Effect of Zn and S Interaction on Soil Properties and Yield of Rice (*Oryza sativa L*)

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Abstract- A field experiment was conducted during *Kharif* season of 2018 on research plot of Udai Pratap (Autonomous) College, Varanasi (U.P.) adjoining the Department of Agricultural Chemistry and Soil Science. The physicochemical properties of the experimental soil were ; pH (7.65), EC (0.26 dS m^{-1}); organic carbon (0.58%), available nitrogen (258.5 kg ha^{-1}), available phosphorus (12.6 kg ha^{-1}), available potassium (165 kg ha^{-1}),available sulphur (9.4 kg ha^{-1}) and available (DTPA extract) zinc (2.17 ppm). The experiment was carried out in randomized block design (RBD) with three replications and following six treatments: T_0 = Control (RDF) T_1= RDF + Zinc @ 20 kg ha^{-1},T_2= RDF + Sulphur @ 40 kg ha^{-1}, T_3= RDF + Zinc @ 20 kg ha^{-1} + Sulphur @ 60 kg ha^{-1} ,T_4= RDF + Zinc @ 25 kg ha^{-1} + Sulphur @ 40 kg ha^{-1} , T_5= RDF + Zinc @ 30 kg ha^{-1}+ Sulphur @ 30 kg ha^{-1}. Application of Zn and S significantly affected the growth parameters (plant height and tillers) of rice. Plant height and number of tillers significantly increased over without Zn and S. Maximum was registered with T_4 (Zn @ 25 kg ha^{-1} + S @ 40 kg ha^{-1}). Grain and straw yields were also significantly increased by the different treatments and highest yields were registered with T_4.The minimum concentration of Zn and S were registered with treatment T_0 and the maximum in T_4 (Zn @ 25 kg ha^{-1} + S @ 40 kg ha^{-1}).The application of Zn and S increased the availability of the nutrients (N, P, K, S and Zn) in the post harvest soil. It can be concluded from the present study that adequate Zn and S availability during entire cultivation period is important for good rice growth and yields.

Index Terms- S, Zn, Rice, Interaction

I. INTRODUCTION

Sulphur is an essential secondary plant nutrient play key roles in chlorophyll synthesis and oil formation. Sulphur is an important constituent of methionine, cysteine and cystine, amino acids and glutothion, biotine, thiamine linoleic acid, acetyl co-A structural constituent. Sulphur improves both yield and quality of crops. Deficiency of sulphur is increasing due to continuous use of S- free fertilizers and increasing cropping intensity with high yielding cultivars and is more conspicuous in coarse textured soils low in organic matter (Sipai *et al*., 2016).

Micronutrients are essential for increasing crop production and enhancing animal and human health. Zinc is one of essential plant micronutrients and its importance for crop productivity is similar to that of major nutrients. Intensive agriculture coupled with the continuous use of N, P_2O_5, and K_2O fertilizers have remarkably increased the production but simultaneously brought about problems related to micronutrient deficiencies, particularly that of Zn in soil. About one third of agricultural soils in the world are estimated to be low in available zinc (Zn), resulting in poor crop yields and nutritional quality of the harvested grains (Alloway 2008; Cakmak 2008).

Rice (*Oryza sativa* L.) is the most common and important food crop of India in terms of both area, production and consumer preference. Rice production in India crossed the mark of 112 million tonnes achieved in 2017-18 accounting for 21.19% of global production in the year. The productivity of rice has 3742 kg per hectare in 2017-18. India has largest area (43.20 million hectare) followed by China (30.35 m ha), Indonesia (12.16), Bangladesh (12.0 m ha) and Vietnam (7.66 m ha). In respect of production India rank second (FAO STAT 2017).The responses to the application of sulphur and zinc in rice crop have been supported by many findings. There is need to ascertain and promote the uses of fertilizers required to correct the deficiency of S and Zn. Keeping in the view of the importance of rice in the Indo Gangatic plain and role of sulphur and zinc nutrient in crop physiology and ultimately in the yield, this experiment was undertaken.

