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Response of Zinc and Sulphur on Growth and Yield of Rice (*Oryza sativa* L.) under Sodic Soil

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A B S T R A C T

A field experiment entitled "Response of Zinc and sulphur on the growth and yield of rice (*Oryza sativa* L.) under sodic soil" was conducted during *Kharif* season of 2015–16 at Agronomy Research Farm of Narendra Deva University of Agriculture & Technology, Narendra Nagar, Kumarganj, Faizabad, Uttar Pradesh, India during *Kharif* season. Sixteen treatment combinations consisted of four Zinc level viz., 0 kg, 5 kg, 10 kg, 15 kg was kept and four sulphur levels viz., 0 kg 15 kg, 30 kg, 45 kg was kept in different plot. Then experiment was kept in Factorial RBD and replicated in three times. The soil type was a silt loam, sand 26.52%, silt 50.08%, clay 23.40%, pH 8.6, organic carbon 0.39 and EC 0.36 dsm^{-1}, Available nitrogen 185.50 kg ha^{-1}, Phosphorus 14.21%, Potassium 231.50 kg ha^{-1} Result revels that all the growth, yield attributes and yields were increased significantly under 15 kg Zn ha^{-1} applied. Number of shoot $hill^{-1}$, Plant height (cm), and Dry matter accumulation (gm^{-2}), Yield attributes, grain and straw yield (q ha^{-1}) of Rice crop were significantly higher with sulphur applied at 45 kg S ha^{-1}. The Zinc level at 10 kg ha^{-1} and Sulphur level at 45 kg ha^{-1} was found to be best suitable levels for obtaining the higher yield of Rice.

Keywords

Sulphur level, zinc level, yield, dry matter accumulation

Introduction

Rice (*Oryza sativa* L.) is a popular cereal crop commonly used as human food. It is actually a type of grass and belongs to a family gramineae (poaceae) includes other cereals such as wheat and maize. It is a source of magnesium, thiamin, niacin, phosphorus, Vitamin B_6, zinc and copper. Some varieties have iron, potassium and folic acid. White rice is one of the poorest cereals in proteins; some improved varieties however may provide 14 g of protein in 100 g^{-1}. It is an excellent source of complex carbohydrates, the best source of energy. However, a lot of these nutrients are lost during milling and polishing, which turns brown rice into white rice by removing the outer rice husk and bran to reveal the white grain. In the beginning rice grew wild, but today most countries cultivate varieties belonging to the *Oryza* type which has around twenty different species. Only two of them offer an agriculture interest for humans, *Oryza sativa* and *Oryza glaberrima.* Rice grows under a variety of agro-ecological condition much wider than that for any other major crop. It tolerates water as deep as 5 m in flood prone areas of South and East Asia and grows well in drought prone upland areas of Asia, Latin America and Africa. The geographic range of rice is from the equator to temperatures areas of Northern Japan and South Australia and from sea level to attitudes of more than 2500 m. As a conseques, there is great variability in the soil on which the crop is grown and equally real variability in appropriate varieties and management practices for this crop. Rice being the staple food for more than 70% of our national population and source of livelihood for 120–150 million rural households is backbone to the Indian agriculture. Rice is cultivated worldwide over an area about 156.69 mha with an annual production of about 660.18 mt with an average productivity of 4.2 t ha^{-1}. (2013–14 according to Ministry of Agriculture) In the latest report, The International Grains Council has projected India's rice production to touch a new record at 107 mt in 2013–14 and area planted under rice has increased to 46 mha. Uttar Pradesh is an important rice growing state in the country. The area and production of rice in this state is about 13.84 mha and 32.64 mt, respectively, with productivity of 2358 kg ha^{-1} (DAC, GOI, 2012).

