

ZINC AS A LIMITING NUTRIENT FOR RICE GROWTH IN THE MID COUNTRY WET ZONE OF SRI LANKA

S. NAGARAJAH, B. M. NIZAR, M. M. M. JAUFFER and S. de SILVA
*Central Agricultural Research Institute,
Gannoruwa, Peradeniya, Sri Lanka.*

ABSTRACT

Studies on the response of rice to added zinc were carried out in farmers' fields at Gampolawela and Kaudupellella. At Kaudupellella, where the soil is poorly drained, alkaline and very low in available zinc, there was a significant response to zinc in 3 out of 4 seasons tested. However, plant symptoms were not clearly visible except for some yellow to brown discolouration in Bg 400—1 during the first two seasons. With the 3—3½ month old varieties which were subsequently grown, even this symptom was not shown.

No grain yield response was obtained at Gampolawela where the soil is moderately well-drained, acidic and high in available zinc content.

INTRODUCTION

Crops, in addition to the primary nutrients, nitrogen (N), phosphorus (P) and potassium (K), require the secondary nutrients, calcium (Ca), magnesium (Mg) and sulphur (S) and the micronutrients, iron (Fe), copper (Cu), zinc (Zn), manganese (Mn), boron (B), molybdenum (Mo) and chlorine (Cl) for normal growth. Rice is no exception to this. Presently, rice in Sri Lanka is recommended only N (as urea), P (as concentrated superphosphate) and K (as muriate of potash). The use of these P and K fertilizers will also provide Ca and Cl. However, with intensive cultivation and the use of modern high yielding varieties and high levels of NPK fertilizers, other secondary and micronutrients can become limiting as a result of their depletion from soils.

Of the secondary nutrients, sulphur is the one which has been found to be deficient in the lowland rice fields of many Asian countries (Blair, Mamaril and Momuat, 1978). The possibilities of sulphur limiting rice yields in Sri Lanka has already been reported (Lathiff and Amarasiri, 1982).

Among the micronutrients, only zinc has been found to be deficient in lowland rice soils. Zinc was first recognized as an essential micronutrient in 1926 (Sommer and Lipman). Subsequently, numerous instances of zinc deficiency in upland crops have been reported (Sommer, 1928; Viets, 1951). It was first discovered as a field problem in rice on an alkali soil in India by Nene (1956). Subsequently zinc deficiency was observed in calcareous soils (Yoshida and Tanaka, 1969), continuously wet soils (IRRI, 1971 and 1972; Katyal and Ponnampereuma, 1974) and peat soils (IRRI, 1977 and 1978). It is also found to occur in sandy soils low in total zinc (Castro, 1977). Zinc deficiency is extensive and widespread in India, Pakistan and the Philippines. It has also been recognized in Bangladesh, Burma, Indonesia, Japan, Korea, Taiwan and Thailand.

Zinc deficiency is characterized by the blanching at the base of the emerging leaves and by rusty brown to yellow discolouration of the older leaves. These symptoms have been found to appear between 2 to 4 weeks after transplanting (Castro, 1977). In mild cases, plants recover but maturity is delayed. In severe cases, plants may die (Forno, Yoshida and Asher, 1975; Yoshida, Ahn and Forno, 1973).

Several methods of correcting zinc deficiency in rice are available. These are ZnO seed coat at the rate of 1% by weight of the dry seeds (Castro, 1977), 0.5% ZnSO₄ spray at 10 days after transplanting followed by a 0.25% spray 10 days later (Katyal, 1975), seedling root dip in 2% ZnO suspension (Yoshida *et al*, 1970) and soil applications of ZnO and ZnSO₄.7H₂O (Yoshida *et al*, 1973; Katyal & Ponnampereuma, 1974; IRRI, 1971).

This paper deals with some studies on the response of rice to zinc application conducted in farmers' fields located in the mid country wet zone.

MATERIALS AND METHODS

An experiment to test the response of rice to two forms of zinc (ZnO and ZnSO₄.7H₂O) at three levels (10, 20 and 30 kg Zn/ha) was conducted in farmers' fields at Gampolawela (Kandy District) and Kaudupellella (Matale District). The experiment consisted of nine treatments and was a simple randomized complete block design with four replicates at each location. The dipping of rice seedlings in a 2% suspension of zinc oxide in water

ZINC AS A LIMITING NUTRIENT FOR RICE GROWTH

before transplanting as a method of correcting zinc deficiency was also tested in this experiment. One of the treatments received neither zinc nor sulphur. All other treatments received sulphur equivalent to 15.3 kg/ha.

