

SHARE OF ANTHROPOPHYTES IN THE CROP SEQUENCE: WINTER WHEAT – MAIZE – SPRING WHEAT DEPENDING ON TILLAGE SYSTEM

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Abstract

An experiment, conducted over the period 2008–2010, evaluated the effect of tillage system on the occurrence and species composition of anthropophytes in winter wheat, maize and spring wheat. Regardless of crop plant and tillage system, anthropophytes (73.9%), represented by archaeophytes and kenophytes, were the main component of the flora in the crops studied, whereas apophytes accounted for the remaining 26.1%. Most archaeophytes (13 species) were found in the spring wheat crop under no-tillage, while their lowest number (6 species) occurred in the spring wheat crop under conventional tillage. The only kenophyte, *Conyza canadensis*, was found to occur in the spring wheat and maize crops in the no-tillage system. The following taxa were dominant species among archeophytes: *Geranium pusillum*, *Anthemis arvensis*, and *Viola arvensis* (regardless of tillage system and crop plant), *Anthemis arvensis* (in spring wheat – conventional tillage), *Echinochloa crus-galli* and *Setaria glauca* (in maize – reduced tillage and no-tillage), *Chenopodium album* (in maize – no-tillage) as well as *Apera spica-venti*, *Anthemis arvensis* and *Papaver rhoeas* (in winter wheat – no-tillage).

Key words: anthropophytes, tillage system, winter wheat, maize, spring wheat

INTRODUCTION

Plant communities accompanying field crops are determined by habitat conditions and agronomic practices used (e.g. type of previous crop, tillage system, fertilization, or crop protection treatments, etc.) [1–4]. Plant cover transformations resulting from the effects of anthropogenic factors are termed synanthropization [5]. As a result of human (farming) activity, a decrease in the number of stenotopic species in

favor of apophytes and anthropophytes can be observed [3,6–8].

Reduced tillage is one of the factors that shape agrophytocenoses, since this tillage system contributes to the creation of different growth and development conditions for the crop plant and weeds. The use of reduced tillage practices in crop rotations also creates conditions for compensation or temporary disappearance of some weed species [9–11].

The aim of this study was to determine the effect of tillage system on the occurrence and species composition of anthropophytes in the crop sequence: winter wheat – maize – spring wheat.

MATERIALS AND METHODS

Crop growing experiments with winter wheat, maize and spring wheat were conducted over the period 2008–2010 in production fields of the Jelcz-Laskowice Experimental Station of the Institute of Soil Science and Plant Cultivation (IUNG-PIB). Experimental fields (for each crop plant separate) were divided into three parts that differed in tillage system: conventional tillage, reduced tillage, and no-tillage (direct drilling). More important elements associated with the tillage systems used during the 3-year study period are shown in Table 1.

The research material consisted of the results of observations of the state and level of weed infestation of the respective crops depending on tillage system. The analysis of weed infestation, that is, the species composition of weeds and their number per unit area, was performed using the quadrat sampling method. Quadrat sampling was carried out twice during the growth period: 2 weeks before herbicide application

and 4 weeks before crop harvest (separately for each tillage system) [12].

The results obtained from the observations allowed us to make a list of species found in the experiments; these species were broken down into apophytes and anthropophytes, among which archeophytes [8,13] and kenophytes [8,14] were distinguished. Species

nomenclature used in this paper follows Mirek et al. [15], whereas the assignment of species to historical-geographical groups was determined according to Sikorski et al. [3], Latowski et al. [8], and Jackowiak [16]. Furthermore, species found in the experiments were divided into annual and perennial ones [17,18].

Table 1
Tillage system

Tillage system	Tillage operations
Conventional tillage	grubber at 15 cm + string roller
	ploughing to a depth of 25 cm
	tillage unit (cultivator + string roller)
Reduced tillage	grubber at 15 cm
	tillage aggregate (cultivator + string roller)
No-tillage	herbicide Roundup 360 SL at a rate of 4.0 l per ha direct drilling

RESULTS

Regardless of tillage system, 11 weed species were found to occur in the winter wheat crop in 2008. Among them, 5 native species (apophytes) were distinguished, which accounted for 45.5% of the total number of taxa. The other 6 species belonged to alien taxa (anthropophytes) which accounted for the remaining 54.5%. Only archeophytes were found to occur in the group of anthropophytes (Table 2).

