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## Effect of soil and foliar application of zinc on growth, yield attributes and yield of rice (*Oryza sativa* L.)

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### Abstract

The experiment was performed in Randomized block design with 4 replications by taking 6 treatments viz., foliar application of zinc @ 250 ml ha<sup>-1</sup>, 500 ml ha<sup>-1</sup>, 750 ml ha<sup>-1</sup>, combination of basal application of zinc sulphate @ 10 kg ha<sup>-1</sup> + foliar application of zinc @ 750 ml ha<sup>-1</sup> or alone basal application of zinc sulphate @ 10 kg ha<sup>-1</sup> and Untreated control. Maximum growth parameters viz., number of leaves plant<sup>-1</sup>, number of tillers plant<sup>-1</sup>, dry matter accumulation, leaf area index and yield attributes viz., number of effective tillers m<sup>-2</sup>, filled grains panicle<sup>-1</sup>, panicle weight, panicle length, number of filled grain per panicle, grain yield and straw yield was noted with foliar application of zinc @ 750 ml ha<sup>-1</sup> which was comparable with foliar application of zinc @ 500 or 250 ml ha<sup>-1</sup> or combination of basal application of zinc sulphate @ 10 kg ha<sup>-1</sup> + foliar application of zinc @ 750 ml ha<sup>-1</sup> and alone basal application.

**Keywords:** *Oryza sativa*, application of zinc, *kharif*

### Introduction

Rice (*Oryza sativa* L.) is one of the most staple food crops for more than half of the world population by providing 25% calories and 20% protein. More than 2 billion people get 60-70% of their energy requirement from rice and its derived products. Rice (*Oryza sativa* L.) is one of the important cereal crops which play a vital role in food security. More than 90 per cent of total rice production in the world is consumed by Asian countries, where it is a staple food for a majority of the population (Mohanty, 2013) [9]. During 2018-19, India has recorded production of rice to the tune of 99.3 million tonnes but considering the present growth rate of population as well as per capita consumption, the demand for rice has been projected as 156 million tonnes by 2030 (Anonymous, 2016) [3]. Rice is the world's most important cereal and potentially important source of zinc. Zinc is one of the most important micronutrient which is essential for plant growth especially for rice grown under submerged condition. Plant uptake zinc in Zn<sup>2+</sup> form; it is a micronutrient but plays a vital role in growth and metabolism of plant. Zinc is a major component and activator of several enzymes involved in metabolic activities (Klug and Rhodes, 1987) [7]. It is essentially required for protein synthesis and gene expression in plants (Cakmak, 2000) [4]. It has been estimated that about 10% of the proteins in biological system need zinc for their structural and functional integrity (Andreini *et al.*, 2006) [2]. Rice grown in flooded conditions has higher requirement of zinc because the availability of other nutrients in submerged condition increases which decreases zinc availability to crop. Plants take up zinc in the form of Zn<sup>2+</sup> ions. Diffusion is believed to be the dominant mechanism for Zn<sup>2+</sup> transport to plant roots (Rashid, 2001) [14]. Zinc deficiency causes multiple symptoms that usually appear 2 to 3 weeks after transplanting of rice seedlings. Deficient leaves develop brown blotches and streaks that may fuse to cover older leaves entirely, plants remain stunted and in severe cases may die, while those that recover will show substantial delay in maturity and reduction in yield. It's deficiency leads to appearance of dusty brown spots on upper leaves, stunted growth of plants, decrease tillering ability and increases spikelets sterility. Deficiency symptoms are prolonged during early growth stage due to immobilization of zinc, it's deficiency in rice crop is commonly known as Khaira disease.

