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研究簡報

植物揮發性成分對東方果實蠅 [*Bactrocera dorsalis* (Hendel)] 之誘效評估

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摘要

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本研究於室內網籠測試 44 種植物揮發性成分對東方果實蠅雌蟲之誘引效果，結果顯示 44 種供試成分中有 15 種化合物對東方果實蠅雌蟲有明顯的誘引效果，其中丁酸丁酯、乙酸異戊酯及己酸乙酯對雌蟲誘捕率分別為 53.5、69.0 及 60.0%，效果最好。此 15 種室內試驗篩選出之有效成分續於戶外進行網籠試驗，結果丁酸丁酯、乙酸異戊酯、己酸乙酯及乙酸正丁酯對雌蟲之誘捕率分別為 18.2、15.1、9.5 及 18.2%，與對照組間有顯著差異。此 4 種植物揮發性成分值得進一步探討其可能的應用性。

關鍵詞：東方果實蠅、植物揮發性成分、誘效、果實蠅防治。

東方果實蠅 [*Bactrocera dorsalis* (Hendel)] 危害番石榴、蓮霧及印度棗等多種經濟果樹，是我國重要的果樹害蟲 (Liu 1981)。在台灣東方果實蠅全年發生，雌蟲將卵產於果實內，孵化後的幼蟲蛀食果肉影響水果產量和品質。此害蟲亦被世界各國認為是重要的檢疫害蟲，因此在水果貿易時常形成障礙 (Chen *et al*. 2001)。

東方果實蠅因寄主散發的氣味可誘引雌蠅前來產卵，其中參與誘引的成分自然受到研究人員重視。Chen & Dong (2000) 證實山刺番荔枝 (*Annona montana*)、鷹爪花 (*Artabotrys uncinatus*)、阿勃勒 (*Cassia fistula*)、爪哇鳳果 (*Garcinia dulcis*) 和欖仁 (*Terminalia catappa*) 葉片之乙醚萃取物可以誘引東方果實蠅，且誘得的雌蟲數顯著較雄蟲多。在其他類果實蠅研究，洋香瓜及胡瓜揮發性成分中證實含有誘引雌瓜實蠅物質 (Lu 2002; Siderhurst & Jang 2010)，而 Maria *et al*. (2013) 研究指出地中海果實蠅 (*Ceratitits capitata*) 對不同品系桃樹之危害程度差異來自其中揮發性成分與含量之不同。上述研究結果皆顯示植物揮發性成分可有效誘引果實蠅雌蠅，值得利用其開發成雌蟲誘引劑用於果實蠅防治工作。

果實蠅寄主植物揮發性成分眾多，本試驗測試 44 種由農業試驗所陳健忠博士自番石榴、山刺番荔枝及鷹爪花等東方果實蠅寄主植物果實或葉片鑑定出之揮發性成分對東方果實蠅之誘效，期篩選出適合用以開發成東方果實蠅雌蟲誘引劑之成分。此 44 種供試成分之名稱、純度與出品廠商如表 1。

室內測試各成分對東方果實蠅之誘效時，於網籠 (40 cm × 40 cm × 40 cm) 內放入 25 對 10–20 日齡人工飼料飼養未饑餓果實蠅 30 min 後，放入加蓋透明捲邊杯 (250 mL)，內置含 0.5 mL 未稀釋揮發性成分之棉片 (1.5 cm × 1.5 cm)。捲邊杯蓋有一正方形內凹開口 (1.5 cm × 1.5 cm)，供氣味散出及果實蠅進出，試驗組

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表 1. 供試用揮發性成分。

Table 1. Volatiles for test.

