

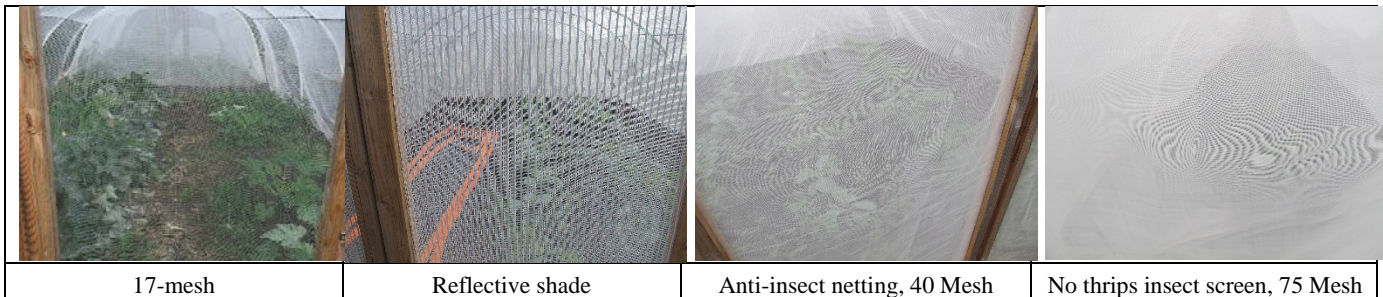


DIY Screenhouse for Insect Management in the Tropics: Part II Hoop Houses

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Introduction

A recent publication in volume 28 of Hanai’Ai (Wang et al., 2017) present three Do-It-Yourself (DIY) screenhouse designs using materials available from local hardware stores and 17-mesh insect exclusion net that can withstand gusty winds occasionally encountered in Hawaii. These screenhouse prices range from \$0.68 to \$0.95 per sq ft., which is equivalent to \$510 to \$713 for a 15’ × 50’ × 6’ house. Among the 7,000 farms in Hawaii, 63 % are less than 10 acres, and 64 % earn less than \$10,000 a year (NASS, 2014). With the increasing number of small-acreage farms in Hawaii, more farmers are looking for lower cost screenhouse designs for insect pest management. Although the 17-mesh screen can block out larger insect pests, it allows the entrance of smaller insect pests such as aphids, whiteflies and thrips. Therefore, the authors conducted another experiment to compare prices and the insect pest management effects of screenhouses using different mesh sizes.



Zucchini was planted in 6 treatments to evaluate plant growth, yield, and pest damage in this study. The treatments were: 1) 17-mesh with OMRI certified insecticides (17-I); 2) 17-mesh without insecticide (17-0); 3) 30% reflective shade (Solaro Exterior Reflective Shade, Greenhouse Megastore); 4) 40-mesh (Anti-insect Netting, Greenhouse Megastore); 5) 75-mesh (No-Thrips Insect Screen, Greenhouse Megastore); and 6) open field. All screen materials evaluated were constructed in the hoop house design as described below.

Hoop house design: Dimensions 14’× 20’× 6’

1. Install ½” rebar 5’ long into the ground at a 5’ spacing with a total of 10 rebars, 5 on each side.
2. Put PVC on one rebar, bend to form a “hoop” shape and place it on the opposite side rebar.
3. Flatten ends and middle of the EMT conduits and screw a hole in the PVC and the EMT conduits
4. Attach EMT conduits to PVC with machine bolts, washers, and nuts for the structural support on the sides and the top.
5. Install door; pound 2 T-posts into the ground and secure to the door jamb with several pipe straps and deck screws.
6. Adjust the height of the house accordingly by moving the PVC pipe up or down on the rebar and use the ½” self-tapping screws to keep the PVC pipe at the desired height.
7. Cover frame with insect exclusion net, use weed mat staples to hold net in place and bury the edges with soil.
8. Staple netting to door frame, for a clean finish, nail 1” × 2” lumber over all spots with staples, and cut excess screen.



Hoop structure with rebar and PVC pipes.



EMT conduits provide structural support between PVC pipes.



Install a door and adjust the height of PVC structure, then secure the PVC to rebar using self-tapping screws. Cover the structure with insect netting.



Staple netting to the door before cutting off excess netting.



Install irrigation, then bury the screen with soil surrounding the house.



Zucchini was planted inside and outside of hoop houses.

