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THE EFFECT OF FARMING METHOD ON THE DYNAMICS OF COMMUNITIES FROM THE ALLIANCE *Radiolion linoidis* (RIAS GODAY 1961) PIETACH 1965 IN KAŁUSZYN UPLAND AGROCENOSES

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Abstract

The work presents the results of studies carried out from 1994 to 2010 on changes in phytocenoses with *Radiolion linoidis* species due to increased intensification of the farming process. The research material consisted of 136 phytosociological relevés taken from the same sites located in cereals, tuber crops/maize and stubble fields. The relevés were grouped based on three periods reflecting changes in farming system: period I (1994–1997) – traditional farming system; period II (2002–2004) – shift from traditional to intensive farming; period III (2008–2010) – intensive farming system. Communities with *Radiolion linoidis* continued to disappear over the whole study period due to farming intensification. The phytocenoses *Spergulario-Illecebretum verticillati* found in stubble fields and communities with *Illecebrum verticillatum* observed in cereals and tuber crops in period I were replaced with patches of *Echinochloo-Setarietum* in maize and stubble fields as well as the association *Vicietum tetraspermae* in cereals in period III. The values of Sørensen's index of community similarity and of the dynamics index emphasize how advanced the process of changes in and impoverishment of communities was.

Key words: field weeds, threatened species, field under cultivation, dynamics index (V), Sørensen's index of similarity

INTRODUCTION

Intensive development of agricultural production technology in Europe began in the first part of the 20th century [1] and in Poland in the second part of the 20th century. Modern agrotechnology and intensive application of chemicals in field production have led to the disappearance of many specialised species and whole communities [2–5]. Other factors that have promoted the impoverishment of flora in agrocenoses include abandoning marginal land, reduced diversity of cultivated fields, for example smaller percentages of fields under *Secale cereale* L. and *Linum usitatissimum* L., and ploughing under of stubble fields which are the main place where many short-lived ground species develop [6,7]. They also include communities with *Radiolion linoidis* included in the list of endangered segetal communities in Poland [8].

In the study area, traditional cultivation methods in the 1990s supported communities from the alliance *Radiolion linoidis* with a large share of *Illecebrum verticillatum* in agrocenoses [9–13].

The purpose of this work was to analyse transformations of communities from the alliance *Radiolion linoidis* due to changes in habitat conditions resulting from intensification of the farming process.

MATERIALS AND METHODS

Field observations were performed over the period 1994–2010 in the same sites located in cultivated fields of 23 localities of the Kałuszyn Upland [14] (Fig. 1). There was a total of 136 phytosociological relevés taken using the Braun-Blanquet approach [15] in fields under cereals, root crops/maize and in stubble fields. Next, the relevés were grouped according to the following three periods to reflect changes in farming methods:

– period I (1994–1997) – traditional farming system;
– period II (2002–2004) – transformation period – shift form traditional to intensive farming;
– and period III (2008–2010) – intensive farming system.

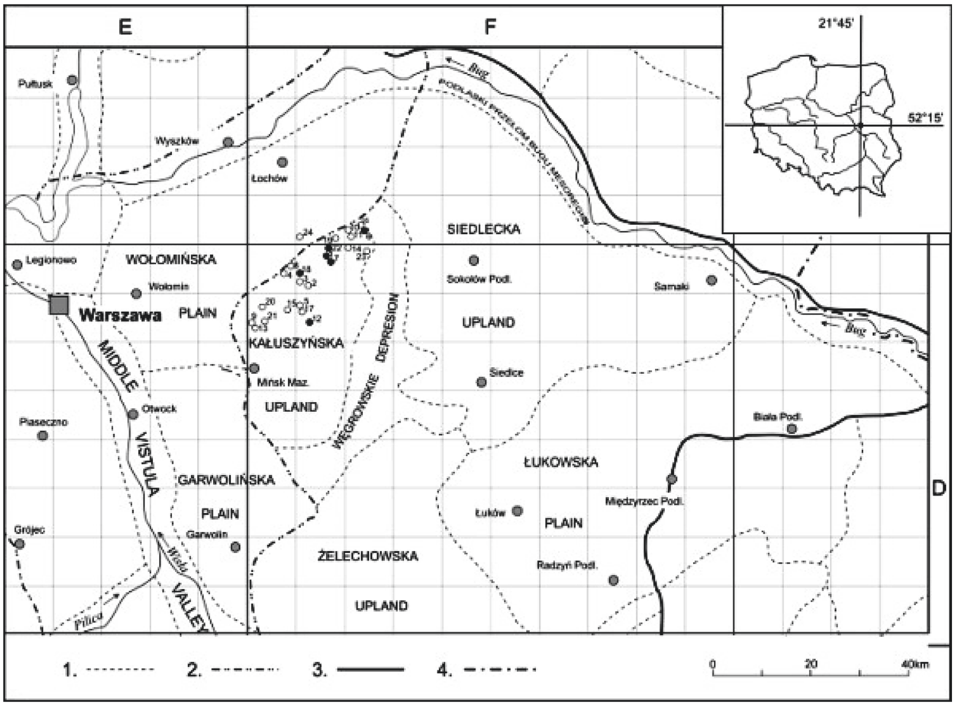

Fig. 1. The location of study area.
1– current locality *Illecebrum verticillatum* (2008–2010); 2 – locality *Illecebrum verticillatum* do 1994–2002; 3 – limits of the mesoregions; 4 – limits of the macroregions; 5 – limits of the provinces; 6 – borders of coumtry.

