Effect of Different Levels of Zinc and varieties on Growth and uptake of Rice (*Oryza sativa* L.)

ABSTRACT

A field experiment was conducted to study the effect of different level of zinc on various variety of rice during two consecutive *kharif* seasons year 2022 and 2023 respectively. The experiment was laid out in split plot design with four variety of rice (Sarju-52**,** NDR-2064**,** NDR-2065 and Swarna Sub-1) in Main plot. Each main plot was further divided in five Sub plot *i.e* (Control, Zn @ 2.5 kg/ha, Zn @ 5 kg/ha, Zn @ 7.5 kg/ha and Zn @ 10 kg/ha). The data recorded that the variety NDR 2065 maximum Plant hight (95.6cm, 97.5cm), number of tillers m^{-2} (251.8 m^{-2}, 256.4 m^{-2}), and Dry matter accumulation g m^{-2} (1362.7 ,1372.1), during 2022 and 2023 respectively. Among Zn level Maximum value NDR 2064 in plant hight, number of tillers $m^{-2,}$ Dry matter accumulation g m^{-2} were recorded under Zn @10 kg/ha which was at par with 7.5 kg/ha, for NDR 2064 in, number of tillers $m^{-2,}$ Dry matter accumulation g m^{-2} and 5 kg/ha in plant hight. The maximum uptake of nutrient was recorded under the varieties NDR-2065(776g/ha and 820.5g/ha) the application of Zn 10kg/ha was recorded maximum uptake of rice during 2022 and 2023 respectively.

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

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 mt in the current rice production (Dass *et al.,* 2016). In India, rice is cultivated round the year in one or the other part of the country, in diverse ecologies spread over 44.00 m ha with a production of 121.60 million tonnes however, productivity (2700 kg ha^{-1}) of rice (WTO, 2020-21).

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 and no 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

The field experiment was conducted at Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya, Uttar Pradesh (U.P.), located at latitude of 26.40^0 North and longitude of 82.12^0 East with an elevation of 113 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 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 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 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

Growth parameters

Data regarding Growth parameters *viz*., Plant height (cm), No. of tillers (m^2) and dry matter accumulation (g m^2) is mentioned in Table 1. It indicate that varities and Zn level had significant effect on growth paramerter during both years data further reveld that varities (NDR-2065) exhibited taller plant (95.6 & 97.5cm) during 2022 and 22023 respectively which was at par with (NDR-2064). whereas, the lowest plant height was recorded under V_4 (Swarna Sub-1) during 2022 and 2023 respectively. among Zn level maximum plant hight recorded under Zn @ 10 kg/ha (98.7cm and 99.8 cm) in 2022 and 2023 respectively. which was at par with Zn @7.5 kg/ha and Zn @ kg/ha while significantly higher than rest of the treatment during both years. this might be adequate supply of nutrient which leads to increase in plant hight.

In Table 1. It indicate that varities and Zn level had significant effect on growth paramerter during both years data further reveld that Highest number of tillers (m^2) were recorded in NDR-2065 (251.8 and 256.4m^{-2}) during 2022 and 22023 respectively which was at par with (NDR-2064). whereas, the minimum number of tiller was recorded under V_4 (Swarna Sub-1) during 2022 and 2023 respectively. among Zn level maximum tiller recorded under Zn @ 10 kg/ha (249.1 and 253.5) in 2022 and 2023 respectively. which was at par with Zn @7.5 kg/ha. while significantly higher than rest of the treatment during both years.

Zn level had significant effect on the dry matter accumulation growth paramerter during both years data further reveld that varities (NDR-2065) exhibited maximum dry matter accumulation (1362.7g/m^2 and 1372.1 g/m^2) during 2022 and 22023 respectively which was at par with (NDR-2064). whereas, the lowest dry matter accumulation was recorded under V_4 (Swarna Sub-1) during 2022 and 2023 respectively. Among Zn level maximum dry matter accumulation recorded under Zn @ 10 kg/ha (1342.1 g/m^2 and 1350.2 g/m^2) in 2022 and 2023 respectively. which was at par with Zn @7.5 kg/ha and Zn @ kg/ha while significantly higher than rest of the treatment during 2022 and 2023 respectively.

