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THE INFLUENCE OF WATER EXTRACTS FROM *Galium aparine* L. AND *Matricaria maritima* SUBSP. *inodora* (L.) DOSTÁL ON GERMINATION OF WINTER RYE AND TRITICALE

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Abstract. During the research, it was assessed how water extracts from *Galium aparine* and *Matricaria maritima* subsp. *inodora* affect the germination energy and capacity, as well as the length of the seedling root and the first leaf of the Dankowskie Zlote cultivar of *Secale cereale* and of the Janko cultivar of *Triticale rimpaui*. The experiment was conducted under laboratory conditions, with the use of Petri dishes. The influence of three concentrations of water extracts prepared from the dry and fresh mass of the plant's above-ground parts was examined. Petri dishes watered with distilled water constituted the control treatment. Water extracts prepared from the *Matricaria maritima* subsp. *inodora* dry and fresh mass and *Galium aparine* fresh mass reduced the germination capacity and energy of rye and triticale in direct proportion to the increase of concentration. Higher concentrations of water extracts reduced, to a significantly larger extent, the growth of the seedling roots of both species. Lowest-concentration water extracts from the *Matricaria maritima* subsp. *inodora* dry and fresh mass and from the *Galium aparine* fresh mass stimulated the growth of seedling root of the cereals under study. Higher concentrations of water extracts prepared from the *Galium aparine* and the *Matricaria maritima* subsp. *inodora* dry mass reduced, to a significantly larger extent, the growth of the first leaf.

Key words: allelopathy, cleavers, germination energy, germination capacity, scentless mayweed, winter cereals

INTRODUCTION

The mechanism of allelopathic effects consists in plants – donors – secreting to the environment chemical substances which modify the processes of growth and development of other plants – acceptors. This modification can have a inhibitory or stimulating character [Rice 1984, Oleszek 1996, Wójcik-Wojtkowiak et al. 1998]. The

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growth of agricultural crops is accompanied by development of weeds, whose harmfulness can be examined both in respect of their biology and the allelopathic potential. The phenomenon of allelopathy afects significantly changes occurring in field communities. These can be changes in species composition of weeds, but also disturbances of plant growth and yield. Allellopathic effect is complex and difficult to determine in field conditions, e.g. due to the impossibility of separating this phenomenon from plant competition for water, light and living space. This phenomenon can be indicated much easier under controlled laboratory conditions, where we can eliminate the competition factor [Duer 1996, Jaskulski 1997, Dzienia and Wrzesińska 2003]. The results of allelopathic effects can be varied, in plant production, the ability to use this phenomenon for biological control is the most essential. Allelocompounds can be used for plant protection against pests, increasing the resistance of field crops to diseases and as preparations applied for weed control. Herbicidal effect of this kind of compounds is of utmost importance, due to growing, high production costs of synthetic herbicides, as well as harmful effects of remains of chemical pesticides in the environment and in plant products [Bhowmik and Inderjit 2003, Mashkovska et al. 2004]. Studies over allelopathy aim at getting to know the effects between field crops in various cropping systems and between field crops and weeds [Bastek 1962, Bhowmik and Inderjit 2003].

The aim of this study was to estimate the effect of water extracts from *Galium aparine* and *Matricaria maritima* subsp. *inodora* on germination energy and capacity, as well as the length of the seedling root and the first leaf of winter rye of the Dańkowskie Złote cultivar and winter triticale of the Janko cultivar.

MATERIAL AND METHODS

The experiment was carried out in 2008. Water extracts made from the dry and fresh mass of the above-ground parts of *Galium aparine* L. and *Matricaria maritima* subsp. *inodora* (L.) Dostál were used in the study. Water extracts were made from 2 (B), 4 (C) and 8 g (D) of dry and fresh mass of the above-parts of plants (being at 8 main developmental stage according to the BBCH scale), per 100 cm^3 of distilled water [Adamczewski and Matysiak 2002]. After two days of soaking, the obtained solution was filtered through filtration paper. The experiment was conducted in 10 replications, in two series. Seeds of winter rye of the Dańkowskie Złote cultivar and of winter triticale of the Janko cultivar were germinated on a base consisting of two layers of filtration paper, on Petri dishes with a diameter of 10 cm. Cereal grains were sown 25 pieces on each dish. The paper was soaked with 20 ml the appropriate extract from the dry or fresh mass of the above-part of a weed and then watered daily with 10 cm^3 of the solution. The control was grains watered with distilled water (A). The research was conducted under laboratory conditions, in a thermostatic cabinet with the photoperiod 12/12 h, at 20^{o}C. The biometric analysis of cereal seedlings was conducted, after eight days, the length of the first leaf and the longest seedling root was determined. Measurements of germination energy and capacity were made according to the recommendations worked out by ISTA – International Rules for Seed Testing [2009]. Germination energy was assessed after 4 days and germination capacity of grains after 8 days. The results obtained were worked out statistically with the analysis of variance method, using the program ARStat of the Centre of Computer Sciences UP in Lublin.

