**Recession of *Tussilago farfara* (L.) population
from the agrocoenose as a result of cultivation abandonment.
II. The effect of fallowing on shoot morphological
properties and their biomass**

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Abstract

The paper is concerned with changes in morphological properties of *Tussilago farfara* (L.) shoots in the abandoned agrocoenose. An increase in the shading and a decrease in the available space, both caused by overgrowing of two grass species *Agropyron repens* (L.) PB. and *Dactylis glomerata* (L.), resulted in considerable changes of all analysed properties. In the first three years after cultivation had been abandoned both shoot height and leaf blade size increased, but later a decrease in both was found due to a growing intensity of interspecific competition. Mean values of other properties decreased with the fallow age. Under the conditions of strong competition the variation of *Tussilago* shoots increased while their above and belowground biomass diminished.

Key words: *Tussilago farfara*, fallowing, interspecific competition, morphological shoot variation

INTRODUCTION

The differentiation of individuals in respect of their size and habit depends on biotopic and phytocoenotic conditions. Among the agents responsible for morphological diversity of individuals interspecific competition is often crucial (Zarzycki 1965, Harper and White 1974, Werner 1976, Harper 1977).

Many studies indicate that individuals growing in the conditions of strong competition differ in their size and habit from those which do not experience the pressure of other species. A decrease in individual area and deficiency of nutrients result in the delay or even total inhibition of biomass increment, and further of development of generative organs (Falińska 1970, 1979, 1984, Abrahamson and Gadgil 1973, Symonides 1974, 1977, Weiner and Solbrig 1984).

The effect of interspecific competition on the plant growth and development is not unequivocal. It may result either in size equality or in considerable diversity of individual sizes (Symonides 1979, Baskin and Baskin 1979, Liddle et al. 1982, Weiner 1982, Andrzejewska and Falińska 1986).

Size structure of a population affects all main interpopulational processes, like mortality, fecundity (hence dynamics), and productivity, as well as determines their ecological significance for a population and a phytocoenose (Noble et al. 1979, White 1980, Mithen et al. 1984).

The work is a part of wider studies on the recession of *Tussilago* population from the agrocoenose after cultivation abandonment. In the first part it was shown that an increase in the competition from grass species resulted in a decrease of density of *Tussilago* shoots and almost eliminated the population in only four years (Namura-Ochalska 1988). The present paper attempts to answer the question whether the recession of *Tussilago* population from the fallow is accompanied by the changes in morphological properties of vegetative and generative shoots. Morphological properties of *Tussilago* shoots from the fallow were compared with respective features in the population of adjacent agrocoenose (similar soil and weather conditions).

METHODS

The field studies were conducted in 1982-1985 in the Mazury, in the neighbourhood of Nidzica on the same permanent plots where the effect of fallowing on the population dynamics was observed (Namura-Ochalska 1988). In the arable field two $2 \times 25 \text{ m}^2$ study areas were located 50 m apart, one of them was fallowed in spring 1982. Considerable increase in the density of grass species, *Agropyron repens* and *Dactylis glomerata* in the fallow resulted, already in the first year, in 100% cover of these two species and consequently increased overgrowing of the area.

The analysis of morphological differentiation of *T. farfara* shoots was conducted on the measurements of randomly selected 200 generative and 200 vegetative shoots, separately for each study area. However, in the last study year only 60 shoots were measured in the fallow due to a dramatic decrease in the population density. To obtain representative sample also shoots from the

neighbourhood of the study area had to be included. Generative shoots were measured once a year in April, vegetative — in July. Following properties were analysed: generative shoot height at full flowering, vegetative shoot height (i.e. the length of the longest leaf stalk within a node), mean leaf stalk length, width and length of a leaf blade, leaf number, leaf bud number and generative shoot number within nodes.

For each property basic statistical characteristics were calculated: mean, standard deviation and coefficient of variation. The method of interval estimation at 5% error risk was applied to determine whether the differences in mean values of properties in successive years and in compared study areas were significant. The values of the properties analysed were compared by Jentys-Szaferowa method (1959).

To determine a type and degree of the relationship between shoot height and leaf blade length, as well as between length and width of a leaf blade, correlation coefficients were calculated.

From every April to every October in the fallow, and from every May to every August in the arable field, once a month heights of randomly chosen 200 vegetative shoots per each study area were measured in order to determine seasonal changes in the height of an average individual.

