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Abstract

There is renewed interest in using cereal-legume mixtures silages in ruminant ration to assist forage self-sufficiency and climate change adaptation. However, data on feed value of cereal-legume silages remains limited in Europe. The objective of this study was to evaluate dry matter intake (DMI) and organic matter digestibility (OMD) of three cereal-legume silages harvested at two stages of growth using Texel sheep. The three mixtures were wheat with pea and vetch (WPV), bearded triticale with pea and vetch (+TPV) and beardless triticale with pea and vetch (-TPV). The DMI was on average 65.4 g kg^{-1} $BW^{0.75}$ for silages harvested at early stage without significant difference between mixtures; the DMI was lower for silages harvested at late stage (28.0, 37.5 and 46.2 g kg^{-1} $BW^{0.75}$ for +TPV, –TPV and WPV respectively). The OMD for WPV and +TPV was higher than for –TPV at both growth stages. Finally, the digestible organic matter intake was on average 41.5 g kg^{-1} $BW^{0.75}$ at early stage, but was lower for +TPV and –TPV (16.8 and 21.1 g kg^{-1} $BW^{0.75}$) than for WPV (28.1 g kg^{-1} $BW^{0.75}$) at late stage. Overall, these results suggest that the cereal-legume silages harvested at early stage have a higher nutritive quality.

Keywords: *in vivo* digestibility, dry matter intake, cereal-legume silages, sheep

Introduction

Intercropping is an old practice used in many areas of the world. This practice, especially those employing cereals with legumes, is developing in French ruminant production systems to permit forage self-sufficiency, reduce N fertilizers and for climate change adaptation. Several environmental, agronomic and economic interests of cereal-legume intercrops mixtures have been reported (Pelzer *et al.*, 2012). Combining the growth of cereal forages with legumes enhance also the forage yields and crude protein (CP) concentrations in comparison with cereals whole crops or grass silages (Adesogan *et al.*, 2002). Previous works have compared few cereal-legume silages in terms of nutritive values and fermentation characteristics (Adesogan *et al.*, 2002; Mustapha and Seguin, 2004). These works have shown that fermentation pattern and nutritive value were first affected by stage of growth at harvest and the proportion of legume to cereal. Despite these works, data on feed value of cereal-legume silages remain limited in Europe, mainly due to a lack of *in vivo* measurements and the potential vast number of mixtures used. Thus, the objective of this study was to evaluate the effect of three common cereal-legume silages used in France and harvested at two stages of growth on dry matter intake (DMI) and organic matter digestibility (OMD).

Materials and methods

Three 5-ha plots were sown at the INRA experimental farm of Lusignan (France) with associations of field pea (*Pisum sativum* L., cv. Assas), common vetch (*Vicia sativa* L., cv. Savane) and cereal at the seed ratio of respectively 17, 20 and 220 seeds m^{-2}. The cereals used were wheat (*Triticum aestivum* L., cv. Soisson), bearded triticale (*X Triticosecale*, cv. Ragtac) or beardless triticale (*X Triticosecale*, Agri Obtentions). The three mixtures were harvested at two stages: early (20 May 2010, cereal at the end of stem elongation) and late (22 June 2010, cereal at dough-milky stage). Crops harvested at early stage were wilted before ensiling to target 25-30% dry matter (DM) content whereas at late stage, crops were directly ensiled in experimental

silos of approximately 450 kg DM and then stored before *in vivo* evaluation. Just before harvesting, the botanical composition of each mixture was determined from three randomly chosen 1 m^2 plots.

