Enhancing Effect of Micronutrients on the Grain Production of Toria (*Brassica Campestris Duth. Var. Toria*) in Chitwan Valley

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Abstract

Experiments were conducted during 2001 and 2002 in farmers' fields as well as on the farmland of the National Maize Research Programme (NMRP) to evaluate the effects of different micronutrients, namely, boron (B), zinc (Zn), sulphur (S), and agricultural lime (calcium [Ca], and magnesium [Mg]) on the grain production of toria (Brassica campestris Duth. Var Toria). Plant growth (plant height, branch numbers, and pod numbers per plant) was significantly affected by the use of different micronutrients on toria crops when planted in the farmers' fields, but the increase was not significant at the research farmland of NMRP, Rampur. Application of B, Zn, and S produced the highest grain yield (1115 kg/ha) of toria under farmers' field conditions. Sulphur and boron together produced only 1077 kg/ha. The productivity of toria was very low on the research farmland of NMRP. Similar amounts of Zn, B, and S micronutrients produced only 568 kg grains/ha. Approximately 55% increment in yield over the control plot in farmers' field conditions and 52% on research farmland were observed when the crop was supplied with S, Zn, and B. The results suggest that the soil type, production environment, and management practices were quite different between the farmer's field and the research farmland. Nevertheless, they showed that the application of micronutrients (S, B, and Zn) is essential for achieving higher yields.

Introduction

Micronutrients are elements with specific and essential physiological functions in plant metabolism (Epstein 1965). Compared to macronutrients, micronutrients are required for growth in lower amounts and serve mainly as activators of enzyme reactions. The most characteristic visible symptoms of zinc (Zn) deficiency in dicotyledons are short internodes (rosetting) and a decrease in leaf expansion (little leaf). Stunted growth is often combined with chlorosis of the youngest leaves. In monocotyledons, chlorotic bands occur along the midribs of leaves combined with red, spot-like discoloration. Zinc deficiency symptoms on older-leaves are mainly the result of phosphorous-toxicity (Marschner and Cakmak 1986). Plant species differ considerably in their boron (B) requirements. The concentration range between B-deficiency and B-toxicity is quite narrow, so special care is required when B-fertiliser or composts rich in boron are applied (Romheld and Marschner 1991). Boron deficiency symptoms appear at the terminal buds and in the youngest leaves as retarded growth or necrosis. The diameters of stem and petioles are increased. The latter may lead to symptoms such as stem crack. Boron deficiency induces an increase in the drop of buds, flowers, and developing fruits. In addition to the reduction or even failure of seed and fruit set, the quality of fruit is often affected by malformation (Romheld and Marschner 1991). The total concentration of boron in most soils varies from 2-200 mg per kg, and less than 5% of the total soil boron is generally available to plants (Das 2002). Sulphur (S) deficiency is rarely a primary constraint in acid tropical soils but can readily become a problem once they are brought into intensive cropping systems. Sulphur deficiency is now recognised to be widespread in intensive cropping systems (Probert and Samosir 1983). Many tropical soils have much lower total and available sulphur contents than temperate soils (Neptune et al. 1975). Burning the vegetation during land clearance depletes soil S-reserves by releasing large amounts into the atmosphere. According to Kamprath and Till (1983) 5-7 ppm of S are needed in the soil solution of highly-weathered soils to enable most crops to make good growth. Crops differ widely, however, in their S requirements. Oilseeds (toria), grain legumes, and cotton have high S requirements. Micronutrients such as sulphur (S) and boron (B) have been found deficient in the maize- growing soils of Chitwan Valley. Thus, these elements should be applied to increase yields (Pandey and Srivastava 1987). Pandey and Srivastava (1987) conducted experiments on micronutrients at Rampur for five years and reported that S and B were the nutrient elements limiting yields under Rampur's soil conditions. Sulphur is a major nutrient that is rarely in the spotlight. Plants that have insufficient S show characteristic symptoms that may resemble those of N-starvation. Khhatri-Chhetri (1982) studied the role and occurrence of major and micronutrients in the soils of Chitwan Valley. He recognised the deficiencies of primary, secondary, and micronutrients in these soils. Srivastava and Neupane (1997) carried out long-term fertility trials on maize-toria rotations.

