# A PRELIMINARY EVALUATION OF RESIN EXTRACTABLE MOLYBDENUM AS A SOIL TEST

G.S.P. Ritchie

## ABSTRACT

Resin extractable Mo explained 72% of the variation in yield of wheat (Triticum aestivum) grown on ten acid soils as measured by the relative yield of the tops or by the uptake of Mo by the youngest emerged blade.

## INTRODUCTION

Molybdenum (Mo) deficiencies have been observed in plants grown on many acid soils[13]. It is desirable to determine plant available Mo precisely to correct deficiencies and to avoid overfertilization which may cause luxury uptake of Mo by plants and result in copper deficiencies in animals grazing pastures. Gupta and Lipsett[7] concluded that none of the existing methods of soil analysis for assessing Mo availability could identify Mo responsive soils adequately.

Resin extractable Mo may prove to be a suitable method to identify Mo responsive soils but refinement and re-evaluation of the technique is required. Bhella and Dawson[3] found that resin-extractable Mo was well correlated with modybdenum uptake by subterranean clover whereas Karimian and Cox[9] did not observe a good correlation between resin extractable molybdenum and molybdenum uptake by cauliflower. The conflicting results could be due to limitations in the methods of extraction used by both research groups. Firstly, the soils were ground which could lead to some molybdenum becoming more accessible for exchange onto resin than under natural conditions. Secondly, neither study states the anion type that is adsorbed onto the resin before extraction. In the case of phosphorus anions, Sibbesen[11] found that if the anion on the exchange resin was bicarbonate, then resin extractable phosphorus was better correlated with phosphorus uptake than when chloride was the exchangeable ion. Bhella and Dawson[3] and Karimian and Cox[9] presumably used the resin in the chloride form because this is the form commonly supplied by manufacturers. Thirdly, the soil:water:resin ratios were not kept constant. Barrow and Shaw[2], Sibbensen[11]and Bache and Ireland[1] have all shown that these ratios affect the amount of anion that is extracted by resins. It would appear, therefore, that the method has not been developed to its full potential.

The objectives of this research were to refine the method of extracting Mo from soils with resin and then to make a preliminary assessment of the ability of the method to determine whether Mo is present in adequate quantities to support plant growth.

## MATERIALS AND METHODS

### Method Development

Preliminary experiments were conducted to establish the type of resin, initial saturating anion and eluting solution that gave the highest recovery of Mo from stock solutions.

Molybdenum was extracted by shaking 10 g of soil for one hour with 0.5 g of phosphate-saturated Dowex 1 x 8 resin contained in a nylon mesh bag and suspended in 20 ml of double deionised water. The resin bag is removed from the soil, washed with deionised water, and shaken with 20 mls of a solution containing both 0.16 M $HNO_3$ and 1 M $KNO_3$ for 30 minutes to elute the Mo from the resin. The eluting solution is then filtered, 200 ul of 2% hydroxylammonium sulphate is added and the solution is heated to boiling for 15 minutes. The volume is made up to its original value with double deionised water. Fifty ul of 6 M $K_2HPO_4$ is added to a 5 ml aliquot before determining Mo by Differential Pulse Polarography[6].

### Evaluation of Resin Extractable Mo as a Soil Test

A glasshouse experiment consisting of a complete factorial assay of two molybdenum applications (0 and 300 ug/pot) and ten soils (Table 1) was used to assess if resin extractable Mo was a suitable test to measure the ability of a soil to supply adequate Mo for wheat (*Triticum aestivum*).

TABLE 1

Some Chemical Properties of the Soils used in the Pot Experiment.

| Soil | Organic matter (%) | c.e.c. (cmol(1/2$Ba^{2+}$) ($Kg^{-1}$) | pH (0.01M $CaCl_2$) | resin Mo (ppb) |
|---|---|---|---|---|
| Wongan Hills A | 0.96 | 4.8 | 4.49 | 17.7 |
| Wongan Hills B | 1.02 | 4.3 | 4.27 | 23.2 |
| Wyalkatchem | 0.93 | 3.5 | 4.18 | 23.4 |
| Mungite | 2.78 | 12.2 | 4.10 | 12.4 |
| W. Binnu A | 2.23 | 10.7 | 4.72 | 21.8 |
| W. Binnu B | 0.35 | 1.2 | 5.15 | 8.6 |
| Redmond | 7.36 | 14.9 | 4.19 | 8.4 |
| Pindar | 0.94 | 4.6 | 4.31 | 9.8 |
| Yalanbee | 2.46 | 5.8 | 4.97 | 46.0 |
| Malebelling | 3.04 | 7.7 | 4.85 | 24.0 |

