МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ
ПО БИОЛОГИЧЕСКОЙ БОРЬБЕ
С ВРЕДНЫМИ ЖИВОТНЫМИ
И РАСТЕНИЯМИ

ВОСТОЧНОПАЛЕАРКТИЧЕСКАЯ
СЕКЦИЯ

INTERNATIONAL ORGANIZATION
FOR BIOLOGICAL CONTROL
OF NOXIOUS ANIMALS
AND PLANTS

EAST PALEARCTIC SECTION

Информационный бюллетень
№ 42

ФЕРОМОНЫ В СЕЛЬСКОМ И ЛЕСНОМ ХОЗЯЙСТВЕ: ПРАКТИКА И ПЕРСПЕКТИВЫ

БЫКОВО, 2011

FROM THE DEVELOPMENT OF PHEROMONE TRAPS TO PRACTICAL APPLICATIONS: THE EXAMPLE OF THE WESTERN CORN ROOTWORM *DIABROTICA V. VIRGIFERA*, INVADING EUROPE

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Key Words: western corn rootworm, traps, pheromone, floral bait, etection, monitoring

Западный кукурузный жук (ЗКЖ) является одним из важнейших инвазивных вредителей сельского хозяйства в Европе. Он появился первоначально в Сербии и быстро стал распространяться в странах Центральной и Западной Европы. Изучением возможностей применения феромонов для мониторинга распространения этого вредителя мы занимаемся в течение последнего десятилетия.

Для привлечения жуков в ловушки обычно используют один или более визуальных или химических стимулов. Наиболее известный из числа визуальных стимулов – это оттенки желтого цвета, которые аттрактивны для многих насекомых, в том числе и для ЗКЖ.

В качестве химических стимулов используют половой феромон, привлекающий самцов. В некоторых случаях используют синтетический пищевой аттрактант, привлекающий как самцов, так и самок.

Типы ловушек также различаются по использованию методов фиксации прилетевших в них насекомых. Для такой фиксации можно использовать несохнущий клей. А в безклеевых ловушках используют инсектицидные пластины или воронки, не дающие насекомым вылетать из приемной части.

У довольно популярных клеевых ловушек есть несколько важных отрицательных особенностей. Во-первых, на клеевые поверхности прилипает много нецелевых насекомых. Во-вторых, регулярное удаление прилипших насекомых обязательно, но оно не только трудоемко, но часто сопряжено с неприятными контактами с клеем.

Безклеевые ловушки обычно производительней клеевых, они более избирательны по отношению к нецелевым объектам. Но они сложнее устроены, чем клеевые и в них желательно всегда добавлять инсектицид (возможно в разных препаративных формах, но чаще в виде пластин) для умертвления пойманных насекомых.

Феромонные ловушки, без сомнения, являются наиболее чувствительным инструментом, позволяющим выявлять ЖКЗ, хотя они вылавливают только самцов. Они превосходят по своей эффективности

цветовые ловушки желтого цвета, но зато такие ловушки вылавливают как самцов, так и самок.

Abstract

The western corn rootworm (WCR) ranks among the most important new insect pests in Europe. It first appeared in Europe in the early nineties, and by now most countries of Central and Western Europe are infested. My institute took a significant part in the research and development of trapping devices for WCR in the past decade.

Trapping devices for WCR exploit one or more visual or chemical stimuli for attracting the beetles into the trap. The best known visual stimulus can be several hues of bright yellow colour. WCR, common to many other insects, is attracted to objects in yellow.

Chemical stimuli include synthetic sex pheromone, which attracts the males only. Another option is the synthetic floral bait, which attracts females, and to a lesser extent also males.

Trapping devices can be also classifed on the basis of the method they inhibit the insects once attracted to the trap from escaping. Sticky traps retain insects on a surface covered with non-drying glue. Non-sticky traps retain insects attracted by some funnel-like mechanical setup.

In general, sticky traps are of simple design and easy to set up. However, they have a limited catch capacity, they may catch many non-target insects, especially the yellow ones, and their maintenance in the field is dirty (sticky).

Non-sticky traps have a very high capacity, they are usually highly selective, but they are a more complicated device, and some killing agent must be added to kill beetles captured.

Pheromone baited traps are invariably the most sensitive in detecting the occurrence of WCR, but they catch only males. The activity of the pheromone bait overwhelms by far the activity of yellow colour as visual cue. Floral baited traps are usually less sensitive than pheromone baited ones, but the larger portion of the catch will be females.