Table 1 Effect of different level of Zinc on plant height (cm), number of tillers (m^2) and dry matter accumulation (g m^2) of rice

Treatments		**Plant height (cm)**		**Number of tillers (m^2)**		**Dry matter accumulation (g m^2)**	
		2022-23	**2023-24**	**2022-23**	**2023-24**	**2022-23**	**2023-24**
(A) Varieties							
Sarju-52	V_1	94.4	96.5	227.6	231.7	1323.6	1334.6
NDR-2064	V_2	94.5	96.6	250.4	254.8	1355.7	1365.8
NDR-2065	V_3	95.6	97.5	251.8	256.4	1362.7	1372.1
Swarna Sub-1	V_4	90.3	92.2	215.9	219.7	1278.8	1284.5
SE(m)±		***1.01***	***1.05***	***1.84***	***1.81***	***2.32***	***2.70***

C.D. (P=0.05)		***3.44***	***3.67***	***6.37***	***6.25***	***7.72***	***7.69***
(B) Zinc levels							
Control	Z_1	87.8	89.7	226.6	230.6	1306.6	1317.5
Zn @ 2.5 kg/ha	Z_2	93.2	95.2	233.1	237.6	1323.3	1334.4
Zn @ 5 kg/ha	Z_3	94.7	96.8	237.4	241.5	1328.4	1339.4
Zn @ 7.5 kg/ha	Z_4	97.6	98.7	243.1	247.3	1335.9	1343.1
Zn @ 10 kg/ha	Z_5	98.7	99.8	249.1	253.5	1342.1	1350.2
SE(m)±		***1.88***	***1.92***	***2.45***	***2.51***	***2.70***	***2.75***
C.D. (P=0.05)		***5.37***	***5.50***	***7.02***	***7.17***	***8.02***	***9.50***

2. Zinc content (ppm) and uptake by grain and straw

Data on zinc content and uptake by grain and straw (Table 2) indicated that there was a gradual change in zinc content and uptake with increasing different varieties. The zinc content in grain as well as straw was found highest (43.25 & 44.74 and 86.90 & 87.65 ppm) under V_3 (NDR-2065), which was at par with V_1 (Sarju-52) during 2022 and 2023.

Zinc levels caused significant variation in zinc content in grain and straw of rice. Application of Z_5 (Zn @ 10 kg/ha) recorded maximum zinc content in grain and straw as 44.34 & 45.78 and 88.65 & 90.55 ppm, respectively, which was at par with Z_4 (Zn @ 7.5 kg/ha) treatment. The zinc uptake by grain and straw was also found highest under the treatment Z_5 (Zn @ 10 kg/ha) which was at par with Z_4 (Zn @ 7.5 kg/ha) during both the year. The lowest zinc uptake was recorded with the application of Z_1 (Control) in case of both grain and straw.

A critical study of the data on total zinc uptake revealed significant variation due to different varieties. Total zinc uptake increased progressively with different varieties. The treatment V_3 (NDR-2065) have recorded highest total zinc uptake (776.0 & 820.5 g ha^{-1}), which was at par with V_1 (Sarju-52) during 2022 and 2023 respectively.

There was a significant difference in total zinc uptake due to different zinc levels. The highest total zinc uptake was recorded highest (837.5 & 893.3 g ha^{-1}) under the treatment Z_5 (Zn @ 10 kg/ha), which was at par with Z_4 (Zn @ 7.5 kg/ha) during 2022 and 2023. The significantly lowest total zinc uptake was recorded under the treatment Z_1 (Control).

Conclusion

Nutrient uptake which is a product of nutrient content and yield was affected significantly under various treatments. Significantly more availability of nutrients in V_3 (NDR-2065) and Z_5 (Zn @ 10 kg/ha) treatment resulted higher nutrient content in plants it may leads to produce higher plant hight, number of tillers, higher dry matter yields which improves growth and development of plants which ultimately resulted in higher nutrient uptake. Application of V_3 (NDR-2065) and Z_5 (Zn @ 10 kg/ha) found maximum nutrient content and uptake. However, the minimum recorded in V_4 (Swarna Sub-1) and Z_1 (control) plot which was significantly lower than other treatments.

Table 4.13 Effect of different level of Zinc on zinc content (ppm) and uptake (g ha^{-1}) of rice

