COOPERATIVE EXTENSION
UNIVERSITY OF HAWAI'I AT MĀNOA
COLLEGE OF TROPICAL AGRICULTURE AND HUMAN RESOURCES

Screenhouse Systems

Environmentally friendly, non-chemical pest control

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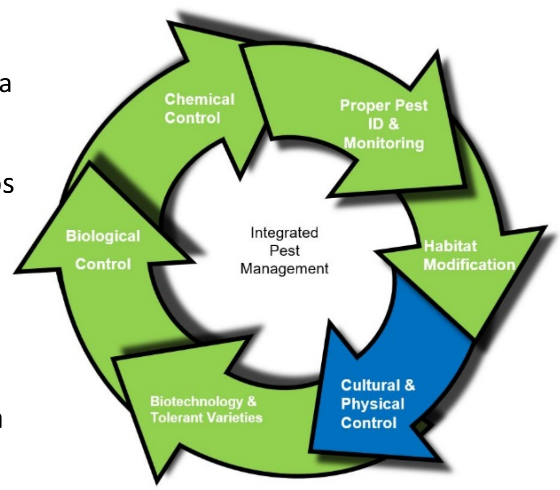
SUMMARY
A screenhouse is an effective tool to minimize pest from damaging crops which may result in reduced productivity, crop and financial losses. It serves as a non-chemical, physical barrier which puts the pest at a disadvantage. Building a screenhouse does not have to be costly. Construction of a screenhouse using home improvement store supplies may help minimize pest populations, reduce pesticide applications and increase production yields. A return on investment can be seen within a few crop cycles, depending on the crop and other external conditions.

USDA NRCS offers financial assistance for commercial grade, high tunnels through the Environmental Quality Incentives Program (EQIP) to growers who qualify for the USDA NRCS conservation cost share program. ***Replicated and observational field trials have shown screen units provide excellent control of agricultural pest such as birds, fruit flies, Chinese rose beetles, Lepidoptera (worm type) pests.*** We are still running field trials to manage small insect pest within these systems. Adoption of resistant varieties helps to manage small insect plant vectors that transmit plant viruses.



Excellent Pest Control

- ***Birds***
- ***Fruit flies***
- ***Chinese rose beetles***
- ***Lepidoptera (worm type)***

BACKGROUND:
Vegetable growers expressed interest in the USDA NRCS' season extender or high tunnel systems, but did not know if the benefits outweighed the initial cost share investment. Prior to 2016, high tunnel systems funded by USDA NRCS, *required the purchase and installation of a kit type, greenhouse-grade unit with a UV resistant (6 mil) polyethylene covering*. In high rainfall areas, the plastic covering provides rain protection and supplemental heat which allows growers to extend their growing season into the winter. However, in many low rainfall and hot environmental areas, the mandatory 6 mil polyethylene plastic is not beneficial to the underlying edible crops.

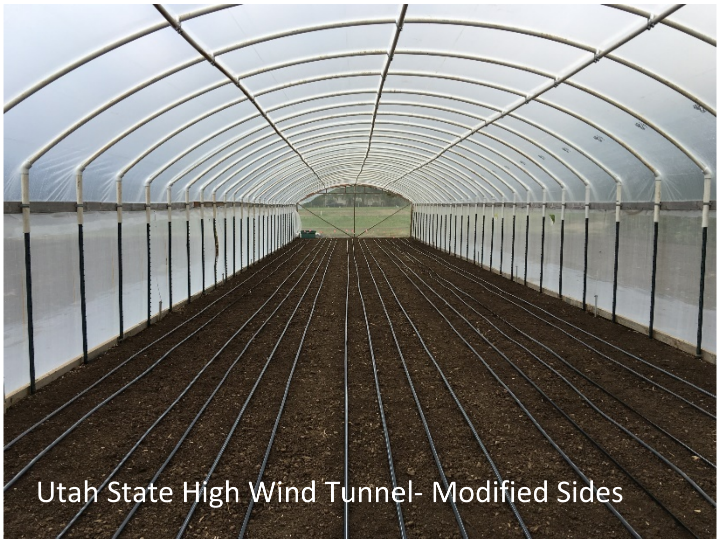
While the polyethylene cover protects the crop from the environmental effects, the sides of these units are typically exposed year-round, which allows pest and plant vectors to damage crops and minimize crop yields.

In 2016, we installed two Conley Coldframes Series 1100 units (Conley's, Montclair, CA) and the Utah State High Wind Tunnel System, with the 6 mil polyethene cover. We modified the sides to include insect exclusion screen (17 mesh) to prevent pest from entering the units. Unfortunately, the structure and the plastic of the Utah State High Wind Tunnel, Conley 1100 and other DIY units with the polyethylene coverings, did not hold up against the tropical storms and high winds that swept through the state. USDA NRCS changed the EQIP criteria in 2017 to allow for screen coverings vs. solely polyethylene.