Data on the changes in farming intensification and percentages of area under individual crops were derived from surveys carried out among the owners of the fields where permanent study areas were located. Soil conditions were determined using agricultural soil maps at a scale of 1:5000. Relevés from the study periods were arranged into tables according to individual crops and stubble. Then, phytosociological classification was made [16] and used to analyse the structural changes in the communities.

Sørensen's index of similarity (SW_s) was employed to reflect the extent of changes in communities in individual study periods. The index was calculated according to the following formula:

Moreover, the dynamics index V was used to analyse changes in the floristic composition of agrophytocenoses in the sites studied. The index reflects an increase or decrease in constancy of occurrence and is a measure of species dynamics [17]:

$$V=S_3/S_1*100\%$$

where:

S_1 – constancy of occurrence of a given species in period I (1994–1997);

S_3 – constancy of occurrence of a given species in period III (2008–2010).

The species which were characterised by an absolute increase or decrease in constancy of 4 percent points were considered to be species whose constancy changed significantly. Vascular plant terminology in the study followed M i r e k et al. [18].

RESULTS

Comparisons of the present state of the communities with their state 17 years ago revealed dynamic changes taking place in the structure of agrocenoses for all the crop groups and stubble fields. A number of community transformations associated with changes in the land use structure and farming intensification took place.

Changes in stubble communities

Changes in syntaxonomic affiliation of communities were observed in the study area in stubble fields. Two associations including lower units were recognised in period I: *Spergulario-Illecebretum verticillati* and *Digitarietum ischaemi*. They were floristically rich phytocenoses: there was a total of 113 species in stubble fields (Table 1). Number of species per relevé ranged between 26 and 53, on average 32 species. There was observed a mass occurrence of *Illecebrum verticillatum* in both associations. Moreover, a large cover of the following hygrophilous species was observed: species of the association *Radiolion linoidis* such as *Hypericum humifusum, Radiola linoides* and *Centunculus minimus*, of the classes *Isoëto-Nanojuncetea – Juncus bufonius, Juncus capitatus, Gnaphalium uliginosum* and *Plantago intermedia* as well as other moisture-loving species like the most numerous *Veronica serpyllifolia, Polygonum hydropiper* and *Sagina procumbens*. There was observed a mass occurrence of the following acidophilous weeds: *Rumex acetostella* and *Spergula arvensis* and others.

Table 1
Changes in stubble communities in years 1994-2010

Farming system	traditional		transformation period		intensive	
In period	1994-1997		2002-2004		2008-2010	
Numbers of species with in the releve	26-53 32		22-37 27		19-28 24	
Numbers of releves	31		16		16	
No	1		2		3	
	S	D	S	D	S	D
I. Ch. *Spergulario-Illecebretum verticillati*						
Illecebrum verticillatum	V	1389	IV	250	II	31
Spergularia rubra	IV	152	III	119	II	81
II. Ch. *Radiolion linoidis*						
Hypericum humifusum	V	839	IV	237	II	165
Radiola linoides	V	397	III	75	I	6
Gypsophila muralis	II	46	II	96	I	12
Centunculus minima	IV	219	III	93	I	12
III. Ch. *Isoëto-Nanojuncetea*						
Juncus bufonius	V	516	V	250	IV	162
Juncus capitatus	IV	213	IV	112	I	12
Plantago intermedia	IV	258	III	100	II	67
Gnaphalium uliginosum	V	316	III	312	III	62
Gnaphalium luteo-album	II	22	I	6	I	6
IV. D. var. hygrophilous species						
Veronica serpyllifolia	V	442	IV	187	II	5
Polygonum hydropiper	IV	406	III	100	III	334
Sagina procumbens	IV	179	III	69	II	18
Mentha arvensis	III	555	III	93	II	87
Peplis portula	III	147	II	50	II	319
Stachys palustris	II	202	II	56	III	197
Bidens tripartita	II	77	II	56	IV	372
Potentilla anserina	II	32	II	31	III	68
Lysimachia nummularia	II	64	II	31	I	19
IV. Ch. *Aperion spicae-venti, Centauretalia cyani*						
Scleranthus annuus	IV	87	III	50	I	19
Anthemis arvensis	III	111	IV	112	IV	197
Centaurea cyanus	III	51	II	69	II	25
Arnoseris minima	III	61	I	6	I	43
Anthoxanthum aristatum	II	58	II	25	II	75
Vicia hirsuta	II	26	II	31	II	31
Apera spica-venti	II	26	II	25	I	6
Vicia angustifolia	II	25	I	19	I	12
Teesdalea nudicaulis	II	32				
V. Ch. *Digitarietum ischaemi*						
Digitaria ischaemum	IV	425	V	628	III	281
VI. Ch. *Echinochloo-Setarietum*						
Echinochloa crus-galli	I	32	IV	1022	V	1246
Raphanus raphanistrum	III	67	II	31	II	56

