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RELATIONSHIP BETWEEN CHLOROPHENOXYACETIC ACID HERBICIDES, INDOLEACETIC ACID AND REPRODUCTION OF CEREAL APHIDS ON WHEAT

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Abstract: Phenoxy acids significantly increased the number of *Sitobion avenae* F. and *Rhopalosiphum padi* L.on wheat treated with Aminopielik D and Illoxan 36 EC. This herbicidal effect could be caused directly by derivatives of phenoxy acid or indirectly by altered metabolism of wheat plant.

Key words: *Sitobion avenae*, *Rhopalosiphum padi*, phenoxy acid herbicides, indoleacetic acid, phenolic compounds

I. INTRODUCTION

Herbicides make up the biggest group among plant protection products. This group includes compounds of very high biological activity directed not only against weeds but also against protected plants whose metabolism they can modify. In this way herbicides can indirectly influence the biology of agrophages. It is not excluded that this influence may be direct. There are many examples of induction or inhibition of fungi infection (Katan and Eshel 1973) and the development of nematodes (Beane and Perry 1990; Levene et al. 1998; Perry and Beane 1989; Yardin and Edwards 1998) or insects (Adams and Drew 1969; Ingram et al. 1964; Ishii and Hirano 1963; Pimental and Oka 1974) after application of herbicides. At the earliest and the best was known a side effect caused by 2,4-D and its derivatives. Adams and Drew, already in 1965, observed more numerous colonies of cereal aphids on the oat plantations treated with phenoxyacetic acids herbicides as compared with untreated fields. According to Ruszkowska (1988) treatment of wheat with 2,4-D derivatives as Aminopielik and Chwastox cause increased inhabitation of the crop by cereal aphid *Sitobion avenae* F. and bird-cherry aphid *Rhopalosiphum padi* L.

Biochemical changes in plants caused by herbicides may lead to better or worse conditions for the development of pathogens and parasites of insects. Recognition of this phenomenon and its mechanisms may allow for determination of possible threats to agricultural environment resulting from side effects caused by application of certain group of herbicides. One of the factors contributing to the increase of the cereal aphid number may be the rise of auxin level (IAA) in plant (Bur 1985). The presence of activators or inhibitors of indoleacetic acid oxidase among other factors may modify the auxin level. Based on our ex-

periments we had found that addition of wheat extract prepared from the plants treated with phenoxy acids results in inhibition of indoleacetic acid breakdown in the *in vitro* systems (Giebel et al. 1998). Therefore we should examine if the better development of aphids on the plants treated with herbicides is dependent on the activity of factor inhibiting IAA oxidation.

II. MATERIAL AND METHODS

Spring wheat cv. Banti was sown on the experimental fields of $1 m^2$ size. At the beginning of tillering the foliage treatment of plants was performed with Aminopielik D (a.i. 2,4-D sodium salt + dikamba amine salt) in concentration of 6 l/ha and compared to untreated wheat. During the second year of experiments Illoxan 36 EC (diclofop methyl) was used in dose equal to 3 l/ha. Wheat spikes were put to the tubes filled with water and the cereal aphids were placed on them (3 aphids on a spike in 10 replications) and kept in a growth chamber in controlled conditions (16 hours in light/ 8 hours in dark; temp. 22°C, humidity 70–80%). The aphids were counted everyday for a week.

From the wheat growing at the experimental fields the 100 g samples of culms, flag leaves and spikes were taken and used for preparation of ethanol extracts by Johnson and Schaal method (1957).

The extracts were used also for the measurements of the phenol compounds level by colorimetric methods with Folin reagent and using chlorogenic acid as a standard (Swain and Hillis 1959). Monophenols were separated from polyphenols on the column containing aluminium oxide as an adsorbent of polyphenols (Zuker and Ahrens 1958). The amount of polyphenols was determined based on the difference of the total amount of phenols and monophenols.

