Dynamics of stand composition changes in grass and grass-clover stands and relations between dominant species

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ABSTRACT

Changes in the species composition of temporary grass and grass-clover crops stands were studied in 1994–2000. The assessment consisted in determination of the dominance of individual species, measurement of their aboveground biomass weight and subsequent comparison of detected values. The measurements were evaluated by the method of determination of distance between vectors of stand composition and by the subsequent standardization. Resulting values are in a good agreement with the hither to knowledge and confirm that more favourable yield parameters are achieved within 30–60% of total changeability. Changes of species composition and stand changeability are at their initial stages of succession given by external changes mainly contributed to by the group of clumpy grass species and by internal changes within the group of pod-bearing plants.

Keywords: grass and grass-clover stands; phytocenological relations

Priority goals of research into grass-clover crops communities at down-scaling the sources of additional energy will be disclosure of internal intraspecific relations and their harmonization as a factor of agreement between forage production and quality. Effects of intraspecific competition on biomass production have long been a subject of many research works (Laštůvka 1986). Influence of competition on fodder quality and contents of substances important for animal nutrition is still little known so far (Opitz von Boberfeld and Biskupek 1995). Not negligible are also non-fodder-producing functions of grass stands such as landscaping role, erosion control, aesthetics, etc. As to the representation of individual species, the botanical composition of grass-clover crops stands is not entirely unchanging in the course of years. Klečka et al. (1938) pointed out as early as at this time that each newly established stand passes through a succession in the first five years, at which the less resistant species are replaced by those with greater hardiness. In order to be able to produce mixtures, we have to be familiar with a great number of coherences and variances in the development and growth of plants used in them. Some species develop for example very early after sowing later exhibiting a retarded growth, other ones develop very slowly keeping their share within the community over a long time, some species will not survive the competition of other species in the mixture at all, etc. (Klapp 1974). Opitz von Boberfeld (1994) reminds a necessity of respecting different competition behaviour of species in the newly established stands and recommends not to exceed the critical sowing amount of strongly competitive species. It was also shown that soil nitrogen content is an important factor of competition variance. The competing potential of dominants can be overestimated due to higher N contents in the soil (Glimskär 1999). Neither it is advised to neglect the interaction between stand composition changes nor production changes since a regular relation was demonstrated to exist between the two characteristics (Klimeš 1987).

MATERIAL AND METHODS

The paper aims at an evaluation of changes in the stand composition of sown grass-clover crops stand of temporary character, assessment of interactions between important species and expression of dependence between changeability and chain index of yields. Four grass and grass-clover crops variants were studied over a period of six years. In all variants, percentage representation of individual species in dry forage was determined by using the method of weighing in the produce from the first cut of productive years.

The trial was established on 18 August 1994 and was maintained in the period from 1994–2000 as a small-plot experiment on the site of Vatín located some 9 km south of Žďár nad Sázavou. The region is characterized by average annual temperature and mean annual precipitation of 6.91°C and 659.98 mm, respectively. The figures being slightly higher or lower, respectively, if compared with a 50-year average of temperatures (6.06°C) and total precipitation (736 mm). Soil characteristic: soil type Cambisol, soil kind sandy-loam, pH/KCl 4.2, humus 2.03%. Content of available nutrients in soil: P 49 mg/kg, K 170 mg/kg.

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Table 1. Schare and numbers of species and cultivar in the sowing rate

Forage community	Sowing rate share (%)		Number of species			Number of cultivars		
	clover crops	grass	clover crops	grass	total	clover crops	grass	total
1. Singl cultivar grass stands	0	100	0	7	7	0	7	7
2. Multi cultivars grass stand	0	100	0	7	7	0	11	11
3. Singl cultivars clover-grass stand	30	70	1	7	8	3	7	10
4. Multi cultivars clover-grass stands	30	70	1	7	8	3	11	14

Species numbers for the respective variants are listed in Table 1. Species and variety compositions of the communities are presented in Table 2. Each variant was made in four repetitions. Sample plot area was 10 m^2 (1.25 × 8 m). Regarding the favourable climatic conditions in 1995 and 1996, the harvest was carried out in four cuts with the other experimental years having only three cuts. Harvest in the last year (2000) was made only in two cuts with respect to a following additional strip sowing.

