The effect of zinc application on rice yield and some agronomic characters [On-line]

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The effect of zinc application on rice yield and some agronomic characters

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Summary: The objectives of this study are to examine the effect of zinc application on rice grain yield and some agronomic characters and to find out a suitable Zn application rate. The research carried out in a randomized complete block design with 3 replications in the farmer fields of Edirne province in 1998 and 1999. Four zinc treatments, 0, 15, 30, and 45 kg ha^{-1} were utilized and $ZnSO_4$. 7 H_2O was used as zinc source. The concentration of DTPA-extractable Zn in the soils was 0.22 and 0.43 mg kg^{-1} in 1998 and 1999, respectively.

Although Zn application was not significantly effective on rice grain yield. A considerable increase observed in grain yield with Zn application. It was 12.3% and 8.4% in 1998 and 1999, respectively. On average, grain yield increase was 8.9% and also, Zn concentration of the plant and the rice grain increased with Zn application. In addition to these, the day to maturity and spikelet sterility decreased, and the number of panicle per squarmetter and head rice yield increased with Zn application. Homogeneous matured rice harvested from Zn applied plots.
As a result, 15 kg ha^{-1} Zn seems to be suitable for Zn application in Thrace-Marmara Region.

Key words: Rice, zinc, zinc application, agronomic character.

Introduction

For rice, 16 elements are essential, these are divided into major and minor elements. The major elements, C, H, O, N, P, K, Ca, Mg, and S, are needed by plant relatively higher amounts than the minor elements, Fe, Mn, Cu, Zn, Mo, B, and Cl. All essential elements must be presented in the soils in optimum amounts and in forms usable by rice plants. Nitrogen, phosphorus, zinc, and potassium are nutrients most commonly applied by rice farmers (De Datta, 1981).

As long as 70 years ago, zinc was recognised as essential micronutrient (Sommer and Lipman, 1926). Since than, numerous studies have indicated that zinc deficiency is a serious nutritional problem for upland crops. Nene (1966) in India, first reported zinc deficiency in lowland rice. After then, it has recognized as a widespread and important nutritional problem throughout the rice-growing world.

In the last years, the induce of zinc deficiency has increased due to the replacement of traditional rice varieties by modern varieties that are less tolerant to zinc deficiency, removal of large amount of zinc by modern high yield potential varieties, continuous cropping without rotation, excessive phosphate fertilizer using, and the other factors. Thus, next to N and P deficiency, zinc is becoming the most important nutritional factor, limiting the grain yield of wetland rice.

Zn deficiency is more common under the conditions of high pH, calcareous, light and sandy soils, high phosphorus levels, and wet soils. Qi (1987) reported that the available Zn in the soils correlated negatively with soil pH and $CaCO_3$ content and positive with clay content.

Zn is essential for several biochemical processes in the rice plant, such as cytochrome and nucleotide synthesis, auxin metabolism, chlorophyll production, enzyme activation, and membrane integrity (IRRI, 2000).
Numerous researches were conducted on Zn in rice crop. Nand and Ram (1996), Sagwal et al., (1994), Selvi and Ramaswami (1995), and Korayem (1993) observed increase in grain yield with Zn application. On the other hand, increases in grain yield and straw yield of rice with Zn application reported by Maharana *et al*., (1993) and

Dutta and Rahman (1987). Dutta and Rahman (1987) also determined reduction in maturity time and increase in tiller number with Zn treatment.

The studies carried out in IRRI (2000) indicated that under severe Zn deficiencies, tillering decreased or could stop completely, and time to crop maturity increased. Zn deficiencies could also increase spikelet sterility in rice. Zinc removal by rice ranged from 0.04 to 0.06 kg Zn per ton of grain yield, with an average of 0.05. A rice crop yielding 6 t ha^{-1} takes up about 0.3 kg/Zn ha, of which 60% remains in the straw at maturity (IRRI, 2000). Similarly, Nand and Ram (1996), Rajan (1993) and Maharana *et al*., (1993) reported incereases in uptake of Zn by rice plants with Zn application.

Sahay *et al*., (1993), Maharana *et al*., (1993), and Srivastava *et al*., (1999) observed that additional Zn application increased grain and straw Zn concentration.

