Evaluating the Efficacy of Multi-cultivar Grafted Apple Trees as Perennial Trap Crops for Multiple Pests: Research Results Year One

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Habitat manipulation through the incorporation of non-crop plants such as trap crops (very attractive plants that lure pests away from the cash crop) into agroecosystems is an ecological approach to pest management. To be effective, trap cropping systems must congregate and retain the pest on trap crop plants, thereby reducing pest populations in the cash crop. The fundamental tenet of this definition involves differential pest preference between plant species, the plants that function as trap crops and those to be protected. It is known that some apple cultivars are more attractive to some insect pests than others. For example, Red Astrachan is a cultivar highly susceptible to apple maggot fly (AMF) attack, and growers have indicated that Yellow Transparent and Dabinett are also favored by AMF over other cultivars. The cultivars Ginger Gold and Liberty are reported to be attractive to plum curculio (PC). While for these two insect pests effective lures are commercially available for monitoring and control (e.g., attract-and-kill systems), their comparatively high cost has prevented growers from adopting monitoring or control systems that are based on synthetic lures. For other insect pests such as tarnished plant bug (TPB) and European apple sawfly (EAS), no lures have been developed. Consequently, we sought to exploit natural sources of plant odor represented by apple cultivars that have the potential to aggregate pests on selected apple trees that are grafted with six cultivars, thereby serving as perennial 'trap crops'.

In the spring of 2018, the lead author (Piñero) sought grower input to gauge the level of interest in research aimed at developing permanent monitoring (and potentially attract-and-kill) sites using selected perimeter-row apple trees grafted with six apple cultivars that are highly attractive to PC and AMF. The growers that were consulted expressed support for the project, and some growers immediately requested scion wood of the cultivars that were proposed, knowing that it would take at least two years to have experimental trees available for the research.

From the onset, the new concept of multi-cultivar grafting for pest management is considered to be simple (i.e., grower-friendly) and inexpensive. If this new IPM approach proves to be effective, then permanent monitoring sites could be developed and farm inputs might be reduced in support of sustainable agriculture. By mid-May 2018, over 40 trees in Massachusetts, New Hampshire, and Maine had already been grafted. Each grafted tree received 6 cultivars reported to be attractive to PC and AMF. In the spring 2020, the number of trees grafted in 13 commercial orchards (10 in MA, two in NH, one in ME) had exceeded 100.

Here, we present the research results for the first year of insect pest monitoring in grafted and non-grafted trees in 10 Massachusetts orchard blocks. In 2020, the target pests were TPB, EAS, PC, and AMF. The main goal of this long-term study is to establish the attractiveness of perimeter-row trees grafted with multiple cultivars to develop permanent monitoring, and potentially attract-and-kill sites, for multiple pests.

Materials & Methods

This study was conducted in 10 commercial apple orchard blocks in Massachusetts. The size of the experimental blocks in Massachusetts ranged from 0.2 to 7.3 acres and most blocks had a density of 3 grafted trees per acre. Four blocks have perimeter-row trees that were grafted in 2018, and six blocks have trees that were grafted in 2019. Each tree was grafted with six cultivars: Liberty, Red Astrachan, Yellow Transparent, Ginger Gold, Dabinett, and Wickson (Fig. 1). For nearly all trees, the grafting was conducted by Jim Krupa (UMass cold Spring Orchard) using the cleft technique.

