Assessing the Mortality of Tractor Mounted Vacuuming on Spotted Wing Drosophila (*Drosophila suzukii*) and Common Fruit Fly (*Drosophila melanogaster*) in Strawberries

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Summary

The tractor-mounted vacuum system called the "bug vacuum" is used by most strawberry growers in California in their integrated pest management programs of lygus bugs (*Lygus spp*.). The bug vacuum has been shown to reduce lygus bug adults and nymphs in strawberries with regular bi-weekly use. In bug vacuum samples obtained from a grower's field in Salinas in 2020, vinegar flies including spotted wing drosophila (SWD) were found which showed they were being picked up by the vacuums suction power, however it was unclear whether the vacuum would ultimately cause any fly mortality. For this study vinegar flies were collected out of growers' fields in Salinas, CA in 2020 and were reared in the lab. Each type of vacuum barrel head that is available to growers was used to measure efficacy against the flies. There are three types currently available, the grower standard made of fiberglass barrel, C&N Tractors, Watsonville, CA, (C&N) molded plastic barrel model, and a Cal Poly build consisting of an aluminum barrel. One of each of the types of barrels was placed on an experimental vacuum used in the study. A known number of live vinegar flies was placed under each barrel and a large net was placed over the top of each barrel to collect the flies as they exited the barrel. This was compared to fly mortality in the net alone without passing through the barrel. The number of vinegar flies physically vacuumed up and mortality was quantified for each barrel type. Each barrel type consistently caused over 87% mortality to vinegar flies used in the study. This demonstrates that the vacuum has the potential to cause mortality to vinegar flies if they are present while the vacuum is being used in the field. It is unclear how many passes a vacuum would have to make per row in strawberry fields to show clear declines in the populations and future use of the bug vacuum for SWD management is discussed.

Introduction

In California, bug vacuums have been available to help manage *Lygus spp*. for almost a decade and the efficiency of the vacuums has grown recently with several upgrades and barrel types available (Thomas and Legard 2014, 2015, Wells et al., 2020). Adoption of these vacuums has also increased to over 90% with most growers using them once to twice weekly in their strawberry fields (Nay 2021). There are three types of bug vacuums currently available to growers which are the grower standard made of fiberglass or plastic barrel, C&N molded plastic barrel model, and a Cal Poly build consisting of an aluminum barrel. The standard fiberglass barrel used by growers has been the only style available for many years. The other two styles are newly available, and some growers have chosen to adopt these more efficient styles configuring them as either a double or single barrel for each row pass. The suction power of these three-barrel types mounted on the tractors can pull up Lygus sp. nymphs as well as adults in strawberry fields and cause significant mortality, but not much is known about other insect species that may be vacuumed up and to what extent damage or mortality will occur to these other species.

Vinegar flies, including the common fruit fly, *Drosophila melanogaster*, and the spotted wing drosophila (SWD), *Drosophila suzukii*, are common pests in most strawberry growing areas of California with SWD being the most damaging species. These flies cost growers 20%+ of their yield if not managed properly (Goodhue et al., 2011). Although insecticides have been used to manage SWD populations since their introduction into Santa Cruz county in 2008 (Goodhue et al., 2011), many populations are starting to show resistance to the most utilized insecticides (Zalom, personal communication). In addition to insecticides, growers can use sanitation practices to remove fruit that is ripe but is not marketable from the field, so SWD and fruit flies do not develop in them. However, many growers feel like this practice of having their pickers remove some or all of the unmarketable leftover fruits is not economically feasible. Other management strategies are necessary to explore in order to control SWD in the areas with known resistance and where full removal of unmarketable berries via sanitation practices are not feasible.

