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柑桔粉介殼蟲 (*Planococcus citri* (Risso)) 性費洛蒙誘捕器之開發

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摘 要

在飛行室以轉盤嗅覺檢定裝置，測試費洛蒙誘捕器之型式、顏色，及擺置之高度對柑桔粉介殼蟲之誘捕效果。結果以口徑 8 cm 及長度 8 cm 透明塑膠圓筒，與 8×12.5 cm² 白色黏膠板組合成之性費洛蒙誘捕器，顯示最佳誘捕效果，同時小型圓筒形誘捕器之誘蟲效率優於大型圓筒形者。費洛蒙誘捕器擺置於轉盤面上或懸掛於距盤面50公分高處，均比懸掛於離盤面 50 公分低處者，顯著地誘捕更多柑桔粉介殼蟲雄成蟲。

(關鍵字：柑桔粉介殼蟲、費洛蒙誘捕器型式、誘捕器顏色、誘捕器擺置高度。)

ABSTRACT

Hwang, Jenn-Sheng and Yau-I Chu. (1987). **The Development of Sex Pheromone Traps for the Citrus Mealybug, *Planococcus citri*** (Risso). Plant Prot. Bull. (Taiwan, R.O.C.) 29：297—305 (Pesticide Formulation Department, Taiwan Agricultural Chemicals and Toxic Substances Research Institute, Taichung, Taiwan 41301, R.O.C. and Department of Plant Pathology and Entomology, National Taiwan University, Taipei, Taiwan 10764, R.O.C.)

The effects of pheromone trap design, trap color and trap height on catches of male citrus mealybug, *Planococcus citri* (Risso), were tested with turntable olfactometer in free-flight room. Among fourteen tested trap designs, the cylindrical trap which consists of transparent plastic trap (dia. 8 cm, leng. 8 cm) with white sticky-card (8 ×12.5 cm²) inserted into the bottom of trap was the most effective one. About 50 percent of total attracted males were caught by the trap on the same elevation where the males were released, the recapture rate of the traps set above and below 50 cm of the released point were about 37 and 13 percent respectively.

(Key words: Citrus mealybug, *Planococcus citri*, Pheromone trap design, Cylindrical trap, Trap color, Trap height.)

緒　　言

目前綜合蟲害管理（Integrated pest management）的理念，其基礎在於建立一個簡易有效的害蟲偵測或監視系統。介殼蟲類昆蟲多爲農林作物上之重要害蟲，因其體型細小並多被覆臘質物或硬介殼，並喜群棲於寄主縫隙之習性，一般對介殼蟲類小型昆蟲發生爲害的偵測與防治，確是不易、費時的事。最近昆蟲性費洛蒙的研究，曾發現並鑑定出四種盾介殼蟲科的硬介殼蟲及二種粉介殼蟲科的粉介殼蟲之雌性性費洛蒙組成份[12]，其中包括柑桔粉介殼蟲（*Planococcus citri* (Risso)），其性費洛蒙主成分爲（+）-2, 2-二甲基-3-（異丙烯基）-環丁烷甲基乙酯[2]。Moreno *et al.* 曾以柑桔粉介殼蟲處女雌蟲與黏膠板組成性費洛蒙誘捕器，調查柑桔園內該粉介殼蟲雄蟲季節性消長情形，認爲是種可靠的偵測該介殼蟲發生之工具，並可因此把握精確的防治適期，降低殺蟲劑的過量使用[6]。將來柑桔粉介殼蟲性費洛蒙誘捕偵測系統的建立，除有賴鑑定、合成該粉介殼蟲性費洛蒙外，並須發展設計簡易、經濟、有效的費洛蒙誘捕裝置，以提供田間應用。

本研究之目的在開發設計不同類型誘捕裝置，測試其對柑桔粉介殼蟲雄蟲誘捕之效率，並探討誘捕器之顏色及擺放位置對誘捕雄蟲可能之影響，期能開發標準化的該粉介殼蟲雌性費洛蒙誘捕器，以應未來於果園調查偵測柑桔粉介蟲族群發生、消長之用。