Materials for Structure

Materials/Supplies	Quantity
1/2" rebar, 5' long	10
1" PVC, 20' long	5
3/4" EMT conduit, 10' long	6
Machine bolts #8-32 x 1-3/4 in	1 box
Washers #8	1 box
Nuts #8-32	1box
1/2" self-tapping screws	1box
Deck screws	1box
2" × 4" × 8' lumber	7
1" × 2" × 8' strip lumber	3
3/4" pipe strap	6
4" galvanized door hinge	2
galvanized door pull handles (inside and outside)	2
8' T-posts (to anchor door frame to screen structure)	2
Hook and eye (for door)	1
Total Estimated Cost	\$183.54
Price per sq ft.	\$0.66

Screen Material (24'×40')

Insect Netting	Price	Total
17 mesh	\$0.125/ sq ft	\$120.00
Solaro Exterior Reflective Shade, 30% shade	\$0.22/ sq ft	\$211.20
Anti-Insect Netting, 40 Mesh	\$0.345/ sq ft	\$331.20
No Thrips Insect Screen, 75 Mesh	\$0.85 / sq ft	\$816.00

Six zucchini seedlings were transplanted in a row with a 3-ft wide spacing in each screenhouse on Nov 4 2016. The crop was fertigated weekly with 16-16-16. Plants in 17-I were foliar sprayed with Entrust (a.i. Spinosad, DowAgroSciences, Indianapolis, IN) and Trilogy (a.i. hydrophobic extract of neem oil, Certis USA, Columbia, MD) + Oroboost (a.i. alcohol ethoxylate Inc., Oro Agri, Trophy Club, TX) on a weekly rotation. Light intensity and ambient emperature in each house along with plant height, canopy width, and chlorophyll content measured using chlorophyll meter (SPAD-502, Minolta Camera Co. Ltd., Japan) were measured weekly from one month after transplanting. Infestation levels of pests encountered were monitored weekly using rating scales. Aphid infestations were rated with a scale of 0-7 where 0 = 0, 1 = 1-2, 2 = 3-10, 3 = 11-30, 4 = 31-100, 5 = 101-500, 6 = 501-1000, 7 = 1001- 5000 aphids per leaves. Silverleaf symptoms were rated on a scale of 0-5 where 0 = no silver symptom, 1 = 1-33%, 2 = 34-50%, 3 = 51-99% leaves have silver color; 4 = most leaves have silver color but only one leaf is totally silver, and 5 = most leaves have silver color but 2 or more leaves are totally silver. Powdery mildew symptoms were rated with a 0-5 scale where 0 = no powdery mildew symptom, 1= 1-33%, 2 = 34-50%, 3 = 51-99% leaves have powdery mildew, 4 = most leaves have powdery mildew but only one leaf is totally mildew covered, and 5 = most leaves have powdery mildew but 2 or more leaves are totally mildew covered. Zucchini fruits were first harvested on Dec 16, 2016 and continued through Jan 11, 2017 when the crop was terminated. Marketable and unmarketable fruits were counted and weight recorded. All data were subjected to one way analysis of variance using SAS (SAS Inc, Cory,

NC) and repeated measured analysis and Waller-Duncan multiple range test were used wherever appropriate.

Results

Table 1. Ambient light intensity and temperature recorded weekly in hoop houses covered by different shade or screen materials compared to that in an open field during a zucchini crop at Waimanalo, Dec 2016- Jan 2017.

Screen materials	Light ($\mu\text{mol m}^{-2}\text{s}^{-1}$)	Temperature ($^{\circ}\text{C}$)
Open field	979.6	28.6
Reflective shade	446.4	26.7
17-I mesh	802.5	28.4
17-0 mesh	662.5	27.3
40-mesh	766.9	29.1
75-mesh	563.5	28.8

Effects on Zucchini Growth: Light and temperature recorded weekly show that all screen materials reduced light intensity to some extent compared to the open field (OF) (Table 1). In particular, the reflective shade reduced the light by 55% and the 75-mesh reduced light by 43% compared to OF. Whereas the 17-mesh only reduced light by 26%. In terms of temperature, only the 40- and 75-mesh houses had slightly higher temperatures than the OF. Despite reduction of light intensity in these screenhouses, zucchini growth (canopy width and height) in the 40- and 75-mesh houses was improved compared to that in the OF ($P < 0.05$; Fig. 1a, b). Plants under 40-mesh also had higher chlorophyll content than the OF ($P < 0.05$; Fig. 1c). The reflective shade reduced zucchini height and chlorophyll content than the OF ($P < 0.05$; Fig. 1 b, c).

