Legume-cereal mixtures ensiling in Sardinia

Sulas C., Ruda P., Salis M., Atzori A.S., Correddu F., Cannas A., Carroni A.M.

in

Acar Z. (ed.), López-Francos A. (ed.), Porqueddu C. (ed.).
New approaches for grassland research in a context of climate and socio-economic changes

Zaragoza : CIHEAM
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 102

2012
pages 489-492

Legume-cereal mixtures ensiling in Sardinia

C. Sulas[1], P. Ruda[1], M. Salis[1], A.S. Atzori[2], F. Correddu[2], A. Cannas[2] and A.M. Carroni[1]

[1] Unità di Ricerca per i Sistemi Agropastorali in Ambiente Mediterraneo (CRA-AAM), Sanluri (Italy)
[2] Dipartimento di Agraria, Sezione di Scienze Zootecniche, Università di Sassari, Sassari (Italy)

Abstract. Animal feeding accounts more than 50% of farm production costs, often principally due to the protein component acquisition. Cereals and legume mixtures silage could represent an interesting source of high nutritive value forage in non-irrigated lands. Mixtures can provide an adequate proportion of nitrogen and carbohydrates in the ensiling substrates, needed to help lactic fermentation and pH reduction, essential to the conservation process. The aim of this trial was to compare silage of three leguminous-triticale mixtures, in order to obtain a preliminary evaluation for high quality and stable forages production, destined to ruminant feeding in Mediterranean areas. The trial was carried out in Sardinia between autumn 2010 and spring 2011. Mixtures of Triticale (*Triticosecale* WittMack)-white lupin *(Lupinus albus* L.), triticale-pea (*Pisum sativum* L.) and triticale-faba bean (*Vicia faba minor* L.) were evaluated. After six months of ensiling process in glass jars, silage was analyzed, by determining: pH, dry matter, fibrous fractions, crude protein, ash content, NFC+lipids and estimated DM digestibility. Mixtures with pea and triticale Amarillo reached the highest content of DM. When used in mixtures with triticale and in respect to lupin and pea, faba bean obtained the lowest values of NDF, ADF, and ADL and the highest content of NFC+lipids. Faba bean was also able to maintain the highest protein content. Considering the CP content of silage, the 30:70 seeding ratio resulted the more convenient. A more detailed evaluation of obtained results should be performed also considering the biomass production per hectare at farm level.

Keywords. Legume silage – Triticale – *Lupinus albus* L. – *Pisum sativum* L. – *Vicia faba minor* L.. – Small ruminants.

L'ensilage des mélanges légumineuses-céréales en Sardaigne.

Résumé. *L'alimentation animale représente plus de 50% des coûts de production des exploitations, souvent dû à l'acquisition des protéines. L'ensilage de mélanges de céréales et de légumineuses pourraient constituer une source intéressante de fourrage de haute valeur nutritive dans les terres non irriguées. Les mélanges peuvent fournir une proportion adéquate d'azote et de glucides dans les substrats d'ensilage, ce qui est essentiel pour la fermentation lactique, la réduction du pH et la conservation du fourrage. Le but de cet essai était de comparer l'ensilage de trois légumineuses avec triticale, afin d'obtenir une évaluation préliminaire de ces fourrages destinées a l'alimentation des ruminants dans les régions méditerranéennes. Les essais ont été réalisés en 2010/2011. On a testé trois différents mélanges : triticale (*Triticosecale *Wittmack) - lupin blanc (*Lupinus albus *L.); triticale-pois (*Pisum sativum *L.) et triticale-fève (*Vicia faba minor *L.). La qualité des ensilages a été évaluée en déterminant le pH, la matière sèche, les composants fibreuses (NDF, ADF, ADL), les protéines brutes, les cendres, NFC + lipides et digestibilité. Les mélanges avec de petits pois et le triticale Amarillo atteignent le plus haut contenu de MS. La fève a obtenu les plus faibles valeurs de NDF, ADF, ADL et la plus forte teneur en NFC + lipides par rapport au lupin et au pois. La fève était également en mesure de maintenir la teneur en protéines plus élevée. Compte tenu de la CP de l'ensilage le taux d'ensemencement 30:70 était le plus efficace. Une évaluation plus détaillée des résultats obtenus doit être également effectuée pour tenir compte de la production de biomasse par hectare au niveau des exploitations.*