材 料 與 方 法

一、供試昆蟲

試驗之柑桔粉介殼蟲之飼育方法，及雌、雄性成蟲之分離方法，概如黃和朱報告[1]之方式進行。

二、柑桔粉介殼蟲處女雌蟲性費洛蒙誘捕器之製備

粉介殼蟲雌性費洛蒙誘捕器之製備係依黃和朱之方法[1]再稍加修改而成，即先於一鋼製小網罩內，置放附有40隻9日齡處女雌蟲之番石榴葉片，再將此內含粉介殼蟲之小網罩與另一小網罩，以口對口密接，周圍則以雙面膠帶貼合，如此，使粉介殼蟲雌性費洛蒙可自小網罩兩側細孔目散發，以誘引雄蟲。若將前述含雌蟲之網罩以膠圈懸掛於各類型之黏膠捕蟲盒內，則組合成各種型式之雌性費洛蒙誘捕器。本試驗測試各種型式誘捕器對雄蟲之誘捕效率，概以黃和朱所述圓形轉盤檢定法[1]，進行測試及統計分析結果。

三、柑桔粉介殼蟲性費洛蒙誘捕器之設計

(1)不同型式性費洛蒙誘捕器對雄蟲誘捕之效果

爲開發適用於誘捕粉介殼蟲雄蟲之性費洛蒙誘捕器，仍參考前人研究果實蠅（*Ceratitis capitata, Dacus dorsalis, D. cucurbitae*）[3]，及梨圓介殼蟲（*Ouadraspidious perniciosus*）誘捕器之構造[4]，設計五種如圖一之基本誘捕器裝置，並測試其對雄蟲之誘捕效能。其中：A爲長方形誘捕器，由二片長 20 cm 寬 10.5 cm 之黏膠紙板以釘書針釘合而成，再於紙板一端距邊緣1.5 cm 處挖一直徑 3.5 cm之圓孔，可將含雌蟲之網罩裝置於此圓孔。B爲圓筒形誘捕器，先以透明塑膠片製成兩端開口之圓筒（筒口直徑 8 cm，筒身長 16 cm），再將長 16 cm 寬 12.5 cm 之黏膠紙板放置於圓筒底部，處女雌蟲則以膠圈懸掛於圓筒頂部。C爲開放式帳幕形誘捕器（或倒V字形誘捕器），係由長 25 cm 寬 8 cm 之黏膠紙板以 60 度角度對折而成。D爲密封式帳幕形誘捕器，先以長 23 cm 寬 20 cm 之紙板以 45 度角度對折成倒V字形，再將長 20 cm 寬 10 cm 之黏膠紙板放置於倒V字形底部，並以釘書針釘合而成。E爲配對形誘捕器，係以一長 15.5 cm 寬 13 cm 黏膠紙板爲底，再於距底板 7 cm 處平置同形無黏膠之紙板爲頂，並利用鐵絲串連固定，處女雌蟲則懸掛於頂部。

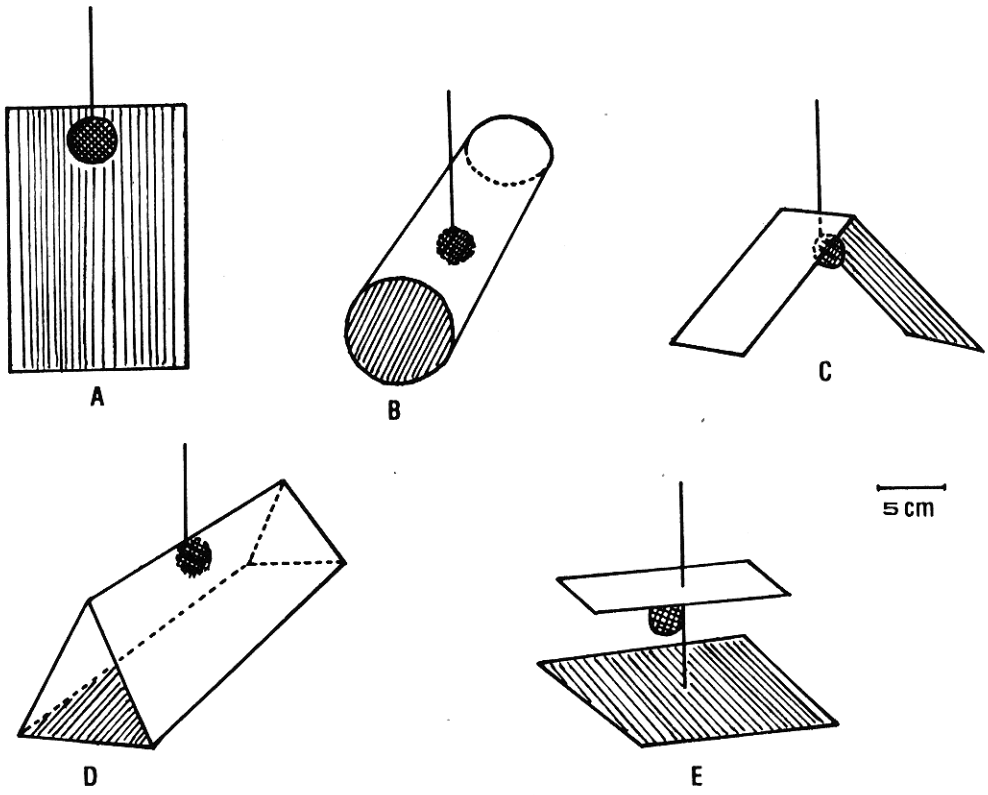
檢測五種型式誘捕器對雄蟲誘捕之效力，係使用粗鐵線於圓形轉盤周圍架設支柱，再將誘捕器懸掛於距盤面 30 cm 高處，進行檢定試驗。

