UDC 632.934: 634.25 (477.7)

DOI: https://doi.org/10.36495/2312-0614.2021.4.10-14

TECHNICAL EFFICIENCY OF INSECTICIDES

against oriental fruit moth and peach twig borer in peach orchards of southern Ukraine

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Goal. *To determine the effectiveness of insecticides for peach orchards protection from the main Lepidoptera pests on the basis of clarifying their biological characteristics in the conditions of the South of Ukraine.* ***Methods.*** *Field methods. Technical effectiveness of insecticides was determined in peach orchards of Redhaven and Zolota Moskva cultivars. The scheme of the experiment included 6 variants using 5 chemical insecticides. Biological features of Lepidoptera pests development were specified using pheromone traps, in accordance with the generally accepted methodology.* ***Results****. It was determined that in the conditions of the South of Ukraine during the vegetation periods of the studied years, the development of the oriental fruit moth (Grapholitha molesta Busck.) took place in four generations (one overwintering and three summer generations). The seasonal dynamics of the flight of peach twig borer (Anarsia lineatella Zell.) took place with three peaks, which indicates the development of three generations of the pest. Insecticide trials in the control of oriental fruit moth and peach twig borer in peach orchards allowed to determine that the level of damage to shoots and fruits of the studied peach cultivars by caterpillars of Lepidoptera pests decreased by 4.3—11.3 times compared to the control variant. High technical efficiency was observed when using Lufox 105 EC (1.0 l/ha) and Match 050 EC (1.0 l/ha) insecticides — 88.0—91.2% and 84.5—88.2%. Use of Radiant 120 SC (0.5 l/ha) and Proclaim 5 SG, (0.5 kg/ha) provided a reduction in the harmfulness of oriental fruit moth and peach twig borer by 76.5—83.3% and 80.0—86.1% compared to the control.* ***Conclusions.*** *Evaluation of the effectiveness of insecticide application in peach orchards showed that all preparations can effectively control the number and harmfulness of oriental fruit moth and peach twig borer in peach orchards in Southern Ukraine. Under the conditions of registration of insecticides Lufox 105 EC, Match 050 EC and Radiant 120, SC can be recommended to protect plantations of this crop.*

***Grapholitha molesta* Busck.; *Anarsia lineatella* Zell.; insecticides; peach; technical effectiveness; pests**

Pests of fruit crops, including peach annually destroy a significant part of the crop, significantly weaken the trees, which reduces the period of operation of orchards. Therefore, the sustainable development of horticulture is not possible without the protection of plants from pests [1, 2].

In peach orchards, the main and most economically significant pest is the oriental fruit moth (*Grapholitha molesta* Busck.), which belongs to the family of Tortricidae [3]. This species has certain features that distinguish it from other species of moth, in particular the ability of caterpillars during the growing season to feed on both shoots and fruits of grains and stone crops of the family Rosaceae, especially peach (Fig. 1) [4].

According to O.B. Balikina in the Crimea during 2011—2016, the damage of peach fruits by the oriental fruit moth was 13.4—19.7% [3]. In Moldova, in the period 2012—2015, in peach and apple orchards, the percentage of fruit damaged by pest caterpillars was 10—15%, in uncultivated areas up to 40% [5].

A secondary, but no less harmful species in peach plantations is peach twig borer (*Anarsia lineatella* Zell.) from the family of Gelechiidae [6]. The caterpillars of this species, as the oriental fruit moth well as, damage annual shoots, forcing their passages down to the woody parts. In summer, in addition to shoots, caterpillars feed on both green and ripening fruits of stone crops (mostly peach and apricot), penetrating them under the skin near the petiole, or on the side (Fig. 2), making moves to the stone [7].

In the South of Ukraine, the damage of shoots and fruits of peach and apricot by caterpillars of peach twig borer reaches 6.1—14.8% and 5.3—21.4%, respectively [3].

