Improving vetch growth and nodulation on Mallee sands

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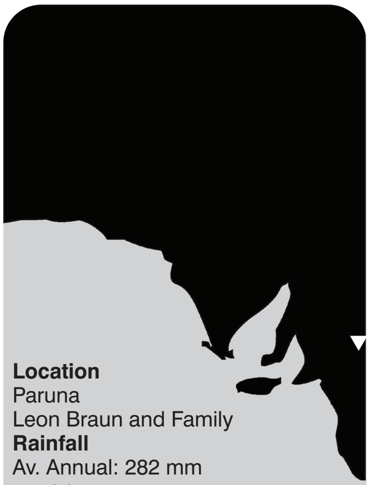

Location
Paruna
Leon Braun and Family
Rainfall
Av. Annual: 282 mm
Av. GSR: 190 mm
2019 Total: 136 mm
2019 GSR: 105 mm
Paddock history
2019: Vetch
2018: Wheat
Soil type
Sand
Soil test
pH (Water): 7.45
Plot size
15 m x 2 m x 3 reps
Trial design
Factorial RCBC with 3 replicates
Yield limiting factors
Moisture, compaction

Key messages

- **Placing P with the seed or banded to a depth of 8 cm below the seed does not affect vetch nodulation, leaf tissue P concentration and late flowering shoot dry matter.**
- **Leaf tissue P concentration and late flowering shoot dry matter increase with increasing rates of P.**

Why do the trial?

Phosphorous (P) is an essential macronutrient which influences plant shoot and root growth. It is generally the least available nutrient, particularly in sandy soils due to chemical bonding with Fe, Al, Ca and Mn in most production regions of Australia. Inadequate P restricts root and shoot growth and other functions which reduce N fixation by legumes. Vetch (*Vicia sativa*), a versatile pasture legume that can be used for grain, pasture, hay/silage or green manure, is being grown on naturally infertile Mallee soils which are often quite deficient in P. Vetch struggles to achieve optimum productivity on low P soils resulting in less fixed nitrogen returned to the system. This article reports on the responses of vetch to different rates of P placed at different depths below the seed at seeding. By achieving the optimum rate and right depth to place the P at sowing, productivity gains in the form of improved dry matter production, grain yield, nodulation and N fixation can result in multiple benefits, particularly in low rainfall mixed farming systems.

How was it done?

A replicated field trial was established in 2019 at Paruna (northern SA Mallee) on a red loamy sand (Colwell P, 16 mg/kg). The trial was sown to Volga vetch @ 35 kg/ha on 23 May. Five rates of P were applied as triple superphosphate (TSP) (0:46:0), at 3 different depths below the seed (Table 1). Plot length was 15 m and all treatments were replicated three times.

Emerged plants were counted on 19 June 2019 to determine plant population, and on 15 August, Clethodim @ 500 ml/ha + 1 L/ha wetter was applied to control grassy weeds. Samples for nodulation and leaf tissue P were taken on 8 August. Late flowering/early podding biomass was sampled on 5 September.

What happened?

With total growing season rainfall of only 105 mm, crop growth and productivity was severely limited. However, visual responses to the different rates of P applied at different depths were evident during the early part of the growing season, before flowering.

Response to P rates

Mean plant population for the site was 70 plants/m^2 and was not consistently affected by increasing rates of P (Figure 1a), regardless of its position. This shows there are situations where P applied at sowing up to 32 kg P/ha will not have a negative impact on crop establishment (but this will not always be the case). Overall nodulation for the site was good, as the mean total number of nodules per root was 48. For vetch on light soils, 20 nodules per plant at 8 weeks post sowing is considered satisfactory (GRDC, 2014). The mean nodules per root were not consistently affected by the different rates of P (Figure 1c).