Only once, in 1984 in the neighbourhood of study areas $40.25 \times 0.25 \times 0.25$ m soil monoliths were sampled from which above and belowground parts of *Tussilago farfara* were isolated. Then they were dried at 105°C for 48h, and weighed with the accuracy of 0.01 g. The data were used to establish a type and a degree of the relationship between above and belowground plant biomass.

In August 1985 aboveground biomasses of 60 vegetative coltfoot shoots in the fallow were compared to those of 200 shoots in the agrocoenose.

RESULTS

The analysis of morphological properties of vegetative and generative shoots of *T. farfara* showed that in the agrocoenose year-to-year differences in their size and habit are insignificant (Table 1). No differences were also found in the heights of generative shoots between the areas compared before fallowing. However, the cultivation abandonment caused a significant increase or decrease in values of the analysed properties already in the first fallowing year (Table 2).

The studies indicated that the leaf number, the leaf bud number and the number of generative shoots in nodes decreased with the fallow age. Mean values of other properties (the height of both shoot types, leaf stalk length, length and width of leaf blade) increased rapidly in the first year of fallowing. In successive years the rises in values of the properties discussed were smaller,

Table 1

Statistical characteristics of morphological properties

Properties	1982			1983	
	mean value	coefficient of variation (%)	confidence interval	mean value	coefficient of variation (%)
Generative shoot height	9.2 ± 2.4	25.8	9.6:8.9	10.3 ± 2.5	24.3
Vegetative shoot height	10.9 ± 3.6	32.7	11.5:10.5	10.4 ± 4.9	45.2
Leaf stalk length	8.8 ± 3.0	33.6	8.9:8.7	9.2 ± 3.5	38.1
Leaf blade length	6.8 ± 2.3	33.5	7.1:6.5	6.6 ± 2.5	38.1
Leaf blade width	7.8 ± 3.0	38.1	8.2:7.4	7.6 ± 3.2	41.7
Leaf number in a node	3.3 ± 1.3	37.9	3.5:3.1	3.3 ± 1.6	47.8
Leaf bud number in a node	2.4 ± 1.3	51.9	2.6:2.3	2.6 ± 1.6	63.1
Generative shoot number in a node	4.0 ± 2.2	55.2	4.3:3.7	4.3 ± 2.1	48.6

Table 2

Statistical characteristics of morphological properties

Properties	1982			1983	
	mean value	coefficient of variation (%)	confidence interval	mean value	coefficient of variation (%)
Generative shoot height	11.3 ± 2.5	22.4	11.9:10.9	20.5 ± 5.5	27.9
Vegetative shoot height	20.5 ± 8.9	43.2	21.7:19.3	25.5 ± 13.6	53.4
Leaf stalk length	17.2 ± 7.7	44.6	18.3:16.2	21.1 ± 10.8	51.2
Leaf blade length	9.9 ± 3.9	39.8	10.4:9.3	10.9 ± 4.6	42.1
Leaf blade width	12.0 ± 5.1	41.9	12.7:11.3	12.8 ± 5.8	45.5
Leaf number in a node	2.2 ± 0.8	36.6	2.3:2.1	2.2 ± 1.0	46.8
Leaf bud number in a node	1.3 ± 1.0	77.8	1.4:1.1	0.9 ± 0.8	83.5
Generative shoot number in a node	3.9 ± 2.4	62.3	4.0:3.8	1.9 ± 1.1	56.1

of *Tussilago farfara* shoots in the agrocoenose

confidence interval	1984			1985		
	mean value	coefficient of variation (%)	confidence interval	mean value	coefficient of variation (%)	confidence interval
10.6:9.9	9.7±2.7	27.5	10.1:9.3	10.0±2.4	24.5	10.3:8.0
11.1:9.8	11.9±5.0	42.4	12.6:11.2	12.3±5.1	41.7	12.9:11.6
9.7:8.7	9.1±3.7	40.7	9.6:8.6	10.5±4.1	39.1	11.1:8.5
6.9:6.2	8.6±3.7	43.3	9.1:8.1	7.6±3.2	42.3	8.1:7.2
8.1:7.2	10.2±4.6	45.2	10.8:8.0	8.8±3.9	44.7	9.4:8.3
3.5:3.1	3.5±1.4	40.7	3.7:3.3	3.4±1.8	52.8	3.7:3.2
2.8:2.3	2.8±1.5	53.9	3.1:2.6	2.6±1.5	55.5	2.8:2.4
4.6:2.4	3.9±2.1	54.2	4.2:3.6	4.1±2.1	52.1	4.4:3.7

