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使用生命表评价烯啶虫胺对异色瓢虫的影响

王秀梅¹, 陈 鹏¹, 张锡珍², 阮长春^{1,*}

(1. 吉林农业大学生物防治研究所/天敌昆虫应用技术工程中心, 长春 130118; 2. 吉林省农业技术推广总站, 长春 130051)

摘要:为正确评估广谱杀虫剂烯啶虫胺对天敌昆虫异色瓢虫 *Harmonia axyridis* (Pallas) 的影响, 采取滤纸接触法测定了烯啶虫胺(防治蚜虫田间推荐用量)对异色瓢虫影响, 并使用生命表研究了烯啶虫胺对异色瓢虫实验种群的影响, 为协调害虫的化学防治与生物防治提供参考。结果表明: 该剂量烯啶虫胺对异色瓢虫当代(F_0)取食具有显著影响, 药剂处理后 7d 内, 成虫取食量显著降低; 对 F_0 代成虫寿命及雌虫繁殖能力未见负面影响; 烯啶虫胺处理对异色瓢虫初产卵、 F_1 代幼虫及蛹的历期没有显著影响; 卵孵化率明显小于对照组, 幼虫存活率及蛹羽化率没有显著影响。 F_0 代种群净增值力、周限增长率、内禀增长率与对照相比差异不显著, 分别为 812.66 粒(对照 899.73 粒)、1.084(对照 1.093)、0.081(对照 0.089), 药剂处理种群加倍时间为 8.557d, 与对照 7.888d 相比没有显著延长。这些结果说明, 大田中使用烯啶虫胺防治蚜虫时理论上对异色瓢虫种群繁殖及发育没有显著影响, 但施药初期会影响异色瓢虫的取食量。

关键词: 异色瓢虫; 烯啶虫胺; 生命表

Evaluation of the effect of nitenpyram on *Harmonia axyridis* (Pallas) using life table technique

WANG Xiumei¹, CHEN Peng¹, ZHANG Xizhen², RUAN Changchun^{1,*}

1 Engineering Research Center of Natural Enemy Insects, Institute of Biological Control of Jilin Agricultural University, Changchun 130118, China

2 Jilin Provincial Agro-Tech Extension Center, Changchun 130051, China

Abstract: Nitenpyram is a class of neonicotinoid insecticide and also a so-called low risk insecticide which targets the pest. Nitenpyram has been registered for controlling a variety of insect pests, such as aphid, whitefly and thrip, in China. In order to investigate its non target effects, we estimated the effect of nitenpyram on *Harmonia axyridis* (Pallas) (Coleoptera: Coccinellidae) which is considered an important generalist predator that can be used as a biological control agent against Hemiptera Sternorrhyncha, Thysanoptera, and the eggs and larvae of Lepidoptera, Coleoptera and Diptera. The filter paper touch method normally used to estimate the killing effect of insecticide on insects was used in our report, and the field recommended dose (25 mg/L) and control (0 mg/L) were adopted. The effects of nitenpyram on *Harmonia axyridis* (Pallas) were investigated which included assessing fecundity, feeding amount and the longevity of the ladybird in F_0 . The results showed that when insecticides were applied at the adult stage, with 25 mg/L dosage or control, there were some negative effects on predation number of F_0 . When being treated by nitenpyram, predation of the adult *Harmonia axyridis* decreased greatly after 1—7 days; but had no negative impact on the longevity and fecundity of F_0 adult *Harmonia axyridis*, however, the pre-ovipositing period was prolonged from 8.79 days to 9.79 days. At the same time, the survival rate and developmental time of *H. axyridis* in F_1 were examined. Some characteristics were significantly reduced if treated with the

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* 通讯作者 Corresponding author. E-mail: bio-control@126.com

field recommended dose of nitenpyram. The hatching and emergence rate of pupation were significantly decreased from 92.89% to 83.67% and from 77.74% to 59.99%, respectively; but the survival rate of larvae was not obviously influenced. At the same time, the laboratory population life table of ladybirds in F_0 which were treated with 25 mg/L dosage or control was established by calculating the longevity, survival rate and adult reproduction. The net reproduction rate (R_0), finite rate of increase (K), population doubling time (t) and intrinsic rates of increase (r_m) of the F_0 generation were no different from that of the control group. For example, the net reproduction rate (R_0) of the treated population was 812.66 (899.23 for the control). The calculated population doubling time (t) were 7.788 d (control) and treated 8.557 d (treated); intrinsic rates of increase (r_m) were 0.089 (control) and 0.081 (treated), respectively. All these results suggested that in an agricultural ecosystem, at the recommended field dose (25 mg/L), nitenpyram is a safe insecticide for the natural enemy. Nitenpyram has no obvious impact on the population fecundity and growth of *Harmonia axyridis* (Pallas) in prevention of aphids theoretically, but it has an influence on the predation of *Harmonia axyridis* (Pallas) in the early stage of pesticide delivery.

