

THE WEED SPECIES COMPOSITION IN A REED CANARY GRASS (*Phalaris arundinacea* L.) PLANTATION FOR ENERGY PURPOSES DEPENDING ON ITS AGE

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Abstract

The present experiment, carried out in nine production fields of reed canary grass (*Phalaris arundinacea*) grown for energy purposes, evaluated the effect of plantation age on the occurrence and species composition of weeds. The selected plantations were divided into 3 groups that were conventionally called “young” (1–2 years old), “middle-aged” (3–5 years old), and “older” plantations (6–8 years old). Regardless of plantation age, altogether 43 species were found in the experimental fields. Moreover, 6 species were common for all the plantations and were found in them regardless of plantation age. The least species, only 18, were found on the “young” plantations, almost twice more on the “older” ones (30 species), whereas the largest spectrum of species was found in the “middle-aged” plantations (33 species). In the “young” plantations, annual weeds were the most common, with the highest constancy and coverage index found for *Chenopodium album*, *Matricaria maritima* ssp. *inodora* and *Echinochloa crus-galli*. The greatest variation in species was found in the “middle-aged” plantations. However, only 4 species achieved the highest constancy and coverage index: *Matricaria maritima* ssp. *inodora*, *Cirsium arvense*, *Poa trivialis* and *Taraxacum officinale*. Furthermore, perennial weeds were found to be dominant in the “older” plantations. Within this group, *Poa trivialis*, *Taraxacum officinale*, *Urtica dioica*, *Plantago maior*, and *Cirsium arvense* had the highest constancy and coverage index.

Key words: *Phalaris arundinacea*, plantation age, weed species, coverage index, constancy

INTRODUCTION

Phalaris arundinacea L., commonly called reed canary grass, is an upright, rhizomatous, cool season perennial grass from the *Poaceae* family. It is a wetland species that can survive even long-term surface water-

logging and can be grown as an aquatic plant, although drought-tolerant. Moreover, it is a nitrophilous species that is found commonly growing wild in the temperate climate [1–4]. Also in Poland this species is a well-known, wild growing plant, found especially in fertile swampy meadows where it forms natural or semi-natural permanent meadows [5]. Not a long time ago, this plant was a component of sward which was used as feed for cattle and horses [6–8]. However, recently reed canary grass has been newly adopted as a source of energy. This grass can be easily turned into bricks and pellets, pressed straw, briquettes, or biogas [9–16].

There are more and more papers regarding the possible use of various perennial plants for energy purposes. However, these papers provide more information on the cultivation or harvesting methods, but they do not give enough information on how to manage infestation in these plantations [17–23]. Publications concerning the qualitative and quantitative composition of weeds found in plantations of energy crops are found rarely [24–26]. Furthermore, publications concerning relationships between species composition and habitat type or plantation age are hardly ever found. If so, they refer to a few common species such as basket willow (*Salix viminalis*), giant miscanthus (*Miscanthus x giganteus*), or Virginia fanpetals (*Sida hermaphrodita*) [27–30]. It is worth mentioning that the identification of species occurring in energy plantations is a very important issue and has strong scientific as well as practical significance.

Therefore, the aim of this research was to identify the composition of species occurring in reed canary grass (*P. arundinacea*) plantations for energy purposes depending on their age.

MATERIALS AND METHODS

Nine productive fields (with a total area of 45 ha) that belong to Lesaffre Polska, located in Wołczyn (51°4'N, 17°57'E), were the source of material for the experiment on reed canary grass (*P. arundinacea*). The selected plantations were divided into 3 groups that were conventionally called “young” (1–2 years old), “middle-aged” (3–5 years old), and “older” plantations (6–8 years old) (Fig. 1–4). The analysis of weed infestation status and rate was conducted three times during the whole growing period for each group separately. Species composition and quantity were evaluated on the basis of phytosociological relevés

and the Braun-Blanquet scale. 216 relevés were taken altogether and their surface area was 25 m². The number of species was shown as a mean from the coverage index (D), while the frequency of occurrence in the relevés as constancy (S) [31,32]. The results obtained from the observations enabled us to prepare a list of species occurring in the experimental plantations and to divide them as follows: annual and perennial monocotyledonous weeds as well as annual and perennial broadleaved weeds [33,34]. Plant nomenclature follows Mirek et al. [35], while affiliation to geographical and historical groups follows Jackowiak [36], Latowski et al. [37], and Sikorski et al. [38].

