Effect of different levels of zinc on productivity of various varieties of rice (*Oryza sativa* L.)

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ABSTRACT

A field experiment was conducted at Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya, Uttar Pradesh, with a view to compare the production potential under different varieties and zinc levels application and also to find out the economic viability of this cultivar for soil quality. The treatments comprised of Main factor (Sarju-52, NDR-2064, NDR-2065 and Swarna Sub-1 Sub factor (Control, Zn @ 2.5 kg/ha, Zn @ 5 kg/ha, Zn @ 7.5 kg/ha and Zn @ 10 kg/ha) exhibited significant influence on yield attributes and yields of rice as compared to the application of control. The maximum gross return was obtained in V_3 (NDR-2065) and Z_5 (Zn @ 10 kg/ha) followed by V_1 (Sarju-52) and Z_4 (Zn @ 7.5 kg/ha). The highest net return was obtained in V_3 (NDR-2065) and Z_5 (Zn @ 10 kg/ha) followed by V_1 (Sarju-52) and Z_4 (Zn @ 7.5 kg/ha), while minimum gross return and net return was obtained in V_4 (Swarna Sub-1) and Z_1 (Control). Higher values of B: C ratio (2.56 & 2.76) and (2.83 & 3.03) was obtained in V_3 (NDR-2065) and Z_5 (Zn @ 10 kg/ha).

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Keywords: Rice, different varieties and different zinc levels, production potential, profitability

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Introduction

Rice (*Oryza sativa* L.) is a belongs to Poaceae family and is relished as staple food by majority (more than 60%) of world's population. Rice plays a pivotal role in Indian agriculture. Among the cereal crops, it serves as the principal source of nourishment for over half of the global population. Rice is the most important staple food in Asia, providing on an average 32% of total calorie uptake (Maclean *et al.,* 2002). However, to meet this demand the crop should perform to its full potential. Certain factors tend to restrict the crop's potential performance. Rice is the principal food for more than 50% people and contributes about one- fifth to the total calories consumption of the world (Singh *et al.,* 2012). Rice is cultivated world-wide over an area of about 162.06 million ha with an annual production of about 757.00 million tonnes and productivity 4.60 tonnes per hectare in 2019-20 (WTO). About 90% of all rice grown in the world is produced and consumed in the Asian region. To meet the food and nutritional requirements in these densely populated and rice dominant regions, the projected demand for rice by 2030 has been estimated at 904 mt for the world and 824 mt for Asian region. India alone would require about 156 mt of rice by the year 2030 (ICAR, 2010) at an annual increment of 3

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Zinc is one of the most important micronutrients essential for plant growth especially for rice grown under submerged condition. After nitrogen, phosphorus and potassium, widespread of zinc deficiency has been found responsible for yield reduction in rice (Fageria *et al.*, 2002). Zinc deficiency continues to be one of the key factors in determining rice production in several parts of the country (Muthu Kumararaja and Srirama Chandrasekharan, 2012). Zinc deficiency during the last three decades appears to be the most widespread due to intensive cropping with use of high analysis fertilizers, use of high yielding crop varieties andno use of organic matter by farmers. Zinc deficiency reduces not only the grain yield but also the nutritional quality of human diet. Zinc is essential component of enzymes responsible for assimilation of nitrogen which helps chlorophyll formation and plays an important role in nitrogen metabolism contributing towards increase in growth and development of plant. Zinc also plays a vital role in different metabolism process like development of cell wall, respiration, photosynthesis, metabolism of carbohydrates and other biochemical functions (Alloway, 2008).

Zinc deficiency in rice has been reported in lowlands of India (Mandal *et al.*, 2000) Zinc deficiency in plant is noticed when the supply of zinc to the rice plant is inadequate. Among the many factors which influence zinc supply to the plants, pH, concentration of zinc, iron, manganese and phosphorus in soil solution are very important.

