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梨小食心虫初孵幼虫药效测定方法研究

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摘 要:【目的】建立梨小食心虫初孵幼虫的药效测定方法。【方法】采用浸果法和显微观察法,分析不同发育状态苹果、害虫及调查时间等对蛀果率和药效的影响。【结果】采用将孵化卵和苹果幼果试验,梨小食心虫蛀果率较高,为76.81%~77.18%。用浸泡幼果、成熟半果和成熟整果法测定高效氯氰菊酯药效时,药液质量浓度为3.33 mg·L^{-1}和4.00 mg·L^{-1}时,3种果实、同一药液浓度间药效无显著差异;当药液质量浓度增加至5.00 mg·L^{-1}及更高时,使用成熟半果的药效为48.98%~98.96%,均显著高于使用幼果和成熟整果的40.63%~94.79%和38.80%~97.01%。观察害虫危害特征,接种卵30 h时,蛀果孔上附有虫粪的幼虫为活虫;54 h和78 h时蛀果孔下附有虫道数的幼虫为活虫。高效氯氰菊酯药液浓度较低时,接卵54 h前药效随试验时间增加而增加,54 h时趋于稳定。用氯虫苯甲酰胺验证上述试验,结果合理。【结论】可采用农药浸泡苹果幼果法及接种将孵化卵测定农药对初孵幼虫的药效,试验过程、调查方法与梨小食心虫田间接触农药和危害情况相似,试验结果合理,操作过程简便,可作为测定农药对梨小食心虫初孵幼虫效果的新方法。

关键词:梨小食心虫;初孵幼虫;药效测定

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Testing method of pesticide on *Grapholitha molesta* (Busck) neonate larvae

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Abstract:【Objective】*Grapholitha molesta* is a destructive pest of many fruits. Although difficult, chemical pesticide spray is still the most common way to control the pests. There are serious problems in the current testing methods which are aimed at the adults and eggs, for instance, more dosage and longer times are needed to effectively control the pests. We had proved that *G. molesta* neonate larvae were more sensitive to chemical pesticides than the adults and eggs. Neonate larvae should be one of the key methods of chemical control. But currently there is no toxicity testing method to measure the efficiency to *G. molesta* neonate larvae because of the high mortality of neonate larvae crawling and gnawing on apples after hours. This paper aims to study a way to measure the pesticide efficiency with fewer errors.【Methods】In order to study the control efficiency determination method of pesticide to *G. molesta* neonate larvae, the survival rate and damage rate of *G. molesta* neonate larvae was measured by using different developmental states of the pests and the apple fruit. The pests included ready-to-hatch eggs and neonate larvae, the apples included fruitlet (d=3.5-4.0 cm), ripening fruit (d≥7.0 cm) and cut-ripening fruit. The neonate larvae and larvae were fed in a artificial intelligence incubator with (25±1) ℃, 3 000-4 000 lx light, D∶L=15∶9. The number of eggs laid on the apples was 13 or 14 eggs per fruitlet, 40 eggs per ripening fruit or 20 eggs per cut-ripening fruit. The number of neonate larvae laid on the apples was 10 neonate larvae per fruitlet, 15 neonate larvae per ripening fruit or 30 neonate larvae per cut- ripening fruit. The survival rate was surveyed in 14 h after laying the eggs or 8 h after laying the neonate larvae. The damage rate was surveyed 5

