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Japanese Beetle Mass Trapping in Massachusetts Grapes and Blueberries

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Abstract

Expanding populations of the invasive pest, the Japanese Beetle *(Popillia japonica)*, in North America are damaging the region's ornamental and fruit-growing businesses. This pest is known to favor grapes, roses, elder, raspberry, blackberry, and blueberry, as well as soybean, an important crop in the Midwest. Research in Missouri has shown mass trapping using semiochemical lures is effective for *P. japonica* management in blueberry and elderberry in organic systems. During the summer of 2023, we evaluated the same mass trapping system for *P. japonica* at the University of Massachusetts Cold Spring Orchard Research Facility in Belchertown MA, specifically in conventionally-managed grape and blueberry crops. Over the two months (July-August) of data collection, the traps in both grapes (six traps) and blueberries (one trap) accumulated 1.42 kg, equivalent to 20,518 adult *P. japonica*. Between crops, 12,496 (61%) beetles were captured in the grape block and 8,022 (39%) beetles in the blueberry block. During the trapping period, visual surveys were conducted simultaneously to assess pest pressure on the foliage of both crops. Blueberry surveys showed little to no pest pressure on the crop while a high number of insect catches were recorded in the traps nearby. However, in the first two weeks of data collection, high Japanese beetle counts on foliage and low catches in a single trap in the grape block data showed that our two-trap system, effective in blueberries, was not effective in grapes at the peak of beetle activity. Accordingly, an insecticide spray was applied to prevent further defoliation. After this, we increased the number of traps from one number to six and reached effective control without pest resurgence. In conclusion, a single mass trapping system provided effective control of *P. japonica* in blueberry, but multiple perimeter traps were required to avoid *P. japonica* resurgence on grapes. Mass trapping may offer small-fruit growers in MA a new tool to combat the japanese beetle under low or no insecticide spray regimens.

1 Introduction

The Japanese beetle *(Popillia japonica)* is a pest responsible for the defoliation of crops and ornamentals, particularly grapes. While extensive defoliation and pest pressure are more concerning in young vines and new growth whereas mature vines and fruit are less susceptible to dying from defoliation[1], the adult beetles can cause economic damage to fruit as well. In New England, adult beetles emerge in early July and defoliate plants throughout July and August. Then, the adults lay eggs in the soil that emerge the following summer.

Different chemical treatments for *P. japonica* are used to manage populations of adults and larvae. Although adults are the cause of defoliation and the reproduction of future offspring, controlling larvae before they emerge can prevent the rapid rise of adult populations in the summer. On the one hand, larvae burrowed underground are usually targeted with turf insecticide treatment and, as an alternative to chemical controls, biological control options such as entomopathogenic nematodes[2]. On the other hand, adults are targeted with foliar sprays, mainly neonicotinoids and pyrethroids in conventional managment systems.

Neonicotinoids have lethal effects within the first day of application, as well as systemic effects after a few days. Imidacloprid, a commercially available neonicotinoid, kills feeding beetles within the first day or two and paralyzes beetles that eat leaves a few days after application[21]. Pyrethroid (synthetic) and pyrethrins (organic) are also commonly used to control *P. japonica*. Another difference from neonicotinoids is that the pyrethroids are not absorbed by the plant. Instead, they are lethal to the pests upon contact but wear off quicker than neonicotinoids[21].

In organic settings, chemical control options are more limited and include microbial and plant-derived insecticides, such as Neem oil. Neem targets *P. japonica* and other insects through multiple modes of action. Adult beetles are less attracted to leaves that are sprayed with neem (antifeedant effect) and their mating and sexual communication becomes distrubed upon contact with the agent. The oil then coats the treacheal tubes of the insects, suffocating them. The insects that survive this and sucessfully mate proceed to leave the oil on their larvae where it acts as a molting disruptor, mimicking hormones needed for the larvae to mature[3]. However, neem does not kill the pest directly, and the active ingredient is degraded quickly by UV light and heat. Thus, organic growers sometimes struggle to effectively repel and control *P. japonica*.

Unlike organic pesticides, conventional, broad-spectrum insecticides are relatively inexpensive and effective. That being said, these insecticides generally have negative environmental impacts such as run off into waterways[12] and damage to local wildlife[22]. The availability of organic management options are limited, less effective, and more expensive, and some instances less harmful to the environment.