Key Words: *Harmonia axyridis* (Pallas); nitenpyram; life table

在害虫综合管理(IPM)过程中,尽管采用化学药剂与天敌昆虫的协调应用进行害虫防治从理论上相驳^[1-3],但在昆虫种类丰富的农田生态系统中,对害虫进行防治过程中会出现农药与天敌昆虫自然种群对害虫协同作用的现象,因此,评价药剂对天敌昆虫的影响对害虫综合管理具有重要意义。长期以来,评价农药对天敌昆虫的影响常用致死中浓度(LC_{50})或致死中量(LD_{50})来表示,但 LC_{50} 或 LD_{50} 只能表现出测试昆虫在某一发育阶段对药剂的反应,不能反映杀虫剂对测试昆虫种群的影响,而生命表技术可以从种群水平上分析种群动态规律,能较好的阐明杀虫剂对昆虫的影响^[4-7]。

异色瓢虫 *Harmonia axyridis* (Pallas) 是一种非常重要的捕食性天敌昆虫,在全世界农业生产中得到了广泛应用。我国特别是东北地区作为异色瓢虫种群自然分布地,资源十分丰富^[8],该种群资源对农业害虫具有一定的控制作用。但农田生态系统中害虫种类繁多、发生复杂、世代重叠,瓢虫往往只能控制某种或几种害虫,因此在生产中往往需要同时采用化学农药进行防治^[9-10]。烯啶虫胺(nitenpyram)是一种新型烟酰胺类杀虫剂,具有卓越的内吸性和渗透作用,对有益生物安全,害虫不易产生抗药性等特点^[11-12]。近两年该药剂已广泛应用于农业,防治白粉虱、蚜虫、梨木虱、叶蝉、蓟马等。目前,有关烯啶虫胺对褐飞虱、蚜虫、烟粉虱等活性及田间应用效果已有报道^[13-15],但对于同一生境中的天敌昆虫异色瓢虫的安全性尚未见报道。因此,本文研究了田

间推荐用量烯啶虫胺对异色瓢虫的取食、寿命、繁殖力及子代发育等方面影响,使用生命表,探讨异色瓢虫经烯啶虫胺处理后的种群参数变化,旨在评价烯啶虫胺对异色瓢虫的全面影响,为合理使用该药协调蚜虫的化学防治和生物防治提供参考。

1 材料与方法

1.1 供试材料

1.1.1 试虫

豆蚜 *Aphis craccivora* (Koch) 饲养于吉林农业大学生物防治研究所养虫室内蚕豆苗上;异色瓢虫于2012年10月中旬采自吉林农业大学校园,带回室内提供20%蜂蜜水于11℃冷驯化4d后,置于3—6℃的冰箱中低温存储备用。实验开始前将成虫取出,11℃恢复24h,转移至实验条件下饲养,挑取个体大小一致的瓢虫作为供试虫体。

实验条件为:(25±1)℃,RH(60±5)%,L:D=16:8,以下所有实验均在此条件进行。

1.1.2 杀虫剂

50%烯啶虫胺可溶粒剂,南通江山农药化工股份有限公司生产,有效成分分子式: $C_{11}H_{15}N_4O_2Cl$ 。

1.2 实验方法

1.2.1 烯啶虫胺对异色瓢虫 F_0 代的影响

以防治蚜虫田间推荐剂量(25 mg/L)烯啶虫胺处理异色瓢虫,施药方法采用滤纸接触法,具体参照 Galvan 等人的方法^[16];在培养皿(直径=9 cm,高=2 cm)的底部铺一层滤纸,然后吸取1 mL 药剂均匀

展布至滤纸上,风干 1 h,分别接入待试的异色瓢虫雌、雄成虫,处理 24 h 后,配对饲养于培养皿中,每皿 1 对(♀:♂=1:1)。(1)对取食量的影响:将存活的一对个体分别移至放有一层滤纸的干净培养皿中,每皿 300 头蚜虫饲喂,每 24 h 更换 1 次蚜虫,连续饲喂 10 d,统计每对异色瓢虫的日取食量;(2)对繁殖及寿命的影响:每皿挑取足量豆蚜饲喂异色瓢虫,每日观察 3 次(8:00;14:00;20:00),24 h 后更换蚜虫,记录每头异色瓢虫雌虫产卵前期、产卵历期、产卵量及雌雄虫寿命,直至成虫死亡。上述处理各设 20 次重复,以清水处理的异色瓢虫为对照。

