Screening faba bean for tolerance to low pH

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Key findings

- The critical pH_{Ca} threshold is in the range of 5.2 to 5.4, below which faba bean growth is reduced.
- Variability for tolerance to low pH is present within the species with cultivar (cv) PBA Zahra⍉ more tolerant at low pH than cultivars (cvv) PBA Samira⍉, Farah⍉ or PBA Nasma⍉.
- The sensitivity of uninoculated faba bean plants to low pH suggests it may not be sufficient to overcome the poor performance of faba bean on acid soils simply by developing more acid-tolerant rhizobium. Further research is warranted to address this question.

Introduction

Faba bean (*Vicia fabae* L.) is a popular pulse crop in the high rainfall zone (HRZ) of south-eastern Australia because of all the pulse species adapted to temperate climates, it has good waterlogging tolerance and high grain yield potential. Waterlogging is a commonly encountered abiotic constraint to growth in the HRZ and it is important that adapted crop species exhibit some tolerance. In addition, the HRZ has a long growing season and crops need to be flexible enough to use these conditions to maximise yield for growers. Acid soils, however, are widespread across this zone and faba bean appears to have little tolerance to this constraint (Matthews & Marcellos 2003).

Soil acidity presents several problems for crops, including toxicities caused by low pH (H^+), aluminium (Al) and manganese (Mn). Research in developing faba bean rhizobia with enhanced tolerance to acid soils is currently underway. Information about the level of tolerance of this species to low pH is scant, with no indication of whether within-species variability exists. This preliminary screening had two objectives:

1. ascertain the presence of any pH threshold below which the tolerance of the species declined
2. study the response of several faba bean cvv to a range of pH to determine whether there were any genetic differences in tolerance to low pH.

Materials and methods

Screening conditions and germplasm

A solution culture experiment was conducted in a temperature controlled growth chamber for 14 days. The temperature was set at 23 °C and light was artificially provided above the plants at an average photosynthetic photon flux density of 340 ± 70 µmol/m^2 per second on a 14/10 hour day/night cycle. The concentration of nutrients in the basal nutrient solution in micro moles (µM) was: 500 calcium (Ca); 2000 nitrogen (N) (300 NH_4, 1700 NO_3); 500 potassium (K); 201 sulphate (SO_4); 200 magnesium (Mg); 50 phosphate (PO_4); 23 boron (B); 10 iron (Fe); 9 Mn; 0.8 zinc (Zn); 0.3 copper (Cu); and 0.1 molybdenum (Mo).

The test solutions' pH were set at 4.5, 4.8, 5.1, 5.4 and 5.7 over the course of the experiment and adjusted daily using 1 M hydrochloric acid (HCl) or 1 M sodium hydroxide (NaOH). Deionised water was added to the containers when necessary to account for evaporation and transpiration losses.

The four cvv of faba bean evaluated were PBA Samira⍉, PBA Zahra⍉, Farah⍉ and Nasma⍉. Seeds were not inoculated with any rhizobium and were germinated on filter paper in dishes containing deionised water. Each seedling was transferred to its individual cell set in a plastic tray, which was suspended on the surface of the tub containing the nutrient solution held at the relevant test pH. All seedlings were transferred on the same date and occurred when radicles were long enough to reach the solution. Each tub contained 21 L, which was under continual aeration and agitation. All seedlings were harvested after 14 days of growth in the nutrient solution.

The experiment was a split plot design with pH levels as the main plots and genotypes as subplots with two replicates. Within each tub (main plot), 10 adjacent seedlings of each genotype were grown in individual cells within a tray, representing the subplot in this experiment design. At harvest, seedlings were removed from their cells and individual shoot lengths measured before all plants were separated into roots and shoots. Individual roots and shoots from each subplot were bulked, dried at 70 °C for 48 hours and weighed.

Results and discussion

Cultivar PBA Zahra⊕ had greater shoot weight (Figure 1a) than the three other test cvv at pH 4.8 and although not significant, it was tending to have greater weight at pH 4.5. PBA Zahra⊕ also had greater shoot length (Figure 1c) than the three other cvv at pH 4.5 and 4.8. PBA Zahra⊕ was also tending to have greater root weight (Figure 1b) than the other cultivars at the lower pH levels 4.5 and 4.8 although not significant. It appears that there is genetic variability for tolerance to low pH within faba bean and that the attempt to develop an acid tolerant cultivar could be achievable.

