HO FARMS
h a w a i i
Kahuku's Finest

Fine Mesh Netting Screenhouse for Exclusion of Insect Pests

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Background

Wei Chong Ho: Ho Farms LLC was founded 1992 on 5 acres in Kahuku, Oahu. It was a humble beginning as Mr. Ho left his full time job to overcome the agriculture industry which was unfamiliar to him. Today Ho Farms consists of 40 acres growing a variety of Asian fruits and vegetables. Year-round we harvest Japanese cucumbers, long squash, long bean and tomatoes. Our products are sold into local restaurants and supermarkets. At Ho Farms our emphasis is to bring quality and environmentally friendly produce to local community.

Dr. John McHugh, crop consultant and owner of Crop Care Hawaii, LLC. Dr. McHugh has been assisting Mr. Ho by providing technical advice for his farming operation since 1998. Dr. McHugh has a PhD. in entomology from Purdue University and a Master of Science degree in Horticulture from the University of Hawaii at Manoa. Dr. McHugh has been active in the Hawaiian agriculture

community as a farmer, crop pest control advisor, agronomist, and agricultural professional since 1974. Dr. McHugh is Secretary-Treasurer of the West Oahu Soil and Water Conservation District, Director of the Oahu Resource Conservation Development Council, Director of the Hawaii Agricultural Leadership Foundation, and Chair of the Hawaii Farm Bureau Federation Environmental Stewardship Committee.

Jari S.K. Sugano: University of Hawaii at Manoa, College of Tropical Agriculture and Human Resources (UH-CTAHR). She carries a B.S. in general agriculture from University of Hawaii at Manoa and a M.S in Agriculture and Extension Education/Distance Education Technologies at Michigan State University. Since 1997 Jari S.K. Sugano has been with CTAHR working under program such as Intergrated Pest Management and Area wide fruit fly suppression. She has also working in the private agriculture section with Del Monte in their diversified agriculture programs. Beginning 2004, she assumed the role of county extension agent for windward Oahu specializing in edible crops.

Introduction

Melon Fly

White Flies

Hawaii's climate fosters perfect breeding grounds for serious insect pest such as Melon flies (*Bactrocera cucurbitae*), silverleaf whiteflies (*Bemisia tabaci*), melon thrips (*Thrips palmi*), and pickleworm (*Diaphania nitidales*). These insect pests cause economic losses due to the reduction in marketable yields, increase in off grade produce and are a serious concern because they can host various plant related viruses. Because of Hawaii's delicate ecosystem, importing biological control agents are not an option. Ho Farms utilize an integrated pest management approach to managing economically important pest and diseases. In addition to chemical and cultural control options, Ho Farm utilizes physical control measures such as the Fine Mesh Netting Screenhouses to physically deter pest and reduce the risk of pesticide resistance. Mr Wei Chong Ho has travel to Thailand, Taiwan, and China to observe innovative agriculture practices used to mange pest and improve food quality. One technique observe in Taiwan was the Fine Mesh Netting Screenhouse.

Objective

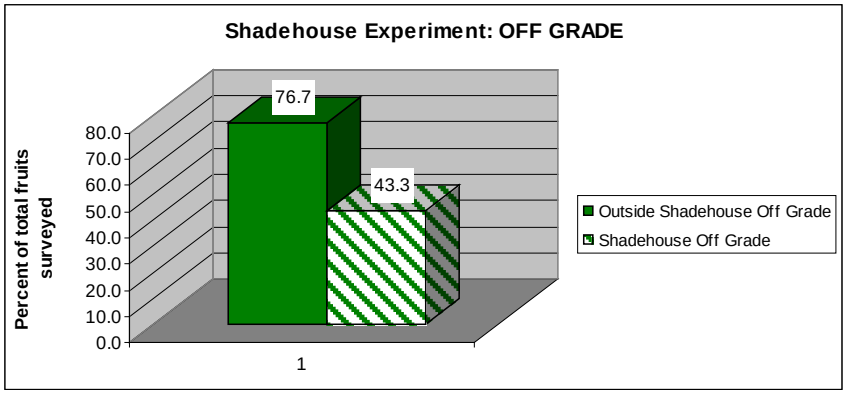
1. Reduce pesticide use by excluding specific insect pests of cucumbers
2. Improve air quality in the area surrounding the production field by reducing pesticide application (versus open field cultivation), and
3. Determine the cost effectiveness of the system for commercial use for vegetable production in Hawaii.