The location at Gampolawela is moderately well-drained and the soil has a high content of available Zn. On the other hand, Kaudupellella is poorly drained with a very low available Zn. The total Zn content of the two soils are of the same order. In addition, the field at Kaudupellella is continuously wet due to upwelling. Some soil characteristics of the two locations are presented in Table 1.

The experiment at Gampolawela was carried out for two consecutive seasons while at Kaudupellella it was for four consecutive seasons. At both locations the experiments were continued by maintaining the same treatments in the same plots.

The plot size at Gampolawela was 4m×4m while plant spacing was 16cm×16cm. At Kaudupellella the plot size was 3m×3m with a plant spacing of 15cm×15cm. At maturity harvesting was carried out after discarding two and four border rows of plants at Kaudupellella and Gampolawela respectively. Panicles were threshed, winnowed and paddy yield corrected to 14% moisture.

RESULTS AND DISCUSSION

There was no significant response to application of zinc at Gampolawela either in yala 1981 or in maha 1981/82 (Table 2 & 4). At the early stages of growth, plants in the treatment where seedlings were dipped in 2% ZnO suspension, showed a somewhat retarded growth which subsequently recovered. The reason for the retarded plant growth is not clear.

At Kaudupellella zinc treated plots generally gave higher yields than those without zinc. The grain yields also increased with increasing levels of zinc (for both ZnO and ZnSO₄.7H₂O) except during maha 1982/83 (Table 3). The response to zinc application was statistically significant except in maha 1982/83 (Table 4).

In yala 1983 where the variety Bg 276-5 was grown, response to levels of zinc was significant and linear with both forms of zinc fertilizer (Table 4).

At both locations there was no difference between ZnO and ZnSO₄.7H₂O. There was also no response to 15.3 kg S/ha at both locations during the period of the experiment.

At Kaudupellella during maha 1981/82 and yala 1982 when Bg 400-1 was grown, yellow to brown discolouration was noticed in the older leaves (mainly in the plots which did not receive zinc) between 3 and 5 weeks after transplanting. There was no noticeable growth retardation. No further discolouration in the leaves appeared after 5 weeks from transplanting. This discolouration did not appear during maha 1982/83 and yala 1983 when 3—3½ month-old varieties were grown.

Kaudupellella soil has a pH of 7.5 and is continuously wet and these conditions are ideal for the occurrence of zinc deficiency (Castro, 1977). Furthermore, available soil zinc as determined by the method of Katyal and Ponnampereuma (1974) is only 0.24 ppm. On the other hand, Gampolawela (pH 5.2) has an available soil zinc of 3.20 ppm (Table 1). The critical level of available soil zinc as determined by this method is 1.0 ppm for soils in the Philippines (IRRI, 1973; Katyal and Ponnampereuma, 1974). On this basis zinc deficiency is unlikely in Gampolawela but highly probable in Kaudupellella. But the rather mild symptom shown (and that too only with the variety Bg 400-1) at Kaudupellella despite its extremely low available soil zinc indicates the need to examine the applicability of this critical level to rice soils in Sri Lanka. It is however, useful to note that the total Zn contents of the two soils are not widely different (Table 1).

Plant analysis is another useful tool for diagnosing zinc deficiency. According to Orticio (1979) zinc deficient plants contain less than 20 ppm Zn in the dry matter of the shoot at 6 weeks after planting or less than 27 ppm Zn in the straw at maturity. In the present study, the plants at Gampolawela contained very much higher zinc than these critical limits (Table 5). On the other hand, at Kaudupellella the values were only marginally different from the critical limits (Table 6). Thus plant analysis has reflected fairly well the observed response to zinc at the two locations.

ACKNOWLEDGEMENTS

The authors thank Mr. A. L. Gunasekera, Biometrician for the statistical analysis, and M/s S. M. Rambanda and P. G. Karunatileka for their assistance in the field work. They also thank Mr. W. G. Nandasiri for typing the manuscript.