The situation prevailing in our country in global terms is that we have 16% of human population 15% of farm animal population 2% of the forest and 0.5% grazing land. India entered the distinction of emerging as the second country after china to exploit hybrid vigour in rice, when it successfully developed and released for commercial cultivation the first set of 5 hybrids in 1994. The availability of sulphur gradually limiting in sodic and fine texture soil, poor in organic matter. Zinc deficiency in sodic soils has been recognized as an important and widespread nutritional disorder for growing hybrid rice. Sulphur as essential mineral nutrient plays key roles in protein production chlorophyll formation and oil synthesis. To Sulphur deficiency in crop plants has been recognized as a limiting factor not only for crop growth and seed yield but also for poor quality of products, because Sulphur is a constituent of several essential compounds such as (cystine methionine, coenzyme, thioredoxine and sulpholipids). About 2% of organic sulphur in the plant is present in the water soluble thiol fraction. Sulphur requirement for optimal growth vary between 0.1% and 0.5% of the dry weight basis of plants and its increase in the order of gramineas<leguminaceae<cruciferae. Zinc is one of the important Micro-nutrient which is essential for plant growth. Plant root absorbs zinc as ion (Zn^{++}) and as component of synthetic and natural molecular complexes can also enter the plant system directly through leaves. Zinc is closely involved in the diversity of enzymatic and N metabolism of plant in zinc deficient plant protein.

Synthesis and level are markedly reduced and amino acid and amides are accumulated. Zinc is the essential mineral for IAA synthesis. Zinc deficiency is closely related to the inhibition of RNA synthesis reduces root and shoot growth and chlorophyll concentration in leaves. The available zinc in Indian soils ranges between 0.08–20.5 ppm. Application of zinc has been found to boost growth and yield of crops to a greater extent (Zaidi *et al.,* 1997). Zinc deficiency causes poor tillering leading to decreased productivity of crop. Since zinc is a co-factor carbonic anhydrase and aldosase. Therefore it may adversely affect enzyme activities and carried corresponding metabolic reactions when zinc is deficient in soil. It is also involved in synthesis of protein and tryptophane. It is indicated that zinc is an essential structural components for normal functioning of super oxide dismutase enzyme. Aiming the above mentioned views, the present study "Response of Zinc and Sulphur on growth and yield of rice (*Oryza sativa* L.) under sodic soil." has been proposed with following objectives:

To study the effect of zinc and sulphur on growth and yield of rice.

Materials and Methods

The field experiment was conducted at Agronomy Research Farm, Narendra Deva University of Agriculture and Technology, Narendra Nagar, Kumarganj, Faizabad, Uttar Pradesh, India during the *Kharif* season 2015. The experimental site falls under sub-tropical zone in Indo-gangatic plains and lies between 26°47′ North latitude, 82°12′ East longitudes, at an attitude of about 113.0 m from mean sea level. The experimental field was well leveled having good irrigation and drainage facility and source of irrigation was tube well. The soil of experimental field was low in available nitrogen (192.50 kg ha^{-1}) and organic carbon (0.39%), medium in available phosphorus (15.50 kg ha^{-1}) and high in potassium (231.06 kg ha^{-1}). The reaction of the soil was slightly alkaline. The total rainfall during course of experimentation was 124.0 mm. During the crop season, the lowest temperature (5.9°C) was recorded in the month of December to January and the maximum (36.8°C) in the month of April. The highest mean relative humidity (86.6%) was recorded in the month of January. The experiment was laid out in randomized block design with four varieties (HD-2639, HUW-234, PBW-373 and HD-2285) and five nitrogen management practices (90 kg N ha^{-1}, 120 kg N ha^{-1}, 90 kg N ha^{-1}+25% N through FYM, 120 kg N ha^{-1}+25% N through FYM, 150 kg N ha^{-1}) with three replication. There were twenty treatment combinations comprised of 4 varieties and 5 nitrogen management practices. The sowing was done on 15th December 2014 with the seed rate of 125 kg ha^{-1} and spacing between rows was 20 cm apart. The nitrogen as treatment^{-1} through FYM was applied 15 days before sowing, while rest of the nitrogen was applied through Urea and DAP (18% N and 46% P_2O_5). Half of the Urea was applied as basal (at time of sowing) and remaining half dose of nitrogen was applied at 30 days after sowing through the Urea. However, 60 kg P_2O_5 ha^{-1} through DAP and 40 kg K_2O ha^{-1} through muriate of potash was applied at the time of sowing as a basal dose. Five irrigations were given, coinciding with the critical stage of the plant growth, beside pre-sowing irrigation by Tube-well. In order to check the weeds growth one manual weeding was done at 35 days after sowing. The crop was harvested at proper stage of maturity as determined by visual observations on 25th April 2015. Half meter length on either end of each plot and 2 border rows from each side (border rows) were first removed from the field to avoid error. The crop in net plot was harvested for calculation of yield data. Produce was tied in bundles and weighted for biomass yield. Threshing of produce of each net plot was done by using pull man's thresher. Five plants selected randomly were tagged from the net plot area of each treatment for recording various biometric observations and the data collected were analyzed statistically following the procedure described by Gomez and Gomez (1984).

