Succession changes of temporary grass stands on set-aside land

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ABSTRACT

The mixtures of *Bromus marginatus* Nees ex Steud. + *Coronilla varia* L., *Festuca pratensis* L. + *Lotus corniculatus* L., *Dactylis aschersoniana* Graebn. + *Trifolium repens* L., *Arrhenatherum elatius* (L.) P. Beauv. ex J.S. et K.B. Presl + *Medicago lupulina* L. were sown in rows of 125 mm in the year 1997 in Prague (chernozem, altitude 281 m a.s.l., average precipitation is 472 mm per year, average year temperature 9.3°C). The stands were one or three times per year cut with the mass removing or one or two times mulched. Botanical composition (by weight method), number of present species and agrobotanical groups (grasses, legumes, other dicotyledonous) coverage were measured during 6 years of vegetation. The species number was highest on plots cut 3 times (6–17), it increased linearly. The sown species share in the dry mass yield was 75–99% and the share of grasses decreased linearly with time. The significantly highest dry mass yield was reached when mulched two times per year *Bromus marginatus* Nees ex Steud. with *Coronilla varia* L. (till 14 t/ha). The stands coverage was 43–80%.

Keywords: grass-legume stands; setting-aside; cutting; mulching; botanical composition; coverage

One of the most natural and ecological ways of reversibility, setting arable land aside, is establishing a temporary grass stand with a special management and biomass utilisation (Firbank et al. 2003). The influence of the way of the setting, the land aside on the following crops, its means on their nutrition and weed control requirements, is often researched.

Pure stands of legumes are important as good forecrops especially in the agricultural systems with limited inputs, but they have a very low coverage in winter. Grass stands have a better coverage but nitrogen fertilisation is necessary when they are destined for more years of growing to maintain complete and dense sward. Temporary grass-legume mixtures with different species and components shared can be a good solution (Svobodová et al. 2001).

The utilisation of the produced biomass is the other problem. If it is not used for example as a source of energy, it is necessary to leave it on the field surface, best cut up as a mulch, that is for a source of nutrients and organic matter for the soil microflora, microfauna and plants. The influence of mulching on yields and botanical composition of temporary grass monoculture stands was researched on the arable land by Šantrůček et al. (2002), on perennial grass stands for example by Kvítek et al. (1998), Fiala and Gaisler (2000). The relations among grasses [*Arrhenatherum elatius* (L.) P. Beauv. ex J.S. et K.B. Presl] and weed species [*Elytrigia repens* (L.) Desv., *Rumex crispus* L.] in grass stands described by Klimeš (1988), changes of species composition of temporary grass-legume stands were studied by Matušinský and Hrabě (2003).

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, and average year temperature 9.3°C). Mixtures of *Bromus marginatus* Nees ex Steud. cv. Tacit + *Coronilla varia* L. cv. Eroza (20 + 10 kg/ha), *Festuca pratensis* L. cv. Otava + *Lotus corniculatus* L. cv. Lotar (20 + 6 kg/ha), *Dactylis aschersoniana* Graebn. cv. Tosca + *Trifolium repens* L. cv. Hajek (15 + 6 kg/ha), *Arrhenatherum elatius* (L.) P. Beauv. ex J.S. et K.B. Presl cv. Median + *Medicago lupulina* L. cv. Alice (20 + 10 kg/ha) were sown to rows with 125 mm space without a companion crop in the spring. The stands were cut (one or three times per year) with removing of the mass or mulched (one or two times per year) by a mulcher AS 27/2 Enduro (BRD). The last harvest was done always in the end of vegetation season. 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

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groups (grasses, legumes and the other dicotyledonous) and mulch coverage and the share of gaps in the end of vegetation were measured by a point method (5 times 60 points on each plot) each year. The Statgraphics Plus programme, version 4.0, evaluated the results.