ZINC AS A LIMITING NUTRIENT FOR RICE GROWTH

REFERENCES

- Blair, G. J., Mamaril, C. P. and Momuat, E. (1978). Sulphur nutrition of wetland rice. *IRRI Res. Pap. Ser. 21*, 29 p.
- Castro, R. U. (1977). Zinc deficiency in rice: A review of research at the International Rice Research Institute. *IRRI Res. Pap. Ser. 9*, 18 p.
- Forno, D. A., Yoshida, S. and Asher, C. J. (1975). Zinc deficiency in rice. 1. Soil factors associated with the deficiency. *Plant and Soil*, 42, 537—550.
- International Rice Research Institute, (1971). *Annual Report for 1970*, Los Banos, Philippines, 265 p.
- International Rice Research Institute, (1972). *Annual Report for 1971*, Los Banos, Philippines, 238 p.
- International Rice Research Institute, (1973). *Annual Report for 1972*, Los Banos, Philippines, 246 p.
- International Rice Research Institute, (1977). *Annual Report for 1976*, Los Banos, Philippines, 548 p.
- International Rice Research Institute, (1978). *Annual Report for 1977*, Los Banos, Philippines, 478 p.
- Katyal, J. C. (1975). Zinc-deficient soils of India. *International Rice Conference*, Los Banos, Philippines, April 21—24.
- Katyal, J. C. and Ponnampereuma, F. N. (1974). Zinc deficiency: A widespread nutritional disorder of rice in Agusan del Norte. *Philipp. Agric. J.* 58, (3 & 4), 79—89.
- Lathiff, M. A. and Amarasiri, S. L. (1982). Responses to sulphur fertilization in rice soils of Sri Lanka. *Trop. Agricst.* 138, 93—98.
- Nene, Y. L. (1966). Symptoms, cause and control of Khaira disease of paddy. *Bull. Ind. Phytopathol. Soc.* 3, 97—101.
- Orticio, M. R. (1979). Zinc deficiency: A widespread nutritional disorder of rice in the Philippines. *Saturday Seminar IRRI*, Los Banos, Philippines, March 10, 8 p.
- Sommer, A. L. (1928). Further evidence of the indispensable nature of zinc for higher plants. *Plt. Physiol.* 3, 217—221.
- Sommer, A. L. and Lipman, C. B. (1926). Evidence for the indispensable nature of zinc and borax for higher plants. *Plt. Physiol.* 1, 231—249.
- Viets, F. G. Jr. (1951). Zinc deficiency of corn and beans on newly irrigated soils in Central Washington. *Agron. J.* 43, 150—151.
- Yoshida, S., Ahn, J. S. and Forno, D. A. (1973). Occurrence, diagnosis and correction of zinc deficiency in lowland rice. *Soil Sci. and Plant Nutr.* 19 (2), 83—93.
- Yoshida, S., Mclean, G. W., Shafi, M. and Muller, K. E. (1970). Effects of different methods of zinc application on growth and yields of rice in a calcareous soil, West Pakistan, *Soil Sci and Plant Nutr.* 16 (4), 147—149.
- Yoshida, S. and Tanaka, A. (1969). Zinc deficiency of the rice plant in calcareous soils. *Soil Sci and Plant Nutr.* 15, 75—80.

Table 1. Some properties of the experimental soils

Location	Texture	pH	Organic	Total	Exch. K	P		Zn (ppm)	
			matter %	N %	meq/ 100g	Total** %	Avail* ppm	Total**	Avail***
Gampolawela	Clay	5.2	5.6	0.30	0.24	0.09	10.0	138	3.20
Kaudupellella	Sandy loam	7.5	3.6	0.15	0.12	0.03	10.2	108	0.24

*Olsen's method, **Perchloric acid method,
***Method of Katyal and Ponnampereuma (1974)

Table 2. Grain yield response to application of zinc fertilizer at Gampolawela (t/ha)

Zinc application		Season	
kg Zn/ha	Form	yala 1981	maha 1981/82
0 (Without S)	—	5.80	6.37
0 (With S)	—	6.08	6.56
10	ZnO	5.98	6.10
20	ZnO	5.88	6.30
30	ZnO	5.93	6.30
10	ZnSO ₄ .7H ₂ O	6.24	6.47
20	ZnSO ₄ .7H ₂ O	6.33	6.48
30	ZnSO ₄ .7H ₂ O	5.69	6.33
2% Dip	ZnO	5.50	6.39
C. V. %	—	7.2	4.2
Rice Variety	—	Bg 276-5 (3m)	Bg 400-1 (4½m)

All treatments received N,P,K according to the recommendations of the Department of Agriculture which is 99.4 kg N, 55.6 kg P₂O₅ and 43.2 kg K₂O per ha for 4—4½ month-old varieties and 85.2 kg N, 55.6 kg P₂O₅ and 43.2 kg K₂O per ha for 3—3½ month-old varieties. All except the no sulphur (S) treatment received S equivalent to that coming from 30 kg Zn/ha as ZnSO₄.7H₂O (i.e. 15.3 kg S/ha). Any balance S was given as gypsum (CaSO₄.2H₂O). (3m)=3 months, (3½m)=3½ months and (4½m)=4½ months.

