Ecologically Based Pest Management via In-Field Inoculations of Male *Macaranga* Flowers on Insectary Crops in Eggplant Production Systems

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December 2019

Long eggplant (*Solanum melongena*) cultivars are preferred by many of Hawaii's growers and consumers. Commercial producers face resistance issues in managing Western Flower Thrips (*Frankliniella occidentalis*) and melon thrips (*Thrips palmi*), as many conventional and reduced- risk insecticides are not highly effective against these species of thrips. Even the slightest physical damage caused by thrips (streaking) will create financial losses for commercial producers.

Photo 1. Male flowers of *Macaranga tanarius* along the roadside in Waimanalo, Oahu.

The minute pirate bug is an effective predator of the adults and larvae of all thrips species (Ramachandran et al. 2001, Reitz et al. (2003). Funderburk (2009) discovered that a ratio of one minute bug predator to 180 thrips was sufficient to suppress thrips population in field conditions. Dr. Robert Hollingsworth (2015) of the USDA ARS found that the *Macaranga tanarius* tree served as a good host for the minute pirate bug and evaluated its effect on thrips management in greenhouse orchid systems. He indicated that *Macaranga tanarius* was a fast growing and easy to cultivate tree that supported anthocorid predators.

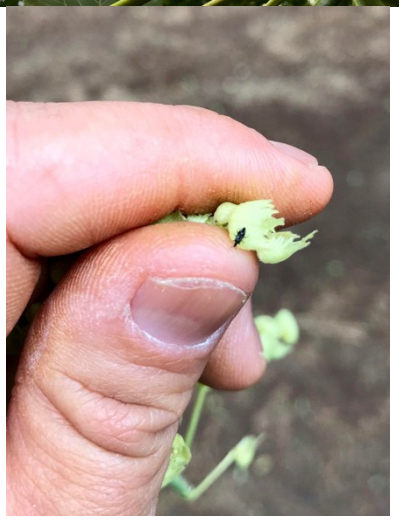


***Photo 2** (right).* Minute pirate bug on a male *Macaranga tanarius* flower.

We received funding from CTAHR's statewide IPM Program, to evaluate the effectiveness of inoculating eggplant with *Macaranga tanarius* flower panicles to suppress thrips populations. Observations of the *Macaranga tanarius* male flowers showed that flowers were abundant in spring and summer months on Oahu. Flowers became less available in the fall and varied by location. In winter 2017, flowers were observed in Kahuku, Oahu, but nonexistent in Pearl City, Honolulu and Waimanalo, Oahu (2017-2019).

Noteworthy, the Hawaii Invasive Species Council rated *Macaranga tanarius* as a high risk weed with a Hawaii-Pacific Weed Risk Assessment Score of 12. Due to the invasive nature of this plant, we opted NOT to install an in row *Macaranga tanarius* cropping systems (as originally proposed). Sunn hemp was used as a border crop around plots and inoculated with *Macaranga* due to its attractiveness to beneficial insects. UH

CTAHR's Tolentino eggplant cultivar was selected for this trial and transplanted into the middle of the block, surrounded by sunn hemp borders.

For the control plots, the same variety of eggplant was transplanted, with no border crop.

Photo 3 & 4. Treatment block with sunn hemp borders and eggplant inoculated with male *Macaranga* flowers

The initial observational trial was installed in February 2017 and sprayed weekly with wettable sulfur for mite control. Sulfur treatments were discontinued on the plants between the sunn hemp rows in May 2018 when flowering began. Male *Macaranga* flowers were collected in June 2018 from the Magoon Research Station. Eggplants between the sun hemp borders were inoculated twice with the pirate bug infested *Macaranga* flowers.

Three leaves per plant were randomly sampled and collected from each plot. Leaves were subjected to an alcohol leaf wash to dislodge the pests in a laboratory setting. Thrips and mites were counted by Dr. Koon Hui Wang's laboratory. Overall, the plants that were surrounded by the sunn hemp borders or insectary plants had higher levels of thrips and mites than the control plots which actively received sulfur treatments. This was largely due to the fact that predatory mites could not be distinguished from regular mites and pollen eating thrips commonly found on male *Macaranga* flowers could not be separated from thrips that damage eggplants under the microscope (**Figure 1**).

