

# 桃小食心虫在苹果免套袋果园发生动态及双酰胺类杀虫剂的防治效果

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**摘要:**【目的】研究免套袋苹果园中桃小食心虫(*Carposina sasakii* Matsumura)成虫发生动态, 探讨双酰胺类杀虫剂对桃小食心虫的防治效果。【方法】2017—2018年, 在山东威海文登区免套袋栽培苹果园中, 采用性诱剂诱捕器对桃小食心虫的种群动态进行系统监测。2018年系统调查桃小食心虫的蛀果率和脱果率, 以高效氯氰菊酯为对照, 研究了氯虫苯甲酰胺、溴氰虫酰胺和四唑虫酰胺对桃小食心虫的田间防效。【结果】桃小食心虫在威海一年发生2代, 越冬代高峰期在6月下旬至7月上旬, 第一代高峰期在8月下旬至9月上旬, 幼虫蛀果高峰期在7月, 最高蛀果率为44.4%, 幼虫脱果高峰期在8月, 最高脱果率为26.4%。氯虫苯甲酰胺50 mg·kg<sup>-1</sup>、溴氰虫酰胺30 mg·kg<sup>-1</sup>和四唑虫酰胺40 mg·kg<sup>-1</sup>对桃小食心虫的幼虫蛀果防治效果低于高效氯氰菊酯22.5 mg·kg<sup>-1</sup>, 但幼虫脱果防治效果与高效氯氰菊酯相近。【结论】在免套袋栽培苹果园中, 可轮换使用双酰胺类杀虫剂和拟除虫菊酯类杀虫剂, 以保证对桃小食心虫的防治效果。

**关键词:**桃小食心虫;发生动态;蛀果率;脱果率;双酰胺类杀虫剂;防治效果

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## Population dynamics of *Carposina sasakii* Matsumura and the control efficiency of diamide insecticides in an apple orchard without fruit bagging

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**Abstract:**【Objective】This study aimed to investigate the pattern of the population occurrence of *Carposina sasakii* Matsumura adults, and explore the control effects of diamide insecticides against *C. sasakii* Matsumura in apple orchards without fruit bagging. 【Methods】The experiment was conducted in an apple orchard located in Wendeng, Weihai, Shandong Province from 2017 to 2018. The population dynamics of *C. sasakii* Matsumura was monitored with sex pheromone traps, and the rate of damaged fruit and exiting rate caused by *C. sasakii* Matsumura larva were investigated during the occurrence period of *C. sasakii* Matsumura adults from May to October in 2018. Field efficacy of diamide insecticides such as chlorantraniliprole, cyantraniliprole and tetrananliprole against *C. sasakii* Matsumura were investigated before and during the emergence peak of overwintering adults (June 23 and July 7), using beta-cypermethrin as the control. 【Results】In Wendeng Weihai, there were 2 generations of *C. sasakii* Matsumura which emerged from late May to early September in the orchard mainly from June to September in 2017 and 2018. The dynamic pattern of *C. sasakii* Matsumura adults was basically similar in the two years, with slight difference in the initial and final adult occurrence dates. The initial occurrence

