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Impact of selected phenylpropanoid acids on the growth and development of grain aphid *Sitobion avenae* (F.)

GRZEGORZ CHRZANOWSKI

Department of Biochemistry and Molecular Biology, University of Podlasie
Prusa 12, 08-110 Siedlce, Poland
grzegorzc@ap.siedlce.pl

Introduction

Phenolic acids are chemical compounds with carboxy- and hydroxy- group. Depending on the length of side chain (the number atoms of Carbon) the following acids are distinguished (Fig. 1.): benzoic, phenylacetic and cinnamic.

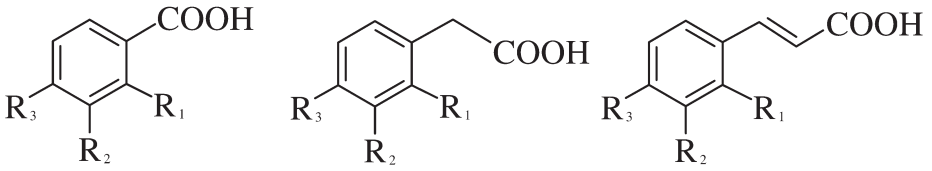

Fig. 1. Structure of phenolic acids (STOBIECKI, 1995).

In plants these compounds are synthesized mainly as a result of aromatic amino-acid (phenylalanine and tyrosine) transformation. As a result of anaerobic deamination with L-phenylalanine ammonia-lyase (PAL) *trans*-cinnamic acid is formed (JONES, 1984; PARR & BOLWELL, 2000). Some simple phenylpropenoids may be synthetised with cinnamate as a result of methylation, hydroxylation or dehydration. The following can be counted to belong to compounds obtained according to the mentioned changes: *para*-coumaric, caffeic and fe-

rulic acids (SOLECKA, 1997). Cinnamic acid derivates occur in plants both in a free and complex form of glicosides or depsides. Their presence was registered in cell wall, vacuoles, and as complexes in cell nucleus (HUTZLER *et al.,* 1998).

Aphids feeding on plants damage their tissues and take in assimilates formed in the process of photosynthesis. This leads to chlorosis and sometimes additionally causes necrosis (RYAN *et al.,* 1990). Moreover, PAPURA *et al.* (2002) proved that the grain aphid (*Sitobion avenae* F.) showed an ability to transfer BYDV-PAV.

According to SMITH & BOYKO (2006) many authors suggest that phenolic compounds, especially those which are formed as a result of PAL activation take part in the plant's response to aphid feeding. Also CIEPIELA & CHRZANOWSKI (2001) found that a high level of constitutional resistance of winter triticale was additionally correlated with a high concentration of ferulic acid. LESZCZYŃSKI *et al.* (1985) proves that phenylpropenoid acids limited bird cherry-oat aphid (*Rhopalosiphum padi* L.) feeding.

The aim of this paper is to determine the influence of caffeic, ferulic and *para*-coumaric acids on the growth and development of grain aphid (*S. avenae*).

Material and methods

All entomological experiments were made in a chamber room with temperature kept under control. The photoperiod was determined 16h:8h respectively for the light and dark phase. Relative humidity was 65 ± 5%. The temperature during the light phase was 24 ± 2°C, during the dark phase 16 ± 2°C. The intensity of lighting was 100 μmol · $m^{-2}s^{-1}$ and was achieved after white light fluorescent lamps and daylight fluorescent lamps had been installed (ratio 1:1).

Initial dilution ratio of the tested phenylpropenoid acids was prepared by dissolving an adequate amount (10 mg and 20 mg) of the standard (obtained from Sigma Chemicals Co., St. Louis, USA) in 5 cm^3 of absolute methanol. Next, in order to obtain solutions the concentration of which there were 10 mg% and 20 mg% of the studied phenylpropenoids the initial dilution ratios were diluted with distilled water up to the final volume 100cm^3.

In order to study the antibiotic effect of phenylpropenoid acids on the grain aphid, 20 of seven-days-old seedlings (for each concentration of the analysed acid) of the susceptible cultivar of winter triticale of the Marko cultivar were sprayed with the studied solutions (about 5 cm^3 per each seedling) and were then left in the chamber so that the sprayed solutions could dry out. Meanwhile, a control experiment was prepared in which seedlings were sprayed with 5% (v/v) water solution of methyl alcohol. After about 1 hour one wingless female of *S. avenae* was put on each seedling. Each plant with a wingless female

was isolated with a use of a plexiglas isolator in a shape of a cylinder. When a female gave birth to first offspring, one newly-born larva was left on the plant whereas the female and other larvae were removed from the plant. The new-born larva was observed until it was mature (and until it naturally died). The time from the birth of larva until the moment when it became adult (i.e. when it gave birth to its first offspring) constituted the prereproductiv period (PRP). From the moment of first larva's birth the number of new-born larvae was registered daily and then they were removed. On the basis of the number of born larvae in the period of reproduction daily fertility (DF) was counted. On the basis of the obtained parameters PRP and DF the intrisic rate of natural increase (r_m) of grain aphid population was counted with the use of an equation by WYATT & WHITE (1977).