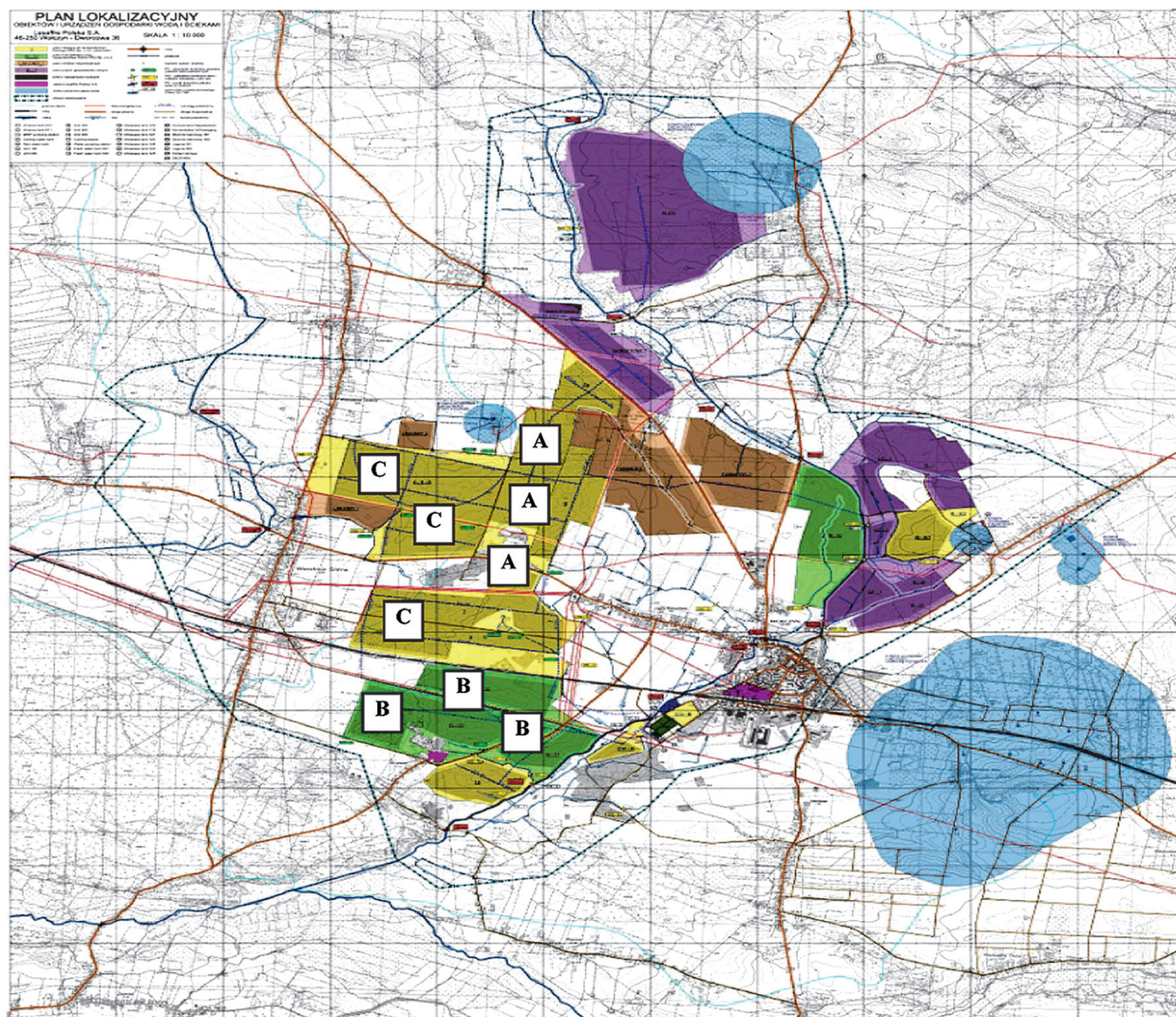


Fig. 1. Location of the investigated area: A – “young” plantations (1–2 years old); B – “middle-aged” plantations (3–5 years old); C – “older” plantations (6–8 years old).



