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TESTING TRUNK EXCLUSION METHODS TO MONITOR AND CONTROL THE PLUM CURCULIO WEEVIL IN AN ORGANIC APPLE ORCHARD - PRELIMINARY RESULTS.

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RÉSUMÉ

EVALUATION DE METHODES D'EXCLUSION DES TRONCS POUR DEPISTER ET CONTROLER LE CHARANÇON DE LA PRUNE EN VERGER DE POMMIERS BIOLOGIQUE-RESULTATS PRELIMINAIRES

Le charançon de la prune, *Conotrachelus nenuphar* (Herbst) (Coleoptera: Curculionidae), est un ravageur important dans les vergers de pommes, de prunes, de pêches et de poires au Canada. Dans les vergers biologiques, le charançon de la prune est le principal ravageur causant jusqu'à 85% des dégâts. L'objectif était de tester l'efficacité des méthodes d'exclusion du tronc pour le dépistage et pour lutter contre le charançon de la prune. Des pièges pyramidaux et des bandes synthétiques (utilisés en combinaison avec de la colle et/ou une phéromone) ont été comparés. Les résultats préliminaires indiquent que les pièges pyramidaux sont plus efficaces que les pièges avec bandes synthétiques, qu'ils soient combinés avec de la colle ou une phéromone. Cependant, l'utilisation de ces pièges n'a pas considérablement réduit les dommages observés sur les fruits à la récolte. Ainsi, le piège pyramidal permet d'effectuer un suivi des populations du charançon mais pas de réduire les populations. Les bandes synthétiques ne sont efficaces ni pour effectuer le dépistage ni pour lutter contre le charançon de la prune.

Mots-clés : charançon de la prune, dépistage, lutte intégrée, exclusion, *Conotrachelus nenuphar*

ABSTRACT

The plum curculio weevil *Conotrachelus nenuphar* (Herbst) (Coleoptera: Curculionidae) is frequently found in apple, plum, peach and pear orchards in Canada. In organic orchards, the plum curculio weevil is the main pest causing up to 85% of damages. The aim of this study was to test the efficacy of trunk exclusion methods to both monitor and control the plum curculio weevil in organic apple orchards. Pyramidal traps and synthetic strips (used in combination with glue and/or pheromones) were compared. Our preliminary results indicate that, to monitor populations of the plum curculio weevil and other weevils, the pyramidal traps are more efficient than synthetic traps whether combined with glue or pheromones. However, the use of these traps did not significantly reduce damages observed on apple fruits. Hence, pyramidal traps are efficient monitoring devices but do not control weevils. Synthetic strips are not efficient to monitor nor to control the plum curculio weevil.

Keywords: plum curculio weevil, monitoring, integrated pest management, exclusion, *Conotrachelus nenuphar*

INTRODUCTION

The plum curculio weevil *Conotrachelus nenuphar* (Herbst) (Coleoptera: Curculionidae) is a ubiquitous pest in organic apple orchards in Quebec and Canada. In organic apple orchards, the plum curculio weevil is the main pest; it can cause up to 85 % of damages (Vincent and Bostanian, 1988; Vincent and Roy, 1992). It also threatens other fruit crops such as plum, peach and pear (Armstrong, 1958). The adults overwinter under the litter of forests, nearby orchards. During the period of apple flowering (in May), weevils migrate to orchards to reproduce and then females lay their eggs on growing fruits (Armstrong, 1958; Hoyt et al., 1993; Racette et al., 1990). Female adults move on apple fruit at night to oviposite and move back to the bottom of the tree to hide on the ground (Chouinard et al., 1992a). Feeding larvae move toward the heart of the fruit causing fruit drops (Armstrong, 1958; Racette et al., 1992). Apples that remain on the tree are declassified at harvest due to aesthetic damages. The use of highly persistent insecticides (e.g neonicotinoids, oxidiazines, organophosphates) are mainly used against the plum curculio weevils (Wise et al., 2007). However, these pesticides are found in all the apple tree parts including the fruit skin (Wise et al., 2007) and represent important risks to the environment and beneficials. The use of such insecticides in organic apple orchards is forbidden and alternative approaches must be elaborated.