Introduction

The western corn rootworm (WCR) ranks among the most important new insect pests in Europe. It first appeared in Europe in the early nineties (Camprag and Baca, 1995), and by now most countries of Central and Western Europe are infested.

In the present paper I attempt to summarize the main characteristics of attraction-based trapping devices which are in use for detection and monitoring of the western corn rootworm (WCR) *Diabrotica v. virgifera*. My institute took a significant part in the research and development of such devices in the past decade.

Stimuli exploited

Trapping devices for WCR exploit one or more visual or chemical stimuli for attracting the beetles into the trap.

The best known visual stimulus can be several hues of bright yellow colour. WCR, common to many other insects, is attracted to objects in yellow (Tollefson et al., 1975, Ball, 1982, Kuhar and Youngman, 1998).

Chemical stimuli include synthetic sex pheromone, which attracts the males only. Another option is the synthetic floral bait, which attracts females, and to a lesser extent also males.

Trap designs

Trapping devices can be also classifed on the basis of the method they inhibit the insects once attracted to the trap from escaping. Sticky traps retain insects on a surface covered with non-drying glue. Non-sticky traps retain insects attracted by some funnel-like mechanical setup. Practically proven combinations of the above characteristics are shown in Table 1.

In general, sticky traps are of simple design and easy to set up. However, they have a limited catch capacity, they may catch many non-target insects, especially the yellow ones, and their maintenance in the field is dirty (sticky). All sticky traps have the inherent deficiency that their capture efficiency changes over time (due to the changes in the "stickiness" of the sticky surface resulting from the collection of insects, plant debris, weathering, etc.), so such traps can predominantly be suggested to be used for qualitative trapping (detection).

Non-sticky traps have a very high capacity, they are usually highly selective, they do not change their efficacy over time, and can be operated over a longer time period, but they are a more complicated device than sticky traps, and some killing agent (i.e. small piece of insecticide like an anti-moth strip) must be added to kill beetles captured.

Pheromone-baited traps

Female WCR emits a pheromone by which she attracts the males for mating. The pheromone is available in synthetic form, and can be used as a bait (Guss et al., 1982). Pheromone baited traps catch only males, but they are of very high sensitivity. Such traps are the ideal tools for detection purposes. The activity of the pheromone bait overwhelms by far the activity of yellow colour as visual cue, so it is not advisable to add yellow colour to the design of pheromone-baited traps. In fact, in case of sticky designs, addition of yellow decreases specificity, through increasing the number of non-target insects caught (which also respond to yellow).

Conventional sticky Delta trap designs baited with the pheromone are not suitable for catching WCR, instead, trap designs with an open sticky surface are optimal (Tóth et al., 1996, 2003). The most widespread such pheromone trap used in Europe today is the CSALOMON® PAL (sticky cloak) trap (Tóth et al., 20023, Tóth 2005). Information on the spread and occurrence of WCR in European countries has largely been collected by using PAL traps in the past decade. The

EU-research project DIABROTICA (QLK5-CT-1999-01110) recommended to use PAL traps baited with pheromone as the standard detection tool for WCR in Europe. An example of a non-sticky trap design baited with the pheromone is the CSALOMON® KLPfero+, which, when compared with the sticky PAL, showed similar sensitivity, but was far more selective (Fig 1) (Tóth et al., 2006).

Floral baits

In the case of WCR it was also known that certain floral compounds isolated from pumpkin flowers exerted strong attraction towards both sexes of adult beetles (Metcalf, 1994). This bait was tested in transparent and yellow PAL-shaped sticky traps, and it appeared that the presence of yellow colour as visual cue was more important for females than for males, increasing female catches significantly (Tóth et al., 2003). Therefore a female-targeted sticky "cloak" trap (CSALOMON® PALs) became available with a sticky surface in yellow colour (Tóth et al., 2003, Tóth 2005). The PALs trap is baited with the floral lure. Although in most situations not as sensitive as the PAL trap with the pheromone, the great advantage of the PALs trap is that it catches predominantly females, and to a lesser extent also males (Imrei et al., 2002, Tóth, 2005). The non-sticky design CSALOMON® KLPflor+ (supplied also with floral bait) proved to be as sensitive as the sticky PALs (Fig. 2), but was found to be more selective towards females (Fig 3 - 4). At present the most efficient trap for catching female WCR is the KLPflor+ (Tóth et al., 2007).