Fig. 2. Reed canary grass (*P. arundinacea*) – a 2-year-old plantation.



Fig. 3. Reed canary grass (*P. arundinacea*) – a 5-year-old plantation.



Fig. 4. Reed canary grass (*P. arundinacea*) – an 8-year-old plantation.

RESULTS

Based on the observations carried out in the reed canary grass plantations, 43 species were found there in total, regardless of the age of the plantations. 18 species were found in the “young” plantations (1–2 years old), 33 species in the “middle-aged” plantations (3–5 years old), whereas 30 species were identified in the “old” plantations (6–8 years old). 6 common species were distinguished, meaning that all of them were present in every type of plantation, regardless of its age. Among these species, one annual monocotyledonous species was found, three annual broadleaved weeds and two perennial broadleaved species (together with *Equisetum arvense*). Two annual broadleaved species i.e. the archaeophyte *Geranium pusillum* and the apophyte *Veronica hederifolia*, were present only in the “young” plantations (1–2 years old). Among the perennial broadleaved weeds, only the apophyte *Tussilago farfara* was present in the “middle-aged” plantations. The remaining 8 types among all the identified weeds were species that were present only in the “older” plantations (6–8 years old). One perennial monocotyledonous weed was found in these plantations, i.e. the apophyte *Phragmites australis*, whereas among perennial broadleaved weeds five apophytes were present: *Arctium lappa*, *Daucus carota*, *Plantago lanceolata*, *Plantago maior*, *Symphytum officinale*, and two hemicryptophytes – *Carduus crispus* and *Potentilla anserina* (Tables 1 and 2).

“Young” plantations (1–2 years old)

“Young” plantations can be characterized as having the lowest differentiation in comparison to the other types of plantations, as only 18 weed species were identified. The highest constancy and coverage index were found only for 3 species: *Chenopodium album* (S=IV, D=2210), *Matricaria maritima ssp. inodora* (S=III, D=910), and *Echinochloa crus-galli* (S=III, D=487). Moreover, within this weed community, com-

panion species (*Stellaria media* and *Apera spica-venti*) were reported to have lower constancy and coverage index (S=II, D – from 155 to 171). The remaining 13 species were present in constancy class I, having a low coverage index (Table 1).

“Middle-aged” plantations (3–5 years old)

Based on the observations carried out in these plantations, they were found to have the most diverse floristic composition (33 species) in comparison to the other plantations. Within this group, one species achieved the highest constancy and coverage index – *Matricaria maritima ssp. inodora* (S=III, D=1210), while another 3 species, *Cirsium arvense* (S=II, D=278), *Poa trivialis* (S=II, D=195), and *Taraxacum officinale* (S=II, D=175), can be characterized as having a significantly lower coverage index. 3 companion species were also reported for this type of plantation, classified in constancy class II, however with a low coverage index: *Apera spica-venti* and *Chenopodium album* (D=95) as well as *Conyza canadensis* (D=125). Furthermore, the largest number of species (i.e. 26) occurred in constancy class I with a very low coverage index (Table 1).

“Older” plantations (6–8 years old)

In the older plantations, 5 species were reported as occurring in the largest number and most frequently: *Taraxacum officinale* (S=III, D=610), *Poa trivialis* (S=III, D=595), *Urtica dioica* (S=III, D=565), *Plantago maior* (S=III, D=455), and *Cirsium arvense* (S=III, D=315). The next 6 species: *Artemisia vulgaris*, *Tanacetum vulgare*, *Phleum pratense*, *Achillea millefolium*, *Matricaria maritima ssp. inodora*, and *Equisetum arvense*, were defined as companion species, with lower constancy and coverage index (S=II, D – from 155 to 255). The remaining 19 species that were observed in the reed canary grass plantation occurred occasionally and only in constancy class I and with a low coverage index (Table 1).

