The effect of cutting strategy on production and quality of high-yielding multispecies grasslands

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Abstract

There is an increasing focus on biodiversity and feed resources for pollinators. However, the integration of these elements into high-yielding temporary grasslands is a challenge. With the main aim of continuous flowering we examined three strategies with four cuts per year, in which the time of the spring cut varied. In total we had 10 different harvest times during the season. This was combined with 12 different species mixtures in two categories. One was high-yielding mixtures composed of perennial ryegrass (*Lolium perenne*), white clover (*Trifolium repens*) and red clover (*Trifolium pratense*), either alone or with either chicory (*Cichorium intybus*), ribwort plantain (*Plantago lanceolata*) or caraway (*Carum carvi*). The other category was lower-yielding two-species mixtures composed of one legume (red clover, lucerne (*Medicago sativa*) or birdsfoot trefoil (*Lotus corniculatus*)) and one spring-flowering non-leguminous forb (salad burnet (*Sanguisorba minor*) or dandelion (*Taraxacum officinale*)). Annual dry matter yield was only slightly affected by cutting strategy. Feeding value and weekly change in feed value differed considerably between species. Weekly decrease of digestibility of organic matter ranged from 0.4% in caraway to 5.0% in birdsfoot trefoil. For the two-species mixtures, birdsfoot trefoil was the least-useful companion legume for non-leguminous forbs.

Keywords: continuous flowering, forbs, cutting strategy, feeding value

Introduction

In high-output dairy farming systems, field size is often large and plant diversity low. This may, at least partly, be the reason that pollinators are declining in many parts of the world with negative consequences for pollination of field crops and wild plants. One way of negating the pollinator crisis is to increase plant diversity of leys by including species in the mixtures with complementary flowering throughout the season. It has been demonstrated that the diversity of pollinator species is positively related to the number of plant species (Ebeling *et al.*, 2008). Spring is often critical due to few natural feed resources and alternative resources in the grasslands could be helpful. The aim of the experiment was to examine if cutting strategy combined with field design could give continuous feed resources throughout the season for pollinators without compromising herbage production and quality.

Materials and methods

Two groups of mixtures were established in 2011 on loamy sand in a dairy crop rotation at Foulum research farm by undersowing in spring barley in a randomized plot experiment with three replicates and a seeding rate of 25 kg ha^{-1}. One group was grass-clover alone or with one forb (Mixture 1-4 in Table 1). The other group was composed of one legume and one non-leguminous forb (Mixture 5-10). The amounts of legume seeds were adjusted to the expected competitive ability (Table 1). No fertilizer N was applied. The plots were harvested following three strategies. Spring harvest was carried out over four weeks, with 14 days between strategy 1 and 2 and between strategy 2 and 3. First and second regrowth were six weeks in all strategies and the third regrowth was varied, since the last harvest was at the same date in mid-October for all strategies. Hereby, different morphological stages were obtained of the species simultaneous during the growing season. The plots were harvested in 2012 and 2013, botanical composition was analysed by hand separation of subsamples, and herbage quality in the species was analysed by near-infrared spectrometry in the spring cut.

Results and discussion

The cutting strategy had limited effect on annual dry matter yield (Table 1). Overall, highest yield was found with a late first cut and the lowest with a medium first cut, with the exception of mix 5 and 8 including birdsfoot trefoil. However, the seasonal production varied considerably with the same trend for all mixtures and was most pronounced in the first two cuts. On average, the percentage distribution of harvested dry matter (DM) over cuts 1 to 4 was in strategy 1: 21-41-21-16, strategy 2: 43-24-25-8 and strategy 3: 55-21-22-2. The yield of the two-species mixtures (no. 5-10) was lower than of mixtures with grass and clover (no. 1-4). However, the yield of two species including red clover was close to that of the grass-clover mixture, while the yields of mixtures with birdsfoot trefoil were significantly lower. The average yields in 2012 and 2013 were 12.6 and 8.9 Mg DM ha^{-1}, respectively. Lower yields in 2013 were partly due to drought stress and to an older sward.

The content of forbs in the grass-clover mixtures (no. 1-4) was for caraway and chicory at the same level (5-6% of DM) as the seeding rate (Table 1), whereas it was twice as high for plantain. The three forbs have previously shown competitive ability in productive grasslands (Søegaard *et al.*, 2011). On average, in mixtures 1-4 there were 38% grass, 15% white clover and 41% red clover (data not shown). The vigorous growth of grass and clover only left only limited space for unsown species/weeds (1-2%). In the two-species mixtures (no. 5-10) the content of birdsfoot trefoil (34%) was much lower than lucerne (66%) and red clover (71%), even though the seeding rate was considerable higher for birdsfoot trefoil. Thus, the weed content became high (26-46%) in the birdsfoot trefoil mixtures. In the two-species mixtures red clover showed a very high production, even though the seeding rate was only 0.5 kg ha^{-1}. In contrast to salad burnet, dandelion produced more when mixed with birdsfoot trefoil than with lucerne and red clover. Furthermore, the content of weeds was much lower in mixtures with dandelion than with salad burnet, indicating that the broad leaves of dandelion left less space for colonization by weeds than did the small leaves of salad burnet.

If the cutting strategy is to be used as a tool for continuous flowering, the challenge is to develop seed mixtures which minimize negative effects on the nutritive value of the herbage. We examined the sensitiveness of harvest time on nutritive value in the spring (Table 2). Red clover under very different growing conditions showed no significant differences on herbage quality, indicating limited effects of mixtures on herbage quality.