For special purposes it is possible to operate traps (preferably non-sticky) with both the pheromone and floral baits together, since the two types of baits do not interfer with each other. In such a case the sex ratio captured will be close to the natural sex ratio of the population. A trap type supplied with both baits is the CSALOMON® VARs+ modified funnel trap, which was the first non-sticky trap design found suitable for the capture of WCR in Europe (Tóth et al., 2000, Tóth, 2005).

Practical use of the different trap types

The attractive activity of yellow sticky traps with no bait is very weak, so they can be advised to be used only by very high population densities (Imrei et al., 2002).

Suitability of the trapping devices discussed in the most frequent monitoring situations are shown in Table 2.

Acknowledgements

TM is greatly indebted to all cooperators who participated in one or more parts of the present research: Hungary: Gyula Törőcsik, Zoltán Imrei, Géza Vörös, István Ujváry, Zoltán Ilovai, István Szarukán, József Vuts, Italy: Lorenzo Furlan, Serbia: Ivan Sivcev, Ivan Tomasek.

This research was partially supported by grant NKFP07-A3-KUKBOGMV.

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Table 1. Main characteristics of trapping devices for WCR

Trapping device	Attractive stimulus			Trap design		Sex ratio
	visual yellow	chemical pherom.	chemical floral	sticky	non-sticky	(as compared to natural)
yellow sticky	yes	no	no	yes	no	more females
pheromone sticky (i.e. PAL)	no	yes	no	yes	no	>99% males
floral sticky (i.e. PALs)	yes	no	yes	yes	no	more females
pheromone non-sticky (i.e. KLPfero+)	no	yes	no	no	yes	>99% males
floral non-sticky (i.e. KLPflor+)	no	no	yes	no	yes	mostly females
combined bait non-sticky (i.e. VARs+)	no	yes	yes	no	yes	similar to natural ratio

Table 2. Suitability of trapping devices for WCR in different monitoring situations

Monitoring situation	yellow sticky, no bait	pherom. sticky (i.e. PAL)	floral sticky (i.e. PALs)	pherom. non-sticky (i.e. KLPfero +)	floral non-sticky (i.e. KLPflo r+)	combined bait non-sticky (i.e. VARs+)
First detection in an area (no previous record of WCR)	no	yes	no	yes	no	yes
Beginning of flight, non-quantitative seasonal monitoring (established populations)	no	yes	maybe	yes	maybe	yes
Catch of females for special purposes (medium to high established	maybe	no	yes	no	yes	yes, but non-optimal

populations)						
Quantitative seasonal monitoring (established populations)	no	maybe	maybe	yes	yes	yes
Establishment of thresholds, quantitative aspects (medium to high populations)	maybe (very high pops)	maybe, non-optimal	maybe, non-optimal	yes	yes	yes
Natural sex ratio, quantitative monitoring (medium to high populations)	no	no	no	no	no	yes