1.2.2 烯啶虫胺对异色瓢虫 F_1 代的影响

挑取按上述药剂处理的 F_0 代成虫初产卵 120 粒(卵日龄小于 12 h),转移至培养皿中发育,一旦发现若有虫孵化出来,立即单头接入放有蚕豆叶片的新培养皿中,同时放入豆蚜作为食物,每日添加蚜虫量分别为 15、20、100、170、240、280、200、100 头,直至化蛹,每个处理 60 头若虫,每日观察 4 次(8:00,12:00,16:00,20:00),记录卵期、幼虫龄期、蛹期及各龄期存活率(或孵化率、羽化率),对照组:以清水处理的 F_0 代成虫初产卵 120 粒(卵日龄小于 12 h),其他方法同处理组。

1.3 生命表参数计算方法

生命表中参数的计算参照黄寿山的方法求得^[17]。具体公式如下:净增殖率 $R_0 = \sum l_x m_x$;平均世代周期 $T = \sum l_x m_x X / R_0$;内禀增长率 $r_m = \ln R_0 / T$;周限增长率 $K = e^{r_m}$;种群加倍时间 $t = \ln 2 / r_m$,式中 X 为按年龄划分的单位时间间距, l_x 表示任一个体在 X 期间的存活率, m_x 表示在 x 期间平均每雌产雌数。

1.4 数据统计分析

所有数据的统计分析均采用 Microsoft Excel 2003 和 DPS 数据处理系统^[18]进行,采用独立样本 t 检验进行差异显著性分析。

2 结果与分析

2.1 烯啶虫胺对异色瓢虫 F_0 代取食能力的影响

烯啶虫胺处理对当代异色瓢虫成虫取食的影响见图 1 曲线。药剂处理后 10 d 内处理组的取食量低于对照组,且调查期内两组处理异色瓢虫的取食量趋势相同,即取食量随饲喂天数逐渐增加至趋于稳定。其中 1—7 d 内,处理组的取食量显著低于对照组,8—10 d 两者间无显著差异。最低取食量出现在实验开始后第 1 天,处理组每对异色瓢虫取食 152 头蚜虫,对照组为 207 头,之后取食量逐渐增加,到第 7 天时对照组和处理组取食量分别为 241 头和 266 头。8—10 d 内两组处理异色瓢虫取食量趋于稳定。

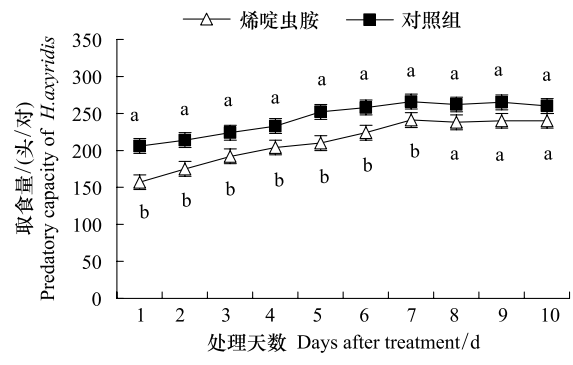


图 1 烯啶虫胺处理后异色瓢虫连续 10d 日取食量变化比较

Fig.1 Compared predation number of *H.axyridis* couple in 10d after nitenpyram treatment

2.2 烯啶虫胺对异色瓢虫 F_0 代雌虫繁殖力的影响

烯啶虫胺处理异色瓢虫成虫后,对雌成虫繁殖力影响见表 1。从表中可以看出,经药剂处理后,当代成虫的产卵前期明显增长;而产卵历期、产卵总量及日均产卵量略低于对照组,但两组间没有显著差异。说明烯啶虫胺对当代成虫生殖力未见显著负面影响。

表 1 烯啶虫胺处理对 F_0 代雌成虫繁殖能力的影响

Table 1 Effects of nitenpyram on fecundity of *H.axyridis* in F_0

处理 Treatment	产卵前期/d Pre-ovipositing period	产卵总量/粒 Number of eggs /female	产卵历期/d Ovipositing period	日均产卵量/粒 Average eggs oviposited per female
0 mg/L	8.79±0.261b	911.36±2.87a	37.77±5.29a	33.87±3.76a
25mg/L	9.79±0.45a	824.21±2.13a	31.15±5.09a	30.49±2.84a