The evaluation of the level and trend of stand changes was made by using a method of calculation of stand composition changes – so called total changeability and its components (both internal and external). The procedure is based on determination of distance between vectors of stand composition with the subsequent standardization (Klimeš 1987, 1988, 2000).

$$\rho(sm) = 0.5\sum_{i=1}^{n}|x_i - y_i|$$

where: $\rho(sm)$ = total change of stand composition in %
n = total number of species
x_i = coverage representation of the i^{th} species in one year in %
y_i = coverage representation of the i^{th} species in the following year in %

Further steps included determination of chain and basic indexes of yield and calculation of the regression function between changeability and chain index (Hamadejová 2001). Mutual interactions of dominant species were expressed by the regression function.

RESULTS AND DISCUSSION

It follows from Table 3 with the evaluation of yield characteristics by means of basic and chain indexes which reflect relative level of changes in the produce of individual harvest years that the purely grass community (var. 1 and 2) show their lower levels in the comparison with stands containing *Trifolium pratense* (var. 3 and 4). The positive influence of clover crops representation on production stability was recorded both in the period of the first stage (production year 1, 2 and 3) and in the following period (production year 4, 5 and 6) when *Trifolium pratense* practically did not occur in the stand any more.

Incorporation of two species into the community consisting of yield-dominant species (*Lolium perenne* and intergeneric hybrid *Festuca arundinacea × Lolium multiflorum* hereinafter *Festulolium*) showed particularly in

Table 2. Species and cultivars and their shares in the sowing rate

Species	Variant 1		Variant 2		Variant 3		Variant 4	
	cultivar	%	cultivar	%	cultivar	%	cultivar	%
Lolium perenne	Mustang	20	Mustang	10	Mustang	10	Mustang	5
			SE-202	10			SE-202	5
Festulolium								
(*F. arundinacea × L. multiflorum*)	Felina	20	Felina	10	Felina	10	Felina	5
			Hykor	10			Hykor	5
Poa pratensis	Slezanka	20	Slezanka	10	Slezanka	10	Slezanka	5
			Baron	10			Baron	5
Alopecurus pratensis	Rožnovská	10	Rožnovská	10	Rožnovská	10	Rožnovská	10
Phleum pratense	Sobol	10	Sobol	10	Sobol	10	Sobol	10
Arrhenatherum elatius	Rožnovský	10	Rožnovský	5	Rožnovský	10	Rožnovský	5
			Modus	5			Modus	5
Trisetum flavescens	Rožnovský	10	Rožnovský	10	Rožnovský	10	Rožnovský	10
Trifolium pratense					Tábor	10	Tábor	10
					Vesna	10	Vesna	10
					Beskyd	10	Beskyd	10

Table 3. Relative expression of yields by means of chain indices in the sequence of experimental years, and basic indices derived from year 1995

Variant	Indexes	1995	1996	1997	1998	1999	2000
1.	$i_{t/t0}$	100.00	59.58	104.36	95.07	118.60	117.65
	$i_{t/t-1}$	100.00	59.58	175.16	91.09	124.75	99.20
2.	$i_{t/t0}$	100.00	49.71	94.10	65.52	94.48	115.43
	$i_{t/t-1}$	100.00	49.71	189.27	69.64	144.19	122.18
3.	$i_{t/t0}$	100.00	76.73	110.00	96.92	113.46	120.58
	$i_{t/t-1}$	100.00	76.73	143.36	88.11	117.06	106.27
4.	$i_{t/t0}$	100.00	75.36	107.54	93.28	108.55	118.13
	$i_{t/t-1}$	100.00	75.36	142.70	86.74	116.38	108.82

$i_{t/t0}$ = basic index, $i_{t/t-1}$ = chain index

the pure grass stand by lower values of basic index, i.e. in the lower production stability. The trend was not demonstrated in the grass-clover crops community. It is assumed that the subsidy of symbiotic N compensates for the unfavourable reaction of some grass species to the lack of nitrogen, which is necessary to build production.

The calculated values of chain index indicate the level of produce fluctuation between respective subsequent years, expressing the influence within the difference of e.g. climatic effects of individual years. Considerable variances in the level of chain index between the pure grass community and the grass-clover crops stand corroborate the above opinion about the positive influence of clover crops on the development and stability of forage production. The wider range of chain index in the community with a more diverse species composition suggests a significant influence of variety (some of varieties) onto produce stability or its disturbance.

