Secondary Succession on an Early Abandoned Field: Vegetation Composition and Production of Biomass

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Abstract

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During 1996–2000 the secondary succession on a field left fallow was investigated. The experimental area was divided into a ploughed and an unploughed part. Both parts were divided into 5 × 5 m plots that were either left intact (control), mowed in June or July, or superficially cultivated in June. The position of the plots was identical each year. In successive years total dry matter production decreased in all experimental plots; in unploughed plots more than in ploughed ones. The spread of *Cirsium arvense* (L.) Scop. was increased by ploughing and superficial cultivation. Ploughing stimulated the spread of perennial dicotyledonous plants more than mowing in June and July. Superficial cultivation increased the spread of perennial dicotyledonous plants in the first years. Later on the proportion of perennial dicotyledonous plants decreased and after 5 years the plots were dominated by *Anisantha sterilis* (L.) Nevski. The incidence of *Elytrigia repens* (L.) Desv. was highest in the 5th year on unploughed control plots. The spread of perennial monocotyledonous plants was lowest in ploughed and superficially cultivated plots.

Key words: fallow-field; ploughing; weeds; biomass; monocotyledonous plants; dicotyledonous plants; perennial; annual; secondary succession

In early stages of secondary succession on fields left fallow, annual plants are replaced by perennial plants. This process may take 1 (BROWN *et al*. 1987) to 40 years (BEGON *et al*. 1997). Its rate is affected by soil, climate, seed bank in the soil and initial level of occurrence of perennial plants. This process can be changed by disturbances which return plant communities to a higher proportion of annual plants. Weed communities on arable land are then early stages of succession maintained by ploughing and weed control (HÅKANSON 1995). Several works studied the rate of invasion of perennial weeds on early abandoned fields (SCHMIDT 1986; WILCOX 1998, BRUSSAARD *et al*. 1996).

The recent change of land ownership and systems of agricultural production in the Czech Republic increased the number of abandoned fields. This allows the spread of perennial weeds that are hard to eradicate and it makes a later reversion of an abandoned field for renewed agricultural use difficult. A study of the rate of weed succession under local conditions was thus relevant.

In this paper I studied how ploughing, mowing and superficial cultivation influence the rate of secondary succession on an abandoned field in Central Bohemia.

MATERIAL AND METHODS

Experimental ground. The experiment was performed at Prague-Ruzynì (50°06' N, 14°15' E, altitude 350 m) on a field used for small plot experiments since the 1950ies. It had been routinely cultivated each year (medium depth ploughing in the autumn, harrowing and rolling in the spring) and sown with different cover crops (mustard, mixtures of oats and peas, millet) without fertilisation. The present study was performed on an experimental area of 20 × 41 m situated in the western part of the experimental field. Nearly the whole area was surrounded by cover crops, but a part bordered on a neighbouring experimental area. The paper reports data of the first to the fifth year of succession.

