The Journal of Animal & Plant Sciences, 24(6): 2014, Page: 1844-1848
ISSN: 1018-7081

ALLELOPATHIC EFFECT OF FIELD BINDWEED (*CONVOLVULUS ARVENSIS* L.) WATER EXTRACTS ON GERMINATION AND INITIAL GROWTH OF MAIZE

R. Baličević, M. Ravlić, M. Knežević, and I. Serezlija*

University of Josip Juraj Strossmayer in Osijek, Faculty of Agriculture in Osijek, Department of Plant Protection, Kralja Petra Svačića 1d, Osijek, Croatia; *Student, University of Josip Juraj Strossmayer in Osijek, Faculty of Agriculture in Osijek, Kralja Petra Svačića 1d, Osijek, Croatia
Corresponding author: mravlic@pfos.hr

ABSTRACT

Field bindweed (*Convolvulus arvensis*) is a noxious weed of agricultural crops. The objective of the research was to study allelopathic effect of above ground mass of field bindweed on maize using Petri dish bioassay. Water extracts from stem and leaf dry plant powder in three concentrations (10, 50 and 100 g/l) were tested on germination, seedling length and fresh biomass of two maize hybrids (Bc 574 and OSSK 596) in experiment set out as completely randomized design. Reduction of seed germination amounted up to 36%. Stem extract showed higher inhibition effect on germination and shoot length, while both stem and leaf equally inhibited root length and fresh weight of maize seedling. With the increase of concentration, germination and growth parameters of maize decreased. Lowest concentrations of both stem and leaf extract showed stimulatory effect on shoot length of maize for 19.2 and 26.9%. Maize hybrids differed in their susceptibility to water extracts. The results indicated that field bindweed water extracts have both inhibitory and stimulatory effects on germination and growth parameters depending on plant part, concentration and maize hybrid.

Key words: Allelopathy, field bindweed, hybrids, maize, water extracts.

INTRODUCTION

Weeds cause substantial damage to agricultural crops. Worldwide loses in maize due to weeds are estimated to 10.5 % (Oerke, 2006). Besides competing for light, nutrients, moisture and space with the crop, weeds can also affect crops growth through allelopathy (Khanh, 2006).

Allelopathy is defined as any direct or indirect harmful or beneficial effect of one plant, fungus or microorganism on the other ones through production of allelochemicals that escape into the environment (Rice, 1984). Allelochemicals are present in all plant tissues, roots, stems, leaves, flowers, seeds, and they can be released into the environment through various ways (Zeng *et al.*, 2008). Allelopathy is a mechanism by which weeds affect seed germination dynamics and growth of field crops (Benyas *et al.*, 2010).

Convolvulus arvensis L., field bindweed, is a perennial plant and a noxious weed in cultivated crops, pastures and gardens. It grows in wide range of conditions from full sun to full shade, on all soils, particularly on warm, drier soils, and is drought-tolerant. Stems emerge in spring, and it flowers from May till September (Knežević, 2006; Culhavi and Manea, 2011). It suffocates young seedlings, grows rapidly and covers that it makes up invades the crops and decrease the yield. The estimate losses caused by this weed in the United States are above 377 million US$ in 1998 alone (Berca, 2004). As one of the most problematic weeds it can make up to 8% (Culhavi and Manea, 2011) or even 20% (Khan and Haq, 2004) of the total weed population in maize. Allelopathic potential of field bindweed on different crops such as wheat, barley and lentil (Yarnia, 2010; Shahrokhi *et al.*, 2011; Rahimzadeh *et al.*, 2012) and weeds (Om *et al.*, 2002) has been previously reported. Phenolic compounds such as p-coumaric, p-Hydroxybenzoic, caffeic, syringic and ferulic acid are detected in field bindweed methanol extract of shoot residues (Hegab and Ghareib, 2010).

