Performance of ley systems-experience from Belgium

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Gent University has an experience in ley-arable farming of over 50 years. In 1966 emeritus Prof. Behaeghe designed a latin square (trial code M66.1) with 4 agricultural systems: (1) permanent arable land, (2) permanent grassland, (3) ley-arable: 3 years ley followed by 3 years arable crops and (4) arable-ley: 3 years arable crops followed by 3 years ley. Soil type: sandy loam. Annual rainfall, about 750 mm.

The grassland was used as follows: first cut mowed; subsequent cuts grazed by heifers in a rotational grazing system. Annual nitrogen dressing between 240 and 350 kg/ha.
The main crop on the arable plots was forage maize, either grown in monoculture or in rotation with e.g. faba bean and fodder beet. Results of this trial have been published in Nevens and Reheul (2002, 2003), Reheul (2017) and in several volumes of Grassland Science in Europe.

M66.1 was ploughed out in 2007. Part of the trial was resown into grassland and planted with potato and forage maize. The results of this research are documented in the PhD of L. Bommelé (2007) and in several volumes of Grassland Science in Europe.
In 2005 a new ley-arable trial was established. Forage maize was established in ploughed out *grazed and cut temporary grass-white clover* and in ploughed out *permanent grassland*. Its performance was compared with forage maize grown on permanent arable land. Results will be published soon in Cougnon *et al.* 2018.

The main messages from these trials are the following:

(i) Newly established grassland performs way better in arable land compared to reseeded grassland, particularly in dry years (Table 1).
(ii) White clover establishment and its persistence is way better in arable land than in reseeded grassland (Figure 1a and 1b).
(iii) After ploughed out grass and grass-white clover any crop can be grown without nitrogen fertilization in the first year after ploughing. From year 2 on, the nitrogen fertilization replacement value decreases and becomes nearly nihil in year 3. Substantial savings in nitrogen fertilization are possible (Table 2).
(iv) After ploughed out permanent grassland, forage maize needs no N fertilization to deliver a full harvest during the first 3 years. From year 3 on, a significant non-nitrogen effect allows yield increases up to 20% with a N dressing of 150 kg/ha.
(v) Soil nitrate surpluses mostly are manageable; a very N-demanding crop as e.g. fodder beet is the best option as opener crop after plowing out grassland. An acceptable option is an early maturing variety of forage maize followed by Italian ryegrass as a cover crop.
(vi) In our circumstances, the ley-arable system sequestered on average 400 kg C per year, just about the half of permanent grassland.
(vii) Soil biological quality of ley-arable systems are in between the quality of permanent arable land and permanent grassland (Table 3)

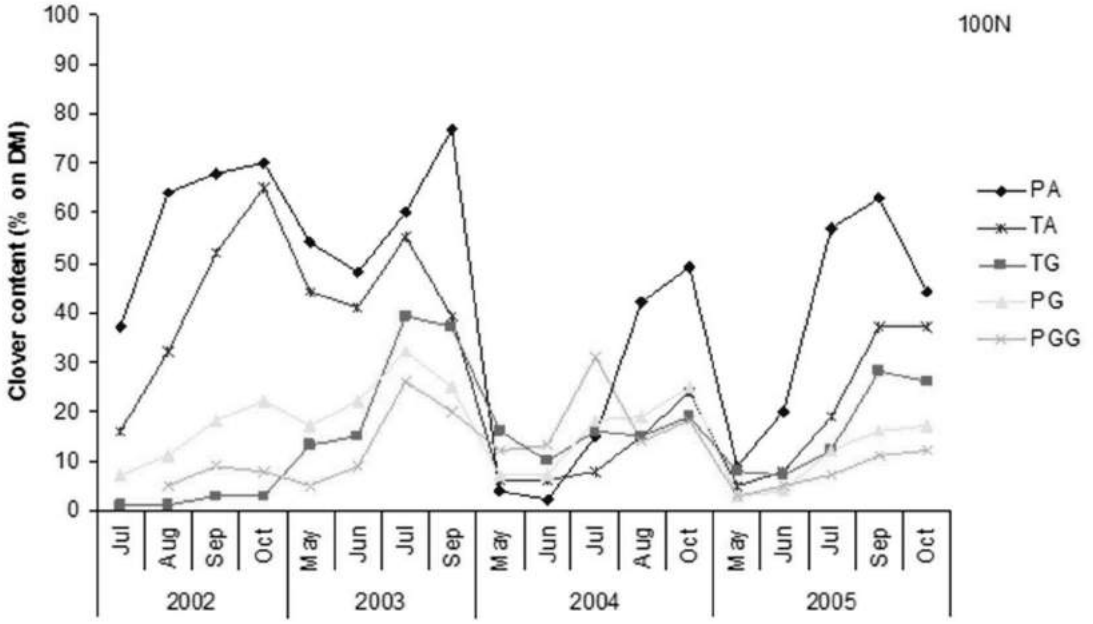

Figure 1a: Evolution of percentage white clover in forage DM yield. Performances in PA, TA: permanent, temporary grassland; PG, TG: permanent, temporary ploughed out grassland. PGG: untouched permanent grassland. All cutting regime. Annual N fertilization: 100 kg/ha. Reheul *et al.* 2017.