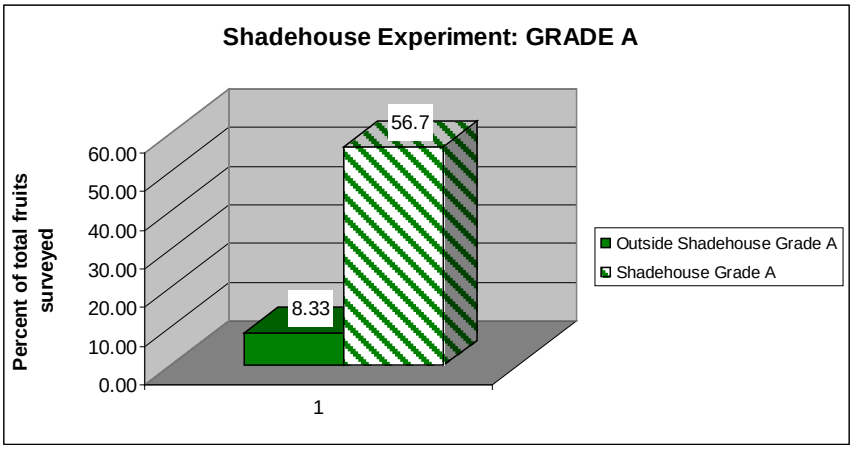
Pickleworm (Fruit)

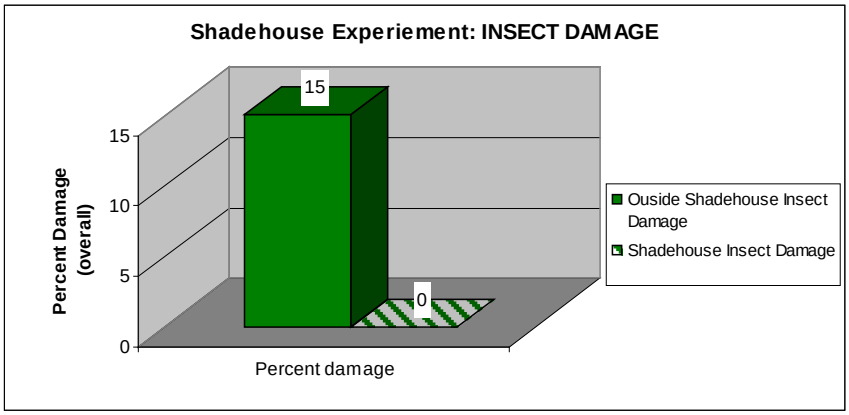
TRIAL 1 – November 2007 - Jari Sugano, UH county extension Agent

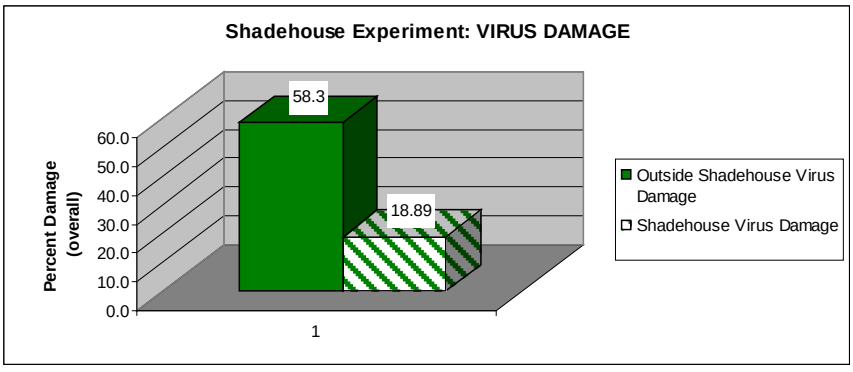
Use of a shadehouse around Japanese cucumbers helped Ho Farms increase the percentage of GRADE A cucumbers, and minimized OFF GRADES. The variety selected for this field trial was not the standard variety used by Ho Farms, so harvest was shortened and yields were lower than expected.

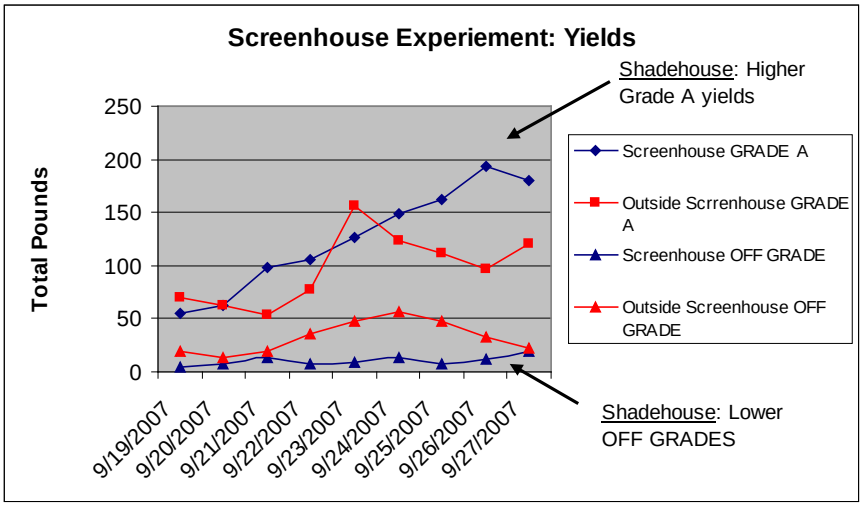
Utilization of the screenhouse also minimized insect and virus damage. *Due to the susceptibility of this variety to viruses, Ho Farms also noted that an additional 4 applications of crop protection chemicals were applied to the fields not covered by the screenhouse. Utilization of the screenhouse minimized crop protection chemicals on crop, reduced worker exposure, improved yields and minimized pest and diseases.* A second field trial (standard variety) will be conducted to verify this statement.