Table 1
Constancy (S) and coverage index (D) for different weed species in the studied plantations

Description	G-H	Crop					
		Reed canary grass (<i>P. arundinacea</i>)					
		Number of relevés					
		48		72		96	
Plantation age							
“Young” (1-2 years old)		“Middle-aged” (3-5 years old)		“Older” (6-8 years old)			
S	D	S	D	S	D		
Monocotyledonous weeds (annual)							
1	<i>Apera spica-venti</i>	ar; t	II	171	II	95	*
2	<i>Bromus hordeaceus</i>	ap; t	-	-	*		*
3	<i>Echinochloa crus-galli</i>	ar; t	III	487	*		-

4	<i>Poa annua</i>	ap; t	*	*	-	-
5	<i>Setaria viridis</i>	ar; t	*	*	-	-
Monocotyledonous weeds (perennial)						
6	<i>Phleum pratense</i>	ap; h	-	-	*	II 250
7	<i>Phragmites australis</i>	ar; g;	-	-	-	*
8	<i>Poa trivialis</i>	ap; h	-	-	II	195 III 595
Dicotyledonous weeds (annual)						
9	<i>Brassica napus</i>	er	*	*	-	-
10	<i>Capsella bursa-pastoris</i>	ar; t	*	*	-	-
11	<i>Chenopodium album</i>	ap; t	IV	2210	II	95 - -
12	<i>Conyza canadensis</i>	kn; t	*	*	II	125 *
13	<i>Fallopia convolvulus</i>	ar; t	*	*	*	*
14	<i>Geranium pusillum</i>	ar; t	*	-	-	- -
15	<i>Matricaria maritima ssp. inodora</i>	ar; t	III	910	III	1210 II 205
16	<i>Stellaria media</i>	ap; t	II	155	*	- -
17	<i>Thlaspi arvense</i>	ar; t	*	*	*	- -
18	<i>Sinapis arvensis</i>	ar; t	*	*	*	- -
19	<i>Veronica hederifolia</i>	ap; t	*	-	-	- -
20	<i>Viola tricolor</i>	ar; t	*	*	*	- -
Dicotyledonous weeds (perennial)						
21	<i>Achillea millefolium</i>	ap; h	-	-	*	II 255
22	<i>Arctium lappa</i>	ar; h	-	-	-	- *
23	<i>Artemisia vulgaris</i>	ap; ch	-	-	*	II 155
24	<i>Carduus crispus</i>	ar; h	-	-	-	- *
25	<i>Cirsium arvense</i>	ap; g	*	*	II	278 III 315
26	<i>Convolvulus arvensis</i>	ap; g; h	-	-	*	*
27	<i>Daucus carota</i>	ap; h	-	-	-	- *
28	<i>Malva neglecta</i>	ar; h	-	-	*	*
29	<i>Melandrium album</i>	ap; g	-	-	*	*
30	<i>Urtica dioica</i>	ap; h	-	-	*	III 565
31	<i>Plantago lanceolata</i>	ap; h	-	-	-	- *
32	<i>Plantago maior</i>	ap; h	-	-	-	- III 455
33	<i>Potentilla anserina</i>	ap; h	-	-	-	- *
34	<i>Rumex acetosa</i>	ap; h	-	-	*	*
35	<i>Rumex crispus</i>	ap; h	-	-	*	*
36	<i>Solidago canadensis</i>	kn; ag	-	-	*	*
37	<i>Solidago gigantea</i>	kn; ag	-	-	*	*
38	<i>Sonchus arvensis</i>	ap; h	-	-	*	*
39	<i>Symphytum officinale</i>	ap; h	-	-	-	- *
40	<i>Taraxacum officinale</i>	ap; h	-	-	II	175 III 610
41	<i>Tanacetum vulgare</i>	ap; h	-	-	*	II 170
42	<i>Tussilago farfara</i>	ap; g	-	-	*	- -
Others						
43	<i>Equisetum arvense</i>	ap; g	*	*	*	II 185
Total coverage (%)			39.9	23.1	32.8	

