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EFFECT OF FARMYARD MANURE, ZINC AND SULPHUR ON YIELD AND QUALITY OF RICE (*Oryza sativa* L.) IN HILLY REGIONS OF MEGHALAYA

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ABSTRACT: Integrated nutrient management (INM) maintains soil fertility and plant nutrient supply to an optimum level for sustaining the desired crop productivity. INM practice not only maintains soil fertility but also improve physical, chemical and biological properties of the soil. Nutrient build up is also reported due to integrated nutrient management. Very little information is available regarding changes in the status of different nutrients in soil as well its season. The present investigation was, therefore conducted to monitor the effect of FYM, Zn and S in soil as well as its uptake by the growing rice crop due to adoption of integrated nutrient management through recommended doses of N, P and K fertilizers along with FYM addition as well as S and Zn as a treatment combinations. Results of the present investigation revealed that irrespective of treatment combinations highest amount of Zn and S-uptake as well as crude protein, starch and sugar content in rice is recorded in soil treated combinedly with recommended doses of N, P, K fertilizers alongwith FYM and higher doses of S at 40kg ha^{-1} and Zn at 5kg ha^{-1} treated plots over that of control. Dry matter yield and uptake by rice straw decreased with increase in the growth of rice. Results show in general more amount of Zn and S are taken up by grain than that of straw of rice crop.

Key words: Rice, Sulphur, Zinc, Straw, Grain, Crude protein content, Starch content, Sugar content.

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INTRODUCTION

Rice is the main crop and accounts for about 60% of the cultivable area of the state but productivity is still below 2.0 metric tons per hectare as against the all India average of 2.85 metric tons per hectare .Meghalaya produces only 2.5 lakh tones of food grains annually of which paddy accounts for a major share of the total food grain production. Against this total production, there is always a shortfall to the total requirement of food grains, especially rice which is estimated to be more than 2.7 lakh M.T annually and the figure is steadily increasing year after year. [1]. Rice is the main staple food and cultivation is usually done by submerging the soil followed by puddling. Under such conditions some of the plant nutrients are becoming deficient especially Zn and S. To overcome such problem integrated and balanced use of these limiting nutrients through fertilizer materials are required to be applied to the soil along with appropriate amount of organic manures.

Sulfur, one of the essential mineral nutrients all plants need to grow, has key roles in protein production, chlorophyll formation and oil synthesis. The major reason for low grain out put in the country, apart from natural constraints, is failure to supply enough plant nutrients in balanced proportion including sulfur and zinc. Combined application of sulfur and zinc significantly increased grain yield of rice [2]. Prasad *et al.,* [3] reported that long term application of zinc and crop residues increased the organic matter content of the soil. The combined application of zinc and crop residues significantly increased crop yield, uptake and availability of micronutrients in soil over chemical fertilizer alone.

MATERIALS AND METHODS

Field experiments were conducted in succession consecutively for two years (2013-14 and 2014-15) in a farmer's field situated at Nongpoh in Ri-Bhoi district of Meghalaya. The field was generally cultivated for rice crop .The area experiences different types of climate ranging from tropical to temperate climate. The maximum rainfall is in the month of June and July. The district lies between 25.9052^0N latitude and 91.7747^0E longitude. The total area of the district is 2448 sq. Km.Initial Composite soil sample (0-15cm depth) was collected from the experimental field before the start of experiment. The collected soil samples was air-dried, graced and passed through 0.5mm sieve. The soil sample was analyzed for different physical and chemical properties and are presented in Table-1. The field experiments were conducted following simple Randomized Block Design. The plot size was 4m x 2m. Altogether 33 plots were included in the field experimentation. The following 11 treatments were adopted to study the effect of INM practice. All the treatments were replicated thrice. Rice variety Arize-6444 was selected for the experimention purpose. Row-to-row spacing was maintained at 25cm x 25cm. Both organic and inorganic fertilizers such as Farm Yard Manure (10t ha^{-1}) and 80:60:40kg ha^{-1} Nitrogen (N) in the form of Urea, Phosphorus (P) in the form of Single Super Phosphate and Potash (K) as Muriate of Potash were applied as per treatment combinations. Two doses of sulphur i.e 20kg ha^{-1} and 40kg ha^{-1} as Elemental sulphur and two doses of Zinc *i.e* 5kg ha^{-1} and 10kg ha^{-1} as Zinc-EDTA were also included as per treatment combinations.

