

桃潜叶蛾与梨小食心虫性信息素互作效应

孙 媛¹, 蓝陈仪航¹, 施程程¹, 沈志杰¹, 房明华²,
洪文英³, 沃林峰², 刘 涛², 邓建宇^{1*}

(¹浙江农林大学农业与食品科学学院, 杭州 311300; ²杭州市原种场, 杭州 311115;

³浙江省杭州市植保土肥总站, 杭州 310019)

摘要:【目的】明确桃潜叶蛾与梨小食心虫性信息素的互作效应。【方法】通过触角电位技术和田间诱捕试验, 分别探究桃潜叶蛾与梨小食心虫雄虫对异种昆虫性信息素的触角电位反应以及不同剂量2种性信息素混合使用时对桃潜叶蛾与梨小食心虫田间诱捕效果的影响。【结果】桃潜叶蛾雄虫触角能够感知剂量为0.1 μg的梨小食心虫性信息素, 梨小食心虫雄虫能够明显感知100.0 μg桃潜叶蛾性信息素且触角电位值随性信息素剂量增加而增大。50.0~500.0 μg梨小食心虫与1.0 mg桃潜叶蛾性信息素混用时的诱蛾效果与1.0 mg桃潜叶蛾对照诱芯相比无显著差异, 1.0~2.0 mg桃潜叶蛾与50.0 μg梨小食心虫性信息素混用时的诱蛾效果与50.0 μg梨小食心虫对照诱芯相比也无显著差异。【结论】桃潜叶蛾与梨小食心虫能相互感知对方性信息素, 且2种性信息素混合使用时对二者田间诱捕效果无影响, 今后可作为复合诱芯或迷向剂在果园内同时监测或防治桃潜叶蛾与梨小食心虫。

关键词:桃; 桃潜叶蛾; 梨小食心虫; 性信息素; 复合诱芯

中图分类号:S662.1 S436.621 S436.612

文献标志码:A

文章编号:1009-9980(2021)09-1563-06

Interaction effect between *Lyonetia clerkella* and *Grapholitha molesta* sex pheromones

SUN Yuan¹, LAN Chenyihang¹, SHI Chengcheng¹, SHEN Zhijie¹, FANG Minghua², HONG Wenying³, WO Linfeng², LIU Tao², DENG Jianyu^{1*}

(¹College of Agriculture and Food Science, Zhejiang A & F University, Hangzhou 311300, Zhejiang, China; ²Hangzhou Raw Seed Growing Farm, Hangzhou 311115, Zhejiang, China; ³Hangzhou Centre for Agricultural Technology Extension, Hangzhou 310019, Zhejiang, China)

Abstract:【Objective】*Lyonetia clerkella* L.(Lepidoptera, Lyonetiidae) and *Grapholitha molesta* B. (Lepidoptera, Tortricidae) are important pests in orchards, which damage leaves, twigs and fruits of peach, pear, apple, plum, apricot and other fruit crops. Due to the damaging characteristics of the two pests, the control effect by chemical pesticide is limited. Insect sex pheromones have been widely used in integrated pest management including the sex pheromone of *L. clerkella* and *G. molesta*. Their occurrence periods of two insects overlap throughout the year. The purpose of this study was to explore the interaction effect between two sex pheromones by means of Electroantennogram (EAG) and field trapping tests. One of the objectives of this study was to test whether male moths of *L. clerkella* and *G. molesta* can perceive sex pheromones of each other; and another objective was to determine whether the two synthetic sex pheromones could be blended into a lure for monitoring and controlling the both insect pests simultaneously. The results can provide a basis for the development of a blending lure to save the cost of management and improve multi-species control efficiency.【Methods】This study was divided into two parts: EAG test and field trapping test. The sex pheromone of *L. clerkella* used was 14-meth-

收稿日期:2021-03-09 接受日期:2021-04-24

基金项目:杭州市农业和社会发展科研主动设计项目(20180416A03)