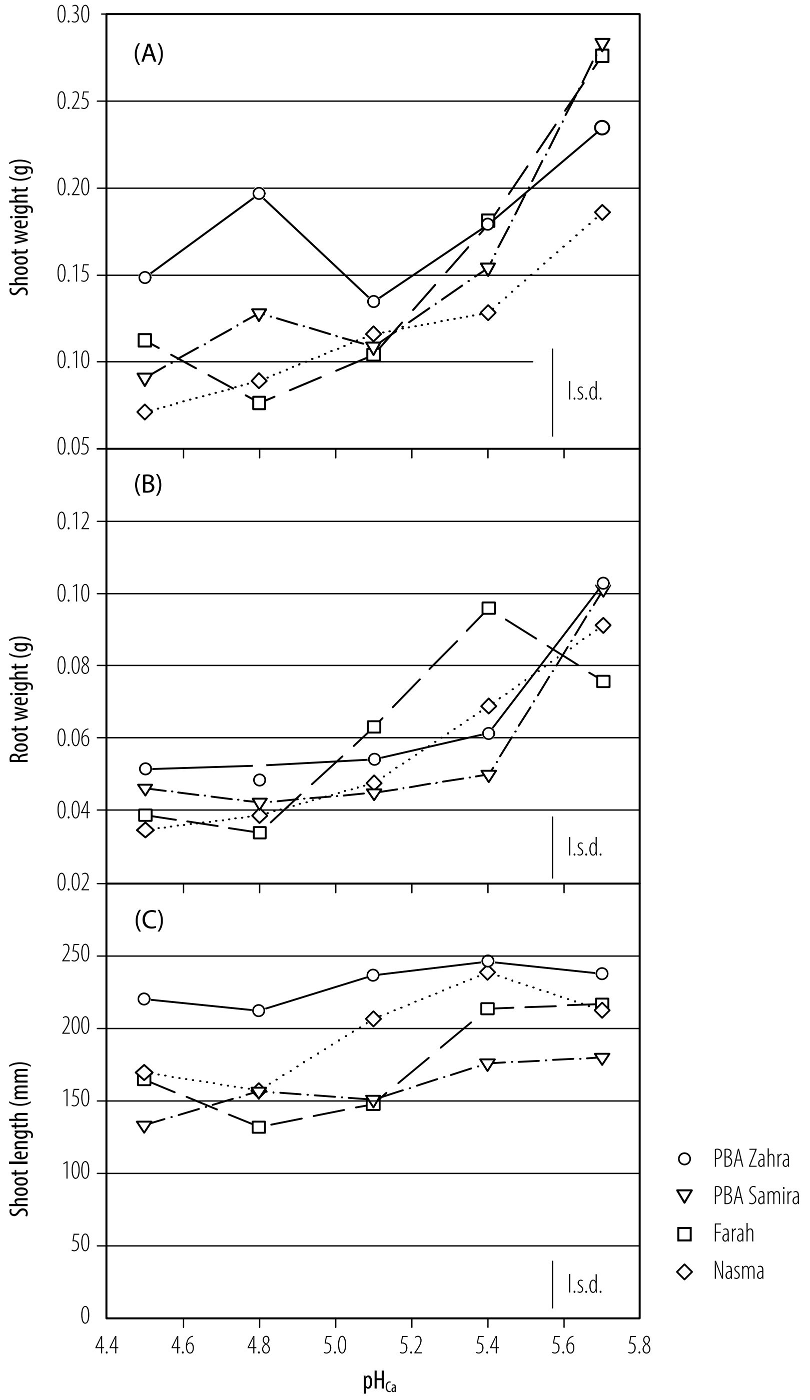

Figure 1. The effects of pH on (A) shoot weight, (B) root weight and (C) shoot length of the faba bean cultivars PBA Zahra⊕, PBA Samira⊕, Farah⊕ and Nasma⊕.

These results also confirm the general observation made by Matthews and Marcellos (2003) that faba bean performs poorly once soil pH_{Ca} levels fall below 5.2, which makes it one of the more acid-sensitive crops grown by farmers in southern Australia.

Conclusions and future research requirements

- Faba bean itself is sensitive to low pH and there appears to be scope to improve low pH tolerance within the species. Therefore, it may not be sufficient to overcome the poor performance of faba bean on acid soils simply by developing more acid tolerant rhizobium. Further research is required to explore this question.
- Further research needs to address the effects of Al and Mn toxicity on faba bean as these are associated constraints on many acidic soils.
- Appropriate lime management to ameliorate soil acidity must not be neglected as acidification processes are on-going in agricultural production systems. Genetic improvement either of the plant or the rhizobia is not a 'magic bullet' and can only ever partially address constraints to produce acid-sensitive pulses on acidic soils.

Reference

Matthews, P & Marcellos, H 2003, *Faba bean*, Agfact P4.2.7, second edition, Agdex 164, NSW Department of Primary Industries, Orange.

Acknowledgements

This experiment was part of the GRDC project 'N fixing break crops and pastures on high rainfall zone acid soils', DAN00191, July 2014–June 2018. We are grateful to Helen Burns for her advice and encouragement and wish to acknowledge our collaborators, CSIRO Agriculture and Food, Mackillop Farm Management Group, Holbrook Landcare Network and Roberts Ltd.