Journal of Advances in Biology & Biotechnology

Volume 27, Issue 7, Page 326-333, 2024; Article no.JABB.118257
ISSN: 2394-1081

Effect of Different Levels of Zinc on Yield of Various Varieties of Rice (*Oryza sativa* 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.

Article Information

DOI: https://doi.org/10.9734/jabb/2024/v27i7992

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/118257

Original Research Article

Received: 03/04/2024
Accepted: 07/06/2024
Published: 11/06/2024

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 result recorded that the variety NDR 2065 maximum panicle length (24.8cm ,25.3), number of panicles m^{-2} (134.1, 137.5), number of grains per panicles (149.1 ,152.6), test weight (23.6g, 23.7g) grain yield (44.19, & 46.01) q ha^{-1},straw yield

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Cite as: Gupta , Satya Prakash, Rajesh Kumar, Ankur Tripathi, Abhinav Kumar, Om Chandra Pandey, Niyaj Ahamad, and Deeksha Tiwari. 2024. "Effect of Different Levels of Zinc on Yield of Various Varieties of Rice (Oryza Sativa L.)". Journal of Advances in Biology & Biotechnology 27 (7):326-33. https://doi.org/10.9734/jabb/2024/v27i7992.

(67.31 & 70.13) q ha^{-1},and biological yield (111.50 &116.14) q ha^{-1}during 2022 and 2023 respectively. Among Zn level Maximum value of yield attributes and yield was recorded under Zn @10 kg/ha which was at par with 7.5 kg/ha, and 5 kg/ha for number of panicles, number of grains per panicle, 1000 grain seed weight, grain yield, straw yield, biological yield during both years.

Keywords: Rice; different varieties and different zinc levels; production potential; profitability.

1. INTRODUCTION

Among cereals rice (*Oryza sativa* L.) is the most important and extensively grown in tropical and subtropical regions of the world, and is staple food for more than 60 per cent of the world population. In Asia about 90% of the world's rice is grown and produced is 142 million ha area with the production of 622 million tonnes [1]. Over 2 billion people in Asia alone derive 80% of their energy needs from rice which contains 80% carbohydrates, 7-8% protein, 3% fat and 3% fiber. Middle Eastern nations, Malaysia, Korea, Japan, Australia, the United States, Canada, the United Kingdom, Italy, and Sweden are the export destinations (Das and Baqui, 2000). Rice is one of the major contributors to the food grain production contributing approximately 43% of the total food grain production in India [2].

In India rice is grown in 46.38 million ha with production of 130.29 million tones with average productivity of 2809 kg ha^{-1}. Uttar Pradesh has largest area of rice *i.e*. 5.70 million ha with production of 15.27 million tonnes [3].

Apart from improved varieties, imbalance uses of inorganic fertilizers leading to the emergence of multiple nutrient deficiencies are major constraints in realizing higher yield of rice. So, for achieving higher productivity and nutrient use efficiency, balanced fertilizer is necessary. Moreover, nutrient status of soil plays a major role for obtaining the optimum crop production. Not only the quantity of various nutrients has in soil but also their availability to plants in proper ratio played significant role to optimize crop production.

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 [4]. Zinc deficiency continues to be one of the key factors in determining rice production in several parts of the country [5]. 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 [6].

Zinc deficiency in rice has been reported in lowlands of India [7] 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 [8]. 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.

2. MATERIALS AND METHODS

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, 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. Zinc was applied at the time of sowing in the form of Zinc sulphate. 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.

3. RESULTS AND DISCUSSION

3.1 Effect of Different Zinc Levels on Yield Attributes of Different Varieties of Rice

Yield attributes *viz*., Panicle length (cm), No. of panicle (m^{-2}), 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).

Given in Table 1. It indicate that the Maximum panicle length (cm) was observed in treatment V3 (NDR-2065) which is significantly higher than the rest of the verities during both year.