The highest incidence of apophytes in the winter wheat crop was found under no-tillage, it was lower under reduced tillage, while they showed the lowest cover in conventional tillage. Among apophytes, annual species (therophytes) were predominant, whereas from perennial species only 2 geophytes occurred, out of which only *Elymus repens* was found in the no-tillage system. Anthropophytes also had the largest numbers under no-till conditions, followed by reduced tillage, and the lowest numbers were observed in conventional tillage. In this case, archeophytes, among which only therophytes were found to occur, were the group of anthropophytes that determined the level of weed infestation of the winter wheat crop depending on tillage system. 4 therophytes: *Apera spica-venti*, *Geranium pusillum*, *Anthemis arvensis* and *Viola arvensis*, determined the level of weed infestation in the winter wheat crop (in particular under no-tillage and reduced tillage conditions) (Table 2).

15 weed species were found to occur in the maize crop in 2009. 6 apophytes were distinguished among them and they accounted for 40.0% of the total number of all taxa. The remaining 9 species belonged to anthropophytes and constituted 60.0% of the total flora.

Archeophytes (8 species) were the dominant group of anthropophytes, whereas kenophytes were only represented by one species – *Conyza canadensis* (Table 2).

Most native species (apophytes) were found under no-till, followed by reduced and conventional tillage. Perennial species predominated among apophytes – 3 geophytes: *Elymus repens* (observed only under no-tillage), *Cirsium arvense* and *Equisetum arvense* as well as one chamaephyte: *Artemisia vulgaris*. The other native species, *Chenopodium album* and *Setaria glauca*, belonged to annual ones (therophytes). Among anthropophytes, the dominant group was made up of alien species (archaeophytes), among which only therophytes were found to occur. The following monocotyledons: *Echinochloa crus-galli* and *Setaria glauca*, were dominant taxa in this group under no-tillage and reduced tillage. On the other hand, only one dicotyledonous species, *Geranium pusillum*, was found under conventional and reduced tillage. Moreover, the only kenophyte found – *Conyza canadensis*, which occurred only under no-till, did not play a major role in weed infestation of the maize crop (Table 2).

In 2010 the highest number of weed species was found in the spring wheat crop. Regardless of tillage system, 22 taxa occurred in it, out of which 8 belonged to apophytes (36.4% of the total number of species) and 14 to anthropophytes (63.6% of the total number). Among anthropophytes, archeophytes (13 species) predominated over kenophytes (1 species) (Table 2).

No-tillage was characterized by the highest number of apophytes (8 species). Perennial taxa – *Elymus repens* (geophyte), *Equisetum arvense* (geophyte), and *Artemisia vulgaris* (chamaephyte), were found only in this tillage system. A native geophyte – *Cirsium*

arvense, occurred as the only one in all the three tillage systems. Under reduced and conventional tillage, 4 native species were found to occur; they belonged to therophytes (*Chenopodium album*, *Stellaria media*, and *Veronica hederifolia*) and geophytes (*Cirsium arvense*). Most taxa infesting the spring wheat crop were anthropophytes, among them annual archaeophytes. The following species were predominant under no-till: *Echinochloa crus-galli* and *Setaria glauca* as well as 4 dicotyledonous species: *Geranium pusillum*, *Anthe-*

mis arvensis, *Lamium purpureum*, and *Viola arvensis*. 2 therophytes, *Lamium purpureum* and *Myosotis arvensis*, and one kenophyte – *Conyza Canadensis*, were found to occur only in the no-tillage system. Nevertheless, apart from *Lamium purpureum*, they were of marginal importance for weed infestation of the spring wheat crop. Under reduced and conventional tillage, only 4 dicotyledonous therophytes occurred, i.e. *Anthemis arvensis*, *Geranium pusillum*, *Papaver rhoeas*, and *Viola arvensis* (Table 2).

Table 2

List of anthropophytes and apophytes in particular crop rotations and their numbers (plants × m²) depending on tillage system

