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THE SPREAD OF POLLEN BEETLES (*MELIGETHES AENEUS*) IN SPRING OILSEED RAPE (*BRASSICA NAPUS*) AND THE EFFICACY OF PYRETHROIDS

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Abstract

This paper presents an overview of the data from the field trials devoted to the studies of pollen beetle occurrence and harmfulness in spring rape and possibilities of insecticide resistance development in *M. aeneus*. The findings of pest abundance assessments indicate that pollen beetle tended to occur in spring rape during the stem elongation – bud formation stages. The variation of the pollen beetle abundance and harmfulness depended on the meteorological factors, especially the air temperature. In field trials pollen beetles were controlled with six different insecticides: the pyrethroids zeta-cypermethrin 100 g l^{-1}, deltamethrin 25, 50 and 100 g l^{-1}, alpha-cypermethrin 50 g l^{-1}, beta-cyfluthrin 25 g l^{-1}, lambda-cyhalotrin 5 g l^{-1} and a mixture of neonicotinoid and pyrethroid-tiachloprid + deltametrin 100 + 10 g l^{-1}. The population of pollen beetles was found to vary during the experimental period and the efficacy of the insecticides tested tended to decline. The efficacy of the insecticides against pollen beetle one day after the spray-application ranged from 86 to 100%, while after 4 and 7 days the population of pollen beetles increased and the efficacy of insecticides tended to drop down. A significant rapeseed yield reduction ranging from 3.3 to 30.1%, resulting from the damage of pollen beetle was identified.

Key words: *Meligethes aeneus*, pollen beetles, spring oilseed rape, occurrence, seed yield, pyrethroids.

Introduction

During the period from 1999 to 2006, the area under oilseed rape has doubled in Lithuania. Spring oilseed rape is more common in Lithuania than winter oilseed rape (winter rape accounts for one fourth of the total area sown with oilseed rape). The largest oilseed cultivation area and the highest yields are obtained in the regions of Central Lithuania. However, oilseed rape productivity is still insufficiently high and part of rapeseed yield is lost annually to diseases and pests. The pollen beetle is one of the pests of great economic importance occurring in oilseed rape crops in Lithuania.

Pollen beetles (*Meligethes* spp.) are important pests in various cruciferous crops throughout Europe /Bromand, 1990; Ojczyk, Jankowski, 1999; Alford et al., 2003/. Adult pollen beetles may damage any of the flowering structures particularly during the green to yellow bud stages, when damage to the ovary results in podless stalks /Free, Williams, 1979; Sedivy, 1993/. Beetle population density depended on the growing stage, duration of flowering and production of lateral stems. Differences in population density, sex ratio and oogenesis are accounted for by differences in the growth stages of rape for feeding and oviposition /Sedivy, 1993/.

The threshold of harmfulness of pollen beetles differs between countries: in Denmark, Switzerland and Scotland it is 1 pollen beetle per plant, in France, 2–3 beetles per plant at the green buds, in England 15 pollen beetles per plant /Hansen, 1996; Derron, 2007/.

Pollen beetles can cause serious yield losses, and for spring oilseed rape more than 80% yield reduction can occur /Hansen, 2003 a; 2003 b/. Pests cause visible direct losses in seed yield and decrease strength of plant response to favourable environmental and agricultural conditions. The beetles were controlled with different insecticides, but mainly with pyrethroids. The pollen beetle is an example of insect species that can develop strong resistance mechanisms to most active ingredients used to control it in Europe /Hansen, 2003 a; Węgorek, 2005; Heimbach, 2007/. The results show that up to 99% of the pollen beetles survived Danish standard doses of pyrethroids and up to 36% of the beetles survived standard doses of dimethoate /Hansen, 2003 a/.

This paper presents the data from the field experiments on the spread of pollen beetles in spring oilseed rape in Lithuania and the efficacy of various insecticides against these pests.

