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藥劑對蔬菜斑潛蠅 (雙翅目：潛蠅科) 之岡崎釉小蜂與底比斯釉小蜂 (膜翅目：釉小蜂科) 之影響[1]

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摘　要

錢景秦、張淑貞。2011。藥劑對蔬菜斑潛蠅 (雙翅目：潛蠅科) 之岡崎釉小蜂與底比斯釉小蜂 (膜翅目：釉小蜂科) 之影響。台灣農業研究 60:185–196。

岡崎釉小蜂 [*Closterocerus okazakii* (Kamijo)] 與底比斯釉小蜂 [*Chrysoncharis penthesu* (Walker)] 在台灣是蔬菜斑潛蠅 (*Liriomyza sativae* Blanchard) 之重要本地種寄生蜂。本文以藥劑浸漬帶有寄生蜂與僅帶有斑潛蠅豆葉之方法，於室內測試歐殺滅 (oxamyl SL)、阿巴汀 (abamectin EC) 及賽滅淨 (cyromazine SL, WP) 等藥劑，對二種寄生蜂未成熟期與成蟲期之影響。結果得知上述三種藥劑雖對二種寄生蜂之未成熟期 (卵、幼蟲及蛹期) 均無顯著毒害，但對其成蟲期則均具顯著毒害。成蜂各接觸三種藥劑 24 小時，其間雌與雄蜂之存活率，僅阿巴汀降低岡崎釉小蜂各 62.9 與 7.1%，歐殺滅降低底比斯釉小蜂各 36.0 與 7.0%，其餘藥劑對寄生蜂無影響、或僅降低 4.0–8.2%；生殖力方面，三種藥劑中以阿巴汀與賽滅淨對二種寄生蜂之抑制力較大，達 75.0–87.7%，歐殺滅次之達 50.6–58.3%。成蜂各接觸三種藥劑 24 小時後，繼之供以未經藥劑處理之寄主斑潛蠅，觀察對二種寄生蜂之雌蜂壽命、雄蜂壽命、子代成蜂數及致死寄主數等，均以阿巴汀毒效最大，各減少 79.0–94.6%、61.7–67.5%、100 及 99.8–100%。其他藥劑則依蜂種而定，在岡崎釉小蜂測試中，僅賽滅淨二劑型減少該蜂 23.8%子代成蜂數，歐殺滅降低該蜂 30.2%子代雌性比；底比斯釉小蜂測試中，歐殺滅與賽滅淨二劑型均減少該蜂 42.4–52.5%子代成蜂數與 21.9–34.5%致死寄主數。三種藥劑分別與岡崎釉小蜂或底比斯釉小蜂并用對斑潛蠅之致死率，比單獨使用岡崎釉小蜂或底比斯釉小蜂各增加 0.6 與 1.5 倍。阿巴汀與二種寄生蜂皆不相容，歐殺滅與底比斯釉小蜂不相容，僅賽滅淨與二種寄生蜂較為相容。慎選賽滅淨防治蔬菜斑潛蠅，岡崎釉小蜂與底比斯釉小蜂即可獲得較佳的保育。

關鍵詞：蔬菜斑潛蠅、岡崎釉小蜂、底比斯釉小蜂、藥劑、蟲期。

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前　　言

蔬菜斑潛蠅 (*Liriomyza sativae* Blanchard) 在美國之番茄、芹菜、或阿根廷之紫苜蓿 (*Medicago sativa* L.) 及中國之蔬菜與花卉生產上均曾造成嚴重經濟損失 (Anonymous 2002; Pang *et al*. 2005)，亦為荷蘭與英國 A1 級之重要檢疫害蟲 (Anonymous 1984)。由於斑潛蠅對化學藥劑容易產生抗藥性 (Parrella *et al*. 1984; Hara 1986; Brodbent & Pree 1989)，且廣效性藥劑對其寄生蜂之毒害 (Spencer 1973)，以及防治斑潛蠅藥劑之有效期 (effective life) 不及 2 年 (Leibee 1981) 等因素，致使斑潛蠅防治不易。針對此點，多位學者建議降低施藥頻率與劑量 (Mason *et al*. 1989) 及採取藥劑輪用 (Trumble 1985a)，以減緩斑潛蠅抗藥性之發展外，在保育本地種寄生蜂方面，除篩選對寄生蜂低毒之選擇性藥劑外 (Bai *et al*. 2009; Huang *et al*. 1999; Saito *et al*. 1996; Zeng *et al*. 2004)，Poe *et al*. (1978)、Waddill (1978)、Trumble & Toscano (1983) 及 Trumble (1985b) 等亦建議當使用一種藥劑防治斑潛蠅前，應先測試該藥劑對其寄生蜂種類之影響，並據此作為使用該藥劑之參考。在台灣，防治蔬菜斑潛蠅之有效藥劑，如歐殺滅 (oxamyl SL)、阿巴汀 (abamectin EC) 及賽滅淨 (cyromazine SL, WP) (Chien & Chang 2010) 外，該蠅之本地種寄生蜂種類多達 7 種 (Chien & Chang unpublished data)，其中岡崎釉小蜂 [*Closterocerus okazakii* (Kamijo)] 與底比斯釉小蜂 [(*Chrysoncharis pentheus* (Walker)] 不但為優勢蜂種 (Chien & Chang unpublished data)，且為有效寄生蜂 (Chien & Chang 2008a, b, 2009a, b)。因而在蔬菜斑潛蠅防治中，有關藥劑對蔬菜斑潛蠅寄生蜂之影響，即成為一重要研究項目。本研究以防治蔬菜斑潛蠅有效之藥劑-歐殺滅、阿巴汀及賽滅淨 (Chien & Chang 2010) 為供試藥劑，於室內偵測此三種藥劑對蔬菜斑潛蠅二種重要寄生蜂-岡崎釉小蜂與底比斯釉小蜂之影響，期能將結果提供蔬菜斑潛蠅綜合防治之參考。

材料與方法

寄主植物之栽培

參照 Chien & Ku (1996) 於溫室內栽培菜豆苗 (*Phaseolus vulgaris* var. *communis* Aeschers) 之方法，經 10–13 日，待菜豆苗發育至株高 15–20 cm，子葉 (cotyledons) 葉寬達 7–9 cm 時，即可供室內蔬菜斑潛蠅產卵用。

寄主斑潛蠅與寄生蜂之採集

在雲林縣林內鄉菜豆 (*P. vulgaris* L.) 上採集被蔬菜斑潛蠅幼蟲危害之葉片，攜回室內並將被害葉放入塑膠盤內，待幼蟲化蛹，然後將蛹與被害葉置入內徑 21 cm 之塑膠圓盤內，罩以一端有紗網覆蓋之壓克力筒 (直徑 20 cm、高 25 cm)。待成蠅與其二種寄生蜂-岡崎釉小蜂與底比斯釉小蜂羽化，供做飼育之蟲源。