RESULTS AND DISCUSSION

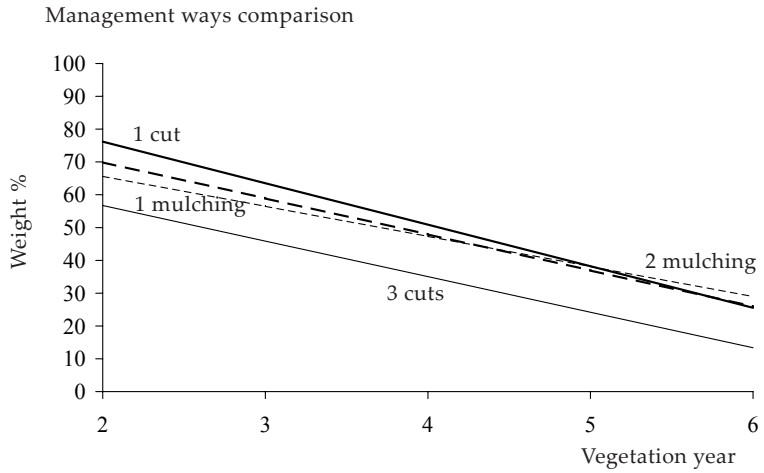
The main aim of this trial was to evaluate the legume grass mixtures reaction to the way of harvest and their suitability for temporary setting the arable land aside in defined soil climatic conditions.

The average aboveground biomass production (Table 1) was from 4 to 13 t/ha. The highest amount of the mass was produced by the mixture of *Bromus marginatus* Nees ex Steud. and *Coronilla varia* L. (in average 8 t/ha, maximally 14 t/ha), significantly lower yield (by 29%) was found at the mixture of *Dactylis aschersoniana* Graebn. with *Trifolium repens* L.

An acceptable share of each sown component of a mixture maintained during all the vegetation years is an important measure of the mixture and a suitable management way.

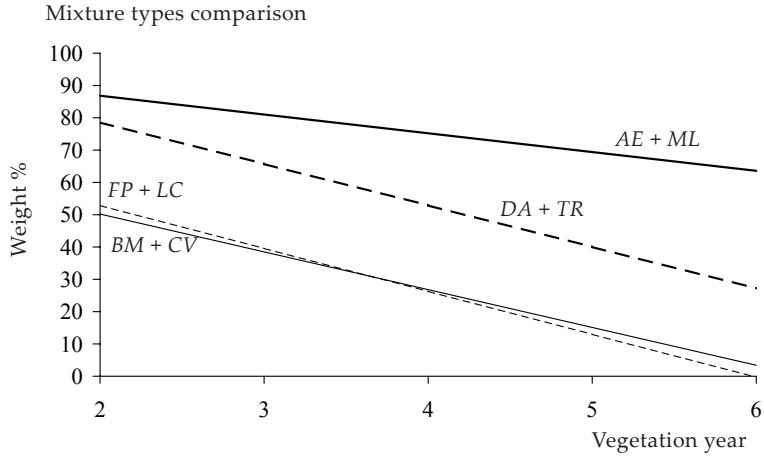
Table 1. Dry mass yield (t/ha) and the share of sown species (weight %); average the 2nd–6th vegetation year

Mixture	Stand management	Dry matter yield	Sown grass	Sown legume
		(t/ha)	(%)	(%)
*Bromus marginatus N*ees ex Steud. + *Coronilla varia* L.	3 cuts	9.05	32.93	53.73
	2 mulching	12.18	32.85	55.08
	1 mulching	4.85	27.23	71.80
	1 cut	5.95	32.45	66.45
Festuca pratensis L.+ *Lotus corniculatus* L.	3 cuts	9.38	28.40	61.60
	2 mulching	8.35	31.70	57.75
	1 mulching	4.43	27.95	49.50
	1 cut	4.65	31.95	48.03
Dactylis aschersoniana Graebn.+ *Trifolium repens* L.	3 cuts	6.25	36.58	38.38
	2 mulching	7.43	65.20	14.28
	1 mulching	4.17	72.93	5.68
	1 cut	5.05	73.90	1.18
Arrhenatherum elatius (L.) P. Beauv. ex J.S. et K.B. Presl + *Medicago lupulina* L.	3 cuts	7.30	62.30	23.35
	2 mulching	8.90	80.83	10.28
	1 mulching	5.08	88.98	3.98
	1 cut	5.47	88.60	4.60
	D_{min} 0.05	4.20	50.38	38.17
Average	3 cuts	7.99	40.05	44.26
	2 mulching	9.21	52.64	34.34
	1 mulching	4.63	54.26	32.74
	1 cut	5.28	56.73	30.06
	D_{min} 0.05	2.10	25.18	19.09
	BC + CV	8.01	31.36	61.76
	FP + LC	6.70	30.00	54.22
	DA + TR	5.73	62.15	14.88
	AE + ML	6.69	80.18	10.55
	D_{min} 0.05	2.09	25.19	19.09