Sample preparation: Freshly harvested paddy grain samples 50g each of different treatments were collected and dried in the sun before drying in an air oven at 30^0C until a constant weight was obtained. Each sample was dehusked by gently beating with a wooden bag and then ground to a fine powder. The powdered dried samples were then stored in plastic lock bag for analysis.

Analysis of Total Sugar and Starch content: The total Sugar and Starch contents were determined using universal anthrone method. The free sugars were extracted from a one gram dried powdered sample with three extractions 10ml each with hot 80% ethanol/water at 80^0C for 30mins. The combined ethanol extract obtained after centrifugation for 15mins was evaporated in water bath at 80^0C until most of the alcohol dried up and made upto a total volume of 25ml with distilled water. This extract was used for sugar analysis. The residue left in the centrifuge tube was dried after sugar extraction in an oven at 80^0C for starch extraction. To this residue, 5ml of dil H_2O was added and the tube was put in a boiling water bath for 15 mins with occasional stirring. Then, after cooling 6.5ml of 52% $HClO_4$ was added to it. The tube was left as such for 15mins with occasional stirring followed by centrifugation for 15mins. The supernatant was collected in 50ml volumetric flask. The residue was extracted with 52% $HClO_4$ using the same procedure. The combined supernatant was made to 50 ml with dil H_2O. 5ml of this solution was diluted with dil H_2O and starch was analysed from this extract. The amount of sugar and starch was estimated from the standard curve, which was prepared using a series of standard glucose solution.

Analysis of crude protein: the crude protein content was based on the organic N content, which was determined by the Kjeldalh procedure. To the dried sample (0.1g) taken in a Kjeldahl flask was added 5g of digestion mixture (NaSO4 + CuSO4 10:1), 50ml H_2O and 35ml conc H_2SO_4. The mixture was heated at 450^0C for 30mins until a clear solution was produced. The flask was then cooled, then 350ml H_2O and 100ml 40% NaOH was added to the flask. Thereafter the flask was placed in the distillation apparatus with few glass beads. The ammonium from the sample was steam distilled for 10mins into a receiver flask, which contained 25ml of a 4% solution of boric acid. The ammonia in the receiving flask produced by the breakdown of organic N containing compounds in the sample was titrated with standard 0.1 N H_2SO_4 which was prestandardized by 0.1N NaOH, until solution was changed from green to pink at the end point. The organic N content of the sample was calculated using the formula

Total percent N = (T-B)/W x 1.4 x N

T- burette reading with the sample
B- blank reading
N- normality of H_2SO_4
W- weight of the sample taken
The crude protein content was calculated by the equation: **Crude protein content (%) = %N x 6.25**

Table 1. Physico-chemical properties of soil

Parameters	Unit	
Soil order		Ultisol
pH	Soil: water=1:2.5	5.19
pH	$CaCl_2$=1:2.5	4.76
Electrical conductivity	dSm-1 at 25^0C	0.1
Oxidizable organic carbon	%	0.93
Cation Exchange Capacity	(C mol p+kg^{-1})	10.7
Mechanical analysis		
Sand	%	28.56
Silt	%	22
Clay	%	49.44
Textural class		Clay loam
Water Holding Capacity	%	44.06
Available N	(Kg ha^{-1})	198.7
Available P_2O_5	(Kg ha^{-1})	25.66
Available K_20	(Kg ha^{-1})	305.8
Available SO_4^{2-}	(Kg ha^{-1})	60.5
Available Zn	(Kg ha^{-1})	2.34
Exchangeable (Ca+Mg)	(Kg ha^{-1})	3190

RESULTS AND DISCUSSION

In general, dry matter production is highest in grain and that's why higher amount of S uptake by rice plant is recorded in all the treatment combinations under study. Combined application of S and N fertilizers increases the net photosynthetic rate in crop plants, which in turn increases their dry matter and yield (Table 2), as 90% of the plants dry weight is considered to be derived from products formed during photosynthesis [4]. The production of highest amount biomass in T_8 treatment leads to uptake significantly highest amount of S in the same treatment as well. Result of S-uptake is related to the dry matter production of rice. Critical examination of the data in Table 2 revealed that significantly highest amount of S-uptake by both straw and grain is recorded in T_8 treatment which received recommended doses of N, P and K along with FYM at 10t ha^{-1} as well as S at 40kg ha^{-1} and Zn at 5kg ha^{-1}. N and S both are involved in plant protein synthesis, or process that may determine yield of crops. As a result, requirement of N by plants when N is fertilised with S, as their metabolism is coupled in the synthesis of S containing amino acids, membrane lipids, enzymes and co-enzymes [5]. Consequently, poor use efficiency of N by the plant is caused by insufficient S availability to convert N into biomass production, which in turn may increase N losses from cultivated soils [6].

