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Participation of amino acid decarboxylases in biochemical interactions between triticale (*Triticosecale*; Poaceae) and bird cherry-oat aphid (*Rhopalosiphum padi*; Aphididae)

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ABSTRACT

The roles of ornithine decarboxylase, lysine decarboxylase and tyrosine decarboxylase in biochemical interactions of two cultivars of winter triticale (*Triticosecale*), Tornado and Witon, and bird cherry-oat aphid (*Rhopalosiphum padi* L.) were determined. Results showed the resistant Witon had higher lysine decarboxylase activity than the susceptible Tornado. There was a significant negative correlation between the density of *R. padi* populations and lysine decarboxylase activity. Such correlations did not occur for the other decarboxylases. Aphid feeding induced a decrease of lysine decarboxylase activity within both cultivars after one week of infestation and increased its activity after two weeks in the moderately resistant Witon. Ornithine decarboxylase activity was induced in tissues of the susceptible Tornado and inhibited in Witon after two weeks of infestation. Aphid infestations did not change tyrosine decarboxylase activity in Witon, whereas in Tornado it decreased in activity after one day of aphid feeding and then increased after two weeks. It was concluded that of the three enzymes studied, lysine decarboxylase was the most important in the response of winter triticale to infestation by *R. padi*.

1. Introduction

Amino acid decarboxylation is a key step of biogenic amines biosynthesis within plant tissues. Diamine putrescine is synthesised from ornithine by the action of ornithine decarboxylase (EC 4.1.1.17). The putrescine biosynthesis starts from arginine, which is decarboxylated to agmatine by arginine decarboxylase (ADC; EC 4.1.1.19) and metabolised to putrescine via N-carbamoylputrescine (Smith, 1985). The putrescine is next converted to spermidine and spermine by spermidine and spermine synthases, respectively, and amino propyl groups required for these reactions come from decarboxylated *S*-adenosylmethionine, formed earlier by the action of *S*-adenosylmethionine decarboxylase (SAMDC; EC 4.1.1.50) (Fuell et al., 2010). Moreover, plants from families *Fabaceae*, *Poaceae* and *Solanaceae* contain lysine decarboxylase (EC 4.1.1.18), which participates in the conversion of lysine to cadaverine (Bagni and Tassoni, 2001). Aromatic amino acid decarboxylases, including tyrosine decarboxylase (EC 4.1.1.25), decarboxylates tyrosine convert 3,4-dihydroxyphenylalanine to tyramine and

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dopamine, respectively, and tryptophan decarboxylase (TDC; EC 4.1.1.27) converts tryptophan to tryptamine. Thus aromatic amino acid decarboxylases are important parts of the biogenic amines metabolism within plant tissues (Facchini et al., 2000).

Biogenic amines, especially aliphatic polyamines (PAs), are metabolites commonly occurring in living cells, and their importance in the plant's response and/or tolerance to pathogenic fungi, bacteria and viruses is well known (Walters, 2003). However, participation of plant amines in insect–plant interactions is not clear. Klose et al. (2002) showed that derivatives of plant PAs and aromatic monoamines obtained through conjugation with hydroxycinnamic acids, named hydroxycinnamic acid amides (HCAAs), may be toxic for insects, since they cause paralysis by binding to quisqualate-type glutamate receptors located on exoskeletal muscles and block synaptic transmission. According to Tebayashi et al. (2007), sweet pepper (*Capsicum annuum* L.) treated with jasmonic acid showed ovipositional deterrence towards leaf miner *Liriomyza trifolii* (Burgess), and this was connected with the simultaneous accumulation of caffeoyl putrescine. *p*-Coumaroyl putrescine and dicaffeoyl spermidine accumulated within *Nicotiana attenuata* (Torr. ex Wats.) tissues as the result of silencing of the NaMYB8 transcription factor, which reduced the performance of *Manduca sexta* (L.) and *Spodoptera littoralis* (Boisduval) (Bassard et al., 2010). PAs and α-difluoromethyl-ornithine (a well-known inhibitor of polyamine biosynthesis) affected sensitivity of *Plutella xylostella* (L.) antennae to odours (Zhang et al., 2008).

Our earlier studies proved that 0.01% solutions of free spermidine and spermine decreased food assimilation by wingless females of grain aphid (*Sitobion avenae* F.) and 0.1% concentration of agmatine, cadaverine, putrescine, spermidine and spermine strongly reduced body mass and survival of the aphid (Sempruch et al., 2010a). *S. avenae* feeding affected activity of ODC, LDC and TyDC within triticale tissues, and the changes were dependent on triticale cv. as well as aphid density and duration of infestation (Sempruch et al., 2008, 2009a; 2010b). The enzymes' activity was reduced during the first week of grain aphid infestation, with the exception of TyDC, and induced after two weeks, with exception of LDC, within tissues of susceptible Tornado cv. Moreover, the levels of the PAs and tryptamine were decreased in susceptible triticale cv. and increased in the moderately resistant one after two weeks of *Ropalosiphum padi* infestation (Sempruch et al., 2012).

The present paper reports on changes in the activity of amino acid decarboxylases involved in plant amine biosynthesis during biochemical interactions between triticale and bird cherry-oat aphid.

2. Materials and methods

2.1. Triticale cultivars

Two cultivars of winter triticale (*Triticosecale*, Wittm. ex A.Camus), Tornado and Witon, that are characterised by different levels of susceptibility to bird cherry-oat aphid, were used in the experiments. Seeds of both cultivars were obtained from the Plant Breeding and Acclimatization Institute (IHAR) in Strzelce near Łódź (Poland).

2.2. Field experiments

The field experiments were carried out at the Agricultural Experimental Station in Zawady near Siedlce (Central eastern region of Poland; 52°03′41″ N, 22°33′22″ E). The density of bird cherry-oat aphid on the triticale was estimated in random block arrangements, with three replicates for both studied cultivars according to the methods described earlier by Wratten et al. (1979) and Lykouressis (1984). The observations were carried out on experimental plots (2 m × 9 m) from the aphid arrival on the triticale until its disappearance (G.S.52 – 88; Tottman and Broad, 1987), in one-week intervals. The technique of counting aphids on 50 randomly selected blades diagonally across the field was applied. Obtained results were calculated as an average aphid number per blade and per cent of infested plants.

2.3. Laboratory experiments

2.3.1. Plants

Seeds of the studied cultivars were germinated in a climatic chamber at 24 °C at day and 18 °C at night, 70% RH and photoperiod 16L:8D. Plants were grown in medium nutrient fine-structure compost with sand, in 8.0 × 9.5 cm plastic pots, and regularly watered.

2.3.2. Aphids

Parthenogenetic multiclonal generations of *R. padi* were reared on winter wheat seedlings (Tonacja cv.) in a climatic chamber at 24 °C at day and 18 °C at night, 70% RH and photoperiod 16L:8D.

2.3.3. Influence of the bird cherry-oat aphid feeding on the enzymes' activity within triticale tissues

Twenty-five of the 7-day-old seedlings of the studied cultivars were artificially infested with 10 adult wingless females of *R. padi* each, and control plants (without aphids) were simultaneously prepared. Infested and control seedlings were collected after one day (24 h), one week and two weeks from the beginning of the experiment. On each occasion, the aphid number was counted on 10 randomly selected seedlings before the plant material collection. Obtained results were calculated as an average aphid number per seedling. The aerial parts of the freshly collected seedlings were used for enzymatic assays.