## Materials and Methods

The study on “Effect of soil and foliar application of zinc on growth, yield attributes and yield of rice (*Oryza sativa* L.)” was performed during the season of *kharif*, 2019 at Instructional cum Research farm in Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh). The experimental site is located in the central part of Chhattisgarh at longitude 81.36°E and latitude 21.16°N with an altitude of 298 meters above the mean sea level. The experiment was performed in Randomized block design with 4 replications by taking 6 treatments *viz.*, foliar application of zinc @ 250 ml ha<sup>-1</sup>, 500 ml ha<sup>-1</sup>, 750 ml ha<sup>-1</sup>, combination of basal application of zinc sulphate @ 10 kg ha<sup>-1</sup> + foliar application of zinc @ 750 ml ha<sup>-1</sup> or alone basal application of zinc sulphate @ 10 kg ha<sup>-1</sup> and Untreated control. In this research recorded growth parameters *viz.*, number of leaves plant<sup>-1</sup>, number of tillers plant<sup>-1</sup>, dry matter accumulation, leaf area index and the crop from each net plot was harvested separately and panicle weight, panicle length, number of filled grain per panicle, grain yield and straw yield recorded and expressed in q ha<sup>-1</sup>.

## Result and Discussion

Field experiment on “Effect of soil and foliar application of zinc on growth parameters, yield attributes, yield and economics of rice” conducted during *kharif* season of 2019 at Research cum Instructional Farm, I.G.K.V., Raipur (C.G.).

The objective was to assess the impact of zinc on performance of rice. In this chapter, results are presented with the help of tables and graphics and discuss the cause and effect relationship from observations recorded during the course of investigation along-with established scientific views of national and international research workers.

## Growth parameters

### Plant height

The plant height was recorded at 30, 60 and 90 days after transplanting (DAT) and presented in Table 1. Plant height was increased with the advancement of crop age. Irrespective of the treatments, plant height increased 49.69 per cent from 30 to 60 DAT and 5.13 per cent between 60-90 DAT. The effect of treatments on plant height was not noticed at 30 DAT. Foliar application of zinc @ 750 or 500 or 250 ml ha<sup>-1</sup> or combination of basal application of zinc sulphate @ 10 kg ha<sup>-1</sup> + foliar application of zinc @ 750 ml ha<sup>-1</sup> or alone basal application of zinc sulphate @ 10 kg ha<sup>-1</sup> were being at par to each other and produced the tallest plants than that of untreated control during both period of observations *i.e.* 60 and 90 DAT. Application of zinc reduced the disease infection supported with sufficient nutrients increased the cell division causing more stem elongation resulting in increased the plant height. Similar findings have been also reported by Mumba and Ambara (2013)<sup>[10]</sup>.

**Table 1:** Effect of soil and foliar application of zinc on plant height of rice

Treatment	Plant height (cm)		
	30 DAT	60 DAT	90 DAT
Foliar application of liquid zinc 39.5 % @ 250 ml ha <sup>-1</sup> at tillering and panicle initiation stage	68.85	104.41	110.16
Foliar application of liquid zinc 39.5 % @ 500 ml ha <sup>-1</sup> at tillering and panicle initiation stage	68.88	104.56	110.20
Foliar application of liquid zinc 39.5 % @ 750 ml ha <sup>-1</sup> at tillering and panicle initiation stage	70.75	105.09	110.83
Application of Zinc Sulphate 33% @ 10 kg ha <sup>-1</sup> as basal fb liquid zinc 39.5 % @ 500 ml at tillering and panicle initiation stage	70.82	107.90	110.43
Application of Zinc Sulphate 33% @ 10 kg ha <sup>-1</sup> as basal	70.66	104.40	110.05
Untreated control	68.60	100.18	107.02
SEm±	1.70	1.35	0.71
CD (P=0.05)	NS	4.06	2.13

### Number of leaves

Number of leaves plant<sup>-1</sup> recorded at 30, 60 and 90 days after transplanting (DAT) and influenced due to zinc application in rice (Table 2). In general, number of leaves increased up to 60 DAT and declined thereafter. Significant effect of treatments on number of leaves was not noted at 30 DAT. Foliar application of zinc @ 750 or 500 or 250 ml ha<sup>-1</sup> or combination of basal application of zinc sulphate @ 10 kg ha<sup>-1</sup> + foliar application of zinc @ 750 ml ha<sup>-1</sup> or alone basal

application of zinc sulphate @ 10 kg ha<sup>-1</sup> were found to be equally effective and superior over untreated control for the production of leaves. The lowest number of leaves was observed under untreated control which was comparable with foliar application of zinc @ 250 ml ha<sup>-1</sup> and basal application of zinc sulphate @ 10 kg ha<sup>-1</sup> at 60 DAT. Application of zinc favourably influenced the cell division and enlargement which facilitated more number of leaves. This is in accordance with the findings of Rana *et al.* (2014)<sup>[13]</sup>.