The mentioned trends are characteristic even if evaluating relations between the chain index and the level of stand composition changeability (Figure 1). If there are more grass varieties included into the grass variant (var. 2) but also into the grass-clover crops mixture (var. 4), the chain index will exhibit variance from the normal already

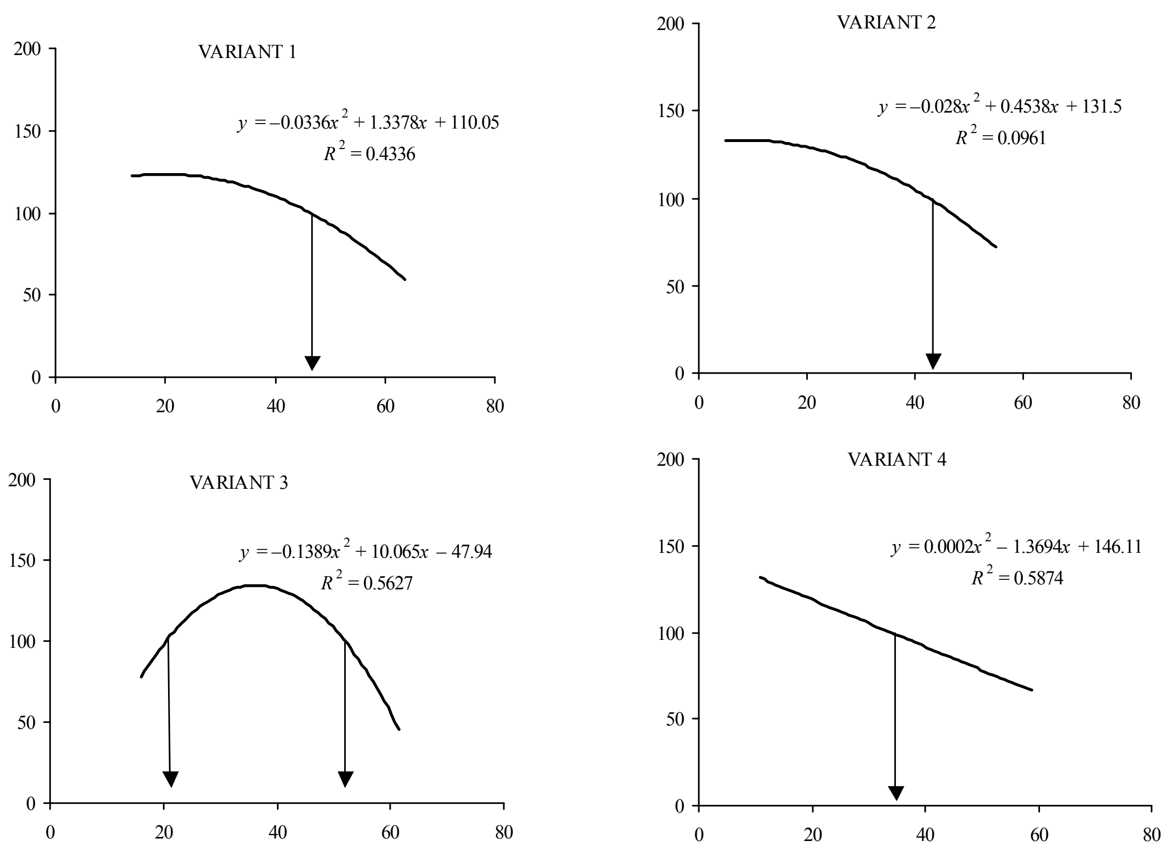

Figure 1. Dependence of interannual yield changes expressed by means of individual chain indices $i_{t/t-1}$ (= y) in total changeability of stand composition (= x) in years 1995–2000