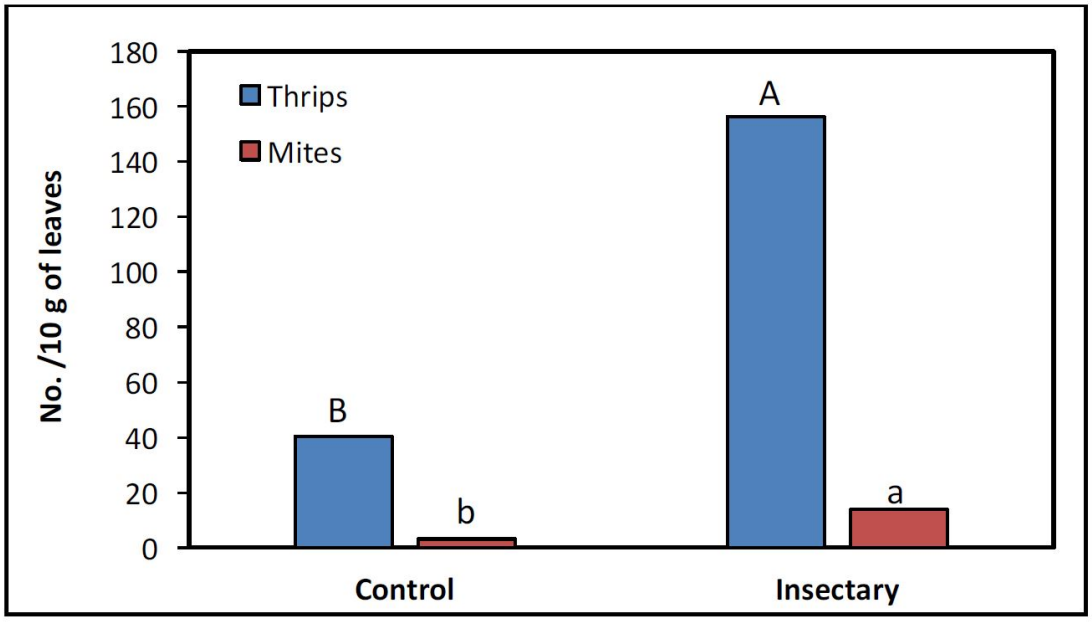


Figure 1. Overall, the plants that were surrounded by the sunn hemp borders or insectary plants had higher levels of thrips and mites than the control plots which actively received sulfur treatments. However, his was largely due to the fact that beneficial mites and thrips could not be differentiated under the microscope.

Damage caused by thrips to marketable sized fruits were observed a week after treatment 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%. Preliminary findings (**Figure 2**) showed that eggplants inoculated with the pirate bugs on *Macaranga tanarius* flower panicles had lower crop damage (2.1) as compared to the fruits in the control plot (3.3). When sunn hemp was chopped and placed under the plants and inoculated with *Macaranga* flowers, the damage decreased further from 2.2 to 1.8. Only 2.5% of fruits were Grade A in the control plots due to heavy scaring vs 16% in the *Macaranga* inoculated plots, with no other crop protection treatments.

