

Investigation of pesticides effect on pollination of bumblebees in greenhouse tomatoes

Elena Survilienė, Laimutis Raudonis, Julė Jankauskienė

*Lithuanian Institute of Horticulture, Kauno 30, LT-54333 Babtai, Kaunas distr.,
Lithuania, e-mail e.surviliene@lsdi.lt*

The study was conducted in three 400–800 m² type greenhouses: Multi Rovero 640 TR, Rovero 961 and Multispan 9.60 SR of the Lithuanian Institute of Horticulture in 2007. Trial data shows that the efficiency of tomato pollination by bumblebees during cultivation season ranged from 83.3 to 87.2 %. The pollination is effective, if there are found 60 % of flowers pollinated by bumblebees. An efficiency of pollination depends on used pesticides and number of hives. Insecticides Aztek 140 EC (triazamat) a concentration of 1.0 ml l⁻¹, NeemAzal-T/S (azadirachtin A) of 5.0 ml l⁻¹ and fungicides Previcur 607 SL (propamocarb hydrochloride) of 1.5 l ha⁻¹ had not negative affect to bumblebee activity and efficiency of pollination. The effect of pollination and activity of bumblebees was reduced due to the use of Euparen M 50 WG (tolylfluanid) at the rate of 1.5 mg l⁻¹.

Key words: *Bombus terrestris*, fungicide, insecticide, *Lycopersicon esculentum*, pollination.

Introduction. To maximize fruit set in tomatoes and other crops, plant growth bioregulator (Pak, Kim, 1999), plant or truss vibration, honeybees and bumblebees (Banda, Paxton, 1991; Ilbi, Boztok, 1994; Paydas et al., 2000; Dag, Kammer, 2001) are frequently used. In the last years the use of *Bombus terrestris* (L.) colonies is more and more widespread in the pollination of protected crops. The results indicated that bumblebees could be used successfully in greenhouses for tomato plant pollination. Bumblebee-pollinated tomatoes gave higher yield, higher number of seeds, better weight-size correlation, higher specific gravity and higher fruit firmness than other pollinating agents; plant growth bioregulator and plant vibration (Banda, Paxton, 1991; Ravestijn van, Steen van der, 1991; Morandin et al., 2001; Al-Attal et al., 2003).

During their foraging behaviour, bumblebees are exposed to the risk of poisoning due to pesticide treatments. Therefore, it is necessary to assess the possible dangerousness of pesticides. Such a research was begun in some European countries and permitted to prepare experimental protocols and to evaluate the toxicity of some of the most commonly used active compounds; the results have been recently reviewed and discussed by Thompson and Hunt (1999), Thompson (2001) and van der Steen

(2001). The toxicity towards *Bombus terrestris* (L.) of various insecticides and acaricides widely used on protected crops was tested at the laboratory by oral, topic contact, and indirect contact trials (Marletto et al., 2003).

Knowledge of the effects of pesticides on biological control agents is required for the successful implementation of integrated pest management (IPM) programs in greenhouse production systems.

The aim of this study was to investigate the influence of pesticides widely used on protected crops on effectiveness of bumblebee (*Bombus terrestris*) pollination in tomato production.

Object methods and conditions. The study was conducted in three 400–800 m² type greenhouses: Multi Rovero 640 TR, Rovero 961 and Multispan 9.60 SR of the Lithuanian Institute of Horticulture in 2007. Seedlings of tomato varieties ‘Cunero’ F₁ were transplanted in rockwool into Multi Rovero 640 TR and Rovero 961 on 27 of March, in peat bag into Multispan 9.60 SR greenhouse on 19 of March at the density of 2.5 plants m⁻². Tomato plants were grown up to the 15 cluster, and then the apical growing points were removed to stop plant growth.

The bumblebee colonies used in the experiment were got from Biobest Belgium N. V. The hives were placed by following requirements: the first ones were introduced on 24 of April, when 10 % of flowers were opened, and additionally – on 8 of June and 30 of July.

During research time tomato plants were treated with insecticides and fungicides. A concentration of 1.0 ml l⁻¹ of Aztek 140 EC (active ingredient triazamat) was sprayed only in Multispan 9.60 SR greenhouse on 28 of May; 5.0 ml l⁻¹ of NeemAzal-T/S (a. i. azadirachtin A) was sprayed in all greenhouse on 11 of June and 16 of July; 1.5 l ha⁻¹ Previcur 607 SL (a. i. propamocarb hydrochloride) was used by drip irrigation system on 9 of August and 1.5 mg l⁻¹ of Euparen M 50 WG (a. i. tolylfluanid) was sprayed on 20 of August.

