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INTERACTION OF VIRUSES AND HERBICIDES ON HOST PLANTS

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ABSTRACT

Regarding, that 50 % of pesticide sales is made up by herbicides, from practical point of view it is important to know the beneficial side effect of several herbicides, including the effect on host-virus relations. The best known in this respect is the antiviral activity of triazine, carbamide, dinitroaniline and auxine-type herbicides. The aim of our study was to examine the effect of some active herbicide ingredients (pendimethalin, napropamide, fluazifop-P-butyl) on local [*Obuda pepper virus* (ObPV)- *Nicotiana glutinosa,* ObPV - *Chenopodium amaranticolor*], systemic (ObPV - pepper, ObPV - *Nicotiana tabacum* 'Samsun') and local+systemic [*Alfalfa mosaic virus* (AMV) - *Chenopodium amaranticolor*] host - virus relations. It is concluded that the effect of herbicides on host-virus relations greatly depends on hosts (species, varieties), type of herbicides, mode and dosage of application. In ObPV - *Nicotiana glutinosa* local host-virus relations pendimethalin reduced the number of the virus induced local lesions by 55%. In systemic host virus relations four types of herbicide effect were observed: (1) Plants were not infected due to the herbicide treatments, (2) Plants infected, but the virus concentration was significantly lower, as compared to positive control, (3) Herbicides did not influence the virus concentration in the leaves, and (4) Herbicides (only in one case) significantly enhanced virus concentration. Our results pay attention to the fact, that certain herbicides may play important role not only against weeds, but also have inhibitory effect on economically important viruses, occuring in agricultural ecosystems.

Key words: *Alfalfa mosaic virus*, *Obuda pepper virus,* herbicides, virus hosts, interactions

IZVLEČEK

VPLIV INTERAKCIJE MED VIRUSI IN HERBICIDI NA GOSTITELJSKE RASTLINE

Ker 50 odstotkov prodaje pesticidov predstavljajo herbicidi, je s praktičnega vidika dobro poznati koristne stranske učinke nekaterih herbicidnih substanc, vključno z vplivom na odnos gostitelj-virus. V tem smislu je najbolj znano protivirusno delovanje triazinov, karbamida, dinitroanilina in herbicidov tipa avksinov. Namen raziskave je bil, preučiti vpliv nekaterih aktivnih snovi v herbicidih (pendimetalin, napropamid, fluazifop-P-butil) na lokalne (Obuda pepper virus – *Nicotiana glutinosa*, Obuda pepper virus – *Chenopodium amaranticolor*) in sistemične (Obuda pepper virus – paprika (*Capsicum annum*), Obuda pepper virus – *N. tabacum* 'Samsum', alfalfa mosaic virus – *C. amaranticolor*) okužbe. Raziskave kažejo, da je vpliv herbicidov na odnos gostitelj – virus močno odvisen od vrste in varietete gostitelja, tipa herbicidov, načina aplikacije in odmerka. Pri lokalni okužbi rastlin vrste *N. glutinosa* z Obuda pepper virus, je pendimetalin zmanjšal število lezij za 55 %. Pri sistemični okužbi smo opazili 4 tipe reakcije na herbicid: (1) zaradi uporabe herbicidov rastline niso bile okužene, (2) rastline so bile okužene, vendar je bila koncentracija virusov znantno nižja kot pri pozitivni kontroli, (3) herbicidi niso vplivali na koncentracijo virusov v listih in (4) herbicidi so (samo v enem primeru) znatno povečali koncentracijo virusov. Rezultati kažejo, da nekateri herbicidi delujejo ne le na plevele temveč zavirajo tudi gospodarsko pomembne vrste virusov, ki se pojavljajo v agroekosistemih.

Ključne besede: *Alfalfa mosaic virus*, *Obuda pepper virus,* herbicidi, gostitelji virusov, interakcije

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1 INTRODUCTION

Plant viruses participate in 15-30% out of the whole plant diseases (plant physiological, genetical, caused by microorganisms). Both *Obuda pepper virus* (ObPV) (syn: Ob-strain of *Tomato mosaic virus*) and *Alfalfa mosaic virus* (AMV) are economically important viruses, occurring in a lot of crops, including pepper, potato, tomato and tobacco (Brunt *et al.*, 1996).

Several artificial substances are known to inhibit the spreading and replication of viruses and reduce the virus concentration in the hosts (Yordanova *et al.,* 1996, Sano 1997, Faccioli and Zoffoli 1998, Kálmán and Gáborjányi 1998).

Regarding the fact, that even now chemical plant protection takes major part inside the integrated pest management, and 50% of the pesticide is herbicide, from practical point of view it is important to know the side effects of herbicides, including also the effect on host – virus relations. So far only little data is available in this respect. The best known is the antiviral activity of some triazine (Mackenzie *et al.,* 1970, Schuster 1982, Arenhövel and Schuster 1982), carbamide (Schuster 1972), dinitroaniline (Horváth and Hunyadi 1973, Rao *et al.*, 1994) and auxine-type (Schuster 1972) herbicides.