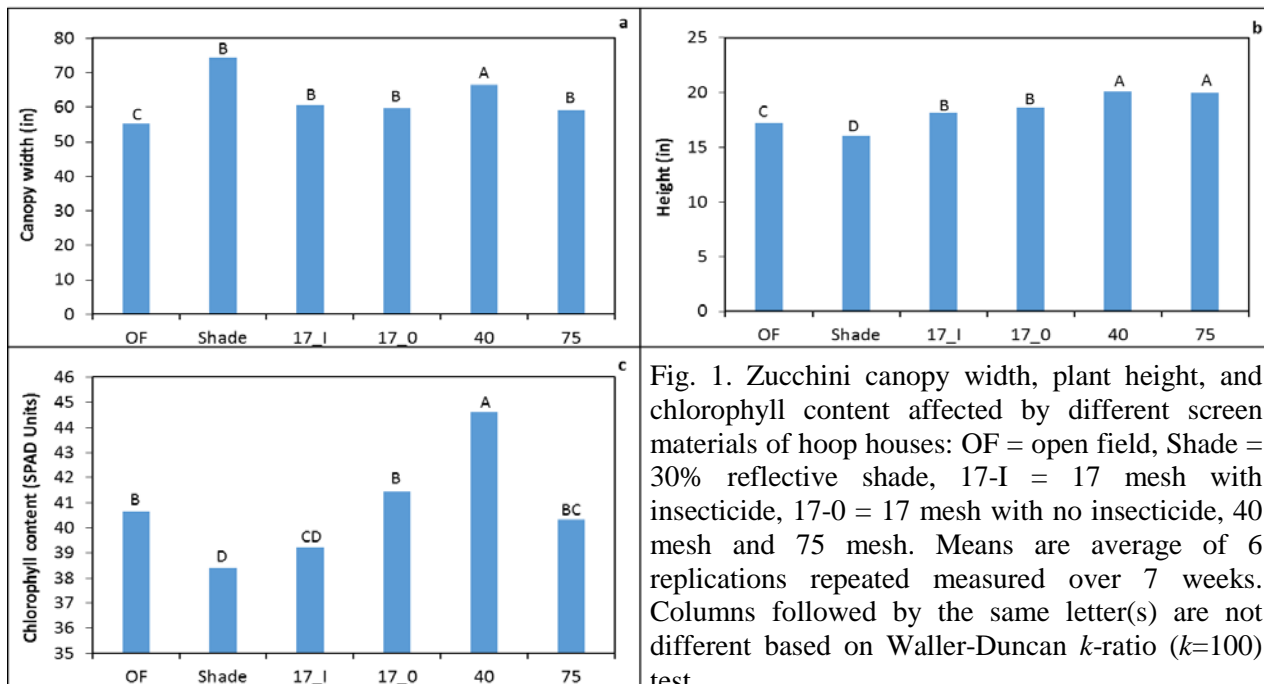


Fig. 1. Zucchini canopy width, plant height, and chlorophyll content affected by different screen materials of hoop houses: OF = open field, Shade = 30% reflective shade, 17-I = 17 mesh with insecticide, 17-0 = 17 mesh with no insecticide, 40 mesh and 75 mesh. Means are average of 6 replications repeated measured over 7 weeks. Columns followed by the same letter(s) are not different based on Waller-Duncan k -ratio ($k=100$) test.

Effects on Pests: Early pests encountered by zucchini in this trial included melon aphids (*Aphis gossypii*) that can potentially transmit viruses, and silverleaf whiteflies (*Bemisia tabaci*) that cause silverleaf symptoms. *Erysiphe cichoracearum* that causes powdery mildew (Fig. 2) only occurred towards the end of the cropping cycle.

Severe aphid infestations occurred in the reflective shade and the 40-mesh houses. The 75-mesh and the 17-0 houses had less aphids than the OF (Fig. 3a). The finer-mesh screenhouses (40- and 75-mesh) had less silverleaf symptoms than the OF whereas the reflective shade increased silver leaf symptomatic plants. Powdery mildew symptoms were reduced by most of the screenhouses except for 17-0 (Fig. 3b).