Zinc deficiency is usually corrected by application of zinc sulphate ($ZnSO_4.7H_2O$) which interacts with various soil components like organic matter, clay sesquioxide, fixing or forming its insoluble complexes which ultimately decrease the availability of zinc in soil. Zinc deficiency and response of rice to zinc under flooded condition have been studied by many workers (Naik and Das, 2007;). The recommendation for zinc, which is generally marketed as zinc sulphate heptahydrate ($ZnSO_4.7H_2O$), varies from 10 to 25 kg ha^{-1} $season^{-1}$, depending upon the crop, environmental and soil conditions.

However, the effects of N on Zn concentration in rice grains are not unambiguous, though N fertilization on increasing nutrient concentration in other crops had been proved to be effective (Zebarth *et al*. 2002; Wangstr and *et al*. 2006). Furthermore, Zn accumulation in different organs of the rice plant has not been studied in detail yet. So, the aim of the present study was to evaluate the effect of N on the accumulation of Zn in the grains and other parts of the rice plant and to determine the optimum N rate at which the optimal Zn density in rice could be attained as well as grain yield.

Material and Methods

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Commented [ZB17]: The aim of the present study was to study the influence of different varieties and zinc levels on productivity and economics of rice.

The field experiment was conducted at Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya, Uttar Pradesh (U.P.), located at latitude of 29^0 40′ North and longitude of 77^0 46′ East with an elevation of 237 meters above the mean sea level. The Ayodhya area lies in the heart of Utter Pradesh and has sub-tropical climate. The experimental site has an even topography with good drainage facilities.

The experiment was carried out at Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya, Uttar Pradesh (U.P.) to study the influence of different varieties and zinc levels on productivity and profitability of rice in Split Plot Design with 20 treatments (Table 1), replicated three times. The maximum and minimum temperatures recorded were 40.3 ºC and 16.1 ºC during the crop growth period. Maximum temperature ranged from 16.3 ºC to 40.3 ºC during maturity phase of the crop. Relative humidity varied from 88.1% to 95.8% and 41.7 ºC to 46.8ºC during crop growth period. The total annual rainfall 587.6 and 369.8 mm. The soil of the experimental field was sandy loam in texture, low in available nitrogen (180.5 kg ha^{-1}) and organic carbon (0.47%), medium in available phosphorous (13.5 kg ha^{-1}) and potassium (180.0 kg ha^{-1}), available zinc (16.1 ppm) and slightly alkaline (pH 8.0) in reaction with electrical conductivity of 0.16 dS m^{-1}. The gross and net plot size were 4 m X 5 m and 3.2 m X 4 m respectively. The crop variety Sarju-52, NDR-2064, NDR-2065 and Swarna Sub-1was sown on 10 June 2022 and 12 June 2023 and harvested on 24 October 2022 and 27 October 2023. The seed rate was 30 kg ha^{-1}. Seeding was done in the row to row spacing of 20 cm and plant to plant spacing of 10 cm. The recommended dose of nitrogen (120 kg ha^{-1}) was applied in two equal split, thehalf 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. 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 appliedas per treatments before the sowing. One thinning was done after 30 days of sowing to maintain a plant to plant distance of about 10 cm. Weeding and hoeing operation were performed manually after first and second irrigation at proper soil moisture condition of the soil. At the harvest, number of grains per panicle, 1000 grains weight, grain 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

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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 levels on yield attributes of rice

Yield attributes *viz*., Panicle length (cm), No. of panicle, No. of grain per panicle and weight of 1000 grains of rice were affected significantly by different varieties and zinc levels treatments (Table 1 and Fig 1).