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date in 2017 was May 26, 5 days earlier than in 2018; the final occurrence date in 2018 was September 22, 10 days later than in 2017. In 2018, the total number of *C. sasakii* Matsumura adults caught by each sexual pheromone trap was 1015, which was significantly higher ( $p < 0.05$ ) than that in 2017 (399.5). The period of *C. sasakii* Matsumura larva boring fruit mainly occurred from early June to early October with 5 boring peaks occurring in the field on June 18, July 12, July 30, August 23 and September 10. The highest boring rate of 44.4% occurred in July. The larva exiting from the fruit mainly occurred from early July to early October, and 5 peaks of larva exiting from the fruit occurred on July 18, August 11 and August 29, September 16 and October 4, with the highest larva exiting rate of 26.4% occurring in August. In 2018, the dynamic patterns of *C. sasakii* Matsumura larva boring and exiting from the fruit in the apple orchard were basically the similar, but larva exiting the from fruit occurred 24 to 30 days later than the larva boring the fruit. Before 2018 August, the fruit boring rate of *C. sasakii* Matsumura larva in the field maintained high but decreased significantly after August, while the rate of larva exiting from the fruit in the field increased gradually from July and reached the peak in August. In general, the rate of larva exiting from the fruit throughout the year (53.6%) was lower than the rate of larva boring the fruit (80.9%). The diamide insecticides (chloramphenicol, cyanamide and tetrazolamide) showed control effect on *C. sasakii* Matsumura. The field efficacy of 35% chlorantraniliprole WG at  $50 \text{ mg} \cdot \text{kg}^{-1}$ , 10% cyantraniliprole OD at  $30 \text{ mg} \cdot \text{kg}^{-1}$  and  $200 \text{ g} \cdot \text{L}^{-1}$  tetraniliprole SC at  $40 \text{ mg} \cdot \text{kg}^{-1}$  for controlling larva boring the fruit were 81.01% to 85.85% and 72.89% to 86.33% on the 7th day and the 14th day after spraying before the emergence peak of overwintering adults (June 23), respectively, with no significant difference among the two days, but they had a significantly lower efficacy than 4.5% beta-valerate at  $22.5 \text{ mg} \cdot \text{kg}^{-1}$  (99.28% and 97.44%, respectively). The field efficacy was 81.88%~89.87% and 78.36% to 80.29% on 7th day and 14th day after spraying at the emergence peak of overwintering adults (July 7), respectively, with no significant difference among the days, but still the efficacy was significantly lower than that of 4.5% beta-valerate at  $22.5 \text{ mg} \cdot \text{kg}^{-1}$  (90.77% and 89.91%, respectively). Moreover, the field efficacy of 35% chlorantraniliprole WG at  $50 \text{ mg} \cdot \text{kg}^{-1}$ , 10% cyantraniliprole OD at  $30 \text{ mg} \cdot \text{kg}^{-1}$ , and  $200 \text{ g} \cdot \text{L}^{-1}$  tetraniliprole SC at  $40 \text{ mg} \cdot \text{kg}^{-1}$  for larva exiting from the fruit were 81.10% to 91.91% on the 35th day and 38th day after spraying, with no significant difference between the three diamide insecticides and beta-cypermethrin.【Conclusion】In conclusion, the population dynamic patterns of *C. sasakii* Matsumura adults in 2017 and 2018 were basically similar, but the initial and final occurrence dates were different between the two years in the apple orchard without fruit bagging, and the annual rate of *C. sasakii* Matsumura larva exiting from the fruit was lower than the annual rate of larva boring the fruit. Although the control effect of the diamide insecticides on larva boring fruit was lower than that of beta-cypermethrin, chlorantraniliprole, cyantraniliprole and tetraniliprole performed well in the control of *C. sasakii* Matsumura. Therefore, it is suggested that chlorantraniliprole, cyantraniliprole and tetraniliprole can be used as the alternative insecticides to beta-cypermethrin in the control of *C. sasakii* Matsumura.

**Key words:** *C. sasakii* Matsumura; Population dynamics; Boring rate; Exiting rate; Diamide insecticides; Control effect

桃小食心虫(*Carolina Sasakii* Matsumura),属鳞翅目(Lepidoptera)蛀果蛾科(Carposinidae),是我国北方果树生产中发生面积最大、危害最严重的食心虫类害虫之一。桃小食心虫以幼虫蛀果为害,主要

蛀食苹果、山楂、枣等仁果类和核果类果实<sup>[1]</sup>。果实套袋是防治桃小食心虫的主要措施之一,但近年来,在苹果产业转型升级和节本提质增效、环境友好的需求下,套袋技术在苹果现代化生产中的限制性因

素(果袋消耗纸张过多、劳动力紧缺及成本上涨、套袋苹果苦痘病重等)越来越多,苹果栽培由套袋向免套袋转变将成为果树生产的必然趋势<sup>[2-3]</sup>。

随着苹果免套袋栽培面积的增加,桃小食心虫在苹果生产中的危害将日趋加重,山东烟台、威海、泰安地区免套袋苹果园中桃小食心虫的蛀果率为6.13%~8.63%,显著高于套袋苹果园的0.38%~0.50%<sup>[2]</sup>。目前,应用桃小食心虫信息素诱杀及迷向技术防控桃小食心虫是国内外的研究热点之一,但因其诱杀/干扰交配防治效果不稳定,限制了在生产中推广与应用<sup>[2,4-6]</sup>,因此,化学防治依然是防控桃小食心虫的主要手段。高效氯氰菊酯和高效氯氟氰菊酯是当前防治桃小食心虫的首选药剂,二者均属拟除虫菊酯类杀虫剂,兼具触杀和胃毒作用,击倒速度快,但其作用位点单一,频繁大量使用易诱使害虫产生抗药性<sup>[7-9]</sup>。双酰胺类杀虫剂是近年来防治鳞翅目害虫的新型药剂,具有作用机制新颖、使用剂量低、与传统农药无交互抗性、对非靶标生物安全和对环境相容性好等特点<sup>[10]</sup>。氯虫苯甲酰胺作为双酰胺类第一代鱼尼汀受体抑制类杀虫剂,防治桃小食心虫效果突出,幼虫脱果率低,畸形果少<sup>[11]</sup>。而双酰胺类杀虫剂中的溴氰虫酰胺、四唑虫酰胺(氟氰虫酰胺)作为第二代鱼尼汀受体抑制类杀虫剂,在桃小食心虫幼虫蛀果危害方面的防治效果尚未有相关报道。