To understand why herbivores are attracted to their host plants, one must discuss the importance of plant volatiles (i.e. wind-borne chemicals) emanating from the crops and, the way in which these chemicals draw in pests and beneficial insects to plants. Plants secrete compounds that the wind naturally picks up and carries to insects (e.g. beetles) that sense them via specialized chemical receptors in their antennae[18]. Capture and processing of these chemical signals then directs behavior, such as movement toward host plants[10]. For some insect species including *P. japonica*, feeding over time leads to more volatiles being released from the plant and from the insect themselves (e.g., sex pheromones). This results in more insects becoming attracted to the host crop, causing further aggregation. Both plant volatiles and pheromones fall under a category of chemicals called semiochemicals which are compounds that influence insect behaviors such as feeding, aggregation, and mating[10,18]. The same semiochemicals involved in mating and feeding frenzies can be synthesized into lures that cab used to develop integrated pest management (IPM) strategies including attract-and-kill (A-K) systems[13,6,]. AK systemjs influence insect behavior mostly through their olfactory systemand one example of an AK system is mass trapping.

Semiochemical lures are synthetic versions of semiochemicals naturally found in the environment which have been integrated into traps designed to attract specific insects. Mass trapping also incorporates visual cues such as colorful spheres to attract insects[17] . A study conducted in Missouri provided the foundation for the use of mass trapping systems as an alternative to spraying and a cheaper option compared to the current organic management practices for the pest[13]. The Missouri study tested the efficacy a dual-lure mass trapping system as a mangement option for P. japonica which replaced the need for spraying pesticides. The design for a mass trapping system used in Missouri consisted of a large mesh cylindrical sock attached to the yellow trap top with tape and hung nearby the crops. Another system used in Missouri was a trash bin system useful for massive infestations which at the time in 2017, Missouri was suffering from. Massive trash bins with aeration holes cut into the sides and sealed with mesh were used for large quantities of the pest.

The goal of the present study was to evaluate the efficacy of the Missouri mass trapping system here in Massachussets in two crops: grape and blueberry. We wondered if the system used previously in blueberry in Missouri would hold up to different conditions and perform as effectively on other crops here in Massachussetts such as grapes.

2 Materials and Methods

2.1. Study Site

This study was conducted at the University of Massachusetts Amherst Cold Spring Orchard (CSO) during July and August of 2023. We used one block of Frontenac grapes and one block of blueberries (mixed cultuivars). Each block measured about 2000 square meters.

2.2 Trap Assemblance

Pest pressure in Massachussetts is not nearly as strong as in Missouri as reported by Piñero & Dudenhoeffer (2018). Therefore, large traps made of 32-gallon trash bins were not deemed necessary. Instead, we initially tested two designs (Fig. 1): a new in-ground trap designed to auto-compost *P. japonica* which was unsuccessful, and the sock trap design, which in Missouri was effective at controlling the pest and easy to implement due to its portability, size, and low cost.

Figure 1. Above *left*, sock trap design used in MO. Above *right*, failed in-ground trap for automatic JB composting.

We followed the protocol established by Piñero & Dudenhoeffer (2018) to manufacture mass trapping socks. Briefly, we used rectangular 0.75 meter x 0.5-meter cuts of a plastic mesh material, which was folded and stapled onto itself on the side and bottom to create a cylindrical shape. Then this mesh cylinder, or "sock", was securely taped to a plastic trap acquired from Trécé (Trécé Inc., Adair, OK, USA), which consists of a one-piece molded vane of yellow panels that intersect at 90◦ with a funnel underneath ending in a wide rim. Beetles hitting the vane fall through the funnel into the collecting device (sock).

All traps were baited with a double lure system comprised of a floral-based lure (eugenol, geraniol, and 2-phenyl ethyl propionate) and the *P. japonica* sex pheromone japonilure [(R,Z)-5-(1-decencyl)-dihydro-2(3H)-furanone]. Each dual lure was inserted inside vane slots. Yellow tops and lures were purchased from a distributor of Trécé products, Great Lakes IPM (Vestaburg, MI, USA).

2.3 Monitoring for Pest Emergence

Monitoring for *P. japonica* was necessary to determine when to implement trapping systems to effectively intercept the beetles emerging from the orchard's soil in early July. To that end, we implemented a monitoring system using the same pheromone lure and a commercial *P. japonica* trap (available at Great Lakes IPM). The monitoring system was hung from vegetation in the perimeter on June 12th and the first *P. japonica* were captured on June 26th.