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d after laying the eggs or neonate larvae. Damage symptoms and the growing development of the *G. molesta* was observed with an Olympus stereoscope in 10 h, 14 h, 18 h, 30 h, 54 h, 78 h and 5 d. The survey method was determined by carefully observing pest morphological characteristics and damage symptoms of *G. molesta* on apples and the damage rate at different times. The pesticides included λ-Cyhalothrin and Chlorantraniliprole. 96.0% λ- Cyhalothrin and 95.3% Chlorantraniliprole were dissolved in propanone and 5 different series concentrations were diluted with water. That was done as follows: washing and drying apples were dipped into a solution for 5 min, pulled out and the solution was removed with filter paper, then laying eggs or neonate larvae were applied. The borers were investigated in 30, 54, 78 h and 5 d. The number of borers was the same as the number of holes 30 h and the number of borers was the same as the number of traces at 54 h and 78 h. Experimental data were analyzed with Duncan's new multiple range test statistical methods. 【Results】The survival rate of *G. molesta* neonate larvae was > 90% and its damage rate was 76.81%-77.18% using ready-to-hatch eggs and apple fruitlets. The borer rate was 76.80%, 77.18% laid eggs on fruitlets and cut-ripening fruit and greater than 62.60% laid eggs on ripening fruit. The borer rate dropped to 65.56%, 53.32% and 56.68% from 76.80%, 62.60% and 77.18% when *G. molesta* neonate larvae was laid on the fruitlets, cut-ripening fruit and ripening fruit, respectively. The control efficacy of λ-cyhalothrin to *G. molesta* neonate larvae using cut-ripening fruit was higher than ripening fruit and fruitlets. The control efficiency of 3.00 and 4.00 $mg \cdot L^{-1}$ λ-cyhalothrin to *G. molesta* were 21.88%, 22.38%, 26.04% and 31.25%, 31.33%, 35.42% for the laid eggs on fruitlets, cut-ripening fruit and ripening fruit respectively, and there were no significant differences among similar concentrations. The control efficiency of 5.00 and above λ-cyhalothrin to *G. molesta* were 48.98%-98.96% on cut-ripening fruit which was higher than the 38.80%-97.01% on fruitlets and ripening fruit. Damage symptoms of *G. molesta* larvae changed constantly with prolongation of time after laying ready-to-hatch eggs on the apples. The number of traces of endangered pests was the same as the number of living *G. molesta* larvae in 54 h and 78 h after laying ready-to-hatch eggs on the apples. *G. molesta* larvae was affirmed as dead after showing no action after being touched or not moving freely in 14 h after laying ready-to-hatch eggs on the apples or in 8 h after laying neonate larvae on the apples. The damage rate was investigated in 30 h and 54 h after ready-to-hatch eggs laid on apple based damage symptoms. The holes which had adhering frass and no traces of endangered pests in 54 h and 78 h after laying ready-to-hatch eggs on the apples could not be counted as borers. *G. molesta* larvae still died even if bored into the apples, particularly in pesticide treatments. The *G. molesta* larvae could continue to damage and grow when the individuals lived in 54 h after laying ready-to-hatch eggs on the apples. The control efficiency of 3.33 and 5.00 $mg \cdot L^{-1}$ λ-cyhalothrin to *G. molesta* were 19.19% and 33.33% in 30 h and were significantly lower than 23.96% and 40.63% in 54 h and after. So 54 h after laying ready-to-hatch eggs on the apples is reasonable surveying time of the toxicity test for *G. molesta* neonate larvae. The control effect of Chlorantraniliprole to *G. molesta* neonate larvae increased with the increase of the concentrations using the above methods and measured parameters. Its corresponding linear equation was y=2.148 4x+1.367 8, R^2 was 0.937 1. 【Conclusion】Using the methods of immersion fruitlets and inoculation ready-to-hatch eggs, the survival rate of the controlled processing was no less than 90% and its damage rate was no less than 70%, the number of borers were determined according to pest damage symptoms. The above methods and parameters could test the control efficiency of *G. molesta* neonate larvae. It needs to be validated whether this control efficiency method was appropriate for measuring the toxicity test of *G. molesta* neonate larvae.

Key words: *Grapholitha molesta*; Neonate larvae; Control efficiency testing

梨小食心虫[*Grapholitha molesta*(Busck)]是危害梨、桃、苹果等多种果树的一种重要害虫,因其钻蛀危害隐蔽性强,发生代数多且易世代重叠等特性[1-2],加上气候变暖、果树栽培模式变化等因素影响,近年来造成多种果树大幅减产或绝产事件频繁发生[3]。目前梨小食心虫防控技术主要包括化学防治、性信息素防治、生物防治和物理防治等,后3种技术受我国栽培模式和管理技术及产品自身限制,在实际生产上还需进一步完善,化学农药防治仍是梨小食心虫防控应用最普遍的技术[4]。

农药对害虫防治效果主要通过农药的室内毒力、室内药效或田间防效等来反映。相比于食叶类和一般钻蛀性害虫,梨小食心虫仅成虫和卵在外界环境中长时间暴露,而直接危害的幼虫仅刚从卵中孵化出时在果面上爬行数小时外,其他时间均在果实中蛀食,直至发育成老熟幼虫[5]。因此,目前主要通过梨小食心虫成虫和卵来筛选高效药剂[6-8],并据此制定出相应的防治技术和规程[2],但该技术施药量大,施药次数多。尤其在桃梨混栽园和梨果发育后期,梨小食心虫极易发生世代重叠,需要频繁施药才能有较好防效[2]。笔者在室内试验中发现,梨小食心虫刚孵化出的初孵幼虫在浸过农药果面上爬行数小时和蛀食果皮后,会有大量个体死亡,且幼虫对农药敏感性要远高于成虫和卵。因而梨小食心虫初孵幼虫虽在外界环境中暴露时间很短,但应是化学防治一个关键时期,需要采取合适方法测试农药对其的效果。