Conley 1100

Utah State High Wind Tunnel

Conley 1100-Modified Sides



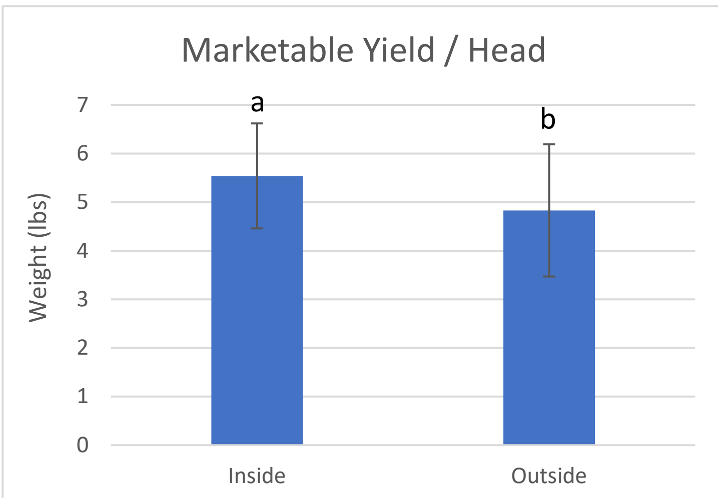
Utah State High Wind Tunnel- Modified Sides

In 2017, we installed 3 commercial, kit type, high tunnel Conley units in Waimanalo (2) and Maui (1). All units were modified to be 100% screen, no polyethylene plastic. We reinforced the side pipes for the Conley 1100 and doubled the cement base of the foundation. For the Conley 1000 unit, the arches were secured into the ground with road pavement and the screen was attached to the structure using wiggle wire. Our do it yourself (DIY) and commercial hoop house system installed with screen coverings endured minimal damage by tropical storms as air flows through the units. Nearly all polyethylene covered houses and its structures were destroyed during our assessment period by strong winds.

MAUI SCREEN FIELD TRIALS:
Five field trials were conducted to date verifying that screened units provide excellent control of pest such as birds, fruit flies, Chinese rose beetles, and *Lepidoptera* (worm type pest with a high probability of resistance issues) pests.

In April 2017, we planted a field trial to evaluate the control of *Lepidoptera* pests in head cabbage on Maui. The trial was conducted in Kula, Maui at the agricultural park where natural field populations of *Lepidoptera* exist in moderate to high levels. We compared head cabbage grown inside the Conley 1100 (commercial cold frame) unit covered with a 17-mesh screen to commercial growers' standard practice (outside).

Results: Head Cabbage Trial at Kula Agricultural Park



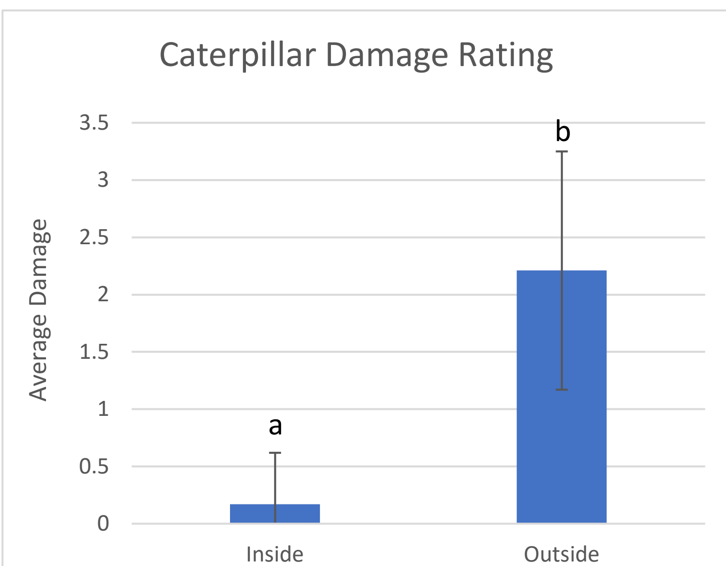


Figure 1. Marketable Yield/ Head
Figure 2. Caterpillar damage rated using a modified Kemerait et. al. scale of 0=none, 1=trace to 5%, 2=6-15%, 3=16-35%, 4=36-67%, 5=68-100%.

Field trials in Maui confirmed that the screened units ***significantly reduced Lepidoptera pest damage and reduced the number of pesticide applications***. However, use of the screen was not effective in reducing damage caused by small insects such as aphids, mites, white flies, etc.

An economic threshold of 10% was used for pest populations which included *Lepidoptera* pest, aphids, thrips, etc. When thresholds were surpassed outside of the unit, a commercial rotation of crop protection chemicals (Entrust, Belt, Dipel, Pasada, Radiant and Xentari) was used in accordance with Maui's Diamond Back Moth (DBM) Insecticide Resistance Program.