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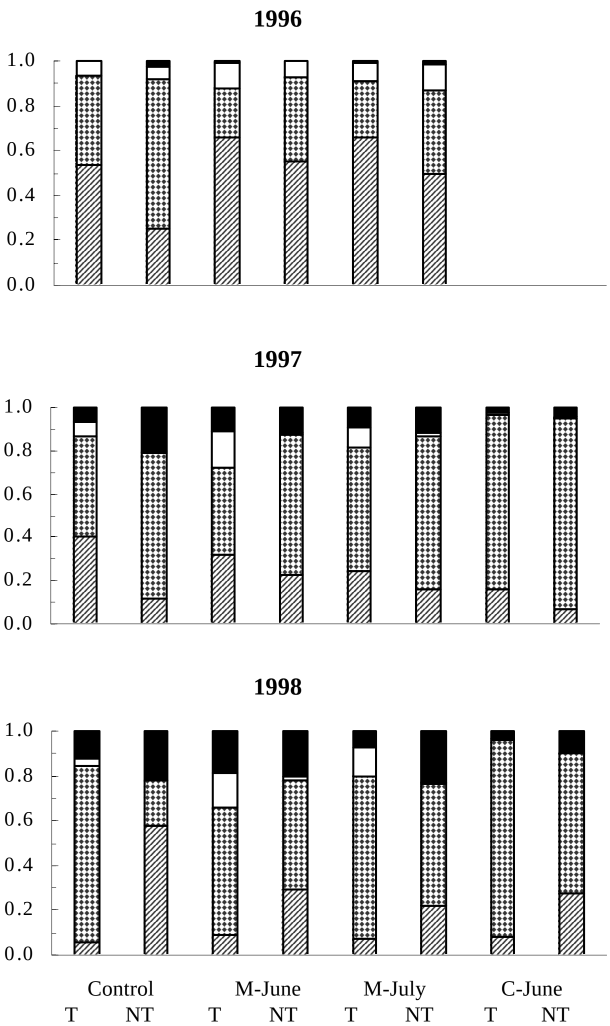
Experimental treatment. The experiment started in 1996 and continued until 2000 on an area that consisted of two parts of 20 × 20 m. One part was every year in the autumn (November–December) ploughed to a medium depth (15–20 cm), next spring (early April) it was machine harrowed and rolled (to prevent uneven soil compression) and will be further referred to as TILL. In the second half of the experimental area there were no autumn ploughing and spring harrowing, and it will be further referred to as NO TILL. Both parts were then divided into 16 plots of 5 × 5 m, whose position was identical each year. The weed stands were left to develop spontaneously. There were four plots for each of the following treatments: early mowing (June 25, 1996; June 17, 1997; June 19, 1998; June 21, 1999 and June 19, 2000) further referred to as M-June; late mowing (July 24, 1996; July 23, 1997; July 21, 1998; July 20, 1999 and July 24, 2000) further referred to as M-July; early cultivation of the superficial soil layer (following the same dates as early mowing) further referred to as C-June, and no treatment (control). The mowing consisted of manual cutting of the aboveground parts of weeds taller than 5 cm. Superficial cultivation (which followed mowing and removal of the aboveground biomass) consisted of machine harrowing of the upper 5–10 cm. Plots with different treatments were arranged in a latin square design so that the same treatments were not repeated in rows and columns. During the first year of the experiment, the part NO TILL appeared to be influenced by the aftereffects of previous experiments on plots of the former experimental field; therefore, only half of NO TILL was used for the next experiment.

Measuring plant cover characteristics. The aboveground biomass of weeds was measured after mowing in June or July, in 1999 and 2000 also at the time of superficial cultivation, and at the end of the season (between September 15 and October 15). After mowing, the weeds were separated into annual and perennial or biennial dicotyledonous, and annual and perennial monocotyledonous plants and their dry mass was determined. At the end of the vegetation season the aboveground biomass of each experimental plot was calculated from biomass of two