目前,农药对梨小食心虫幼虫的室内毒力、室内药效或田间防效等研究很少,仅有农药对其老熟幼虫残效等室内研究[9],但老熟幼虫不再蛀食果实,与幼虫实际接触农药的状态和过程有较大差距,而与实际情况相似的初孵幼虫室内毒力测定或室内药效研究等则鲜有报道。笔者根据梨小食心虫初孵幼虫蛀果特性,模拟幼虫接触农药的实际过程,研究害虫和果实发育状态及调查时间等对蛀果率和药效的影响,为初孵幼虫室内药效测定所需的各项参数的确定提供依据,制定出合理、简单易行的室内药效测定方法,同时为其室内毒力测定方法的研究提供参考。

1　材料和方法

1.1　材料与仪器

1.1.1　供试昆虫和苹果　供试昆虫:梨小食心虫将孵化卵和初孵幼虫(孵化后6 h内),为本实验室饲养种群,饲养条件(25±1)℃、RH 70%~80%,光照3 000~4 000 lx,光周期为Light 15 h:Dark 9 h。

供试苹果:‘富士’苹果幼果和成熟果实,幼果(直径3.5~4.0 cm)采自山西省太谷县白城村的苹果园。‘富士’苹果成熟果实(直径7.0 cm以上),市售,分为整果处理和半果处理(半果处理是从果柄处将苹果垂直平分成为两半)。

1.1.2　供试试剂　96.0%高效氯氟氰菊酯原药(λ-Cyhalothrin),常州天择化工有限公司;95.3%氯虫苯甲酰胺原药(Chlorantraniliprole),美国杜邦公司。

1.1.3　仪器　RQX-380D智能人工气候箱,宁波海署赛福实验仪器厂;Olympus体视镜SZX7,奥林巴斯(中国)有限公司。

1.2　方法

1.2.1　害虫虫态和果实发育状态对蛀果率的影响　将果实洗净晾干,剪去果柄,平放于具盖的玻璃或塑料容器(倒圆锥形,直径8~10 cm,高6~8 cm,盖上有通风小孔)中。将梨小食心虫将孵化卵或初孵幼虫接于幼果、成熟整果和成熟半果上,盖上盖子,放置在1.1的条件下饲养。其中,幼果上接卵量每果13~14粒或初孵幼虫每果10头,每个处理3个幼果;成熟整果上接卵量每果40粒或初孵幼虫每果30头,每个处理1个果实;成熟半果接卵量20粒/块或初孵幼虫15头/块,每个处理2块果实。接种将孵化卵14 h或初孵幼虫8 h后调查幼虫死亡率(触之不动或不能正常爬行为死亡),5 d时剖开苹果调查蛀果虫数。通过蛀果虫数和初孵幼虫总数,计算蛀果率,蛀果率/%=100×蛀果虫数/初孵幼虫数。试验设5次重复。

1.2.2　果实发育状态对药剂效果的影响　在1.2.1试验基础上,选择将孵化卵、农药浸泡苹果法进行(果实仍为‘富士’苹果幼果、成熟整果和成熟半果)。高效氯氰菊酯原药用少量丙酮溶解,再用自来水(含0.02%的吐温-80)稀释成5个浓度梯度药液,每个处理配制药液100~150 mL。试验时,将果实完全浸泡在药液中,轻摇5 s后拿出,用滤纸吸掉多余药液,平稳放置于玻璃或塑料容器中,接将孵化卵。自来水浸泡(含0.02%的吐温-80)为对照处理。饲养条件、接卵量、调查方法同1.2.1,药效/%=100×(对照蛀果虫数-处理蛀果虫数)/对照蛀果虫数。试验设3次重复。

1.2.3 幼虫形态和蛀果危害症状观察 将将孵化卵接在苹果幼果上，分别于接卵后10、14、18、30、54和78 h及5 d观察或剖开果实剥取幼虫，随机选取10头幼虫，观察幼虫发育状况。观察前用75%酒精杀死，将虫体展平放置于载玻片上，在Olympus体视镜SZX7下将幼虫体长和体宽拍照，使用图像分析软件测定幼虫体长及体宽。同时观察幼虫蛀果危害特征。

