A strategy of controlling pollen beetle (*Meligethes aeneus* F.) and cabbage seed weevil (*Ceutorhynchus assimilis* Payk) in Poland considering differences in resistance level of both species to insecticides

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INTRODUCTION

A considerable increase of cabbage seed weevil (*Ceutorhynchus assimilis* Payk) and pollen beetle (*Meligethes aeneus* F.) population density was recorded in Poland during last years. Pollen beetle attack begins usually in the phase BBCH51 and lasts till the phase BBCH67. However the biggest damages are caused till the phase BBCH57. Cabbage seed weevil attack begins later, more or less in the phase BBCH61 and lasts till the phase BBCH70. This means that both species are present together on oilseed rape fields for a long time. Each chemical treatment between BBCH60 and BBCH69 automatically influences both species even when one of them does not exceeds the economical threshold and only the second one must be controlled. Such a situation is bound with parallel selective pressure of insecticides on both species. Management of pollen beetle and cabbage seed weevil in Poland is based on insecticides belonging to three chemical groups: pyrethroids, neonicotinoids and organophosphates (only in case of pollen beetle). Several chemical treatments are often necessary against these species. Managing both species in the phases BBCH57–69 requires very careful insecticides' selection, considering honeybees and other pollinators protection. Both species: pollen beetle and cabbage seed weevil show higher or lower susceptibility to the same active substances of insecticides. Among pollen beetle populations there are a lot of populations showing high resistance to pyrethroid insecticides. Cabbage seed weevil populations are usually resistant to acetamiprid. This phenomenon, known as resistance, or tolerance, leads to big losses in oilseed rape crops and restriction in use and sales of less effective insecticides. Problems caused by the growing insects resistance usually result from an inappropriate or simplified way of applying insecticides, with successive applications being carried out in a given area using one or more products, often from the same chemical class. Study of resistance mechanisms show that selection based on one mode of action, after a period of time, leads to development of genetically inherited features in the target population. Working out proper strategies considering selective pressure, resistance risk, honeybees protection and physiochemical properties of recommended insecticides is necessary. The work presents the strategy of controlling of both species, recommended in Poland

Table 1. Insecticides recommended for pollen beetle and cabbage seed weevil control in Poland

Active substance	**Toxicity against pollen beetle**	**Toxicity against cabbage seed weevil**	**The threat of honeybees' poisoning (LC50 [µg / insect])**
Alpha-cypermethrin	medium	very high	high (0,033)
Beta-cyfluthrin	low	very high	very high (0.001)
Bifenthrin	high	high	high (0.015)
Cypermethrin	low	not recommended	high (0.02)
Deltamethrin	very low	very high	very high (0.0015)
Esfenvalerate	low	very high	high (0.06)
Etofenprox	low	very high	medium (0.13)
Gamma-cyhalothrin	very low	not recommended	very high (0.005)
Lambda-cyhalothrin	low	very high	high (0.035)
Tau-fluvalinate	high	high	no threat (12)
Zeta-cypermethrin	low	very high	very high (0.002)
Acetamiprid	high	low	no threat (8.09)
Tiacloprid with deltamethrin	high	very high	no threat (17.32) + very high (0.0015) = very high
Chlorpyrifos with alpha-cypermethrin	very high	not recommended	high (0.059) + high (0.033) = high

General principles of the strategy for preventing insects resistance to insecticides

1. Constant monitoring of the pest`s susceptibility level using standard methods. Monitoring before the commercial introduction of an active substance establishes the baseline sensitivity of insects and should be a continuous process after registration. The results of the monitoring indicate whether resistance is developing and management strategies may need to be introduced or modified.
2. Using a given active substance only once per season. Rotation of active substances, and, if it is only possible, rotation of chemical groups is the major factor preventing resistance increase.
3. Selecting the most effective active substance against a controlled species, from a given chemical group.
4. Products should be applied in the full effective doses, recommended by the producer. Reduced doses quickly select populations with average level of tolerance, while too large ones lead to resistance development at a very high level.
5. Timing of the application must coincide with exceeding by the insect its economic threshold and with the moment of the greatest susceptibility in the life stage of the pest to the particular product.
6. Appropriate temperature must be taken into consideration as well as physiochemical properties of a given active substance and product formulation.
7. In case of using insecticide mixture, it should be ensured that the compounds belong to different classes and are applied in effective equivalent control rates.
8. If the activity of the product proves ineffective and must be repeated, the reasons of ineffectiveness must be defined and, if necessary, a product of different class should be used.
9. If the local population is found to be resistant to compounds of some specific class, products with similar action mechanism should not be used in the rotation strategy.
10. Withdrawing the use of the product that the pest has developed resistance to must be continued until the pest shows high susceptibility.
11. Attention must be paid to protection of beneficial organisms, natural enemies of pests, since these play a major role in the management of resistance.

A strategy of controlling pollen beetle and cabbage seed weevil in oilseed rape in Poland

1. As both species are controlled together in later vegetation stages, the insecticide selection must be adjusted to the pest whose population density is higher in a given moment as well as to the potential of harmfulness of a given species (for example: pollen beetle is not very harmful in later vegetation stages).
2. Applying insecticides should be planned carefully. Taking into consideration honeybees protection, it is better to use less selective active substances earlier in the season and more selective and safe for pollinators insecticides, later. It is also possible to use only selective active substances considering they belong to different chemical groups.
3. At the beginning of vegetation (BBCH 51–54) substances toxic to honeybees may be used. For example chlorpyrifos, a dangerous pyrethroid active substance or a mixture. Recommended neonicotinoids and tau-fluvalinate should not be used then in order to have the possibility of using them later, when honeybees protection will be necessary.
4. In the phases BBCH 55–57, taking into consideration honeybees protection, using chlorpyrifos should be avoided. A pyrethroid, neonicotinoid or a mixture may be used considering a given active substance has not been used earlier.
5. BBCH 58–60 and the beginning of flowering: only active substances safe for honeybees: acetamiprid or tau-fluvalinate (when the temperature is below 20°C).