**Table 2:** Effect of soil and foliar application of zinc on number of leaves of rice

Treatment	Number of leaves			
	30 DAT	60 DAT	90 DAT	At harvest
Foliar application of liquid zinc 39.5 % @ 250 ml ha <sup>-1</sup> at tillering and panicle initiation stage	32.75	52.75	16.95	13.16
Foliar application of liquid zinc 39.5 % @ 500 ml ha <sup>-1</sup> at tillering and panicle initiation stage	33.25	55.75	17.85	13.30
Foliar application of liquid zinc 39.5 % @ 750 ml ha <sup>-1</sup> at tillering and panicle initiation stage	35.33	56.75	17.75	15.75
Application of Zinc Sulphate 33% @ 10 kg ha <sup>-1</sup> as basal fb liquid zinc 39.5 % @ 500 ml at tillering and panicle initiation stage	36.33	56.00	18.00	15.39
Application of Zinc Sulphate 33% @ 10 kg ha <sup>-1</sup> as basal	33.75	52.10	16.85	13.15
Untreated control	31.92	48.50	15.53	11.25
SEm±	2.30	1.56	0.43	0.48
CD (P=0.05)	NS	4.68	1.30	1.45

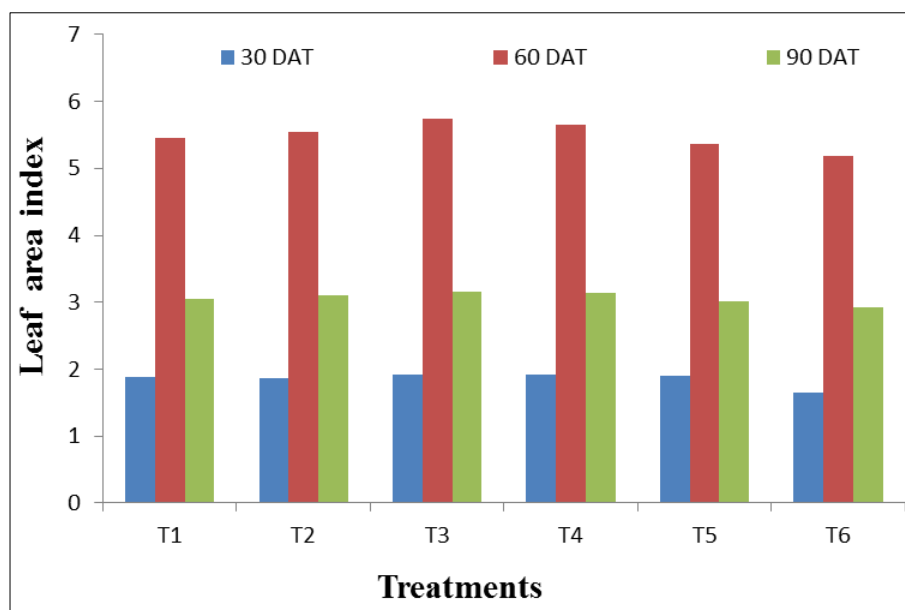
### Leaf area index (LAI)

Leaf area index was observed at 30, 60 and 90 DAT and presented in Fig.1. Irrespective of the treatments, leaf area

index increased with increasing crop age up to 60 DAT. The intensity of increasing of LAI was more between 30 to 60 DAT than that of 60-90 DAT. Leaf area index was the highest

under the foliar application of zinc @ 750 ml ha<sup>-1</sup> which was closely followed by basal application of zinc sulphate @ 10 kg ha<sup>-1</sup> + foliar application of zinc @ 750 ml ha<sup>-1</sup>. The lowest LAI was noticed under untreated control at all the stages of

observations. Application of zinc increased the number of leaves and leaf area and subsequently increased the LAI. This also the conformity of the findings of Amanullah *et al.* (2016) [1].



