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INFLUENCE OF WATER EXTRACTS FROM SELECTED WEEDS ON GERMINATION AND GROWTH OF MAIZE SEEDLING

Summary

The aim of the presented research was to determine the influence of aqueous extracts from selected common weeds, such as tansy (Tanacetum vulgare L.), goldenrod (Solidago virgaurea L.) and soapweed (Saponaria officinalis L.) on the germination capacity and initial development of maize (Zea maize L.). The research was carried out using a modified short-term germination test and early growth of Phytotoxkit plants. The tests were carried out in three series of three replications. The series were made at two-week intervals. During the experiment, the germination capacity of maize seed was determined based on the amount of normally germinated caryopses after 5 days from the time of sowing, and after the end of the experiment the length of roots and shoots was measured. Water extracts were made from dried individual parts of weeds (flowers, leaves and roots). Among the analyzed extracts, the strongest effect of maize roots growth, inhibition was caused by the extract made from soapweed leaves (80%), while water extracts from tansy leaves and goldenrod leaves limited root development to 50%. However, the extracts from the flowers of tansy and goldenrod leaves caused over 30% inhibition of root growth. Maize shoots showed greater tolerance for the presence of analyzed water extracts. The strongest inhibition of shoots development did not exceed 25% and was observed in the presence of tansy root extract, as well as the water extracts from leaves and root of soapweed and goldenrod flower. In conclusion, the obtained results indicate that aqueous extracts of common weeds may negatively effects on the germination and seedlings growth of maize. The impact depends on the type of plant from which the extract was made.
***Key words**: phytotoxicity, water extract, maize, weeds, germination*

WPŁYW WODNYCH WYCIĄGÓW Z WYBRANYCH CHWASTÓW NA KIEŁKOWANIE I POCZĄTKOWY ROZWÓJ SIEWEK KUKURYDZY

Streszczenie

Celem prezentowanych badań było określenie wpływu wodnych wyciągów z wybranych pospolitych chwastów, takich jak wrotycz, nawłoć oraz mydlnica na zdolność kiełkowania i początkowy rozwój kukurydzy (Zea maize L.). Badania przeprowadzono z wykorzystaniem zmodyfikowanego krótkoterminowego testu kiełkowania oraz wczesnego wzrostu roślin Phytotoxkit. Badania przeprowadzono w trzech seriach po trzy powtórzenia. Serie wykonano w dwutygodniowych odstępach czasowych. Podczas realizacji doświadczenia określono zdolność kiełkowania ziarniaków kukurydzy na podstawie ilości normalnie kiełkujących ziarniaków po upływie 5 dni od momentu wysiania, a po zakończeniu eksperymentu zmierzono długość korzeni zarodkowych oraz pędów. Wodne wyciągi sporządzono z wysuszonych poszczególnych części roślin (kwiatów, liści oraz korzeni). Spośród analizowanych wyciągów najsilniejszy efekt zahamowania wzrostu korzeni kukurydzy wywoływał ekstrakt sporządzony z liści mydlnicy (80%), z kolei ekstrakty wodne z liści wrotyczu i kwiatów nawłoci ograniczały rozwój korzeni w 50%. Natomiast ekstrakty z kwiatów wrotyczu oraz liści nawłoci powodowały ponad 30% inhibicję wzrostu korzeni. Pędy kukurydzy wykazywały większą tolerancję na obecność analizowanych wyciągów. Najsilniejsze zahamowanie rozwoju pędów nie przekraczało 25% i były obserwowane w obecności ekstraktu z korzeni wrotyczu oraz liści i korzeni mydlnicy, a także kwiatu nawłoci. Podsumowując, otrzymane wyniki wskazują, że wodne wyciągi z pospolitych chwastów mogą negatywnie wpływać na kiełkowanie i wzrost siewek kukurydzy. Oddziaływanie to jest uzależnione od rodzaju rośliny, z której został sporządzony wyciąg.
***Słowa kluczowe**: fitotoksyczność, wyciągi wodne, kukurydza, chwasty, kiełkowanie*

1. Introduction

Many factors have influence on seeds germination and plant development. These include, among others, the type of soil, the composition and availability of mineral substances, and the presence of xenobiotics, such as organic substances (petroleum, complexing compounds), pharmaceutical compounds, as well as salinity and the presence of heavy metals [5, 15, 16, 17]. The presence of these ingredients may cause both, inhibition of seeds germination and affect on the plants development at every stage of development. The potency of xenobiotics depends on the type and concentration of pollutants and also the type of plant. The presence of other plants can also influence on cereals development [5, 15, 16, 17].

