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# Associative effects between forage species on intake and digestive efficiency in sheep

Niderkorn V., Martin C., and Baumont R.

INRA, UMR1213 Herbivores, F-63122 Saint-Genès-Champanelle, France

## Abstract

There is evidence that multispecies swards can increase biomass productivity and provide number of ecosystem benefits. However, little is known regarding the possible interactions between forage species that can modulate positively or negatively the use of nutrients by ruminants. The objective of this study was to provide a better understanding of the associative effects between some forage species on intake and digestion parameters. Three sheep feeding experiments were conducted according to a repeated Latin square design using models of simple forage mixtures under the form of fresh forage or silage, and during which intake behaviour, DM digestibility, and methane emissions were measured. Synergies between cocksfoot silage and red clover silage, and between ryegrass and chicory, were observed on DM intake and eating rate, with optimums for the proportion 50:50. For the cocksfoot-red clover association, the synergy was also observed on daily intake of the digestible fraction that can reflect animal performances. No associative effect was observed on methane yield and the lowest emissions were observed for pure red clover and pure chicory.

Keywords: associative effects, grass-legume mixtures, chicory, intake, digestion, methane

## Introduction

Diversified pastures are considered as having the potential to better serve production and ecosystem services than species poor grasslands. However, there is a need for an improved understanding of the utilisation of complex grasslands by ruminants to optimise their management. This implies investigations of animal responses to multi-species swards and in particular a better understanding of the interactions that can occur between plants on digestion, intake and pollutant emissions as enteric methane. Indeed, the digestibility and feed intake of a combination of forages can differ from the balanced median values calculated from forages considered separately leading to synergistic or antagonistic effects instead of simple additivity (Niderkorn and Baumont, 2009). The objective of this study was to assess the associative effects between some common or less known (e.g. chicory) forage species on intake and digestive processes in sheep.

## Materials and methods

Three sheep feeding experiments were conducted at INRA Clermont-Ferrand-Theix (France) between 2010 and 2012. Models of simple forage mixtures were designed under the form of fresh forage or silage according common use for the tested species. The combinations tested were i) binary mixtures of silages of cocksfoot (*Dactylis glomerata* L., cv Starly) and red

clover (*Trifolium pratense*, cv Diadem) in five controlled proportions (in % dry matter (DM), 100:0; 75:25; 50:50; 25:75; 0:100), ii) binary mixtures of fresh forages of perennial ryegrass (*Lolium perenne* L., cv AberAvon) and white clover (*Trifolium repens*, cv Merwi) in the same proportions, and iii) mixtures of fresh forages containing chicory (*Cichorium intybus*, cv Puna II): 100% ryegrass, 50% ryegrass + 50% chicory, 100% chicory, 50% ryegrass + 25% white clover + 25% chicory. For each experiment, housed rumen cannulated sheep were used in a repeated Latin-square design, 4×4 or 5×5 according to the number of treatments. Mixtures were prepared from five-weeks regrowth plants cultivated in pure swards. Each experimental period consisted in an adaptation week to diet followed by a measurement week. During the measurement period, chemical composition of plants, intake kinetics and behaviour (Baumont *et al.*, 2004), DM digestibility, and methane emissions using the SF<sub>6</sub> tracer method according to the procedure described by Martin *et al.* (2008) were determined. Data were analysed using the MIXED procedure of SAS<sup>®</sup> v.9.1 software. Linear and quadratic contrasts were tested to highlight potential associative effects between species.