Due to climate change in the direction of warming, there are

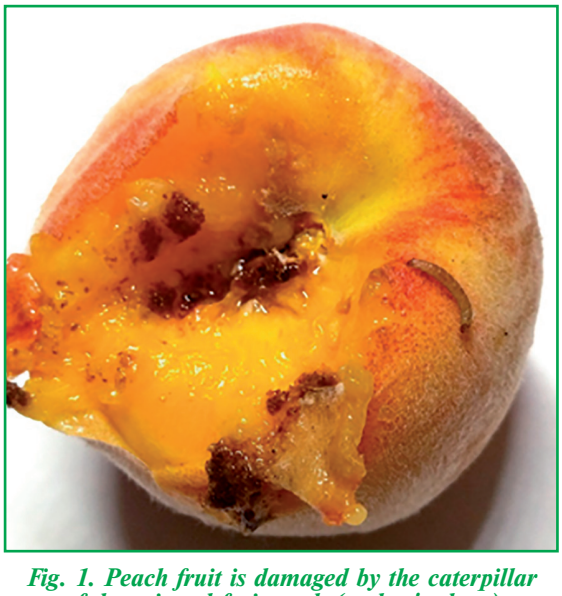

Fig. 1. Peach fruit is damaged by the caterpillar of the oriental fruit moth (author's photo)

changes in the development of pests of fruit crops. In the South, there is an increase in the harmfulness of Lepidoptera species, in particular the oriental fruit moth, which requires increased control over their numbers [8].

Organophosphorus insecticides, later synthetic pyrethroids, which previously provided a high percentage of caterpillar deaths, were previously used to protect orchards from oriental fruit moth and peach twig borer [9, 10]. However, the impact of highly toxic compounds of these drugs has a negative impact on the environment and led to the emergence of resistant populations of pests [11].

The expediency of introducing drugs from the group of regulators of growth and development of insects into the system of protection of peach orchards against Lepidoptera pests was noted. Control and reduction of the number of phytophages occurred due to the violation of their development at different stages of ontogenesis, as well as the sterilizing effect in insects. In peach orchards in Bulgaria, the use of chitin synthesis inhibitors Dimilin, 25% w.p. and Alsistin, 25% w.p. provided a reduction in the population density of Lepidoptera pests to 94.0%, with the maximum preservation of parasitic and predatory insects [12]. In studies, O.A. Ignatova determined that with double spraying of peach orchards with the drug Dimilin, w.p. the level of fruit damage by the oriental fruit moth decreased by 89.5% [13].

As noted by Kos A., Kragl M., Paradžik, B. [14], effective protection against Lepidoptera insects is achieved by using insecticides with active substances spinosad or spinetoram. The last of the active substances has ovicidal and larvicidal action on pests of the Lepidoptera, as well as Thysanoptera, Diptera, Coleoptera. In Europe, since 2017, two drugs Delegate 250 WG, 25% and Radiant, 12%, whose active ingredient is spinetoram, have been registered. According to the results of field trials in peach orchards in northern Greece, the effectiveness of the drug with the active substance spinetoram, 250 g/kg against fruit damage by the oriental fruit moth varied between 83.0—85.0% [15].

Fig. 2. Peach fruit is damaged by the caterpillar of the peach twig borer (author's photo)

Thus, analyzing the «List of pesticides and agrochemicals approved for use in Ukraine» revealed a limited list of drugs approved for use on peaches, some of which contain highly toxic organophosphorus compounds [16]. Due to the rather narrow range of insecticides against Lepidoptera phytophages in peach orchards, there is a need to study low-toxic drugs against them to obtain the maximum effect and increase the environmental safety of the environment.

Goal. To determine the technical efficiency of chemical insecticides against the oriental fruit moth and peach twig borer on the basis of clarification of their seasonal dynamics of development in peach orchards in the south of Ukraine.

Research methods — field. The experiments were carried out during 2020—2021 in peach orchards at the SPS «Naukova» of Melitopol fruit growing research station (MFGRS) named after M.F. Sydorenko of IH of NAAS of Ukraine, varieties Redhaven and Zolota Moskva. Year of planting — 2001, scheme of planting trees 6x4 m, type of crown formation — bowl, soil retention system — black steam. Repeat — 4 times. Placement of options — randomized, by the method of blocks.