Srivastava and Neupane (1997) reported that the fourth toria crop yield had seriously declined with all treatment applications compared to that of the second crop of toria in a five-year study cycle. The fourth crop of toria produced the highest grain yield of 364.3 kg/ha in the plots that received 100:40:30 kg NPK/ha plus 20 kg sulphur, one kg of boron and one ton of dolomitic lime applied to the 3^{rd} crop of maize. The residual effects of micronutrients to toria production were observed to be positive in this experiment. Toria (*Brassica campestris*) and rapeseed yield the most important edible oils. The oil content of the seeds ranges from 30 to 48%. Toria is an annual plant and is more or less surface fed, enabling its successful cultivation under drier conditions. The crop is grown in both tropical and sub-tropical countries. India occupies the first position in the world with regard to both acreage and production of toria and rapeseed. Toria thrives best in light to heavy loam soils. Forty kg nitrogen (N) is optimum for all rapeseed and toria crops in rainfed areas. Besides nitrogen, toria requires sulphur and other micronutrients, especially boron, for increased grain yield production in Chitwan soils as they are not present in sufficient quantity for good crop growth. Singh (1983) recommended sulphur application along with NPK fertilisers at 60-90 kg N, 60 kg P_2O_5, and 40 kg K_2O/ha to toria crops. Tuladhar et al. (2004) reported that Chitwan soils (196 composite samples) were deficient in B and zinc (Zn) but sufficient in copper (Cu), iron (Fe), and manganese (Mn). More than 50% of samples collected were found to be high in Cu and Fe, whereas 100% of soils were found to be low in B and Zn. The overall objective of the study described here was to increase toria grain yield using micronutrients in Chitwan soils.

Materials and Methods

Field experiments on the use of micronutrients with toria (*Brassica campestris* Duth. Var. Toria) were carried out in a farmer's field at Sukra Nagar, Chitwan, in 2001 and on-station (OS) on the farmland of the National Maize Research Programme (NMRP) in 2002 to evaluate the effects of different micronutrients on plant growth and grain production. A local variety of toria was used in the experiments. A randomised complete block design (RCBD) with three replications was used at both sites. A total of eight treatments, see below, were used in the experiment. The farmer's practice treatment was excluded from the experiment carried out on NMRP farmland. Fertilisers were applied on all the plots at the rate of 60:40:20 kg $N:P_2O_5:K_2O$ per ha except on the farmer's practice plots. In one treatment, NPK was supplied by single super phosphate (SSP), ammonium sulphate (AS), and muriate of potash (MOP), in all others from urea, diammonium phosphate (DAP), and muriate of potash (MOP). In one treatment no micronutrients were added, in another agricultural lime was added instead of micronutrients in the form of fertiliser. Micronutrients were added to the selected plots at the rate of 20 kg sulphur (elemental S), 10 kg borax, and 5 kg of Zn/ha from zinc chloride ($ZnCl_2$), with one treatment including all three micronutrients and the other treatments two each of the three. The toria seeds were broadcast on 20 sq.m plots (4 x 5m). The crop was sown in the month of Kartik (November) and harvested in Magh (February). The plant growth characteristics and grain yield were recorded and analysed statistically using the least square deviation (LSD) method (Gomez and Gomez 1984). The treatments are listed below.

- T1 = farmer's practice (0.5 kg/plot of oil-cakes; treatment not used in on-station research).
- T2 = per ha: no micronutrient application, + 60:40:20 kg $N:P_2O_5:K_2O$ from urea, diammonium phosphate (DAP), and muriate of potash (MOP)
- T3 = per ha: 10 kg borax + 5 kg Zn + 20 kg elemental sulphur + 60:40:20 kg $N:P_2O_5:K_2O$ from urea, DAP, and MOP
- T4 = per ha: 10 kg borax + 5 kg Zn + 60:40:20 kg $N:P_2O_5:K_2O$ from urea, DAP, and MOP
- T5 = per ha: 5 kg Zn + 20 kg elemental sulphur + 60:40:20 kg $N:P_2O_5:K_2O$ from urea, DAP, and MOP
- T6 = per ha: 10 kg borax + 20 kg elemental sulphur + 60:40:20 kg $N:P_2O_5:K_2O$ from urea, DAP and MOP
- T7 = per ha: 60:40:20 kg $N:P_2O_5:K_2O$ from ammonium sulphate (AS), single super phosphate (SSP), and muriate of potash (MOP)
- T8 = per ha: 2t of agricultural lime plus 60:40:20 kg $N:P_2O_5:K_2O$ from urea, DAP and MOP