Table 1 Effect of different level of Zinc on yield attributes characters of rice

Treatments		**Yield attributes**							
		Panicle length (cm)		**No. of panicle**		**No. of grain per panicle**		**1000 grain weight (g)**	
		2022	**2023**	**2022**	**2023**	**2022**	**2023**	**2022**	**2023**
(A) Varieties									
Sarju-52	V_1	23.6	24.1	131.8	135.2	143.2	146.6	22.7	22.8
NDR-2064	V_2	22.9	23.4	130.5	133.7	139.9	143.3	22.1	22.2
NDR-2065	V_3	24.8	25.3	134.1	137.5	149.1	152.6	23.6	23.7
Swarna Sub-1	V_4	22.5	23.0	127.7	130.9	137.5	140.8	20.2	20.3
SE(m)±		***0.15***	***0.16***	***0.53***	***0.54***	***0.76***	***0.78***	***0.25***	***0.25***
C.D. (P=0.05)		***0.52***	***0.55***	***1.83***	***1.87***	***2.61***	***2.69***	***0.86***	***0.87***
(B) Zinc levels									
Control	Z_1	21.3	21.7	112.2	115.1	138.4	141.8	20.1	20.2
Zn @ 2.5 kg/ha	Z_2	22.8	23.2	132.5	135.8	140.7	144.2	21.5	21.6
Zn @ 5 kg/ha	Z_3	23.8	24.3	134.9	138.3	143.6	147.1	22.5	22.6
Zn @ 7.5 kg/ha	Z_4	24.3	24.9	135.7	139.1	144.1	147.5	23.2	23.4
Zn @ 10 kg/ha	Z_5	25.3	25.8	137.4	140.8	144.9	148.5	23.5	23.6
SE(m)±		***0.44***	***0.46***	***1.47***	***1.51***	***1.38***	***1.41***	***0.47***	***0.48***
C.D. (P=0.05)		***1.27***	***1.31***	***4.22***	***4.32***	***3.94***	***4.03***	***1.36***	***1.38***

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From the given data (Table 1) it can be inferred that the maximum panicle length (cm) were produced in the treatment V_3 (NDR-2065) and Z_5 (Zn @ 10 kg/ha) followed by V_1 (Sarju-52) and Z_4 (Zn @ 7.5 kg/ha) and Z_3 (Zn @ 5 kg/ha) during both the year. However, the lowest panicle length (cm) were recorded in treatment V_4 (Swarna Sub-1) and Z_1 (Control) which was significantly lower than rest of the other treatments during 2022 and 2023. The results were in accordance with those reported by **Naik *et al*. (2005) and Yadav (2007).**

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Significantly higher number of panicle was recorded in treatment V_3 (NDR-2065) and Z_5 (Zn @ 10 kg/ha) followed by V_1 (Sarju-52) and Z_4 (Zn @ 7.5 kg/ha) and Z_3 (Zn @ 5 kg/ha) during both the year. Treatment V_4 (Swarna Sub-1) and Z_1 (Control) recorded the lowest number of panicle and next in order was treatment V_3 (Sarju-52) and Z_4 (Zn @ 7.5 kg/ha). It might be due to increased and prolonged availability of nutrients from integrated use of micronutrients, which ultimately resulted in rapid cell multiplication and cell elongation under sufficient nutrient supply. The results were in accordance with those reported by **Sowmyalatha *et al.* (2012) and Choudhary *et al.* (2013).**

It is evident from the data that the significantly higher number of grains panicle^{-1} were produced in treatment V_3 (NDR-2065) and Z_5 (Zn @ 10 kg/ha) followed by V_1 (Sarju-52) and Z_4 (Zn @ 7.5 kg/ha) and Z_3 (Zn @ 5 kg/ha) during both the year. Treatment V_4 (Swarna Sub-1) and Z_1 (Control) recorded lowest number of grains panicle^{-1} during 2022 and 2023. 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 panicle^{-1}. These findings were almost similar to the results reported by **Hardev *et al*. (2014).**

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Different levels of zinc treatments significant variation in test weight maximum 1000 grains weight was recorded in V_3 (NDR-2065) and Z_5 (Zn @ 10 kg/ha) during both the year, whereas the lowest test weight was recorded in V_4 (Swarna Sub-1) and Z_1 (Control) during 2022 and 2023. Zinc might increase availability of plant nutrients which result into better nourishment of plants and the formation of bold seeds, ultimately increased weight of seeds.

