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Effect of *Morus alba* L. leaf extracts on seeds germination and the seedlings growth of *Sinapis alba* L. and *Cucumis sativus* L.

Introduction

Hans Molisch (1937) was the first to introduce and apply the concept of allelopathy to biological systems. He defined the mutual – both adverse and beneficial, biochemical interactions of all plants, including soil microorganisms as allelopathy (Wójcik-Wojtkowiak et al., 1998). The concept of allelopathy (Harborne, 1997) was consolidated in the second half of the 20th century as a result of pioneering research by Muller and Chou (1972), followed by Rice (1984). Currently, research on this phenomenon is growing because it is seen as an opportunity for more effective weed control; through learning about their allelopathic properties, natural compounds could be used to inhibit weed development (Vyvyan, 2002; Możdżeń et al., 2018).

Allelochemical substances that stimulate plant growth may actually act as inhibitors at high concentrations, and compounds considered to be inhibitors at low concentrations may stimulate some growth processes. There are more than 10,000 different allelopathic compounds, and the main sources of their mass release are from crop plants, weeds, and soil microorganisms (Leather, Einhellig, 1988; Barazani, Friedman, 2001; Weston, 2005; Kong et al., 2019). These compounds primarily belong to low-molecular-weight secondary metabolites (Rice, 1984; Einhelling, 1994). In the case of microorganisms, they can include enzymes involved in secondary metabolism pathways and antibiotics (Sturz, Christe, 2003).

Most allelopathic substances are highly soluble in water, hence they easily penetrate into the soil solution. The most common allelo-inhibitors include: organic acids, including phenolic acids; flavonoids; tannins; glycosides; terpenoids; alkaloids; unsaturated lactones; coumarins; and quinones. Allelopathins can be released into the immediate environment of plants through their various organs or parts: roots, seeds, fruits, flowers, and leaves. In the roots, inhibiting substances usually have weak

properties and occur in lower concentrations. One example of an exception to this is the root of alfalfa (*Medicago sativa* L.), which is actually the primary source of saponin inhibitors. Roots usually contain large amounts of allelopathic substances with a wide spectrum of activity. In seeds, inhibitors prevent rotting and control germination by imposing absolute dormancy. Fruits contain inhibitors that play a role in regulating seed germination. Some flowers also possess similar chemical substances (Gniazdowska, Bogatek, 2005).

Most researchers believe that, under balanced natural conditions, allelopathins from seeds, fruits, and flowers are not released in amounts that could pose a threat to nearby plants (Wójcik-Wojtkowiak et al., 1998). The concentration of allelopathic compounds depends on the season, the age of the plant, and ecological and habitat factors. Allelopathins are released in the highest amounts by young plants in spring as compared to mature and aging plants in autumn (Wardle et al., 1993; Ahmed, Wardle, 1994). The biological activity of allelopathic compounds is assessed relatively easily using biotests. The simplest biotest is seed germination. A more accurate method may be to measure plant growth parameters (Oleszek, 1992). The biotest that consists of measuring the mass of plants treated with allelopathic compounds is an order of magnitude more sensitive than the biotest based on seed germination, and the measurement of seedling growth is even five times more sensitive than that.

The aim of this study was to determine the effect of aqueous extracts of mulberry (*Morus alba* L.) leaves, with different percentage concentrations, on: (*1*) germination of mustard (*Sinapis alba* L.) and cucumber (*Cucumis sativus* L.) seeds – as crop plants, (*2*) their growth, and (*3*) the fresh and dry mass of underground and aboveground organs.

Material and methods

Plant material

Mulberry leaves (*Morus alba*) were collected in southern Poland, and then dried in laboratory conditions. Mustard (*Sinapis alba*) and cucumber (*Cucumis sativus*) seeds were purchased from PlantiCo Zielonki Spółka z.o.o., POLAN Cultivation and Seed Plant.