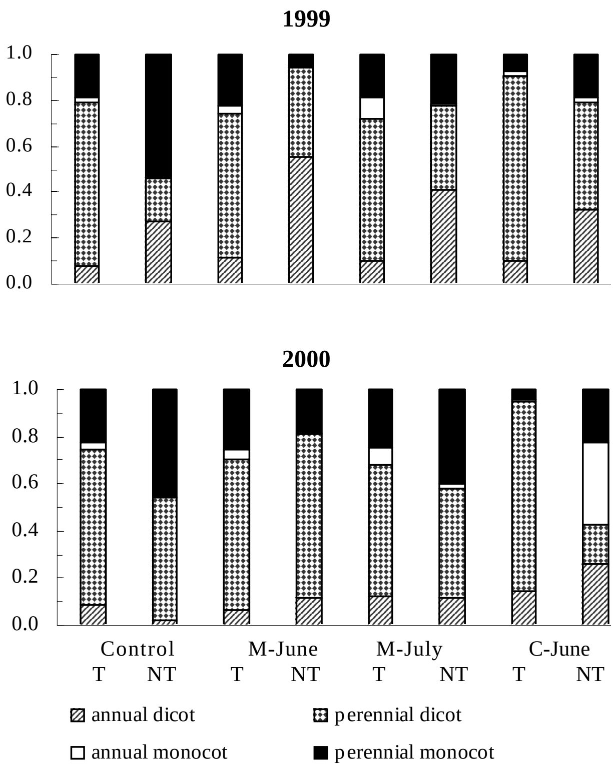


Fig. 1. The proportion of biomass of annual and perennial monocotyledonous (monocot) and dicotyledonous (dicot) plants on plots with different treatments (see Material and Methods for explanation of abbreviations) in TILL (T) and NO TILL (NT) in the years 1996–2000

1m² plots. The harvested weeds were divided into species and their dry biomass was measured. The total biomass of control plots was calculated as the sum of dry biomassess of each species. Total production on mowed plots was calculated as aboveground dry mass of weeds at the time of mowing plus dry matter harvested at the end of the vegetation season. In 1999 and 2000 the total biomass of weeds on C-June cultivated plots was calculated as dry mass at the time of C-June plus dry matter at the end of the vegetation season. In 1996, 1997 and 1998 the biomass of weeds on C-June plots was not established and the data were replaced by values from mowed plots.

Data analysis. The statistical significance of differences between treatments and years were tested by LSD test of contrasts included in one-way analysis of variance (ANOVA) of Statistica for Windows (StatSoft 1994).

The botanical nomenclature followed DOSTÁL (1989).

RESULTS

Total biomass production. The dry biomass production during the whole season varied between years and experimental plots. In the course of the experiment, dry matter production decreased on all plots. The decrease in TILL was lower than in NO TILL plots (Table 1). Ploughing had a greater impact on dry biomass production than early or late mowing or superficial cultivation.

Annual dicotyledonous plants represented 50–60% of the total biomass in the 1st year both in TILL and NO TILL**,** with *Galinsoga parviflora* Cav. and *G. urticifolia* (Humb., Bonpl. et Kunth.) Benth. in Oerst. being dominant. From the 2nd year on the proportion of dicotyledonous annuals decreased in TILL and NO TILL (Fig. 1). Exceptions were NO TILL controls in 1998 due to high dry biomass of *Matricaria maritima* L., and NO TILL M-June and M-July plots in 1999 due to dominant *Medicago lupulina* L. (Fig. 2).

The proportion of dicotyledonous annuals was maintained mainly in plots with superficial cultivation in NO TILL, and was lowered most in those that left the weed community without any treatment (control plots in NO TILL).

Perennial dicotyledonous plants. From the 2nd year on, dicotyledonous perennials constituted most of the total dry biomass of every experimental plot, and *Cirsium arvense* (L.) Scop. was the dominant plant.

In TILL plots the proportion of dicotyledonous perennials increased until the 3rd year. Total dry biomass of dicotyledonous perennials on TILL plots was significantly higher than on NO TILL (Fig. 3). During the experimental years the proportion of *C. arvense* decreased and was replaced by *Tussilago farfara* L..

In NO TILL in the 3rd successional year *C. arvense* was replaced by *Taraxacum officinale* Weber in Wiggers. In the 5th year the spread of *Trifolium pratense* L. and

Table 1. The total season aboveground dry biomass of weeds (mean ± SD, g/m²). See Material and Methods for explanation of abbreviations of treatments