Effect of different zinc levels on Productivity

Data with regard to the effect of different zinc levels 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 different level of Zinc on yield and harvest index of rice

Treatments		Yield (q ha^{-1})`						Harvest index (%)	
		Grain		Straw		Biological			
		2022	2023	2022	2023	2022	2023	2022	2023
(A) Varieties									
Sarju-52	V_1	43.16	44.92	66.25	69.03	109.41	113.96	39.28	39.18
NDR-2064	V_2	42.07	43.79	65.04	67.77	107.11	111.56	39.04	39.02
NDR-2065	V_3	44.19	46.01	67.31	70.13	111.50	116.14	39.63	39.28
Swarna Sub-1	V_4	38.46	40.04	60.58	63.12	99.04	103.16	39.19	38.60
SE(m)±		***0.83***	***0.86***	***0.93***	***0.97***	***1.15***	***1.20***	***0.57***	***0.56***
C.D. (P=0.05)		***2.87***	***2.98***	***3.23***	***3.35***	***3.98***	***4.15***	***NS***	***NS***
(B) Zinc levels									
Control	Z_1	27.94	29.08	54.73	57.02	82.67	86.11	33.86	33.84
Zn @ 2.5 kg/ha	Z_2	42.56	44.30	64.25	66.95	106.82	111.26	39.83	39.81
Zn @ 5 kg/ha	Z_3	45.16	47.02	68.58	71.46	113.75	118.48	39.68	39.66
Zn @ 7.5 kg/ha	Z_4	47.26	49.20	69.26	72.17	116.53	121.37	40.59	40.57
Zn @ 10 kg/ha	Z_5	48.78	50.72	70.07	73.01	118.85	123.80	40.95	40.92
SE(m)±		***1.30***	***1.35***	***1.66***	***1.72***	***2.19***	***2.28***	***0.90***	***0.89***
C.D. (P=0.05)		***3.72***	***3.87***	***4.74***	***4.93***	***6.26***	***6.52***	***2.57***	***2.55***

Among the different zinc levels, the treatment V_3 (NDR-2065) and Z_5 (Zn @ 10 kg/ha) exhibited significantly higher grain yield (44.19 & 46.01 q ha^{-1}) and (48.78 & 50.72 q ha^{-1}) which was at par with V_1 (Sarju-52) & V_2 (NDR-2064) and Z_4 (Zn @ 7.5 kg/ha) and Z_3 (Zn @ 5 kg/ha) during 2022 and 2023. Treatment V_4 (Swarna Sub-1) and Z_1 (Control) with no application of any fertilizer recorded lowest grain yield of 38.46 & 40.04 and 27.94 & 29.08 q ha^{-1}. Mean increasing grain yield with V_3 (NDR-2065) was 14.8 & 14.9 per cent over V_4 (Swarna Sub-1) and Mean increasing grain yield with Z_5 (Zn @ 10 kg/ha) was 74.5 & 74.4 per cent over Z_1 (Control) treatment, respectively. This might be due to slow release of nutrient and efficient use of zinc.

In the same way, straw yield of rice (Table 2) was significantly influenced by different zinc levels treatments. Results revealed that the differences in straw yield were found significant due to different treatments. Though significantly higher straw yield 67.31 & 70.13 and 70.07 &

73.01 q ha^{-1} was recorded under V_3 (NDR-2065) and Z_5 (Zn @ 10 kg/ha), it was statistically on par with V_1 (Sarju-52) and V_2 (NDR-2064) and Z_4 (Zn @ 7.5 kg/ha) and Z_3 (Zn @ 5 kg/ha) during 2022 and 2023. The lowest straw yield (60.58 & 63.12 q ha^{-1}) and (54.73 & 57.02 q ha^{-1}) was recorded in V_4 (Swarna Sub-1) and Z_1 (Control) during 2022 and 2023. Similar trend was observed in Biological yield, whereas maximum harvest index (39.63 & 38.60 %) and (40.95 & 40.92 %) was recorded in V_3 (NDR-2065) and Z_5 (Zn @ 10 kg/ha) during both the year. The increase in straw yield was mainly due to increased growth attributing characters like plant height and number of grains $panicle^{-1}$. The use of different zinc levels had profound effect on vegetative growth due to improved nutrients availability in the soil. These findings are in conformity with the results of **Jana *et al.* (2009), Kumar and Kumar (2010)**, **Sridevi *et al*. (2010), Ahmad *et al*. (2012) and Hussain *et al*. (2017).**