of *Tussilago farfara* shoots in the fallow

confidence interval	1984			1985		
	mean value	coefficient of variation (%)	confidence interval	mean value	coefficient of variation (%)	confidence interval
21.2:19.7	22.7±5.2	22.8	23.5:22.0	19.2±9.5	49.4	22.2:17.2
27.4:23.6	23.5±9.5	40.4	24.8:22.1	13.3±11.9	88.9	16.4:10.3
22.6:19.6	18.9±7.3	38.2	20.0:17.9	11.5±9.7	84.6	14.3:8.8
11.6:10.3	10.6±4.4	41.4	11.2:10.0	5.9±3.9	65.9	6.9:4.9
13.6:12.0	12.3±5.3	42.9	12.4:12.1	6.5±4.9	76.0	7.8:5.2
2.4:2.1	2.2±1.0	45.0	2.3:2.0	1.9±1.3	64.1	2.2:1.7
1.1:0.9	0.9±0.9	96.6	1.0:0.7	0.7±0.8	126.4	0.9:0.5
2.1:1.8	1.9±0.9	45.7	2.0:1.8	1.6±1.1	66.3	1.9:1.4

but only in the fourth following year the differences in leaf stalk length between two study areas were insignificant. Moreover, length and width of leaf blade were bigger in the agrocoenose than in the fallow (Table 2).

The studies indicated that the leaf number, the leaf bud number and the number of generative shoots in nodes decreased with the fallow age. Mean values of other properties (the height of both shoot types, leaf stalk length, length and width of leaf blade) increased rapidly in the first year of fallowing. In successive years the rises in values of the properties discussed were smaller, but only in the fourth following year the differences in leaf stalk length between two study areas were insignificant. Moreover, length and width of leaf blade were bigger in the agrocoenose than in the fallow (Table 2).

The highest differences in morphological properties of shoots between study areas occurred in the second following year (Fig. 1). Then the shoots in the fallow were the highest, whereas their leaf blades the biggest. In the last study year shoots in the fallow were as high as in the agrocoenose, but they had only 1-2 leaves of considerably smaller blades.

Fig. 1. Comparison of morphological properties of *Tussilago farfara* shoots in the fallow (broken line) and in agrocoenose (vertical line) by Jentys-Szaferowa method (1959). 1 — generative shoot height, 2 — vegetative shoot height, 3 — leaf stalk length, 4 — leaf blade length, 5 — leaf blade width, 6 — leaf number in a node, 7 — leaf bud number in a node, 8 — generative shoot number in a node

Most analysed shoot properties seemed to be very plastic, indicated by almost twofold increase in the shoot height and 1.5 times increase in the size of leaf blade already in the first fallowing year (Fig. 1).

The fallowing also affected variation in both shoot heights, hence changed the size structure of shoots in the areas compared (Figs. 2 and 3). High variation of properties was characteristic of the fallow throughout the studies.

With the fallowing percentage of high generative shoots increased, while that of the lowest shoots decreased (Fig. 2a). If the shoots not higher than 12.5 cm constituted in the agrocoenose 85% of a population, in the two-year fallow it was only 18%, in the three-year fallow — 6%, whereas in the four-year fallow no shoots lower than 12.5 cm were found. In the two-year fallow shoot height ranged 4.5-32.5 cm, in the four-year fallow 12.5 to 32.5 cm, while in the agrocoenose 4.5-20.5 cm (Fig. 2b).

The height frequency distribution of vegetative shoots changed differently in successive study years. For the first three years in the fallow an increase in the percentage of the highest shoots was accompanied by a decrease in the percentage of the smallest, however in the fourth year the latter grew rapidly compared to the agrocoenose. Hence in the four-year fallow the smallest values of the property were the most frequent, almost 80% of shoots were not higher than 10.5 cm. Only a very few shoots were of mean height. Hence in the last study year in the fallow frequency distribution of vegetative shoot heights was asymmetric and positively skewed (Fig. 3a). The range of height values of vegetative shoots was twofold bigger in the fallow and oscillated between 0.5 to 50.5 cm, while in the arable field — between 0.5 and 25.5 cm. In the agrocoenose height frequency distribution of both shoot types more or less approached the normal distribution (Fig. 3b).