Because of all abovementioned, the identification of allelopathic effects of field bindweed and effect of water soluble chemicals can lead to a better understanding of the weed and reduction of the negative impact on early growth of maize. The objective of the study was to determine allelopathic effect of field bindweed (*C. arvensis*) water extracts prepared from dry biomass on germination and initial growth of two maize hybrids.

MATERIALS AND METHODS

The plants of field bindweed were collected during the summer of 2012 at the flowering stage (Hess *et al.*, 1997) from maize fields in Osijek-Baranja County, Croatia (latitude 45°33′ N, longitude 18°41′ E, and an altitude of 102 m). The aboveground mass was air-dried and separated into stems and leaves. Dried plant parts were cut into small pieces, ground separately with electronic grinder into fine powder and stored in dark and dry place until use.

The experiment was conducted during 2013 in Laboratory for Phytopharmacy, at the Faculty of Agriculture in Osijek, Croatia. Water extracts were prepared according to Norsworthy (2003) by mixing 100 g of plant powder (stem or leaf) with 1000 ml of distilled water, after which the mixture was kept for 24 h at room temperature. The obtained stem and leaf extracts were diluted with distilled water to give final concentrations of 1, 5 and 10% (10, 50 and 100 g of plant biomass per liter).

Seeds of two maize hybrids, Bc 574 (Bc Institute Zagreb, Croatia) and OSSK 596 (Agricultural Institute Osijek, Croatia), were used in the germination test. The seeds were surface-sterilized with 1% NaOCl (4% NaOCl commercial bleach) for 20 min, and then rinsed three times with distilled water (Siddiqui *et al.*, 2009). In sterilized Petri dishes (10 cm in diameter) ten seeds were placed on top of filter paper. In each Petri dish 8 ml of extract was added, while distilled water was used in control. Petri dishes were kept at 22 °C ± 2 °C for eight days. Each treatment had four replications and the experiment was conducted twice as completely randomized design.

Germinated seeds were counted daily for eight days and germination percentage was calculated for each replication using the formula: G = (Germinated seed/Total seed) x 100. After eight days seedling root length (cm), shoot length (cm) and fresh weight (g) were determined. The collected data were analyzed statistically with ANOVA and differences between treatment means were compared using the LSD-test at probability level of 0.05.

RESULTS AND DISCUSSION

Water extracts from *C. arvensis* showed significant effect on germination of maize seeds (Figure 1). Both stem and leaf extracts reduced seed germination, for 40.8% and 32.8% as compared to the control, respectively. With the increase of extract concentration, the percentage of maize seed germination significantly decreased, except with the lowest concentration of leaf extract. Stem extracts of the highest concentration (100 g l^{-1}) reduced germination up to 65.9%. The results of the study are in accordance with findings of Shahrokhi *et al.* (2011) who showed that bindweed water extracts from leaf and stem reduced germination percentage of barley seeds.

C. arvensis water extracts showed allelopathic effect on root and shoot length of maize seedlings (Table 1). Inhibition of root length ranged from 1.7 to 92.0%, while shoot length was decreased by 50%. The highest concentrations of both stem and leaf extract showed the highest inhibition. On the other hand, lower concentrations of extracts stimulated the seedling growth, especially shoot length. On average, seedling root length was more suppressed than shoot length. This is in agreement with Fateh *et al.* (2012) who found that root length of millet and basil was more sensitive to water extracts of *C. arvensis* than the shoots. Esmaeili *et al.* (2012) argue that the stronger inhibitory effect on root growth is a result of direct contact of allelochemicals with the root compared to shoot. Germination was less inhibited than seedling growth, up to 36%. According to Marinov-Serafimov (2010) the influence of allelochemicals is manifested in germination inhibition, but can be more pronounced on the growth of the seedlings.

Fresh weight of maize seedlings was significantly reduced in treatments with higher concentrations of stem and leaf extract, by 78.2 % and 57.6% (Figure 2). On the other hand, lower concentrations of stem extract showed no significant suppression, while leaf concentration of 10 g l^{-1} stimulated fresh biomass concentration for 3.7%.