Shadehouse Experiment: OFF GRADE
Percent of total fruits surveyed
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
76.7
43.3
1
Outside Shadehouse Off Grade
Shadehouse Off Grade


Shadehouse Experiment: GRADE A
Percent of total fruits surveyed
60.00
50.00
40.00
30.00
20.00
10.00
0.00
56.7
8.33
1
Outside Shadehouse Grade A
Shadehouse Grade A


Shadehouse Experiement: INSECT DAMAGE
Percent Damage (overall)
15
10
5
0
15
0
Percent damage
Ouside Shadehouse Insect Damage
Shadehouse Insect Damage


Shadehouse Experiment: VIRUS DAMAGE
Percent Damage (overall)
60.0
50.0
40.0
30.0
20.0
10.0
0.0
58.3
18.89
1
Outside Shadehouse Virus Damage
Shadehouse Virus Damage



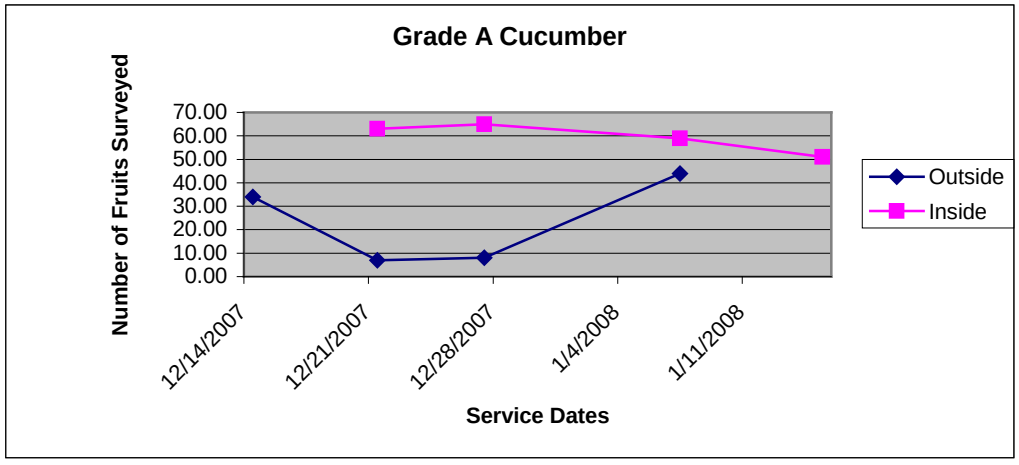
TRIAL 2 – January 2008 - Jari Sugano, UH county extension Agent

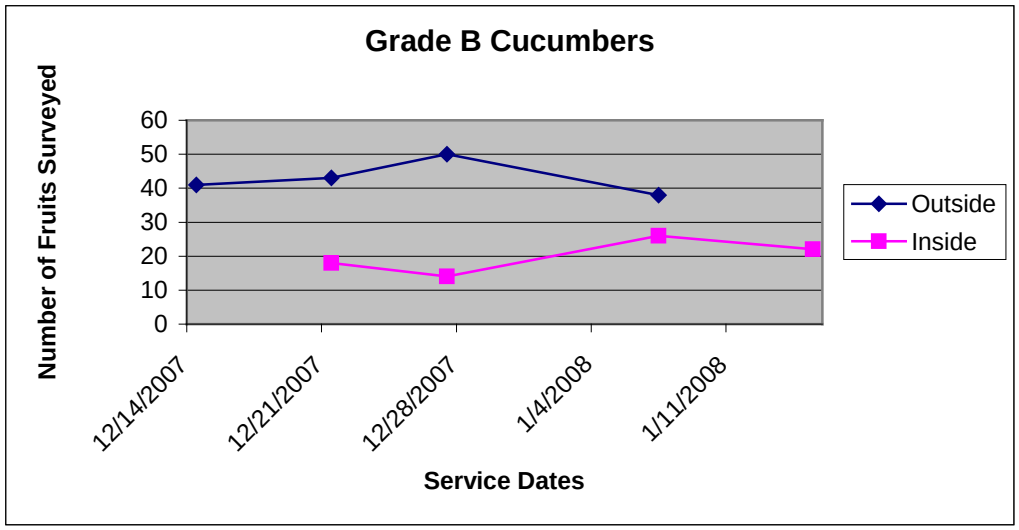
This is a follow up report to the report submitted in November 2007. In our fall cucumber experiment there were no significant differences between cucumbers grown inside of screenhouses and those grown outside.

