Changes of botanical composition of grass stands under different types of management

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ABSTRACT

A field trial with *Bromus catharticus* Vahl. cv. Tacit, *Arrhenatherum elatius* (L.) P. Beauv. ex J.S. et K.B. Presl cv. Median, *Festuca pratensis* Huds. cv. Otava and *Dactylis aschersoniana* Graebn. cv. Tosca sown in rows 125 mm, was established in the year 1996 in Prague (chernozem, altitude 281 m a.s.l., average precipitation 472 mm per year, average year temperature 9.3°C). The stands were cut one or three times per year. The mass was removed or once or twice mulched. The share of the botanical species (by weight method), number of present species and agrobotanical groups (grasses, legumes, other dicotyledonous) coverage were measured from the third to the sixth year of vegetation. The results were evaluated by the analysis of variance (Tukey $\alpha = 0.05$) and by time series analysis (forecasting) by the Statgraphics Plus programme, version 4.0. The species number increased rapidly with the three times cut variant during the four years, from 4 to 25 species, under the other management it was in average from 7 to 14 species, in the sixth year. The highest share of the sown species with the lowest reduction during the years was at *Arrhenatherum elatius* (41–72% in the sixth year). *Bromus catharticus* was extinct in the fifth year. The species chosen had a higher importance for conserving of the original botanical composition than the way of harvest. There was the significantly lower ground cover with the variant one cut per year (on average less than 70%). Mulch covered 15–64% of the surface in dependence on the dry mass yield and mulching frequency. The plants coverage was highest on the two or three times harvested variants (75–80%D).

Keywords: arable land; setting-aside; grass; cutting; mulching; botanical composition; coverage

The questions of the suitable ways of arable land or grassland setting aside are examined by many research establishments in the Czech Republic as well as abroad. A lot of research work is aimed at the nutrients, especially nitrate leaching risk on the set-aside land as well as after the ploughing the stand. From this point of view, grass stands appear as the most suitable (Koch 1998, Opitz Von Boberfeld and Schultheiss 1994). The influence of the way of setting the land aside on the following crops, its effects on their nutrition and weed control requirements, is often investigated. Opitz Von Boberfeld and Jasper (1994), Opitz Von Boberfeld and Schultheiss (1994) consider *Festuca rubra* as a suitable species from these points of view. In some cases even the possibilities of natural regeneration of the non-used land are compared, but it is clear that it brings a lot of problems and the species succession in the direction to a typical meadow stand lasts, according to the individual conditions and stand treatment, many years (Critchley and Fowbert 2000). The utilisation of the produced biomass is the other problem. If it is not used for example as a source of bioenergy, it is necessary to leave it on the field surface, best cut up as a mulch, that is a source of nutrients and organic matter for the soil microflora, microfauna and plants. The influence of mulching on perennial grass stands yields and botanical composition was studied for example by Kvítek et al. (1998), Fiala and Gaisler (2000), on the arable land, including the possibilities of spreading of various weed species and their control, by Brant et al. 2001a, b, 2002. The relations among grasses (*Arrhenatherum elatius*) and weed species (*Elytrigia repens*, *Rumex crispus*) in grass stands studied Klimeš (1988).

MATERIAL AND METHODS

A field trial (1 plot dimensions 3 × 10 m) was established in the year 1996 on the experimental field of the University of Agriculture in Prague (chernozem, altitude 281 m a.s.l., average annual precipitation 472 mm, average year temperature 9.3°C). *Bromus catharticus* Vahl. cv. Tacit (20 kg.ha^{-1}), *Arrhenatherum elatius* (L.) P. Beauv. ex J.S. et K.B. Presl cv. Median (20 kg.ha^{-1}), *Festuca pratensis* Huds. cv. Otava (20 kg.ha^{-1}) and *Dactylis aschersoniana* Graebn. cv. Tosca (15 kg.ha^{-1}) were sown in rows 125 mm apart without a companion crop in spring. The stands were cut (one or three times per year) with removing of the mass or mulching (one or two times per year) by a mulcher AS 27/2 Enduro (BRD). The last harvest was done always at the end of vegetation period.