Differences between the averages were assessed with Tuckey's test. The results of the study concerning germination energy and capacity were transformed with the function arcsin√x. The nomenclature of species proposed by Mirek et al. [2002] was used in the study.

RESULTS AND DISCUSSION

The effect of allelocompounds on germination of acceptor plant seeds is connected with their concentration in the environment. Water extracts, made from the fresh mass of *Galium aparine*, along with the growth in concentration decreased the germination energy of the tested plants. A similar relation was found concerning extracts from the dry mass of *Galium aparine*, except from a concentration of 4%, where germination energy was slightly higher than that in the treatment with the solution 2%. The highest applied concentrations of extracts from the dry and fresh mass of *Matricaria maritima* subsp. *inodora* as compared with the other concentrations significantly decreased the germination energy of grains of the tested cereal species (Table 1). Dzienia and Wrzesińska [2003] presented the inhibitory effect of mayweed on the germination energy of cereals (wheat, rye and triticale). Jaskulski [1999], in turn, indicated that water extracts of dicotyledonous weeds significantly decreased the germination energy of barley and wheat. In the authors' study, a varied sensitivity of species to allelocompounds was observed. Extracts from the fresh mass of mayweed had a more inhibitory effect on winter rye, as compared with winter triticale (Table 1). On dishes with grains watered with a water extract from the dry mass of *Galium aparine*, the observed interaction between the species and concentration indicates that at 4% concentration winter triticale was characterized with a significantly smaller germination energy than winter rye (Table 1). In treatments with triticale, watered with the extract of the lowest concentration from the dry mass of mayweed, a significantly higher germination energy was observed in relation to the treatments with rye. In the treatments watered with extracts from the fresh mass of mayweed, observed interactions between species and concentrations indicate that triticale in all the concentrations used – in comparison with rye – showed a significantly higher germination energy (Table 1).

A significant reduction in the germination capacity of grains watered with water extracts made from *Galium aparine* and *Matricaria maritima* subsp. *inodora* was observed at 8% concentration, in comparison with the other tested solutions and the control (Table 2). The proved interaction between species and concentrations indicates that active substances contained in extracts, from the fresh mass of mayweed at concentrations 2% and 4%, significantly decreased the germination capacity of winter rye as compared with triticale. It should be stressed, however, that extracts of relatively high concentrations were used in this study, and consequently, with considerable amounts of allelosubstances, usually not occurring in the natural conditions. At the same time, it is worth noting that the germination energy of winter triticale watered with extracts from *Matricaria maritima* subsp. *inodora* and the fresh mass of *Galium aparine* was slightly higher than germination capacity, which resulted from dying of already germinating grains. This indicates the presence of allelocompounds of inhibitory character in these extracts (Table 1, 2).

Table 1. Germination energy of winter rye and winter triticale watering with water extracts from *Galium aparine* and *Matricaria maritima* subsp. *inodora* (in the brackets present transformed data), %

Tabela 1. Energia kiełkowania żyta ozimego i pszenżyta ozimego podlewanych wodnymi wyciągami z *Galium aparine* i *Matricaria maritima* subsp. *inodora* (w nawiasach podano wartości transformowane), %