There were three replicates of each treatment arranged in a randomised block design. The soils were air dried, sieved (<2 mm) and 3 kg of each soil were placed in 16 cm-diameter pots lined with a polyethylene bag. The basal and treatment nutrients were applied as solutions (purified by hydroxyquinoline-chloroform extraction[8]) and thoroughly mixed into the soil. Previous experiments indicated the levels of nutrients that were added would not limit plant growth except for some soils where no molybdenum was supplied. Subsamples of soil were taken from each pot before growing the plants. Throughout the experiment, the pots were held in root cooling tanks at 20°C and the soils were maintained at field capacity with double deionised water. Sixteen wheat seeds, selected for their low Mo content, were sown in each pot at a depth of 20 mm. They were thinned to eight seedlings per pot after ten days.

The plants were harvested when the plants provided with adequate Mo had six leaves on the main stem. The shoots were cut off at the soil surface and the youngest emerged blades (YEB) were separated from the rest of the tops. Fresh and dry weights of shoots and YEB were determined.

The soils were analysed for organic matter (the Walkley-Black method[10]), CEC (0.1 M $BaCl_2$[10]) and pH in 0.01 M $CaCl_2$[5]. Resin extractable Mo was determined by the method described in the previous section.

Molybdenum was determined in a nitric-perchloric acid digest of the shoots and of the youngest emerged blade (YEB)[12].

## RESULTS AND DISCUSSION

There was no consistent relationship between resin extractable Mo and organic matter content, pH or the c.e.c. of the soils.

In the absence of molybdenum, there was a reduction in the dry weight of shoots of wheat grown on six of the ten soils in comparison to the yields determined in the presence of 300 ug Mo/pot (Table 2).
The molybdenum concentrations in the YEB of wheat grown on eight of the soils were <50 ug/g, the critical concentration estimated by Robson (personal communication). The percentage variation in yield and

TABLE 2

Dry Weight (g) and Molybdenum Content (ng/plant) of Tops and the Concentration of Mo (ng/g) in the YEB of Wheat Plants Grown in Ten Acid Soils in the Presence (+M, 300 ug/pot) and Absence (-M) of added Mo.

| Soil | Dry weight tops (g) | | Relative yield (%) | Mo content tops (ng/plant) | | Mo concentration YEB (ng/g) | |
|---|---|---|---|---|---|---|---|
| | -Mo | +Mo | -Mo/+Mo | -Mo | +Mo | -Mo | +Mo |
| Wongan Hills A | 3.7 | 5.0 | 73 | 6.3 | 230.3 | 11 | 381 |
| Wongan Hills B | 4.1 | 5.5 | 75 | 6.5 | 383.4 | 10 | 614 |
| Wyalkatchem | 3.8 | 4.8 | 79 | 3.5 | 474.4 | 9 | 116 |
| Mungite | 5.1 | 6.7 | 76 | 5.4 | 72.5 | 6 | 78 |
| W. Binnu A | 0.3 | 0.3 | 100 | 4.5 | 171.4 | 34 | 1219 |
| W. Binnu B | 0.2 | 0.2 | 100 | 2.5 | 184.2 | 24 | 1792 |
| Redmond | 1.2 | 2.6 | 47 | 1.5 | 23.8 | 6 | 91 |
| Pindar | 2.3 | 3.5 | 65 | 3.7 | 36.5 | 5 | 116 |
| Yalanbee | 5.7 | 5.6 | 102 | 59.3 | 644.1 | 62 | 1178 |
| Malebelling | 5.4 | 5.4 | 100 | 61.7 | 435.4 | 93 | 785 |

TABLE 3

Percentage of the Variation in Yield or Molybdenum Content of Wheat Explained by the Level of Resin-Extractable Mo in the Soil (ng/g).

| Regression Factor | % variation explained | |
|---|---|---|
| | linear | logarithmic |
| Dry weight, tops (g) | 35 | 31 |
| Dry weight, YEB (g) | 50 | 56 |
| Relative yield, tops (%) | 61 | 72 |
| Relative yield, YEB (%) | 56 | 59 |
| Mo uptake, tops (ng/pot) | 52 | 56 |
| Mo uptake, YEB (ng/pot) | 45 | 72 |
| Mo concentration, tops (ng/g) | 50 | 42 |
| Mo concentration, YEB (ng/g) | 37 | 58 |