2.3 烯啶虫胺对异色瓢虫 F₀代寿命的影响

药剂处理对异色瓢虫雌雄虫寿命没有显著影响。药剂处理组雌虫平均寿命为 49.31 d,略低于对

照组的 51.69 d,两者之间差异不显著 ($t=1.390,df=19,P=0.4569$);雄虫平均寿命为 46.54 d,略低于对照组平均寿命 49.77 d,两者之间差异不显著 ($t=0.7711,df=19,P=0.2704$)。这表明施用烯啶虫胺对异色瓢虫雌雄虫寿命未产生显著负面影响。

2.4 烯啶虫胺处理对 F₀代生命表参数的影响

根据所得实验数据,求出药剂处理后异色瓢虫 F₀代生命表参数(表 2)。从反映种群动态较为敏感的参数 r_m 值来看,受药处理后,异色瓢虫种群内禀增长率低于对照;处理组净增值率低于对照组而种群加倍时间大于对照,但各组种群参数间差异均不显著。上述结果表明药剂处理后的异色瓢虫种群生殖力没有明显降低,药剂未对异色瓢虫种群增长速率产生明显抑制作用。

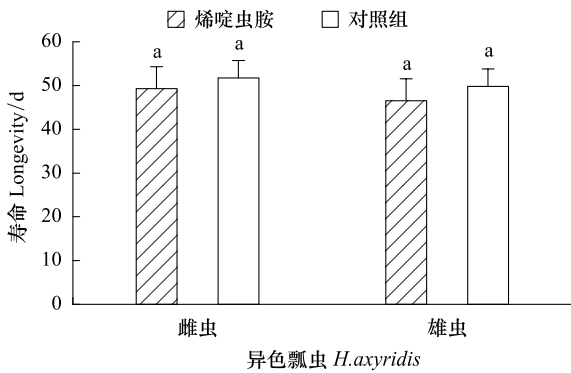


图 2 烯啶虫胺处理对 F₀ 代雌雄虫寿命的影响

Fig.2 Effects of nitenpyram on longevity of *H.axyridis* in F₀

表 2 烯啶虫胺处理对异色瓢虫 F₀ 代生命表参数影响

Table 2 Effects of nitenpyram on life table parameters of *H.axyridis* in F₀

处理 Treatment	净生殖力 R_0 Net reproduction	平均世代 T / Generation average period/d	内禀增长率 r_m Intrinsic rate of increase	周限增长率 K Finite rate of increase	种群加倍时间 t/d Population doubling time
0 mg/L	899.23	76.42	0.089	1.093	7.788
25mg/L	812.66	82.72	0.081	1.084	8.557

2.5 烯啶虫胺处理对异色瓢虫子代发育的影响

实验结果表明(表 3),烯啶虫胺处理对异色瓢虫次代各虫态发育历期与对照相比,均未见明显差

异,这表明药剂对异色瓢虫的发育速率没有抑制作用。

表 3 烯啶虫胺处理成虫对 F₁ 代各虫态发育历期的影响

Table 3 Effects of nitenpyram on developmental time of *H.axyridis* in F₁

处理 Treatment	各虫态发育历期 Development duration of different stages/d					
	卵期 Egg	1 龄 1 st instar	2 龄 2 nd instar	3 龄 3 rd instar	4 龄 4 th instar	蛹 pupae
0 mg/L	2.36±0.13a	2.04±1.76a	1.81±0.29a	1.68±0.10a	3.52±0.11a	4.34±0.06a
25mg/L	2.63±0.05a	2.08±0.11a	1.85±0.43a	1.63±0.13a	3.50±0.08a	4.30±0.07a

2.5 烯啶虫胺处理对异色瓢虫子代存活的影响

从表 4 可以看出,烯啶虫胺处理异色瓢虫所得的初产卵其孵化率明显小于对照组 ($t=3.3988,df=$

$19,P=0.0246$),幼虫各龄期存活率处理组与对照组间没有显著差异,蛹羽化率处理组显著低于对照组 ($t=4.199,df=59,P=0.0362$)。

表 4 烯啶虫胺处理成虫对 F₁ 代各虫态存活的影响

Table 4 Effects of nitenpyram on survival rate of *H.axyridis* in F₁

处理 Treatment	卵孵化率/% Hatching rate	存活率 Survival rate/%				羽化率/% emergence rate
		1 龄 1 st instar	2 龄 2 nd instar	3 龄 3 rd instar	4 龄 4 th instar	
0 mg/L	92.89±2.36a	85.61±3.79a	82.92±0.30a	82.92±0.09a	82.92±0.11a	77.74±1.57a
25mg/L	83.67±4.38b	76.73±4.30a	71.25±0.43a	67.26±0.13a	63.23±0.08a	59.99±1.41b