Extracts preparation

Aqueous extracts of dry mulberry leaves were prepared at three different percentage concentrations: 3, 5, and 10; for this purpose, 3 g of dry leaves were weighed and flooded with 97 ml of distilled water, 5 g of leaves were flooded with 95 ml of distilled water, and 10 g of leaves were flooded with 90 ml of distilled water, respectively. After 24 hours of extraction at room temperature and in the dark, the extracts were filtered

through Whatman type filter paper and stored in the 8°C temperature for the duration of the experiment.

Seeds preparations and germination conditions

Fifty seeds, mustard or cucumber, were rinsed with running and distilled water and placed on sterilised Petri dishes with filter paper, moistened with prepared extracts. The control consisted of seeds on Petri dishes with distilled water. All seed dishes were placed in a dark 25°C thermostat. The percentages of germinated seeds were checked systematically after 24, 48, 72, and 96 h. To be considered a germinated seed, the sprout length was equal to or higher than 2 mm (Możdżeń et al., 2018).

Plant growth

Proceeding analogously as in the first stage of the experiment (germination), Petri dishes were prepared with filter paper moistened with distilled water (control) and mulberry extracts. On each of the 7 Petri dishes 50 mustard or cucumber seeds were placed, after washing under running and distilled water. The Petri dishes were placed in a dark, 25°C thermostat for 48 h. In the meantime, 70 pots were prepared with sand washed in running and distilled water. Morphologically similar mustard and cucumber seedlings were planted into 35 pots, from controls and extracts, previously rinsed with distilled water. Seedlings were watered alternately every 48 h with 15 ml distilled water per plant and 10 ml Steiner medium per plant (Steiner, 1961). The mustard and cucumber seedlings that were germinated in distilled water were planted in the remaining 35 pots. Seedlings were watered alternately every other day with distilled water (15 ml/plant) and mulberry extracts (5 ml/plant) and once a week with Steiner medium (10 ml/plant). All pots were placed in a growth chamber, with a light intensity of 200 $\mu mol \times m^{-2} \times s^{-1}$, in the photoperiod 12 h/12 h, day temperature 25°C, night temperature 20°C, and relative humidity (RH) 70–80%.

Biometric analysis

Biometric analysis of mustard and cucumber organs was carried out on day 21 since planting the seedlings in the pots with sand. Plants were removed from pots and their roots were washed in water and dried with paper towel. Using a ruler, with an accuracy of 1 mm, the length of the root, hypocotyl, petioles and remaining part of the shoot, among other parts, was measured.

Fresh and dry mass

The fresh mass of mustard and cucumber organs was determined using an electronic scale (Radwag 120 WPS, Poland). To obtain the dry mass, open Petri dishes with plants were placed in a dryer (WAMED SUP-100, Poland) for 48 h at a temperature

of 105°C. The dried plant material was placed in a desiccator for 1.5 h. After this time, the dry mass of the plants was determined on an electronic scale, with an accuracy of 0.1 mg.

Statistical analysis

The statistical analysis of significance differences between the means ±SE were made by Tukey test at $p \leq 0.05$ in StatSoft, Inc. (2018).

Results

Seeds germination

A much higher percentage of mustard seeds germinated under control conditions than on aqueous mulberry leaf extract (Tab. 1). 58% of seeds watered with distilled water began germination after 24 h. This percentage subsequently increased and after 72 h reached 92%. Germination of mustard seeds on 3% extract began after 48 h, when 4% of seeds had germinated; after 96 h, the seeds had germinated to a level of 40% less than control. Petri dishes saturated with 5 and 10% extracts exhibited germination delayed by 2 and 3 days, respectively, from the time when the seeds were placed on the extracts. As a result, after 96 h, 14% of seeds germinated on the 5% extract and only 8% had germinated on the 10% extract.

Tab. 1. Germination seeds capacity [%] of mustard (*Sinapis alba* L.) – A and cucumber (*Cucumis sativus* L.) – B, on the aqueous mulberry leaves extracts (*Morus alba* L.)