Materials and Methods

Field experiments were conducted during 1999–2006 in the spring oilseed rape crops (1999 cv. 'Star', 2000–2003 cv. 'Mascot', 2004–2006 cv. 'Landmark'). The crops were grown following the approved technologies. Plant growth stages were assessed according to BBCH scale /Lancashire et al., 1991/. The pollen beetles were recorded when the spring oilseed rape fields were at the stem elongation – bud stages (BBCH 31–59). Automatic weather station (Metpole) was placed in the oilseed rape field. The weather data were collected every 30 minutes and averaged over each day during the whole period of pollen beetle occurrence in the spring oilseed rape crop.

Table. Characteristics of insecticides, used in the field trials

Insecticide	Active ingredients	Cipher
Furry	Zeta-Cypermethrin 100 g l^{-1}	pyrethroid 1
Decis	Deltamethrin 25 g l^{-1}	pyrethroid 2
Decis Exra	Deltamethrin 100 g l^{-1}	pyrethroid 3
Decis	Deltamethrin 50 g l^{-1}	pyrethroid 4
Fastac	Alpha-Cypermethrin 50 g l^{-1}	pyrethroid 5
Bulldock	Beta-Cyfluthrin 25 g l^{-1}	pyrethroid 6
Karate	Lambda-Cyhalothrin 5 g l^{-1}	pyrethroid 7
Proteus	Tiachloprid + Deltametrin 100 g l^{-1}+10 g l^{-1}	neonicotinoid + pyrethroid

Insecticides were applied against pollen beetles taking into account the economic threshold of harmfulness (1–2 beetles per plant). On the untreated plots no insecticide was applied. Pollen beetle assessments in the control treatments were done every 3 days and in the insecticide-treated plots – one, four and seven days after insecticide application. The assessments of pest abundance (counts of pollen beetles per plant) were done on ten successive plants in three chosen places per plot. Rape seed yield was harvested separately for each plot by a harvester Sampo. The seed moisture was determined. The seed yield per plot was weighed and calculated as yield per hectare (9% moisture content). The trials involved four replications with a record plot size of 20 m^2.

The experimental data were compared using analysis of variance (ANOVA). For the statistical analysis of the insecticide efficacy and spring rape seed yield, means and the standard error of the mean were calculated using MS EXCEL /Tarakanovas, Raudonius, 2003/.

Results and Discussion

Pollen beetle migration activity and abundance in relation to spring rape growth stages and the weather conditions were determined during the period 1999–2006 (Figure 1).

Experimental evidence suggests that pollen beetles appeared in the spring rape crop at the end of stem elongation stage (BBCH 39) in 2000, 2003 and 2005, or at the beginning of bud formation stage (BBCH 50) in 1999, 2001, 2002, 2004, and 2006. At the time of pollen beetle appearance, the maximal air temperature was 15–25^{o} C, and minimal from 6 to 14^{o} C. Literature sources indicate that at the air temperature above 15^{o} C, pollen beetles fly to the oilseed rape fields /Ulber, Thieme, 2007/.

The variation of the pollen beetle abundance and harmfulness depended on the meteorological factors, especially the air temperature. The years 1999, 2000 and 2006 were distinguished for the highest air temperature, especially the year 1999, when even the minimal daily air temperature exceeded the 15^{o} C limit, the spring rape plants developed very rapidly and the bud formation stage was shorter (15 days) than in the other experimental years (21–27 days). The period of pollen beetle occurrence was extremely short and pest abundance was up to 3 beetles per plant. The highest incidence of pollen beetles was identified in 2001, when during the spring rape bud formation stage the maximal and minimal daily air temperature was close to 15^{o} C, the longest plant growth stage was that of bud formation, which lasted for 27 days. The maximum number of pollen beetles was 7 adults per plant that year.

Pollen beetles were found to be most active at green bud stage (BBCH 53–57), when their highest incidence was recorded. Other researchers provide similar data suggesting that the highest incidence of pollen beetles – more than 5 pests per plant was identified at green-yellow bud stage. At later growth stages the number of pollen beetles per plant significantly declines /Walter, Northing, 2007/.