Variants of the experiment included control (without spraying) and application of insecticides: Karate Zeon 050 SC, (lambda-cyhalothrin, 50 g/l) 0.3 l/ha (standard); Match 050 EC (lufenuron, 50 g/l) 1.0 l/ha; Lufox 105 EC (fenoxycarb, 75 g/l + lufenuron, 30 g/l) 1.0 l/ha; Radiant 120, SC (spinetoram, 120 g/l) 0.5 l/ha; Proclaim 5 SG (emamectin benzoate, 50 g/kg) 0.5 kg/ha.

The timing of treatments with drugs against oriental fruit moth and peach twig borer was determined using pheromone traps, which were placed in peach orchards at the beginning of the theoretical flight of pests. We used traps of the Atracon-A type with synthetic pest pheromone manufactured by Biochemtech (2 traps/ha). After setting the time of appearance of the pest in the traps, accounting was carried out once every 5—10 days.

Spraying of peach orchards was performed during the mass flight of butterflies of the oriental fruit moth of the overwintering generation (after flowering). It should be noted that the period of the first treatment also coincided with the hatching and flight of butterflies of the first-generation peach twig borer. Subsequent treatments were carried out in the 1st—2nd decades of June (the flight period of the first generation of the oriental fruit moth and peach twig borer) and a month later.

Determination of technical efficiency of drugs was performed according to the generally accepted method [17]. Damage to shoots was determined by examining on all sides of 25 pcs. (100 pieces on a tree) on each model tree. Drowned, withered and dried, as well as with isolated gums were dissected and the cause of death was determined. During the period of technical ripeness of the fruit was determined by the damage of the fruit by pests. Technical efficiency was determined by the formula:

$$Te = \frac{Dk - Dv}{Dk} \times 100\%;$$

where Te — technical efficiency, %;
Dk — damage to shoots, fruits in control;
Dv — damage to shoots, fruits in experimental variants.

Statistical processing of the results was carried out according to the method of B.O. Dospehova.

Research results. Clarifications of the peculiarities of the development of the oriental fruit moth showed that during 2020—2021, four peaks of pest butterfly flight were observed in peach orchards. This indicates the development of the generation of oriental fruit moth, which overwintered and three summers.

The first adults of the pest in 2020 were found in traps in the 2nd decade of April (13.04), with the accumulation of the sum of effective temperatures (SET) above 10°C — 8.3°C. Due to the low average daily temperature in the first half of April 2021 in the range of +5.1...+11.7°C, the flight of butterflies of the oriental fruit moth was observed 7 days later (21.04) than last year.

It was noted that the mass age of the adult pest was observed in peach orchards during the second half of May with the number of 11.2—12.5 insects/trap for 10 days, which exceeded the ETH. It should be noted that the increase in the intensity of butterfly fishing coincided with the period of egg laying by individuals of the oriental fruit moth and is a signal for protective measures.

During the years of observations, the flight of the first generation of phytophagous butterflies was observed in peach orchards in the 2—3rd decades of June. During the mass flight, the number of males in pheromone traps increased to 18.0—20.8 insects/trap for 10 days. Laying eggs by females of the oriental fruit moth in the older generations occurred 1—2 days after departure, and the duration of their embryonic development decreased to 5—8 days due to high temperatures.

The third peak of the flight of the imago of the oriental fruit moth, corresponding to the departure of the second generation was observed a month after the previous one, in particular in 2020 and 2021 — during the 2nd and 3rd decades of July, respectively, with a number of 20.8 to 23.0 insects/trap 10 days.

During 2020—2021, the flight of the last generation of the pest was observed in peach orchards during the 3rd decade of August.

Regarding the peculiarities of the development of the peach twig borer, it was found that in the years of research there were three peaks of flight of butterflies of the pest. Due to the fact that this species, in contrast to the oriental fruit moth, overwinters caterpillars of the 1st—4th centuries and in the spring is their reactivation. In 2020, due to low air temperatures in the first half of April, namely frosts (−0.5...−5.4°C), the caterpillars of the pest began to restore nutrition in the 2—3rd decade of April. During 2021, this period also began in late April at an air temperature of +5.6...+ 15.0°C.