2.4 Mass Trapping Design

A new design for our mass trapping system consisted an in-ground trap, which was set up on the 26th of July after the first capture of the pest in our monitoring system. The in-ground trapping system was a 0.5m x 0.5m x 0.5m hole in the ground with a wooden board covering it. The lure system with the yellow TRECE trap top was placed into a hole cut in the center of the board, allowing beetles to fly down into it. Further holes were cut along the sides (and covered with metal mesh) to promote aeration and further aggregation of the pest. However, we found that the in-ground trap was not effective at capturing beetles and consequently we switched to the sock traps used in Missouri.

2.5 Experimental Approach and Estimation of Adult Beetle Counts

One single mass trapping sock was deployed at the grape block and also at the blueberry block. The sock traps in both blueberry and elderberry were emptied weekly and weighed. To estimate the population of beetles caught by weight we used the formula developed by Piñero & Dudenhoffers (2018) which uses the weight of beetles captured per trap capture to estimate the number of beetles trapped .

2.6 Assessments of *P. japonica* on Foliage

We assessed the densities of *P. japonica* on the foliage of both the grapes and blueberries weekly. Walking down every other row of a block, the surveyor would stop once every 2 m. and record how many beeltes they could see in thirty seconds at that stop. Due to the size of the feilds and density of foliage, 10 stops were made in the blueberry rows while 20 were made in the grape.

3 Results

3.1 Mass Trapping Catch Results

One single sock was initially deployed at each of the two blocks (grape and blueberry). Due to unacceptable numbers of *P. japonica* found on grape foliage at the peak of activity, (see results below), on July 13th we increased the number of traps from one to six at the grape block, and from one to two a the blueberry block.

Figure 2 shows the total number of *P. japonica* captured on each of five collection dates, for each crop. Trap capture data stemmed from six traps in grape and two traps in blueberry. Comparing *P. japonica* between the two crops, 12,496 (61% of the total) beetles were captured in traps within the grape block and 8,022 (39%) beetles in blueberry-adjacent traps (Fig. 2). The highest number of adult *P. japonica* were captured on July 25th, and captures quickly subsided after that date. At the blueberry block, no insecticides were sprayed and little to no damage was found on plant foliage, highlighting the high efficacy of the mass trapping system for blueberry.

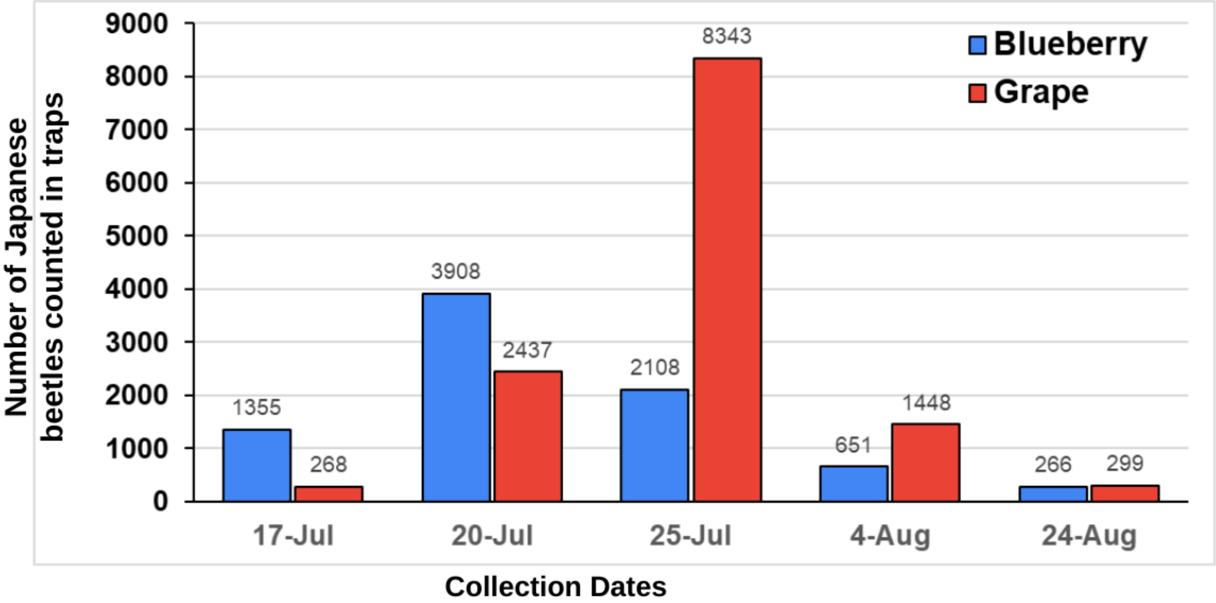

Figure 2. Weekly captures of *P. japonica* in mass trapping socks according to crop.