Similar trend of results with respect to Zn content, dry matter yield and Zn-uptake by rice is observed as were observed for (Table 2 and 3). Application of either dose of Zn increased dry matter yield and in turn Zn-uptake by rice plant. Addition of Zn as treatment material increased Zn content as well as Zn-uptake by rice. The result is at par with earlier works of Mustafa *et al.,* [7]; Dixit *et al.,* [8]; El- Hadidi *et al.,* [9]. Zn requirement of flooded rice is higher because the availability of other nutrients in submerged conditions increases which decreases Zn availability to crop. Plants take up Zn in the form of Zn^{2+} ions. Diffusion is believed to be the dominant mechanism for Zn^{2+} transport to plant roots [10]. Rice is one of the highly sensitive crops to Zn deficiency and Zn is the most important micronutrients limiting rice growth and yield. Application of Zn significantly affected total number of tillers. Number of panicle bearing tillers per m^2 contributes towards the production potential of rice crop. Increase in productive tillers per m^2 might be ascribed to adequate supply of Zn that increased the uptake and availability of essential nutrients, resulting in improvement of plant metabolic process and finally increased crop growth [11]. Irrespective of treatments, sulphur content in grain is comparatively higher over that of straw at any phenological stages. This trend of result is observed due to higher requirement of available sulphur at flowering phase of crop growth. The results of the present investigation are at par with earlier works of Blair and Lefroy [12]. Furthermore, comparatively higher order of sulphur content is recorded in straw and grain of rice which received either doses of sulphur. Addition of sulphur encourages rice plant to consume more amount of sulphur from the sulphur treated system showing comparatively higher amount of sulphur in both straw and grain. The present result is supported with earlier findings of Ofori *et al.,* [13].

Table 2. Effect of FYM, Zn and S on the yield of rice

Treatments	2013-14			2014-15		
	Straw	Grain	Total biological yield	Straw	Grain	Total biological yield
T_0	2923.20	2276.40	5199.6	3462.92	2824.40	6287.32
T_1	3398.00	2645.20	6043.2	4048.38	3304.40	7352.78
T_2	3539.60	2756.40	6296	4095.59	3321.20	7416.79
T_3	4032.80	3197.60	7230.4	4468.65	3642.40	8111.05
T_4	4719.60	3811.20	8530.8	5049.57	4151.20	9200.77
T_5	5607.20	4533.20	10140.4	5474.27	4410.80	9885.07
T_6	5970.80	4881.60	10852.4	5801.89	4723.60	10525.49
T_7	6806.40	5708.40	12514.8	6149.43	5062.40	11211.83
T_8	7596.00	6274.00	13870	6671.12	5364.00	12035.12
T_9	6645.60	5607.60	12253.2	5878.30	4850.80	10729.1
T_{10}	6081.60	5101.20	11182.8	5727.04	4756.80	10483.84
CD(P=0.05)	**79.97**	**69.20**	**149.17**	**108.01**	**26.58**	**134.59**
SEm(+)	**26.92**	**23.29**	**50.21**	**36.36**	**8.95**	**45.31**
CV	**1.25**	**1.46**	**2.71**	**1.69**	**0.56**	**2.25**

To=Control; T_1=Recommended doses of NPK at 80:60:40Kg ha^{-1} as Urea, SSP and MOP; $T_2=T_1$+FYM at 10 t ha^{-1}; $T_3=T_2+Zn_1$ at 5Kg ha^{-1} as Zinc-EDTA, $T_4=T_2+Zn_2$ at 10Kg ha^{-1}; $T_5=T_2+S_1$ at 20Kg ha^{-1} as Elemental Sulphur; $T_6=T_2+S_2$ at 40Kg ha^{-1}; $T_7=T_2+Zn_1+S_1$; $T_8=T_2+Zn_1+S_2$; $T_9=T_2+Zn_2+S_1$; $T_{10}=T_2+Zn_2+S_2$