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Economics

From Table 3 it can be seen that among the different zinc levels, the cost of cultivation (Rs. ha^{-1}) varied from 32421 to 35967, 32851 to 36674 and 25482 to 36524, 26247 to 37230 Rs. ha^{-1}. The highest cost of cultivation was registered with the application of V_3 (NDR-2065) and Z_5 (Zn @ 10 kg/ha) (T_9) followed by V_1 (Sarju-52) and Z_4 (Zn @ 7.5 kg/ha) and Z_3 (Zn @ 5 kg/ha), while the application of no fertilizer V_4 (Swarna Sub-1) and Z_1 (Control) registered the lowest cost of cultivation. Maximum gross returns (127496 & 137159 Rs. ha^{-1}) and (139804 & 150125 Rs. ha^{-1}) was obtained by the application of V_3 (NDR-2065) and Z_5 (Zn @ 10 kg/ha) followed by V_1 (Sarju-52) and Z_4 (Zn @ 7.5 kg/ha) and Z_3 (Zn @ 5 kg/ha) during both the year. The lowest Gross return of 111401 & 119884 and 83288 & 89863 Rs. ha^{-1} was obtained in treatment V_4 (Swarna Sub-1) and Z_1 (Control). Maximum net return of 91526 & 100485 and 103280 & 112895 Rs ha^{-1} was recorded by the application of V_3 (NDR-2065) and Z_5 (Zn @ 10 kg/ha) followed by V_1 (Sarju-52) and Z_4 (Zn @ 7.5 kg/ha) and Z_3 (Zn @ 5 kg/ha). However, the maximum Benefit cost ratio of 2.58 & 2.81 and 2.83 & 3.03 was obtained by the application of V_1 (Sarju-52) and Z_5 (Zn @ 10 kg/ha) followed by V_2 and Z_4. The higher net returns and BCR was mainly due to increase in grain yield. Similar results recorded by **Pooniya and Shivay (2012), Firdous *et al.* (2018) and Ram *et al*. (2020).**

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Table 3 Effect of different level of Zinc on economics of rice

Treatments		**Cost of cultivation (₹ ha^{-1})**		**Gross returns (₹ ha^{-1})**		**Net returns (₹ ha^{-1})**		**B:C ratio**	
		2022	**2023**	**2022**	**2023**	**2022**	**2023**	**2022**	**2023**
(A) Varieties									
Sarju-52	V_1	34795	35170	124633	134050	89838	98880	2.58	2.81
NDR-2064	V_2	34158	34743	121587	130797	87429	96054	2.56	2.76
NDR-2065	V_3	35967	36674	127493	137159	91526	100485	2.54	2.74
Swarna Sub-1	V_4	32421	32851	111401	119884	78980	87033	2.44	2.65
SE(m)±		-	-	***2969***	***3433***	***2969***	***3433***	***0.06***	***0.06***
C.D. (P=0.05)		-	-	***10473***	***12112***	***10472***	***12110***	***0.20***	***0.23***
(B) Zinc levels									
Control	Z_1	25482	26247	83288	89863	57806	63616	2.27	2.42
Zn @ 2.5 kg/ha	Z_2	34750	35542	122663	131918	87913	96376	2.53	2.71
Zn @ 5 kg/ha	Z_3	35220	35762	130246	140117	95026	104355	2.70	2.92
Zn @ 7.5 kg/ha	Z_4	35862	36354	135750	145963	99888	109609	2.79	3.02
Zn @ 10 kg/ha	Z_5	36524	37230	139804	150125	103280	112895	2.83	3.03
SE(m)±		-	-	***3974***	***4614***	***3974***	***4614***	***0.08***	***0.09***
C.D. (P=0.05)		-	-	***11410***	***13354***	***11500***	***13354***	***0.23***	***0.26***

