The influence of time of setting land aside on weed spectrum and changes of ecological parameters of environment based on plant indicator values

Veronika Venclová[1]*, Václav Brant[1], Martin Duchoslav[2], Josef Soukup[1], Karel Neckář[1]
1 Czech University of Life Sciences Prague, Faculty of Agrobiology, Food and Natural Resources,
Kamýcká 957, Prague 6 – Suchdol, 165 21,
2 Palacký University, Faculty of Science, Department of Botany, Šlechtitelů 11, Olomouc, 783 71
* Corresponding author, venclova@af.czu.cz

Summary

The time factor on the weed spectrum of setting land aside was observed on small plot trials in the years 2002-2004. Development of weeds was observed on spontaneous fallow and on plots sown with *Dactylis polygama + Trifolium repens* and *Dactylis polygama.* The weediness was evaluated by means of a modified weighting method. The influence of the treatments on weed vegetation during time was evaluated by Principal Components Analysis and Redundancy Analysis. Variation of ecological factors was evaluated on the basis of Ellenberg's indicator values for light, moisture and nitrogen. Experiment demonstrated influence of different ways of setting-aside on the number of species and the composition of weed vegetation. Significantly different development of vegetation on spontaneous fallow in contrast to artificially revegetated treatments was observed. On the other hand, no significant differences in development of weed vegetation were found between artificial treatments. The mean indicator values for light and nitrogen changed significantly in time in all treatments. High and stable nutrient availability was indicated by indicator values at spontaneous fallow over all three years while plant composition in other treatments indicated decrease in nutrient availability over time.

Materials and methods

The primary aim of the experiment was to evaluate the influence of different ways of setting land aside (spontaneous fallow and two types of artificial revegetation) on changes of species composition over three successive years (2002–2004). Twelve plots (four replications per treatment, randomised design) were established in autumn 2001 on the experimental field at the experimental station of the Czech University of Life Sciences Prague in Červený Újezd. The station is located at altitude of 405 m a.s.l. with the average annual temperature 7.9°C and precipitation 525.8 mm. *Triticum aestivum* L. (winter wheat) was used as a forecrop before trial establishment. The clay-loamy soil was tillaged by cultivator with a depth of 10 cm after *T. aestivum* harvest in August 2001. The plots representing spontaneous fallow (treatment 1 – in tables and figures) were established in autumn 2001. In spring 2002, artificial revegetation took place after the second tillage by sowing either grass-legume mixture of *Dactylis polygama* Horv. (cv. Tosca) and *Trifolium repens* L. (cv. Hajek) – 15 + 6 kg ha-1 (treatment 2 – in tables and figures) or *Dactylis polygama* – 18 kg ha-1 (treatment 3 – in tables and figures). The area of each experimental plot was 6 x 10 m. The spontaneous fallow and artificial revegetation were mulched twice in each year (17.June and 30 September in the year 2002, 19June and 1 October in the year 2003 and 23 June and 4 October in the year 2004). Aboveground biomass production was evaluated using modified weight method (Brant et al. 2000) on the central area (14 m2) of each plot in the time of mulching. Biomass of each species was estimated cumulatively (sum of drymass of first. and second. mulching) and used as an estimation of species importance. We used multivariate statistical methods for the exploratory analyses and statistical testing using the software package Canoco for Windows 4.5 (ter Braak and Šmilauer 1998). Repeated measures ANOVA was used to test the differences in mean Ellenberg indicator values (sensu Ellenberg et al. 1992) among treatments and over time with treatments as between-subject factor, year as within-subject factor and plots as subjects. Indicator values were not weighted by biomass data. Post-hoc multiple comparisons were done by the means of Bonferroni test (Zar 1996). Nomenclature of species follows Kubát et al. (2002).

