Multispecies grasslands for crop productivity and carbon storage

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Implications

Organic grasslands have long been recognized for their provision of ecosystem functions and services and this may be further increased by inclusion of appropriate herb species. Inclusion of herb species in grasslands has in the present experiment shown to increase yield stability. Furthermore, the data presented here has indicated some potential of species known to have deeper and denser rooting systems to increase belowground biomass, an important asset for C sequestration in grasslands.

Background and objectives

In grasslands, most C originates from roots and total allocated C increases with plant species richness (Adair *et al.*, 2009). The larger roots seem to be more important than small roots to enhance the C pools (Rasmussen *et al.*, 2010). However, the storage of C in soils depends on both the inputs and the decomposition rate, which is especially important in farming systems with frequent grassland cultivation. We investigated above and belowground biomass in differently managed multispecies mixtures and CO_2 emission upon grassland cultivation.

Key results and discussion

Aboveground biomass increased considerably with increasing content of herbs (including lucerne) in the mixture and also with fertilizer application in plots with a 4-cut strategy (Table 1). With a 6-cut strategy, aboveground biomass was much depressed compared to the 4-cut strategy; in the previous years this depression was only noticed in the 100% herb mixture (Mortensen *et al.*, 2012). The herb mixture was dominated by lucerne, most pronounced without fertilizer, and caraway, most pronounced with fertilizer application.

Table 1. Aboveground biomass and botanical composition of swards with different herb seeding rates, manure application and cutting frequency in spring cut in the third production year. Biomass values with different letters are statistically different (P<0.05). Annual biomass production in Mortensen *et al.* (2012).

Herbs in mix	Manure applied	Cuts per year	Biomass	Rye-grass	White Clover	Lucerne	Caraway	Chicory	Salad burnet	Plantain	Birds-foot trefoil	Unsown
			t DM ha^{-1}	Proportion of dry weight (%)[1]								
5%	0 N	4	2.6[d]	61	32	4	3	0	0	0	0	0
50%	0 N	4	3.6[c]	34	10	40	14	1	0	0	0	0
100%	0 N	4	4.7[b]	0	0	77	17	1	2	0	1	2
5%	200 N	4	3.2[cd]	74	22	0	5	0	0	0	0	0
50%	200 N	4	4.4[b]	37	7	26	30	0	0	0	0	1
100%	200 N	4	5.9[a]	0	0	30	67	1	1	0	0	1
5%	0 N	6	1.8[e]	59	39	0	0	0	0	0	0	2
50%	0 N	6	1.7[e]	61	33	0	3	0	0	1	0	2
100%	0 N	6	1.6[e]	0	0	15	39	5	8	6	8	20

[1]Chervil, melilot and fenugreek were not present at all.

Total root biomass (small and large roots at all depths) was not significantly affected by treatments or by species type in the pure stand experiment (Fig. 1). However, differences appeared in specific size classes and depths. Thus, in the 100% herb mixture the biomass of small roots (<8 mm) in the top layer were significantly lower (P<0.001) than in mixtures with white clover and ryegrass, and similarly, the root biomass in this fraction was lower without fertilizer application (P<0.01). The biomass of large roots (>8 mm) in mixtures with herbs showed considerable variation probably as a result of more taproots, and there was a non-significant tendency towards increased biomass in the large root fraction with increasing herb content. This was probably related to the high contents of lucerne and caraway both having significantly larger root biomass in 10-20 and 20-50 cm in the pure stand plots

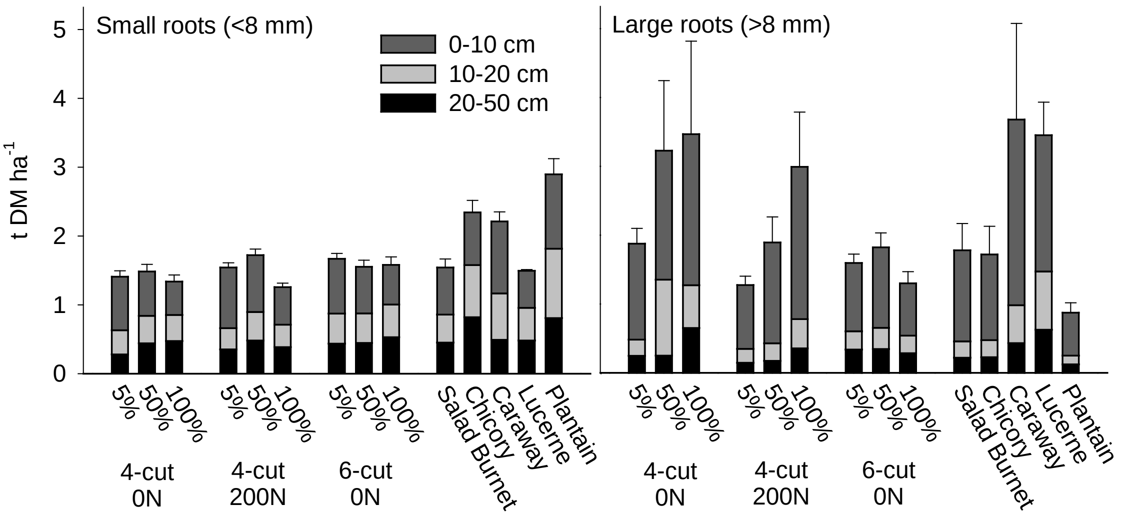

Figure 1. Root biomass at different depth of swards with variable herb seeding rate (5, 50 or 100%), manure application (0 or 200N) and cutting frequency (4- or 6-cut) and of selected species in pure stand in a separate experiment. Error bars: SE.

How the work was carried out

A plot experiment was established in two replicates with three mixtures: 1) a herb mixture containing salad burnet, fenugreek, chicory, caraway, birdsfoot trefoil, chervil, plantain, lucerne and melilot, 2) 50% of the herb mixture and 50% of a white clover/perennial ryegrass mixture, and 3) 5% of the herb mixture and 95% of the white clover/ryegrass mixture. Also, some herbs were established in pure stands (Fig. 1). All mixtures were managed with 4 or 6 cuts per year with and without fertilizer application (200 kg N ha^{-1} via cattle slurry) for the 4-cut system. The pure stand was managed with 4 cuts and without fertilizer. In the spring of the 3rd production year, aboveground biomass was determined by harvesting plots of 1.5x12 m and belowground biomass were determined by wet sieving of eight soil samples per plot from three depths (0-10, 10-20 and 20-50 cm) sampled with an 8.75 cm inner diameter auger. Furthermore, CO_2 release following simulated cultivation was investigated in an incubation experiment for soils from 0-10 and 10-20 cm depths. Data were analyzed as a split-split-plot experiment using the MIXED procedure of the SAS statistical package with fertilization as main plot, fertilization and cutting regime as split plots.

References

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