Results and Discussion

Response of micronutrients on plant growth of toria

Plant height, production of branch numbers, and pods per plant of toria (*Brassica campestris* Duth. Var. Toria) were significantly affected by the application of micronutrients under farmer's field conditions at Sukra Nagar, Chitwan (FF) (Table 1). The effects on plant height, branch numbers, and pod production observed on-station (OS) were not significant. The tallest plant height of 76.3 cm was observed when the crop was treated with S, B, and Zn with NPK (T3) whereas the lowest plant height of 56 cm was observed at the 'farmer's practice' plots which were only treated with oil-cakes (T1) in farmer's fields (FF). The highest number of branches (7.2 branches per plant) was produced by the crop treated only with S and B with NPK and the lowest number of branches (3.2 branches per plant) was also produced in 'farmer's practice' plots (T1). No significant effects on branch production were observed when the crop was planted on the farmland of NMRP (OS) at the same levels of fertilisation and micronutrient application (Table 1). In the farmer's field trials, the highest pod numbers (104.3 pods per plant) were produced when the crop was supplied with NPK from ammonium sulphate, single super phosphate, and muriate of potash (T7) followed by the crop treated with S and B plus NPK supplied from urea, DAP, and MOP (T6, Table 1). Production of the highest number of grains per pod (16.6) was obtained when the crop was treated with B and Zn plus NPK in the farmer's field (T4); but the effects of micronutrients were not significant (Table 1). On station, the highest number of grains per pod (10.4) was produced when the crop was supplied with S, B, and Zn plus NPK (T3) and the lowest (6.6) when the crop was fertilised only with NPK from urea, DAP, and MOP (T2). Application of NPK from AS, SSP, and MOP (T7) led to better grain production (7.7 grains per pod) than application of NPK from urea, DAP, and MOP (6.6 grains per pod) (T2, Table 1).

Table 1: **Plant growth of toria as affected by micronutrient applications in farmer's field (FF) conditions and in the NMRP on -station- farmland (OS)**

Treatment	Plant height (cm)		Branch numbers (no.)		Pods per plant (no.)		Grains per pod (no.)	
	FF	OS	FF	OS	FF	OS	FF	OS
T1	56.0	ND	3.2	ND	36.3	ND	14.2	ND
T2	65.3	51.6	5.2	2.6	60.3	75.3	15.0	6.6
T3	76.3	62.0	6.8	2.6	94.3	104.6	14.5	10.4
T4	73.3	56.3	6.1	2.4	92.3	78.6	16.6	8.3
T5	67.0	58.3	6.2	2.6	87.3	99.0	16.0	8.9
T6	68.3	55.0	7.2	2.9	100.0	92.3	11.7	8.4
T7	71.3	59.3	6.2	2.5	104.3	86.0	14.1	7.7
T8	66.0	57.3	5.3	2.6	76.3	78.3	14.0	7.1
CV (%)	4.36	18.26	15.57	9.10	9.69	15.94	4.90	14.90
F-test	***	NS	***	NS	***	NS	NS	*
LSD (0.05)	5.31	18.55	1.59	0.42	13.80	24.89	3.73	2.18

FF = farmer's field; OS = on -station; ND = not done; NS = not significant; LSD = least square deviation

Effects of micronutrients on toria yield

Table 2 shows the response of straw and grain yield to the different treatments. The impact of micronutrients on grain yield was highly significant. The highest grain yield of 1115 kg/ha was recorded when the crop was treated with S, B, and Zn plus NPK (T3) followed by treatment with S and B plus NPK (1076.6 kg/ha, T6), both under farmer's field conditions (FF). The lowest yield under FF conditions (605 kg /ha) was from the 'farmer's practice' plot (T1). The crop produced higher yields (985.3 kg/ha) when fertilised with NPK from AS, SSP, and MOP (985.3 kg/ha, T7) than with NPK from urea, DAP, and MOP (715.6 kg/ha, T2). The response of grain yield on-station was not significant, but as in the FF experiments, the highest grain yield (568 kg/ha) was also recorded following treatment with S, B, and Zn plus NPK (T3) and the lowest (372 kg/ha) following treatment with only NPK from urea, DAP, and MOP (T2). The latter was also lower than the yield obtained following application of NPK from AS, SSP and MOP (553 kg/ha, T7).

The effect of micronutrients on straw yield production (Table 2) was significant under farmer's field conditions with the highest straw yield (3440 kg/ha) observed when the crop was treated with S, B, and Zn (T3). The effects on-station were not significant but the highest straw yield (1013.3 kg/ha) was obtained after treatment with NPK alone from AS, SSP, and MOP (T7) and the lowest with NPK alone from urea, DAP, and MOP (T2).