When comparing extracts from different plant parts, results showed that stem extract had higher inhibition effect on germination and shoot length, while both stem and leaf extract equally inhibited root length and fresh weight of maize seedling. Differences in allelopathic potential of various plant parts of *C. arvensis* have been observed by other researchers (Shahroki *et al.*, 2011; Fateh *et al.*, 2012) and are caused by different concentration of allelochemicals in plant organs.

The highest concentration of extracts had the greatest inhibitory effect on germination and all growth parameters, while lower concentration showed stimulatory effects. Inhibitory effect of higher and stimulatory effect of lower concentrations of weed water extracts was also reported by Marinov-Serafimov (2010) and Fateh *et al.* (2012).

Maize hybrids differed in their susceptibility to water extracts (Table 2). Compared to the control, inhibition of germination for Bc 574 hybrid amounted to 24.9 %, while the OSSK hybrid germination was reduced for 50.7%. On the contrary, OSSK hybrid root length showed higher tolerance to allelochemicals. Both stem and leaf lowest concentration and leaf concentration of 50 g l^{-1} promoted shoot growth of OSSK hybrid from 44 to 48%, but the highest concentrations greatly reduced both shoot length and fresh weight. In other words, Bc 574 hybrid had better tolerance to high concentration. The sensitivity of plant to allelopathic compounds is different among species and genotypes within species (Asghari and Tewari, 2007). Aleksieva and Marinov-Serafimov (2008) showed that soybean genotypes differ in their sensitivity to weed water extracts.

The results of the study showed that *C. arvensis* stem and leaf water extracts have both inhibitory and stimulatory effect on maize germination and growth. The presence and mismanagement of field bindweed population and high concentrations of water soluble chemicals produced can negatively affect germination and early growth of maize. On the other hand, since maize hybrids differed in their sensitivity, the growth of tolerant hybrids can lower herbicide application and thereby costs of production. Positive effect of lower concentrations of extracts should be further investigated and possibly exploited to promote crop growth and yield.

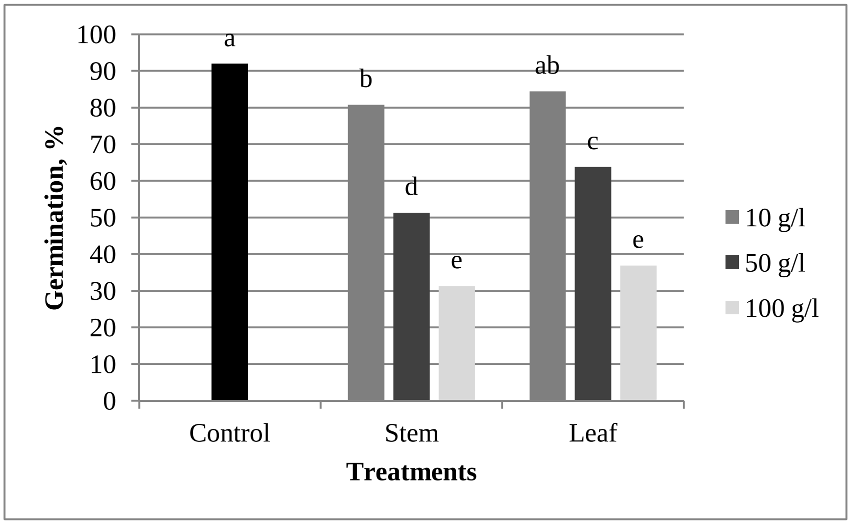

Fig. 1. Effect of different concentrations of *C. arvensis* stem and leaf water extract on germination (%) of maize.

Table 1. Effect of different concentrations of *C. arvensis* stem and leaf water extract on root and shoot length (cm) of maize (percent of reduction, %).

