# A comparative study of simple and complex 'grass-legume' mixtures implanted with or without cover crop

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## Abstract

Grass/legume mixtures are often used, in organic farming systems, to improve system productivity and therefore to provide autonomy towards nitrogen resources. However, is the productivity, quality and profitability of the forage obtained a function of the mixture complexity?

Three temporary grassland trials, in four blocks, were established in 2000, 2001 and 2002 in the south-eastern part of Belgium. In each trial, a complex (5 grass species with 4 legume species) and a simple (2 grass species with 1 legume species) grass/legume mixture, sown with or without cover crops, were compared from their DM yield, nutritive value and botanical composition point of view, over 3 seasons. In the present paper we develop the results relative to the 2001 implantation.

Grassland sown under cover crops showed a better yield in the first year but no additional differences were underlined thereafter. No significant difference has been highlighted between the complex and the simple mixtures neither from their dry matter yield nor from their feeding value. In the complex mixture, only one legumes species out of five has persisted more than one winter. In consequence, under our soil and climatic conditions, the most profitable grass/legume mixtures were the simplest ones.

**Keywords:** temporary grassland, grass/legume mixture, cover crop, legumes species, organic farming

## Introduction

During last decade, after a long period of intensive farming systems promotion and following the emergence of different environmental problems (water pollution by nitrate, climatic changes, biodiversity erosion, …), European agricultural policies have searched to favour systems with lower level of inputs.

Such context has motivated grassland researchers to focus their attention on the study of legumes use potentialities in ruminant livestock production systems. Indeed, following its nitrogen fixation in symbiosis with *Rhizobium* bacteria, legume use can lead to high yields of good quality forage. Additionally grass/legume mixture seems to stabilize sward composition by reducing weed invasion. (Sanderson, 2004).

Now, some authors underline the superiority, in term of productivity, of complex grass/legume mixtures in comparison with simple ones (Daly *et al.*,1996 cited by Hopkins, 2004, Tilman *et al.,* 1996 and Hector *et al.,* 1999. cited by Drake, 2003). Such results being explained by a better exploitation of soil resources by the complex mixture. However, others authors emphasize the importance of legume presence in the mixture rather than the complexity of the grass/legume mixture.

The aim of the experiment reported here was to compare productivity, nutritive value and botanical composition evolutions of complex and simple grass/legume mixtures sown and managed respecting organic farming rules.

## Material and methods

The study site is located in the south-eastern part of Belgium (49°55'N - 5°22'E, altitude about 480 m above sea level). A temporary grassland trial was established in 2001 (23rd May) in a field converted to organic farming since September 1997. The grassland was preceded by a triticale-pea mixture crop. The soil is a loam characterised by a large amounts of stones.

The performances of a complex [CM] (*Lolium perenne* (26%, as weight proportion), *L. multiflorum* (13%), *Phleum pratense* (17%), *Dactylis glomerata* (7%), *Festuca pratense* (7%), *Trifolium repens* (17%), *T. hybridum* (17%), *Lotus corniculatus* (3%) and *Medicago lupulina* (3%)) and a simple [SM] (*Lolium perenne* (64 %), *Phleum pratense* (26 %) and *Trifolium pratense* (11 %)) grass/legume mixtures were compared during 3 seasons (one year of establishment and two years of plenty production). Each mixture was sown, at a rate of 40 $kg.ha^{-1}$, with or without cover crops. Detailed information on the type of cover crops and their sowing rates are given in table 1.

Experimental design was a completely randomised block design with four replications. Elementary plot size was of 8 x 1,5 m. Fertilisation scheme was as follow :

- in 2001, before sowing : 15 t of composted cattle manure $ha^{-1}$ (fertilising value : 6 kg of N, 1.9 kg of P and 4.5 kg of K per tonne of fresh product) and a phosphorus correction of 56 kg $P.ha^{-1}$, under the form of natural Gafsa,
- in 2002 : a phosphorus correction of 79,5 kg $P.ha^{-1}$, under the form of natural Gafsa,
- in 2003 : 17 t of composted cattle manure $ha^{-1}$ and a phospho-potassium correction of 30,5 kg $P.ha^{-1}$ (Gafsa) and 67 kg $K.ha^{-1}$ (Patenkali).

Three cuts was performed each year, excepted during the sowing year where only two cuts were done. Dry matter yield and grass nutritive value were measured for each plot at each cut, during the 3 seasons. Botanical composition was recorded yearly, in September, during all the trial lasting while sward mineral composition was measured for the two first cuts of the first full exploitation year.