The flight of peach twig borer during the research years was observed from 18.05 in 2020 and 23.05 — 2021 with the accumulation of SET>8°C 227.8—230.9°C. The first peak of pest flight in peach orchards occurred in late May — early June with a maximum of 10.3—11.0 insects/trap 10 days and, as in the oriental fruit moth, coincided with the mass egg-laying activity of females and the revival of caterpillars.

During the summer period of the studied years, the flight of the second generation of the peach twig borer was observed in the 1st—2nd decade of July. During the mass flight, the intensity of male pest catch in peach orchards increased to 21.8—26.0 insects/trap for 10 days, which is 2.0—2.5 times more than in the first peak.

The third peak of flight, which corresponds to the development of the last generation of peach twig borer, was observed a month after the previous one, namely in mid-August with a number of 14.8—15.2 insects/trap for 10 days.

Observations of the development of Lepidoptera phytophages made it possible to determine the exact timing of spraying peach orchards against them. To expand the range of effective drugs against the above species of pests, insecticides from different chemical groups were tested.

It was determined that according to biennial data on varieties Redhaven, Zolota Moskva, the drug Lufox 105 EC (1.0 l/ha) reduced the damage of peach shoots by oriental fruit moth and peach twig borer on two varieties of peach to 0.3—0.6%, which was statistically significantly different from the reference drug Karate Zeon 050 SC (Table 1).

After spraying peach orchards against Lepidoptera pests with insecticide Match 050 EC (1.0 l/ha) damage to shoots did not exceed 0.4—0.9%, technical efficiency was 84.5—88.2%.

When using the insecticide Radiant 120, SC (0.5 l/ha) damage to peach shoots by caterpillars of the oriental fruit moth and peach twig borer on varieties Redhaven and Zolota Moskva was 0.6—1.3%, technical efficiency reached 83.3%, Proclaim 5 SG (0.5 kg/ha), respectively 0.5—1.1% and 81.4—86.1%.

Evaluation of the effectiveness of chemical insecticides during harvest revealed that the average damage to fruits by the oriental fruit moth and peach twig borer in the control variant on the two varieties was 16.1—21.0% and 7.5—9.0%, respectively (Table 2). The used insecticides reduced the damage of peach fruits of two varieties by caterpillars of Lepidoptera pests by 4.7—10.1 times compared to the control.

The highest technical efficiency was found with the use of insecticides Lufox 105 EC (1.0 l/ha) and Match 050 EC (1.0 l/ha) — 88.0—90.1% and 86.7—88.2%, respectively. Damage of fruits by caterpillars of Lepidoptera pests in the above variants was lower than in the standard Karate Zeon 050 SC (0.3 l/ha) by 1.4—1.9 times.

Insecticides of biological origin Radiant 120, SC (0.5 l/ha) and Proclaim 5 SG (0.5 kg/ha) were inferior in efficiency against the oriental fruit moth and peach twig borer to the drugs Lufox 105 EC (1.0 l/ha) and Match 050 EC (1.0 l/ha).Their use restrained damage to peach fruits by caterpillars of Lepidoptera phytophagous by 78.7—80.5% and 80.0—82.6%, respectively, compared with the control.

The use of insecticides had a positive effect on peach fruit yield. In the control variant, the varieties Redhaven and Zolota Moskva yielded an average of 6.67 and 6.56 t/ha of fruit, respectively, in 2020—2021. Spraying of orchards with Lufox 105 EC (1.0 l/ha) and Match 050 EC (1.0 l/ha) made it possible to save an additional 1.98—2.12 t/ha of yield on two varieties of peach. Yields in such variants were at the level of 8.68—8.72 and 8.60—8.65 t/ha of peach fruits. Slightly lower rates of preserved yield were obtained with the use of insecticides Proclam 5 SG (0.5 kg/ha) and Radiant 120, SC (0.5 l/ha) 1.72—1.84 t/ha, while the yield of fruits in the two varieties was 8.40—8.50 and 8.32—8.39 t/ha, respectively.