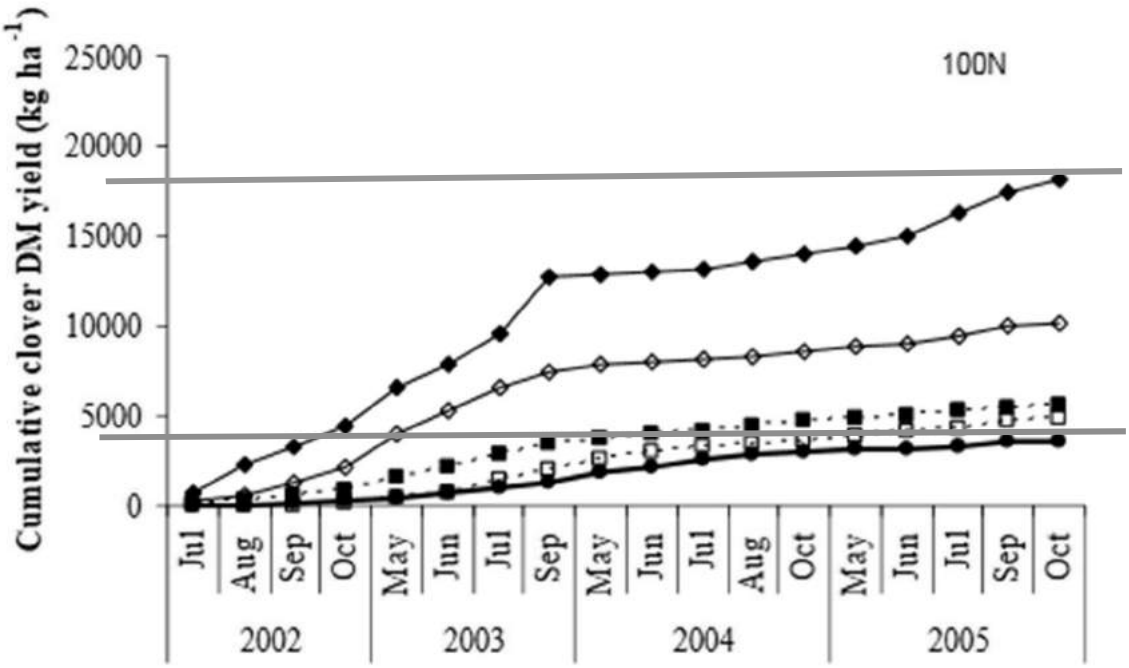

Figure 1b: Cumulative white clover DM yield after 3 full growing seasons. Symbols top down: TA, PA, TG, PG, PGG: see Figure 2a.

Table 1. Performance of different grassland types in 2003, a very dry summer.

Forage DM yield in 2003 (very dry summer); cutting regime; sown in April 2002.		
Sown/reseeded into	**100 kg N/ha**	**300 kg N/ha**
Permanent arable land	100	**100**
Temporary arable land	80	**92**
Permanent grassland	78	**90**
Temporary grassland	55	**85**
Untouched permanent grassland	**56**	**87**
100=kg/ha DS	14925	**14917**

Table 2. Performance of forage maize grown in monoculture, either on permanent arable land or in ley-arable farming (3 years ley, 3 years arable) on a sandy loam soil in Belgium in the period 1990-1998. The figures in the table are accumulated yields over 9 years, registered in three successive ley-arable cycles; relative values between brackets. Deduced from Nevens and Reheul 2002.

	Forage maize grown in monoculture on permanent arable land fertilized with 180 kg N/ha	Forage maize grown in ley-arable farming with 0 N in year 1 after the ploughing-out of temporary grassland, 75 kg N/ha in year 2 and 180 kg/ha in year 3
DM yield (kg/ha)	177,500 (100)	173,100 (98)
Applied N (kg/ha)	1,620 (100)	765 (47)
Kg DM/kg applied N	109 (100)	226 (207)
N concentration of the forage in year 2	9.0 (100)	9.7 (108)

Table 3. Earthworm numbers, biomass, species, functional groups and earthworm burrows in permanent grassland (PG), temporary grassland (TG), temporary arable land (TA) and permanent arable land (PA): averages from three consecutive years (2002-2004). Van Eekeren *et al.* 2008

Earthworms	Units	Treatments					Year	Treatment × year
		PG	TG	TA	PA	P-value	P-value	P-value
Number of earthworms	n m^{-2}	256 a	187 b	62 c	30 c	<0.001	NS	0.008
Body biomass	g worm^{-1}	0.65 a	0.25 b	0.23 b	0.12 b	<0.001	0.033	NS
Total biomass	g m^{-2}	166 a	52 b	14 bc	5 c	<0.001	NS	NS
Number of species	n m^{-2}	2.0 a	1.3 b	0.5 c	0.2 c	<0.001	NS	<0.001
Epigeic adults	n m^{-2}	20 a	25 a	1 b	0 b	0.016	0.011	NS
Endogeic adults	n m^{-2}	46 ab	49 a	22 bc	7 cd	0.009	NS	0.031
Anecic adults	n m^{-2}	71 a	4 b	2 b	0 c	<0.001	NS	NS
Earthworm burrows[a]								
10 cm depth	n m^{-2}	388 a	238 b	106 c	6 d	<0.001	–	–
20 cm depth	n m^{-2}	356 a	206 b	100 c	6 d	<0.001	–	–

Values followed by the same letter (a–d) within a row are not statistically different at the 5% error level for the main treatment effect.
[a] Earthworm burrows were counted in 2004 only.

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