桃小食心虫卵产在果面或叶片背面,孵化后爬

行数分钟即行蛀果,一旦蛀入果内,药剂防控就更加困难,因此要抓住关键防治期<sup>[1]</sup>。笔者于2017—2018年在威海免套袋苹果园中开展了桃小食心虫发生动态监测,调查了幼虫蛀果率和脱果率,并以高效氯氰菊酯为对照药剂,在越冬代成虫羽化高峰前和羽化高峰期进行两次施药,比较了氯虫苯甲酰胺、溴氰虫酰胺和四唑虫酰胺3种双酰胺类杀虫剂对桃小食心虫的防治效果,探讨了双酰胺类杀虫剂防控免套袋苹果园中桃小食心虫的技术可行性,以期为免套袋苹果园中桃小食心虫的合理化学防控提供理论依据和数据支持。

## 1 材料和方法

### 1.1 材料

试验地位于威海市文登区葛家镇吕明麦家庭农场果园(北纬N37°09'33.51"东经E121°51'4.85")。以红富士苹果('烟富3')为试验材料,其中不套袋栽培面积为3.0 hm<sup>2</sup>,采取矮砧密植集约栽培,苹果树龄7 a(年),株行距为1.5 m×4.0 m,果园自然生草,一直采用免套袋栽培模式。桃小食心虫性信息素诱芯由中国科学院动物研究所提供,载体为红色天然橡胶,每枚诱芯含性信息素200 μg。性信息素诱捕器为绿色三角形诱捕器,由北京中捷四方科贸公司生产。试验化学药剂及生产厂家见表1。

### 1.2 方法

表1 供试药剂及生产厂家

Table 1 Pesticides used in the experiment and their manufacturers

序号 Order number	药剂名称和剂型 Pesticide name and formulation	有效成分 Active ingredient dosage/ (mg·kg <sup>-1</sup> )	英文通用名称 English common name	生产厂家 Manufacturer
1	4.5%高效氯氰菊酯 EC 4.5% Beta-cypermethrin EC	45.0	Beta-cypermethrin	江苏辉丰生物农业股份有限公司 Jiangsu Hufeng Agrochemical Co., Ltd.
2	200 g·L <sup>-1</sup> 四唑虫酰胺 SC 200 g·L <sup>-1</sup> Tetraniliprole SC	40.0	Tetraniliprole	德国拜耳作物科学公司 Bayer AG
3	35%氯虫苯甲酰胺 WG 35% Chlorantraniliprole WG	50.0	Chlorantraniliprole	美国富美实公司 FMC Corporation
4	10%溴氰虫酰胺 OD 10% Cyantraniliprole OD	30.0	Cyantraniliprole	美国富美实公司 FMC Corporation
5	清水对照 Blank control	—	—	—

1.2.1 桃小食心虫成虫发生动态监测 2017—2018年的3—11月采用性信息素诱捕器在免套袋栽培苹果园进行监测。每年的3月19日,将三角形诱捕器悬挂于苹果树体2/3高度外缘树枝处,果园东、南、西、北四个方位共放置4个,各诱捕器间相距50 m以上,每个诱捕器与田边距离不少于5 m。每3 d调查

1次各诱捕器诱捕到的雄成虫数,并进行记录。诱芯每隔30 d更换一次,备用诱芯于-4~0 ℃冰箱内保存。

1.2.2 桃小食心虫幼虫蛀果率和脱果率监测 2018年,在试验果园中东、南、西、北、中5个方位各选择2棵苹果树全年不喷施杀虫剂。性信息素诱捕器监测

到桃小食心虫越冬代成虫开始羽化后,在每棵树的树冠四周及内膛的中上部随机检查100个果实,共计200个果实,每6 d调查1次桃小食心虫幼虫蛀果率和脱果率,并进行记录。

