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Comparison of fertility and germination of seeds in selected taxa of the genus *Polygonum*

Porównanie plenności i zdolności kiełkowania nasion u wybranych taksonów z rodzaju *Polygonum*

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Abstract

The study compared the fertility of common segetal weeds of the *Polygonum* type: *Polygonum persicaria* L., *Polygonum lapathifolium* L. subsp. *lapathifolium* and *Polygonum lapathifolium* L. subsp. *pallidum* (With.) Fr. from different agroecosystems from the area of the Wigry National Park and its buffer zone. These taxa are particularly found in large numbers in root crops and spring cereals. Owing to favourable habitat conditions in a potato crops they reach large sizes and produce a much larger number of seeds compared with specimens from other agroecosystems. On the stubble, they constitute a component of secondary infestation, reaching fertility similar to that of cereal crops.

In addition, the germination of seeds *P. persicaria* L., *P. lapathifolium* L. subsp. *lapathifolium* and *P. lapathifolium* L. subsp. *pallidum* (With.) Fr. tested in various combinations, in light and darkness, after the treatment of stratification and using gibberellic acid. It was shown that regardless of the conditions, the seeds that best germinated were *P. lapathifolium* L. subsp. *pallidum* (With.) Fr.

Streszczenie

W pracy porównano plenność pospolitych chwastów segetalnych z rodzaju *Polygonum*: *Polygonum persicaria* L., *Polygonum lapathifolium* L. subsp. *lapathifolium* oraz *Polygonum lapathifolium* L. subsp. *pallidum* (With.) Fr. pochodzących z różnych agroceoz z terenu Wigierskiego Parku Narodowego i jego otuliny. Taksony te szczególnie licznie spotykane są w uprawach roślin okopowych oraz zbóż jarych. Dzięki sprzyjającym warunkom siedliskowym panującym w uprawach ziemniaka osiągają duże rozmiary i wytwarzają znacznie większą liczbę nasion w porównaniu z okazami z pozostałych agroceoz. Na ścierniskach stanowią składnik zachwaszczenia wtórnego, osiągając plenność zbliżoną do tej z upraw zbożowych.

Ponadto sprawdzano zdolność kiełkowania nasion *Polygonum persicaria* L., *Polygonum lapathifolium* L. subsp. *lapathifolium* oraz *Polygonum lapathifolium* L. subsp. *pallidum* (With.) Fr. w różnych kombinacjach: na świetle i w ciemności, po zabiegu stratyfikacji oraz z zastosowaniem roztworu kwasu giberelinowego. Wykazano, że niezależnie od warunków najlepiej kiełkowały nasiona *Polygonum lapathifolium* L. subsp. *pallidum* (With.) Fr.

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1. INTRODUCTION

The seeds are the main form of the spread of the plants in the natural environment. Reproducing generatively, weeds produce a huge number of seeds, even dating back to several million pieces of one plant. In addition to genetics, their fertility depends largely on the conditions of habitat: the length of the growing season, soil fertility, cultivated plant species abundance and size of weeds. High fertility provides a permanent presence of weeds in crop fields, despite conducted agricultural treatments aimed at their elimination. Dropping from plants seeds supply the soil seed bank, providing a source of infestation for many growing seasons [Jędruszczak 2000, Kwiecińska 2004, Kwiecińska-Poppe 2006, Majda et al. 2007]. Germination of weed seeds extends to many months and even years. This property is probably the ability to maintain a state of rest and is associated with longevity seeds. Under unfavourable environmental conditions, the seeds of some species may be able to rest survive in the soil even

decades without losing germination. When seeds reach the morphological and physiological maturity and will be provided with the appropriate environmental conditions to germinate rest is intermittent [Dobrzański 2009, Gniazdowska et al. 2013].