The *in vivo* study was carried out at the INRA experimental farm of Le-Pin-au-Haras (France). Six Texel male castrated sheep (on average 61.3 kg at the beginning of the study) were used to determine the OMD and DMI of the six silages. Two measurement periods per forage type were carried out successively. After an adaptation period of 14 days, a 5-days digestion trial was performed followed by 7 days off and then a second 5-days digestion trial. For each digestion trial, individual daily DMI was measured and total faeces collected and weighed. Silages were fed *ad libitum* in two meals. Offered forage and refusals were recorded daily and representative samples of the silage offered and refused, and of faeces from each sheep were collected daily. These samples were pooled at the end of the trial into: one sample of offered silage per forage type, one sample of refusal and one sample of faeces per sheep and forage. Faeces and refusal samples were analysed for ash, whereas silages were analysed for ash, CP (Rapid N Cube, Elementar) and for neutral detergent fibre (NDF) and acid detergent fibre (ADF) content using an Ankom fibre analyser (Ankom Technology) with heat-stable amylase. Data were analysed using the mixed procedure of SAS. Data for chemical composition were analysed with 'silage', 'growth stage' and 'silage × growth stage' as fixed effects. Data for *in vivo* measurements were analysed with 'silage', 'growth stage' and 'silage × growth stage' as fixed effects and 'sheep' as random effect. Multiple comparisons of means were performed with an adjusted Tukey-Kramer test.

Results and discussion

Despite the use of the same seed ratio for the three crops, the legume proportion was greater for the silages with wheat (WPV) than for silages with triticale: 0.32 and 0.41 for WPV at early and late stage, respectively vs 0.14 and 0.19 at early stage and 0.14 and 0.27 at late stage for the silages with triticale without and with spikes. Consequently, the CP content for WPV silages was higher than CP contents for silages with triticale at both stages (Table 1). For silages with triticale, the CP content decreased with maturity at harvest whereas for WPV the CP content at early stage (132 g kg^{-1} DM) was lower than that at late stage (142 g kg^{-1} DM). The higher legume proportion at this growth stage can partially explain these values. The NDF and ADF contents were similar between silages and stages of growth (P>0.10).

The DMI and OMD results are shown in Table 2. The DMI was on average 65.4 g kg^{-1} $BW^{0.75}$ for the three silages harvested at early stage. The DMI decreased with maturity at harvest for all mixtures (P<0.001) and especially for the bearded triticale+pea+vetch silage (+TPV): 28.0 g kg^{-1} $BW^{0.75}$ vs 46.2 and 37.5 g kg^{-1} $BW^{0.75}$ for WPV and the beardless triticale+pea+vetch silage (-TPV) respectively. These intake values were lower than DMI measured with pea+wheat silages at late stage (on average, 51 g kg^{-1} $BW^{0.75}$, Salawu *et al.,* 2002). The low intake level for +TPV at late stage, was probably due to palatability problems with the triticale related to the presence of barbs (Scerra *et al.,* 1994). The OMD was higher

Table 1. Dry matter (DM, g kg^{-1}) and chemical composition expressed as g kg^{-1} DM of the three cereal-legume silages (+TPV: bearbed triticale+pea+vetch; -TPV: beardless triticale+pea+vetch and WPV: wheat+pea+vetch) harvested at two stages of growth.[1]

	Early stage			Late stage				Effects		
	+TPV	-TPV	WPV	+TPV	-TPV	WPV	SEM	Sil	Gs	Sil×Gs
DM	207^{b}	269^{ab}	268^{ab}	240^{ab}	277^{a}	241^{ab}	11.0	0.011	0.60	0.08
CP[a]	120^{ab}	102^{bc}	132^{a}	98^{bc}	84^{c}	142^{a}	5.0	<0.001	0.05	0.04
NDF[a]	561	548	525	550	498	510	24.1	0.33	0.23	0.72
ADF[a]	352	317	317	332	302	306	16.5	0.27	0.20	0.80

[1] CP = crude protein; NDF = neutral detergent fibre; ADF = acid detergent fibre; Sil = effects of the types of silage; Gs = effect of the growth stage at harvest; SEM = standard error of means.