When pest populations of *Lepidoptera* and small insect pest (aphids, thrips, etc) exceeded 10% within the unit, organic insecticides were used. Entrust was used for *Lepidoptera* pests. Crymax and or Dipel were selected as rotational chemicals for Entrust, but they were not needed due to low *Lepidoptera* pressure. M-Pede (2% v/v) and Pyganic 5% (17 fl.oz. / acre) were selected and used for aphid control. A total of 7 crop protection chemicals were used outside of the Conley house in comparison to 3 crop protection chemical applications used within the screened unit. Six conventional chemicals were used for *Lepidoptera* control outside of the unit compared to 1 Entrust application within the Conley screened structure.

SUMMARY: Small insect pests were able to move in and out of the screen and/or were transported into the screened units at transplant. The use of M-pede and Pyganics were not suffice to control aphid populations within the screened unit when pest populations exceeded the economic threshold. Aphids multiply very quickly without the need to mate.

We implemented two field trials in 2017 to improve the management of aphid pest under screen units by 1) increasing the frequency of organic insecticide applications and 2) evaluating different spray systems to achieve better spray coverage. However, both trials endured problems due to unforeseen environmental issues. We will continue this work in 2018.

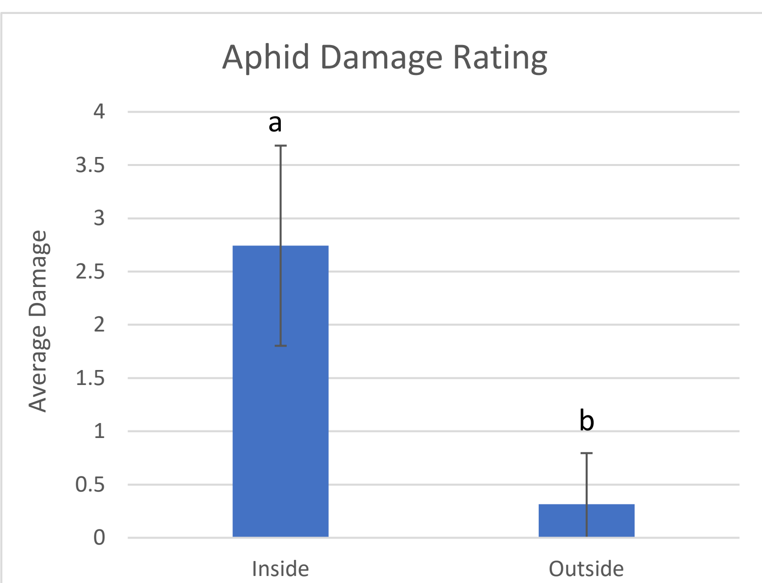


Figure 3. Aphid damage on head cabbage. Rated using a modified Kemerait et. al. scale of 0=none, 1=trace to 5%, 2=6-15%, 3=16-35%, 4=36-67%, 5=68-100%.

Results: Evaluation of Pak Choy Grown Under Two Types of Screen

OAHU FIELD TRIALS
In March 2017, we planted a replicated field trial to evaluate the control on webworm in pak choy on Oʻahu. The trial was conducted at the Waimanalo Research Station where natural field populations of webworm pests exist in moderate to high levels. We compared pak choy cabbage grown under different screen systems (with a hoop for structure) to commonly used organic insecticides.

In a previous field trial using daikon in Waimanalo, we found that the 17-mesh screen provided improved *Lepidoptera* control over the untreated control (Wong, 2017). **The 17-mesh screen also provided *equivalent webworm control to the organic insecticides Entrust and Crymax as well as the conventionally used insecticide, Coragen.***