CONCLUSIONS

Evaluation of the effectiveness of insecticides in peach plantations showed that all drugs showed sufficient insecticidal action against Lepidoptera phytophagous. In this regard, under the conditions of registration of drugs Lufox 105 EC, Match 050 EC and Radiant 120, SC against oriental fruit moth and peach twig borer and their compliance with hygienic regulations for safe use on peaches, given that the fruit is consumed mostly

1. Technical efficiency of chemical insecticides against damage of shoots of a peach by Lepidoptera pests, varieties Redhaven, Zolota Moskva, (SPS «Naukova», MFGRS named after M.F. Sydorenko of IH of NAAS, 2020—2021)

Name of the drug, consumption rate, l, kg/ha	Damaged shoots, %		Reduction of damage relative to control, %	
	oriental fruit moth	peach twig borer	oriental fruit moth	peach twig borer
Redhaven variety				
Control (without spraying)	5.9	3.4	–	–
Karate Zeon 050 SC, 0.3 l/ha (standard)	1.4	0.6	76.3	82.4
Match 050 EC, 1.0 l/ha	0.9	0.4	84.5	88.2
Lufox 105 EC, 1.0 l/ha	0.6	0.3	89.8	91.2
Radiant 120, SC 0.5 l/ha	1.3	0.8	78.0	76.5
Proclaim 5 SG, 0.5 kg/ha	1.1	0.5	81.4	85.3
LSD05	0.5	0.5	–	–
Zolota Moskva variety				
Control (without spraying)	5.5	3.6	–	–
Karate Zeon 050 SC, 0.3 l/ha (standard)	1.1	0.6	80.0	83.3
Match 050 EC, 1.0 l/ha	0.8	0.5	85.5	86.1
Lufox 105 EC, 1.0 l/ha	0.5	0.4	90.9	88.9
Radiant 120, SC 0.5 l/ha	1.1	0.6	80.0	83.3
Proclaim 5 SG, 0.5 kg/ha	0.9	0.5	83.6	86.1
LSD05	0.4	0.4	–	–

2. Technical efficiency of insecticides against damage of peach fruits by Lepidoptera insects, varieties Redhaven, Zolota Moskva, (SPS «Naukova», MFGRS named after M.F. Sydorenko of IH of NAAS, 2020—2021)

Name of the drug, consumption rate, l, kg/ha	Damaged fruit, %		Reduction of damage relative to control, %	
	oriental fruit moth	peach twig borer	oriental fruit moth	peach twig borer
Redhaven variety				
Control (without spraying)	16.1	7.5	–	–
Karate Zeon 050 SC, 0.3 l/ha (standard)	3.0	1.6	81.4	78.7
Match 050 EC, 1.0 l/ha	1.9	1.0	88.2	86.7
Lufox 105 EC, 1.0 l/ha	1.6	0.9	90.1	88.0
Radiant 120, SC 0.5 l/ha	3.2	1.6	80.1	78.7
Proclaim 5 SG, 0.5 l/ha	2.8	1.5	82.6	80.0
LSD05	1.3	0.8	–	–
Zolota Moskva variety				
Control (without spraying)	21.0	9.0	–	–
Karate Zeon 050 SC, 0.3 l/ha (standard)	3.7	1.7	82.4	81.1
Match 050 EC, 1.0 l/ha	2.5	1.2	88.1	86.7
Lufox 105 EC, 1.0 l/ha	2.2	1.0	89.5	88.9
Radiant 120, SC 0.5 l/ha	4.1	1.8	80.5	80.0
Proclaim 5 SG, 0.5 l/ha	3.7	1.7	82.4	81.1
LSD05	1.5	0.7	–	–

fresh, can be recommended for the protection of crops.

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Технічна ефективність інсектицидів проти східної плодожерки та фруктової смугастої молі у насадженнях персика Півдня України

