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SYNANTHROPIC FLORA OF STRAWBERRY PLANTATIONS AND THEIR SURROUNDINGS

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Summary

Research on synanthropic flora was conducted on the strawberry plantations in Central Poland (surroundings of Skierniewice). In 2007-2010, 104 phytosociological releves were taken on plantations – in herbicide fallow, tillage places, and mulched places. The same number of releves was taken in surroundings of plantations – trodden and rutty places and roadsides. In the plantations examined, the occurrence of 127 species belonging to 30 botanical families was noted, out of which *Asteraceae* (17%), *Poaceae* (15%), *Brassicacea* (11%), *Fabaceae* (9%) and *Polygonaceae* (8%) were represented most numerously. 61% of species found in the plantations occurred occasionally or rarely. 21%, among others *Equisetum arvense*, *Polygonum aviculare*, *Chenopodium album*, *Amaranthus retroflexus*, *Stellaria media*, *Capsella bursa-pastoris*, *Geranium pusillum*, *Convolvulus arvensis*, *Viola arvensis*, *Galinsoga parviflora*, *Cirsium arvense*, *Taraxacum officinale*, *Poa annua*, *Echinochloa crus-galli*, occurred frequently or very frequently in the herbicide fallow and tillage places. They were recognised as the most significant strawberry weeds. The most numerous group in the plantations constituted of therophytes (64%), which predominated over hemicryptophytes (20%) and geophytes (11%). Apophytes – native species (48%) predominated over archeophytes (39%) and kenophytes (9%). Within the vascular flora of the plantations examined, segetal species (43%), ruderal species (20%) and meadow species (14%) were predominant. Among the 48 species noted in the plantation surroundings therophytes (48%) predominated over hemicryptophytes (35%) and geophytes (13%). In trodden and rutty places and roadsides, apophytes (60%) predominated over archeophytes (25%) and kenophytes (15%). Ruderal species (50%) were more numerous than meadow species (15%) and segetal species (8%).

key words: synanthropic plants, weeds, strawberries, Poland

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INTRODUCTION

The research aimed to assess the diversity of synanthropic flora of commercial strawberry plantations and their near surroundings in Central Poland. Identification of synanthropic plants which cause economic losses is essential for creating strategy and programme of weed control. Technology of cultivation of strawberry, including protection against weeds and the soil management, is varied depending on the future use of fruits, economic profitability and environmental factors. In Polish conditions, the plantations are usually used for 2-4 seasons. On the plantation of strawberry used for processing the treatment relies mainly on mechanical cultivation of soil and application of herbicides. Plantations of table strawberries are treated in similar way, with the addition of soil mulching with grain straw. Other methods of protection against weeds, like soil mulching with black plastic, poliacrylic and poliprophylene films, wood bark and sawdust, use of cover crops or soil fumigation (Pritts & Kelly 2001; Kęsik & Maskalaniec 2004, Fennimore *et al*. 2010) are seldom practised. Soil solarization in Poland has no practical use due to cool climatic conditions, as opposed to Mediterranean countries or California (Boz 2004; Fennimore *et al*. 2010). Species composition of flora which consists predominantly of weeds, is most frequently presented together with results concerning means of weed control (Kahu 2003; Boz 2003). On strawberry plantations in European countries, Turkey and the USA, segetal and ruderal weeds are common (Boz *et al.* 2002; Kęsik & Maskalaniec 2004; Hanson & Zandstra 2011; Fennimore *et al*. 2010). Many of the strawberry weed species grow also in orchards and arable fields (Tymrakiewicz 1976; Mowszowicz 1984; Wróbel 1999; Lipecki 2004; Skrajna & Kubicka 2011; Lisek 2012). Aiming for a better characterization of the flora under examination, authors of phytosociological works give indexes of synanthropization, modrenization and lability of the flora (Kornaś 1977; Kryszak 2004; Balcerkiewicz & Pawlak 2010, Paszkiewicz-Jasińska & Żyszkowska 2011; Piżuch *et al*. 2011; Reczyńska 2011).

MATERIALS AND METHODS

Field research was conducted in Central Poland near Skierniewice (Skierniewice - Pomological Orchard, Dąbrowice, Rowiska, Miedniewice, Sierakowice, Mokra, Lisowola, Trzcianna). 104 phytosociological releves according to the Braun-Blanquet method (1964), taken on plantations – in herbicide fallows, tillage places, and mulched places, in the years 2007-2010, were analysed. The same number of releves was taken in surroundings of plantations – trodden and rutty places and roadsides. Surface of releves taken on plantations amounted to 100 m^2, and the surface of releves taken in the surroundings of plantations came to 50 m^2. One half of the releves testifying to species composition of flora in primary weed infestation was taken in April and May. The other half of the releves, taken from June to

September, testified to secondary weed infestation. Plantations were most often located on flat area and pseudopodsolic soil graded Class IV, rarely III, slightly acidic (pH 4.8-6.9). Soil from three selected sites (Dąbrowice, Rowiska, Miedniewice), was characterised by the following mechanical composition: sand: 69-84%; silt: 12-35%; clay: 1-6% and contained 1.5-2.0% of organic matter. Commercial plantations producing strawberries for processing and a few nursery plantations served as the place of research. Soil on newly established, nursery and bearing plantations at the age of 1-4 years was cultivated in the inter-rows with the use of inter-row cultivators and soil millers while the rows were manually weeded or sprayed with herbicides (lenacil, pendimethalin, metamitron, napropamide, chlopyralid, glufosinate ammonium, quizalofop). On some plantations cultivation was combined with the use of herbicides. On plantations of table strawberries the soil was mulched with straw from the second half of May till July. Plants growing in the surroundings of plantations were reaped or sprayed with herbicides. Names of taxa were given after Mirek *et al*. (2002) as amended. Taxa were analysed according to the following criteria.

