Crop Protection 30 (2011) 617–622

Contents lists available at ScienceDirect

Crop Protection

journal homepage: www.elsevier.com/locate/cropro

A comparison of monitoring systems used for *Ceratitis* species (Diptera: Tephritidae) in South Africa

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ARTICLE INFO

Article history:
Received 4 May 2010
Received in revised form
24 January 2011
Accepted 28 January 2011

Keywords:
Ceratitis capitata
C. cosyra
C. rosa
Sensus trap
BioLure
Capilure
Monitoring

ABSTRACT

For 16 years a bucket-type trap known as the Sensus fruit fly trap has been used to monitor three fruit fly pest species *Ceratitis capitata*, *Ceratitis rosa* and *Ceratitis cosyra* in South African fruit industries. The relative efficiencies of lures sold for monitoring fruit flies with the Sensus trap in South Africa were determined in field experiments where laboratory-reared *C. capitata, C. rosa* and *C. cosyra* were released in a mango orchard within a few metres of Sensus traps containing either Capilure (trimedlure or tert-butyl 4 (or 5) -chloro-2-methylcyclohexane carboxylate), Ceratitislure (protein hydrolysate plus β-caryophyllene) or Questlure (protein hydrolysate plus plant extracts). When using 12-day-old flies, Capilure caught 3 times more *C. capitata* males than *C. rosa* males and this difference was more extreme when 3-day-old flies were released. Ceratitislure caught significantly more 12-day-old *C. cosyra* males than 12-day-old *C. capitata* males, but the difference was reversed when 3-day-old flies were compared. Questlure showed the least differences between species and age but recovered the lowest proportion of released species. Further comparisons were conducted in an orchard with wild flies using other known attractants in larger yellow Probodelt bucket traps. Capilure caught more male *C. capitata* than BioLure Fruit Fly 3-component, but BioLure 2-component (trimethylamine and ammonium acetate) was more effective than Questlure for *C. capitata* females. The 3-component lure was also more effective than both Capilure and Questlure for male and female *C. rosa*, respectively. Ceratitislure was the most effective lure for male *C. cosyra* flies and BioLure 3-component was more effective than Ceratitislure and Questlure for female *C. cosyra* flies. The intervention threshold of 4 flies/trap/week previously used in citrus with Capilure for *C. rosa* was lowered to 2 *C. rosa*/trap/week when using the Sensus trap due to the lower sensitivity of this trap-lure combination found for *C. rosa* in this study. The 3-component lure, or the 2-component combination of trimethylamine and ammonium acetate in a ratio of 1:8 in the Sensus trap capsule, would be more effective for both sexes of all three *Ceratitis* species than the Questlure that is currently being used.

1. Introduction

In South Africa, the three tephritid species *Ceratitis (Ceratitis) capitata* (Wiedemann), Medfly, *Ceratitis (Pterandrus) rosa* Karsch, Natal fly, and *Ceratitis (Ceratalaspis) cosyra* (Walker), Marula fly, are considered to be the most economically important fruit flies on horticultural crops (Annecke and Moran, 1982). *C. capitata* is widely distributed throughout South Africa while *C. rosa* is more common in the eastern and northern parts of the country. *C. cosyra* is not found in the cooler southern regions but is a tropical to subtropical species that is more common in the north of the country. In the 1970s when the monitoring of fruit fly was first introduced (Georgala, 1970), the citrus industry opted for a male-targeted trapping system consisting of a 'dry' trap. This comprised a modified Steiner trap, baited with trimedlure (tert-butyl 4, (or 5), -chloro-2-methylcyclohexane carboxylate) (Steiner, 1957). Most of the citrus production areas had both *C. capitata* and *C. rosa* and the males of both these species are attracted to trimedlure (later Capilure (Nakagawa et al., 1981), comprising approximately 70% trimedlure and 30% proprietary extenders, was used). No intervention thresholds were developed in South Africa for the use of this trap in citrus but by the 1980s it had become accepted that if 1 or more flies (either *C. capitata* or *C. rosa*) were being caught in the trap within a week, additional control measures were warranted. One trap was generally used for every 6 ha of citrus. The need for a more sensitive trap where an intervention threshold could be

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doi:10.1016/j.cropro.2011.01.005

used, led to the development of the Sensus trap baited with Capilure (Buitendag and Naude, 1994). The intervention threshold used with this system for both *C. capitata* and *C. rosa* was initially 7 males per week but this was lowered to 4 males per week in 2003 (Ware, 2003) and 1 trap per 3 ha recommended.

An alternative lure, Ceratitislure (Green Trading, Pretoria, South Africa) containing protein hydrolysate and β-caryophyllene, was found to be very effective against male *C. cosyra* and was used primarily in mango orchards (Buitendag and Naude, 1997). A few years later, Questlure (Green Trading, Pretoria, South Africa), containing protein hydrolysate and various plant extracts, became available and was useful because it caught female flies of all three economically important *Ceratitis* species. The intervention threshold used with this lure in the Sensus trap was 2 male flies per week (Ware, 2003) or 1 female fruit fly. In 2001 the Sensus trap was modified to make the lid attachment more secure but the overall design with the 12 peripheral entrance holes in the top edge of the bucket remained the same (Fig. 1). Typically, citrus farmers will use 2 Sensus traps in blocks of citrus up to 6 ha in size with 1 trap containing Capilure to monitor males, and the other trap containing Questlure to monitor females, of *C. capitata* and *C. rosa* (Manrakhan and Grout, 2010). Although the 3-component lure (Suterra BioLure Fruit Fly) (Heath et al., 1997; Robacker and Czokajlo, 2005) is available in South Africa, intervention thresholds have not been developed for this lure so few growers of horticultural crops use it.

