Residual effects of different organic matters compared with mineral nitrogen on a mown permanent grassland.

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Abstract

The effect of four slow acting organic fertilisers (SA : cattle manure, farmyard manure compost, compost of separately collected green refuse and sewage sludge) and three fast acting organic fertilisers (FA : cattle slurry, deep litter fermentation of pig and poultry droppings) was compared with increasing level of mineral nitrogen fertilisation (0, 50, 100, 150, 200 kg N ha^{-1} y^{-1}). Applications of fertilisers were performed during seven years (1993-2000), on a permanent grassland from the Eastern part of Belgium. In this paper, we focus our attention on the analysis of the residual effects, observed in 2001, i.e. one year after the last application, on forage yield and plant species occurrence. Compared to mineral fertilisation of 200 kg N ha^{-1} y^{-1} (100%), SA have a better back effect on yield (141%) than FA (135%). After seven years of application, plant species composition was in general better with SA than FA organic fertilisers or mineral fertilisers.
So, using SA organic fertilisers, regularly on grassland, secure the productivity even if there's no fertiliser application during one year.

Keywords: organic fertilisation, residual effect, grassland, nitrogen, yield

Introduction

In reaction to the evolution of the agricultural market, farmers are looking for alternatives to lower the costs of their productions. In herbivore systems, this means more especially for forage production costs (Szewczyk *et al.*, 2004). To do so, some breeders reduce the use of expensive mineral fertiliser through a better valorisation of organic fertilisers produced on farm or out of it. One potential drawback is that the organic fertilizer, depending of its nature, may not release enough of its principal nutrients when the plant needs them. So it is important to be able to define its effects as a fertiliser in order to take it into account in the global fertilisation scheme, to adjust the applications to the plant needs.
In spite of this difficulty, there is a huge interest to apply organic matters on grasslands as this crop allows several applications per year and are able to export more nutrients than annual crops (Bittman et al., 2004).
In such a context, the objective of this experiment was to compare in the long run, the effectiveness and the residual effects of different organics fertilisers on a mown permanent grassland. The references are the effectiveness and the residual effects observed following the use of different levels of mineral fertilisers.

Material and methods

This trial was carried out between 1993 and 2001, on a permanent grassland dominated by perennial ryegrass, in the Eastern part of Belgium (about 600 m above sea level, in average (1995-2000) 580 mm of rainfall during the growing season (April-September). An oversowing, with 44 kg/ha of different perennial ryegrass varieties, was carried out in April 1994. The experiment was set up in a randomised block design with 4 replicates. Each experimental plot had a size of 75 m^2 (5 m x 15 m). Four slow acting organic fertilisers (SA : cattle manure (M), composted cattle manure (CM), compost of separately collected green refuse (GC) and sewage sludge (SS)) and three fast acting organic fertilisers (FA : cattle slurry (S), deep litter fermentation of pig (PL) and poultry droppings (PD)) were compared to increasing levels of mineral nitrogen fertilisation (0, 50, 100, 150, 200 kg N ha^{-1} y^{-1}). Sewage sludge and poultry droppings were only applied since 1996.

The objective was to apply, for each of the organic matter, a total amount of 200 kg N ha^{-1} y^{-1}, until 2000. To do so, each organic matter was analysed to adjust the N input for the different treatments. Per year, in average for all the organic treatments, 147 kg $P_2O_5.ha^{-1}$ and 90 kg $K_2O.ha^{-1}$ were applied under a mineral form to complete organic fertilizers supplies. All mineral treatments received, in average, per year, 155 kg $P_2O_5.ha^{-1}$ and 201 kg $K_2O.ha^{-1}$ each year (table 1). No fertilisation was applied in 2001. Three to four cuts were performed each year. In 2001, dry matter yield (DM) and grass nutritive value were measured for each plot, at each cut for DM and for the 1^{st}, 2^{nd},3^{rd} cuts for nutritive value. Botanical composition and species cover were recorded during each year, in September, using B% method (DeVries *et al.*, 1959). Statistical analyses were performed using a two ways ANOVA, with a mixed model (proc GLM – SAS). The two factors taken into account were the 'treatment' and the 'block'. The factor treatment was tested against the interaction 'treatment*block'. Multiple means comparisons were performed with Student-Newman-Keuls test.

Table 1: Average annual fertilisation (organic + mineral), during the 1993-2000 period

Treatment	N ($kg.ha^{-1}.y^{-1}$)	P_2O_5 ($kg.ha^{-1}.y^{-1}$)	K_2O ($kg.ha^{-1}.y^{-1}$)
M (SA)	192	257	321
GC (SA)	186	280	241
MC (SA)	202	267	326
SS (SA)	146	338	229
PD (FA)	144	239	220
S (FA)	201	213	288
PL (FA)	225	409	398
N0	0	154	197
N50	50	156	197
N100	101	156	197
N150	150	154	206
N200	197	154	206