Results and Discussion

Growth character

Plant height (cm)

Plant height was measured at four successive stages. The data related to plant height recorded at 30, 60, and 90 days after transplanting and at harvest as influenced by various levels of Zinc and Sulphur are presented in (Table 1). Plant height increased as the dose of zinc and sulphur increased at all the stages of crop growth. Zinc application also influenced the plant height significantly at all the stages of crop growth. At 30 DAT there was significant response on plant height noted due to different doses of zinc levels more over 15 kg Zn ha^{-1} zinc responded the higher plant height fallowed by 10 kg Zn ha^{-1}. Which was significantly superior over dose of 5 kg Zn ha^{-1} and 0 kg ha^{-1} at 60 DAT and the same trend was observed on rest of at all the growth stages of crop. Further, perusal of data indicate that sulphur application significantly influenced the plant height was recorded higher with higher dose 45 kg S ha^{-1} being statistically at par with 30 kg S ha^{-1}. It was significantly superior over dose of 15 kg S ha^{-1} and 0 kg ha^{-1} and the same tend was observed on rest of at all the growth stages of crop.

Leaf area index

The data related to leaf area index recorded at 30, 60, and 90 days after transplanting as influenced by various levels of Zinc and Sulphur are presented in (Table 2). The leaf area index was recorded higher with higher dose 15 kg Zn ha^{-1} being at par with 10 kg Zn ha^{-1} and it was significantly superior over dose of the rest treatment. Same trend was observed at 60 DAT and at 90 DAT it was found decreased. At 30 DAT leaf area index was recorded maximum with 45 kg S ha^{-1} being at par with 30 kg ha^{-1} and significant superior over dose of the rest of the treatment. The same trend was noted at 60DAT, and at 90 DAT was found decreased.

Dry matter accumulation (g m^{-2})

The data pertaining to dry matter accumulation (g m^{-2}) recorded at 30, 60, and 90 days after transplanting and at harvest as influenced by various levels of Zinc and Sulphur are presented in (Table 3). The dry weight g m^{-2} was recorded maximum with higher dose 15 kg Zn ha^{-1} being at par with 10 kg Zn ha^{-1} significantly superior over dose of 5 kg Zn ha^{-1} and 0 kg ha^{-1} at 30 DAT and same trend was recorded at all the stage of crop growth. The dry weight g m^{-2} was recorded maximum with higher dose 45 kg S ha^{-1} being at par with 30 kg S ha^{-1}. It was significantly superior over dose of 15 kg S ha^{-1} and 0 kg ha^{-1} at 30 DAT and same trend was recorded at all the stage of crop growth.

Higher doses of $ZnSO_4$ have slightly increased the plant stand, although the difference could not cross the level of significance. This may be due to the fact that in alkaline condition availability of Zn is restrained. When the zinc oxide was applied, it had helped in quick rejuvenation of seedling and provided the viability to plant and ultimately increased initial plant stand.