Treatments		Zinc content (ppm)				Zinc uptake (g ha^{-1})				Total uptake (g ha^{-1})	
		Grains		Straw		Grains		Straw			
		2022-23	2023-24	2022-23	2023-24	2022-23	2023-24	2022-23	2023-24	2022-23	2023-24
(A) Varieties											
Sarju-52	V_1	41.84	42.58	82.37	83.25	180.6	191.3	545.7	574.7	726.3	765.9
NDR-2064	V_2	38.12	40.29	78.20	80.47	160.4	176.4	508.6	545.3	669.0	721.8
NDR-2065	V_3	43.25	44.74	86.90	87.65	191.1	205.8	584.9	614.7	776.0	820.5
Swarna Sub-1	V_4	32.67	33.61	62.59	64.28	125.6	134.6	379.2	405.7	504.8	540.3
SE(m)±		***1.94***	***2.04***	***1.88***	***1.96***	***8.3***	***9.0***	***13.1***	***13.3***	***18.2***	***20.2***
C.D. (P=0.05)		***5.80***	***6.08***	***5.60***	***5.85***	***24.8***	***26.9***	***40.5***	***41.2***	***54.5***	***60.5***
(B) Zinc levels											
Control	Z_1	28.67	30.60	60.49	61.47	80.1	89.0	331.1	350.5	411.2	439.5
Zn @ 2.5 kg/ha	Z_2	37.98	39.41	79.20	81.67	161.6	174.6	508.9	546.8	670.5	721.4
Zn @ 5 kg/ha	Z_3	40.45	41.87	82.40	83.69	182.7	196.9	565.1	598.0	747.8	794.9
Zn @ 7.5 kg/ha	Z_4	42.64	43.25	86.45	87.21	201.5	212.8	598.8	629.4	800.3	842.2
Zn @ 10 kg/ha	Z_5	44.34	45.78	88.65	90.55	216.3	232.2	621.2	661.1	837.5	893.3
SE(m)±		***2.10***	***2.21***	***1.94***	***2.12***	***10.2***	***11.7***	***13.4***	***14.2***	***21.2***	***23.5***
C.D. (P=0.05)		***6.27***	***6.60***	***5.86***	***2.34***	***30.5***	***34.9***	***40.1***	***42.5***	***63.5***	***70.4***