Table 1. Species, seed composition, annual yield with different strategies (early-medium-late spring cut) and annual weighted proportion of non-leguminous forb and weeds/unsown species (mean of strategies). Average of 1st and 2nd harvest year.

Mix	Species[1]	% of seed	Annual yield[2] (Mg dry matter ha^{-1})			% of dry matter	
		seed composition	Strategy 1 (early)	Strategy 2 (medium)	Strategy 3 (late)	Non legumous forb[3]	Weed[3]
1	PR-WC-RC	82-15-4	10.3^{b}	10.1^{b}	11.4^{a}	-	2^{e}
2	PR-WC-RC-CI	78-14-4-5	10.2^{b}	10.2^{b}	11.7^{a}	5^{e}	1^{e}
3	PR-WC-RC-CA	78-14-4-5	10.2^{b}	9.9^{b}	11.5^{a}	6^{de}	2^{e}
4	PR-WC-RC-PL	78-14-4-5	11.4^{ab}	10.1^{b}	12.1^{a}	11^{d}	2^{e}
5	SB-BT	50-50	7.7^{a}	6.5^{c}	7.1^{b}	20^{bc}	46^{a}
6	SB-LU	94-6	8.9^{a}	8.9^{a}	9.9^{a}	18^{c}	16^{c}
7	SB-RC	98-2	9.1^{b}	8.3^{c}	10.0^{a}	18^{c}	18^{c}
8	DA-BT	50-50	7.6^{a}	6.1^{b}	6.2^{b}	40^{a}	26^{b}
9	DA-LU	94-6	8.5^{b}	7.7^{b}	8.8^{a}	24.3^{b}	9.7^{d}
10	DA-RC	98-2	10.0^{a}	8.8^{b}	10.5^{a}	19.3^{bc}	3.7^{de}

[1] Species: PR (perennial ryegrass), WC (white clover), RC (red clover), BT (birdsfoot trefoil), LU (Lucerne), CI (chicory), CA (caraway), PL (plantain), SB (salad burnet) and DA (dandelion).

[2] Different letter in rows of annual yield indicate significant differences between cutting strategy ($P<0.005$).

[3] Different letter in columns indicate significant differences between mixtures ($P<0.005$).

Table 2. Nutritive value in the single species in spring growth. The value at harvest time 2 (strategy 2) and the rate (changes per week).[1,2]

	Mix	IVOMD		CP		NDF		WSC
		Time 2	Rate	Time 2	rate	Time 2	rate	
Perennial ryegrass	1	79.1[de]	-3.1[bc]	116[f]	-14[c]	495[a]	35[ef]	168[a]
White clover	1	84.7[bc]	-1.2[ef]	236[a]	-10[c]	278[e]	9[ab]	107[bcd]
Red clover	1	77.9[ef]	-1.8[de]	187[d]	-21[b]	307[d]	18[c]	134[b]
Red clover	7	76.9[efg]	-1.3[ef]	197[cd]	-23[b]	304[d]	18[c]	119[bc]
Lucerne	6	76.4[fg]	-3.5[b]	211[bc]	-22[b]	351[c]	33[e]	82[def]
Birdsfoot trefoil	5	74.7[g]	-5.0[a]	215[b]	-30[a]	352[c]	43[f]	57[f]
Chicory	2	90.4[a]	-2.0[de]	131[f]	-11[c]	292[de]	24[cd]	132[b]
Plantain	3	81.1[d]	-2.4[cd]	124[f]	-15[c]	315[d]	19[c]	97[cde]
Caraway	4	86.9[b]	-0.4[fg]	156[e]	-11[c]	310[d]	5[a]	75[ef]
Salad burnet	6	70.2[h]	-3.2[bc]	89[g]	-10[c]	409[b]	29[de]	108[bcd]
Dandelion	9	84.2[c]	0.3[g]	84[g]	5[d]	294[de]	17[bc]	95[cde]

[1] IVOMD = *in vitro* organic matter digestibility (% of organic matter; % of organic matter week^{-1}); CP = crude protein (% of DM; % of DM week^{-1}); NDF = neutral detergent fibre (% of DM; % of DM week^{-1}); WSC = water soluble carbohydrates (% of DM).

[2] Different letters within columns indicates significant differences between species (P<0.005)

Between species the level and the weekly change varied considerably, indicating different suitability for inclusion under different cutting strategies. At harvest time 2, a high *in vitro* organic matter digestibility (IVOMD) combined with a low neutral detergent fibre (NDF) content was found in white clover, chicory, caraway and dandelion (Table 2). It was also accompanied by a modest change over time (change per week in Table 2). In contrast to these species, ryegrass, lucerne, birdsfoot trefoil and salad burnet had lower IVOMD and higher NDF levels and the weekly change was greater. Dandelion flowering peaked before the early cut of strategy 1 and it had only old inflorescences at the harvest time of strategy 2 and 3. This may be the reason for increasing IVOMD and crude protein during the one-month period between harvests of strategies 1 and 3 (Table 2).

Conclusion

Grasslands with services for pollinators and dairy production can be designed using a combination of grass, clover and forbs with high competitive ability, and smaller restricted areas with low competitive forbs, and combined with different cutting strategies. The results demonstrated possibilities for reaching the goal of integrating productivity and biodiversity.

References

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