Plant height, number of shoot m^{-2}, leaf area index, and dry matter accumulation m^{-2} of plant a linear increase in all the parameters was recorded due to increasing doses of zinc levels. The results are in accordance with the results of Kushwaha *et al.,* (1992) and Scheudzhen *et al.,* (1992). The availability of zinc to plants is conditioned by several soil factors, such as pH, organic matter and adsorption by clays. High pH, induced deficiency of zinc which occurs in the pH range from 6 to 8. Since the pH of experimental plot was 8.6 all thought the increased solubility of zinc ions with NaOH or the rise of pH above 6.5 is a common phenomenon, but in alkaline soils because of the interaction with Ca in this pH range, the solubility of this zinc decreases. This may be the reason of poor zinc available in experimental area consequently as the increasing doses of Zn were applied, they have exhibited their response in linear way.

Table.1 Plant height influenced by levels of zinc and sulphur at various stages of crop growth

Treatment	Pant height (cm)			
Zinc levels (kg ha^{-1})	30 DAT	60 DAT	90 DAT	At harvest
Zinc levels (kg ha^{-1})				
Z_0 0 kg	55.48	76.35	86.05	91.70
Z_1 5 kg	58.20	80.13	90.30	96.43
Z_2 10 kg	61.80	85.10	95.84	102.33
Z_3 15 kg	62.78	86.46	97.48	103.98
SEm±	1.217	1.659	1.907	2.031
CD (*p*=0.05)	3.51	4.79	5.50	5.86
Sulphur levels (kg ha^{-1})				
S_0 0 kg	54.60	75.08	84.63	90.25
S_1 15 kg	57.60	79.31	89.41	95.40
S_2 30 kg	62.60	86.20	97.15	103.65
S_3 45 kg	63.45	87.45	98.48	105.13
SEm±	1.217	1.659	1.907	2.031
CD (*p*=0.05)	3.51	4.79	5.50	5.86

Table.2 Leaf Area Index (LAI) at 30, 60, and 90 DAT as influenced by levels of and zinc and sulphur

Treatments	Leaf area index		
Zinc levels (kg Zn ha^{-1})	30 DAT	60 DAT	90 DAT
Z_0 0 kg	3.44	5.12	3.91
Z_1 5 kg	3.62	5.38	4.10
Z_2 10 kg	3.84	5.71	4.36
Z_3 15 kg	4.90	5.80	4.43
SEm±	0.07	0.11	0.08
CD (*p*=0.05)	0.22	0.32	0.25
Sulphur levels (kg S ha^{-1})			
S_0 0 kg	3.39	5.03	3.84
S_1 15 kg	3.58	5.32	4.06
S_2 30 kg	3.89	5.78	4.42
S_3 45 kg	3.95	5.86	4.48
SEm±	0.07	0.11	0.08
CD (*p*=0.05)	0.22	0.32	0.25

Table.3 Response of zinc and sulphur on dry matter accumulation of rice

Treatment	Dry matter accumulation (g m^{-2})			
	30 DAT	60 DAT	90 DAT	At harvest
Zinc levels (kg ha^{-1})				
Z_0 0 kg	213.95	558.19	693.10	843.69
Z_1 5 kg	224.81	586.49	728.13	860.08
Z_2 10 kg	238.68	623.45	773.18	913.26
Z_3 15 kg	242.58	632.78	785.70	928.05
SEm±	4.76	13.82	15.43	19.37
CD (*p*=0.05)	13.76	39.92	44.59	55.96
Sulphur Level (kg ha^{-1})				
S_0 0 kg	210.53	549.14	681.85	805.41
S_1 15 kg	222.44	580.37	720.63	851.21
S_2 30 kg	241.81	630.74	783.18	925.06
S_3 45 kg	245.25	640.58	794.45	963.39
SEm±	4.76	13.82	15.43	19.37
CD (*p*=0.05)	13.76	39.92	44.59	55.96