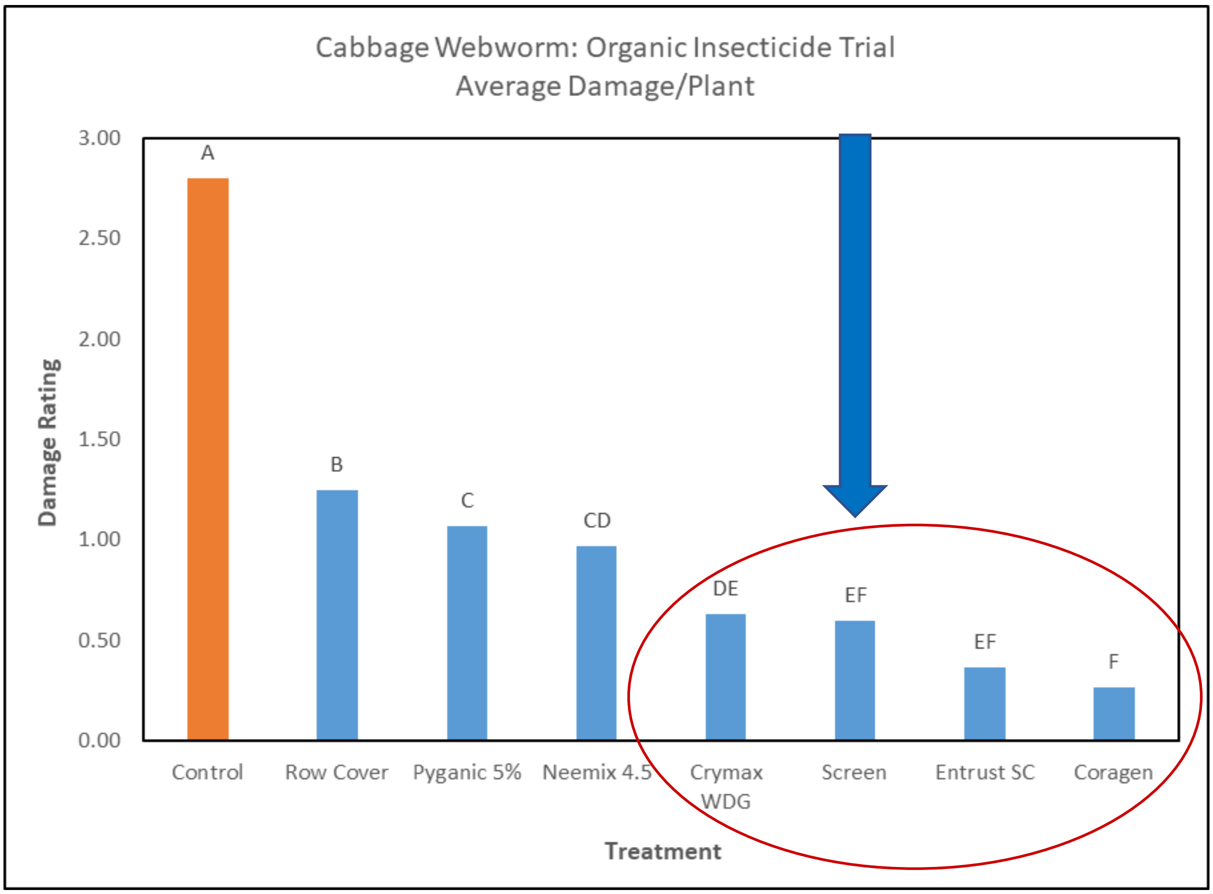
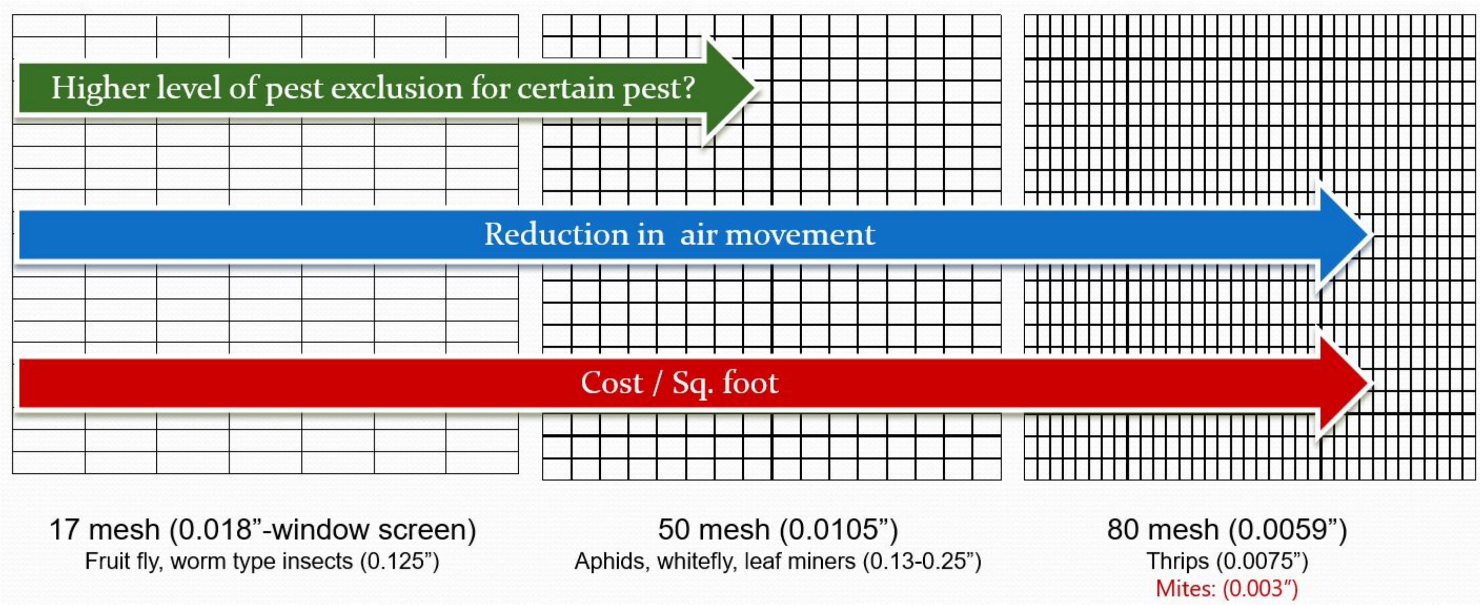


Figure 4. Webworm damage rated using a modified Kemerait et. al. scale of 0=none, 1=trace to 5%, 2=6-15%, 3=16-35%, 4=36-67%, 5=68-100%.

