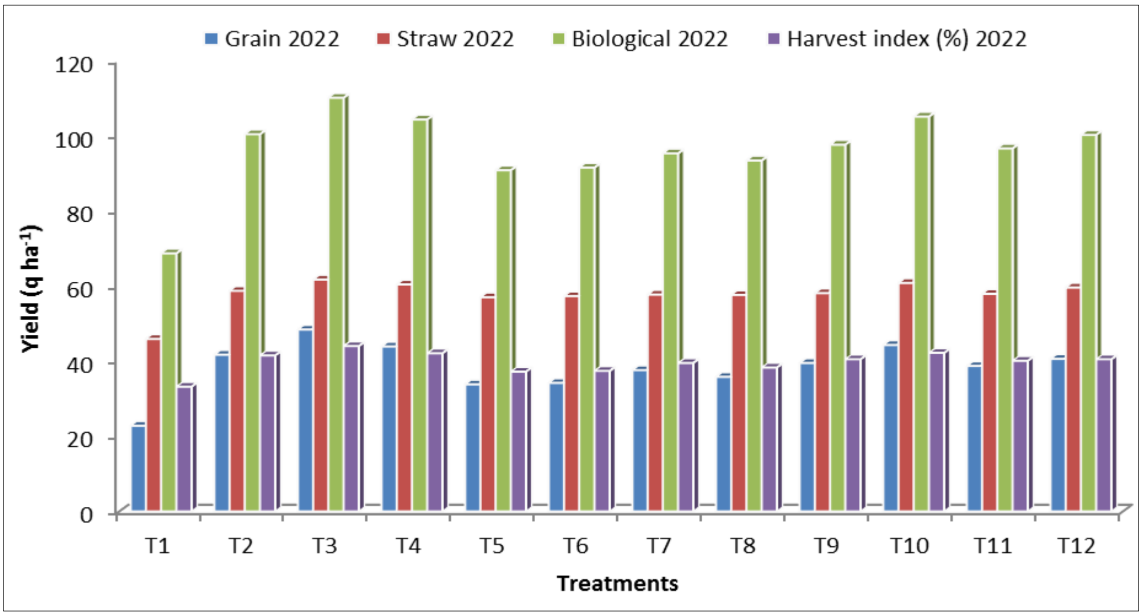
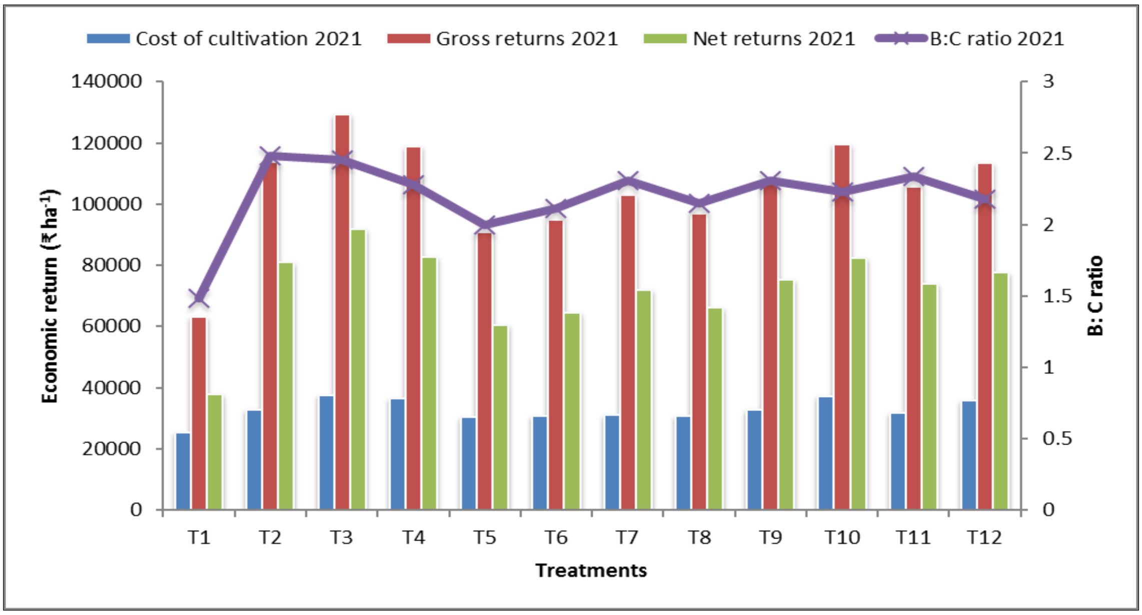