Concentration of water extract Stężenie wodnego wyciągu		Species – Gatunek		Mean Średnia
		winter rye żyto ozime	winter triticale pszenżyto ozime	
Dry mass of *Galium aparine* Sucha masa *Galium aparine*	A*	82 (1.26)	91 (1.36)	87 (1.31)
	B	48 (0.98)	47 (0.98)	48 (0.98)
	C	66 (1.12)	37 (0.89)	52 (1.01)
	D	23 (0.77)	13 (0.65)	18 (0.71)
	mean średnia	55 (1.04)	47 (0.98)	–
$LSD_{0.05}$ – $NIR_{0.05}$				
between concentration – między stężeniami			0.086	
for interaction – dla interakcji:				
species × concentration – gatunek × stężenie			0.144	
Fresh mass of *Galium aparine* Świeża masa *Galium aparine*	A*	79 (1.23)	84 (1.28)	82 (1.26)
	B	64 (1.11)	77 (1.21)	71 (1.16)
	C	46 (0.97)	68 (1.14)	57 (1.05)
	D	34 (0.87)	36 (0.91)	35 (0.88)
	mean średnia	56 (1.05)	66 (1.12)	–
$LSD_{0.05}$ – $NIR_{0.05}$				
between concentration – między stężeniami			0.100	
Dry mass of *Matricaria maritima* subsp. *inodora* sucha Masa *Matricaria maritima* subsp. *inodora*	A*	88 (1.32)	65 (1.12)	77 (1.21)
	B	57 (1.05)	75 (1.20)	66 (1.12)
	C	55 (1.04)	57 (1.05)	56 (1.05)
	D	33 (0.86)	39 (0.91)	36 (0.89)
	mean średnia	58 (1.06)	59 (1.07)	–
$LSD_{0.05}$ – $NIR_{0.05}$				
between concentration – między stężeniami			0.081	
for interaction – dla interakcji:				
species × concentration – gatunek × stężenie			0.136	
Fresh mass of *Matricaria maritima* subsp. *inodora* Świeża masa *Matricaria maritima* subsp. *inodora*	A*	55 (1.04)	68 (1.14)	62 (1.09)
	B	35 (0.88)	84 (1.28)	60 (1.08)
	C	33 (0.86)	77 (1.21)	55 (1.04)
	D	17 (0.70)	49 (0.99)	33 (0.86)
	mean średnia	35 (0.88)	70 (1.16)	–
$LSD_{0.05}$ – $NIR_{0.05}$				
between species – między gatunkami			0.040	
between concentration – między stężeniami			0.075	
for interaction – dla interakcji:				
species × concentration – gatunek × stężenie			0.126	

* A – control (without plant extract) – kontrola (bez wyciągu roślinnego)
B – concentration 2% – stężenie 2%
C – concentration 4% – stężenie 4%
D – concentration 8% – stężenie 8%

Table 2. Germination capacity of winter rye and winter triticale watering with water extracts from *Galium aparine* and *Matricaria maritima* subsp. *inodora* (in the brackets present transformed data), %

Tabela 2. Zdolność kiełkowania żyta ozimego i pszenżyta ozimego podlewanych wodnymi wyciągami z *Galium aparine* i *Matricaria maritima* subsp. *inodora* (w nawiasach podano wartości transformowane), %