Table 3. Effect of FYM, Zn and S on uptake of Zn and S by rice crop

Treatments	Zn-uptake						S-uptake					
	2013-14			2014-15			2013-14			2014-15		
	Straw	Grain	Total	Straw	Grain	Total	Straw	Grain	Total	Straw	Grain	Total
T_0	0.49	0.68	1.17	1.04	0.85	1.89	2.34	4.00	6.34	3.46	5.01	8.47
T_1	0.68	0.79	1.47	1.21	1.21	2.42	3.96	5.94	9.90	5.42	7.57	12.99
T_2	0.71	0.83	1.54	1.23	1.33	2.56	5.43	7.08	12.51	6.66	8.66	15.32
T_3	1.08	1.49	2.57	1.49	1.70	3.19	6.72	9.42	16.14	8.23	10.88	19.11
T_4	1.26	2.16	3.42	2.02	2.36	4.38	9.44	12.47	21.91	11.38	13.81	25.19
T_5	1.31	1.51	2.82	2.01	1.76	3.77	14.39	18.36	32.75	15.55	18.06	33.61
T_6	1.39	1.63	3.02	2.32	2.05	4.37	18.71	21.03	39.74	20.31	20.73	41.04
T_7	2.27	3.04	5.31	2.87	3.21	6.08	24.28	27.59	51.87	24.74	24.97	49.71
T_8	3.29	4.18	7.47	3.78	3.57	7.35	27.85	33.48	61.33	27.80	36.43	64.23
T_9	1.77	2.62	4.39	2.55	3.07	5.62	16.17	21.14	37.31	18.82	18.69	37.51
T_{10}	2.03	2.89	4.92	3.05	3.33	6.38	13.38	17.70	31.08	16.47	16.84	33.31
CD(P=0.05)	**0.31**	**0.18**	**0.45**	**0.31**	0.32	**0.29**	**1.12**	**1.40**	**1.75**	**2.50**	**2.33**	**2.82**
SEm(+)	**0.10**	**0.06**	**0.15**	**0.10**	**0.10**	**0.10**	**0.37**	**0.47**	**0.59**	**0.84**	**0.78**	**0.94**
CV	**17.29**	**8.50**	**11.51**	**11.57**	**12.67**	**5.71**	**7.20**	**7.94**	**5.29**	**13.80**	**12.33**	**7.61**

To=Control; T_1=Recommended doses of NPK at 80:60:40Kg ha^{-1} as Urea, SSP and MOP; $T_2=T_1$+FYM at 10 t ha^{-1}; $T_3=T_2+Zn_1$ at 5Kg ha^{-1} as Zinc-EDTA, $T_4=T_2+Zn_2$ at 10Kg ha^{-1}; $T_5=T_2+S_1$ at 20Kg ha^{-1} as Elemental Sulphur; $T_6=T_2+S_2$ at 40Kg ha^{-1}; $T_7=T_2+Zn_1+S_1$; $T_8=T_2+Zn_1+S_2$; $T_9=T_2+Zn_2+S_1$; $T_{10}=T_2+Zn_2+S_2$

Closer examination of the data revealed that significantly highest S-content is recorded in T_8 treatment like those of N, P and K which received recommended doses of N, P and K along with FYM at 10t ha^{-1} as well as S at 40kg ha^{-1} and Zn at 5kg ha^{-1}. Addition of higher dose of sulphur registered higher amount of S in both rice straw and grain particularly where the dose of applied zinc is lowest (5kg ha^{-1}) along with sulphur. Presence of higher amount of zinc along with sulphur restricts translocation of S within the plant system. [14,15]. Singh *et al.,* [16] also reported earlier the failure of higher amount of uptake, of S due to combined application of higher doses of S and Zn.). Combined application of S and Zn further accentuates Zn-uptake by rice crops (Table-3). However, highest Zn-uptake is recorded in T_8 treatment which received recommended doses of N, P and K along with FYM at 10t ha^{-1} as well as S at 40kg ha^{-1} and Zn at 5kg ha^{-1}. Combined application of higher amount of both S and Zn fails to produce highest yield and in turn Zn uptake by rice crops. Therefore, it may be said that application of 5 kg Zn in presence of 40kg S ha^{-1} is sufficient to produce highest yield as well as highest Zn-uptake by rice plants under Meghalaya situation.