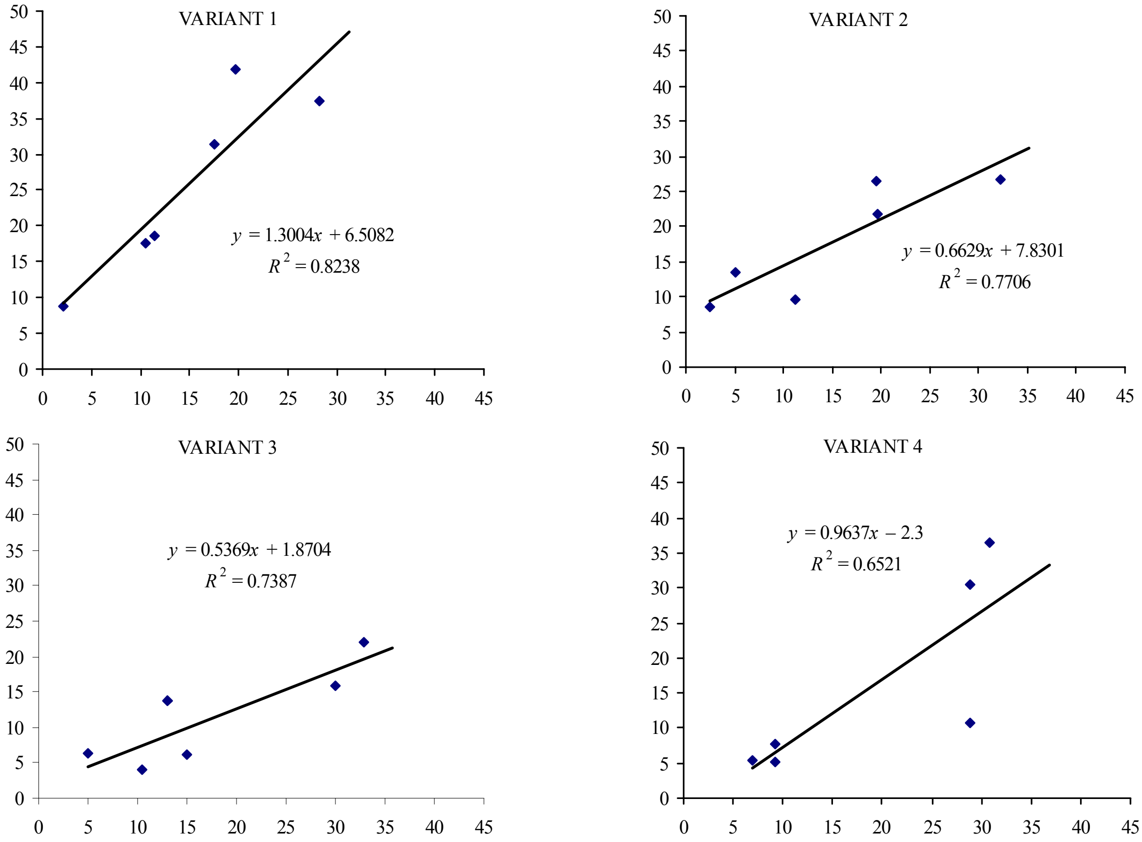

Figure 2. Interaction between relative weight representations (%) of dominant grasses *Arrhenatherum elatius* (= x) and *Festulolium* (= y) in years 1995–2000