Results

species composition

Figures 1 and 2 show results of PCA based on species composition of plots over three years. Results suggest that the first axis can be interpreted as a combined gradient of time (= succession) and type of management (treatments). Species composition of the samples from the first year of the experiment (2002) is apparently different from that of the successive years but it is clear from the ordination that this difference is caused mainly by the control treatment, i.e. plots on spontaneous fallow. Samples from the first year of the experiment are typical of apparently high species richness of annual weeds with dominance of *Tripleurospermum inodorum*, *Avena fatua*, *Chenopodium album,* but also of important representation of perennial plants, especially of *Cirsium arvense* and *Elytrigia repens*. At spontaneous fallow, winter wheat dominated in the first year after cessation of management due to germination of seeds from postharvest residues. Artificially revegetated plots were overgrown by the sown crops during the first year and therefore *Cirsium arvense* with deeply rhizomes and small sized annuals with quick and early development (e.g. *Lamium amplexicaule*, *Thlaspi arvense*, *Veronica persica*) are typical for them while other annuals produced smaller amount of biomass.

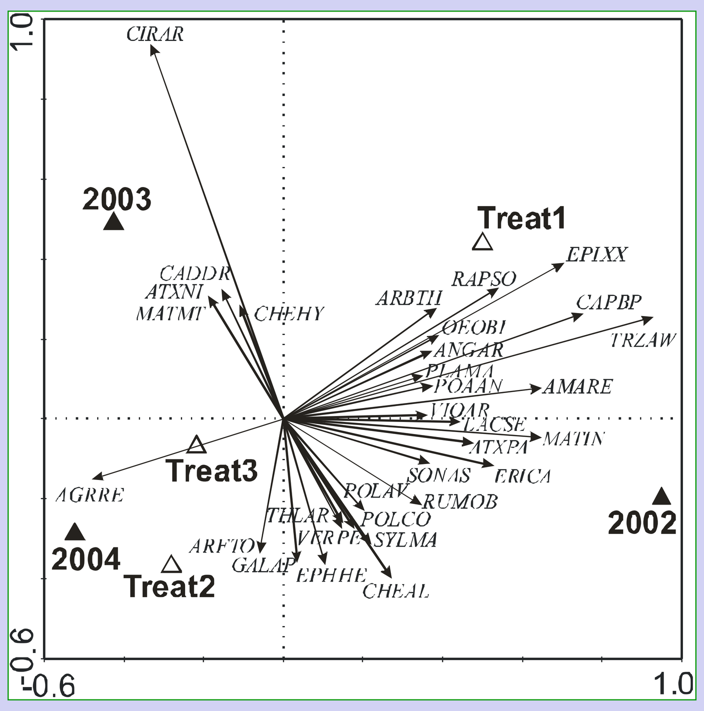

Fig. 1. PCA biplot of species and environmental factors. Centroids of samples belonging to the respective treatments or years are marked by triangles (the species are identified by the BAYER Code System).