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

Treatments		Yield attributes							
		Panicle length (cm)		No. of panicle (m^{-2})		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

Data recorded on panicle length (cm) as influenced by different varieties and zinc levels

Application of Zn @ 10 kg/ha recorded highest panicle length (25.3 & 25.8 cm) which was at par with Zn @ 7.5 kg/ha, while significantly high than rest of treatment whereas lowest panicle length (21.3 & 21.7 cm) was found under the treatment Z_1 (Control). This might be due to application of zinc which enhance the availability of other micronutrient

It is obvious from the data in the table that different varieties significantly influenced the number of panicle production. Amongst the treatments, the treatment V_3 (NDR-2065) recorded higher number of panicle (134.1 & 137.5) which was significantly higher than remaining treatments during 2022 and 2023 respectively. The treatment V_4 (Swarna Sub-1) recorded lowest (127.7 & 130.9) number of panicles

Variation in number of panicle due to zinc levels also recorded significant. data further reveled that the maximum number of panicles recorded under (Zn @ 10 kg/ha) (137.4 & 140.8) during 2022 and 2023 respectively which was at par with Z_4 and Z_3. The significantly lowest number of panicles was found under the treatment Z_1 (Control) during both the year. 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 Choudhary et al. [9].

Data recorded on number of grains/panicles as influenced by different varieties and zinc levels given in Table 1. It is clear from the data that number of grains/panicles significantly varied due to different varieties and Zn levels during both years. Among all the different varieties higher number of grains/panicle (149.1 & 152.6 panicle^{-1}) was recorded under V_3 (DR-2065) during 2022 and 2023 respectively which was significantly higher than rest of the varieties. The significantly lowest number of grains/panicle (137.5 & 140.8 panicle^{-1}) was recorded under the treatment V_4 (Swarna Sub-1).

Variations in number of grains/panicle due to different zinc levels was significant during both years. Among the zinc levels, the treatment Z_5 (Zn @ 10 kg/ha) recorded maximum number of grains/panicle (144.9 & 148.5 panicle^{-1}) during 2022 and 2023 respectively, which was at par with Z_4 (Zn @ 7.5 kg/ha) and Z_3 (Zn @ 5 kg/ha) while significantly higher than remaining treatments. However, the significantly lowest number of grains/panicle (138.4 & 141.8 panicle^{-1}) was found under the treatment Z_1 (Control) during both the year. 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}.

Data recorded on 1000- grains weight of rice under different treatments are presented in Table 1 It is clear from the data that 1000- grains weight of rice varied significantly due to different varieties. Amongst all the treatments, the highest 1000- grains weight (23.6 & 23.7 g) was recorded under V_3 (NDR-2065) during 2022 and 2023respectively, which was at par with V_1 (Sarju-52) during 2022 and 2023 respectively. The lowest 1000- grains weight recorded in V_4 (Swarna Sub-1) treatment.

The variations in 1000- grains weight due to different zinc levels were also affected significantly. The higher 1000- grains weight (23.5 & 23.6 g) was observed in Z_5 (Zn @ 10 kg/ha) during 2022 and 2023 respectively which was at par with (Zn @ 7.5 kg/ha) and (Zn @ 5 kg/ha). The significantly lowest 1000- grains weight (20.1 & 20.2 g) was recorded under the treatment Z_1 (Control) during both the year. 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.

3.2 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.

Data recorded on grains yield of rice under different treatments are presented in Table 2. It is clear from the data that maximum grains yield was on NDR 2065 (44.19 q/ha ,46.01 q/ha) during 2022 and 2023 respectively. Which was at par with sarju-52 and NDR-2064 during 2022 and 2023 respectively. Among the Zn level maximum grain yield recorded with application of Zn @10kg/ha which was at par Zn @7.5kg/ha and 5 kg/ha during both years. 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.

