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ORIGINAL RESEARCH PAPER

Changes in weed infestations on plantations of sugar beet (*Beta vulgaris* L. subsp. *vulgaris*) cultivated on black soil near Wrocław in 1989–1995 and 2006–2012

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Abstract

Field studies were carried out in 1989–1995 and 2006–2012 on plantations of sugar beet (*Beta vulgaris* L. subsp. *vulgaris*). During this period, 542 phytosociological relevés were made using the Braun-Blanquet method. In total, 46 weed species were found. In 1989–1995, the occurrence of 36 segetal species was reported. The highest cover indices were determined for *Chenopodium album* and *Amaranthus retroflexus*. *Galium aparine*, *Echinochloa crus-galli*, and *Elymus repens* were the dominant species, as well. Analysis of the frequency of occurrence revealed one constant species (*Chenopodium album*), two frequent species (*Amaranthus retroflexus* and *Galium aparine*), and two medium-frequent species (*Echinochloa crus-galli* and *Matricaria maritima* ssp. *inodora*).

In 2006–2012, the occurrence of 40 weed species on the sugar beet plantations was recorded. The plantations were clearly dominated by *Chenopodium album*, accompanied by *Polygonum persicaria* and *Polygonum lapathifolium* ssp. *lapathifolium*. Other dominant species comprised *Setaria viridis*, *Galinsoga parviflora*, *Brassica napus* ssp. *napus*, and *Fallopia convolvulus*. The *Chenopodium album* was a constant component of the sugar beet plantations. In turn, no frequent species were observed and six medium-frequent species were found (*Setaria viridis*, *Galinsoga parviflora*, *Brassica napus* ssp. *napus*, *Echinochloa crus-galli*, *Amaranthus retroflexus*, and *Capsella bursa-pastoris*).

Noteworthy, the presence of previously unreported species, e.g., *Abutilon theophrasti*, *Hyoscyamus niger*, or *Artemisia vulgaris*, was revealed. These species are rare components in sugar beet crops. A reverse phenomenon, i.e., the disappearance of some species such as *Euphorbia helioscopia*, *Malva neglecta*, *Rumex acetosella*, *Sinapis arvensis*, or *Sisymbrium officinale*, was also observed.

Keywords

Beta vulgaris L. ssp. *vulgaris*; weeds; changes in weed infestation; communities

Introduction

The sugar beet (*Beta vulgaris* L. subsp. *vulgaris*) is highly susceptible to weed infestation, which is related to the cultivation of this species with wide row spacing and a low growth rate in the initial growth period. Over the last 30–40 years, cultivation technology and weed control of sugar beet have undergone evolution. In the 1970's and mid-1980's, multigerm seeds of sugar beets were applied and plantations were weeded mainly mechanically. Herbicides were occasionally used, usually in the form

Tab. 1 Comparison of the degree of weed infestation of the sugar beet plantations between 1989–1995 and 2006–2012 (based on 542 phytosociological relevés).

Weed species	Cover index (Wp)	
	1989–1995	2006–2012
Chenopodium album	4417 a	3449 a
Amaranthus retroflexus	1117 b	112 a
Galium aparine	649 b	166 a
Echinochloa crus-galli	321 a	141 a
Elymus repens	240 a	84 a
Polygonum persicaria	170 a	858 b
Matricaria maritima ssp. *inodora*	125 a	102 a
Brassica napus ssp. *napus*	111 a	366 a
Thlaspi arvense	103 a	138 a
Myosotis arvensis	87 a	51 a
Anthemis arvensis	78 a	58 a
Polygonum aviculare	59 a	55 a
Capsella bursa-pastoris	54 a	82 a
Melandrium album	51 a	40 a
Solanum nigrum	34 a	63 a
Aethusa cynapium	32 a	64 a
Polygonum amphibium	29	-
Stelaria media	24 a	64 a
Sinapis arvensis	22	-
Fallopia convolvulus	20 a	250 a
Polygonum lapathifolium ssp. *lapathifolium*	14 a	705 b
Viola arvensis	12 a	154 a
Sisymbrium officinale	12 a	-
Lamium purpureum	10 a	58 a
Euphorbia helioscopia	10	-
Malva neglecta	10	-
Rumex acetosella	10	-
Veronica hederifolia	9 a	35 a
Daucus carota	8 a	2 a
Galinsoga parviflora	4 a	368 b
Fumaria officinalis	4 a	19 a
Sonchus arvensis	4 a	16 a
Anagallis arvensis	4 a	5 a

