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Comparative performance of traps for the Mediterranean fruit fly *Ceratitis capitata* Wiedemann (Diptera: Tephritidae) baited with female-targeted or male-targeted lures

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Summary: Results of trapping trials in Italy confirmed that the non-sticky CSALOMON® VARs+ funnel trap was highly efficient for the capture of Mediterranean fruit fly (*Ceratitis capitata* Wiedemann) (Diptera: Tephritidae), when baited with either male-targeted (trimedlure), or synthetic female-targeted (ammonium carbonate, ammonium acetate, trimethylamine, putrescine) baits. Trimedlure-baited traps cauught ten times more flies (all males), than traps with synthetic female-targeted lures (which cauught predominantly females). Although less efficient, traps with the female-targeted lures had the significant advantage over trimedlure that they attracted predominantly females, so in cases when for control or experimental purposes the capture of female flies is more informative (i.e. timing of egg-laying, fertility and fecundity studies, etc.), these lures would be the best choice. The present results suggested that putrescine could be left out from female-targeted lure combinations without dramatic change in activity.

Key words: VARs+ funnel trap, trapping, Mediterranean fruit fly, *Ceratitis capitata,* ammonium acetate, putrescine, trimethylamine, ammonium carbonate, trimedlure

Introduction

The Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann), is among the most important pests of very many fruits and vegetables worldwide (*Liquido* et al., 1997). In Hungary, the species has regularly been detected, however it appears that the specimens were not overwintering insects, rather insects introduced during the season by fruit commerce (Papp 1994). Due to global warming however, the invasion of *C. capitata* into Central Europe can occur with increasing chance. The usefulness of pheromone-baited traps in detection of similar invasions of some other new pests preferring warmer climate, i.e. the cottom bollworm *Helicoverpa armigera* Hbn. have been documented (*Szöcs* et al. 1994, 1995). In this situation knowledge of characteristics of trapping devices for detection and monitoring of *C. capitata* is of significant importance.

Male-targeted trapping systems for this pest typically use a formulation of trimedlure, a blend of the isomers of tert-butyl esters of 4- and 5-chloro-2-methylcyclohexanecarboxylic acids (*Beroza* et al., 1961). This male-targeted attractant is in very widespread use in trapping studies on *C. capitata* worldwide.

As for female attractants, ammonium carbonate has long been known to attract several fruit fly spp., including *C. capitata* (*Gothilf & Levin*, 1989, *Reynolds & Prokopy*, 1997). Later on, chemical attractants for female *C. capitata* have been optimized to contain ammonium acetate and putrescine (1,4-diaminobutane), and the additon of trimethylamine as a third component was claimed to be synergistic (*Heath* et al., 1995, 1997). Traps baited with the above three compounds proved to be effective in capturing female *C. capitata* in several countries worldwide (*Epsky* et al., 1999). However, later *Heath* et al. (2004) reported that the ternary ammonium acetate / trimethylamine / putrescine combination was not catching significantly more *C. capitata* than the binary ammonium acetate / trimethylamine combination in 3, 4 and 4 cases out of 5 experiments (males, females, and total flies, resp.).

Most studies in the literature report on tests with either the male-targeted, or the female-targeted *C. capitata* attractants. The present research was undertaken with the principal aim of comparing how these two types of attractants perform in parallel trapping tests, so that their value and usefulness in different monitoring situations can be evaluated. Also, since in our earlier studies the modified funnel trap design CSALOMON® VARs+ (baited with trimedlure) proved to be more efficient than conventional sticky trap designs (*Tóth* et al., 2004), the two types of baits were tested parallelly in both VARs+ and sticky traps. Additionally, a treatment of VARs+ traps with baits lacking putrescine was also included to cross-check the necessity of this compound in female-targeted baits.

Material and method

Experimental site

Trapping tests were performed in experimental peach (the late cv Regina Bianca) orchards of the Ciampino Institute (Italy), from August 22 to October 30, 2006, with 4 replicate blocks. Traps were suspended from branches in the crown of peach trees, at a height of ca 1.5–1.7 m. One replicate of each treatment was incorporated into a block so that individual treatments were 5–8 m apart and blocks were sited 15–20 m apart.

Capture data were transformed to $(x+0.5)^{1/2}$ and were analysed by ANOVA. Treatment means were separated by Games-Howell post-hoc test (*Games & Howell*, 1976, *Jaccard* et al., 1984). In case one or more of the treatments were catching nil, significant difference from zero catch was calculated by Bonferroni-Dunn post-hoc test (see also Table legends).

All statistical procedures were conducted using the software packages StatView® v4.01 and SuperANOVA® v1.11 (Abacus Concepts, Inc., Berkeley, USA).