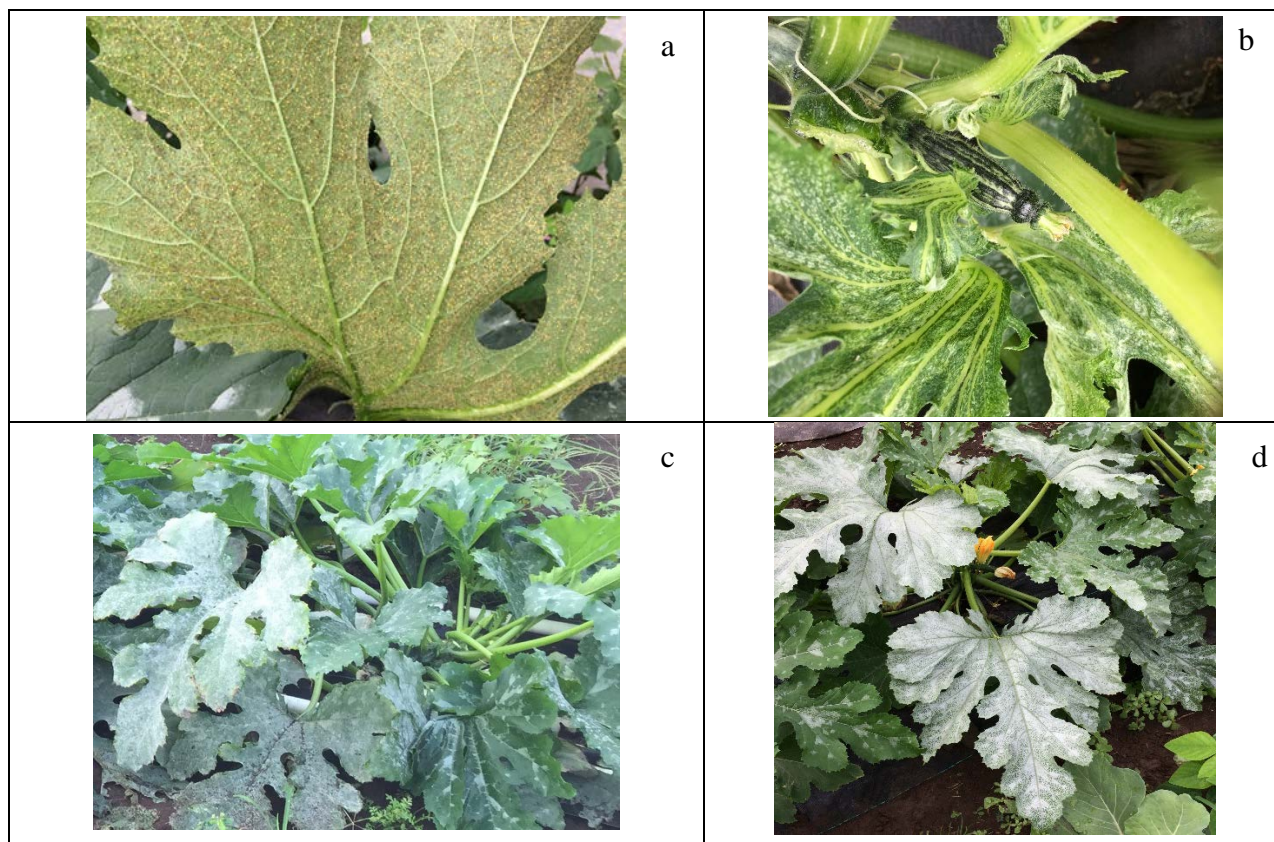


Fig. 2. A) Melon aphids (*Aphis gossypii*) that can potentially transmit virus b) viruses; c) silverleaf whiteflies (*Bemisia tabaci*) that cause silverleaf symptoms, and d) *Erysiphe cichoracearum* that cause powdery mildew.