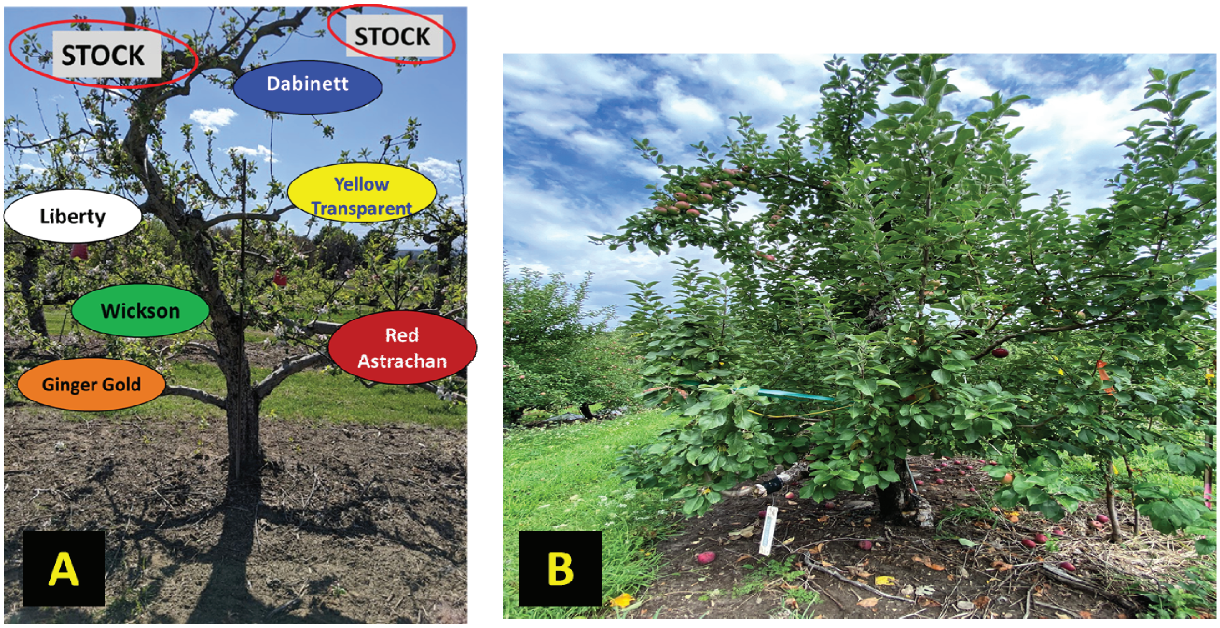

Figure 1. Representative example of one apple tree grafted with six cultivars (A) Early season, (B) Late season. For each grafted tree, non-grafted branches are referred to as 'stock' branches.

Monitoring insect pest activity: To monitor EAS and TPB, unbaited white sticky cards were deployed on lower branches of grafted and non-grafted tree trees on 30 March, 2020, at the silver tip bud stage (Fig. 2A). PC monitoring was done using unbaited black pyramid traps deployed near grafted and non-grafted trees starting in early May 2020, at the pink tree stage (Fig. 2B). AMF was monitored from 30 June to 18 September, 2020, using unbaited red sticky spheres deployed in optimal position within the tree canopies (Fig. 2C). All insect traps were inspected once a week. Tree phenology was recorded twice a week (data not shown).

Assessment of fruit injury. Starting on June 2nd, levels of fruit injury by PC, TPB, and EAS were recorded weekly until July 7th, 2020. Fresh fruit injury by PC was recorded by marking the scar with sharpie, in order to avoid counting the same fruits. The level of fruit injury by all pests was recorded at harvest (in mid-September, 2020) by sampling 20 fruits from every cultivar of grafted trees and 20 fruits from non- grafted trees.

Results

Insect captures in grafted vs. non-grafted trees. During the pre-bloom period, white traps deployed on grafted trees captured 2.3 times more TPB than traps placed on non-grafted trees. However, results are statis-

Figure 2. Insect monitoring devices: (A) unbaited white sticky card for tarnished plant bug and European apple sawfly, (B) unbaited black pyramid trap for plum curculio, and (C) unbaited red sticky sphere for apple maggot fly.