Мета. *Встановити ефективність інсектицидів для захисту насаджень персика від основних лускокрилих фітофагів на основі уточнення їхніх біологічних особливостей в умовах Півдня України.* **Методи.** *Польовий. Технічну ефективність інсектицидів визначали у насадженнях персика сортів Редхавен і Золота Москва. Схема досліду включала 6 варіантів із застосуванням п'яти хімічних інсектицидів. Біологічні особливості розвитку лускокрилих шкідників уточнювали за допомогою феромонних пасток, відповідно до загальноприйнятої методики.* **Результати.** *Встановлено, що в умовах Півдня України впродовж вегетаційних періодів досліджуваних років розвиток східної плодожерки відбувався у чотирьох поколіннях (покоління, що перезимувало, і три літніх). Сезонна динаміка льоту метеликів фруктової смугастої молі проходила з трьома піками, що вказує на розвиток трьох генерацій шкідника. Випробування інсектицидів проти східної плодожерки та фруктової смугастої молі у насадженнях персика дало змогу встановити, що рівень пошкодження пагонів і плодів гусеницями лускокрилих шкідників на досліджуваних сортах персика зменшився у 4,3—11,3 раза порівняно з контрольним варіантом. Високі показники технічної ефективності було виявлено при застосуванні інсектицидів Люфокс 105 ЕС, КЕ (1,0 л/га) та Матч 050 ЕС, к.е. (1,0 л/га) — 88,0—91,2 і 84,5—88,2% відповідно. Використання препаратів Радіант 120, SC (0,5 л/га) та Проклейм 5 SG, р.г. (0,5 кг/га) забезпечило зниження шкідливості гусениць східної плодожерки та фруктової смугастої молі відповідно на 76,5—83,3 і 80,0—86,1% порівняно з контролем.* **Висновки.** *Оцінка ефективності застосування інсектицидів у насадженнях персика показала, що всі препарати дають змогу ефективно контролювати чисельність та шкідливість східної плодожерки та фруктової смугастої молі у насадженнях персика на Півдні України. За умов реєстрації інсектицидів Люфокс 105 ЕС, КЕ, Матч 050 ЕС, к.е. та Радіант 120, SC можна буде рекомендувати їх для захисту насаджень даної культури.*

***Grapholitha molesta* Busck.; *Anarsia lineatella* Zell.; інсектициди; персик; технічна ефективність; шкідники**

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Техническая эффективность инсектицидов против восточной плодожорки и фруктовой полосатой моли в насаждениях персика Юга Украины

Цель. *Установить эффективность инсектицидов для защиты насаждений персика от основных чешуекрылых фитофагов на основе уточнения их биологических особенностей в условиях Юга Украины.* **Методы.** *Полевой. Техническую эффективность инсектицидов определяли в насаждениях персика сортов Редхавен и Золотая Москва. Схема опыта включала 6 вариантов с применением пяти химических инсектицидов. Биологические особенности развития чешуекрылых вредителей уточняли с использованием феромонных ловушек, в соответствии с общепринятой методикой.* **Результаты.** *Установлено, что в условиях Юга Украины, в течение вегетационных периодов исследуемых лет развитие восточной плодожорки проходило в четырех поколениях (перезимовавшее поколение и три летних). Сезонная динамика лета бабочек фруктовой полосатой моли проходила с тремя пиками, что указывает на развитие трех поколений вредителя. Испытания инсектицидов против восточной плодожорки и фруктовой полосатой моли в насаждениях персика позволило установить, что уровень повреждения побегов и плодов гусеницами чешуекрылых вредителей на исследуемых сортах персика уменьшился в 4,3—11,3 раза по сравнению с контрольным вариантом. Высокие показатели технической эффективности были обнаружены при применении инсектицидов Люфокс 105 ЕС, КЭ (1,0 л/га) и Матч 050 ЕС, к.э. (1,0 л/га) — 88,0—91,2 и 84,5—88,2%. Использование препаратов Радиант 120, SC (0,5 л/га) и Проклейм 5 SG, г.г. (0,5 кг/га) обеспечило снижение вредоносности гусениц восточной плодожорки и фруктовой полосатой моли на 76,5—83,3 и 80,0—86,1% по сравнению с контролем.* **Выводы.** *Оценка эффективности применения инсектицидов в насаждениях персика показала, что все препараты позволяют эффективно контролировать численность и вредоносность восточной плодожорки и фруктовой полосатой моли в насаждениях персика на Юге Украины. При регистрации инсектицидов Люфокс 105 ЕС, КЭ, Матч 050 ЕС, к.э. и Радиант 120, SC можно рекомендовать их для защиты насаждений данной культуры.*

***Grapholitha molesta* Busck.; *Anarsia lineatella* Zell.; инсектициды; персик; техническая эффективность; вредители**

Received on October 26, 2021