

**EFFICACY OF DIFFERENT RATES OF SEXUAL PHEROMONE OF  
*Phthorimaea operculella* (ZELLER) (LEPIDOPTERA: GELLECHIIDAE)  
IN MALES OF POTATO TUBER MOTH CAPTURES**

**Efectividad de distintas dosis de feromona sexual de *Phthorimaea operculella* (Zeller) (Lepidoptera: Gelechiidae) en la captura de machos de polilla de la papa**

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**A B S T R A C T**

Potato tuber moth (PTM), *Phthorimaea operculella* (Zeller), widely world distributed, is one of the most serious insect pest attacking potatoes (*Solanum tuberosum* L.). Larvae develop in foliage and tubers of potato causing direct losses of edible product. Chemicals treatment to control this pest have shown limited efficacy, especially when larvae is under the soil. The utilization of synthetic pheromones as a tool that interferes with insects mating had been widely demonstrated in numerous moth and others insects species. With the objective to evaluate the efficacy of different doses of pheromone per trap in PTM males captures for its future utilization as a mass trapping technique, two experiments in a complete randomized blocks design, were carried out at Valle del Elqui, Coquimbo Region, Chile, during the summer season 2003-2004, and spring 2004. Doses of 0.2, 0.5, 1, 2 and 5 mg and 0.05, 0.1, 0.2, and 0.5 mg of PTM sex pheromone mixture (E4-Z7 Tridecadienil acetate, and E4-Z7-Z10 Tridecatrienil acetate at rate 1:1.5) per trap were evaluated. Results showed that pheromone's dispensers loaded with the rates of 0.2 and 0.5 mg, captured the larger numbers of PTM males per trap. With the optimization of the pheromone rate per trap, studies will continue to propose PTM mass trapping technique, a non chemical environmentally safe method of control.

**Key words:** potato tuber moth, pheromone, mass trapping.

**R E S U M E N**

La polilla de la papa, *Phthorimaea operculella* (Zeller) (Lepidoptera: Gelechiidae), es uno de los insectos plaga más importantes que atacan al cultivo de la papa (*Solanum tuberosum* L.). Las larvas se desarrollan en el follaje y tubérculos de papa causando pérdidas directas del producto a comercializar. Los tratamientos químicos para el control de esta plaga han mostrado eficiencia limitada, especialmente cuando la larva está bajo el suelo. La utilización de feromonas sintéticas como una herramienta que interfiere con el apareamiento, ha sido ampliamente demostrada en innumerables especies de polillas y otros insectos. Con el fin de evaluar la efectividad de diferentes dosis de feromona en la captura de machos de *P. operculella*, para su futura utilización como técnica de trapeo masivo, se realizaron dos ensayos en un diseño de bloques completos al azar, durante las temporadas verano 2003-2004, y primavera 2004, en el Valle del Elqui, Región de Coquimbo, Chile. Dosis de 0,2; 0,5; 1; 2 y 5 mg y 0,05; 0,1; 0,2 y 0,5 mg de la mezcla de las feromonas sexuales sintéticas de la polilla de la papa (E4-Z7 Tridecadienil acetate, and E4-Z7-Z10 Tridecatrienil acetate, en tasa de 1:1,5) por trampa. Los resultados obtenidos indican que la mayor captura de machos ocurre con dosis de 0,2 y 0,5 mg de feromona por trampa. Con la optimización de la dosis de feromona por trampa, los estudios continuarán para proponer la técnica de capturas masivas de polilla de la papa, como un método de control no químico y ambientalmente seguro.

**Palabras clave:** polilla de la papa, feromonas, trapeo masivo.

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## INTRODUCTION

The potato tuber moth, *Phthorimaea operculella* (Zeller) (Lepidoptera: Gellechiidae), is one of the pests that causes the most extensive damages in the field and storage of potatoes (*Solanum tuberosum* L.), especially in warm dry climates. The larvae of this insect develop on the leaves and tubers of the potato, causing direct losses of the product to be marketed (Salas *et al.*, 1985; Larraín, 2003).

In Chile, as in many other countries, the control of this pest is based in the application of wide spectrum insecticides; many of these are at present questioned due to their high toxicity. On the other hand, the chemical control of larvae is not possible when these infest the tubers under the ground, as this limits the success of the aspersions.

Sexual pheromones have shown to be a tool to reduce the reproductive potential of numerous insect species, and are particularly important in the integrated management of pests, as their active ingredients affect specific insects only.