The greatest number of species in the root crops and cereals are annual weeds wintering in the form of seeds. These are short-lived weeds that reproduce from seed and die after their release [Klaaßen, Freitag 2004]. Stimulus for seed germination of these species are low winter temperatures and increasing temperature in spring [Dobrzański 2009]. This group weeds include taxa of the genus *Polygonum*: *Polygonum persicaria* L., *Polygonum lapathifolium* L. subsp. *lapathifolium* and *Polygonum lapathifolium* L. subsp. *pallidum* (With.) Fr. The fruit of these plants is hard, smooth and shiny, black or brown, a few millimetres, round nut, filled completely by seed. In the case of *P. persicaria* L., it is triangle or both sides convex lenticular, with the

other two taxa – lenticular concave on both sides. Nuts in the soil are very persistent and do not lose their germination after 10–20 years, in the case of *P. persicaria* L. even after 30 years [Timson 1965a, Mądański 1967, Woźnica 2008, Paradowski 2009, Sudnik - Wójcikowska 2011, Kantachot, Chantaranothai 2011].

The aim of the work was to evaluate fertility of common segetal weeds of the *Polygonum* type, *P. persicaria* L., *P. lapathifolium* L. subsp. *lapathifolium* and *P. lapathifolium* L. subsp. *pallidum* (With.) Fr., from different agroecosystems from the area of the Wigry National Park and its buffer zone and to check the germination of their seeds stored in the dry state.

2. MATERIALS AND METHODS

The study was conducted in the Wigry National Park and its buffer zone. Agricultural land in the area of the park occupy 2,200 ha and are approximately 15% of the area. Most of them are small family farms with an area of about 10 ha. Natural and climatic conditions (topography, poor soils, harsh climate) prevailing in this area are not conducive to agricultural production. Agriculture is extensive and little mechanised, mineral fertilisers and plant protection products are reduced to necessary, and potatoes and cereals are the basis of crop production [Górecka 2004].

Research material were the three individuals of taxa of the genus *Polygonum*: *P. persicaria* L., *P. lapathifolium* L. subsp. *lapathifolium* and *P. lapathifolium* L. subsp. *pallidum* With. (Fr.) [Mirek et al. 2002]. Test plants were collected in 2008–2010 from winter and spring cereal crops and late varieties of potatoes and stubble. Owing to the large diversity of plants within those taxa as well as the occurrence of hybrids, the individuals with characteristics of the species and subspecies were analysed [Rutkowski 2007]. The plants were tested in terms of the typical characteristics of stereoscopic microscope in a laboratory.

Each year, 30 plants were randomly sampled from individual fields and measured to obtain values describing their fertility, including the number of spikelet-like inflorescences and their average length. Seed number per plant was calculated as the sum of seeds from all the spikelet-like inflorescences of a plant. Also, the weight of 1,000 seeds was determined.

Results of measurements of morphological characteristics were statistically analysed. The medium mean and coefficient of variation were calculated. The coefficient of variation was obtained by dividing the standard deviation by the arithmetic mean and expressed as a percentage. Differences between means were checked using Tukey's test.

The ability of seed germination of *P. persicaria* L., *P. lapathifolium* L. subsp. *lapathifolium* and *P. lapathifolium* L. subsp. *pallidum* (With.) Fr. a month after harvest plants and after 1 year, 3 and 5 years of storage in dry conditions at room temperature was tested. The selected random seeds (50 pieces) without dry sepals germinated in three parallel repetitions on a 9-cm diameter Petri dishes on filter paper moistened with distilled water. The water was supplemented during observation that were held every day for 14 days. Petri dishes were placed in a temperature of 25°C in light and in darkness. In addition, the germination of the seeds stored for five years were examined, previously giving them stratification treatment (48 hours at a temperature of 4°C) and

applying gibberellic acid solution (containing 400 ppm) instead of distilled water.

3. RESULTS AND DISCUSSION

Biometric measurements have shown large morphological variation of individuals of the selected taxa of the genus *Polygonum* within features associated with fertility. Table 1. contains the mean values of compared characteristics and range of variability for each observed habitat.