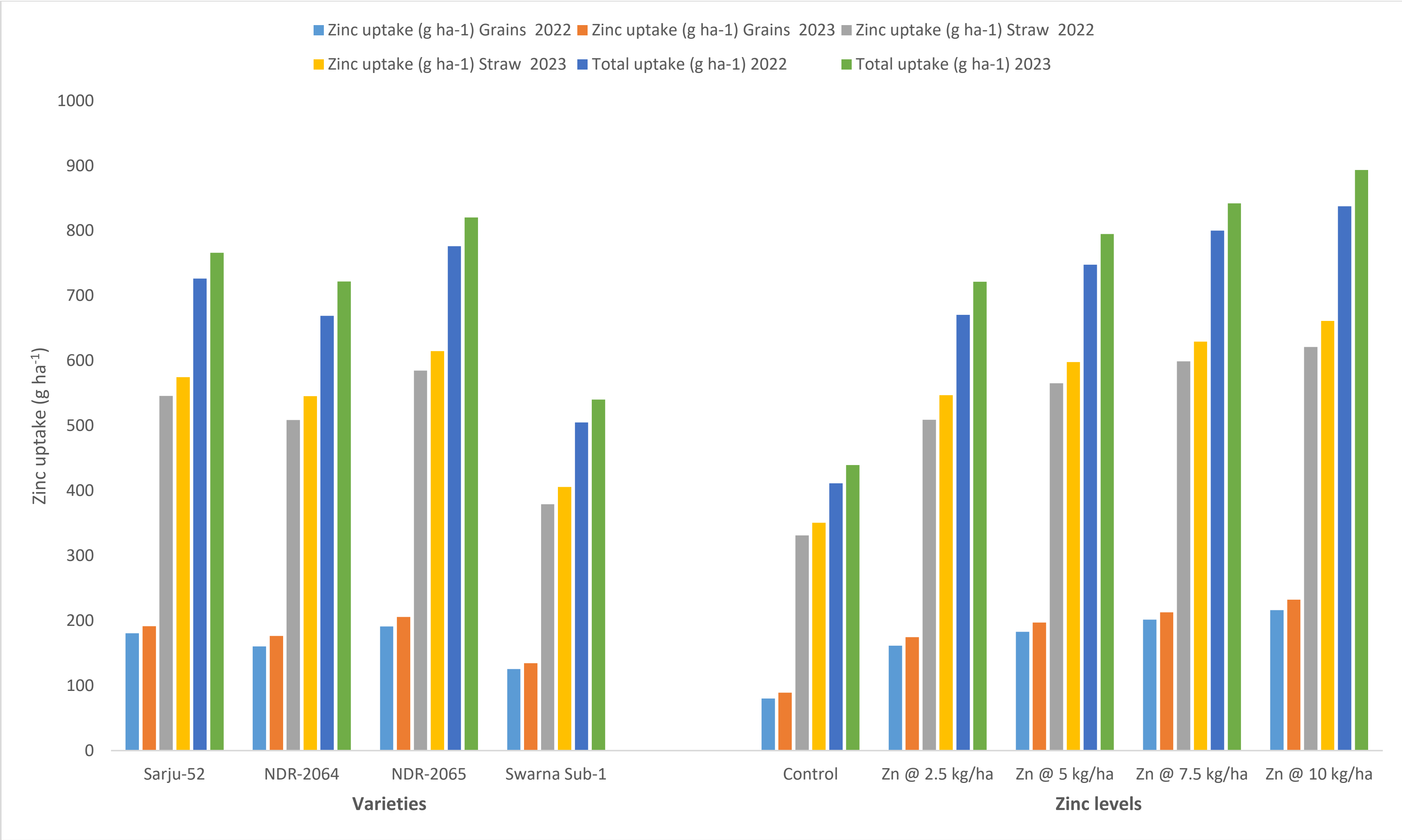

Fig. 1 Effect of different level of Zinc uptake (g ha^{-1}) of rice

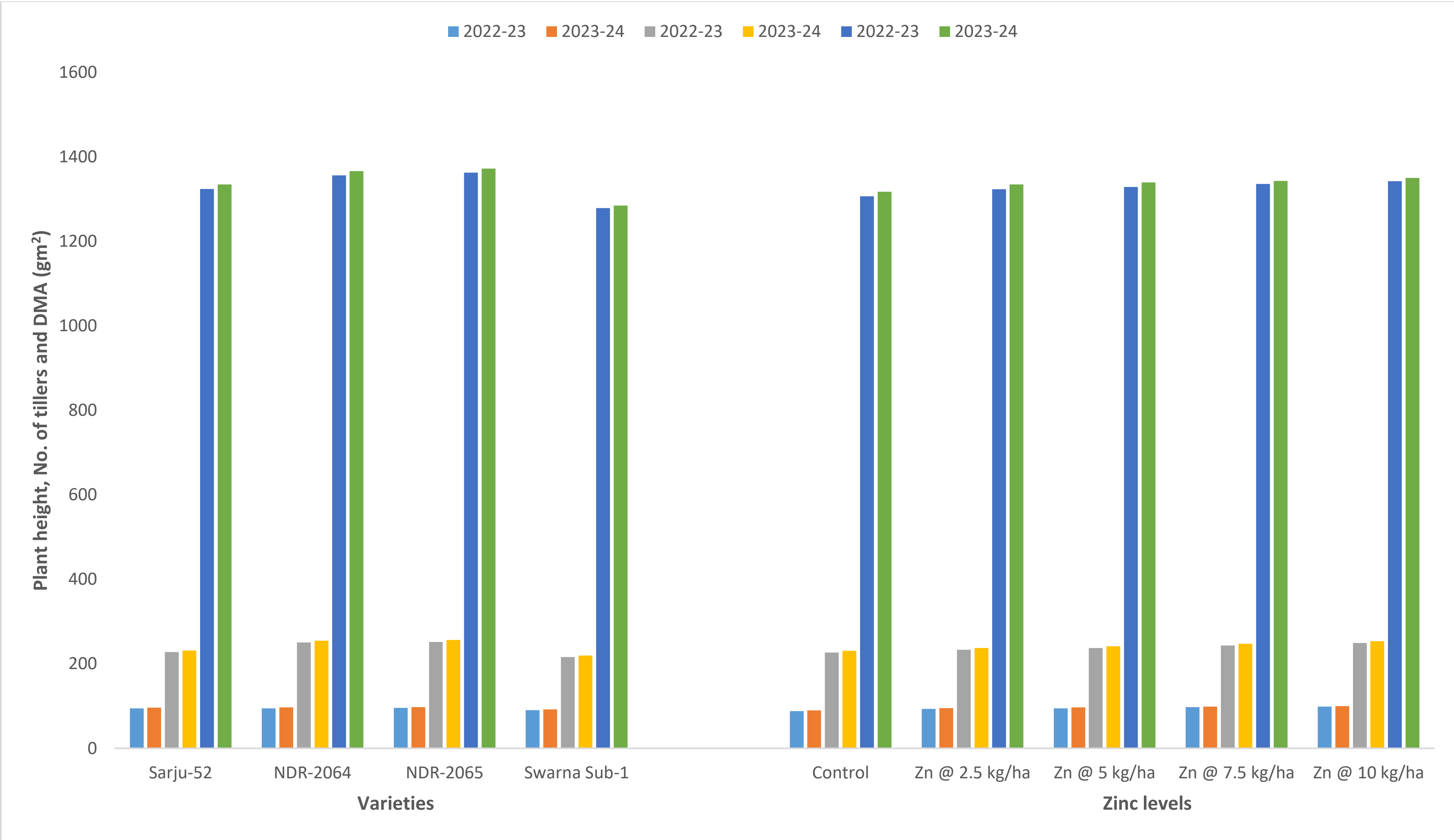

Fig. 2: Influence of different micronutrients on Growth parameters of rice at harvest

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