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Mass trapping of *Rhagoletis batava* in organic sea-buckthorn plantations

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Abstract

The growing interest of consumers in products obtained from sea-buckthorn (Hippophae rhamnoides L.) has contributed to an increase in the area under cultivation in Poland and world-wide. The greatest threat to this crop is the sea buckthorn fruit fly (Rhagoletis batava Hering) which can destroy even the entire harvest. A commercial cone trap with an attractant designed for Ceratitis capitata and a homemade plastic bottle trap containing a 4% ammonium phosphate solution resulted being the most effective in attracting the flies in a preliminary trial and further tested in various orchards for four years. Improved attractants were also assessed together with the ammonium phosphate solution but resulted in a limited increase in flies trapping. A reduction in the share of damaged fruits was observed in all trials, but with a generally low positive correlation with the number of catches, statistically significant only for the cone and bottle traps.

Keywords: ammonium phosphate solution, *Ceratitis capitata*, sticky trap.

Introduction

Sea buckthorn (*Hippophae rhamnoides* L.) is a berry species that has long been used in traditional medicine in Europe and Asia (Suryakumar, Gupta, 2011) and is currently experiencing an increasingly interest as raw material in the food industry, to produce juice or jams from the pulp and oil from seeds used as an additive to enrich the composition of food products (Chen et al., 2023). The growing demand for high-quality sea buckthorn fruits, specially produced in organic farming, has led to increased land area of sea buckthorn orchards across Europe (Poland, Germany, Latvia, Greece). However, this has also led to a growing risk of pests' occurrence, particularly the sea buckthorn fruit fly (*Rhagoletis batava* Hering, 1958) in various European countries (Stalažs, Balalaikins, 2017).

Control of *R. batava*, like other species of the Tephritidae family, is limited by the insect biological cycle, with larvae spending their entire life cycle in the fruit pulp, which makes them less susceptible to control measures, thus having to target mainly the imago stage, i.e., the fly. The present study aimed at identifying a suitable trap-attractant combination that could optimize the mass trapping of *R. batava* and support its control within a strategy of integrated management feasible for organic orchards of sea buckthorn.

Material and Methods

Two trials were carried out over four growing seasons on sea buckthorn plantations located in the Pomeranian Province (Przezmark II) and in the Lublin Province (Pereszczówka). A randomized block design with three replicates, each formed by about 0.2 ha plot was applied for all trials. Additionally, a 3.5 m-wide buffer zone was designated on each side of each plot, where no treatments were carried out, and the fruits were always sampled from the central parts of the plot.

Two types of traps were used in the trials: a commercial cone trap (C) containing a lure developed to capture *Ceratitis capitata* flies (C.C.) (Probodelt, Spain) with the inside cover coated with an insecticide (pyrethroid); a homemade bottle trap (B) using 1.5 liter-volume

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PET plastic bottles, containing a 4% aqueous solution of ammonium phosphate fertilizer with 18:20 N:P content (N). The control plots did not have any trap.

A trap density rate of 80 traps/ha was used in each plantation. Traps were deployed in three rows: in two of them the traps were placed every 16.5 m and in one row every 20.0 m. The traps were hung on the plantations before the emergence of the fruit fly. During the season, the number of adults caught in all traps was counted with a 10-day frequency. At harvest, the degree of fruit damage was assessed on a random sample of 1200 fruit.

Results and Discussion

The deployment of the cone traps resulted in almost halving the percentage of damaged fruits compared to the control during the four-year long trial carried out in the two locations (Table 1 and Figure 1). Interestingly, the bottle traps with the ammonium phosphate attractant caught a similar average number of flies in both trials (Figure 1). This resulted, for both kinds of traps, in a significant reduction in the percentage of damaged fruit compared to the control (Table 1).

Table 1: Average number of fruits damaged by *R. batava* flies as affected by the deployment of the cone and bottle traps in two locations in the seasons 2019-2022.