Plant tissue analysis is an important tool because it shows the nutrient status of plants at the time of sampling. This, in turn, is a guide as to whether soil nutrient supplies are adequate. Plant tissue analysis can also detect unseen deficiencies and may confirm visual symptoms of deficiencies. The most sensitive tissue for detecting P deficiency is the youngest mature leaf. The critical level for vetch during vegetative growth is 0.3% (GRDC, 2018). Leaf tissue P at the site ranged from 0.15–0.24%, which is lower than the critical level. Leaf tissue P in vetch increased with increasing P applied at sowing (Figure 1b).

Table 1. Treatment details, Paruna 2019.

Crop	Volga vetch
Main plot factor (P placement)	With seed
	Shallow (4 cm below seed)
	Deep banded (8 cm below seed)
Sub-plot factor (kg P/ha)	0, 4, 8, 16, 32
Experimental design	Factorial RCBD x 3 replicates

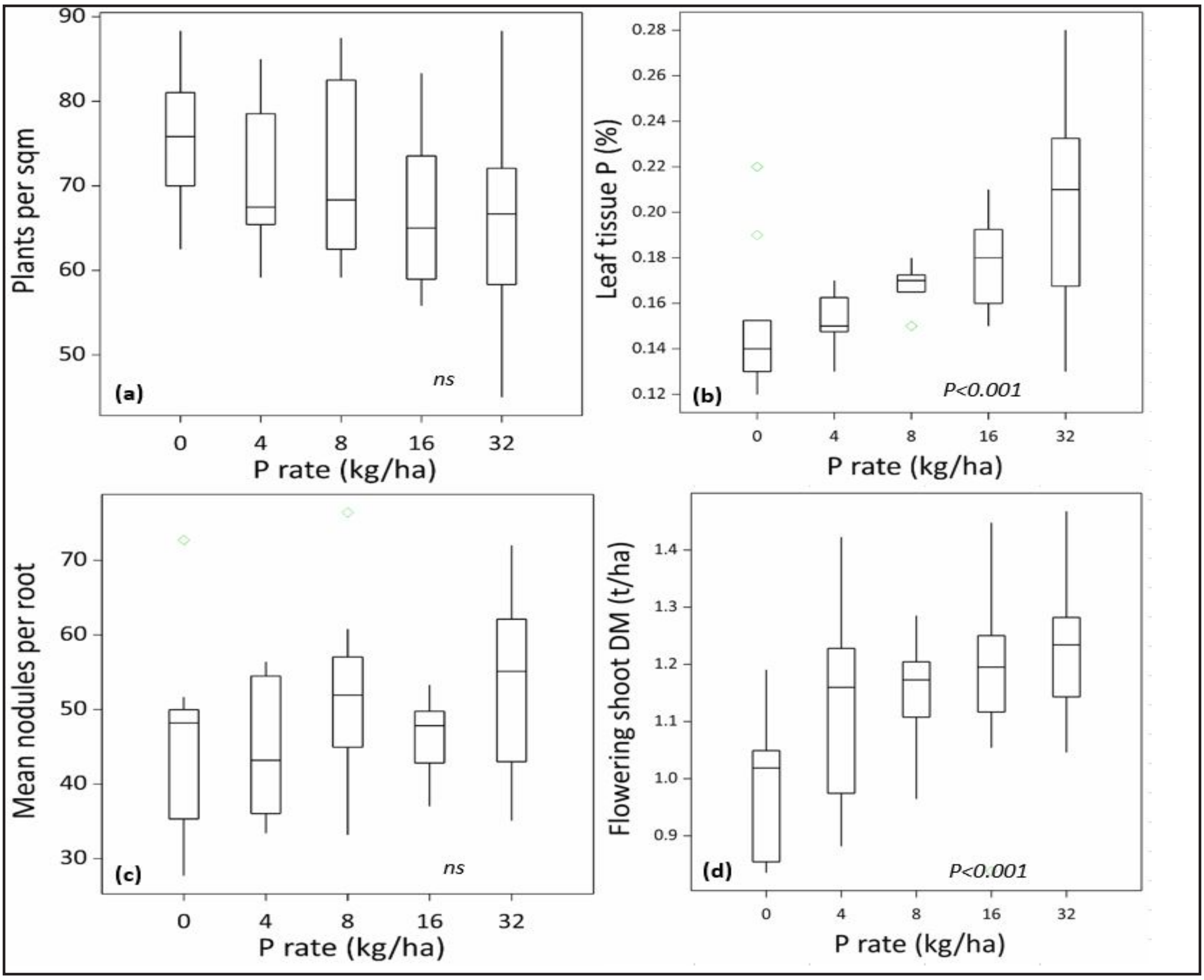

Figure 1. (a) Effect of different P rates on crop establishment leaf tissue, (b) P concentration, (c) nodules per root and (d) late flowering shoot dry matter.
Box and whisker plots show the shape of the distribution, the central value, and the variability. The lines extending from the boxes indicating variability outside the upper and lower quartiles, and the median is shown as a line in the centre of the box