(2)不同尺寸圓筒形誘捕器對雄蟲誘捕之效果

上述五種型式誘捕器經測試結果，圓筒形誘捕器顯具經濟、有效、操作簡易等特性，乃

進一步依下述原則進行構造上之改善：①變換圓筒之口徑，但維持原圓筒底部黏膠紙板之面積，②固定圓筒之口徑但縮短圓筒之長度，並使圓筒底部黏膠紙板之面積縮減；設計不同尺寸之圓筒形誘捕器，再以轉盤生檢法檢測各種尺寸圓筒形誘捕器對雄蟲誘捕之效率。

供試之七種圓筒形誘捕器之代號，及各部位尺寸詳列如表一。



圖一、五種柑桔粉介殼蟲性費洛蒙誘捕器之型式

A. 長方形誘捕器（20×10.5 公分），具兩黏膠表面。
B. 圓筒形透明塑膠誘捕器（口徑 8 公分，長 16 公分），於圓筒底部具黏膠紙板（12.5×16 公分）。
C. 倒 V 字形誘捕器（25× 8 公分），於倒 V 形紙板底面塗佈黏膠。
D. 密封式帳幕形誘捕器，於誘捕器底部具黏膠板（20×10 公分）。
E. 配對形誘捕器（15.5×13 公分），兩紙板水平相距 7 公分，底部紙板具黏膠。

Fig. 1. Five types of trap designs used to catch males of *Planococcus citri*.

A. Rectangular trap (20×10.5 cm) with two sticky surfaces.
B. Cylindrical, transparent plastic trap (dia. 8 cm, 1. 16 cm) with corrugated sticky card (12.5×16 cm) inserted into the bottom of trap.
C. V-shaped trap (25×8 cm) with sticky glue on the under surface of trap.
D. Enclosed tent trap with sticky card (20×10 cm) inserted into the bottom of trap.
E. Paired board trap (15.5×13 cm) placed horizontally 7 cm apart with sticky glue on the bottom board.

表一、七種供試圓筒形誘捕器之尺寸

Table 1. Sizes (cm.) of seven cylindrical traps tested.

Trap type	Cylindrical part			Sticky-card used		
	diameter		length			
A	8.0	×	8.0	12.5	×	8
B	8.0	×	10.6	12.5	×	10.6
C	8.0	×	13.3	12.5	×	13.3
D	8.0	×	16.0	12.5	×	16.0
E	9.1	×	14.0	14.2	×	14.0
F	10.2	×	12.5	16.0	×	12.5
G	12.7	×	10.0	20.0	×	10.0

四、紅、白色圓筒形誘蟲器與黏膠板之組合對雄蟲誘捕之影響

黃及朱曾報告柑桔粉介殼蟲雄蟲對紅色性費洛蒙誘捕器具顯著之偏好性[1]，乃進一步以口徑 8 cm 長度 8 cm 紅、白顏色之圓筒形誘蟲器，分別搭配紅、白色黏膠板(12.5×8 cm)，組成包括：①紅色圓筒誘蟲器底置紅色黏膠板，②紅色圓筒誘蟲器底置白色黏膠板，③白色圓筒誘蟲器底置白色黏膠板，及④白色圓筒誘蟲器底置紅色黏膠板等四種誘捕器，再測定其對雄蟲誘捕之效果。

五、費洛蒙誘捕器放置高度對雄蟲誘捕之影響

將處女雌蟲與圓筒形黏膠捕蟲盒組成性費洛蒙誘捕器，再利用圓形轉盤周圍的鐵線支柱，將六個誘捕器分別交錯地懸掛於距離盤面50 cm 高處與低於盤面 50 cm 處，及圓盤平面處之支柱上，如此使每一種高度有二個誘捕器，供試雄蟲則放置於圓盤中心位置，依前述方法進行檢定試驗。