All tested taxa showed the highest fertility in potato crops. Plants from this habitat produced the greatest number, the longest spikelet-like inflorescences. The average number of seeds per plant was measured in thousands and ranged from 1,525.4 in *P. lapathifolium* L. subsp. *pallidum* (With.) Fr. to 3,591.0 on *P. lapathifolium* L. subsp. *lapathifolium*. Amongst the plants of latter taxon, the most fertile specimen that produced almost 11,000 seeds was noted. This is not a surprise, many authors [Kwiecińska-Poppe 2006, Różyło, Pałys 2007] indicates just the crop roots as the best habitat for weed. The wide spacing of the rows, good natural light, high soil moisture, soil richness in nutrients resulting from manure, slow growth of potatoes in the early stages of development and long growing season and weaker competition conducive to high fertility weeds.

Plant seeds collected from the potato cultivation were also much bigger, as evidenced by higher than in plants of the other agroecosystems, the weight of 1000 seeds. According to Jankowska-Błaszczuk [1996], the weight of the seeds is a constant within species and there is greater variation. From observations, it is known that environmental conditions has a significant impact on the size and degree of seeds of the species.

The possibility of developing, producing fruit and seeds to weeds are greatly reduced in close-knit field cereals [Podstawka-Chmielewska et al. 2000 Kwiecińska 2004]. On these habitats, taxa of the genus *Polygonum* produced much less spikelet-like inflorescences and seeds, and in winter, crops were listed less frequently. Probably, it is connected with the term of *Polygonum* seed germination. Examined taxa require high temperatures to germinate with the optimum of 25–40°C. They germinate until late spring and early summer when the cultivated plant is in the stage of promoting provides stiff competition for germinated seeds [Klaaßen, Freitag 2004, Dobrzański 2009, Paradowski 2009].

After harvesting cereals, unploughed stubble often remains until late autumn become ideal for the growth and development of weed. Provide good thermal conditions, light and humidity prevailing in the post-harvest period. Undamaged plants during the harvest of cereals may pass the seeds, and plants cut during the harvest season grow back to form the branches of the generative organs [Jędruszczak 2000]. *P. persicaria* L., *P. lapathifolium* L. subsp. *lapathifolium* and *P. lapathifolium* L. subsp. *pallidum* (With.) Fr. on stubble produced more spikelet-like inflorescences; the first two species produced significantly more seeds than those of cereal crops.

Statistical treatment of the obtained results showed that the populations of *P. persicaria* L., *P. lapathifolium* L. subsp. *lapathifolium* and *P. lapathifolium* L. subsp. *pallidum* (With.) Fr.

Table 1. Mean values, range of variability and variation coefficient (V%) in *Polygonum persicaria* L., *Polygonum lapathifolium* L. subsp. *lapathifolium* and *Polygonum lapathifolium* L. subsp. *pallidum* (With.) Fr. populations between 2008 and 2010

