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PRODUCING HIGH-QUALITY HONEYCRISP APPLES UNDER EXCLUSION NETS: HOW TO ALLOW POLLINATION WHILE EXCLUDING PESTS?

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INTRODUCTION

In order to prevent insects from damaging apples without using pesticides, a row-by-row net exclusion system (Chouinard et al., 2016) has been tested in an experimental orchard for the last five years. The nets, installed before bloom, proved to be effective against many key pests, including species active early in the season. However, it was necessary to open the nets during bloom to allow access to pollinators. To obtain a yield of one apple per cluster, different pollinating periods were tested by controlling the duration of net opening during bloom. Observations were made on pollinator activity, fruit load, fruit thinning and number of seeds per fruit at harvest.

MATERIALS AND METHODS

The study took place in an orchard located in Saint-Bruno-de-Montarville, Quebec. The pollination treatments were carried out in 2014 and 2015 in a high density plot (cv. Honeycrisp on B9 and M26 rootstock), which had been producing fruits under nets yearly since 2012. Sleeves made from the same netting material as these nets (ProtekNet 60 g/m^2, average mesh size: 0.95 mm × 1.9 mm) were used to control for the different pollinating periods. Depending on the treatment, nets were opened once or twice.

The duration of net opening (duration of expected pollination) for each treatment was:

1. 0 h
2. 3 h
3. 6 h
4. 6 h (2 d × 3 h)
5. 12 h
6. 12 h (2 d × 6 h)
7. 18 h (1 d × 12 h + 1 d × 6 h) (control without sleeve)
8. >100 h (control without sleeve and net)

Four replications for each treatment were arranged in a completely randomised design. Each experimental unit consisted of a single tree, covered or not by a sleeve **(Photo 1)**. These trees were in rows covered or not by a net. Both sleeves and nets were attached using clips (EasyKlip) so that pollinators would be excluded.

The sleeves and nets were deployed before bloom and were opened on two days deemed favourable to bee activity: temperature >15 °C, wind speed <16 km/h, solar radiation >300 W/m^2. The time of opening varied from a treatment to the other, but all sleeves and nets were closed at 8 PM.

In 2014, beehives were present in the orchard from May 19 to 28 and nets were opened on the 20th (all treatments except 0 h and >100 h) and 21st (treatments 2 d × 3 h, 2 d × 6 h and 18 h). In 2015, beehives were present in the orchard from May 12 to 20 and nets were opened on the 14th (treatments 2 d × 3 h, 2 d × 6 h and 18 h) and 17th (all treatments except 0 h and >100 h). Nets and sleeves were opened at eye-level, using the existing wires and clips used for pest exclusion.

Pollinator activity was evaluated on these four dates on 12 trees: four covered by both sleeve and net, four covered by a net only and four uncovered. Pollinators were separated into three groups: honey bees, other hymenopterans excluding ants, and other pollinators. The number of visits of flowers by pollinators on branches lower than 1.5 m from the ground was counted; higher portions of the trees were still covered by opened nettings **(Photo 2)**. Pollinators had to touch carpels and/or stamens for at least one second in order to be considered as a visit. Observations were made every two hours and lasted 10 minutes each.

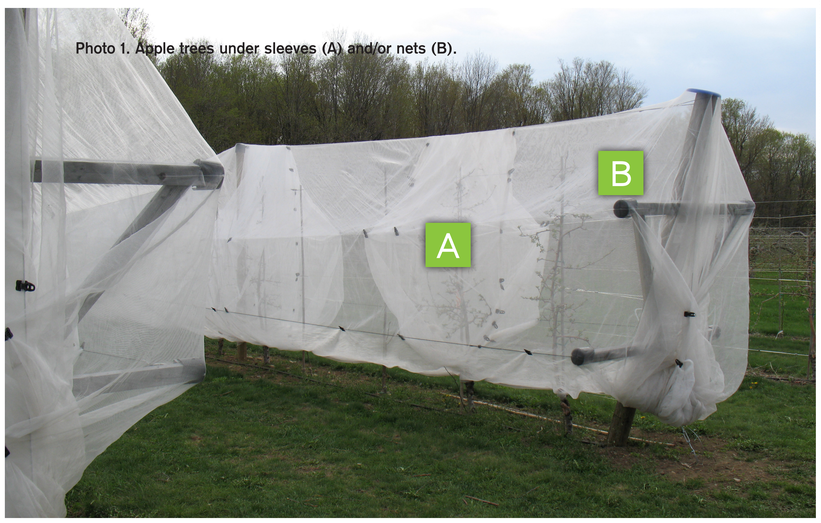


Photo 1. Apple trees under sleeves (A) and/or nets (B).

The fruit load of all experimental units was evaluated in June. Afterward, trees were thinned using the Équilifruit method (Yelle and Mantha, 2014), which promotes a balance between vegetative growth and fruit production. Apples removed during this process were counted.