In this trial we wanted to see if Mesh 40, a finer mesh, would provide similar or improved *Lepidoptera* control as previous field trials. We also wanted to evaluate the impact of this screen on smaller pest types such as aphids, white flies and thrips. Mesh 40 is slightly more expensive than the Mesh 17. We aimed to determine if this mesh could minimize small insect damage and provide a heightened non-chemical option for organic producers due to its smaller mesh size.



Seedlings were started under screen material to ensure minimal worms were transported into the screen unit. Normal horticultural practices were followed for the crop's nutritional and irrigation needs.

We evaluated two screen types (mesh 17 and mesh 40) and two organic chemicals for *Lepidoptera* control. Twelve plants were planted within each treatment. The treatments were replicated 3 times within the area. Hoops were used to hold the screen systems above the crop. Screened units received no crop protection chemical treatments.

Preventative weekly sprays were used to control pest populations outside of the screened units which included *Lepidoptera* pests, thrips and aphids. Entrust SC (6 oz/ acre) and Neemix 4.5 (10 oz / acre) were selected for this trial and applied for 4 weeks. The surfactant, Latron 1956 was used for the first three weeks and Liberate (penetrating surfactant) was used for the last application. Four applications of crop protection chemicals were used to provide comparable control to the different mesh screen systems.

Ten plants were sampled per treatment and assessed for pest damage at harvest. Insect damage on pak choy were rated based on modified Kemerait et al. scale of 0=none, 1=trace to 5%, 2=6-15%, 3=16-35%, 4=36-67%, 5=68-100%.

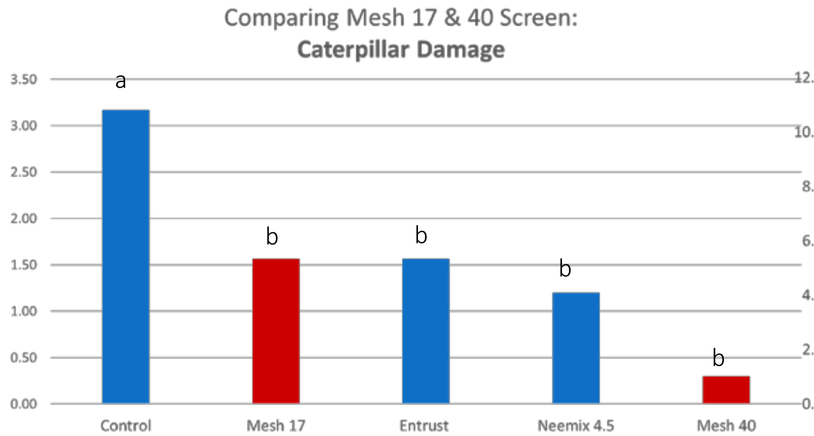


Figure 5. Pest damage rated using a modified Kemerait et. al. scale. Crops grown under the screened unit (17 and 40 mesh) had reduced caterpillar damage than the control and comparable to crops grown outside with organic insecticides, Entrust and Neemix 4.5.

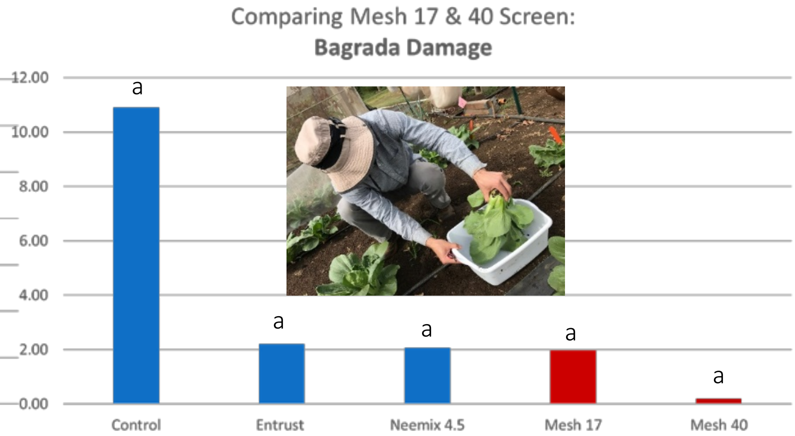
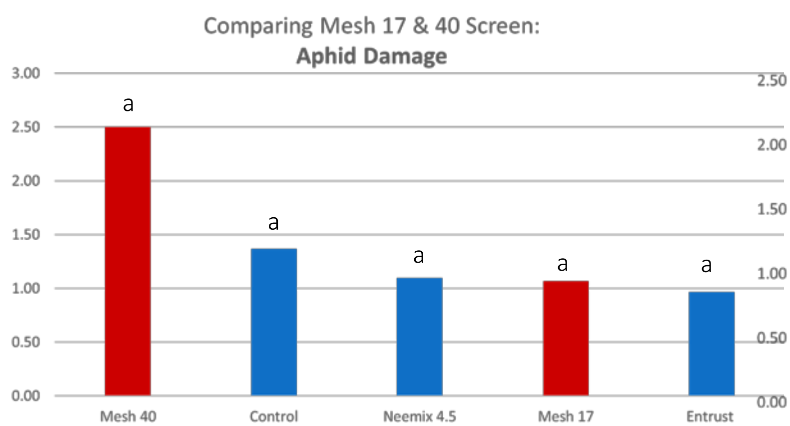


