NODULAR DIAGNOSIS FOR INTEGRATED IMPROVEMENT OF SYMBIOTIC NITROGEN FIXATION IN CROPPING SYSTEMS

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Nodular diagnosis consists of measuring the nodulation of a legume in an area of production, and relating it to the growth and subsequent yield of the legume (Drevon, 2001; Drevon et al., 2001; 2003). The objective of this procedure is to respond to the following questions: (i) does symbiotic nitrogen fixation (SNF) cover the N requirement of the legume in the cropping system? and (ii) what are the environmental factors limiting SNF in the area?

The nodular diagnosis is based on sampling a site chosen from the fields of the bean farmers who agreed to participate in the agronomic survey on the nodulation of their plants. Each site was divided into two parts, one without N fertilization and the other receiving a non-limiting N fertilizer with the aim of establishing whether the N nutrition is indeed the major factor limiting the legume growth in that area. Once this was established, two practices (local practice versus an alternative) were assessed in an agronomic trial within the area. Thus, the sites of nodular diagnosis were multi-locational, so that tests could be shared with many extension agents. However, it was decided not to test more than one alternative bio-technique with farmers. A reliable number of sites for use was determined to be ten per area. At flowering, corresponding to the stage when the SNF potential starts to decline, 20 plants were dug out (20-cm depth) at four sampling points within a homogeneous site. Plants with roots and nodules were preserved in a cold room for subsequent measurement of their individual biomass of shoots and nodules.

Spatial Variation in Nodulation and Efficiency in Use of the Rhizobial Symbiosis

Figure 1 illustrates the variation in nodule number, from less than 5 up to more than 50, which was generally observed at each site with instances of the total absence of nodules on some or all plants surveyed in fields of common bean in rotation with wheat in Lauragais farming systems.

F. D. Dakora et al. (eds.), *Biological Nitrogen Fixation: Towards Poverty Alleviation through Sustainable Agriculture*.

A simple regression was obtained from plots of the nodulation parameter (number or biomass) and the growth of plants as shown in Figure 1. This allowed for calculation of the ratio of additional shoot growth for each additional nodule, i.e., the slope of the regression was considered as an assessment of the efficiency of use of the rhizobial symbiosis (EURS) at that site. This EURS varied significantly between sites.

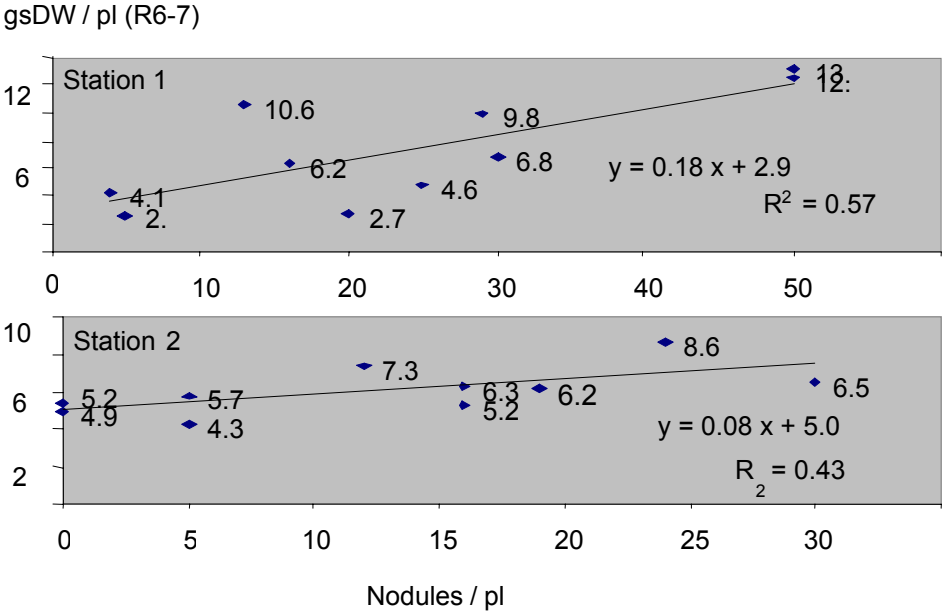

Figure 1. Efficiency in utilisation of the rhizobial symbiosis varies among fields in Lauragais.

The comparison of growth and yield of common bean with or without an optimal N fertilization within each site (Figure 2) made it possible to assess whether the nodulation or the shoot is the determining variable of the regression. As observed in site 5 and 6, the higher growth with N fertilization established that the low nodulation at those sites was the major factor that limited bean yield. These were fields where improving SNF could directly contribute to yield improvement. This may be obtained by inoculation with a native rhizobia isolated from sites with high EURS. This was not the case with sites 1 and 2 where it was found that SNF could complement soil N efficiently to support such a high bean grain yield of 3 t ha^{-1}. However, exceptionally higher grain yield than 4 t ha^{-1} were found at site 3, although the EURS was relatively high in the non-fertilized part of the site. This result suggested that the plant genotype did not have an effective capacity for SNF. This prompted the farmers to request genetic improvement of the lingot type beans, including (among other selection parameters) the height of the pods in order to decrease the losses at harvest.

