RESPONSE OF RICE TO ZINC-APPLICATION AND DIFFERENT N-SOURCES IN CALCAREOUS SOIL

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ABSTRACT

Widespread Zn deficiency in soil causes serious yield-reduction in rice. Use of zinc (Zn) alongwith nitrogenous fertilizers does improve crop-yield and fertilizer-use efficiency. Therefore, a pot experiment using four N fertilizers viz., urea, ammonium sulfate, calcium ammonium nitrate (CAN) and ammonium nitrate (AN) each @ 100 kg/ha, with and without Zn, was conducted. Paddy and straw-yield and paddy-to-straw ratio of rice increased significantly by the application of fertilizer N, accompanying zinc in all treatments. Paddy and straw-yield increased by 25 and 14% in ammonium sulfate - Zn , 28 and 13% in urea –Zn, 19 and 9% with CAN –Zn and 12 and 9% with AN - Zn, over control, respectively.

Ammonium sulfate by reducing soil pH enhanced growth and paddy yield more than other sources. All N sources used in the absence of zinc produced low paddy and straw yield. A significant increase in paddy-to-straw ratio, tissue nitrogen and zinc concentration and their uptake in rice were achieved in case of ammonium sulfate and urea. Application of zinc alongwith N had synergistic effect on N and Zn uptake in rice.

key words: Oryza sativa, nitrogen, zinc, urea.

INTRODUCTION

Rice Response to Zinc and Nitrogen

Zinc (Zn) deficiency, the most common nutrient disorder constraining rice-productivity, world wide, is effectively controlled by field-application of zinc sulfate ($ZnSO_4$) (Rashid, 1996). Due to clayey, alkaline and calcareous nature of soils in Pakistan (Tahir *et. al*., 1991), fertilizer Zn is mainly adsorbed by soil and very little is available and recovered by plants. Zinc, being an expensive fertilizer must, therefore, be applied in a way that may enhance its availability as well as efficiency in soils. Nitrogenous fertilizers are commonly used for crop-production in Pakistan. Use of nitrogen from different sources may influence the efficiency of Zn (Sing *et al*., 1995; Tahir and Kausar, 1994). Application of acid-forming N-fertilizer, like ammonium sulfate, by reducing soil pH causes enhanced availability of Zn to plants. In contradiction to the positive effect, several workers (Forno *et al*., 1975, Halder and Mandal, 1979) found depressing effect of urea on Zn uptake due to interference of HCO_3 ions in plant. The soils of Pakistan, being situated in arid and semiarid regions, are deficient in Zn (Rashid *et. al*., 1999). Liberal application of N on these soils may further aggravate Zn-deficiency, due to enhanced Zn uptake causing substantial yield-losses in the long run (Rashid, 1996). Therefore, this study was aimed at studying the response of rice to Zn application and different N-sources.

MATERIALS AND METHODS

A pot experiment to study the effect of N-sources, with and without Zn, on rice-growth was conducted on sandy clay loam soil. Bulk soil sample from 0-15 cm depth was collected from experimental field-area, with its characteristics (Table 1). After soil preparation, it was filled in glazed pots @ 10 kg per pot. The various nitrogen sources used were : urea, ammonium sulfate, calcium ammonium nitrate (CAN) and ammonium nitrate (AN). Nitrogen was applied @ 100 kg/ha in two splits(half at transplanting and half at booting stage). Basal dose of P and K was applied each @ 50 kg/ha as single super-phosphate and potassium sulfate, before transplanting the nursery plants of rice variety IR-6. Application of $ZnSO_4$ @ 10 kg/ha was added in the following sequence:

- T_1 100 kg N/ha as urea, with no zinc.
- T_2 100 kg N/ha as urea, with 10 kg $ZnSO_4$/ha.
- T_3 100 kg N/ha as ammonium sulfate, with no zinc.
- T_4 100 kg N/ha as ammonium sulfate, with 10 kg $ZnSO_4$/ha.
- T_5 100 kg N/ha as calcium ammonium nitrate (CAN), with no zinc.
- T_6 100 kg N/ha as calcium ammonium nitrate (CAN), with 10 kg $ZnSO_4$/ha
- T_7 100 kg N/ha as ammonium nitrate (AN), with no zinc.

