Title
Evaluation of manganese efficiency of wheat (Triticum aestivum L.) and raya (Brassica juncea L.) grown in manganese-deficient soils

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Introduction

In Punjab, Mn deficiency is severe on coarse textured soils; with alkaline and calcareous reaction where wheat is followed by rice due to reduction and leaching losses of Mn in soil. A major difficulty in managing severe Mn deficiency is the low efficiency of soil applied Mn at high soil pH (Nayyar *et al*., 1985). The common method of correcting Mn deficiency is the foliar application of Mn in the form of three sprays with 0.5 per cent manganese sulphate, which appears to be a temporary solution. Further, under severe Mn deficiency, even foliar application of Mn may prove less efficient if not done at right time. Moreover, low Mn efficiency of durum wheat cultivars was related to their reduced root growth at low soil Mn supply and lower internal Mn requirement (Sadana *et al.,* 2005).

In these circumstances, improving the ability of crops to mine Mn under Mn-deficient soil conditions provides a cost effective means of increasing yield. The preferable approach could be sowing of Mn efficient crop species that can grow well on low Mn soils and also help to ameliorate Mn deficiency in the following crops by mobilization of Mn in the rhizosphere. Crop species also vary widely in their Mn efficiency. Krahmer and Sattelmacher (2001) reported that wheat had the strongest yield decrease under Mn deficiency conditions and thus the lowest Mn efficiency amongst 16 crop species tested in pot culture experiment on Mn deficient peat soil. Further research work needs to be carried out to identify most promising and Mn mobilizing crop species which can grow well on Mn deficient soil. Wheat is the main *rabi* crop and raya is one of the important oil seed crops grown in Punjab. Therefore, the present investigation was planed to study Mn efficiency of wheat and raya under field conditions on Mn-deficient soils.

Methods

Four manganese deficient fields were selected to study the response of wheat and raya to 0.5% foliar spray of manganese sulphate in Ludhiana district of Punjab. The experimental soils had pH range from 7.8 to 8.2 and DTPA-extractable Mn from 2.68 to 3.24 mg kg^{-1} soil. Wheat (cv PBW 343) and raya (cv RLM 619) were sown at all the four sites. The experiments were laid down in a randomized block design with three replications. Recommended doses of 125 kg N/ ha and 62.5 kg P_2O_5 /ha to wheat and 100 kg N/ ha and 62.5 kg P_2O_5 /ha to raya were applied through urea and di ammonium phosphate, respectively. The treatment consisted of control and three foliar sprays with 05% solution of $MnSO_4.H_2O$ at weekly interval. Shoot and root samples of wheat and raya were collected after 60 days of growth from experiment 1 to study root-shoot relations and Mn uptake by wheat and raya. The grain and straw yields of both the crops were recorded at maturity from all the experiments and grain and straw samples were collected for analysis. Roots from experiment 1 were carefully separated from soil by washing and floating over the sieves. After cleaning of any foreign material, roots were kept between two filter papers to remove surface water. Root length (RL) was measured by line interception method of Tennant (1975).

Results and discussions

After 35 days of growth, wheat crop grown under Mn deficiency conditions showed severe Mn deficiency symptoms in the form of chlorotic spots in the interveinal area at the basal part of the middle leaves. These spots later extended towards the tip. On the other hand no Mn deficiency symptoms were observed in raya. Under Mn deficiency conditions, wheat produced 57 per cent of its maximum dry matter yield (DMY) with 47 per cent of its maximum root length (RL), while raya produced 94 per cent of its maximum DMY with 80 percent of its maximum RL at 60 days of growth. Shoot Mn concentration of raya was 22.3 mg/ kg DW, whereas wheat could take up only 12.3 mg Mn /kg DW on Mn-deficient soil. Spray application of 0.5% $MnSO_4.H_2O$ solution significantly increased wheat DMY, but there was no significant effect of Mn spray on raya DMY. Raya had 2.3 times higher root length than that of wheat in no-Mn treatment but the RL/DMY ratio of wheat and raya was almost same (Table 1). This was due to 2.2 times higher DMY of raya. Spray application of Mn significantly increased RL/DMY ratio of both the crops which shows that under Mn deficiency conditions, the size of the root system became smaller for supplying Mn to the shoot. A reduced root growth at Mn deficiency was also observed for tomato by Abbott (1967) who found that cell elongation was impaired and formation of lateral roots ceased. Nable and Loneragan (1984) observed in a split root experiment that the portion of the root system devoid of Mn was reduced to half.

