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Effect of Various Levels of Fertility, Sulfur and Zinc on Yield, Quality and Chemical Composition of Rice

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Abstract

A field experiment was conducted to assess the influence of various fertility levels, sulfur and zinc on yield, quality and chemical composition of rice cv Swarma (MTU-7029)during the *kharif* seasons of 2000 and 2001. The experiment was laid out in split-plot design with three replication keeping three fertility levels (80-40-40 ; 120-60-60 and 160-80-80 kg N-P_2O_5-K_2O/ha) in the main plot, three sulfur levels (control, 25 and 50 kg S/ha) in the sub-plot and three zinc levels (control, 0.75 and 1.50 kg Zn EDTA/ha foliar spray) in the ultimate plot. The results revealed that grain yield of rice increased significantly with increasing levels of fertility, sulfur and zinc upto 120-60-60 kg N-P_2O_5-K_2O/ha, 25 kg S/ha and foliar spray of 0.75 kg Zn EDTA/ha, respectively while, straw yield and quality parameters of rice i.e. hulling percentage, milling percentage, head rice recovery, protein content in grain and grain protein yields improved significantly upto 160-80-80 kg N-P_2O_5-K_2O/ha, 50 kg S/ha and 1.5 kg Zn EDTA/ha foliar spray. The chemical composition of rice was also improved significantly by increasing the content of nitrogen, phosphorus, potassium, sulfur and zinc in grain and straw with increasing levels of fertility, sulfur and zinc application upto the highest levels of fertility (160-80-80 kg N-P_2O_5-K_2O/ha), sulfur (50 kg S/ha) and zinc (1.5 kg Zn EDTA/ha).
Key words : Rice, Fertility levels, Sulfur, Zinc, Yield.

Rice is the staple food crop of the world and supplies major portion of the world's dietary energy. Balanced nutrient supply not only increases the crop productivity to feed the burgeoning population and maintain soil health but also improved the quality of the produce. The rice yield from paddy is determined by the husk content of the variety, the degree of milling and grain breakage. The husk content of variety is genetically controlled and the degree of milling depends on customers preference but the extent of breakage is unpredictable. Eventhough, the crack development, varietal characteristics and milling machinery are some of the important factors which affect milling breakage, the causes of breakage are still well understood (1). Other factors influencing head rice recovery include shape, size, appearance of grains and environmental factors (2). Among environmental factors the mineral nutrients are considered as the key input determining the quality and chemical composition of crop as they are involved in various physiological and metabolic process of the plant. Thus adequate supply of plant nutrients is highly essential for quantitative and qualitative production of rice. Keeping in view, the significance of mineral nutrients in quality rice production, the present study was conducted to assess the performance of rice at different levels of fertility, sulfur and zinc in terms of yield, quality and chemical composition.

Methods

A field experiment were conducted with rice variety Swarna (MTU 7029) for two consecutive *kharif* seasons of 2000 and 2001 at the Agricultural Research Farm of Institute of Agricultural Sciences, Banaras Hindu University, Varanasi to find out the effect of fertility levels with sulfur and zinc application on yield, quality and chemical composition of rice. The soil of the experimental field was Gangetic alluvial (Ustochrept) with pH 7.3. It was moderately fertile-being low in organic carbon (0.42%), available nitrogen (210.0 kg/ha), sulfur (18.10 kg/ha) and zinc (0.45 kg/ha) and medium in available P_2O_5 (27.6 kg/ha) and K_2O (235.0 kg/ha). The experiment was laid out in split plot design with three replication keeping three fertility levels (80-40-40 ; 120-60-60 and 160-80-80 kg N-P_2O_5-K_2O/ha) in the main plot, three sulfur levels (control, 25 and 50 kg S/ha) in the sub plot and three zinc

Table 1. Effect of fertility, sulfur and zinc levels on grain yield, straw yield, relative efficiency and harvest index of rice.

Treatments	Grain yield (kg/ha)		Relative efficiency		Straw yield (kg/ha)		Harvest index	
	2000	2001	2000	2001	2000	2001	2000	2001
Fertility Levels N-P_2O_5-K_2O (kg/ha)								
80-40-40	4343	4728	100	100	6609	7007	39.82	40.41
120-60-60	5146	5583	118.5	118.1	8352	8633	38.27	39.31
160-80-80	5425	5889	124.9	124.5	9360	9629	36.69	38.01
SE ±	121	121			219	247	0.75	0.40
CD (P = 0.05)	475	477			859	970	2.94	1.56
Sulfur Levels (kg/ha)								
0	4634	5074	100	100	7342	7792	39.01	39.65
25	5054	5472	109.0	107.8	8221	8545	38.25	39.26
50	5226	5654	112.8	111.4	8759	8932	37.52	38.82
SE ±	72	61			186	223	0.53	0.49
CD (P = 0.05)	223	188			574	688	NS	NS
Zinc EDTA Foliar Spray (kg/ha)								
0	4784	5228	100	100	7564	8036	39.04	39.54
0.75	5023	5469	105.0	104.6	8253	8514	38.10	39.29
1.5	5106	5503	106.7	105.3	8504	8718	37.64	38.90
SE ±	59	65			100	114	0.33	0.29
CD (P = 0.05)	170	188			287	328	0.96	NS