The trunk exclusion methods are potentially efficient approaches that can be alternatives to insecticides. The methods are efficient against various arboreal weevil species in olive, citrus and avocado trees (Haney and Morse, 1988; Jiati, 2008; Barnes et al.,1995, 1996) successfully maintained apple fruit damages by the weevil *Phlyctinus callosus* (Schonberr) (Coloptera: Curculionidae) under economic threshold using synthetic strips surrounding trunks. Synthetic strips prevent weevils that walk up the trunk to reach fruits and cause damages. The walking insects get stuck in the synthetic strips and eventually die. The plum curculio weevil preferentially walks to/from the canopy when temperatures are lower than 20°C (Prokopy et al., 1999). Hence, the use of exclusion methods (e.g. synthetic strips attached to the trunk) could efficiently decrease the weevil populations. Haney and Morse (1988) reported that synthetic strips combined with glue were up to 100 % efficient against the fuller rose beetle *Pantomorus cervicus* (Godmani) (Coloptera: Curculionidae) in citrus trees. Similarly, Leskey et al. (2008) observed an increase in damages caused by plum curculio weevil in apple trees treated with attractive substances. Aggregation pheromones (i.e. grandisoic acid) paired with benzaldehyde were very attractive to the plum curculio weevil (Prokopy et al., 2000; Leskey et Wright, 2004). Therefore, synthetic strips could be enhanced with the addition of olfactive attractive substances and/or glue.

Exclusion methods could be used as monitoring tools to predict the risk of damage by plum curculio weevils. Currently, weevil populations are monitored in Quebec by counting damage on fruit from fruit set to end of July (Morin et al., 2015). Pyramidal traps were successfully used to bait and monitor the plum curculio weevil (Chouinard et al., 2011). This device, adapted from a trap conceived to capture other weevils, mimics the apple tree and deceives the weevil (Tedder and Wood, 1994). Its efficiency increases when it is placed near an apple tree (Prokopy and Wirth, 1997a, b). However, the effectiveness of pyramidal traps and synthetic strips (used in combination with glue and/or attractive substances) to monitor and control the plum curculio weevil are yet to be demonstrated.

In this study, we tested various exclusion methods (e.g. pyramidal traps, synthetic strips) both as a means to monitor and control the plum curculio weevil in an organic apple orchard.

METHODS

Study site

The study site was an organic apple orchard (Verger bio d'Oka) located in Oka, Quebec, Canada (45.494944; -74.080225). This orchard has a history of several weevil infestation in 2015. The apple varieties were McIntosh and Empire.

Experimental design

A randomized complete block design was used to set up four blocks around the orchard (in peripheral zones). Each block was composed of seven plots of three apple trees and the following treatments were randomly applied: 1) control treatment (without any traps); 2) pyramidal trap; 3) synthetic strip; 4) double layer synthetic strip; 5) synthetic strip with Tangle Foot glue; 6) synthetic strips with pheromones (grandisoic acid and benzaldehyde); 7) synthetic strips with Tangle Foot glue and pheromones (Figure 1). All trees in a plot received the same treatment.

Figure 1: Different traps tested to control plum curculio (A) pyramidal trap; B) synthetic strip; C) synthetic strip with pheromone)
(Différents types de pièges évalués pour lutter contre le charançon de la prune (A) piège pyramidal; B) bande synthétique; C) bande synthétique avec phéromone)

Measured parameters

Weevil monitoring and trap efficiency. Weevil populations were monitored weekly during the period when adults were present (from May 12th to July 7th, and from August 18th to October 4th). All traps were observed individually and visual observation was done on trunk in the control treatment. Individuals were identified and classified. The monitoring was performed every two weeks outside this period. Predators such as spiders and coccinellids were counted simultaneously.

Apple fruit damage. Weevil damage to apple fruit was counted at two moments during the season corresponding to the end of the two periods of activity recorded for the weevil (July 7th and September 8th). Thirty fruits per tree were observed to note plum curculio damage.

Statistical analysis

Generalized linear mixed models (GLMM) were implemented to test the effect of treatments on the number of weevils captured (each species being tested separately). The plot was introduced in the model due to repeated measures.