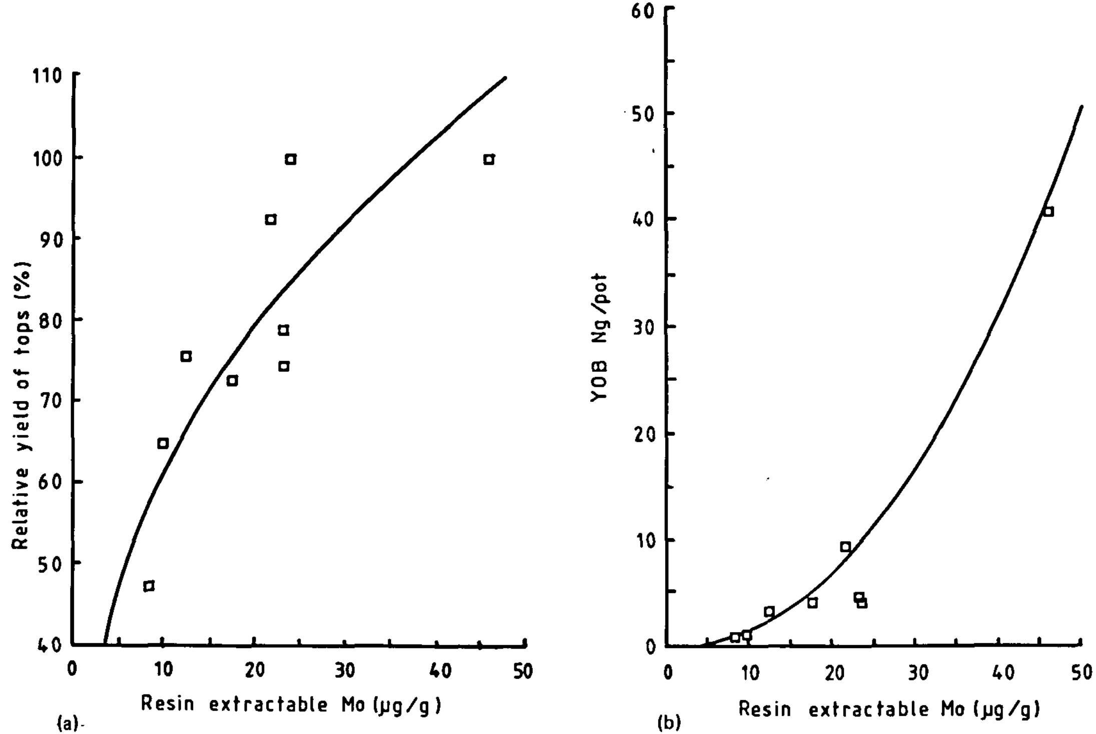


FIG. 1

The variation in (a) the relative yield of tops (%) and (b) the molybdenum content (ng/pot) of the youngest emerged blade of wheat with the level of resin extractable Mo in the soil (ng/g).

molybdenum uptake by the wheat that may be explained by resin extractable Mo varied from 31-72% (Table 3). The West Binnu B soil was omitted from the regressions as it was considered to be phosphorus deficient due to an error in phosphorus addition at the beginning of the pot experiment. The relative yield of the tops and the uptake of molybdenum by the YEB were found to have the highest correlation ($r^2$ = 72%) with plant growth. However, Fig. 1 shows that the distribution of the data points was more uniform when plant response to Mo was expressed as relative yield of the tops rather than as Mo uptake by the YEB. Approximately 25 ug/g of resin extractable Mo resulted in 75-100% relative yield of the tops. Resin extractable Mo explained 57% of the variation in the relative yield of the tops when the data was analysed by the method of Cate and Nelson[4]. The method indicated that the critical level of resin extractable Mo was 18-22 ug/g.

## CONCLUSIONS

Resin extractable Mo was able to explain 72% of the variation in yield of wheat grown on ten acid soils as measured by the relative yield of the tops or by the uptake of molybdenum by the youngest emerged blade. The method shows good promise as a soil test and merits further investigation. A wider variety of soils needs to be tested and more than one rate of Mo application should be used.

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