Raman (1982; 1984) determined that the mixture of *trans*-4, *cis*7-tridecadienil-1-ol-acetate and *trans*-4, *cis*7, *cis*10 tridecatrienil-1-ol-acetate at a rate of 1:1.5, was more attractive to capture male of *P. operculella* than each compound separately, and that the attraction of this mixture remained active during 90 days in potato fields of Lima, Peru. Although this mixture has been used in research studies and in demonstrations by Raman (1988) and Salas *et al.* (1985; 1991), as monitoring and control tool by means of mass captures, in doses of 1 mg per trap, there is scarce information concerning the optimization of the pheromone mixture per trap. This becomes important when intending to employ pheromones as a mass capture tool, as on one hand it is necessary to use the most attractive dose, capturing the greatest possible number of males, and on the other it is important to assess the cost of this technology and compare it with the use of insecticides.

The purpose of the present study was to evaluate the effect of different doses of the potato tuber moth synthetic sexual pheromone *trans*-4, *cis*7-tridecadienil-1-ol-acetate and *trans*-4, *cis*7, *cis*10 tridecatrienil-1-ol-acetate in the capture of potato tuber moth males.

## MATERIALS AND METHODS

### Experimental plots

Two experiments were carried out in the Coquimbo Region of Chile to evaluate the efficacy of different doses of potato tuber moth sexual pheromone in the capture of male moths. The tests were carried out in two localities: El Romero (29°53' South lat.; 71°55' West long.) belonging to the commune of La Serena, and Pan de Azúcar (30°04' South lat.; 71°55' West long.) belonging to the commune of Coquimbo.

The potato plantations, of the Cardinal variety, were carried out on December 15 2003 at El Romero, and August 21 at Pan de Azúcar. The surface planted was of approximately 5 ha in each locality; the plantation distance was of 0.3 x 0.75 m on and between rows, respectively.

### Agronomic management of the host crop

Fertilization was carried out in two occasions at the El Romero locality: the first at plantation, using 100 units of nitrogen, 100 units of potassium and 200 units of phosphorus per hectare. The second application was done 45 days afterwards, in doses of 100 units of nitrogen and 100 units of potassium incorporated into the soil together with hilling, carried out on January 31 and February 1st. 2004. Irrigation was done weekly by rows.

At the Pan de Azúcar locality, fertilization was done with 104 units of nitrogen, 184 units of phosphorus and 144 potassium units on sowing and, 69 nitrogen units and 230 potassium units were incorporated 60 days afterwards. Irrigation was by aspersion and done twice weekly.

The control of potato blight was carried out in both localities by means of five applications of 1.6 kg a.i. ha<sup>-1</sup> of mancozeb (Mancozeb 80% WP).

### Pheromone traps

Rubber dispensers containing a mixture of the compounds E4-Z7 Tridecadienil acetate, and E4-Z7-Z10 Tridecatrienil acetate in rates of 1:1.5 were used as release media of the commercial sexual pheromone. These were provided by Agrisense-BCS Ltd., South Wales, United Kingdom.

The rubber dispensers were placed on wires and suspended above water traps, made up by 5 liter

cans containing 2 liters water and 0.2% detergent to break the surface tension of the water, in order this to kill the captured males by drowning.

Based on the studies of Rodríguez *et al.* (1991) and Nieto-Hernández *et al.* (1989) the traps were placed at 50 m from each other, to be sure no interference in attraction between them would occur.

The traps were placed among the plants, 50 cm above the ground, hanging from posts. They were installed on February 10, 2004 at El Romero, and on November 29, 2004 at Pan de Azúcar.

### Evaluations

The evaluations consisted in weekly counts of the *P. operculella* male moths captured inside each trap. At El Romero this was done in four opportunities, February 17 and 24; March 3 and 9, 2004. At Pan de Azúcar the counting of captured males was done on December 6, 13 and 20, 2004.

### Experimental design

A design of complete randomized blocks was employed in both localities. Five treatments with four repetitions were distributed at El Romero. The treatments consisted in doses of: 0.2, 0.5, 1, 2 and 5 mg of a mixture of sexual pheromones *trans*-4, *cis*7-tridecadienil-1-ol-acetate and *trans*-4, *cis*7, *cis*10 tridecatrienil-1-ol-acetate at the rate of 1:1.5, in the same way as done by Raman (1984).

On the other hand, the experiment at Pan de Azúcar was carried out in five treatments with eight replicates. The treatments in this locality were done on the basis of the following doses of the chemical

compounds mixture as indicated above: 0.05, 0.1, 0.2, and 0.5 mg. There were more dispensers available during this research season so it was possible to have more replicates.