II. MATERIALS AND METHODS

A field experiment was conducted during *Kharif* season of 2018 on research plot of Udai Pratap (Autonomous) College, Varanasi (U.P.). The soils of Varanasi formed on alluvial, deposited by river Ganga have predominance of illite, quartz and feldspars. Illite minerals are partly inherited from micas which are predominant in the sand and silt fractions. The physicochemical properties of the experimental soil were ; pH (7.65), EC (0.26 dS m^{-1}); organic carbon (0.58%), available nitrogen (258.5 kg ha^{-1}),available phosphorus (12.6 kg ha^{-1}), available potassium (165 kg ha^{-1}), available sulphur (9.4 kg ha^{-1}) and available (DTPA extract) zinc (2.17 ppm). The experiment was carried out in randomized block design (RBD) with three replications and following six treatments: T_0 = Control (RDF) T_1= RDF + Zinc @ 20 kg ha^{-1},T_2= RDF + Sulphur @ 40 kg ha^{-1}, T_3= RDF + Zinc @ 20 kg ha^{-1} + Sulphur @ 60 kg ha^{-1} ,T_4= RDF + Zinc @ 25 kg ha^{-1} + Sulphur @ 40 kg ha^{-1} , T_5= RDF + Zinc @ 30 kg ha^{-1}+ Sulphur @ 30 kg ha^{-1}. Recommended doses of nitrogen, phosphorus and potassium @ 120, 60 and 60 kg ha^{-1} respectively applied. Half dose of nitrogen and full doses of phosphorus and potassium were applied as a basal dressing at the time of transplanting. Rest amount of N was applied in two equal splits, first at tillering and second at ear head initiation stage as top dressing. Zn and S were applied as per treatments requirement as basal dose before transplanting.

III. Soil and Plant Analysis

Soil samples were collected at 0-15cm depth after harvest of the crop and analyzed by standard method of analysis. Soil reaction (pH) was determined using soil : water suspension (1:2.5) with the help of glass electrode digital pH meter (Jackson, 1973), EC by TDS meter (Bower and Wilcox, 1965), OC by Walkley and Black's rapid titration method (Walkley and Black, 1934), available P_2O_5 (Olsen's *et al*., 1954), available K_2O by neutral normal ammonium acetate extraction method (Jackson 1973), available N by alkaline permanganate method (Subbiah and Asija, 1956) and available Zn by A.A.S. method using DTPA extract (Lindsay and Norvell,1978). Plant samples were also collected and dried at 70^0C for 12 hours. 0.5 gram ground plant sample was digested in sulphuric acid and perchloric acid with the ratio of 9:1 and digested samples were used to determine the nitrogen by micro kjeldahl's method, phosphorus by spectrophotometer and potassium by flamephotometer (Jackson,1973). Sulphur in plant samples was determined by the turbideimetric method (Chesnin and Yein, 1951).

IV. Results and Discussion

The growth parameters (plant height and number of tillers) presented in table 1 were significantly increased by different treatments. The minimum value was recorded in treatment T_0 and maximum with treatment T_4 (RDF + Zn @25kg ha^{-1} + Sulphur@40 kg ha^{-1}).

The increase in growth due to Zn application might be attributed due to its significant role in various enzymatic and physiological activity of the plant system. It is also essential for photosynthesis, nitrogen metabolism and cell division. Sulphur nutrition enhances cell multiplication, elongation and imparts a green colour to leaves. Significant effect on growth parameters by the use of S and Zn were also documented by Singh *et al*. (2012). Maximum increase in growth attributes was registered with T_4 where Zn was applied @ 25 kg ha^{-1} in combination of S @ 40 kg ha^{-1}.