Irrespective of treatments, crude protein content in grain increased in the 2nd over that of 1st year. N uptake by grains in the 2nd year is more than that of the 1st year and because of higher N content in grains, the protein content is also of higher order in the 2nd year of rice. N is the constituent of amino acids which in turn dictate the synthesis of protein in grains [5] Results in Table 4 further showed that highest amount of crude protein is accumulated in T_8 followed by T_7 treatment. The pooled data of two years also showed similar trend of results. Highest amount of N is taken up by grains of rice grown in T_8 followed by T_7 treatment. The results of crude protein in grains thus followed the similar trend of results of N content present in grains. The result correspond the earlier findings of Dixit *et al.*, [8].

Practically very little variation is observed in starch content of grains of rice grown consecutively for two years. Furthermore, although starch content is significantly higher in treated plots over that of control but practically no significant variation is observed in starch content of grains of rice which received combined application of either doses of S and Zn along with recommended doses of N, P and K as well as FYM at 10t ha^{-1}. The pooled data of two years also showed similar trend of results of starch content in rice grain (Table 4). Similar observation is also reported earlier by Singh *et al.,* [14]. Irrespective of treatments, sugar content in grains slightly increased in the 2nd year over that of 1st year of experiment. Data in Table 4 revealed that combined application of either doses of S and Zn significantly increased sugar content in rice grains over that of control. However, no significant variation in sugar content is observed in grains of rice which received combined application of either doses of S and Zn alongwith recommended doses of N, P and K as well as FYM at 10t ha^{-1}.The result thus clearly pointed out that quality parameters of rice grains particularly starch and sugar are influenced by combined application of S and Zn but not by their doses. The present result is in accordance with earlier works carried out by Singh *et al.,* [14] and Das *et al.,* [17].

Table 4. Effect of FYM, Zn and S on the crude protein content, starch content and sugar content on rice grain

Treatments	Crude protein (%)		Starch (%)		Sugar (%)	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
T_0	5.94	6.69	72.89	72.10	0.70	0.75
T_1	6.42	7.25	73.50	73.05	0.71	0.76
T_2	7.23	8.08	74.11	74.12	0.73	0.77
T_3	7.69	8.40	74.41	75.35	0.76	0.83
T_4	8.00	8.80	75.06	76.58	0.77	0.86
T_5	8.33	9.35	76.00	76.43	0.81	0.88
T_6	8.63	9.66	76.12	77.43	0.86	0.95
T_7	9.02	9.69	77.18	78.02	0.90	1.02
T_8	9.33	10.16	78.00	79.03	0.95	1.07
T_9	8.79	9.27	77.01	78.34	0.90	1.04
T_{10}	8.54	8.93	77.00	77.16	0.91	1.04
CD(P=0.05)	**0.79**	**1.12**	**0.59**	**0.22**	**0.02**	**0.04**
SEm(±)	**0.26**	**0.37**	**0.20**	**0.07**	**0.01**	**0.01**
CV	**5.81**	**7.46**	**0.45**	**0.17**	**1.52**	**2.57**

To=Control; T_1=Recommended doses of NPK at 80:60:40Kg ha-1 as Urea, SSP and MOP; $T_2=T_1$+FYM at 10 t ha^{-1}; $T_3=T_2+Zn_1$ at 5Kg ha^{-1} as Zinc-EDTA, $T_4=T_2+Zn_2$ at 10Kg ha^{-1}; $T_5=T_2+S_1$ at 20Kg ha^{-1} as Elemental Sulphur; $T_6=T_2+S_2$ at 40Kg ha^{-1}; $T_7=T_2+Zn_1+S_1$; $T_8=T_2+Zn_1+S_2$; $T_9=T_2+Zn_2+S_1$; $T_{10}=T_2+Zn_2+S_2$

CONCLUSION

Two consecutive years (2013-14 and 2014-15) field experiment was conducted on rice crop (oryza sativa) in hilly regions of Meghalaya revealed that addition of farmyard manure as well as zinc and sulphur have significance influence on the yield, uptake and quality of rice grain. Results revealed that highest S and Zn contents in straw and grain as well as dry matter yields were recorded in treated plots which received recommended doses of N, P and K along with FYM at 10 t ha^{-1} as well as 40 kg S ha-1 and 5 kg Zn ha^{-1}. Irrespective of treatments in general comparatively higher amount of crude protein, starch and sugar content in rice grains are recorded in the 2nd over that of 1st year of experimentation. Again, pooled data of two years revealed highest protein, starch and sugar content are recorded in T_8 treatment.

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