of single treatments before germination of the crop plant [1]. From the mid-1980's, herbicide treatments with lower doses in very early growth stages of weeds were introduced into farming practice [2–4]. Another step in the development of beet protection was the idea of treatment with the so-called microdoses, i.e., application of appropriately selected herbicide mixtures whose components were used at 50–67% lower doses [5–8]. Obviously, besides the changes occurring over the recent years in the technology of sugar beet cultivation, changes in weed infestation of this plant have become evident [9–11]. In the 1970's and mid-1980's perennial weeds, such as *Elymus repens* or *Circium arvense*, were a considerable problem. Herbicide application resulted in a reduction in their occurrence in the next years. However, the number of annual weeds, i.e., *Amaranthus retroflexus*, *Chenopodium album*, *Echinopchloa crus-galli*, and *Galium aparine*, increased [12]. The successive changes consisted in the penetration of segetal communities by ruderal species, mainly *Aethusa cynapium*, *Descurainia sophia*, and *Artemisia vulgaris* [13,14]. As regards climate change, in the last several years thermophilic weed species such as *Hyoscyamus niger* and *Solanum nigrum* have occurred more frequently in sugar beet fields or new alien species, like *Abutilon theophrasti*, have been observed [15].

The aim of the study was to compare the rate of weed infestation of a sugar beet plantation in Lower Silesia in 1989–1995 and 2006–2012.

Material and methods

The field study was conducted in 1989–1995 and 2006–2012. The observations were carried out on large-area intensive commercial plantations of sugar beet (*Beta vulgaris* ssp. *vulgaris*) cultivated on black soils near Wrocław. Weed infestation was assessed in herbicide-untreated areas of the analyzed fields. In total, 542 phytosociological relevés were made using the Braun-Blanquet method, including 255 relevés from the first analysis period and 287 from the other period. The relevés were the basis for making a list of weed species infesting the sugar beet plantations in the analyzed periods, and phytosociological constancy (S) as well as the cover index (Wp) were determined for the observed species [16]. The nomenclature of names of weeds described in this paper was given according to *Flowering plants and pteridophytes of Poland – a checklist* [17].

The statistical analysis of the results was based on one-way analysis of variance (ANOVA). Given the high variation of the cover indices expressed in percent, these values were transformed for calculations using the following formula: $y = \text{arc sin } \sqrt{x}$, where: x – values of the cover indices expressed in percent; y – values for statistical calculations.

Tab. 1 Continued

Weed species	Cover index (Wp)	
	1989–1995	2006–2012
Cirsium arvense	2 a	73 a
Veronica persica	2 a	41 a
Descurainia sophia	2 a	17 a
Setaria viridis	-	440
Convolvulus arvensis	-	179
Setaria pumila	-	144
Avena fatua	-	79
Papaver rhoeas	-	51
Artemisia vulgaris	-	27
Hyoscyamus niger	-	23
Oxalis acetosella	-	21
Abutilon theophrasti	-	10
Geranium pusillum	-	4

Values marked with the same letter do not differ significantly between study periods.

Tab. 2 Changes in weed frequency on the sugar beet plantations between 1989–1995 and 2006–2012 (based on 542 phytosociological relevés).

Weed species	Phytosociological constancy (S)	
	1989–1995	2006–2012
Constant		
Chenopodium album	V	V
Echinochloa crus-galli	III	III
Polygonum persicaria	II	II
Myosotis arvensis	II	II
Aethusa cynapium	I	I
Anagallis arvensis	I	I
Daucus carota	I	I
Descurainia sophia	I	I
Elymus repens	I	I
Fumaria officinalis	I	I
Melandrium album	I	I
Polygonum aviculare	I	I
Sonchus arvensis	I	I