Management	Equation of the line $y = a + bt$	R	R^2 (%)
3 cuts	78.4037 – 10.841t	–0.995**	98.91
2 mulching	83.9644 – 9.167t	–0.925*	85.45
1 mulching	91.8569 – 10.983t	–0.981**	96.25
1 cut	101.517 – 12.6616t	–0.956*	91.33

y = share of sown grasses
a, b = parameters of the equations
t = vegetation year (2^{nd}–6^{th})



Mixture type	Equation of the line $y = a + bt$	R	R^2 (%)
BM + CV	73.5963 – 11.6985t	–0.832*	69.21
FP + LC	79.4343 – 13.2939t	–0.883*	77.89
DA + TR	104.265 – 12.8492t	–0.759	57.69
AE + ML	98.4455 – 5.81147t	–0.622	38.67

BM + CV =
Bromus marginatus + Coronilla varia
FP + LC =
Festuca pratensis + Lotus corniculatus
DA + TR =
Dactylis aschersoniana + Trifolium repens
AE + ML =
Arrhenatherum elatius + Medicago lupulina

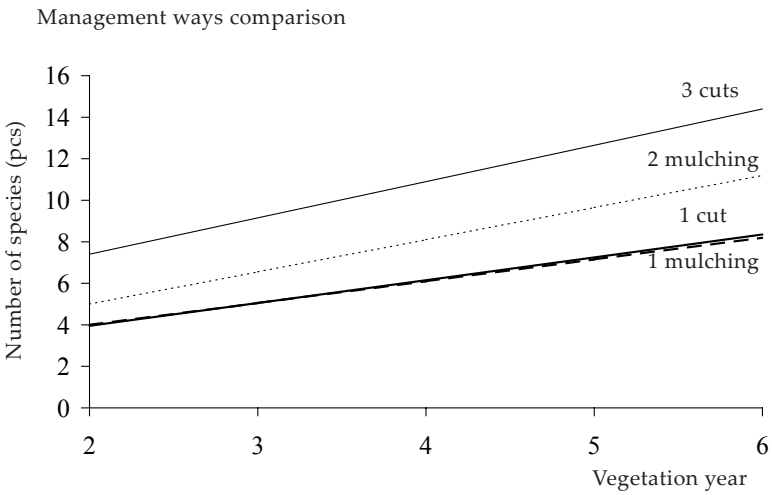
Figure 1. Share of sown grasses – y (%) in the yield in dependence on the time (regression lines)

The average share of both of the sown components (Table 1) was very high in the first five years of vegetation (75–99%). The sown grass share in the biomass was significantly higher in the mixtures with *Dactylis aschersoniana* Graebn. (62%) or *Arrhenatherum elatius* (L.) P. Beauv. ex J.S. et K.B. Presl – in average 80%. *Bromus marginatus* Nees ex Steud. and *Festuca pratensis* L. shared in the yields in average by 30%. The results have shown considerable differences in the relations of the sown grasses and legumes in particular mixture in the dependence of the management way. According to the proportions of their sowing rates *Coronilla varia* L. would share in the stand by 60%, *Lotus corniculatus* L. by 40%, *Trifolium repens* L. by 40%, *Medicago lupulina* L. by 55%. In the second (third) vegetation year, when a complete development of each sown species could be presupposed, *Coronilla varia* L. share was 16–99%, *Lotus corniculatus* L. 29–66%, *Trifolium repens* L. on the plots two or three times harvested per year shared by 44–49 weight percent. The competitive capacity of *Medicago lupulina* L. in comparison with that of *Arrhenatherum elatius* (L.) P. Beauv. ex J.S. et K.B. Presl was considerably lower, so that it, similarly like *Trifolium repens* L. did, was found only on the 3 times per year cut plots (1–32%) from the third year of vegetation. *Coronilla varia* L. and *Lotus corniculatus* L. developed similarly under all of the harvest ways and frequency (Table 1).