寄主斑潛蠅與寄生蜂之繁殖

參照 Chien & Ku (1996, 2001) 飼育非洲菊斑潛蠅與其寄生蜂之方法，在室內 25℃ 定溫下，以株高 15–20 cm、子葉寬 7–9 cm 之菜豆苗供蔬菜斑潛蠅產卵，待幼蟲發育至第三齡時，再以帶有該幼蟲潛食之罐插菜豆苗，供岡崎釉小蜂與底比斯釉小蜂產卵及幼蟲與蛹之發育。

供試藥劑

供試藥劑與濃度係採用 Chien & Chang (2010) 報導有效防治蔬菜斑潛蠅之歐殺滅溶液、阿巴汀乳劑、賽滅淨溶液及賽滅淨可濕性粉劑。各藥劑之濃度、化學類別及出品公司詳見表 1。

帶蟲豆苗之預備

帶有寄主斑潛蠅豆苗之預備：參照 Chien & Chang (2007) 之方法，在 25℃定溫下，將 120 隻

表 1. 供試藥劑種類、濃度、化學類別及出品公司
Table 1. Chemical insecticides used in this study

Common name and formulation	Dilution factor	Chemical group	Activity	Manufacturer
Oxamyl 10% SL	250	carbamate	Insecticide, acaricide, nematicide	Syngenta Taiwan Ltd., Taichung, Taiwan
Abamectin 2% EC	1000	avermectin	Insecticide, acaricide, nematicide	Syngenta Taiwan Ltd., Taichung, Taiwan
Cyromazine 8.9% SL	1000	triazine	Insecticide (insect growth regulator), acaricide	Syngenta Taiwan Ltd., Taichung, Taiwan
Cyromazine 75% WP	4000	triazine	Insecticide (insect growth regulator), acaricide	Syngenta Taiwan Ltd., Taichung, Taiwan

蔬菜斑潛蠅雌蟲接入內置有 30 株菜豆苗之繁殖網箱 (長 75 cm、寬 55 cm、高 50 cm)，經產卵 7 小時 (上午 9 點至下午 4 點) 後，將子葉內帶有蠅卵之菜豆苗移出，並放置於溫度 25℃、相對濕度 65–85%及光週期 14 L：10 D (上午 5 點至下午 7 點間照光) 下之室內繼續飼養，待斑潛蠅發育至第三齡幼蟲時 (產卵後第六日)，一方面供應後述寄生蜂之產卵，另方面則供應帶有斑潛蠅豆苗浸藥與不浸藥時之材料。所有供試之帶有斑潛蠅豆苗祇留有 2 片子葉，本葉 (plumule leaf) 均摘除。

帶有寄生蜂豆苗之預備：參照 Chien *et al.* (2007) 之方法，在與上項相同溫度、濕度、光週期及產卵時間下，先將 4 至 5 株帶有共約 300 隻斑潛蠅之豆苗合插於一個罐蓋上有圓孔 (直徑 1.5 cm) 之盛水塑膠罐內 (直徑 4 cm、高 5 cm)，置入內徑 21 cm 之塑膠圓盤，並罩以上述相同大小之壓克力筒，各接入 30 隻已交尾且有產卵經驗之岡崎釉小蜂或底比斯釉小蜂雌蜂，4 小時後，供試斑潛蠅幾全部被寄生或取食 (Chien & Chang 2008a; Chien & Chang 2009a)，此時將子葉內斑潛蠅體內帶有蜂卵之菜豆苗移出，置於相同環境下繼續飼養，以供後述藥效試驗，包括帶有蜂卵 (產卵後第二日)、或帶有寄生蜂第四齡老熟幼蟲 (產卵後第五日)、或帶有蜂蛹 (化蛹當日) 之豆苗。所有供試之帶有寄生蜂豆苗祇留有 2 片子葉，本葉均摘除。至於各供試寄生蜂卵、幼蟲及蛹之數量，可藉二種寄生蜂單員寄生之特性、取食致死寄主與產卵寄生寄主外形之差異、及第四齡老熟幼蟲會鑽出寄主體外在豆葉內化蛹之習性 (Chien & Chang 2008a, 2009a)，由每片豆葉上被寄生之斑潛蠅數先估算寄生蜂之卵數，待寄生蜂老熟幼蟲鑽出寄主後，再經解剖葉片內所有已死但外形仍飽滿之斑潛蠅，檢視其體內未孵化之蜂卵數與死亡寄生蜂幼蟲數，確認實際供試蜂卵數。供試寄生蜂第四齡老熟幼蟲與蛹數，則藉幻燈片檢視器 (Hakuba, lightbox Pro II) 以透光法計數之。

帶蟲豆苗浸漬藥劑之處理

帶有寄生蜂豆苗之浸藥：參照 Chien *et al.* (2007) 之方法，將上述子葉內各有 20–30 粒寄生蜂卵、或子葉內各有 20–30 隻寄生蜂第四齡老熟幼蟲，或子葉內各有 20–40 個寄生蜂蛹之單株菜豆苗，齊根剪下，分別倒插浸漬在盛有稀釋藥液之 1000 mL 玻璃燒杯內 1 分鐘，之後再將其分別插入試管架上已有水之試管內 (直徑 1.5 cm、高 7 cm)，自然風乾 30 分鐘後，距豆苗剪口 5 cm 處以海綿片束紮，並直插入上述相同大小之盛水塑膠罐底部。然後每罐插豆苗再分別置入前述之塑膠圓盤，並罩以壓克力筒，供各項試驗用。

帶有寄主斑潛蠅豆苗之浸藥：在 25℃下，將子葉內各帶有 30–40 隻第三齡蔬菜斑潛蠅幼蟲之單株菜豆苗，齊根剪下照上述浸漬法浸藥後供試。

對照組之浸水處理：其方法與過程與浸藥處理相同，僅豆苗浸漬藥劑時，對照組係以水替代之。

寄生蜂卵期施藥對其未成熟期之影響

參照 Chien *et al*. (2007) 之方法，25℃定溫下，距帶蟲 (寄生蜂卵) 豆苗浸藥處理後第五天，剪下葉片，置入直徑 9 cm、高 1.5 cm 之塑膠培養皿內，記錄各處理組寄生蜂卵期之死亡數、其後幼蟲、蛹期及卵至蛹期之存活率，及卵至蛹期之發育日數。另設僅浸水處理之對照組。每處理各做 4–5 重複。蜂卵存活百分率公式為 [幼蟲數 ÷(幼蟲數 + 未孵化卵數) × 100%]。