In 2020, SWD and fruit flies were observed in samples taken from a bug vacuum during a prototype test of different barrel types (Table 1). For the sample, a net was secured on the bottom of each barrel and 800 feet of row of strawberries were vacuumed on a grower's field (Table 1). This showed not only lygus bugs but also fruit flies, SWD, moths, and even beneficial insects like minute pirate bugs and syrphid flies (Table 1). Because of what was observed in these preliminary samples, it was clear that vinegar flies could be vacuumed up but would passing through the barrel cause any measurable mortality to them. The objective of this study was to understand the efficacy of the three commercially used bug vacuum barrel types on *Drosophila sp.'s* in strawberry fields.

Table 1. Insects that were obtained from each barrel of the "hydra" bug vacuum during an experimental plot test from 800 ft row of strawberries in Salinas in October 2020 where the insects were vacuumed up but were stopped from entering the barrel with a sample net stretched across the bottom of each barrel.

Bug vacuum barrel style	Fruit flies	SWD	Adult lygus	Nymph lygus	Other pests	Beneficials
Grower standard fiberglass	1	0	1	2	0	0
C&N plastic	3	0	22	3	5	6
Cal Poly aluminum	10	3	31	12	6	7

Methods

For this study, we used the experimental tractor-mounted vacuum called the "hydra bug vacuum" (Figure 1) which has been fitted with the three different barrel styles available to strawberry growers commercially in California.

Vinegar flies, spotted wing drosophila and the common fruit fly, were collected in October from strawberry fields in Salinas, CA. The SWD colonies did not multiple fast enough to use them in this study, therefore, its close relative, the common fruit fly, was used as a proxy for SWD. The common fruit fly is the same size (2mm) and has similar behavior as SWD. The flies were reared on a standard artificial diet in the lab at room temperature. Fifty adult fruit flies were collected using an aspirator from the colony vials and were temporarily knocked out with CO_2 to count and place in the travel vials. Adult fruit flies were randomly chosen from the colonies to represent the mixture of ages that would be in the fields at that time. The vials were kept at room temperature during transportation to and from the study site.

To assess mortality a net (6 ft x 4 ft) was constructed out of chiffon fabric which was sturdy enough to hold up to 40+ mph wind and still allow air to pass through (Figure 2). The net was sewn with a few minor bends to slow down the acceleration of the insects as they exited the barrel but straight enough to keep them suspended in the top pocket of air. The net was tied on with bungee cords and was fully inflated with the barrel blades operating at full speed before any flies were released for the experiment. The air intake speed was measured for each barrel. The flies were released 30cm below the center of the barrel and allowed to fly out of the travel vial (Figure 3). They then passed through the barrel and were collected in the net. The net was closed at the top and the power was cut to the barrel after all flies successfully left the vial which took about 10 seconds. The net was then carefully turned inside out and a backpack vacuum was used to collect all flies and any debris inside the net into a container. Two separate controls were used to assess mortality 1) during travel (5 hours round trip between the lab and where the hydra vacuum was located), and 2) mortality caused by being in the net with the force of the air from the turning blades (not passing through the barrel and its blades). For the travel control 50 flies were placed in the same vials as the rest but were not used in the vacuum but were treated in the same manner. If there were any fly mortality from handling, CO_2 use, or traveling we would be able to differentiate it from the treatment mortality. For this later control, 50 flies were released into the net while attached to the barrel through a small side opening of the net, then collected through the normal means by the backpack vacuum into the collection containers. These flies did not pass through the barrel at any time.

All flies from each replication were temporarily knocked out with CO_2 once back at the lab and were placed into an open shallow petri dish lid which was then placed inside a larger clear plastic container that contained an artificial diet for an additional 24 hours. Any flies that recovered and moved out of the petri dish were counted as live after this period. Any flies that could not move out of the shallow petri dish lid were counted as dead. Since these flies can escape quickly this was necessary to avoid the flies escaping when transferring to the observation containers.

The net covering the top of the barrel could affect the air intake speed and thus the efficiency of the vacuum so air intake speed was measured for each barrel during the experiment with the net on and with the net not attached. The study consisted of a randomized complete block with seven replications completed. All data were analyzed using SAS Proc MIXED and the efficacy data was corrected using the Henderson-Tilton correction formula for corrected efficacy (Henderson and Tilton 1955).