Differences between mean parameters of antibiosis were estimated on the basis of analysis of variance (ANOVA) with the use of Tukey's test at level significance of $p \leq 0.05$.

Results and discussion

On the basis of entomological experiments it was proved that all the acids in both studied concentrations negatively influenced the growth and development of the grain aphid population.

When analyzing the impact of the studied phenylpropenoid acids on the length of prereproductiv period (PRP) it has to be stated that from all the tested compounds it was the ferulic acid in dilution ratio of $10mg \cdot 100cm^{-3}$ that most strongly prolonged the time of reaching maturity by *S. avenae* larvae (Fig. 2.). It was the *para*-cumaric acid in dilution ratio 20mg% that prolonged this period in aphids to the least extent, which was confirmed by the Tukey's test. Although its impact was the weakest, still this acid had a negative influence on larvae reaching their maturity.

Subsequent indicators which characterized *S. avenae* population development were: daily fecundity (DF) and the intriusic rate of natural increase (r_m). It was observed that each of the tested acids inhibited daily fecundity (Fig. 3.). When comparing the results between particular acids no statistically significant differences were found. Nonetheless, daily fecundity of females developing on plants sprayed with water methanol solution was statistically higher than the fecundity of females feeding on plants treated with phenolic acids. The least fecundity was observed in aphids which developed on plants sprayed with caffeic acid and such a situation was observed both for dilution ratio of 10 mg% and 20 mg% of this acid. The lowest growth of grain aphid population and development of this insect was recorded after treatment of caffeic acid concentration 10 mg %. It has to be stated that each of the tested acids inhibited development of *S. avenae* population (Fig. 4.).

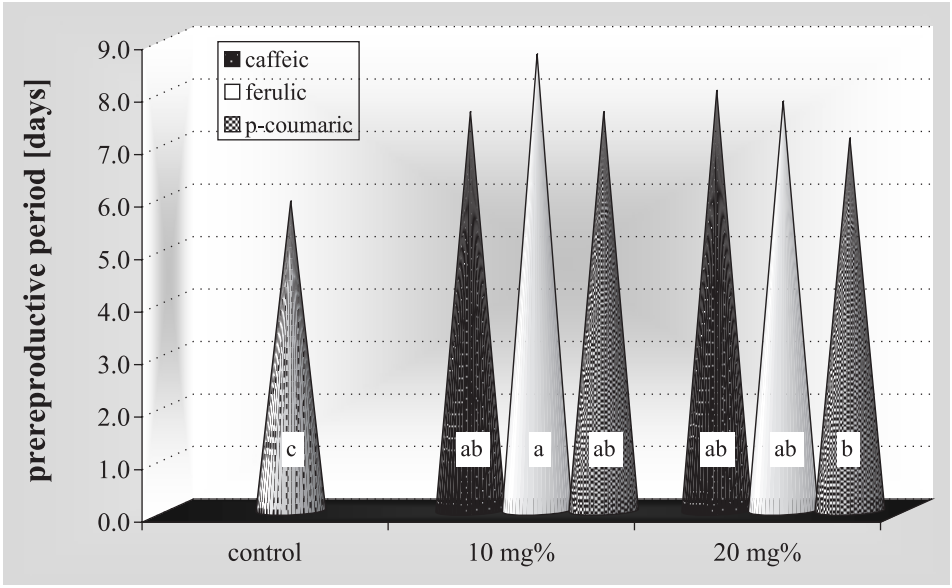

Fig. 2. Prereproductive period of the grain aphid developing on the triticale sprayed with solutions of phenylpropenoid acids, other letters on the cones indicate statistically significant differences at p≤0.05 (Tukey's test)

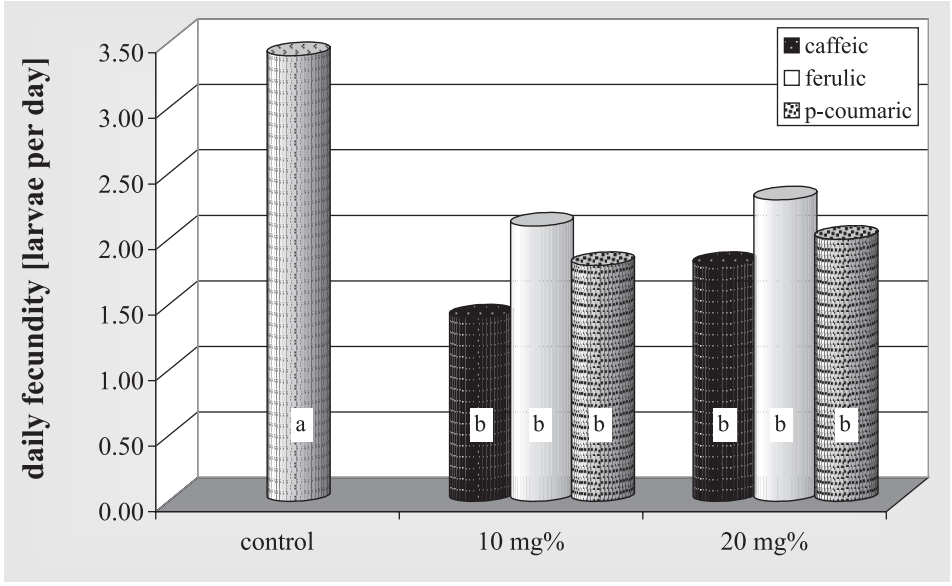

Fig. 3. The number of larvae born during the day by female of the grain aphid developing on triticale sprayed with solutions of phenylpropenoid acids, other letters on the cylinders indicate statistically significant differences at p≤0.05 (Tukey's test)

