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EFFECT OF ZINC, IRON AND MANGANESE ON GROWTH AND YIELD OF RICE *(ORYZA SATIVA* L.)

Muhammad Abid[1], Niaz Ahmad[2], Maqsood Jahangir[2] and Iftikhar Ahmad[2]
[1]University College of Agriculture, B.Z. University, Multan
[2]Soil and Water Testing Laboratory, Multan

The effect of Zn, Fe and Mn on yield and yield contributing parameters and mineral contents of rice variety KS-282 was studied in the IO-kg sandy clay loam soil pot'. Two rates of Zn (0; 5 and 10 mg kg' soil) and one rate of each Fe and Mn (5 mg kg' soil) along with a basal dose of NPK (100-50-50 mg kg") were added in various combinations before the transplanting of rice seedlings. Number of tillers pori, number of grains panicle", 1000-grain weight and grain yield increased significantly with the application of Zn, Fe and Mn alone or in various combinations. However, more increase in paddy yield and yield contributing growth parameters was noted in treatment comprising 10 mg kg' Zn along with 5 mg kg"[1] Mn and a basal dose of N. P and K fertilizers. The Zn and Mn concentration in the grain were 46.53 and 99.40 mg kg"[1], respectively in the treatment, where 10 mg kg"[1] Zn was applied along with NPK+Mn. The maximum Fe was 166.1 mg kg"in grain, where 5 mg kg'l Zn was applied along with the NPK +Fe.

Key words: In. Fe. Mn, Growth, Yield, Rice

INTRODUCTION

The soils in the Indus plains of Pakistan are generally alkaline in reaction. rich in bases, having low organic matter contents, low in Nand P and calcareous to varying degree. In such kinds of soils trace elements lime Zn, Fe and Mn form insoluble compounds not easily available to plants. Additionally. flooded soil conditions for the cultivation of lowland rice have been reported to accentuate the Zn disorder (Rahrnatullah, 1976). Hence the crops are prone to micronutrient deficiencies under the prevailing soils and climatic conditions (Khattak and Perveen, 1985; NFDC, 1998).

Rice *(Ory:a saliva* L) is second the largest staple food crop and is generally grown on soils where Fe and Mn concentrations increase manifold due to submerged and reduced conditions while their high amounts disturb the balance of other micronutrients in the soil as well as within the plants (Ganwar and Mann, 1972; Chaudhry et al., 1977). High level of In and Fe in the growth medium may impede Mn uptake by plants while Fe deficiencies are evolved by excess of nutrients such as Cu, Mn and Zn (Tisdale et al., 1985). A favorable balance of macro and micronutrients is required for optimum crop production but nutrient imbalances can occur due to non-judicious and liberal use of major and low level of micronutrients in soil.. Increase in paddy yield with Zn has been reported in literature (Takkar and Singh, 1978: Kausar et al., 2001). For instance, Kausar et al. (2001) reported 4.9 and 6.1 % increase in paddy yield with 5 and 10 mg Zn kg"[1] soil, respectively over control. Similarly in a pot experiment, Gangwar et al. (1989) reported higher dry matter and grain yields of rice with 10 mg Zn kg"[1] soil..

More work on interaction is needed to till the gaps In knowledge under different soil and agro-climatic conditions. Since last few years Zn application along with N. P and K has been a common practice that might has caused some imbalance with respect to Fe and Mn nutrition of rice. Hence, the present study was designed to ascertain the influence of Zn application on the uptake of Fe and Mn by rice in the presence of N, P and K and also to explore the necessity of Fe and Mn fertilization in combination with different levels of Zn.

MATERIALS AND METHODS

A bulk soil sample from 0-15 cm was collected tram Experimental area of Soil and Water Testing Laboratory, Multan. The soil was air-dried, ground, passed through a 2-mm sieve thoroughly mixed, and filled in polythene lined glazed pots @ 10 kg pot[1]. Some of the physical and chemical characteristics of the soil under investigation are listed in table 1. The analyses of the soil were made by using standard methods outlined by U.S. Salinity Lab. Staff (1954) and Winkleman et al. (1986). Eight treatment combinations tested are given below:

Treatment	Nutrients applied	N	P	K	Fe	Mn	Zn_1	Zn_2
		mg kg^{-1} soil						
T1	Control	-	-	-	-	-	-	-
T2	NPK	100	50	50	-	-	-	-
T3	NPK+Fe	100	50	50	10	-	-	-
T4	NPK+Mn	100	50	50	-	10	-	-
T5	NPK+Fe+Zn_1	100	50	50	10	-	5	-
T6	NPK+Fe+Zn_2	100	50	50	10	-	-	10
T7	NPK+Mn+Zn_1	100	50	50	-	10	5	-
T8	NPK+Mn+Zn_2	100	50	50	-	10	-	10