	TILL				NO TILL			
	M-June	M-July	C-June	Control	M-June	M-July	C-June	Control
1996	309.78 ± 50..91^{Ak}	320.64 ± 70.97^{A}	–	308.24 ± 108.13	238.94 ± 14.40^{ACk}	340.38 ± 4.97^{ACDE}	–	316.01 ± 141.74
1997	212.18 ± 16.64^{B}	248.18 ± 18.36^{B}	266.3 ± 0.64	244.02 ± 43.76	197.71 ± 10.78^{BD}	242.19 ± 6.28^{BCFG}	269.02 ± 36.18^{ABC}	270.01 ± 62.22
1998	264.16 ± 26.19^{acl}	286.02 ± 13.01^{Cbm}	228.32 ± 4.19^{abcn}	311.97 ± 51.95^{ck}	106.59 ± 14.83^{CDl}	127.67 ± 0.08^{DFm}	133.04 ± 9.48^{Bn}	185.82 ± 33.52^{k}
1999	258.87 ± 29.43 ^{Dl}	250.26 ± 22.01^{Dm}	244.30 ± 43.49^{n}	238.02 ± 40.82^{k}	179.36 ± 57.44^{l}	130.98 ± 5.31^{EGn}	112.25 ± 1.45^{Cn}	153.15 ± 35.95^{k}
2000	156.88 ± 8.92^{ABCDk}	179.06 ± 17.70^{ABCDl}	221.83 ± 25.38^{m}	214.77 ± 19.98	106.42 ± 40.24^{ABak}	95.82 ± 17.97^{ABbl}	98.76 ± 9.03^{Acm}	218.85 ± 36.74^{abc}

The figures followed by the same letters are different at $P < 0.05$. Tested were differences between years within treatments (A–G), between treatments within TILL or NO TILL and within the years (a–c), between TILL and NO TILL within treatment and within the years (k–n)

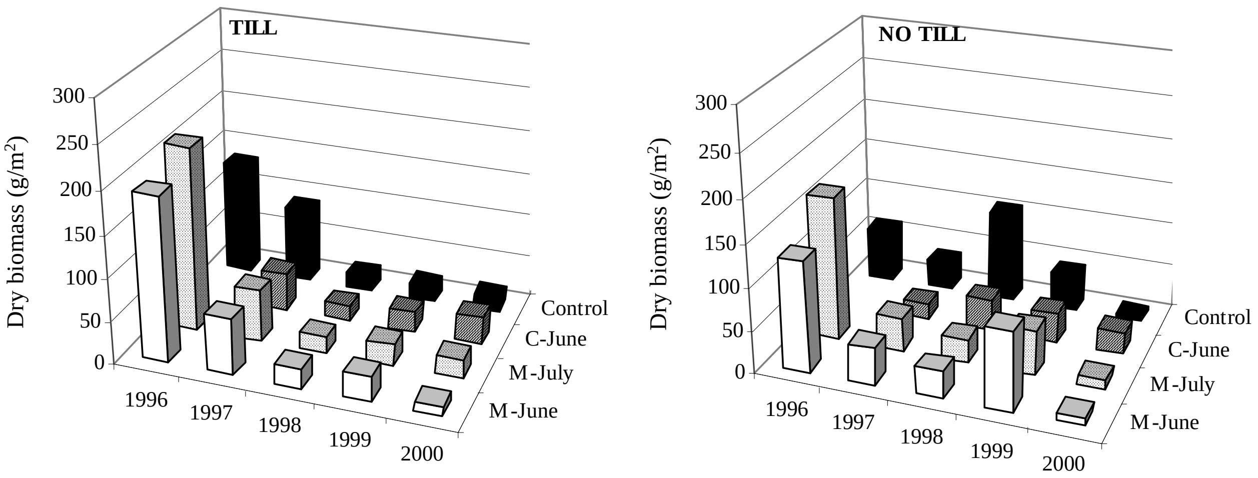


Fig. 2. The total season dry biomass of dicotyledonous annuals in plots with different treatments (see Material and Methods for explanation of abbreviations) in TILL and NO TILL in the years 1996–2000