結果與討論

一、柑桔粉介殼蟲性費洛蒙誘捕器之設計

(1)不同型式性費洛蒙誘捕器對雄蟲誘捕之效果

五種不同型式誘捕器對雄蟲之誘捕效果，經試驗結果呈現顯著之差異（表二）。以長方形誘捕器之誘雄效率最佳（36.4%），其次爲圓筒形（20.2%）及開放式帳幕形（17.7%），而密封式帳幕形（12.0%）及配對形誘捕器（13.6%）之誘雄效率較差。長方形誘捕器之誘捕率約爲圓筒形或開放式帳幕形者之二倍，但長方形誘捕器之黏膠板面積亦爲圓筒形或開放式帳幕形者之二倍，故圓筒形或開放式帳幕形誘捕器之誘捕效率不亞於長方形者。

Rice & Hoyt 及 Hoyt *et al.* 曾比較不同型式誘捕器對梨圓介殼蟲雄蟲之誘捕效率[4,9]，咸認爲具相同面積之黏膠板直立式誘蟲紙盒(Carton trap with vertically sticky-card)與開放式帳幕形誘捕器（Open tent trap），對雄蟲之誘捕力無顯著性差異[9]，開放式帳幕形誘捕器之誘蟲效率則較密封式者（Closed tent trap）爲優，同時帳幕形誘捕器之角度大小不影響誘雄效果，而以小型誘捕器較大型誘捕器之誘蟲效率爲高[4]。另圓筒形誘捕器亦曾被使用於田間，以誘捕柑桔粉介殼蟲雄蟲，並具良好之誘雄效果[10]；再考慮圓筒形誘捕器較帳幕形者不但具有更佳之防雨防塵效果，其操作也較簡易，故圓筒形誘捕器可認爲適於田間應用之誘捕器。

(2)不同尺寸圓筒形誘捕器對雄蟲誘捕之效果

在本試驗中，共測定七種尺寸之圓筒形誘捕器對雄蟲之誘捕效率，所得結果如表三。在圓筒底部黏膠紙板面積固定爲 200 cm^2 時，隨圓筒筒口直徑在 8.0 cm～12.7 cm 範圍之變大，圓筒形誘捕器之誘雄效率有增加之趨勢

(自 13.4%至 16.4%)。當圓筒筒口直徑固定爲 8.0 cm，隨圓筒長度自 16.0 cm 縮短到 8.0 cm，而黏膠板之長度亦照此比例自 16.0 cm 縮減到 8.0 cm 時，圓筒形誘捕器之誘雄效率自 13.4% 稍微增加到 14.5%。惟經統計分析結果，七種尺寸之圓筒形誘捕器誘捕雄蟲之效率，並無顯著性差異（表三）。若將各種誘捕器之誘雄百分率資料轉換爲每 10 平方公分黏膠板面積之誘捕雄蟲數（表三），再經統計分析，則以A型圓筒形誘捕器（口徑 8 cm 及長度 8 cm 之圓筒搭配 12.5×8.0 cm 之黏膠板），其在單位面積黏膠板誘捕之雄蟲數爲 2.7 隻/10 cm²，較其他尺寸圓筒形誘捕器之 1.3～1.6 隻/10 cm² 顯著爲多。

表二、五種型式誘捕器對柑桔粉介殼蟲雄成蟲之誘捕效果
Table 2. Trapping efficiency of various trap designs baited with forty 9-day-old virgin females of *Planococcus citri* on males.

Trap type[1]	% of total males captured[2]
Rectangular	36.4 ± 8.0[3] a
Cylindrical	20.2 ± 7.1 b
V-shaped	17.7 ± 4.9 b
Enclosed tent	12.0 ± 3.2 c
Paired board	13.6 ± 4.5 c
Total males captured[2]	245.6 ±73.6

1) The diagram of various trap designs are the same as fig. 1.
2) Mean±S. D. derived from 18 trials. Mean (±S. D.) number of males flew away for each trial was 405.5±62.3.
3) Data were transformed to arc sine $\sqrt{X}$ prior to analysis, and means followed by the same letter were not significantly different at the 5% level according to Duncan's multiple range test.