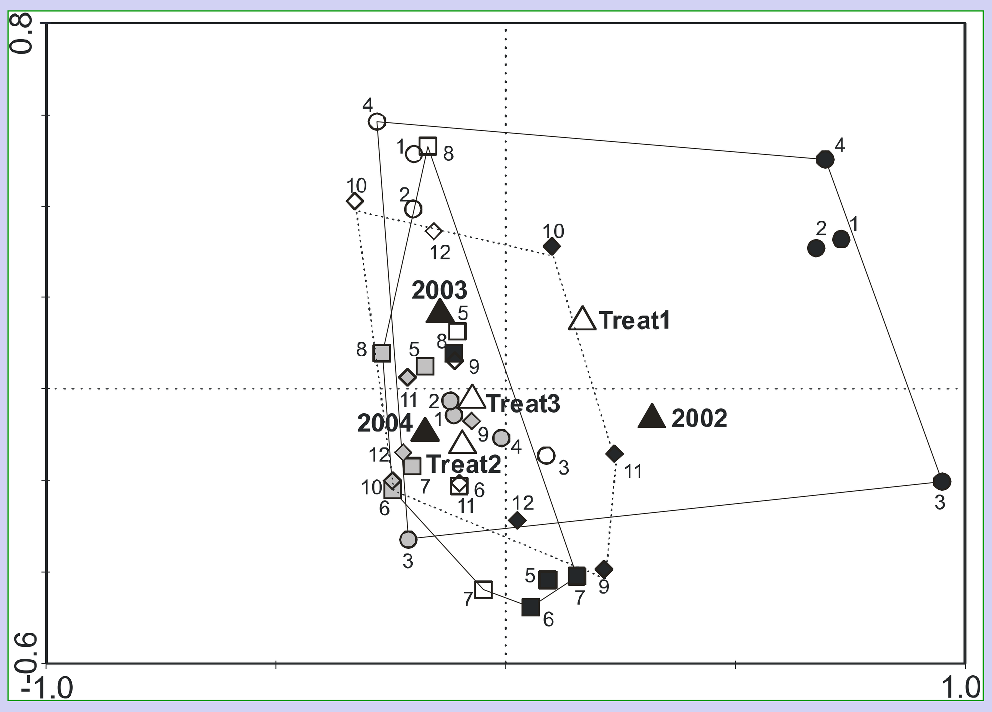

Fig. 2. PCA biplot of samples and environmental factors. Centroids of samples belonging to the respective treatments or years are marked by triangles. Envelopes are drawn around plots belonging to the respective treatments (treat1: dots, treat2: squares, treat3: diamonds). Each treatment consists of four plots sampled three times (2002: black, 2003: empty, 2004: grey symbols).

Over time, species spectrum decreased in plots of all treatments but it was more rapid on sown plots, where the number of species per plot was two times lower in the second and third year of the experiment than in plots of spontaneous fallow. In 2003, high variability in species composition was observed among plots of treatments 2 and 3 (sowed seeds) that is documented by large variation of sample scores along the second ordination axis (Fig. 2). *Cirsium arvense* and *Elytrigia repens* were dominant species on plots of all treatments. On the plots of treatment 2, occurrence of *Lactuca serriola* was apparent while on the plots of treatments 3 *Taraxacum* sect. *Ruderalia* was common. Further development of species composition lead to the dominance of two perennial weeds *Cirsium arvense* and *Elytrigia repens* in all treatments in the third year (2004) and to high floristic similarity of weed vegetation in plots of two artificially seeded treatments. On the other hand, species composition of plots of spontaneous fallow was still species various that is visible from the ordination (Fig. 2). Results of constrained ordination (Table 1) confirmed results of the PCA. Over three years, directional changes in species composition that are common to all treatments and also divergence in species composition among treatments were found. Analysis however showed that only species composition of spontaneous fallow had significantly different direction than that of other treatments over time while no significant differences were found between both treatments with artificial revegetations.