VII. Ch. *Panico-Setarion*						
Spergula arvensis	V	135	IV	87	II	87
Rumex acetosella	V	585	III	106	III	81
Setaria pumila	II	61	IV	578	IV	584
Setaria viridis	II	58	III	284	II	100
VIII. Ch. *Polygono-Chenopodietalia Polygono-Chenopodion*						
Chenopodium album	III	252	V	569	IV	459
Polygonum aviculare s.	III	58	IV	62	III	68
Sonchus arvensis	II	22	I	44	I	37
Galinsoga parviflora			II	35	III	203
Veronica persica			II	100	II	184
Capsella bursa-pastoris	I	6	I	12	II	25
IX. Ch. *Stellarietea mediae*						
Viola arvensis	IV	61	IV	451	IV	284
Fallopia convolvulus	IV	81	IV	112	II	56
Stellaria media	III	80	V	600	IV	265
Matricaria maritima subsp. *inodora*	I	69	II	106	IV	353
Conyza canadensis	II	106	II	37	II	62
Myosotis arvensis	I	22	I	6	II	37
X. Accompanying species						
Achillea millefolium	IV	64	III	44	I	19
Elymus repens	III	71	III	106	III	725
Equisetum arvense	III	61	III	69		
Veronica arvensis	II	26	II	31	III	125
Polygonum lapatifolium	II	45	II	25	III	68
Cerastium holosteoides	II	26	II	31	I	6
Cirsium arvense	II	39	I	37	I	44
Convolvulus arvensis	II	26	I	19	I	12
Ranunculus repens	II	35	I	9	I	6
Hypochoeris radicata	II	8	I	6	I	12
Plantago lanceolata	II	6	I	6	I	6
Erodium cicutarium	II	29	I	6	I	6
Leontodon autumnalis	II	48			I	6
Polygonum persicaria	I	13	II	56	III	100
Rorippa sylvestris	I	13			III	184
Trifolium repens	I	13			II	25
Agrostis stolonifera	I	6			II	128

Sporadical species: II – *Ranunculus sardous 1,2; Riccia sorocarpa 1; Anthoceros punctatus 1; IV – Arabidopsis thaliana 1,2,3; Odontites verna 1,2; Myosotis stricta 1,2; Polygonum tomentosum 1,3; Vicia tetrasperma 1; Vicia sativa 1; Spergula morisonii 1; Chamomilla recutita 1; Melandrium noctiflorum 2,3;VIII-Atriplex patula 1,2,3;Geranium pusillum 1,2,3; Oxalis fontana 1,2,3; Rumex crispus 1; Euphorbia helioscopia 2,3; Lamium purpureum 2,3; Chenopodium polyspermum2,3; Sonchus oleraceus 2; Sonchus asper 2;Veronica agrestis 2; IX-Galeopsis tetrahit 1,2,3; Thlaspi arvense 2,3; Lapsana communis 3; Sinapis arvensis 3; X-Stellaria graminea 1,2,3;Poa annua 1,2,3; Plantago major1,2,3; Equisetum sylvaticum1,2,3; Trifolium arvense 1,2; Medicago lupulina 1,2; Galeopsis ladanum 1,2; Holcus lanatus 1,2; Cerastium semidecandrum 1,2; Arenaria serpyllifolia 1,3; Amaranthus retroflexus 1,3; Taraxacum officinale 1,3; Symphytum officinale 1,3; Potentilla norvegica 1,3; Lactuca serriola 1; Medicago sativa s. falcata 1; Lysimachia vulgaris 1; Artemisia vulgaris 1; Tanacetum vulgare 1; Chamomilla suaveolens 1; Cerastium arvense 1; Lathyrus pratensis 1; Polygonum amphibium 1;Artemisia campestris 1; Allium vineale 1; Dactylis glomerata 1; Knautia arvensis 1; Hieracium pilosella 1; Hypericum perforatum 1; Trifolium pratense 1; Galium aparine 2,3; Crepis capillaris 2; Daucus carota 3; Epilobium montanum3; Gnaphalium sylvaticum 3; Tussilago farfara 3;*

Explanatory notes: numbers after species inform about numbers of columns in the table:

S – phytosociological constancy, D – cover factor;

In period II, one more association was distinguished, i.e. *Echinochloo-Setarietum*, as well as the community *Setaria pumilla-Setaria viridis*. The cover of *Illecebrum verticillatum*, all the species from *Radiolion linoidis* and *Isoëto-Nanojuncetea* and acidophilous species was markedly reduced. On the contrary, a higher share of the following nitrophilous species was observed: *Chenopodium album, Stellaria media* and *Matricaria maritima* subsp. *inodora*. Additionally, new species established, e.g. *Veronica persica* and *Galinsoga parviflora*. The overall number of stubble species was lower: 85. The average number of species per relevé was lower, too, and amounted to 27.