表三、七種尺寸圓筒形誘捕器對柑桔粉介殼蟲雄成蟲之誘捕效果
Table 3. Trapping efficiency of various sizes of cylindrical traps baited with forty 9-day-old virgin femals of *Planococcus citri* on males.

Trap type[1]	% of total males captured[2]	No. of males captured per 10 cm² sticky surface[2]
A	14.5 ± 3.1[3] a	2.7 ± 1.4[3] a
B	11.5 ± 2.1 a	1.6 ± 1.0 b
C	14.5 ± 4.7 a	1.6 ± 1.0 b
D	13.4 ± 3.9 a	1.3 ± 1.0 b
E	13.6 ± 5.1 a	1.3 ± 1.0 b
F	16.1 ± 5.2 a	1.5 ± 1.1 b
G	16.4 ± 3.6 a	1.5 ± 0.4 b
Total males captured[2]	182.9 ±57.1	———

1) The sizes of cylindrical trap and sticky-card used are illustrated as table 1.
2) Mean±S. D. derived from 10 trials. Mean (±S. D.) number of males flew away for each trial was 322.0±51.0.
3) Data were transformed to arc sine $\sqrt{X}$ prior to analysis, and means in each column followed by the same letter were not significantly different at the 5% level according to Duncan's multiple range test.

在另行試驗所得結果顯示，A、B、C 三種長度圓筒形誘捕器之誘雄效率無顯著性差異（表四），惟將表中各種誘捕器之誘雄百分率資料轉換爲每10平方公分之誘雄數（表四），則亦以A型短圓筒形誘捕器在每 10 cm^2 面積中誘雄效率（2.8 隻）較B型（1.8 隻）或C型（1.7 隻）長圓筒形者爲高，且具顯著性差異。並且比較A型圓筒形誘捕器與 Moreno's 誘捕器[6]對雄蟲之誘捕效率，結果顯示二者之誘雄效率分別爲 49.3 及 50.7%（表五），無顯著性差異。因A型圓筒形誘捕器較其他型式誘捕器，具備高誘蟲效率而其製作亦低廉，將來可提供田間應用之需要。

表四、三種長度圓筒形誘捕器對柑桔粉介殼蟲雄成蟲誘捕之影響

Table 4. Influence of length of cylindrical traps baited with forty 9-day-old virgin females of *Planococcus citri* on male captures.

Trap type[1)]	% of total males captured[2)]	No. of males captured per 10 cm^2 sticky surface[2)]
A	35.1 ± 3.5[3)] a	2.8 ± 2.2[3)] a
B	28.8 ± 4.7 a	1.8 ± 1.3 b
C	36.1 ± 7.1 a	1.7 ± 1.2 b
Total males captured[2)]	157.2 ±82.8	———

1) The size of cylindrical trap and sticky-card used are illustrated as table 1.
2) Mean±S. D. derived from 6 trials. Mean (±S. D.) number of males flew away for each trial was 412.2±137.9.
3) Data were transformed to arc sine $\sqrt{X}$ prior to analysis, and means in each column followed by the same letter were not significantly different at the 5% level according to Duncan's multiple range test.

表五、Moreno 式與圓筒形A型誘捕器對柑桔粉介殼蟲雄成蟲之誘捕效力

Table 5. Trapping efficiency of Moreno's and cylindrical type A traps baited with forty 9-day-old virgin females of *Planococcus citri* on males.

Trap type	% of total males captured[1)]
Moreno's	50.7 ± 8.1
Cylindrical type A	49.3 ± 8.1 n. s.[2)]
Total males captured[1)]	88.9 ±44.7

1) Mean±S. D. derived from 10 trials. Mean (±S. D.) number of males flew away for each trial was 453.1±46.1.
2) No significant different at 5% level by t-test.

二、紅、白色圓筒形誘蟲器與黏膠板之組合對雄蟲誘捕之影響

以紅、白顏色圓筒形誘蟲器分別搭配紅、白顏色黏膠板，組成四種不同顏色之性費洛蒙誘捕器，並測定其對柑桔粉介殼蟲雄蟲誘捕之影響，其結果如表六。資料顯示四種不同顏色性費洛蒙誘捕器對雄蟲之誘捕效率不具顯著性差異，關於此點，與黃和朱曾認爲柑桔粉介殼蟲雄蟲對紅顏色性費洛蒙誘捕器具顯著偏好性者