Time [h]	Control		Concentration of *Morus alba* extracts [%]					
			3		5		10	
	A	B	A	B	A	B	A	B
24	58	78	0	72	0	74	0	22
48	87	94	4	90	0	94	0	72
72	92	94	28	92	8	96	0	80
96	92	94	52	92	14	96	8	82

Cucumber seeds on Petri dishes with aqueous mulberry extract began to germinate after the first day (Tab. 1); after this time point, the percentage of germinated seeds was lower than in the control sample. Starting from day 2, the percentage of germinated seeds on the 3 and 10% extracts decreased. However, the percentage of germinated seeds on the 5% extract after the second day was the same as in the control; after 3 and 4 days it remained at a level 2% higher than the control. The use of an extract with a concentration of 10% most strongly inhibited the germination of cucumber seeds.

Tab. 2. Length of selected mustard organs (*Sinapis alba* L.) for plants watered with extracts of mulberry leaves (*Morus alba* L.): A – during germination phase, B – during growth phase; mean ±SE values from 5 replicates marked with different letters differ significantly according to Tukey test at $p \leq 0.05$

Organ length [cm]	Control	Concentration of *Morus alba* extracts [%]					
		3		5		10	
		A	B	A	B	A	B
Root	5.6 a	4.6 ab	5.1 a	4.8 ab	3.5 b	0.0 cde	3.8 b
Hypocotyl	5.5 a	4.4 b	4.8 b	4.4 b	4.5 b	0.0 cde	4.5 b
Petioles of leaf	1.2 a	1.3 a	1.0 ab	1.0 ab	0.6 b	0.0 cde	0.3 b
Remaining part of shoot	1.7 b	2.3 a	0.5 c	2.2 a	0.0 d	0.0 cde	0.0 d

Biometric analysis

Biometric analysis of mustard organs revealed an adverse effect on root growth and hypocotyls for plants grown from seeds watered with extracts for 48 h. These organs were shorter than similar organs grown in control plants (Tab. 2). Slight changes in length were observed for leaf petioles. Growth in 3 and 5% extracts resulted in increased lengths of the remaining parts of the shoot, relative to the control. The 10% concentration extracts completely inhibited growth and development of the tested plants. Compared to control, the length of mustard plant organs from seedlings watered with mulberry extracts during the growth period was significantly inhibited. Regardless of the time point of watering, 10% extracts exerted the most adverse effect on plant growth.

Tab. 3. Length of selected cucumber organs (*Cucumis sativus* L.) for plants watered with extracts of mulberry leaves (*Morus alba* L.): A – during germination phase, B – during growth phase; mean ±SE values from 5 replicates marked with different letters differ significantly according to Tukey test at $p \leq 0.05$

Organ length [cm]	Control	Concentration of *Morus alba* extracts [%]					
		3		5		10	
		A	B	A	B	A	B
Root	15.8 b	23.8 a	7.6 c	21.1 a	6.1 cd	7.3 c	5.6 d
Hypocotyl	5.1 a	5.1 a	4.0 b	5.3 a	4.1 b	4.5 b	5.7 a
Petioles of leaf	2.1 a	2.2 a	1.4 b	2.3 a	1.4 b	2.1 a	1.5 b
Remaining part of shoot	1.8 ab	2.0 a	1.3 b	2.4 a	1.1 b	0.6 c	1.2 b

Fresh and dry mass

Measurement of fresh and dry mustard organ masses revealed that 3% extract as a seed germination medium resulted in an increase in the value of all tested parameters compared to control (Tab. 4–5). The 5% extract resulted in an increase in fresh mass only for cotyledons and the remaining part of shoot. The dry mass of the cotyledons of plants watered with 3% and 5% extracts in germination phase, exceeded the dry mass of the control. Dry mass values for other organs were significantly lower

than in the control. The percentage of water content in mustard organs was lower for each of the extract concentrations used (Fig. 1A – Appendix 1).