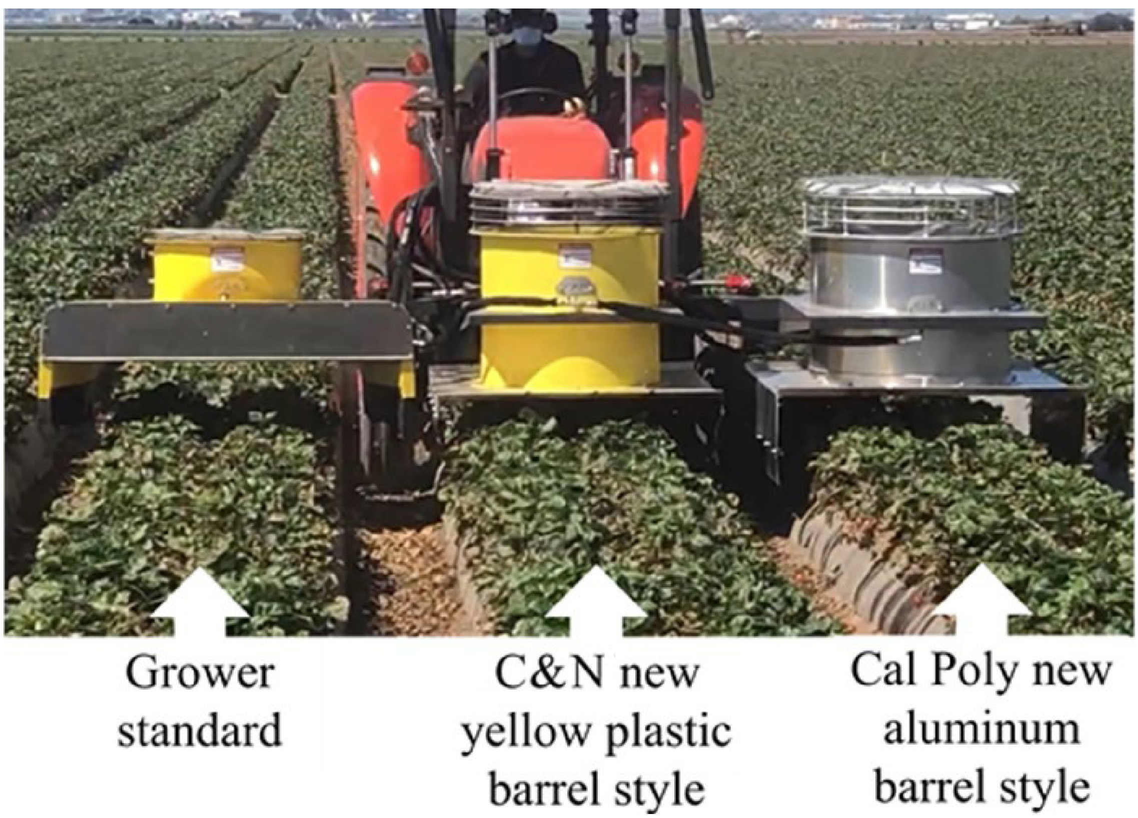

Figure 3 The "hydra", an experimental vacuum used in the study that contains all three styles of barrel designs currently available to strawberry growers including the grower standard fiberglass barrel, the new C&N plastic single barrel design, and the new Cal Poly aluminum single barrel design.