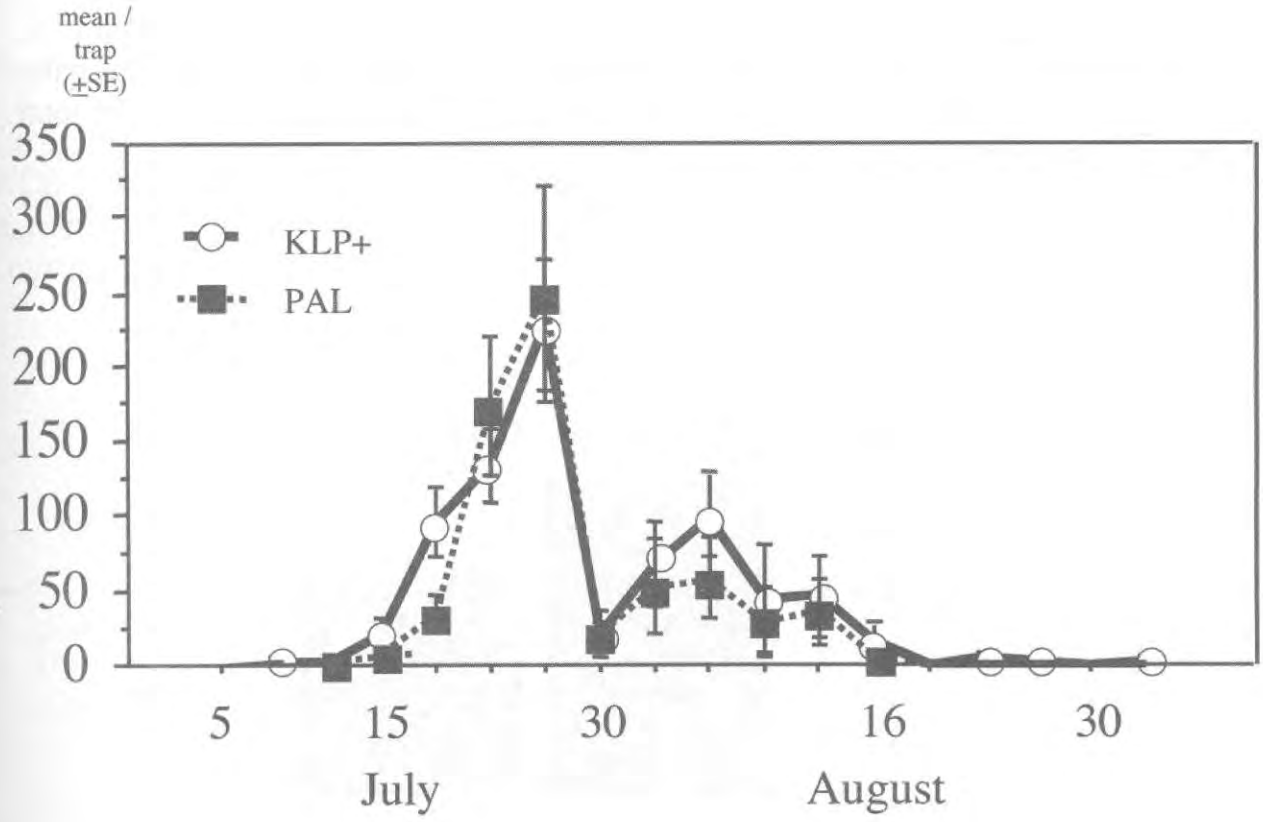

Fig 1. Seasonal distribution of mean WCR catches in KLP+ and PAL traps baited with pheromone. (Szekszárd, Hungary, 2004, after Tóth et al., 2006; total caught in test: 6077 beetles.)

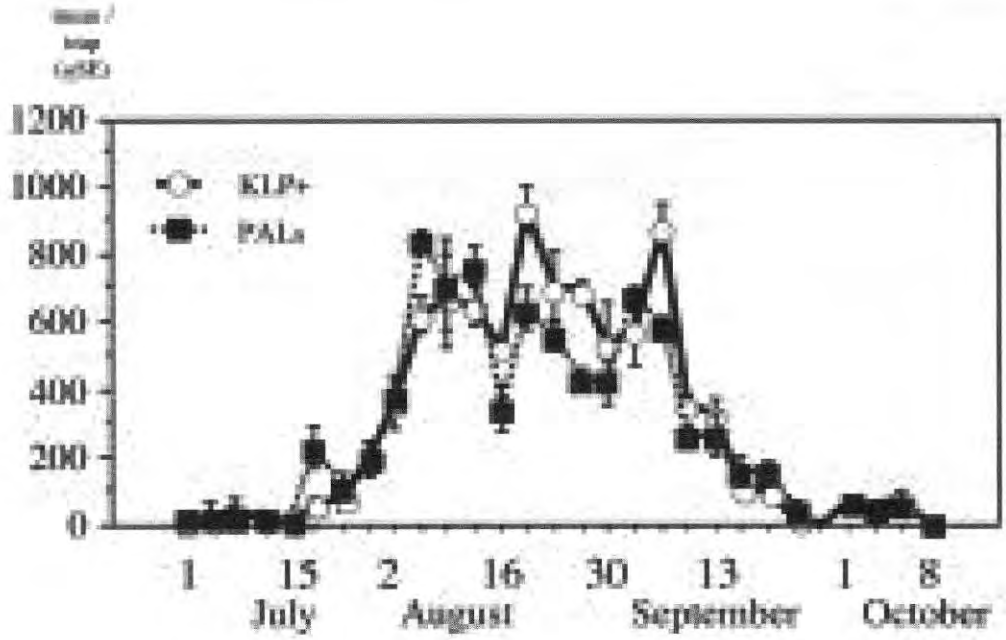

Fig 2. Seasonal distribution of mean WCR catches in KLP+ and PALs traps baited with the WCR floral bait. (Debrecen, Hungary, 2004, after Tóth et al., 2006; total caught in test: 66890 beetles.)