Tab. 4. Fresh mass of selected mustard organs (*Sinapis alba* L.) for plants watered with extracts of mulberry leaves (*Morus alba* L.): A – during germination phase, B – during growth phase; mean ±SE values from 5 replicates marked with different letters differ significantly according to Tukey test at $p \leq 0.05$

Organ fresh mass [mg]	Control	Concentration of *Morus alba* extracts [%]					
		3		5		10	
		A	B	A	B	A	B
Root	496.6 ab	562.2 a	288.8 b	436.6 ab	174.4 c	0.0 e	120.0 cd
Hypocotyl	944.4 a	1006.6 a	598.8 c	768.6 b	338.8 d	0.0 e	344.4 d
Cotyledons	770.0 b	906.6 a	694.4 bc	1056.6 a	572.2 c	0.0 e	406.6 d
Petioles of leaf	132.2 b	164.4 a	84.4 c	98.6 bc	24.4 d	0.0 e	16.6 de
Leaf blades	740.0 a	762.2 a	446.6 b	468.8 b	138.8 c	0.0 e	114.4cd
Remaining part of shoot	116.6 bc	298.8 a	16.6 c	148.8 b	0.0d	0.0 e	0.0 d

The fresh and dry mass of mustard organs from plants watered during the growth phase with the extracts were significantly lower than the control values (Tab. 4–5). The mass values varied depending on the concentration of the extract; as the concentration of allelopathins increased, a decrease in the values of these parameters was observed. The water content in plant organs decreased as the concentration of extracts increased (Fig. 1B – Appendix 1).

The fresh mass of cucumber organs grown from seeds germinating for 48 h on 3 and 5% extracts increased with an increase in the concentration of allelopathins in the extracts (Tab. 6). The exception were leaf petioles and the remaining part of the shoot, whose masses were less than the fresh mass of control plants. Plants grown from seeds germinating on 10% mulberry extract had a lower fresh mass for almost all organs, compared to the control. Similar results were obtained for cucumber dry mass (Tab. 7). The water content of the cucumber organs was lower than the control. An increase in the water content value for organs watered with 10% mulberry extracts was observed (Fig. 1C – Appendix 1).

The fresh and dry mass of cucumber organs from plants watered with extracts during the growth phase was generally less than the masses of control plants (Tab. 6–7). Mulberry extracts with a concentration of 3 and 5% caused a significant increase in fresh and dry mass of cotyledons and the 10% extract increased leaf mass. In the case of percentage water content, no statistically significant differences were observed (Fig. 1D – Appendix 1).

Tab. 5. Dry mass of selected mustard organs (*Sinapis alba* L.) for plants watered with extracts of

mulberry leaves (*Morus alba* L.): A – during germination phase, B – during growth phase; mean ±SE values from 5 replicates marked with different letters differ significantly according to Tukey test at $p \leq 0.05$

Organ dry mass [mg]	Control	Concentration of *Morus alba* extracts [%]					
		3		5		10	
		A	B	A	B	A	B
Root	180.0 b	234.4 a	74.4 c	176.6 b	65.5 c	0.0 d	50.0 c
Hypocotyl	40.0 ab	52.2 a	27.7 c	40.0 ab	25.5 c	0.0 d	24.4 c
Cotyledons	48.8 b	54.4 ab	41.1 bc	60.0 a	40.0 bc	0.0 d	40.0 bc
Petioles of leaf	6.0 b	14.4 a	4.4 b	6.6 b	2.2 c	0.0 d	0 d
Leaf blades	74.4 a	80.0 a	45.5 b	46.6 b	30.0 c	0.0 d	20.0 cd
Remaining part of shoot	16.6 b	34.4 a	2.2 c	16.6 b	0.0 d	0.0 d	0 d

Tab. 6. Fresh mass of selected cucumber organs (*Cucumis sativus* L.) for plants watered wit–h extracts of mulberry leaves (*Morus alba* L.): A – during germination phase, B – during growth phase; mean ±SE values from 5 replicates marked with different letters differ significantly according to Tukey test at $p \leq 0.05$

