Evaluation of the competition between alfalfa and sainfoin sown in mixture

I. Delgado¹*, F. Muñoz¹ and D. Andueza²,³

¹Centro de Investigación y Tecnología Agroalimentaria de Aragón 
Avda. Montañana 930, 50059 Zaragoza (Spain) 
²INRA-UMR1213 Herbivores, F-63122 Saint Genès Champanelle (France) 
³Clermont Université, VetAgro Sup.-UMR Herbivores, F-63000 Clermont-Ferrand (France) 
*e-mail: idelgado@aragon.es

Abstract. Alfalfa and sainfoin are pluriannual forage legumes that are well adapted to the agronomic conditions of NE Spain. However the persistence of sainfoin decreased when sown with alfalfa in mixture. It could be attributed to the fact that the cutting frequency was more suitable for alfalfa. In order to evaluate the persistence of sainfoin in mixture, the evolution of the annual forage yield in these species was compared, when sown in pure stands or using two types of mixtures, on alternate rows or mixed on the same row. Two harvesting rates were established, one that was most suited to alfalfa and the other to sainfoin. The study was conducted in rainfed conditions in Badules (Teruel) and under irrigation in Zaragoza during 2011-2013. The results confirm the lower yields and persistence of sainfoin when mixed with alfalfa under irrigation, which could be attributed to the allelopathic effects of alfalfa on sainfoin. There is no evidence of allelopathic phenomena arising in rainfed conditions in the two sowing modes employed. Cutting frequency had no influence on the occurrence of allelopathic phenomena.

Keywords. Medicago sativa L. – Onobrychis viciifolia Scop. – Dry matter – Crude protein – Allelopathy.
ued for its hardiness and not-bloating qualities. Given these complementing characteristics, it has been suggested that both species should be included in meadows in the Ebro valley (Hycka and Benítez-Sidón, 1979; Delgado et al., 2009). However persistence of sainfoin decreases when sown with alfalfa in a mixture and this has been attributed to the cutting frequency at the start of blooming in alfalfa (Hycka and Benítez-Sidón, 1979; Delgado et al., 2009). This practice may be indirectly detrimental to the persistence of sainfoin since it blooms later than alfalfa and its optimal use is recommended at full bloom (Koch et al., 1972; Borreani et al., 2003), furthermore this cutting frequency gives the plant less time to recover its nutrient reserves.

The lack of persistence of sainfoin when sown with alfalfa may also be due to allelopathic phenomena between the two species. Both alfalfa and sainfoin display strong allelopathic effects with other species (Chung and Miller, 1995; Li, 2009). Chocarro y Lloveras (2012) compared allelopathic effects between alfalfa and sainfoin, finding that alfalfa has a greater allelopathic effect on sainfoin, which may be one of the causes for the rapid disappearance of sainfoin in meadows that also contain alfalfa. In order to assess the persistence of sainfoin in a mixture, the species dynamics, in terms of annual forage yield, was compared when sown in pure stands and using two types of mixtures, on alternate rows and mixed in the same row, in two standard sites, under irrigation and in rainfed high lands.

II – Materials and methods

The study was conducted in rainfed conditions in Badules (41°9′N; 11°15′W, altitude 930 m a.s.l.) and under irrigation in Zaragoza (41°3′N; 0°47′W, altitude 225 m a.s.l.) during 2011-2013. In Badules climatic and edaphologic conditions showed monthly mean temperatures of 8.9°C min and 18.5°C max, annual precipitations of 320.6 mm, loam soil, salinity 0.2 CE (1:5 dΩ/m), pH (H₂O) 8.5, P (Olsen) 18 mg/kg, K (extracted in NH₄NO₃) 250 mg/kg and organic matter 2.33%. Conditions in Zaragoza were monthly mean temperatures of 21.4°C max and 8.1°C min, annual precipitations of 245.7 mm, silty-loam soil, salinity 0.24 CE (1:5 dΩ/m), pH (H₂O) 8.24, P (Olsen) 7 mg/kg, K (extracted in NH₄NO₃) 134 mg/kg and organic matter 1.99%.

Two cultivars of alfalfa were tested: ‘Tierra de Campos’, under rainfed conditions and ‘Aragón’ under irrigation, and one “two-cut” type sainfoin cultivar from Reznos (Soria). The cultivars were sown in plots of 5 x 2 m, in pure stands or using two types of mixtures, on alternate rows and mixed in the same row, with two cutting frequencies: alfalfa at early bloom and at full bloom, in four replications. Sowing took place on 11 March 2011 in Badules and 21 October 2010 in Zaragoza, using, for the pure stands of alfalfa a sowing rate of 15 kg ha⁻¹ in rainfed conditions and 30 kg ha⁻¹ under irrigation, and 80 kg ha⁻¹ and 100 kg ha⁻¹ respectively for sainfoin. The mixture comprised 50% seed density of both species in each of the conditions. An N-P-K basic dressing of 20-37.5-37.5 kg ha⁻¹ in rainfed conditions and 40-75-75 kg ha⁻¹ in irrigated conditions was applied the first year and both quantities were replicate in winter every two years in rainfed conditions and every year in irrigated conditions.

Dry matter (DM) was obtained by cutting two 0.5 m² per plot and drying in a forced ventilation stove at 60°C until a constant weight was achieved. Dry samples were used to determine crude protein (CP) contents, evaluated by the Dumas method (AOAC, 1990) and neutral detergent fibre (NDF), evaluated by the Van Soest method (Van Soest et al., 1991). Mortality rate is presented as the percentage of dead plants at the end of the trial.