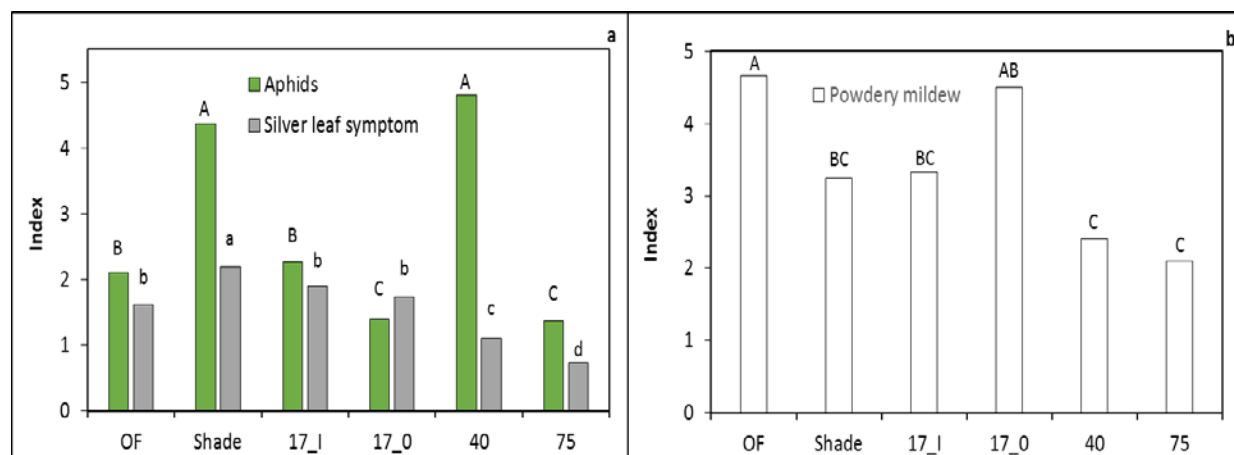


Fig. 3. a) Aphid infestation rate (0-7 scale) and silver leaf (0-5 scale); b) powdery mildew (0-5 scale). OF = open field, Shade = reflective shade, 17-I = 17 mesh with insecticide, 17-0 = 17-mesh without insecticide, 40-mesh and 75-mesh. Means (n=6) repeated measured over 7 weeks. Columns followed by the same letter(s) are not different based on Waller-Duncan k -ratio ($k=100$) t-test.

Effects on yield, pickleworm and melon fly damage: Pickleworm (*Diaphania nitidalis*) and melon flies (*Bactocera cucurbitae*) were the most damaging pests on zucchini at this experimental site. The damage from these two pests resulted in unmarketable fruits (Fig. 4a, b, c). No fruit from inside of any of the screenhouses evaluated had pickle worm or melon fly damage (Fig. 4d).

