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The influence of selected plant polyamines on feeding and survival of grain aphid (*Sitobion avenae* F.)

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Abstract: The influence of common plant polyamines on feeding behaviour and survival of grain aphid (*Sitobion avenae* F., Hemiptera: Aphididae) has been studied. Laboratory tests showed that wingless females of *S. avenae* assimilated higher quantities of food from triticale seedlings placed in 0.01% solutions of agmatine and cadaverine, and lower in case of spermidine and spermine. Increase in the polyamines concentrations up to 0.10% caused strong decrease in food assimilation, especially under the agmatine, cadaverine and putrescine treatment. Moreover, 0.10% concentration of the all analyzed polyamines decreased body mass and reduced survival of grain aphid wingless females. The 0.01% concentration of the polyamines were not affecting survival and body mass of *S. avenae* with exception of spermidine. Importance of the polyamines as potential natural biopesticides to the grain aphid is discussed.

Key words: plant polyamines, *Sitobion avenae*, aphid body mass, aphid survival

INTRODUCTION

Polyamines are small molecular weight organic compounds that participate in plant reactions to different abiotic and biotic stresses [1, 2]. Plant responses to harmful biological factors, include polyamines acted *via* signaling molecules such as jasmonate, ethylene, salicylate, H_2O_2, NO, and Ca^{2+} influx [3, 4]. They induce programmed cell death (PCD) while hypersensitive responses (HR), and activate R genes that induce biosynthesis of PR proteins during systemic acquired

resistance (SAR) and/or participate in induced systemic resistance (ISR) [5, 6]. Moreover, hydroxycinnamic acid amides (HCAAs) of many plant polyamines are classified as phytoalexins and phytoanticipins and/or effective toxins for arthropods [7, 8]. These substances cause paralysis of insects by binding to quisqualte type glutamate receptors on the exoskeletal muscles and blocking synaptic transmission [9]. Such abilities suggest that plant polyamines and its phenolic derivatives might serve as natural bioinsecticides.

There are not data on role of plant polyamines as biological modulators of piercing-sucking herbivorous insects. The aim of the work was to determine an influence of polyamines commonly occurred within plant cells on feeding behaviour and survival of the grain aphid (*Sitobion avenae* F.).

MATERIAL AND METHODS

All tests were performed in environmental chamber at 20 ±3 °C temperature, 65 ±5% relative humidity and photoperiod 16L:8D according to Khan and Saxena [10]. The procedure developed for piercing-sucking insects with use of 0.01% and 0.1% watery solutions of agmatine, cadaverine, putrescine, spermidine and spermine. During experiment, seven days old seedlings of winter triticale cv. Lamberto and parthenogenetic individuals of *S. avenae* reared on the Lamberto seedlings in environmental chamber were used.

While feeding tests, the triticale seedling without roots were put into glass tubes (9.5 x 1.0 cm) with 2.0 cm^3 of tested solutions or 2.0 cm^3 of distilled water (control). Five wingless females of grain aphid, previously weighted with Sartorius balance 7085/01 type, were put on each plant and the tubes were covered with Plexiglas isolators (20.0 x 8.0 cm). After 24 h treatment, the aphids were weighted again and increase of the body mass was recorded. Quantity of assimilated food was calculated using the following equations after Khan and Saxena [10]:

$$F_A = W_1 \times \frac{C_1 - C_2}{C_1} + W_2 - W_1$$

where F_A is food assimilated, W_1 aphid weight (mg) before feeding on the triticale seedlings placed in amine solutions, W_2 aphid weight after 24 h of feeding on the seedlings placed in polyamine solutions, C_1 aphid weight before feeding on the control seedlings (placed in water), C_2 aphid weight after 24 h of feeding on the control seedlings.

The survival of *S. avenae* on the triticale seedlings placed in the studied solutions of the polyamines was tested in similar way. Duration of the aphid life period (in days) was determined. The aphids were transferred on fresh triticale seedling every second day during the test.

All experiments were conducted in three independent replicates. Differences between influence of the polyamines on food assimilated, increase of body mass and on survival of *S. avenae* were subjected to Tukey's test separately for two analyzed concentrations.

RESULTS AND DISCUSSION

Obtained results showed that *S. avenae* wingless females assimilated higher quantities of food on triticale seedlings placed in 0.01% solutions of agmatine and cadaverine, and lower in case of spermidine and spermine (Figure 1). The increase of polyamine concentration to 0.1% caused a decrease of food assimilation, especially strong after agmatine, cadaverine and putrescine treatment. The *S. avenae* individuals assimilated lower quantities of food on seedlings settled in 0.1% solutions of agmatine, putrescine and spermine than in case of cadaverine and spermidine. All the analyzed polyamines at 0.1% concentration decreased *S. avenae* body mass (Table 1).