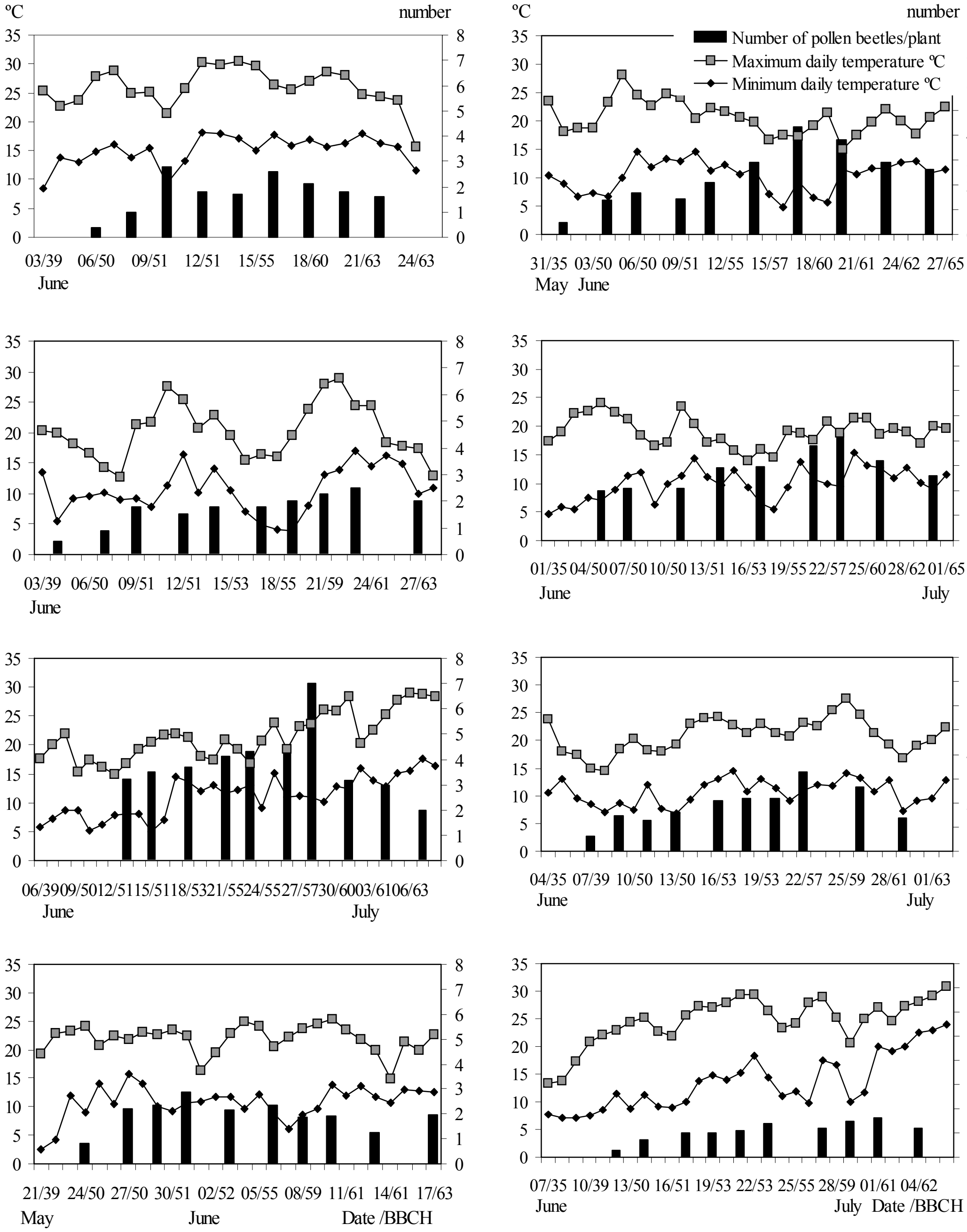

Figure 1. Dynamics of the spread of pollen beetles in SOSR at the stem elongation – budding stages, *max* and *min* daily temperatures ºC (May–June–July), 1999–2006