The aim of this study was to examine the effect of some herbicide ingredients (napropamide, pendimethalin and fluazifop-P-butyl) on virus concentration in host plants, which are either important crops or test species in virus diagnosis.

2 MATERIALS AND METHODS

2.1 Preplant (PP) treatments

Preplant treatments with pendimethalin at 4 and 8 l/ha and napropamide with 3 and 6 l/ha dosages were applied one week before planting. Herbicide amount was calculated based on the surface area of pots (12 cm diam). Plants (*Nicotiana tabacum* ‘Samsun’, *Capsicum annuum* ‘Macskapiros’ and ‘Csipke’ varieties) - each in seven replicates - at 4-6 leaf stages were inoculated with ObPV. Sörensen phosphate buffer (pH 7.2) in the ratio of 1:1 was used.

2.2 Postemergent (POST) treatments

Chenopodium amaranticolor, N. glutinosa, N. tabacum ‘Samsun’, *C. annuum* ‘Macskapiros’ and ‘Csipke’ were grown in plastic pots (12 cm in diameter) in our virological glasshouse free from virus vectors. *C. amaranticolor* plants at 8-10 leaf stages was inculated with AMV and ObPV. Beside this, *N. tabacum* ‘Samsun’, pepper varieties and *N. glutinosa* was inoculated with ObPV. Pendimethalin at 1% concentration was mixed to the inoculum. In case of pepper varieties pendimethalin at 2% and fluazifop-butyl at 0.75 and 1.5 % concentrations were also mixed to the inoculum.

2.3. Evaluation of virus infection

Systemically infected plants were tested for the presence of ObMV and AMV on the basis of symptoms and using double-antibody sandwich ELISA (DAS ELISA) serological method, five weeks after inoculation (Clark and Adams 1977). Extinction values were measured 20 minutes after adding the substrate at 405 nm wavelength by Multiscan ELISA reader. The higher the concentration of viruses in the plant samples, the higher extinction values were measured, therefore from the extinction values one could conclude to the virus concentration. Test samples were considered susceptible to virus infection if their extinction values exceeded three times those of the healthy (uninfected) control ones. Back inoculation to *N. tabacum* ‘Xanthi’ and ‘Samsun’ as indicator plants have been also carried out.

In local host – virus relations the leaf area was determined using a planimeter (LICOR 3000) and the local lesions was counted five days after inoculations.

3 RESULTS

3.1 Preplant (PP) treatments

ObPV concentration in 'Macskapiros' pepper leaves was not significantly influenced when preplant treatments with napropamide and pendimethalin were applied at lower dosages, while higher dosages significantly reduced virus concentration in systemically infected leaves as compared to positive control ones with no herbicide treatments.

In case of 'Csipke' pepper variety napropamide at 3 l /ha dosage did not influence virus concentration, while at 6 l /ha dosage and pendimethalin applied as preplant treatments prevented the virus infection. Symptoms did not occur, extinction values during DAS ELISA tests did not exceed three times those of the negative control. Incompatible host-virus relations were also confirmed by the results of back inoculation.

Pendimethalin reduced the concentration of ObPV in systemically infected *N. tabacum* 'Samsun' leaves. Lower virus concentration had been observed at the higher dosage (8 l/ha) as compared to the 4 l/ha one (Table 1).

3.2 Postemergent (POST) treatments

Table 1: The effect of preplant herbicides on the host-virus relations

Virus	Host	Herbicide treatments	Symptoms*	Extinction values
ObPV	*C. annuum* 'Macskapiros'	-	-/Mo, Led, Bli	1.319
ObPV	*C. annuum* 'Macskapiros'	napropamide PP 3 l/ha	-/Mo, Led, Bli	1.304
ObPV	*C. annuum* 'Macskapiros'	napropamide PP 6 l/ha	-/Mo, Led, Bli	1.002
ObPV	*C. annuum* 'Macskapiros'	pendimethalin PP 4 l/ha	-/Mo, Led, Bli	1.312
ObPV	*C. annuum* 'Macskapiros'	pendimethalin PP 8 l/ha	-/Mo, Led, Bli	1.012
		SD(P=5%)		0.274
Negative control				0.285
ObPV	*C. annuum* 'Csipke'	-	-/Mo, Led, Bli	1.321
ObPV	*C. annuum* 'Csipke'	napropamide PP 3 l/ha	-/Mo, Led, Bli	1.191
ObPV	*C. annuum* 'Csipke'	napropamide PP 6 l/ha	-/-	0.379
ObPV	*C. annuum* 'Csipke'	pendimethalin PP 4 l/ha	-/-	0.401
ObPV	*C. annuum* 'Csipke'	pendimethalin PP 8 l/ha	-/-	0.312
		SD (P=5%)		0.350
Negative control				0.279
ObPV	*N. tabacum* 'Samsun'	-	-/Mo, Led, Bli	0.643
ObPV	*N. tabacum* 'Samsun'	pendimethalin PP 4 l/ha	-/Mo, Led, Bli	0.577
ObPV	*N. tabacum* 'Samsun'	pendimethalin PP 8 l/ha	-/Mo, Led, Bli	0.510
		SD(P=5%)		0.063
Negative control				0.126

*Local/systemic symptoms; -, symptomless; Mo, mosaic; Led, leaf deformation; Bli, blistering

Five days after inoculation with AMV local and systemic symptoms could be observed on *C. amaranticolor* leaves. Pendimethalin at 1% concentration mixed to the inoculum did not infuence the number of local lesions but delayed the appearance of the systemic symptoms by one week and lower extinction values as compared to positive control suggested that herbicide reduced the virus concentration in systemically infected leaves. The number of local lesions on *N. glutinosa* leaves was reduced by 55%, when pendimethalin was added to the inoculum contained ObPV. Pendimethalin at 1% concentration seemed to have no effect on *N. tabacum* 'Samsun'-ObPV and *C. amaranticolor* - ObPV relations (Table 2).