Table 1 Dry matter yield (DMY), root length (RL), Mn uptake, root surface area (RSA) and RL: SDW ratio of wheat and raya as influenced by spray application of Mn at 60 days of growth

No. of 0.5% Mn sprays	DMY (mg/ plant)	RL (cm/ plant)	RSA (cm^2 /plant)	RL/ DMY ratio (cm/ mg)	Mn concentration (mg/ kg DW)	Mn uptake (nmol/ plant)
Wheat						
0	565	3123	274	5.53	12.3	127
3	987	6678	575	6.77	21.1	379
CD (5%)	49	190	29	0.45	1.7	17
Raya						
0	1251	7061	514	5.64	22.3	508
3	1332	8876	698	6.66	29.3	711
CD (5%)	NS	610	41	0.58	2.3	46

The grain yield of wheat in no-Mn treatment varied from 27.4 to 36.4 q/ ha with the mean values of 32.9 q/ha in all the four field experiments. Foliar application of 0.5% $MnSO_4.H_2O$ solution significantly increased the wheat grain yield at all the sites, but the magnitude of response varied among the sites which appeared to be dependent upon the severity of Mn deficiency. The grain yield of wheat ranged between 43.4 and 50.4 q/ ha with mean value of 47.4 q/ ha with the application of three sprays of 0.5% $MnSO_4.H_2O$ solution. The results showed that wheat produced 63 to 75 per cent of its maximum yield in no Mn treatment in all the four experiments. However, raya produced 96 to 98 per cent of its maximum yield under Mn deficiency conditions in all the experiments. This revealed no significant response of raya to foliar application of Mn. As such the two investigated crops differed appreciably in utilizing the limited supply of Mn available from the soil. The results further divulged that wheat is more sensitive as compared to raya to the same level of Mn deficiency in soil.

Considering relative DMY and grain yield as parameters of Mn efficiency, raya was more efficient than wheat under Mn deficiency conditions. The results showed that raya could take up 1.2 to 1.9 times more Mn than wheat in all the experiemnts. Higher Mn uptake by raya than wheat even under Mn deficiency conditions could be due to its 1.9 times larger root surface area that could exploit Mn from a greater volume of soil. Higher Mn uptake by raya even under Mn deficiency conditions showed that raya is more tolerant to Mn deficiency conditions than wheat. Similar results were reported by Krahmer and Sattelmacher (2001) in pot experiment, who found that spring oilseed rape (*Brassica napus*) produced 90 per cent of its maximum yield, whereas wheat produced only 14 percent of its maximum yield on Mn deficient peat soil.

References

Nayyar VK, Sadana US, Takkar PN. Methods and rates of application of Mn and its critical levels for wheat following rice on coarse textured soils. Fertilizer Research, 1985; 8: 173-178.

Sadana US, Sharma P, Castañeda ON, Samal D, Claassen N. Manganese uptake and Mn efficiency of wheat cultivars explained by root growth and Mn uptake kinetics. Journal of Plant Nutrition and Soil Science, 2005;168: 581-589.

Krahmer R, Sattelmacher B. Determination of Cu and Mn efficiency of crop plants in pot experiments. In *Plant Nutrition - Food security and sustainability of agro-ecosystem through basic and applied research*; Horst, W.J. et al. Eds.; Kluwer academic publishers: The Netherlands; 2001: 118-119.

Tennant D. A test of a modified line intersect method of estimating root length. Journal of Ecology, 1975; 63: 995-1001.

Abbott AJ. Physiological effects of micronutrient deficiencies in isolated roots of *Lycopersicon esculentum*. New Phytology, 1967; 66: 419-437.

Nable RO, Loneragan JF. Translocation of manganese in subterranean clover (*Trifolium subterraneum* L. cv. Seaton Park). II. Effects of leaf senescence and of restricting supply to part of a split root system. Australian Journal of Plant Physiology, 1984; 11: 113-118.