Critical levels of Mn in coarse textured rice soils in India for predicting response of barley to Mn application

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Abstract. Green house studies of 20 soils, having a range in DTPA extractable Mn, were made to determine the critical deficiency level of Mn for predicting response of barley to Mn application. Soil Mn was significantly related with both Bray's per cent dry matter yield ($r = 0.70^{**}$) and Mn uptake ($r = 0.65^{**}$). Soil application of 25 mg Mn kg$^{-1}$ soil significantly increased yield. Both graphical and statistical models of Cate and Nelson indicated the critical level to be 2.05 mg kg$^{-1}$ soil of DTPA extractable Mn. The critical Mn deficiency level in 45 day barley plants was 18.6 mg kg$^{-1}$ dry matter. The predictability of soil and plant critical Mn level was 91 and 80 per cent respectively.

Manganese deficiencies are most often observed on well-drained neutral or calcareous soils [7]. Recently wide spread Mn deficiency has occurred in upland cereals and fodders grown on coarse textured alkaline soils cropped with rice for 5–7 years or more in Punjab, India [8, 12]. Although there have been spectacular responses to applied Mn, information is lacking on the critical level of Mn and the Mn requirement of barley grown on such soils. 1 mg kg$^{-1}$ DTPA extractable Mn is said to be critical for wheat [6], but response to applied Mn and deficiency symptoms have been observed on soils testing greater than 1.0 or less than 3.5 mg Mn kg$^{-1}$ soil [8]. The present greenhouse investigation was therefore undertaken to study:—

(1) the response of barley to Mn application to soils with a range of DTPA extractable Mn

(2) the critical limit of the DTPA-Mn in these soils.

Methods and materials

Twenty soil (0–15 cm) samples representing a range in DTPA extractable Mn were collected from coarse textured rice fields in Ferozepur and Faridkot districts of Punjab, India. The soils belong to great group Ustipsamments and Ustifluvents. Each soil was air dried, ground in a wooden mortar to pass a 2 mm sieve. A greenhouse pot culture experiment was conducted with barley, variety DL 70, as a test crop. Each pot was filled with 3 kg of soil in a polythene bag and the soils were treated uniformly with a solution supplying 100, 50, 50 and 5 mg kg$^{-1}$ soil elemental N, P, K and Zn respectively. Manganese
was added at the rate of 0, 25, 50 and 100 mg kg\(^{-1}\) soil as MnSO\(_4\) \(\cdot\) H\(_2\)O solution. There were 3 replicates. Ten seeds were sown in each pot and were thinned to four after emergence. The soil was initially adjusted to approximately 60 per cent water holding capacity and losses were made up by daily watering.

Plants were harvested at 45 days by cutting at the soil surface. These were washed successively with 0.1 N HC\(_1\), distilled and deionized water, oven dried, weighed, ground in a Wiley mill to pass a 40 mesh stainless steel screen. The plant samples were wet ashed with nitric-perchloric-sulphuric acid mixture.

The soils were analysed for pH, organic carbon, CaCO\(_3\) and available P according to the standard procedures [1], and K by extraction with neutral normal ammonium acetate solution. The soil texture was determined by the hydrometer method [11]. The DTPA method [6] was employed for the estimation of initial available Mn. Manganese in the soil filtrates and plant extracts was measured by atomic absorption spectrophotometry.

Bray's per cent yield as well as Mn uptake were chosen to evaluate the parameter of soil Mn availability and were calculated as:

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\frac{\text{Yield or uptake without Mn application}}{\text{Yield or uptake with optimum Mn application}} \times 100
\]

The critical deficiency level on Mn in soil and plant was determined by the procedure of Cate and Nelson [3, 4].

Results and discussion

The soils under study were coarse textured, loamy sands; alkaline in reaction, pH 8.7 to 9.1; non-calcareous, CaCO\(_3\) 0.5 to 1.7%; low in organic carbon, 0.18 to 0.45%; low in available P, 2 to 12 mg kg\(^{-1}\) soil and medium in K, 39 to 89 mg kg\(^{-1}\) soil (Table 1). There was a wide variation in soil available Mn. Consequently the dry matter yield and Mn uptake also varied markedly (Table 2).

\textbf{Soil critical deficiency level and response to Mn}

The DTPA extractable soil Mn was significantly correlated with Bray's per cent yield (\(r = 0.70^{**}\)), Bray's per cent Mn uptake (\(r = 0.63^{**}\)) and dry matter yield (\(r = 0.61^{**}\)) as well as Mn content (\(r = 0.63^{**}\)) of plants grown in the control treatments indicating that the DTPA extractant was a good indicator of soil Mn status.

The method described by Cate and Nelson [3] was used to determine critical deficiency level of soil Mn. The method consists in plotting Bray's per cent yield against soil Mn. A cross is placed over the data and moved until the upper left and lower right-quadrants have a minimum number of points (Figure 1a). The critical deficiency value is read from the X-axis where the cross intercepts it. This value can also be computed using the statistical model.