Improving the adaptation, profitability and reliability of pulses growing on hostile alkaline subsoils

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ABSTRACT

Poor pulse growth in the southern Mallee has been attributed to high levels of boron and salinity in the subsoils. In order to increase the reliability of these crops, variation in tolerance to subsoil toxicities must be identified. Field surveys are being conducted in the southern Mallee to establish relationships between pulse growth, yield and the distribution of soil boron and salinity within growers' paddocks of field pea (*Pisum sativum* L.) and lentil (*Lens culinaris* Medik.). Glasshouse screening trials will be used to determine variation in tolerance to boron and salinity for field pea, lentil and chickpea (*Cicer arietinum* L.). Plants grown in high concentrations of boron are scored for visual symptoms of boron toxicity after 28 days to determine relative tolerance. A clear understanding of the soil-plant interactions will assist in improving the profitability and reliability of pulses in the southern Mallee.

KEY WORDS

Boron toxicity, salinity, subsoil, chickpea, field pea, lentil.

INTRODUCTION

Pulse crops are an important component of profitable and sustainable farming systems. However, in the southern Mallee region of Victoria, pulses are often seen as unreliable. Patchy growth can lead to substantial yield losses. A major factor underlying the poor performance of these crops appears to be high concentrations of subsoil boron and salinity. Pulse crops are more sensitive to salinity and boron than cereal crops (8), which, at this time, are considered a more reliable option for grain farmers in these areas.

Research proposed in this paper will identify variation in response to boron and salinity, and determine their critical tolerances for field pea (*Pisum sativum* L.), lentil (*Lens culinaris* Medik.), and chickpea (*Cicer arietinum* L.). The mechanisms that confer this tolerance, interactions between subsoil limitations and seasonal rainfall patterns, and the physiological responses will also be investigated.

The identification of genotypes that have some resistance to boron and salinity will not only be of benefit to farmers, who will be able to include more 'reliable' pulses in their rotations, but also to breeders, who can use this information to improve the boron and salinity tolerance of future cultivars.

MATERIALS AND METHODS

This research contains two components, a paddock survey and a glasshouse screening.

Paddock survey

A paddock survey is being conducted in the southern Mallee and northern Wimmera to determine the distribution of boron and salt throughout the soil profile, and its spatial variation both between and within paddocks. The soils are alkaline (pH 8-10), some sodic, and textures range from a sandy loam to a clay loam. Five sites are being sampled in the 2000 season, four field pea crops and one lentil crop. Each site consists of 12 sample points on a 3 x 4 grid. A further ten paddocks are planned to be included next year, giving a total of 180 sample points. Field pea and lentil are also being sampled on a grey cracking clay (with no potential subsoil limitations) at Dooen for comparison. Soil moisture content was recorded at sowing for 0-10cm, 10-20cm, 20-40cm, 40-60cm, 60-80cm, 80-100cm and 100-120cm. Soil moisture, root growth, nodulation, plant weight and foliar diseases will be recorded at flowering and grain maturity, in addition to grain yield. The soil will also be analysed for pH, exchangeable sodium percentage, electrical conductivity, boron, calcium carbonate, and chloride.

Glasshouse screening

A glasshouse screening trial is being prepared to test large numbers (300 per species) of cultivars and accessions from different landraces for variation in response to high levels of boron. Seeds are pre-germinated on moist towelling at room temperature for 4 days. Seedlings are sown at 1cm depth into tote boxes containing a steam sterilised loamy clay top soil (5-20cm) collected from the southern Mallee, which was mixed with toxic concentrations of boron as H_3BO_3 (10), (concentrations are currently being determined in preliminary experiments). Plant symptoms of boron toxicity are scored on a scale of 0-8 (2) after 28 days to determine response to boron. Screening for tolerance to salinity is also planned.

DISCUSSION

Soils of the southern Mallee are typically highly alkaline (pH 8- 10) with boron and salt increasing with depth. Basic salts contributing to salinity are sodium chloride and sodium sulphate as used by Holloway (7). The high levels of boron and salt found in these areas are believed to be derived from marine and wind blown deposits that were left behind as sea that once covered the area receded (9). These deposits have not diminished over time because of the low rates of leaching in this environment (average annual rainfall 374 mm).

Salinity is a problem in many cropping areas of Australia. High salt levels lead to decreased root and shoot growth, reduced plant biomass and yield, and at extreme levels, plant death. Preliminary work on pulses indicates that salt levels above 4 dS m^{-1} may be detrimental to plant growth (8). Boron toxicity, in particular in subsoils has only been recognised relatively recently in Australia (mid 1980s) (3). Boron levels that induce toxicity in plants are hard to define, as the incremental difference between deficiency and toxicity is the smallest of all the micronutrients. Boron causes necrosis of the leaf, loss of yield and in high concentrations, plant death (2). Critical boron concentrations for pulse crops have yet to be determined, although preliminary studies indicate that pulse crops are more sensitive to boron than cereals. In years without limiting moisture, plant symptoms of boron toxicity or salinity may not be evident, as the roots have access to ample water supply without extending into the subsoils. However in dry times, symptoms of toxicity may appear, as roots take up stored water from subsoils containing toxic levels of boron and salt.

In order to improve tolerance to a particular toxicity, genetic variation for this trait within a crop is essential. While previous research has shown genetic variation for tolerance to boron in field pea (11) and to salinity in field pea, chickpea and lentil (5,4,1), plant responses may vary between environments (6). Thus it is important to identify genotypes that respond differently when produced on the soils of the southern Mallee. As variation is identified, research on mechanisms that confer tolerance, rooting habits of tolerant versus susceptible cultivars and responses to different environmental stimuli (ie.: rainfall) will be conducted.

CONCLUSIONS

Identification of genotypes of lentil, chickpea and field peas that have improved tolerance to boron and salinity will increase their reliability and profitability in the southern Mallee of Victoria.

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