寄生蜂第四齡老熟幼蟲期施藥對其幼蟲與蛹之影響

參照 Chien *et al*. (2007) 之方法，25℃定溫下，距帶蟲 (寄生蜂第四齡老熟幼蟲) 豆苗浸藥處理後之第二天，剪下葉片，置入前述相同大小之塑膠培養皿內，記錄各處理組寄生蜂幼蟲期之死亡數及蛹期之發育情形。另設僅浸水處理之對照組。每處理各做 4–5 重複。

寄生蜂蛹期施藥對其蛹之影響

參照 Chien *et al*. (2007) 之方法，25℃定溫下，距帶蟲 (寄生蜂蛹) 豆苗浸藥處理後第二天，剪下葉片，置入前述相同大小之塑膠培養皿內，記錄各處理組寄生蜂蛹之發育情形。另設僅浸水處理之對照組。每處理各做 4 重複。

藥劑對成蜂之影響

帶有寄主斑潛蠅豆苗浸藥後接蜂 24 小時之處理：參照 Chien *et al.* (2007) 之方法，在 25℃定溫下、上午 9 點將二日齡已交尾成蜂 10 對，釋入直徑 20 cm、高 25 cm 壓克力筒內，同時將浸藥後 30 分鐘之帶蟲 (200 隻第三齡斑潛蠅幼蟲) 豆苗，供其產卵與取食，另以細毛筆將純蜂蜜塗於壓克力筒內壁，供成蜂食用。24 小時後，移出成蜂，記錄雌、雄蜂之存活數，豆苗仍留在原壓克力筒內，距雌蜂與藥劑接觸後之次日、7 日及 12–14 日，分別記錄原浸藥豆葉上斑潛蠅幼蟲之死亡數、子代寄生蜂之蛹數與成蜂數等。另設僅浸水處理之對照組，其方法與過程與浸藥處理相同。每處理各做 6–14 重複。

成蜂接觸藥劑 24 小時後存活個體之後續觀察：參照 Chien *et al*. (2007) 之方法，在上述成蜂經接觸 24 小時帶有寄主斑潛蠅豆苗藥膜後，自存活者中隨機選取 1 對成蜂，釋入另一直徑 20 cm、高 25 cm 壓克力筒內，每日供應純蜂蜜與未經浸藥處理帶有 30–40 隻第三齡斑潛蠅幼蟲之單株罐插豆苗，直至雌蜂死亡為止。然後依 Chien & Ku (2001) 之方法，計數該蜂之壽命、生殖力、子代雌性比、寄生致死寄主數、取食致死寄主數及致死寄主總數。對照組之雌蜂則是選自藥劑試驗中對照組之存活者，其方法與過程與浸藥處理相同。每處理各做 8–12 重複。

統計分析

各項處理之試驗資料利用 SAS-EG (SAS Enterprise Guide) 4.1 版本統計分析軟體先進行變方分析 (analysis of variance, ANOVA)，再以最小顯著差異性 (least significant difference, LSD) 測驗，在 5%顯著水準下比較處理間之差異；若遇百分率時，資料先進行角度轉換 (arcsine transformation)，再進行分析。

結 果

寄生蜂卵期施藥對其未成熟期之影響

岡崎釉小蜂與底比斯釉小蜂卵，經三種不同藥劑與劑型處理後，二種寄生蜂卵之孵化率均達 100%，與對照組間無顯著差異 (表 2)。若持續觀察孵化幼蟲之發育，各藥劑對二種寄

生蜂幼蟲期與蛹期之存活率與對照組間無顯著差異 (表 2)。另外各藥劑對二種寄生蜂卵至蛹期之發育日數亦與對照組無顯著差異 (表 3)。

寄生蜂第四齡老熟幼蟲期施藥對其幼蟲與蛹之影響

岡崎釉小蜂與底比斯釉小蜂第四齡老熟幼蟲，經三種不同藥劑與劑型處理後，二種寄生蜂幼蟲之存活率各達 97.1–100 與 95.9–100%，蛹期之存活率各達 100 與 98.8–100%，均與對照組無顯著差異 (表 4)。

寄生蜂蛹期施藥對其蛹之影響

岡崎釉小蜂與底比斯釉小蜂蛹，經三種不同藥劑與劑型處理後，二種寄生蜂蛹之羽化率均達 98.9–100%，與對照組間無顯著差異 (表 5)。

藥劑對成蜂之影響

帶有寄主斑潛蠅豆苗浸藥後接蜂 24 小時之處理：就雌蜂之存活率而言，僅歐殺滅、阿巴汀及賽滅淨可濕性粉劑具顯著毒害，且其毒害強度因蜂種而異，其中歐殺滅對底比斯釉小蜂較毒 (降低 36.0%)，而阿巴汀則對岡崎釉小

表 2. 岡崎釉小蜂與底比斯釉小蜂卵經不同藥劑處理後未成熟期之存活率

Table 2. Effect of insecticide treatment of eggs of *Closterocerus okazakii* and *Chrysocharis pentheus* on survival at egg, larva and pupa stages [z]

		Survival (%)			
Insecticides	*n*	Egg	Larva	Pupa	Egg to pupa
Closterocerus okazakii					
Oxamyl	5	100.0 ± 0.0 a [y]	98.8 ± 1.3 a	100.0 ± 0.0 a	98.8 ± 1.3 a
Abamectin	4	100.0 ± 0.0 a	99.0 ± 1.0 a	100.0 ± 0.0 a	99.0 ± 1.0 a
Cyromazine SL	4	100.0 ± 0.0 a	100.0 ± 0.0 a	100.0 ± 0.0 a	100.0 ± 0.0 a
Cyromazine WP	5	100.0 ± 0.0 a	100.0 ± 0.0 a	100.0 ± 0.0 a	100.0 ± 0.0 a
CK	4	100.0 ± 0.0 a	100.0 ± 0.0 a	100.0 ± 0.0 a	100.0 ± 0.0 a
Chrysocharis pentheus					
Oxamyl	4	100.0 ± 0.0 a	96.4 ± 2.1 a	100.0 ± 0.0 a	96.4 ± 2.1 a
Abamectin	4	100.0 ± 0.0 a	98.6 ± 1.4 a	100.0 ± 0.0 a	98.6 ± 1.4 a
Cyromazine SL	4	100.0 ± 0.0 a	100.0 ± 0.0 a	100.0 ± 0.0 a	100.0 ± 0.0 a
Cyromazine WP	4	100.0 ± 0.0 a	100.0 ± 0.0 a	97.5 ± 2.5 a	97.5 ± 2.5 a
CK	4	98.8 ± 1.3 a	99.3 ± 0.8 a	98.8 ± 1.3 a	96.8 ± 1.2 a

[z] One seedling of field bean infested with 20–30 wasp eggs was dipped in an insecticide solution for 1 min. For untreated control, one seedling infested with 20–30 wasp eggs was dipped in distilled water. At 30 min after treatment, one seedling was placed in an acrylic cylinder (20 cm diameter × 25 cm height) and kept at 25°C under light (14 h light: 10 h dark) at 65–85% R.H.