The control and effectiveness of pollination were estimated on 10 closed tomato flowers in 10 places every week by monitoring bite marks on flowers according to 1–5 points scale: 1 – black marks, damage on the pistil possible; 2 – brown marks; very well pollinated; 3 – flowers are slightly marked; well pollinated; 4 – not all flowers are marked; poorly pollinated; 5 – no bite marks; no pollination. The first observations were started on 30 of April, the last – on 23 of August.

Data statistically were analyzed using Fisher LSD_{0.5} test.

Results. Investigation of tomato flower pollination. According to the efficiency of pollination, not only activity of bumblebees in greenhouses was analysed, but also introduction of new hives. Trial data shows that during all activity of bumblebees the effectiveness of pollination of tomato flowers was high. Efficacy of pollination in Multi Rovero 640 TR greenhouse on average reached 84.7 % (Fig. 1), Rovero 961 – 87.2 % (Fig. 2) and Multispan 9.60 SR – 83.3 % (Fig. 3). Air temperature was not higher than 25 °C, and relative humidity ranged from 78–85 % during all the investigation period.

Efficiency of pollination of first hive during six weeks in Multi Rovero 640 TR reached on average 81.8 %, the quality of pollination corresponded to 2–3 points, which

mean very well and well pollination. The lowest activity of bumblebees was during sixth week, the efficiency of pollination was only 56.7 %, the quality of pollination corresponded to 4th point, which means poorly pollination (Fig. 1). After introduction of additional hive on 8 of June, efficiency of pollination increased by 31.3 %. Activity of bumblebees of this hive during seven weeks reached on average 79.9 %. The efficiency of third hive activity was observed from 31 of July to 23 of August. During three weeks the efficiency of pollination was high and reached on average 92.5 %.

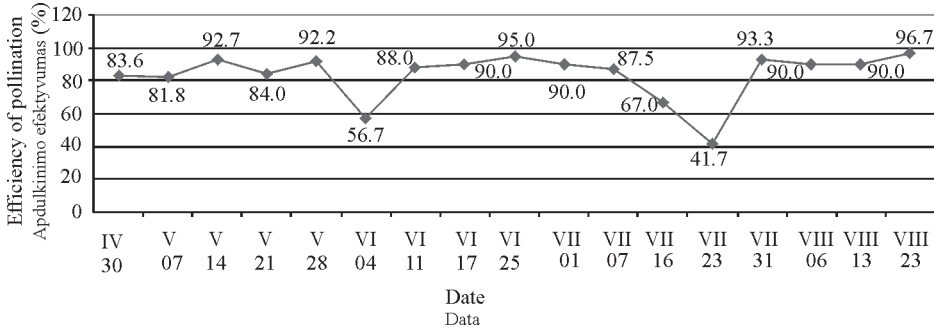


Fig. 1. Efficiency of pollination using bumblebees in Multi Rovero 640 TR greenhouse, 2007. $LSD_{0.5} - 7.9$ (treatment with NeemAzal-T/S on 11 of June, on 16 of July and with Previcur 607 SL – on 9 of August)

1 pav. Pomidorų apdulkinimo efektyvumas naudojant kamanes Multi Rovero 640 TR šiltnamyje, 2007 m. $R_{0.5} - 7,9$ (apdorota Nimazaliu T/S 10 g/l k.e. birželio 11 d., liepos 16 d. ir Previkuru 607 g/l v. t. rugpjūčio 9 d.)

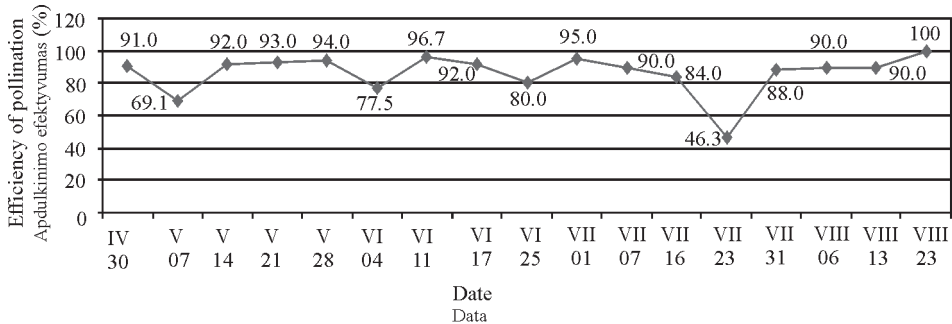


Fig. 2. Efficiency of pollination using bumblebees in Rovero 961 greenhouse, 2007. $LSD_{0.5} - 8.61$ (treatment with NeemAzal-T/S on 11 of June and Previcur 607 SL on 9 of August)

2 pav. Pomidorų apdulkinimo efektyvumas naudojant kamanes Rovero 961 šiltnamyje, 2007 m. $R_{0.5} - 8,61$ (apdorota Nimazaliu T/S 10 g/l k.e. birželio 11 d. ir Previkuru 607 g/l v. t. rugpjūčio 9 d.)