Zn deficiency has been observed in the rice field of Thrace-Marmara Region in Turkey in early 1990's. However, it first recognized as Zn deficiency in 1997. A test experiment conducted in 1997. For this, Zn application was done in the field, where Zn deficiency symptoms observed previous year. And then, Zn deficiency corrected in the Zn applied plots. Thus, a research project designed in 1998 to solve this problem and to find out a suitable Zn application rate to recommend the farmers.

I – Materials and methods

The experiments were carried out in the farmer fields in Edirne province during 1998 and 1999 cropping seasons. Baldo variety was used in the experiment.

The soil of the experimental fields had clay loam texture with pH 7.7, 8% $CaCO_3$ and 2.4 % organic matter. The concentration of DTPA-extractable Zn measured according to Lindsay and Norvell (1978) was 0.22 and 0.43 mg kg^{-1} in 1998 and 1999 respectively. They are less than critical Zn concentration of 0.8 mg kg^{-1} (IRRI, 2000).

The experiment conducted in randomized complete block design with 3 replications. Four zinc treatments, 0, 15, 30, and 45 kg ha^{-1} Zn were utilized and $ZnSO_4$. 7 H_2O was used as zinc source. Zinc sulphate broadcasted on soil surface and incorporated with cultivator. Recommended N and P fertilizers were applied in all treatment plots. All phosphorous, 40 kg ha^{-1} was applied with 40 kg ha^{-1} nitrogen pre-planting and incorporated with disk-plow. In addition, 50 kg ha^{-1} N at tillering and 50 kg ha^{-1} N at panicle initiation stage were top-dressed.

The plants were sampled at panicle formation stage for the plant and at maturity stage for the grain to determine Zn concentration. The samples were digested in concentrated nitric and perchloric acid (4:1-HNO_3:$HClO_4$) and analyzed for Zn by AAS.

The data recorded for grain yield, the days to maturity, plant height, panicle length, the number of panicle per squarmetter, the number of filled grain per panicle, spikelet sterility, 1000 grain weight, head rice yield, zinc concentration of the shoot and the grain.

II – Results and discussion

Among the plant nutrient micro-elements, only zinc, manganese, and iron are known to have limiting effect on rice yield. However, Zn is the most wide spread yield limiting micro-element for rice crop (Atanasiu and Samy, 1983). Only the zinc deficiency has been observed in the rice fields of Turkey upto now. It was first observed in the western part of Black Sea Region in 1980 where rice is continually cultivated without crop rotation and the soils contain high $CaCO_3$ and available phosphorus due to high phosphorus fertilizer application (18:46:0 compound fertilizer). Teceren and Karaçal (1983) conducted a research on Zn deficiency in rice in 1981 and 1982 in this those. They obtained a considerable yield increase with Zn aplication.

The Zn deficiency has been observed in north-western part of Thrace-Marmara Region in 1990's. And then, it showed limiting effect on rice yield, where rice is grown without rotation, harvested high yield, the soil have high pH and organic matter.

Table1. The results of grain yields obtained in 1998 and 1999, and the average of two years'

Zn treatment Kg/ha	Yield t/ha		Yield t/ha		Average yield t/ha	Yield Increase %
	1998	Increase %	1999	Increase %		
0	4.38	--	6.56	--	5.47	--
15	4.81	9.8	7.11	8.4	5.96	8.9
30	4.92	12.3	6.58	0.3	5.75	5.1
45	4.90	11.8	6.62	0.9	5.76	5.3
F Values	0.19		0.65		0.36	
LSD (0.05)	NS		NS		NS	
CV (%)	20.9		8.5		14.4	

In order to solve Zn deficiency problem, a research carried out in Edirne province of Thrace-Marmara Region in 1998 and 1999. The results of the experiments revealed that the rice yield increased with Zn application in both years (Table-1). In the first year, the grain yield increases ranged from 9.8% to 12.3% and in the second year ranged from 0.3% to 8.4%. On average, the yield increases ranged from 5.1% to 8.9%. However, significantly yield increase was not observed with zinc application in both years. The highest yield increase obtained with 30 kg ha^{-1} Zn application in 1998 and with 15 kg ha^{-1} in 1999. On average, 15 kg ha^{-1} Zn application seems to be enough to correct zinc deficiency. Similar results reported by Nand and Ram (1996), Sagwal *et al*., (1994), Selvi and Ramaswami (1995).

