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New annual legumes as winter crops for intensive forage rotations in Galicia (NW Spain). I – Dry matter yield

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Abstract. It is presented in this paper the dry matter yield results obtained in an experiment where six species of annual legumes were sown in small plots in mid-October 2009 as a winter monoculture crop and harvested in the next spring following a silage-cutting strategy. Legume species were: Crimson clover; Balansa clover; Persian clover (ssp. *resupinatum* and ssp. *majus*); Arrowleaf clover and French serradella. Forage was given a first cut at two weeks intervals in six harvest dates beginning at mid-march, and a second cut was taken after six weeks of regrowth. Sown legume dry matter yield varied broadly among species across cutting dates (from 3.3 to 6.6 t ha^{-1} and from 0.8 to 3.4 t ha^{-1} in first and second cycles, respectively) and among cutting dates across species (from 1.5 to 8.5 t ha^{-1} in the first cycle and from 3.7 to 0.2 t ha^{-1} in the second). In spite of the good average productivity of most of the legume species studied, their low dry matter (DM) content in spring (from 9.8 to 19.0% DM) could make difficult to obtain and adequate fermentation quality of silage harvested by the end of April to fit in the rotation with maize.

Keywords. Forage potential – Monoculture crops – Serradella – Clovers.

Les neuvelles légumineuses annuelles utilises comme des cultures d'hiver pour les rotations fourragères intensives en Galice (NO Espagne). I – Rendements en matière sèche

***Résumé**. Ces travaux présentent des résultats sur la production observée au cours d'un essai qui a évalué six espèces de légumineuses annuelles semées à l'automne 2009 et soumises à une stratégie de coupe pour ensilage au printemps suivant. Les espèces étaient: le trèfle rouge (*Trifolium incarnatum *L.), trèfle migueliano (*T. michelianum *Savi), trèfle de Perse (*T. resupinatum *L.) ssp. resupinatum et ssp. majus, trèfle vésiculeuse (*T. vesiculosum *Savi) et serradelle (*Ornithopus sativus *Brot.). La récolte s'est effectuée à six dates différentes à intervalles de deux semaines à partir de mi-mars, avec une deuxième utilisation de la repousse à six semaines. La production de matière sèche (MS) a montré une variation considérable entre les espèces (de 3.3 à 6.6 t MS ha^{-1} en moyenne sur les différentes dates sur la première coupe), et également entre les dates de coupe (1.5 à 8.5 t de MS ha^{-1} entre la première date et la dernière, en moyenne sur toutes les espèces). Malgré les bons rendements obtenus pour la plupart des espèces évaluées, leur utilité en tant que fourrage pour ensilage de printemps, en rotation avec le maïs, pourrait s'avérer délicate en raison de la faible teneur en matière sèche atteinte dans le fourrage, entre 9.8% et 19.0%.*

***Mots-clés.** Potentiel fourragère – Cultures pures – Serradelle –Trèfles.*

I – Introduction

Crimson clover and Serradella were used in the traditional livestock farming systems of the coastal zone of Galicia as winter forage in rotation with maize. Although previous studies (Lloveras,1987) showed that it was possible to obtain a good quality forage for silage in spring from

these species, they did not find a place in the modern dairy farms which use predominantly the Italian ryegrass for this purpose. The emerging concern about the rising costs of inputs and environmental issues of agriculture production have led to a renewed interest about the inclusion of forage legumes in the livestock farming systems in Europe. New species of forage legumes have emerged in the last ten years as a consequence of the re-examination of the pasture legumes used in Australian ley-faming. Among the new traits sought in these species are deeper root systems, acid-tolerant rhizobial symbioses and tolerance to pests and diseases (Loi *et al*., 2008). In conditions of mid-mountain pastures in the Mediterranean area of the south of Galicia, with acid soils of medium-low fertility, Piñeiro *et al*., (2008) found good results in sward establishment and performance for grazing and a summer hay cut in beef production systems, concluding that the recommended species were Crimson clover, Balansa clover, Persian clover, Arrowleaf clover and French Serradela. Until the date there is not local information available about the forage potential and nutritive value of these new species in the context of intensive double-cropping systems of Galician dairy farms, with maize as the summer crop. The objective of this study was to evaluate and compare the forage potential of different cultivars of annual legumes, grown as winter fodder crops for silage production in spring, assessing their utility to be included in the intensive double cropping forage rotation systems with maize, typical of many of the Galician dairy farms.