The persistence and competition ability of sown species were measured as their share in the stands by the weight method. The changes of the agrobotanical groups (grasses, legumes and the other dicotyledonous) and mulch coverage and the share of gaps at the end of vegetation were measured by a point method (5 times 60 points on each plot) each year. The results were evaluated by the analysis of variance (Tukey $\alpha = 0.05$) and by time series analysis (forecasting) by the Statgraphics Plus programme, version 4.0.

Table 1. Botanical composition of the stands (% of dry matter) in the 6th year of vegetation

Stand composition (species with higher share than 1%)	*Bromus*	*Arrhenatherum*	*Festuca*	*Dactylis*	*Bromus*	*Arrhenatherum*	*Festuca*	*Dactylis*
	3 cuts				2 mulching			
Sown species	**0.2**	**72.2**	**9.2**	**12.6**	**2.8**	**41.9**	**21.0**	**26.6**
Arrhenatherum elatius	70.6		49.0	19.7	27.6		7.5	3.3
Other grasses					18.2	6.8	20.5	5.3
Achillea millefolium L.					13.6	3.4	9.1	1.1
Cirsium arvense (L.) SCOP.	5.5	4.5	2.6	4.7		12.8	9.2	10.4
Convolvulus arvensis L.		3.0	8.1	18.1	3.7	7.8	3.2	12.7
Elytrigia repens (L.) DESV.			2.1	36.0	2.9	1.6	9.5	8.9
Lactuca serriola L.					0.8	0.7	1.8	0.9
Medicago lupulina L.	15.9	15.3	26.0		2.9	2.0	5.9	3.1
Pastinaca sativa L.					3.4	1.1		
Taraxacum officinale WEB.	1.3		1.6		13.3	7.1	7.4	17.5
Trifolium repens L.	1.7				2.9	8.5	3.0	7.6
	1 mulching				1 cut			
Sown species	**0.1**	**66.8**	**2.4**	**25.3**	**0.1**	**68.0**	**3.1**	**31.8**
Arrhenatherum elatius	44.5		53.2	29.5	45.5		66.7	37.1
Cirsium arvense (L.) SCOP.		1.5	3.9	1.4				1.0
Convolvulus arvensis L.	1.9	6.9	8.3	21.3	1.9	7.1	10.5	26.8
Coronilla varia L.	47.3	24.3	4.0		48.5	24.7	5.0	
Elytrigia repens (L.) DESV.				2.2				
Falcaria vulgaris BERNH.			19.5	16.5			5.4	
Medicago sativa L.	1.7		6.9		1.7		8.7	
Rumex crispus L.				2.9				

RESULTS AND DISCUSSION

This article is aimed to the state and development of the swards in the years 1998–2001 (the third to sixth year of vegetation), it means after their complete establishment and after a complete year cycle of the searched way and frequency of harvesting in the year 1997. Dry mass yields of the grass stands ranged in average from 3.2 to 5.4 t.ha^{-1} in the third to sixth year. The stands of *Arrhenatherum elatius* produced the significantly largest amount of dry mass (with the exception of the year 2000 more than 5 t.ha^{-1}). The stands of grasses of less growing capacity (*Festuca pratensis* and *Dactylis aschersoniana*) produced 2.2–4.8 t.ha^{-1} per year in average of the third to sixth year.

The stands botanical composition (Table 1) developed in dependence on the sown species and the way of harvest. The present species number increased from 3–5 species to 19–30 (Table 2) on the three times cut variant during four years of vegetation. Statistically significant dependence was linear (number of species = –2.875 + 6.95t, P = 0.010, 0.0002). The number of species was lower and its year increasing slower (by 3.15 per year on the two times mulched plots, by 2.3 and by 1.1 on the one times mulched respectively cut ones) under lower harvest frequency (calculated by the times series analysis). The influence of the sown grass on the species number trend during the years was less considerable. The number of species increased most quickly in *Bromus catharticus* stands (4.8 per year),

Table 2. Number of present species in the stands (pcs.)