Organ fresh mass [mg]	Control	Concentration of *Morus alba* extracts [%]					
		3		5		10	
		A	B	A	B	A	B
Root	579.6 b	803.4 a	408.8 bc	846.2 a	315.8 c	219.5 d	255.8 cd
Hypocotyl	216.2 a	219.2 a	169.0 c	226.8 a	152.0 c	180.5 b	269.8 a
Cotyledons	335.6 b	389.2 b	496.6 a	421.0 a	448.2 a	352.5 b	291.8 c
Petioles of leaf	86.2 ab	70.4 b	35.4 d	101.0 a	39.0 c	45.0 c	72.4 b
Leaf blades	435.6 b	496.8 a	93.8 e	545.8 a	154.6 d	292.0 c	470.0 a
Remaining part of shoot	59.0 b	55.2 b	35.4 c	86.2 a	32.2 c	24.2 d	39.0 c

Tab. 7. Dry mass of selected cucumber organs (*Cucumis sativus* L.) for plants watered with extracts of mulberry leaves (*Morus alba* L.): A – during germination phase, B – during growth phase; mean ±SE values from 5 replicates marked with different letters differ significantly according to Tukey test at $p \leq 0.05$

Organ dry mass [mg]	Control	Concentration of *Morus alba* extracts [%]					
		3		5		10	
		A	B	A	B	A	B
Root	43.2 b	116.2 a	45.6 b	123.6 a	43.6 b	33.2 c	42.4 b
Hypocotyl	11.2 a	11.8 a	8.6 b	12.2 a	7.8 c	8.5 b	10.8 b
Cotyledons	25.4 c	29.2 b	48.0 a	30.8 b	37.8 ab	26.2 bc	22.0 c
Petioles of leaf	4.0 ab	3.6 b	1.8 d	4.8 a	1.8 d	2.5 c	3.8 b
Leaf blades	45.4 b	52.0 a	9.2 de	54 a	14.2 d	30.2 c	48.0 b
Remaining part of shoot	4.2 b	4.2 b	2.8 c	5.6 a	2.6 c	2.0 d	2.8 c

Discussion

This experiment demonstrated the adverse effects of mulberry leaf extracts on the germination and growth of mustard and cucumber (Tab. 1–7). Considering the fact that most allelopathics are phenolic compounds that belong to secondary metabolites (Grześkowiak, Łochyńska, 2017), it can be assumed that, to a large extent, they could be responsible for inhibiting the germination process of the analysed species. Allelopathic substances already exert negative effects during the seed swelling process and then disrupt the metabolic processes that occur in the germinating seed. In this study, each concentration significantly inhibited mustard seed germination (Tab. 1). However, for cucumber the reactions were slightly different and likely related to the size of seeds and other structures of the seed coat (Możdżeń, Rzepka, 2017; Mazur, 2019). The percentage of germinated cucumber seeds, for low concentrations of mulberry extracts (3 and 5%), did not differ greatly from the percentage of germinated seeds for distilled water (Tab. 1). Only at a 10% concentration of mulberry extract was a significant germination delay observed. Zandi et al. (2018) showed that aqueous extracts from *Stellaria media* L. (Vill.) at low concentrations stimulated seed germination of *Raphanus sativus* var. *radicula*, and extracts from *Helianthus annuus* L., regardless of concentration, inhibited growth of *Sinapis alba* L. cv. Barka (Puła et al., 2020). The negative effect of 10% mulberry extract on seed germination was probably due to the higher content of allelochemical compounds in the extracts. These results suggest that mulberry extracts caused oxidative stress due to allelopathins. After use of allelopathic compounds, plant tissues increased the production of reactive oxygen species which caused lipid peroxidation and oxidative damage (Ding et al., 2020). Inhibition of germination is a secondary effect of allelopathics. Before their effects become visible, allelopathic substances first affect metabolic changes and physiological processes (Możdżeń et al., 2018; Szafraniec et al., 2019), such as cell membrane permeability and water-ion balance (Skrzypek et al., 2015).