[y] Mean ± standard error. Means within each column of *Closterocerus okazakii* and *Chrysocharis pentheus*, respectively, followed by the same letter are not significantly different at 5% level by LSD test. Data were transformed to arcsin $\sqrt{x}$ prior to ANOVA.

表 3. 岡崎釉小蜂與底比斯釉小蜂卵經不同藥劑處理後之發育日數

Table 3. Effect of insecticide treatment of eggs of *Closterocerus okazakii* and *Chrysocharis pentheus* on duration (days) of development from egg to pupa stages [z]

	Closterocerus okazakii		*Chrysocharis pentheus*	
Insecticides	*n*	Mean ± SEM	*n*	Mean ± SEM
Oxamyl	29	13.0 ± 0.1 a [y]	42	13.2 ± 0.2 a
Abamectin	25	13.1 ± 0.2 a	29	13.1 ± 0.1 a
Cyromazine SL	39	13.2 ± 0.1 a	43	13.2 ± 0.1 a
Cyromazine WP	40	13.0 ± 0.1 a	40	13.2 ± 0.3 a
CK	38	13.1 ± 0.2 a	40	13.2 ± 0.1 a

[z] One seedling of field bean infested with 25–40 wasp eggs was dipped in an insecticide solution for 1 min. For untreated control, one seedling infested with 25–40 wasp eggs was dipped in distilled water. At 30 min after treatment, one seedling was placed in an acrylic cylinder (20 cm diameter × 25 cm height) and kept at 25°C, under light (14 h light: 10 h dark) at 65–85% R.H.

[y] Mean ± standard error. Means within each column followed by the same letter are not significantly different at 5% level by LSD test.

表 4. 岡崎釉小蜂與底比斯釉小蜂老熟幼蟲經不同藥劑處理後未成熟期之存活率

Table 4. Effect of insecticide treatment of mature larvae of *Closterocerus okazakii* and *Chrysocharis pentheus* on survival at larva and pupa stages [z]

		Survival (%)		
Insecticides	*n*	Larva	Pupa	Larva to pupa
Closterocerus okazakii				
Oxamy	4	97.1 ± 1.7 a [y]	100.0 ± 0.0 a	97.1 ± 1.7 a
Abamectin	4	100.0 ± 0.0 a	100.0 ± 0.0 a	100.0 ± 0.0 a
Cyromazine SL	4	98.7 ± 1.3 a	100.0 ± 0.0 a	98.7 ± 1.3 a
Cyromazine WP	4	100.0 ± 0.0 a	100.0 ± 0.0 a	100.0 ± 0.0 a
CK	4	100.0 ± 0.0 a	100.0 ± 0.0 a	100.0 ± 0.0 a
Chrysocharis pentheus				
Oxamyl	4	95.9 ± 2.4 a	98.8 ± 1.2 a	94.7 ± 2.0 b
Abamectin	4	100.0 ± 0.0 a	100.0 ± 0.0 a	100.0 ± 0.0 a
Cyromazine SL	5	99.3 ± 0.7 a	99.5 ± 0.5 a	98.8 ± 0.8 ab
Cyromazine WP	4	98.1 ± 1.9 a	99.4 ± 0.7 a	97.4 ± 1.8 ab
CK	4	100.0 ± 0.0 a	98.5 ± 1.6 a	98.5 ± 1.6 ab

[z] One seedling of field bean infested with 20–30 wasp larvae was dipped in an insecticide solution for 1 min. For untreated control, one seedling infested with 20–30 wasp larvae was dipped in distilled water. At 30 min after treatment, one seedling was placed in an acrylic cylinder (20 cm diameter × 25 cm height) and kept at 25°C under light (14 h light:10 h dark) at 65–85% R.H.

[y] Mean ± standard error. Means within each column of *Closterocerus okazakii* and *Chrysocharis pentheus*, respectively, followed by the same letter are not significantly different at 5% level by LSD test. Data were transformed to arcsin $\sqrt{x}$ prior to ANOVA.

表 5. 岡崎釉小蜂與底比斯釉小蜂蛹經不同藥劑處理後之羽化率

Table 5. Effect of insecticide treatment of pupae of *Closterocerus okazakii* and *Chrysocharis pentheus* on percentage of emergence of adults [z]

	Closterocerus okazakii		*Chrysocharis pentheus*	
Insecticides	*n*	Mean ± SEM	*n*	Mean ± SEM
Oxamyl	4	100.0 ± 0.0 a[y]	4	100.0 ± 0.0 a
Abamectin	4	100.0 ± 0.0 a	4	98.9 ± 1.1 a
Cyromazine SL	4	100.0 ± 0.0 a	4	100.0 ± 0.0 a
Cyromazine WP	4	100.0 ± 0.0 a	4	100.0 ± 0.0 a
CK	4	100.0 ± 0.0 a	4	98.8 ± 1.3 a

[z] One seedling of field bean infested with 20–40 wasp pupae was dipped in an insecticide solution for 1 min. For untreated control, one seedling infested with 20–40 wasp pupae was dipped in distilled water. At 30 min after treatment, one seedling was placed in an acrylic cylinder (20 cm diameter × 25 cm height) and kept at 25°C under light (14 h light: 10 h dark) at 65–85% R.H.

[y] Mean ± standard error. Means within each column followed by the same letter are not significantly different at 5% level by LSD test. Data were transformed to arcsin $\sqrt{x}$ prior to ANOVA.