After the cultivation abandonment morphological properties of *T. farfara* shoots were still strongly correlated. Correlation coefficients for shoot height and leaf blade length ranged from +0.73 to +0.92 in the fallow and from +0.76 to +0.89 in the agrocoenose, while for leaf blade width and length from +0.83 to +0.96 in the fallow, and from +0.80 to +0.96 in the agrocoenose.

The studies showed that differences in the heights of vegetative coltfoot shoots between the areas studied were significant throughout the growing season, shorter for the agrocoenose (Fig. 4). Only in the fourth fallowing year seasonal changes in shoot heights in the fallow and in the agrocoenose were almost the same. Regardless of the mean value, the curves of the changes in shoot height from month to month took similar course in both study areas, a rapid rise in spring and maximum in July.

After the cultivation was abandoned both above and belowground biomass of *T. farfara* decreased (Fig. 5). A fall in the dry weight of rhizomes was much bigger than in that of leaves. In the three-year fallow, compared to agrocoenose, belowground biomass was tenfold lower, while aboveground biomass

Fig. 2. Height frequency distribution for generative shoots of *T. farfara* in the fallow (a) and in the agrocoenose (b)

Fig. 3. Height frequency distribution for vegetative shoots of *T. farfara* in the fallow (a), and in the agrocoenose (b)

Fig. 4. Changes in vegetative shoot height throughout growing season in the fallow (a) and in the agrocoenose (b)

Fig. 5. Belowground against aboveground biomass of *T. farfara* in the three-year fallow (a) and in the agrocoenose (b)

decreased five times. Both properties were positively correlated, (in the arable field $r = +0.70$, in the fallow $r = +0.86$).

In the last study year, as a result of fallow transformation the biomass of aboveground shoots was twofold smaller, while their variation also decreased compared to the agrocoenose. In 1985 almost 50% of shoots in the fallow (fivefold more than in the agrocoenose) were lighter than 0.5 g, while only 3% (fivefold less than in the agrocoenose) heavier than 3.5 g (Fig. 6).

Fig. 6. Biomass frequency distribution for *T. farfara* in the four-year fallow (a) and in the agrocoenose (b)

DISCUSSION

The studies have showed that overgrowing of the area by two grass species, *Agropyron repens* and *Dactylis glomerata*, in the course of fallowing causes significant transformation in phytocoenotic relations. An increase in the cover of these tall (more than 1 m) grasses causes still growing shading of the area, as well as reduces the space available to coltfoot population. In the consequence all analysed morphological properties have been significantly modified. Many studies indicate that the height and habit of individuals (shoots) changes with light conditions and available area (Zarzycki 1965, Symonides 1974, 1983, Harper 1977, Corré 1983a, b, Walter and Breckle 1985, Andrzejewska and Falińska 1986).

Tussilago farfara responses to light deficiency by larger leaf size (both stalk and blade) already in the first fallowing year. Myerscough and Whitehead (1967) have found similar coltfoot reaction to shading. They have showed that only at very low light intensity a decrease in leaf size and biomass occurs. It

may seem that smaller leaf size in the agrocoenose results from shorter life cycle (harvest). However, intense growth of colsfot takes place in two months before harvest hence this cannot be a cause of a smaller leaf size.

Intense leaf growth in spite of overshadowing seems to occur not only due to high substrate fertility but also to morphological properties of a plant. Fertile, loose, abandoned arable soils, extended rhizome system and large assimilation surface of leaves can, at least at the beginning, fulfil nutrient requirements of colsfot individuals. It is worth stressing that other species growing on fertile soils can response similarly to light deficit (Donald 1961, Werner 1976, Falińska 1979, Watkinson 1984). However, at the very low light intensity, caused by strong intraspecific competition, constant overshadowing may reduce leaf growth and consequently result in their precocious death (Ogden 1974).

Interspecific competition growing with fallowing caused gradual decrease in the number of leaves and leaf buds within a node. After the cultivation abandonment generative shoot height increased, but their number in a node decreased. Both phenomena indicate plastic management of available resources that depends upon the conditions of growth and development of a plant studied (Kozłowski 1986). It has to be stressed that great height of generative shoots under the conditions of luxuriant vegetation cover is an important adaptation that enables effective achene dissemination (Sheldon and Burrows 1973).