II – Materials and methods

A field experiment was performed from October 2009 to July 2010 in the research station farm of the Centro de Investigacións Agrarias de Mabegondo, (Galicia, NW Spain, 43º 15´ N, 8º 18´ W, 100 m altitude) on a silt loam soil, with marine Mediterranean climate, under rain fed conditions.

The legume species evaluated were Crimson clover (*Trifolium incarnatum* L.) cv. Viterbo; Balansa clover (*T. michelianum* Savi.) cv. Bolta; Persian clover (*T. resupinatum* L.) ssp. *resupinatum* cv. Kyambro and ssp. *majus* cv. Maral; Arrowleaf clover (*T. vesiculosum* Savi.) cv. Zulu II and French serradella (*Ornithopus sativus* Brot.) cv. Margurita. In the first growth, a harvest schedule of six cutting dates, one cut every two weeks from 15 March to 24 May, was imposed. The regrowth was harvested six weeks later, following the same schedule, from 26 April to 5 July.

The experimental lay out was a split plot with ten blocks where the species (sown as monocultures) were assigned to the whole-plots and the harvest dates, to the subplots. The plots were sown with inoculated seed broadcasted on 13-16 October 2009, using a seed rate of 30 kg ha^{-1} for French serradella and crimson clover, and 10 kg ha^{-1} for the rest. The size of individual plots was 1.3 m x 6.0 m. The herbage was cut to a 10 cm stubble height, using a reciprocating mower, and the whole production was measured on a strip of 5.0 x 0.9 m per plot. The samples were weighted in the field using a portable scale and a representative sample (1.0 kg) was taken per plot and immediately sent to the laboratory for the determination of dry matter content (DM) and botanical composition. Data were subjected to ANOVA and multiple comparison of means by Fisher's Least Significant Difference procedure using Proc GLM of SAS (SAS Institute, 2000).

III – Results and discussion

Climate characteristics (monthly rainfall and mean temperature) of the experimental site during growing season (October 2009 to July 2010) are shown in Table 1.

Table 1. Monthly rainfall and average temperature over the experimental period

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Mean temperature (ºC)	16.4	12.5	8.3	7.9	7.7	9.6	12.7	14.1	16.8	18.9
Rainfall (mm)	127.4	276.2	214.8	184.0	159.6	84.0	44.6	84.5	117.0	38.1

Forage production depended significantly ($p<0.001$) on the legume crop used, both in first and second growth. Dry matter yield of sown legume (DMY) was also affected ($p<0.001$) by harvest dates and a significant interaction ($p<0.001$) between legume specie and harvest dates was observed. As shown in Table 2, in the first growth, average DMY, DM content and percentage of sown legume (in DM basis) were, respectively, 5.35 (±3.26) t ha^{-1}, 12.1% (±2.8%) and 86.5% (±13.3%), and in the re growth, 1.81(±2.13) t ha^{-1}, 11.8% (±2.8%) and 88.2% (±11.9%). French serradella was the earliest flowering specie (29 March), followed by Balansa clover (12 April), Persian clover ssp. *resupinatum* (23 April), Crimson clover (26 April), Arrowleaf clover (5 May) and Persian clover ssp. *majus* (22 May).

Table 2. Dry matter yield (DMY), dry matter content (DM) and percentage of sown legume species (DM basis) averaged by species across harvest dates and by harvest dates across species

Species†	DMY (t ha^{-1})	DM (%)	Sown species (%)	Harvest dates††	DMY (t ha^{-1})	DM (%)	Sown species (%)
			First cycle				
French serradella	5.42	11.8	87.3	15 March	1.57	15.8	73.4
Crimson clover	6.24	11.9	88.5	29 March	2.54	10.4	82.6
Balansa clover	6.68	11.6	95.1	12 April	4.38	10.8	87.6
Persian clover *resupinatum*	4.92	12.1	88.9	26 April	6.65	10.5	91.0
Persian clover *majus*	3.39	12.8	72.2	10 May	8.41	9.8	94.0
Arrowleaf clover	5.48	12.6	86.7	24 May	8.59	15.4	90.1
l.s.d.	*0.59*	*0.3*	*3.7*	*l.s.d.*	*0.56*	*0.7*	*3.9*
			Regrowth				
French serradella	0.87	11.3	80.2	26 April	3.76	10.5	89.7
Crimson clover	2.40	11.2	93.7	10 May	3.52	10.2	89.9
Balansa clover	0.92	10.6	88.6	24 May	1.92	14.0	84.2
Persian clover *resupinatum*	1.29	11.9	86.7	7 June	0.70	12.2	92.9
Persian clover *majus*	3.41	12.7	88.0	21June	0.64	15.4	92.1
Arrowleaf clover	1.96	12.1	90.7	5 July	0.27	19.0	70.6
l.s.d.	*0.35*	*1.0*	*3.2*	*l.s.d.*	*0.46*	*0.8*	*3.0*

† Mean values across harvest dates for each species; †† Mean values across species for each harvest date. *l.s.d.*: least significant difference between two means in the same column at $p<0.05$.