蜂較毒 (降低 62.9%)，賽滅淨可濕性粉劑對底比斯釉小蜂之毒性僅降低 4.0%存活率；雄蜂存活率方面，僅歐殺滅與阿巴汀對岡崎釉小蜂顯著各降 6.0 與 7.1%，歐殺滅與賽滅淨可濕性粉劑對底比斯釉小蜂顯著各降 7.0 與 5.0%，此時阿巴汀對岡崎釉小蜂雌蜂與歐殺滅對底比斯釉小蜂雌蜂存活率之影響顯著大於雄蜂 (表 6)。致死寄主率方面，三種供試藥劑分別與岡崎釉小蜂或底比斯釉小蜂并用，各處理組致死寄主率高達 98.9–100%，與單獨使用岡崎釉小蜂 (61.8%) 或底比斯釉小蜂 (39.6%) 間呈顯著差異 (表 6)。生殖力方面，三種供試藥劑與岡崎釉小蜂或底比斯釉小蜂并用，各處理組之子代成蜂數各為 10–40 與 11–20 隻，均較對照組顯著各減少 50.6–87.7 與 58.3–77.1%，其中對二種寄生蜂毒害較輕者為歐殺滅，該劑與阿巴汀或賽滅淨間呈顯著差異 (表 6)。子代雌性比方面，僅阿巴汀對岡崎釉小蜂雌性比較對照組顯著增加 31.3%，其餘各處理組與對照組無顯著差異，但三種供試藥劑卻均對底比斯釉小蜂雌性比顯著減少 41.0–64.1%，處理間無顯著差異 (表 6)。

表 6. 岡崎釉小蜂與底比斯釉小蜂成蟲經不同藥劑處理 24 小時內之存活率、致死寄主率及子代數

Table 6. Effect of insecticide treatment of adult of *Closterocerus okazakii* and *Chrysocharis pentheus* on survival, progeny and death rate of the host, *L. sativae* [z]

Treatment	*n*	Survival of adult wasp (%)		Host killed (%)/ 10 females	Progeny of wasp/10 females	
		Female	Male		No. adults	Female proportion
Closterocerus okazakii						
Oxamyl + wasp	6	93.3 ± 3.3 Ab [y]	94.0 ± 4.0 Ab	98.9 ± 1.1 a	40 ± 3 b	0.48 ± 0.04 b
Abamectin + wasp	7	37.1 ± 5.7 Bc	92.9 ± 3.6 Ab	99.6 ± 0.3 a	10 ± 1 c	0.63 ± 0.06 a
Cyromazine SL + wasp	9	100.0 ± 0.0 Aa	100.0 ± 0.0 Aa	100.0 ± 0.0 a	12 ± 2 c	0.35 ± 0.05 b
Cyromazine WP + wasp	8	100.0 ± 0.0 Aa	98.9 ± 1.1 Aab	99.9 ± 0.1 a	10 ± 4 c	0.46 ± 0.04 b
Water + wasp	6	100.0 ± 0.0 Aa	100.0 ± 0.0 Aa	61.8 ± 2.6 b	81 ± 6 a	0.48 ± 0.03 b
Chrysocharis pentheus						
Oxamyl + wasp	10	64.0 ± 3.4 Bd	93.0 ± 2.0 Ac	99.5 ± 0.3 a	20 ± 4 b	0.23 ± 0.05 b
Abamectin + wasp	11	91.8 ± 2.6 Ac	97.8 ± 1.5 Aab	99.8 ± 0.2 a	12 ± 2 c	0.18 ± 0.06 b
Cyromazine SL + wasp	9	98.9 ± 1.1 Aab	100.0 ± 0.0 Aa	99.9 ± 0.1 a	11 ± 2 c	0.19 ± 0.05 b
Cyromazine WP + wasp	10	96.0 ± 2.2 Ab	95.0 ± 2.7 Abc	100.0 ± 0.0 a	12 ± 2 c	0.14 ± 0.04 b
Water + wasp	14	100.0 ± 0.0 Aa	100.0 ± 0.0 Aa	39.6 ± 1.8 b	48 ± 2 a	0.39 ± 0.02 a

[z] One seedling of field bean infested 40–50 third-instars of *L. sativae* was dipped in an insecticide solution for 1 min. For untreated control, one seedling infested with 40–50 third-instars of *L. sativae* was dipped in distilled water. At 30 min after treatment, 4–5 seedlings (200 larvae) were placed in an acrylic cylinder (20 cm diameter × 25 cm height). Ten pairs of 2-day-old adult wasps were released into each cylinder. All the treatments were kept at 25°C under light (14 h light: 10 h dark) at 65–85% R.H. Data were collected at 24 hrs after treatment.

[y] Mean ± standard error. Means within each row of percent survival of *Closterocerus okazakii* and *Closterocerus pentheus*, respectively, followed by the same uppercase letter denote no significant differences between sexes at 5% level by LSD test. Means within each column of *Closterocerus okazakii* and *Closterocerus pentheus*, respectively, followed by the same lowercase lette are not significantly different at 5% level by LSD test. Percent survival of adult wasp and percent host killed were transformed to arcsin $\sqrt{x}$ prior to ANOVA.

成蜂接觸藥劑 24 小時後存活個體之後續觀察：成蜂接觸三種供試藥劑與劑型 24 小時後，移至未處理藥劑之帶斑潛蠅豆苗上，記錄其壽命、生育力及致死寄主總數。結果顯示供試藥劑中僅阿巴汀對岡崎釉小蜂與底比斯釉小蜂之壽命，各較對照組顯著減少 61.7–94.6 與 67.5–79.0%，且藥劑對岡崎釉小蜂雌蜂壽命之影響顯著大於雄蜂 (表 7)。生殖力方面，供試藥劑對二種寄生蜂子代成蜂數之減少率，均以阿巴汀最大 (100%)，其他藥劑則依蜂種而定，在岡崎釉小蜂測試中，賽滅淨二劑型次之 (23.8%)，歐殺滅無抑制力；但在底比斯釉小蜂測試中，歐殺滅與賽滅淨處理組次之 (42.4–52.5%)，處理間無顯著差異 (表 7)。子代雌性比方面，僅歐殺滅對岡崎釉小蜂顯著減少 30.2%，其餘各藥劑處理與對照組間無顯著差異 (表 7)。致死寄主總數方面，在岡崎釉小蜂測試中，供試藥劑中僅阿巴汀對該蜂具 100% 之抑制力，其餘各處理與對照組間無顯著差異；在底比斯釉小蜂測試中，各藥劑對該蜂之抑制強度，依序最大為阿巴汀 (99.8%)，歐殺滅與賽滅淨二劑型次之 (21.9–34.5%)。產卵與取食比值方面，歐殺滅與賽滅淨二劑型對岡崎釉小蜂或底比斯釉小蜂之抑制力各為 50.0–55.0 與 28.6–38.1%，處理組間雖無顯著差異，但與對照組間呈顯著差異 (表 7)。

討　論

藥劑防治害蟲時，因藥劑化學類型 (chemical group) 與作用機制之不同，對害蟲防治效果不同，同時各地防治害蟲之常用藥劑亦不相同。在中國福州，岡崎釉小蜂是蔬菜斑潛蠅之優勢種寄生蜂，Huang *et al*. (1999) 於室內測得六種殺蟲劑對蔬菜斑潛蠅不同蟲期毒性之大小，依序為成蠅、幼蟲及蛹。其中威寶 (avermectins)、殺蟲雙 (dimehypo, nereistoxin)、