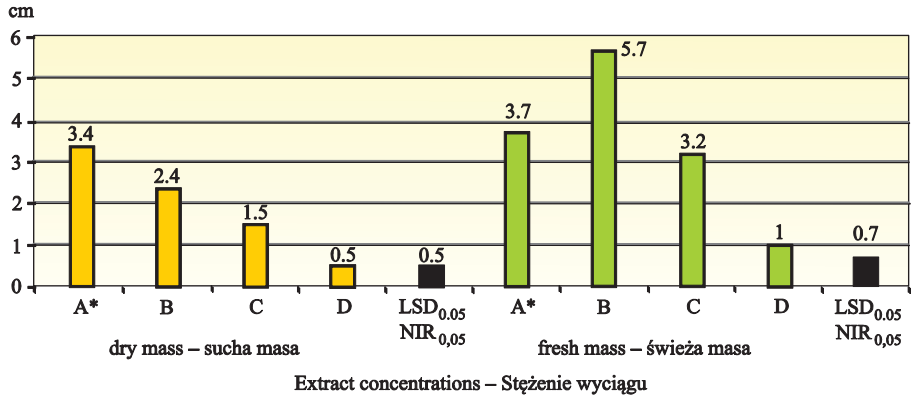
Concentration of water extract Stężenie wodnego wyciągu		Species – Gatunek		Mean Średnia
		winter rye żyto ozime	winter triticale pszenżyto ozime	
Dry mass of *Galium aparine* Sucha masa *Galium aparine*	A*	88 (1.32)	93 (1.38)	91 (1.36)
	B	65 (1.12)	77 (1.21)	71 (1.16)
	C	60 (1.08)	56 (1.05)	58 (1.06)
	D	24 (0.78)	31 (0.84)	28 (0.81)
	mean średnia	59 (1.07)	64 (1.11)	–
$LSD_{0.05}$ – $NIR_{0.05}$				
between concentration – między stężeniami		0.111		
for interaction – dla interakcji: species × concentration – gatunek × stężenie		0.187		
Fresh mass of *Galium aparine* Świeża masa *Galium aparine*	A*	91 (1.36)	90 (1.34)	91 (1.36)
	B	72 (1.17)	70 (1.16)	71 (1.16)
	C	50 (1.00)	66 (1.12)	58 (1.06)
	D	31 (0.84)	34 (0.87)	33 (0.86)
	mean średnia	61 (1.08)	65 (1.12)	–
$LSD_{0.05}$ – $NIR_{0.05}$				
between concentration – między stężeniami		0.141		
Dry mass of *Matricaria maritima* subsp. *inodora* sucha Masa *Matricaria maritima* subsp. *inodora*	A*	88 (1.32)	65 (1.12)	77 (1.21)
	B	63 (1.10)	69 (1.15)	66 (1.12)
	C	52 (1.01)	48 (0.98)	50 (1.00)
	D	24 (0.78)	22 (0.75)	23 (0.77)
	mean średnia	57 (1.05)	51 (1.01)	–
$LSD_{0.05}$ – $NIR_{0.05}$				
between concentration – między stężeniami		0.091		
for interaction – dla interakcji: species × concentration – gatunek × stężenie		0.152		
Fresh mass of *Matricaria maritima* subsp. *inodora* Świeża masa *Matricaria maritima* subsp. *inodora*	A*	69 (1.15)	68 (1.14)	69 (1.15)
	B	45 (0.96)	70 (1.16)	58 (1.06)
	C	40 (0.92)	59 (1.07)	50 (1.00)
	D	23 (0.77)	36 (0.89)	30 (0.83)
	mean średnia	44 (0.95)	58 (1.06)	–
$LSD_{0.05}$ – $NIR_{0.05}$				
between concentration – między stężeniami		0.072		
for interaction – dla interakcji: species × concentration – gatunek × stężenie		0.121		

* for explanations, see Table 1 – objaśnienia pod tabelą 1

The interaction observed between the species of the tested cereals and concentrations of extracts shows that in the treatments with rye and triticale watered with solutions from

the dry mass of *Galium aparine* and the dry and fresh mass of *Matricaria maritima* subsp. *inodora* with the concentration of 8%, germination capacity was significantly lower than in the other treatments. At the same time, winter triticale watered with 4% water extract from the dry mass of mayweed had a smaller germination capacity than that in the treatment with a lower concentration (Table 2).

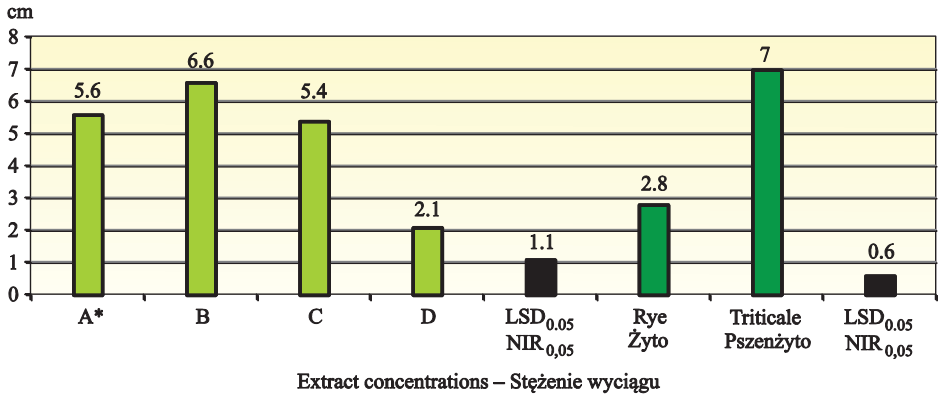
Stimulating effect of water extracts from *Galium aparine*, with low concentrations, on the growth of coleoptile and seedling roots of wheat was indicated by Duer [1996]. Also Jaskulski [1999] in his study observed similar relations, using e.g. extracts from cleavers. He found that extracts of low concentration from weed shoots stimulated the growth of barley seedlings, and they were neutral for wheat, whereas the extracts of higher concentrations had an inhibitory effect on the growth of seedlings of both cereals. Similar observations were made in the presented experiment. The largest length of seedling roots usually occurred in treatments watered with the lowest concentrations, whereas increasing concentration resulted in considerable shortening in the length of seedling roots. Duer [1988] indicated that allelopathins occurring in water extracts of the plants of *Galium aparine* caused a strong stimulation of growth of the seedling roots of tested cereals (wheat, barley, rye). Allellopathic potential depended on the concentration of an extract and cereal species sensitivity. In the presented study, the highest concentrations of all the extracts applied significantly shortened the length of seedling roots in comparison with the control and the other concentrations. Aziz et al. [2008] testing the effect of water extracts from *Galium aparine* on the germination and early growth of wheat indicated their reducing effect on root and shoot length; the extract from cleavers fruits turned out to be the most harmful, i.e. reducing shoot and root growth. In the conducted experiment, extracts with the lowest concentrations – both from dry and fresh mass of mayweed and from the fresh mass of cleavers – considerably stimulated growth in seedling roots of the tested cereal species. No such stimulation, however, was observed in the case of extracts from the dry weight of *Galium aparine* of the lowest concentration (Fig. 1, 2, 3). Additionally, the shortening of seedling roots of winter rye occurred to a significantly higher extent than in winter triticale in treatments watered with extracts from mayweed (Fig. 2, 3).