Results

The phytosociological relevés taken in 1989–1995 and 2006–2012 on the plantations of sugar beet (*Beta vulgaris* ssp. *vulgaris*) revealed 46 weed species in total. In the first period, 36 taxa were noted and 40 taxa were found in the second period (Tab. 1, Tab. 2). *Chenopodium album* was the dominant species throughout both study periods. Although the cover index for this species decreased from 4417 to 3449, the change was not statistically confirmed. Additionally, *Amaranthus retroflexus* (Wp = 1117) and *Galium aparine* (Wp = 649) were found as the dominant species on the sugar beet plantations in 1989–1995. In the second period (2006–2012), the frequency of *Amaranthus retroflexus* and *Galium* declined and their cover indices decreased to 112 and 166, respectively. The next high values of the cover index in 1989–1995 were found for *Echinochloa crus-galli* (Wp = 321) and *Elymus repens* (Wp = 240). The other assessment of their frequency revealed a slight decline in their cover indices to 141 and 84, respectively, but the significance of this change was not statistically confirmed. Another four species, *Polygonum persicaria*, *Matricaria maritima* ssp. *inodora*, *Brassica napus* ssp. *napus*, and *Thlaspi arvense*, were characterized by cover indices in the range from 103 to 170. The evaluation performed in 2006–2012 showed a statistically significant increase in the frequency of *Polygonum persicaria*, with a cover index of 858, and an increase in this parameter for *Brassica napus* ssp. *napus* (Wp = 366), which was however not confirmed statistically. The cover indices for the other 27 taxa observed in 1989–1995 were low and ranged from 2 to 87. The second evaluation of the weed infestation rate carried out in 2006–2012 revealed that the values of the cover indices significantly increased only for *Polygonum lapathifolium* ssp. *lapathifolium* and *Galinsoga parviflora* to 705 and 368, respectively. In the case of *Fallopia convolvulus* and *Viola arvensis*, an over 10-fold increase in the cover index value was recorded, but it was not confirmed statistically. Six species, i.e., *Polygonum amphibium*, *Sinapis arvensis*, *Sisymbrium officinale*, *Euphorbia helioscopia*, *Malva neglecta*, and *Rumex acetosella*, were not found during the second period of assessment. The analyses of weed infestation carried out in 2006–2012 showed the occurrence of 10 taxa that had not been noted before, i.e., *Setaria viridis*, *Convolvulus arvensis*, *Setaria pumila*, *Avena fatua*, *Papaver rhoeas*, *Artemisia vulgaris*, *Hyoscyamus niger*, *Oxalis acetosella*, *Abutilon theophrasti*, and *Geranium pusillum*. The first one was characterized by a relatively high cover index of 440. The next two, i.e., *Convolvulus arvensis* and *Setaria pumila*, reached cover index values of 179 and 144, respectively. The cover indices in the case of the other species did not differ considerably (Wp = 4–79) – see Tab. 1.

Tab. 2 Continued

Weed species	Phytosociological constancy (S)	
	1989–1995	2006–2012
Veronica hederifolia	I	I
Veronica persica	I	I
Progressive		
Brassica napus ssp. *napus*	II	III
Capsella bursa-pastoris	II	III
Galinsoga parviflora	I	III
Cirsium arvense	I	II
Fallopia convolvulus	I	II
Lamium purpureum	I	II
Polygonum lapathifolium ssp. *lapathifolium*	I	II
Solanum nigrum	I	II
Stelaria media	I	II
Viola arvensis	I	II
Setaria viridis	-	III
Artemisia vulgaris	-	II
Setaria pumila	-	II
Abutilon theophrasti	-	I
Avena fatua	-	I
Convolvulus arvensis	-	I
Geranium pusillum	-	I
Hyoscyamus niger	-	I
Oxalis acetosella	-	I
Papaver rhoeas	-	I
Disappearing		
Amaranthus retroflexus	IV	III
Galium aparine	IV	II
Matricaria maritima ssp. *inodora*	III	II
Anthemis arvensis	II	I
Thlaspi arvense	II	I
Euphorbia helioscopia	I	-
Malva neglecta	I	-
Polygonum amphibium	I	-
Rumex acetosella	I	-
Sinapis arvensis	I	-

The assessment of the changes in weed phytosociological constancy (S) occurring in 1989–1995 and 2006–2012 demonstrates that there was only one constant weed component of the sugar beet plantations (S = V), i.e., *Chenopodium album*. In 1989–1995, two species (*Amaranthus retroflexus* and *Galium aparine*) that are frequent components of agrocoenoses (S = IV) were recorded. In the next period (2006–2012), the constancy of these species was lower, i.e., III and II, respectively, and no other taxon reached such a constancy (Tab. 2, Fig. 1). The share of medium-frequent species (S = III) increased from 2 in the first study period to 6 in the other one. This was similar to the case of taxa that are infrequent components of the community (S = II), as their number increased from 6 in 1989–1995 to 13 in 2006–2012. The number of sporadic components (S = I) decreased from 25 to 20 (Fig. 1).

