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INSECTICIDES RESIDUAL HAZARD TO BEES

SUMMARY

The objective of the study was to determine the insecticides residual effect duration to honey bee, alfalfa leaf-cutting bee and bumble bee. The bees can be ranged by the increase of susceptibility to insecticides as follows: bumble bee, honey bee and alfalfa leaf-cutting bee.The most ecologically safe chemicals to bees were pyrethroids. Their residues on plant surface were non hazardous to bumble bee. Non hazardous to honey bee were the residues of Fastac, Sumicidin, Mavrik; low hazardous - Decis, Ambush, Cymbush, Sumi-alfa and Talstar. To leaf-cutting bee the residues of only Mavrik were non-toxic. Detoxication of other pyrethroids took 0.5 – 5.0 days. More hazardous to pollinators were organophosphorus insecticides. Bazudin, Fosfamid, Dursban applied at minimal application rates were hazardous, at maximal rates – highly hazardous during 6.0 – 7.5 days to honey bee and 8.0 -10.0 days to leaf-cutting bee. To bumble bee the residues of Carbofos and Hostaquick were not hazardous at minimal rates and low hazardous at maximal ones. Zolone and Actellic were not hazardous at all rates. These insecticides were low hazardous to honey bee, but hazardous to leaf-cutting bee at all rates. Karate took the intermediate position to these 2 kinds of bees. Zolone was slightly toxic to honey bee at maximal rate. Of tested neonicotinoid insecticides the residues of Pondus were practically not hazardous to bees, the residues of Confidor were hazardous to honey bee for 2 days and to alfalfa leaf-cutting bee – 4 days, but not hazardous to bumble bee.

Keywords: insecticides, residues, hazard, bees.

INTRODUCTION

The danger of bees poisoning is becoming one of the most important factors of sustainable agricultural system’s functioning, particularly for those crops that need cross-pollination by bees (UNEP, 2010; Cane and Tepedino, 2001). The main objective of pesticides use on these crops – the prevention of a negative effect of pest on a yield, contradicts the purposes of entomophilic crop cultivation because pollinating activity of bees primarily determines the potential crop productivity.

Even prohibition of pesticide treatments of entomophilic crops during their bloom can not fully prevent the possibility of pollinators contacts with pesticides,

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because bees usually explore larger spectrum of flowering plants than target pollinated crop (Dobrynin, 1998).

The need to solve this dilemma forces to search for special approaches in chemical plant protection based on the study of ecological factors determining the possibility of intoxication of pollinators by pesticides, on knowledge of toxicity and rate of pesticides hazard to pollinators.

The studies of pesticide effect on pollinators were mostly conducted on one bee species – honey bee, much more seldom on artificially reared solitary bees and some bumble bee species. In most of the works it was pointed out that the effect of chemicals in field conditions was much less than in laboratory ones and one of the main causes of bee poisoning at chemical treatments of plants is a violation of pesticide application regulations (Atkins, 1993).

The probability of appearance, the course and consequences of the process of intoxication greatly depends upon biological features of pollinators and pollinated crops, abiotic environmental features, pesticide properties, methods and objects of their application (Dobrynin, 2013).

Three biological groups of pollinators: wild solitary bees, bumble bees and honey bees differ both in their anatomic-morphological and bio-ecological features, life cycle and the extent of management by man. It became clear that these differences significantly influence the probability of a contact of every pollinator group with pesticides and that a trophic factor plays a leading role since foraging activity of pollinators presumes obligatory contact with pollinated plant which, when treated with pesticide, can perform as a mediator between toxicant and pollinators (Dobrynin, 2000). In turn, foraging activity of pollinators is significantly influenced by abiotic environmental factors (mostly the weather ones). Different combinations of these factors determine the intensity of pollinator flight on entomophilic crops and hence probability of pollinator-pesticide contact in case of chemical treatment of plants (Dobrynin, 2000). The possibility and manifestation of pesticide toxic effect on pollinators also depend on the properties of a pesticide itself. Its composition, target direction, character of action on pest objects, ways of penetration into insect body, time of application and other properties greatly influence the probability of contacts with pollinators and the rise of intoxication process in them (Dobrynin, 2000). On the whole, the analysis of ecological factors influencing pesticide-pollinator relationships showed that application of selective pesticides and activation of ecological mechanisms preventing or reducing the realization of pesticide toxic effect to insect pollinators can serve as a basis of bee safe pesticide application techniques in the system of chemical crop protection (Dobrynin, 2013), where the first rule is avoiding of direct impact of pesticide on bees by treating the plants out of pollinators' day flight time. Once insecticide is applied out of the time of pollinators day activity, the major factor determining the hazard of a chemical to bees is its residual effect duration, the determination of which was the main objective of the present study.