Figure 6. Average number of *Bagrada hilaris* (Burmeister) per head. On March 25, 2017, the Bagrada bug returned to Waimanalo. It was originally detected in March 2016 and then went undetected for over a year. Due to the presence of the Bagrada bug in this trial, we collected data between the different treatments. For this pest, we shook each head and counted the number of bagrada bugs within each head of pak choy. Overall, there were more Bagrada bugs in the control treatment (number of bugs / head) but there were no significant differences when the data was analyzed.



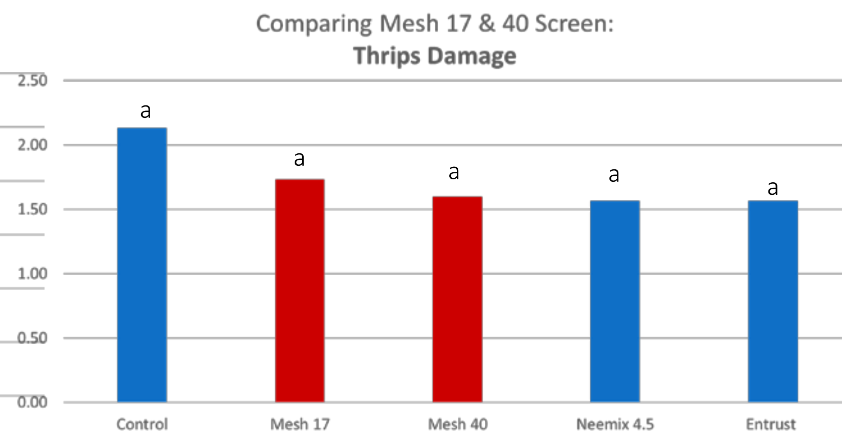
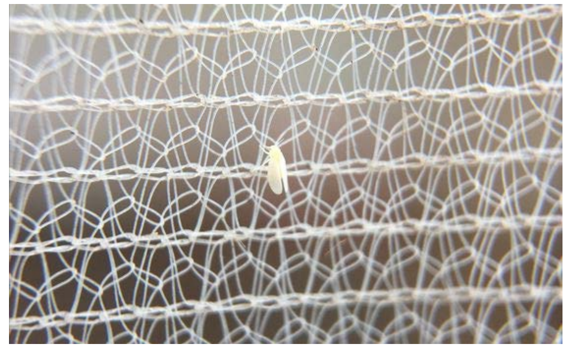


Figure 7A and 7B. Aphid and thrips damage rated using a modified Kemerait at al. scale of 0=none, 1=trace to 5%, 2=6-15%, 3=16-35%, 4=36-67%, 5=68-100%.

We found high levels of damage inside of the screened unit due to small insects such as aphids and thrips. Neither insecticides (Entrust or Neemix) nor the 17 and 40-mesh screens could reduce aphids and thrips damage.

Summary of Mesh 17 and 40 on Pest Management



Data from various field trials conducted by CTAHR provides evidence that Mesh 17 & 40 screen significantly reduced Lepidoptera pest damage and reduced the need for weekly pesticide applications of Lepidoptera type pest. However, there were no added benefits in using Mesh 40 to reduce damage caused by small insects such as aphids, mites, white flies, etc. In many instances, insects that entered the unit were trapped and populations increased (Wang, et. al 2017. Sugano, et.al, 2017)

Evaluation of Different Screen Units on Fruit Fly and Pickleworm

Melon fly (*Bactrocera cucurbitae*) and pickle worm (*Diaphania nitidalis*) are two economically important pests that affect cucurbit production.

Pickleworm (*Diaphania nitidalis*) is known to damage zucchini, kabocha squash, melons and other cucurbit vegetables. Pickleworm caterpillars feed on flower blossoms and tunnel into fruits leaving a distinctive round hole. Damaged fruits are not marketable.

Each year, fruit flies cause significant economic losses that greatly affect the profitability and sustainability of many tropical vegetable and fruit crop productions statewide. Furthermore, with increased export regulations, tropical fruits and vegetables with fruit fly damaged do not meet the state and federal requirements for export to continental United States (U.S.) and international markets. In the past, a common practice to combat these pests involved the use of pesticides containing chemicals such as organophosphates, carbamates, etc. on a routine basis. Targeted protein baits in combination with the organic insecticide, spinosad, have replaced blanket sprays of insecticides for melon fly control.