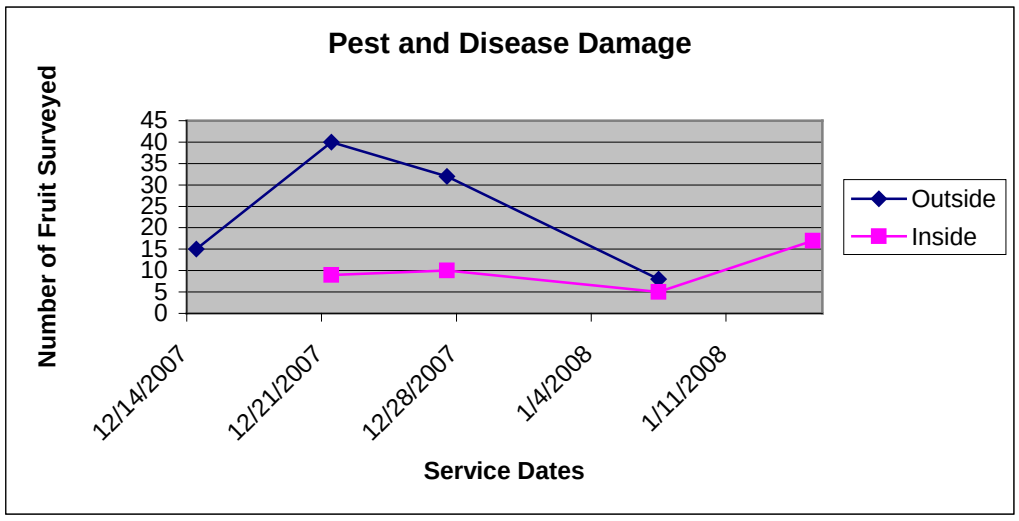
In the previous experiments, we showed that the use of the screenhouses minimized insect and virus damage and reduced insecticidal use. After 4 weeks of yield data we are now able to show that the use of the screenhouse has a significant effect on marketable yields. One hundred and eighty fruits are sampled every week. Each fruit is surveyed based on HDOA grading standards and assessed for pest damage (see below). *Based on the preliminary data, fruits grown inside screenhouse have significantly higher (P=0.00) Grade A fruit, less Grade B fruit (P=0.00) and less pest and virus damage (P=0.00) than cucumbers grown outside the screened area.*

Fields which were originally exposed have been covered with a screenhouse (~ 12/21/07) and are increasing in yields, due to less pest pressure and wind damage. An increased number of Grade B fruits were noted on cucumbers grown outside of the screenhouse due to excessive rains and winds in December 2007. Three weeks after being screened in, cucumbers once outside and now increasing in productivity. Observational data such as fruit quality and skin appearance is also improving.

It appears that the screenhouse significantly benefits Ho Farms during the winter and high wind seasons versus spring, summer and fall production. This is ideal as Ho Farms can get more $ per pound during the winter season with the utilization of the screen houses.




Grade B Cucumbers
Number of Fruits Surveyed
60
50
40
30
20
10
0
12/14/2007
12/21/2007
12/28/2007
1/4/2008
1/11/2008
Service Dates
Outside
Inside


Pest and Disease Damage
Number of Fruit Surveyed
45
40
35
30
25
20
15
10
5
0
12/14/2007
12/21/2007
12/28/2007
1/4/2008
1/11/2008
Service Dates
Outside
Inside

HAWAII FANCY (GRADE AA)	HAWAII NO. 1 (GRADE A)	HAWAII NO. 2 (GRADE B)
Basic Requirements	Basic Requirements	Basic Requirements
Similar varietal characteristics (1)	Similar varietal characteristics (1)	Similar varietal characteristics (1)
Clean (2)	Clean (2)	Clean (2)
Well colored (3)	Fairly well colored (4)	Moderately colored (5)
Well formed (6)	Fairly well formed (7)	Not badly deformed (8)
Not overgrown (9)	Not overgrown (9)	Not overgrown (9)
Fresh	Fresh	Fresh
Firm (10)	Firm (10)	Firm (10)
Free From	Free From	Free From
Decay	Decay	Decay
Breakdown	Breakdown	Breakdown
Worm holes	Worm holes	Worm holes
Clipped ends	Clipped ends	Clipped ends
Insect stings	Insect stings	
Shrivelling	Shrivelling	
Pulled ends		
Free From Damage (11)	Free From Damage (11)	Free From Damage (11)
Caused By	Caused By	Caused By
Freezing	Freezing	Freezing
Yellowing	Yellowing	
Scars	Scars	Serious Free From Damage (12) Caused By
Hollowness	Hollowness	Yellowing
Broken skin	Broken skin	Scars
Bruises	Bruises	Bruises
Mosaic or other diseases	Mosaic or other diseases	Pulled ends
Insects	Insects	Broken skin
Mechanical or other means	Mechanical or other means	Shrivelling
	Pulled ends	Mosaic or other diseases
		Insect stings
		Insects
		Mechanical or other means