Explanations: S – constancy, D – cover index; * – species occurring in constancy class I with a low cover; – species did not occur; G–H – geographical and historical groups; ap – apophyte, ar – archaeophyte, kn – kenophyte, ag – agriophyte, er – ergasiophytophyte, ch – chamaephyte, g – geophyte, h – hemicyptophyte, t – therophyte

Table 2
Number of weed species in particular biological groups depending on the age of a reed canary grass (*P. arundinacea*) plantation

Species	Plantation age		
	“Young” (1-2 years old)	“Middle-aged” (3-5 years old)	“Older” (6-8 years old)
Monocotyledonous weeds (annual)	4	5	2
Monocotyledonous weeds (perennial)	0	2	3
Dicotyledonous weeds (annual)	12	10	3
Dicotyledonous weeds (perennial)	1	15	21
Other	1	1	1
Total in the age group	18	33	30
The sum of all species occurring in the studied plantations		43	

DISCUSSION

According to Duern and Feledyn-Szewczyk [39], forecrop, herbicide treatment, or lack of it, and plantation age have a great effect on the species composition of perennial plants in plantations for energy purposes. It was noticed by the above mentioned authors that in older (5 years) plantations of energy crops, such as basket willow (*S. viminalis*), giant miscanthus (*M. x giganteus*) or reed canary grass (*P. arundinacea*), mainly perennial weeds were found, i.e. *Taraxacum officinale*, *Artemisia absinthium*, *Urtica dioica*, *Cirsium arvense*, *Plantago maior*, and *Equisetum arvense*.

The results based on the author's own research carried out in different-age plantations of reed canary grass (*P. arundinacea*) also lead to a relationship between the age of a plantation and its species composition. It clearly appears that in the older plantations (6–8 years old) perennial plants were dominant, i.e. *Poa trivialis*, *Taraxacum officinale*, *Urtica dioica*, *Plantago maior*, *Cirsium arvense*, *Achillea millefolium*, and *Equisetum arvense*, whereas in the youngest plantations annual species were dominant, i.e. *Chenopodium album*, *Matricaria maritima ssp. Inodora*, and *Echinochloa crus-galli*.

Other authors imply similarly that the period of plantation use could have a significant impact on the species composition of the perennial plantation. Piórek et al. [28] observed that together with the plantation age, the coverage index for common weeds increased in basket willow (*S. viminalis*) plantations. One of the explanations for this phenomenon could be the situation where photophilous weeds were replaced by species with lower light demand. Very often they were perennial species, i.e. *Deschampsia caespitosa*, *Poa trivialis*, *Glechoma hederacea*, *Ranunculus repens*, *Epilobium parviflorum*, *Galium mollugo*, *Lycopus europaeus*, and *Urtica dioica*.

Borowska and Molas [30] came to similar conclusions and showed that during the second year of cultivation of Virginia fanpetals (*S. hermaphrodita*), short-lived species prevailed, i.e. *Echinochloa crus-galli*

and *Galinsoga parviflora*, whereas during the fifth year of cultivation more perennial species were found, i.e. *Convolvulus arvensis*, *Artemisia vulgaris*, and *Elymus repens*.

Grzelak et al. [40] showed interesting results concerning the floristic composition of *Phragmites australis typicum*. They proved that the floristic composition of the experimental area was little diverse. Native species predominated over all other species. It is worth mentioning that 80% of the indigenous species were apophytes, while only 6% were kenophytes. In this example, perennial species were dominant over annuals (82.5% and 17.5%, respectively). As a confirmation, the results of the author's own research can be taken into consideration, where apophytes (58%) dominated over archeophytes (35%) and kenophytes (7%). Also perennial species (geophytes, hemicryptophytes) were dominant in the “older” plantations in comparison to the “young” plantations where terophytes were more frequent.