Efficiency of bumblebees from the first introduced hive during six weeks in Rovero 961 greenhouse reached on average 86.1 % (2–3 pollination quality points). The lowest pollination was during sixth week of introduction, the efficiency was 77.5 % or 4 points of pollination quality (Fig. 2). Second additional introduction of hive increased efficiency of pollination by 19.17 %. Efficiency of pollination during seven weeks totally reached on average 83.4 % and only later decreased to 46.3 %. The third additional introduction of hive increased efficiency during three weeks from 88 to 100 %.

Analogical situation was in Multispan 9.60 SR greenhouse. After introduction of the first hive of bumblebees, pollination efficiency during six weeks reached on average 85.8 % (2–3 pollination quality points) (Fig. 3). The activity of bumblebees decreased in the end of sixth week and the efficiency of pollination reached 76.7 %. After additional second and third introduction of hives, the efficiency of bumblebee activity on average was 78.4 % and 85.7 %, respectively.

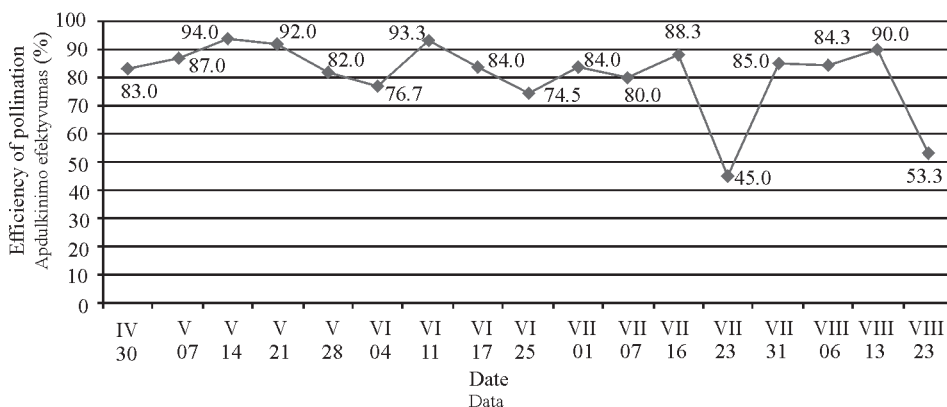


Fig. 3. Efficiency of pollination using bumblebees in Multispan 9.60 SR greenhouse, 2007. $LSD_{0.5} = 15.62$ (treatment with Aztek 140 EC on 28 of May, NeemAzal-T/S on 11 of June, Previcur 607 SL on 9 of August and Euparen M 50 WG on 20 of August)

3 pav. Pomidorų apdulkinimo efektyvumas naudojant kamanes Multispan 9.60 SR šiltnamyje, 2007 m. $R_{0.5} = 15,62$ (apdorota Acteku 140 g/l v. e. gegužės 28 d., Nimazaliu T/S 10 g/l k. e. birželio 11 d., Previkuru 607 g/l v. t. rugpjūčio 9 d. ir Euparenu M 50 % v. t. g. rugpjūčio 20 d.)

Side-effect of pesticides on bumblebees. Aficide Aztec 140 EC applied only in hot spots at the rate of 1.0 ml l⁻¹ solution had very small side-effect on activity of bumblebees. Efficiency of pollination was reduced only by 5 %. This reduction can be explained as natural (Fig. 3). The activity of bumblebees was reduced to 56.7 % in Multi Rovero 640 TR, and to 77.5 in Rovero 961 greenhouses where Aztec 140 EC was not used (Fig. 1, 2). Insecticide NeemAzal-T/S used for the first time did not have any side-effect on bumblebees or pollination of flowers. Efficacy of

pollination of flowers after a day and later was about 90 %. The second NeemAzal-T/S application superposed with the end of bumblebee life in hive; therefore, the activity of bumblebees reached only 42 % on 23 of July (Fig. 1). Efficiency of pollination of tomato flowers in Rovero 961 and Multispan 9.60 SR greenhouses shows that activity of bumblebees depends on life time of hives, not on the NeemAzal-T/S used. Though NeemAzal-T/S was not used additionally the efficacy of pollination on 23 of July reached only 45–46 % (Fig. 2, 3).

Previcur 607 SL used by drip irrigation system on 9 of August in all types of greenhouses did not have any negative impact on activity of bumblebees. Efficiency of pollination reached about 90 % (Fig. 1–3).

Euparen M 50 WG (1.5 mg l^{-1}) used on 20 of August on the average reduced efficiency of tomato pollination in Multispan 9.60 SR greenhouse to 53 %; meanwhile, where Euparen M 50 WG was not used in other greenhouses efficiency was 96.7–100 % (Fig. 1, 2).