The analysis of the changes in weed frequency on the sugar beet plantations occurring over the study period demonstrated that 15 taxa had not changed its occurrence frequency in the examined communities. Besides the dominant *Chenopodium album*, these were *Echinochloa crus-galli*, *Polygonum persicaria*, *Myosotis arvensis*, *Aethusa cynapium*, *Anagallis arvensis*, *Daucus carota*, *Descurainia sophia*, *Elymus repens*, *Fumaria officinalis*, *Melandrium album*, *Polygonum aviculare*, *Sonchus arvensis*, *Veronica hederifolia*, and *Veronica persica* (Tab. 2). Progressive species, which increased their frequency, constituted the most numerous group. Besides the 10 species observed during the two investigation periods, such as *Brassica napus* ssp. *napus*, *Capsella bursa-pastoris*, *Galinsoga parviflora*, *Cirsium arvense*, *Fallopia convolvulus*, *Lamium purpureum*, *Polygonum lapathifolium* ssp. *lapathifolium*, *Solanum nigrum*, *Stellaria media*, and *Viola arvensis*, there were also taxa that had not been recorded earlier (Tab. 2). The group of disappearing species comprised 11 taxa, including five (*Amaranthus retroflexus*, *Galium aparine*, *Matricaria maritima* ssp. *inodora*, *Anthemis arvensis*, and *Thlaspi arvense*) that exhibited a lower frequency in the agrocoenoses and six that disappeared completely.

Discussion

A comparison of the results of the floristic analyses carried out during the study periods on the sugar beet (*Beta vulgaris* ssp. *vulgaris*) plantations demonstrated both quantitative and qualitative changes in the weed infestation rate. In general, there was a slight increase in the number of weed species from 36 to 40. As reported by Rola [18], the causes of the weed infestation increase is due to the simplification of agricultural technology, untimely weed control treatments or abandonment thereof, and

Tab. 2 Continued

Weed species	Phytosociological constancy (S)	
	1989–1995	2006–2012
Sisymbrium officinale	I	-

Phytosociological constancy (S): V – constant components; IV – frequent components; III – medium-frequent components; II – infrequent components; I – rare or sporadic components.

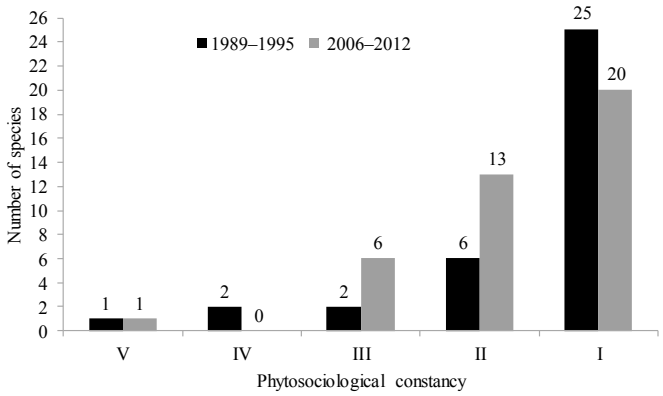

Fig. 1 Changes in the phytosociological constancy of weeds between 1989–1995 and 2006–2012.

inappropriate choice of herbicides and application techniques. This phenomenon, however, has not been confirmed in the papers of other authors who investigated weeds on sugar beet plantations in other regions of Poland and reported a tendency towards impoverishment of the species composition in plant communities [10,11]. A decrease in the number of species in communities has also been noted in Germany [19].

Increasing, continuous and long-term human intervention in agricultural fields modifies the composition and structure of plant communities, but changes occurring in them are primarily related to changes in agricultural techniques and crop protection practices [20,21]. The changes in the crop structure that have been introduced in the recent decades are an important factor, as well. On the national scale, the area of sugar beet cultivation in 2011 was lower by 52% than in 1989. This tendency was also evident in the Lower Silesia region [22,23]. This results in the abandonment of extensive cultivation practices by small-area farmers in favor of more intensive production in large-area fields [24].