Treatment	Root length (cm)	Shoot length (cm)
Control	11.3 a (0.0)	2.6 a (0.0)
Stem 10 g l^{-1}	11.5 a (+1.8)	3.1 ab (+19.2)
Stem 50 g l^{-1}	6.85 b (-39.4)	2.5 b (-3.8)
Stem 100 g l^{-1}	0.9 e (-92.0)	1.3 d (-50.0)
Leaf 10 g l^{-1}	11.1 a (-1.7)	3.3 a (+26.9)
Leaf 50 g l^{-1}	5.2 c (-54.0)	2.8 ab (+7.7)
Leaf 100 g l^{-1}	2.9 d (-74.3)	1.8 c (-30.8)

Means followed by the same letter within the column are not significantly different at $P \leq 0.05$.

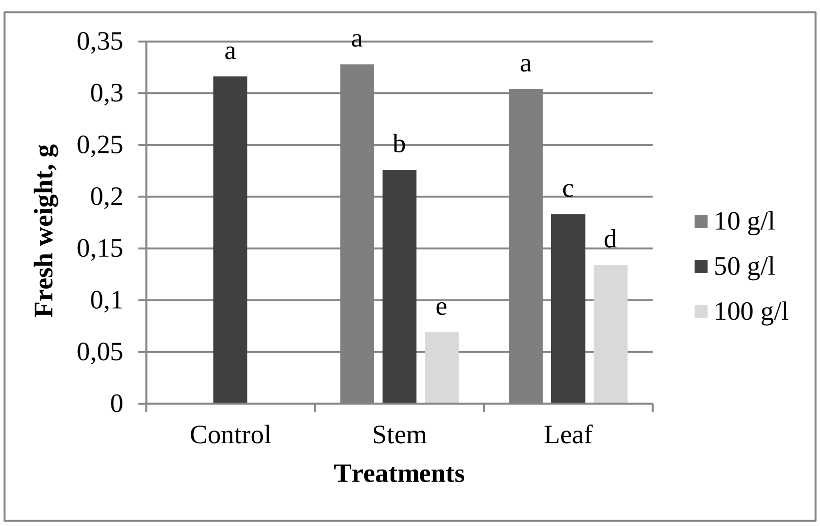

Fig. 2. Effect of different concentrations of *C. arvensis* stem and leaf water extract on fresh weight (g) of maize.

Table 2. Effect of different concentrations of *C. arvensis* stem and leaf water extract on germination (%) and growth parameters of maize hybrids.

Treatment	Germination (%)		Root length (cm)		Shoot length (cm)		Fresh weight (g)	
	Bc 574	OSSK 596	Bc 574	OSSK 596	Bc 574	OSSK 596	Bc 574	OSSK 596
Control	98.7 a	85.0 a	12.3 a	10.3 a	2.7 ab	2.5 b	0.33 a	0.30 a
Stem 10 g l^{-1}	93.8 ab	67.5 b	11.9 a	11.1 a	2.6 ab	3.6 ab	0.31 a	0.35 a
Stem 50 g l^{-1}	63.8 c	38.8 c	6.5 b	7.2 b	2.1 b	2.9 b	0.22 b	0.24 b
Stem 100 g l^{-1}	51.3 c	11.3 d	1.7 c	0.3 e	1.8 b	0.8 d	0.11 c	0.03 d
Leaf 10 g l^{-1}	98.8 a	70.0 b	12.0 a	10.2 a	2.9 a	3.7 a	0.30 a	0.31 a
Leaf 50 g l^{-1}	82.5 b	45.0 c	4.9 b	5.4 c	1.9 b	3.7 a	0.14 c	0.22 b
Leaf 100 g l^{-1}	55.0 c	18.8 d	3.2 c	2.7 d	2.0 b	1.6 c	0.15 c	0.12 c

Means followed by the same letter within the column are not significantly different at $P \leq 0.05$.

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