**Table 1.** Sward mixture codes in accordance to their composition and to cover-crop species

| | |
|---|---|
| Complex mixture (CM) or simple mixture (SM) without cover crop | |
| Simple mixture (SM+AP) | + *Avena sativa* (80 $kg.ha^{-1}$) and *Pisum sativa* (30 $seeds.m^{-2}$) as cover crop |
| Complex mixture (CM+AP) | + *Avena sativa* (80 $kg.ha^{-1}$) and *Pisum sativa* (30 $seeds.m^{-2}$) as cover crop |
| Complex mixture (CM+A) | + *Avena sativa* (80 $kg.ha^{-1}$) as cover crop |
| Complex mixture (CM+M) | + *Setaria italica var. moharica* (15 $kg.ha^{-1}$) as cover crop |
| Complex mixture (CM+T) | + *Trifolium alexandrum* (15 $kg.ha^{-1}$) as cover crop |

## Results and discussion

The complex and the simple mixtures allowed to reach very similar performances (table 2). So when considering the pure mixtures together with the mixtures sown under the "*Avena-Pisum*" cover crop we couldn't found any significant differences during the sowing year or the first year of full exploitation, and this whatever the parameter taken into account. During the second year of full exploitation, DM yield (+ 5,5%) ($F(1,18) = 15.96$ ; $p = 0,0008$) and energy production (+ 6,8%) ($F(1,18) = 20.12$ ; $p = 0,0003$) of SM was significantly higher than for CM. However, the high proportion of red clover (figure 1) in SM didn't give significant difference in protein content. This result could be explain by the proportion of cooksfoot and hybrid clover in CM, both species are rich in protein content.

During the sowing year, the cover-crop "*Avena-Pisum*" allowed to increase significantly, whatever the mixture taken into account, dry matter (+ 12% for CM and + 14% for SM) ($F(1,18)=30.85$; $p < 0.0001$) and energy (+5.7 % for CM and + 13.4% for SM) ($F(1,18)=27.71$; $p < 0.0001$ ) productions. There were no additional impact of this cover crop during the two years of full exploitation.

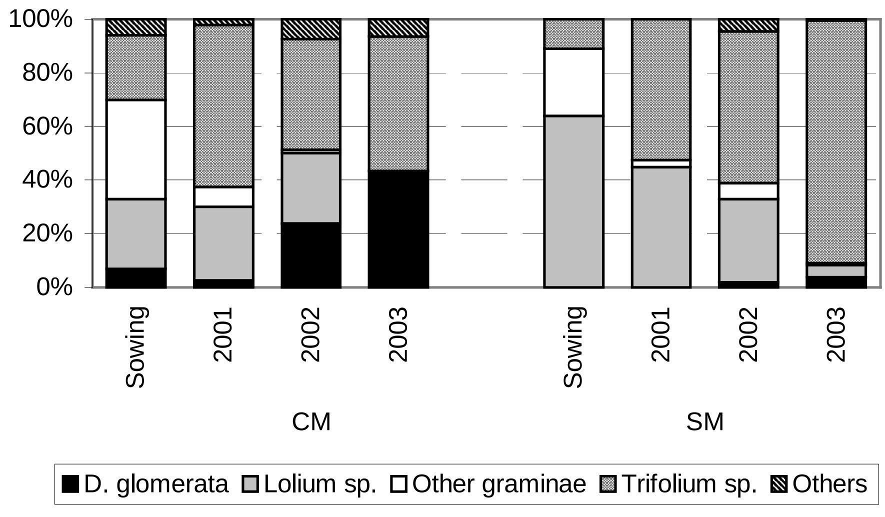
**Table 2:** Annual dry matter yield [DM] ($t.ha^{-1}$), energy production ($10^6$ VEM) and crude protein content ($g.kg^{-1}$) from the two mixtures under the different cover-crop.

