Development of a soil assay for screening rapeseed (*Brassica napus* L.) resistant to high manganese

J. Sergio Moroni, Mark Conyers, **Brendan Scott**, Neil Wratten, Rod Fisher and Graeme Poile

NSW Agriculture, Wagga Wagga Agricultural Institute, Pine Gully Road, PMB, Wagga Wagga, NSW 2650 Australia. WEB: www.agric.nsw.gov.au . E-mail: sergio.moroni@agric.nsw.gov.au

Abstract

Manganese (Mn) toxicity is a significant problem in many acidic soils. Extreme climatic environments such as waterlogging and dry, hot conditions can also lead to Mn toxicity even on some limed and near-neutral soils. The use of Mn resistant cultivars would allow producers to maximise their yields where Mn toxicity is a problem. Selection of Mn resistant crop germplasm is normally done in nutrient solution assays. However, solution assays do not reflect the natural Mn-root-soil interaction that may be required for evaluating resistance of crop plants to Mn toxicity. The objective of this study was to develop a soil assay for screening rapeseed (*Brassica napus* L.) genotypes resistant to high Mn. The surface 10 cm of a soil with pH 4.10_{CaCl2} was treated to produce soils with high Mn concentrations. Eight Mn treatments consisting of a combination of soil drying, soil heating, 80% soil field capacity and soil waterlogging were applied over a period of 19 days. Two *B. napus* genotypes known to differ in their response to high Mn concentration in nutrient solution were used to determine their response in the high Mn soils. The resulting soil Mn concentrations ranged from 2.2 to 31.2 µg mL^{-1} ($CaCl_2$ extractable). The intermediate Mn tolerant genotype performed significantly better than the Mn sensitive genotype in 7 of the 8 treatments. We concluded that some of the soil treatments that reproduce the environmental conditions that give rise to high Mn concentrations in the field can be used to develop a soil assay for screening genotypes of *Brassica* for resistance of excess Mn.

Keywords

Soil acidity, abiotic stress, canola, nutrition

Introduction

Manganese toxicity is an important growth limiting factor in many acidic soils (1). High Mn concentrations can be a problem in subsoils (2), thus making soil amendment difficult and expensive. In addition, water logging and dry and hot conditions can lead to high Mn concentration (3) even on some limed (4) and near-neutral soil (5). The utilisation of Mn resistant crop cultivars, adapted to soils where elevated Mn is a problem, may be an economic solution. We have recently identified sources of rapeseed (*B. napus* and *B. rapa* L.) tolerant to high Mn (6) that may be introgress to sensitive cultivars to ameliorate the negative effects on yield by high Mn soils. Selection of crop germplasm resistant to high Mn is normally done in nutrient solution assays (1). However, solutions assays do not reflect the natural Mn-root-soil interaction that may be required for evaluating resistance of crop plants to Mn toxicity and may fail to detect important mechanism(s) by which plants resist excess Mn. The objective of this study was to develop a soil assay with high Mn for screening rapeseed genotypes resistant to excess Mn.

Material and Methods

Brassica napus genotypes S98-51 (intermediate in Mn tolerance) and S24 (Mn sensitive) were grown in a soil with different Mn concentrations. Both genotypes have been shown to differ in response to high Mn (5.5 to 16.5 µg ml^{-1}) in solution culture (6). Eight treatments (T1-8) were imposed on pots containing 700 g of soil to develop Mn concentrations grater than 2 µg mL^{-1} (the Mn concentration in moist soils). The treatments were a combination of glass house drying, oven drying (60?C), watering (80% FC) and flooding. Each treatment combination was imposed consecutively for different lengths of time totalling 19 days (Table 1). Each pot contained 4 plants and there were 4 replicates per treatment. Plants were watered daily to 80% FC and grown in greenhouse conditions for 14 days.

Results

High Mn concentrations were achieved with 7 of the 8 soil treatment combinations (Table 1).

Table 1. Soil treatment combinations of glasshouse drying, oven drying, watering and flooding for developing different Mn toxicity levels. Manganese and pH levels at seeding.

Treatments[#]	Mn** µg ml^{-1}	pH $CaCl_2$
T8: WL 16d+ OD 2d+ GD 1d	31.17*a*	5.10*b*
T7: WL 15d + GD 4d	26.97*b*	5.31*a*
T3: OD 2d + GD 17d	7.91*c*	4.37*c*
T2: GD 17d + OD 2	6.98*d*	4.35*cd*
T5: GD 14d + 80%FC 3d + OD 2d	6.90*d*	4.37*c*
T4: 80%FC 3d + OD 2d + GD 14d	6.78*d*	4.36*cd*
T1: GD 19d	5.52*e*	4.35*de*
T6: 80%FC 19d	2.17*f*	4.32*e*

[#] d days; GD Glasshouse drying; OD oven dry at 60 ?C; 80%FC 80% Field Capacity; WL Waterlogged.
** Means followed by the same letter are not significantly different at the $p \leq 0.05$ level according to LSD

Manganese concentrations ranged from 2.2 to 31.2 µg ml^{-1} ($CaCl_2$ extract) while pH_{CaCl2} ranged from 4.32 to 5.31. Except for treatment T1, the intermediate Mn tolerant genotype S98-51 produced more shoot biomass than the Mn sensitive genotype S24 (Fig. 4). This indicated that the intermediate Mn tolerance selected in the solution assay is also reflected in a high Mn soil. The differential response between both rapeseed genotypes was not an artefact of the solution assays and may be adequate for screening rapeseed plants. The soil treatment T4 best discriminated between the genotypes under study. The Mn concentration of T4 (6.78 µg ml^{-1}) Mn was within the range at which 12 rapeseed genotypes have been characterised in solution culture for tolerance of high Mn(6).

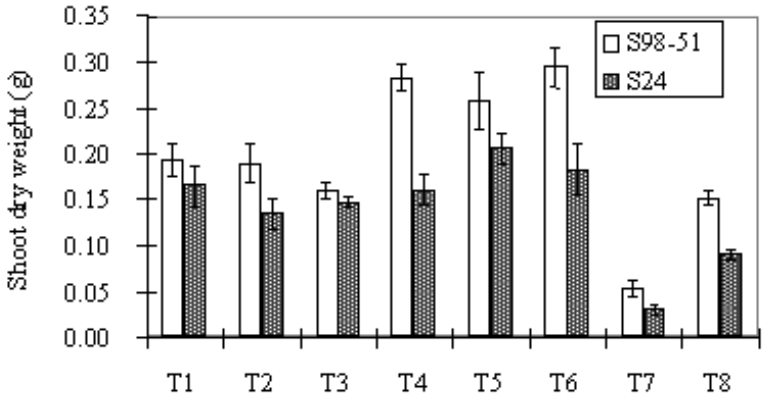

Figure 1. Shoot dry weight of Mn tolerant (S98-51) and Mn sensitive (S24) rapeseed genotypes. The 8 Mn treatments were developed by a combination of soil drying, soil wetting and soil heating.

Conclusion

Soil treatments that imitate the environmental conditions that give rise to high Mn concentrations in the field can be used to develop a soil assay for screening genotypes of rapeseed for resistance of excess Mn. The utilisation of a soil assay may be better suitable for screening plant material under greenhouse conditions.

Acknowledgments

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