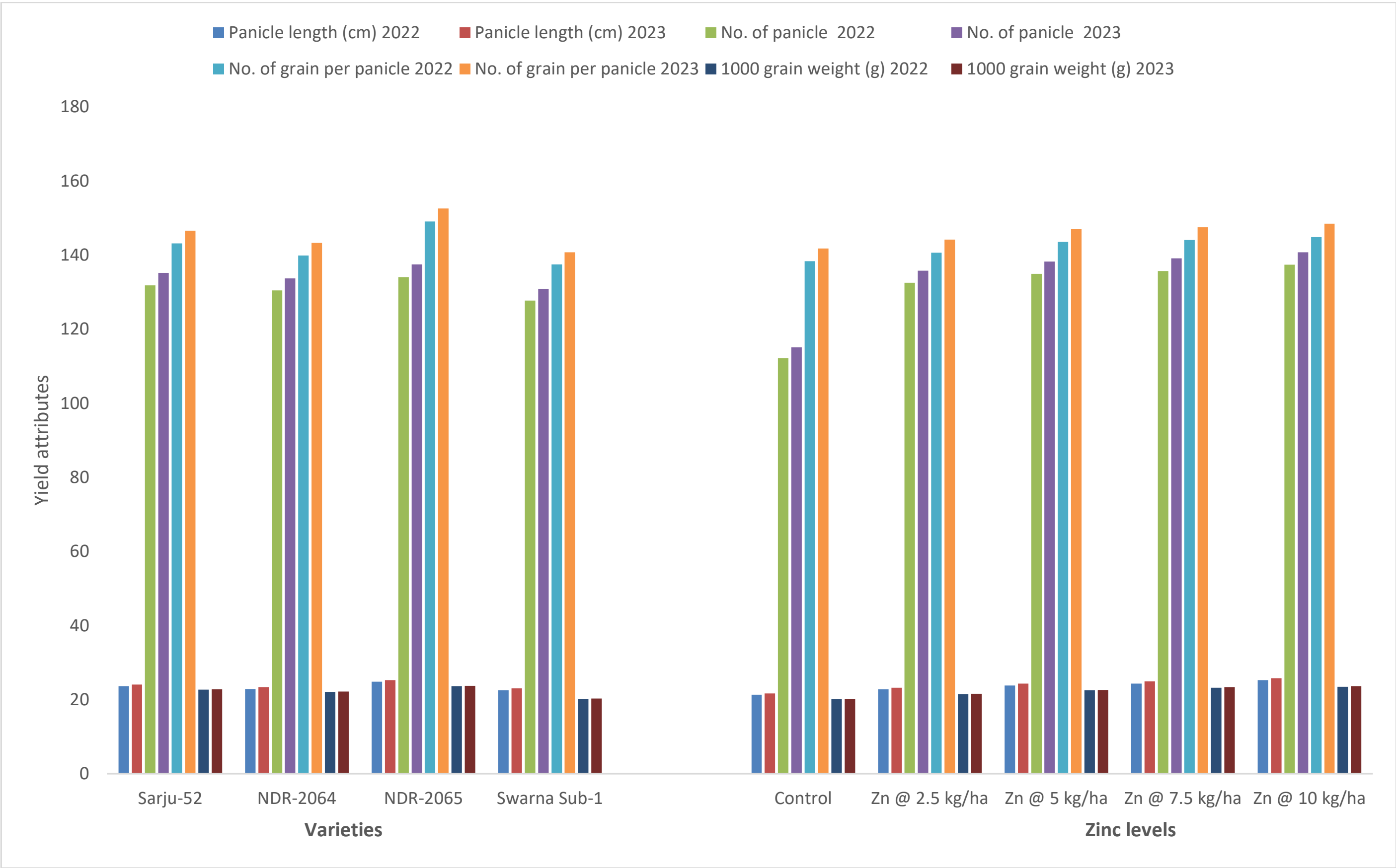

Fig. 1 Effect of different level of Zinc on yield attributes characters of rice