TRIAL 3 – September 2008 - Jari Sugano, UH county extension Agent

This is a follow up report to the report submitted in November 2007 & January 2008. In our fall 2007 cucumber experiment we found no significant differences between cucumbers grown inside of screenhouses and those grown outside. The trial was re-installed in the winter of 2008 with cucumbers, and the results were quite different. In the winter of 2008, we found that fruits grown inside screenhouses had significantly higher (P=0.00) marketable fruit, less unmarketable fruit (P=0.00) and less pest and virus damage (P=0.00) than cucumbers grown outside the screened area.

The experiment was conducted again in TRIAL 3. While the crop grown inside of screen houses yielded approximately 7,400 pounds more cucumbers than cucumbers grown outside, the difference was not significant based on independent t-tests used to compare marketable yields. In this trial, marketable fruits from 12 crop rows were harvested, counted and sorted by Ho Farms staff.

Thirty plants from each treatment were surveyed weekly for whiteflies and leaf conditions. However, there were no siginificant differences between crops grown inside vs outside screenhouses. A limiting factor in this trial was an unexpected crop failure due an incorrect fertilizer application. As a result, the harvest period for the crop grown inside the screenhouse was shortened. Another possible reason for the similarity in crop yields this season could be due to the collection of fruits for data sampling.

A follow up trial is currently in place. All fruits from two crop rows will be harvested. Unmarketable fruit that may have been left back in previous trials will be counted and sorted. We expect the unmarketable yields to increase due to losses caused by pickleworm, birds, etc.

Through the use of the screenhouses, we have been able to show a reduction in chemical applications. Crops grown inside the screenhouse received 12 pesticide applications, while crops grown outside required 14 applications to maintain its productivity. The insecticide applications were equivalent, however crops grown outside the screenhouses required 2 additional fungicide applications this season.

Despite the yields and pest pressure not being statistically different, the use of screenhouses resulted in higher marketable yields of 7,400 pounds which translates into an approximate $6,290 gain (based on wholesale estimates of 0.85 cents/ lb).

ESTIMATED WEIGHT: **Inside** **18840**
20#/ bucket **outside** **11440**

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*	
Mean	33.64285714	27.238	
Variance	882.6825397	278.09	
Observations	28	21	
Pooled Variance	625.4093212		
Hypothesized Mean Difference	0		
Df	47		
t Stat	0.887179377		
P(T<=t) one-tail	0.1897499		
t Critical one-tail	1.677926722		
P(T<=t) two-tail	0.3794998	**No difference**	
t Critical two-tail	2.01174048		

AFFECT OF WHITEFLY
t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*	
Mean	0.798319328	1.0461	
Variance	0.586098846	0.7859	
Observations	119	152	
Pooled Variance	0.698279909		
Hypothesized Mean Difference	0		
Df	269		
t Stat	-2.42203408		
P(T<=t) one-tail	0.008047606		
t Critical one-tail	1.650537874		
P(T<=t) two-tail	0.016095211	**No difference**	
t Critical two-tail	1.968821915		

AFFECT ON LEAF CONDITION
t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	0.042016807	0.8421

Variance	0.040592508	0.8756
Observations	119	152
Pooled Variance	0.509295324	
Hypothesized Mean Difference	0	
df	269	
t Stat	-9.15933174	
P(T<=t) one-tail	6.85844E-18	
t Critical one-tail	1.650537874	
P(T<=t) two-tail	1.37169E-17	**No Difference**
t Critical two-tail	1.968821915	

Inside was started 2 weeks earlier and had problems with fertilizer rates
June 20/08
12 rows inside and 12 rows outside

FIELD	**N**	marketable	**FIELD L**		
	Inside	# buckets			marketable
07/21/08	Inside	3		**Outside**	# buckets
07/22/08	Inside	6	08/18/08	Outside	3
07/23/08	Inside	8	08/19/08	Outside	5
07/24/08	Inside	8	08/20/08	Outside	7
07/25/08	Inside	8	08/21/08	Outside	7
07/26/08	Inside	13	08/22/08	Outside	9
07/27/08	Inside	17	08/23/08	Outside	10
07/28/08	Inside	15	08/24/08	Outside	35
07/29/08	Inside	15	08/25/08	Outside	45
07/30/08	Inside	16	08/26/08	Outside	49
07/31/08	Inside	19	08/27/08	Outside	40
08/01/08	Inside	30	08/28/08	Outside	41
08/02/08	Inside	33	08/29/08	Outside	36
08/03/08	Inside	32	08/30/08	Outside	45
08/04/08	Inside	40	08/31/08	Outside	46
08/05/08	Inside	25	09/01/08	Outside	46
08/06/08	Inside	32	09/02/08	Outside	40
08/07/08	Inside	34	09/03/08	Outside	37
08/08/08	Inside	64	09/04/08	Outside	27
08/09/08	Inside	65	09/05/08	Outside	15
08/10/08	Inside	120	09/06/08	Outside	15
08/11/08	Inside	105	09/07/08	Outside	14
08/12/08	Inside	89		TOTAL	572
08/13/08	Inside	48			
08/14/08	Inside	27	14 chemical applications		
08/15/08	Inside	22	7 insecticides		
08/16/08	Inside	26	6 fungicide treatment		
08/17/08	Inside	22			
	TOTAL	942			