作者简介:孙媛,女,在读硕士研究生,研究方向为农业有害生物综合防控。Tel:17612568330, E-mail:515533894@qq.com

*通信作者 Author for correspondence. Tel:0571-63741276, E-mail:jydeng70@aliyun.com

yl-1-octadecene and the sex pheromone of *G. molesta* was composed of (*Z*)-8-dodecenyl acetate (Z8-12:OAc), (*E*)-8-dodecenyl acetate (E8-12:OAc) and (*Z*)-8-dodecen-1-ol (Z8-12:OH) in a ratio of 95:5:5. In the EAG test, the different doses of sex pheromone of *G. molesta* (0.1, 1.0, 10.0, 100.0 and 500.0 µg) were used to stimulate the antenna of *L. clerkella* male moth, and then the 5 same pheromone doses of *L. clerkella* were to stimulate the antenna of *G. molesta* male moth conversely. The paraffin oil was used as control. Each EAG test was repeated for 8 times. In the field trapping test, the different doses of sex pheromone of *G. molesta* (50.0, 100.0, 200.0, 300.0 and 500.0 µg) were mixed respectively with 1.0 mg pheromone of *L. clerkella*, and then 1.0 mg and 2.0 mg doses of sex pheromone of *L. clerkella* were mixed respectively with the 50.0 µg pheromone of *G. molesta*. In addition, 1.0 mg pheromone of *L. clerkella* and 50.0 µg pheromone of *G. molesta* were used as control respectively. The type of trap used was triangle trap that was hung on the branch at a height of 1.5 m above the ground. Check was done once a week and the location of traps in the same block was exchanged circularly. Five replicates were used for each treatment. 【Results】Male moth of *L. clerkella* could perceive as low as 0.1 µg sex pheromone of *G. molesta* and the responses of 5 doses (0.1, 1.0, 10.0, 100.0 and 500.0 µg) were significantly higher than those of control ($p < 0.05$). The EAG responses of *G. molesta* increased with the increase of sex pheromone of *L. clerkella*. When the dose was 0.1-10.0 µg, there was no significant difference compared to control ($p > 0.05$); when the dose increased to 100.0 µg, there was significant difference compared to control and 0.1-1.0 µg treatments ($p < 0.05$), but no significant difference compared to 10.0 µg ($p > 0.05$); when the dose increased to 500.0 µg, the EAG response was the highest, which was significantly higher than control and 0.1-100.0 µg treatments ($p < 0.05$). The field trapping test showed that when 50.0, 100.0, 200.0, 300.0 and 500.0 µg sex pheromones of *G. molesta* were mixed with 1.0 mg sex pheromone of *L. clerkella* respectively, the average *L. clerkella* moth catch per trap per week was slightly lower than control (1.0 mg sex pheromone of *L. clerkella*), which were 39.8, 42.1, 43.5, 41.0, 38.2 and 46.3 respectively, and there were no significant differences among the six relative trapping rates ($p > 0.05$), which were $16.50\% \pm 1.44\%$, $16.13\% \pm 1.32\%$, $17.27\% \pm 0.82\%$, $16.80\% \pm 1.00\%$, $15.21\% \pm 0.41\%$ and $18.09\% \pm 0.76\%$ respectively. When 1.0 mg and 2.0 mg sex pheromones of *L. clerkella* were mixed with 50.0 µg sex pheromone of *G. molesta*, the average *G. molesta* moth catch per trap per week was also slightly lower than control (50.0 µg sex pheromone of *G. molesta*) but there was also no significant difference among the three relative trapping rates ($p > 0.05$), which were $17.89\% \pm 5.20\%$, $22.98\% \pm 6.07\%$ and $35.17\% \pm 3.80\%$ respectively. 【Conclusion】Male moth of *L. clerkella* and *G. molesta* can perceive sex pheromones of each other at some dosages and different doses of mixed attractants containing both *L. clerkella* and *G. molesta* synthetic sex pheromones had no significant effect on the two moth captures in the fields. Therefore, to save the manpower and cost, the two pheromone blend can be used to monitor and control both *L. clerkella* and *G. molesta* simultaneously in orchards.

Key words: Reach; *Lyonetia clerkella*; *Grapholitha molesta*; Sex pheromone; Multiple-species attractant

桃潜叶蛾(*Lyonetia clerkella* L.)属鳞翅目(Lepidoptera), 潜叶蛾科(Lyonetiidae); 梨小食心虫(*Grapholitha molesta* B.)属鳞翅目(Lepidoptera), 卷蛾科(Tortricidae)。二者均为果树重要害虫, 常常混合发生于桃、李、杏、苹果等果树, 前者刺破叶片表皮钻入内部取食叶肉, 后者蛀梢、蛀果且在梢、果外停留时间短。桃潜叶蛾在日本、韩国及我国北京、山