To determine a direct effect of increased IAA level on the reproduction of aphids the following tests were performed. Wheat seedlings with 3 aphid females on each seedling (in 10 replications) were placed in tubes containing 0,1 mM indoleacetic acid. Seedlings placed in water were treated as a control. The experiments were carried out on the cereal aphid *Sitobion avenae* and bird-cherry aphid *Rhopalosiphum padi*. The aphids were counted everyday for a week. The results were presented as the averages regarding mean deviation of the population. Similarly, in the analogous conditions, the effect of 0,1 mM cinnamic acid (as an IAA oxidase activator) and a mixture of IAA and cinnamic acid on the reproduction of cereal aphid *Sitobion avenae* was tested.

III. RESULTS AND DISCUSSION

On the wheat cultivated in the field treated with herbicides from phenoxyacetic acid group a faster rate of aphids reproduction was observed (Giebel et al. 1998). Laboratory experiments carried out on the cereal aphid *Sitobion avenae* feeding on the flag leaves and spikes of spring wheat treated with Aminopielik D and on the spikes of wheat treated with

Illoxan 36 EC showed that aphids reproduce much more intensely on the wheat treated with herbicides. The data concerning these experiments are presented in figs. 1–3.

The effect of extracts obtained from leaves and spikes of wheat treated with herbicides on the IAA oxidase activity in the *in vitro* systems was studied earlier (Giebel et al. 1998). A clear effect of the extracts on the inhibition of IAA decomposition was found. The chemicals that could modify activity of IAA oxidase are phenolic compounds (Henderson and Nitsch 1962; Tomaszewski and Thimann 1966).

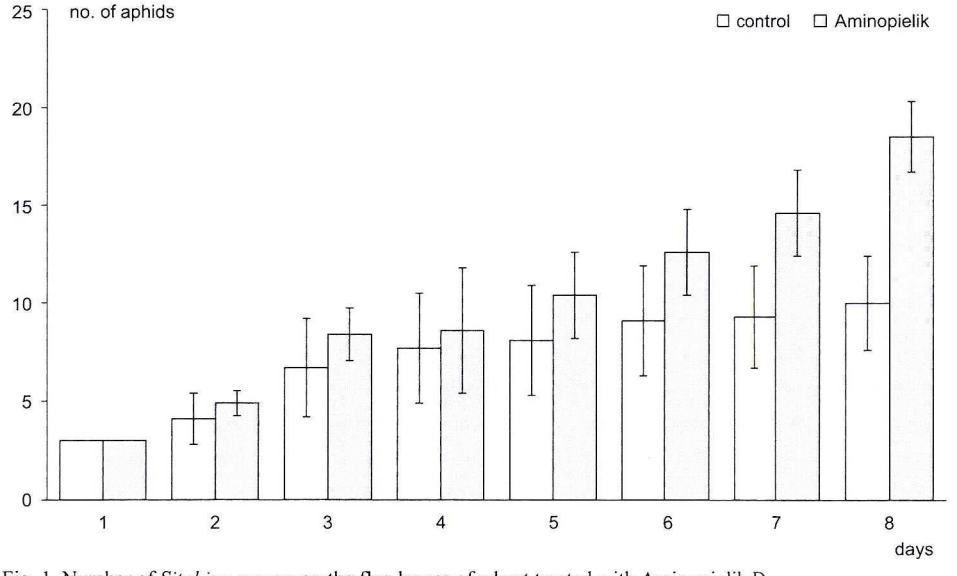

Fig. 1. Number of *Sitobion avenae* on the flag leaves of wheat treated with Aminopielik D