The proportion of grass species increasing from year to year, beside overshadowing of the area, intensifies competition both above (increased sodding) and below (strong development of rhizomes and grass roots) the ground. With the fallow age more and more colsfot shoots are suppressed by compact grass sod. Unfavourable environmental conditions usually affect belowground organs more strongly (Łukasiewicz 1976, Turkington and Harper 1979, Walter and Breckle 1985), which is also true for *Tussilago farfara*. In overdense *Tussilago* populations many suppressed individuals do not form rhizomes (Ogden 1974). This may explain a decrease in belowground biomass in the three-year fallow, compared to the agrocoenose. However, the growth of colsfot rhizomes is mainly restricted by the lack of available space underground occupied by grass stolons. Weak development of subterranean organs results in the biomass decrease in above-ground plant parts, hence significant positive correlation between them. It is fully understandable as colsfot rhizomes are storage organs (Hahn et al. 1979).

The studies have showed an increase in the height variation of vegetative and generative shoots of *T. farfara* under the conditions of growing competition, the phenomenon encountered, also in other species (Bazzaz and Harper 1976, Grant and Antonovics 1978, White 1980, Antonovics and Fowler 1985, Andrzejewska and Falińska 1986). It may results from the increased environment heterogeneity, i.e. the presence of sites more or less

favourable to shoot growth, which depends on the degree of grass overgrowth. It is worth mentioning that low vegetative shoots emerge in the agrocoenose throughout the growing season, while in the fallow most appear in spring. In the fallow there were only a few low generative shoots, compared to vegetative shoots because, growing in sites occupied by old vegetative shoots, they were less suppressed. As the agrocoenose creates more uniform growth conditions for *Tussilago farfara* variation of morphological properties is similar in years.

Summing-up, the studies have showed that an increase in the grass competition with the fallowing causes not only a decrease in shoot number but also changes of their morphological properties (Namura-Ochalska 1988). Hence, coltfoot exhibits plastic habit and size of assimilation organs, a property characteristic of species with wide ecological amplitude (Bakker 1960, Grime and Hunt 1975). As in many other species shoot height and leaf size are the most variable (Harper 1977, Falińska 1979, 1982, Symonides 1983, Mithen et al. 1984, Czarnecka 1985).

REFERENCES

- Abrahamson W. G., Gadgil M., 1973. Growth form and reproductive effort in Goldenrods (*Solidago*, *Compositae*). *Amer. Nat.* 107: 651-661.
- Antonovics J., Fowler N. L., 1985. Analysis of frequency and density effects on growth in mixtures of *Salvia splendens* and *Linum grandiflorum* using hexagonal fan designs. *J. Ecol.* 73: 219-234.
- Andrzejewska L., Falińska K., 1986. Struktura wielkości osobników w populacji. In: *Populacje roślin i zwierząt. Ekologiczne studium porównawcze*. Andrzejewski R., Falińska K. (eds.). PWN, Warszawa, pp. 111-133.
- Bakker S. J., 1960. A comparative life-history of *Cirsium arvense* (L.) Scop. and *Tussilago farfara* (L.) the most troublesome weeds of the newly reclaimed polders of the former Zuiderzee. In: *The biology of weeds*. Harper J. L. (ed.). Blackwell, Oxford, pp. 205-222.
- Baskin J. M., Baskin C. M., 1979. Studies on the autecology and population biology of the weedy monocarpic perennial, *Pastinaca sativa*. *J. Ecol.* 67: 601-610.
- Bazzaz F. A., Harper J. L., 1976. Relationship between plant weight and numbers in mixed populations of *Sinapis alba* (L.) Rabenh. *Lepidium sativum* L. *J. Appl. Ecol.* 13: 211-216.
- Corré W. J., 1983a. Growth and morphogenesis of sun and shade plants. I. The influence of light intensity. *Acta Bot. Neerl.* 32: 49-62.
- Corré W. J., 1983b. Growth and morphogenesis of sun and shade plants. II. The influence of light quality. *Acta Bot. Neerl.* 32: 185-202.
- Czarnecka B., 1985. Reakcja populacji *Majanthemum bifolium* (L.) F. W. Schm. na zróżnicowane warunki panujące w ekosystemach leśnych i strefach przejścia. Ph. D. Thesis, Institute of Biology UMCS, Lublin.
- Donald C. M., 1961. Competition for light in crops and pastures (Mechanisms in biological). *Symp. Soc. Exp. Biol.* 15: 282-313.
- Falińska K., 1970. Zmienność produkcji owoców borówki czernicy (*Vaccinium myrtillus* L.) na tle zróżnicowania fitosocjologicznego borów w Puszczy Białowieskiej. *Acta Soc. Bot. Pol.* 3: 395-404.