* for explanations, see Table 1 – objaśnienia pod tabelą 1

Fig. 1. The seedling root length of rye and triticale watered with extracts from *Galium aparine* dry and fresh mass

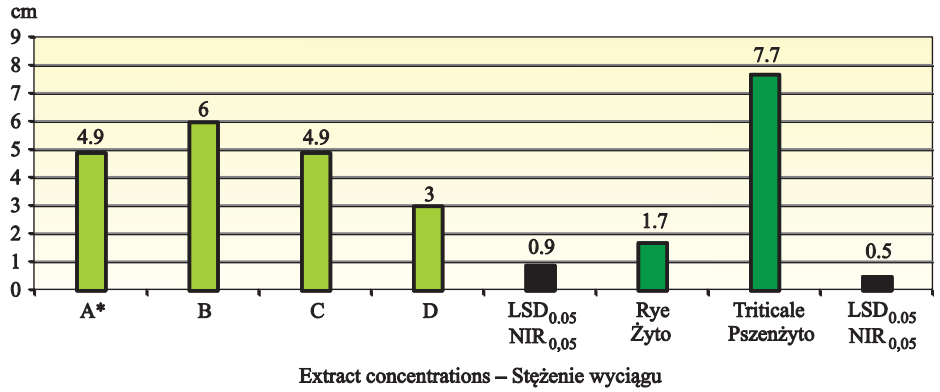
Rys. 1. Długość korzenia zarodkowego żyta i pszenżyta podlewanych wodnymi wyciągami z suchej i świeżej masy *Galium aparine*



* for explanations, see Table 1 – objaśnienia pod tabelą 1

Fig. 2. The seedling root length of rye and triticale watered with extracts from *Matricaria maritima* subsp. *inodora* dry mass

Rys. 2. Długość korzenia zarodkowego żyta i pszenżyta podlewanych wodnymi wyciągami z suchej masy *Matricaria maritima* subsp. *inodora*



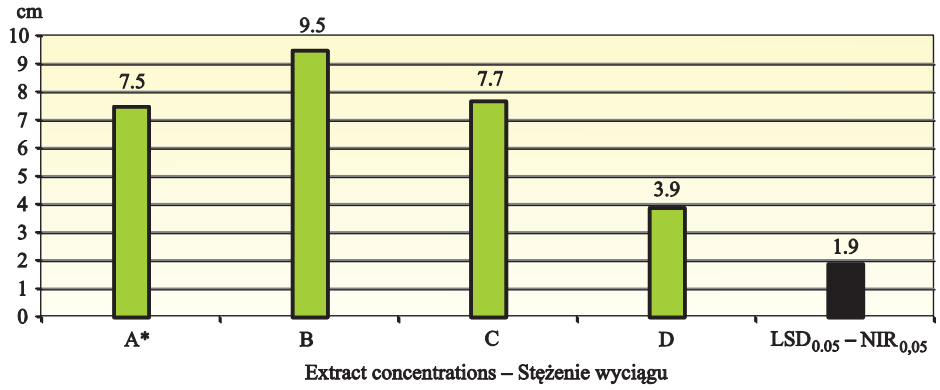
* for explanations, see Table 1 – objaśnienia pod tabelą 1