| | 2001 | | | 2002 | | | 2003 | | |
|---|---|---|---|---|---|---|---|---|---|
| Mixtures | DM ($t.ha^{-1}$) | Energy ($10^6$VEM $ha^{-1}$) | Protein ($g.kg^{-1}$) | DM ($t.ha^{-1}$) | Energy ($10^6$VEM $ha^{-1}$) | Protein ($g.kg^{-1}$) | DM ($t.ha^{-1}$) | Energy ($10^6$VEM $ha^{-1}$) | Protein ($g.kg^{-1}$) |
| CM | 5.6[b] | 4.9[b] | 14.4[a] | 15.1[a] | 12.3[a] | 13.6[ab] | 10.4[b] | 9.0[b] | 14.1[a] |
| CM+A | 6.5[ab] | 5.5[ab] | 12.2[a] | 14.1[a] | 11.4[a] | 14.0[ab] | 9.6[b] | 9.0[b] | 14.2[a] |
| CM+AP | 7.1[a] | 6.0[a] | 13.2[a] | 15.2[a] | 12.2[a] | 13.7[ab] | 10.3[b] | 8.9[b] | 14.0[a] |
| CM+M | 6.2[ab] | 5.2[ab] | 13.4[a] | 15.9[a] | 12.9[a] | 13.1[b] | 9.9[b] | 8.6[b] | 13.6[a] |
| CM+T | 6.4[ab] | 5.3[ab] | 13.9[a] | 14.9[a] | 12.1[a] | 13.0[b] | 10.3[b] | 8.5[b] | 14.6[a] |
| SM | 5.2[b] | 4.5[b] | 14.7[a] | 14.7[a] | 11.8[a] | 13.7[ab] | 11.6[a] | 10.3[a] | 15.0[a] |
| SM+AP | 7.2[a] | 5.9[a] | 12.7[a] | 14.1[a] | 11.4[a] | 14.6[a] | 11.7[a] | 10.2[a] | 14.4[a] |

Values marked by different letters within the same column are highly significantly different ($p<0.01$)

Concerning the botanical composition of the mixtures, sown without cover-crop, there was a clear evolution during the three years of observation (figure 1). Some species (*Festuca pratense*, *Lotus corniculatus* and *Medicago lupulina)* that have been sown in the CM were never recorded by the B% method. Others species such as *Phleum pratense*, representing the other graminae in SM, had never represented an important part of forage production. There was a clear evolution of the CM botanical composition towards an association of cocksfoot and hybrid clover, evolution accelerated by the drought summer of 2003 and by the use of a significant part of *Lolium multiflorum* in the mixture. In the SM, following the drought summer of 2003, there was a big domination of the red clover over the perennial rye-grass (figure 1).
In this trial there was no clear effect of cover-crop use on weed pressure evolution.

**Figure 1**: Evolution of the botanical composition of the CM and SM, without cover-crop, during three years of exploitation.




There was no effect neither of the mixture complexity nor of the cover crop utilisation on the K, P or Mg sward content. While Na ($F(3,9) = 9.11$; $p = 0.004$) and Ca ($F(3,9) = 8.93$; $p = 0.005$) concentration were highly significantly influenced by the mixture parameter : the SM showing the highest concentrations (table 3). This could be linked to the higher legume content of this sward.

**Table 3:** Mineral concentration ($g.kg^{-1}$) of the forage collected during the two first cuts of the first full exploitation year.

| | K | P | Na | Mg | Ca |
|---|---|---|---|---|---|
| CM | $30.57^{a}$ | $2.55^{a}$ | $0.145^{b}$ | $3.19^{a}$ | $10.34^{b}$ |
| CM+AP | $30.23^{a}$ | $2.54^{a}$ | $0.145^{b}$ | $3.24^{a}$ | $10.53^{b}$ |
| SM | $30.01^{a}$ | $2.40^{a}$ | $0.200^{ab}$ | $3.30^{a}$ | $11.27^{a}$ |
| SM+AP | $30.98^{a}$ | $2.52^{a}$ | $0.230^{a}$ | $3.31^{a}$ | $11.11^{a}$ |

Values marked by different letters within the same column are highly significantly different ($p<0.01$)

## Conclusions

All the mixtures allowed to reach good and similar performances. The only advantage of the CM lies in a better persistence of cocksfoot under drought summer leading to a better grass/legume ratio for silage making. The high legume proportion observed with the simple mixture was reflected by the higher sward Ca and Na content.

However, seeds cost is higher for the complex mixture. Some species, like *Festuca pratense, Lotus corniculatus* and *Medicago lupulina*, added in the complex mixture, are not adapted to our soil and climatic conditions. Some influent factors like soil, climate, manuring favour species in the mixture. These species dominate more or less rapidly the others that have often a secondary importance. So, the biodiversity advantage of such complex mixture, proposed in organic farming for temporary grassland, is weak after two years of full exploitation.

The use of a '*Avena-Pisum*' cover-crop during the sowing year remains a good alternative to improve yield potential with the production of a forage of good quality if cut at the good stage : flowering stage for the pea and oat.

## References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