12 chemical applications
7 insecticdes
4 fungicide treatments

Inside	**18840**
outside	**11440**

7400

Wholesale price: est 0.85 cents/ pound

Inside	16014	6290
Outside	9724	

Insect counts survey 30 plants/ week
rating 0=none, 1=low, 2=fair pressure, 3=moderate, 4=high, 5= extreme pressure
(WF=white fly, Leaf condition= disease, insect, wind, etc.)

date	inside	wf	Leaf condition		outside	wf	Leaf condition
07/10/08	inside	3	0	07/30/08	outside	0	0
07/10/08	inside	1	0	07/30/08	outside	0	0
07/10/08	inside	2	0	07/30/08	outside	0	0
07/10/08	inside	1	0	07/30/08	outside	1	0
07/10/08	inside	2	0	07/30/08	outside	0	0
07/10/08	inside	3	0	07/30/08	outside	0	0
07/10/08	inside	1	0	07/30/08	outside	0	0
07/10/08	inside	0	0	07/30/08	outside	0	0
07/10/08	inside	1	0	07/30/08	outside	1	0
07/10/08	inside	0	0	07/30/08	outside	0	0
07/10/08	inside	1	0	07/30/08	outside	0	0
07/10/08	inside	1	0	07/30/08	outside	0	0
07/10/08	inside	2	0	07/30/08	outside	0	0
07/10/08	inside	1	0	07/30/08	outside	0	0
07/10/08	inside	1	0	07/30/08	outside	0	0
07/10/08	inside	1	0	07/30/08	outside	0	0
07/10/08	inside	1	0	07/30/08	outside	0	0
07/10/08	inside	1	0	07/30/08	outside	1	0
07/10/08	inside	2	0	07/30/08	outside	0	0
07/10/08	inside	1	0	07/30/08	outside	0	0
07/10/08	inside	1	0	07/30/08	outside	0	0
07/10/08	inside	1	0	07/30/08	outside	0	0
07/10/08	inside	2	0	07/30/08	outside	0	0
07/10/08	inside	1	0	07/30/08	outside	1	0
07/10/08	inside	1	0	07/30/08	outside	0	0
07/10/08	inside	2	0	07/30/08	outside	1	0
07/10/08	inside	3	0	07/30/08	outside	0	0
07/10/08	inside	1	0	07/30/08	outside	0	0
07/10/08	inside	1	0	07/30/08	outside	0	0
07/10/08	inside	2	0	07/30/08	outside	0	0
07/23/08	inside	0	0	07/30/08	outside	0	0
07/23/08	inside	0	0	08/06/08	outside	1	0
07/23/08	inside	0	0	08/06/08	outside	2	0
07/23/08	inside	0	0	08/06/08	outside	1	0
07/23/08	inside	1	0	08/06/08	outside	1	0
07/23/08	inside	1	0	08/06/08	outside	2	0
07/23/08	inside	0	0	08/06/08	outside	2	0
07/23/08	inside	0	0	08/06/08	outside	1	0
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07/23/08	inside	0	0	08/06/08	outside	1	0

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07/23/08	inside	0	0	08/06/08	outside	1	0
07/30/08	inside	1	0	08/06/08	outside	1	0
07/30/08	inside	0	0	08/21/08	outside	1	0
07/30/08	inside	0	0	08/21/08	outside	1	3
07/30/08	inside	0	0	08/21/08	outside	2	2
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07/30/08	inside	0	0	08/21/08	outside	0	1
07/30/08	inside	0	0	08/21/08	outside	0	1
07/30/08	inside	1	0	08/21/08	outside	0	1
07/30/08	inside	1	0	08/21/08	outside	1	0
08/06/08	inside	2	0	08/21/08	outside	1	0
08/06/08	inside	1	0	08/21/08	outside	1	1
08/06/08	inside	1	1	08/25/08	outside	1	2
08/06/08	inside	1	1	08/25/08	outside	1	2
08/06/08	inside	1	0	08/25/08	outside	2	2
08/06/08	inside	0	0	08/25/08	outside	1	1
08/06/08	inside	2	0	08/25/08	outside	1	2
08/06/08	inside	2	0	08/25/08	outside	1	2
08/06/08	inside	0	0	08/25/08	outside	2	2
08/06/08	inside	1	0	08/25/08	outside	2	2
08/06/08	inside	2	0	08/25/08	outside	1	2
08/06/08	inside	1	0	08/25/08	outside	1	2
08/06/08	inside	2	0	08/25/08	outside	1	2
08/06/08	inside	1	0	08/25/08	outside	1	1
08/06/08	inside	2	0	08/25/08	outside	1	1