All analyses were performed using R (R Core Team 2013) and lmer function of the lme4 library (Zuur et al. 2009; Bates et al. 2016).

RESULTS

Weevil populations and trap efficiency

The pyramidal trap was more effective in capturing plum curculio weevil than any other trap (LRT = 66.18; df = 5; $p < 0.0001$) (Figure 2). Adding glue to synthetic strips reduced its efficiency (Figure 2). The results indicated two peaks of plum curculio weevil populations during the season corresponding to the end of May and the middle of August (Figure 3). The second generation lasted for about four weeks (Figure 3), whereas the first generation had a shorter duration (about two weeks). Our results indicate that the pyramidal traps are an efficient device to monitor plum curculio weevil population.

The use of synthetic strips along with glue and pheromones captured more black weevils than the double synthetic strips (LRT = 17.39; df = 5; $p = 0.004$) (Figure 4). However, the number of black weevils captured were low relative to the number of captured plum curculio or other weevils (Figure 4). Other weevils were more abundant in pyramidal traps than in other monitoring systems (LRT = 43.96; df = 5; $p < 0.0001$) (Figure 4). Most predators captured in our different weevil traps were spiders. Pyramidal traps captured more spiders than any other system (LRT = 56.56; df = 5; $p < 0.0001$) (Figure 5). Few coccinellids were collected in all traps.

Figure 2: Mean number of plum curculio weevils by traps as a function of the type of exclusion method. (Nombre moyen de charançons de la prune par piège en fonction de la méthode d'exclusion utilisée)

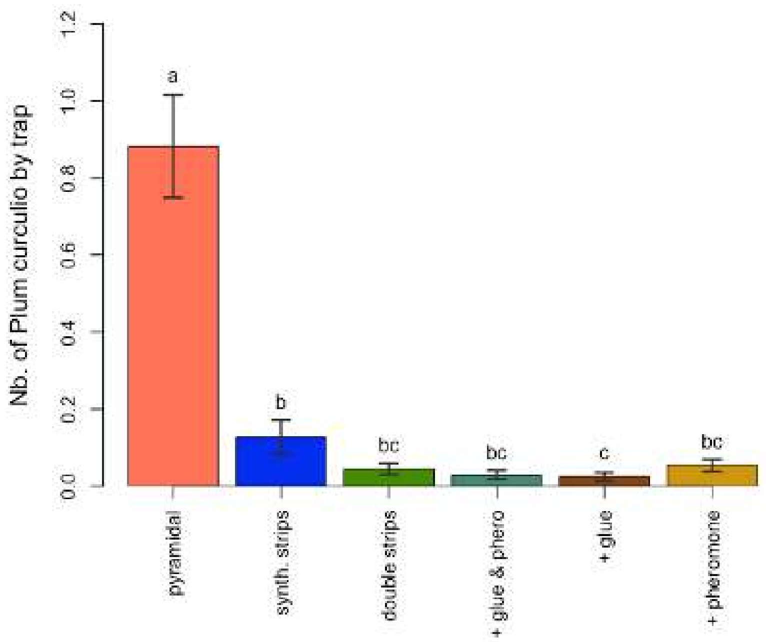


Figure 3: Number of plum curculio weevils captured in various types of exclusion methods during the 2016 season.
(Nombre de charançons de la prune capturé dans les divers types de pièges durant la saison 2016)