In consultation with Dr. Ronald Mau, emeritus extension specialist at UH CTAHR and a review of current literature, we confirmed an insecticide resistant population of melon fly occurred on Oahu beginning in 2008 (Hu, 2011). Bioassays conducted by USDA ARS and National Taiwan University and National Chung Hsing University in 2017 verified ongoing resistance issues, making melon fly suppression very difficult in commercial operations.

Zucchini was grown under four different types of screen material with the purpose of obtaining non chemical pest control in Waimanalo, O'ahu (Wang et al 2017). Graduate students with Dr. Koon Hui Wang's Lab helped to build the PVC hoop units and implemented the field trial. Overall, field trial data confirmed the implementation of screens (17, 40, 70-mesh and a shaded screen) helped to significantly reduce fruit fly and pickleworm damage on this fruiting vegetable (graph below). Each type of mesh screen had a set of benefits and drawbacks. Finer screen units did not keep out small insect pest as originally hypothesized.

Excerpt of the field data is below. A copy of the field trial data can be found here: https://gms. ctahr.hawaii.edu/gs/handler/getmedia.ashx?moid=2972&dt=3&g=12

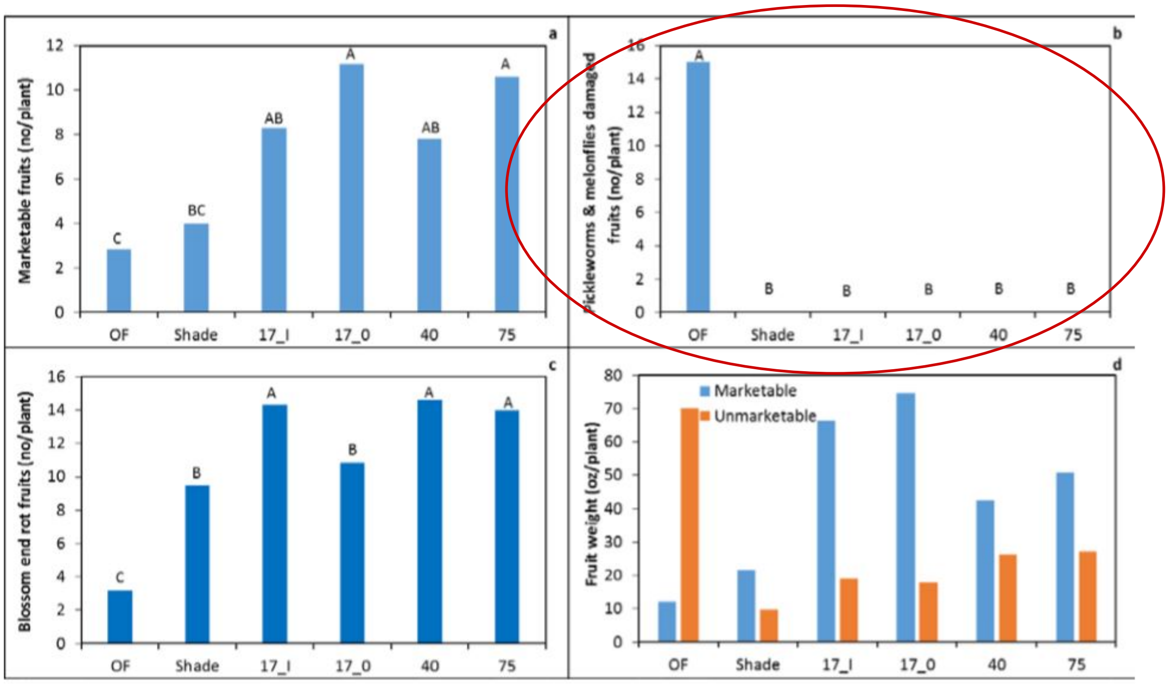


Fig. 5. a) Marketable fruit number, b) Pickleworms and melonflies damaged fruit number, c) blossom end rot fruit number, and d) marketable and unmarketable fruit weight. OF = open field, Shade = 30% reflective shade, 17-I = 17-mesh with insecticide, 17-0 = 17-mesh with no insecticide, 40-mesh and 75-mesh. Means are average of 6 replications repeated measured weekly for 5 weeks. Columns in a, b, and c followed by the same letter(s) are not different based on Waller-Duncan *k*-ratio (*k*=100) test. No statistical analysis was conducted in d.