The evaluation conducted in 1989–1995 in Lower Silesia revealed the highest cover indices for *Chenopodium album* and *Amaranthus retroflexus*. Moreover, *Galium aparine*, *Echinochloa crus-galli*, and *Elymus repens* were found to be the dominant species. In terms of frequency of occurrence, one constant weed species (*Chenopodium album*), two frequent species (*Amaranthus retroflexus* and *Galium aparine*), and two medium-frequent species (*Echinochloa crus-galli* and *Matricaria maritima* ssp. *inodora*) were distinguished. The observations carried out in 2006–2012 revealed some changes. *Chenopodium album* was still a dominant weed, but it was accompanied by *Polygonum persicaria* and *Polygonum lapathifolium* ssp. *lapathifolium*. The next species on the dominant species lists were *Setaria viridis*, *Galinsoga parviflora*, *Brassica napus* ssp. *napus*, and *Fallopia convolvulus*. The analysis of the frequency of the individual taxa in the sugar beet plantations indicated that *Chenopodium album* was a constant component, there were no frequent species, and six medium-frequent taxa were distinguished, i.e., *Setaria viridis*, *Galinsoga parviflora*, *Brassica napus* ssp. *napus*, *Echinochloa crus-galli*, *Amaranthus retroflexus*, and *Capsella bursa-pastoris*. These species were highly competitive and restricted the growth and development of the sugar beet. *Chenopodium album* and the majority of the aforementioned weed taxa pose a threat to beet cultivation also in other regions of the country. This has been confirmed by investigations conducted in the regions of Wielkopolska [25], Opolszczyzna [26], Mazowsze [27], Mazury [28], and Podlasie [29].

It should be emphasized that several thermophilic species were found in the analyzed communities throughout the study period. Besides the frequent components of the phytocoenoses such as *Echinochloa crus-galli* or *Amaranthus retroflexus*, there were also sporadic taxa, *Aethusa cynapium* and *Solanum nigrum*. These taxa were also found in the communities of root crops in the regions of Ziemia Łódzka [11], Podlasie [10], and Lubelszczyzna [30]. Moreover, in 2006–2012 two new species with high thermal requirements, i.e., *Hyoscyamus niger* and *Abutilon theophrasti*, were reported.

The *Abutilon theophrasti*, deserves particular attention. The first reports of its occurrence in Poland can be found in the paper by Rostafiński and Sowa [31], who cited (after other researchers) its localities in Wielopolska and Opolszczyzna as well as in the cities of Kraków, Łódź, and Siemianowice Śląskie. However, this information concerns ruderal rather than segetal habitats. In the crop fields of Lower Silesia, *Abutilon*

theophrasti was reported for the first time in 2001 [15]. Since then, the species has been expanding its occurrence range and, although currently it constitutes a rare component of phytocoenoses and reaches minimum cover indices, it can be assumed to become a noxious weed in the future, as is the case in other countries [32–37]. It should also be expected that climate change might contribute to the enrichment of the floristic lists of field plants with new thermophilic species [38].

Conclusions

- Quantitative and qualitative changes in the weed infestation rate of sugar beet (*Beta vulgaris* L. ssp. *vulgaris*) plantations between the periods of 1989–1995 and 2006–2012 have been demonstrated.
- In both study periods, *Chenopodium album* was the dominant weed species and a constant component of the sugar beet plantations.
- In 1989–1995, the dominant weed species additionally comprised *Galium aparine*, *Echinochloa crus-galli*, and *Elymus repens*. In 2006–2012, the dominant *Chenopodium album* was accompanied by *Polygonum persicaria*, *Polygonum lapathifolium* ssp. *lapathifolium*, *Setaria viridis*, *Galinsoga parviflora*, *Brassica napus* ssp. *napus*, and *Fallopia convolvulus*.
- The disappearance of some weed taxa, e.g., *Euphorbia helioscopia*, *Malva neglecta*, *Rumex acetosella*, *Sinapis arvensis*, or *Sisymbrium officinale*, was revealed. However, some species that had not been reported earlier, e.g., *Abutilon theophrasti*, *Hyoscyamus niger*, or *Artemisia vulgaris*, were recorded among the rare weed components of the sugar beet plantations.