Frequency of occurrence in the investigated area: 1 - occasionally (≤5% of sites); 2 - rarely (5.1 - 10% of sites); 3 - average (10.1 - 30% of sites); 4 - often (30.1 - 50% of sites); 5 - very often (>50.1% of sites).

Life form according to Raunkiaer (Rutkowski 2007):

- perennials: G-geophyte; H-hemicryptophyte;
- short-lived: T1 - annual therophyte; T2 - biennal therophyte.

Geographical-historical classification according to Kornaś (1981), Zając and Zając (1992): Ap. - apophyte; Arch. - archeophyte; Ken. - kenophyte; Erg. - ergasiophyte.

Socio-ecological groups according Ellenberg *et al*. (1992): DW - decideuous woodland species; CD - coniferous woodland species; SE - shrub edges species; M - meadow species; SS - sandy sward species; XS - xerothermic sward species; RD - ruderal species; SG - segetal species; SW - swamp species; N - other classification.

Sites of occurrence in investigated plantations: TP - tillage places; HF - herbicide fallow; MP - mulched places.

Sites of occurrence in investigated plantations surroundings: TR - trodden and rutty places; RS - roadsides.

Proportion in weed infestation and weed cover was presented for selected species.

Index of flora synanthropization (S_1) was calculated according to the formula:

$S_1 = (Ap + A) / C \cdot 100\%$, according to Wysocki and Sikorski (2002), where

Ap - number of apophytes

A - number of antropophytes (archeophytes, kenophytes, ergasiophytes)

C - total number of species in releves

Index of flora modernization (M), according to Kornaś (1977):

M = Ken / Arch, where

Ken - number of kenophytes;

Arch - number of archeophytes;

Index of the degree of flora lability (I), according to Kornaś (1977):

I = Efem + Ergas;

Efem - number of efemerophytes;
Ergas - number of ergasiophytes.

RESULTS

STRAWBERRY PLANTATIONS

Frequency of occurrence of vascular plants. From among 127 vascular plants, 77 species (61%) occurred occasionally or rarely, including *Urtica dioica*, *Chenopodium polyspermum*, *Melandrium album*, *Fumaria officinalis*, *Malva neglecta*, *Epilobium adenocaulon* (Table 1). Plants of 27 species (21% of the total number), eg. *Equisetum arvense*, *Polygonum aviculare*, *Chenopodium album*, *Amaranthus retroflexus*, *Stellaria media*, *Capsella bursa-pastoris*, *Geranium pusillum*, *Convolvulus arvensis*, *Viola arvensis*, *Galinsoga parviflora*, *Cirsium arvense*, *Taraxacum officinale*, *Poa annua*, *Echinochloa crus-galli*, occurred frequently or very frequently.

Species affiliation with botanical families. Plants growing in the examined plantations belonged to 30 botanical families. Most numerously represented were: *Asteraceae* - 22 species (17%), *Poaceae* - 19 species (15%), *Brassicacea* - 14 species (11%), *Fabaceae* - 10 species (8%), and *Polygonaceae* - 10 species (8%). Number of species belonging to other families was as follows: *Amaranthaceae* (1), *Apiaceae* (1), *Boraginaceae* (4), *Caryophyllaceae* (7), *Chenopodiaceae* (4), *Clusiaceae* (*Hypericaceae*) (1), *Convolvulaceae* (1), *Equisetaceae* (1); *Euphorbiaceae* (2), *Fumariaceae* (1), *Geraniaceae* (3), *Lamiaceae* (5), *Malvaceae* (1), *Onagraceae* (1), *Oxalidaceae* (1), *Papaveraceae* (3), *Plantaginaceae* (2), *Primulaceae* (1), *Ranunculaceae* (1), *Rosaceae* (2), *Rubiaceae* (1), *Scrophulariaceae* (3), *Solanaceae* (1), *Urticaceae* (2); *Violaceae* (2).

Participation of Raunkiaer's life forms. 81 species (64% of the total number of plants collected) constituted therophytes (T), i.e. short-lived forms, above all annuals. 26 species (20%) were classified as hemicryptophytes (H), and 14 species (11%) as geophytes (G). 4 species (3%): *Cerastium holosteoides*, *Spergularia rubra*, *Malva neglecta*, *Matricaria maritima* constituted both short lived forms and long lived forms. 2 species of perennials - *Oxalis stricta* and *Solidago canadensis* were classified as geophyte/hemicryptophyte.

Geographical-historical classification. Flora of evaluated plantations consisted mostly of apo-phytes (native plants), of which 61 species were collected (48%). Noted was also the occurrence of 50 species of archeophytes (39% of all species), 12 kenophytes (9%) and 4 ergasio-phytes.