levels (control, 0.75 and 1.50 kg Zn EDTA/ha foliar spray) in the ultimate plot. Nutrients were applied as per treatment. For nitrogen (DAP, ammonium sulfate and urea were used) and was applied in three equal splits (½ as basal + ¼ at tillering + ¼ at panicle initiation stage). A basal dose of full P_2O_5 in the form of diammonium phosphate, K_2O through muriate of potash, S (50% each through ammonium sulphate and elemental sulfur) as per treatment, was applied as basal application. Foliar spray of 0.02% concentration of Zn-EDTA (as per treatments) was done at 20, 35 and 50 days after transplanting. Twenty-eight days old seedlings of rice cv Swarna were used for transplanting and three seedlings/hill were transplanted by maintaining a spacing of 20 cm between row-to-row and 15 cm between plant-to-plant. Appropriate management practices such as irrigation, weed control and plant protection measures were adopted. The crop was harvested at physiological maturity and the grain and straw yields were recorded from the net plot of each treatment to compute the yield per hectare. Grain and straw samples were collected from each treatment and taken to laboratory for quality analysis. The samples were dried in oven at 65 C for 24 hours and ground in a Wiley Mill, and passed through 0.2 mm sieved. These samples were analysed for nitrogen by Micro Kjeldahl, phosphorus by colorimetric method, potassium by Flame-photometric method (3), sulfur by turbidimetric method (4) and zinc by atomic absorption spectrophotometry method (5). The percentage of protein in grain was estimated by multiplying nitrogen content by a factor of 6.25 (6).

Hulling percentage (proportion of kernel to husk) was calculated as :

$$\text{Hulling (\%)} = \frac{\text{Brown rice obtained after dehusking (g)}}{\text{Total rice grain taken for dehusking (g)}} \times 100$$

Milling percentage, which depends on the removal of polished layer from dehusked rice, was calculated as:

Table 2. Effect of fertility, sulfur and zinc levels on quality parameters of rice.

Treatments	Hulling (%)		Milling (%)		Head rice recovery (%)		Protein content in grain (%)		Grain protein yield (kg/ha)	
	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001
Fertility Levels N-P_2O_5-K_2O (kg/ha)										
80-40-40	72.88	72.06	61.69	60.72	60.02	59.40	7.17	6.88	311.20	325.41
120-60-60	74.42	73.74	63.27	62.12	61.20	60.69	7.76	7.46	399.71	416.67
160-80-80	75.90	75.14	64.85	63.45	62.35	61.92	8.43	8.09	458.31	477.13
SE ±	0.26	0.27	0.27	0.27	0.20	0.31	0.07	0.06	9.97	8.58
CD (P = 0.05)	1.02	1.05	1.07	1.04	0.77	1.21	0.29	0.23	39.15	33.68
Sulfur Levels (kg/ha)										
0	73.53	72.79	62.35	61.30	60.58	59.83	7.59	7.31	352.89	372.71
25	74.40	73.70	63.28	62.09	61.20	60.70	7.75	7.46	394.14	410.33
50	75.27	74.44	64.18	62.90	61.79	61.48	8.01	7.67	422.18	436.16
SE ±	0.23	0.23	0.23	0.24	0.18	0.23	0.03	0.03	6.43	3.86
CD (P = 0.05)	0.71	0.71	0.70	0.74	0.56	0.71	0.11	0.11	19.81	11.90
Zinc EDTA Foliar Spray (kg/ha)										
0	73.91	73.18	62.78	61.61	60.79	60.18	7.68	7.38	370.22	388.81
0.75	74.40	73.67	63.29	62.12	61.21	60.68	7.78	7.47	392.33	410.98
1.5	74.88	74.09	63.74	62.56	61.58	61.14	7.89	7.59	406.67	419.42
SE ±	0.14	0.13	0.14	0.13	0.11	0.13	0.03	0.02	5.19	4.42
CD (P = 0.05)	0.39	0.37	0.39	0.38	0.31	0.37	0.08	0.06	14.92	12.70

$$\text{Milling (\%)} = \frac{\text{White polished kernels obtaind (g)}}{\text{Brown rice taken for polishing (g)}} \times 100$$