表 7. 岡崎釉小蜂與底比斯釉小蜂成蟲經不同藥劑處理 24 小時後之壽命、生育力及致死寄主數

Table 7. Longevity, fertility and host-killing capability of *Closterocerus okazakii* and *Chrysocharis pentheus* survived from the insecticide treatment for 24 hrs [z]

		Longevity (d)		Fertility		No. hosts killed/female			
Treatment	*n*	Female	Male	(no. offspring wasps/female)	Female proportion	Parasitized	Host feeding	Total	Parasitized/ host feeding
Closterocerus okazakii									
Oxamyl	10	17.6 ± 2.0 Aa [y]	17.8 ± 1.7 Aa	199 ± 18 ab	0.37 ± 0.03 b	202 ± 25 a	216 ± 22 a	418 ± 45 a	1.0 ± 0.1 b
Abamectin	11	1.0 ± 0.0 Bb	6.9 ± 1.4 Ab	0 ± 0 c	—	0 ± 0 b	0 ± 0 c	0 ± 0 b	—
Cyromazine SL	10	17.6 ± 1.2 Aa	16.7 ± 2.0 Aa	173 ± 21 b	0.46 ± 0.03 ab	184 ± 23 a	201 ± 21 a	385 ± 39 a	0.9 ± 0.1 b
Cyromazine WP	11	16.7 ± 1.4 Aa	15.8 ± 1.7 Aa	173 ± 12 b	0.48 ± 0.03 a	182 ± 17 a	210 ± 14 a	392 ± 24 a	0.9 ± 0.1 b
CK	8	18.5 ± 2.4 Aa	18.0 ± 2.2 Aa	227 ± 25 a	0.53 ± 0.05 a	242 ± 26 a	133 ± 26 b	375 ± 48 a	2.0 ± 0.2 a
Closterocerus okazakii									
Oxamyl	9	24.9 ± 2.0 Aa	18.9 ± 2.0 Aa	122 ± 7 b	0.51 ± 0.04 a	159 ± 10 b	113 ± 9 a	272 ± 16 b	1.4 ± 0.1 b
Abamectin	11	4.8 ± 0.3 Ab	6.5 ± 0.3 Ab	0 ± 0 c	—	0 ± 0 c	1 ± 1 b	1 ± 1 c	—
Cyromazine SL	10	22.0 ± 1.3 Aa	19.4 ± 1.2 Aa	148 ± 10 b	0.47 ± 0.04 a	161 ± 8 b	112 ± 6 a	273 ± 11 b	1.5 ± 0.1 b
Cyromazine WP	12	24.7 ± 2.2 Aa	20.7 ± 2.7 Aa	143 ± 10 b	0.42 ± 0.03 a	181 ± 14 b	143 ± 14 a	324 ± 25 b	1.3 ± 0.1 b
CK	8	22.9 ± 1.3 Aa	20.0 ± 2.5 Aa	257 ± 44 a	0.47 ± 0.03 a	270 ± 46 a	146 ± 30 a	415 ± 62 a	2.1 ± 0.4 a

[z] For each replicate, one pair of 3-day-old adult wasp that had survived after insecticide treatment for 24 hrs was placed in an acrylic cylinder (20 cm diameter × 25 cm height) and kept at 25°C under light (14 h light: 10 h dark) at 65–85% R.H. Third-instar larvae of *L. sativae* on bean seedling without insecticide treatment were placed in the acrylic cylinder on daily basis, 30–40 larvae/seedling/day.

[y] Mean ± standard error. Means within each row of longevity of *Closterocerus okazakii* and *Closterocerus pentheus*, respectively, followed by the same uppercase letter denote no significant differences between sexes at 5% level by LSD test. Means within each column of *Closterocerus okazakii* and *Closterocerus pentheus*, respectively, followed by the same lowercase letter are not significantly different at 5% level by LSD test.

芬普寧 (fenpropathrin, pyrethroid) 及陶斯松 (chlorpyrifos, organophosphate) 對成蠅 24 小時後之死亡率達 100%；對幼蟲 72 小時後之死亡率，前三種藥劑達 86.9–92.1%，而陶斯松僅 67.6%；但此六種殺蟲劑對岡崎釉小蜂成蜂甚毒，接觸 12 小時後之死亡率均達 100%。在中國廣州，底比斯釉小蜂為蔬菜斑潛蠅之主要寄生蜂，Zeng *et al*. (2004) 於室內與田間測試五種殺蟲劑對蔬菜斑潛蠅及其釉小蜂 *Chrysocharis* sp.之影響，結果得知陶斯松、殺蟲雙及綠寶 (avermectins) 均對蔬菜斑潛蠅具控制效果，各種殺蟲劑雖均對釉小蜂具較強毒力，但以綠寶對寄生蜂較為安全。在中國天津，寄生蔬菜斑潛蠅之寄生蜂以華釉小蜂 [*Neochrysocharis formosa* (Westwood)] 最多，占 57.43%，其次為潛蛾釉小蜂 [*Closterocerus lyonetiae* (Ferriere)] 占 27.72%，此外還有岡崎釉小蜂與潛蠅釉小蜂 [*Diglyphus isaea* (Walker)] 等，Bai *et al*. (2009) 於設施菜豆上測試各九種殺蟲劑與殺菌劑對蔬菜斑潛蠅寄生蜂羽化之影響，其中對寄生蜂無毒與輕度有害之殺菌劑各有六與三種，殺蟲劑中對寄生蜂無毒者有益達胺 (imidacloprid, neonicotinoids)、賽速安 (thiamethoxam, neonicotinoids) 及賽滅淨 (校正死亡率 < 25%)，輕度有害者有高氯 (beta-cypermethrin, pyrethroids)、亞滅培 (acetamiprid, neonicotinoids) 及畢達本 (pyridaben, mitochondrial complex electron transport inhibitors) (校正死亡率 27.92–41.76%)；中度有害者有阿巴汀 (校正死亡率 55.29%)，有害者為畢芬寧 (bifenthrin, pyrethroids) 與陶斯松 (校正死亡率 89.21–98.60%)。在台灣，Chien & Chang (2010) 證實歐殺滅、阿巴汀及賽滅淨，不論其化學類型均可有效防治蔬菜斑潛蠅幼蟲，但若考慮成蠅之取食刻點與幼蟲食痕對寄主植物苗期之影響，防治蔬菜斑潛蠅之最佳藥劑則為歐殺滅與