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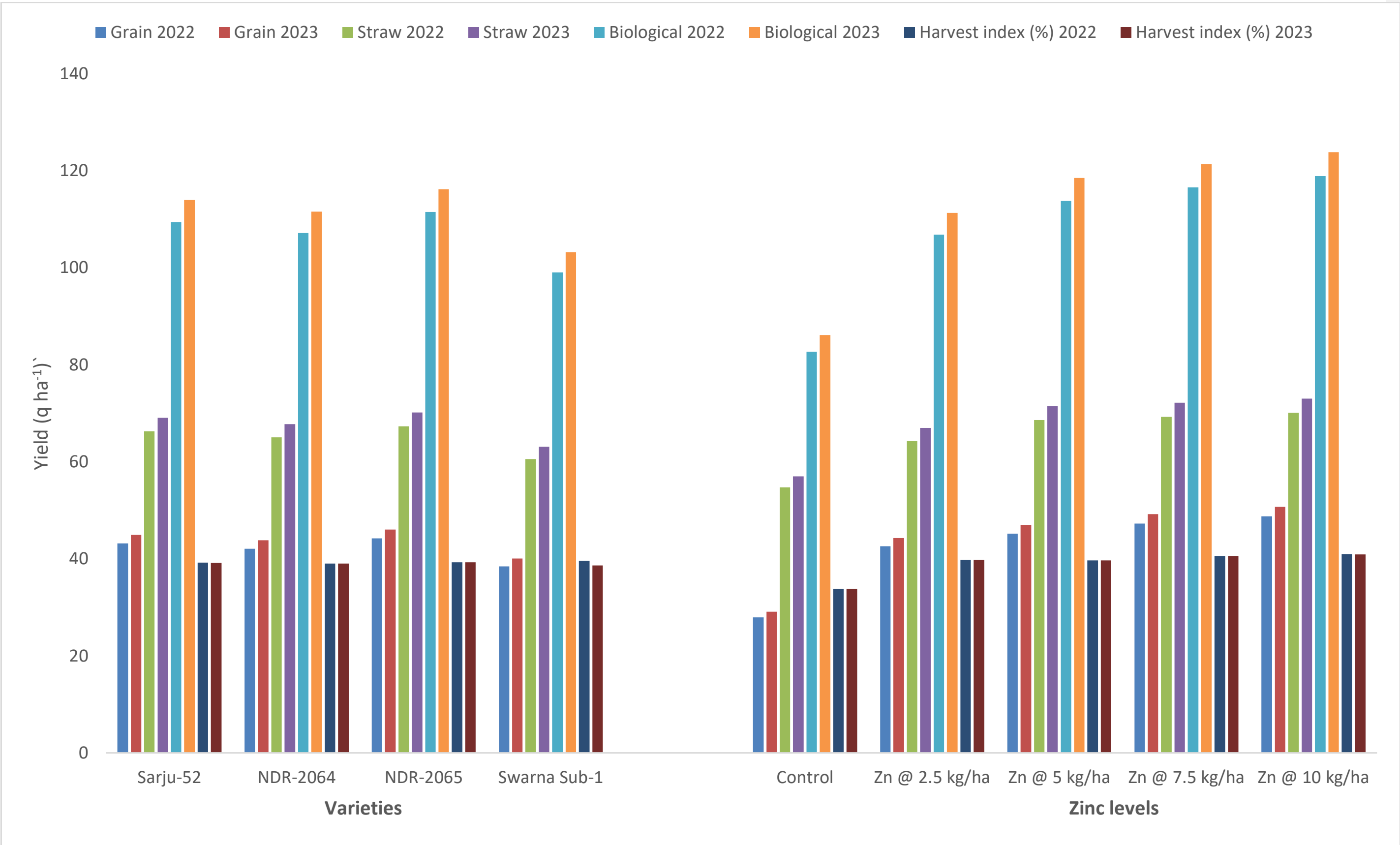