Cultivated land Feature	Stubble		Root crops (potatoes)		Winter cereals		Spring cereals	
	Mean values (range of variability)	V%	Mean values (range of variability)	V%	Mean values (range of variability)	V%	Mean values (range of variability)	V%
<i>Polygonum persicaria</i> L.								
Number of inflorescences	18,1* (4–51)	62,59	67,9* (7–217)	68,95	5,1 (1–39)	120,8	6,3 (1–48)	112,1
Inflorescence length (cm)	0,9 (0,5–2,2)	36,72	1,5* (0,7–2,7)	29,06	1,2 (0,5–2,2)	29,72	1,2 (0,6–2,5)	34,88
Seed number per plant	174,7* (26–724)	76,85	1888,5* (63–8957)	90,77	65,7* (1–603)	145,92	113,6* (3–974)	129,89
Number of seeds in inflorescence	11,2 (2,9–37,6)	68,78	28,6* (4,9–117,3)	75,91	12,9 (0,33–29,4)	54,54	17,1 (3–50,6)	55,04
The 1000 seed weight (g)	1,55 (1,02–2,35)	19,43	1,82* (1,11–2,52)	22,42	1,503	•	1,383	•
<i>Polygonum lapathifolium</i> L. subsp. <i>lapathifolium</i>								
Number of inflorescences	23,5* (10–89)	64,32	82,2* (6–395)	86,61	3,3* (1–11)	79,15	7,0* (1–31)	86,14
Inflorescence length (cm)	1,0 (0,5–2,0)	33,74	1,9* (1,0–3,2)	27,05	1,1 (0,5–1,6)	23,63	1,0 (0,5–1,5)	23,71
Seed number per plant	298,1* (36–673)	67,43	3591,0* (118–10904)	93,74	38,1* (11–191)	94,5	112,5* (8–937)	143,2
Number of seeds in inflorescence	13,4 (3,3–35,7)	67,77	38,6* (10,6–98,2)	55,19	12,9 (2,6–31,8)	42,63	13,3 (2,7–32,3)	52,02
The 1000 seed weight (g)	2,17 (1,59–2,83)	17,71	2,58* (1,87–3,8)	19,06	1,84	•	2,02	•
<i>Polygonum lapathifolium</i> L. subsp. <i>pallidum</i> (With.) Fr.								
Number of inflorescences	11,2* (1–38)	69,29	47,2* (8–137)	69,6	4,5* (1–43)	148	7,6* (1–38)	92,19
Inflorescence length (cm)	0,8 (0,3–1,5)	29,41	1,6* (0,9–2,9)	29,26	1,0 (0,6–1,6)	25,82	1,1 (0,7–2,6)	28,28
Seed number per plant	58,9* (12–97)	45,31	1525,4* (148–4177)	68,11	73,2* (6–1203)	231,33	133,3* (10–869)	123,49
Number of seeds in inflorescence	5,0* (3,1–7,9)	41,73	32,5* (12,0–106,2)	54,92	13,6 (4–34)	49,82	16,4 (5–42,8)	50,51
The 1000 seed weight (g)	1,95	•	2,63* (1,54–3,88)	26,03	2,29	•	2,15	•

* significance at $\alpha = 0,05$.

growing in potato crops differ substantially in terms of the tested characteristics of the population of these taxa observed in other cultures.

The experiment carried out with the germination of seeds of *P. persicaria* L., *P. lapathifolium* L. subsp. *lapathifolium* and *P. lapathifolium* L. subsp. *pallidum* (With.) Fr. showed that they germinate better in the light than in the dark (Table 2). According to Woźnica [2008] and Dobrzański [2011], many weed species require light to germinate. It interrupts the period of dormancy of seeds and is a kind of protection against their premature germination on too much depth in the soil where seedling has no chance for further development.

Seeds of the studied taxa of the genus *Polygonum* germinated slowly; the appearance of the first roots was noted after about six to seven days. In addition, large variations in the percentage

of germinated seeds between populations of the same taxon were observed. These differences may result from the diversity of quality of seeds, their genetic and ecological variation [Ratuszniak et al. 2007].

None of the studied taxa showed germination after a month of storage from the collection of plants. For annual plants seeds without the camera flying characteristic is rest polymorphism, which prevents germination of all seeds at a time. Seeds that have not reached physiological maturity can be found in a state of deep rest, whilst those that have reached maturity relatively rest because of unfavourable external factors. This feature allows better use of habitat and promotes the collection of seeds in the soil [Czarnecka 1997, Ratuszniak et al. 2007]. Usually, most of the weed seeds entering into the soil in a given year germinate over the next four to six years. If the seeds germinate immediately

Table 2. Germination of seeds of *Polygonum persicaria* L., *Polygonum lapathifolium* L. subsp. *lapathifolium* oraz *Polygonum lapathifolium* L. subsp. *pallidum* (With.) Fr. depending on the time of storage

Seed storage time	% germinated seeds					
	<i>Polygonum persicaria</i> L.		<i>Polygonum lapathifolium</i> L. subsp. <i>lapathifolium</i>		<i>Polygonum lapathifolium</i> L. subsp. <i>pallidum</i> (With.) Fr.	
	Light	Darkness	Light	Darkness	Light	Darkness
1 month	0	0	0	0	0	0
1 year	0	0	2,33	1,00	19,00	3,67
3 years	4,54	3,56	27,32	17,11	89,12	81,32
5 years	0,80	0	8,60	4,67	19,40	11,17

Table 3. Effects of low temperature and gibberellic acid on germination of seeds of *Polygonum persicaria* L., *Polygonum lapathifolium* L. subsp. *lapathifolium* oraz *Polygonum lapathifolium* L. subsp. *pallidum* (With.) Fr. stored for five years.