阿巴汀，其次為賽滅淨。本試驗得知對岡崎釉小蜂影響較重之藥劑為阿巴汀，較輕者為歐殺滅與賽滅淨；對底比斯釉小蜂影響較重之藥劑為阿巴汀與歐殺滅，較輕者為賽滅淨。就中國大陸與台灣之試驗結果，顯示賽滅淨對蔬菜斑潛蠅寄生蜂較為安全。

本試驗顯示三種供試藥劑對二種寄生蜂之毒害均僅在成蜂期。其原因或與二種寄生蜂之產卵方式屬非共育寄生性 (idiobiont)、寄生方式屬內寄生 (solitary) 及致死寄主方式有寄生與取食寄主等有關 (Chien & Chang 2008a, 2009a)。成蜂在搜尋寄主產卵與取食寄主 (host feeding) 時，其觸角、口器、足及產卵管直接接觸豆葉上之藥膜，並取食已帶毒之寄主體液，因而受到藥劑之直接與亞致死毒害；而未成熟期中之卵、老熟幼蟲及蛹卻因未曾與藥劑直接接觸，所以沒受到藥劑之毒害。

當第二日齡雌蜂數與蔬菜斑潛蠅第三齡幼蟲數之比例為 10 隻：200 隻時，岡崎釉小蜂與底比斯釉小蜂一日內致死寄主率各為 61.8 與 39.6% (表 6)；但當三種供試藥劑單獨使用時，其致死寄主率達 100% (Chien & Chang 2010)，另藥劑分別與寄生蜂并用時亦高達 98.9–100% (表 6)。顯示就致死蔬菜斑潛蠅方面，藥劑之效果確實優於寄生蜂，且藥劑與寄生蜂并用對蔬菜斑潛蠅之致死率，較岡崎釉小蜂與底比斯釉小蜂單用時各增加 0.6 與 1.5 倍。證實蔬菜斑潛蠅田間族群密度若高至寄生蜂無法控制時，施用藥劑確可迅速降低該蠅之密度。但若考慮避免藥劑對寄生蜂之毒害、降低藥劑對蔬菜斑潛蠅與其寄生蜂族群穩定消長之干擾、減緩斑潛蠅抗藥性之產生、延長選擇性藥劑之使用壽命及降低防治成本等，在蔬菜斑潛蠅防治上必須慎選藥劑之種類與施用時機。

斑潛蠅屬於侵入性害蟲，本地種寄生蜂在其防治上扮演重要角色 (Murphy & LaSalle 1999)。廣效性藥劑不當施用時，不僅引發斑潛蠅抗藥性之產生，且對天敵造成殺傷力，致使斑潛蠅防治困難，因此在斑潛蠅防治上所採行之策略為綜合防治，而不僅限藥劑防治。在台灣，蔬菜斑潛蠅之寄主植物範圍包括葫蘆科、豆科、茄科、菊科及十字花科等；該蠅雖於苗期、生長期、開花期及結果期危害葉片，但以苗期最嚴重 (Chien & Chang unpublished data)。本試驗結果顯示阿巴汀與二種寄生蜂均不相容，歐殺滅與底比斯釉小蜂不相容，僅賽滅淨與二種寄生蜂較為相容。因此為顧及該蠅之危害特性、經濟重要性、瓜果連續採收農藥安全性、有效寄生蜂自然發生不需人為釋放、及寄生蜂保育等條件，建議作物苗期時蔬菜斑潛蠅之防治應以藥劑防治為主，苗期過後則採以生物防治為主之綜合防治策略。因此祇要在岡崎釉小蜂發生盛期慎選賽滅淨與歐殺滅、底比斯釉小蜂發生盛期慎選賽滅淨防治蔬菜斑潛蠅，田間岡崎釉小蜂與底比斯釉小蜂即可獲得較佳的保育，進而達成蔬菜斑潛蠅有效之綜合防治。

引用文獻 (Literature cited)

Anonymous. 1984. Data sheets on quarantine organisms. Bull. OEPP 14:78.

Anonymous. 2002. Crop Protection Compendium. CAB Int. Wallingford, Oxon, UK.

Bai, Y. C., X. S. Gu, W. H. Xu, X. X. Hu, Y. J. Hao, and B. M. Liu. 2009. Susceptibility of the parasitoids populations of *Liriomyza sativae* Blanchard to chemicals commonly used in vegetable crops. Acta Agric. Boreali-Sinice 24:83–86. (in Chinese with English abstract)

Broadbent, A. B. and D. J. Pree. 1989. Resistance to pyrazophos in the serpentine leafminer *Liriomyza trifolii* (Burgess) (Diptera: Agromyzidae) in Ontario greenhouses. Can. Entomol. 121:47–53.

Chien, C. C. and S. C. Chang. 2007. Morphology, life history and life table of *Liriomyza sativae* (Diptera: Agromyzidae). Formosan Entomol. 27:207–227. (in Chinese with English abstract)

Chien, C. C. and S. C. Chang. 2008a. Morphology and life history of *Chrysocharis pentheus* (Walker) (Hymenoptera: Eulophidae). Formosan Entomol. 28:159–181. (in Chinese with English abstract)

Chien, C. C. and S. C. Chang. 2008b. Influence of temperature on the population increase and host-killing capability of *Chrysocharis pentheus* (Hymenoptera: Eulophidae). Formosan Entomol. 28:277–291. (in Chinese with English abstract)

Chien, C. C. and S. C. Chang. 2009a. Morphology and life history of *Closterocerus okazakii* (Kamijo) (Hymenoptera: Eulophidae). Formosan Entomol. 29:25–36. (in Chinese with English abstract)

Chien, C. C. and S. C. Chang. 2009b. Influence of temperature on the life table and host-killing capability of *Closterocerus okazakii* (Kamijo) (Hymenoptera: Eulophidae). Formosan Entomol. 29:37–50. (in Chinese with English abstract)

Chien, C. C. and S. C. Chang. 2010. Effect of common insecticides on *Liriomyza sativae* Blanchard (Diptera: Agromyzidae). Formosan Entomol. 30:41–50. (in Chinese with English abstract)

Chien, C. C. and S. C. Ku. 1996. Morphology, life history and reproductive ability of *Liriomyza trifolii*. J. Agric. Res. China 45:69–88. (in Chinese with English abstract)

Chien, C. C. and S. C. Ku. 2001. Instar preference of five species of parasitoids of *Liriomyza trifolii* (Hymenoptera: Eulophidae, Braconidae). Formosan Entomol. 21:89–97. (in Chinese with English abstract)

Chien, C. C., S. C. Ku, and S. C. Chang. 2007. The effect of common insecticides on two parasitoids (Hymenoptera: Eulophidae) of *Liriomyza trifolii* (Burgess) (Diptera: Agromyzidae). Formosan Entomol. 27:277–292. (in Chinese with English abstract)

Hara, A. H. 1986. Effect of certain insecticides on *Liriomyza trifolii* (Burgess) (Diptera: Agromyzidae) and its parasitoids on chrysanthemums in Hawaii. Proc. Hawaii Entomol. Soc. 26:65–70.