References

1. Rola J, Rola H. Problemy zwalczania chwastów we współczesnym rolnictwie. Zeszyty Naukowe Akademii Rolniczej we Wrocławiu. Rolnictwo. 1996;290:157–165.
2. Paradowski A, Adamczewski K. Ocena wpływu zmiany technologii odchwaszczania buraka cukrowego na przestrzeni 15 lat. Biuletyn IHAR. 2002;222:271–277.
3. Rola J, Rahban BA, Marczewski K. Porównanie systemów chemicznego odchwaszczania buraków cukrowych. In: Proceedings: XXXIV Sesja Naukowa Instytutu Ochrony Roślin; 1994 Feb 10–11; Poznań, Poland. Poznań: Instytut Ochrony Roślin; 1994. p. 96–103.
4. Wilson RG. New herbicides for postemergence application in sugar beet (*Beta vulgaris*). Weed Technol. 1994;8:807–811.
5. Dexter AG. History of sugar beet (*Beta vulgaris*) herbicide rate reduction in North Dakota and Minnesota. Weed Technol. 1994;8:334–337.
6. Domaradzki K. Optymalizacja stosowania herbicydów w systemach chemicznej ochrony buraka cukrowego. Progress in Plant Protection / Postępy w Ochronie Roślin. 2007;47(3):64–73.
7. Wilson RG, Smith JA, Yonts CD. Repeated reduced rates of broadleaf herbicides in combination with methylated seed oil for postemergence weed control in sugar beet (*Beta vulgaris*). Weed Technol. 2005;19:855–860. http://dx.doi.org/10.1614/WT-04-258R1.1
8. Woźnica Z, Adamczewski K, Szeleźniak E. Stosowanie mikrodawek herbicydów w uprawie buraka cukrowego. Progress in Plant Protection / Postępy w Ochronie Roślin. 2004;44:523–530.
9. Rola H, Rola J. Pozytywne i negatywne aspekty stosowania herbicydów w uprawach rolniczych w Polsce w latach 1950–2000. Progress in Plant Protection / Postępy w Ochronie Roślin. 2001;41(1):47–57.
10. Rzymowska Z. Współczesne zmiany we florze i zbiorowiskach segetalnych Podlaskiego Przełomu Bugu. Siedlce: Wydawnictwo Uniwersytetu Przyrodniczo-Humanistycznego; 2013. (Rozprawa Naukowa; vol 124).