## Results and discussion

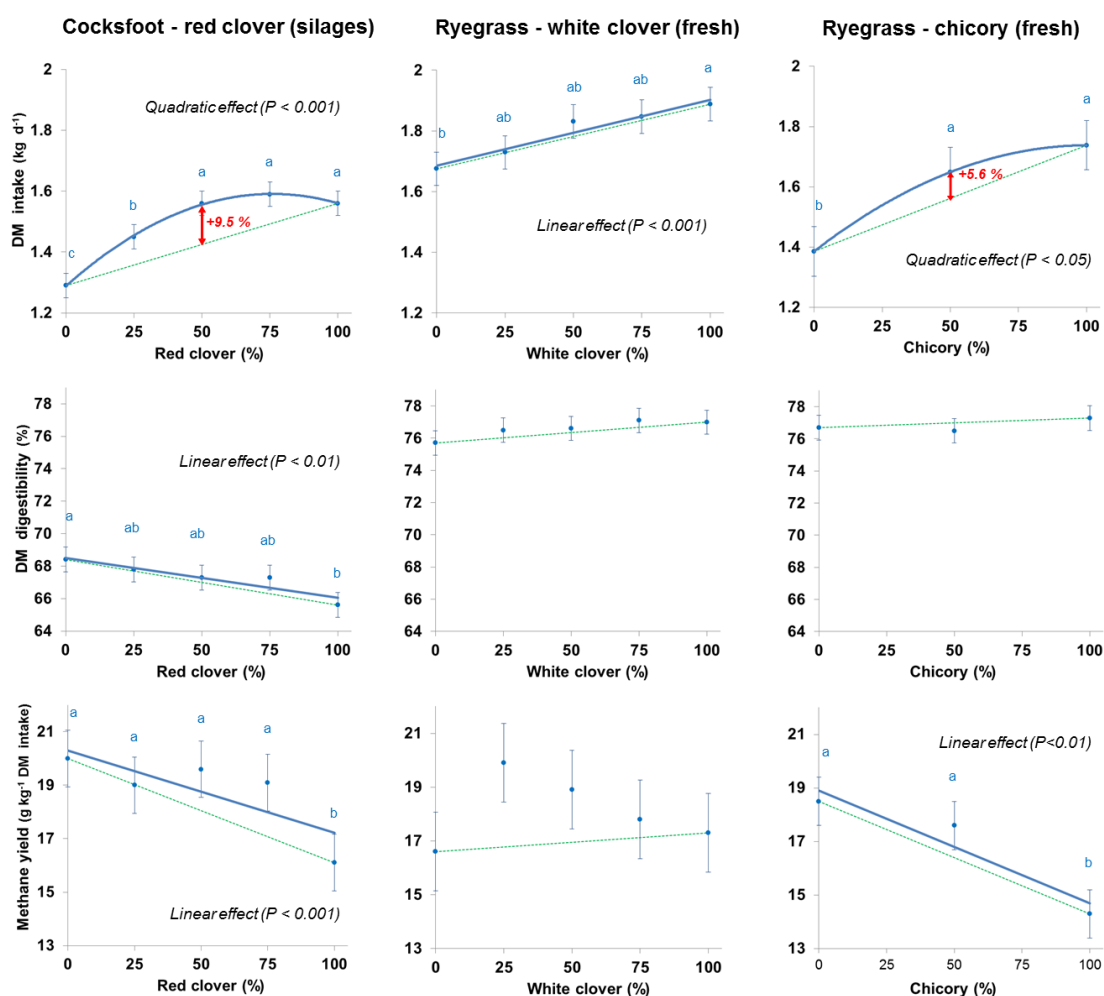


Figure 1. Voluntary dry matter (DM) intake, DM digestibility and methane yield in sheep fed with different proportions of cocksfoot and red clover silages, ryegrass and white clover (fresh), and ryegrass and chicory (fresh). Full lines represent smoothed linear or quadratic responses, and dotted lines represent theoretical responses calculated from values obtained from pure forages.

Significant positive quadratic effects were observed between silage of cocksfoot and silage of red clover ( $P < 0.001$ ), and between fresh ryegrass and fresh chicory ( $P < 0.05$ ) on voluntary DM intake indicating synergistic effects (Figure 1). The optimums were observed with the proportions 50-50, and the differences between the values measured for the plant combinations and the balanced median values from pure forages were +9.5% and +5.6% in voluntary DM intake for the mixtures cocksfoot-red clover and ryegrass-chicory, respectively. Adding a third species (chicory) did not improve intake and digestive efficiency of the ryegrass-white clover mixture (data not shown).

These synergies did not seem to be due to a more efficient digestion as positive quadratic effects were not observed on DM digestibility ( $P > 0.05$ ). For the mixture cocksfoot-red clover, a quadratic effect was observed on daily eating rate ( $P = 0.008$ ) suggesting a greater motivation to eat. For all the mixtures, very strong positive quadratic effects ( $P < 0.001$ ) were observed on DM intake and eating rates during the main meals distributed in the morning and the afternoon, indicating that the diversity in the ration stimulated intake in the short-term. A particularly relevant result was observed with the mixture cocksfoot-red clover as a synergy was also observed on daily intake of the digestible fraction that can be seen as an indicator of animal performances (Niderkorn *et al.*, 2012). No associative effect was observed on methane yield (emissions in g/kg DM intake,  $P > 0.05$ ). The lowest emissions were observed for pure red clover and pure chicory.

## Conclusion

Taken together, our results indicate that synergy between some species in binary mixtures can be observed on voluntary intake in sheep, with an optimum for the proportion 50:50 without associative effects on methane emissions. Synergy seems to be rather due to a greater motivation to eat than to a more efficient digestion.

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