Fig. 3. The seedling root length of rye and triticale watered with extracts from *Matricaria maritima* subsp. *inodora* fresh mass

Rys. 3. Długość korzenia zarodkowego żyta i pszenżyta podlewanych wodnymi wyciągami ze świeżej masy *Matricaria maritima* subsp. *inodora*

Water extracts made from *Galium aparine* and *Matricaria maritima* subsp. *inodora* significantly differentiated also the length of the first leaves of the tested cereal species. Extracts from fresh mass of cleavers and the dry mass of mayweed, with the highest concentration, affected to the highest extent the shortening of the length of the first leaf as compared with the other concentrations (Fig. 4, 5). The results of many studies confirm the thesis that the effect of allelocompounds on seed germination is connected with their concentration [Bastek et al. 1962, Stachurska-Bac and Szczuwalska 1965, Polcyn 1999, Kraska and Kwiecińska-Poppe 2007]. Larger lengths of the first leaf were recorded while testing lower concentrations (2 and 4%) of extracts from the dry mass of

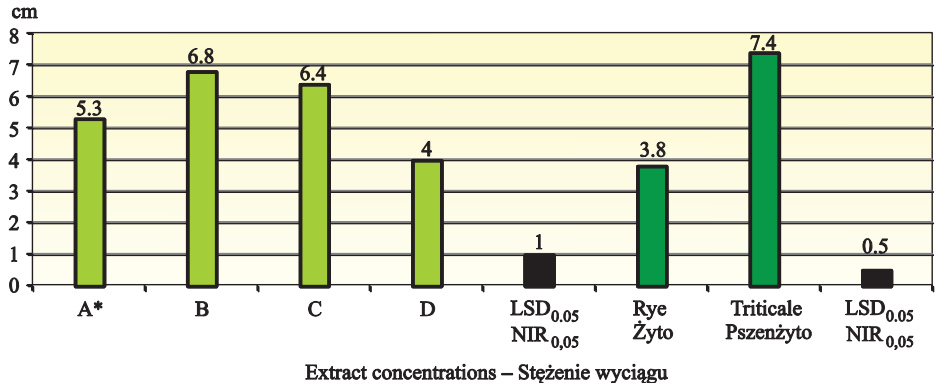
mayweed and 2% extract from the fresh mass of *Galium aparine* as compared with the control treatment, which can indicate their stimulating properties (Fig. 4, 5). Similar results were obtained by other authors [Chun et al. 1988, Duer 1988, Jaskulski 1999], who observed the stimulating effect of low-concentration solutions on the length of the first leave. The study by Oleszek [1996], on the effect of water extracts from cleavers on cereal germination also confirms the information showing that a small proportion of some weeds in the stand of a field crop can have a positive effect on its growth. Water extracts from mayweed considerably stimulated the growth in the first leaf of winter triticale in comparison with winter rye, which indicates different sensitivity of the tested cereal species (Fig. 5, 6).



* for explanations, see Table 1 – objaśnienia pod tabelą 1

Fig. 4. The first leaf length of rye and triticale watered with extracts from *Galium aparine* fresh mass

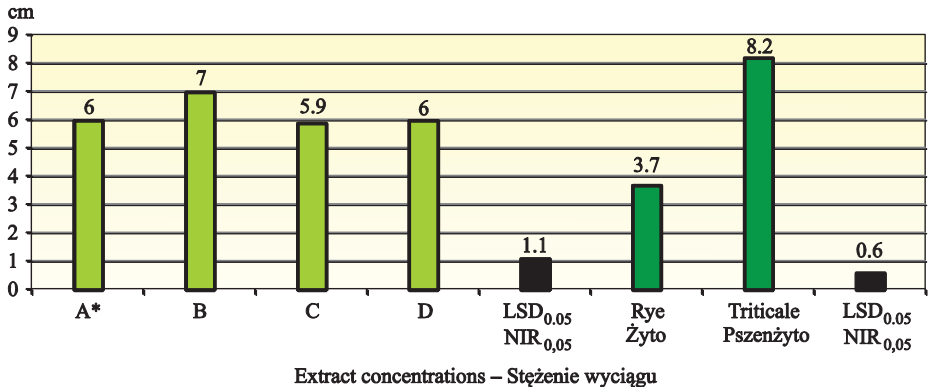
Rys. 4. Długość pierwszego liścia żyta i pszenżyta podlewanych wodnymi wyciągami ze świeżej masy *Galium aparine*