**Fig 1:** Effect of soil and foliar application of zinc on Leaf area index of rice

#### Number of tillers

Number of total tillers plant<sup>-1</sup> was counted at 30, 60 90 DAT and at harvest (Table 3). It increased up to 60 DAT and thereafter decreased till harvest. Irrespective of the treatments, tillers appeared at 30, 60, 90 DAT and at harvest was 10.66, 9.38, 8.21 and 7.00, respectively. Basal application of zinc sulphate @ 10 kg ha<sup>-1</sup> produced significantly higher number of tillers than that of other treatment except basal application of zinc sulphate @ 10 kg ha<sup>-1</sup> + foliar application of zinc @ 750 ml ha<sup>-1</sup> and foliar application of zinc @ 750 or 500 or 250

ml ha<sup>-1</sup> at 30 DAT. Further advancement of crop age, foliar application of zinc @ 750 or 500 or 250 ml ha<sup>-1</sup> or combination of basal application of zinc sulphate @ 10 kg ha<sup>-1</sup> + foliar application of zinc @ 750 ml ha<sup>-1</sup> or alone basal application of zinc sulphate @ 10 kg ha<sup>-1</sup> were statistically at par and obtained significantly higher number of tillers as compared to untreated control. Higher growth due to increased photosynthetic rate under application of zinc might be the reasons for increasing the number of tillers. Similar findings were also reported by Ghani *et al.* (1990) [6].

**Table 3:** Effect of soil and foliar application of zinc on number of tillers of rice

Treatment	Number of tillers			
	30 DAT	60 DAT	90 DAT	At harvest
Foliar application of liquid zinc 39.5 % @ 250 ml ha <sup>-1</sup> at tillering and panicle initiation stage	10.08	9.43	8.13	7.11
Foliar application of liquid zinc 39.5 % @ 500 ml ha <sup>-1</sup> at tillering and panicle initiation stage	10.33	9.50	8.50	7.14
Foliar application of liquid zinc 39.5 % @ 750 ml ha <sup>-1</sup> at tillering and panicle initiation stage	11.08	9.90	8.98	7.27
Application of Zinc Sulphate 33% @ 10 kg ha <sup>-1</sup> as basal fb liquid zinc 39.5 % @ 500 ml at tillering and panicle initiation stage	11.16	9.62	8.53	7.17
Application of Zinc Sulphate 33% @ 10 kg ha <sup>-1</sup> as basal	11.39	9.33	8.08	7.07
Untreated control	9.91	8.50	7.05	6.25
SEm±	0.31	0.23	0.31	0.21
CD (P=0.05)	0.92	0.70	0.92	0.62

#### Dry matter accumulation

Dry matter accumulation plant<sup>-1</sup> biomass was recorded at 30, 60 and 90 DAT and at harvest (Table 4). Irrespective of treatments, the rate of dry matter accumulation was at lower pace up to 30 DAT, after that, it got momentum and increases up to harvest. At all the stages of observations, dry matter accumulation under foliar application of zinc @ 750 or 500 or 250 ml ha<sup>-1</sup> or combination of basal application of zinc sulphate @ 10 kg ha<sup>-1</sup> + foliar application of zinc @ 750 ml ha<sup>-1</sup> and alone basal application of zinc sulphate @ 10 kg ha<sup>-1</sup> were comparable to each other and found to be superior over untreated control except 30 DAT. At this stage, basal

application of zinc sulphate @ 10 kg ha<sup>-1</sup> produced higher dry matter accumulation which was at par with combination of basal application of zinc sulphate @ 10 kg ha<sup>-1</sup> + foliar application of zinc @ 750 ml ha<sup>-1</sup> and foliar application of zinc @ 750 ml ha<sup>-1</sup>. The lowest dry matter accumulation was registered under untreated control which was comparable with foliar application of zinc @ 500 or 250 ml ha<sup>-1</sup> at 30 DAT. More number of leaves and LAI reflected through increased in photosynthetic activities which ultimately increased the dry matter accumulation under the application of zinc. These results are also corroborated by Kumar *et al.* (2017) [8].