In this experiment, the action of 10% mulberry extract was the most apparent; watering mustard seeds with it for 48 h completely inhibited their development and similarly to cucumbers caused a reduction in the length of individual organs and their fresh and dry mass (Tab. 2–7). This effect was probably associated with a high concentration of allelo-inhibitors (Możdżeń et al., 2020). Inhibition of plant growth may result from the delay or incubation of mitotic divisions and reduction of cell elongation (Vaughan, Ord, 1991). Rice (1984) believed that allelopathic substances inhibit cell division and elongation by deforming the nucleus and strong cell vacuolisation. Inhibition of plant growth may also be associated with a reduction in nutrient uptake due to impaired membrane integrity (Klein, Blum, 1990; Baziramakenga et al., 1995; Możdżeń et al., 2016), inhibition of plasmolemic proton pump activity, which plays

a key role in the growth of plant cells (Janicka-Russak et al., 2004), or with changes in hormonal balance (Rice, 1984; Vaughan, Ord, 1991; Wójcik-Wojtkowiak, 1998). The effects of phenolic compounds can be observed in this study, as mentioned previously (Grześkowiak, Łochyńska, 2017). Phenols reduce protein biosynthesis, disrupt lipid metabolism, and inhibit the synthesis of porphyrin compounds, including chlorophyll synthesis (Wójcik-Wojtkowiak, 1998). In this experiment, symptoms of chlorosis were noted in mustard plants watered with 10% extracts. Bright patches on the leaf surface indicated a chlorophyll deficiency and most likely affected photosynthesis and dark respiration (Einhelling, 1994; Hussain, Reigosa, 2011; Możdżeń, Repka, 2014; Skrzypek et al., 2015). Inhibitory activity of allelopathic compounds includes disorders of oxidative phosphorylation, reduction of ATP levels, and reduction of oxygen uptake. Energy deficiency interferes with active transport of substances within the plant and functioning of cytoplasmic membranes for which a constant supply of metabolic energy is necessary (Barkosky, Einhelling, 2003; Einhelling, 1994).

Many studies (e.g. Wójcik-Wojtkowiak, 1998; Hussain, Reigosa, 2011; Możdżeń et al., 2018, 2020) indicate that allelochemical compounds interfere with water intake, its transport, and cause its gradual loss. As a result of these phenomena, they reduce the intensity of transpiration, induce the closing of stomata, and reduce the overall and active sorption surface of the roots. In studies with mulberry leaf aqueous extracts, differences were found in the water content of mustard and cucumber organs treated with this type of extracts (Fig. 1 – Appendix 1). The withering of mustard plants watered with 10% mulberry extract may have been a sign of irregularities in the uptake of water by the roots and reduction of their sorption surface.

It is not known whether the production of plant allelopathic substances is a deliberate strategy developed to counter competition or an accidental occurrence, preserved in subsequent generations, allowing the plant to synthesise an advantage over other plants in a particular ecosystem (King, 2003). Whittaker (1972) put forward the theory that allelopathic interactions of chemical compounds present in plants are created as a result of pressure from herbivores. It was intended to be a reaction that repelled herbivores by releasing plant secretions from leaves, stems, and roots into the environment. These types of substances may have accidentally played a role in plant-plant interactions. Because they gave the plant the benefit of reduced competition, their synthesis was maintained. The need to reduce the use of chemicals in horticulture and agriculture, due to the high costs of synthetic plant protection products and the emergence of herbicide-resistant weeds, provides an opportunity to use allelopathy as a source of safer substances that improve the quality of agricultural production (Cheng, Cheng, 2015). This is why plant-based chemicals are constantly being sought as a basis for synthesising natural herbicides (Duke et al., 2000; Vyvyan, 2002; Gniazdowska, Bogatek, 2005).