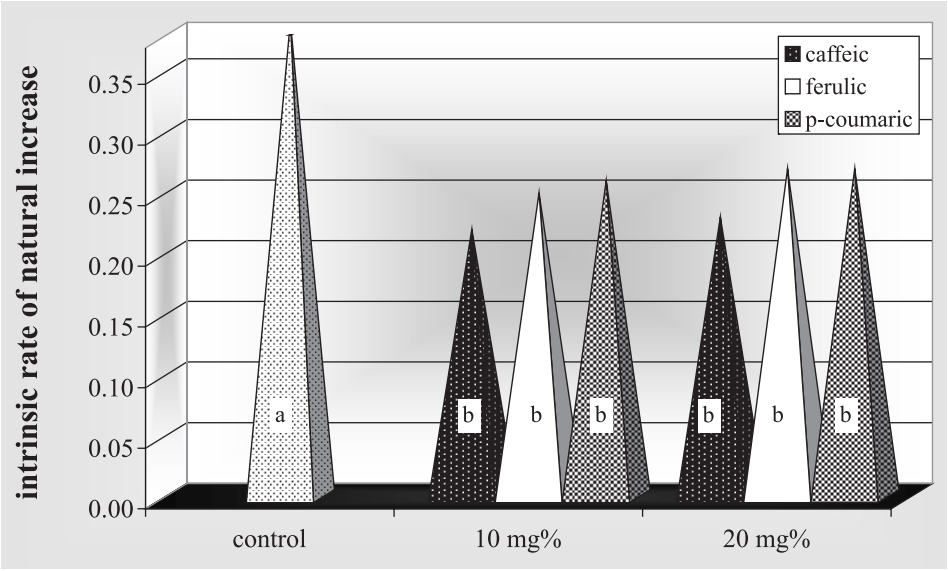

Fig. 4. The intrinsic rate of natural increase of the grain aphid *Sitobion avenae* in response to phenylpropenoid acids, other letters on the cones indicate statistically significant differences at $p \leq 0.05$ (Tukey's test)

Leszczyński *et al*. (1985) also proved that ferulic and caffeic acids in dilution ratio lower than 62.5 mg · dm^{-3}, inhibited *Rhopalosiphum padi* feeding. Similar results were obtained by Ciepiela (1990), who claimed that there was a negative impact of phenolic compounds on aphids during their feeding which resulted in a decrease of their population level and the number of generations. Cabrera *et al*. (1995) asserted that aphid feeding caused an increase of ferulic acid concentration in plant tissues which led to a lowering of aphid survival. These works were concerned with the content of compounds in plants and their share in resistance. On the basis of results obtained in this paper it has to be claimed that phenolic acids may be used in processes of integrated plant protection and the so called biocontrol.

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Wpływ wybranych kwasów fenylopropenowych na wzrost i rozwój mszycy zbożowej (*Sitobion avenae* (F.))

Streszczenie

Kwasy fenylopropenowe zaliczane są do najczęściej spotykanych grup związków wtórnego metabolizmu występujących w roślinach. Kwasy te wykazują toksyczność w stosunku do patogenów i szkodliwych owadów, jak również stanowią produkty pośrednie syntezy innych związków o znacznej toksyczności (m. in. alkaloidy, garbniki i flawonoidy).

Celem przeprowadzonych badań było określenie parametrów antybiozy dla mszyc rozwijających się na siewkach pszenżyta ozimego spryskiwanych wodnymi roztworami kwasu ferulowego, kawowego i *para*-kumarowego.

Doświadczenia wykonano na siewkach pszenżyta ozimego odmiany Marko, odznaczającego się bardzo niskim poziomem odporności w stosunku do mszycy zbożowej. Testowane kwasy nanoszono na roślinę w postaci oprysku, stosując dwa stężenia (10.0 i 20.0 mg%) dla każdego związku.

Wykazano, że spośród testowanych związków, kwas kawowy w stężeniu 10.0 mg% najsilniej ograniczał płodność dzienną (DF) i wrodzone tempo wzrostu populacji (r_m). Długość okresu przedreprodukcyjnego była najsilniej wydłużana przez kwas ferulowy (w stężeniu 10 mg%). Wszystkie stosowane kwasy wpływały negatywnie na wzrost i rozwój populacji mszycy zbożowej (*Sitobion avenae* (F.)).