Fig 2: Effect of nutrients doses and sources on grain, straw, biological yield (q ha^{-1}) and harvest index (%) of rice crop 2021-22



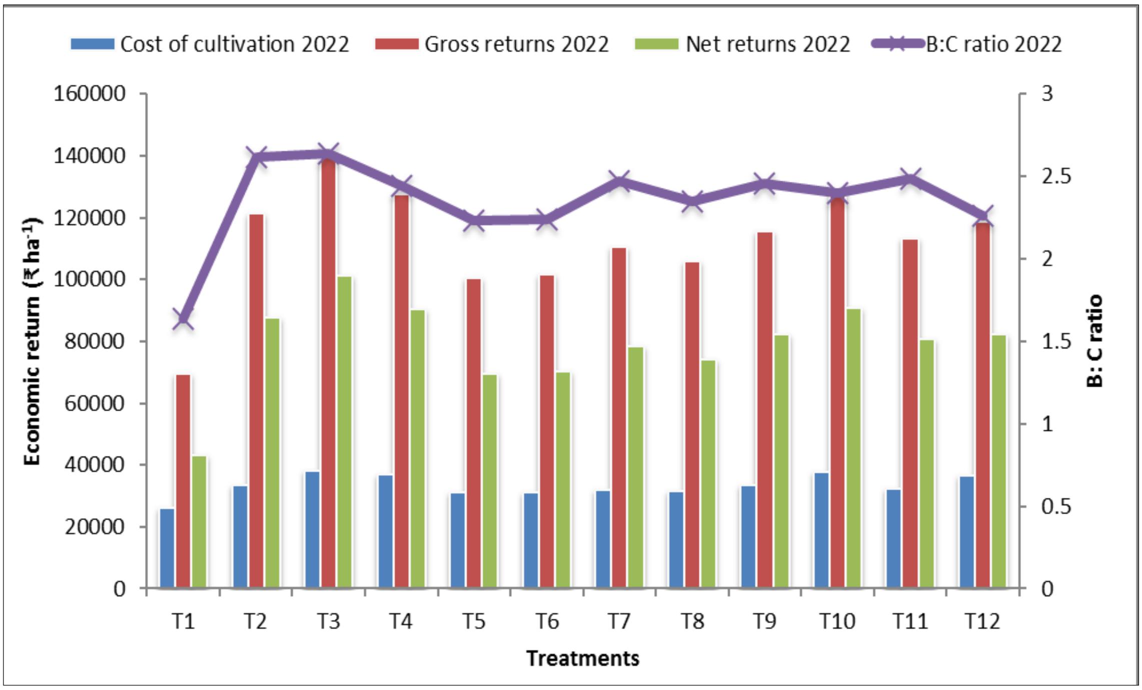


Fig 3: Effect of nutrients doses and sources on economics of rice 2021-22

Conclusion

All the growth, yield attributes and yield of rice improved with the application of different micro nutrients and achieved maximum value with 100% NPK + Nano Zn Spray (25 DAT). 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 + Nano Zn Spray (25 DAT) followed by 75% NPK + NPK Consortia + NPK spray (25 DAT) + Bio-stimulant Spray (25 DAT) + Nano Zn spray (25 DAT) during both years.

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