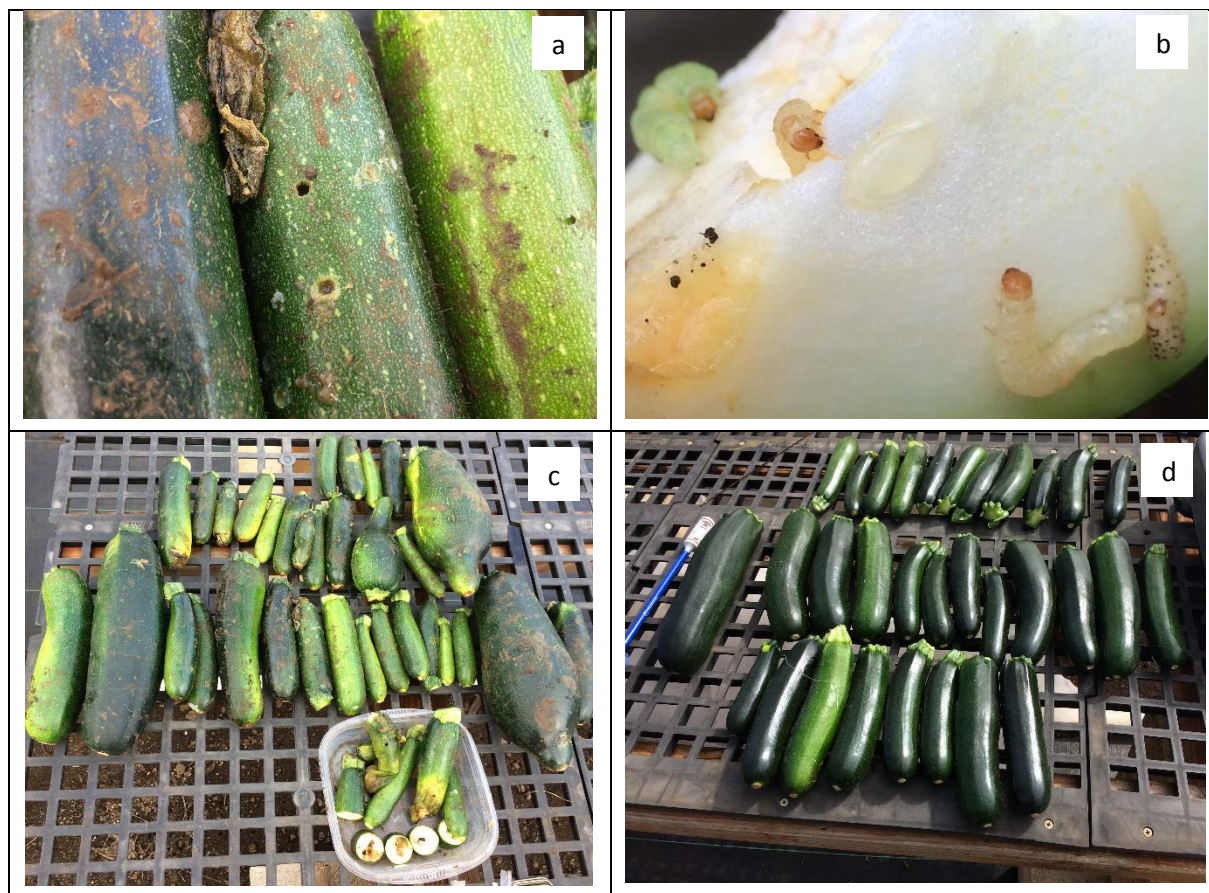


Fig. 4. a) Damage on zucchini fruits caused by pickleworm and melon flies, b) various instar stages of pickleworm larva can be found in a zucchini fruit, c) zucchini fruits harvested from open field damaged by pickleworms and melon flies, and d) zucchini fruits harvested from screenhouses evaluated.

Cumulative marketable fruit number harvested per plant was higher in 17-mesh hoop houses regardless of insecticide treatment (17-I and 17-0), the 40-mesh and 75-mesh houses compared to the OF (Fig. 5a). Fruits with pickleworm and melon fly damage were only found in OF (Fig. 5b). However, many fruits in the hoop houses suffered from blossom end rot and the numbers were higher in all the hoop houses compared to the OF control (Fig 5c). These fruits either rot entirely or were unmarketable. Although the data of marketable and unmarketable fruit weight were not statistically analyzed, hoop houses with finer mesh screens (17-, 40-, and 75-mesh) tended to have more marketable fruit weight than shade and OF (Fig. 5d), whereas unmarketable fruit weight was highest in the OF.

Discussion and Conclusion

Zucchini yield from this trial clearly demonstrated that all the insect exclusion screens (17-, 40- and 75-mesh) protected zucchini fruits from the key pests of zucchini i.e. pickleworms and melon flies. This had resulted in higher marketable yield in hoop houses than the OF. Using shade materials which are more readily available from local agricultural distributors in Hawaii and have a mesh size 2 times larger

than the 17-mesh and is not an alternative to insect exclusion nets if the grower's interest is to protect the crop from insect pests.