Up to 25 fruits per tree were picked (depending on availability) at harvest time. These fruits were cut in half and seeds were counted.

Data were analysed using ANOVA tests, or the Kruskal-Wallis test when normality and homoscedasticity assumptions were not met. Multiple comparison tests were conducted when necessary. The significance level was set at 5 % for all analyses.

RESULTS

IMPACT OF THE EXCLUSION SYSTEM ON POLLINATOR ACTIVITY

When opened, the presence of sleeves and/or nets did not have a significantly impact on pollinator activity in 2014: honey bees ($F_{2,6} = 2.49$; $p = 0.163$), other hymenopterans excluding ants ($F_{2,6} = 0.26$; $p = 0.780$), and other pollinators ($F_{2,6} = 0.57$; $p = 0.594$), and in 2015: honey bees ($F_{2,18} = 1.33$; $p = 0.290$), other hymenopterans ($F_{2,18} = 2.73$; p = 0.092), and other pollinators ($F_{2,18} = 3.42$; $p = 0.055$) **(Figure 1)**.

Figure 1 (a).

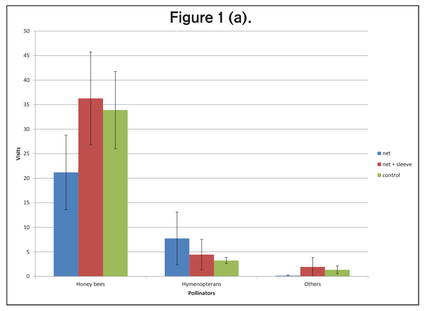
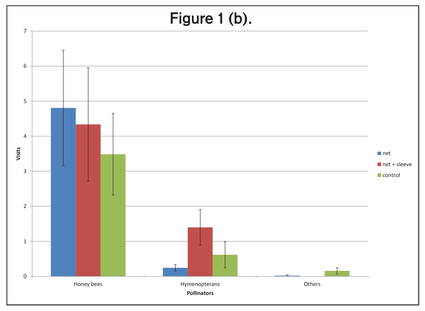


Figure 1 (b).



IMPACT OF THE DURATION OF POLLINATING PERIODS ON FRUIT LOAD

In 2014 and 2015, the duration of the pollinating periods had a significant impact on fruit load ($X^2 = 24.61$; df = 7; $p < 0.001$; and $X^2 = 24.32$; df = 7; $p = 0.001$; respectively) **(Figure 2)**. Clusters from the treatments 12 h, 18 h and >100 h had the most apples in 2014, with an average nearing one apple per cluster. In 2015, clusters from the treatments 18 h and >100 h had the most apples, with an average slightly below or above one apple per cluster, respectively.

Figure 2 (a).

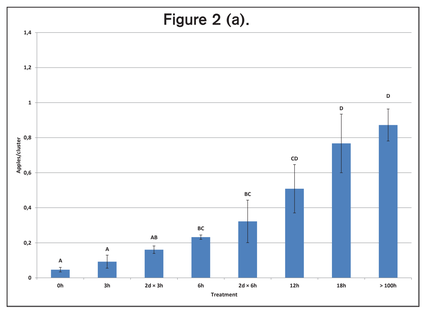
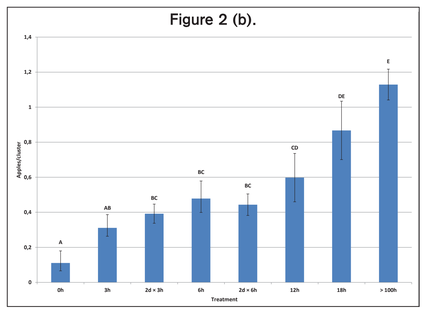


Figure 2 (b).



IMPACT OF THE DURATION OF POLLINATING PERIODS ON THINNING

The duration of the pollinating periods also had a significant impact on the number of apples removed as part of thinning operations in 2014 ($X^2 = 22.78$; df = 7; $p = 0.002$) and in 2015 ($X^2 = 23.64$; df = 7; $p = 0.001$) **(Figure 3)**. Less than one apple per ten clusters was removed for the treatments 0 h, 3 h, 2 d × 3 h, 6 h and 2 d × 6 h in 2014. In 2015, about one apple per five clusters, or less, was removed for the same treatments. For both years, there were more apples removed in the 12 h than in the 0 h treatment, but less than in the >100 h treatment.

Figure 3 (a).