ZINC AS A LIMITING NUTRIENT FOR RICE GROWTH

Table 3. Grain yield response to application of zinc fertilizer at Kaudupeliella (t/ha)

<i>Zinc application</i>		<i>Season</i>			
<i>kg Zn/ha</i>	<i>Form</i>	<i>maha 1981/82</i>	<i>yala 1982</i>	<i>maha 1982/83</i>	<i>yala 1983</i>
0 (Without S)	—	4.62	4.37	4.19	5.61
0 (With S)	—	4.18	4.33	4.74	5.53
10	ZnO	5.16	4.48	5.19	5.96
20	ZnO	5.19	4.83	4.96	6.62
30	ZnO	5.46	5.34	5.48	7.17
10	ZnSO ₄ ·7H ₂ O	4.81	4.83	4.80	6.01
20	ZnSO ₄ ·7H ₂ O	5.10	4.97	4.26	6.46
30	ZnSO ₄ ·7H ₂ O	5.62	4.99	5.74	6.87
2% Dip	ZnO	5.41	4.73	3.89	5.79
C.V. %		11.7	5.8	17.3	6.8
Rice Variety		Bg 400-1(4½m)	Bg 400-1(4½m)	Bg 94-1(3½m)	Bg 276-5 (3m)

Details of N,P,K and S application were same as that given under Table 2.

Table 4. Analysis of variance

	<i>Gampolawela</i>		<i>Kaudupellella</i>			
	<i>yala 1981</i>	<i>maha 1981/82</i>	<i>maha 1981/82</i>	<i>yala 1982</i>	<i>maha 1982/83</i>	<i>yala 1983</i>
Replicates	*	**	*	**	**	**
Treatments	n.s	n.s	almost*	*	n.s	**
Zn vs No Zn	n.s	n.s	**	*	n.s	**
Dip vs Soil Treat.	*	n.s	n.s	n.s	*	**
Soil Treat.	n.s	n.s	n.s	n.s	n.s	**
ZnO vs ZnSO ₄	n.s	n.s	n.s	n.s	n.s	n.s
Within ZnO	n.s	n.s	n.s	*	n.s	**
ZnO linear	n.s	n.s	n.s	**	n.s	**
Dev. from linear	n.s	n.s	n.s	n.s	n.s	n.s
Within ZnSO ₄	n.s	n.s	n.s	n.s	n.s	*
ZnSO ₄ linear	n.s	n.s	n.s	n.s	n.s	**
Dev. from linear	n.s	n.s	n.s	n.s	n.s	n.s

*Significant at 5% level,

**Significant at 1% level,

n.s. = not significant

Table 5. Zn content in plant (ppm)—Gampolawela

<i>Treatment</i>	<i>Season</i>			
	<i>yala 1981</i>		<i>maha 1981/82</i>	
	<i>Leaf*</i>	<i>Straw</i>	<i>Leaf*</i>	<i>Straw</i>
Without Zn	56	160	40	90
With Zn	59	159	49	96
Rice Variety	Bg 276-5		Bg 400-1	

*6 weeks after transplanting

Table 6. Zn content in plant (ppm)—Kaudupellella

<i>Treatment</i>	<i>Season</i>							
	<i>maha 1981/82</i>		<i>yala 1982</i>		<i>maha 1982/83</i>		<i>yala 1983</i>	
	<i>Leaf*</i>	<i>Straw</i>	<i>Leaf*</i>	<i>Straw</i>	<i>Leaf*</i>	<i>Straw</i>	<i>Leaf*</i>	<i>Straw</i>
Without Zn	33	38	27	23	24	16	28	20
With Zn	35	37	31	25	28	19	29	24
Rice Variety	Bg 400-1		Bg 400-1		Bg 94-1		Bg 276-5	

*6 weeks after transplanting