**1.2.3 双酰胺类杀虫剂防治桃小食心虫试验** 试验共设5个处理(表1),每4~6株树为1小区,随机区组排列,重复4次。试验以桃小食心虫幼虫作为防治对象,根据性信息素诱捕监测结果,在桃小食心虫越冬代成虫羽化高峰期前(6月23日)和高峰期(7月7日)施药,共施药2次。使用机动喷雾器(工作压力为20~25 kg·cm<sup>-2</sup>,喷孔直径1.2 mm,双喷孔喷雾2.5~3 kg·min<sup>-1</sup>)全株均匀喷雾施药。施药量以叶片反、正面均匀着药为度。每株树用药液1.5~2.0 kg,每亩(666.7 m<sup>2</sup>)用药液165~220 kg。在第2次喷药后14 d内不喷施任何杀虫剂,其他时间所施用的杀菌剂、杀虫剂相同。试验调查期间(6月23日—8月14日)共降雨146.2 mm,属多雨年份。

### 1.3 调查及统计分析

**1.3.1 调查方法** 1)桃小食心虫蛀果率调查。在试验果园中,每小区选择2棵树,在每棵树的树冠四周及内膛的中上部随机检查100个果实,共计200个果实。药前调查桃小食心虫蛀果基数,第1次药后7 d(6月30日)和14 d(7月7日),第2次药后7 d(7月14日)和14 d(7月21日)进行5次调查。

2)桃小食心虫脱果率调查。在试验果园中,每小区选择2棵树,在每棵树的树冠四周及内膛的中上部随机检查100个果实,共计200个果实。于第1次药后35 d(7月28日)和第2次药后38 d(8月14日)调查脱果数。

**1.3.2 防治效果计算方法** 1)蛀果率药效计算新增虫果数=药后虫果数—药前虫果数,防治效果(%)=[(空白对照区新增虫果数—药剂处理区新增虫果数)/空白对照区新增虫果数]×100。

2)脱果率药效计算。新增脱果数=药后脱果数—药前脱果数,防治效果(%)=[(空白对照区脱果率—药剂处理区脱果率)/空白对照区脱果率]×100。

**1.3.3 数据分析** 田间桃小食心虫监测数据以3 d为单位,蛀果率和脱果率以6 d为单位进行归集,采用Excel 2010与数据处理软件DPS 16.05对结果进行方差分析和显著性检验(Duncan新复极差法)。试验结果用平均值(mean)±标准差(SD)表示。

## 2 结果与分析

### 2.1 桃小食心虫雄蛾发生动态

2017—2018连续2 a根据性信息素诱捕器对桃小食心虫雄成虫的诱捕数量绘制出威海地区免套袋苹果园中桃小食心虫成虫发生动态图(图1)。桃小食心虫一年发生2代,成虫2个高峰期的界限比较明显,即7月底之前为越冬代成虫发生期,7月底之后为第1代成虫盛发期。2017—2018年越冬代成虫羽化高峰期均为6月下旬至7月上旬,第1代成虫羽化高峰期均为8月下旬至9月上旬。

2018年桃小食心虫雄成虫总虫量为1 015头/诱捕器,显著高于2017年的399.5头/诱捕器( $p < 0.05$ )。2017—2018年桃小食心虫成虫发生动态趋势基本一致,但成虫始发期和终见期存在差异,其中,2017年5月26日首次诱集到越冬代成虫,而

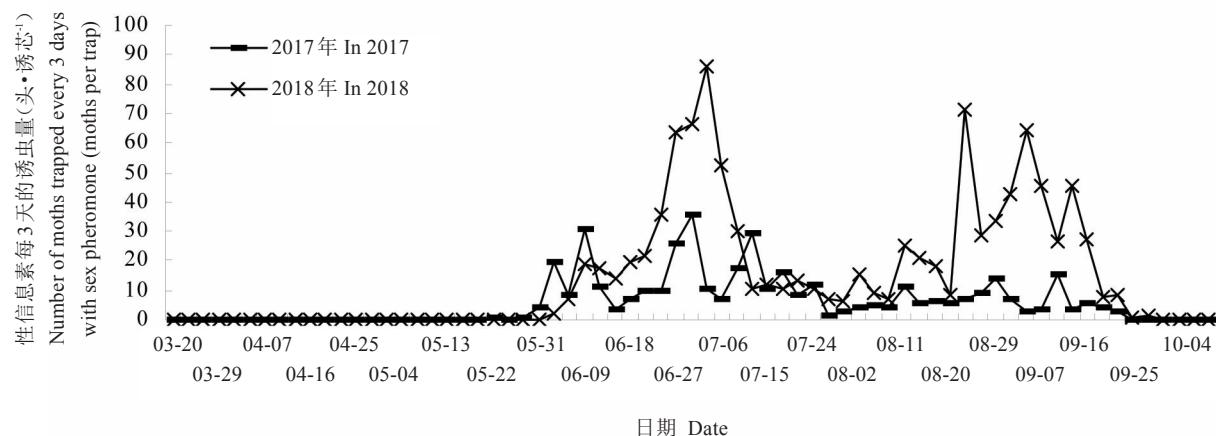


图1 2017—2018年免套袋栽培苹果园中桃小食心虫成虫发生动态

Fig. 1 The population dynamics of *Carposina sasakii* Matsumura in an apple orchard without fruit bagging in 2017 and 2018