Variant	*Bromus*		*Arrhenatherum*		*Festuca*		*Dactylis*	
	Year of vegetation							
	3.	6.	3.	6.	3.	6.	3.	6.
3 cuts	5	26	3	30	4	24	4	19
2 mulching	4	16	3	11	6	11	5	16
1 mulching	2	15	4	7	7	13	4	9
1 cut	4	11	3	4	6	7	5	6

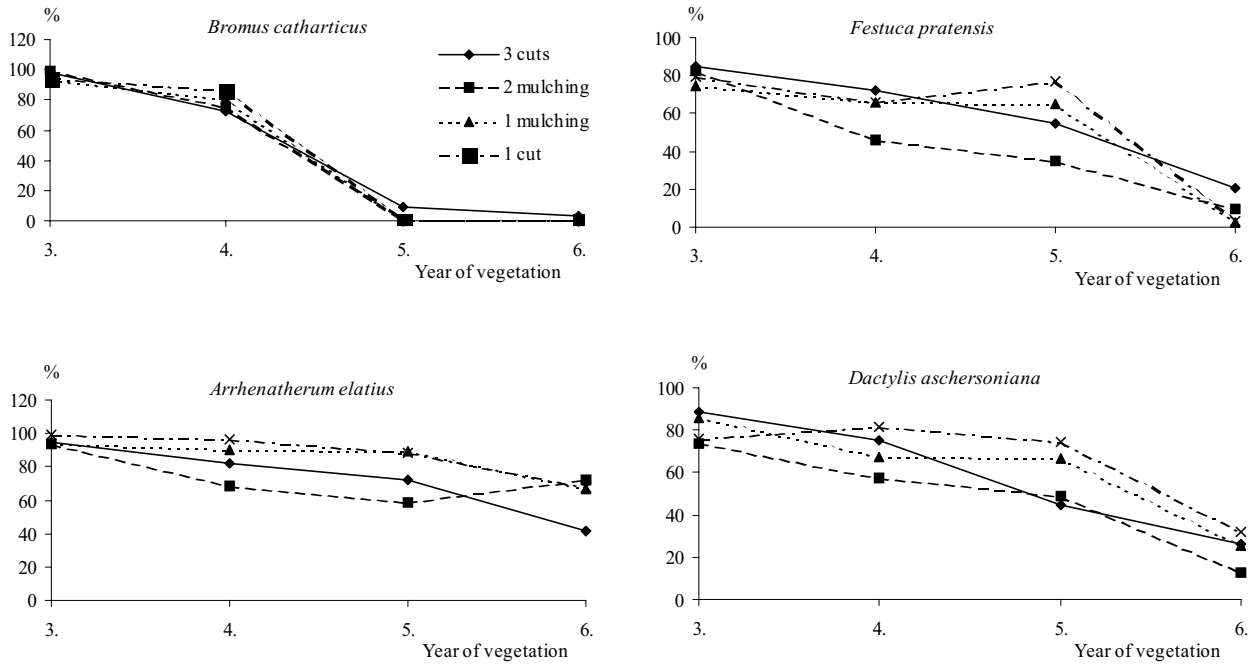

Figure 1. The share of the sown species (weight %) in the stand

slowest in *Dactylis aschersoniana* stands (number of species = 4.25 + 1.125*t*, *P* = 0.052, 0.004).

The number of species with the share higher than 1% was 11–15 (Table 1) on the three times cut variant in the sixth year, they represented 91–99.9% of the biomass. It increased in average by 11 from the third year, by 1.9 on the other variants.