有異[1]，此似與二者所供試誘捕器構造之不同，致影響雌蟲所分泌費洛蒙流出氣團之型式及雄蟲對顏色反應行爲改變有關。Moreno *et al.* 及 Rice & Moreno 曾各研究黃圓介殼蟲 (*Aonidiella citrina*) 及加州圓介殼蟲 (*Aonidiella aurantii*) 雄蟲對顏色的偏好性，指出誘捕器不含雌性費洛蒙時，以黃、白色黏膠板較其他顏色者，對兩種硬介殼蟲之雄蟲具顯著性誘蟲效果[5,7]。但在誘捕器中含有性費洛蒙時，除黑色黏膠板之誘雄效果特差外，其他顏色黏膠板誘捕雄蟲數之間則無顯著性差異。Rice & Moreno 認爲是性費洛蒙強烈的誘引力掩蔽了 (Masking) 雄蟲對顏色的偏好性[7]，惟確切原因，有待進一步探討。

表六、紅、白兩色不同組合圓筒形誘捕器對柑桔粉介殼蟲雄成蟲誘捕之影響

Table 6. Influence of red and white combined colored cylindrical traps baited with forty 9-day-old virgin females of *Planococcus citri* on male captures.

Trap color[1)]	% of total males captured[2)]
RR	21.9 ± 7.2
RW	21.0 ± 5.9
TR	28.4 ± 7.0
TW	28.7 ± 7.0 n. s.[3)]
Total males captured[2)]	113.0 ±70.5

1) RR means red plastic trap with red sticky plate, RW means red plastic trap with white sticky plate, TR means transparent plastic trap with red sticky plate, TW means transparent plastic trap with white sticky plate.
2) Mean±S. D. derived from 10 trials. Mean (±S. D.) number of males flew away for each trial was 436.7±68.4.
3) Data were transformed to arc sine $\sqrt{X}$ prior to analysis, and no significant difference between means at 5% level according to Duncan's multiple range test.

三、費洛蒙誘捕器放置高度對雄蟲誘捕之影響

誘捕器放置的高度對雄蟲之誘捕效率具顯著性之影響（表七）。誘捕器吊置於離釋放雄蟲平面下 50 cm 處時，其誘雄效率顯著地最差（13.1%），而置於與釋放雄蟲同一平面高度時，其誘雄效率最佳（50.0%），若置於距釋放雄蟲平面 50 cm 高處時，其誘雄率居中（36.9%）。前人研究誘捕器擺置高度對梨圓介殼蟲、黃圓介殼蟲、加州圓介殼蟲雄蟲誘捕之影響時，亦顯示懸掛於果樹中、上層高度的誘捕器較下層者，能夠誘捕更多雄蟲[4,5,8]。

目前未曾有商品化的柑桔粉介殼蟲性費洛蒙誘捕器上市，Moreno *et al.* 曾以所謂 "Moreno type" 的誘捕器[6]，進行該粉介殼蟲發生消長之偵測，惟其構造複雜，操作不易。最近帳幕形誘捕器被廣泛用來誘捕偵測加州圓介殼蟲及梨圓介殼蟲之發生[4,9,11]，因其係紙質構造，極易受雨、露破壞而變形失效。本試驗結果顯示，圓筒形誘捕器之誘雄效率不亞於前述諸種誘捕器；並以口徑 8 cm 及長度 8 cm 透明塑膠筒，裝配 8×12.5 cm 之白色黏膠紙板組成捕蟲器，捕蟲器再與處女蟲或合成性費洛蒙劑組合成誘捕器，此種誘捕器設計較前述諸種誘捕器，具製作簡易、有效、防雨塵、耐用及操作容易等多項特性，故其頗具實用價值。而實際設置誘捕器時，宜將其吊掛於果樹中、上層高度較具誘蟲效果。

表七、柑桔粉介殼蟲費洛蒙誘捕器懸掛高度對雄成蟲誘捕之影響

Table 7. Influence of height of cylindrical traps baited with forty 9-day-old virgin females of *Planococcus citri* on male captures.

Trap height	% of total males captured[1)]
50 cm above released level[2)]	36.9 ± 5.6[3)] b
Same as released level	50.0 ± 2.8 a
50 cm below released level	13.1 ± 6.5 c
Total males captured[1)]	265.5 ±55.1

1) Mean±S.D. derived from 6 trials, Mean (±S.D.) number of males flew away for each trial was 423.3±25.2.
2) The released level is ca. 100 cm above the floor.
3) Data were transformed to arc sine $\sqrt{X}$ prior to analysis, and means followed by the same letter were not significantly different at the 5% level according to Duncan's multiple range test.

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