Quantitative analysis of phenolics in selected crop species and biological activity of these compounds evaluated by sensitivity of *Echinochloa crus-galli*

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Abstract

The purpose of this study was to determine the content of selected phenolic compounds in white mustard, buckwheat, spring barley, oat and rye grown under field conditions. Moreover, the allelopathic efficiency of these compounds was evaluated by sensitivity of *Echinochloa crus-galli*. The aromatic acids: *trans*-cinnamic, salicylic, ferulic, chlorogenic, *p*-hydroxybenzoic, protocatechuic, *p*-coumaric and vanillic were separated from crop plants by TLC and determined spectrophotometrically.

Differences in concentrations of analysed compounds were observed for most of the examined plant species. The highest concentration was noticed for cinnamic acid and ranged from 360 µg·g⁻¹ DW in rye to 2770 µg·g⁻¹ DW in spring barley. The relatively high concentration was noticed for ferulic acid (from 73.8 µg·g⁻¹ DW in buckwheat to 1046 µg·g⁻¹ DW in spring barley) and *p*-coumaric acid (from 50 µg·g⁻¹ DW in oat to 1499 µg·g⁻¹ DW in buckwheat). The observed differences in the phenolics content between two successive vegetation seasons can reflect the effect of abiotic and biotic environmental factors on the phenolics level in studied plants.

In the greenhouse experiment the effect of particular compounds on the growth of *Echinochloa crus-galli* was also studied. It has been found that the examined phenolics, and especially *trans*-cinnamic acid and mixture of phenolic compounds, significantly inhibit the growth of *Echinochloa crus-galli*. The obtained results may contribute to the explanation of the biological activity of some phenolic compounds.

List of abbreviations: TLC, thin - layer chromatography; AE, allelopathic efficiency; x, x/2, x/4, concentrations of the phenolic compounds.

Introduction

Plants produce many organic compounds which play a significant role in plant-plant interactions and are used as herbicides. Recently, a range of secondary metabolites have been intensively studied for allelochemical properties. So far several categories of allelochemicals in plants have been identified, namely, phenolic acids, phenylpropanoids, hydroxamic acids, and short-chain fatty acids. Besides these, catechins, epicatechins, rutin and quercitin were recognized as compounds highly contributing to inhibitory effects in some plant species
(Wu et al. 1999, Olofsdotter et al. 2002, Inderjit and Duke 2003). Allophathically active compounds from plants act as natural herbicides and some have been explored as natural substitutes for commercial herbicides (Duke et al. 2000). The selection of genotypes with the enhanced allelochemical potential, focused on the weed growth controlling properties and increasing grain yields, has been carried out in several field crops (Putnam et al. 1983, Rice 1984, Yenish et al. 1996, Romagni et al. 2000, Sène et al. 2001). Some allelochemicals isolated from higher plants inhibit photosynthesis and consequently the production and growth of competing plants including weeds (Einhellig et al. 1993, Gonzalez et al. 1997, Smith and Doan 1999, Wu et al. 1999). According to Blum (1999) the donor plants must produce and release allelochemicals (i.e. phenolic acids, phenylpropanoids) which are able to affect the growth or other physiological functions of other plants. Phenolic compounds which are thought to be part of the chemical defence of plants are secondary metabolites widely distributed in the plant tissue (Harborne 1985). The synthesis of plant phenolic compounds depends on both genetic and environmental factors. Among environmental factors, an increase in phenolics level is caused by the water deficit, high irradiance, UV radiation, pathogen attack, fungicide and herbicide application, nutrients deficiency, herbivore attack and insect damage (Tempel 1981, Guinn and Eidenbock 1982, Caldwell et al. 1983, Harborne 1985, Delalone et al. 1996, Einheilig 1996, Schweiger et al. 1996). Some of phenolics have been found to be responsible for allelopathic interactions (Inderjit 1996, Mattice et al. 2001).

Much attention was focused on the allelopathic effect of *Echinochloa crus-galli* and its competition not only with maize crops (Roll 1986, Vangessel and Renner 1990, Olofsdotter and Navarez 1996, Piskorz 1997). It was shown that under field conditions the donor plant biomass (white mustard, buckwheat, spring barley, oat and rye) reduced numbers and mass of *Echinochloa crus-galli* in interrows of maize crop (Stupnicka-Rodzynkiewicz et al. 2004).

One of the most important aspects discussed recently is the identification of allelochemical compounds. The identification of such substances in plant materials provides information about allelopathic properties of crops or crop residues important for weed control and is vital for understanding of allelopathy mechanisms. In the present work, phenolic acids and phenylpropanoids were identified in white mustard, buckwheat, spring barley, oat and rye which were used as donor plants in field experiments. Moreover, the biological activity of these compounds was evaluated by sensitivity of *Echinochloa crus-galli* in the greenhouse experiment.

**Materials and methods**

**Plant materials and growth conditions**

Experiments were conducted at the Experimental Station of the Department of Soil Management and Plant Cultivation at Mydlniki near Kraków during two successive vegetation seasons 2002-2003. The concentration of phenolic compounds and cinna
cmic acid was estimated in white mustard (cv. Barka), buckwheat (cv. Hruszowska), spring barley (cv. Klimek), oat (cv. Dragon) and rye (cv. Esprit).

The oat, spring barley, rye and white mustard were sown on 14 March 2002 and 31 March 2003 (set I). The buckwheat was sown on 12 April in 2002 and 15 April in 2003 (set I). Additionally, the above mentioned plants were sown together with maize on 6 May 2002 and 2003 in the interrows of maize (set II). For each year two sets (I and II) of experiments were performed. Set I represents plants which were incorporated as mulch into soil before maize sowing while set II refers to plants which were sown in the interrows of maize, on the same day as maize, and were next incorporated into the soil. The reason for two sets of experiments was to compare the weed control effect of both obtained biomasses of donor plants.

**Sampling for quantification experiment**

Oat, spring barley, rye and white mustard plants from set I of the experiment were collected for analysis 53 days after sowing in both years while buckwheat plants were collected 23 days after sowing. For the set II of the experiment plants were collected 30 days after sowing in both years.