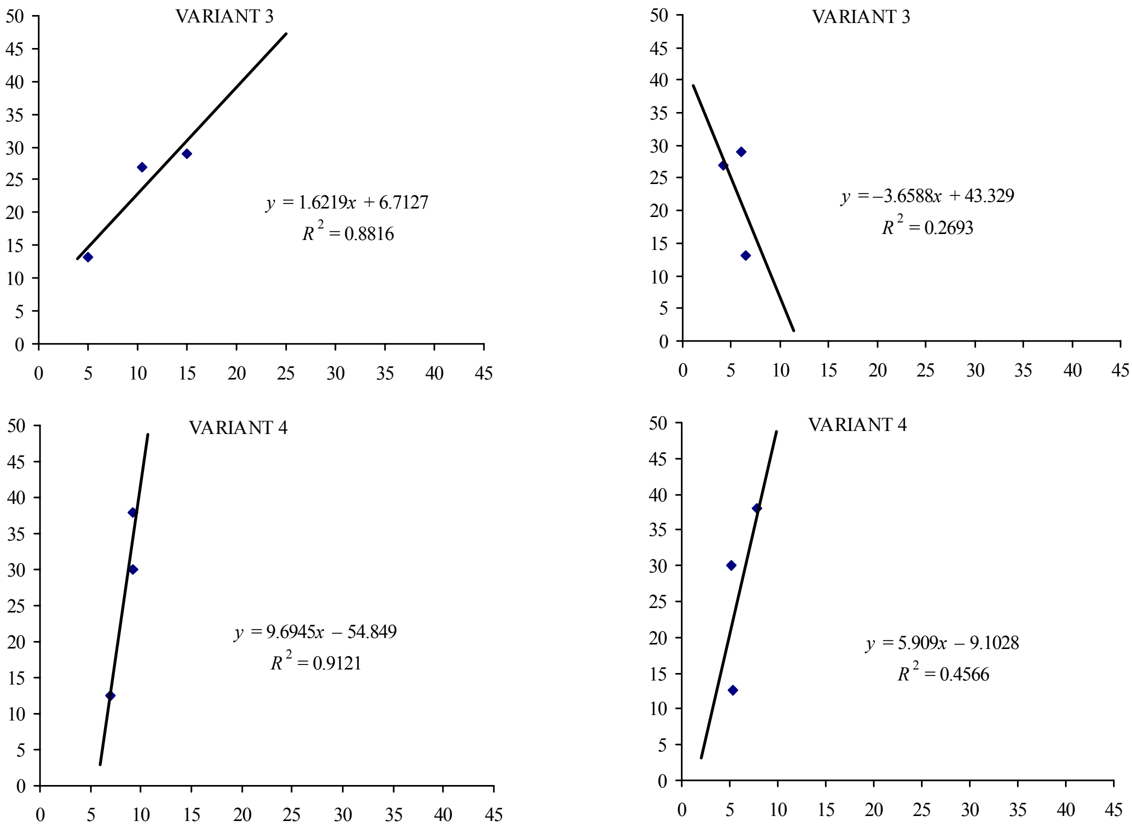

Figure 3. Interaction of relative weight representations (%) of *Trifolium pratense* (= y) with *Arrhenatherum elatius* (= x) (left) and *Festulolium* (= x) (right) in the first three productive years 1995–1997 in grass-clover crops variants 3 and 4

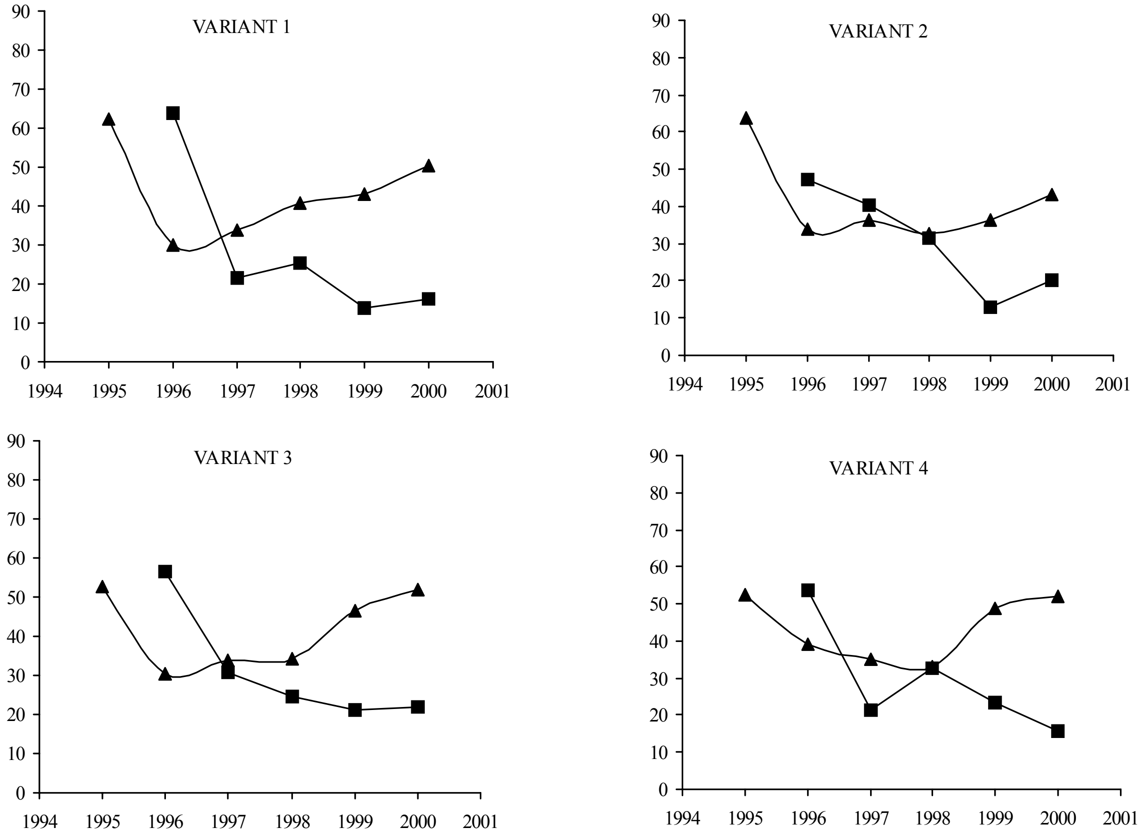

Figure 4. Changeability of the stand of basic character as related to sowing rate and total changeability of interannual character (= y) in the studied years 1995–2000 (= x)