The presence of different and high amount of weeds in agricultural fields influence on lower crop yields. Among others, this phenomenon is connected with allelopathic effect that weeds can cause. Weeds influence crop growth by causing phytotoxicity from fallen seeds, leaves, flowers, roots, decomposition of plant residues, exudates, air and water discharges, etc. Numerous research conducted all over the world proves that plants provide the environment with different kinds of allelophatic compounds, including phenols, alcaloids, fatty acids, terpenoids, flavonoids [2, 6]. They are able to influence other plants in a negative or a positive way [26, 31]. A number of allelophatic compounds are provided by leaves, roots, pollen, flowers, seeds and fruit [27, 29]. This is a considerable importance from agricultural point of view. Negative or positive effects of water extracts from weeds on seeds depend on a weed species, concentration of water extracts and acceptor sensitivity [10-12]. Mostly plant residues release phytotoxic compounds that show inhibitory effect on the growth of nearby plants. These phytotoxic compounds mostly contained phenolics that alter the soil structure and plant growth processes are significantly lowered due to altered soil quality. In addition to the phenolic compounds, salt concentrations also showed inhibitory effect on germination and seedling growth and this impact of salinity is highly dependent on type of genotype [1, 14].

Tansy (*Tanacetum vulgare* L.), goldenrod (*Solidago virgaurea* L.) and soapweed (*Saponaria officinalis* L.) are important and most widespread weed in areas where major agricultural crops are grown in Europe and also in Poland [24, 25, 28]. They belong to a group of weeds with evidenced allelopathic effects. The inhibitory effect of plant extracts of various johnsongrass parts results from the presence of chlorogenic acid, p-coumaric acid, thujone, saponins, ethers oils [10, 22], phenols and tannins [8]. Phenolic acids cause destruction of mineral ions, depolarization of the plasmalemma, and increased membrane permeability violations in all of plant metabolism [13].

Giant goldenrod (*Solidago gigantea* Ait.), is an invasive species which prefers ruderal habitats, riversides, forests, roadsides etc. Its number and aggressiveness is extensive on abandoned agricultural areas where it eliminates indigenous plants, however it is rarely found on agricultural fields [20, 21]. Allelopathic potential of goldenrod extracts on different seeds was reported by numerous researchers [4, 23]. Dzikić et al. [7] states that emission of allelopaths to soil by *S. gigantea* may be a potential threat in case of reinstating wasteland colonized by this species for agricultural production.

Baličević et al. [3] described impact of the extracts from dry goldenrod biomass on crops and weeds. The results showed that the extracts had certain allelopathic effect on all crops (carrot, barley, coriander) and some weeds as velvetleaf (*Abutilon theophrasti* Med.) and redroot pigweed (*Amaranthus retroflexus* L.). Further research, towards determination of different doses and application time of goldenrod extract, as well as finding tolerant crops and susceptible weeds is in need to fully assess goldenrod allelopathic potential.

The aim of the presented research was to determine the influence of aqueous extracts from selected common weeds, such as tansy, goldenrod and soapweed on the germination capacity and initial development of maize (*Zea maize* L.).

2. Material and methods

The most popular weeds are tansy (*Tanacetum vulgare* L.), goldenrod (*Solidago virgaurea* L.), and soapweed (*Saponaria officinalis* L.). The weeds parts (flower, leaves and root) were collected from the fields located in the region near arable fields. The plants materials were cut and dry. From the material prepared in this way 10 g of dry matter was used in experiments which was added into 100 mL of distilled water and shaked after 24 hours at room temperature. Prepared extract was centrifuged, filtrated and obtained solution were applied in the experiments.