International markets receiving fruit from South Africa require assurances that fruit flies are monitored in orchards and control methods are increased when intervention thresholds are exceeded. However, the lures currently in use in the Sensus monitoring system have not been compared with internationally recognised lures such as the 3-component lure, so this required investigation. Relative attraction to the South African lures by the three economically important *Ceratitis* spp. in South Africa was previously determined on an experimental farm near Nelspruit (Ware, 2002) but the size of the wild populations of each species of fruit fly was unknown when the lures were compared, so the relative attractiveness of lures between species could not reliably be determined. In this study, we determined the relative attractiveness of the three fruit fly attractants used in South Africa through mark-release-recapture field experiments using known numbers of flies. We also compared the South African lures with other commercially-used trap-lure combinations.

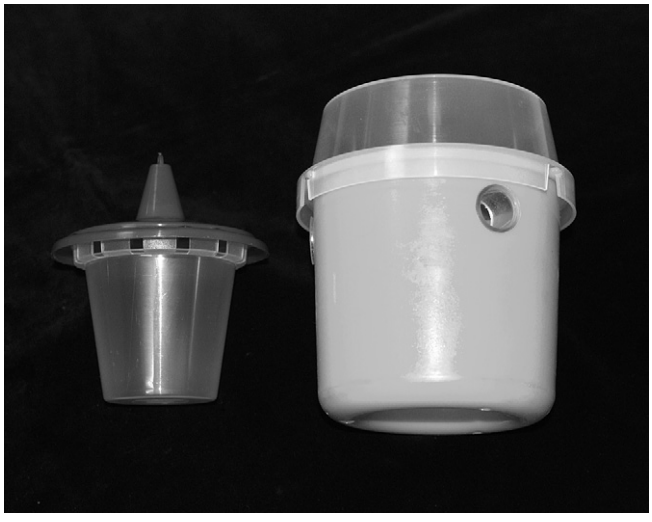

Fig. 1. The Sensus trap on the left with a royal blue lid and transparent container and the Probodelt bucket trap having a yellow container and a transparent lid.

2. Materials and methods

2.1. The competitive efficiency of Questlure, Ceratitislure and Capilure in Sensus traps when using a known number of released flies

Colonies of *C. capitata*, *C. rosa* and *C. cosyra* have been maintained at Citrus Research International (CRI) in Nelspruit, South Africa since 1999; wild male flies are selected from flies emerging from collected fruit and added to the culture at regular intervals to ensure genetic diversity. In 2005, adult *C. capitata*, *C. rosa* and *C. cosyra* from the CRI colonies at Nelspruit were marked with Dayglo fluorescent dye and packaged in 18 lots of 500 (equal numbers of males and females). Protein was withheld, although the adults were allowed more water and granulated white sugar than they required. The flies were released 2–3 days after eclosion.

The flies were transported to the release site, a harvested mango (*Mangifera indica* L.) orchard at Neos Estates (25°39′47.44″S and 31°34′47.37″E) in the Onderberg area of Mpumalanga Province, South Africa. A single lot of *C. capitata* was placed under a tree in a selected row (designated the release row). The lid of the holding container was removed and the flies were allowed to disperse naturally. *C. cosyra* flies were released under the adjacent tree and *C. rosa* flies under the following tree in the same release row. Tree spacing in the row was 3 m and the trees were approximately 3 m high. The sequence of releases was repeated 18 times in the same row and a total of 9000 individuals of each species were released. Releases were made between 10h00 and 11h00 during dry, sunny weather. The trial was conducted three times on 27 May, 9 June and 15 July 2005.

The Sensus trap (River Bioscience, Port Elizabeth, South Africa) was used to compare the South African lures. This trap is a clear, plastic bucket trap (85 mm deep with a top diameter of 98 mm and a bottom diameter of 57 mm) with a blue, overhanging lid (Fig. 1). There are 12 rectangular entrance holes (7 × 8 mm) evenly spaced around the top edge of the clear bucket, 16 mm apart. The 3 attractants tested in the Sensus traps were Capilure, Ceratitislure and Questlure (all obtained from River Bioscience, Port Elizabeth, South Africa). The same quantity (2.5 g) of each attractant was placed on a sponge in a plastic capsule that clipped into the lid of the trap. Dichlorvos in the form of an impregnated plastic block (8 × 10 × 15 mm) was used in each trap to kill the captured flies. Sensus traps were placed in trees that were two rows east of the release row (approximately 13 m away as rows were 6.5 m apart) and were emptied before each release. A Sensus trap containing Questlure was placed in a tree. Three trees further down the row a Sensus trap with Ceratitislure was hung and a further 3 trees down the row a Sensus trap with Capilure was used. The sequence was repeated until 6 traps of each Sensus-lure combination were positioned along one row. This arrangement of Sensus traps with lures was repeated 2 rows (13 m) west of the release row giving a total of 12 replications per lure. All lures and dichlorvos blocks were replaced on 15 July for the third release and trapping was terminated 2 weeks after the third release.

The traps were monitored and emptied daily for the first 6 days after a release of flies, and weekly for 2 weeks thereafter. However, by the fifth day after release, numbers of released flies being caught were almost negligible so only the first 4 days after release were used for comparison purposes. All flies caught were taken to the laboratory where they were checked for the presence of dye (to confirm that they were released flies) and identified to species (based largely on thoracic markings) and sexed. The recovery rate for the flies attracted to the different lures could then be determined.