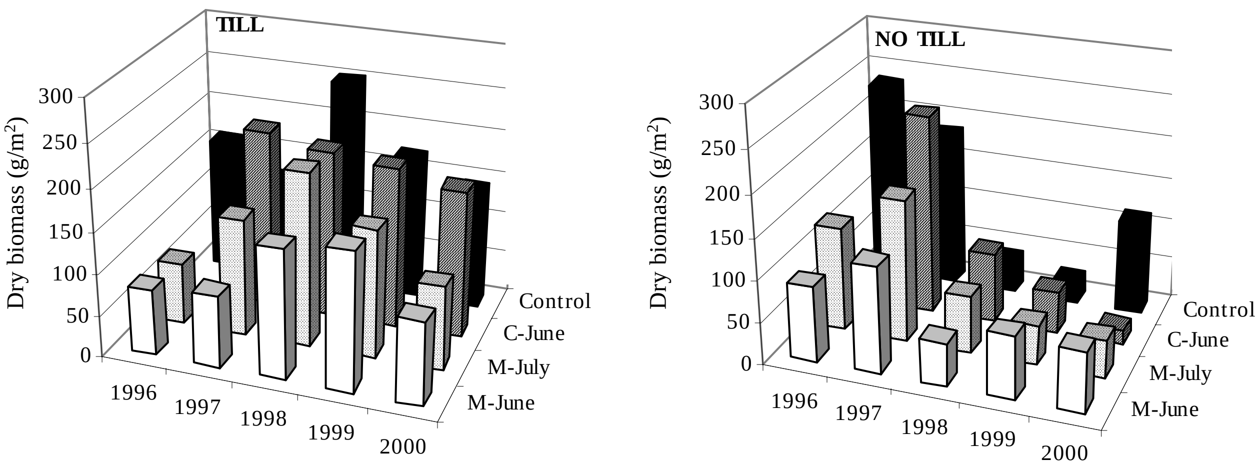


Fig. 3. The total season dry biomass of dicotyledonous perennials in plots with different treatments (see Material and Methods for explanation of abbreviations) in TILL and NO TILL in the years 1996–2000

Amoria repens (L.) C. B. Presl. on M-June, M-July and control plots was noticed.

After 5 experimental years the proportion of dicotyledonous perennials was the lowest on NO TILL superficially cultivated plots and was significantly different from all other experimental plots; the highest proportion of dicotyledonous perennials was found on TILL superficially cultivated plots (Fig. 1).

Annual monocotyledonous plants. In the 1st year the only monocotyledonous annual was *Echinochloa crus–galli* (L.) Beauv.. The proportion of monocotyledonous annuals remained low on most TILL and NO TILL plots. After 5 years of superficial cultivation in NO TILL there was a significantly increased dry biomass of monocotyledonous annuals (Fig. 4), with *Anisantha sterilis* (L.) Nevski being most frequent.

Perennial monocotyledonous plants. The largest proportion of biomass from monocotyledonous perennials was produced by *Elytrigia repens* (L.) Desv.. Its spread on all experimental plots started in the 2nd year and was more rapid in NO TILL than in TILL; it was fastest in NO TILL controls and slowest in superficially cultivated TILL plots (Fig. 5).

Changing proportion of annuals and perennials. After 5 years the total proportion of perennial weeds was high, in both TILL and NO TILL. There were no significant differences between control, M-June, M-July and M-cultivation plots in TILL with 88, 87, 79 and 80% of perennial weeds resp.. Significant differences were found in NO TILL, where perennial weeds represented 93% of the biomass on control plots, 89% on M-June, 86% on M-July, and only 39% on superficially cultivated plots.