Table 2. Dry matter intake (DMI), *in vivo* organic matter digestibility (OMD) and digestible organic matter intake (DOMI) of the three cereal-legumes silages (+TPV: bearbed triticale+pea+vetch; -TPV: bearbless triticale+pea+vetch and WPV: wheat+pea+vetch) harvested at two stages of growth.[1]

	Early stage			Late stage				Effects		
	+TPV	-TPV	WPV	+TPV	-TPV	WPV	SEM	Sil	Gs	Sil×Gs
DMI, kg d^{-1}	1.44^a	1.42^a	1.47^a	0.55^c	0.82^b	0.91^b	0.08	<0.001	<0.001	<0.001
DMI, g kg^{-1} $BW^{0.75}$	65.2^a	65.4^a	65.5^a	28.0^d	37.5^b	46.2^c	2.85	<0.001	<0.001	<0.001
OMD	0.69^a	0.67^b	0.71^a	0.64^b	0.59^c	0.65^b	0.008	<0.001	<0.001	0.20
DOMI, g kg^{-1} $BW^{0.75}$	41.1^a	40.5^a	42.9^a	16.8^c	21.1^c	28.1^b	1.69	<0.001	<0.001	<0.001

[1] Sil = effects of the types of silage; Gs = effect of the growth stage at harvest; SEM = standard error of means

for WPV and +TPV than for –TPV whatever the stage of growth (P<0.001). Otherwise, for all silages, the OMD decreased with the maturity at harvest (P<0.001) and varied from 0.71 to 0.59. These OMD values were lower than OMD found in Feed Table for grass silages (INRA, 2007), but were consistent with OMD previously measured on cereal-legume silages (Salawu *et al.*, 2002; Arrigo *et al.*, 2014 and 2015). The DOMI was on average 41.5 g kg^{-1} $BW^{0.75}$ at early stage, but was lower for +TPV (16.8 g kg^{-1} $BW^{0.75}$) and –TPV (21.1 g kg^{-1} $BW^{0.75}$) than for WPV (28.1 g kg^{-1} $BW^{0.75}$) at late stage. The very low DOMI values for silages harvested at late stage suggest that these silages, especially those with triticale, had a poor nutritive quality.

Conclusions

The results of this study show that for early harvesting silages, the feed value of the three cereal-legume mixtures was similar. At late growth stage, the feed value of the mixture with wheat was higher than the feed value of mixtures containing triticale. Overall, the results suggest that silages harvested at early stage have a higher nutritive quality than silages harvested at late stage. However, forage yields are generally lower at early stage compared to late stage.

References

Adesogan A.T., Salawu M.B. and Deaville E. R. (2002) The effect on voluntary feed intake, *in vivo* digestibility and nitrogen balance in sheep of feeding grass silage or pea-wheat intercrops differing in pea to wheat ratio and maturity. *Animal Feed Science and Technology* 96, 161-173.

Arrigo Y. (2014) Estimating the nutritional value of silages composed of protein plant and immature cereal mixtures. *Recherche Agronomique Suisse* 5, 52-59.

Arrigo Y., Henneberger S. and Wyss U. (2015) Digestibility and degradability of silages from whole-plant pea-cereal mixtures. *Recherche Agronomique Suisse* 6, 144-151.

INRA (2007) *Alimentation des bovins, ovins et caprins*. Ed. Quae, Versailles, France

Mustapha A.F. and Seguin P. (2004) Chemical composition and *in vitro* digestibility of whole-crop pea and pea-cereal mixtures silages grown in south-western Quebec. *Journal of Agronomy and Crop Science* 190, 416-421.

Pelzer E., Bazot M., Makowski D., Corre-Hellou G., Naudin C., Al-Rifai M., Baranger E., Bedoussac L., Biarnes V., Boucheny P., Carrouee B., Dorvillez D., Foissy D., Gaillard B., Guichard L., Mansard M.C., Omon B., Prieur L., Yvergniaux M., Justes E. and Jeuffroy M.H (2012) Pea-wheat intercrops in low-input conditions combine high economic performances and low environmental impacts. *European Journal Agronomy* 40, 39-53.

Salawu M.B., Adesogan A.T., Fraser M.D., Fychan R. and Jones R. (2002) Assessment of the nutritive value of whole crop peas and intercropped pea-wheat bi-crop forages harvested at different maturity stages for ruminants. *Animal Feed Science Technology* 96, 43-53.

Scerra V., Galvano F., Angelis A., Galvano M. and Rapisarda A (1994) Research on nutritive value of Sicilian fodders and by-products. 6. *In vivo* digestibility and estimation of energy value of triticale silage. *World Review of Animal Production* 29, 66-71.