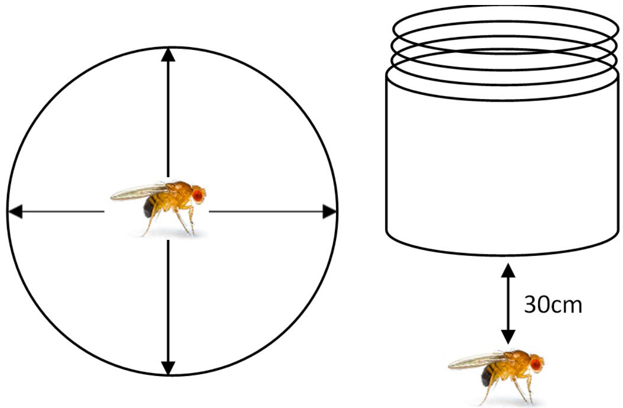

Figure 2. A The vinegar flies that were deceased after exiting the barrel were mostly intact and easily counted, and B) both live and dead flies were recovered inside the net after passing through each barrel.

Figure 3. The release point of the flies under each barrel: flies were released in the center of each barrel 30cm from the bottom of the barrel.

Results and Discussion

All barrel types produced a high amount of mortality (>87%) on the flies passing through the barrels although the grower standard was significantly higher with an average of 94% mortality (Figure 4) (after transforming the efficacy percentage to account for the control mortality). There was an average of 20.12%±SE5.0 direct mortality from traveling as observed in the control vials and an additional 17.24±SE2.73% mortality from the flies in the net only control. Despite having the tractor head raised to max level to avoid any debris going into the net while running the experiment, some sand still entered the net and likely contributed to the mortality seen in the net-only control treatments. In the field during regular usage, a significant amount of debris is observed coming from the tops of the barrels and this likely only increased mortality further as the air intake and debris is traveling at over 40 mph in each barrel.

The air intake speed was significantly slower with the net attached to the Cal Poly aluminum barrel than with no net attached however there was no difference between the air intake speeds of all three types with the nets on overall (Figure 4). This difference may account for the difference observed in the Cal Poly aluminum barrel mortality compared to the other two types (Figure 4). The intake speed was similar with and without the net on the grower standard and the C&N plastic barrel type (Figure 5).

For *Lygus spp*. management using the bug vacuum, it takes two to three passed per row consecutively to remove a significant portion of lygus bugs using any of the barrel types although the C&N and Cal Poly versions increased lygus efficacy by 2.2 times compared to the grower standard barrel version as shown in a recent study (Wells et al., 2020). However, it is unclear how many passes the vacuum would have to make to show a true decline in the number of vinegar flies per row in strawberry fields. Understanding the population pressure of SWD and other vinegar flies on growers' fields with and without the vacuum and accounting for other practices and insecticide resistance that may be present would yield a better understanding of this and should be looked at in the future. Furthermore, additional studies that work to understand the affect of the bug vacuums on other pests and even beneficials should be explored. Having a better understanding of this would help growers utilize the bug vacuums more efficiently and avoid hurting any beneficial insects while managing their target pests.