The dependence of the sown legumes share at that time was not statistically proved. But it can be seen from the dates that the share of *Lotus corniculatus* L. and especially of *Coronilla varia* L. was maintained on an approximately same level on the plots, where the given species was established well

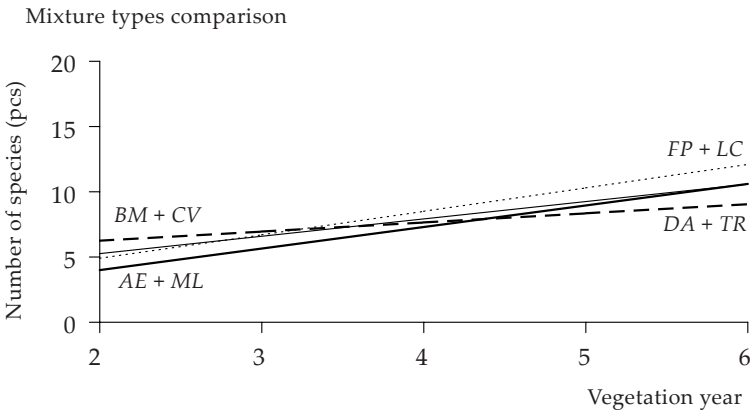
Table 2. Average number of species

Management	Year of vegetation				
	2nd	3rd	4th	5th	6th
3 cuts	7.3	6.3	13.3	17.3	10.5
2 mulching	6.3	4.8	7.5	11.3	10.8
1 mulching	4.8	4.0	6.5	6.5	8.8
1 cut	5.0	3.3	5.8	9.3	7.5
Mixture					
BC + CV	6.0	3.5	10.0	10.5	9.0
FP + LC	5.0	5.3	9.0	13.3	10.0
DA + TR	7.5	5.5	6.5	10.0	8.8
AE + ML	4.8	4.0	7.5	10.5	9.8
Average	5.8	4.6	8.3	11.1	9.4



Management	Equation of the line $y = a + bt$	R	R^2 (%)
3 cuts	$3.9 + 1.75t$	0.62	37.8
2 mulching	$1.9 + 1.55t$	0.87*	75.2
1 mulching	$1.9 + 1.05t$	0.90*	81.2
1 cut	$1.75 + 1.1t$	0.75	56.7

y = number of species
a, b = parameters of the equations
t = vegetation year (2nd–6th)



Mixture type	Equation of the line $y = a + bt$	R	R^2 (%)
BM + CV	$2.6 + 1.3t$	0.69	47.9
FP + LC	$1.3 + 1.8t$	0.82*	67.7
DA + TR	$4.85 + 0.7t$	0.62	38.6
AE + ML	$0.7 + 1.65t$	0.98*	80.8

BM + CV =
Bromus marginatus + Coronilla varia
FP + LC =
Festuca pratensis + Lotus corniculatus
DA + TR =
Dactylis aschersoniana + Trifolium repens
AE + ML =
Arrhenatherum elatius + Medicago lupulina

Figure 2. Number of species – y (pcs) – regression lines

Table 3. Botanical composition (weight %) in the 4th year of vegetation (species with higher content than 1%) and number of species (pcs)