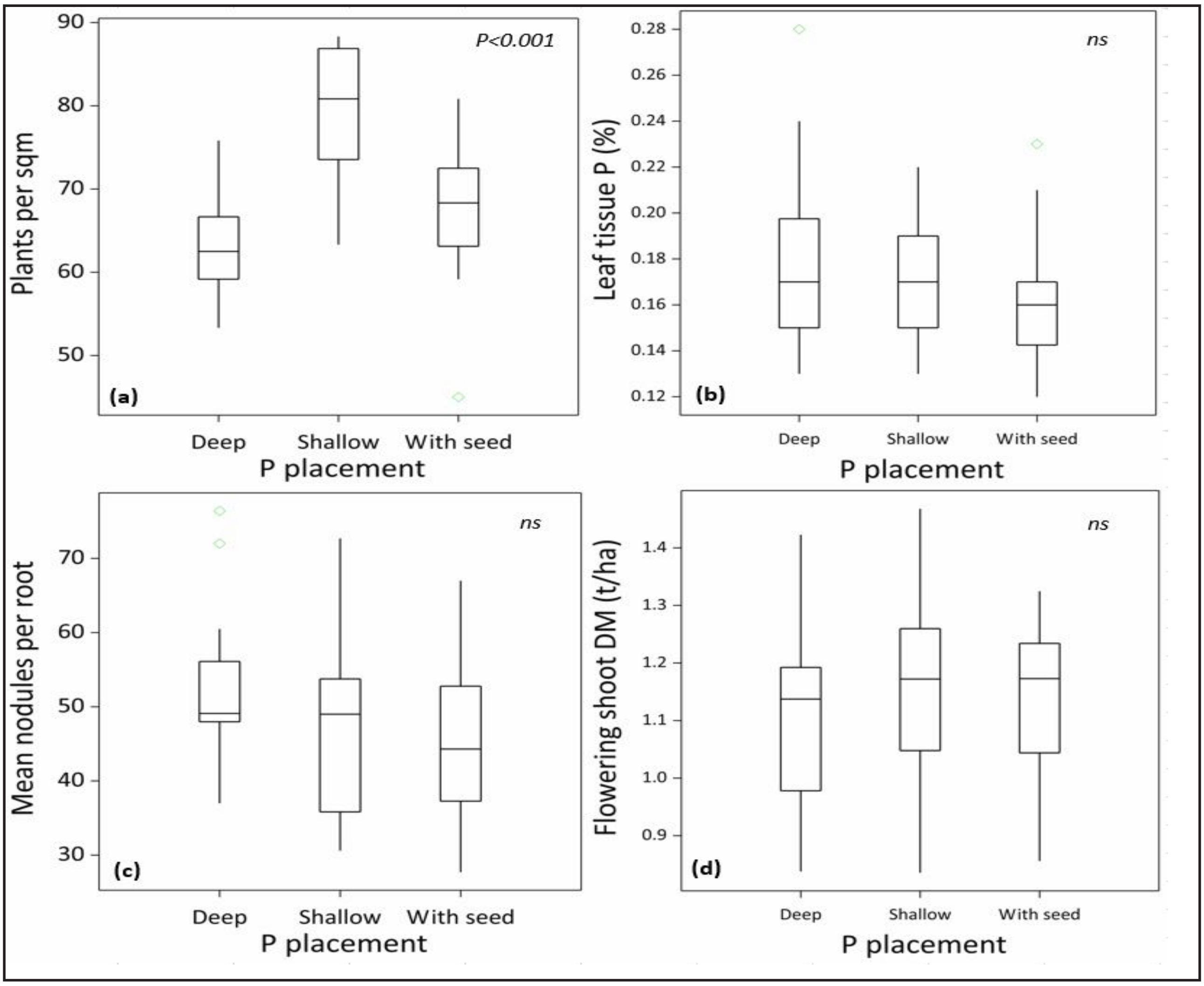

Figure 2. (a) Effect of P placement on crop establishment, (b) leaf tissue P concentration, (c) nodules per root and (d) late flowering shoot dry matter.

Crop biomass production was low because of a hot dry finish to the season. Flowering shoot DM for the site ranged from 0.95–1.30 t/ha, and the vetch crop responded positively to higher rates of P (Figure 1d). Matic *et al*., (2006) reported that average DM yield for Rasina vetch grown in 2006 at a trial site in Kingsford was 4.8 t/ha and 2.5 t/ha in Lameroo and Nagel *et al*., (2011) have reported that average grain yield for 2009, 2010 and 2011 was 2.2 t/ha from 4 sites in SA. Our trial site mean of 1.3 t DM/ha for late flowering DM reflects the impact of a below average season for the SA northern Mallee.

Responses to P placement

Establishment was significantly affected by the depth of placement of P at sowing. Plants/m^2 ranged from 63 (deep), 67 (with seed) and 79 (shallow). The shallow banding of P at sowing had significantly more plants/m^2 than deep banding or placing the P in the seed zone at sowing (see Figure 2a). Establishment with P in the seed row was possibly depressed by fertiliser toxicity, by P deficiency with deep P and better with shallow P because it avoided fertiliser toxicity and also supplied P to the crop (i.e. avoided P deficiency). Several authors (Singh *et al*., 2005; Bell *et al*., 2018 and McBeath *et al*., 2007) have reported that applying P at depth (15 to 30 cm deep on 50 cm bands) can improve yields over a number of cropping seasons (if other nutrients are not limiting). With our deepest treatment (8 cm below the seed), P was placed in the top 10 cm soil layer which is often dry. This explains the lack of response because of the immobile nature of P, limited rainfall and crop root architecture. There was no response in leaf tissue P, number of nodules per root and flowering shoot DM, to P placement as shown in Figures 2b-d.

What does this mean?

Vetch is now a significant legume rotation in cereal cropping systems in Australia's low and medium rainfall zones. There is limited recognition of the impact of phosphorus on vetch productivity in low rainfall Mallee environments. Estimates of the impact of soil P levels on nodulation and N fixation in alkaline coarse textured soils are also poorly understood.

We imposed four different rates of P as TSP at three different placement depths to investigate productivity responses that can be achieved by vetch on soils with low P reserves. Our results have shown that P fertiliser placed up to 8 cm below the seed will not result in more nodules on roots and will not improve DM production above P placed closer to the surface which is consistent with the results from a similar trial at Peebinga, 2018 (Dzoma *et al*., 2018).

However, it should be noted that if targeting higher plant densities, shallow banding P fertiliser can improve plant numbers and crop establishment. To improve vetch productivity on soils with low P reserves, the results show that dry matter production can be significantly improved by increasing the rate of P fertiliser at sowing. Matic *et al*., 2008 have also noted the importance of adding P when sowing Woolly pod vetch, as it generally provides a good start and growth. P applications, however, need to be matched against expected productivity gains for different soil types and rainfall regions to make sure fertiliser applications are economically justifiable.

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