Mots-clés. *Ensilage de légumineuses – Triticale –* Lupinus albus *L. –* Pisum sativum *L. –* Vicia faba minor *– Petits ruminants.*

I – Introduction

Animal feeding represents more than 50% of farm production costs. The biggest nutritional expense is often attributable to the protein component acquisition. Mixtures with legume silage could be a good source of forage of high nutritive value and make a significant contribution to farm economy; specially if it could maintain an high content of protein (CP), high content of non-fibrous carbohydrates (NFC), and low content of neutral or acid detergent fiber (NDF; ADF) and lignin (ADL). In optimal conditions sugars are mainly fermented to lactic acid, required for the indispensable pH decrease and fermentation stabilization. The main problem linked to the ensilage of high protein raw material is to reach a quick biomass pH reduction and rapid protein degradation in non-protein nitrogen (NPN) (Cavallerin et al., 2007). This issue can be solved combining legumes with the cereals, providing adequate quantity of soluble sugars to lead fermentations to lactic. This trial was aimed to identify an ensiling system of Triticale-legume mixture in order to obtain forages with proper chemical characteristics for animal nutrition.

II – Materials and methods

The trial was carried out in Sardinia at Agricultural Research Council experimental fields (Sanluri 39° 31' N, 8° 51' E) between autumn 2010 and spring 2011. White lupin (*Lupinus albus* L; var. 'Multitalia' (L)), pea (*Pisum sativum* L.; var. 'Attika' (P)), and faba bean *(Vicia faba minor* L.; var. 'Prothabat 69' (F)) crops were evaluated in mixture with Triticale (*Triticosecale* WittMack). Two triticale cultivars, var. 'Amarillo 105' (T1) and var. 'Oceania' (T2), were tested with each legume species. Was experiment arranged in completely randomised design (plot size 3000 square feet) with two replication and Triticale-legume mixture proportion were compared: 50:50% (50:50) and 30:70% (30:70); the mixture ratio was defined as seeding ratio. The forages were harvested in two different periods, according to triticale flowering and with a difference of 15 days between Early and Late harvesting. The forages were ensiled in 5-liter capacity glass jars. Thus, after six months of storage, jars were opened and a silage sample was collected from each jar; pH was measured and samples were then dried and milled with 1 mm grid. Chemical composition was determined for: dry matter content, crude protein, fiber components (NDF, ADF, ADL), and ashes. The NDF was determined using the method of Mertens (2002), ADF e ADL as suggested by Van Soest et al. (1991), while Crude Protein (CP) using the AOAC (1990); ashes were determined for incineration at 550°C. The content of non-fibrous carbohydrates and lipids was obtained by difference as NFC+lipids = 100 – (PG + NDF + Ash); the silage digestibility (DMDig) was estimated using the summative equation of Goering and Van Soest cited by Van Soest (1994). Statistical analysis were performed using the Minitab software package (Minitab Inc., 2003). The obtained dataset was analysed using descriptive statistics and Pearson correlations; a General Linear Model (GLM) was also used considering the Triticale variety, leguminous species, mixture proportion, and harvesting period as fixed factors and replication as a random factor, to evaluate differences in chemical composition; interactions were not included in the model and Tuckey test was preferred for comparisons between factors.

III – Results and discussion

Table 1 reports reported the mean values of silage chemical composition observed in the collected samples, while in Table 2 are reported the results of the GLM with the comparisons between the experimental factors. The pH was on average 4.83±0.24 units resulting higher than values of Kriszan *et al.* (2007); however the observed pH in this trial are included in the medium class of pH range observed in Italy (Crovetto, 2008) for cereal and legume silages.

Also according with Crovetto (2008) the pH was positively correlated with the DM ($r = 0.42$; $P < 0.05$), with the NDF ($r = 0.51$; $P = 0.01$), the ADF ($r = 0.38$; $P = 0.07$) and negatively correlated with the NFC+lipids ($r = -0.56$; $P < 0.01$). A significant difference for pH was observed between T1 and T2 (4.92 and 4.75 respectively; $P<0.05$); it was probably due to the higher content in NFC+lipids ($P<0.05$) and the lower DM ($P < 0.05$) of T2 with respect of T1. A big variation in DM was observed ranging from 17.5% to 45.6% (Table 1). Significant differences in DM were observed between mixtures, the highest values mixtures including T1 and Pea; no differences were observed for seeding ratio or harvesting time for DM.