- Falińska K., 1979. Modification of plant populations in forest ecosystems and their ecotones. *Pol. Ecol. Stud.* 5: 89-150.
- Falińska K., 1982. The biology of *Mercurialis perennis* L. polycormones. *Acta Soc. Bot. Pol.* 51: 127-148.
- Falińska K., 1984. Demografia roślin. *Wiad. Bot.* 28: 105-130.
- Grant M. C., Antonovics J., 1978. Biology of ecologically marginal populations of *Anthoxanthum odoratum*. I. Phenetics and Dynamics Evolution. 32: 822-838.
- Grime J. P., Hunt R., 1975. Relative growth rate: It's range and adaptive significance in a local flora. *J. Ecol.* 63: 393-422.
- Hahn W., Wolf A., Schmidt W., 1979. Untersuchungen zum Stickstoff-Umsatz von *Tussilago farfara* — und *Agropyron repens* — Beständen. *Ökologie* 7: 369-380.
- Harper J. L., 1977. Population biology of plants. Academic Press, London.
- Harper J. L., White J., 1974. The demography of plants. *Ann. Rev. Ecol. System.* 5: 419-463.
- Jentys-Szaferowa J., 1959. Graficzna metoda porównywania kształtów roślinnych. *Nauka Pol.* 7: 79-110.
- Kozłowski J., 1986. Optymalizacja wieku dojrzewania i rozmiarów ciała zwierząt i roślin. *Rozprawy Habilitacyjne* Nr 115: 1-130 UJ, Kraków.
- Liddle M. J., Budd C. S. J., Hutchings M. J., 1982. Population dynamics and neighbourhood effects in establishing swards of *Festuca rubra*. *Oikos* 38: 52-59.
- Łukasiewicz A., 1976. Wyróżnianie przyrostów w nadziemnych i podziemnych częściach bylin. *Bad. Fizjograf. Pol. Zach.* 29, B, Poznań: 147-178.
- Mithen R., Harper J. L., Weiner J., 1984. Growth and mortality of individual plants as a function of "available area". *Oecologia (Berlin)* 62: 57-60.
- Myerscough P. J., Whitehead F. H., 1967. Comparative biology of *Tussilago farfara* L., *Chamaenerion angustifolium* (L.) Scop., *Epilobium montanum* L., and *Epilobium adenocaulon* Hausskn. II. Growth and ecology. *New. Phytol.* 66: 785-823.
- Namura-Ochalska A., 1988. Recession of *Tussilago farfara* (L.) population from the agrocoenose as a result of cultivation abandonment. I. The effect of fallowing on population dynamics. *Acta Soc. Bot. Pol.* (in press).
- Noble J. C., Bell A. D., Harper J. L., 1979. The population biology of plants with clonal growth. I. The morphology and structural demography of *Carex arenaria*. *J. Ecol.* 67: 983-1008.
- Ogden J., 1974. The reproductive strategy of higher plants. II. The reproductive strategy of *Tussilago farfara* L. *J. Ecol.* 62: 291-324.
- Sheldon J. C., Burrows F. M., 1973. The dispersal effectiveness of the achene-pappus units of selected *Compositae* in steady winds convection. *New Phytol.* 72: 665-675.
- Symonides E., 1974. Populations of *Spergula vernalis* Willd. on dunes in the Toruń Basin. *Ekol. Pol.* 25: 635-651.
- Symonides E., 1977. Mortality of seedlings in natural psammophyte populations. *Ekol. Pol.* 25: 635-651.
- Symonides E., 1979. The structure and population dynamics of psammophytes in inland dunes. III. Populations of compact psammophyte communities. *Ekol. Pol.* 27: 235-257.
- Symonides E., 1983. Population size as a result of intra-population interaction. II. Effect of density on the growth rate, morphological diversity and fecundity of *Erophila verna* (L.) C. A. M. individuals. *Ekol. Pol.* 31: 883-912.
- Turkington R., Harper J. L., 1979. The growth, distribution and neighbour relationships of *Trifolium repens* in a permanent pasture. II. Inter- and intra-specific contact. *J. Ecol.* 67: 219-230.
- Walter H., Breckle S-W., 1985. Ecological systems of the geobiosphere. I. Ecological principles in global perspective. Springer-Verlag, Berlin-Heidelberg-New York-Tokyo.