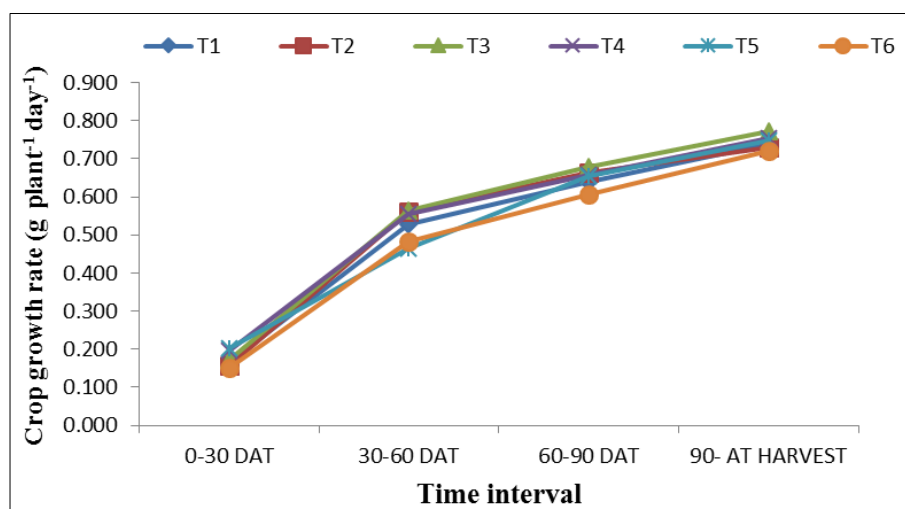
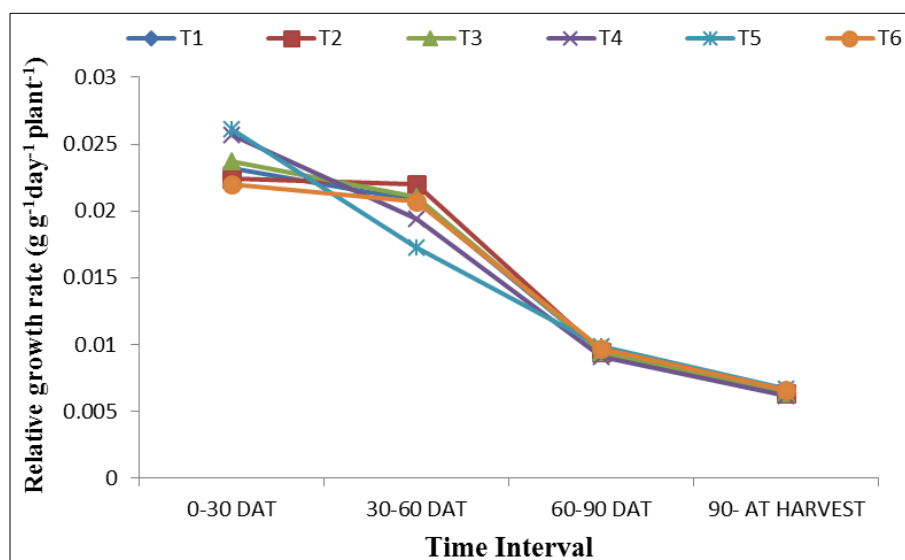
**Table 4:** Effect of soil and foliar application of zinc on Dry matter accumulation g plant<sup>-1</sup> of rice

Treatment	Dry matter accumulation (g plant <sup>-1</sup> )			
	30 DAT	60 DAT	90 DAT	At harvest
Foliar application of liquid zinc 39.5 % @ 250 ml ha <sup>-1</sup> at tillering and panicle initiation stage	4.96	20.80	39.99	62.18
Foliar application of liquid zinc 39.5 % @ 500 ml ha <sup>-1</sup> at tillering and panicle initiation stage	4.72	21.59	41.47	63.40
Foliar application of liquid zinc 39.5 % @ 750 ml ha <sup>-1</sup> at tillering and panicle initiation stage	5.16	22.06	42.40	65.53
Application of Zinc Sulphate 33% @ 10 kg ha <sup>-1</sup> as basal fb liquid zinc 39.5 % @ 500 ml at tillering and panicle initiation stage	5.91	22.58	42.26	64.87
Application of Zinc Sulphate 33% @ 10 kg ha <sup>-1</sup> as basal	6.07	20.02	39.63	62.02
Untreated control	4.57	19.05	37.22	58.85
SEm±	0.34	1.09	1.62	1.37
CD (P=0.05)	1.03	3.29	4.89	4.14