Period III saw an even faster rate of disappearance of species and whole syntaxa representing the class *Isoëto-Nanojuncetea*. What is more, phytocoenoses of the association *Spergulario-Illecebretum verticillati* were not found, whereas rare patches of *Digitarietum ischaemii Illecebrum verticillatum* were replaced by numerous plants of *Polygonum hydropiper, Peplis portula* and *Bidens tripartita*.

Changes in weed communities of cereal crops

At the beginning of the study, rye was the only winter cereal, with its cover ranging from 45 to 60%. These agrocenoses included the association *Arnoserido-Scleranthetum*, either typical or the variant with *Illecebrum verticillatum*, as well as the community with *Aperion spicae-venti*, the variant with *Illecebrum verticillatum*. The vertical structure of the stand was not distinct and often consisted of just one stratum. Thinner rye stands at the stage of grain maturation favoured the development of ground weeds. *Illecebrum verticillatum* plants were common and were accompanied by numerous species of the association *Radiolion linoidis* and of the class *Isoëto Nanojuncetea*, in which the species with the highest constancy and cover included the following: *Radiola linoides*, *Centunculus minimus*, *Hypericum humifusum, Juncus bufonius* and *Juncus capitatus*. *Arnoseris minima* was also a numerous characteristic species in the lowest layer, whereas *Apera spica-venti* was the dominant species in the upper one (Table 2). Cereal communities were infested by 82 weedy species, on average 24 species per relevé.

In 2002–2004 the total area of land under winter cereals decreased and half of it was under *Triticale*. The average cover of this cereal was higher and reached 64%. Higher stand density substantially reduced the development of ground weeds. Agrocenoses in this period included the community *Aperion spicae-venti*, the typical variant and the hygrophilous variant with *Juncus bufonius* and the dominating species *Apera spica-venti*. The withdrawing species included *Arnoseris minima* and other acidophilous species. What is more, there was a drastic drop in the constancy and cover of the following species from the order *Radiolion linoidis*: *Illecebrum verticillatum, Radiola linoides, Centunculus minimus,* and *Hypericum humifusum*. The greater cover of *Matricaria maritima subsp. inodora, Vicia tetrasperma* and *Polygonum lapathifolium* subsp. *pallidum* indicates the improved nutrient status of the habitats. Agrocenoses included 66 species. The number of species per-relevé was slightly lower and ranged from 15 to 29, averaging 23 species. There was also a decrease in total weed cover.

Triticale was the only winter species cultivated in period III and its average cover reached 70%. The agrophytocenoses underwent further transformations; the association *Vicietum tetraspermae*, the typical variant with *Juncus bufonius* and *Rhinanthus serotinus*, became the leading dominant. Great numbers of new species, *Bromus secalinus* and *Vicia villosa*, were found in some patches. In addition, the following nitrophilous newcomers increased their cover: *Matricaria maritima subsp. inodora, Sonchus arvensis* and *Galium aparine*. Hygrophilous species of the alliance *Radiolion linoidis* became very rare, whereas moisture--lowing species characterised by higher nutrient requirements, like *Bidens tripartita*, increased their cover. The community was made up of 65 species, 22 species per relevé on average.

Changes in weed communities of tuber crops/maize

In period I, potatoes were grown for livestock under the traditional farming system. They were characterised by substantial secondary weed infestation. These phytocenoses included two associations; *Digitarietum ischaemi* was frequently found in the typical variant and the variant with *Illecebrum verticillatum*, whereas the variant with *Echinochloo-Setarietum sperguletosum* was infrequent (Table 3). Hygrophilous species from the class *Isoëto-Nanojuncetea – Juncus bufonius* and *Illecebrum verticillatum,* present in all patches at high cover, made them easily recognisable. These phytocenoses consisted, respectively, of a total of 61 and 19 species per patch, on average.

During the period of farming process transition, 60% of cropped land was under maize. Patches of *Digitarietum ischemii* were seldom, whereas patches of *Echinochloo-Setarietum* became the dominant association which was much more diversified internally compared to period I. Hygrophilous species representing the syntaxa analysed clearly withdrew from the phytocenoses. Similarly, there was a clear decrease in the number of acidophilous species, particularly *Spergula arvensis*, *Anthemis arvensis* and *Rumex acetosella*. Moreover, there was observed a marked increase in the share of panicoid weeds but the overall weed cover in maize decreased. Also, the number of species making up the phytocenoses and the average number of species per relevé diminished (58 and 15, respectively). The above-mentioned changes progressed during the period of intensive farming, when only maize was cultivated. The dominance of *Echinochloa crus-galli* increased by further 30% compared with the previous period. The number and cover of nitrophilous species increased, the greatest changes being observed for *Thlaspi arvense*. The overall number of species slightly decreased to a level of 50, but the average number of species per patch remained the same.