东、山西、云南等地均有分布, 不同地区发生代数不同, 我国自北向南1 a(年)发生4~7代。7—8月随着气温升高, 湿度增加, 桃潜叶蛾繁殖速度加快, 种群数量激增, 导致桃树被害严重, 提前落叶, 树势衰弱, 果实产量和质量下降, 严重时造成果园绝产, 给经济带来巨大损失^[1-3]。梨小食心虫是世界性的蛀果害虫, 除我国以外, 在日本、美国东西部、欧洲中西部、

澳大利亚南部等水果产区均有分布^[4]。在国内,梨小食心虫广泛分布于除西藏外各水果主要产区,北至黑龙江,南至广东,1 a发生3~7代^[5]。2种害虫的取食特性导致对二者的化学防控难度增加且防效不佳。性信息素是雌虫自身性腺体分泌的微量化学物质,具有活性高、特异性强、使用简便、不污染环境、不伤害天敌等优点。因此,从食品安全和环境保护的角度出发,采用性信息素对害虫进行综合管理具有切实的可行性,是果树害虫综合防控的重要方向^[6]。

桃潜叶蛾与梨小食心虫全年重叠发生与为害,为了节约人力和物力,复合性信息素技术(性诱剂与交配干扰剂)亟待开发^[7]。关于桃潜叶蛾与梨小食心虫性诱剂结合试验,已有文献报道,但研究结果不一致^[8-9]。本研究旨在将二者性信息素混合使用,探究2种害虫性信息素的互作效应,为今后降低应用成本、提高防控效率、研发复合诱芯及交配干扰剂提供理论依据。

1 材料和方法

1.1 试验地点与时间

桃潜叶蛾触角电位试验地点:浙江农林大学农业与食品科学学院实验室;试验时间:2019年10月。梨小食心虫触角电位试验地点:同上;试验时间:2020年8月。桃潜叶蛾田间试验地点:浙江省杭州市临安区龙岗镇花果山家庭农场($30^{\circ}11'24''$ N, $119^{\circ}6'36''$ E),海拔281.0 m。桃树株距4.0 m,行距4.0 m,株高4.0~5.0 m,树龄8 a,品种湖锦蜜桃;试验时间:2019年10月。梨小食心虫田间试验地点:浙江省杭州市余杭区径山镇绿景堂生态园($30^{\circ}18'6''$ N, $118^{\circ}48'6''$ E),海拔60.0 m。桃树株距4.0 m,行距3.0 m,株高3.0~4.0 m,树龄12 a,品种锦绣黄桃;试验时间:2020年8月。

1.2 供试虫源

桃潜叶蛾的蛹采于浙江省杭州市临安区龙岗镇花果山家庭农场,梨小食心虫的蛹购于中国农业科学院果树研究所,将其各自放入试管中,加入蘸有蜂蜜水的棉花,而后放入培养箱[温度(26 ± 10)℃,光照14 h,黑暗10 h,湿度80%],取羽化2~3 d内的成虫用于触角电位试验。

1.3 试验试剂

桃潜叶蛾性信息素:14-甲基-1-十八碳烯(14-methyl-1-octadecene,纯度>92%),购于日本信越化

学工业株式会社(Shin-Etsu Chemical Co., Ltd.)。梨小食心虫性信息素:顺-8-十二碳烯醇乙酸酯(Z8-12:OAc,纯度>97%),反-8-十二碳烯醇乙酸酯(E8-12:OAc,纯度>99%),顺-8-十二碳烯-1-醇(Z8-12:OH,纯度>99%),3种药剂均购于常州宁录生物科技有限公司。溶剂:石蜡油(paraffin oil,纯度>95%)购于天津大茂化学试剂厂;正己烷(n-Hexane,分析纯,纯度≥97%),购于国药集团化学试剂有限公司。

1.4 试验仪器与诱捕器

触角电位仪:购自荷兰Syntech公司,主要由刺激控制器“Stimulus Air Controller Type CS-55”、双USB接口采集控制器IDAC-2、触角固定显微操作台及电脑装置软件组成。

诱捕器:三角形黏胶型诱捕器(长24 cm,宽18 cm,高18 cm),购于北京中捷四方生物科技股份有限公司。

1.5 试验方法

1.5.1 触角电位试验 试剂配制:分别以桃潜叶蛾和梨小食心虫性信息素为溶质,石蜡油为溶剂,依次配制成0.1、1.0、10.0、100.0和500.0 g·L⁻¹共5种质量浓度的溶液,完成后置于4℃冰箱中备用,对照为石蜡油。