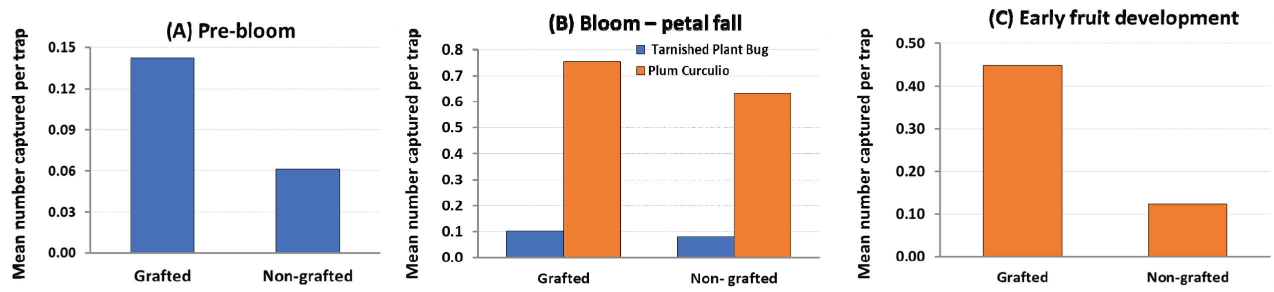

Figure 3. Captures of tarnished plant bug (blue bars) and plum curculio (orange bars) on grafted and non-grafted trees at three phenological tree stages: (A) Pre-bloom (B) Petal fall, and (C) Early fruit development.

tically non-significant due to variability among samples (Fig. 3A). From bloom to petal fall, PC and TPB captures were similar in grafted and non-grafted trees (Fig. 3B). During the early fruit development period,

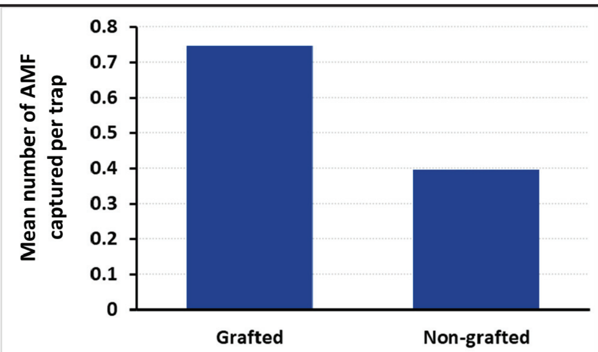

Figure 4. Captures of adult apple maggot fly (AMF) on unbaited red sticky spheres deployed in grafted and non-grafted trees.

significantly more PCs (over 3 times more) were captured on grafted trees than on non-grafted trees (Fig. 3C).

Across the 10 commercial orchards, unbaited sticky spheres placed on grafted trees captured nearly twice as many AMF as unbaited sticky spheres deployed on non-grafted trees (Fig. 4).

Level of fruit injury caused by insect pests in grafted vs. non-grafted trees. There were significant differences among cultivars in terms of level of fruit injury caused by PC during May and June. Stock fruit (fruit sampled from non-grafted branches in grafted trees), followed by Ginger Gold, received the most injury by PC. The least damaged cultivars across the 5-week period were Dabinett, Wickson, Yellow Transparent, and Liberty (Fig. 5). Ginger Gold received the highest levels of fruit injury by TPB (see blue bars in Fig. 6) recorded at harvest.

AMF injury was very low across all blocks. Only a single fruit, sampled from a grafted tree (cultivar: Ginger Gold) was found to be infested by AMF. It is important to note that all trees were subject to standard insecticide applications by the growers so infestation levels were expected to be low.