Head rice recovery percentage was calculated by separating whole white kernels from the total white polished rice obtained after milling.

$$\text{Head rice recovery (\%)} = \frac{\text{Whole white kernels obtained (g)}}{\text{White polished kernels obtained after milling (g)}} \times 100$$

Results and Discussion

Grain and Straw Yield

Highly significant differences in grain and straw yield were observed due to different treatments and maximum grain and straw yield was associated with the highest fertility level (160-80-80 kg N-P_2O_5-K_2O/ha) (Table 1). However, significant improvement in grain and straw yield was obtained upto 120-60-60 N-P_2O_5-K_2O/ha and 160-80-80 kg N-P_2O_5-K_2O/ha, respectively. The harvest index was significantly higher under low nutrients level (80-40-40 kg N-P_2O_5-K_2O/ha) than under high level of nutrient fertilisation (120-60-60 and 160-80-80 kg N-P_2O_5-K_2O/ha). Marked improvement in grain and straw yield was also obtained with increasing sulfur levels and application of 25 kg S/ha and 50 kg S/ha produced significantly higher grain and straw yield, respectively. The harvest index of crop decline with increase in sulfur levels however, the variation between the harvest index due to sulfur levels was not found significant. Zinc application also significantly influenced the grain and straw yield and foliar application of 0.75 kg Zn EDTA/ha was found to be the most effective in augmenting the grain and straw yield. Further increase in zinc rates did not cause significant variation in grain and straw yield during both the years of study. Increasing Zn level resulted in reduction of harvest index culminating to signifi-

Table 3. Effect of fertility, sulfur and zinc levels on nitrogen, phosphorus and potassium content of rice grain and straw.

	Nitrogen content (%)				Phosphorus content (%)				Potassium content (%)			
	Grain		Straw		Grain		Straw		Grain		Straw	
Treatments	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001
Fertility Levels N-P_2O_5-K_2O (kg/ha)												
80-40-40	1.147	1.100	0.502	0.485	0.185	0.179	0.067	0.064	0.269	0.264	1.436	1.414
120-60-60	1.242	1.194	0.589	0.577	0202	0.193	0.085	0.080	0.292	0.286	1.625	1.581
160-80-80	1.348	1.295	0.696	0.685	0.225	0.208	0.104	0.098	0.322	0.313	1.840	1.782
SE ±	0.012	0.009	0.006	0.008	0.003	0.002	0.001	0.002	0.004	0.005	0.018	0.013
LSD (P = 0.05)	0.046	0.037	0.025	0.033	0.012	0.009	0.006	0.008	0.016	0.018	0.070	0.052
Sulfur Levels (kg/ha)												
0	1.215	1.169	0.569	0.553	0.196	0.188	0.078	0.073	0.285	0.277	1.564	1.535
25	1.240	1.194	0.592	0.579	0.203	0.193	0.085	0.080	0.293	0.286	1.628	1.586
50	1.282	1.226	0.626	0.616	0.213	0.200	0.093	0.089	0.305	0.300	1.709	1.655
SE ±	0.005	0.006	0.004	0.005	0.001	0.001	0.001	0.001	0.002	0.003	0.011	0.007
LSD (P = 0.05)	0.017	0.017	0.011	0.016	0.004	0.004	0.005	0.004	0.006	0.008	0.034	0.023
Zinc EDTA Foliar Spray (kg/ha)												
0	1.229	1.180	0.583	0.569	0.198	0.188	0.081	0.077	0.286	0.281	1.611	1.569
0.75	1.244	1.195	0.594	0.580	0.203	0.193	0.084	0.080	0.294	0.287	1.632	1.589
1.5	1.263	1.214	0.610	0.598	0.210	0.200	0.091	0.085	0.303	0.295	1.658	1.619
SE ±	0.005	0.003	0.002	0.003	0.001	0.001	0.001	0.001	0.002	0.002	0.006	0.004
LSD (P = 0.05)	0.013	0.010	0.006	0.009	0.003	0.003	0.003	0.002	0.004	0.005	0.018	0.012

cant difference between control and highest levels (1.5 kg Zn EDTA/ha). The decrease in harvest index under high fertility level or sulfur or zinc level may be attributed to source-sink efficiency factor. Such observations have also reported by Ramadass et al. (7).