The share of the sown species (measured by weight method) during the years is shown in the Figure 1. *Arrhenatherum elatius* shared by more than 94–99% in the third year (Figure 1), in the following years it decreased to 40–70%, especially on the two or three times harvested plots. Its share on the plots harvested once per year maintained on the level about 90% until the fifth year. The decreasing of this species share was statistically the slowest one from those of all the used species (Table 3). *Bromus catharticus* disappeared most quickly. In the fourth year, it formed 72–86% of the stand, in the following years (fifth and sixth) only 8.6%-0% of the total dry mass. *Festuca pratensis* and *Dactylis aschersoniana* share was highest in the third year (85%), in the following years decreased until less than 3% (*Festuca pratensis*). *Dactylis aschersoniana* always created the highest part of the dry mass on the one times cut variant (25–31% in the sixth year) – Figure 1, Table 1.

In the sixth year of vegetation there were also present other grass species in the stands, especially *Arrhenatherum elatius* invaded the stands of *Bromus catharticus* and *Festuca pratensis* and its share (up to 70%) increased with the sown species share decreasing (Table 1). *Arrhenatherum elatius* had a relatively lower presence in the *Dactylis aschersoniana* stands. The share of *Elytrigia repens* was low in grass stands (with the exception of two times mulched stand of *Dactylis aschersoniana*). Neither the dicotyledonous weeds as *Cirsium arvense* (L.) SCOP., *Convolvulus arvensis* L., *Falcaria*

Table 3. Sown species share decreasing in the stand in dependence on the time (% of dry matter) – times series analysis

Sown species, variant	Equation	*P* constant	*P* slope	Significance
Bromus catharticus	$y = 134.8 - 36.17t$	0.038	0.066	
Arrhenatherum elatius	$y = 106.4 - 10.66t$	0.00068	0.00892	+
Festuca pratensis	$y = 107.3 - 21.93t$	0.0256	0.075	
Dactylis aschersoniana	$y = 104.1 - 18.22t$	0.012	0.047	+
3 cuts	$y = 117.9 - 23.63t$	0.0019	0.0063	+
2 mulching	$y = 106.2 - 21.68t$	0.00357	0.0113	+
1 mulching	$y = 112.8 - 20.96t$	0.0063	0.0238	+
1 cut	$y = 115.6 - 20.71t$	0.012	0.048	+