试验操作:使用滤纸为试剂载体,剪成0.6 cm×2.0 cm的大小,放入1000 μL枪头中备用,用移液枪分别吸取1 μL 5种不同质量浓度的试剂和石蜡油均匀涂抹在枪头内的滤纸条上并固定于出气管口,用于刺激触角的挥发气体。将昆虫触角沿基部切下,两端切除微许,将基部放入已注入2/3生理盐水的玻璃毛细管中,连接仪器右边参考电极,调整仪器,使触角端部连接左边记录电极的玻璃毛细管中。刺激顺序为石蜡油→0.1 μg→1.0 μg→10.0 μg→100.0 μg→500.0 μg,试验重复8次。

1.5.2 田间试验 诱芯配制:实验室自制。梨小食心虫性信息素由三组分Z8-12:OAc、E8-12:OAc和Z8-12:OH按质量比95:5:5配制而成,桃潜叶蛾性信息素为其组分14-甲基-1-十八碳烯。以正己烷为溶剂,将2种性信息素配置成8种所需诱芯,分别为:(1)1.0 mg桃潜叶蛾性信息素;(2)50.0 μg梨小食心虫性信息素;(3)1.0 mg桃潜叶蛾性信息素+100.0 μg梨小食心虫性信息素;(4)1.0 mg桃潜叶蛾性信息素+200.0 μg梨小食心虫性信息素;(5)1.0 mg桃潜叶蛾性信息素+300.0 μg梨小食心虫性信息素;(6)

1.0 mg 桃潜叶蛾性信息素+500.0 μg 梨小食心虫性信息素;(7)1.0 mg 桃潜叶蛾性信息素+50.0 μg 梨小食心虫性信息素;(8)2.0 mg 桃潜叶蛾性信息素+50.0 μg 梨小食心虫性信息素。

田间采用随机区组设计,诱捕器悬挂于距地面高度1.5 m的树枝上,每个诱捕器间隔10.0~15.0 m^[10]。每个处理5次重复,每周调查1次虫量,更换诱捕器黏板并循环交换同组内诱捕器的位置,2019年桃潜叶蛾田间试验共调查7次,2020年梨小食心虫田间试验共调查8次。

1.6 数据分析

使用Excel 2016进行初步统计,用SPSS22.0进行数据分析。因试验地不同小区虫量差异,故田间试验采用相对诱蛾率进行分析。

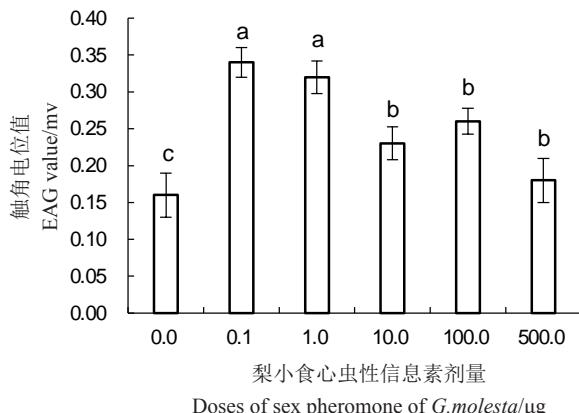
相对诱蛾率(%)=所在小区中某一处理的诱蛾量/所在小区诱蛾总量×100

除梨小食心虫触角电位试验使用Dunnett-T外,其余均使用单因素方差(one-way ANOVA)分析,最小显著差异法(least significant difference,LSD)进行差异显著性分析。

2 结果与分析

2.1 桃潜叶蛾触角电位试验

由图1可知,桃潜叶蛾触角反应值随着梨小食



不同小写字母表示在 $p < 0.05$ 水平上差异显著,梨小食心虫性信息素(Z8-12:OAc:E8-12:OAc:Z8-12:OH=95:5:5)。下同。

Different small letters indicate significant difference at $p < 0.05$, the synthetic sex pheromone of *G. molesta* (Z8-12:OAc:E8-12:OAc:Z8-12:OH=95:5:5). The same below.