Socio-elogical classification. Species typically segetal, in the number of 54 (43%) predominated in the flora of the examined plantations. Substantial was also the share of typically ruderal species - 26 (20%), meadow species - 18 (14%), sandy and xerothermic sward species - 4 (3%). Species typical of other socio-ecological groups were not numerous.

Participation of species in weed infestation and weed cover. 15 species' proportion of weed infestation and weed cover was higher than 25%

in at least one releve (Table 2). Proportion in weed infestation and weed cover of other species was lower than 25% in all releves. Cover during the assessment amounted from 10 to 100%. For 45 releves total weed cover was higher than 80%.

Preferences of site. Occurrence of weeds at the particular sites of the plantation was presented in Table 1.

Index of synathropization. Only synanthropic species occurred in the plantations and S_1 came to 100%.

Index of modernization M = 0,24.

Index of lability I = 4.

Table 1. Synanthropic plants on strawberry plantations in central Poland, Skierniewice, 2007-2010

No.	Species	Frequency	Life form	Geographical-historical class.	Socio-ecological class.	Sites
1.	*Achillea millefolium* L.	3	G	Ap.	M	MP, HF, TP
2.	*Agropyron repens* L.	4	G	Ap.	RD	HF, TP, MP
3.	*Agrostis capillaris* L.	2	H	Ap.	SS, XS	MP, HF, TP
4.	*Agrostis gigantea* Roth	1	G	Ap.	M	MP, HF, TP
5.	*Amaranthus retroflexus* L	4	T1	Ken.	SG	HF, TP
6.	*Anagalis arvensis* L.	1	T1	Arch.	SG	TP, HF
7.	*Anchusa arvensis* (L.) M. Bieb.	1	T1	Arch.	SG, SS	TP, HF
8.	*Anthemis arvensis* L.	3	T1	Arch.	SG	HF, TP
9.	*Apera spica-venti* (L.) P. Beauv.	2	T1	Arch.	SG	TP, HF
10.	*Arabidopsis thaliana* (L.) Heynh.	1	T1	Arch.	SG	HF, TP
11.	*Arenaria serpyllifolia* L.	3	T1	Ap.	SS	TP, HF
12.	*Armoracia rusticana* G., M. et Sch.	1	H	Arch.	RD	HF
13.	*Artemisia vulgaris* L.	3	H	Ap.	RD	HF, TP, MP
14.	*Atriplex patula* L.	1	T1	Ap.	SG	TP, HF
15.	*Bromus hordeaceus* L.	3	T2	Ap.	RD	HF, TP
16.	*Bromus inermis* Leyss.	1	G	Ap.	RD	MP, HF, TP
17.	*Bromus sterilis* L.	1	T2	Arch.	SE	HF, TP
18.	*Capsella bursa-pastoris* (L.) Med.	5	T1	Arch.	SG, RD	TP, HF
19.	*Centaurea cyanus* L.	1	T1	Arch.	SG	MP, TP, HF
20.	*Cerastium arvense* L.	3	H	Ap.	M	HF, TP
21.	*Cerastium holosteoides* Fr. em. Hyl.	2	T2, H	Ap.	M	HF, TP
22.	*Chaenorhinum minus* (L.) Lange	1	T1	Ap.	SG	HF, TP
23.	*Chamomilla recutita* L. Rauschert	3	T1	Arch.	SG	TP, HF
24.	*Chamomilla suaveolens* (Pursh) Rydb. (*Matricaria discoidea* DC.)	4	T1	Ken.	RD	HF, TP
25.	*Chenopodium album* L.	5	T1	Ap.	SG	TP, HF
26.	*Chenopodium polyspermum* L.	1	T1	Ap.	SG	TP, HF
27.	*Chenopodium rubrum* L.	1	T1	Ap.	RD	TP, HF
28.	*Cirsium arvense* (L.) Scop.	4	G	Ap.	RD	HF, MP, TP
29.	*Convolvulus arvensis* L.	4	G	Ap.	RD	MP, HF, TP
30.	*Conyza canadensis* (L.) Cronq.	3	T1-T2	Ken.	RD	HF, TP
31.	*Dactylis glomerata* L.	1	H	Ap.	M	HF, TP
32.	*Daucus carota* L.	2	T2	Ap.	M	HF, TP
33.	*Descurainia sophia* (L.) Webb ex Prantl	1	T1-T2	Arch.	RD	HF, TP