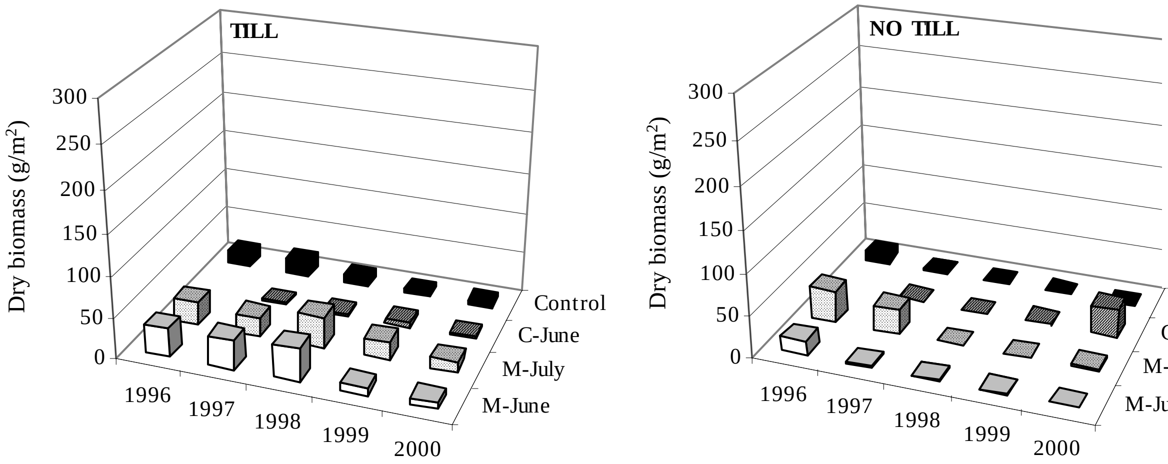


Fig. 4. The total season dry biomass of monocotyledonous annuals in plots with different treatments (see Material and Methods for explanation of abbreviations) in TILL and NO TILL in the years 1996–2000

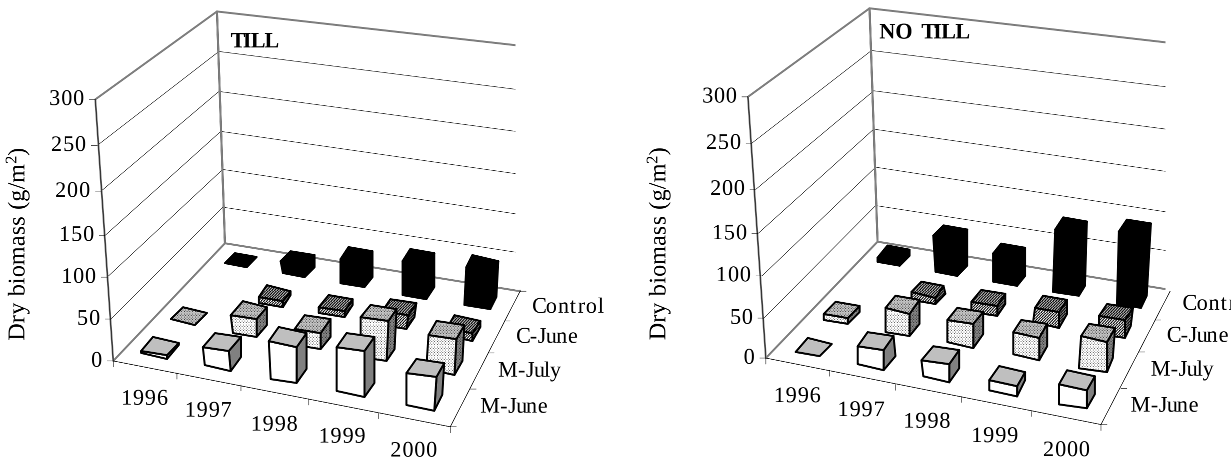


Fig. 5. The total season dry biomass of monocotyledonous perennials in plots with different treatments (see Material and Methods for explanation of abbreviations) in TILL and NO TILL in the years 1996–2000

DISCUSSION

The fluctuation of total season dry biomass production could be affected by several factors. Significantly lower biomass was produced in NO TILL than in TILL in the 3rd to 5th year. This could be caused by a different composition of weed communities (OSBORNOVÁ *et al*. 1990), but probably also because of nutrition depletion in NO TILL.