Mixture composition	*BM + CV*	*FP + LC*	*DA + TR*	*AE + ML*	*BM + CV*	*FP + LC*	*DA + TR*	*AE + ML*
Species/management	3 times cut				2 times mulched			
Sown grass	6.1	22.8	52.4	62.7	25.2	6.9	72.6	88.0
Sown legume	77.2	71.5	21.4	29.9	72.6	80.5	1.3	
Other grasses								
Arrhenatherum elatius (L.) P. Beauv. ex J.S. et K.B. Presl	4.2		1.84					
Dactylis aschersoniana Graebn.	2.1							
Trisetum flavescens (L.) P. Beauv.	3.6							
Other dicotyledonous								
Cirsium arvense (L.) Scop.			3.1			1.0	8.1	4.8
Convolvulus arvensis L.	1.4	3.4	17.6	5.63	1.5	9.6	17.8	6.9
Rumex crispus L.			1.0			1.7		
Taraxacum officinale Web.	3.7		2.2					
Total number of species	17	12	10	14	11	9	5	5
Species/management	1 times cut				1 times mulched			
Sown grass	53.4	7.5	87.9	90.0	8.4	1.8	94.5	92.6
Sown legume	43.3	81.1			88.7	84.4		
Other grasses								
Arrhenatherum elatius (L.) P. Beauv. ex J.S. et K.B. Presl						3.3	1.6	
Other dicotyledonous								
Artemisia vulgaris L.				1.6				
Cirsium arvense (L.) Scop.				2.7				
Convolvulus arvensis L.				1.2	1.0	6.8	3.8	2.4
Lactuca serriola L.	2.7	10.4	10.9	4.5	1.7	2.3		4.7
Total number of species	5	7	5	6	8	9	5	4

from the first vegetation year. However the share of legumes considerably varied in particular years and it was highest in the year 2000 (the fourth vegetation year).

The development of the sown grasses share in the aboveground biomass in dependence on the time is described (in the done period) by linear equations (Figure 1). A strong relationship was found in most cases. Analysing the influence of the stands management way on the curves course, 85–99% of the relation is explained by the grass share dependence on the time factor. The Figure 1 shows, that the sown grass share on the mulched plots decreases more slowly, than on the fields, where the cut mass was removed, but the differences are not big (slopes of lines 9.2–12.7). The sown grass share was lowest on the three times cut plots (Table 1, Figure 1). The *Arrhenatherum elatius* (L.) P. Beauv. ex J.S. et K.B. Presl share decreased most slowly (slope of line 5.8, at the other grasses 11.7–13.3).

The yield was constituted also by other species of grasses, legumes and other dicotyledonous species. In the course of the vegetation years the number of present species increased linearly (Table 2, Figure 2). The highest number of species was found on the three times cut plots, it decreased with the harvest frequency, the significantly lower number of species was found on the once per year cut plots. The number of species increased also with the vegetation year's number. From the fourth vegetation year the average number of species was significantly higher