11. Warcholińska AU. Zmiany roślinności segetalnej Równiny Piotrkowskiej w ostatnich 22 latach. Cz. II. Zbiorowiska chwastów upraw lnu i roślin okopowych. Acta Agrobot. 1994;47(1):37–54. http://dx.doi.org/10.5586/aa.1994.002
12. Rola J, Rola H. Ekspansywne chwasty segetalne w uprawach rolniczych w Polsce. Zeszyty Naukowe Akademii Techniczno-Rolniczej w Bydgoszczy. Rolnictwo. 1996;196(38):17–22.
13. Rola J, Rola H. Przenikanie *Aethusa cynapium* L. i *Descurainia sophia* (L.) Webb do zbiorowisk segetalnych. Zeszyty Naukowe Akademii Techniczno-Rolniczej w Bydgoszczy. Rolnictwo. 1996;196(38):235–237.
14. Gołębiowska H. Effects of the penetration of *Artemisia vulgaris* L. into maize crops as a result of the use of reduced tillage. Acta Agrobot. 2014;67(2):109–116. http://dx.doi.org/10.5586/aa.2014.018
15. Domaradzki K, Snopczyński T, Jezierska-Domaradzka A. Zaślaz pospolity (*Abutilon theophrasti* Medik.), nowy groźny chwast upraw polowych – charakterystyka, występowanie i możliwości zwalczania. Progress in Plant Protection / Postępy w Ochronie Roślin. 2008;48(2):567–574.
16. Pawłowski B. Skład i budowa zbiorowisk roślinnych oraz metody ich badania. In: Szafer W, Zarzycki K, editors. Szata roślinna Polski. T. I. Warszawa: Pánstwowe Wydawnictwo Naukowe; 1972. p. 237–269.
17. Mirek Z, Mirek Z, Piękoś-Mirkowa H, Zając A, Zając M, editors. Flowering plants and pteridophytes of Poland – a checklist. Cracow: W. Szafer Institute of Botany, Polish Academy of Sciences; 2002. (Biodiversity of Poland; vol 1).
18. Rola J. Ekologiczno-ekonomiczne podstawy chemicznej walki z chwastami na polach uprawnych. In: Proceedings: XXXI Sesja Naukowa Instytutu Ochrony Roślin; 1991 Feb 7–8; Poznań, Poland. Poznań: Instytut Ochrony Roślin; 1991. p. 110–124.
19. Hurle K, Maier J, Amann A, Weishaar T, Moser B, Pulcher-Hausling N. Auswirkungen unterlassener Pflanzenschutz- und Düngungsmaßnahmen auf die Unkrautflora – Erste Ergebnisse aus einem mehrjährigen Versuchsprogramm. Zeitschrift für Pflanzenkrankheiten und Pflanzenschutz, Sonderheft. 1988;12:175–187.
20. Warcholińska AU. *Vicietum tetraspermae* w Polsce. Fragm Flor Geobot Pol. 1999;6:95–117.
21. Weber R, Hryńczuk B. Effect of long-term fallow tillage method on weed abundance in the first three years of fallow being brought into cultivation. Electronic Journal of Polish Agricultural Universities. Series Agronomy. 2004;7(2):23–37.
22. Central Statistical Office of Poland. Statistical yearbook. Warsaw: Central Statistical Office of Poland; 1990.
23. Central Statistical Office of Poland. Statistical yearbook of agriculture. Warsaw: Central Statistical Office of Poland; 2012.
24. Golinowska M. Efektywność ochrony roślin w indywidualnych gospodarstwach rolnych południowo-zachodniej Polski. Zeszyty Naukowe Akademii Rolniczej we Wrocławiu. Rolnictwo. 2002;433:1–199.
25. Latowski K, Czarna A. Florystyczne cechy zachwaszczenia wtórnego upraw buraka i ziemniaka na przykładzie wybranych regionów Zachodniej Polski. Proceedings: XXI Krajowa Konferencja Naukowa "Rejonizacja chwastów segetalnych w Polsce"; 1997 Sep 22–23; Wrocław, Poland. Puławy: Institute of Soil Science and Plant Cultivation; 1997. p. 23–35.
26. Kuźniewski E. Aktualne wtórne zachwaszczenie plantacji roślin okopowych na Dolnym Śląsku. Proceedings: XXI Krajowa Konferencja Naukowa "Rejonizacja chwastów segetalnych w Polsce"; 1997 Sep 22–23; Wrocław, Poland. Puławy: Institute of Soil Science and Plant Cultivation; 1997. p. 37–41.
27. Łęgowiak Z, Wysmułek A. Zachwaszczenie wtórne roślin ze szczególnym uwzględnieniem buraka cukrowego. Proceedings: XXI Krajowa Konferencja Naukowa "Rejonizacja chwastów segetalnych w Polsce"; 1997 Sep 22–23; Wrocław, Poland. Puławy: Institute of Soil Science and Plant Cultivation; 1997. p. 53–59.
28. Rychcik B, Tyburski J. Wpływ herbicydu i następstwa roślin na zachwaszczenie buraka cukrowego. Progress in Plant Protection / Postępy w Ochronie Roślin. 2009;49(3):1375–1378.
29. Skrzyczyńska J, Skrajna T. Zachwaszczenie upraw roślin okopowych w środkowej części Równiny Bielskiej. Proceedings: XXI Krajowa Konferencja Naukowa "Rejonizacja chwastów segetalnych w Polsce"; 1997 Sep 22–23; Wrocław, Poland. Puławy: Institute of Soil Science and Plant Cultivation; 1997. p. 61–68.
30. Trąba C, Ziemińska-Smyk M. Różnorodność florystyczna zbiorowisk chwastów

w uprawach roślin okopowych otuliny Roztoczańskiego Parku Narodowego. Pamiętnik Puławski. 2006;143:195–206.