2018年越冬代成虫始见期比2017年推后了5 d;2017年桃小食心虫终见期为9月22日,2018年比2017年则推后了10 d。

## 2.2 桃小食心虫蛀果和脱果动态

根据桃小食心虫幼虫的蛀果率和脱果率,绘制出威海地区免套袋苹果园中桃小食心虫幼虫的蛀果和脱果的危害动态(图2)。2018年免套袋苹果园中桃小食心虫的蛀果动态与脱果动态趋势基本一致,

幼虫全年的脱果率(53.6%)低于蛀果率(80.9%),脱果时间比蛀果时间推后24~30 d,其中蛀果高峰依次出现在6月18日、7月12日、7月30日、8月23日和9月10日,而脱果高峰依次出现在7月18日、8月11日、8月29日、9月16日和10月4日。8月份之前,桃小食心虫田间蛀果率一直处于一个较高水平,8月份之后明显降低,而桃小食心虫田间脱果率则从7月份开始逐渐增加,在8月份达到脱果高峰后也明

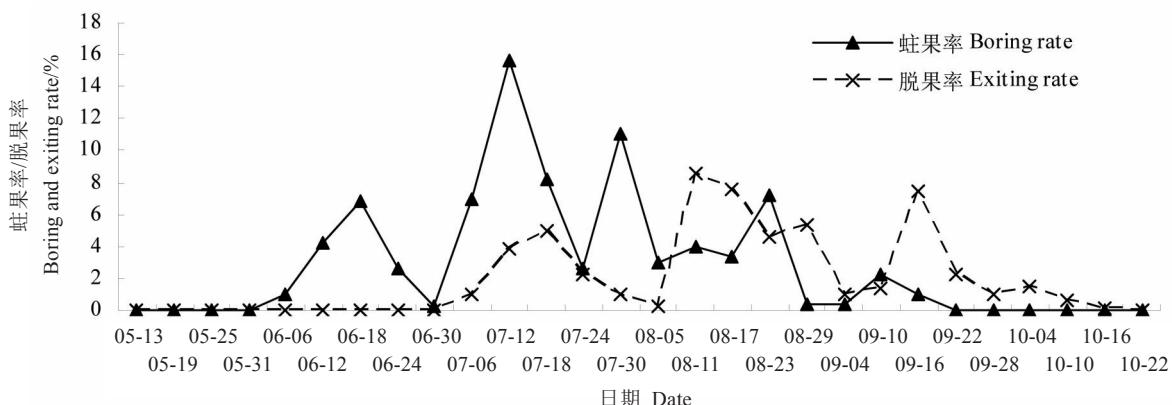


图2 2018年免套袋栽培苹果园中桃小食心虫幼虫蛀果和脱果危害动态

Fig. 2 The dynamics of fruit damage caused by *Carposina sasakii* Matsumura reflected by rates of larva boring and exiting from the fruit in the apple orchard without fruit bagging in 2018

显降低。

2018年5—10月,桃小食心虫成虫每月总虫量分别为0.33、257.67、239.00、237.67、271.00和0.33头/诱捕器,其中6—9月每月诱捕总虫量差异不显著,但均显著高于5月和10月的总虫量( $p < 0.05$ );桃小食心虫幼虫蛀果率分别为0%、14.8%、44.4%、18.0%、3.6%和0.1%,其中7月份幼虫蛀果率最高,

显著高于其他月份,6月和8月幼虫蛀果率次之( $p < 0.05$ );桃小食心虫幼虫脱果率分别为0%、0%、13.0%、26.4%、12.0%和2.2%,其中8月份幼虫脱果率最高,显著高于其他月份,7月和9月脱果率次之( $p < 0.05$ )(图3)。