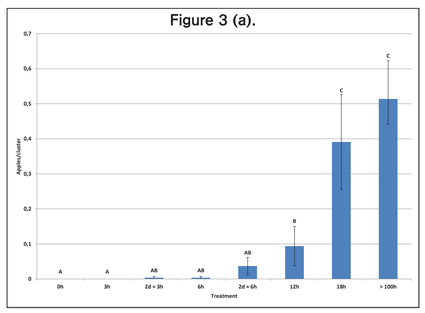
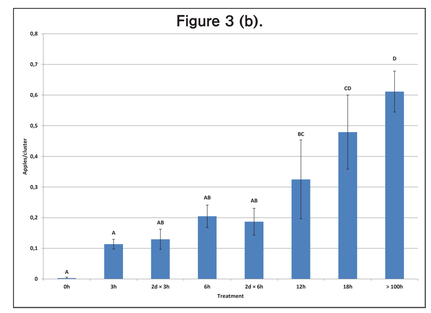


Figure 3 (b).



IMPACT OF THE DURATION OF POLLINATING PERIODS ON THE NUMBER OF SEEDS

The number of seeds varied significantly depending on the duration of the pollinating periods in 2014 ($X^2 = 22.40$; df = 7; $p = 0.002$) and in 2015 ($F_{7,21} = 13.15$; $p < 0.001$) **(Figure 4)**. Apples from the treatments 18 h and >100 h were the ones with the most seeds, around five on average in 2014. In 2015, apples from the treatments 12 h, 18 h and >100 h had the most seeds, around five on average.

Figure 4 (a).

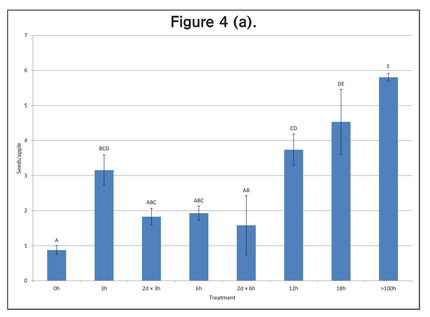


Figure 4 (b).

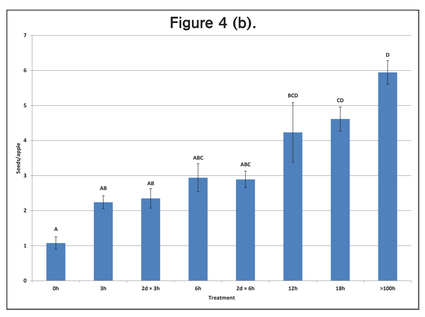


Photo 2. Opened sleeves and nets.

DISCUSSION

Pollinators visited flowers from trees under sleeves and/or nets as much as flowers from completely uncovered trees. This confirms that the differences observed between treatments for fruit load, thinning and number of seeds were not caused by the presence of structures, but by the treatments themselves, i.e. the different durations of pollination.

Except when pollinator access was not restrained in 2015, the average number of apples never reached the value of one apple per cluster. However, as this value is too high for Honeycrisp apples (Yelle and Mantha, 2014), the fruit load yielded by 12 hours of pollination might be ideal as it is the highest one significantly different from that of uncovered trees, in 2015 only.

Opening the nets for two periods of 6 h instead of a single period of 12 h did not have a significant impact on fruit load. However, trees pollinated for two periods of six hours yielded significantly less apples than trees pollinated for a period of 12 h followed by a period of 6 h, whereas trees pollinated for a single period of 12 hours produced as much as the latter. It appears that by opening sleeves at 2 PM, treatment 2 d × 6 h as opposed to 8 PM for treatment 12 h, the peak of pollinator activity is missed.

Although fruit load was lower than optimal in most cases, some apples still had to be removed from trees from almost all treatments during the thinning operations. However, the number of apples removed significantly decreased as the duration of pollinating periods decreased, which implies that nets could play a part in thinning operations.

As apples with five or more seeds have a better preservation potential (Tanguay et al., 2014), apples from trees that were subjected to at least 12 (2015) or 18 (2014) hours of pollination are the most interesting from a storage perspective.

Overall, it appears that, assuming favourable pollinating conditions, a single day of pollinating would suffice in terms of fruit load and number of seeds on otherwise productive trees. It should also facilitate thinning operations.

ACKNOWLEDGMENTS

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REFERENCES CITED

Chouinard, G., A. Firlej and D. Cormier. 2016. Going beyond sprays and killing agents: Exclusion, sterilization and disruption for insect pest control in pome and stone fruit orchards. Scientia Horticulturae 208: 13–27.

Tanguay, N., R. Joannin, P.E. Yelle and M. Lachapelle. 2014. Suivi de la maturation et de la qualité des fruits. Fact sheet 118, in Chouinard, G. (coord.), Guide de référence en production fruitière intégrée à l'intention des producteurs de pommes du Québec, IRDA. 484 p.

Yelle, P.E. and S. Mantha. 2014. Contrôle de la charge (éclaircissage chimique et manuel). Fact sheet 43, in Chouinard, G. (coord.), Guide de référence en production fruitière intégrée à l'intention des producteurs de pommes du Québec, IRDA. 484 p.

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