34.	*Digitaria sanguinalis* (L.) Scop.	3	T1	Arch.	SG	HF, TP
35.	*Echinochloa crus-galli* (L.) P. Beauv.	5	T1	Arch.	SG	HF, TP
36.	*Epilobium adenocaulon* Hausskn.	1	H	Ken.	RD, SW	HF, TP
37.	*Equisetum arvense* L.	5	G	Ap.	SG	HF, MP, TP
38.	*Erodium cicutarium* (L.) L'Hér.	3	T1	Ap.	XS, SG	HF, TP
39.	*Erophila verna* (L.) Chevall.	1	T1	Ap.	SS	HF
40.	*Erysimum cheiranthoides* L.	1	T1-T2	Ap.	SG	TP, HF
41.	*Euphorbia helioscopia* L.	2	T1	Arch.	SG	TP, HF
42.	*Euphorbia peplus* L.	1	T1	Arch.	SG	TP, HF
43.	*Fallopia convolvulus* (L.) A. Löve	4	T1	Arch.	SG	HF, TP
44.	*Fumaria officinalis* L.	1	T1	Arch.	SG	HF, TP
45.	*Galeopsis tetrahit* L.	2	T1	Ap.	DW, CW	TP, HF
46.	*Galinsoga ciliata* (Raf.) S.F. Blake	3	T1	Ken.	SG	TP, HF
47.	*Galinsoga parviflora* Cav.	5	T1	Ken.	SG	TP, HF
48.	*Galium aparine* L.	3	T1	Ap.	SE	HF, TP
49.	*Geranium dissectum* L.	1	T1	Arch.	SG	TP, HF
50.	*Geranium pusillum* Burm. F. ex L.	5	T1	Arch.	SG	HF, TP
51.	*Gnaphalium uliginosum* L.	1	T1	Ap.	M, SW	TP, HF
52.	*Hypericum perforatum* L.	1	H	Ap.	DW	HF
53.	*Lactuca serriola* L.	1	T2	Arch.	RD	HF, TP
54.	*Lamium amplexicaule* L.	4	T1	Arch.	SG	TP, HF
55.	*Lamium purpureum* L.	4	T1	Arch.	SG	HF, TP
56.	*Lithospermum arvense* L.	1	T1	Arch.	SS, RD	HF
57.	*Lolium multiflorum* Lam.	1	H	Ken.	RD	HF, TP
58.	*Lolium perenne* L.	1	H	Ap.	M, RD	HF, TP
59.	*Malva neglecta* L.	2	T2-H	Arch.	RD	HF, TP
60.	*Matricaria maritima* L. ssp. *inodora* (L.) (*Matricaria perforata* Mérat)	4	T1-2,H	Arch.	SG	HF, TP, MP
61.	*Medicago lupulina* L.	1	T1-T2	Ap.	XS, M	HF, TP
62.	*Melandrium album* (Mill.) Garcke (*Silene alba* (Mill.) E.H.L Krause)	1	H	Ap.	RD	HF
63.	*Mentha arvensis* L.	1	G	Ap.	M, SW	HF, TP, MP
64.	*Myosostis arvensis* (L.) Hill	3	T1	Arch.	SG	HF, TP
65.	*Myosostis stricta* Link ex Roem. et Schult.	2	T1	Arch.	SG	TP, HF
66.	*Neslia paniculata* (L.) Desv.	1	T1	Arch.	SG	TP, HF
67.	*Oxalis stricta* L.	1	H, G	Ken.	SG, RD	HF
68.	*Papaver argemone* L.	1	T1	Arch.	SG	TP, HF
69.	*Papaver dubium* L.	1	T1	Arch.	SG	TP, HF
70.	*Papaver rhoeas* L.	2	T1	Arch.	SG	TP, HF
71.	*Plantago lanceolata* L.	1	H	Ap.	M	HF, TP
72.	*Plantago major* L.	2	H	Ap.	RD	HF, TP
73.	*Poa annua* L.	5	T1	Ap.	M, RD	HF, TP
74.	*Poa pratensis* L.	1	H	Ap.	M	HF, TP
75.	*Polygonum amphibium* L. var. *terrestre*	1	G	Ap.	SW	HF, TP, MP
76.	*Polygonum aviculare* L.	5	T1	Ap.	RD	HF, TP
77.	*Polygonum lapathifolium* L. ssp. *lapathifolium*	1	T1	Ap.	SW	TP, HF
78.	*Polygonum lapathifolium* L. ssp. *pallidum* (With.) Fr.	1	T1	Ap.	SG	TP, HF
79.	*Polygonum persicaria* L.	4	T1	Ap.	SG	TP, HF
80.	*Potentilla anserine* L.	3	H	Ap.	M	HF, TP