## 2.3 双酰胺类杀虫剂对桃小食心虫的防治效果

从表2可以看出,越冬代成虫羽化高峰前(6月

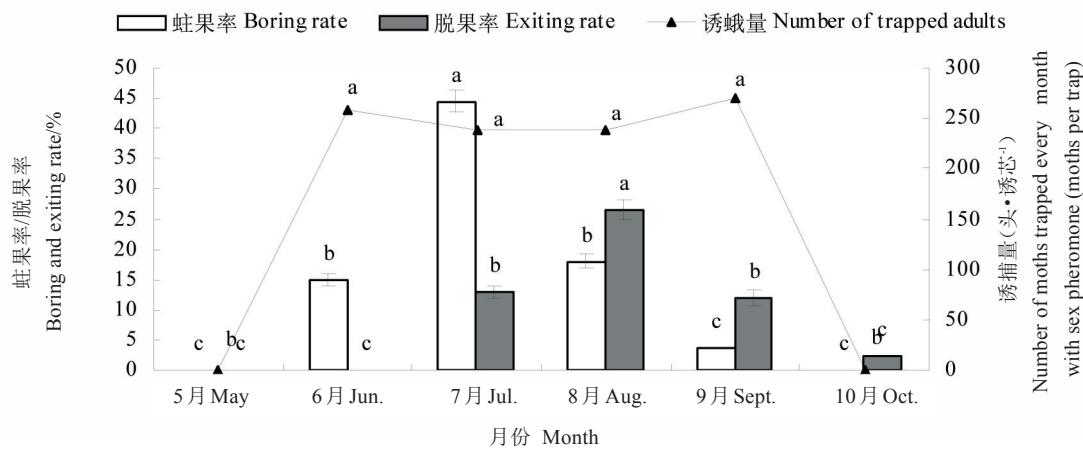


图3 2018年免套袋栽培苹果园中桃小食心虫成虫、幼虫蛀果和脱果月发生量

Fig. 3 The monthly occurrence of *Carposina sasakii* Matsumura adults, larva boring and exiting from the fruit in the apple orchard without fruit bagging in 2018

表2 双酰胺类杀虫剂对桃小食心虫的防治效果

Table 2 The control efficacy of diamide insecticides on *Carpocina sasakii* Matsumura

药剂处理及有效成分用量 Active ingredient dosage/(mg·kg <sup>-1</sup> )	越冬代成虫羽化高峰前施药(6月23日) Sprayed before the emergence peak of overwintering adults (Jun. 23)						越冬代成虫羽化高峰期施药(7月7日) Sprayed at the emergence peak of overwintering adults (Jul. 7)								
	药后7 d(6月30日) 7 days after the first application(Jun. 30)			药后14 d(7月7日) 14 days after the first application(Jul. 7)			药后35 d(7月28日) 35 days after the first application(Jul. 28)			药后7 d(7月14日) 7 days after the second application(Jul. 14)			药后14 d(7月21日) 14 days after the second application(Jul. 21)		
	蛀果率 The rate of damaged fruits/%	治效果 Control efficacy for bored fruits/%	蛀果防 Control efficacy for fruits/%	蛀果率 The rate of damaged fruits/%	治效果 Control efficacy for bored fruits/%	蛀果防 Control efficacy for fruits/%	蛀果率 The rate of damaged fruits/%	治效果 Control efficacy for bored fruits/%	蛀果防 Control efficacy for fruits/%	蛀果率 The rate of damaged fruits/%	治效果 Control efficacy for bored fruits/%	蛀果防 Control efficacy for fruits/%	蛀果率 The rate of damaged fruits/%	治效果 Control efficacy for bored fruits/%	蛀果防 Control efficacy for fruits/%
200 g·L <sup>-1</sup> 四唑虫酰胺悬浮剂 40.0	0.75	83.23	1.63	78.03	0.88	85.62	1.00	89.87	3.25	78.85	2.38	88.13			
200 g·L <sup>-1</sup> tetraniiprole SC 40.0		±3.34 b		±3.29 b			±3.87 a		±4.31 ab		±4.51 b				±1.34 a
35% 氯虫苯甲酰胺水分散粒剂 50.0	0.75	85.85	1.25	86.33	0.75	86.67	1.50	83.06	3.25	80.29	3.13	84.46			
35% chlorantraniliprole WG 50.0		±15.29b		±15.11 ab			±5.10 a		±1.80 b		±1.96 b				±1.94 a
10% 溴氰虫酰胺可分散油悬浮剂 30.0	0.88	81.01	2.00	72.89	1.13	81.10	1.63	81.88	3.5	78.36	3.25	83.61			
10% cyantraniliprole OD 30.0		±5.73 b		±8.37 b			±4.42 a		±0.42 b		±1.94 b				±0.72 a
2.5% 高效氯氟菊酯乳油 22.5	0.13	99.28	0.38	97.44	0.50	92.52	0.88	90.77	1.63	89.91	2.00	89.97			
2.5% beta-cypermethrin EC 22.5		±9.74 a		±10.79 a			±11.04 a		±2.74 a		±2.34 a				±1.90 a
空白对照 Blank control	4.38		7.25		5.75		9.00		16.25		19.88				

注: 同一列中不同小写字母表示 5% 水平上差异显著。

Note: Different lowercase letters in the same column indicate significant difference at  $p < 0.05$ .