Table 2: **Response of micronutrients on the straw and grain yield of toria**

	Grain yield production (kg/ha)		Straw yield production (kg/ha)		Yield increment (%)		
	FF	OS	FF	OS	Over T1 in FF	Over T2 in FF	Over T2 in OS
T1	605.0	ND	2048	ND	00.00	0.00	0.00
T2	715.6	372.0	2560	556.6	18.18	0.00	0.00
T3	1115.0	568.0	3440	813.3	84.29	55.81	52.68
T4	990.0	500.0	3170	790.0	63.63	38.34	34.40
T5	961.7	524.0	3220	653.3	58.95	34.39	40.86
T6	1076.6	508.0	3300	931.6	77.95	50.44	36.55
T7	985.3	553.0	3200	1013.3	62.85	37.68	48.65
T8	756.6	443.0	3160	663.3	25.05	5.72	19.08
CV (%)	6.30		8.90	26.41	41.4		
F-test	***		***	NS	NS		
LSD (0.05)	99.49		463.0	318.4	319.46		

FF = farmer's field; OS = on -station; ND = not done; NS = not significant; LSD = least square deviation

Conclusions

1. Plant height, branch numbers, and pod production per plant were significantly affected by the application of micronutrients under farmer's field conditions, but not on the farmland of NMRP. The highest pod number (104.3 pods /plant) was produced when the crop was supplied with NPK from ammonium sulphate (AS), single super phosphate (SSP), and muriate of potash (MOP) followed by the crop treated with sulphur and boron plus NPK supplied from urea, DAP, and MOP.

2. The impact of micronutrients on grain production was observed to be significant when the crop was planted in the farmer's field, but not on the farmland of the NMRP. The highest grain yield in the farmer's field (1115 kg /ha) was obtained when the crop was treated with B, Zn, and S plus NPK fertilisers; the yield was more than 80% higher than with the usual farmer's practice. The highest grain yield on-station (568 kg/ha) was also recorded when the crop was treated with B, Zn, and S plus NPK fertilisers, and the lowest (372 kg/ha) when the crop was supplied only with NPK fertilisers from urea, DAP, and muriate of potash.

3. The highest straw yield (3440 kg/ha) was observed under farmer's field conditions, after treatment with S, B, and Zn plus NPK.

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References

Das, D.K. (2002) *Micronutrients: their behavior in soils and plants*. New Delhi: Kalyani Publisher

Epstein, E. (1965) 'Mineral metabolism'. In Bonner, J.; Varner, J.E. (eds) *Plant biochemistry*, p 438-466. New York: Academic Press

Gomez, K.A.; Gomez, A.A. (1984) *Statistical procedures for agricultural research.* New York: Wiley Interscience

Khatri-Chhetri, T.B. (1982) *Assessment of soil test procedures for available boron and zinc in the soils of Chitwan Valley, Nepal*. Ph.D. Thesis submitted to the University of Wisconsin, Madison, USA

Marschner, H.; Cakmak, I. (1986) 'Mechanism of P-induced Zn deficiency in cotton, II. Evidence for impaired shoot control of P uptake and translocations under Zn deficiency'. In *Physiol. Plant.,* 68: 491-496

Neptune A.M.L.; Tabatabai, M.J.; Hanway, J.J. (1975) 'Sulphur fraction and carbon-nitrogen-phosphorous-sulphur relationships in some Brazilian and Iowa soils'. In *Proc. Soil Science Society of America,* 39: 51-55

Pandey, S.P.; Srivastava, S.P. (1987) *Identification of grain yield limiting nutrient elements in the soils of Chitwan Valley*. Paper presented at working group meeting held in 1987 at Khumaltar, Lalitpur, Nepal

Romheld, V.; Marschner, H. (1991) 'Function of micronutrients in plants'. In Mortvedt, J.J; Cox, F.R.; Shuman, L.M.; Welch, R.M. (eds) *Micronutrients in agriculture,* No.4, pp.297-328. Wisconsin (USA): Soil Science Society of America

Singh, S. (1983) 'Oil seed crops'. In G.B. Pant University of Agriculture and Technology *Modern techniques of raising field crops*, pp.263-342. New Delhi: Oxford and IBH

Srivastava, S.P.; Neupane, D.D. (1997) 'Long-term fertility trial on maize-toria rotation'. In *Maize Research in Nepal*, Proc. 20th National Summer Crops Workshop held in RARS, Parwanipur, Bara, Nepal, 22-24 April, 1997, pp 165-174. Kathmandu: Nepal Agricultural Research Council

Tuladhar, J.; Sah, K.; Lauren, J.G. (2004) 'Nutrient status of soils of Chitwan District'. In *Abstracts of the 4th National Conference on Science and Technology, March 23-26, 2004, Kathmandu, Nepal*, p 99. Kathmandu: Royal Nepal Academy of Science and Technology (RONAST)