Overall, across the entire season, the mass trapping systems accumulated a total of 1.42 kg.of *P. japonica*, equivalent to approximately 20,518 adults.

3.2 Beetle Densities on Crop Foliage

Surveys were conducted to assess the population of *P. japonica* on the foliage of both crops. As shown in Figure 3, the blueberry surveys consistently showed little to no pest pressure on the crop, while high number of insect catches were recorded in the mass trapping system (see Fig. 2). In contrast, in the grape block, high *P. japonica* counts on foliage and low trap catches (particularly on the July 13-17th and 20th dates) showed that a single mass trapping system was not effective in grapes when *P. japonica* populations were at their peak. Once six mass trapping systems were deployed around the grape block, and after the insecticide spray (applied on July 13th) the densities of *P. japonica* on grape foliage dropped significantly, and they did not bounce back. This coincided with very high *P. japonica* captures by the six mas trapping systems in the grape block (see July 20th captures in Fig. 2).

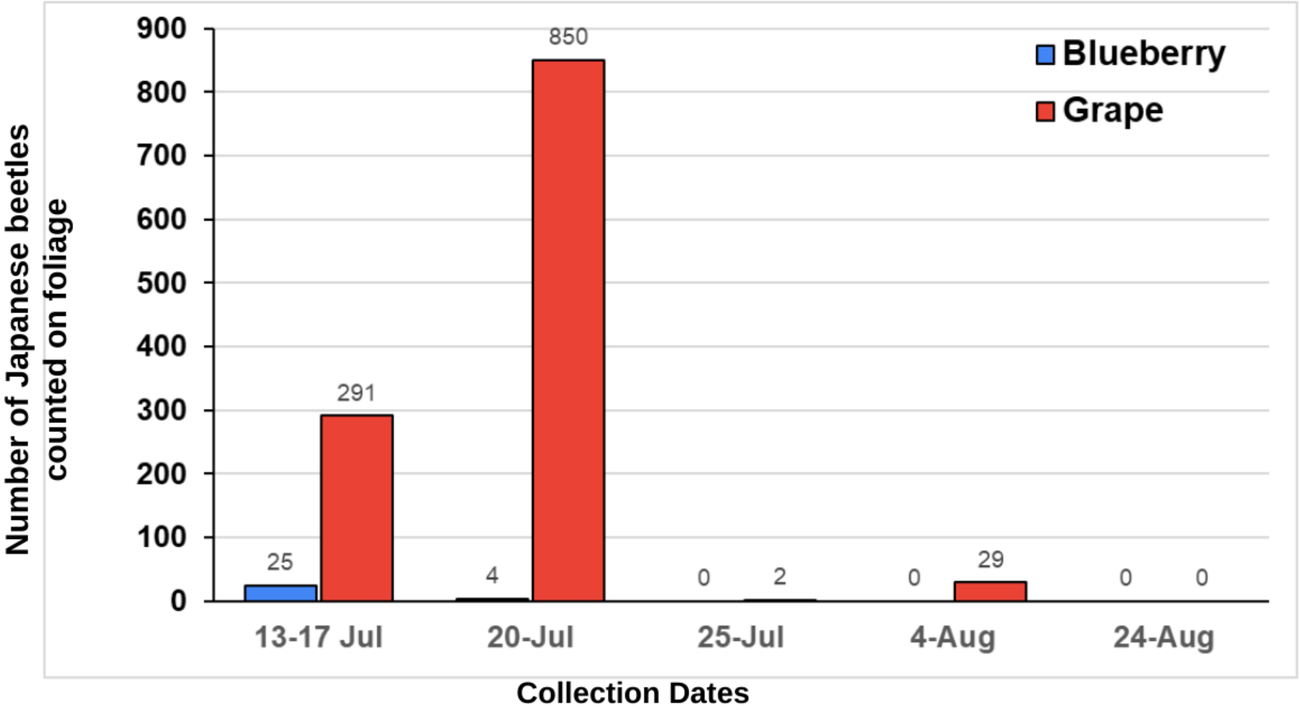

Figure 3. Weekly densities of P. japonica recorded on grape and blueberry foliage.