81.	*Potentilla reptans* L.	3	H	Ap.	M	HF, TP
82.	*Ranunculus repens* L.	3	H	Ap.	M	HF, TP
83.	*Raphanus raphanistrum* L.	4	T1	Arch.	SG	TP, HF
84.	*Rorippa sylvestris* (L.) Besser	4	H	Ap.	RD	HF, TP
85.	*Rumex acetosa* L.	1	H	Ap.	M	HF
86.	*Rumex acetosella* L.	4	G	Ap.	SS, CW	HF, MP, TP
87.	*Rumex crispus* L.	2	H	Ap.	RD	HF, TP, MP
88.	*Rumex obtusifolius* L.	1	H	Ap.	RD	HF, TP, MP
89.	*Secale cereale* L.	2	T1-T2	Erg.	-	MP, TP, HF
90.	*Senecio vulgaris* L.	5	T1	Arch.	SG	HF, TP
91.	*Setaria pumila* (Poir.) Roem et Schult.	4	T1	Arch.	SG	HF, TP
92.	*Setaria viridis* (L.) P. Beauv.	2	T1	Arch.	SG	HF, TP
93.	*Sinapis alba* L.	1	T1	Erg.	-	TP, HF
94.	*Sinapis arvensis* L.	1	T1	Arch.	SG	TP, HF
95.	*Sisymbrium loeselii* L.	1	T1-T2	Ken.	RD	HF, TP
96.	*Sisymbrium officinale* (L.) Scop.	1	T1	Arch.	RD	HF, TP
97.	*Solanum nigrum* L. em. Mill.	1	T1	Arch.	SG	HF, TP
98.	*Solidago canadensis* L.	1	G, H	Ken.	RD	MP, HF, TP
99.	*Solidago gigantea* Aiton	1	G	Ken.	RD	MP, HF, TP
100.	*Sonchus arvensis* L.	2	H	Ap.	SG	HF, TP
101.	*Sonchus asper* (L.) Hill	2	T1	Arch.	SG	TP, HF
102.	*Sonchus oleraceus* L.	3	T1	Arch.	SG	TP, HF
103.	*Spergula arvensis* L.	1	T1	Arch.	SG	TP, HF
104.	*Spergularia rubra* (L.) J. Pres et C. Presl.	2	T1-2, H	Arch.	SG	TP, HF
105.	*Stachys palustris* L.	1	G	Ap.	SW	HF, TP, MP
106.	*Stellaria media* (L.) Vill.	5	T1	Ap.	SG	TP, HF
107.	*Tanacetum vulgare* L.	1	H	Ap.	RD	HF
108.	*Taraxacum officinale* F. H. Wigg.	4	H	Ap.	M	HF, MP, TP
109.	*Thlaspi arvense* L.	4	T1	Arch.	SG	TP, HF
110.	*Trifolium arvense* L.	1	T1-T2	Ap.	SS	HF
111.	*Trifolium dubium* Sibth.	1	T1	Ap.	M	HF
112.	*Trifolium pratense* L.	1	H	Ap.	M	HF, TP
113.	*Trifolium repens* L.	2	H	Ap.	M	HF, TP
114.	*Triticosecale* Wittm. Ex A. Camus	2	T1-T2	Erg.	-	MP, TP, HF
115.	*Triticum vulgare* Vill.	1	T1-T2	Erg.	-	MP, TP, HF
116.	*Tusillago farfara* L.	1	G	Ap.	RD	MP, HF, TP
117.	*Urtica dioica* L.	1	H	Ap.	RD, SE	HF, MP
118.	*Urtica urens* L.	3	T1	Arch.	SG	HF, TP
119.	*Veronica arvensis* L.	3	T1	Arch.	Ap.	TP, HF
120.	*Veronica persica* Poir.	3	T1	Ken.	SG	HF, TP
121.	*Vicia angustifolia* Scop.	3	T1	Arch.	SG	TP, HF
122.	*Vicia cracca* L.	2	G	Ap.	M	HF, MP, TP
123.	*Vicia hirsuta* (L.) S.F. Gray	3	T1	Arch.	M	TP, HF
124.	*Vicia tetrasperma* (L.) Schreb.	1	T1	Arch.	SG	TP, HF
125.	*Vicia villosa* Roth.	3	T1	Arch.	SG	TP, HF
126.	*Viola arvensis* Murray	4	T1	Arch.	SG	HF, TP
127.	*Viola tricolor* L.	1	T1	Ap.	N	HF, TP

Explanation
Frequency of occurrence: 1 - occasionally; 2 - rarely; 3 - average; 4 - often; 5 - very often.
Life form according to Raunkiaer:
- perennials: G – geophyte; H – hemicryptophyte;

- short-lived: T1 – annual therophyte; T2 – biennal therophyte.

Geographical-historical classification: Ap. - apophyte; Arch. - archeophyte; Ken. - kenophyte; Erg. - ergasiophyte.

Socio-elogical classification: DW - decideuous woodland species; CD - coniferous woodland species; SE - shrub edges species; M - meadow species; SS - sandy sward species; XS - xerothermic sward species; RD - ruderal species; SG - segetal species; SW - swamp species; N - other classification.

Sites of occurrence in investigated plantations: TP - tillage places; HF - herbicide fallow; MP - mulched places.

Table 2. Participation of selected species in weed infestation and cover of strawberry plantations, Skierniewice, 2007-2010

Species	Participation of weed infestation			Weed cover		
	25-50%	50-75%	>75%	25-50%	50-75%	>75%
	Number of releves					
Agropyron repens	2	2	0	1	1	0
Capsella bursa-pastoris	2	2	0	1	1	0
Cirsium arvense	1	0	0	0	1	0
Chenopodium album	3	2	1	3	1	1
Convolvulus arvensis	1	0	0	1	0	0
Echinochloa crus-galli	6	4	2	3	1	1
Equisetum arvense	2	2	2	2	1	1
Galinsoga parviflora	4	3	2	3	2	1
Geranium pusillum	1	0	0	1	0	0
Poa annua	5	3	0	2	1	0
Rorippa sylvestris	1	0	0	0	1	0
Senecio vulgaris	1	0	0	1	0	0
Setaria pumila	4	1	0	1	0	0
Stellaria media	4	1	1	3	0	0
Viola arvensis	2	1	0	1	0	0

SURROUNDINGS OF STRAWBERRY PLANTATIONS

Frequency of occurrence of vascular plants. From among 48 vascular plants, 33 species (69%) occurred occasionally or rarely (Table 3). Plants of 7 species (15% of the total number), eg. *Chamomilla suaveolens*, *Polygonum aviculare*, *Poa annua*, occurred frequently or very frequently (Table 2).