Meligethes aeneus infestations are usually controlled at the green-yellow bud stage. Economic thresholds have been determined experimentally for some pests of oilseed rape in different countries. Climate and crop management practices, such as cultivar, plant densities and crop fertilisation, can all influence the thresholds /Garbe et al., 2000/. Experimental findings showed that during test period, at the beginning of bud formation stage (BBCH 51), the number of pollen beetles increased to 1–2 beetles per plant and reached the threshold of harmfulness. The tested insecticides were applied at this stage. One day after the spray application, the biological efficacy of all tested insecticides was as high as 100%, except for pyrethroid 6 in 2001, whose efficacy was 86% and pyrethroids 4, 5 and neonicotinoid + pyrethroid in 2006, whose efficacy was 97 and 99%, respectively (Figure 2).

Four days after the spray application, the population of pollen beetles started to renew in the spring rape crops and the efficacy of the tested insecticides significantly declined, but not identically in all experimental years. The most marked reduction of the efficacy (up to 28%) was noted for pyrethroid 6 in 2001, for pyrethroid 3 and 5 up to 44% (2003), for pyrethroid 2 and 3 up to 63 and 73%, respectively (2000). In 2004, 2005 and 2006, the efficacy of the insecticides belonging to pyrethroids and neonicotinoids was very high – more than 95%. Experimental evidence suggests that the efficacy of the insecticides depends on the weather conditions of the year and on the conditions for the occurrence of pollen beetles.

According to Polish researchers, the efficacy of pyrethroid 1 declined to 40% four days after insecticide application, and seven days after application no effect was exerted. Similar data were obtained with other insecticides belonging to pyrethroid group /Węgorek, Zamoyska, 2007/. Standard error of the mean of pyrethroid 6 (the lowest efficacy) and of neonicotinoid + pyrethroid (the highest efficacy) was Sx 3.75 and 1.42%, respectively.

Seven days after the application the efficacy of insecticides dropped down, the efficacy of pyrethroid 2, 5 and 6 was 54, 23 and 4%, respectively.

One of the factors responsible for the increase in pollen beetle population is reduced susceptibility of the pests to insecticides. With a more rapid restoration of the number of pests, more frequent, and sometimes repeated, insecticide applications are needed, which in turn result in the reduction of insecticide sensitivity of pollen beetles. Although insecticides can give an effective control of oilseed rape pests, there is an urgent need to develop alternative strategies for managing the pests /Horowitz, Ishaaya, 2004/.

Pollen beetles reduced spring rape seed yield (Figure 3). During 8 experimental years the seed yield produced in the unprotected spring rape plots was by 102–447 kg ha^{-1} lower compared with that produced in the plots protected from pollen beetles. Foreign researchers also have reported that application of insecticides, resulting in an effective control of pollen beetles, increase the yield of spring rape seed /Seta et al., 2001/. Danish researchers have indicated that the beetle can cause serious yield losses in both winter and spring oilseed rape crops, and for spring oilseed rape, more than 80% yield reduction can occur /Hansen, 2003 a; 2003 b/.

