Improving pulse nodulation in stressful environments

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New rhizobia to improve the nodulation and production of faba bean and lentil on acid soils

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As the area sown to faba bean and lentil expands, crops are being grown in areas where soil acidity (pH less than 5.0, measured in 0.01M calcium chloride) is limiting crop nodulation and performance. Beans in the high rainfall areas of western Victoria and south-east South Australia (SA) and lentils on well drained acid soils in parts of SA and southern NSW are known to be affected. It is likely to become an issue in other areas, if soil pH continues to decline.

The nodulation of faba bean, lentil, pea and vetch by *Rhizobium leguminosarum* bv. *viciae* (*Rlv*) is sensitive to soil acidity. Below pHCa 5.0, proliferation of the rhizobia around plant germination, steps in the nodulation process and persistence of the rhizobia in the soil are detrimentally affected. Since strains of rhizobia can vary in their acidity tolerance, work is being undertaken to determine if there are strains with greater acidity tolerance than WSM1455, the current Group F inoculant strain for bean and lentil.

Strains of *Rlv*, including some sourced from acidic soils, were selected for further assessment, based on their ability to nodulate seedlings growing in hydroponic solutions maintained at pH 4.2.

Promising *Rlv* strains (SRDI-969, SRDI-970 and WSM-4643) have now been tested at up to 19 field locations (mainly in SA and Vic., covering a range of hosts and soil types) to examine their effect on nodulation, crop biomass production, N2-fixation and grain yield. Included are two studies of soil colonisation by the rhizobia. The ability of the strains to survive on seed post inoculation has also been examined.

Pulse crop performance on acid soils was consistently improved by rhizobia strain SRDI-969, compared to WSM1455. Site means for nodulation, legume dry matter, N2-fixation and grain yield were increased on average by +56, +15, +24 and +14 percentage units respectively. The same measures were increased by approximately +30, +7, +6 and +5 percentage units, by strains SRDI-970 and WSM-4643. Regardless of the rhizobia strain used, nodulation was reduced to negligible levels at pH 4.2, indicating the requirement for liming to increase soil pH above that level.

In acid soil colonisation studies, strains WSM-4643 and SRDI-969 were more persistent and increased nodulation compared to WSM1455. However, soil colonisation by the rhizobia was still limited, indicating that re-inoculation will be needed each time the crop is grown and that there may still be opportunity for further strain improvement.

Survival of the rhizobia strains on seed stored in the laboratory (lentil and bean) varied. In this regard, SRDI-970 survived at highest number. WSM-1455 and SRDI-969 survived at lower but similar number. WSM-4643 survived least well, which may explain reduced nodulation by the strain in some field trials.

Although WSM-1455 has consistently been out-performed, none of the alternative strains performed best across all measures. In terms of crop impact, SRDI-969 has performed best so far, with further evaluation underway in 2019. Pending the outcome of current trials, the replacement of WSM-1455 is planned for 2021.

The efficacy of rhizobial inoculants when sowing pulses into dry soil

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With a push to increase the area of pulses cropped in areas traditionally considered "marginal" comes new challenges. One of these challenges in less reliable rainfall, to help manage this risk farmers often look to dry sow legumes to better manage time demands around sowing and ensure early establishment of crops. However, where legume inoculation is required, there remains a need to improve inoculation guidelines.

A series of greenhouse and laboratory experiments were completed to determine the survival of rhizobia under simulated dry sowing conditions. The three different rhizobia strains assessed (chickpea -Group N strain CC1192, faba bean-Group F strain WSM1455 and lupin-Group G WU425) all had similar survival rates when applied as peat slurry on seed and sown into a dry acid soil (0.5%w/w, pHCa 4.9). Numbers decreased tenfold between 24h and 14 days post sowing. Factors such as soil type, moisture level, temperature, inoculation rate and seed chemical dressing (P-Pickle T®) impacted on the survival of bean rhizobia on seed.

Seven field trials were conducted at four field sites in South Australia in 2017 and 2018 to assess the efficacy of a range of inoculant carriers when sown into dry soil. Three trials included multiple times of sowing (ranging from 0-4 weeks in dry soil (<2% w/w) and another three trials included different inoculant rates (peat on seed). Crop differed with site and included faba bean, lupin, chickpea and field pea. Nodulation (number and/or weight per plant), shoot and root dry weight was measured 10 weeks after crop emergence, peak biomass, shoot % N, %Ndfa (N derived from atmosphere – 15N natural abundance technique, Unkovich et al. 1997) was measured at mid pod fill and grain yield.

Standard inoculation (peat slurry on seed) practices did not provide satisfactory nodulation, especially where extended dry conditions (>2 weeks) were combined with other stresses such as low pH. Doubling the rate of peat slurry inoculant applied to seed significantly improved nodulation of bean, lupin and chickpea when sown into dry soil. The performance of granules varied with carrier and year, however granule formulations that delivered high numbers of rhizobia (>400,000 cells/ seed equivalent) improved nodulation of pulse crops under extended dry sowing conditions.

Ref: Unkovich MJ, Pate JS and Sanford P, 1997, Nitrogen fixation by annual legumes in Australian Mediterranean agriculture, Aust. J. Agric. Res. 48, 267-93.