23日)和羽化高峰期(7月7日)施药,每次药后7 d和14 d,四唑虫酰胺 $40 \text{ mg} \cdot \text{kg}^{-1}$ 、氯虫苯甲酰胺 $50 \text{ mg} \cdot \text{kg}^{-1}$ 和溴氰虫酰胺 $30 \text{ mg} \cdot \text{kg}^{-1}$ 的桃小食心虫幼虫蛀果防治效果相互之间差异不显著,但均低于高效氯氰菊酯 $22.5 \text{ mg} \cdot \text{kg}^{-1}$ 。对于桃小食心虫脱果防治效果(羽化高峰期前施药后35 d和羽化高峰期药后38 d),3种双酰类杀虫剂的桃小食心虫脱果防治效果与高效氯氰菊酯 $22.5 \text{ mg} \cdot \text{kg}^{-1}$ 差异不显著。

### 3 讨 论

苹果免套袋栽培模式下,由于缺少果袋的隔离保护作用,裸露的果实更易受到病虫害的为害,生产者只能通过加大药剂使用量和施用次数才能达到预期防治效果,而农药的过量使用又使无袋果实的农残问题更加突出,因此合理使用化学农药是苹果免套袋栽培防治桃小食心虫的主要策略之一。仇贵生等<sup>[12]</sup>报道在不实行套袋栽培管理或管理较粗放的苹果园,桃小食心虫仍是需要重点监测的防治对象之一。笔者研究发现山东威海地区免套袋苹果园在常规化学防治条件下,桃小食心虫蛀果率为7%,显著高于套袋苹果园的0.38%<sup>[2]</sup>。在本研究中,免套袋苹果园中,在全年未施药的情况下桃小食心虫幼虫的蛀果率高达80.9%,严重限制了苹果免套袋生产技术大面积推广。桃小食心虫在山东威海地区一年发生2代,成虫发生始末期为5月下旬至9月下旬,这与于洁等<sup>[13]</sup>和陈川等<sup>[14]</sup>报道桃小食心虫在北方水果产区一年发生1~2代,7月底或8月初为2个世代的分界线一致。2017—2018年威海地区免套袋苹果园中桃小食心虫成虫变化趋势相似,但成虫发生量、成虫始见期和终见期、成虫发生高峰期在不同年份间存在差异,与陈丽慧等<sup>[15]</sup>的研究结果一致,可能与不同年份间温度、降雨量等气候变化有关。

由于桃小食心虫以钻蛀果实为害,因此研究桃小食心虫的危害规律,掌握防治适期,对于桃小食心虫的有效防控具有重大意义。桃小食心虫的传统防治指标以卵果率作为依据<sup>[16~17]</sup>,但因其卵粒小,并且90%的卵产于果实的萼洼处<sup>[18]</sup>,导致调查计数较为困难。陈丽慧等<sup>[15]</sup>和范保银等<sup>[19]</sup>提出基于性诱剂诱捕的成虫防治指标,当以卵果率1%或2%为苹果园桃小食心虫药剂防治指标时,性诱捕器的诱蛾量为8.3头·诱捕器<sup>-1</sup>·日<sup>-1</sup>或30.0头·诱捕器<sup>-1</sup>·日<sup>-1</sup><sup>[15,19]</sup>。而张乃鑫等<sup>[20]</sup>采用田间接卵结合室内饲养的观察方

法,发现金冠、红玉和国光等苹果上桃小食心虫的蛀果孔数不等同于接卵数,其中蛀果率(蛀果孔/接卵数)在56.2%~77.2%,且蛀果率在不同树种、品种及桃小食心虫幼虫不同孵化时期之间也存在差异。因此,在免套袋苹果园中进行桃小食心虫虫情调查、预测预报和药剂防治时,不能单纯依靠卵果率和性诱剂诱捕虫量作为防治指标,还应根据蛀果率(危害程度)和脱果率(幼虫成活率)进行测报与防治。