V. Grain and Straw Yield

Application of sulphur with zinc significantly increased the dry matter production. Highest grain and straw yields were recorded with T_4 (Fig 1).The increase in dry matter yield may be due to great importance of Zn in growth and development as it involves in various enzyme system as prosthetic group and metallic constitution, in biosynthesis of photosynthetic pigment and auxin which in turn enabled the higher vegetative growth and produce more dry matter yield. On the otherhand S plays significant role in yield through its effect on enzymes necessary for biochemical functioning, increase in effective area for photosynthesis, resulting in relatively greater amount of dry matter accumulation in comparision to S deficient plants. In present study maximum yield (30.70 q ha^{-1}) was recorded with T_4. Rehman *et al*. (2008) also observed that combined application of S and Zn had synergistic effect in increasing dry matter yield.

VI. Nutrient Content and Uptake

All the treatments have significant effect in case of N, P and K content in grain and straw table 2 & 3. The minimum concentrations of N, P and K were recorded in treatment T_0 (RDF+ NPK) and maximum in T_4 (RDF + Zn @25kg ha^{-1} + Sulphur@40 kg ha^{-1}). Similar trend was also found in case of nutrients uptake by straw and grain.Nutrient contents and their respective uptake showed a significant variation by the application of S and Zn alone and in combination. The highest uptake were found when sulphur was applied @ 40 kg ha^{-1} with zinc @ 25 kg ha^{-1} (T_4). These results are in agreement with those of Layek and Shivkumar (2009). The increase in uptake apparently due to high contents and high dry matter yield in respective treatment. The results are in concurrent with the findings observed by Pable and Patil (2011).

VII. Conclusion

It can be concluded from the present study that adequate Zn and S availability during vegetation phase is important for good rice growth and yields. Rice favorably responded to soil applied Zn and S in different combination of doses. Application of Zn @ 25 kg ha^{-1} + S @ 40 kg ha^{-1} in combination of nitrogen, phosphorus and potassium was found to be the best treatment regarding growth and yield of rice and nutrient status of soil

Table 1. Plant height and Number of tillers as affected by different treatments
DAT= Days after transplanting

Treatment	Plant height (cm)						Number of tillers plant^{-1}			
	15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	15 DAT	30 DAT	45 DAT	60 DAT
T_0	36.88	48.48	55.37	61.65	64.24	69.16	2.06	4.0	4.33	4.41
T_1	48.20	60.24	69.98	72.58	81.68	87.38	2.58	4.08	4.50	4.75
T_2	49.90	62.13	73.05	73.29	82.46	88.83	2.66	5.33	5.75	5.91
T_3	52.39	68.25	76.90	79.76	87.19	94.35	3.33	5.66	6.08	6.33
T_4	54.60	70.99	79.81	82.72	89.48	95.58	3.41	5.75	8.08	6.35
T_5	50.67	66.74	75.86	76.52	85.67	92.30	2.91	5.58	6.0	6.24
SEm±	1.337	1.402	0.904	0.767	1.120	0.994	-	0 .068	0.316	0 .316
CD(P=0.05)	2.978	3.123	2.014	1.708	2.495	2.214	-	0.151	0.704	0.704