4 Discussion

4.1 Failure of In-Ground Mass Trapping System

We had first designed an in-ground trap that we predicted would allow us to compost the beetles we caught without having to transport the biomass back and forth from the farm to the laboratory. *Popillia japonica* is known to have a high nitrogen content[14]. Therefore, we planned on adding organic material with high carbon content to promote a proper carbon to nitrogen ratios in the compost, thereby increasing the rate and efficiency of decomposition as well as the quality of the end product. Specifically, we had planned to use sawdust and paper scraps and occasionally mix them up with a shovel as a low-inputs strategy to create compost. The trap did not work because the pheremones at ground level were not circulating in the air as well as they do when a sock trap hangs at head hight. Also there was only one in-ground trap in the grapes and similarly to the single sock trap, this simply was not enough to control the population and as we saw later, a perimeter system was needed.

4.2 Crop Preference

Our results confirmed a difference in *P. japonica* pest pressure between grapes and blueberries. A larger number of beetles were observed on grape leaves and in the traps in almost every collection date (Figs. 1-2). Grapes are among the most attractive crops that *P. japonica* feed on. Both a University of Kentucky study as well as the USDA homeowners handbook for Japanese beetle management both place grapes on lists of highly attractive and susceptible hosts: blueberry cannot be found on either[20] (Table 1).

Table 1. List of plants that are highly attractive to Japanese Beetles[10]