Conclusion

(1) The aqueous extracts of mulberry leaves (*Morus alba* L.) inhibited the germination of mustard seeds (*Sinapis alba* L.); as the concentration of extract increased, the time of seed germination was delayed and number of germinating seeds significantly decreased; for cucumber (*Cucumis sativus* L.) significant inhibition of the seed germination process was only observed with 10% mulberry extract, as compared to control.
(2) Regardless of the concentration of extracts and the time point of watering, a negative effect of mulberry leaf extracts on mustard and cucumber growth was demonstrated; mustard plants were more sensitive to extracts than cucumber plants.
(3) Fresh and dry mass of organs grown from seeds germinated on substrates with mulberry extracts in low concentrations was higher than in the control; with increasing extract concentration, regardless of the time point of watering with extracts, the tested plants were characterised by a smaller increase in fresh and dry mass for almost every organ compared to control; differences in percentage water content depended on the plant organ, extract concentration, and watering time.

Conflict of interest

The author declares no conflict of interest related to this article.

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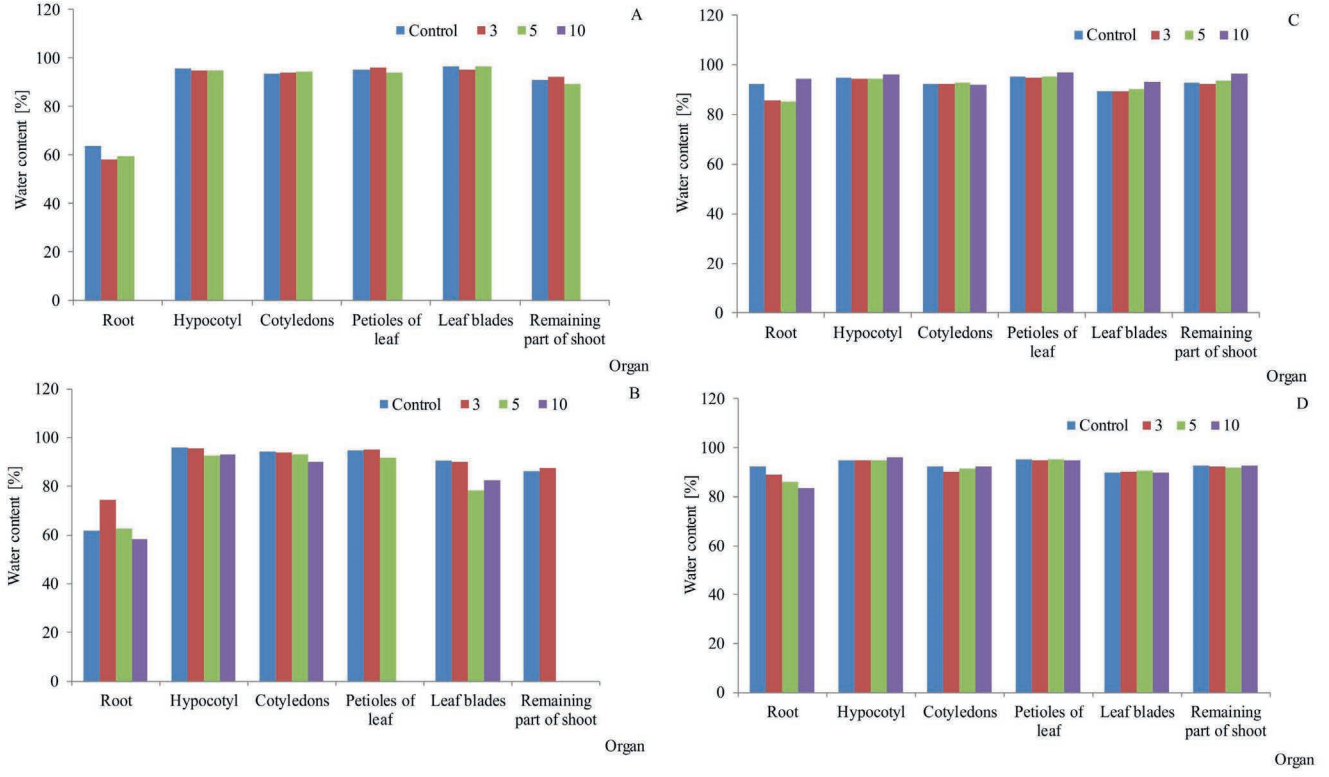