Results and discussion

There were significant DM Yield differences between the treatments during the 2001 season (table 2). Except for PL, all the Slow Acting fertilisers (SA) give better DM yield than FA and mineral fertilisers. In 2001, SA fertilizers keep or even increase their 7 years (1993-2000) average DM yield (6829 $kg.ha^{-1}$ vs 6705 $kg.ha^{-1}$). When comparing the treatments M and S, the most widely used on grassland, to the mineral fertilisation schemes of 150 and 200 kg N

ha^{-1} y^{-1} (100%)., we observed that M has the better back effect on DM (149 %) ($F(1,33) = 44.22$; $p<0.001$) and on energy (146%) ($F(1,33) = 41.84$; $p<0.001$) yields while S has an intermediate position with, respectively, 125% ($F(1,33) = 9.85$; $p<0.005$) and 122 % ($F1,33) = 8.23$; $p<0.005$) of the performances observed with mineral fertilisation schemes.
These results could be explained by the increase of the efficiency of the organic dressings from year to year, especially for the SA. To explain the big DM yield drop of N200 treatment, we draw the hypothesis of a K_2O sub-fertilisation during 7 years (table 1). A second observation supporting this hypothesis is the weak protein value of N200 (104 $g.kg^{-1}$) and N150 (109 $g.kg^{-1}$) compared to the organic treatments. An future analysis of the N, P and K nutritive indexes (Lemaire *et al*, 1997) will allow to test this hypothesis.
There is no significant difference between treatments in terms of energy content in the grass. So, the differences observed in term of energy production result from the difference recorded for DM yield.

Table 2: Annual dry matter yield [DM] ($t.ha^{-1}$), energy production (10^6 VEM) and crude protein content ($g.kg^{-1}$ DM) from the different treatments for 2001. Value marked by different letters within the same column are significantly different ($p<0.05$).

Treatment	DM ($t.ha^{-1}$)	DM (% of N200)	Energy (10^6 $VEM.ha^{-1}$)	Protein ($g.kg^{-1}$ DM)
PL (FA)	7600 ^{a}	157	7.26 ^{a}	122 ^{a}
M (SA)	7194 ^{ab}	149	6.74 ^{ab}	119 ^{a}
GC (SA)	6953 ^{abc}	144	6.62 ^{abc}	122 ^{a}
MC (SA)	6678 ^{abcd}	138	6.39 ^{abc}	121 ^{a}
SS (SA)	6491 ^{bcd}	134	6.07 ^{bc}	113 ^{ab}
N0	6399 ^{bcd}	132	6.07 ^{bc}	118 ^{ab}
PD (FA)	6062 ^{bcde}	125	5.71 ^{bcd}	110 ^{ab}
S (FA)	6041 ^{bcde}	125	5.64 ^{bcd}	111 ^{ab}
N50	5922 ^{cde}	122	5.65 ^{bcd}	121 ^{a}
N100	5713 ^{def}	118	5.50 ^{cd}	113 ^{ab}
N150	5178 ^{ef}	107	4.92 ^{de}	109 ^{ab}
N200	4843 ^{f}	100	4.60 ^{e}	104 ^{b}

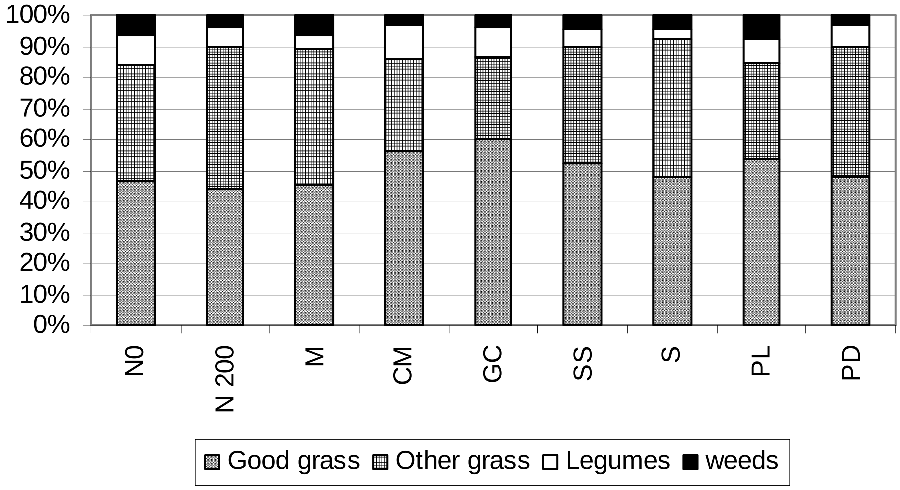

Figure 1 : Botanical composition (B%) in 2001 for SA, FA, N0 and N200 treatments

In figure 1, classification of the botanical composition was made with De Vries method (1942). In this case, *Lolium perenne*, *Festuca patrensis*, *Phleum patrense* and *Poa patrensis* are considered as good grass. After 7 years of application of the different fertilisation schemes, the percentage of good grass and legumes is the highest for the 2 composted matters : CM and GC. Legumes percentage is not higher in N0 treatment (10%) than in the CM and GC (11.5 vs 10%). The application of M and futhermore of S does not stimulate the development of legumes (5% vs 3.8%). These results underline the real interest to compost manure before its application on grassland. Compare to M, the flora observed following the application of CM integrates 11% more of good grass, 6.5% more of legumes, essentially white clover, and 3.3% less weeds.

Conclusions

These results confirm that organic fertilizers have a larger residual effect than mineral ones. This is especially true for SA fertilizers. So, a regular dressing of organic matter on mown permanent grasslands secure DM and protein yields through an increase of nitrogen supplying by the soil, in comparison to mineral fertilisation schemes. In addition, botanical composition of the sward is the same and even better following organic fertilisation schemes especially for composted organic matters, at least if the applications are done under good conditions.

Acknowledgement

This research was supported by the Ministry of the Walloon region (MRW-DGA)

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