The experiment was conducted in laboratory conditions with the use of modified test of germination and early growth of seedlings – Phytotoxkit [18]. Investigation was carried out in 3 independent experimental series, in three replications for each parts of weeds water extract. Experimental series took place in two-week intervals.

To the plates were applied 100 g of soil, and then was added the same quantity of the analyzed substance (25 ml). As the control sample was soil with distilled water. Phytotoxkit plastic containers were placed in a dark, constant parameters such as temperature (25 ± 1°C) and humidity (70%). On the prepared soil, was put 10 maize seeds. During the experiment, germination capacity of maize seeds was determined based on the amount of normally germinated seeds after 5 days. After the end of the experiment count the number of germinated seeds and measuring shoots and roots length. Based on the results, the percentage inhibition of roots and shoots growth were calculated following formula:

$$Inhibition = (\frac{L_c - L_x}{L_c}) * 100\%$$

or

$$Inhibition = (\frac{P_c - P_x}{P_c}) * 100\%$$

where: L_x and L_c are the length of root in the sample and control; P_x and P_c are the height of shoot in the sample and control respectively.

The soil used in experiment had the following elemental composition: 81 mg P/kg soil, 88 mg K/kg soil, 69 mg Mg/kg soil and pH of 5.92, C organic content of 1.01% (10.1 g/kg soil). Typologically the field soil was of black earth type, black earth subtype with cambic horizon. The influence of pyridineamidoximes were investigated using the phytotoxicity test based on the ISO-11269-2:2012 International Standard [9].

Average values were calculated for each analysed group. Average values were evaluated with their standard deviations (SD). Results were plotted with Microsoft Excel software. The date were compared by the Student`s *t* test and statistical significance was set as $p < 0.05$.

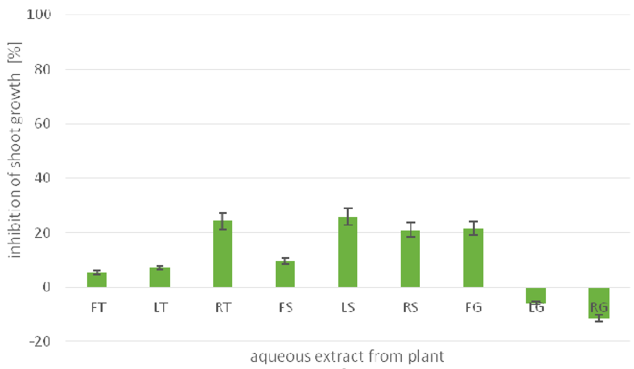
3. Results and discussion

Germination is one of the most important plant growth stages and severely affected by allelochemical components [19]. Water extracts from individual weeds show a varied effect on germination of maize seeds. This effect is both dependent on the type of part of the weed from which the extract was made, but also on the type of weeds. Table 1 presents the results about the influence of aqueous extracts on the germination capacity of maize seeds. On the basis of the results obtained, it can be concluded that extracts made from soapweed flower limited the germination of maize seeds the most from all analyzed water extracts. An inhibition of seeds germination was also observed, both under the presence of extracts made of flowers, leaves and soapweed root. The presence of soapweed flower extracts caused that only 60% of maize seeds germinated. Under the influence of extracts made of tansy leaves and goldenrod leaves 70% of maize seeds germinated. A slight reduction in germination capacity was also observed under the influence of aqueous extracts from soapweed root and goldenrod flowers.

Table 1. Effect of water extracts from selected weeds on seed maize (*Zea maize* L.) germination capacity
Tab. 1. Wpływ wyciągów wodnych z wybranych chwastów na zdolność kiełkowania nasion kukurydzy (Zea maize L.*)*

Treatment	Germination capacity [%] ± Std. Dev.
Control	100 ± 0
FT (flower of tansy)	98 ± 1.30
LT (leaves of tansy)	72 ± 3.03
RT (root of tansy)	100 ± 0
FS (flower of soapweed)	60 ± 2.77
LS (leaves of soapweed)	90 ± 2.04
RS (root of soapweed)	80 ± 3.16
FG (flower of goldenrod)	80 ± 2.99
LG (leaves of goldenrod)	70 ± 1.46
RG (root of goldenrod)	90 ± 1.87