MATERIAL AND METHODS

The study was conducted on 3 most commercially used species of bee pollinators: honey bee (Apis mellifera L.), alfalfa leaf-cutting bee (Megachile rotundata F.) and bumble bee (Bombus terrestris L.). The degree of insecticides hazard to bees was determined by the length of the time period necessary for reducing of the amount of an active ingredient of a chemical on treated plants to the level non-hazardous to pollinators. It was assumed that an average lethal doze (LD50) to be such level, because when determining LD50 in laboratory conditions the tested insects kept in cages have to be in contact with pesticide treated plants 24 hours a day during the experiment, whereas in field conditions the daily activity of pollinators lasts not more than 10 - 12 hours and a considerable part of this time between flights they spend in their nests, having no contacts with treated plants.

LD50 for three commercially used species of bees (honey bee Apis mellifera L., alfalfa leaf-cutting bee Megachile rotundata F. and bumble bee Bombus terrestris L.) were determined earlier in laboratory conditions by the method of bees contact with insecticide treated surface (Illarionov, Dobrynin, 1995), since the main cause of pollinator intoxication under field conditions is most often a contact toxicity of insecticide residues on visited plants.

Determination of pesticides LD50 is mainly a method of preliminary evaluation and comparison of different chemicals toxic activity and the susceptibility of different objects. It cannot fully characterize toxic parameters of pesticides to pollinators because it provides no information for practice about the duration of the period of insecticide toxic activity in the field. The degree of pesticide hazard under field conditions depends both on composition, rate, time of pesticide application and also on environmental factors influencing conservation of pesticide toxic activity on plants and pollinators behavior.

To predict the rate of pesticide hazard and to prove the waiting period for using the bees on pollination, we studied the duration of the period of detoxication of the most used insecticides applied on plants of alfalfa (Medicago sativa L.) in recommended dosages to the level safe to bees under field conditions. Samples of alfalfa plants were taken periodically (every 12 hours) for analysis of insecticides residues until they reach the LD50 level. Experiments were conducted under optimum or close to weather conditions for pollinator flight activity. The amount of each tested insecticide on alfalfa samples was determined using a standard method of gas chromatography.

RESULTS AND DISCUSSION

The results of the study are presented in the following table 1. The data of the table show that different kinds of bees can be ranged by the increase of susceptibility to insecticides as follows: bumble bee, honey bee and alfalfa leaf-cutting bee.

From the point of view of pollinators protection the most ecologically safe chemicals to bees were pyrethroid compounds. Their residues on plant surface (when these chemicals applied at the recommended rates) were below levels of susceptibility of bumble bee B. terrestris. Non toxic to honey bee were the residues of Fastac, Sumicidin, Mavrik,; and the residues of Decis, Ambush, Cymbush, Sumi-alfa and Talstar with not prolonged (0.5 – 2.5 days) period of toxic activity were low hazardous to the bee.

At the same time, to alfalfa leaf-cutting bee only the application of Mavrik did not leave toxic residues on plants. Detoxication of other tested pyrethroids to the safe level to the bee took 0.5 – 5.0 days after treatment, depending on the rate of application.

More hazardous to pollinators were organophosphorus insecticides. Long residual toxicity of Bazudin, Fosfamid, Dursban applied even at minimal rates is the reason to characterize them as hazardous, and at maximal rates – as highly hazardous with long toxic activity (6.0 – 7.5 days to honey bee and 8.0 -10.0 - to leaf-cutting bee).To bumble bee the residues of Carbofos and Hostaquick were not hazardous at minimal or close to minimal rates of application and also of Zolone at all the dozes.

Low hazardous to bumble bee were only the residues of Carbofos and Hostaquick at maximal dozes, and of Actellic - at all the dozes. These insecticides can also be related as low hazardous to honey bee, but hazardous to leaf-cutting bee at all the rates. Pyrethroid Karate took the intermediate position by its residual action on these two kinds of bees. Slightly toxic action of Zolone on honey bee was observed only at maximal rate of application.

Neonicotinoid insecticides (Pondus and Confidor) differed by their effect on bees, that can probably be explained by the specifics of their structure. While the residues of cyanogen substituted chemical (Pondus) were practically not hazardous to honey and bumble bees and if applied the night before - to alfalfa leaf-cutting bee either; the residues of nitro substituted chemical (Confidor) were hazardous to honey bee during 2 days and to alfalfa leaf-cutting bee – 4 days, but not hazardous to bumble bee. The experiments also showed that upon precipitation more than 5 mm after pesticide treatment or at the air temperature higher than 25 0 C the length of hazardous period for bees was reduced by 1-2 days, and at the temperature below 16 0 C the hazardous period for bees increased by 1 day. The data of the table can help agriculturists to make reasonable decision both for purchase and usage of pesticides, which, on the one hand, could reliably protect plants from pests and, on the other hand, be non- or low hazardous to insect-pollinators.