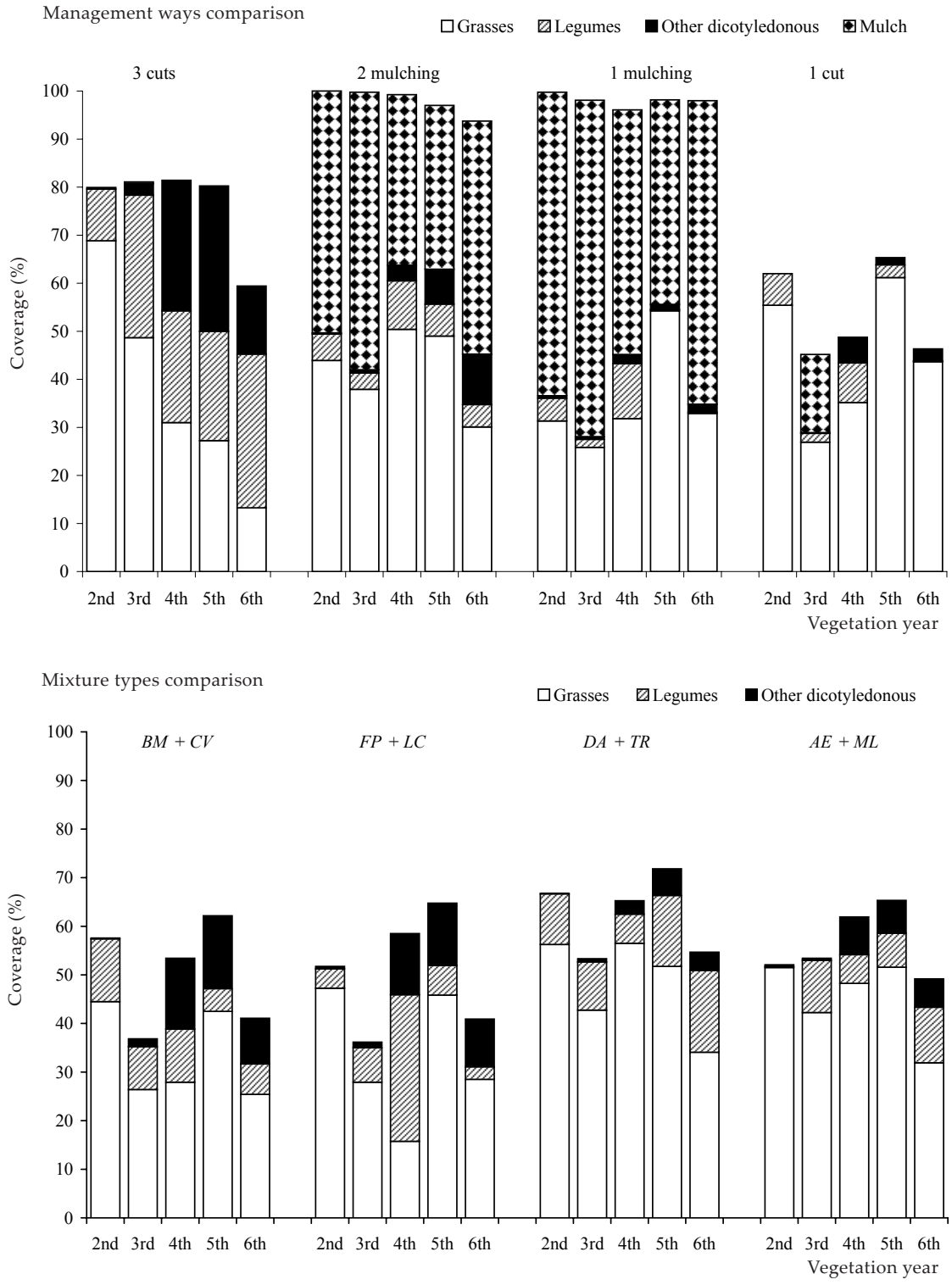


Figure 3. Coverage of agrobotanical groups (% dominance)

than in the preceding three years (Table 2, Figure 2). The species composition of the stands in the meant fourth year is described in the Table 3. It is seen that, in spite of the high present species number, only *Taraxacum officinale* Web., *Cirsium arvense* (L.) Scop., *Convolvulus arvensis* L. and *Lactuca serriola* L. had a notable importance in some stands (according to the species and management way).

As a very important property of temporary grass stands meant for setting land aside their good coverage in winter and anti-erosion effect is found. The soil surface is protected not only by live plants but

Table 4. Grass coverage (% dominance) – ANOVA table

Source	*SS*	*mS*	*F*	*p*
Main effects				
A management	5 267.9	1 755.99	32.35	0.0000
B mixture type	18 678.4	6 226.13	114.71	0.0000
C year	23 668.1	5 917.02	109.01	0.0000
Interactions				
AB	5 364.3	596.04	10.98	0.0000
AC	44 313.6	3 692.80	68.03	0.0000
BC	10 550.4	879.20	16.20	0.0000
ABC	11 439.2	317.76	5.85	0.0000
Repetition	440.1	110.03	2.03	0.0937
Residual	7 816.0	54.278		