A higher rate of succession without ploughing than with ploughing was recorded. The increase of dicotyledonous perennials in the 2nd year on all plots of NO TILL was probably accelerated by the absence of ploughing. The rapid decrease in the proportion of dicotyledonous perennials following the 3rd year may be attributed to mechanical inhibition of root growth of *C. arvense* by compact soil (MOKSHIN 1978). The same effect, of compact lower soil layers, could cause the decline of *C. arvense* on cultivated plots without ploughing. Availability of bare ground after superficial cultivation probably facilitated the establishment of the annual *A. sterilis*. Coincident plots, but ploughed, were dominated by *C. arvense*. Not only ploughing itself, but also the timing of this soil disturbance could play a role in these differences in the composition of weed communities (SANS & MASALLES 1994; HEITZMANN-HOFMANN 1995; SQUIERS 1989).

Population flushes of annuals (*Matricaria maritima* in the present study) were reported also in other old-field studies (OSBORNOVÁ *et al*. 1990; GREGG 1973), but in the 1st year after disturbance. In our study the plants were probably established from seed dispersed in the previous year. The decrease of *M. maritima* in the next year was probably due to competition with *E. repens*. Similarly, the population peak of *Medicago lupulina* in 1999 could follow the decline of *C. arvense*. The transient dominance of annual dicots on control, M-June and M-July plots in the 3rd and the 4th years temporarily changed the typical increase of perennial plants during secondary succession. In spite of these transient returns of dicotyledonous annuals on NO TILL, the rapid penetration by monocotyledonous perennials and with *Elytrigia repens* being dominant, mainly on intact plots, manifests a higher rate of secondary succession than on TILL. *Elytrigia repens* was also dominant in a study of a 5–10 year succession in Czech Karst (OSBORNOVÁ *et al.* 1990). The unexpected lower proportions of dicotyledonous annuals on TILL compared to NO TILL could be attributed to competition of *C. arvense* and *T. farfara*. Neither ploughing alone nor ploughing with superficial cultivation could maintain a high proportion of annuals. By contrast, disturbing the soil supported an expansion of *C. arvense* and *T. farfara*.

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Souhrn

ŠTOLCOVÁ J. (2002): **Sekundární sukcese na raném úhoru: zmìny slo•ení vegetace a produkce biomasy**. Plant Protect. Sci., **38**: 00–00.

V letech 1996–2000 byla v Èeské republice (50°06' N, 14°15' E) studována sekundární sukcese na pokusném úhoru rozdìleném na èást s orbou a bez orby. Obì èásti byly rozdìleny na plochy 5 × 5 m s následujícími variantami: kontrolní (bez zásahu), seèení v èervnu, seèení v èervenci, pleèkování v èervnu. Uspoøádání variant bylo ka•dý rok identické. Bìhem 5 let sukcese produkce biomasy na všech variantách poklesla; v èásti bez orby více ne• v èásti s orbou. Šíøení pcháèe osetu [*Cirsium arvense* (L.) Scop.] bylo podporováno orbou a pleèkováním. Orba samotná (kontrola) stimulovala šíøení vytrvalých dvoudìlo•ných plevelù více ne• seèení v èervnu a èervenci. Pleèkování bez orby podporovalo šíøení vytrvalých dvoudìlo•ných plevelù v prvních letech; pozdìji podíl vytrvalých dvoudìlo•ných plevelù poklesl a po 5 letech na pleèkovaných plochách dominoval sveøepec sterilní [*Anisantha sterilis* (L.) Nevski]. Pýr plazivý [*Elytrigia repens* (L.) Desv.] byl v 5. roce sukcese nejvíce rozšíøen na kontrolních plochách bez orby, nejménì na pleèkovaných plochách s orbou.

Klíèová slova: úhor; orba; plevele; biomasa; jednodìlo•né rostliny; dvoudìlo•né rostliny; vytrvalé rostliny; jednoleté rostliny; sekundární sukcese

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