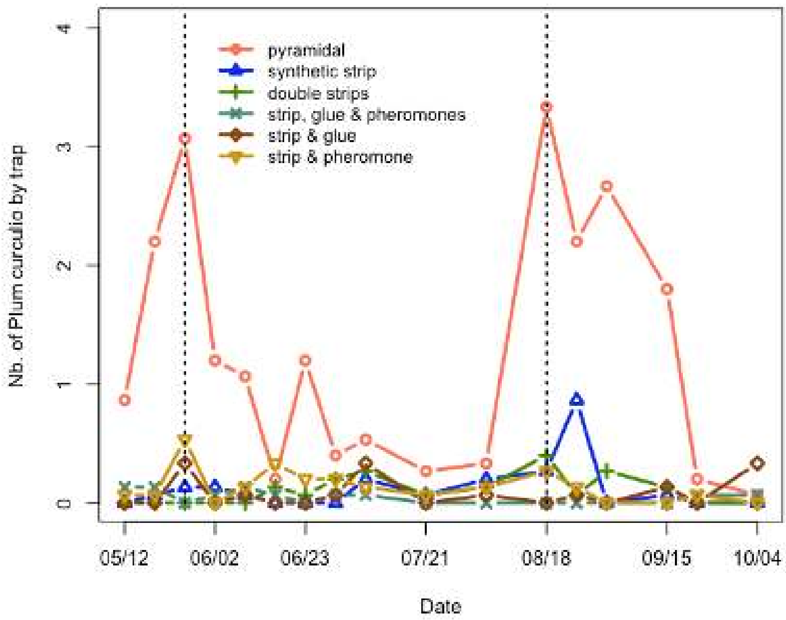


Figure 4: Mean number of different weevils captured as a function of various types of exclusion methods.
(Nombre moyen de diverses espèces de charançon capturé en fonction des types de pièges)

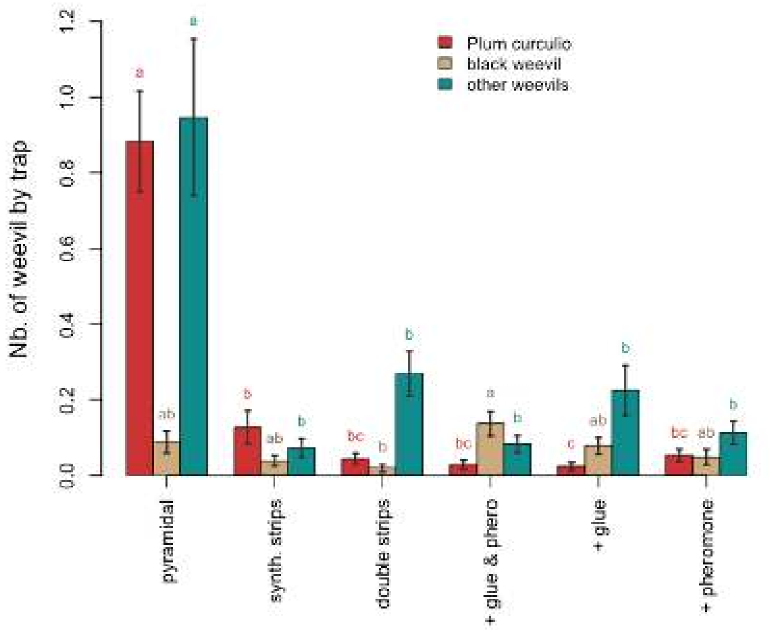


Figure 5: Mean number of other predators collected in the different traps.
(Nombre moyen d'autres prédateurs collectés dans les divers types de pièges)