Tabela 2
Changes in weed communities of cereal crops in years 1994-2010

Farming system	traditional		transformation period		intensive	
In period	1994-1997		2002-2004		2008-2010	
Numbers of species with in the releve	17-32 24		15-29 23		17-27 22	
Numbers of releves	23		10		10	
Cultivated plant:	*Secale cereale*		*Secale cereale/Triticale*		*Triticale*	
no	1		2		3	
	S	D	S	D	S	D
I. Ch. Isoëto-Nanojuncetea						
Juncus bufonius	V	502	V	465	III	275
Juncus capitatus	IV	215	III	40		
Plantago intermedia	III	61	III	100	II	30
Gnaphalium uliginosum	III	123	III	180	II	70
II. Ch. Radiolion Linoidis						
Hypericum humifusum	IV	306	III	90	II	40
Radiola linoides	V	572	III	50	I	10
Gypsophila muralis	I	17	II	30	I	10
Centunculus minimus	V	274	II	80	I	20
Myosurus minimus	II	69	III	130	II	70
III. Ch. Spergulario-Illecebretum verticillati						
Illecebrum verticillatum	V	865	IV	150	II	20
Spergularia rubra	IV	83	II	30	II	30
IV. D. var. hygrophilous species						
Polygonum hydropiper	IV	174	III	140	IV	140
Sagina procumbens	IV	189	II	40	II	30
Peplis portula	III	113	III	50	II	40
Veronica serpyllifolia	III	61	III	50	I	10
Bidens tripartita	III	56	III	50	IV	60
Mentha arvensis	II	74	II	80	II	30
Stachys palustris	II	35	II	40	II	80
Potentilla anserina	II	22	I	20	I	20
Lysimachia nummularia	I	13	III	20		
V. Ch. Arnoserido-Scleranthetum						
Arnoseris minimus	III	350	I	10		
Anthoxanthum aristatum	II	133	II	30	III	130
Scleranthus annuus	II	22	I	90	I	10

VI. Ch. Vicietum tetraspermae						
Vicia tetrasperma	I	6	II	235	IV	520
Bromus secalinus					III	345
Polygonum tomentosum	I	13	II	30	II	40
VII. Ch.D. Aperion spicae-venti						
Centauretalia cyani						
Apera spica-venti	V	750	V	785	V	505
Anthemis arvensis	IV	233	IV	355	IV	200
Spergula arvensis	IV	91	IV	110	II	80
Centaurea cyanus	III	74	III	90	III	60
Vicia hirsuta	I	128	II	370	III	360
Arabidopsis thaliana	I	4	I	10	II	70
Vicia angustifolia	I	9	I	10	II	30
Vicia villosa					III	500
VII. Ch. Stellarietea mediae						
Viola arvensis	IV	96	V	170	V	210
Fallopia convolvulus	III	52	IV	70	IV	110
Stellaria media	II	22	I	20	II	30
Polygonum aviculare s.	II	22	II	30	I	20
Chenopodium album	II	22	I	10	I	10
Myosotis arvensis	II	26	I	20	II	30
Matricaria maritima subsp. inodora	I	9	III	130	III	220
Sonchus arvensis	I	17			III	130
Oxalis fontana	I	4	I	10	II	30
Echinochloa crus-galli			I	20	II	30
VIII. Accompanying species						
Rumex acetosella	IV	243	IV	110	II	40
Equisetum sylvaticum	IV	78	III	100	II	30
Veronica arvensis	II	26	II	40	III	50
Cirsium arvense	II	22	II	40	II	120
Elymus repens	II	30			I	20
Equisetum arvense	II	26	I	10	I	10
Rhinanthus serotinus	I	52	II	120	II	235
Daucus carota	I	13	II	20	II	30
Poa annua	I	17	II	30	II	30
Arenaria serpyllifolia			I	60	II	30
Galium aparine					III	130

Sporadical species: *II – Riccia sorocarpa 1; Anthoceros punctatus 1; V – Teesdalea nudicaulis 1; VII – Capsella bursa-pastoris 1,2,3; Galeopsis tetrahit 1,2,3; Geranium pusillum 1,2; Digitaria ischaemum 1,2; Raphanus raphanistrum 1; Setaria pumila 1; Sonchus oleraceus 2,3; Conyza canadensis 3; VIII – Polygonum lapathfolium 1,2,3; Ranunculus repens 1,2,3; Achillea millefolium 1,2,3; Melandrium album 1,2,3; Cerastium arvense 1,2; Rumex obtusifolius 1,2; Trifolium repens 1,2; Rorippa sylvestris 1,2; Erodium cicutarium 1,2; Agrostis stolonifera 1,3; Convolvulus arvensis 1,3; Knautia arvensis 1,3; Lactuca serriola 1,3; Allium vineale 1; Cerastium holosteoides 1; Epilobium montanum 1; Galeopsis ladanum 1; Leontodon autumnalis 1; Lysimachia vulgaris 1; Medicago sativa falcata 1; Plantago lanceolata 1; Polygonum amphibium 1; Stellaria graminea 1; Cerastium semidecandrum 2; Symphytum officinale 3;*