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Table – 1: Physico-chemical properties of the soil

Property	Value
Texture	Sandy clay loam
pH_s	8.0
EC_e (dS/m)	1.7
OM (%)	0.44
Olsen P (mg/kg)	6.22
DTPA-Zn (mg/kg)	1.4
Total nitrogen (%)	0.05

T_8 100 kg N/ha as ammonium nitrate, with 10 kg $ZnSO_4$/ha.

Experiment consisting of eight (8) treatments was laid out in a completely randomized design. Crop was irrigated with distilled water, throughout the growth-period, and was harvested at maturity. Oven dry weight of grain and straw was recorded. Grain and straw samples were analyzed for N by Kjeldahl method (Bhargra and Raghupathi., 1993) and Zn by atomic absorption spectrophotometer. The data for paddy and straw-yield and their chemical composition was analyzed statistically and LSD was used for mean separation (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Paddy and Straw-Yield

Different nitrogen sources, used alongwith zinc, significantly increased paddy and straw-yield of rice (Table 2). Ammonium sulfate used as N source was better than rest of the sources. Paddy and straw-yield obtained in different nitrogen-sources, used without zinc, was minimum and statistically similar with each other. Rice gave significantly higher yield as 25% in grain and 14 % in straw with ammonium sulfate - zinc, and 28% in grain and 13 % in straw with urea-Zn, as against 19 and 9% in grain and straw, respectively, with calcium ammonium nitrate-Zn and only 12 and 9% with ammonium nitrate-Zn, over their respective control. Some earlier studies have also shown that Zn used alongwith nitrogen (Singh *et al*., 1995; Tahir and Kausar, 1994; Singh and Singh, 1981) increased crop-yields. On the contrary, though application of Zn alongwith N to rice stimulated plant growth, but it decreased grain weight and paddy yield due to Cu deficiency at later stages (Alam *et. al*., 1997). Ammonium sulfate, used with and without Zn, was superior to all other sources. Probably more reduction of soil pH in ammonium sulfate increased the Zn-availability and its useful effect on rice-growth and yield. These results are also in agreement with those of Shinde and Patil (1980) and Amer *et al*. (1980).

A significant improvement in paddy : straw ratio was observed by application of Zn (Table 2). Probably increased grain-weight and percentage of filled grain per panicle were due to Zn application (Tahir and Kausar, 1994). Grain to straw ratio in T4 (ammonium sulfate + Zn) was significantly higher than T6 (CAN+Zn) and T8 (ammonium nitrate + Zn). The higher paddy to straw ratio in ammonium sulfate-Zn was possibly due to availability of more Zn and more number of filled grains under reduced pH (Tahir *et. al*., 1992). The differences in grain to straw ratio among all nitrogen sources without zinc were non-significant. Perhaps deficiency of Zn produced small-sized grains and low percentage of filled grain per panicle. Similar results were reported by Singh *et al*. (1995).

Nitrogen Concentration and Uptake

Application of zinc alongwith nitrogen enhanced nitrogen concentration, both in grain and straw (Table 3). Nitrogen concentration was significantly higher in

Table – 2: Effect of nitrogen sources and zinc on paddy, straw yield and paddy: straw ratio in rice

Treatment	Paddy yield	Straw yield	Paddy : Straw ratio
	--------------------(g/pot)--------------------		
T1	36.1d	47.4e	0.72b
T2	46.1b	53.3b	0.87a
T3	39.9c	51.2bc	0.76b
T4	49.9a	58.4a	0.91a
T5	34.5d	45.8e	0.75b
T6	41.0c	49.7cd	0.76b
T7	33.5d	45.5e	0.68b
T8	39.8c	49.6cd	0.74b

Means sharing the same letter (s) are statistically non-significant at < 0.05 probability.