Species affiliation with botanical families. Plants growing in the examined plantations surroundings belonged to 13 botanical families. Most numerously represented were: *Asteraceae* - 10 species (21%), *Poaceae* - 8 species (17%), *Brassicacea* - 8 species (17%), *Fabaceae* - 6 species (13%). Number of species belonging to other families was as follows: *Boraginaceae* (3), *Caryophyllaceae* (2), *Convolvulaceae* (1), *Geraniaceae* (1), *Oxalidaceae* (1), *Plantaginaceae* (2), *Polygonaceae* (4), *Rosaceae* (1), *Scrophulariaceae* (1).

Participation of Raunkiaer's life forms. 23 species (48% of the total

number of plants collected) constituted therophytes (T), i.e. short-lived forms, above all annuals. 17 species (35%) were classified as hemicryptophytes (H), and 12 species (13%) as geophytes (G). 2 species of perennials - *Oxalis stricta* and *Solidago canadensis* were classified as geophyte/ hemicryptophyte.

Geographical-historical classification. Occurrence of 29 species of apophytes (60% of all species), 12 species of archeophytes (25%), 7 kenophytes (15%) was noted in the surroundings of plantations.

Socio-elogical classification. The 24 typically ruderal species (50%) predominated over meadow species - 7 (15%), and typically segetal species - 4 (8%) - in the flora of the examined plantations surroundings.

Preferences of site. Occurrence of synanthropic plants was presented in Table 3. Trodden and rutty places belonged to sites occupied by the most limited number of species.

Index of synathropization S_1 = 100%.
Index of modernization M = 0,58.
Index of lability I = 0.

Table 3. Synanthropic plants on strawberry plantations surrounding, Skierniewice, 2007-2010

No.	Species	Frequency	Life form	Geographical-historical class.	Socio-ecological class.	Sites
1.	*Achillea millefolium* L.	4	G	Ap.	M	RS
2.	*Anchusa arvensis* (L.) M. Bieb.	1	T1	Arch.	SG, SS	RS
3.	*Arabidopsis thaliana* (L.) Heynh.	1	T1	Arch.	SG	RS
4.	*Arenaria serpyllifolia* L.	3	T1	Ap.	SS	RS
5.	*Armoracia rusticana* G., M. et Sch.	2	H	Arch.	RD	RS
6.	*Bromus hordeaceus* L.	3	T2	Ap.	RD	RS
7.	*Bromus inermis* Leyss.	1	G	Ap.	RD	RS
8.	*Bromus sterilis* L.	1	T2	Arch.	SE	RS
9.	*Chamomilla recutita* L. Rauschert	3	T1	Arch.	SG	RS
10.	*Chamomilla suaveolens* (Pursh) Rydb. (*Matricaria discoidea* DC.)	5	T1	Ken.	RD	TR, RS
11.	*Cichorium intybus* L.	2	H	Arch.	RD	RS
12.	*Convolvulus arvensis* L.	3	G	Ap.	RD	RS
13.	*Conyza canadensis* (L.) Cronq.	4	T1-T2	Ken.	RD	RS
14.	*Dactylis glomerata* L.	1	H	Ap.	M	RS
15.	*Descurainia sophia* (L.) Webb ex Prantl	1	T1-T2	Arch.	RD	RS
16.	*Echium vulgare* L.	3	T2	Ap.	RD	RS
17.	*Erodium cicutarium* (L.) L'Hér.	3	T1	Ap.	XS, SG	RS
18.	*Erysimum cheiranthoides* L.	2	T1-T2	Ap.	SG	RS
19.	*Hordeum murinum* L.	2	T2	Arch.	RD	RS
20.	*Lactuca serriola* L.	2	T2	Arch.	RD	RS
21.	*Lathyrus pratensis* L.	1	H	Ap.	M	RS
22.	*Linaria vulgaris* Mill.	1	G	Ap.	SS	RS
23.	*Lithospermum arvense* L.	1	T1	Arch.	SS, RD	RS

24. *Lolium multiflorum* Lam.	1	H	Ken.	RD	RS
25. *Lolium perenne* L.	2	H	Ap.	M, RD	RS
26. *Medicago lupulina* L.	1	T1-T2	Ap.	XS, M	RS
27. *Melandrium album* (Mill.) Garcke (*Silene alba* (Mill.) E.H.L Krause)	1	H	Ap.	RD	RS
28. *Melilotus alba* Medik.	2	H	Ap.	RD	RS
29. *Neslia paniculata* (L.) Desv.	1	T1	Arch.	SG	RS
30. *Oxalis stricta* L.	1	H, G	Ken.	SG, RD	RS
31. *Plantago lanceolata* L.	2	H	Ap.	M	RS
32. *Plantago major* L.	4	H	Ap.	RD	TR, RS
33. *Poa annua* L.	5	T1	Ap.	M, RD	TR, RS
34. *Polygonum aviculare* L.	5	T1	Ap.	RD	TR, RS
35. *Potentilla anserina* L.	3	H	Ap.	M	RS
36. *Rorippa sylvestris* (L.) Besser	4	H	Ap.	RD	RS
37. *Rumex acetosa* L.	2	H	Ap.	M	RS
38. *Rumex crispus* L.	2	H	Ap.	RD	RS
39. *Rumex obtusifolius* L.	1	H	Ap.	RD	RS
40. *Sisymbrium loeselii* L.	1	T1-T2	Ken.	RD	RS
41. *Sisymbrium officinale* (L.) Scop.	1	T1	Arch.	RD	RS
42. *Solidago canadensis* L.	1	G, H	Ken.	RD	RS
43. *Solidago gigantea* Aiton	1	G	Ken.	RD	RS
44. *Tanacetum vulgare* L.	1	H	Ap.	RD	RS
45. *Trifolium arvense* L.	1	T1-T2	Ap.	SS	RS
46. *Trifolium dubium* Sibth.	1	T1	Ap.	SS	RS
47. *Trifolium repens* L.	3	H	Ap.	M	RS
48. *Tusillago farfara* L.	1	G	Ap.	RD	RS

Explanation

Frequency of occurrence: 1 - occasionally; 2 - rarely; 3 - average; 4 - often; 5 - very often.