1.2.4 调查时间对药剂效果的影响 在试验1.2.2和1.2.3基础上，选择苹果幼果进行试验。将高效氯氰菊酯原药配制成3.33、5.00、10.00 mg·L^{-1}的溶液，配制方法和对照处理同1.2.2。在浸过药液的幼果上接种将孵化卵，饲养条件同1.1，接卵量同1.2.1。于30、54、78 h和5 d时调查害虫蛀果虫数。30 h时调查苹果上有虫粪的蛀果孔数，记为蛀果数；54、78 h时调查蛀果孔下果皮中的虫道数，记为蛀果数。药剂效果/%=100×(对照蛀果虫数–处理蛀果虫数)/对照蛀果虫数。试验设3次重复。

1.2.5 氯虫苯甲酰胺对初孵幼虫的药效 综合上述结果，采用浸泡幼果法、接将孵化卵，使用氯虫苯甲酰胺进行验证。将氯虫苯甲酰胺原药配制成系列浓度梯度药液，配制方法和对照处理同1.2.2。选择发育期一致的'富士'苹果幼果，每处理3个幼果，接种将孵化卵14 h后调查害虫死亡率，54 h时调查蛀果率。计算氯虫苯甲酰胺对梨小食心虫的幼虫药效，药效计算方法同1.2.4，并分析农药药液与防效间的线性关系。试验设3次重复。

1.3 数据分析

采用Excel软件对试验数据进行统计分析，计算蛀果率、药剂效果、线性方程。用SPPS软件的Duncan氏新复极差法进行差异显著性分析。

2 结果与分析

2.1 害虫虫态和果实发育状态对梨小食心虫蛀果率的影响

从表1中可看出，使用将孵化卵试验时，幼虫成活率为94.22%~96.48%，高于初孵幼虫的89.36%~92.45%。同时，害虫虫态、果实发育程度和状态对幼虫蛀果率影响较大。将将孵化卵接种在苹果上5 d时，害虫在幼果和成熟半果上蛀果率分别为76.80%、77.18%，显著高于成熟果实上的62.60%。而使用初孵幼虫时，害虫在幼果、成熟果实、成熟半果上的蛀果率分别为65.56%、53.32%、56.68%，3者间差异不显著，但均低于使用将孵化卵的蛀果率。结果表明，在苹果幼果和成熟半果上接将孵化卵时，梨小食心虫蛀果率相对较高，为73.61%~79.99%。相比其他害虫药效测定方法中的要求[10-11]，梨小食心虫使用将孵化卵接种的蛀果率虽较低，但可稳定在70%以上。因此，梨小食心虫初孵幼虫药效测定中的对照幼虫成活率应不低于90%、蛀果率应不低于70%。

表1 虫态和果实状态对梨小食心虫蛀果率的影响

Table 1 Effects of different stages of *G. molesta* and apples on the damage rate

处理 Treatments	卵 Egg		初孵幼虫 Neonate larvae	
	幼虫成活率 Larval survival rate/%	蛀果率 Damage rate/%	幼虫成活率 Larval survival rate/%	蛀果率 Damage rate/%
幼果 Fruitlets	95.63±2.56 aA	76.80±3.19 aAB	89.36±4.48 aB	65.56±5.09 aA
成熟整果 Ripening fruit	94.22±2.67 aA	62.60±2.96 bB	90.44±3.74 aA	53.32±3.34 aA
成熟半果 Cut-ripening fruit	96.48±2.67 aA	77.18±2.67 aA	92.45±5.14 aA	56.68±8.82 aA

注：表中数据为平均数±标准误。同列数据后不同小、大写字母分别表示邓肯氏新复极差法检验差异显著($P < 0.05$)和极显著($P < 0.01$)。下同。

Note: Data are mean ±SE. Different lowercase letters in same column indicate significantly different by Duncan's new multiple range test($P < 0.05$), and different capital letters indicate extremely significantly different by Duncan's new multiple range test ($P < 0.01$). The same below.