08/06/08	inside	1	0	08/25/08	outside	1	1
08/06/08	inside	1	0	08/25/08	outside	1	2
08/06/08	inside	1	0	08/25/08	outside	1	2
08/06/08	inside	1	0	08/25/08	outside	1	2
08/06/08	inside	1	0	08/25/08	outside	1	2
08/06/08	inside	2	0	08/25/08	outside	1	2
08/06/08	inside	2	0	08/25/08	outside	1	2
08/06/08	inside	1	0	08/25/08	outside	1	2
08/06/08	inside	1	0	08/25/08	outside	1	1
08/06/08	inside	1	0	08/25/08	outside	1	1
08/06/08	inside	2	0	08/25/08	outside	1	2
08/06/08	inside	1	1	08/25/08	outside	1	1
08/06/08	inside	1	0	08/25/08	outside	1	2
08/06/08	inside	1	1	08/25/08	outside	1	2
08/06/08	inside	0	1	08/25/08	outside	1	2
PAU HARVEST				08/25/08	outside	2	2
08/21/08	inside	0	3	08/25/08	outside	1	2
08/21/08	inside	0	3	09/04/08	outside	2	2
08/21/08	inside	0	3	09/04/08	outside	3	3
08/21/08	inside	0	4	09/04/08	outside	2	2
08/21/08	inside	0	3	09/04/08	outside	2	2
08/21/08	inside	0	4	09/04/08	outside	3	1
08/21/08	inside	0	4	09/04/08	outside	2	2
08/21/08	inside	1	3	09/04/08	outside	3	2
08/21/08	inside	0	3	09/04/08	outside	3	2
08/21/08	inside	0	4	09/04/08	outside	3	2
08/21/08	inside	0	4	09/04/08	outside	2	2
08/21/08	inside	0	3	09/04/08	outside	2	2
08/21/08	inside	1	4	09/04/08	outside	3	1
08/21/08	inside	0	4	09/04/08	outside	3	1
08/21/08	inside	0	3	09/04/08	outside	3	2
08/21/08	inside	0	3	09/04/08	outside	3	2
08/21/08	inside	0	3	09/04/08	outside	3	1
08/21/08	inside	1	3	09/04/08	outside	3	2
08/21/08	inside	0	4	09/04/08	outside	2	1
08/21/08	inside	0	4	09/04/08	outside	1	2
08/21/08	inside	1	4	09/04/08	outside	1	1
08/21/08	inside	0	4	09/04/08	outside	2	1
08/21/08	inside	0	4	09/04/08	outside	1	1
08/21/08	inside	1	3	09/04/08	outside	1	2
08/21/08	inside	0	3	09/04/08	outside	1	2
08/21/08	inside	0	4	09/04/08	outside	1	2
08/21/08	inside	1	3	09/04/08	outside	3	2
08/21/08	inside	0	4	09/04/08	outside	3	3
08/21/08	inside	0	4	09/04/08	outside	3	3
08/21/08	inside	0	3	09/04/08	outside	3	2
08/25/08	inside	2	5	09/04/08	outside	2	2
08/25/08	inside	3	5	09/04/08	outside	1	2
08/25/08	inside	2	5				
08/25/08	inside	1	4				
08/25/08	inside	1	5				
08/25/08	inside	1	4				
08/25/08	inside	1	5				
08/25/08	inside	2	5				
08/25/08	inside	1	4				
08/25/08	inside	2	5				
08/25/08	inside	2	5				

08/25/08	inside	2	4
08/25/08	inside	2	5
08/25/08	inside	3	5
08/25/08	inside	3	5
08/25/08	inside	1	4
08/25/08	inside	1	4
08/25/08	inside	2	5
08/25/08	inside	1	4
08/25/08	inside	1	5
08/25/08	inside	1	5
08/25/08	inside	2	5
08/25/08	inside	3	5
08/25/08	inside	3	5
08/25/08	inside	2	4
08/25/08	inside	3	5
08/25/08	inside	2	5
08/25/08	inside	1	5
08/25/08	inside	3	5
08/25/08	inside	3	5

TRIAL 4 – Field Day - Jari Sugano, UH county extension Agent

Cucumbers grown inside Screen Houses	Cucumbers grown Outside
Harvest period: 9/11/08-9/28/08	
Total Yields: 2 harvest rows (252 square feet) 1301 pounds (marketable yield) Income: 1301 lbs * 0.85 cents / pound=$1106.00 **$1106.00 / 18 days** Bird/ Insect damage: 0.3% crop loss	Total Yields: 2 harvest rows (252 square feet) 1222 pounds (marketable yield) Income= 1222 lbs * 0.85 cents/ pound =$1038.00 **$1038/ 18 days** Bird/ Insect damage: 9% crop loss
Combined field acreage: 0.76 acre	

Based on figures of 40,000 pounds of cucumbers / acre @ $0.85 / pound, Ho Farms can generate approximately $2,049.00 more per acre when crops are grown under the screenhouse system.