图1 桃潜叶蛾对不同剂量梨小食心虫性信息素的触角电位反应

Fig. 1 EAG responses of antennae of male *L. clerkella* to different doses of *G. molesta* synthetic sex pheromone

心虫性信息素剂量的增加而降低。当剂量为0.1~1.0 μg 时,触角反应值较大,显著高于10.0~500.0 μg ($p < 0.05$),且所试5种剂量与对照相比均有显著差异($p < 0.05$)。

2.2 梨小食心虫触角电位试验

由图2可知,梨小食心虫雄虫触角反应值随着桃潜叶蛾性信息素剂量的增加而增强。当桃潜叶蛾性信息素剂量为0.1~10.0 μg 时,与对照石蜡油相比无显著差异($p > 0.05$);当剂量增加至100.0 μg 时,与对照和剂量0.1~1.0 μg 相比差异显著($p < 0.05$),但与剂量10.0 μg 相比无显著差异($p > 0.05$);当剂量增加到500.0 μg 时,触角反应值最大,显著高于剂量0.1~100.0 μg ($p < 0.05$)。

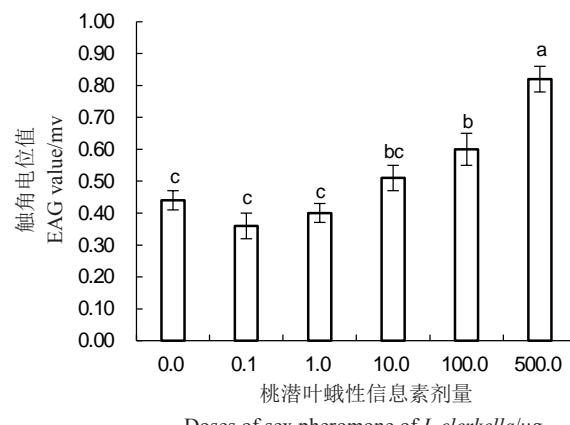


图2 梨小食心虫对不同剂量桃潜叶蛾性信息素的触角电位反应

Fig. 2 EAG responses of antennae of male *G. molesta* to different doses of sex pheromone of *L. clerkella*

2.3 桃潜叶蛾与梨小食心虫性信息素混用对田间桃潜叶蛾诱捕效果的影响

2019年田间试验结果如表1所示,50.0、100.0、200.0、300.0和500.0 μg 梨小食心虫性信息素分别与1.0 mg 桃潜叶蛾性信息素混合使用时,桃潜叶蛾每周平均诱蛾量略低于桃潜叶蛾性信息素剂量1.0 mg 标准诱芯,分别为39.8头、42.1头、43.5头、41.0头、38.2头和46.3头,但相对诱蛾率无显著差异($p > 0.05$),分别为(16.50±1.44)%、(16.13±1.32)%、(17.27±0.82)%、(16.80±1.00)%、(15.21±0.41)%和(18.09±0.76)%。综上,2种性信息素混合使用时不影响田间桃潜叶蛾诱捕效果。

2.4 桃潜叶蛾与梨小食心虫性信息素混用对田间梨小食心虫诱捕效果的影响

2020年田间试验结果如表2所示,剂量1.0与

表1 不同剂量的梨小食心虫性信息素添加对桃潜叶蛾田间诱捕效果的影响

Table 1 Effect on trapping catch of *L. clerkella* in the field by addition of different doses of *G. molesta* synthetic sex pheromone

| 处理 | 桃潜叶蛾性信息素剂量 | 梨小食心虫性信息素剂量 | 桃潜叶蛾每周平均诱蛾量/(头·周 ⁻¹ ·诱捕器 ⁻¹) | 相对诱蛾率% |
|-----------|--|--|---|--------------------------|
| Treatment | Dose of sex pheromone of <i>G. molesta</i> /mg | Dose of sex pheromone of <i>L. clerkella</i> /μg | Moths captured per trap per week | Relative trapping rate/% |
| 1 | 1.0 | — | 46.3 | 18.09±0.76 a |
| 2 | 1.0 | 50.0 | 39.8 | 16.50±1.44 a |
| 3 | 1.0 | 100.0 | 42.1 | 16.13±1.32 a |
| 4 | 1.0 | 200.0 | 43.5 | 17.27±0.82 a |
| 5 | 1.0 | 300.0 | 41.0 | 16.80±1.00 a |
| 6 | 1.0 | 500.0 | 38.2 | 15.21±0.41 a |
| 7 | — | 50.0 | 2.4 | 0.13±0.10 b |

注:不同小写字母表示差异显著($p < 0.05$)。下同。

Note: Different small letters indicate significant differences($p < 0.05$). The same below.