Trap types

The modified funnel CSALOMON® VARs+ traps (Plant Prot. Inst., HAS, Budapest, Hungary) (*Figure 1*) were originally developed as a high capacity trapping device for the corn rootworm *Diabrotica v. virgifera* LeConte (Coleoptera: Chrysomelidae) (*Tóth* et al., 2000), and were found to be very efficient later on for the capture of *C. capitata* (*Tóth* et al., 2004, 2006). For killing insects captured we added a small (1 x 1 cm) piece of a household anti-moth insecticide strip (Chemotox® Sara Lee, Temana Intl. Ltd, S!outh, UK; active ingredient 15% dichlorvos). The bait was attached to the roof, so that the bait dispenser was positioned into the middle of the large hole on the roof (trimedlure), or was placed just above the large hole on the roof, below the plastic cone (female-targeted lure). (Photos of the VARs+ trap can be viewed at www.julia-nki.hu/traps)

Sticky traps used were the ISAGRO „Pagoda Traptest" traps with sticky floors (ISAGRO, Milano, Italy)

Chemicals

Commercial trimedlure was a generous gift sample from A.B. DeMilo (USDA, Beltsville, USA).

Ammonium carbonate, ammonium acetate, putrescine and trimethylamine hydrochloride were purchased from Reanal Fine Chemicals Ltd. (Budapest, Hungary) and were >95% pure as stated by the supplier.

Baits

For formulating the male-targeted baits, 600 mg of trimedlure was administered onto a 1 cm piece of dental roll (Celluron®, Paul Hartmann Ag. Heidenheim, Germany),

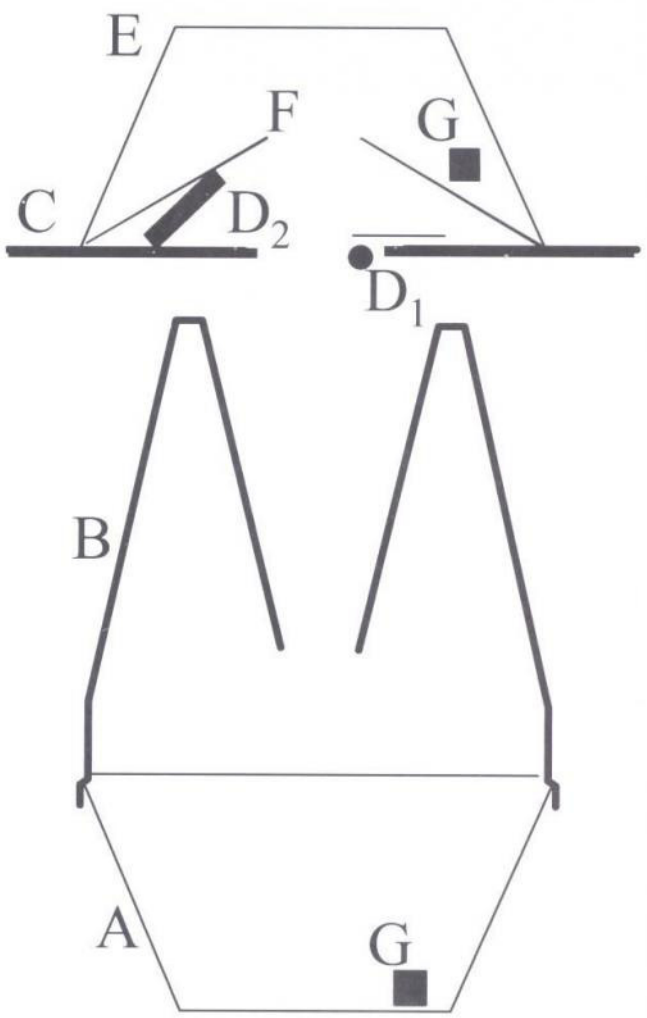

Figure 1 Diagram of cross view of the modified funnel VARs+ traps. A = lower catch container (transparent plastic); B = plastic funnel; C = plastic lid; D_1 = bait dispenser (trimedlure, putrescine); D_2 = bait dispenser (ammonium carbonate, ammonium acetate, trimethylamine); E = upper catch container (transparent plastic); F = cone (transparent plastic); G = small piece of anti-moth strip.

which was put into a tight polyethylene bag (size 1 cm x 1.5 cm) made of 0.02 mm linear polyethylene foil.

For female-targeted baits, 2 g of each of ammonium carbonate and ammonium acetate crystals were weighed and introduced into a single 5 x 5 cm polyethylene bag covered with alufoil, and the bag was sealed. There was a ca 1 cm diameter circular hole on the covering alufoil, so that volatiles from the active ingredients could evaporate through the surface of the polyethylene below this hole. Trimethylamine hydrochloride (2 g) was formulated separately, in similar dispensers, while putrescine (1 ml) was formulated in polyethylene bags with dental roll, similar to the trimedlure dispensers.

All dispensers were wrapped singly in pieces of alufoil and were stored at -18 °C until use.