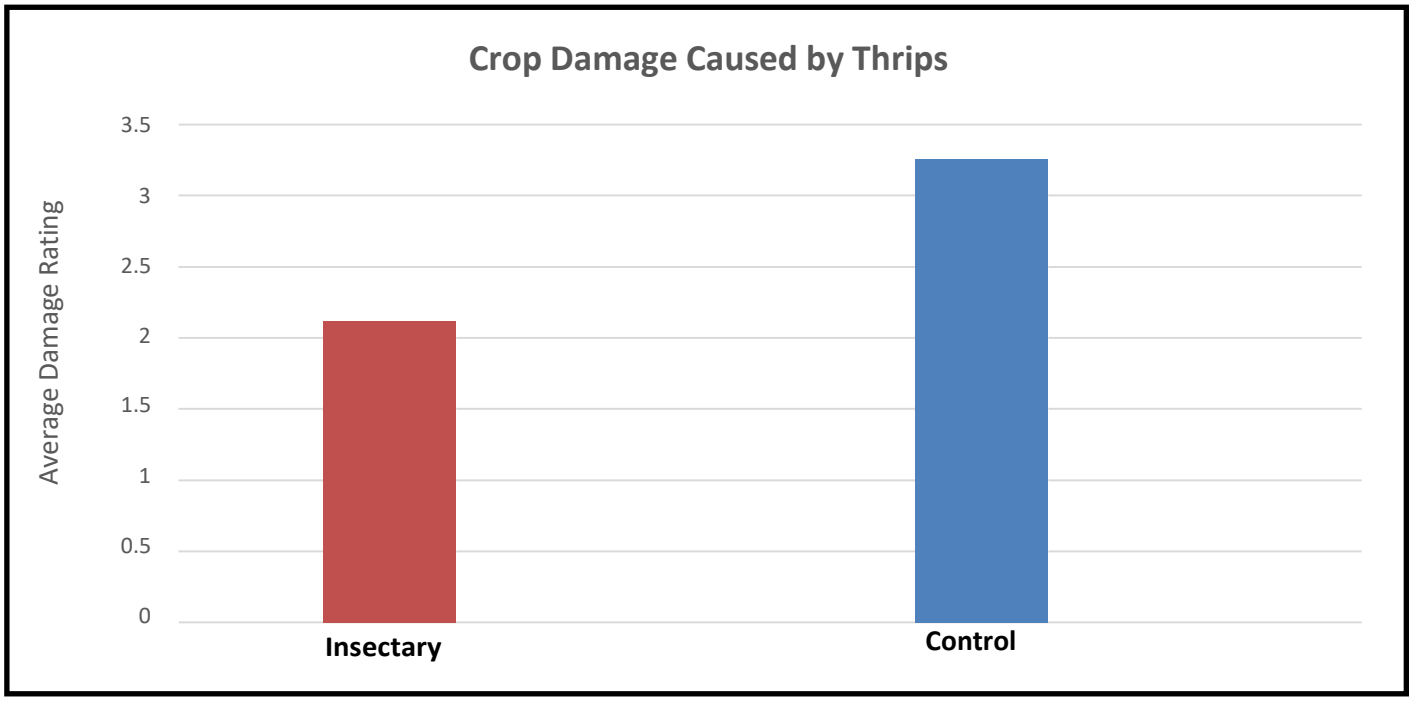


Figure 2. Damage rating (fruit scarring) based on a modified Kemerait et. al. scale of 0=none, 1=trace to 5%, 2=6-15%, 3=16- 35%, 4=36-67%, 5=68-100%. Preliminary findings showed that eggplants inoculated with the pirate bugs on *Macaranga tanarius* flower panicles had **lower** crop damage (2.1) as compared to the fruits in the control plot (3.3). When sunn hemp was chopped and placed under the plants and inoculated with *Macaranga* flowers, the damage decreased further from 2.2 to 1.8.




Photo 5. (left to right). Adult thrips on underside of eggplant leaf.
Photo 6. Streaking and scars the on eggplant fruits caused by thrips damage.
Photo 7. Thrips damage to the plant's terminal shoot. Leaves are discolored, stunted and irregular.
Photo 8. Eggplant fruits with minimal to no thrips damage.