表2 不同剂量的桃潜叶蛾性信息素添加对梨小食心虫田间诱捕效果的影响

Table 2 Effect on trapping catch of *G. molesta* in the field by addition of different doses of sex pheromone

| 处理 | of <i>L. clerkella</i> | | | |
|-----------|--|--|--|--------------------------|
| Treatment | 梨小食心虫性信息素剂量 | 桃潜叶蛾性信息素剂量 | 梨小食心虫每周平均诱蛾量/(头·周 ⁻¹ ·诱捕器 ⁻¹) | 相对诱蛾率% |
| | Dose of sex pheromone of <i>G. molesta</i> /ug | Dose of sex pheromone of <i>L. clerkella</i> /mg | Moths captured per trap per week | Relative trapping rate/% |
| 1 | 50.0 | — | 28.8 | 35.17±3.80 a |
| 2 | 50.0 | 1.0 | 17.4 | 17.89±5.20 ab |
| 3 | 50.0 | 2.0 | 24.3 | 22.98±6.07 ab |
| 4 | — | 1.0 | 1.4 | 0.03±1.23 c |

2.0 mg 桃潜叶蛾性信息素分别与 50.0 μg 梨小食心虫性信息素混合使用时,梨小食心虫每周平均诱蛾量略低于梨小食心虫性信息素剂量 50.0 μg 标准诱芯,分别为 17.4、24.3 和 28.8 头,但相对诱蛾率无显著差异($p > 0.05$),分别为(17.89±5.20)%、(22.98±6.07)% 和(35.17±3.80)%,综上,2 种性信息素联合使用时不影响田间梨小食心虫诱捕效果。

3 讨 论

已有文献表明,不同种类昆虫的信息素联合应用会产生不同的效应。近缘种之间信息素常常会产生拮抗作用,干扰目标昆虫的引诱效果,推测跟物种间生殖隔离相关。例如甜菜夜蛾(*Spodoptera ex-*

igua)和斜纹夜蛾(*S. litura*)均为夜蛾科同域昆虫,2 种信息素混合使用时均对 2 种害虫产生抑制作用,降低诱蛾效果^[11];再如 *Cydia pomonella* 和 *Cydia ulicetana*,当 2 种信息素混合时,会降低 *C. pomonella* 的引诱效果,但对 *C. ulicetana* 的引诱效果无影响^[12]。除此之外,不同昆虫信息素互相混合还可引诱更多物种^[13]。如柑橘潜叶蛾的引诱剂可引诱同属不同种的潜叶类昆虫^[14];不同种类天牛的信息素混用可同时引诱多种天牛^[15],且不影响各自的诱捕效果^[16];3 种实蝇科昆虫(*Ceratitis capitata*、*Bactrocera cucurbitae*、*Bactrocera dorsalis*)信息化学物质混合使用对各自的引诱效果也无影响^[17];将盲蝽科同域的 2 种昆虫(*Stenotus rubrovittatus*、*Trigonotylus caelestialium*)的性信息素混合使用,均对各自引诱效果无影响,可置于同一诱捕器中同时监测及防治多种害虫^[18]。除性信息素外,某些昆虫的聚集信息素也可吸引同目不同科的昆虫,如 Heteroptera: Alydidae 和 Heteroptera: Pentatomidae^[19]。多种鳞翅目害虫性信息素可兼容,结合使用时能增加靶标害虫防控种类,提高防治效率,具有一定潜力和切实可行性^[20]。

当多种果树害虫同时发生及为害时,为了节约人力和物力,复合性诱剂亟待开发。已有前人在梨小食心虫、苹小卷叶蛾和桃小食心虫均发生的果园进行性信息素合用的相关研究,发现苹小卷叶蛾和桃小食心虫性信息素的添加对梨小食心虫诱捕效果无影响;桃小食心虫和梨小食心虫性信息素的添加对苹小卷叶蛾诱捕效果无影响;但苹小卷叶蛾性信息素的添加对桃小食心虫诱捕效果具有干扰作用,不宜将这 2 种昆虫性信息素结合使用^[21]。

关于田间桃潜叶蛾与梨小食心虫性信息素联合使用,已有文章报道,但结果不一致。徐劭等^[8]试验结果表明,桃潜叶蛾与梨小食心虫性信息素联合使用后,2 种害虫诱蛾量均大幅上升,互相增效作用明显;而姜瑞德等^[9]试验结果表明,将 2 种害虫性信息素联合使用时均比单用时诱蛾量略微减少,但差异不显著,且不影响 2 种害虫的发生动态。该结果与前者的增效作用存在差异但与本试验结果一致,推测与试验时虫量密度及诱芯气味的复杂性有关。前者于虫量中、低密度发生时进行试验且诱芯设置多元化,运用了 5 种果树害虫的性信息素互相联合使用,可能对桃潜叶蛾和梨小食心虫的感受机制产生影响;而后者于虫量中、高密度发生时进行试验且仅