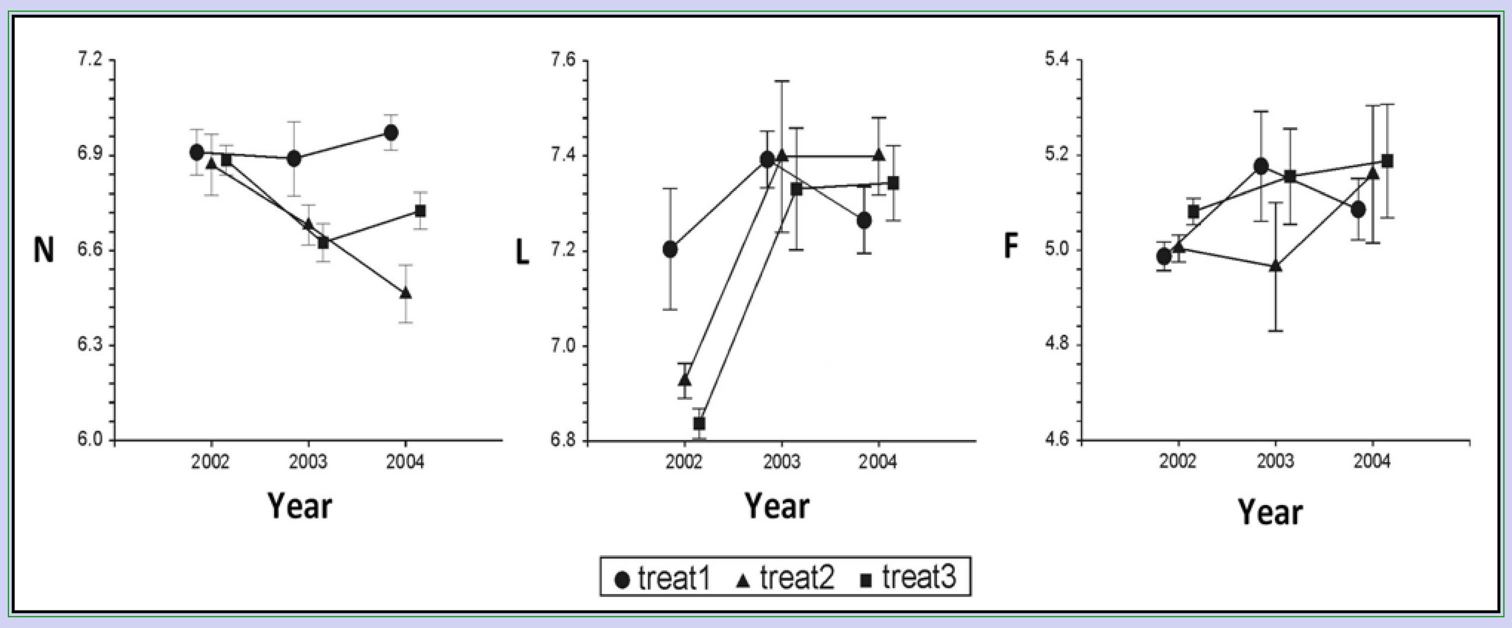

Fig. 3. Changes of Ellenberg´s indicator values (mean ± standard error) for nitrogen (N), light (L) and moisture (F) in plots of three treatments during three successive years.

environmental factors

Moisture showed no clear pattern of variation both among treatments and years and therefore no significant effects were found in RM-ANOVA (Table 2). On the other hand, significant effects of treatment, year and their interaction on nutrient availability (N) were found. In the first year of experiment, no significant differences in nutrient availability were found among treatments (Table 2, Fig. 3). In the following years, species composition of spontaneous fallow (treatment 1) indicated high and stable nutrient availability, while plant composition in other treatments indicated mainly decrease in nutrient availability. At the end of the experiment (2004), spontaneous fallow showed significantly higher nutrient availability than other treatments that did not differ each other in mean indicator values (Bonferroni test at P = 0.05). Only the year had significant effect on the mean indicator values for light (Table 2) with the mean indicator values significantly lower in the first year than in the following years in all treatments (Bonferroni test at P = 0.05, Fig. 3).

Tab. 1.: Results of the redundancy analysis (RDA) testing five hypothesis concerning changes of species composition over time with respect to different treatments. Monte Carlo permutation test with 499 permutations were used to assess the significance of the RDA analyses (see Methods for explanations).

Tested hypothesis	Explanatory variables	Covariables	% explained	F	P
H1: there are no directional changes in time in the species composition that are common to all the treatments or specific for particular treatments.	Yr*treatment1 Yr*treatment2 Yr*treatment3	PlotID	50.1	7.04	0.002
H2: changes in time in the species composition are independent of the treatments.	Yr*treatment1 Yr*treatment2 Yr*treatment3	Yr, PlotID	25.6	3.61	0.002
H3: there is no difference in effect on the temporal changes in the species composition between spontaneous fallow (treatment 1) and revegetation with *D. polygama* + *T. repens* (treatment 2).	Yr*treatment1 Yr*treatment2	Yr, PlotID,	21.7	5.84	0.002
H4: there is no difference in effect on the temporal changes in the species composition between spontaneous fallow (treatment 1) and revegetation with *D. polygama* (treatment 3).	Yr*treatment1 Yr*treatment3	Yr, PlotID,	16.5	4.14	0.002
H5: there is no difference in effect on the temporal changes in the species composition between revegetation with *D. polygama* + *T. repens* (treatment 2) and *D. polygama* (treatment 3).	Yr*treatment2 Yr*treatment3	Yr, PlotID,	3.9	0.85	0.350

Tab. 2.: Results of repeated measures ANOVA (RM-ANOVA) testing the influence of the treatment (between-subject factor) and year (within-subject factor) on the mean indicator values (sensu Ellenberg et al. 1992) in plots (N = nutrition, L = light, F = moisture).