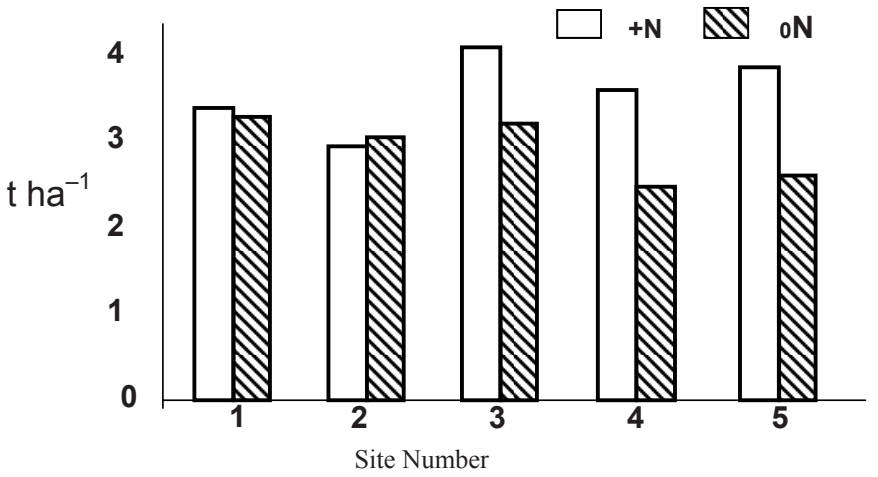

Figure 2. Yield of common bean with or without N in tons of bean per hectare.

Temporal Variation in Nodulation

Nodulation was found to vary extensively during a follow-up nodule analysis over a number of years of participation in the bean-cereal cropping systems in Lauragais (Figure 3). The low nodulation values found could be due to high residual soil mineral N that varied during and between years.

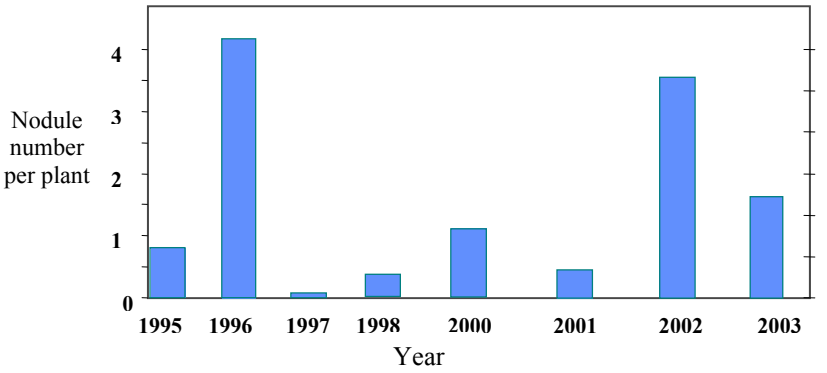

Figure 3. Temporal variations of nodulation in one season.

Participatory Assessment of Contrasting Line for EUP and SNF

The relationship of nodular diagnostics with participatory breeding was based on sowing 2-m rows of genotypes in the research plots within each site of the nodulation survey in that area. The data revealed the extent of variation in both nodulation and growth of snap bean in four fields, which belonged to horticultural organic farmers, where the mean nodulation value for the local cv Pongo was higher than 50 mg nod (DW plant)$^{-1}$, in contrast to six other sites in the area, where the nodule number per plant was less or even nil (Figure 4). The nodulation was generally higher for the recombinant inbred lines with higher efficiency in the use of phosphorus for symbiotic nitrogen fixation, namely 115, and this was associated with a significantly higher shoot growth than for 147.

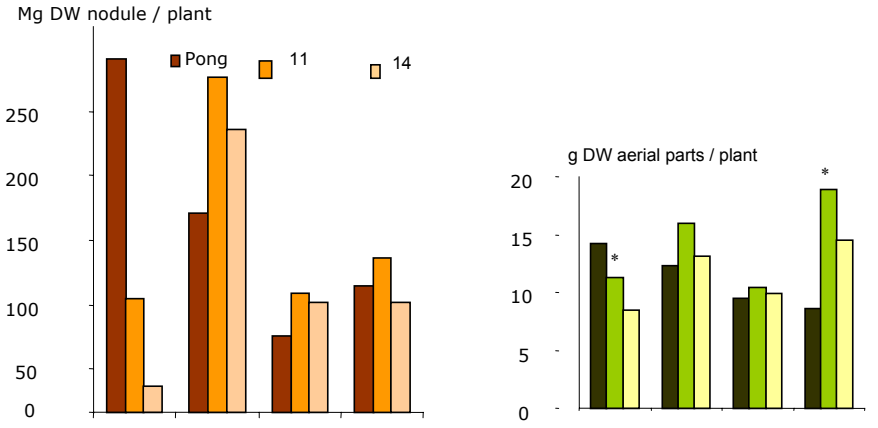

Figure 4. Growth and nodulation of snap-bean in stations where N_2 fixation contributes to growth in organic horticulture of Lauragais.

Conclusions

The nodule analysis for common bean in either the conventional or organic cropping systems of Languedoc in southern Mediterranean France showed large spatial and temporal variation in nodulation and efficiency in the use of the symbiotic nitrogen fixation for growth and subsequent grain yield. The higher nodulation and growth in the bean line selected for the efficient use of P suggest that P is a limiting factor of the symbiosis in the organic horticultural systems and that improving the use of P for N_2 fixation could contribute to an increase in the yield of bean and also benefit the N and P biogeochemical cycles.

References

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