Volatile	Purity	Manufacturer	Volatile	Purity	Manufacturer
Hexyl acetate	≥ 98%	Merck	n-Butyl acetate	≥ 99%	Merck
Methyl acetate	≥ 99%	Merck	Isoamyl acetate	≥ 99%	Merck
Propionic acid	≥ 99%	Merck	Ethyl propionate	≥ 99%	Merck
Methyl butyrate	≥ 98%	Merck	Ethyl butyrate	≥ 98%	Merck
Butyl butyrate	≥ 98%	Merck	Methyl hexanoate	≥ 98%	Merck
Ethyl hexanoate	≥ 98%	Merck	Hexaldehyde	≥ 98%	Merck
Ethyl isopentanoate	≥ 98%	Merck	cis-3-Hexen-1-ol	≥ 98%	Merck
2-Methylheptanoic acid	≥ 99%	Merck	1,4-Diaminobutane	≥ 98%	Merck
n-Hexadecane	≥ 99%	Merck	α-Phellandrene	≥ 60%	Merck
Myrcene	≥ 85%	Merck	DL-Limonene	≥ 95%	Merck
(1R)-(+)-α-Pinene	≥ 97%	Merck	(1S)-(-)-α-Pinene	≥ 95%	Merck
Dimethyl disulfide	≥ 99%	Sigma-Aldrich	n-Undecane	≥ 99%	Sigma-Aldrich
Dodecane	≥ 99%	Sigma-Aldrich	Pentadecane	≥ 99%	Sigma-Aldrich
Di-tert-butyl dicarbonate	99%	Sigma-Aldrich	Octamethylcyclotetrasiloxane	98%	Sigma-Aldrich
Cyclohexanecarboxylic acid	98%	Sigma-Aldrich	Methyl formate	99%	Sigma-Aldrich
Methyl 2-furoate	98%	Sigma-Aldrich	Ethyl pentanoate	≥ 98%	Sigma-Aldrich
n-Amyl alcohol	≥ 99%	Sigma-Aldrich	Decane	≥ 99%	Sigma-Aldrich
3-Octanol	99%	Sigma-Aldrich	Eucalyptol	99%	Sigma-Aldrich
Methyl amine	≥ 98%	Sigma-Aldrich	Aminoethyl ethanolamine	99%	Sigma-Aldrich
Diethyl ketone	≥ 99%	Sigma-Aldrich	b-Caryophyllene	≥ 80%	Sigma-Aldrich
3-Caren	≥ 90%	Sigma-Aldrich	Naphthalene	99%	Sigma-Aldrich
Isovaleraldehyde	97%	Sigma-Aldrich	Gamma undecalactone	98%	Acros

網籠與對照組於室內不同區域進行，間隔 10 m 以上以減少氣味之干擾。捲邊杯經 1 d 後計算杯中果實蠅數目，以未加揮發性成分棉片為對照組，每次試驗 8 重複。戶外東方果實蠅誘效測試方法是將上述室內試驗中誘引效果較好之丁酸丁酯、乙酸異戊酯、己酸乙酯、乙酸正丁酯、二硫二甲烷、DL-寧烯、癸烷及石竹烯等 8 種成分各 0.5 mL 分別裝入容量 1.5 mL 加蓋透明聚丙烯塑膠管 (polypropylene，耐酸鹼及化學物質，不與供試揮發性成分起反應影響氣味) 中，塑膠管蓋上方開一直徑 0.3 cm 之圓孔供氣味散出。塑膠管懸掛於黑色改良型麥氏誘蟲器中，內加 350 mL 水 (減少麥氏誘蟲器原黃顏色對果實蠅誘引效果)。將 125 對 10–20 日齡未飢餓東方果實蠅放入網籠 (5 m × 5 m × 2 m) 中，經 30 min 後掛入誘蟲器，經 1 d 後計算誘捕果實蠅數目。以未加揮發性成分之誘蟲器為對照組，每次試驗 6 重複。上述試驗所得雌、雄蠅誘捕率以 SAS-EG (Version 4.1, 2006) 統計分析軟體進行 *t*-test 分析其差異顯著性。

室內誘效試驗結果顯示 44 種揮發性成分中有 15 種成分對東方果實蠅雌、雄蟲具明顯誘引效果，其中以丁酸丁酯 (雌、雄蟲誘捕率分別為 53.5%、62.5%)、乙酸異戊酯 (雌、雄蟲分別為 69.0%、51.0%) 及己酸乙酯 (雌、雄蟲分別為 60.0%、62.0%) 3 種成分效果最好，對東方果實蠅雌蠅誘捕率均達 50.0% 以上。癸烷 (雌、雄蟲誘捕率分別為 33.0%、78.0%) 及 DL- 寧烯 (雌、雄蟲分別為 34.0%、72.0%) 則對東方果實蠅雄蠅具明顯誘引效果，誘捕率達 70.0% 以上 (表 2)。戶外誘效試驗結果顯示 8 種揮發性成分中，丁酸丁酯對雌、雄蟲誘捕率分別為 18.2%、16.5%；乙酸異戊酯之捕率分

表 2. 15 種植物揮發性成分於室內網籠對東方果實蠅之誘引效果。

Table 2. Attractiveness of 15 plant volatiles to the oriental fruit fly in laboratory cage tests.