When sown legume yield was averaged across harvest dates it was observed differences among species, being Balansa clover and Crimson clover (6.68 and 6.24 t DM ha^{-1}, respectively) more productive in the first cycle than the rest of species, and Persian clover ssp. *majus* (3.39 t DM ha^{-1}) the least productive. The latter species was the most productive in the second cycle (3.41 t DM ha^{-1}), given its high capacity of regrowth. DM content remained very low in all species along the different harvest dates, ranging from 11.6% to 12.8% in the first growth and from 10.6% to 12.7% in the second growth.

Averaged among species, legume DM yield increased in the first cycle from 1.57 t ha^{-1} by 15 March (first harvest date) to 8.59 t ha^{-1} by 24 May (sixth harvest date). Daily forage growth rate in the five intervals between harvest dates was 69.2, 131.4, 162.1, 125.7 and 12.8 kg DM ha^{-1} day^{-1} indicating a high growth potential of these species that, in the conditions of the experiment, concentrates between the beginning of April to mid-May, reaching a ceiling by the second half of

April. A regrowth was observed for all species until the third harvest date of the first cycle. From this time on, only the Persian clover ssp. *majus* showed an appreciable growing capacity and consequently this species was the most productive, on average, in the second cycle (3.41 t DM ha^{-1}). In spite of this, in the regrowth of the first and second harvest dates forage production of Crimson clover (5.70 and 5.78 t DM ha^{-1}) and Arrowleaf clover (4.99 and 4.68 t DM ha^{-1}) clearly outyielded that of Persian clover (2.28 and 3.96 t DM ha^{-1}).

Table 3 shows the mean values of the DM yield of each species along the six harvest dates in the first cycle. Whilst Balansa clover and Crimson clover were the most productive species from the beginning of April to the fifth harvest date (10 May), Arrowleaf clover significantly outyielded the rest of legumes in the last cut (24 May). Although a maximum of DM yield was observed for all species by 10 May, this was not the case for Arrowleaf clover, which maintained a fairly high growing rate (180 kg DM ha^{-1} day^{-1}) during the second half of May.

Table 3. Interaction of Species x Harvest date for dry matter yield (t ha^{-1}) of sown legumes

	Harvest date (First cycle)					
Species	**15 March**	**29 March**	**12 April**	**26 april**	**10 May**	**24 May**
French serradella	2.2	3.3	4.8	6.8	8.1	7.1
Crimson clover	1.1	2.2	5.0	7.7	10.8	10.4
Balansa clover	2.6	4.0	5.9	8.7	9.1	9.1
Persian clover *resupinatum*	1.4	2.6	4.1	5.6	7.7	7.9
Persian clover *majus*	1.2	1.4	2.4	3.7	5.4	5.7
Arrowleaf clover	0.7	1.5	3.8	6.9	8.6	11.1

Least significant difference between two means in the same row or column ($p<0.05$): 0.92.

Little information can be found in the literature on productive performance of these legumes as monocrops. In the research station farm Mabegondo, Iglesias and Lloveras (1998) reported yields of 5.8 and 6.2 t DM ha^{-1} at the third week of May for local ecotypes of French serradela and Crimson clover. In Australia, Loi *et al.*, (2000) indicate values of 5 t DM ha^{-1} for French serradela and Balansa clover in spring at flowering stage. Other studies have reported yields up to 6 t DM ha^{-1} for Crimson clover harvested at flowering stage in EEUU, and about 4 t DM ha^{-1} for a cultivar of Persian clover ssp. *resupinatum* under irrigation conditions in Italy (Hoveland and Evers, 1995, and Martiniello, 1999, respectively, cited by Frame, 2005).

IV – Conclusions

The preliminary results showed a high productivity of the annual legumes studied, indicating that they could fit in the rotation with maize. Crimson clover and Balansa clover seem the most promising species for harvesting by the end of April. However, their low DM content could make it difficult to obtain a satisfactory silage quality with these species.

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