Table.4 Response of Zinc and sulphur on yield and yield attributes of rice

Treatment	Yield and yield attributes			
	Number of shoots m^{-2}	Length of panicle (cm)	No. of Grains $panicle^{-1}$	Test weight(gm)
Zinc levels (kg ha^{-1})				
Z_0 0 kg	312.82	21.06	161.41	22.48
Z_1 5 kg	331.16	24.39	170.58	22.76
Z_2 10 kg	354.74	25.63	182.37	23.04
Z_3 15 kg	361.28	25.72	190.64	23.11
SEm±	7.07	0.51	3.17	0.43
CD (p=0.05)	20.43	1.47	9.17	1.24
Sulphur levels (kg ha^{-1})				
S_0 0 kg	306.93	21.02	158.46	22.53
S_1 15 kg	327.23	24.31	168.61	22.81
S_2 30 kg	359.97	25.55	184.99	22.94
S_3 45 kg	365.87	25.92	192.93	23.10
SEm±	7.07	0.51	3.17	0.43
CD (p=0.05)	20.43	1.47	9.17	1.24

Table.5 Response of sulphur and zinc on grain yield, straw yield and harvest index of rice

Treatment	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index (%)
Zinc Level (kg ha^{-1})			
Z_0 0 kg	34.01	45.20	42.93
Z_1 5 kg	38.20	50.05	43.15
Z_2 10 kg	42.00	55.10	43.19
Z_3 15 kg	44.03	57.82	43.29
SEm±	0.82	1.07	0.52
CD (p=0.05)	2.38	3.10	NS
Sulphur level (kg ha^{-1})			
S_1 0 kg	35.64	47.71	42.76
S_1 15 kg	37.98	49.76	43.28
S_2 30 kg	41.19	54.15	43.19
S_3 45 kg	43.19	56.54	43.29
SEm±	0.82	1.07	0.52
CD (p=0.05)	2.38	3.10	NS

Since the soil had a tendency of mild salinity and alkalinity, this variation might have been induced due to mortality created by high salt concentration in soil solution due to incorporation of increasing doses of fertilizer. Sulphur plays a pivotal role in protein production, chlorophyll formation and oil synthesis.

As it is evident from the data (Table 1 & 2) that the increasing doses of sulphur have increased the plant height, number of shoot $hill^{-1}$ and leaf area index, and this might due to favorable utilization of sulphur and thus increased the rate of optimal growth. According to Mrinal ~~B.~~ and Sharma, ~~S.H.~~ (2008). First cell division is stimulated in shoot apex, especially in the more basal meristamatic cell from which develop the long files of cortex and pith cell (Sachs, 1965) second gibberellins some time promote cell growth because they increase hydrolysis of starch, fructose and sucrose into glucose and fructose molecule.

These hexodes provide energy via respiration, they contribute to cell wall formation; and they also make the cell's water potential momentarily more negative. As a result of decreased in water potential, water enters more rapidly causing cell expansion but diluting the sugars. Third hormones (gibberellins) increased wall plasticity of rice plant in which growth promotion of young cells derived from the intercalary meristem is usually dramatic, if the availability of water to rice plant is sufficient.

Deficiency of sulphur results in increase in nitrate, soluble organic nitrogenous compounds, amides and ammonia and a decrease in insoluble (protein) nitrogen. S deficiency symptoms mostly resemble that of N deficiency. Leaves become pale yellow or light green and the symptoms will persist even after N application. Plants become small and spindly with short and slender stalks and crop growth is retarded. In sulphur deficient plants, the stem becomes hard woody. According to Singh G. R (2006). Sulphur application increases the plant height significantly and the tallest plants were recorded with 45 kg S ha^{-1} at all the stages. This might be due to rapid growth causes by adequate Sulphur supply to the crop, which resulted increased in various metabolic processes and performed carbohydrate metabolism of the crop plants; thus allowed the plant to grow faster. Results are in agreement to Oh (1991) also recorded significant effect in plant height of rice with successive increased in the dose of sulphur.