* for explanations, see Table 1 – objaśnienia pod tabelą 1

Fig. 5. The first leaf length of rye and triticale watered with extracts from *Matricaria maritima* subsp. *inodora* dry mass

Rys. 5. Długość pierwszego liścia żyta i pszenżyta podlewanych wodnymi wyciągami z suchej masy *Matricaria maritima* subsp. *inodora*



* for explanations, see Table 1 – objaśnienia pod tabelą 1

Fig. 6. The first leaf length of rye and triticale watered with extracts from *Matricaria maritima* subsp. *inodora* fresh mass

Rys. 6. Długość pierwszego liścia żyta i pszenżyta podlewanych wodnymi wyciągami ze świeżej masy *Matricaria maritima* subsp. *inodora*

Research over plant allelopathic potential creates a chance of their use in biological methods of weed control. Looking for chemical compounds of plant origin, which will enable the synthesis of natural herbicides, seem to be particularly important. The results obtained indicate the ability to undertake further, more detailed research. This includes the analyses of phytotoxins contained in particular parts of the tested species of plants and their effect on weed germination.

CONCLUSIONS

1. The significant effect of using water extracts from *Galium aparine* and *Matricaria maritima* subsp. *inodora* on germination of winter rye and triticale grains was indicated. The allelopathic potential of extracts depended on their concentration and origin.

2. Water extracts from the fresh weight of *Galium aparine* reduced the germination energy of winter rye and triticale in direct proportion to the growth in concentration.

3. Water extracts from *Galium aparine* and *Matricaria maritima* subsp. *inodora* applied in the highest concentrations lowered the germination capacity of grains and shortened the length of seedling roots of cereals. Extracts of the lowest concentrations, from the dry and fresh mass of mayweed and from the fresh mass of cleavers, stimulated the growth in seedling roots of both cereal species.

4. Water extracts from mayweed had a greater effect on the shortening of the length of seedling roots in rye than in triticale.

5. Extracts of the highest concentration, from the fresh mass of cleavers and the dry mass of mayweed, affected to the highest extent the shortening of the length of the first leaf. Growth stimulation of the first leaf was obtained after the application of lower concentrations of extracts from the dry mass of mayweed and from the fresh mass of cleavers.

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WPŁYW WODNYCH WYCIĄGÓW Z *Galium aparine* L. I *Matricaria maritima* SUBSP. *inodora* (L.) DOSTÁL NA KIEŁKOWANIE ŻYTA I PSZENŻYTA OZIMEGO

Streszczenie. W badaniach oceniono oddziaływanie wodnych wyciągów z suchej i świeżej masy *Galium aparine* i *Matricaria maritima* subsp. *inodora* na energię, zdolność kiełkowania oraz długość korzenia zarodkowego i pierwszego liścia *Secale cereale* (odmiany Dańkowskie Złote) oraz *Triticale rimpaui* (odmiany Janko). Wyciągi wodne sporządzone ze świeżej masy *Galium aparine* zmniejszały energię kiełkowania żyta i pszenżyta ozimego wprost proporcjonalnie do wzrostu stężenia. Wyciągi wodne o najwyższym stężeniu sporządzone z *Galium aparine* i *Matricaria maritima* subsp. *inodora* obniżały zdolność kiełkowania ziarniaków, a także istotnie skracały długość korzeni zarodkowych w porównaniu z pozostałymi badanymi roztworami oraz obiektem kontrolnym. Wyciągi o najniższym stężeniu, z suchej i świeżej masy maruny oraz świeżej masy przytulii, wyraźnie natomiast stymulowały wzrost korzeni zarodkowych badanych gatunków zbóż. Testowane wodne wyciągi w istotnie większym stopniu skracały długość korzeni zarodkowych żyta ozimego niż pszenżyta ozimego, co świadczy o różnej wrażliwości badanych gatunków zbóż. Wyciągi ze świeżej masy przytulii i suchej masy maruny, o najwyższym stężeniu, w największym stopniu skracały długość pierwszego liścia w porównaniu z pozostałymi stężeniami i kontrolą.

Słowa kluczowe: allelopatia, energia kiełkowania, maruna bezwonna, przytulia czepna, zboża ozime, zdolność kiełkowania

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