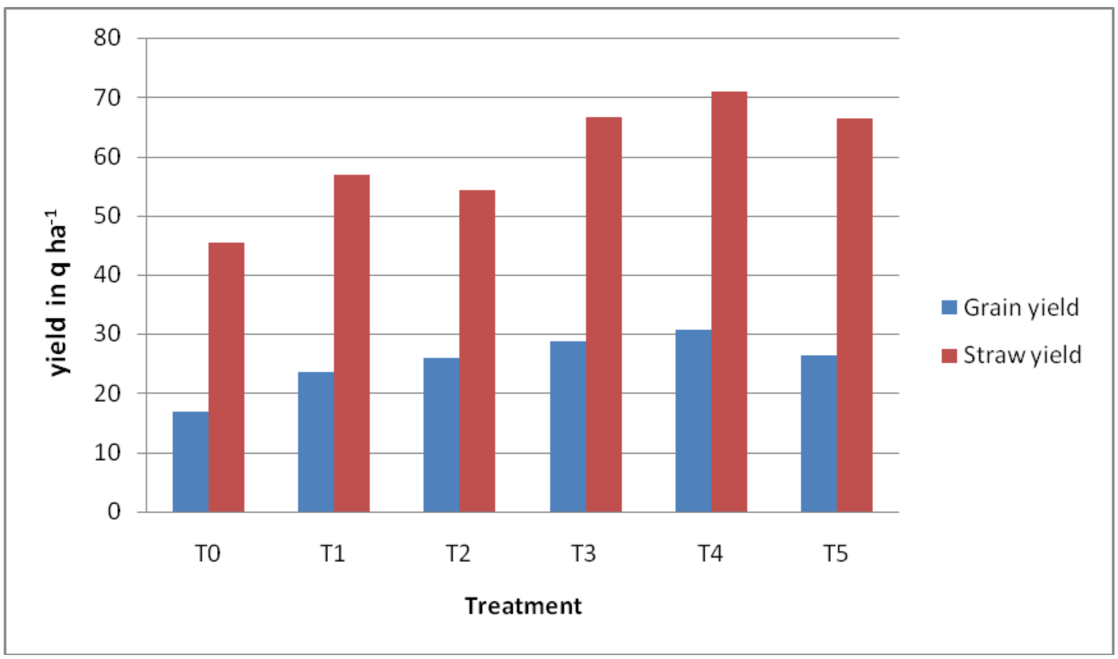

FIG 1. EFFECT OF TREATMENTS ON DRY MATTER (STRAW AND GRAIN) YIELD OF RICE

TABLE 2. EFFECT OF TREATMENTS ON N, P, K, S AND ZN CONTENT IN RICE

Treatment	**Nitrogen (%)**		**Phosphorus (%)**		**Potassium (%)**		**Sulphur (%)**		**Zinc (ppm)**	
	Straw	**Grain**	**Straw**	**Grain**	**Straw**	**Grain**	**Straw**	**Grain**	**Straw**	**Grain**
T_0	0.18	1.55	0.12	0.35	0.40	0.06	0.07	0.11	22	14.2
T_1	0.30	1.60	0.15	0.48	0.66	0.13	0.09	0.16	27	15.8
T_2	0.32	1.66	0.18	0.50	0.72	0.16	0.12	0.17	28	16.4
T_3	0.48	1.83	0.23	0.57	0.85	0.23	0.18	0.22	31	18.0
T_4	0.50	1.92	0.26	0.65	0.92	0.27	0.19	0.23	33	19.5
T_5	0.45	1.75	0.21	0.53	0.78	0.21	0.16	0.20	30	17.5
SEm±	0.012	0.075	0.012	0.014	0.021	0.020	0.004	0.006	1.581	0.054
CD (P=0.05)	0.026	0.167	0.02	0.031	0.046	0.044	0.008	0.013	3.522	0.120

TABLE 3. EFFECT OF TREATMENTS ON N, P AND K UPTAKE BY RICE

TREATMENT	NITROGEN ($KG\ HA^{-1}$)			PHOSPHORUS ($KG\ HA^{-1}$)			POTASSIUM ($KG\ HA^{-1}$)		
	STRAW	GRAIN	TOTAL	STRAW	GRAIN	TOTAL	STRAW	GRAIN	TOTAL
T_0	8.17	26.0	34.17	5.44	5.87	11.31	18.16	1.0	19.16
T_1	17.02	37.68	54.7	8.51	11.30	19.81	37.46	3.06	40.52
T_2	17.36	43.24	60.6	9.77	13.02	22.79	39.08	4.16	43.24
T_3	31.97	52.52	84.49	15.32	16.35	31.67	56.62	6.60	63.22
T_4	35.47	58.94	94.41	18.44	19.95	38.39	65.26	8.28	73.54
T_5	29.85	46.34	76.19	13.93	14.03	27.96	51.75	5.56	57.31
SEm±	0.298	0.547	0.730	0.349	0.483	0.235	1.425	0.444	0.960
CD (P=0.05)	0.663	1.218	1.626	0.777	1.076	0.523	3.174	0.989	2.138

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