	% fruit flies trapped (Mean ± SE)			% fruit flies trapped (Mean ± SE)	
Plant volatile	Female	Male	Plant volatile	Female	Male
Aminoethyl ethanolamine	0.0 ± 0.0	0.0 ± 0.0	n-Amyl alcohol	1.0 ± 0.7	1.0 ± 0.7
Control	1.0 ± 0.7	0.0 ± 0.0	Control	0.0 ± 0.0	0.0 ± 0.0
Butyl butyrate	53.5 ± 3.0*[z]	62.5 ± 5.4*	n-Butyl acetat	39.0 ± 4.8*	36.5 ± 3.4*
Control	6.0 ± 2.8	6.0 ± 2.0	Control	6.0 ± 2.0	5.0 ± 1.3
3-Carene	3.0 ± 1.5	3.0 ± 1.5	β-Caryophyllene	30.0 ± 5.0*	24.0 ± 5.9*
Control	2.5 ± 1.5	3.0 ± 1.3	Control	4.0 ± 1.6	1.0 ± 1.0
Cyclohexanecarboxylic acid	1.0 ± 0.7	0.0 ± 0.0	Decane	33.0 ± 3.0*	78.0 ± 4.8*
Control	1.5 ± 0.7	1.0 ± 0.7	Control	6.0 ± 1.2	11.0 ± 3.4
1,4-Diaminobutane	2.5 ± 1.1	2.0 ± 0.8	Diethyl ketone	0.5 ± 0.5	1.0 ± 1.0
Control	2.0 ± 0.8	2.5 ± 0.7	Control	1.5 ± 0.7	1.0 ± 0.7
Dimethyl disulfide	35.0 ± 4.1*	46.0 ± 11.4*	Di-tert-butyl dicarbonate	29.0 ± 6.6*	28.0 ± 6.7*
Control	4.0 ± 1.6	4.0 ± 1.6	Control	9.0 ± 5.0	11.0 ± 3.4
DL-Limonen	34.0 ± 6.0*	72.0 ± 6.9*	Dodecane	1.5 ± 1.1	0.0 ± 0.0
Control	9.0 ± 5.0	11.0 ± 3.4	Control	1.0 ± 0.7	1.0 ± 0.7
Ethyl butyrate	1.5 ± 0.7	1.0 ± 0.7	Ethyl hexanoate	60.0 ± 2.3*	62.0 ± 2.0*
Control	0.5 ± 0.5	1.0 ± 0.7	Control	4.0 ± 2.8	2.0 ± 1.2
Ethyl isopentanoate	28.0 ± 4.4*	22.0 ± 3.4*	Ethyl pentanoate	19.0 ± 1.9*	41.0 ± 6.0*
Control	0.5 ± 0.5	0.5 ± 0.5	Control	4.0 ± 1.6	1.0 ± 1.0
Ethyl propionate	5.0 ± 1.5	2.5 ± 1.3	Eucalyptol	20.0 ± 8.5*	38.0 ± 7.7*
Control	4.0 ± 1.1	1.5 ± 0.7	Control	4.0 ± 1.6	4.0 ± 1.6
Gamma undecalactone	3.0 ± 1.5	3.0 ± 1.6	n-Hexadecane	12.0 ± 7.4	18.0 ± 6.6
Control	2.5 ± 1.3	3.5 ± 1.9	Control	7.0 ± 1.2	11.0 ± 3.4
cis-3-Hexen-1-ol	0.0 ± 0.0	0.0 ± 0.0	Hexaldehyde	0.5 ± 0.5	0.5 ± 0.5
Control	0.0 ± 0.0	0.0 ± 0.0	Control	0.0 ± 0.0	0.0 ± 0.0
Hexyl acetat	25.5 ± 2.0*	16.0 ± 1.5*	Isoamyl acetate	69.0 ± 4.1*	51.0 ± 3.5*
Control	1.0 ± 1.0	2.5 ± 1.5	Control	0.5 ± 0.1	1.5 ± 0.3
Isovaleraldehyde	0.0 ± 0.0	1.0 ± 0.7	Methyl acetate	8.5 ± 1.4	7.5 ± 1.6
Control	0.0 ± 0.0	0.0 ± 0.0	Control	5.5 ± 1.7	5.0 ± 1.6
Methyl amine	2.5 ± 1.1	1.5 ± 1.1	Methyl butyrate	8.8 ± 0.9	10.5 ± 1.5
Control	2.0 ± 0.8	2.0 ± 1.3	Control	7.5 ± 1.2	11.0 ± 2.2
Methyl formate	5.0 ± 2.0	5.0 ± 1.6	Methyl 2-furoate	3.0 ± 1.6	4.0 ± 1.7
Control	4.0 ± 1.9	5.0 ± 2.0	Control	3.5 ± 1.4	4.0 ± 2.0
2-Methylheptanoic acid	1.5 ± 1.1	2.0 ± 1.1	Methyl hexanoate	25.0 ± 4.4*	38.0 ± 3.8*
Control	2.0 ± 1.1	1.5 ± 1.1	Control	4.0 ± 2.8	2.0 ± 1.2
Myrcene	0.0 ± 0.0	0.0 ± 0.0	Naphthalene	1.0 ± 0.7	0.0 ± 0.0
Control	0.5 ± 0.5	0.0 ± 0.0	Control	0.0 ± 0.0	0.0 ± 0.0
Octamethylcyclotetrasiloxane	2.0 ± 0.7	1.0 ± 0.7	3-Octanol	1.5 ± 0.7	0.0 ± 0.0
Control	1.5 ± 0.7	1.0 ± 0.7	Control	1.5 ± 0.7	0.0 ± 0.0
Pentadecane	2.0 ± 0.8	1.5 ± 0.8	Propionic acid	1.0 ± 0.7	0.0 ± 0.0
Control	3.5 ± 1.2	2.0 ± 0.8	Control	0.0 ± 0.0	0.0 ± 0.0
(1R)-(+)-α-Pinene	0.0 ± 0.0	0.0 ± 0.0	(1S)-(-)-α-Pinene	0.0 ± 0.0	0.0 ± 0.0
Control	0.0 ± 0.0	0.0 ± 0.0	Control	0.0 ± 0.0	0.0 ± 0.0
α-Phellandrene	31.0 ± 6.0*	46.0 ± 3.5*	n-Undecane	1.5 ± 1.1	0.0 ± 0.0
Control	9.0 ± 5.0	11.0 ± 3.4	Control	1.0 ± 0.7	1.0 ± 0.7