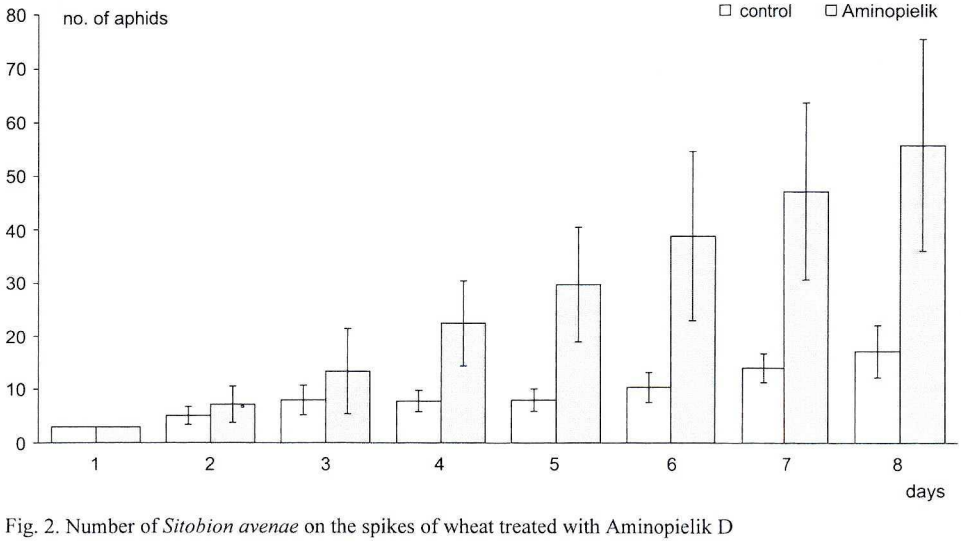

Fig. 2. Number of *Sitobion avenae* on the spikes of wheat treated with Aminopielik D

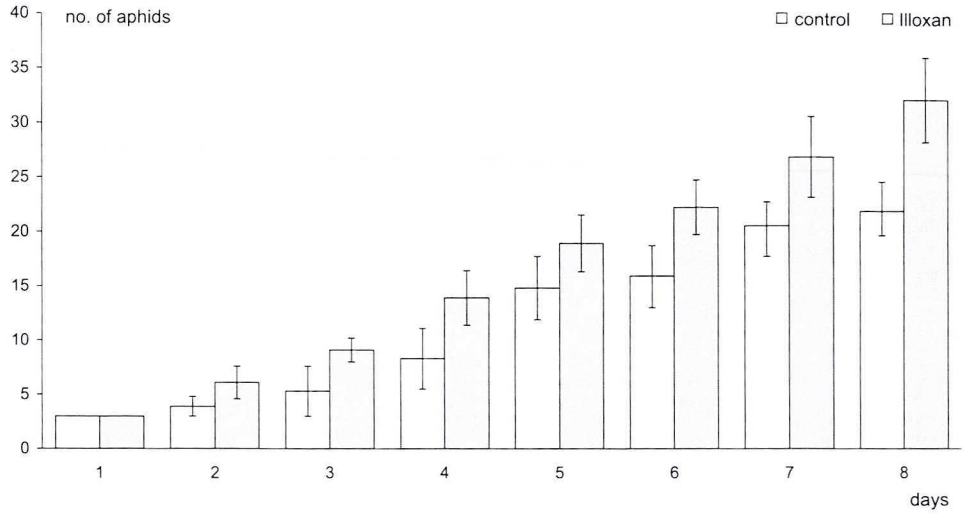

Fig. 3. Number of *Sitobion avenae* on the spikes of wheat treated with Illoxan 36 EC

The content of the phenolic compounds in leaves and spikes of wheat treated with Aminopielik D and Illoxan 36 EC are presented in table 1. The increased level of total phenols in spikes of wheat treated with both herbicides was found, but in case of Aminopielik application it was much higher than after Illoxan treatment. The content of polyphenols was also higher. Polyphenols act usually as the inhibitors of indoleacetic acid oxidase and in this way they protect IAA from breakdown. It is important since indoleacetic acid, similarly as other indole compounds, favors development and reproduction of many aphid species (Bur 1985). The distinct increase of the aphid number on the wheat spikes treated with Aminopielik observed by us accompanying by the increased amount of polyphenols in the spikes may confirm this relationship. The polyphenols content in spikes of wheat treated with Illoxan was not different from control but the aphid number collected from these spikes was about 30% higher as compared with control.

Flückiger (1977) showed that a treatment with 2,4-D may lower peroxidase activity in winter wheat but the effect is totally released after 20 days following application of herbicide on the plant. On the other hand it is known that after this time a level of 2,4-D residues is very low or absent. It seems that in our case the inhibiting effect on the peroxidase /IAA

Table 1

Phenols content (mg/g of fresh weight) in leaves and spikes of spring wheat treated with the studied herbicides

Phenols	Leaves		Spikes		Leaves		Spikes	
	Control	Aminopielik	Control	Aminopielik	Control	Illoxan	Control	Illoxan
total	4908	4872	1436	1828	4200	4200	1224	1260
monophenols	1920	2156	832	668	1140	1244	672	688
polyphenoles	2988	2716	600	1160	3060	2956	552	572

oxidase activity is caused by a factor present in wheat ethanol extracts. Maybe this factor is a polyphenol-like compound and, like polyphenols it is able to decrease peroxidase activity.