Source: own work / Źródło: opracowanie własne

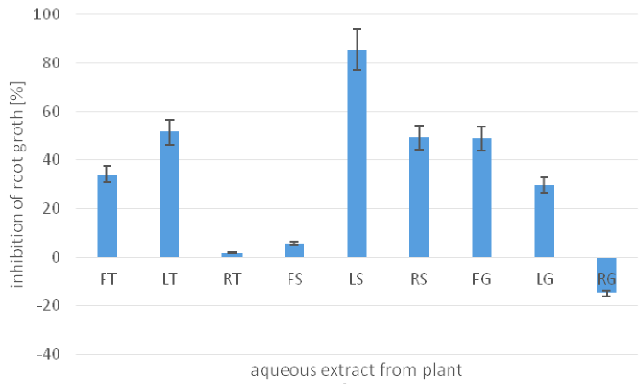


Source: own work / Źródło: opracowanie własne

Fig. 1. Effect of water extracts from selected weeds on maize shoots (*Zea maize* L.) growth. (FT – flower of tansy; LT – leaves of tansy; RT – root of tansy; FS – flower of soapweed; LS – leaves of soapweed; RS – root of soapweed; FG – flower of goldenrod; LG – leaves of goldenrod; RG – root of goldenrod)
Rys. 1. Wpływ wodnych wysięgów z wybranych chwastów na wzrost pędów kukurydzy (Zea maize L.). (FT – kwiaty worotyczu; LT – liście wrotyczu; RT – korzenie wrotyczu; FS – kwiaty mydlnicy; LS – liście mydlnicy; RS – korzenie mydlnicy; FG – kwiaty nawłoci; LG – liście nawłoci; RG – korzenie nawłoci)

Water extracts from weeds affect both the development of maize roots and shoots. Among the extracts made from tansy, the strongest effect on the development of maize shoots was observed in the presence of water extract from tansy root (Fig. 1). They cause 25% inhibition of maize shoots growth. In turn, water extracts from soapweed leaves and roots also limited the development of maize shoots in 25%. However, only extracts made from goldenrod flowers inhibited 20% development of maize shoots. It should be emphasized that aqueous extracts made from the leaves and roots of the goldenrod did not have a negative impact on the development of shoots. In the presence of these extracts, slight growth stimulation was observed (by 10% in the presence of root extracts from the goldenrod).

Water extracts from weeds also influence of the roots maize development. A stronger effect of weeds extracts on the development of maize roots than on the development of shoots was observed (Fig. 2). Water extracts from the tansy flowers and leaves caused 30 to 50% inhibition of the maize roots growth. In turn, water extracts made from tansy roots did not have a negative impact. In the case of aqueous extracts made from soapweed, the strong inhibition of roots growth was noted in the presence of extracts from soapweed leaves and roots. It should be emphasized that water extracts made from soapweed leaves, which inhibited the growth of maize roots in 85%. On the other hand, water extracts made from goldenrod flowers limited the development of maize roots at 50%, the less influence on maize roots growth under water extract made from goldenrod leaves, whereas the presence of water extracts from roots of goldenrod stimulated the development of maize roots (Fig. 2).



Source: own work / Źródło: opracowanie własne

Fig. 2. Effect of water extracts from selected weeds on maize roots (*Zea maize* L.) growth. (FT – flower of tansy; LT – leaves of tansy; RT – root of tansy; FS – flower of soapweed; LS – leaves of soapweed; RS – root of soapweed; FG – flower of goldenrod; LG – leaves of goldenrod; RG – root of goldenrod)
Rys. 2. Wpływ wodnych wysięgów z wybranych chwastów na wzrost korzeni kukurydzy (Zea maize L.). (FT – kwiaty worotyczu; LT – liście wrotyczu; RT – korzenie wrotyczu; FS – kwiaty mydlnicy; LS – liście mydlnicy; RS – korzenie mydlnicy; FG – kwiaty nawłoci; LG – liście nawłoci; RG – korzenie nawłoci)