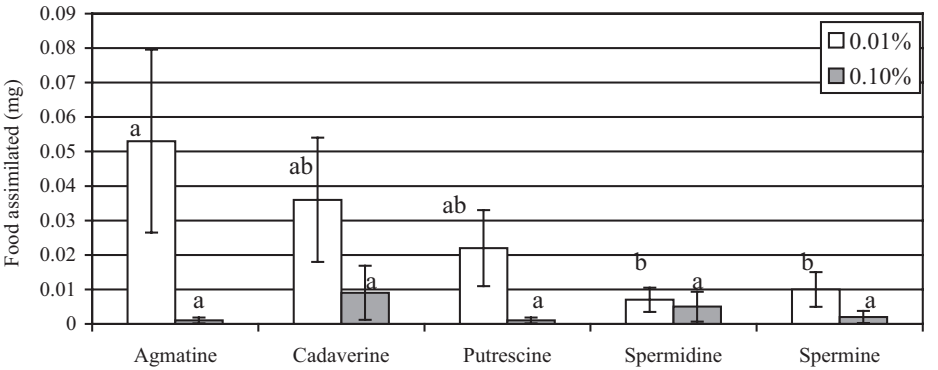

Figure 1. The influence of analyzed polyamines on food assimilated by grain aphid (arithmetic mean ± standard error); differences between activity of the polyamines were analyzed independent for each studied concentrations; values signed by various letters are significantly different at $P \leq 0.05$ (Tukey's test); $F_{4,8} = 2.97$ for 0.01% concentration and $F_{4,8} = 0.85$ for 0.10% one.

Table 1. Influence of the polyamines on increase of mass of grain aphid body (arithmetic mean ± standard error)

Polyamines	Increase of body mass (μg)	
	Polyamine concentration	
	0.01%	0.10%
Agmatine	0.40 ±0.17a	-1.87 ±0.40b
Cadaverine	1.00 ±0.29a	-1.83 ±0.31b
Putrescine	0.80 ±0.23a	-1.89 ±0.26b
Spermidine	-1.60 ±0.46b	-1.82 ±0.19b
Spermine	1.00 ±0.40a	-3.20 ±0.46b
Control	1.00 ±0.35a	1.00 ±0.35a
$F_{5.10}$	10.41	16.02
NIR	1.55	1.70

Values in the same column signed by various letters are significantly different at $P \leq 0.05$ (Tukey's test).

Table 2. Influence of the polyamines on survival of grain aphid (arithmetic mean ± standard error)

Polyamines	Survival (days)	
	Polyamine concentration	
	0.01%	0.10%
Agmatine	1.25 ±0.23a	1.12 ±0.65c
Cadaverine	5.62 ±1.33a	1.87 ±0.38b
Putrescine	3.37 ±1.27a	1.79 ±0.25b
Spermidine	4.75 ±1.56a	1.54 ±0.36bc
Spermine	5.50 ±0.87a	1.66 ±0.35bc
Control	6.12 ±0.65a	6.12 ± 0.65a
$F_{5.10}$	3.06	199.66
NIR	5.04	0.65

Values in the same column signed by various letters are significantly different at $P \leq 0.05$ (Tukey's test).

The influence of lower concentrations (0.01%) of these compounds on the aphid body mass was not statistically confirmed, with exception of spermidine, that caused a decrease of this parameter value. It was noted, that polyamines also limited survival of *S. avenae* wingless females (Table 2). Agmatine showed stronger influence on *S. avenae* survival than other analyzed polyamines at the both studied concentrations. However, differences in duration of the aphid

performance on the triticale seedlings placed in the polyamine solutions were significant at 0.1% concentrations for all the analyzed compounds.

Conducted tests pointed out, that the plant polyamines may act as natural plant substances limiting feeding and survival of the grain aphid. Kusano *et al.* [2] stated that polyamines occur within all living cells in the range of hundred micromolars to a few millimolars and their content is tightly regulated. At higher concentration these substances are toxic for cells by induction of the PCD. Our studies suggest that tested polyamines in the range from 4.90 mM for spermine to 11.40 mM for putrescine (equivalents of 0.1% solutions) may have a harmful effect for *S. avenae*. On the other hand, such polyamines as spermidine, agmatine and spermine limited feeding and/or survival of the grain aphid already in the range from 490 μM to 770 μM, respectively (equivalents of 0.01% solutions). There are also data suggesting that acylpolyamines act as neurotoxins for arthropods [11-14]. These substances may occur in venoms of some spider and wasp species and are structurally similar to HCAA derivatives of plant polyamines. Within plant tissues of *Poaceae* family HCAAs of agmatine, putrescine, spermidine and spermine were reported [15]. Phenolic derivatives of plant polyamines are highly selective and potent ligands for specific ionotropic receptors, particularly certain glutamate receptors subtype and nicotinic and acetylcholine receptors [11]. Thus molecular action of the polyamines and their HCAAs influence on the aphid biology should be study more detail in the future. Since, the influence of free and conjugated polyamines on *S. avenae* biology is dependent on its localization within plant tissues, further study that are focused on occurrence of these biomolecules within plant tissues penetrated by aphids, especially within phloem and peripheral tissues are needed.

CONCLUSIONS

1. Spermidine and spermine at 0.01% concentration and 0.10% solutions of all analyzed polyamines limited food assimilation by wingless females of *S. avenae*.
2. All analyzed polyamines, at 0.10% concentration, decreased body mass and reduced survival of grain aphid wingless females.

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