2.2 果实发育状态对药剂效果的影响

从表2中可以看出，浸果法中的果实状态不同会影响药剂效果。使用幼果、成熟整果和成熟半果浸果，3.00 mg·L^{-1}和4.00 mg·L^{-1}高效氯氰菊酯药液的药效分别为21.88%、22.38%、26.04%和31.25%、31.33%、35.42%，药剂同一浓度处理的不同果实间差异不显著。当药液质量浓度增至5.00 mg·L^{-1}及以上时，使用成熟半果的药效为48.98%~98.96%，均显著高于使用幼果的40.63%~94.79%和成熟整果的38.80%~97.01%。结果表明，使用成熟半果处理时，高效氯氰菊酯的药效可能会高于使用成熟果实的药

表2　不同状态果实对高效氯氰菊酯药效的影响

Table 2 Effects of apple stages on the control of λ-Cyhalothrin to *G. molesta* neonate larvae

ρ(高效氯氰菊酯) λ-Cyhalothrin content/(mg·L⁻¹)	药效 Efficacy/% 幼果 Fruitlets	成熟整果 Ripening fruit	成熟半果 Cut-ripening fruit
3.33	21.88±3.13 aA	22.38±2.59 aA	26.04±1.80 aA
4.00	31.25±3.13 aA	31.33±4.48 aA	35.42±1.80 aA
5.00	40.63±3.13 bB	38.80±2.59 bB	48.96±1.80 aA
6.67	55.21±1.80 bB	53.72±4.48 bB	67.71±4.77 aA
8.00	77.08±3.61 bB	79.10±2.59 bAB	86.46±3.13 aA
10.00	94.79±1.80 bA	97.01±0.00 bA	98.96±1.80 aA

效。综合2.1结果，苹果幼果更符合梨小食心虫初孵幼虫药效测定要求。

2.3　不同调查时间幼虫形态和危害症状

为了调查梨小食心虫蛀果率，需要剖开果实来调查害虫成活与否，但2~3龄前的幼虫个体小、体色透明或半透明，易与苹果果肉混淆；剖开苹果时也易损伤虫体，不易区分幼虫是否为正常死亡。为了简化调查方法，试验观察了不同时间时幼虫的危害症状。从表3中可知，随着试验时间延长，幼虫危害症状变化明显。接种将孵化卵14~18 h时，幼虫啃食果皮，蛀入果皮中；30 h时，发育正常的幼虫在果面形成细小蛀果孔，孔附近附有少量虫粪；仅有蛀果孔、无虫粪的幼虫已经死亡或不能继续危害。54 h时，发育正常的幼虫在果皮下形成虫道，长度为0.5~1.0 cm；78 h时，虫道已增至1.5~2.0 cm；仅有蛀果孔和虫粪，而无虫道，幼虫已死亡或不能进一步危害。结果表明，幼虫蛀果后不同时间，危害症状差异明显，因而，蛀果幼虫成活与否可根据其危害症状来判断。

表3　不同调查时间蛀果幼虫形态和危害症状

Table 3 Morphological characteristics of larvae and damage symptoms of *G. molesta* in apples

接种将孵化卵时间 Time after inoculating ready-to-hatch eggs	形态特征 Morphological characteristics	危害症状 Damage symptoms
8 h	孵化为初孵幼虫，体长约1.00 mm，体宽约0.18 mm，体色透明 1.00 mm body length, 0.18 mm body width, clear body color	–
10 h	同上。 The same above	四处爬行，寻找蛀果点 Crawl and find location to bite
14 h	同上。 The same above	开始啃食果皮 Began biting apple peel
18 h	体长约1.20 mm，体宽约0.20 mm，体色透明 1.20 mm body length, 0.20 mm body width, clear body color	蛀入果实表皮 Bore into apple peel
30 h	体长约1.50 mm，体宽约0.25 mm，体色透明 1.50 mm body length, 0.25 mm body width, clear body color	蛀入果肉，果面形成小蛀果孔，孔附近附有少量、颗粒细小的虫粪 Bore into apple sarcocarp, bore hole with frass
54 h	体长约1.80 mm，体宽约0.32 mm，体色半透明 1.80 mm body length, 0.32 mm body width, translucence body color	果皮下形成虫道，长度为0.5~1 cm 0.5-1 cm traces of pest endangered
78 h	体长2.30 mm，体宽约0.40 mm，体色半透明，发育约为1龄末 2.30 mm body length, 0.40 mm body width, translucence body color, final first instars	虫道长1.5~2.0 cm About 1.5-2.0 cm traces of pest endangered
5~7 d	体长4.50~5.22 mm，体宽0.75~0.80 mm，体色淡黄色，发育期为2~3龄 4.50-5.22 mm body length, 0.75-0.80 mm body width, mild yellow body color, second or third instars	虫道完全重叠 Overlapping traces of pest endangered