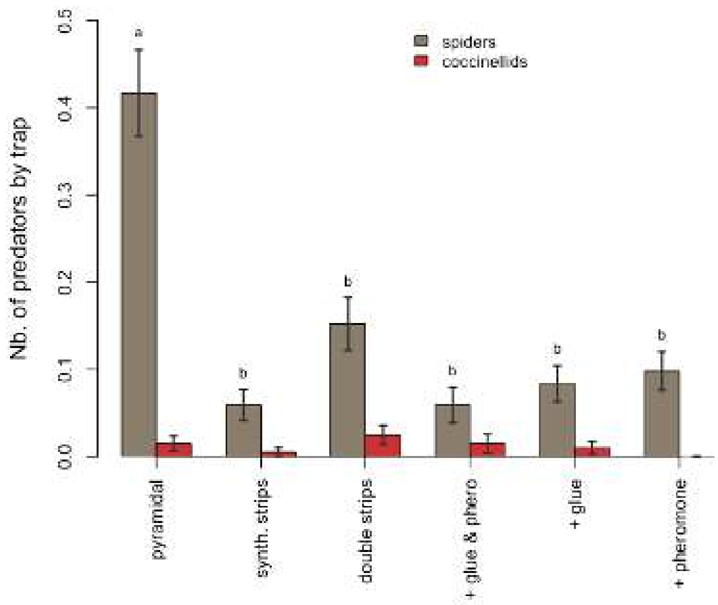
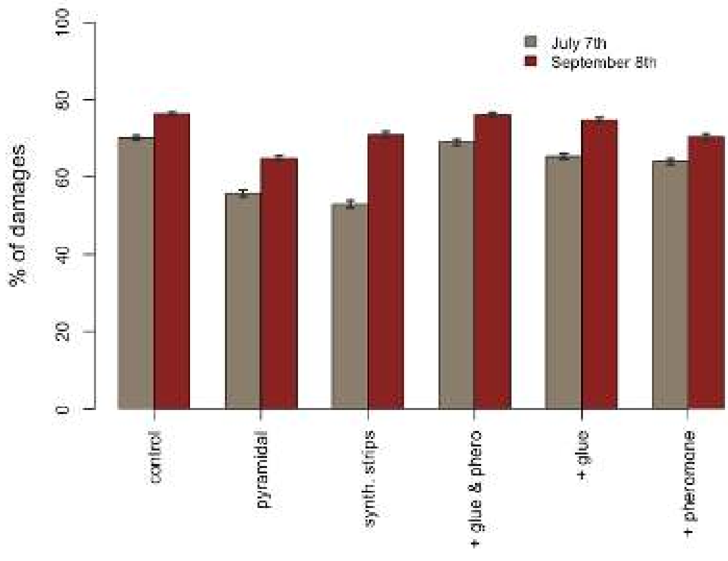


Figure 6: Impact of exclusion methods on apple damage.
(Effet des méthodes d'exclusion sur le taux de dommage des pommes)



Apple damage

The ratio of apples damaged by weevils was not significantly different among traps (LRT = 9.65; df = 5; p = 0.09) (Figure 6). Damages increased slightly from July 7th to September 8th (LRT = 4.12; df = 1; p = 0.04) (Figure 6). The similarities among treatments indicate that pyramidal traps and synthetic strips (whether used with glue or pheromones) are not efficient to control plum curculio weevils.

DISCUSSION

Our preliminary results indicate that the pyramidal traps are an efficient device to monitor plum curculio weevil populations. Also, pyramidal traps are better suited as a monitoring device than synthetic trips because they catch more individuals even when synthetic strips are combined with pheromones. One explanation for these results could be the color of the trap. The black color of the pyramidal trap may be more attractive to plum curculio than the apple trunk. However, other trap characteristics may influence attractiveness of the pyramidal trap to plum curculio because the synthetic trap in combination with pheromones doesn't catch high individuals of this pest. Pheromones (grandisoic acid and benzaldehyde) used in this trap have already been shown to efficiently attract plum curculio weevils (Prokopy et al., 2000; Leskey et Wright, 2004). As observed by Chouinard et al. (2011), pyramidal traps can be used successfully to monitor and catch the plum curculio weevil in apple orchards. However, according to our results, pyramidal traps are not efficient against all weevil species. Attractive pheromones and visual cues are specific for each weevil species. Hence, the pyramidal trap seems to be attractive for the black weevil but not for other species.

For the first experimental year, synthetic strips did not show efficient control or monitoring for plum curculio weevils. Even in the presence of attractive pheromones, trunk exclusion only caught a limited number of individuals of plum curculio and other weevils.

Despite catching a good amount of plum curculio weevils, damage to apple fruits was not reduced even when comparing treatment methods to the control groups. Therefore, the different types of exclusion methods were not successful in sufficiently reducing the number of weevils on the trees. We can conclude then that the most efficient exclusion method (pyramidal traps) is useful to monitor weevil populations but do not reduce damage to apple fruits.

Other predators are found in relatively small amounts which are beneficial to know when using an integrated pest management approach. Many spiders were captured in the pyramidal traps but very few coccinellids.

The results will first provide control tools to reduce the number of chemical treatments against the plum curculio weevil in apple orchards by using efficient monitoring methods. At the end of this study, a weevil monitoring tool will be available before the fruit formation (at the pink bud stage and bloom stage) and as the insects move from their hibernation sites in the woods to the orchards. With effective control and monitoring tools, this project could also encourage the transition from conventional apple growers to organic production because they will have different control methods to effectively manage this crop pest.

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