

Allelopathic effects of *Abutilon theophrasti*, *Asclepias syriaca* and *Panicum ruderales* on maize

Die allelopathische Wirkung von Abutilon theophrasti, Asclepias syriaca und Panicum ruderales auf Mais

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DOI 10.5073/jka.2018.458.067



Abstract

Abutilon theophrasti, *Asclepias syriaca* and *Panicum ruderales* are very important invasive weed species in Hungary. These can cause hard damages firstly in row space crops, because these have good competition ability. The aim our experiment was to study the allelopathic effect of watery extracts from roots and shoots on germination and growth of maize seedlings. Bioassay experiments were made in the laboratory in 2015. Extracts from air dried and grinded roots and shoots of weeds were made with water in 2.5, 5 and 7.5% concentrations. Maize (Cornelius) seeds were put into Petri-dishes, after that they were treated with 15 mL solutions, and put into a thermostat at 20 °C in the dark. After 7 days of germination, % and length and weight of primary roots and shoots of seedlings were determined. The statistical analysis has been done one-factorial analysis of variance. Shoot and root extracts of *Abutilon theophrasti* decreased germination-% and growth of primary roots and shoots of seedlings. Watery extracts from *Asclepias syriaca* resulted in similar effects; these treatments reduced germination and growth of seedlings. Shoot extract of *Panicum ruderales* caused shorter shoots and less shoot weight, and hindered the germination of maize. Root extract decreased shoot length and weight, and also germination, but root development was not influenced significantly. We established that allelopathic effects of *A. theophrasti* and *A. syriaca* were stronger than those of *P. ruderales*. Other publications reported significant results connected to allelopathy of *A. theophrasti* and *A. syriaca*. Mainly the root extracts inhibited the early growth of maize. Allelopathic effects were stronger with increasing concentrations of solutions.

Keywords: Allelopathy, *Abutilon theophrasti*, *Asclepias syriaca*, bioassay, maize, *Panicum ruderales*

Zusammenfassung

Abutilon theophrasti, *Asclepias syriaca* und *Panicum ruderales* sind in Ungarn sehr wichtige invasive Unkräuter. Sie können ernste Schäden verursachen, da diese über eine gute Konkurrenzfähigkeit verfügen. Das Ziel unseres Experiments ist es, die allelopathische Wirkung der Wurzel- und Triebtinkturen auf die Keimung des Mais und das Wachstum der Keimpflanzen zu untersuchen. Das sogenannte „Bioassay-Experiment“ wurde im Jahre 2015 im Laboratorium durchgeführt. Die Tinkturen wurden aus luftgetrockneten und gemahlten Wurzeln und Trieben mit Wasser mit einer Konzentration von 2,5, 5 und 7 % angefertigt. Die Maiskörner (Sorte Cornelius) wurden in eine Petrischale gegeben, dann wurden sie mit 15 ml Tinktur behandelt und bei 20 °C in Dunkel-Thermostate gelegt. Am 7. Tag wurde das Keimungsprozent festgestellt, sowie die Länge und die Masse der primären Wurzel und des primären Triebes wurden gemessen. Die statistische Analyse wurde durch eine Varianzanalyse auf einem Faktor durchgeführt. Die Trieb- und Wurzeltinkturen von *Abutilon theophrasti* reduzierten die Keimung sowie das Wachstum der primären Wurzel und des primären Triebes, abnehmende Länge und Masse wurden gemessen. Die Tinkturen von *Asclepias syriaca* ergaben die gleiche Wirkung. Diese Behandlungen reduzierten die Keimung und das Wachstum der Mais-Keimpflanzen. Die Triebtinktur von *Panicum ruderales* führte zu kürzeren Trieben und einer geringeren der Triebmasse, darüber hinaus hemmte sie die Keimung des Mais. Die Wurzeltinkturen reduzierten die Länge und Masse des Triebes sowie die Keimung, jedoch übten sie auf die Wurzelentwicklung keinen signifikanten Einfluss aus. Es wurde festgestellt, dass die allelopathische Wirkung von *A. theophrasti* und *A. syriaca* stärker war als die von *P. ruderales*. In Verbindung mit der Allelopathie von *A. theophrasti* und *A. syriaca* berichten auch andere Veröffentlichungen über signifikante Ergebnisse. Vorzugsweise hinderten die Wurzeltinkturen das frühe Wachstum von Mais. Mit höherer Konzentration der Tinkturen verstärkte sich auch die allelopathische Wirkung.

Stichwörter: Allelopathie, *Abutilon theophrasti*, *Asclepias syriaca*, Bioassay, Mais, *Panicum ruderales*

Introduction

We know since long, that there are plant species in natural succession, which hinder the colonization of other species. If in this case an increase of biomass production is seen only on one species, we can't explain this symptom with competition for nutrients or water. This is the phenomenon of allelopathy (RICE, 1984). Allelopathy is one form of plant interference. Plants produce numerous metabolites with no known utility to their growth and development. These are often referred to as secondary plant metabolites and are often defined as compounds having no known essential physiological function. Allelochemicals vary from simple molecules to more complex organic molecules. They are produced by any plant organs: roots, leaves, seeds, flowers and fruits. Allelochemical compounds can release from the plants with evaporation, leaching from the foliage, exudates from the roots or decomposition of plant residues. Effects of allelochemicals can be direct on spreading, germination, growth and metabolism or indirect on soil properties, nutrient content, and change of plant population (SZABÓ, 1997; TÓTH et al., 2002).