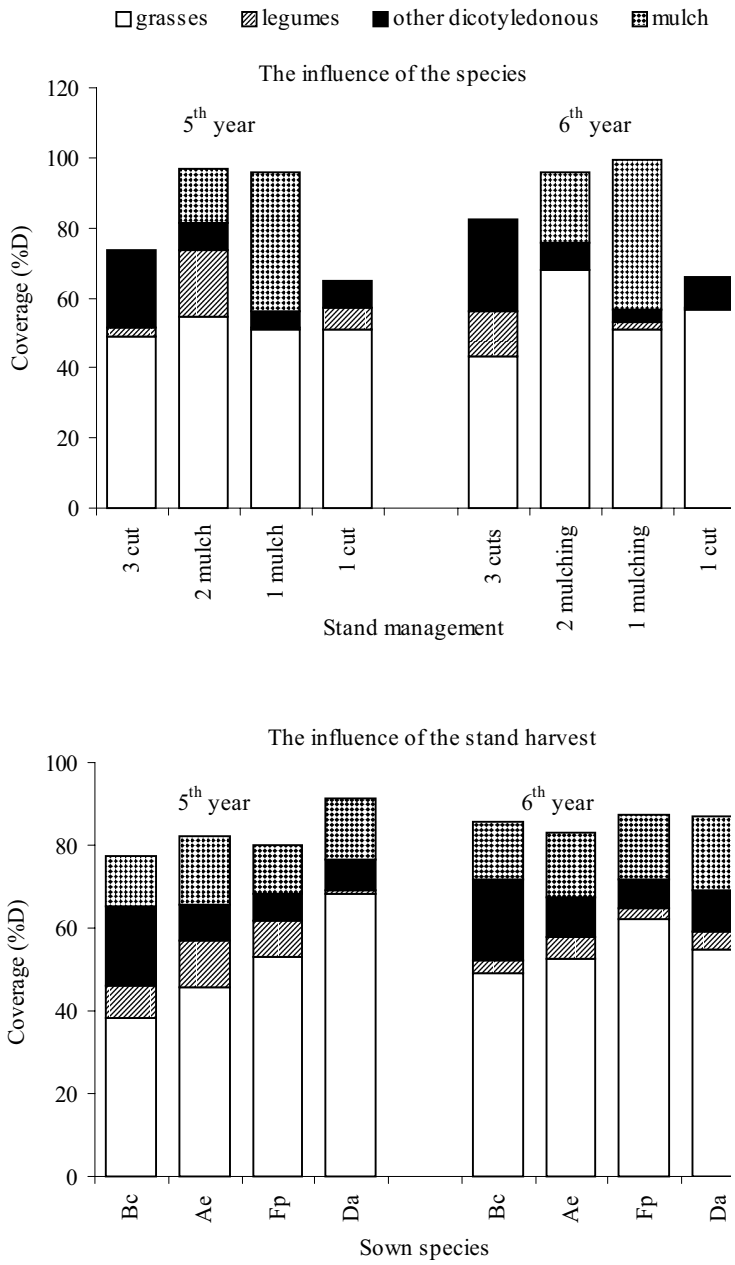

Figure 2. Coverage (%D) of agrobotanical groups and mulch in the 5th and 6th year of vegetation

Bc – *Bromus catharticus*
Ae – *Arrhenatherum elatius*
Fp – *Festuca pratensis*
Da – *Dactylis aschersoniana*

5th year: D_{min} $\alpha_{0.05}$ (Tukey) = 7.2 (grasses), 1.7 (dicotyledonous)
6th year: D_{min} $\alpha_{0.05}$ (Tukey) = 7.6 (grasses), 1.7 (dicotyledonous)

vulgaris BERNH., *Rumex crispus* L. or *Taraxacum officinale* L. did share considerably in the sixth year, it means after a considerable decreasing of the sown species share, their share mostly was not higher than 10% (by weight method). *Dactylis aschersoniana* was the exception again with 12–26% of *Convolvulus arvensis* share under all types of management, with *Taraxacum officinale* on the three times cut plot and *Falcaria vulgaris* presence on the one times mulched plot. The level of weed infestation, it means the danger of weed seeds or other reproduction organs store increasing in the soil or weed infestation of the neighbourhood areas, nevertheless, has to be evaluated by other complementary methods.

The importance of grass stands for setting a land aside is based among others in its function preventing erosion, decreasing of nutrients leached to the underground water and in the land protection against a weed infestation. To fulfil these functions the sward has to create a certain amount of biomass, as far as possible equally distributed in lower levels of the canopy for as long as possible during a year. The sward coverage after a harvest (Figure 2) depended not only on the mass yield of the stand, but it was influenced also by its height and density in the time of the harvest and by the botanical composition (Table 1). The architecture of the aboveground parts of the plants was different with distinct species of dicotyledonous – some of them create flat leaf roses, so as with different grass species with more or less dense tufts, conceivably species with long rhizomes (*Elytrigia repens* L. Desv. etc.), that create relatively thin stands. That was why only the dry mass yield respectively the

share of grasses and dicotyledonous species in the yield were not in a close dependence with the stand coverage (correlation coefficient of the relation between dominance and yields was only 0.07) and they could not be considerable indices for the stand function against erosion. That was the reason of stand coverage measuring closely before onset of winter, it means after the end of vegetation (Figure 2).

It is obvious from the results, that the coverage of all the present grass species was highest on the three times cut variant till the third year of vegetation. However, in the following years this frequency of harvesting proved less suitable for grasses development in the moist conditions. The highest grass coverage was found on the two times mulched variant from the fourth year. The gaps left by grasses were filled by dicotyledonous species and so the total plant coverage on the three times cut variants did not change (74–82%D) and it was nearly always significantly higher than on the one times cut plots, where the share of gaps mostly exceeded 30%. The significantly highest coverage of grasses had the stands of *Dactylis aschersoniana*, where this sown species directly predominated also because of its competitive ability (low growth, intensive sprouting with creeping sterile sprouts) limited spreading of other grass species, till the fifth year even *Elytrigia repens*. A very good coverage was found because of its tuft character also at *Bromus catharticus* until the year 1998, but later it disappeared from the stand. It corresponds also with its share in the mass.