[z] Asterisk indicates a significant difference from the control at $P < 0.05$ (*t*-tests SAS-EG, Version 4.1, 2006). Percentage data were arcsine transformed prior to analysis.

別為 15.1%、17.8%；乙酸正丁酯之誘捕率分別為 18.2%、15.5%，己酸乙酯處理組之誘捕率分別為 9.5%、10.9%，均與對照組間有顯著差異。其餘 4 種揮發性成分對東方果實蠅誘引效果則與對照組間無顯著差異 (表 3)。

使用果實蠅雌蟲誘引劑具有防治上的優勢，可消滅雌蟲及潛在的子代，故引起研究者重視 (Jang & Light 1996)。東方果實蠅寄主植物眾多，每種植物所含之揮發性成分亦有所不同，本研究測試 44 種東方果實蠅寄主植物揮發性成分對東方果實蠅之誘效，試驗結果可供相關研究人員作為進一步研究之基礎。44 種供試成分中之 15 種，於室內試驗中對東方果實蠅雌蟲具誘引效果，但經後續戶外網籠試驗檢測，則僅丁酸丁酯、乙酸異戊酯、乙酸正丁酯及己酸乙酯 4 種成分對東方果實蠅雌蠅具有顯著的誘引效果，但誘捕率低於室內試驗結果。室內試驗之網籠體積較小，顯示誘餌與果實蠅間的距離與果實蠅活動空間範圍產生誘效差異，因此於室內測試的有效成分，均有必要於戶外進一步測試是否具應用潛力。

Swift (1982) 發現蘋果的揮發性成分乙酸正丁酯可有效誘引蘋果果實蠅 (*Rhagoletis pomonella Walsh*)；丁酸丁酯為香蕉與番石榴揮發性成分，可引起 *Bactrocera invadens* 雌蠅觸角電位反應 (electroantennogram detection responses) (Jiang & Song 2010; Biasazin *et al*. 2014)。