■ Changeability of representation with chain indices ▲ Changeability of representation with basic indices

at a lower level of changeability (32–42%) in the comparison with stands with a narrower composition of varieties (var. 1 and 3), i.e. (45–52%). The results confirm that the competition links in grass and grass-clover crops communities should be further studied not only from the viewpoint of their species composition but also variety composition.

The evaluation of dominant species should take into account a possible mutual influencing between the strong competitors. The graphic expression (Figure 2) clearly shows complexity of intraspecific links within the community. Estimated are possible links between *Arrhenatherum elatius* and *Festulolium*. In the grass community for example (var. 1 and 2) the 20% weight representation of *Arrhenatherum elatius* is achieved with *Festulolium* at a level of about 35–23% while in the grass-clover crops community (Figure 2) *Arrhenatherum elatius* reaches the representation of 20% already with *Festulolium* at a level of 15–25%. The stated findings confirm suggestion by Opitz von Boberfeld (1994), that the research into critical seedling amount of particular forage species is essential, particularly in relations between seedling amount and competitive effects in association.

When assessing the relation between the relative weight representation of *Trifolium pratense* and *Arrhenatherum elatius* and also between *Trifolium pratense* and *Festulolium* (Figure 3), we can confirm a more significant link between the representation of *Trifolium pratense* and *Arrhenatherum elatius*, and a rather suppressing effect between *Trifolium pratense* and *Festulolium*.

The results are in a good agreement with findings of Hrabě et al. (1996, 1998) obtained from precise pot trials only between these selected species in which a mildly additive relation was demonstrated to exist between *Trifolium pratense* and *Festulolium* and a highly synergic relation between *Trifolium pratense* and *Arrhenatherum elatius*.

The effect of *variety* on mutual relations between grasses (*Arrhenatherum elatius* and *Festulolium*) is relatively hard to be estimated from the methodological point of view. Each species was used with two varieties. In the grass community (var. 2), a share of *Festulolium* Felina reduced to one half and incorporation of *Festulolium* Hykor resulted in a faster development of dominance in *Arrhenatherum elatius*. In a single-variety grass community (*Arrhenatherum elatius* cv. Rožnovský and *Festulolium* Felina), the 20% representation of *Arrhenatherum elatius* in the produce was achieved with the share of *Festulolium* Felina larger than 30%. If there were two *Festulolium* varieties (Felina and Hykor) the 20% weight representation of *Arrhenatherum elatius* was reached already with *Festulolium* at a level of 23%. How-

Table 4. Total changeability of stand composition and its components (internal and external)