The share of gaps on the mulched plots was small (Figure 2), mostly 0–9%D. The mulch coverage, in dependence on the year and mulching frequency (mass quantity) was in average 15–35% on the plots two times mulched and 32–64% on the one times per year mulched. The mulch coverage during a winter period is no less important for the soil protection against an erosion, especially against the wind one, than plants coverage. Besides it, it influences the microbial activity in the soil, emerging of seeds of different species etc.

CONCLUSIONS

The results have shown the differences in the development, persistence, competitive ability etc. of the investigated grass species under distinct ways of management of stands on the temporarily set-aside land. We have come to the conclusion that mulching two times per year is a suitable way of such stands management from the point of view of the mass distribution and decomposition, sown grass coverage and gaps minimisation. Harvesting (cutting) one time per year was a good way for maintaining as high as possible share of grasses. The way of the stand management had a less impact on the sown species share decreasing than the chosen grass species, but it significantly influenced the total dry mass. The time of the setting the land aside and especially the species adaptation to the soil – climate conditions have to be taken into account for choosing the most suitable grass species. The grasses that produce a big amount of the biomass, as for example *Arrhenatherum elatius*, can be seen less suitable for non-production purposes. However, this species distinguished itself by a strong competitive ability against weeds under all types of management. Taking into account the other points of view (underground water protection etc.), it is evident, that it is necessary to adapt the choice of the species and way of stand management above all to the given stand conditions, the intended time of setting the land aside and to the possibilities of the farmer.

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ABSTRAKT

Změny botanického složení porostů trav při různých způsobech využívání

V roce 1996 byl založen polní pokus na černozemi (nadmořská výška 281 m n. m., průměrná suma ročních srážek 472 mm, průměrná roční teplota 9,3 °C) se čtyřmi druhy trav (*Bromus catharticus* Vahl., odrůda Tacit, *Arrhenatherum elatius* (L.) P. Beauv. ex J.S. et K.B. Presl, odrůda Median, *Festuca pratensis* Huds., odrůda Otava a *Dactylis aschersoniana* Graben, odrůda Tosca) vysetými do řádků 125 mm. Porosty byly sečeny jedenkrát nebo třikrát ročně s odvozem hmoty nebo mulčovány (jedenkrát nebo dvakrát ročně). Poslední sklizeň probíhala vždy na konci vegetačního období. Ve třetím až šestém roce vegetace bylo váhovou metodou sledováno zastoupení jednotlivých druhů, počet zastoupených druhů a pokryvnost agrobotanických složek (trávy, jeteloviny, ostatní dvouděložné druhy), mulče a podíl prázdných míst na konci vegetace. Výsledky byly vyhodnoceny analýzou rozptylu (Tukey $\alpha = 0,05$) a analýzou časových řad programem Statgraphics verze 4.0. Nejrychleji se zvyšovala druhová pestrost u trojsečné varianty v průběhu čtyř let ze 4 na 25 druhů, u ostatních způsobů sklizně byl počet druhů v šestém roce v průměru 7 až 14. Největší podíl setého druhu s nejpomalejším poklesem v průběhu let byl u *Arrhenatherum elatius* (v šestém roce 41 až 72 %). *Bromus catharticus* zcela ustoupil v pátém roce vegetace. Výběr druhu měl pro zachování původního botanického složení porostu větší význam než způsob sklizně. Na jedenkrát ročně sečené variantě byl průkazně největší podíl prázdných míst (v průměru 30 %). Mulč pokrýval 15 až 64 % povrchu v závislosti na výnosu hmoty a frekvenci mulčování. Pokryvnost porostu byla nejvyšší na dva- až třikrát ročně sklízených parcelách (75–80 %D).

Klíčová slova: orná půda; ukládání do klidu; trávy; sečení; mulčování; botanické složení; pokryvnost

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