Life form according to Raunkiaer:

- perennials: G - geophyte; H - hemicryptophyte;
- short-lived: T1 - annual therophyte; T2 - biennal therophyte.

Geographical-historical classification: Ap. - apophyte; Arch. - archeophyte; Ken. - kenophyte; Erg. - ergasiophyte.

Socio-elogical classification: DW - decideuous woodland species; CD - coniferous woodland species; SE - shrub edges species; M - meadow species; SS - sandy sward species; XS - xerothermic sward species; RD - ruderal species; SG - segetal species; SW - swamp species; N - other classification.

Sites of occurrence in investigated plantations surroundings: TR - trodden and rutty places; RS - roadsides.

DISSCUSION

Number of species of synanthropic plants occurring on strawberry plantations and their surroundings in Central Poland - 132 (out of which 127 on plantations) - was smaller than the number of taxa noted in the orchards near Szczecin in the North-Eastern Poland 162 species (Wróbel 1999) and in Central Poland 186 species (Lisek 2012). It is probably a result of even lighting of the soil, lack of many years' swards, shorter period of the plantation being in use and more regular cultivation of soil. For comparison, segetal flora of the Wigry National Park had 181 species, which possibly resulted from higher diversification of environmental

conditions, greater number of phyto-sociological releves and diversification of cereal and root crops cultivation (Skrajna & Kubicka 2011). Flora of trodden and rutty places and roadsides of strawberry plantation was similar to flora occurring in surroundings of orchards (Lisek 2012). Special conditions prevailing in the surroundings of plantations under examination resulted in the dominant role played by ruderal species (50%) and insubstantial role of segetal species (8%). Most weeds occurring in great number on plantations of strawberry such as *Equisetum arvense*, *Polygonum aviculare*, *Chenopodium album*, *Stellaria media*, *Capsella bursa-pastoris*, *Geranium pusillum*, *Convolvulus arvensis*, *Viola arvensis*, *Galinsoga parviflora*, *Cirsium arvense*, *Taraxacum officinale*, *Poa annua*, *Echinochloa crus-galli*, grew also in orchards and arable fields which were assessed in the research of authors mentioned above. Some of the species regarded as cosmopolitan, e.g. *Convolvulus arvensis*, *Stellaria media*, *Capsella bursa-pastoris*, *Echinochloa crus-galli*, *Polygonum aviculare* grow not only in European plantations of strawberry, but also in the European part of Turkey and in the USA - California and Michigan (Boz *et al*. 2002; Kęsik & Maskalaniec 2004; Fennimore *et al*. 2010; Hanson & Zandstra 2011). Fennimore *et al*. (2010) draw attention to changes in the species composition of weeds during the time when the plantation remained in use. After the routine fumigation in the US, on more recently established plantations predominant were those species whose seeds are resistant to fumigation (*Medicago* spp., *Melilotis* spp., *Erodium* spp.). Second were species whose seeds are scattered by wind, such as *Sonchus* spp., *Senecio vulgaris*. As the plantations grow older, perennial weeds are more and more common. Presented data confirms that the number of perennial weeds was increasing along with the age of the plantations, and on plantations mulched with straw, which created conditions suitable for compensation of such geophytes as *Equisetum arvense*, *Convolvulus arvensis*, *Cirsium arvense*. Ergasio-phytes such as *Triticum vulgare*, *Secale cereale*, *Triticosecale* (grain volunteers), proliferated on plantations mulched with crop straw, a source of seeds, rather on other types of plantations. Another ergasiophyte - *Sinapis alba* - was introduced to plantations as a forecrop. Number of plants belonging to such species as *Conyza canadensis* and *Taraxacum officinale* increased on plantations localised near orchards; the presence of *Epilobium adenocaulon* was also noted. Plants of *Solidag*o spp. were noticed in the neighbourhood of wastelands and alluviums. Presented data shows that anthropogenic factors, out of which technology of field preparation and cultivation of strawberries are most significant, greatly influence the composition of synanthropic flora, including weeds. Success of particular species, determined by number of plants, is decided by: tolerance to herbicides (*Equisetum arvense*, *Convolvulus*

arvensis); long period of emergence (*Geranium pusillum*, *Viola arvensis*, *Capsella bursa-pastoris*, *Lamium purpureum*); large number of seeds (*Chenopodium album*), anemochory (*Asteraceae*, *Epilobium adenocaulon*); high permanence of seeds in soil (*Amaranthus retroflexus*, *Echinochloa crus-galli* (Tymrakiewicz 1976; Mowszowicz 1984). Composition of flora of examined plantations was modified by environmental conditions and succession. Simultaneous occurrence of therophytes, hemicryptophytes and geophytes creates difficulties in practical limitation of weeds. For this reason one should agree with Fennimore *et al*. (2010) that the Integrated Weed Management with different methods of weed control is the optimal option for strawberry.