Table 1. Mean chemical composition of silage samples collected in the experimental trial

	pH	DM†	CP††	NDF††	ADF††	ADL††	NFC+ lipids††	ASH††	DM Dig.††
Mean	4.83	29.35	13.10	57.26	37.45	5.35	22.36	7.28	68.61
SD	0.24	7.11	2.26	4.10	3.18	1.01	3.60	0.65	5.46
Max value	5.28	45.61	17.62	65.49	45.34	8.08	29.04	8.62	78.67
Treatment with the max value	T1L 30:70 Early	T1P 30:70 Early	T1F 30:70 Early	T1L 50:50 Early	T1P 30:70 Late	T1P 50:50 Late	T1L 50:50 Late	T2L 30:70 Early	T1L 30:70 Early
Min value	4.31	17.54	9.20	48.23	31.18	3.53	13.61	5.72	56.14
Treatment with the min value	T2P 30:70 Early	T1L 30:70 Early	T2L 30:70 Early	T1F 50:50 Early	T2P 50:50 Early	T2P 50:50 Early	T2F 50:50 Late	T1P 50:50 Late	T2F 50:50 Late

†% AF; ††% DM.

Table 2. Estimated means (LMSE) of silage chemical composition by the 4 fixed factors included in the GLM. Standard deviations from the mean are reported in italic

	Triticale		Legume			Seeding ratio T:L†		Harvesting††	
	$T1_{Amarillo}$	$T2_{Oceania}$	Faba	Lupin	Pea	30:70	50:50	Early	Late
pH	4.92a	4.75b	4.80	4.83	4.86	4.84	4.82	4.88	4.79
	0.47	*0.47*	0.06	0.06	0.06	0.05	0.05	*0.05*	0.05
DM	32.30^{a}	26.40^{b}	27.26^{b}	26.92^{b}	33.87^{a}	29.44	29.26	28.60	30.10
	1.20	*1.20*	*1.47*	*1.47*	*1.47*	*1.20*	*1.20*	*1.20*	*1.20*
CP	13.48	12.72	15.19^{Aa}	11.36^{Bc}	12.75^{Bb}	13.61^{a}	12.59^{b}	13.43	12.77
	0.30	*0.30*	*0.36*	*0.36*	*0.36*	*0.30*	*0.30*	*0.30*	*0.30*
NDF	58.15	56.36	54.46^{b}	58.30^{a}	59.01^{a}	56.80	57.22	57.88	56.63
	0.73	*0.73*	*0.09*	*0.09*	*0.09*	*0.73*	*0.73*	*0.73*	*0.73*
ADF	38.25	36.65	35.41^{b}	38.21^{a}	38.74^{a}	37.38	37.52	37.51	37.40
	0.59	*0.59*	*0.72*	*0.72*	*0.72*	*0.59*	*0.59*	*0.59*	*0.59*
ADL	5.71	4.98	5.28	5.02	5.75	5.34	5.36	4.98	5.72
	0.17	*0.17*	*0.21*	*0.21*	*0.21*	*0.17*	*0.17*	*0.26*	*0.17*
NFC +lipids	21.16^{b}	23.57^{a}	22.92	22.63	21.54	22.19	22.53	21.17^{b}	23.55^{a}
	0.66	*0.66*	*0.81*	*0.81*	*0.81*	*0.66*	*0.66*	*0.66*	*0.66*
Ash	7.20	7.35	7.43^{B}	7.70^{A}	6.70^{B}	7.40*	7.15**	7.51^{A}	7.04^{B}
	0.08	*0.08*	*0.10*	*0.10*	*0.10*	*0.08*	*0.08*	*0.08*	0.08
DM Dig.	72.7^{A}	64.50^{B}	68.93^{ab}	70.27^{a}	66.62^{b}	69.00	67.72	68.23*	67.72**
	0.66	*0.66*	*0.80*	*0.80*	*0.80*	*0.66*	*0.66*	*0.66*	*0.66*

†Seeding ratio (triticale:legume).
††Late was delayed by 15 days from Early.
†††DM digestibility estimated with summative equations (Van Soest, 1994).
A, B, C = P<0.001; a, b, c = P<0.05 ; *,** =P<0.1: within rows of the same factors, different superscripts indicate significant differences.

