SYMBIOTIC BEHAVIOUR OF ALFALFA VARIETIES GROWN IN DIFFERENT SOILS

C.Scotti, S.Gnocchi, M.Carelli and P.Rotili
Istituto Sperimentale per le Colture Foraggere, v.le Piacenza, 29, 20075 Lodi, Italy

ABSTRACT

Six alfalfa (*Medicago sativa*) varieties were grown in two contrasting soils to study their symbiotic ability as estimated by nodule biomass and dry matter yield in presence of the natural population of rhizobia of soil. Varieties can be discriminated on the basis of total (year) nodule biomass; their ranking for nodule biomass was consistent in the different soil types although soils significantly influenced nodulation and dry matter yield.

KEYWORDS

Alfalfa, nodules, *Rhyzobium meliloti*, soil, symbiotic ability

INTRODUCTION

Cultivated alfalfa (*Medicago sativa*) can nodulate in every soil with appropriate pH and in absence of abnormal concentrations of metal ions and salts. This raises the question of the diversity in soil *Rhizobium* populations and of the relationship between plant genotype and bacteria. In order to examine these problems, six alfalfa cultivars of different geographic origin were grown in two soils of contrasting physical and chemical characteristics and in the mixture of the two. Alfalfa varieties should then act as 'probes', sampling the natural *Rhizobium* population of each soil. Aerial dry matter (DMY), root DM and nodule fresh weight (NFW) were followed in the sowing year and in the successive two years both as total biomass formed in the year and separately for the different productive seasons. In each variety-soil treatment, number and composition of nodule biomass for size and shape were studied in a subsample of the material; in fact, developmental stage of nodule set was found to be a determinant in the N fixation activity rate (Scotti,1992). *Rhizobium* strains were also isolated from nodules so as to represent cultivars, soils, seasons, individual plants within cultivar, and nodules within a single plant. Strain diversity is being analysed by means of molecular markers RAPD and RFLP (Paffetti *et al*.,1996). In this paper only data pertaining to DM production and nodulation of the first productive year (1995) will be presented.

MATERIALS AND METHODS

Alfalfa varieties. Non dormant types: cv. Estival (Pioneer Hi-Bred,USA), cv. Gilboa (ecotype, Isreal); intermediate types: cv. Lodi (I.S.C.F.,Italy), cv. Rio (Great Plains Reseach Co.,USA); dormant types: ABI19307 (ABI Alfalfa,USA), cv. Oneida (N.Y.S.I.C.,USA).

Soil types. Lodi soil (L): 66% sand, 27.5% silt, 6.5% clay, organic matter 1.6%, total N 0.114 %, pH 6.5. Roma soil (R): 29.9% sand, 32% silt, 38.1% clay, organic matter 2.13%, total N 0.14% pH 7.3. Mixture L+R: 50% v/v of soils L and R. Both soils came from perennial meadows of north and central Italy, respectively. Forty plants/variety/soil were grown individually in PVC tubes 3 cm diameter and 80 cm high provided with 22 holes 2 cm diameter put in a second tube 5 cm diameter. After transplanting (May 1994), plants were grown in an open greenhouse at Lodi (45°19' N, 9° 30' E, 81 m a.s.l.) in absence of N fertilization and with a non-limiting water supply. In November 1994 plants were extracted and roots and nodules in the intertube soil layer were removed and recorded. In 1995, plant material was split in two parts: subgroup A (19 plants/variety/soil) with a unique underground survey at the 7th cut; subgroup B (21 plants/variety /soil) with 3 underground surveys, at 1st cut (05.05), 5th cut (08.29) and 7th cut (11.13). Cut to cut interval was of 30 days. Height and number of stems, biological stage and DMY were recorded at each cut; at the given cycles root DM and NFW in intertube soil layer were removed and studied.

RESULTS AND DISCUSSION

Total year production for aerial and root DM and NFW in subgroup A (undisturbed condition) and B is shown in Table 1. Variety ranking was similar in the two subgroups for DMY. As for nodule FW, expressing absolute symbiotic ability (ASA), significant differences among cultivars were found in each subgroup but the respective ranking was not consistent: cv. Rio in undisturbed condition (A) showed a low nodule biomass, while it displayed the highest nodulation in subgroup B. The opposite behaviour was found in cv. Gilboa. The effect of soil type was significant for all characteristics and similar in the two subgroups: in sandy-loam soil L nodule biomass appeared greater and DMY lower than in clay soil R. Soil mixture L+R was closer to L soil when considering NFW and to R soil in the case of DMY. Interactions between varieties and soil types were always of less importance than principal factors; in particular, the interaction was not significant for NFW in undisturbed conditions, while in subgroup B non dormant cultivars Estival and Gilboa showed higher nodulation in R or L+R soils than in L soil. It is worthwhile to note that when relative symbiotic ability (NFW per unit of aerial or root DM produced in the same time interval) is concerned, variation between cultivars decreased and, in the case of root relative symbiotic ability, also between soil types.