将这2种害虫性信息素结合使用,得到了与本文一致的结果。因此,将桃潜叶蛾与梨小食心虫性信息素结合,开发复合诱芯或复合迷向剂,可以对果园内桃潜叶蛾和梨小食心虫进行同监测和共防治。

4 结 论

通过触角电位与田间诱捕试验,表明了桃潜叶蛾和梨小食心虫相互能感知对方性信息素,且将50.0~500.0 μg梨小食心虫性信息素与1.0 mg桃潜叶蛾性信息素混用以及将1.0~2.0 mg桃潜叶蛾性信息素与50.0 μg梨小食心虫性信息素混用对桃潜叶蛾与梨小食心虫田间诱捕效果均无影响。本研究结果为今后性信息素联用综合防控这2种重要果树害虫提供了理论依据。

参考文献 References:

- [1] 孔维娜,李捷,赵飞.我国桃潜叶蛾的发生与防治[J].山西农业科学,2007,35(11):39-40.
KONG Weina, LI Jie, ZHAO Fei. Occurrence and control of peach leafminer in China[J]. Journal of Shanxi Agricultural Science, 2007, 35(11):39-40.
- [2] 于伟红,赵廷武.桃潜叶蛾的危害及防治[J].植物医生,2001,14(4):32.
YU Weihong, ZHAO Tingwu. Harm and control of peach leafminer[J]. Plant Doctor, 2001, 14(4):32.
- [3] 刘永琴,叶洪太,任南婷.桃潜叶蛾对桃树的为害及其防治[J].中国南方果树,2009,38(3):55-56.
LIU Yongqin, YE Hongtai, REN Nanting. Damage and control of peach leafminer moth to peach trees[J]. South China Fruits, 2009, 38(3):55-56.
- [4] NEVEN L G, KUMAR S, YEE W L, WAKIE T. Current and future potential risk of establishment of *Grapholita molesta* (Lepidoptera: Tortricidae) in Washington State[J]. Environmental Entomology, 2018, 47(2):448-456.
- [5] 郑锦城.梨小食心虫 *Grapholita molesta* (Busck)地理种群耐热性差异及其相关分子基础[D].北京:中国农业科学院,2015.
ZHENG Jincheng. Heat tolerance variation and molecular basis in geographical populations of *Grapholita molesta* (Busck) (Lepidoptera: Tortricidae)[D]. Beijing: Chinese Academy of Agricultural Sciences, 2015.
- [6] 向玉勇,杨茂发.昆虫性信息素研究应用进展[J].湖北农业科学,2006,45(2):250-256.
XIANG Yuyong, YANG Maofa. Progress in research and application of insect sex pheromone[J]. Hubei Agricultural Science, 2006, 45(2):250-256.
- [7] 徐劭.两种性诱剂混用试验[J].昆虫知识,1987(1):32-33.
XU Shao. Mixed use of two sex attractants[J]. Chinese Bulletin of Entomology, 1987(1):32-33.
- [8] 徐劭,董建臻,赵寨平,尚振清,李荣海,冯昌国,曲殿忠,李萍.果园常用性诱剂混用研究[J].河北农业大学学报,1998,21(3):110-111.
XU Shao, DONG Jianzhen, ZHAO Zhaiping, SHANG Zhenqing, LI Ronghai, FENG Changguo, QU Dianzhong, LI Ping. Study on mixed use of common sex attractants in orchards[J]. Journal of Hebei Agricultural University, 1998, 21(3):110-111.
- [9] 姜瑞德,李晓军,盛如,陈铁牛,盛乘发.梨小食心虫和桃潜叶蛾性诱芯合用的诱蛾效果[J].落叶果树,2013,45(6):7-9.
JIANG Ruide, LI Xiaojun, SHENG Ru, CHEN Tieniu, SHENG Chengfa. Trapping effect of sex pheromone of *Grapholita molesta* and *Lyonetia clerkella*[J]. Deciduous Fruits, 2013, 45(6): 7-9.
- [10] 陈孝兰,陈波,李靖,孙淑霞,陈栋,涂美艳,江国良,植玉蓉.桃潜叶蛾发生动态监测与不同诱捕器诱捕效果研究[J].安徽农业科学,2015,43(25):89-91.
CHEN Xiaolan, CHEN Bo, LI Jing, SUN Shuxia, CHEN Dong, TU Meiyuan, JIANG Guoliang, ZHI Yurong. Study on the dynamic monitoring of the occurrence of peach leaf miner and the trapping effect of different traps[J]. Journal of Anhui Agricultural Science, 2015, 43(25):89-91.
- [11] YAN Q, LIU X L, WANG Y L, TANG X Q, SHEN Z J, DONG S L, DENG J Y. Two sympatric spodoptera species could mutually recognize sex pheromone components for behavioral isolation[J]. Frontiers in Physiology, 2019(10): 1256-1263.