### Crop growth rate and relative growth rate

Crop growth rate (CGR) and relative growth rate (RGR) were computed between 0-30, 30-60, 60-90 DAT and 90 DAT-at harvest and depicted through Fig.2 and 3. Irrespective of the treatments, CGR was increased with the increasing age of

crop but it maximum between 30-60 DAT. CGR and RGR were highest under foliar application of zinc @ 750 ml ha<sup>-1</sup>, whereas, lowest CGR and RGR were observed under untreated control. Almost similar trend was noticed for all the stages of observations.

**Fig 2:** Effect of soil and foliar application of zinc on Crop growth rate of rice**Fig 3:** Effect of soil and foliar application of zinc on Relative growth rate of rice

### Yield attributes and Yield

#### Effective tillers, panicle weight, panicle length, filled grains panicle<sup>-1</sup>, unfilled grains panicle<sup>-1</sup> and test weight

The data related to yield attributes- *i.e.* effective tillers, panicle weight and length, filled grains panicle<sup>-1</sup>, unfilled grains panicle<sup>-1</sup> and test weight have been presented in Table 5 and Table 6. Panicle length and test weight was not affected

due to different treatments. Foliar application of zinc @ 750 ml ha<sup>-1</sup> produced the highest number of effective tillers, panicle weight and number of filled grains panicle<sup>-1</sup>. The comparable performance of above parameters was observed with the foliar application of zinc @ 500 or 250 ml ha<sup>-1</sup> or combination of basal application of zinc sulphate @ 10 kg ha<sup>-1</sup> + foliar application of zinc @ 750 ml ha<sup>-1</sup> and alone basal

application of zinc sulphate @ 10 kg ha<sup>-1</sup>. Significant reduction in effective tillers, panicle weight and filled grains panicle<sup>-1</sup> was observed under untreated control but remained at par with foliar application of zinc @ 250 ml ha<sup>-1</sup> and basal application of zinc sulphate @ 10 kg ha<sup>-1</sup> for panicle weight. The number of unfilled grains panicle<sup>-1</sup> was higher under untreated control which was found comparable with foliar application of zinc @ 250 ml ha<sup>-1</sup> and basal application of

zinc sulphate @ 10 kg ha<sup>-1</sup>. Almost all yield attributes (effective tillers, panicle weight, filled grains panicle<sup>-1</sup> and unfilled grains panicle<sup>-1</sup>) except panicle length and test weight were favourably influenced by the application of zinc. This might be due to efficient utilization of resources by reducing the disease incidence and subsequently increasing the plant dry biomass thereby increasing the yield attributes. Saha *et al.* (2016) also reported the similar findings.

**Table 5:** Effect of soil and foliar application of zinc on yield attributing characters of rice

Treatment	Effective tillers (No. m <sup>-2</sup> )	Panicle Weight (g)	Panicle length (cm)
Foliar application of liquid zinc 39.5 % @ 250 ml ha <sup>-1</sup> at tillering and panicle initiation stage	300.25	2.65	22.11
Foliar application of liquid zinc 39.5 % @ 500 ml ha <sup>-1</sup> at tillering and panicle initiation stage	307.00	2.78	22.28
Foliar application of liquid zinc 39.5 % @ 750 ml ha <sup>-1</sup> at tillering and panicle initiation stage	313.50	2.88	22.93
Application of Zinc Sulphate 33% @ 10 kg ha <sup>-1</sup> as basal fb liquid zinc 39.5 % @ 500 ml at tillering and panicle initiation stage	308.25	2.79	22.69
Application of Zinc Sulphate 33% @ 10 kg ha <sup>-1</sup> as basal	299.85	2.61	21.77
Untreated control	285.50	2.40	21.32
SEm±	4.55	0.09	0.47
CD (P=0.05)	13.71	0.29	NS