The direct effect of indoleacetic acid on the reproduction of aphids is presented in figs. 4 and 5. The numbers of *Sitobion avenae* and *Rhopalosiphum padi* aphids reared on the wheat seedlings grown in 0.1 mM IAA solution were much different from the control conditions. After 8 days indoleacetic acid caused twofold increase in number of the both species

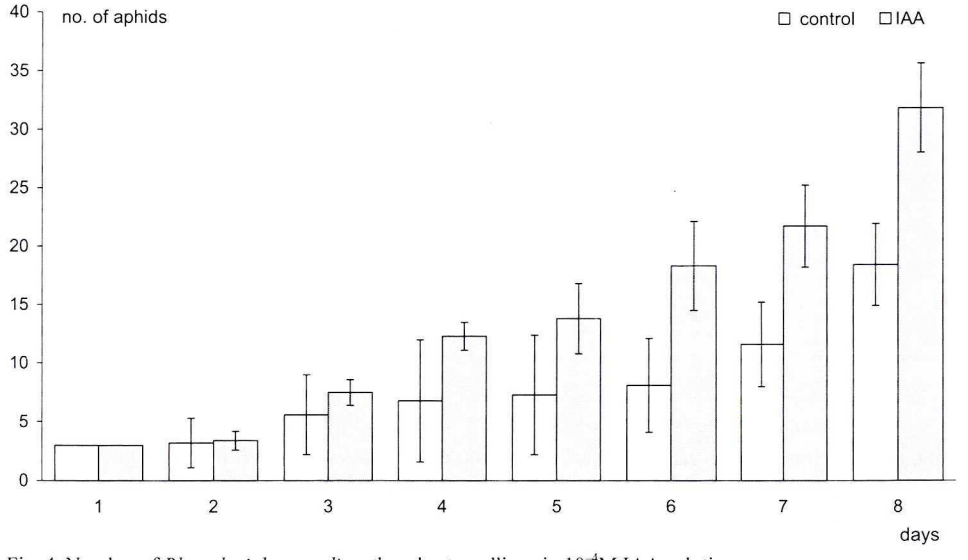

Fig. 4. Number of *Rhopalosiphum padi* on the wheat seedlings in 10^{-4}M IAA solution

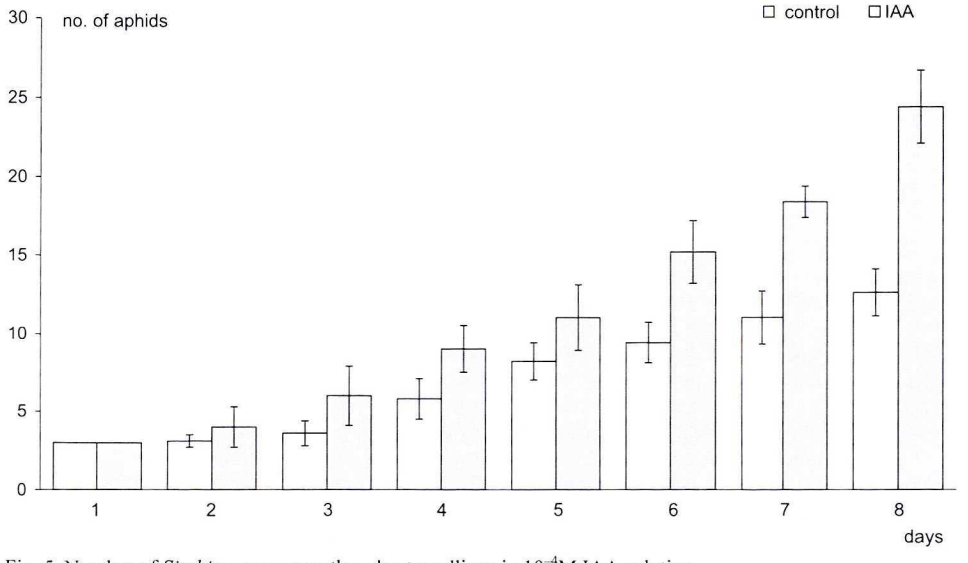

Fig. 5. Number of *Sitobion avenae* on the wheat seedlings in 10^{-4}M IAA solution