2.6 烯啶虫胺处理对异色瓢虫 F_1 代幼虫取食的影响

烯啶虫胺处理对异色瓢虫 F_1 代幼虫取食影响见图 3。由图可知,处理组与对照组幼虫各龄期取食量间没有显著差异,幼虫取食量随龄期增加而增大,进入 4 龄第 2 天取食量达最大值,单头若虫日取食量为 200 头左右。

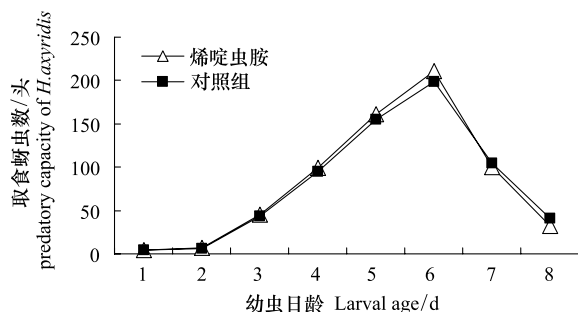


图 3 烯啶虫胺处理成虫对 F_1 代各龄期幼虫取食的影响

Fig.3 Effects of nitenpyram on predation number of larva in F_1

3 结论与讨论

烯啶虫胺是近几年在我国登记上市的一种新型的高效广谱杀虫剂,研究发现它对多种农业害虫具有高效的防治效果,且对非靶标节肢动物具有良好的选择性,对哺乳动物、鱼类和鸟类的毒性极低。本实验结果表明,药剂处理后 7 d F_0 代异色瓢虫取食量显著降低,而 F_0 代寿命、雌虫繁殖能力及 F_1 代发育及取食均无显著影响。可以看出,烯啶虫胺对天敌昆虫异色瓢虫具有一定生物活性,但不具杀虫活性,对异色瓢虫具有较高的安全性。大量研究表明,不同药剂对天敌的安全性差异较大,杨洪等研究发现,氯虫苯甲酰胺处理黑肩绿盲蝽 3 龄若虫对其 F_1 代发育历期、产卵期和产卵量均有一定的影响;王小艺等也发现亚致死剂量鱼藤酮和氰戊菊酯可使异色瓢虫总发育历期显著延长^[19];胡聪等报道的艾美乐和扑虱蚜显著抑制多异瓢虫生殖力有一定的抑制作用^[20];王允场报道的哒螨灵低剂量处理巴氏钝绥螨具有刺激其生殖作用^[21]。产生上述不同结论的原因可能是由于不同杀虫剂对昆虫的作用机理及卵巢发育的作用机制不同。

生命表是研究昆虫种群数量变动机制的重要方法^[22],增长率 r_m 和净生殖力 R_0 是表征昆虫种群动态

的重要参数,其中内禀增长率综合考虑了种群的出生率和死亡率、种群的性比和繁殖力等诸多因素,因此能敏感地反映出各种因素对种群的综合影响^[23-26]。在本研究中,烯啶虫胺处理异色瓢虫后,种群内禀增长率和净生殖力没有发生显著变化,这说明该药剂未对异色瓢虫种群的增长速率产生负面影响。杨洪等人指出种群存活曲线既可以反映物种的特征,又可以反映环境的作用。在本研究中烯啶虫胺处理异色瓢虫 F_0 代成虫,其 F_1 代各虫态存活率与对照相比均未见显著降低,从该结果可知,烯啶虫胺田间推荐用量在种群水平上未延缓异色瓢虫种群发育速率。然而在田间用药过程中,多种因素会作用于天敌昆虫,本研究以防治蚜虫田间推荐用量为施药浓度,在室内稳定的环境条件下进行的,它排除了室外气候、种群密度、猎物是否接触药剂及不同的温湿度组合等条件,与自然种群的真实情况不可能完全一致,但该结论仍可以明确的反映出药剂对各个发育阶段的影响程度以及受药后种群动态的一些重要参数的变化,所得结果在综合治理中可作为参考。

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