Huang, J. C., Z. H. Lin, J. H. Chen, M. L. Li, and S. Y. Zhou. 1999. Toxicity of six common insecticides on *Liriomyza sativae* Blanchard. J. Fujian Agric. Univ. 28:452–456. (in Chinese with English abstract)

Leibee, G. L. 1981. Insecticidal control of *Liriomyza* spp. on vegetables. p.216–220. *in*: the Proceeding of the Institute of Food and Agricultural Sciences Industry Conference on Biology and Control of *Liriomyza* leafminers. IFAS Pub. Florida.

Mason, G. A., B. E. Tabashnik, and M. W. Johnson. 1989. Effect of biological and operational factors on evolution of insecticide resistance in *Liriomyza* (Diptera: Agromyzidae). J. Econ. Entomol. 82:369–373.

Murphy, S. T. and J. LaSalle. 1999. Balancing biological control strategies in the IPM of new world invasive *Liriomyza* leafminers in field vegetable crops. Biocontrol News Inform. 20:91–104.

Pang, B. P., J. A. Chen, E. Y. Huang, and Z. S. Bao. 2005. Effects of different host plants on population parameters of *Liriomyza sativae*. Plant Prot. 31: 26–28. (in Chinese with English abstract)

Parrella, M. P., C. B. Keil, and J. G. Morse. 1984. Insecticide resistance in *Liriomyza trifolii*. Calif. Agric. 38:22–23.

Poe, S. L., P. H. Everett, D. J. Schuster, and C. A. Musgrave. 1978. Insecticidal effects on *Liriomyza sativae* larvae and their parasites on tomato. J. Georgia Entomol. Soc. 13:322–327.

Saito, T., F. Ikeda, and A. Ozawa. 1996. Effect of pesticides on parasitoid complex of serpentine leafminer *Liriomyza trifolii* (Burgess) in Shizuoka Prefecture. Jpn. J. Appl. Entomol. Zool. 40:127–133.

Spencer, K. A. 1973. Agromyzidae (Diptera) of economic importance. p. 342–350. Series Entomologica Volume 9. The Hague Press. Netherlands. 418 pp.

Trumble, J. T. 1985a. Planning ahead for leafminer control. Calif. Agric. 39:8–9.

Trumble, J. T. 1985b. Integrated pest management of *Liriomyza sativae*: influence of avermectin, cyromazine and methomyl on leafminer ecology in celery. Agric. Eco. Environ. 12:181–188.

Trumble, J. T. and N. C. Toscano. 1983. Impact of methamidophos and methomyl on populations of *Liriomyza* species (Diptera: Agromyzidae) and associated parasites in celery. Can. Entomol. 115: 1415–1420.

Waddill, V. H. 1978. Contact toxicity of four synthetic pyrethroids and methomyl to some adult insect parasites. Fla. Entomol. 61:27–30.

Zeng, L., G. W. Liang, and J. J. Wu. 2004. Evaluation of control effect of several insecticides on *Liriomyza sativae* and its natural enemies. J. South China Agric. Univ. 25:44–47.

Effect of Insecticides on *Closterocerus okazakii* and *Chrysoncharis pentheus* (Hymenoptera: Eulophidae), Parasitoids of *Liriomyza sativae* (Diptera: Agromyzidae)[1]

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Abstract

Chien, C. C. and S. C. Chang. 2011. Effect of insecticides on *Closterocerus okazakii* and *Chrysoncharis pentheus* (Hymenoptera: Eulophidae), parasitoids of *Liriomyza sativae* (Diptera: Agromyzidae). J. Taiwan Agric. Res. 60:185–196.

Closterocerus okazakii (Kamijo) and *Chrysocharis pentheus* (Walker) are important native parasitoids of *Liriomyza sativae* Blanchard in Taiwan. In this study, seedlings of field bean (*Phaseolus vulgaris* var. *communis* Aeschers) infested with parasitoids or *L. sativae* were used to determine effect of insecticides (oxamyl SL, abamectin EC, cyromazine SL, and cyromazine WP) on *C. okazakii* and *C. pentheus* at different development stages under laboratory conditions. Results showed that all the three tested insecticides had a significant ($p < 0.05$) lethal effect on *C. okazakii* and *C. pentheus* in adult stage but no lethal effect on other development stages (egg, larva and pupa). When adult wasps were treated with insecticides for 24 hours, survival rates of female and male decreased by 62.9 and 7.1%, respectively, for abamectin in *C. okazakii*, 36.0 and 7.0%, respectively, for oxamyl in *C. pentheus*, whereas the others had no significant effects with decreased survival rates or significantly decreased by 4.0–8.2% only. The progeny of these two species of parasitoids decreased by 75.0–87.7% after the treatment of adults with either abamectin or cyromazine for 24 hours, and 50.6–58.3% by the treatment of adults with oxamyl. Among the three insecticides tested, abamectin was the most toxic insecticide for both parasitoid species. When adult wasps were treated with abamectin for 24 hours and released on untreated bean seedlings infested with hosts daily, the longevity of female wasps, longevity of male wasps, number of wasp progeny, and number of *L. sativae* killed by wasps decreased by 79.0–94.6, 61.7–67.5, 100 and 99.8–100%, respectively. In *C. okazakii*, treatment of adult wasps with both formulations of cyromazine resulted in 23.8% reduction of wasp progeny and treatment of adult wasps with oxamyl resulted in 30.2% reduction of female proportion. In *C. pentheus*, treatment of adult wasps with both formulations of cyromazine or oxamyl resulted in 42.4–52.5% reduction of wasp progeny and 21.9–34.5% reduction in the number of hosts killed by wasps. The percentage of hosts-killed increased 0.6 fold by the combined treatment of insecticide and *C. okazakii*, and 1.5 fold by the combined treatment of insecticide and *C. pentheus*, compared to the treatment of *C. okazakii* or *C. pentheus* alone. Abamectin was incompatible

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when used with both *C. okazakii* and *C. pentheus*, whereas oxamyl was incompatible with *C. pentheus*. The results suggest that cyromazine is less harmful to *C. okazakii* and *C. pentheus* and it can be used with these parasitoids for the control program of *L. sativae*.

Key words: *Liriomyza sativae*, *Closterocerus okazakii*, *Chrysocharis pentheus*, Insecticides, Development stages.