Table – 3: Effect of nitrogen sources and zinc on N concentration and uptake by rice

	N concentration		N-uptake	
Treatment	Grain	Straw	Grain	Straw
	-------------(%)---------------		-------------(g/pot)--------------	
T1	1.09a-c	0.56bc	0.39c-e	0.27d
T2	1.15ab	0.60b	0.53b	0.31b
T3	1.10a-c	0.55bc	0.44c	0.29c
T4	1.19a	0.70a	0.60a	0.40a
T5	0.99c	0.48c	0.34de	0.23f
T6	1.02bc	0.51c	0.42c	0.25f
T7	0.98c	0.49c	0.33e	0.23f
T8	1.03bc	0.53bc	0.40cd	0.26e
SE.	0.046	0.026	0.02	0.015

Table – 4: Effect of nitrogen sources and zinc on Zn concentration and uptake by rice

	Zn concentration		
Treatment	Grain	Straw	Zn-uptake
	-------------(mg/kg)---------------		(g/pot)
T1	12.0c	16.0c	1.19f
T2	20.0ab	24.6ab	2.23b
T3	14.3bc	16.3c	1.41d
T4	22.0a	26.6a	2.60a
T5	11.2c	15.0c	1.07g
T6	15.3a-c	21.6b	1.70c
T7	11.6c	16.3c	1.29e
T8	16.6a-c	22.0b	1.66c
SE.	2.267	1.167	0.096

T4 than T6 (CAN + Zn) and T8 (ammonium nitrate + Zn), but values were at par with T2 in grains. In rice straw, only T4 gave significantly higher N concentration. Treatment T2 (urea + Zn), T6 (CAN + Zn) and T8 (AN + Zn) were statistically non-significant in difference with respect to N values. The treatments where no Zn was applied, nitrogen concentration decreased both in grain and straw. The results are in agreement with the observations of Singh *et. al*., (1995). Dev and Shukla (1982) stated that ammonium sulfate is the better source, with respect to improvement of nitrogen content in rice. Nitrogen uptake, both in paddy and straw, was significantly affected by zinc and nitrogen application (Table 3) . Maximum increase in N uptake was found in T4 (ammonium sulfate + Zn) followed by T2 (Urea + Zn) which, in turn, was statistically different from T6 (CAN + Zn) and T8 (AN + Zn). Fertilization of N and Zn together had synergistic effect on uptake of each other (Chaudhry *et. al*., 1977). In the absence of Zn, plant growth was stunted and nitrogen uptake was relatively smaller.

Nitrogen uptake in grain for T3 (ammonium sulfate) was statistically similar to T1 (urea), but was significantly higher than T5 (CAN) and T7 (AN). Nitrogen uptake in rice-straw was significantly higher in T3 (ammonium sulfate) than T1 (urea), T5 (CAN) and T7 (AN). With application of Zn, higher N uptake in rice is quite evident from the data. Similarly, nitrogen uptake in rice for ammonium sulfate was better than other N sources. Singh *et al*. (1995) and Tahir and Kausar (1994) also recorded higher N uptake in rice where it was applied with Zn, rather than applying nitrogen alone. Urea, ammonium nitrate and calcium ammonium nitrate used were at par with each other. They did not affect N concentration and uptake in rice-grain significantly.

Zinc Concentration and Uptake

Concentration of Zn, both in grain and straw, as well as total uptake increased significantly by application of Zn alongwith different nitrogen sources (Table 4). Concentration and total uptake of Zn was found maximum in T4 (ammonium sulfate + Zn), followed by T2 (Urea + Zn) and T8 (ammonium nitrate +Zn). Having more acidifying effect on soil than other N sources, ammonium sulfate increased growth and availability of Zn in rice. Chaudhry *et. al*. (1977) also reported similar increase in Zn content of rice plants. In case of urea, uptake and translocation of Zn was depressed due to interference by HCO_3 ions in plants. In another study, urea applied with Zn to rice has shown good effect on yield and Zn content in rice (Singh and Singh, 1981). In the treatments where Zn was not applied, Zn concentration and uptake in rice was low. Stunted rice growth in the absence of Zn, perhaps depressed Zn uptake in plants (Tahir and Kausar, 1994). There was non-significant difference among N-sources used. The treatment T3 (ammonium sulfate) was better than T1 (urea) and T7 (ammonium nitrate). Acidic nature of ammonium sulfate probably improved the Zn uptake. The results are in good agreement with those reported by Singh and Singh (1995).

CONCLUSION

Application of N along with Zn increased paddy yield and paddy-to-straw ratio significantly. Among the different N sources used, ammonium sulfate enhanced paddy yield more than other sources. Use of N alone was not so helpful in improving growth and paddy yield. Application of N along with Zn had synergistic effect on N and Zn uptake in rice.

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