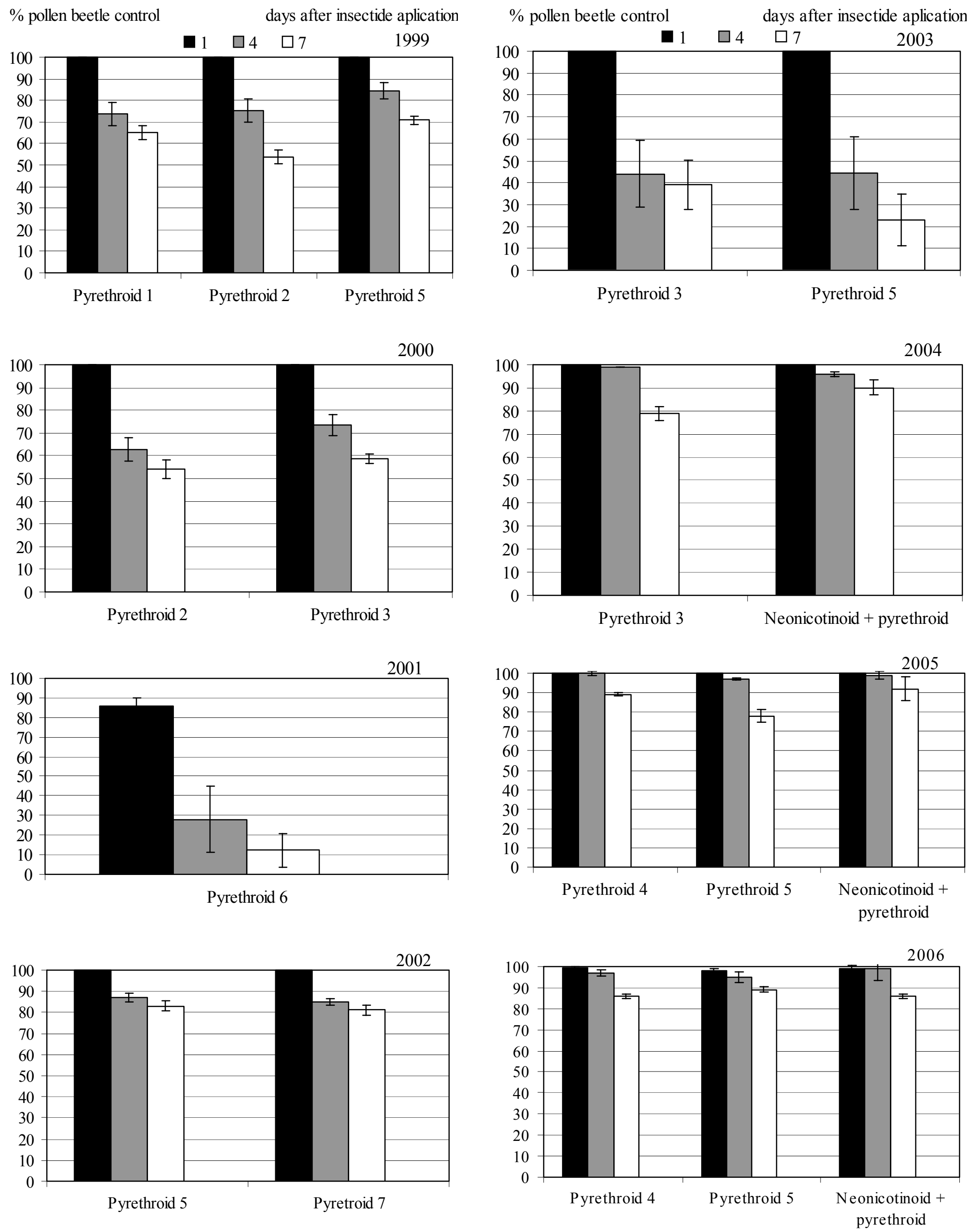

Figure 2. The efficacy of insecticides on pollen beetles (*Meligethes aeneus*) 1, 4 and 7 days after the application, 1999–2006