The diverse influence of water extracts from weeds on germination and the initial development of maize results from the presence of different chemical compounds that have been extracted with water from individual parts of plants. Tansy flowers are characterized by a high content of thujone (etheric compound), which in the largest amounts occurs in flowers, followed in the leaves and stalk, while it does not occur in the tansy root. Tansy content also organic acids (caffeic acid, chlorogenic acid), phytosterols, flavanoids, piperitone, sesquiterpene, kampholenol. Soapweed contain triterpene saponins (mainly saporubrine), sapotoxin, saporubrine acid and glycosides in the rootstocks and roots of the soapweed, much smaller amounts are found in the leaves and no presence in flowers. The soapweed herb contains flavonoid glycoside - saponarin; it is hydrolyzed to saponarein, vitekain and glucose. In addition, the presence of pinite has been demonstrated in the soapweed herb. Goldenrod is in turn a valuable herb containing in flowers and stems tannins, organic acids, saponins and essential oils, flavonoids (rutin and quercetin), poli-phenolic acids (caffeic acid and chlorogenic acid) [19, 30].

The above considerations confirm that the presence of certain chemical compounds in individual parts of the plant influence on the composition of the obtained aqueous extracts. Undoubtedly, the presence of organic acids such as caffeic acid, chlorogenic acid, essential oils, tanins, thujone and saponins in the water extracts effects on the maize seed germination and development, which has been described in the work. In literature, the authors focus on the inhibitory effect of weeds extracts, but does not take into account the considerations regarding the chemical composition of extracts [2, 3, 6, 10, 11, 12, 26, 27, 29, 31]. For example, Baličević et al. [3] described the results of the extracts from dry goldenrod biomass had certain allelopathic effect on both carrots, barley, coriander and weeds (velvetleaf and redroot pigweed). Both weed species germination and growth were greatly suppressed with extract application. Reduction in emergence percent, shoot length and fresh weight of carrot were observed. Barley root length and fresh weight were reduced with the highest extract concentration. No significant effect on seedling emergence and growth of velvetleaf was recorded, while emergence of redroot pigweed was inhibited for 14.4%. Germination and growth of test species decreased proportionately as concentration of weed biomass in water extracts increased. Differences in sensitivity among species were recorded, with redroot pigweed being the most susceptible to extracts. Whereas, Jabeen et al. [10] described the allelopathic effects of three different weeds viz., Onion weed (*Asphodelus tenuifolius Cavase*), pill-bearing spurge/Asthma plant (*Euphorbia hirta Linn*) and Fumitory (*Fumaria indica Haussk* H.N.) on the growth of maize. These studies showed the effect on germination of maize seed, but impact studies on the development of shoots and roots were not consistent.

Ouda et al. [14] was observed different dependence as presented in this work. Authors showed that the water extracts from different plant parts did not influence on maize seeds germination, but the different concentrations could effect on the germination. The authors [14] determined the allelopathic effect of rapeseed (*Brassica napus* L.) on germination and seedling growth of maize under different salinity levels. Root and leaf extracts at 5% concentration produced maximum root length, shoot length and plant dry weight as compared to other plant parts at other concentrations. Our research results showed that extracts obtained from different part of plants could have significantly impact on germination and development of maize. The described observation by different authors, could be explained that the allelopathic effect of water extracts from different plants and different part of plants are dependent on chemical compounds composition and concentration, which are extracted.

4. Conclusion

The obtained results indicate that water extracts of common weeds may negatively effects on the seed germination and initial development of maize. The water extracts impact depends on the type and part (flowers, leaves, root) of weed from which the extract was made. Maize shoots proved to be more tolerant to the exanimate water extracts than maize roots. The inhibitory effect on maize shoots growth was observed by water extracts from tansy flower and leaves and also extracts from leaves and roots of soapweed, but did not exceed 25%. The water extracts from soapweed leaves strongly inhibited maize root development. The water extracts from goldenrod (flower and leaves) and also tansy (flower and leaves) had negative effect and limited maize root development.

The phenomenon of inhibiting the development of plants under the influence of water extracts can be used in organic crops, but the described results unfortunately indicate phytotoxic effects on crops, which is an unfavorable and undesirable phenomenon.

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