Protein content of silages varied from 9.2% to 17.6% of DM with an average value of 13.1±2.26%; it varied principally with the legume species used (P < 005); the highest CP was achieved using Faba instead Pea or Lupin (Table 2). Faba bean, was also able to maintain the highest protein content; considering the soybean grain price of 2011 in Italy (about a value of 8 € per % of DM per ton) the value of the Triticale-Faba silage was 30 and 20 €/ton higher than the value of Lupin and Pea mixtures. As expected, the use of more legume in the seeding ratio increased the percentage of CP in the silage, an increase of 1% of CP, from 12.6 to 13.6%, was observed for 30:70 in respect to 50:50 ($P < 0.05$), while no differences were observed for harvesting time.

The NDF of silages varied from 48.9 to 65.5% of DM with an average value of 57.3±4.1% of DM; on average, the lowest values of NDF were observed using Faba instead Lupin or Pea ($P < 0.05$). Similar results were also observed for ADF, while no differences were observed for effects of the other experimental factor. No significant differences were observed for ADL content. NFC+lipids varied from 13.61 to 29.04% of DM with an average value of 22.4±3.6% of DM. The NFC+lipids content was higher with the use of Oceania instead Amarillo and in Late with respect to Early harvesting. Estimated digestibility varied from 56.1 to 78.7% of DM, with an average vale of 68.6±5.5% of DM. The highest DM digestibility was observed in mixtures with T1 ($P < 0.001$ from T2) or with Faba or Lupin ($P < 0.05$ from peas;); it showed also high significant differences between legume species used in the mixture, different seeding ratio and harvesting time.

IV – Conclusions

In respect to the chemical characteristics of Triticale-legume silages, two cultivars of triticale, three legume species, two levels of seeding ratio and two harvesting times were evaluated. Relatively to the triticale, and in respect with Amarillo, the cultivar Oceania reached a lower pH of the silage biomass during the storage period, an higher content of NFC+lipids, higher digestibility, and also reached a lower content in DM, indicating a probable more aptitude to ensiling process. Relatively to the legumes used in mixtures with triticale and in respect to Lupin and Pea, Faba bean obtained the lowest values of fibrous components, the highest content of protein and the highest values of energy related compounds. The 30:70 seeding ratio resulted the more favorable for silage CP content. Delayed harvesting (15 days) resulted in an increase of NFC+lipids content of the silage. However, in order to estimate the economic convenience of a mixture of triticale-legume choice at farm level, a more detailed evaluation of obtained results should be performed also considering the biomass production per hectare.

References

AOAC. 1990. *Official Methods of Analysis.*15th Ed. Association of Official Analytical Chemists, Inc., Virginia, USA, p. 770-771.

Cavallarin L., Tabacco E. and Borreani G., 2007. Forage and grain legume silages as a valuable source of proteins for dairy cows. In: *Italian Journal of Animal Science*, 6, p. 282-284.

Crovetto M., 2008. Composizione chimica e valore nutritivo dei principali foraggi Lombardi. Progetto "FORAGE" (n° 688) della D.G. Agricoltura - Regione Lombardia.

Mertens D.R., 2002. Gravimetric determination of amylase-treated neutral detergent fiber in feeds using refluxing in beakers or crucibles: collaborative study. In: *J. AOAC*, 85, p. 1217-1240.

Minitab Inc., 2003. MINITAB Statistical Software, Release 12.1 Windows, State College, PA.

Krizsan S.J., Broderick G.A., Muck R.E., Promkot C., Colombini S., Randby A.T., 2007. Effect of Alfalfa Silage Storage Structure and Roasting Corn on Production and Ruminal Metabolism of Lactating Dairy Cows. In: *J. Dairy Sci.*, 90, p. 4793-4804.

Van Soest P.J., 1994. *Nutritional Ecology of the Ruminant*. Cornell University Press, Ithaca, NY.

Van Soest P.J., Robertson B. and Lewis B.A., 1991. Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. In: *J. Dairy Sci.*, 74, p. 3583-3597.