- [12] STEPHENS A E A, SUCKLING D M, EL-SAYED A M. Odour quality discrimination for behavioural antagonist compounds in three tortricid species[J]. Entomologia Experimentalis et Applicata, 2008, 127(3): 176-183.
- [13] HANKS L M, MONGOLD-DIERS J A, ATKINSON T H, FIERKE M K, GINZEL M D, GRAHAM E E, POLAND T M, RICHARDS A B, RICHARDSON M L, MILLAR J G. Blends of pheromones, with and without host plant volatiles, can attract multiple species of cerambycid beetles simultaneously[J]. Journal of Economic Entomology, 2018, 111(2): 716-724.
- [14] AKITO Y K, MONEEN J, QIAN J J, STEPHEN L L, PHILIP A S. A synthetic pheromone for *Phyllocoptis citrella* (Lepidoptera: Gracillariidae) attracts multiple leafminer species[J]. Florida Entomologist, 2013, 96(3): 1213-1216.
- [15] JOSEPH C H W, ROBERT F M, BECCA L S, JOCELYN G M, LAWRENCE M H. Blending synthetic pheromones of cerambycid beetles to develop trap lures that simultaneously attract multiple species[J]. Journal of Economic Entomology, 2012, 105 (3): 906-915.
- [16] RICE M E, ZOU Y F, JOCELYN G M, LAWRENCE M H. Complex blends of synthetic pheromones are effective multi-species attractants for longhorned beetles(Coleoptera:Cerambycidae)[J]. Journal of Economic Entomology, 2020, 113(5): 2269-2275.
- [17] TODD S, JON N, RICK K. Trap capture of three economically important fruit fly species (Diptera: Tephritidae): Evaluation of a solid formulation containing multiple male lures in a hawaiian coffee field[J]. Journal of Economic Entomology, 2012, 105(4): 1186-1193.
- [18] TETSUYA Y, KEIKO O, HIROYA H, TOMOTAKA S, JOJI K, TOSHINORI K, TOMONARI W, AI T, MIKA Y, KEN T, AKIHIKO T, MIYOSHI Y, TAKEHIKO F, FUMIAKI M. A multi-species pheromone lure: a blend of synthetic sex pheromone components for two mirid species, *Stenotus rubrovittatus* (Matsumura) and *Trigonotylus caelestialium* (Kirkaldy) (Heteroptera: Miridae) [J]. Applied Entomology and Zoology, 2010, 45(4): 593-599.
- [19] HYE S H, KI H P, HO Y C, CHUNG G P. Attraction of *Piezodorus hybneri* to the aggregation pheromone components of *Riptortus clavatus*[J]. Journal of Chemical Ecology, 2006, 32 (3): 681-691.
- [20] ECKEHARD G B, MAXWELL S, ALAIN R, HERVÉ J, MANUELA B, ANDREW M T, VICTOR C M, MARK O K. Improving the efficiency of lepidopteran pest detection and surveillance: constraints and opportunities for multiple-species trapping[J]. Journal of Chemical Ecology, 2013, 39(1): 50-58.
- [21] 谌有光,王春华,魏慧雪,朱强,杜志辉,黄丽丽.一个诱捕器同时诱集几种果树害虫的试验[J].昆虫知识,1986(4): 175-177.
SHEN Youguang, WANG Chunhua, WEI Huixue, ZHU Qiang, DU Zhihui, HUANG Lili. Experiment on trapping several fruit tree pests with one trap at the same time[J]. Chinese Bulletin of Entomology, 1986(4): 175-177.