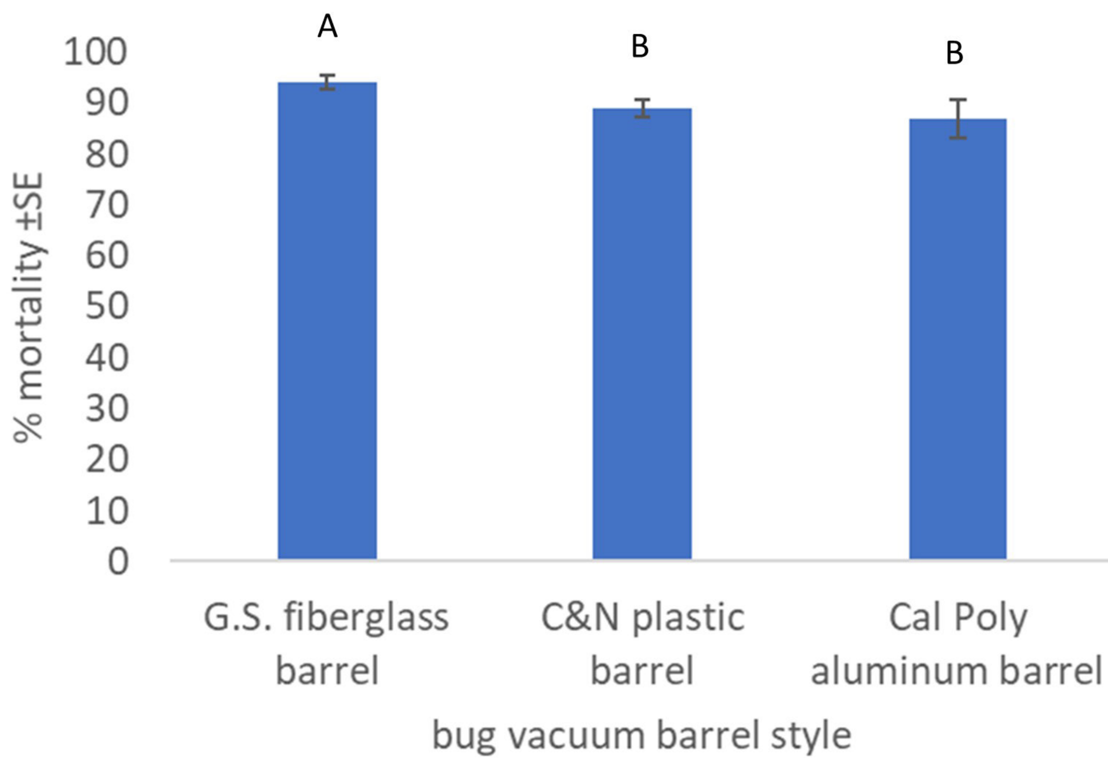

Figure 4. Average percent mortality of the flies after passing through each barrel-style on the experimental vacuum. Data shown corrected using Henderson-Tilton's formula.

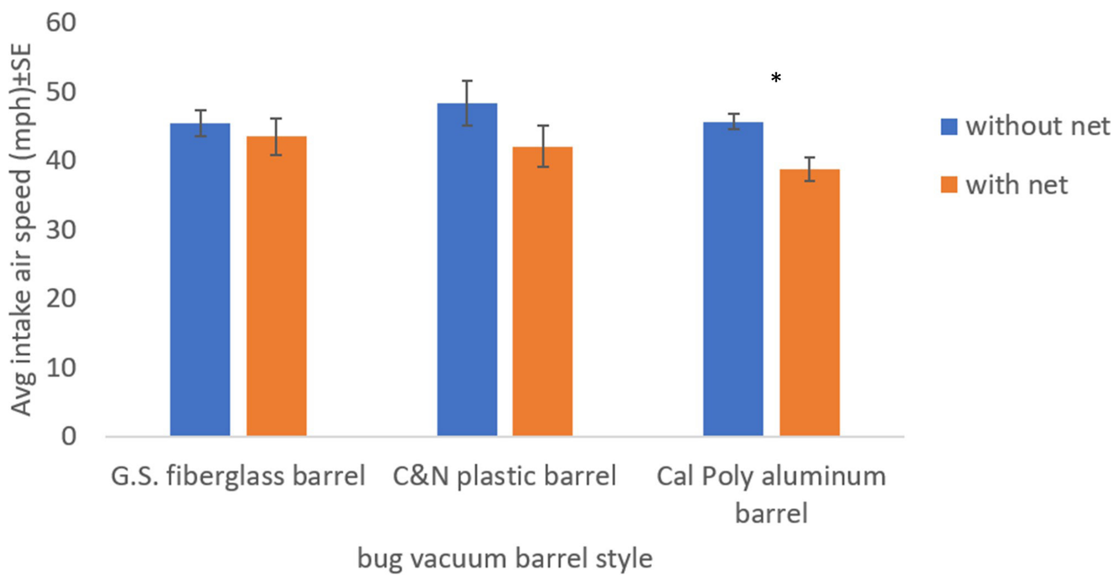

Figure 5. Average air intake speed with and without the net of each barrel-style on the experimental bug vacuum used in the study.

References

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