Species name	Geographical -historical groups	Persistence	Conventional tillage			Reduced tillage			No-tillage		
			Year of study								
			2008	2009	2010	2008	2009	2010	2008	2009	2010
			Crop plant								
I	II	III	Winter wheat	Maize	Spring wheat	Winter wheat	Maize	Spring wheat	Winter wheat	Maize	Spring wheat
<i>Agropyron repens</i> (L.) P. Beauv.	ap; g	p	–	–	–	–	–	–	1.5	0.5	0.1
<i>Anthemis arvensis</i> L.	ar; t	a	2.5	1.0	5.7	3.5	1.3	2.5	8.0	1.0	2.5
<i>Apera spica-venti</i> (L.) P. Beauv.	ar; t	a	2.5	–	1.0	4.5	–	1.5	11.0	–	0.7
<i>Artemisia vulgaris</i> L.	ap; ch	p	–	0.3	–	–	0.5	–	–	1.6	0.5
<i>Capsella bursa-pastoris</i> (L.) Medik.	ar; t	a	–	–	0.7	–	–	1.0	–	–	1.2
<i>Centaurea cyanus</i> L.	ar; t	a	1.5	–	1.0	2.0	–	1.2	6.5	–	1.5
<i>Cirsium arvense</i> (L.) Scop.	ap; g	p	0.2	0.7	0.2	0.3	0.8	0.5	1.3	1.5	0.7
<i>Chenopodium album</i> L.	ap; t	a	0.5	1.8	0.5	0.5	2.5	0.7	1.0	4.3	1.5
<i>Conyza canadensis</i> (L.) Cronquist	kn; t	a	–	–	–	–	–	–	–	1.2	0.1
<i>Descurainia sophia</i> (L.) Webb ex Prantl	ar; t	a	–	0.6	–	–	0.7	1.0	–	0.9	0.8
<i>Echinochloa crus-galli</i> (L.) P. Beauv.	ar; t	a	–	4.8	0.2	–	5.0	0.5	–	8.5	3.0
<i>Equisetum arvense</i> L.	ap; g	p	–	0.2	–	–	0.3	–	–	0.7	0.5
<i>Fallopia convolvulus</i> (L.) A. Löve	ar; t	a	–	1.3	–	–	3.5	–	–	2.5	–
<i>Galium aparine</i> L.	ap; t	a	0.5	–	–	0.8	–	–	1.5	–	0.5
<i>Geranium pusillum</i> Burm. F. ex L.	ar; t	a	7.0	6.0	1.3	11.5	7.8	4.0	10.0	2.8	7.0
<i>Myosotis arvensis</i> (L.) Hill.	ar; t	a	–	–	–	–	–	–	–	–	1.7
<i>Papaver rhoeas</i> L.	ar; t	a	2.0	–	4.5	2.8	–	3.0	5.0	–	1.2
<i>Setaria glauca</i> (L.) P. Beauv.	ar; t	a	–	3.5	0.2	–	6.5	0.5	–	15.5	4.2
<i>Stellaria media</i> (L.) Vill.	ap; t	a	–	1.0	0.7	–	1.0	1.7	–	0.7	1.7
<i>Thlaspi arvense</i> L.	ar; t	a	–	1.0	1.0	–	1.0	1.0	–	0.7	1.2
<i>Veronica hederifolia</i> L.	ap; t	a	1.3	–	1.5	1.3	–	2.0	1.8	–	1.2
<i>Viola arvensis</i> Murray	ar; t	a	3.5	1.8	3.3	4.5	1.2	4.7	7.0	4.8	2.0

Explanations: ap – apophyte, ar – archaeophyte, kn – kenophyte, ch – chamaephyte, g – geophyte, t – therophyte, a – annual, p – perennial

DISCUSSION

In the opinion of Kornas [19], the human impact on flora results in changes in its composition and as a result of this impact some species spread, while some other ones disappear. Depending on these processes, floristic diversity can increase or decrease.

The data on weed infestation of agrophytonoses of cereal plants, in dependence of agronomic practices used, are included in numerous papers. In the opinion of Szymankiewicz et al. [20] as well as Jędruszcak and Antoszek [21], reduced tillage practices and the use of crop rotation or its abandonment cause not only quantitative changes, but also qualitative changes in weed communities. This is manifested in the fact that communities in which there is relatively high biodiversity are replaced by simplified weed communities, mostly composed of several dominant species, e.g. *Apera spica-venti*, *Papaver rhoeas*, *Centaurea cyanus*, or *Viola arvensis*. According to Stupnicka-Rodzyńkiewicz et al. [1], the harmfulness of weed communities composed of several species is often greater than that of a community made up of a dozen or more taxa. In this case, the harmfulness of weeds results not from the number of species, but from their total numbers and the total weight of weeds. This thesis is confirmed by the results of the present study conducted on the first component of the crop rotation, that is, spring wheat.

Woźniak [22] also showed that the dry weight of weeds in a spring wheat crop significantly increased under ploughless tillage conditions compared to conventional tillage. Under plough tillage, spring wheat was most frequently colonized by native therophytes (apophytes), i.e. *Avena fatua*, *Stellaria media*, *Chenopodium album*, and *Galium aparine*, as well as by an annual archaeophyte *Consolida regalis* and a kenophyte *Amaranthus retroflexus*. Under ploughless tillage, on the other hand, apart from 4 annual apophytes, 2 annual archaeophytes, i.e. *Fallopia convolvulus* and *Papaver rhoeas*, also occurred as dominants.