Fig. 1. A water content of organs in mustard (*Sinapis alba* L.) – A, B and cucumber (*Cucumis sativus* L.) – C, D, for plants watered with extracts of mulberry leaves (*Morus alba* L.): A, C – during germination phase, B, D – during growth phase (mean values from 5 replicates)

Abstract

Plant growth and development can be modified, including modification by chemical processes that result from neighbouring plants. If interactions in the natural environment between one plant and another are of a chemical nature, then this phenomenon is called allelopathy. The aim of the study was to determine the effect of aqueous extracts of *Morus alba* L., at concentrations of 3%, 5% and 10%, on the germination and growth of *Sinapis alba* L. (mustard) and *Cucumis sativus* L. (cucumber). It was found that allelopathins contained in the extracts slowed the germination of both species. The highest, 10%, extracts significantly inhibited germination. It was found that with an increase in allelopathin concentration, there was a significant inhibition of the growth of underground and above-ground plant organs. A complete lack of growth was observed for mustard plants grown from seeds watered with extracts during germination for 48 hours. Compared to the control plants, a differences in the growth of fresh and dry mass in plants watered with extracts during the germination and growth phases were found. Depending on the timing of treatment and the type of organ tested, aqueous mulberry leaf extracts at lower concentrations had a positive effect on the growth and development of the analysed species. Extracts with a higher concentration of chemical compounds had a negative impact on both mustard and cucumber.

Key words: aqueous extract, *Cucumis sativus* L., fresh and dry mass, plants length, *Sinapis alba* L.

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Wpływ wyciągów z liści *Morus alba* L. na kiełkowanie oraz wzrost *Sinapis alba* L. i *Cucumis sativus* L.

Streszczenie

Wzrost i rozwój roślin jest modyfikowany, m.in. przez procesy chemiczne, wynikające z sąsiedztwa innych roślin. Jeśli oddziaływania w środowisku naturalnym jednej rośliny na drugą mają charakter rywalizacji chemicznej, to zjawisko określa się mianem allelopatii. Celem przeprowadzonych tu eksperymentów było zbadanie wpływu wodnych wyciągów z liści *Morus alba* L., o stężeniach 3%, 5% i 10%, na kiełkowanie i wzrost *Sinapis alba* L. oraz *Cucumis sativus* L. Okazało się, że zawarte w ekstraktach allelopatiny spowalniały kiełkowanie nasion obydwu gatunków. Najwyższe, 10% ekstrakty, wyraźnie ograniczały zdolność kiełkowania. Stwierdzono, że wraz ze wzrostem koncentracji allelopatin następowało istotne zahamowanie wzrostu organów podziemnych i nadziemnych badanych roślin. Całkowity brak wzrostu wykazano dla roślin gorczycy wyrosłych z nasion podlewanych wyciągami w czasie kiełkowania przez 48 h. W porównaniu z roślinami z kontroli, wykazano zróżnicowanie przyrostu świeżej i suchej masy u roślin podlewanych ekstraktami w fazach: kiełkowania oraz wzrostu. W zależności od czasu traktowania i od rodzaju badanego organu, wodne wyciągi z liści morwy w niższych stężeniach miały pozytywny wpływ na wzrost i rozwój analizowanych gatunków. Ekstrakty o większej koncentracji związków chemicznych wpływały negatywnie, zarówno na gorczycę, jak i na ogórka.

Słowa kluczowe: wyciągi wodne, *Cucumis sativus* L., świeża i sucha masa, wzrost roślin, *Sinapis alba* L.

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