31. Rostafiński K, Sowa R. Alfabetyczny wykaz efemerofitów Polski. Fragm Flor Geobot 1986;31–32(1–2):151–205.
32. Spencer NR. Velvetleaf, *Abutilon theoprasti* (Malvaceae), history and economic impact in the United States. Econ Bot. 1984;38(4):407–416. http://dx.doi.org/10.1007/BF02859079
33. Pyšek P, Sádlo J, Mandák B. Catalogue of alien plants of the Czech Republic. Preslia. 2002;74:97–186.
34. Jursík M, Soukup J, Holec J. Herbicide control of velvetleaf (*Abutilon theophrasti*) in sugar beet. Herbologia. 2004;5(1):13–21.
35. Doncila AI. Retrospection concerning the sugar beet protection on Fundulea Zone, District Calarasi, Romania. Zbornik Matice Srpske za Prirodne Nauke. 2006;110:141–149.
36. Kovács I, Béres I, Kazinczi G, Torma M. Competition between maize and *Abutilon theophrasti* (Medik.) in additive experiments. Z Pflanzenkr Pflanzenschutz. 2006;20:767–771.
37. Meinlschmidt E. Abutilon theophrasti MED. auf dem Ackerland in Sachsen – Ergebnisse des Monitorings aus den Jahren 2000–2004 und Handlungsempfehlungen. Z Pflanzenkr Pflanzenschutz. 2006;20:487–492.
38. Lipa JJ. Następstwa zmian klimatu dla kwarantanny i ochrony roślin. Progress in Plant Protection / Postępy w Ochronie Roślin. 2008;48(3):777–791.

Zmiany zachwaszczenia w latach 1989–1995 i 2006–2012 na plantacjach buraka cukrowego (*Beta vulgaris* L. subsp. *vulgaris*) uprawianego na czarnych ziemiach wrocławskich

Streszczenie

Badania terenowe prowadzono w latach 1989–1995 oraz 2006–2012 na plantacjach buraka cukrowego (*Beta vulgaris* L. subsp. *vulgaris*). Wykonano 542 zdjęcia fitosocjologiczne metodą Braun-Blanqueta. Zanotowano łącznie 46 gatunków chwastów. W latach 1989–1995 zaobserwowano występowanie 36 gatunków segetalnych. Najwyższe współczynniki pokrycia osiągały *Chenopodium album* i *Amaranthus retroflexus*. Ponadto wśród gatunków dominujących wyróżniono *Galium aparine*, *Echinochloa crus-galli* i *Elymus repens*. Analizując częstość występowania wyróżniono jeden gatunek stały – *Chenopodium album*, dwa taksony częste (*Amaranthus retroflexus* i *Galium aparine*) oraz dwa średnio częste (*Echinochloa crus-galli* i *Matricaria maritima* ssp. *inodora*).

Obserwacje wykonane w latach 2006–2012 wykazały występowanie na plantacjach buraka 40 gatunków chwastów. Spośród nich zdecydowanie dominowało *Chenopodium album*, któremu towarzyszyły *Polygonum persicaria* i *Polygonum lapathifolium* ssp. *lapathifolium*. Na kolejnych miejscach listy gatunków dominujących znalazły się *Setaria viridis*, *Galinsoga parviflora*, *Brassica napus* ssp. *napus* i *Fallopia convolvulus*. Analizując agrofitocenozy buraka cukrowego pod względem częstości występowania poszczególnych taksonów chwastów, można stwierdzić, że składnikiem stałym było *Chenopodium album*, natomiast nie obserwowano gatunków częstych, zaś wśród elementów średnio częstych wyróżniono sześć taksonów (*Setaria viridis*, *Galinsoga parviflora*, *Brassica napus* ssp. *napus*, *Echinochloa crus-galli*, *Amaranthus retroflexus* i *Capsella bursa-pastoris*).

Na uwagę zasługuje fakt, że w agrofitocenozach buraka cukrowego wśród składników rzadkich zaczęły pojawiać się nowe, wcześniej nie obserwowane gatunki, jak *Abutilon theophrasti*, *Hyoscyamus niger* czy *Artemisia vulgaris*. Obserwowano również zjawisko odwrotne, ustępowanie niektórych taksonów, takich jak *Euphorbia helioscopia*, *Malva neglecta*, *Rumex acetosella*, *Sinapis arvensis* czy *Sisymbrium officinale*.