Explanatory notes: numbers after species inform about numbers of columns in the table:

S – phytosociological constancy, D – cover factor;

Table 3
Changes in weed communities of tuber crops/maize in years 1994-2010

Farming system	traditional		transformation period		intensive	
In period	1994-1997		2002-2004		2008-2010	
Numbers of species with in the releve	17-24		13-18		14-18	
	19		15		15	
Numbers of releves	10		10		10	
No.	1		2		3	
	S	D	S	D	S	D
I. Ch. *Isoëto-Nanojuncetea*						
Juncus bufonius	V	990	III	140	II	40
Gnaphalium uliginosum	III	140	II	70		
Juncus capitatus	II	40				
Plantago intermedia			I	20	I	10
II. Ch. *Radiolion linoidis*						
Hypericum humifusum	I	10	I	20		
Radiola linoides	II	30				
Ranunculus sardous			I	10		
III. Ch. *Spergulario-Illecebretum verticillati*						
Illecebrum verticillatum	V	630	II	0		
Spergularia rubra	II	40	II	30	II	30
IV. D. var. hygrophilous species						
Bidens tripartita	III	425			II	110
Polygonum hydropiper	III	220	I	20	II	80
Mentha arvensis	II	245	II	30	II	30
Peplis portula	II	245			II	160
Veronica serpyllifolia	II	30	I	30		
Potentilla anserina	I	20	II	30	I	10
Equisetum sylvaticum	I	20	II	40	II	30
Sagina procumbens	I	20			II	30
V. Ch. *Digitarietum ischaemi*						
Digitaria ischaemum	IV	422	V	510	V	250
VI. Ch. *Echinochloo-Setarietum*						
Echinochloa crus-galli	III	850	V	1570	V	2175
Raphanus raphanistrum	III	50	I	20	I	20
VII. Ch. *Panico-Setarion*						
Setaria pumila	III	30	V	405	V	530
Setaria viridis	II	70	II	110	III	170
Spergula arvensis	IV	385	I	10	I	10
Rumex acetosella	IV	110	III	60	II	40
VIII. Ch.D *Polygono-Chenopodion*						
Polygono-Chenopodietalia						
Chenopodium album	IV	315	III	80	III	130
Galinsoga parviflora	I	10	I	60	II	80
Capsella bursa-pastoris	I	10	II	40	II	80

IX. Ch. ***Stellarietea mediae***						
Viola arvensis	V	120	II	30	II	30
Anthemis arvensis	IV	200	II	70	II	30
Fallopia convolvulus	III	80	II	30	II	30
Centaurea cyanus	III	50	I	20	I	20
Conyza canadensis	II	30				
Thlaspi arvense	I	10	II	40	III	295
Stellaria media	I	60	II	30	II	40
Matricaria maritima subsp. *inodora*					II	40
X. Accompanying species						
Elymus repens	V	335	IV	150	III	140
Achillea millefolium	II	30	I	20	I	10
Veronica arvensis	II	70	I	20	II	30
Cirsium arvense	II	30	I	10	I	60
Erodium cicutarium	II	40	I	10	I	10
Galeopsis ladanum	II	40	I	10		
Polygonum persicaria	II	30				
Amaranthus retroflexus	I	50	I	60	II	30
Polygonum lapathfolium	I	20	I	20	II	120
Galium aparine	I	10	II	20	II	40
Agrostis stolonifera			I	20	II	30

Sporadical species: IV – *Stachys palustris 1,2,3; Lysimachia nummularia 2; VIII – Euphorbia helioscopia 1,3; Polygonum aviculare s. 1; Chenopodium polyspermum 1; Sonchus oleraceus 2,3; Sonchus arvensis 2; IX – Anthoxanthum aristatum 1,2; Arnoseris minima 1; Scleranthus annuus 1; Vicia hirsuta 1; Vicia angustifolia 1; Vicia villosa 1; Vicia tetrasperma 3 ; Galeopsis tetrahit 1; Myosotis arvensis 2,3; Lapsana communis 2,3; X – Taraxacum officinale 1,2,3; Convolvulus arvensis 1,2,3; Equisetum arvense 1,2,3; Lactuca serriola 1,2,3; Erysimum cheiranthoides 1; Arenaria serpyllifolia 1; Equisetum sylvaticum 1; Stellaria graminea 1; Stellaria graminea 2; Ranunculus repens 2; Rhinanthus serotinus 2; Leontodon autumnalis 2; Knautia arvensis2; Cerastium holosteoides 2; Medicago falcata 2; Plantago lanceolata 2,3; Rorippa sylvestris 3; Poa annua 3;*

Explanatory notes: numbers after species inform about numbers of columns in the table:

S – phytosociological constancy, D – cover factor;

Index of community dynamics and similarity

The comparison of the conditions in period I and II in the agrophytocenoses studied revealed changes leading to the impoverishment and simplification of communities. In the crop groups analysed, the number of disappearing and withdrawing species was not compensated by new taxa (Table 4).