2.4　调查时间对药效的影响

由表4可知，质量浓度较低的3.33、5.00 mg·L⁻¹高效氯氰菊酯药液处理30 h时的药效分别为19.19%和33.33%，显著低于54 h、78 h和5 d；54 h和78 h时的药效，与5 d时的药效差异均不显著。当药液质量浓度增至10.00 mg·L⁻¹时，30 h的药效与54 h、78 h和5 d的药效无显著差异。结果表明，高效氯氰菊酯药液浓度较高时，接卵后不同时间药效的差异不显著；但当其浓度降低时，54 h之前的不同时间药效差异显著，54 h药效趋于稳定。结合2.3的结果，将调查时间定为接种卵后54 h。

表4　不同时间高效氯氰菊酯对初孵幼虫药效的影响

Table 4 Control of λ-Cyhalothrin to *G. molesta* neonate larvae in different time

ρ(高效氯氰菊酯) λ-Cyhalothrin content/(mg·L⁻¹)	药效 Efficacy/% 30 h	54 h	78 h	5 d
10.00	93.94±0.00 a	94.78±1.81 a	94.78±1.81 a	94.78±1.81 a
5.00	33.33±3.03 b	40.63±3.13 a	41.66±4.78 a	41.66±4.78 a
3.33	19.19±1.75 b	23.96±3.61 a	23.96±3.61 a	23.96±3.61 a

2.5 氯虫苯甲酰胺对梨小食心虫初孵幼虫的药效

为了验证上述方法和技术参数是否合理，试验使用氯虫苯甲酰胺进行验证。从表5中可以看出，氯虫苯甲酰胺对梨小食心虫幼虫的药效随其浓度增加而增加，其线性方程为 $y=2.148\,4x+1.367\,8$，R^2 为 0.937 1，表明使用该方法和参数可以测定氯虫苯甲酰胺对梨小食心虫幼虫的药效，结果合理。

表5 不同浓度氯虫苯甲酰胺药液对梨小食心虫初孵幼虫的药效

Table 5 Toxicity of Chlorantraniliprole on *G. molesta* neonate larvae

ρ(药液) Pesticide concentration/(mg·L^{-1})	药效 Efficacy/%	线性方程 Linear equation
2.67	20.83±1.80	$y=2.148\,4x+1.367\,8$
4.00	47.92±3.61	$R^2=0.937\,1$
6.67	70.83±1.80	
13.33	81.25±3.13	
20.00	88.54±1.80	

3 讨 论

梨小食心虫是一种蛀果性害虫，因其蛀果习性，这种害虫的幼虫室内毒力和室内药效等研究较少。张勇等[8]和张月亮[9]在研究农药对桃小食心虫室内药效和药剂敏感性时，分别使用3龄和末龄幼虫，其中3龄幼虫采用浸果法，5龄幼虫采用浸渍法和毒土法。宫庆涛等[12]在研究农药对梨小食心虫老熟幼虫化蛹及繁殖的影响时，采用浸渍老熟幼虫法。上述方法与梨小食心虫初孵幼虫接触农药的实际情况差异较大，因而笔者模拟与田间害虫接触农药最接近的状态和害虫实际危害特征，来研究药效测定中的各项参数，获得的方法和试验结果会更符合生产实际。

研究中采用初孵幼虫、浸泡幼果法，在药效计算上可采用2种方法：一是对照中死亡率按照害虫自然死亡率来计算，二是按蛀果率计算。其中，自然死亡是指幼虫从卵中孵化出后，不蛀果，爬行一段时间后自然死亡，其死亡率较低，一般不足10%；另一种是在蛀果过程中死亡，死亡率为10%~20%。蛀果率更能反映药剂实际效果，虽蛀果率较低[13-14]，但对照处理蛀果率稳定性好，因而本研究中采用蛀果率来计算药效。同时，文中获得的梨小食心虫初孵幼虫室内药效测定方法试验材料来源方便、成本低，试验过程简便易行，且与田间实际情况基本相似，因而可作为测定农药对梨小食心虫初孵幼虫药效的一种方法。

4 结 论

浸苹果幼果、接种将孵化卵测定农药对初孵幼虫药效，试验过程、调查方法与梨小食心虫田间接触农药和危害情况相似，试验结果合理，操作过程简便，可作为测定农药对梨小食心虫初孵幼虫效果的新方法。

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