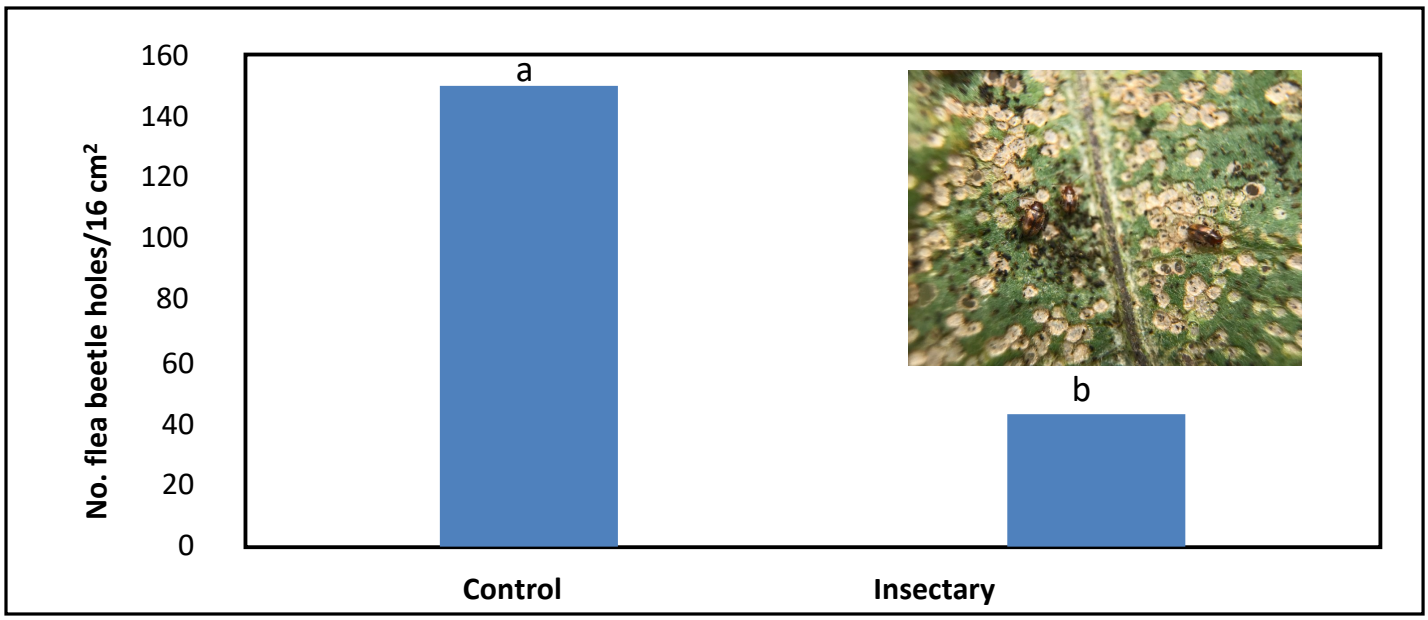
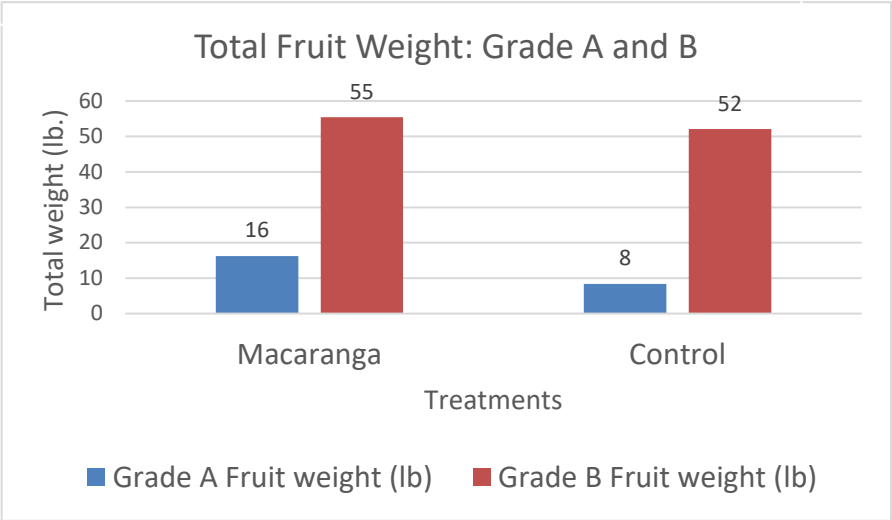


Figure 3. Flea beetle damage was significantly lower in plots which had a sunn hemp border and *Macaranga* inoculations.

The first two field trials were heavily compromised from unforeseen weather in Waimanalo in early 2018. Heavy rainfall and flooding in April 2018 affected overall plant health and vigor. In September 2018, we installed a third field at the Waimanalo Research Station. There were four control blocks and four blocks of eggplants with sunn hemp as borders. There were seven plants per block, with a plant spacing of 3 feet and row spacing of 5 feet. Blocks were randomized and weed mat was installed to reduce the weed pressure in this trial.

Damage caused by thrips to marketable sized fruits was observed during the period of November 16, 2018 to January 11, 2019, 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%. Overall, the average thrips damage was not significantly different between the control (2.3) and *Macaranga* inoculated plots (2.4). Initial inoculation of *Macaranga* flowers occurred on October 24, 2018 in partnership with Dr. Koon Hui Wang's lab and GoFarm Hawaii. Male *Macaranga* flowers were collected from