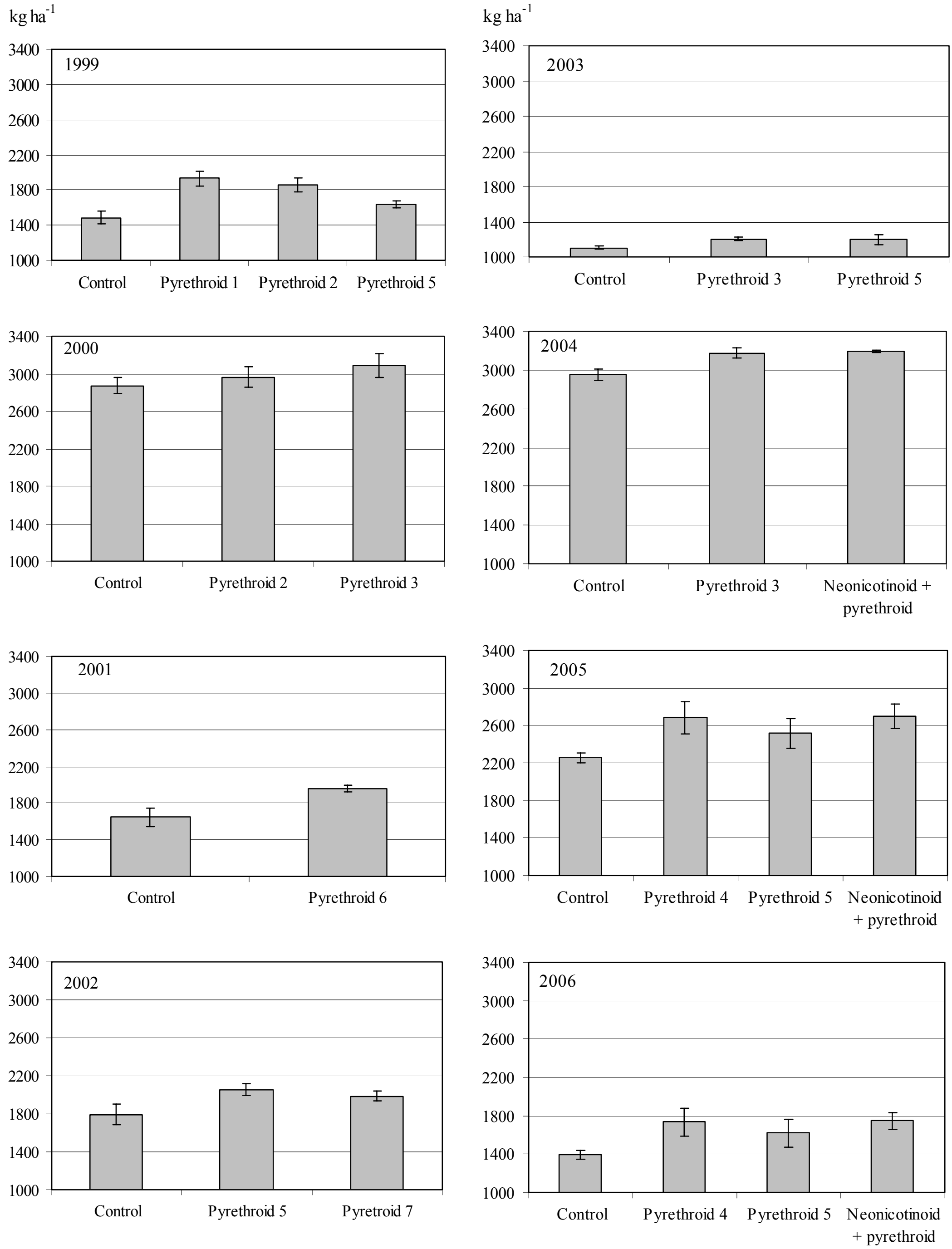

Figure 3. SOSR seed yield increase due to the pollen beetle control during 1999–2006

In all experimental years insecticides used in SOSR significantly increased the seed yield, and the standard error of the mean Sx varied within 14.8–174.6 kg range. The greatest spring rape seed yield increase of 30.1% was determined in 1999 and that of 25.7% in 2006.

Conclusions

1. The findings of pest abundance assessments indicate that pollen beetle tended to occur in spring rape during the stem elongation – bud formation stages. The variation of the pollen beetle abundance and harmfulness depended on the meteorological factors, especially the air temperature.

2. The population of pollen beetles was found to be on the increase during the experimental period and the efficacy of the insecticides tested tended to decline. Pyrethroid efficacy against pollen beetles 1 day after the spray-application ranged from 86 to 100%, while after 4 and 7 days it was 77 and 67%, respectively.

3. A significant rapeseed yield reduction ranging from 3.3 to 30.1%, resulting from the damage done by pollen beetle, was identified.

4. The data accrued during the long-term studies suggest that like in other European countries the conditions for pollen beetles' resistance development in our country are very conducive.

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