Thirty days old seedlings of rice (variety KS-282) were transplanted @ five plants pori. The experimental treatments were repeated thrice in a completely randomized design. After fifteen days the plants were thinned to three plants pot ı. Distilled water was used for irrigation. Full dose of P, K, Zn, Fe and Mn were added as basal, while N was added in two splits (one half of which was incorporated as basal dose and rest half was applied before blooming stage). Nitrogen, P and K were added as urea, single super phosphate and potassium sulphate. respectively. Micronutrients were added in the sulphate form (ZnSO~.7H,O, FeSO~. 7H,O and MnSO~, H2O). The crop was harvested at maturity and the following growth parameters were recorded:

I. Number of tillers par!
2. Number of grains panicle"
3. Grain yield pori
4. IOOO-grain weight (g)

The grains were dried in an oven for 48 hours at 70°C. . One gram paddy was digested in 20 ml of concentrated HNOJ and 10 ml of 72 % HCIO~, cooled and transferred to 100 ml volumetric flask and made the volume (Method 54a: U.S. Salinity Lab. Staff (1954). The Zn, Fe and Mn were determined by using Atomic Absorption Spectrophotometer, Model SP 2900. The data were subjected to statistical analysis according to completely randomized design (Steel and Torrie, 1980) and the comparison of mean values was made by Duncans Multiple Range Test (Duncun, 1955).

RESULTS AND DISCUSSION

Number of fertile tillers pori

Number of ti llers is one of the most critical yield contributing components. More the number of fertile ti llers better will be the crop stand, which ultimately would increase the yield. There was an increase in the tillers. pori with an increase in the Zinc (Zn) levels. It is evident (table 2) that the highest number of tillers (33.67 pori) was recorded in T8 (NPK+Mn+Zn2) followed by T6 (32.0 pori). The results of T6 and T8 differ statistically from all other treatments, while is similar with each other.. The treatments (T5 and '1'7) behaved similarly with each, while non-significant with TI-T4, T6 and T8 (table 2). lonvo and Ion ova (1977) reported that addition of Zn (up to 12.5 mg Zn kg" soil) decreased the intervenal chlorosis and necrosis of rice seedlings and enhanced the number of fertile tillers pori.

Number of grains panicle"

Number of grains panicle" increased significantly by the addition of In, Fe and Mn in various combinations (table 2). It is apparent that the highest number of grains panicle.' (118.66) were recorded in '1'8 (NPK +Mn-rZn.)) which differed significantly from all other treatments. Minimum number of grain panicle'! (66.0) was obtained in TI (control). Application of Fe and/or Mn in separate treatments enhanced the grains panicle" significantly over control.. Both levels of Zn (5 and 10 mg Zn kg'! soil) with Fe in T5 and T6 and lower with Mn in T7 produced significantly more number of grains panicle" than treatments where Zn was not added. i.e. TI to T4. Increasing Zn from 5 to 10 mg kg' at 10 mg Mn kg" soil caused a significant enhancement of grains panicle". The beneficial effect of Zn was perhaps due to the fact that Zn influenced the uptake of major plant nutrients through the enzymatic effect in the metabolic processes (Panda and Nayyak, 1974), which ultimately accounted for greater number of grains. Similar results regarding the effect of Zn on grains panicle" were reported by Chaven and Banarjee (1979).

IOOO-grain weight

Application of Fe and Mn with Zn had a positive influence in producing healthy grains (table 2). It is evident that application of Zn with Fe at both rates (5 and 10 mg kg' soil) in T5 and T6 did not differ significantly for all treatments except TI.. The highest 1000-grain weight (23.93 g) was noted in the produce of T8 (NPK+Mn+Zn2)' which varied significantly from T I and T2. Babiker (1986) observed the similar results and reported that 1000-grain weight increased by the soil application of zinc @ 10 mg kgr soil..

Paddy yield (g pot")

It is evident that maximum paddy yield (78.73 g pori) was exhibited by T8 (NPK+Mn+Zn2) followed by '1'6 and T7 (table 2). The minimum yield (20.53 g pori) was recorded in T 1 (control). Results (table 2) indicated that application of Fe and Mn to soil along with lower dose of Zn (5mg kgr soil) in separated cases showed increasing trend in paddy yield that was significantly higher than control and T2. The paddy yield resulted from T5 (NPK+Fe+Znl) was significantly higher than T3 (NPK+Fe) and T4 (NPK+Mn). More yields were resulted when lower rate of Zn (5 mg kg' soil) was included in NPK +Mn than that when it was added in NPK +Fe. The crop exhibited better response when increasing level of Zn from 5 to 10 mg kgr soil was incorporated in soil with Fe or Mn in separate treatments. Comparatively Zn showed better performance in combination with Mn than that Fe. It was probably due to the mutual antagonism that existed between Fe and Zn as indicated by several workers (Tiwari et al., 1976: Halder and Mandal, 1981). The higher Zn (10 mg kg'l soil) level showed more paddy yield over all other treatments when it was added in NPK and Mn. This might be due to the fact that pronounced effect of micronutrients would be expected only when the micronutrients were in the required ratio and quantity (Chaudhry and Ali, 1986).