	N			L		F	
	DF	F	P	F	P	F	P
A: Treatment	2	7.38	0.013	0.80	0.479	0.56	0.587
C: Year	2	5.02	0.019	19.04	<0.001	1.49	0.252
AC	4	3.23	0.037	2.27	0.102	0.77	0.558

Conclusions

Experiments showed different influence between spontaneous fallow and green fallow on a number of weed species. Differences were highest in the first year of our experiments. Annual weed species were dominant in this year. Better conditions for weed spectrum development are especially on spontaneous fallow because of absence of competitive crops. But spontaneous fallow is not acceptable with regard to weed management aspect because of possibility of seed ripeness and their shattering before or during cutting or mulching. Perennial weeds dominated in next years.

In 2003, apparent variability of species composition in samples of treatments 2 and 3 (Fig. 2) together with remarkable dominance of *Cirsium arvense* (Fig. 1) were observed. As a reason of this phenomenon it is possible to consider very little rainfall in 2003, especially in June. Rainfall absence gave advantage especially to *Cirsium arvense*. Low level of biomass production and porosity of canopies are also evoked by water deficiency. Higher canopy porosity which was caused by mortality of *Trifolium repens* was observed on treatment 2. There was sporadically determinated *Atriplex patula*, *Lactuca serriola*, and *Polygonum aviculare* in these gaps. Conversely on treatment 3 *Taraxacum* sect. *Ruderalia* was determinated. The stands of *D. polygama* (treatment 3) which were weaked by dry period allowed development of this weed. It was probably allowed by lower vegetation cover of sown species and better conditions than on treatment 2. Plants of *T. repens* were efficiently in establishing good canopy. Reduction of *Taraxacum* sect. *Ruderalia* was caused by shading from the crop (treatment 2).

Lower averages of Ellenberg values for light (Fig. 3) in 2002 were caused by occurrence of weed species with lower indicator values (e.g. *Apera spica-venti*, *Avena fatua*, *Veronica persica,* and *Viola arvensis*). These species were not present on experimental plots in next years that gave the opportunity to plants with higher Ellenberg values 7 – 9 to dominate, and it was the reason for increasing of indicator value. The question is if the decrease of these species' occurrence was caused by changes of light conditions or if it was a combination of more competition factors. More possible is that species mentioned above were overdominated by those with higher competitive ability.

The importance of growth speed in relation to the profit from adequate light environment can be shown by permanent occurrence of *Tripleurospermum inodorum* (L = 9) and by increasing occurrence of *Lactuca serriola* (L = 9) on treatments from 2003 till 2004. These species are very sensitive to shading in the early stages of their development. They can survive and achieve only because of their fast growing. Decline of average Ellenberg value for N on treatments 2 and 3 in 2003 and 2004 was probably caused by higher withdrawal of nutrients from soil especially by sown species. Biomass production on treatments 2 and 3 was higher than on treatment 1. There is also important question of leaving mulch on the field and its influence of nutrient availability. Decline of values N can be also reason for decline of species with lower competitive ability like *Chenopodium album* (N = 7) and *Poa annua* (N = 8) and by higher occurrence of species that are typical in the second and third succession year - *Lactuca serriola* (N = 4). Simultaneously it is necessary to awake that Ellenberg values are of substantial influence in phytocoenoses with low species numbers (treatment 2 and 3).

Based on the analyses there was demonstrated positive effect of spontaneous fallow on increase of weed species richness compared with sown fallows. This effect is positive from the agroecological aspects but not from the view of weed management. On the basis of Ellenberg values it is evident, that weed communities have no effect on the conditions of the stand on short-term set aside land. Changes of plant communities are mainly caused by competitive relations between species.

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