Number of shoot hill^{-1} was affected significantly by different levels of Sulphur at all the stages during the crop season (Table 4.3). Maximum number of shoots m^{-2} was found less than 45 kg S ha^{-1} as compared to30, 15, 0, kg S ha^{-1}. This might be due to the fact that higher dose of sulphur (being constituent of Iron sulphur protein and enzymes) has increased the number of shoots m^{-2}, these result are in close accordance to those Oh (1991)**.** Different sulphur levels had significant effect on leaf area index of rice at all the successive stages of the plant growth.

Application of 45 kg S ha^{-1} recorded higher value of leaf area index at all the stage Table (4.4). This might be attributed to more number of shoot m^{-2} and increase of plant height which ultimately increased the size and number of green leaves due to favorable utilization of sulphur and thus contributed to higher leaf area index. The lower leaf area index was obtained under low sulphur condition which may produce poor no of shoots m^{-2} and let to lower leaf area index Chandel *et al.,* (2003) also reported the similar result was found significant increased in leaf area by increasing levels of sulphur. Dry matter accumulation was significantly affected with increased in sulphur levels at all the stages of plant (Table 4.5) this might be due to increased plant height and leaf area index, improved tillering and increased uptake of nutrients reported that results Sarkar *et al.,* (2000).

Yield and yield attributing character

Number of effective shoots m^{-2}

Average number of effective shoots m^{-2} increased as the dose of zinc and sulphur. The maximum number of shoots m^{-2} (361.28) was noted with the application of 15 kg Zn ha^{-1} followed by at 10 kg and minimum with lower dose of 5 kg ha^{-1} and 0 kg Zn ha^{-1}. The number of effective shoots m^{-2} was recorded highest (365.87) with higher dose of 45kg S ha^{-1} being at par with 30 kg S ha^{-1} and it was significantly superior over dose of 15 kg S ha^{-1} and 0 kg S ha^{-1}.

Length of panicle

Length of panicle increased as the dose of zinc and sulphur increases. There was significantly response noted on higher length of panicle found with15 kg Zn ha^{-1} (25.72) being at par with 10 kg Zn ha^{-1} significantly superior over dose of 5 kg Zn ha^{-1} and 0 kg Zn ha^{-1}.

The length of panicle was recorded highest with higher dose 45 kg S ha^{-1} (i.e. 25.92) being at par with 30 kg ha^{-1} significantly superior over lower dose of 15 kg S ha^{-1} and 0 kg S ha^{-1} respectively.

Number of grains panicle^{-1}

Number of grains panicle^{-1} increased as the dose of zinc and sulphur increased. There was significance effect of number of grains panicle^{-1} recorded with different doses of zinc levels. As well as 15 kg Zn ha^{-1} being at par with 10 kg Zn ha^{-1} significantly superior over dose of 5 kg Zn ha^{-1} and 0 kg Zn ha^{-1}. The number of grains panicle^{-1} was recorded highest with higher dose of 45 kg S ha^{-1} being at par with 30 kg S ha^{-1} significantly superior over dose of 15 kg S ha^{-1} and 0 kg S ha^{-1} respectively.

Test weight

There was significantly response noted in test weight due to different levels of zinc more over was recorded highest with higher dose application of zinc 15 kg Zn ha^{-1} (23.11) followed by 10 kg Zn ha^{-1}. Lowest test weight was noted with 5 kg Zn ha^{-1} and 0 kg Zn ha^{-1}. There was significantly response noted in test weight due to different levels of sulphur more over was recorded highest with higher dose application of sulphur 45 kg S ha^{-1} (23.10) followed by 30 kg S ha^{-1}. Lowest test weight was noted with lower dose of 15 kg S ha^{-1} and 0 kg S ha^{-1}.