己酸乙酯為欖仁、番石榴及柑橘共有的揮發性成分，可引起 *B. invadens* 雌蠅、東方果實雌蠅及墨西哥果實蠅 (*Anastrepha ludens* Loew) 雌、雄蠅等觸角電位反應 (Malo *et al*. 2005; Siderhurst & Jang 2006; Jiang & Song 2010; Biasazin *et al*. 2014)。Biasazin *et al*. (2014) 研究指出芒果、香蕉、番石榴及柑橘共有的揮發性成分乙酸異戊酯可引起 *B. invadens* 雌蠅觸角電位反應，以上 4 種酯類經本研究亦證實對東方果實蠅雌、雄蟲亦具誘引效果。綜合上述結果顯示來自不同果實蠅寄主植物中之相同揮發性成分，可對不同種之果實蠅具有誘引效果，隱含某種的生態意義，至於是否應當著重於篩選此類共同成分，有待更多研究結果確認。

Hwang *et al*. (2002) 研究番石榴揮發性成分對東方果實蠅誘引效果，報告指出可藉由不同揮發性成分之組合來提升誘引效果，且於 50% 糖蜜溶液中添加 3% ethyl acetate 可增加誘效 2 倍且與新鮮番石榴的誘引效果無差異，顯示揮發性成分尚有增強食物餌劑誘效之作

表 3. 八種植物揮發性成分於田間網籠對東方果實蠅之誘引效果。

Table 3. Attractiveness of 8 plant volatiles to the oriental fruit fly in field cage tests.

	% fruit flies trapped (Mean ± SE)	
Plant volatile	Female	Male
Butyl butyrate	18.2 ± 2.3*[z]	16.5 ± 2.1*
Control	3.6 ± 1.2	3.3 ± 1.3
n-Butyl acetate	18.2 ± 2.9*	15.5 ± 1.3*
Control	0.9 ± 0.3	0.9 ± 0.4
β-Caryophyllene	1.8 ± 0.7	3.5 ± 1.2
Control	0.7 ± 0.3	1.4 ± 0.3
Decane	1.1 ± 0.4	2.5 ± 0.7
Control	0.5 ± 0.2	1.2 ± 0.2
Ethyl hexanoate	9.5 ± 2.0*	10.9 ± 1.2*
Control	1.5 ± 0.6	1.6 ± 0.8
Isoamyl acetate	15.1 ± 1.9*	17.8 ± 2.2*
Control	0.5 ± 0.1	1.5 ± 0.3
DL-Limonen	1.5 ± 0.5	2.2 ± 0.4
Control	0.5 ± 0.2	1.1 ± 0.1
Dimethyl disulfide	3.8 ± 3.0	3.2 ± 2.2
Control	0.8 ± 0.4	1.1 ± 0.3

[z] Asterisk indicates a significant difference from the control at $P < 0.05$ (*t*-tests SAS-EG, Version 4.1, 2006). Percentage data were arcsine transformed prior to analysis.

用。本試驗篩選出的丁酸丁酯、乙酸異戊酯、乙酸正丁酯及己酸乙酯 4 種揮發性成分於戶外網籠中經 1 d 後，對東方果實蠅雌蠅的誘捕率為 9.5–18.2%，此僅為單獨成分誘引之結果。如何藉由不同成分組合增效配方與添加至食物餌劑提高對東方果實蠅的誘殺效果，達到可以用於田間防治東方果實蠅的目的，仍需進一步探討。

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Evaluation of the Attractiveness of Plant Volatiles to the Oriental Fruit Fly, *Bactrocera dorsalis* (Hendel) (Diptera: Tephirtidae)

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Abstract

Dong, Y. J. and C. C. Chen. 2015. Evaluating the attractiveness of plant volatiles to the oriental fruit fly, *Bactrocera dorsalis* (Hendel) (Diptera: Tephirtidae). J. Taiwan Agric. Res. 64(4):336–341.

Forty-four plant volatiles were tested for their attractiveness to females of the oriental fruit fly in laboratory, and 15 out of 44 volatiles significantly attracted female flies in laboratory cage tests. Butyl butyrate, isoamyl acetate, and ethyl hexanoate were the best three in these 15 volatiles; with female trapping rates of 53.5, 69.0, and 60.0%, respectively. In the following field cage tests for these 15 volatiles, butyl butyrate, isoamyl acetate, n-butyl acetate, and ethyl hexanoate showed significant attractiveness to female flies compared to the controls. The female trapping rates were 18.2, 15.1, 9.5, and 18.2%, respectively. These 4 plant volatiles deserve investigation for possible applications.

Key words: *Bactrocera dorsalis*, Plant volatiles, Attractiveness, Fruit fly control.

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