also by the mulch. If there is a sufficient yield of the mass (at least 2 t/ha) nearly all the area of the gaps and a part of live plants are covered by this material (Figure 3). The mulch covered in average 37–60% of the two times per year mulched areas and 55–70% of the once per year mulched plots. The coverage of the plants depends on their architecture and on the term of the last cut, it means if the plants manage to regrow before the end of the vegetation period. The highest coverage was found at grasses (till 69%), in average 35–45%. It was found that the grass coverage was influenced by all the factors – type of mixture, stand management and vegetation year (Table 4), so as by their interactions. The coverage of grasses in the mixtures with *Dactylis aschersoniana* Graebn. and *Arrhenatherum elatius* (L.) P. Beauv. ex J.S. et K.B. Presl (in average 48.3, resp. 45.1%) was significantly higher than those in the fields with *Bromus marginatus* Nees ex Steud. and *Festuca pratensis* L. (33.4 and 33.1%). Three cuts per year caused a quick grass coverage decreasing in dependence on the time (Figure 3), only the coverage of *Arrhenatherum elatius* (L.) P. Beauv. ex J.S. et K.B. Presl was relatively high till the sixth vegetation year (42.2%). Only under this way of stands management (three times cut) legumes share in the coverage was significant (11 to 32%) so as the other dicotyledonous species (till 30%), especially *Taraxacum officinale* Web. There was no considerable difference between the coverage of the particular botanical groups on the once and two times per year harvested plots (Figure 3). The highest coverage was found at the mixture of *Dactylis aschersoniana* Graebn. and *Trifolium repens* L. because or their aboveground architecture – creeping habit of *Trifolium repens* L. and semi-erect growth of *Dactylis aschersoniana* Graebn. tillers. These species (Table 4), from this point of view, were well proved also in pure stands (Svobodová et al. 2001, Šantrůček et al. 2002).

CONCLUSIONS

These results, and also the other results of our experiments, have shown that the suitability of each grass or legume species for setting land aside, depends on the way and intensity of stand management on the time of intended time of their cultivating, on the competition capacity of the other species in the sown mixture and also on the specific weed infestation of the field. The sown species in our experiment had relatively good persistence but it varied according all the factors (management, time). That is why it is always necessary to choose the mixture type and the share of its components taking in account all the circumstances. The mixtures of grasses and legumes in an optimal share associate good properties of their components and there is a better precondition of their plasticity in changeable weather conditions. The competition capacity of the sown species is related with their yields and that is why the mulch influence not only on the stand development but also on the soil and water quality and on the diversity of plant and zoological species has to be studied as opined Firbank et al. (2003) and other authors.

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ABSTRAKT

Fytocenologický vývin dočasného travního porostu na půdě uložené do klidu

Směsi *Bromus marginatus* Nees ex Steud. + *Coronilla varia* L., *Festuca pratensis* L. + *Lotus corniculatus* L., *Dactylis aschersoniana* Graebn. + *Trifolium repens* L., *Arrhenatherum elatius* (L.) P. Beauv. ex J.S. et K.B. Presl + *Medicago lupulina* L. byly vysety do řádků 125 mm v roce 1997 na stanovišti v Praze (černozem, 281 m n.m., roční suma srážek 472 mm, průměrná roční teplota 9,3 °C). Porosty byly jednou nebo třikrát ročně sečeny s odvozem hmoty a jednou nebo dvakrát ročně mulčovány. V průběhu šesti let vegetace bylo sledováno botanické složení porostů váhovou metodou a počet přítomných druhů a pokryvnost agrobotanických skupin (trav, jetelovin a ostatních dvouděložných druhů) bodovou metodou. Počet druhů byl nejvyšší na třikrát ročně sečených plochách (6–17) a s časem lineárně stoupal. Podíl vysetých druhů ve výnosu sušiny byl 75–99 %, podíl vysetých trav lineárně klesal v závislosti na čase. Průkazně nejvyšší výnosy sušiny byly dosaženy na dvakrát ročně mulčovaných porostech *Bromus marginatus* Nees ex Steud. a *Coronilla varia* L. (až 14 t/ha). Pokryvnost porostů byla 43–80%.

Klíčová slova: jetelovinotravní směsi; ukládání půdy do klidu; sečení; mulčování; botanické složení; pokryvnost

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