Moreover, the data of the table can help the utilization of different techniques for differentiation of bees and toxicants in time and space allowing to the maximum extent to avoid contacts with pesticides. These techniques can be accomplished in two principle ways: the first – by changing the place of foraging, and the second – by isolation of bees.

The first way is the most complicated, requiring great labor and resource expenses and is used if it is necessary to separate bees and the plants treated with toxicant for a long period.

Table 1. The duration of insecticide residual hazard to different kinds of pollinators

№ by the order	Insecticides, (their active ingredients) concentration and preparative form	Rate of application, l/ha	Period of detoxication (days) of insecticides on plants to safety level for		
			honey bee	alfalfa leaf-cutting bee	bumble bee
1.	Actellic (Pirimiphos-methyl), 50 % EC	0.5 1.0	2.5 3.0	3.5 4.0	0.5 1.5
2.	Ambush (Permethrin), 25% EC	0.3 0.4	1.0 1.5	3.0 3.0	0 0
3.	Bazudin (Diazinon), 60 % EC	1.0 2.0 3.0	4.0 5.0 6.0	6 7.0 8.0	0.5 2.5 2.5
4.	Decis (Deltamethrin), 2.5 % EC	0.1 0.5	0 2.0	2.0 3.5	0 0
5.	Dursban (Chlorpyrifos-methyl), 40.8 % EC	0.8 1.5	5.0 5.5	7.5 8.0	1.5 2.5
6.	Zolone (Phosalone), 35 % EC	0.5 1.0 2.0 3.0	0 0 0 0.5	1.0 1.5 2.0 -	0 0 0 0
7.	Carbofos (Malathion), 50 % EC	0.2 0.5 1.0 2.0	1,0 2.0 2.5 3.0	2.0 3.0 4.0 4.5	0 0 0 0.5
8.	Karate (Lambda-cyhalothrin), 5% EC	0.15 0.2 0.5	2.0 2.5 3.5	2.5 3.0 -	0 0 0
9.	Mavrik (Fluvalinate), 2E, 25% EC	0.1 0.3	0 0	0 0	0 0
10.	Sumi-alfa (Esfenvalerate), 5% EC	0.3 0.5	0 0.5	1.5 2.0	0 0
11.	Sumicidin (Fenvalerate), 20% EC	0.3 0.6	0 0	2.0 3.0	0 0
12.	Talstar (Bifethrin), 10% EC	0.4 0.6	2.0 2.5	4.0 4.5	0 0
13.	Fastac (Alfa-cypermethrine), 10% EC	0.15 0.2	0 0.5	0.5 1.0	0 0
14.	Fosfamid (Dimethoate), 40% EC	0.5 1.0	5.0 6.5	8.0 9.0	3.5 4.5

15.	Hostaquick (Heptenophos), 50% EC	0.3 1.0 1.8	2.0 3.0 3.5	3.5 4.0 5.0	0 1.0 2.0
16.	Cymbush (Cypermethrin), 25% EC	0.1 0.24	2.5 3.0	- 5.0	0 0
17.	Pondus (Thiacloprid), 48% SC	0.18	0	0.5	0
18.	Confidor (Imidacloprid),20% WSC	0.5	2.0	4.0	0

The second way presumes isolation of bees, the length of which depends on the duration of the pesticide residual action on treated plants.

Practice showed that the most technologically suitable and effective way is the isolation of bees in hives directly in the field for the period of pesticide application and detoxication. From this point of view, the most promising were insecticides and the rates of their application (see the table) which period of hazard did not exceed 2.5 days to leaf-cutting bee – the average longevity of female's life without feeding in isolated conditions in a field (Dobrynin, 1998), and 3 days - for honey bee provided with enough forage and water (Dobrynin, Illarionov, 1996). Bumble bees do not likely need any particular measures of protection from the most of the tested insecticides. So it is possible to choose the insecticide non- hazardous to bumble bees and at the same time having the period of hazard not more than 2.5 days to leaf-cutting and honey bees.nAs for the protection of other bee species, it is possible to suppose with high rate of probability that if leaf-cutting bee is the most susceptible among the main bee-pollinators, the pesticides non- or low hazardous to the bee, will not be more hazardous to other wild bee species.

CONCLUSIONS

Different kinds of bees can be ranged by the increase of susceptibility to insecticides as follows: bumble bee, honey bee and alfalfa leaf-cutting bee. The most ecologically safe chemicals were pyrethroids. More hazardous to pollinators tested were the organophosphorus insecticides. Neonicotinoid insecticides differed by their effect on bees: Pondus was practically not hazardous to bees, whereas Confidor was hazardous to honey and alfalfa leaf-cutting bee, but not hazardous to bumble bee. The data obtained can help agriculturists to make reasonable decision both for purchase and usage of pesticides, which, on the one hand, could reliably protect plants from pests and, on the other hand, be non- or low hazardous to insect-pollinators.

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