Type of trap + (Attractant)	**Average number of damaged fruits[*] [%]**			
	2019	2020	2021	2022
	Przezmark II			
C + (C.C.)	67.2 ± 5.7 a	49.8 ± 26.4 a	21.8 ± 2.6 a	20.3 ± 2.8 a
B + (N)	70.3 ± 5.8 a	73.8 ± 7.3 b	20.8 ± 4.9 a	24.0 ± 2.5 a
Control (without traps)	99.5 ± 0.8 b	95.0 ± 1.9 c	72.0 ± 12.4 b	48.3 ± 6.6 b
	Pereszczówka			
C + (C.C.)	41.0 ± 2.3 a	3.3 ± 3.3 a	4.0 ± 1.9 a	7.0 ± 7.2 a
B + (N)	59.3 ± 5.6 b	3.2 ± 2.0 a	4.0 ± 3.0 a	12.7 ± 7.5 ab
Control (without traps)	75.2 ± 6.4 c	15.8 ± 3.6 b	16.7 ± 3.7 b	22.5 ± 3.7 b

[$] Bottle traps with an attractant based on ammonium phosphate solution (B + N) and cone traps with an attractant for *C. capitata* (C + C.C.). [*] Values marked with different letters differ from each other at $p \leq 0.001$ significance level

The correlation analysis between the number of *R. batava* flies caught and the percentage of damaged fruits was statistically significant: for the cone trap + (C.C.) (R2=0.76), and for the bottle trap + (N) (R2=0.66).

The practices for the control of *R. batava* used so far have not been sufficiently effective, resulting in crop losses of up to 100% and very often leading to the elimination of the orchard due to lack of profitability. The reduction of the flies' population, as evidenced by the number of adults trapped, was evident at the end of the fourth year of implementation of the control measure. This was paralleled by a significant reduction of the number of damaged fruits, which points to be the result of a stabilization of the overall pest population due to the continuous use of mass traps during subsequent growing seasons. However, despite such significant reduction, the level of fruit damage remained still high, confirming the difficulty of limiting the damage caused by *R. batava* (Shamanskaya, 2015), even if the traps were placed in the sunniest parts of the tree canopy, which gives the highest efficacy (Stalažs et al., 2023). The results obtained with the home-made, recycled plastic bottle traps filled with an aqueous solution of a common fertilizer (ammonium phosphate) make the use of this type of trap financially encouraging, and also in line for the real application of the principles of circular economy at farm level.

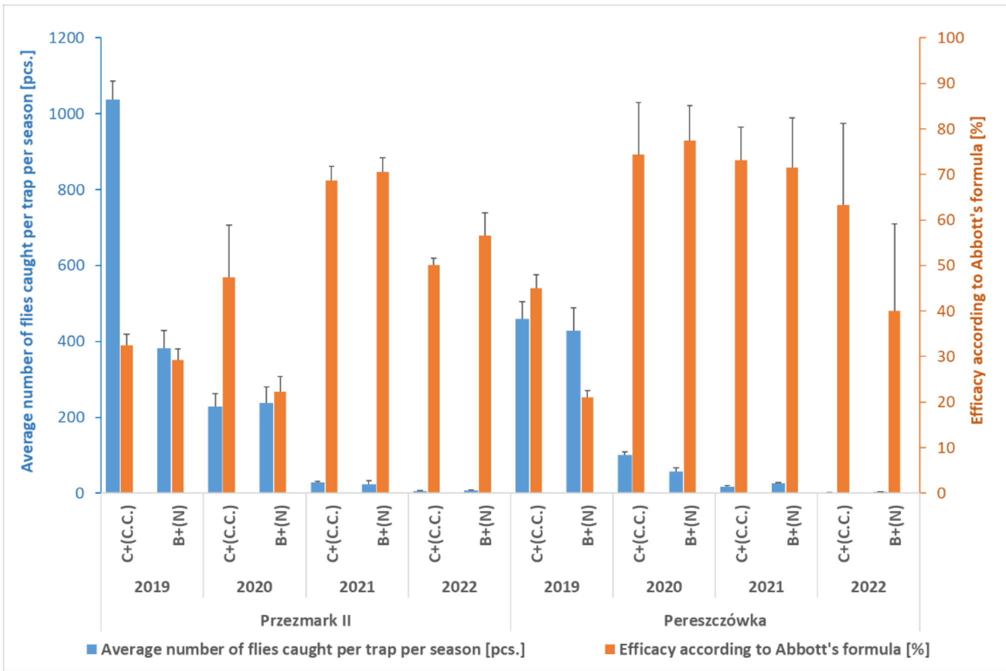

Figure 1: Average number of *R. batava* flies caught per trap per season and efficacy in reducing fruit damage according to Abbott's formula. Mean ± SEM. Bottle traps with an attractant based on ammonium phosphate solution (B + N) and cone traps with an attractant for *C. capitata* (C + C.C.)

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