Grain yield (q ha^{-1})

The grain yield (q ha^{-1}) was recorded and presented in (Table 5). The grain yield was influenced significantly by zinc and sulphur levels. The yield increases gradually as the doses of zinc and sulphur levels were increased. Among zinc levels the higher grain yield (44.03 q ha^{-1}) was recorded due to 15 kg Zn ha^{-1} being at par with (42.0 q ha^{-1}) from 10 kg Zn ha^{-1} significantly superior over dose of 5 kg Zn ha^{-1} and 0 kg Zn ha^{-1}.

The maximum grain yield (43.19 q ha^{-1}) was recorded from higher dose 45 kg S ha being at par with 30 kg S ha (41.19) and significantly superior over dose of 15 kg S ha^{-1} and 0 kg S ha^{-1}.

Straw yield (q ha^{-1})

The data regarding straw yield (q ha^{-1}) has been given in (Table 5). The straw yield was increasing due to levels of zinc and sulphur gradually as the doses were increased. Under the response of zinc there was significant response on straw yield (57.82 q ha^{-1}) was noted due to different doses of zinc levels.15 kg Zn ha^{-1} responded the higher straw yield (55.10 q ha^{-1}) fallowed by 10 kg ha^{-1} and significantly superior over dose of 5 kg Zn ha^{-1} and 0 kg Zn ha^{-1}.

The straw yield (56.54 q ha^{-1}) was recorded highest with higher dose of 45kg S ha^{-1} being at par with 30 kg S ha^{-1} and significantly superior over doses of 15 kg and 0 kg S ha^{-1}.

Harvest index

The data regarding harvest index (%) has been given in (Table 5). It is clear from the data that various levels of zinc and sulphur did not influence the harvest index and non-significantly, taken at after harvesting of the crop.

Yield contributing characters like number of effective tillers number of panicle plant^{-1}, panicle length; number of grain panicle^{-1} and test weight was significantly increased with the increasing doses of zinc oxide. This has consequently increased the grain as well as the straw yield of rice crop.

If we look into the individual character in Table 4 & 5 we find that a dose of 15 kg zinc and 45 kg S ha^{-1} has increased the number of effective shoots by 6.15 and 8.58% and number of panicle $plant^{-1}$ by 0.52 and 0.65% respectively as against control. The length of panicle has increased by 0.65% and number of grains $panicle^{-1}$ was 8.76% against control. This might be because of the fact that Zn had also helped in uptake of nitrogen along with other nutrient elements better has consequently increased these values. A doses of 15 kg Zinc oxide ha^{-1} has increased grain yield by 7.19% by application of 45kg S ha^{-1} as against control and increased in straw yield was found 16.69%. This may be due to the fact that zinc is present in several dehydrogenate proteins and peptidase enzymes being a constituent responsible for growth hormones, has induced more starch formation promoted seed filling $maturation^{-1}$ and ultimately production. Considering yield attributing characters, it was found that the sulphur levels have significant response on number of effective shoot, number of panicle m^{-2}, length of panicle, number of grains $panicle^{-1}$ and test weight. Consequently the grain and straw yield q ha^{-1} has been increased with every increasing levels of sulphur, showing that is heavy feeder of sulphur.

Well-developed source and sink capacity of plant has ultimately resulted in higher yield with higher levels of sulphur. The results are in accordance with the results obtained by Sriramchandrasharan *et al.,* (2004); Bhuvaneswary *et al.,* (2007).

The maximum grain and straw yield were recorded from 45 kg S ha^{-1}. Increase in yield with zinc application might be due to more number of panicle, grain $panicle^{-1}$ and test weight. Higher yield under high nitrogen levels was due to adequate sulphur supply which contributes to increased dry matter production. Productivity of crop is collectively determined by the vegetative growth and yield attributes. Better vegetative growth coupled with higher yield attributes resulted in higher grain and straw yield of rice. Similar result was reported by Mrinal *et al.,* (2008), Chaudhary *et al.,* (1992).

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