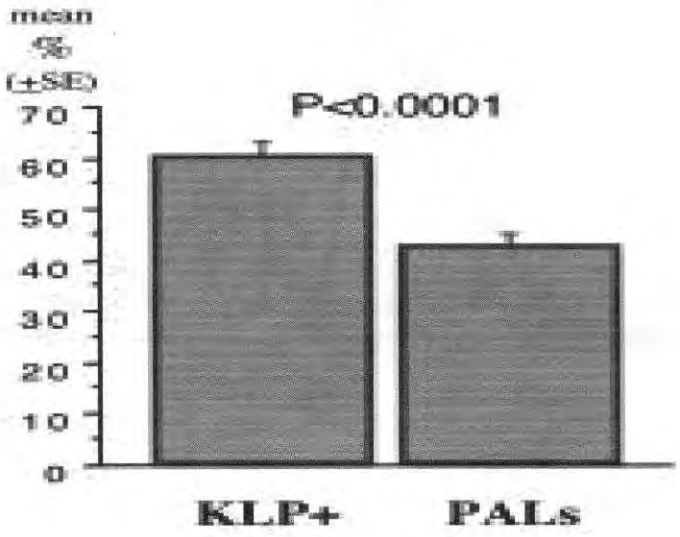

Fig 3. Mean female percentages of WCR in catches of KLP+ and PALs traps baited with the WCR floral bait. (Debrecen, Hungary, 2004, after Tóth et al., 2006; total caught in test: 66890 beetles.)

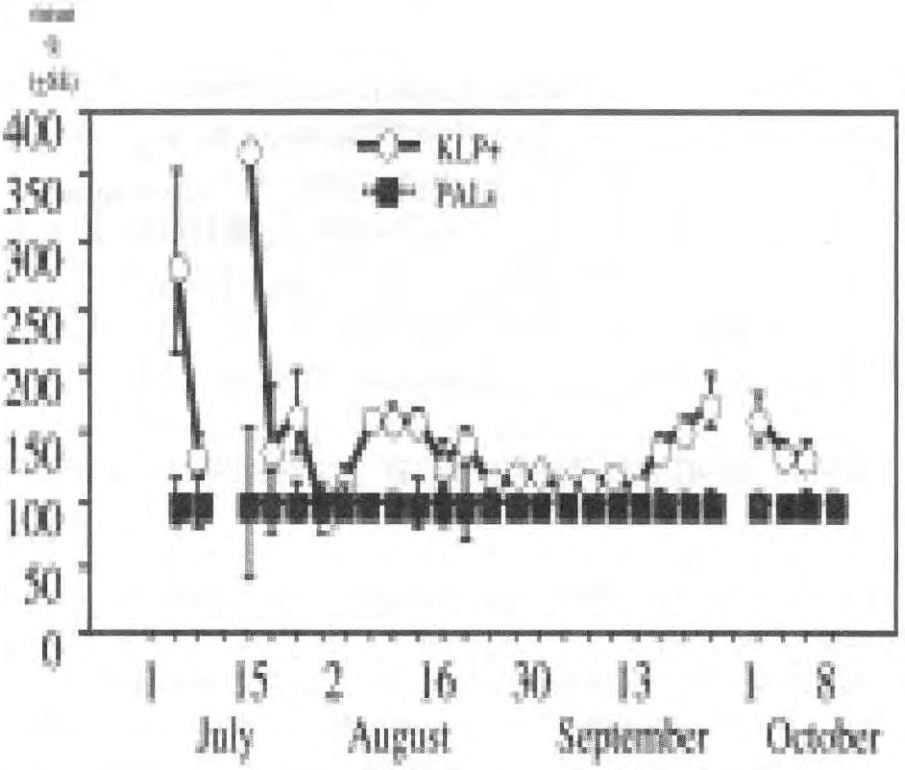

Fig 4. Mean female ratio (%) of WCR in KLP+ and PALs traps baited with the WCR floral bait, shown normalized against female ratio in PALs at the single inspection dates in the course of the experiment (Debrecen, Hungary, 2004, after Tóth et al., 2006).