Discussion. Pollination of flowers and activity of bumblebees depends on life time of hive. It was noticed the reduction of efficiency of pollination by bumblebees in greenhouse after 5–6 weeks. Efficiency of pollination on 4 of June was 56.7 % in Multi Rovero 640 TR, 77.5 % in Rovero 961 and 76.7 % in Multispan 9.60 SR greenhouses. Efficiency of pollination on 20 of July (before introduction of additional hives) was 41.7 % in Multi Rovero 640 TR, 46.3 % in Rovero 961 and 45 % in Multispan 9.60 SR greenhouses (Fig. 1–3). Additional hives should be introduced in greenhouse when efficiency of pollination is highest (Banda, Paxton, 1991; van Ravestijn, van der Steen, 1991; Morandin et al., 2001). Continuously equal pollination of flowers is available only when additional hives are introduced at the beginning of reduction of activity of pollination. In our case hives had to be changed 1–3 weeks earlier to avoid sudden reduction of pollination.

Beneficial fauna and other products are used in greenhouses to control pests for high and good quality of production. It is very important to make trials to know transaction between beneficial organisms and pesticides controlling the pests according to the integrated pest management practices. It is important to select compatible fungicides and insecticides with bumblebees, which are used for pollination, because a lot of chemicals are toxic or could have repellent properties for adults, hatch of bumblebees (Hassan, 1996; Steen van der, 2001).

Insecticides and acaricides both from chemical and biological origins were tested for their toxicity to bumblebees and beneficial organisms. All microbial compounds were very safe for all the tested species. Azadirachtin, indoxacarb, pymetrozine and spinosad were almost completely harmless, although spinosad was moderately toxic to adult *Encarsia formosa*, but just like the effect on bumblebees, the persistence in practice was very short. The neonicotinoids, imidacloprid and thiamethoxam, were very toxic. Acetamiprid and thiacloprid on the other hand were safer. Fipronil was very toxic for all organisms (Sterk et al., 2003).

As described in “Side effect manual” (Sterk, Put, 2004) active ingredient of propamokarb hydrochloride does not have any negative action for bumblebees. Azadirachtin does not have side-effect on bumblebees and can be used for integrated

pest management in vegetables. Active ingredient of triazamat when was sprayed or plants were watered with it had no negative impact on bumblebees as well. The same results were obtained in our study. Other authors stated that azoxystrobin, chlorotalonil, copper oxychloride, sulphur, mancozeb, tolylfluanid, iprodione, metalaxyl, dimetomorf, penconazole do not have adverse effect on beneficial fauna and could be safely used in integrated pest management (Sterk et al., 2003, Sterk, Put, 2004).

Conclusions. Efficiency of bumblebees during all their activity period was high and ranged from 83.3 to 87.2 %.

Efficiency of bumblebees for pollination of tomato flowers depends on additional hives and pesticides used.

Insecticides NeemAzal-T/S (azadirachtin A) 5.0 ml l⁻¹, Aztec 140 EC (triazamat) at the rate of 1.0 ml l⁻¹ and fungicide Previcur 607 SL (propamocarb hydrochloride) at the rate of 1.5 l ha⁻¹ had no negative effect on activity of bumblebees and pollination of tomato flowers.

Spraying tomato with 1.5 mg l⁻¹ solution of fungicide Euparen M 50 WG (tolylfluanid) reduced activity of bumblebees and efficiency of pollination.

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Pesticidų poveikio kamanių entomofilijai šiltnamio pomidoruose tyrimas

E. Survilienė, L. Raudonis, J. Jankauskienė

Santrauka

Tyrimai atlikti Lietuvos sodininkystės ir daržininkystės instituto eksperimentinės bazės Multi Rovero 640 TR, Rovero 961 ir Multispan 9.60 SR šiltnamiuose 2007 m. Rezultatai rodo, kad per visą kamanių veiklos laiką jos veiksmingai apdulkino pomidorų žiedus – 83,3–87,2 %. Kamanių darbo efektyvumui ir apdulkinimo kokybei turi įtakos papildomų avilių pastatymas bei šiltnamiuose naudojami pesticidai. Panaudoti insekticidai Nimazalis T/S 10 g/l k. e. (azadirachtinas A), išpurkštas 0,5 % normos, Actekas 140 g/l v. e. (triazamatas) – 0,1 % normos ir Previkuras 607 g/l v. t. (propamokarbo hidrochloridas) – 1,5 l/ha normos neturėjo neigiamo poveikio kamanių darbingumui ir pomidorų žiedų apdulkinimui. Išpurškus pomidorus 0,15 % normos fungicidu Euparenas M 50 % v. t. g. (tolylfluanas), pastebėtas kamanių veiklos susilpnėjimas ir apdulkinimo efektyvumo sumažėjimas.

Reikšminiai žodžiai: apdulkinimas, *Bombus terrestris*, fungicidai, insekticidai, *Lycopersicon esculentum*.