Table 2 shows the behaviour of subgroup B plants in the three seasons studied. The highest performance both for aerial and root DM was found in the 1st cut; this last represented 51-55% of the total year production for cv. ABI, Oneida and Rio, while 40-47% for cv. Estival, Gilboa and Lodi. Comparing nodule biomass in the 1st cut (Table 2) with year nodulation in undisturbed condition (subgroup A, Table 1) it can be noticed that in cv. Rio 85% of the total year biomass is already present at the 1st cut while in cv. Lodi the percentage is only 51%. This behaviour can explain the inconsistency of symbiotic ability estimate in subgroups A and B for cv. Rio and Gilboa: cv. Rio produced high nodule biomass in summer cycles when 1st cut nodules were removed (Table 2), but in undisturbed condition summer nodulation seemed inhibited. Cv. Gilboa showed low symbiotic ability in summer cycles (Table 2); year nodule production is then higher in undisturbed condition. In fact, during cycles 2-5 (mid May-August) plants showed, in our growing system, the highest nodule biomass production. Finally, in autumn cycles aerial and root production and nodule biomass are low and determined mainly by fall dormancy degree (Table 2).

As for the effect of soil type, in the 1st cycle clay soil R supported a significantly higher production than sandy-loam soil L, in presence of a lower nodule biomass. At the 5th cut, no significant effect of soils for DMY was found. The higher nodule biomass in L soil (+84% compared to R soil) seems sufficient to overcome the difference in nutritional characteristics of the two soils.

Some preliminary conclusions can be drawn from the data examined: the different varieties can be discriminated on the basis of total nodule biomass, that is absolute symbiotic ability (ASA). This last is influenced by nodulation pattern in 1st and summer cycles. The low significance of interactions between varieties and soil types seems to indicate the absence of important specificity variety-soil-

Rhizobium population. The development of nodule biomass seems to change, in our conditions, according to season, productive cycle and soil characteristics.

REFERENCES

Paffetti, D., Scotti, C., Gnocchi, S., Fancelli, S. and M. Bazzicalupo. 1996. Genetic diversity of an Italian *Rhizobium meliloti* population from different *Medicago sativa* varieties. Appl. Environ. Microbiol. 62, 7: 000-000.

Scotti, C. 1992. Breeding for the symbiotic ability in *Medicago sativa*. Proc. 10th Int.Conf. EUCARPIA Medicago spp. Group, Lodi, Italy, pp 236-242.

Table 1
Aerial DMY, root DM and NFW in subgroups A and B: individual plant averages (g). A group- DMY: sum of 7 cuts; root DM , NFW: data recorded at cut 7. B group- DMY: sum of 7 cuts; root DM , NFW: sum of the data recorded at cuts 1,5 and 7.

	Subgroup A			**Subgroup B**		
Variety	DMY	Root DM	NFW	DMY	Root DM	NFW
ABI	43.17a	1.01c,d	0.88b	38.85b,c	1.53b	1.48a,b
Estival	45.81a	1.28b,c	0.86b	39.31b,c	1.54b	1.35b,c
Gilboa	45.49a	1.46a,b	0.90a,b	36.46c	1.42b,c	1.35b,c
Lodi	46.48a	1.58a	1.13a	40.91a,b	2.06a	1.66a
Oneida	34.62b	0.81d	0.76b	30.35d	1.18c	1.15c
Rio	47.86a	0.97d	0.75b	43.40a	1.53b	1.62 a,b
Soil type						
L	37.63b	1.19a,b	1.05a	34.65b	1.68a	1.73a
R	47.06a	1.06b	0.67b	39.47a	1.32b	1.10c
L+ R	47.32a	1.33a	0.94a	40.40a	1.62a	1.47b

Values on the same column with different superscripts are different, P<0.05

Table 2
Aerial DMY, root DM and NFW in subgroup B: individual plant averages (g).DMY: cut 1; sum of cuts 2,3,4 and 5; sum of cuts 6 and 7. Root DM , NFW: data recorded at cuts 1, 5 and 7.

	Subgroup B								
		cut 1			**cut 5**			**cut 7**	
Variety	DMY	Root DM	NFW	DMY	Root DM	NFW	DMY	Root DM	NFW
ABI	22.23b	1.05b	0.56a	13.69b	0.36a,b	0.88a,b	2.93c	0.12b	0.03b,c
Estival	21.70b	0.99b	0.61a	13.70b	0.35a,b	0.69b	3.91a	0.21a	0.05a,b
Gilboa	18.25c	0.85b	0.60a	14.19b	0.36a,b	0.69b	4.02a	0.20a	0.06a
Lodi	21.26b	1.40a	0.58a	16.26a	0.44a	1.02a	3.38b	0.21a	0.05a,b
Oneida	17.91c	0.83b	0.43b	10.78c	0.24c	0.71b	1.65d	0.11b	0.02c
Rio	26.39a	1.07b	0.64a	13.56b	0.28b,c	0.92a	3.45b	0.18a	0.07a
Soil type									
L	18.12b	1.00a	0.65a	13.24a	0.45a	1.01a	3.29a	0.22a	0.07a
R	23.03a	1.05a	0.54b	13.63a	0.18c	0.55b	2.80b	0.09b	0.02c
L + R	22.62a	1.05a	0.51b	14.21a	0.38b	0.90a	3.57a	0.19a	0.05b

Values on the same column with different superscripts are different, P<0.05