The data obtained were analyzed using variance analysis employing the Statistical Analysis System (SAS Institute, 1989). The averages were separated by a multiple separation test LSD (Least Significance Difference).

## RESULTS AND DISCUSSION

At the El Romero site, the sexual pheromone dose of 0.2 mg per trap allowed captures of a significantly higher number ( $P < 0.05$ ) of males than the 1; 2; and 5 mg doses (Table 1). None of the evaluations showed significant differences between the 0.2 and 0.5 mg lower doses assessed. However, there were no significant differences between the 0.5 mg and the 1 and 2 mg doses of pheromone per trap in two of the four dates evaluated. On the other hand, the highest pheromone dose evaluated (5 mg) captured a significantly lower number ( $P < 0.05$ ) of male moths than the 0.2 and 0.5 mg doses in all evaluations carried out. This result coincides with that determined for another Gellechiid (*Keiferia lycopersicella*), whose males are not attracted by high concentrations of sexual pheromones (Jenkins *et al.*, 1990).

At the Pan de Azúcar locality the captures with the different doses evaluated (0.05 to 0.5 mg) were similar during the two first dates evaluated. However, during the last date of evaluation the lower dose of pheromones (0.05 mg) captured a significantly lower number of males ( $P < 0.05$ ) than the doses of

**Table 1. Average daily captures of *Phthorimaea operculella* males with different doses of pheromone per trap. El Romero, 2004.**

**Cuadro 1. Promedio de capturas diarias de machos de *Phthorimaea operculella* con diferentes dosis de feromona por trampa. El Romero, 2004.**

Treatment	February 17	February 24	March 03	March 09
0.2 mg trap <sup>-1</sup>	174.8 a	139.0 a	115.0 a	150.5 a
0.5 mg trap <sup>-1</sup>	142.5 ab	101.0 ab	120.5 a	143.5 a
1 mg trap <sup>-1</sup>	85.5 bc	50.0 bc	68.3 b	78.3 b
2 mg trap <sup>-1</sup>	102.3 abc	49.0 bc	49.3 b	78.8 b
5 mg trap <sup>-1</sup>	68.0 c	42.0 c	68.5 b	79.0 b
VC (%)	21.5	25.4	13.3	24.4

The figures in each column followed by the same letter do not differ significantly, according to the multiple separation LSD test ( $P > 0.05$ ). VC: Variation coefficient.

0.2 and 0.5 mg and a similar number of captures to the 0.1 mg dose (Table 2). This reduction of captures could be attributed to the lowering of the attraction effect of the pheromone, due to high radiation and temperature conditions which can volatilize the compound. At lower doses (0.05 mg) less product might remain stable than in traps containing higher doses.

The sum of the daily averages of captured males of all counts at El Romero resulted significantly

higher for the 0.2 and 0.5 mg doses of sexual pheromones than at doses of 1, 2 and 5 mg (Figure 1). The captures decreased with lower doses (0.05 mg) at the Pan de Azúcar locality (Figure 2).

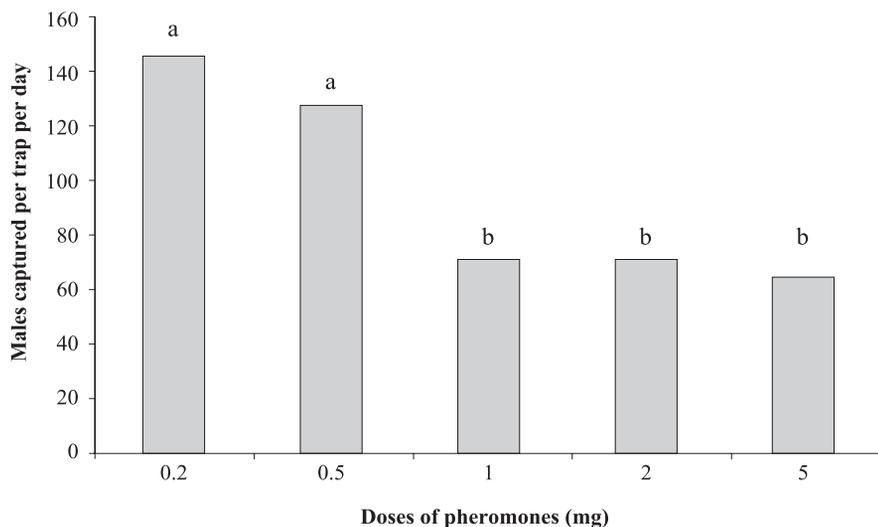
The results in both localities indicated that the higher captures of potato tuber moth males are obtained at doses of 0.2 and 0.5 mg of pheromone per trap. The doses evaluated above this range would not be so attractive to *P. operculella* males, possibly because those concentrations may confuse the males.