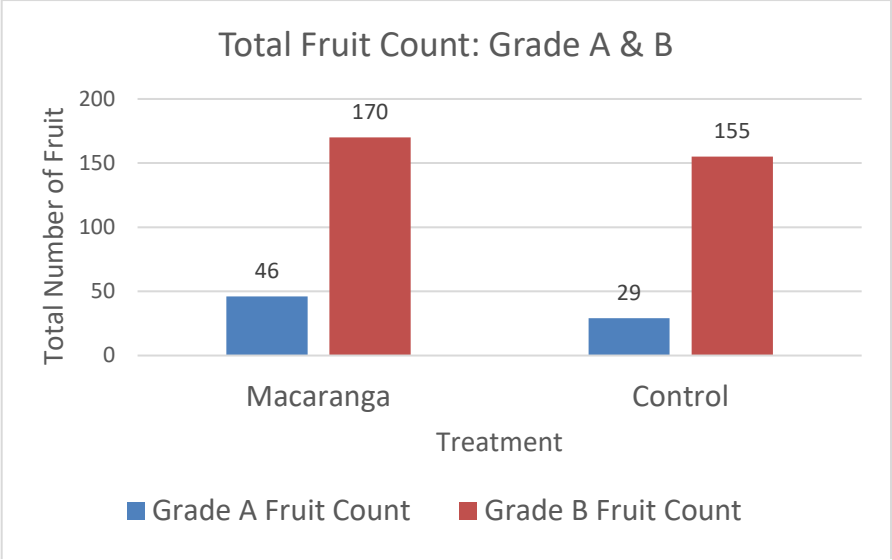


Figure 4 & 5. Plants inoculated with *Macaranga* flowers experienced higher Grade A fruit counts and weight than control plants.

the Magoon Research Station in October 2018. Subsequent inoculations occurred on November 15, 2018 and November 24, 2018 using flowers along Waimanalo's roadways. *Macaranga* flower panicles were hard to find during the winter months and no additional inoculations took place in December 2018.

Overall, the inoculation of male *Macaranga* flowers on eggplants and on the sunn hemp borders helped to increase the yield of Grade A & B eggplants over a nine-week harvest period (**Figure 4 & 5**). Eggplants which were surrounded by a sun hemp border and inoculated with *Macaranga* flower panicles experienced higher fruit counts and improved fruit quality than eggplants without such enhancements (**Photo 9**). While an independent t-Test showed there was no significant difference between the two treatments, the use of sunn hemp as an insectary border inoculated with *Macaranga* flowers helped to increase the number of Grade A fruits by 45%, with no other insecticidal spray treatments.

Photo 9 (top). Eggplants which were inoculated with *Macaranga* flower panicles experienced higher fruit counts and improved fruit quality than eggplants in the control plots.

Photo 10 (bottom). Eggplants are a long-term crop and yielded fruit longer than the lifecycle of our sunn hemp border crop (**Photo 10**).

Summary:
Observations and preliminary field data suggest that the integration of insectary crop borders with the inoculation of male *Macaranga tanarius* flower panicles helped to reduce thrips damage on long eggplant, due to pirate bug predation. However, *Macaranga* is an invasive plant in Hawaii and the of propagating *Macaranga* is highly **inadvisable**.

Macaranga is a dioecious plant with male and female flowers on separate plants. In areas where *Macaranga* is grown in the wild, male flowers with pirate bugs can be harvested and used to inoculate crops suffering from high thrips population.

The biggest limitation of this innovative, ecologically based, sustainable pest management approach was the availability of male *Macaranga* flowers in late fall and early winter in Hawaii.

This approach was initially evaluated on commercial eggplant fields as a method to break resistance when insecticidal treatments were no longer effective. More work is needed for on-farm success.

Future Work:
Eggplants are a long-term crop and can yield fruit up to a year, under optimal conditions. A new insectary crop border (pigeon pea) (**Photo 11)** will be re-evaluated to replace sunn hemp due to *Fusarium* issues which caused the insectary border to die prematurely (**Photo 10**).

Adoption of ecologically based pest management practices (insectary crops, cover cropping, resistant varieties, etc.) would further reduce reliance on crop protection chemicals. Ongoing chemical use may harm the efficacy of the minute pirate bug as a biological control agent in eggplant cropping systems.

References:

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Funderburk, J., S. Olson, J. Stavisky and Y. Avila. 2004. Managing thrips and tomato spotted wilt in pepper. UF/ IFAS Pub. EENY-658, http://edis.ifas.ufl.edu/IN401.

Hollingsworth, R. 2015. *Macaranga tanarius*, a remarkable source of anthocorids for greenhouse and tropical crops. ESA Annual Meeting.

Photo 11. Three-month-old pigeon pea at the Waimanalo Research Station. Alternative insectary border crops will be evaluated in 2020.

Ramachandran, S., J. Funderburk, J. Stavisky, and S. Olson. 2001. Population abundance and movement of Frankliniella thrips (Thysanoptera: Thripidae) in northern Florida. Agricultural and Forest Entomology 3: 1–10.

Funding Source:

Funding provided by the CTAHR Statewide Integrated Pest Management Program