Results and discussion

VARs+ traps baited with trimedlure caught ca. one magnitude more flies than traps baited with female-targeted lures (*Table 1*). Only males were found in traps with

Table 1 Mean catches of *C. capitata* in two trap designs baited with trimedlure or combinations of ammonium carbonate, ammonium acetate, putrescine and trimethylamine. Means with same letter within one column not different significantly at P=5% by ANOVA, Games-Howell, Bonferroni-Dunn.

Bait composition					Trap type	Mean caught (±SE)		
trimedlure	ammonium carbonate	ammonium acetate	putrescine	trimethyl-amine		males	females	both sexes
YES	no	no	no	no	VARs+	102.43±10.35 d	0.00±0.00 a	102.43±10.35 d
YES	no	no	no	no	sticky	20.45±3.33 c	0.11±0.09 a	20.55±3.32 c
no	YES	YES	YES	YES	VARs+	0.75±0.20 b	6.64±1.53 b	6.27±1.42 b
no	YES	YES	YES	YES	sticky	0.02±0.02 a	0.14±0.07 a	0.14±0.07 a
no	YES	YES	no	YES	VARs+	1.45±0.39 b	10.42±1.96 b	10.14±1.94 b

trimedlure, while the ones baited with female-targeted lures caught ca. 80–90% females. There was no significant difference in catches of female or male flies, or catches of both sexes together, between traps with baits containing or lacking putrescine (*Table 1*). This appears to support results of *Heath* et al. (2004), who also reported that good *C. capitata* catches were achieved with baits lacking putrescine. Catches in sticky traps showed the same tendencies as those in VARs+ traps, but were always significantly lower (*Table 1*), irrespective of bait type. This confirms earlier results with trimedlure baits, where the VARs+ trap performed better as compared to sticky trap designs (*Tóth* et al., 2004, 2006).

When the seasonal distribution of catches was studied (*Figure 2*), traps with trimedlure detected the presence of *C. capitata* ca. one week before than traps with female-targeted baits. Later catches until the beginning of October showed similar trends and did not show any outstanding differences between the two bait types. However, trimedlure-baited traps continued to catch sizeable numbers of flies until the beginning to November, while traps with female-targeted baits produced only very low catches after the beginning of October.

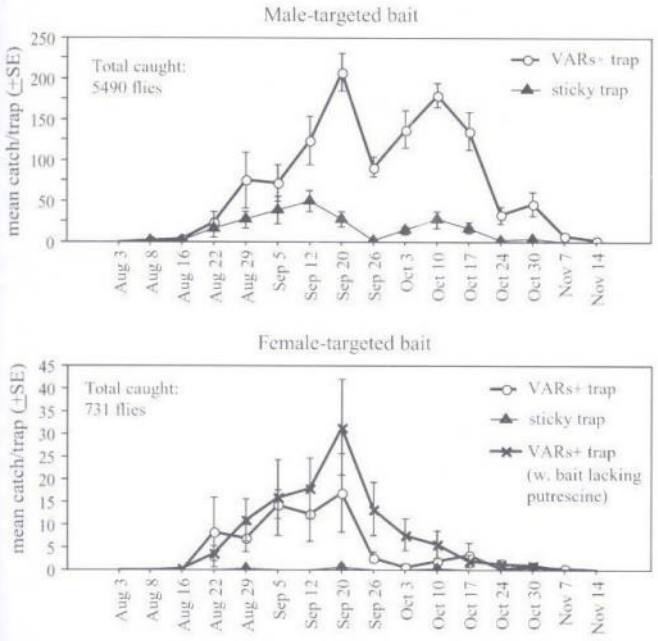

Figure 2 Seasonal catches of *C. capitata* in two trap designs baited with trimedlure (as male-targeted bait) or a combination of ammonium carbonate, ammonium acetate, putrescine and trimethylamine (as female-targeted bait).

The trends in flight pattern were more readily recorded in the non-sticky trap type (VARs+) due to higher fly numbers caught at all inspection dates, with any of the baits (*Figure 2*).

Conclusions

In conclusion, the present results confirm that the non-sticky VARs+ trap is highly efficient for the capture of *C. capitata*, not only when baited with trimedlure (*Tóth* et al., 2004) but also when used with the synthetic female-targeted bait.

In the present study trimedlure-baited traps appeared to be ca. one magnitude more sensitive than traps with female-targeted lures, so it is tempting to suggest that for early detection purposes one should prefer trimedlure-baited

Photo 1: The CSALOMON® VARs+ funnel trap catching *C. capitata*.

trapping devices. In contrast to our results, *Papadopulos* et al. (2001) reported that capture of *C. capitata* in trimedlure-baited traps occurred 2–4 weeks after flies were detected with the female-targeted synthetic lure. At present we cannot offer any explanation for the discrepancy.

Although less efficient, traps with the female-targeted lures have the significant advantage over trimedlure that they attract predominantly females, so in any situation when for control or experimental purposes the capture of female flies is needed (i.e. timing of egg-laying, fertility and fecundity studies, etc.), these lures are the best choice.

The present results suggest that putrescine can be left out from female-targeted lure combinations without dramatic change in activity.

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