Conditions of germination	% germinated seeds					
	<i>Polygonum persicaria</i> L.		<i>Polygonum lapathifolium</i> L. subsp. <i>lapathifolium</i>		<i>Polygonum lapathifolium</i> L. subsp. <i>pallidum</i> (With.) Fr.	
	Light	Darkness	Light	Darkness	Light	Darkness
Low temperature (4°C)	0	0	5,4	2,8	5,8	5,6
Gibberellic acid	1,2	0	5	4,4	11,2	10

after dumping, in the second half of summer or in autumn, the new plants will not develop generative organs and release seeds in the same year. They would die under the influence of low temperatures or mechanical treatments used in late autumn [Dobrzański 2009]. However, according to Timson [1965b], the seeds of some population of *P. lapathifolium* L. germinated well a month after harvesting the plants.

After one year of storage at room temperature in the dry seeds, *P. persicaria* L. was not germinated, whilst *P. lapathifolium* L. subsp. *lapathifolium* and *P. lapathifolium* L. subsp. *pallidum* (With.) Fr. germinated poorly. The best result was obtained on the seeds stored for three years, the viability of seeds of *P. lapathifolium* L. subsp. *pallidum* (With.) Fr. was several times higher than that of the seed of other species. The seeds of all studied taxa stored for five years showed a decline in germination.

Amongst the studied taxa seeds, *P. persicaria* L. germinated the least. Similar results were presented by Timson [1965b]. According to his reports, the seeds of this species stored at room temperature for one to three years did not germinate at all. Only several months of detention of seeds in cold water interrupts their retirement and reported a significant increase in germination. According to Ratuszniak et al. [2007], period of supercooled, next to the light, is for the seeds of many species of weed germination stimulus. The 48-hour period of storage of Petri dishes with seeds at a temperature of 4°C did not affect the growth of seed viability of the studied taxa (Table 3); on the contrary, it recorded a decline.

Rest of the seeds of species of the genus *Polygonum* depends on anatomy of the fruit and seed coat impervious to water [Timson 1965b]. The inhibitory effect of seed coat prevents rapid germination of seeds, even in the same year [Ratuszniak et al.

2007]. It can take place only when the pericarp is destroyed. Puncture or incision cover or destruction using acetone or sulphuric acid would initiate the process of germination [Timson 1965b]. Under natural conditions, the hard pericarp barrier is broken down during several months or even several years residence of seeds in moist soil.

According to Timson [1965b], the germination of seeds of the species of the genus *Polygonum* is a two stage process. The first stage is the swelling and opening of the pericarp, which is followed by the mobilisation of stored materials for a root and hypocotyl growth. During the experiments, we observed that amongst those seeds that were sown after a month of storage, the pericarp was overloaded but vegetative organs – root and hypocotyl – do not appear. This may indicate the insufficient progress of biochemical processes in seeds.

One of the chemical factors affecting the germination of seeds is gibberellic acid, a group of plant hormones that control the important processes of plants' growth and development [Marciniak et al. 2012, Gniazdowska et al. 2013]. Application of gibberellic acid did not significantly increase the number of germinated seeds of studied taxa of the genus *Polygonum* (Table 3.). Similar observations for the seeds of the *Sida hermaphrodita* were noted by Doliński et al. [2007]. In the case of *S. hermaphrodita*, only scarified seeds react positively to the presence of gibberellic acid.

4. CONCLUSIONS

1. The highest fertility of *P. persicaria* L., *P. lapathifolium* L. subsp. *lapathifolium* and *P. lapathifolium* L. subsp. *pallidum* (With.) Fr. was reached in root crops.

2. The seeds of the studied taxa germinated better in the light than in the dark.
3. The presence of light and moist soil do not break seed dormancy in *P. persicaria* L.
4. The most viable turned out to be seeds of *P. lapathifolium* L. subsp. *pallidum* (With.) Fr., for which a high percentage of germinated seeds were observed also in the dark.

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