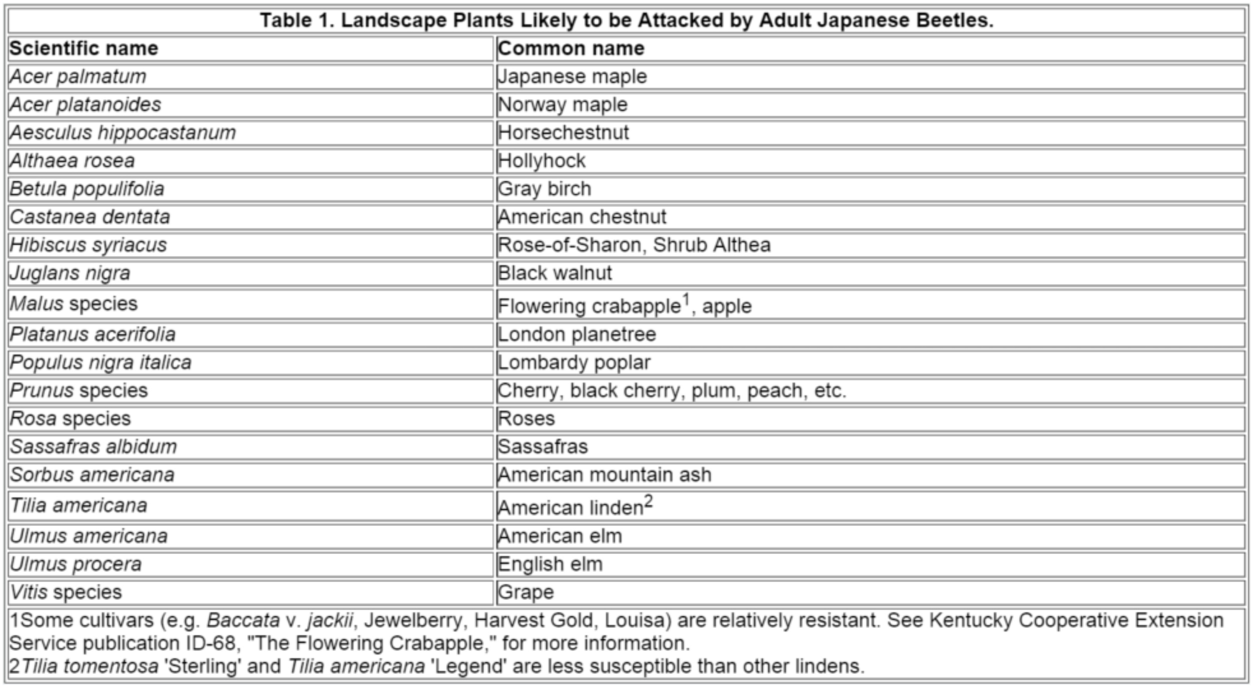

Table 1. Landscape Plants Likely to be Attacked by Adult Japanese Beetles.	
Scientific name	**Common name**
Acer palmatum	Japanese maple
Acer platanoides	Norway maple
Aesculus hippocastanum	Horsechestnut
Althaea rosea	Hollyhock
Betula populifolia	Gray birch
Castanea dentata	American chestnut
Hibiscus syriacus	Rose-of-Sharon, Shrub Althea
Juglans nigra	Black walnut
Malus species	Flowering crabapple[1], apple
Platanus acerifolia	London planetree
Populus nigra italica	Lombardy poplar
Prunus species	Cherry, black cherry, plum, peach, etc.
Rosa species	Roses
Sassafras albidum	Sassafras
Sorbus americana	American mountain ash
Tilia americana	American linden[2]
Ulmus americana	American elm
Ulmus procera	English elm
Vitis species	Grape

1Some cultivars (e.g. *Baccata* v. *jackii*, Jewelberry, Harvest Gold, Louisa) are relatively resistant. See Kentucky Cooperative Extension Service publication ID-68, "The Flowering Crabapple," for more information.
2*Tilia tomentosa* 'Sterling' and *Tilia americana* 'Legend' are less susceptible than other lindens.

Despite this, *P. japonica* can and will feed on blueberries when other options are not as readily available. This is evident from the Piñero and Dudenhofffer (2018) study on mass trapping as well as our data from this summer. At the peak of the beetle population in July, when trap catches were rising and at their highest (Fig. 1, July 17-25th), some *P. japonica* adults were visible on the foliage of blueberries but it was insignificant compared to the amount captured. With the powerful lure present and the beetles coming to the traps and the leaves, one can deduce their attraction to blueberries is still significant and that without the traps in an organic system there would be significant feeding damage. Heavy defoliation of blueberries was the reason why the study on mass trapping using these sock traps was origionally conducted in Missouri.

4.3 Trap Location

Irrespective of crop type, trap location must be discussed to understand why certain trap placements may be more conducive to insect catches than others. The geography of the grape block used in this experiment must also be noted as it is bordered by a wooded edge, another block of grapes with no trapping systems, and many apple trees which were being sprayed for *P. japonica*. These factors, when combined with the relatively high attractiveness of Frontenac grapes, may have influenced the beetles to become further attracted to the unsprayed grapes (prior to the July 13th neonicotinoid spray applied during our study).

When a pest has multiple available plant hosts, the population can become more spread out across the agroecosystem. However, if a farmer manages the pest in every block but one, as occurred in our study with the grapes, that field could suffer massive pest pressure as the pest becomes heavily concentrated in that area. As the fruit blocks on either side of the grape research block were treated with pesticides, the beetles emerging from the soil were drawn to the crops they could comfortably feed on. These factors may have influenced the feeding behavior of the *P. japonica* to even further attract the pest to the grapes as it had few feed sources besides that on the north side of the orchard.

Trap positioning is key to ensuring the protection of the crop against *P. japonica*. We believe the wooded edge a few hundred feet from the grapes was a threat to the crops and functioned as a highway for pests to travel from secondary hosts in the woods to cultivated hosts in the orchard. This is common with many insects such as plum curculio, which is known to emerge from the woods after attacking wild apple or plum trees by being drawn to more favorable cultivars of apple on a maintained orchard. This can make management difficult as farmers cannot use products such as entomopathogenic nematodes (EPNS) to control the larvae population in the soil before the season starts if the population is coming from outside their farms. The same applies here with *P. japonica,* whose larvae can also generally be controlled using EPNS, which would be emerging from the woods, an untouched area where EPNS was not and can not be used to control the pest.

In this study, the pressure of *P. japonica* on the grapes began to overwhelm the crop in early July and the farmer sprayed on July 13th. This was due to the ineffectiveness of a one-trap system in the grape block. As the trap catches remained low compared to the beetle counts on foliage, the insecticide spray was necessary. Shortly after the spray a new, six trap, perimeter system was established with three traps between the woods and the grapes, two between the grapes and the neighboring apples, and one between the grapes in this study and the neighboring block of grapes. This six-trap perimeter system was effective in controlling the resurgence of the *P. japonica* population after the July 13th spray. Further research into trap placement, primary and secondary pest hosts, and the use of perimeter trapping, are all needed to draw a conclusion regarding the impact of trap geography on pest pressure and the effectiveness of mass trapping systems, specifically for *P. japonica* management.