Index of flora synanthropization on strawberry plantations and their surroundings amounted to 100%. For comparison, the average synanthropization factor equalled: in communities of vascular plants from abandoned limestone guarry in Tyniec - 97.1% (Piżuch *et al*. 2011); in meadow communities in Wielkopolska Region 52.8-81%, depending on plant association (Kryszak 2004); in meadow communities of Sowie Mountain - 71.8% (Paszkiewicz-Jasińska & Żyszkowska 2011). Low synanthropization factor in acidophilous communities in oak forests in Sudety Mountain, which amounted to 10-20%, was a proof of little human interference in environment as compared with segetal communities (Reczyńska 2011).

Average index of flora modernization on strawberry plantations – 0.24 - was similar to average index of modernization for segetal communities in Poland (0.22) as provided by Balcerkiewicz & Pawlak (2010). Average index of modernization for the surroundings of plantations - 0.58 - was higher than in the case of plantations and similar to the factor for the flora of abandoned limestone quarry in Tyniec - 0.62 (Piżuch *et al*. 2011).

Degree of lability on strawberry plantations - 4 - was higher than the degree of flora lability in the surroundings of plantations (0), but was considerably lower in comparison with flora lability in cities, which reached from 38 for Rabka to 216 for Szczecin (after Kornaś 1977).

CONCLUSIONS

1. Synanthropic flora of strawberry plantations of Central Poland (in surroundings of Skierniewice) consisted of 127 species of vascular plants belonging to 30 botanical families. *Asteraceae* (17%), *Poaceae* (15%), *Brassicacea* (11%), *Fabaceae* (8%) and *Polygonaceae* (8%) were most frequently represented.
2. Around 61% of the species found in the plantations examined occurred occasionally or rarely, whereas 21% of species were noted frequently or very frequently. Frequently occurring species were numerously represented in the herbicide fallow and tillage places and so they should be acknowledged as the most significant strawberry weeds.

3. Most numerous group of the plantation flora analysed constituted of therophytes (64%), which predominated over hemicryptophytes (21%) and geophytes (11%).
4. Apophytes - native species (48%) predominated over archeophytes (39%) and kenophytes (9%) on plantations.
5. Among the vascular flora of the plantations examined, segetal species (43%) predominated over ruderal (20%) and meadow (14%) species.
6. 48 species of vascular plants belonging to 13 botanical families occurred in surroundings of plantations (trodden and rutty places and roadsides). *Asteraceae* (21%), *Poaceae* (17%), *Brassicacea* (17%) were most frequently represented.
7. Therophytes (48%), apophytes (60%) and ruderal species (50%) dominated in the flora of trodden and rutty places and roadsides.

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FLORA SYNANTROPIJNA PLANTACJI TRUSKAWEK I OTOCZENIA

Streszczenie

Badania flory synantropijnej prowadzono na plantacjach truskawek w centralnej Polsce (okolice Skierniewic). W latach 2007-2010, na plantacjach wykonano 104 zdjęcia fitosocjologiczne, obejmujące ugór herbicydowy, ugór mechaniczny i powierzchnie ściółkowane. Taka samą liczbę zdjęć wykonano w bezpośrednim otoczeniu plantacji, na uwrociach, w miejscach wydeptywanych i na przydrożach. Na badanych plantacjach zarejestrowano występowanie 127 gatunków, należących do 30 rodzin botanicznych, z których najliczniej były reprezentowane *Asteraceae* (17%), *Poaceae* (15%), *Brassicacea* (11%), *Fabaceae* (8%) i *Polygonaceae* (8%). 61% spośród gatunków znalezionych na plantacjach występowało okazjonalnie lub rzadko. 21% gatunków, między innymi *Equisetum arvense*, *Polygonum aviculare*, *Chenopodium*

album, *Amaranthus retroflexus*, *Stellaria media*, *Capsella bursa-pastoris*, *Geranium pusillum*, *Convolvulus arvensis*, *Viola arvensis*, *Galinsoga parviflora*, *Cirsium arvense*, *Taraxacum officinale*, *Poa annua*, *Echinochloa crus-galli* występowało często lub bardzo często, zarówno w ugorze herbicydowym jak i mechanicznym. Uznano je za najważniejsze chwasty truskawek. Najliczniejszą grupę analizowanej flory stanowiły terofity (64%), które przeważały nad hemikryptofitami (20%) i geofitami (11%). Apofity - gatunki rodzime (48%) przeważały nad archeofitami (39%) i kenofitami (9%). Wśród flory naczyniowej badanych plantacji przeważały gatunki segetalne (43%), ruderalne (20%) i łąkowe (14%). Wśród 48 gatunków roślin notowanych w otoczeniu plantacji, terofity (48%) przeważały nad hemikryptofitami (35%) i geofitami (13%). W miejscach wydeptywanych, na uwrociach i przydrożach, apofity (60%) dominowały nad archeofitami (25%) i kenofitami (15%), a gatunki typowo ruderalne (50%) były liczniejsze niż łąkowe (15%) i segetalne (8%).