**Table 6:** Effect of soil and foliar application of zinc on yield attributing characters of rice

Treatment	Filled grain panicle <sup>-1</sup> (No.)	Unfilled grains panicle <sup>-1</sup> (No.)	Test weight (g)
Foliar application of liquid zinc 39.5 % @ 250 ml ha <sup>-1</sup> at tillering and panicle initiation stage	90.05	13.75	27.28
Foliar application of liquid zinc 39.5 % @ 500 ml ha <sup>-1</sup> at tillering and panicle initiation stage	91.40	13.15	28.43
Foliar application of liquid zinc 39.5 % @ 750 ml ha <sup>-1</sup> at tillering and panicle initiation stage	91.95	12.10	27.85
Application of Zinc Sulphate 33% @ 10 kg ha <sup>-1</sup> as basal fb liquid zinc 39.5 % @ 500 ml at tillering and panicle initiation stage	91.90	12.65	28.13
Application of Zinc Sulphate 33% @ 10 kg ha <sup>-1</sup> as basal	89.45	13.85	27.88
Untreated control	80.80	15.70	25.93
SEm±	2.43	0.69	1.18
CD (P=0.05)	7.33	2.07	NS

### Grain yield, straw yield and harvest index

The data pertaining to grain yield, straw yield and harvest index presented in Table 7. Harvest index did not influenced significantly due to different treatments. Irrespective of treatments, grain yield was enhanced under application of zinc by 8.07 per cent compared to untreated control. The grain and straw yield was found comparable and significantly higher under foliar application of zinc @ 750 or 500 or 250 ml ha<sup>-1</sup> or combination of basal application of zinc sulphate @ 10 kg ha<sup>-1</sup> + foliar application of zinc @ 750 ml ha<sup>-1</sup> and alone basal application of zinc sulphate @ 10 kg ha<sup>-1</sup> as compared to untreated control. The significantly reduction in grain and

straw yield was observed under untreated control. A decrease in leaf area causes a reduction in area for interception and absorption of the specific wavelength of light necessary for photosynthesis resulted in reduction of root and plant dry biomass thereby reducing absorption of nutrients subsequently reducing the yield attributes, yield and harvest index. The plants under application of zinc had better partitioning of dry matter, which lead to increase in the number of effective tillers, filled grains panicle<sup>-1</sup> and decrease in the number of unfilled grains panicle<sup>-1</sup> resultant in higher grain yield. These results are in agreement with the findings of Qaisrani (2011) [11].

**Table 7:** Effect of soil and foliar application of zinc on grain yield, straw yield and harvest index of rice

Treatment	Grain yield (q ha <sup>-1</sup> )	Straw yield (q ha <sup>-1</sup> )	Harvest index (%)
Foliar application of liquid zinc 39.5 % @ 250 ml ha <sup>-1</sup> at tillering and panicle initiation stage	48.80	57.93	45.72
Foliar application of liquid zinc 39.5 % @ 500 ml ha <sup>-1</sup> at tillering and panicle initiation stage	50.10	58.63	46.08
Foliar application of liquid zinc 39.5 % @ 750 ml ha <sup>-1</sup> at tillering and panicle initiation stage	50.36	62.45	44.64
Application of Zinc Sulphate 33% @ 10 kg ha <sup>-1</sup> as basal fb liquid zinc 39.5 % @ 500 ml at tillering and panicle initiation stage	50.12	61.80	44.78
Application of Zinc Sulphate 33% @ 10 kg ha <sup>-1</sup> as basal	48.52	57.97	46.30
Untreated control	45.88	52.97	46.41
SEm±	0.81	1.62	0.61
CD (P=0.05)	2.43	4.89	NS

### Conclusion

Foliar application of zinc @ 750 ml ha<sup>-1</sup> produced maximum growth parameters and grain yield of rice which was comparable with foliar application of zinc @ 500, 250 ml ha<sup>-1</sup>

<sup>1</sup>, combination of basal application of zinc sulphate @ 10 kg ha<sup>-1</sup> + foliar application of zinc @ 750 ml ha<sup>-1</sup> and alone basal application.



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