本研究发现2018年桃小食心虫越冬代(5月30日—7月30日)成虫诱捕量为497头·诱捕器<sup>-1</sup>,与第1代(8月2日—10月1日)成虫诱捕量(508.67头·诱捕器<sup>-1</sup>)差异不显著,但第1代幼虫蛀果率为59.2%,显著高于第2代幼虫的蛀果率(21.6%),这与张玉琴等<sup>[21]</sup>的研究结果基本一致。这可能是由于桃小食心虫越冬代成虫出土时间长,部分幼虫在8月中旬以后脱果结冬茧进入越冬状态,而结夏茧幼虫羽化后部分转移至海棠、山楂等果实继续危害<sup>[22~23]</sup>。在本研究中,桃小食心虫幼虫的蛀果动态与脱果动态趋势基本一致,但幼虫脱果率低于蛀果率,这与张乃鑫等<sup>[20]</sup>的报道一致,证实了桃小食心虫蛀入果内幼虫的成活数量和生长情况亦受果肉组织及果实内含物的直接影响。对于性诱剂诱捕桃小食心虫成虫数量、桃小食心虫蛀果率和脱果率三者间的相互关系,以及如何将这种对应关系应用到桃小食心虫的防治中,有待于进一步的研究。

本研究还发现对照药剂高效氯氰菊酯对桃小食心虫的防治效果均较为显著,2次施药后的蛀果防治效果均在89.9%以上,脱果防治效果均在92.5%以上,与高越等<sup>[24]</sup>报道高效氯氰菊酯对桃小食心虫幼虫蛀果防治效果基本一致。高效氯氰菊酯的作用原理为通过延长钠离子通道开放时间,导致靶标昆虫兴奋过度而死<sup>[25~27]</sup>。而四唑虫酰胺、氯虫苯甲酰胺、溴氰虫酰胺属于双酰胺杀虫剂中的邻氨基苯甲酰胺类杀虫剂,除具有触杀特性外,还对出孵幼虫具有强力杀伤性,害虫出孵咬破卵皮或果皮蛀入果实时中毒而死<sup>[10]</sup>。本研究中,四唑虫酰胺 $40 \text{ mg} \cdot \text{kg}^{-1}$ 、氯虫苯甲酰胺 $50 \text{ mg} \cdot \text{kg}^{-1}$ 、溴氰虫酰胺 $30 \text{ mg} \cdot \text{kg}^{-1}$ 对桃小食心虫防治效果相似,三者对桃小食心虫幼虫的蛀果防治效果显著低于高效氯氰菊酯,但幼虫成活率低,其幼虫脱果防治效果略低于高效氯氰菊酯,差异不显著,但三者使用剂量不同,四唑虫酰胺和溴氰虫酰胺的有效成分用量分别为 $40 \text{ mg} \cdot \text{kg}^{-1}$ 和 $30 \text{ mg} \cdot \text{kg}^{-1}$ ,

均低于氯虫苯甲酰胺 $50 \text{ mg} \cdot \text{kg}^{-1}$ 。四唑虫酰胺和溴氰虫酰胺对桃小食心虫的防控特点与氯虫苯甲酰胺类似,其靶标均为鱼尼汀受体,对于四唑虫酰胺、溴氰虫酰胺和氯虫苯甲酰胺在防控桃小食心虫方面是否存在交互抗性以及根据双酰胺类杀虫剂的防控特点科学地交替使用药剂也有待于进一步的研究。

## 4 结 论

桃小食心虫在山东威海地区一年发生2代,成虫发生始末期为5月下旬至9月下旬。桃小食心虫幼虫蛀果主要集中在6—9月发生,其中7月幼虫蛀果率最高为44.4%;幼虫脱果期集中在7—10月,8月幼虫脱果率最高为26.4%。氯虫苯甲酰胺水分散粒剂 $50 \text{ mg} \cdot \text{kg}^{-1}$ 、溴氰虫酰胺可分散油悬浮剂 $30 \text{ mg} \cdot \text{kg}^{-1}$ 、四唑虫酰胺悬浮剂 $40 \text{ mg} \cdot \text{kg}^{-1}$ 对桃小食心虫的防治效果均较为突出,幼虫蛀果防治效果低于高效氯氰菊酯,但幼虫成活率低,其幼虫脱果防治效果与高效氯氰菊酯相近。在免套袋栽培苹果园中,可轮换使用双酰胺类杀虫剂和拟除虫菊酯类杀虫剂,以延缓桃小食心虫对不同药剂的抗药性。

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