CONCLUSIONS

1. The results of the observations of 9 reed canary grass (*P. arundinacea*) plantations identified a total of 43 weed species. The least species, i.e. only 18, were found in the “young” plantations (1–2 years old), almost twice more in the “older” ones (6–8 years old) – 30, but the most species were found in the “middle-aged” (3–5 years old) aged plantations – 33 species.
2. Out of the total number of 43 species, only 6 were found to be present in all of the plantations, regardless of the age, among which 3 archaeophytes: *Apera spica-venti*, *Fallopia convolvulus*, and *Matricaria maritima ssp. inodora*, 2 apophytes: *Cirsium arvense* and *Equisetum ravenae*, and 1 kenophyte *Conyza canadensis* were recorded.
3. In the “young” plantations (1–2 years old), annual weeds were the most common with the highest constancy and coverage index found for 3 species: *Chenopodium album*, *Matricaria maritima ssp.*

Inodora, and *Echinochloa crus-galli*.

4. The greatest variation in species was found among in the “middle-aged” plantations (3–5 years old), because both segetal and ruderal species as well as annual and perennial plants were found there. However, the highest constancy and coverage index were reached by 4 species: the archaeophyte *Matricaria maritima* ssp. *indora* and the apophytes *Cirsium arvense*, *Poa trivialis*, and *Taraxacum officinale*.
5. The “older” plantations (6–8 years old) were dominated mostly by perennial apophytes. Among monocotyledonous, the highest constancy and coverage index were found for *Poa trivialis*, whereas among broadleaved weeds for *Taraxacum officinale*, *Urtica dioica*, *Plantago maior*, and *Cirsium arvense*.

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Authors' contributions

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

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Skład gatunkowy chwastów plantacji mozgi trzcinowatej (*Phalaris arundinacea* L.) przeznaczonej na cele energetyczne w zależności od jej wieku

Streszczenie

W doświadczeniu przeprowadzonym na 9 polach produkcyjnych, oceniano wpływ wieku plantacji na występowanie oraz skład gatunkowy chwastów w łąnie mozgi trzcinowatej (*Phalaris arundinacea*) przeznaczonej na cele energetyczne. Badane plantacje podzielono na 3 grupy, które umownie określono jako: „młode” (1–2 letnie), „średnie” (3–5 letnie) oraz „starsze” (6–8 letnie). Na badanych plantacjach (niezależnie od ich wieku), stwierdzono występowanie łącznie 43 gatunków. Ponadto wspólnych gatunków, czyli występujących na wszystkich badanych plantacjach (niezależnie od ich wieku) wyodrębniono łącznie 6. Najmniej gatunków, bo tylko 18, odnotowano na plantacjach 1–2 letnich, blisko dwukrotnie więcej (bo aż 30) na plantacjach 6–8 letnich, a najwięcej na plantacjach 3–5 letnich – 33 taksony. Na plantacjach 1–2 letnich przeważały gatunki roczne, wśród których najwyższy stopień stałości i współczynnik pokrycia osiągnęły 3 taksony: *Chenopodium album*, *Matricaria maritima* ssp. *inodora* oraz *Echinochloa crus-galli*. Na plantacjach 3–5 letnich obserwowano największe zróżnicowanie gatunkowe. Jednak najwyższy stopień stałości i współczynnik pokrycia osiągnęły tylko 4 gatunki: *Matricaria maritima* ssp. *inodora*, *Cirsium arvense*, *Poa trivialis* oraz *Taraxacum officinale*. Natomiast plantacje 6–8 letnie odznaczały się głównie dominacją gatunków wieloletnich, wśród których, najwyższy stopień stałości i współczynnik pokrycia stwierdzono dla *Poa trivialis*, *Taraxacum officinale*, *Urtica dioica*, *Plantago maior* i *Cirsium arvense*.

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