**Table 2. Average daily captures of *Phthorimaea operculella* males with different doses of pheromone per trap. Pan de Azúcar, 2004.**

**Cuadro 2. Promedio de machos de *Phthorimaea operculella* capturados por trampa por día con diferentes dosis de feromona por trampa. Pan de Azúcar, 2004.**

Treatment Doses (mg)	December 6	December 13	December 20
0.05	93 a	134 a	226 b
0.1	124 a	156 a	287 ab
0.2	126 a	179 a	329 a
0.5	122 a	190 a	342 a
VC (%)	49	41	32

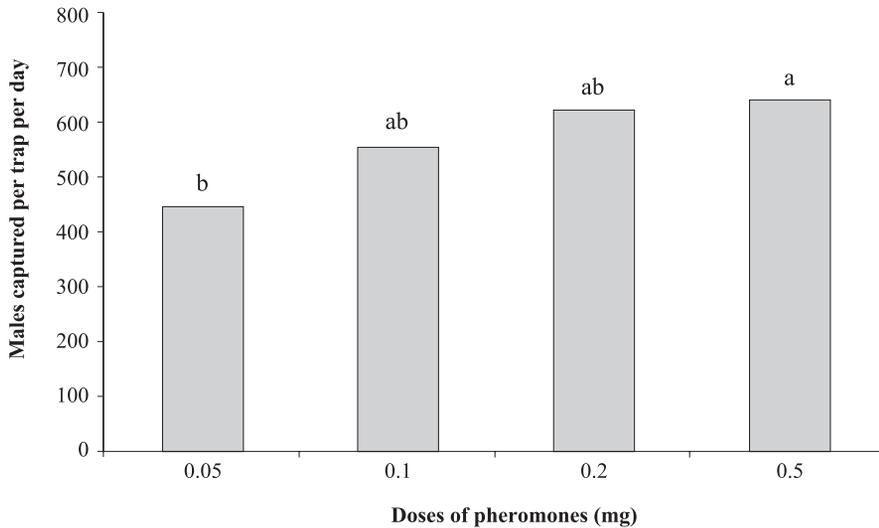
The figures in each column followed by the same letter do not differ significantly, according to the multiple separation LSD test ( $P > 0.05$ ). VC: Variation coefficient.



**Figure 1. Average total number of *Phthorimaea operculella* males captured per trap per day, between February 17 and March 09, with different doses of pheromones. El Romero, 2004.**

**Figura 1. Promedio de capturas diarias por trampa de machos de *Phthorimaea operculella*, colectados entre el 17 de febrero y el 09 de marzo, con diferentes dosis de feromonas. El Romero, 2004.**

Different letters indicate differences according to the multiple separation DMS test ( $P \leq 0.05$ ).



**Figure 2.** Average total number of *Phthorimaea operculella* males, captured per trap per day between December 06 and 20 of december with different doses of pheromones. Pan de Azúcar, 2004.

**Figura 2.** Promedio del total de machos de *Phthorimaea operculella*, capturados por trampa por día entre el 06 de diciembre y el 20 de diciembre con diferentes dosis de feromonas. Pan de Azúcar, 2004.

Different letters indicate differences according to the multiple separation DMS test ( $P \leq 0.05$ ).

The results of this study concur in part with those of Trematerra *et al.* (1996), who found that with lower doses (0.1 mg) the capture of potato tuber moth males increased significantly as compared with doses of 0.5 and 1 mg. However, they found significant differences between 0.1 and 0.5 mg, but using another rate for the pheromone mixture and another type of trap (pagoda and crossed panels). In the present study, there were no differences between the 0.1 and 0.5 mg doses.

## CONCLUSIONS

- 1) The doses of 0.2 and 0.5 mg of the mixture of potato tuber moth sexual pheromones *trans*-4, *cis*7-tridecadinil-1-ol-acetate and *trans*-4, *cis*7, *cis*10 tridecatrienil-1-ol-acetate, at the rate of 1:1.5, were the most effective for the capture of male *P. operculella*.
- 2) The use of lower doses per trap would allow for a greater efficacy in the captures and a decrease in the cost of the pheromone as compared to the 1 mg dose traditionally employed.

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