92 species in stubble fields, 71 in cereals and 50 in tuber crops/maize displayed dynamic tendencies. The withdrawing species included stenotopic taxa, that is, hygrophilous and acidophilous species which were withdrawing due to changes in habitat conditions (Table 5). The group of spreading species was less numerous. These weeds have a wide ecological amplitude; moreover, they are usually common species/ taxa with a high nutrient requirement (Table 6).

The comparison of the communities for the period analysed by means of Sørensen's index (SW_s) confirmed marked similarities between period I and II communities for all the crop groups analysed (Table 7). The changes in agrocenoses over these periods were slow. Much greater differences were found when periods II and III were compared. The value of the index diminished clearly, which was accompanied by an increase in field production intensification and changes in agrophytocenoses. The lowest value of the index was obtained when period I was compared with period III. The similarity was as low as $SW_s = 0.29$ for tuber crops/maize.

Table 4
Number of species responding to changes in farming methods

Site	Stubble	Cereals	Tuber crops / *Zea mays*
Number of species found in period I only	35	19	22
Number of species found in period II only	10	5	10
Number of withdrawing species	55	38	35
Number of species with increasing cover	27	33	15

Table 5
Dynamic index of the weed secies decreasing the coverage in years 1994–1997 – 2008–2010

Cultivated plant:	stubble field	cereals	root crops/ Zea mays
Dynamic index	V	V	V
Radiola linoides	16	11	0
Juncus capitatus	26	0	0
Centunculus minimus	28	22	
Illecebrum verticillatum	31	30	0
Gnaphalium luteoalbum	32		
Potentilla norvegica	28		
Gypsophila muralis	35	58	
Hypericum humifusum	45	51	0
Plantago intermedia	61	63	
Sagina procumbens	41	46	0
Gnaphalium uliginosum	57	58	50
Veronica serpyllifolia	39	23	0
Scleranthus annuus	31	46	0
Digitaria ischaemum	65	0	
Arnoseris minima	39	0	0
Spergularia rubra	51	46	75
Juncus bufonius	65	73	44
Equisetum arvense	39	38	50
Polygonum hydropiper	87	86	67
Peplis portula	83	92	100
Mentha arvensis	68	77	100
Rumex acetosella	65	66	57
Polygonum aviculare	75	92	0
Raphanus raphanistrum	75	0	40
Convolvulus arvensis	48	77	50
Spergula arvensis	47	54	17
Erodium cicutarium	22	0	25
Fallopia convolvulus	46		75
Cirsium arvense	73		67
Oxalis fontana	39		
Galeopsis tetrahit	32		0
Myosotis arvensis	55		
Sonchus arvensis	55		
Centaurea cyanus	48		40
Plantago major	48		
Stellaria graminea	48	0	
Vicia angustifolia	48		0
Lysimachia nummularia	48	0	
Apera spica-venti	24		
Plantago lanceolata	24	0	
Cerastium holosteoides	22	0	

Poa annua	65		
Leontodon autumnalis	22	0	
Ranunculus repens	18		
Achillea millefolium	29		33
Chenopodium album		46	71
Elymus repens		66	67
Potentilla anserina		92	50
Anthemis arvensis			38
Viola arvensis			38
Equisetum sylvaticum		49	
Myosurus minimus		86	

Table 6
Dynamic index of the weed species increasing the coverage in years 1994–1997 – 2008–2010

Cultivated plant:	stubble field	cereals	root crops/ Zea mays
Dynamic index	V	V	V
Amaranthus retroflexus	581		300
Echinochloa crus-galli	517		250
Capsella bursa-pastoris	388	153	400
Veronica arvensis	218	192	100
Polygonum lapathifolium subsp. lapathifolium	151	58	200
Stellaria media	149	138	200
Stachys palustris	113	115	200
Matricaria maritima subsp. inodora	504	690	
Arabidopsis thaliana	129	690	
Arenaria serpyllifolia	129	345	
Agrostis stolonifera	388	115	
Polygonum lapathifolium subsp. pallidum	291	307	
Bidens tripartita	178	106	
Rorippa sylvestris	161	115	
Vicia hirsuta	121	230	
Galinsoga parviflora	221		300
Trifolium repens	194		200
Setaria pumila	194		300
Polygonum persicaria	388		
Symphytum officinale	388		
Geranium pusillum	194		
Chenopodium album	145		
Elymus repens	138		
Potentilla anserina	136		
Vicia tetrasperma		805	
Lactuca serriola		460	
Oxalis fontana		690	
Vicia angustifolia		345	
Sonchus arvensis		288	
Myosotis stricta		230	
Daucus carota		230	
Rhinanthus serotinus		173	
Cirsium arvense		153	
Fallopia convolvulus		134	
Veronica persica			500
Galium aparine			400
Euphorbia helioscopia			200
Setaria viridis			167
Equisetum sylvaticum			150