Var.	Group	Total					Internal					External				
		95/96	96/97	97/98	98/99	99/00	95/96	96/97	97/98	98/99	99/00	95/96	96/97	97/98	98/99	99/00
1	grasses															
	tuft	54.97	16.08	15.31	5.78	6.66	7.29	1.83	9.19	3.64	2.46	47.68	14.24	6.12	2.14	4.20
	stoloniferous	8.01	3.89	9.43	6.59	6.06	8.01	0.35	8.45	5.24	6.06	0.00	3.54	0.98	1.35	0.00
	legumes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	other herbs	0.72	1.48	0.75	1.60	3.60	0.72	1.48	0.75	1.60	3.60	0.00	0.00	0.00	0.00	0.00
	total	63.70	21.45	25.48	13.96	16.32	16.02	3.66	18.38	10.47	12.12	47.68	17.78	7.10	3.49	4.20
2	grasses															
	tuft	38.35	33.23	15.28	4.20	14.65	8.69	3.28	7.04	1.30	2.08	29.66	29.95	8.24	2.90	12.57
	stoloniferous	8.51	6.75	13.68	8.15	4.82	8.51	2.75	4.64	2.00	1.25	0.00	4.00	9.04	6.15	3.57
	legumes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	other herbs	0.19	0.53	2.40	0.70	0.83	0.19	0.53	2.40	0.70	0.83	0.00	0.00	0.00	0.00	0.00
	total	47.04	40.50	31.36	13.04	20.29	17.38	6.55	14.08	3.99	4.15	29.66	33.95	17.28	9.05	16.14
3	grasses															
	tuft	45.28	25.20	5.60	13.72	7.97	9.01	0.35	0.72	3.37	3.89	36.27	24.85	4.88	10.35	4.08
	stoloniferous	2.32	3.48	7.36	2.41	8.05	1.97	0.45	7.36	1.57	1.88	0.35	3.03	0.00	0.84	6.17
	legumes	7.97	1.05	9.24	4.26	1.57	7.97	1.05	9.24	4.26	1.57	0.00	0.00	0.00	0.00	0.00
	other herbs	0.94	0.95	2.59	0.68	4.19	0.94	0.95	2.59	0.68	4.19	0.00	0.00	0.00	0.00	0.00
	total	56.50	30.67	24.78	21.06	21.78	19.88	2.79	19.90	9.87	11.53	36.62	27.88	4.88	11.19	10.25
4	grasses															
	tuft	37.09	13.39	17.92	3.05	6.22	13.79	2.57	1.83	3.05	3.96	23.30	10.82	16.09	0.00	2.26
	stoloniferous	2.54	3.38	5.43	12.58	5.82	2.54	0.68	3.97	10.03	0.15	0.00	2.70	1.46	2.55	5.67
	legumes	12.70	4.00	7.61	7.36	1.94	12.70	4.00	7.61	7.36	1.94	0.00	0.00	0.00	0.00	0.00
	other herbs	1.44	0.74	1.82	0.38	1.87	1.44	0.74	1.82	0.38	1.87	0.00	0.00	0.00	0.00	0.00
	total	53.76	21.50	32.77	23.36	15.84	30.46	7.98	15.22	20.81	7.91	23.30	13.52	17.55	2.55	7.93

ever, in this case it is impossible to find a measure at which the effect showed with additional incorporation of the second *Arrhenatherum elatius* variety, i.e. Modus. The advantage is however not entirely apparent in the grass-clover crops community, the complexity being also documented by courses of the regression curve between the percentage shares of *Trifolium pratense* and *Arrhenatherum elatius* (var. 4). Desirable will be assessment of the relation at a level of simple experiment with the two species based on just a single variety.

As compared with the course of the curve of total interannual changeability, the graphic expression of the changeability of basic character (Figure 4) exhibits a trend that has been slightly increasing since 1996. Differences between the relative sowing rate and the relative biomass representation of individual species have been growing for basic changeability in comparison with the initial stage of succession while the total changeability of interannual character has an unambiguously decreasing trend.

The highest values of total changeability (63.70–47.04%) apparently exist between production years 1 and 2 (Table 4). The following two years exhibited a relatively high level of total changeability values (40.50–21.45%); at a further development the stand exhibited a gradual stabilization onto a level of total changeability ranging from 23.36–13.04%. Values of total changeability most favourable from the viewpoint of yield parameters referred to in literature range from 30–60%, which was corroborated by our research (Figure 1). After a closer study it is possible to made a deduction that the greatest share in total changeability at initial stages of succession is that of external changes which are particularly contributed to by the group of clumpy grasses and in the grass-clover crops variants also that of internal changes in the representation of pod-bearing species. In the experimental study, it was confirmed legality of dynamic production-cenological balance of grass growth (Klimeš 1987).

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ABSTRAKT

Dynamika změn porostové skladby travních a jetelotravních porostů a vztahy mezi dominantními druhy

V letech 1994–2000 byly sledovány změny porostové skladby dočasných travních a jetelotravních porostů. Hodnocení spočívalo ve stanovení dominance jednotlivých druhů a hmotnosti nadzemní biomasy a v jejich následném porovnání. Získané údaje byly vyhodnocovány metodou určení vzdálenosti mezi vektory porostové skladby s následnou standardizací. Výsledné hodnoty jsou v souladu s dosavadními poznatky a potvrzují, že příznivějších výnosových parametrů je dosahováno v rozmezí celkové proměnlivosti 30–60 %. Změny druhového složení a proměnlivosti porostu v počátečních stadiích sukcese jsou dány externími změnami, na nichž se podílí především skupina trsnatých druhů trav, a interními změnami v rámci skupiny vikvovitých.

Klíčová slova: travní a jetelotravní porosty; fytocenologické vztahy

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