The results underwent a variance analysis according to a split-plot model, considering “species” on the main plot and “cutting frequency” on the split-plot. The statistical analysis was performed using the ANOVA procedure of the SAS statistical package (SAS, 2004), considering the cutting date as treatment. Comparison of means was performed by the LSD test. The percentages were arcsine-transformed prior to statistical analysis.
III – Results and discussion

Table 1 shows the mean annual DM yield and CP and NDF contents in the first three productive years under irrigation and two years in rainfed conditions (the sowing year has not been considered as productive given that the establishment of the trials in these conditions is a slow process). The results show that alfalfa is more productive (P<0.001) than sainfoin under irrigation but in rainfed conditions alfalfa and sainfoin yields were the same. The two cutting frequencies established to benefit either alfalfa or sainfoin, did not show any significantly greater yields under irrigation although it did in rainfed conditions where the delay in cutting afforded a greater yield of dry matter (P<0.01).

When alfalfa and sainfoin were sown in a mixture, the mixture yield was not significantly different to that of the pure stands of alfalfa, both under irrigation and in rainfed conditions. The percentage participation of each species in the mixture varied substantially. Under irrigation alfalfa accounted for 89% of the yield since after the first year sainfoin disappeared from the mixture. This would explain why the forage CP content was closer to that of alfalfa than sainfoin. In rainfed conditions, the DM yield participation of sainfoin in the mixture was 40% when the cutting frequency was carried out with alfalfa in full bloom, this being significantly greater (P<0.01) compared to its 31% participation when cutting took place at early bloom of alfalfa.

These results corroborate the findings of other authors (Monserrat, 1956; Martiniello, 1998; Peel et al., 2004; Delgado et al., 2008), in so far as alfalfa is more productive under irrigation than sainfoin but has the same yield as sainfoin in rainfed conditions. With regard to the mixture of the two species, sainfoin quickly disappeared under irrigation and this can be attributed mainly to the allelopathic effects of alfalfa on sainfoin and not to the maturity state of the plants at the time of cutting. Although sainfoin did not adapt well to irrigated conditions, its yield was much higher when sown alone compared to when it was sown in a mixture (100% mortality the second year).

Table 1. Annual dry matter yield (DM), crude protein (CP) and neutral detergent fibre content (NDF), three years mean under irrigation and two years mean in rained conditions. In brackets, the percentage of alfalfa (L) in the mixture

<table>
<thead>
<tr>
<th>Location</th>
<th>Zaragoza (irrigation)</th>
<th>Badules (rainfed)</th>
<th>Species</th>
<th>DM kg/ha</th>
<th>%CP</th>
<th>%NDF</th>
<th>DM kg/ha</th>
<th>% CP</th>
<th>%NDF</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Alfalfa on pure stand</td>
<td>11931a</td>
<td>20.4 a</td>
<td>41.0 b</td>
<td>3964 ab</td>
<td>19.7 a</td>
<td>37.9 a</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sainfoin on pure stand</td>
<td>9456 b</td>
<td>17.8 c</td>
<td>43.1 a</td>
<td>4292 a</td>
<td>16.1 c</td>
<td>38.0 a</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Alfalfa and sainfoin on alternate rows</td>
<td>11675 (87.9% L)</td>
<td>19.9 b</td>
<td>41.5 b</td>
<td>3857 b (61.9% L)</td>
<td>18.3 b</td>
<td>37.9 a</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Alfalfa and sainfoin on mixed rows</td>
<td>12043 a (89.6% L)</td>
<td>19.9 b</td>
<td>41.6 b</td>
<td>3763 b (66.3% L)</td>
<td>18.6 b</td>
<td>37.9 a</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Species significance</td>
<td>***</td>
<td>***</td>
<td>**</td>
<td>***</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cutting frequency significance</td>
<td>NS</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Species x Cutting frequency interaction</td>
<td>NS</td>
<td>**</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

* P<0.05, ** P<0.01, *** P<0.001, NS: non significant. Different letters within each column indicate P<0.05%.
However, the percentage of sainfoin plants present in the pure stand by the third year was 19% vs 37% of alfalfa plants. The mortality of sainfoin, both in the pure stand and in the mixtures was lower in rainfed conditions. At the end of the third year the persistence of sainfoin in the pure stand was 25% vs 62% alfalfa when cutting was carried out at the start of blooming and 17% vs 57% respectively when cutting was carried out at full bloom. The progressive disappearance of sainfoin in the mixture in rainfed conditions, from the first to the third year, could be attributed to the lower persistence of sainfoin rather than to allelopathic effects. Such effects would indeed be more active under irrigation due to the fact that irrigation, which encourages the dispersion of allelopathic chemical components and greater intensity of production, may well accelerate allelopathic actions (de Albuquerque et al., 2011).

IV – Conclusions

The interest held by alfalfa under irrigation and alfalfa and sainfoin in rainfed conditions can be confirmed. There is not evidence that frequency cutting impact on disappearance of sainfoin in the mixture, but their disappearance under irrigation could be attributed to allelopathic phenomena. In rainfed conditions there is no evidence of allelopathic phenomena.

Acknowledgements

This study has been supported by the projects RTA2009-63-C2 and RTA2012-80.

References