This thesis is confirmed by the results of the present study in which 8 apophytes were found to occur in the spring wheat crop under no-tillage, among them 2 perennial geophytes, i.e. *Elymus repens* and *Equisetum arvense*, as well as one chamaephyte – *Artemisia vulgaris*. But under reduced and conventional tillage, only 4 native species were found to be present; therophytes predominated among them, i.e. *Chenopodium album*, *Stellaria media* and *Veronica hederifolia*, as well as one geophyte – *Cirsium arvense*.

According to Sowiński [23], annual species, an apophyte *Chenopodium album* as well as kenophytes *Amaranthus retroflexus* and *Galinsoga parviflora*, contribute to typical weed infestation of maize crops. When determining the effect of previous crop on the

species composition of weeds in maize grown after cereals, Pudełko et al. [24] included annual archeophytes, i.e. *Stellaria media*, *Veronica arvensis*, *Capsella bursa-pastoris*, and *Setaria viridis*, in dominant taxa. The above data are partially consistent with the results of the present study. The occurrence of apophytes, archaeophytes or kenophytes can also be modified by tillage systems, aside from the crop plant itself. An example is no-till under which a perennial apophyte, *Artemisia vulgaris*, was found to occur in great numbers. This thesis is confirmed by the study of Gółębowska and Kaus [25] who also observed increased numbers of this chamaephyte in crops sown using direct drilling. The situation is similar in the case of kenophytes such as *Conyza canadensis* and *Solidago canadensis*, which are observed more and more frequently in maize, particularly under direct drilling. Jezińska-Domaradzka and Domaradzki [26] observed that *Solidago canadensis* encroached into a maize field that was in close vicinity to an abandoned field. In the opinion of Jędruszcak and Antoszek [21], species attached to conditions created as a result of human activity (e.g. by using reduced tillage practices) are few and can appear a bit more distinctly in small amounts only in single years of research.

CONCLUSIONS

1. Regardless of crop plant and tillage system used, antropophytes (73.9%), represented by archaeophytes and kenophytes, were the main component infesting the crop plants studied. Apophytes made up the remaining 26.1% of the weed community.
2. Tillage system was a factor modifying the occurrence of archaeophytes and kenophytes. Most archaeophytes (13 species) were found in the spring wheat crop under no-tillage, while their least amount (6 species) in the winter wheat crop under conventional tillage. The kenophyte *Conyza canadensis* occurred only under no-till in the spring wheat and maize crops.
3. Only 5 species (out of 23 found) were present in each type of crop, including 2 apophytes (*Chenopodium album* and *Cirsium arvense*) as well as 3 archaeophytes (*Geranium pusillum*, *Anthemis arvensis* and *Viola arvensis*).
4. Among archaeophytes, *Geranium pusillum*, *Anthemis arvensis* and *Viola arvensis* were dominant species in the crops studied.

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Authors' contributions

The following declarations about authors' contributions to the research have been made: design of the experiments: TRS, JS; performance of the experiments: TRS; analysis of the experimental data: TRS, JS; writing of the paper: TRS.

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Udział antropofitów w następstwie roślin: pszenica ozima, kukurydza, pszenica jara w zależności od sposobu uprawy roli

Streszczenie

W doświadczeniu przeprowadzonym w latach 2008–2010 oceniano wpływ systemu uprawy roli na występowanie oraz skład gatunkowy antropofitów w pszenicy ozimej, kukurydzy i pszenicy jarej. Niezależnie od rośliny uprawnej oraz zastosowanego systemu uprawy roli, główny składnik flory w badanych roślinach uprawnych stanowiły antropofity (73,9%), reprezentowane przez archeofity i kenofity, natomiast pozostałe 26,1% przypadło na apofity. Najwięcej archeofitów stwierdzono w uprawie zerowej w łanie pszenicy jarej (13 gatunków), a najmniej w uprawie tradycyjnej w łanie pszenicy ozimej (6 gatunków). Jedyny stwierdzony kenofit – *Conyza canadensis*, występował tylko w uprawie zerowej w łanie pszenicy jarej oraz kukurydzy. W obrębie archeofitów gatunkami dominującymi były następujące taksony: *Geranium pusillum*, *Anthemis arvensis* i *Viola arvensis* (niezależnie od sposobu uprawy roli i rośliny uprawnej), *Anthemis arvensis* (w pszenicy jarej – uprawa tradycyjna), *Echinochloa crus-galli* i *Setaria glauca* (w kukurydzy – uprawa uproszczona i zerowa), *Chenopodium album* (w kukurydzy – uprawa zerowa) oraz *Apera spica-venti*, *Anthemis arvensis* i *Papaver rhoeas* (w pszenicy ozimej – uprawa zerowa).

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