Table 7
Values of Sørensen's index for communities in individual study periods

Periods compared Site	I -II	II - III	I - III
Stubble field	0.456	0.405	0.355
Secale cereale	0.484	0.416	0.373
Tuber crops / *Zea mays*	0.336	0.318	0.291

DISCUSSION

The changes due to farming intensification taking place over 17 years in the communities with *Radiolion linoidis* indicated an improved nutrient status of these habitats. The community composition and structure changed; all the syntaxa with species representing the aforementioned association disappeared in stubble fields, cereals and tuber crops. They were replaced by associations widespread in Poland and characterised by wide amplitude of habitats where they grow. The association *Echinochloo-Setarietum* was observed in stubble fields and maize, whereas *Vicietum tetraspermae* and species-impoverished communities representing the association *Aperion spicae-venti* were found in cereals. The scale of these transformations is also reflected in the low value of Sørensen's coefficient. The analysis of the changes in species composition of the communities in period I and III demonstrated that the species disappeared much faster than new ones appeared (Table 4, 5). Many works, both Polish and foreign, have examined the issue of impoverishment and disappearance of specialised communities [2,5,19–24].

Species that spread and reached the highest values of the dynamics index included eurytopic and nitrophilous species, such as: *Echinochloa crus-galli, Chenopodium album, Galinsoga parviflora, Stellaria media, Matricaria maritima* subsp. *inodora* and *Elymus repens*, which are believed to be common expansive weeds in Poland [25,26]. The establishment of these species is possible, because maize has become a dominant crop plant and now the area under maize is around 60% of cropped land. Communities establishing in maize consist of the smallest number of species (an average of 16 species per patch), compared with cereals or tuber crops. According to Gołębiowska and Kaus [27], the number of weedy species in maize depends on weed control methods and ranges from 11 to 16 species per relevé [28], whereas monoculture is associated with the following dominant species: *Chenopodium album, Echinochloa crus-galli, Elymus repens* and others [29]. The application of herbicides, e.g. triazine products, substantially reduces the development of weeds [28] whereas monoculture is associated with the development of weed dominance, for example *Chenopodium album*, *Echinochloa crus-galli*, *Elymus repens*, and others. Compensation of weeds which quickly develop resistance to herbicides has already been noticed in the agrocenoses studied, as exemplified by a mass occurrence of *Echinochloa crus-galli*

CONCLUSIONS

1. Communities from the *Radiolion linoidis* alliance were greatly reduced due to changes in farming methods.
2. Acidophilous phytocenoses *Spergulario-Illecebretum verticillati* disappeared in stubble fields, while phytocenoses with *Illecebrum verticillatum* in cereals and tuber crops.
3. Various forms of the common association *Echinochloo-Setarietum* established in maize and stubble fields, whereas patches of *Vicietum tetraspermae* in cereals.
4. The greatest differences were found for the communities between study period I and III, as reflected by a low value of Sørensen's index (SW_s=0.29).
5. The impoverishment of communities took place; the number of disappearing and withdrawing species was higher than the number of new taxa.

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Wpływ sposobu gospodarowania na dynamikę zbiorowisk ze związku *Radiolion linoidis* (Rias Goday 1961) Pietach 1965 w agrocenozach Wysoczyzny Kałuszyńskiej

Streszczenie

W pracy przedstawiono rezultaty badań przeprowadzonych w latach 1994–2010 dotyczących przemian fitocenoz z gatunkami *Radiolion linoidis* wywołanych wzrostem intensyfikacji procesu produkcji. Materiał badawczy stanowiło 136 zdjęć fitosocjologicznych wykonanych na stałych powierzchniach w uprawach zbóż, okopowych/kukurydzy i na ścierniskach. Zdjęcia pogrupowano na trzy okresy przedstawiające zmiany sposobu produkcji. I–okres (lata 1994–1997) tradycyjny sposób gospodarowania; II – okres (lata 2002–2004) – okres przestawiania produkcji na intensywną i III – okres (lata 2008–2010) – intensywny sposób gospodarowania. W okresie badań, na skutek intensyfikacji uprawy zanikają zbiorowiska z *Radiolion linoidis*. Notowane w I okresie fitocenozy *Spergulario-Illecebretum verticillati* na ścierniskach i zbiorowiska z udziałem *Illecebrum verticillatum* w uprawach zbóż i okopowych zastępowane są w III okresie przez płaty *Echinochloo-Setarietum* w zasiewach kukurydzy i na ścierniskach oraz asocjacje *Vicietum tetraspermae* w zbożach. Wyliczone wartości wskaźników podobieństwa zbiorowisk Sørensena i dynamiki podkreślają głęboki zakres przemian i ubożenia zbiorowisk.

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