Advantages of Screen Systems-Observed

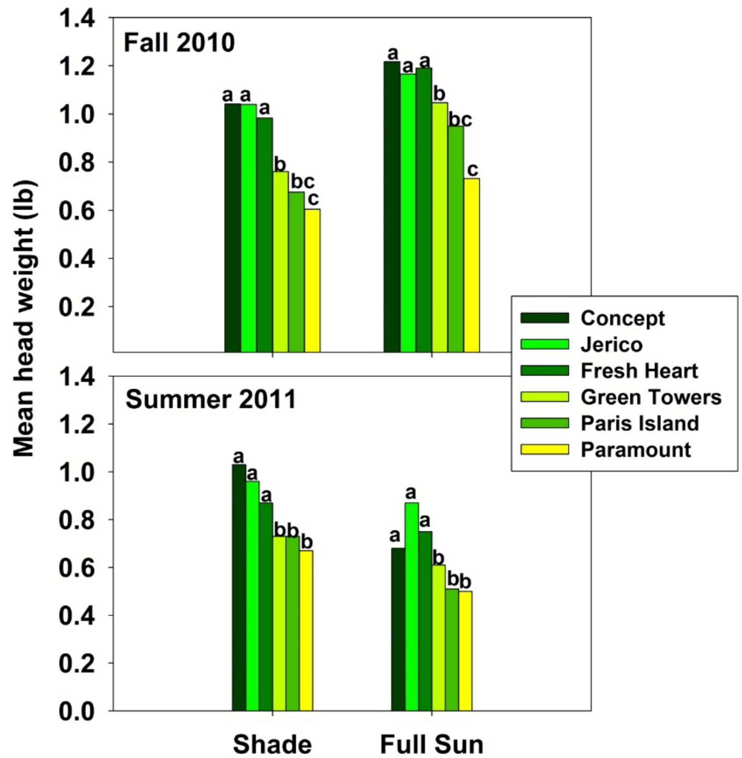
Minimizes Chinese Rose Beetle Damage

Minimizes Bird Damage

(Ho, McHugh and Sugano. 2007)

Reduces Light Intensity and Provides Shade

In 2017, Hobo sensors were installed inside and outside screened units in Kula, Maui. Temperature and light intensity may have played a factor on increased yield and head density inside of the screen. Outside temperatures peaked at 122.076° F with the highest light intensity being 28672 lum/feet^2. Average temperatures outside the unit were 82.8° F. Inside temperatures were lower with peak temperatures at 113.59°F and the highest light intensity at 21504 lum/feet^2. Average temperatures inside the screen unit was 81.3° F.



In previous field trials conducted over several growing seasons at the Poamoho Research Station on O'ahu we noticed that certain crops did better under screen than others. Due to industry's request to identified Romaine varieties that could be adapted for fresh-cut processing, replicated field trials were installed to provide shade (30% shade) to selected Romaine varieties during fall and summer conditions (Sugano, 2011-white paper, Uyeda, 2014,). The screen material selected for the trial in 2010 was Mesh 17. It provided partial shade to the crop and additional screen was supplemented to provide of 30% shade, overall.

Lettuce grows well in cool climates or during cool seasons. When exposed to high temperatures, lettuce has a tendency to bolt (flower), become bitter in taste, and form loose heads. Many of the operations that grow lettuce in Hawai'i are located in cooler areas such as Kula and Kamuela or grow in hydroponic/greenhouse systems.

Field data showed higher fresh-weight-per-head yields outside the shade compared to under shade during fall/spring seasons on O'ahu. *However, contrary to fall production, in summer, there were higher fresh-weight-per-head yields inside the shade compared to outside. Crop quality (less blemishes, softness of leaves, etc.) were also elevated under shade. Implications from this study suggest that shade was only needed for summer cultivation of Romaine lettuce on O'ahu. The use of 30% shade via screen material improved lettuce yields and crop quality during the summer months on O'ahu; however, the yield differences were not significant.*

Benefits of Screen Systems

- *Non-Chemical, Physical Barrier to Pest Control*
    - *Lepidoptera (worm type with resistance issues)*
    - *Birds*
    - *Fruit flies (resistance issues)*
    - *Chinese rose beetles*
- Do It Yourself or Commercial Kit Systems
    - USDA NRCS cost share program
- Reduction of light intensity

Limitations of Screen Systems (still working on these areas in 2018)

- *Small Insect Pest Control*
    - Use resistant varieties
    - Protect & treat seedlings before they enter the screened units
- Reduction of light intensity
    - Seasonal use

Summary

Screen units are an effective tool to minimize pest from damaging crops which may result in reduced productivity, crop and financial losses. It serves as a non-chemical, physical barrier which puts the pest at a disadvantage. Screen can be placed flat on the ground to prevent bird damage or joined together to cover a structure for pest protection. The size of the screen will determine the dimensions of the structure. Sewing or greenhouse wiggle wire material can be used to extend the original dimensions of the screen to cover larger units.

USDA NRCS offers financial assistance for commercial grade, high tunnels through the Environmental Quality Incentives Program (EQIP) to growers who qualify for the USDA NRCS conservation cost share program. *According to USDA NRCS, forty-two (42) high tunnel units have been granted funding under the USDA cost share program in Hawaii since 2013 (USDA NRCS, personal communication).*

We are still running field trials to manage small insect pest within these systems. Adoption of resistant varieties helps to manage small insects that enter screened units which transmit plant viruses.

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