Table 2. The effect of postemergent herbicides on the host-virus relations

Virus	Host	Herbicide treatments	Symptoms*	Number of the local lesions/cm^2	Extinction values
AMV	*C. amaranticolor*	-	Chl/Y, Mo, Bli, Led	1.24	0.811
AMV	*C. amaranticolor*	pendimethalin POST 1%	Chl/Y, Mo, Bli, Led	1.96	0.634
		SD(P=5%)		0.78	0.117
		Negative control			0.172
ObPV	*C. amaranticolor*	-	Chl, Nl/-	9.25	
ObPV	*C. amaranticolor*	pendimethalin POST 1%	Chl, Nl/-	9.21	
		SD(P=5%)		0.86	
ObPV	*N. glutinosa*	-	Chl, Nl/-	12.55	
ObPV	*N. glutinosa*	pendimethalin POST 1%	Chl, Nl/-	5.65	
		SD(P=5%)		3.71	
ObPV	*N. tabacum* 'Samsun'	-	-/Mo, Led, Bli	-	0.635
ObPV	*N. tabacum* 'Samsun'	pendimethalin POST 1%	-/Mo, Led, Bli	-	0.663
		SD(P=5%)			0.127
		Negative control			0.135

*Local/systemic symptoms; Chl, chlorotic lesions; Nl, necrotic lesions; -, symptomless; Mo, mosaic; Led, leaf deformation; Bli, blistering, Y, yellowing

All postemergent treatments -except fluazifop-P-butyl at 1.5 % concentration - did not influenced the ObPV concentration in 'Macskapiros' pepper variety. Fluazifop-P-butyl at 1.5% concentration reduced the ObPV concentration .

In 'Csipke' pepper variety pendimethalin at 1% concentration did not influence ObPV concentration, but applied at higher (2%) one significantly enhanced it. Fluazifop-P-butyl at lower concentration mixed to the inoculum reduced the virus concentration but applied at higher (1.5%) dosages prevented virus infection (Table 3).

Table 3. The effect of postemergent herbicide treatments on pepper-ObPV relations

Virus	Host	Herbicide treatments	Symptoms*	Extinction values
ObPV	*C. annuum* 'Macskapiros'	-	-/Mo, Led, Bli	1.318
ObPV	*C. annuum* 'Macskapiros'	pendimethalin POST 1%	-/Mo, Led, Bli	1.341
ObPV	*C. annuum* 'Macskapiros'	pendimethalin POST 2%	-/Mo, Led, Bli	1.362
ObPV	*C. annuum* 'Macskapiros'	fluazifop-P-butyl POST 0.75%	-/Mo, Led, Bli	1.119
ObPV	*C. annuum* 'Macskapiros'	fluazifop-P-butyl POST 1.5%	-/Mo, Led, Bli	0.967
		SD(P=5%)		0.240
Negative control				0.282
ObPV	*C. annuum* 'Csipke'	-	-/Mo, Led, Bli	1.558
ObPV	*C. annuum* 'Csipke'	pendimethalin POST 1%	-/Mo, Led, Bli	1.591
ObPV	*C. annuum* 'Csipke'	pendimethalin POST 2%	-/Mo, Led, Bli	1.989
ObPV	*C. annuum* 'Csipke'	fluazifop-P-butyl POST 0.75%	-/Mo, Led, Bli	0.949
ObPV	*C. annuum* 'Csipke'	fluazifop-P-butyl POST 1.5%	-/-	0.276
		SD (P=5%)		0.355
Negative control				0.279

*Local/systemic symptoms; -, symptomless; Mo, mosaic; Led, leaf deformation; Bli, blistering

4 CONCLUSIONS

It has been seemed that the effect of herbicides on host-virus relations greatly depends on hosts (species and varieties), type of herbicides, mode and dosage of application. Generally it can be said that virus inhibitory effect at higher dosages was stronger as compared to lower ones. Pendimethalin applied as preplant treatments proved better, regarding virus inhibitory effect as compared to postemergent treatments. In some cases virus infection could not be observed due to the herbicide treatments, while in other cases herbicides significantly reduced the concentration of viruses as compared to positive, virus infected plants without herbicide treatments. Our results pay attention to the fact, that certain herbicides may play important role not only in weed control, but they also have an inhibitory effect on economically important viruses. Nevertheless future investigations are necessary in order to investigate the effect of commonly applied herbicides on important crop host-virus relations.

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