4.4 Mass Trapping System Cost Evaluations

The sock trap system has an upfront cost of $17 for the yellow trap funnel, $4.50 per lure (about two or three per trap per season especially if it rains), and about $10 for a 30m long by 1.25m wide sheet of fine mesh that can be cut into roughly 30 traps costing roughly $.33 a trap. This design was used for research purposes. While the lures must be replaced every season the mesh socks and the yellow funnels can be reused for years to come. After this study our funnels are still in good condition and once washed, the mesh socks can be stored and reused. While the traps may seem to have a moderate upfront cost, as time goes on due to their durability and reuse during a single season as well as season to season. Our individual systems ended up costing roughly $24.50 dollars each plus $4.50 for each extra replacement lure (once every three weeks).

4.5 Cost of Sock Trap vs Cost of Insecticides

Based on the Environmental Protection Agency's warning label for Wrangler™ (imidacloprid): "the maximum amount of spray per year for grape defoliating pests is 12.0 -16.0 oz per acre"[7] (The maximum amount legally applicable to any crop per year is 16 oz.). If one purchased one gallon (128 oz) of imidacloprid for $100, one 16 oz acre application would cost $12, not including labor, fuel, and equipment. Piñero and Dudenhoeffer (2018) assessed the cost of spraying pyrethrins for *P. japonica:*"The cost of spraying PyGanic 5.0 EC against *P. japonica* in a one-acre plot is approx. $77.00 per application, using the high label rate. Therefore, the season-long cost of spraying organic insecticides twice a week for 7 weeks would amount to $924"[13].

4.5 Rainfastness of insecticides and effects on beetle counts on foliage

Imidocloprid, the insecticide applied in our study has imediate lethal effects followed by systemic effects within the week or two after application. Our spray was applied on the 13th of July. While Figure 2 (the chart displaying insects surveyed on the leaves of crops) shows an increase in insects on grapes in the first and second week after this spray, most of those insects had died after feeding on the foliage once the lethal activity of the insecticide wore off. As new insects came to the crop but the systemic effect was still present, the insects that fed on the crops were paralyzed and died slowly, falling off the foliage finally roughly 3 weeks after application. By the third week of the study there were almost no insects on the foliage. The difference between the data from July 20th to July 25th in figure 2. clearly shows the systemic effects of imidoloprid on foliage causing prolonged effects on the population. The systemic nature of neonicotinoids allowed us to sustain a toxic environment for multiple days after the pesticide application thereby efficiently resetting the pest population.

4.6 Weather conditions

The weather being a determining factor in both the life cycles of insects and plants as well as their relationships with each other is important to discuss in this study specifically due to the large amount of rain recorded in Western Massachusetts in the month of July. In Belchertown, over 12 inches of rain was recorded in July. Temperature and weather are determining factors in insect feeding behavior as studies have shown a direct correlation between the two. "The beetles are most active on warm, sunny days, and prefer plants that are in direct sunlight"[10]. The cloudy nature of this summer could possibly have led to a decrease in activity and may not have represented the maximum or even average pest pressure here in Massachusetts during a more sunny summer. Frequent rainfall certainly decreased the longevity of the dual lures, therefore they had to be replaced at least 3 times. In Missouri, a single lure replacement was sufficient to maintain trap effectiveness for at least 7 weeks.

4.7 Limitations of our study and need for further trials

This study was conducted over a single summer with only one block of blueberries and grapes respectively. In order to analyze the efficacy of mass trapping systems here in Massachusetts for other crops such as Honey Crisp apples, raspberries, or roses, further trials would have to be conducted with more trial blocks of each crop, different amounts of traps in each block, control blocks using insecticide and no management, and then comparing the results from all the blocks against one another.

Our study on mass trapping in grapes and blueberries was a trial with the intention of determining if the trapping system used in the Pinero & Dudenhoeffer (2018) study would be effective in Massachusetts. While we have determined that the sock traps work in blueberries and that a perimeter system can control pest resurgances in grapes, we must further investigate perimeter systems in grapes and other crops from the start of the july season which we failed to do in this study.

5 Conclusion

The results of our study show that the implementation of a single mass trapping system in blueberries was successful at controlling *P. japonica* without using insecticides. The same system was not successful at controlling the *P. japonica* population on the grape crop and insecticide was applied on July 13th, resetting the population by July 25th, afterwhich our implementation of a six trap perimeter system successfully controled the population resurgence.

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