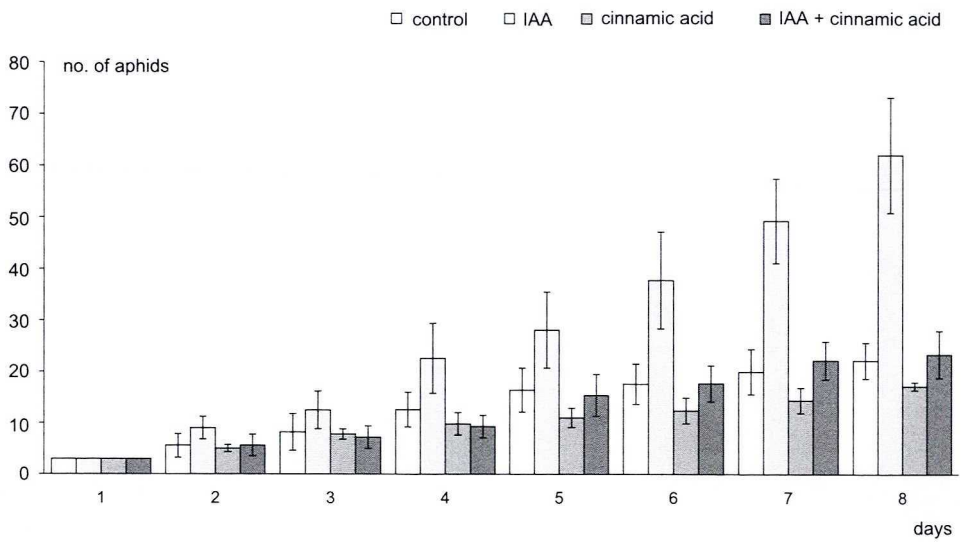

Fig. 6. Number of *Sitobion avenae* on the wheat seedlings in solutions of: IAA, cinnamic acid and cinnamic acid + IAA

of aphids. Woda-Leśniewska and Giebel (2000) showed that cinnamic acid as an IAA oxidase activator cause a decrease of the reared cereal aphid. Therefore we tested the effect of synergistic action of IAA with cinnamic acid. The results of experiments are presented in fig. 6. It turned out that those cinnamic acid reverses stimulating effect of IAA on the aphids development.

It may be assumed that both phenoxyacids and auxin (IAA) itself stimulate reproduction of cereal aphids and occurrence of IAA oxidase inhibitors would limit breakdown of auxin not only in plant but maybe would protect from decomposition the indole compounds in the insect organism.

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V. POLISH SUMMARY

WSPÓŁZALEŻNOŚĆ MIĘDZY POCHODNYMI 2,4-D I KWASEM INDOLOOCTOWYM A ROZMNAŻANIEM SIĘ MSZYC ZBOŻOWYCH

Mszyce zbożowe *Sitobion avenae* i *Rhopalosiphum padi* hodowano w warunkach laboratoryjnych na kłosach pszenicy jarej Banti traktowanej pochodnymi fenoksykwasów herbicydami: Aminopielik D i Illoxan 36 EC. Stwierdzono wyraźny wzrost liczebności mszyc na kłosach pszenicy traktowanej tymi herbicydami w porównaniu z kontrolą. Hodowano również mszycę zbożową *Sitobion avenae* na siewkach pszenicy w hydroponiku z kwasem cynamonowym (jako aktywatorem oksydazy IAA) oraz z mieszaniną roztworów IAA i kwasu cynamonowego. Kwas cynamonowy niwelował stymulujące rozwój mszyc działanie IAA. Kwasy fenoksyoctowe, jak i sama auksyna, stymulowały rozmnażanie się mszyc zbożowych, obecność natomiast inhibitorów (między innymi polifenoli) IAA-oksydazy może ograniczać rozkład auksyny nie tylko w roślinie, ale również w organizmie owada.