Abutilon theophrasti is one of the most important and invasive summer annual weed species in Hungary and in Europe, too. Its dangerousness derives from its biological characteristics of the germination and its strong competitive and allelopathic ability. As weed of cultivated crops with wide line space such as maize, sunflower and soybean it can reduce the yield significantly. Some authors established that the yield reducing ability by bigger nutrient supply is lower. It was established in the Hungarian weed survey in 2007-2008 that velvetleaf was the tenth between the most important weeds at the maize fields in Hungary in Zala County. Danger of this weed can explain with the dormancy of its seeds and the competitive capacity of the plant. Allelopathic effect of velvetleaf was studied by GRESSEL and HOLM (1964), BHOWMIK and DOLL (1984) and furthermore STERLING et al. (1987). They found hard inhibitory effects on the germination of examined plants. We established in our experiments in Keszthely, that water extracts from leaves and roots reduce germination and growth of other plants (KAZINCZI et al., 1991; NÁDASY et al., 2013), by contrast low concentration solutions stimulate the growth of *Ambrosia artemisiifolia* (KAZINCZI et al., 2008) which is a most important weed species in Hungary.

Asclepias syriaca has spread in recent years and can cause several harmful effects. This weed is one of the most dangerous perennial species in Hungary. *A. syriaca* can spread with rootstocks and seeds equally. This plant has strong competitive ability, so often causes damages in arable fields, horticulture, forestry, and in natural ecosystems. Besides of competitive ability, quick growth and shadowing are well known. Its root extract has allelopathic effect on growth of several crop plants and other weeds (RASMUSSEN and EINHELLING 1979; KAZINCZI et al., 1999). Allelochemicals of this species were determined; the plants contain asclepiadin, sitoserol, quercetin, and nicotin (KAZINCZI et al., 1998).

Panicum ruderalis is the wild form of *P. miliaceum* (WILLIAMS et al., 2007). Up-to-date three subspecies of *Panicum miliaceum* appeared in the Hungarian fields: formerly the most common was *P. miliaceum subsp. miliaceum*, but in recent years it has been overshadowed by other two subspecies, the *P. miliaceum subsp. ruderalis* and *P. miliaceum subsp. agricola* (PÁSZTOR et al., 2014). We studied the allelopathic effect of *P. riparium* earlier, and found that 7,5% shoot watery extract reduced shoot length of maize seedlings with 88%, while root length with 30%. Solutions from *P. miliaceum* did not hinder the growth of young maize plants, neither shoot nor root. In contrast, water solutions stimulated growing because of maize utilized the lye as nutrients (PÁSZTOR and NÁDASY, 2016).

Materials and Methods

Investigations were carried out to study the allelopathic effect of three important weed species on germination of maize (variety Cornelius). *Abutilon theophrasti*, *Asclepias syriaca* and *Panicum ruderalis* plants were collected from different cultivated fields belonging to the Georgikon Faculty in Keszthely in August 2015. Roots from shoots and leaves were separated in the laboratory, cut in small pieces and dried in an exsiccator for 24h in 50 °C. The dried roots and shoots were stored in

dark at room temperature until using them. The bioassay experiment was made in the laboratory in September 2015.

Watery extracts were made from shoots and roots of weeds in 3 concentrations: 2.5%, 5.0% and 7.5%. Solutions were made with tap water and let 24h to soaking. The extracts were filtered after 24 hours, and were used immediately. Twenty-five maize seeds were placed into Petri-dishes on filter paper and treated with 15mL-solutions. Into the control dishes 15mL tap water were given. All treatments were made in 8 replications. Petri dishes were put into a thermostat and held at 20 °C in the dark. The germination percentage was studied on the 7th day, and the length and fresh mass of primary roots and shoots of the maize seedlings were measured at the same day. The statistical analysis was done by using computer program; we made one-factorial analysis of variance (ANOVA).

Results and Discussion

Solutions from root and shoot of *A. theophrasti* and *A. syriaca*, furthermore root extract of *P. ruderale* inhibited germination of maize significantly; in contrast, the shoot extract of the *Panicum* did not cause significant changes in germination percentage (Tab. 1).

Tab. 1 Effect of weed extracts on germination of maize.

Tab. 1 Wirkung von Unkraut-Extrakten auf die Keimung von Mais.

Treatments	Control	Germination (%)				LSD _{5%}
		2.5%	5%	7.5%		
<i>Abutilon theophrasti</i> shoot	84	76	72	68	4.31	
<i>Abutilon theophrasti</i> root	84	80	72	68	4.80	
<i>Asclepias syriaca</i> shoot	84	80	76	68	4.45	
<i>Asclepias syriaca</i> root	84	80	76	68	4.43	
<i>Panicum ruderale</i> shoot	84	84	80	80	5.2	
<i>Panicum ruderale</i> root	84	76	72	68	6.3	

The shoot extracts from *A. theophrasty* hindered the shoot length of maize, more and more with higher concentration. The effect was significant, but it was not on root development. Although root weight decreased by 5% and 7.5% treatments, these resulted in slimmer roots (Tab. 2).