Chemical composition of paddy

Chemical composition of paddy is presented in table 3. Maximum Zn concentration was noted in T8 (NPK+Mn+Zn2)' Minimum Zn concentration (25.23 mg Zn kg') was recorded in T3 (NPK+Fe), where Fe was added with NPK (table 3). Generally Fe had the maximum inhibition on the uptake of Zn content. in grains. A significant increase in Zn was observed where Zn was applied @ 5 and/or 10 mg Zn kgr soil in combination with Fe and Mn. However, the effect was more pronounced when

Zn was added with Mn, It could be attributed to the competition of Fe^{2+} and Zn^{2+} at absorbing sites of roots of sesame plants that lead to the antagonism between these two nutrient elements (Muralidharudu and Singh, 1990). Graham et al. (1987) and Reddy et al. (1987) also observed the similar results of Zn concentration of paddy due to Zn application.

Table I. Physico-chemical characteristics of the soil used **in** the study

Characteristics	Unit	Value
Sand	%	72
Silt	"	12
Clay	"	16
Textural class	-	Sandy clay loam
Saturation percentage	-	35
pH,	-	7.9
EC_c	dS m^{-1}	1.26
Organic matter	%	0.73
Total nitrogen (Jackson, 1962)	"	0.04
Extractable phosphorus (Watanabe and Olsen, 1965)	mg kg^{-1} soil	8
Extractable potassium (Method 18, U.S. Salinity Lab. Staff, 1954)	"	126
Extractable Zinc (Lindsay and Norvell, 1978)	"	1.3
Extractable iron (Lindsay and Norvell, 1978)	"	5.55
Extractable manganese (Lindsay and Norvell, 1978)	"	5.10

Table 2. Effect of zinc, iron and manganese on growth and yield of rice KS-282

Treatment	Tillers pori	Grains panicle.'	1000-grain weight (g)	Paddy yield (g pori)
TI =control	12.67c	66.00d	20.87c	20.53e
T2=NPK	26.67b	95.33c	21.70bc	64.23d
T3=NPK tFe	27.67b	99.00c	22.13abc	66.27cd
T4 cNPKI- Mn	28,00b	98.67c	22.83abc	67.23cd
T5~NPK-+ Fe! 1nl	30,33ab	108,00b	23,53ab	71.07bcd
T6=NPK+FetZn2	32.00a	I I 1,00b	23.53ab	75, 10ab
T7oNPK+MntZnl	30.33ab	109.00b	23.57ab	72,30abc
T8'~NPK+MntZn2	33.67a	118.66a	23,97a	78.73a

Means sharing the same letter (s) do not significantly at P = 0.05 level of probability (DMR-test).

Table 3. Effect of zinc, iron and manganese on mineral composition of rice KS-282

Treatment	Zn	Fe mg kg'l	Mn
T I=control	27. I0:	96,37fg	61,43cd
T2=NPK	28.00e	129,03d	63,40c
T3=NPK+Fe	25.23f	183.37a	56.33d
T4=NPK+Mn	26,60ef	100.lOf	83.73b
T5=NPK+Fe+Znl	36,97d	166, lOb	59.37cd
T6=NPK+Fe+Zn2	44,47b	150.66c	60.IOcd
T7=NPK+Mn+Znl	39.17c	108,68e	94.70a
T8=NPK+Mn+Zn2	46.53a	91.82g	99,40a

Means sharing the same letter (s) do not significantly at P = 0.05 level of probability (DMR-test).

Maximum Fe content of paddy was 183.37 mg kg^{-1} where Fe was applied @ 10 mg kg'l soil along with N, P and K basal dose. Minimum Fe concentration in grain (91.92 mg Fe kg'l paddy) was found where Zn and Mn were combined with NPK+Mn+,Zn2, Moore and Patrick (1989) reported that increased uptake of Fe by Zn deficient rice plant might possibly be due to the increased production of divalent earners.

Results (table 3) showed that highest Mn concentration in grain was 99,40 and 94.70 mg kg', respectively in T8 and T7. Both these treatments differed significantly with all other treatments, Lowest Mn (56,33 mg Mn kg'l) was noted in T3 (NPK+Fe). It is evident that application of Fe accentuated the maximum reduction of Mn in paddy and this effect was minimized by the addition of 5 and 10 mg Zn kg^{-1} soil with Fe. Addition of 5 and/or 10 mg Zn kg' soil with Mn significantly enhanced the Mn in paddy. The antagonism effect of Fe on Mn was also reported by Alam (1982) and Chaudhry and Wallace (1976).

CONCLUSIONS

Growth and paddy yield were significantly enhanced by application of Zn, Fe and Mn either alone or in various combinations. The treatment comprising 10 mg each of Mn and Zn added per kg soil along with basal dose of NPK fertilizers proved to the best combination. Best performance of this treatment (T8) was probably due to the more balanced nutrient ratio, which improved the yield and yield contributing characteristics of rice KS-282. It is suggestion that further studies should be carried out with higher rates of zinc (greater than 20 kg ha') because it may reduce the availability and uptake of iron to such an extent to make it a limiting nutrient for proper growth of plants and iron fertilization acquires the status of regular fertilizer along with higher doses of zinc for boosting up rice crop production.

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