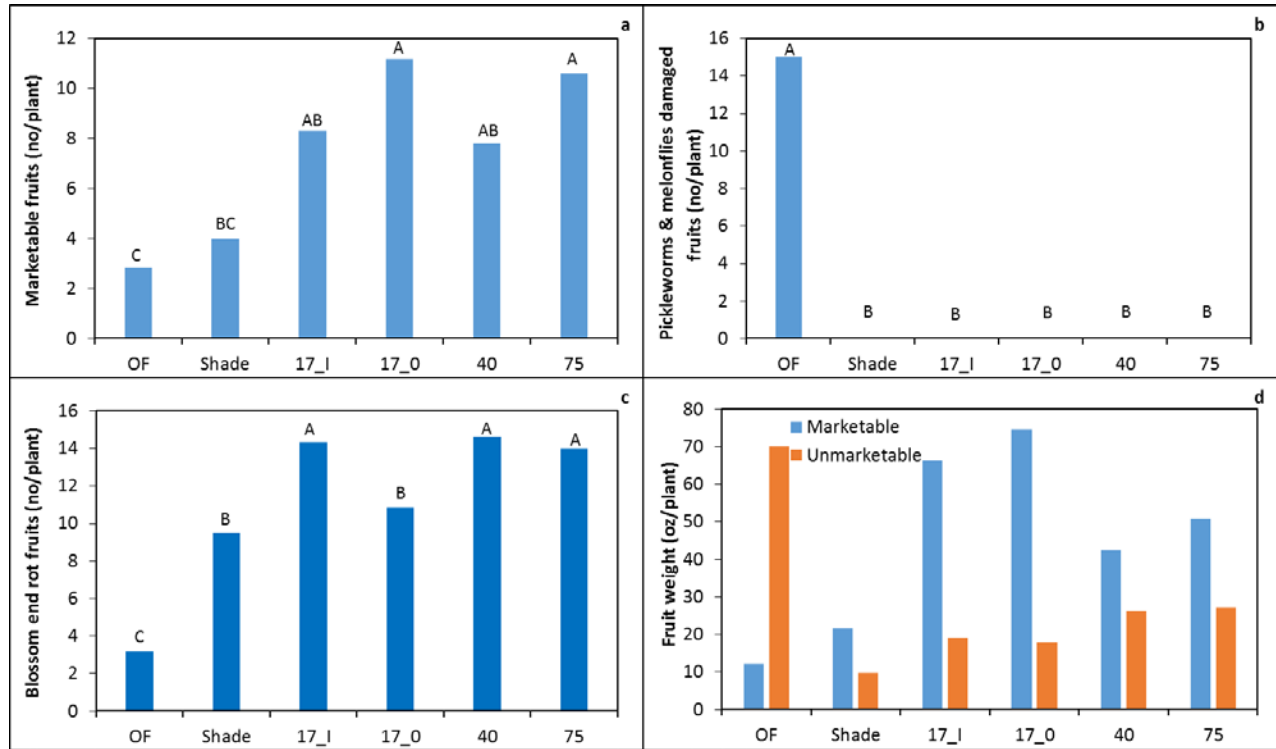


Fig. 5. a) Marketable fruit number, b) Pickleworms and melonflies damaged fruit number, c) blossom end rot fruit number, and d) marketable and unmarketable fruit weight. OF = open field, Shade = 30% reflective shade, 17-I = 17-mesh with insecticide, 17-0 = 17-mesh with no insecticide, 40-mesh and 75-mesh. 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.

On the other hand, screen materials finer than 17-mesh (40- and 75-mesh) that cost more did not protect the crop from aphids but did slow down and reduce whiteflies and powdery mildew damage. High counts of aphids in 40-mesh houses could be due to cross contamination between screenhouses by workers. While the effect of the 40-mesh on aphid infestation needs further evaluation, it is important to pay attention to sanitation when working inside and outside of a screenhouse. The 40-mesh screen is 2.8 times and 75-mesh screen is 6.8 times more expensive than the standard 17-mesh screen. Yet marketable yield of zucchini in this trial was better in 17-mesh than those in 40- and 75-mesh. However, a previous kale trial conducted in a 17-mesh screenhouse resulted in an outbreak of thrips inside the screenhouse (Wang, K.-H., personal communication). Thus, effects of the screening materials are depending on the insect pests present. In addition, since the insect infestation inside the 17-mesh screenhouses was low, weekly insecticide spray rotation did not further protect the crops from aphids or whiteflies damage.

Overall, this zucchini trial demonstrated that the hoop house design with the 17-mesh screen is a worthwhile investment for farmers. The previous 17-mesh screenhouse design used EZ corners and lumbers for the structure and cost \$0.95/ft². The current hoop house design using 17-mesh screen costs \$0.78/ft². Unfortunately, the screen materials from the manufacturer is only 13-ft wide. However, the two pieces of screen can be sewn together using V-69 White Polyester UV Thread (Miami Thread, Drexel, NC) with a regular home sewing machine. Some farmers connect the two pieces of screen together using wiggle wire on the top rib.

Although insect exclusion screens reduced light intensity compared to open field, zucchini growth and health were not compromised and in fact were stimulated in the 40-mesh hoop house. Plants in the 75-mesh house did show sign of elongated growth later in the season. However, reduction in light intensity in all the screenhouses resulted in more blossom end rots. Blossom end rot is due to a Ca deficiency associated with irregular water supply that leads to weakening of cell structure at the tips of fruits. This often occurs after a rainy day. As the fruit responds to sunny weather after the rain and grows faster than Ca uptake, the cells at the tips of fruits begin to collapse. Since plant growth is faster inside the screenhouses (Fig. 2), blossom end rot incidence is also higher inside the screenhouses. Nonetheless, blossom end rot did not contribute to major yield reduction. Eventually, pickleworms and melon flies were the key limiting factors for zucchini yield in this trial.

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