Tab. 2 Effect of *Abutilon theophrasti* extracts on growth and fresh mass of maize seedlings.

Tab. 2 Wirkung von *Abutilon theophrasti*-Extrakten auf Wachstum und Frischmasse von Maiskeimpflanzen.

Treatment		Plumule (mm)	Radicle (mm)	Plumule (g)	Radicle (g)
	Control	19.39	38.26	1.14	1.21
<i>A. theophrasti</i> shoot	2.5%	15.82	39.29	1.08	1.14
	5%	11.90	33.42	0.81	0.79
	7.5%	10.92	33.04	0.47	0.74
	LSD _{5%}	3.28	5.40	0.18	0.19
<i>A. theophrasti</i> root	2.5%	16.52	33.15	1.03	0.96
	5%	15.89	38.90	0.92	0.97
	7.5%	10.32	30.70	0.79	0.80
	LSD _{5%}	3.92	5.48	0.19	0.19

The root extracts of *Abutilon theophrasti* reduced shoot length of maize only in little extent, but the 7.5% treatment did so importantly. But this treatment did not influence the root growth significantly. The root and shoot biomass decreased equally by the effect of the treatments.

The shoot extracts of *A. syriaca* inhibited definitely development of shoot and primary root of maize. We measured 30-37% shorter shoots and roots than at control plants, parallel with higher concentrations (Tab. 3).

Tab. 3 Effect of *Asclepias syriaca* extracts on growth and fresh mass of maize seedlings.

Tab. 3 Wirkung von *Asclepias syriaca*-Extrakten auf Wachstum und Frischmasse von Maiskeimpflanzen.

Treatment		Plumule (mm)	Radicle (mm)	Plumule (g)	Radicle (g)
	Control	19.39	38.26	1.14	1.22
<i>A. syriaca</i> shoot	2.5%	13.65	25.95	0.91	0.91
	5%	13.00	25.05	0.74	0.76
	7.5%	12.40	24.60	0.73	0.67
	LSD_{5%}	3.77	5.20	0.18	0.19
<i>A. syriaca</i> root	2.5%	18.45	35.40	1.27	1.04
	5%	10.20	18.80	0.78	0.53
	7.5%	7.50	14.00	0.58	0.46
	LSD_{5%}	3.55	4.59	0.21	0.24

The fresh shoot weight decreased with 20-30%, while root weigh with 35-45% under the effect of the extracts. Influence was stronger with increasing concentrations.

The root extracts of *Asclepias syriaca* hindered the seedling shoot length even more: 5% treatment with 47%, and 7.5% with 61%. The same concentrations reduced the primary root length with 51% and 63%. Biomass production changed similarly under the effect of these treatments.

Allelopathic effect of *P. ruderalis* shoots was less expressive on maize shoots, but the 7.5% extract decreased it considerably (45%; Tab. 4). Reduction of primary root length was not significant. The 7.5% extract decreased shoot fresh mass significantly with 48%. *P. ruderalis* solutions had stronger effects on maize shoots than on roots.

Tab. 4 Effect of *Panicum ruderalis* extracts on growth and fresh mass of maize seedlings.

Tab. 4 Wirkung von *Panicum ruderalis*-Extrakten auf Wachstum und Frischmasse von Maiskeimpflanzen.

Treatment		Shoot (mm)	Root (mm)	Shoot (g)	Root (g)
	Control	19.39	38.26	1.14	1.21
<i>P. ruderalis</i> shoot	2.5%	18.90	35.75	1.03	1.16
	5%	17.05	34.90	0.93	1.04
	7.5%	11.30	33.80	0.59	1.00
	LSD_{5%}	3.51	5.38	0.20	0.19
<i>P. ruderalis</i> root	2.5%	16.30	41.10	1.05	1.34
	5%	15.44	41.05	0.91	1.36
	7.5%	16.35	40.25	0.74	1.11
	LSD_{5%}	3.51	5.3	3.51	5.30

Root extracts of *Panicum ruderalis* lessened shoot growth and weight slightly, except of the 7.5% treatment which decreased fresh weight with 45%, but the root development was not influenced.

It seemed that between the examined weed species the allelopathic effect of *A. syriaca* extracts was the strongest on germination and early growth of maize, followed by *A. theophrasti*. Other publications reported significant results also connected to allelopathy of *A. theophrasti* (DAVID and RADÓCZ, 2002; ŠĆEPANOVIĆ, 2007; NAGY and SZALAY, 2010) and *A. syriaca* (KAZINCZI et al., 2004). Mainly the root extracts inhibited the early growth of maize. We experienced slight allelopathic effect of

P. ruderale on the development of maize seedlings. Allelopathic effects depend on donor species, plant part and concentration; they become stronger with increasing concentration of solutions.

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