Fig. 2 Effect of different level of Zinc on yield and harvest index of rice

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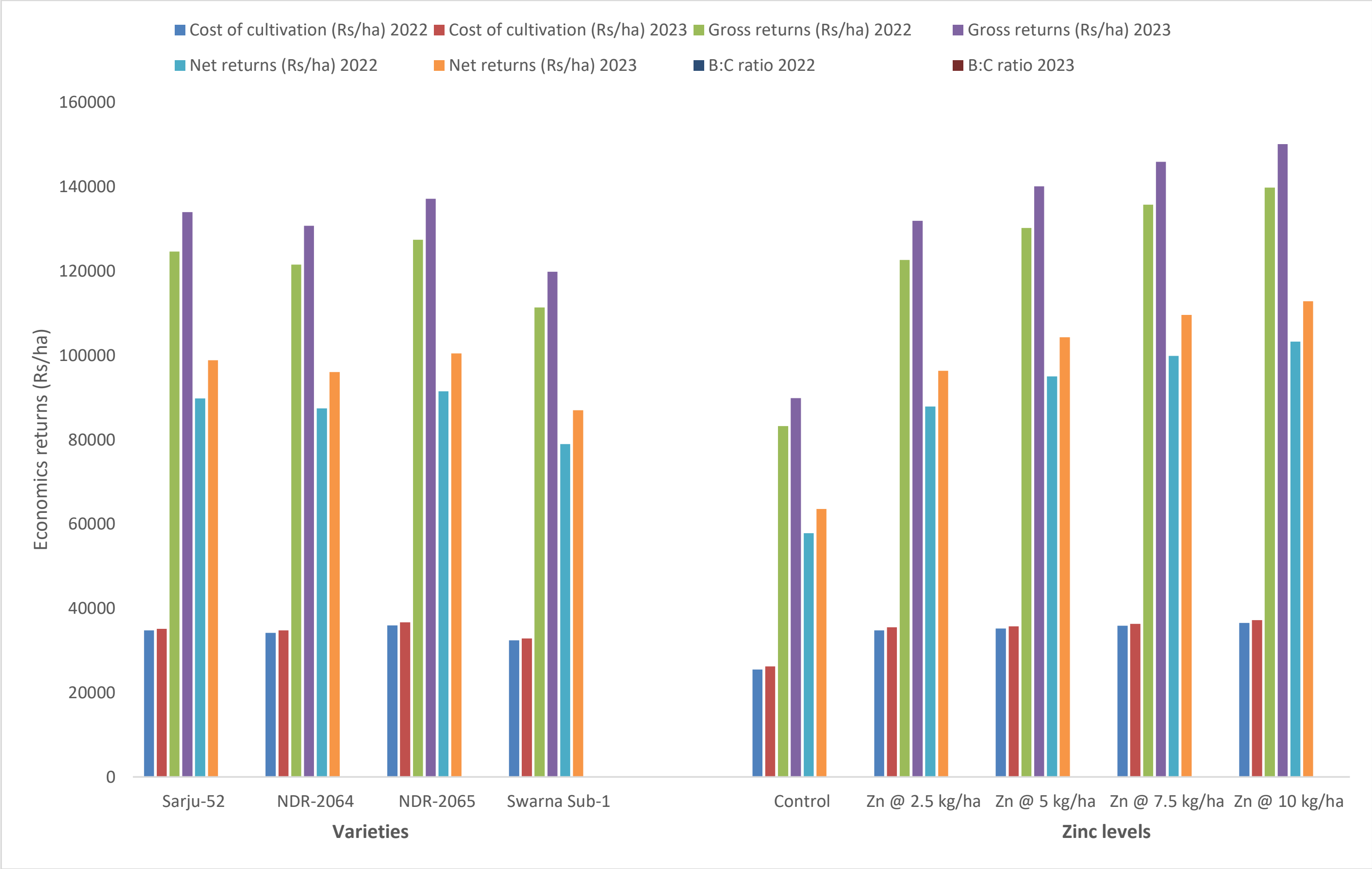

Fig. 3. Effect of different level of Zinc on economics of rice

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Conclusion

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