- Watkinson A. R., 1984. Yield-density relationships: the influence of resource availability on growth and self-thinning in populations of *Vulpia fasciculata*. *Ann. Bot.* 53: 469-482.
- Weiner J., 1982. A neighborhood model of annual-plant interference. *Ecology* 63: 1237-1241.
- Weiner J., Solbrig O. T., 1984. The meaning and measurement of size hierarchies in plant populations. *Oecologia (Berlin)* 61: 334-336.
- Werner P. A., 1976. Ecology of plant populations in successional environments. *Rep. Syst. Bot.* 1: 246-268.
- White J., 1980. Demographic factors in populations of plants. In: *Demography and evolution in plant populations*. Solbrig O. T. (ed.). Blackwell Scientific Publications, Oxford.
- Zarzycki K., 1965. Obecny stan badań nad konkurencją (współzawodnictwem) roślin wyższych (część II). *Ekol. Pol.* 11: 195-240.

Wycofywanie się populacji *Tussilago farfara* (L.) z agrocenozy jako wynik zaprzestania uprawy. II. Wpływ ugorowania na morfologiczne cechy i biomase pędów

Streszczenie

Praca jest częścią szerszych studiów dotyczących wycofywania się populacji *Tussilago farfara* z agrocenozy po zaprzestaniu uprawy. Wzrost konkurencji międzygatunkowej na ugorze był przyczyną, jak wykazano w pierwszej części, prawie całkowitego wycofania się populacji w ciągu zaledwie czterech lat. Celem niniejszej pracy było zbadanie, czy wycofywaniu się populacji *T. farfara* z ugoru towarzyszy zmiana morfologicznych cech pędów zarówno wegetatywnych, jak i generatywnych. Badania prowadzono w latach 1982-1985 na Mazurach w okolicach Nidzicy, na tych samych powierzchniach, na których prześledzono dynamikę liczebności pędów *T. farfara* (Namura-Ochalska w druku). Na polu uprawnym założono dwie powierzchnie, każda o wymiarach 2×25 metrów, a następnie jedną z nich przestano uprawiać. Analizę cech morfologicznych przeprowadzono na podstawie pomiarów losowo wybranych 200 pędów generatywnych i 200 wegetatywnych, oddzielnie dla każdej powierzchni.

Zbadano następujące cechy: wysokość obu rodzajów pędów, wielkość liścia, liczbę liści, liczbę pączków liściowych i liczbę pędów generatywnych w węźle krzewienia, nadziemną i podziemną biomasę *T. farfara* przypadającą na jednostkę objętości gleby oraz biomasę pędów wegetatywnych. Wyniki badań wykazały istotną zmianę wszystkich analizowanych cech pędów *T. farfara* już w pierwszym roku ugorowania. Stwierdzono po zaprzestaniu uprawy: 1) wzrost wysokości pędów i wielkości liści w ciągu trzech lat oraz gwałtowny ich spadek w ostatnim roku badań (tab. 1 i 2, rys. 1); 2) stopniowy spadek, w kolejnych latach, liczby liści, pączków liściowych oraz pędów generatywnych w węźle krzewienia (tab. 1 i 2, rys. 1); 3) większą różnorodność wysokości pędów generatywnych i wegetatywnych (rys. 2 i 3); 4) występowanie istotnych różnic w wielkości pędów przez cały sezon wegetacyjny (rys. 4); 5) zmniejszanie się nadziemnej i podziemnej biomasy, przy czym spadek masy kłaczy był zdecydowanie większy niż liści (rys. 5); 6) spadek biomasy pędu wegetatywnego (rys. 6).

Reasumując, badania wykazały, że wycofywaniu się populacji *T. farfara* wskutek wzrostu konkurencji międzygatunkowej towarzyszyła istotna zmiana morfologicznych cech pędów.