Quality Parameters

Quality of the crop, being the varietal (genetical) character, is affected by the environment including fertilization. The quality parameters i.e. hulling percentage, milling percentage and head rice recovery percentage was significantly affected by graded fertility levels and highest content was recorded at highest fertility level of 160-80-80 kg N-P_2O_5-K_2O/ha (Table 2) which was significantly superior over the lower fertility rates (120-60-60 and 80-40-40 kg N-P_2O_5-K_2O/ha) in both the years. Increase in hulling percentage, milling percentage, head rice recovery percentage may be attributed to increase in boldness of rice grain due to balanced fertilization and corroborates the finding of Dixit and Gupta (8). The protein content in grain and grain protein yield of rice were also improved significantly with each increment of fertility levels and the highest value was associated with the highest fertility level (160-80-80 kg N-P_2O_5-K_2O/ha). The quality characteristics of rice i.e. hulling percentage, milling percentage, head rice recovery were also improved significantly with corresponding increase in sulfur rates upto 50 kg S/ha during both the years. Improvement in these quality characteristics by sulfur application could arise due to better grain filling and resistance against grain breakage. Sulfur being an integral part of essential amino acid, its application significantly increase the protein content in grain and ultimately the grain protein yield upto 50 kg S/ha. Application of zinc markedly influenced the hulling percentage, milling percentage, head rice recovery and the highest value was noted with foliar application of 1.5 kg Zn EDTA/ha followed by 0.75 kg Zn EDTA/ha while the lowest value was recorded under the control in both the years. Zinc is required for the mainte-

Table 4. Effect of fertility, sulfur and zinc levels on sulfur and zinc content of rice grain and straw of rice.

	Sulfur content (%)				Zinc content (%)			
	Grain		Straw		Grain		Straw	
Treatments	2000	2001	2000	2001	2000	20001	2000	2001
Fertility Levels $N-P_2O_5-K_2O$ (kg/ha)								
80-40-40	0.129	0.126	0.174	0.159	0.00211	0.00206	0.00188	0.00179
120-60-60	0.146	0.142	0.188	0.178	0.00224	0.00216	0.00200	0.00189
160-80-80	0.167	0.160	0.208	0.201	0.00242	0.00230	0.00215	0.00203
SE ±	0.002	0.003	0.002	0.003	0.00002	0.00002	0.00002	0.00002
CD (P = 0.05)	0.007	0.011	0.008	0.011	0.00008	0.00009	0.00007	0.00007
Sulfur Levels (kg/ha)								
0	0.115	0.112	0.146	0.132	0.00217	0.00209	0.00195	0.00184
25	0.147	0.142	0.189	0.178	0.00225	0.00216	0.00200	0.00189
50	0.181	0.175	0.236	0.228	0.00235	0.00227	0.00207	0.00198
SE ±	0.001	0.002	0.001	0.002	0.00002	0.00002	0.00001	0.00001
CD (P = 0.05)	0.005	0.007	0.004	0.006	0.00007	0.00007	0.00004	0.00005
Zinc EDTA Foliar Spray (kg/ha)								
0	0.141	0.136	0.185	0.170	0.00201	0.00192	0.00174	0.00168
0.75	0.147	0.142	0.190	0.178	0.00224	0.00217	0.00200	0.00189
1.5	0.155	0.151	0.196	0.190	0.00252	0.00243	0.00228	0.00214
SE ±	0.001	0.002	0.001	0.001	0.00001	0.00002	0.00001	0.00001
CD (P= 0.05)	0.003	0.005	0.002	0.003	0.00004	0.00007	0.00002	0.00004

nance of integrity of bio-membranes facilitating lower grain breakage thus improving the quality parameters i.e., hulling (%), milling (%), head rice recovery (%) in rice (9). Increasing zinc rate resulted in increase in protein content in grain values being maximum with 1.5 kg Zn EDTA/ha which was significantly higher over its lower rate of application (0.75 kg Zn EDTA/ ha and control). Application of 0.75 kg Zn EDTA/ha and 1.5 kg EDTA/ha significantly improved the grain protein yield over control in both the years. However, 1.5 kg Zn EDTA/ha and 0.75 kg Zn EDTA/ha remained at par between themselves during both the years.

Chemical Composition of Rice

The chemical composition of rice i.e. nitrogen, phosphorus, potassium, sulfur and zinc contents in grain and straw improved significantly with increase in graded fertility levels upto 160-80-80 kg $N-P_2O_5-K_2O$/ha. Increase in nitrogen, phosphorus, potassium, sulfur (Table 3) and zinc content in grain and straw were also recorded with increasing rate of sulfur application and the highest nitrogen, phosphorus, potassium, sulfur and zinc contents in grain and straw were recorded under 50 kg S/ha (Table 4). Marked effect of zinc application on nitrogen, phosphorus, potassium, sulfur and zinc contents in grain and straw were also recorded and each additional dose of 0.75 kg Zn EDTA/ha and the highest value was observed at 1.5 kg Zn EDTA/ha during both the years. These results are in conformity with the findings of Dixit and Gupta (8) and Wani and Rafique (10).

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