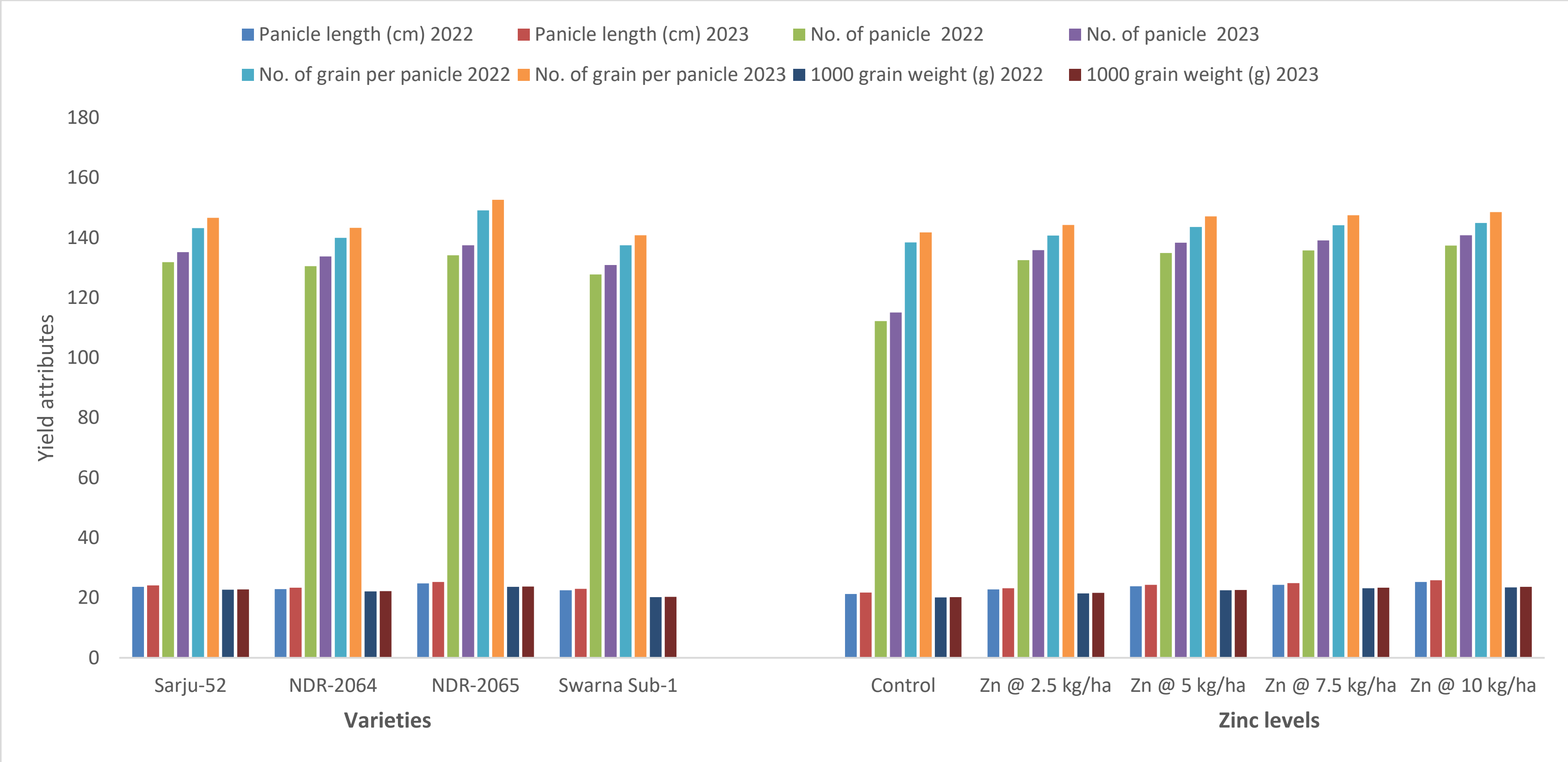

Fig. 1. Effect of different level of Zinc on yield attributes characters of rice

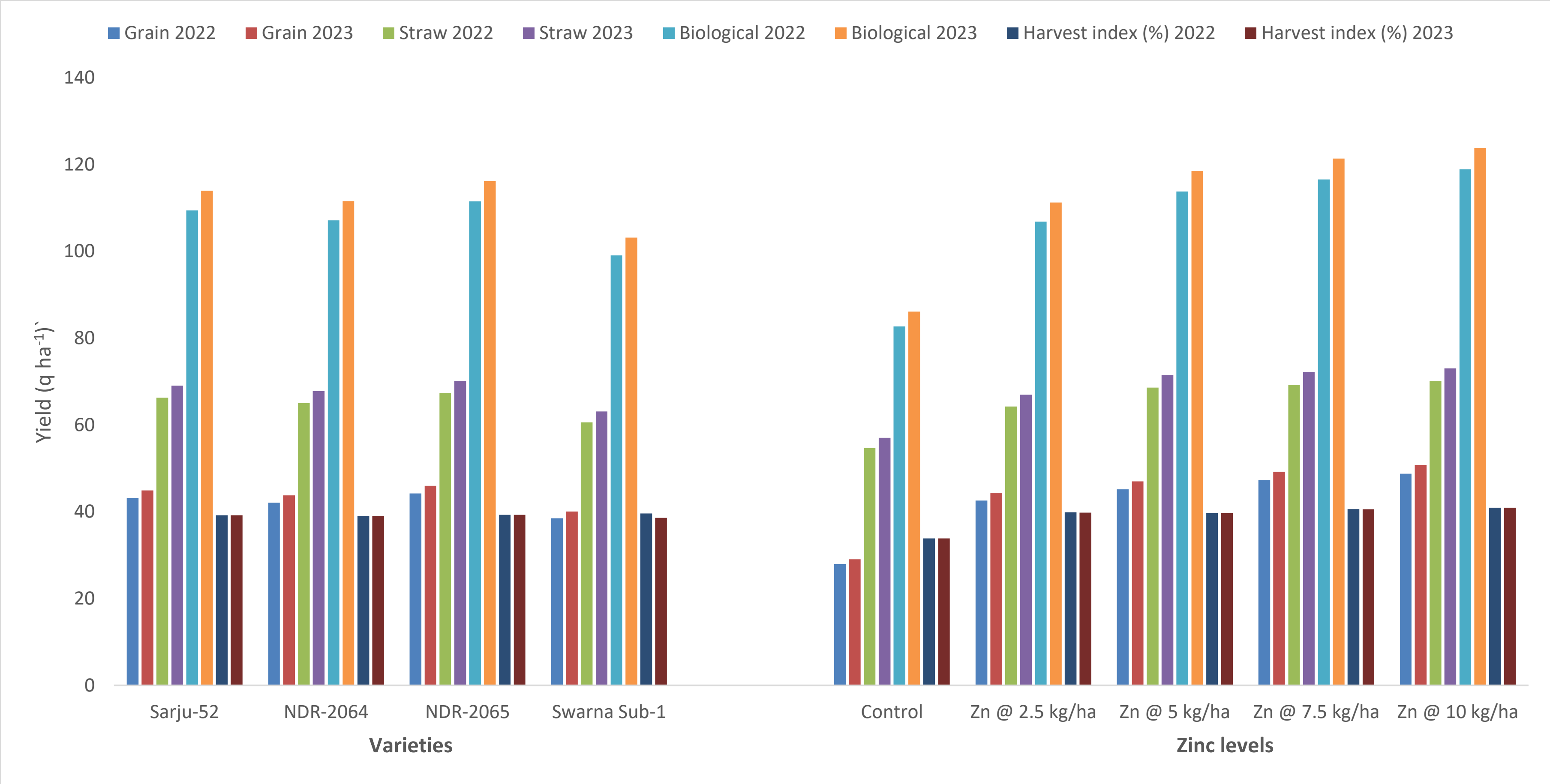

Fig. 2. Effect of different level of Zinc on yield and harvest index of rice

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

In the same way, straw yield of rice (Table 2) was significantly influenced by different zinc levels. It is clear from the data that maximum straw yield was on NDR 2065 (67.31q/ha ,70.13 q/ha) during 2022 and 2023 respectively. Which was at par with sarju-52 and NDR-2064 during 2022 and 2023 respectively. Among the Zn level maximum straw yield recorded with application of Zn @10kg/ha is (70.07q/ha and 73.01q/ha) which was at par Zn @7.5kg/ha and 5 kg/ha during both years [10].

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. [11], Kumar and Kumar [12], Sridevi et al. [13] and Ahmad et al. [14].

4. 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.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/118257