Conclusions

Based on the first-year results of this long-term study, we recorded evidence supporting our hypothesis that grafted trees may be more attractive to some insect pests than non- grafted trees. Ginger Gold, one of the six cultivars selected for grafting, was highly attractive

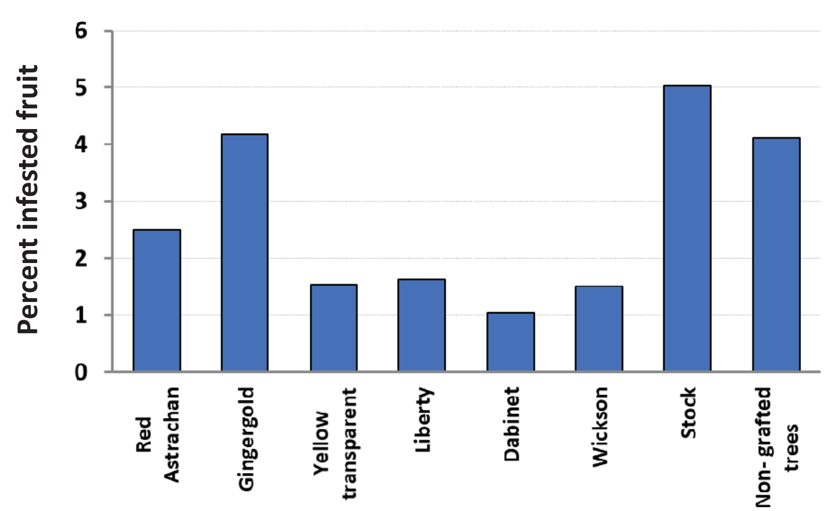

Figure 5. Mean percentage of fruit infested by plum curculio in grafted and non- grafted trees across 5 weeks (June 2 to July 7, 2020).

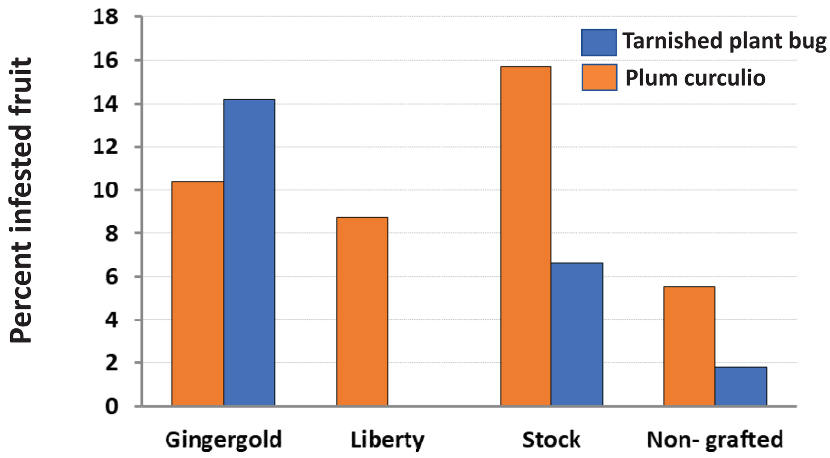

Figure 6. Mean percentage of fruit damaged by tarnished plant bug (blue bars) and plum curculio orange bars) in grafted and non- grafted trees at harvest.

to TPB and PC, based on trapping and fruit injury data. Because tree branches were grafted in 2018 and 2019, multiple years of research are therefore needed, under multiple levels of pest pressure, before firm conclusions can be drawn concerning the relative attractiveness of grafted trees to insect pests.

Acknowledgments

We thank Joanne Dinardo (Sholan Farms), Keith Arsenault (Ragged Hill Orchard), Tom and Ben Clark (Clarkdale Orchards), Shawn McIntire (Cold Spring Orchard, Belchertown, MA), Kenneth Nicewicz (Nicewicz family farm) Albert Rose (Red Apple Farm, Phillipston, MA), and Mo and Andre Tougas (Tougas family farm) for allowing us to work on their orchards. We also thank Ajay Giri for assistance.

The University acknowledges the support of the Massachusetts Society for Promoting Agriculture provided in memory of David Chandler, who worked tirelessly to promote the best agricultural practices in the Massachusetts apple industry. The USDA National Institute of Food and Agriculture provided additional financial support for this work through project award number 2019-70006-30445.