As it seen in table-2, both zinc concentration of the plant and the grain increased with Zn application in 1998 and 1999. In 1998, significantly increases observed for both characters, however, it was not significant in 1999. On average, the Zn concentration of the plants was also significant. On the other hand, Sahay *et al*., (1993) and Maharana *et al.,* (1993) reported the same results in rice.

Although, a little increase or decrease occurred for the day to maturity, the number of filled grain Per panicle, the number of panicle Per squarmatter and spikelet sterility with zinc application (table-3). The Zn deficiency not significantly effected any agronomic traits examined. Zn application decreased the days to maturity, the number of filled grain per panicle and spikelet sterilty and increased the number of panicle per squarmetter. Similar results observed by Dutta and Rahman (1987) for the maturity time and tiller number and at IRRI (2000) for tillering, time to crop maturity and spikelet sterility. A homogeneous maturity occurred in the Zn applied plots, whereas, a heterogeneous maturity observed in no zinc applied plots.

Zn application was not effective on 1000 grain weight and it was effective on head rice yield. This effect was no significant in 1998 and it was significant in 1999. It showed significant effect on average as well. The head rice yield increased with Zn application. The highest head rice yield obtained with 30 kg ha^{-1} Zn application. The milled rice obtained from Zn applied plots contained less unmaturied or unfilled and chalky grains. Their appearance are better than no Zn applied rice.

Table 2. Zn concentration of the plant and the grain in 1998 and 1999

Zn Treatment Kg/ha	1998		1999		The average	
	The plant (ppm)	The grain (ppm)	The plant (ppm)	The grain (ppm)	The plant (ppm)	The grain (ppm)
0	15.4b	10.9b	13.3	11.7	14.3	11.3b
15	18.0a	13.7a	16.3	12.7	17.2	13.1ab
30	17.9a	13.4a	16.1	12.5	17.0	12.9ab
45	18.9a	13.0a	16.4	14.4	17.6	13.7a
F Values	5.10*	4.81*	1.09	2.34	2.95	3.9*
LSD (0.05)	2.31	2.04	NS	NS	NS	2.21
CV (%)	6.6	8.0	15.9	14.1	11.53	11.6

Table 3. The averages of data observed in 1998 and 1999 for some agronomic characters

Zn Treatment Kg/ha	Plant Height (cm)	Panicle Length (cm)	No. of filled Grain Per panicle	No of panicle Per Square meter	Spikelet Sterilty (%)	The days To Maturity
0	95.8	15.7	70.8	299.7	8.1	130.5
15	92.4	15.6	69.3	334.8	6.7	128.3
30	94.4	15.5	64.8	338.7	6.3	127.3
45	93.9	15.2	63.9	342.8	5.9	124.8
F Values	3.11	0.19	0.52	0.68	0.52	1.13
LSD (0.05)	NS	NS	NS	NS	NS	NS
CV (%)	2.9	8.2	4.5	14.8	20.5	21.8

Table 4. The results obtained for 1000 grain weight and head rice yield

Zn Treatment Kg/ha	1000 grain weight (gr)			Head rice yield (%)		
	1998	1999	Average	1998	1999	Average
0	40.1	39.7	39.9	63.4	48.4c	55.9b
15	39.8	39.2	39.5	63.4	55.4a	59.4a
30	40.6	39.5	40.1	65.1	56.7a	60.9a
45	41.0	40.5	40.8	66.3	51.9b	59.1a
F Values	0.81	0.61	1.27	1.97	19.64**	10.21**
LSD (0.05)	NS	NS	NS	NS	2.92	2.03
CV (%)	2.6	3.1	2.8	2.7	2.7	2.8

Conclusion

Even though, Zn application was not significantly effective on rice grain yield. A considerable increase observed in grain yield with Zn application. Also, Zn application decreased maturity time, spikelet sterility, and it increased the number of panicle per squarmetter and head rice yield. Homogeneous matured rice crop harvested in Zn applied plots. Their milled rice appearance was better than no Zn applied plots.
It seems to be 15 kg ha^{-1} Zn application suitable to solve zinc deficiency problem in Thrace-Marmara Region.

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