Trial 5 – September 2008 - Jari Sugano, UH county extension Agent

The purpose of this trial was to determine the extent of damage Ho Farms experiences due to the lack of screenhouses. Based on data obtained from prior trials, we ensured the crop was grown under optimum conditions to minimize previous problems due to variety selection, fertilizer problems, fertilizer injector issues, etc. In September 2008, crops in TRIAL 5 grown outside of screenhouses experience crop losses of 6% (birds, insects, etc), while crops grown inside of the screenhouses experienced losses less than 1%. Cucumbers grown under shadehouses had increased yields over crops grown outside of screenhouses.

Based on figures of 40,000 pounds of cucumbers / acre @ $0.85 / pound, we estimate that Ho Farms can generate approximately $1,700.00 more per acre when crops are grown under the screenhouse system.

***These numbers maybe more realistic than previous field trial data, as the crop under went a complete harvest. Some trials in the past only had 1-2 weeks of harvest data due to poor weather and field conditions.

			TRIAL AREA			
	Daily crop total	Overall Trial Area	Total Outside	Outside damage	Total Inside	Inside damage
9/26/2008	160	8	6	0	2	0
9/27/2008	240	7	5	0	2	0
9/28/2008	320	13	8	1	4	0
9/29/2008	340	17	10	1	6	0
9/30/2008	410	32	16	1	15	0
10/1/2008	520	30	18	2	10	0
10/2/2008	750	37	22	3	12	0
10/3/2008	940	36	21	1	14	0
10/4/2008	1140	48	26	2	20	0
10/5/2008	1080	68	38	3	27	0
10/6/2008	1230	80	40	2	38	0
10/7/2008	1420	101	43	4	54	0
10/8/2008	1580	155	72	3	80	0
10/9/2008	1620	141	76	3	62	0
10/10/2008	1780	205	96	4	105	1
10/11/2008	1860	289	110	3	175	1
10/12/2008	1940	305	120	4	160	1
10/13/2008	2100	292	134	5	152	1
10/14/2008	2480	315	141	5	168	1
10/15/2008	2120	283	118	7	158	0
10/16/2008	1410	231	98	8	123	2
10/17/2008	980	170	68	5	97	0
10/18/2008	760	117	48	4	65	0
10/19/2008	680	88	43	3	41	1
10/20/2008	430	65	31	5	28	1
10/21/2008	400	39	21	2	15	1
		3172	1429	81	1633	10

percent damage outside	5.67
percent damge inside	0.61

Building, Construction Cost and Repair

Supply and construction cost are fairly reasonable at $14,810 per acre or $0.34/sq ft. The insect netting and plastic wire were sourced from a wholesaler. Lumber for Interior/Exterior post and cement were purchased at our local hardware store. In our case we used 4X4X12 lumber but factor such as termite and soil density must be considered. The most costly part of the project is construction labor. It took approximately 10.5 day with 7 people to construct .21 acres of the screenhouse. The time also account for the errors and correction that were made during the construction. Labor cost would decrease once the labor force gain experience. Cost of small purchases such as nails, PVC connector, zip tie and etc are accounted for in misc cost.

Cost – example 96' X 96' screen house – 9216 square feet = 0.21 acres

Interior/Exterior Post	$600
Insect Netting	$900
Plastic Wire	$70
Cement	$150
Labor	$1200
Misc	$250
Total	$3170

approx $0.34/sq ft or $14,810/acre

Construction began with 4 main exterior support post to distinguish the perimeter of the screenhouse. Additional exterior support post was positioned every 10.5 ft 2 parallel to the trellis. Perpendicular to the trellis the exterior support post was positioned every 18 feet to maximize growing space. All exterior support post positioned 2 feet below ground leaving 10 ft height clearance. Plastic cables laid and secure to form 18 x 10.5 rectangles above which the fine mesh will lay. Once all exterior support post have been placed scrap 2x4 was used to create an 11 feet high interior support post. On perpendicular side to the trellis interior post is sequenced every 10.5 feet until the end was reached. The extra 1 foot on the interior post help future tighten the plastic wires. Fine mesh could now be carefully positioned and secured.

The main cause of damage to the fine mesh is constant movement caused by wind. High winds that allow the fine mesh to stretch and rapidly brush on the lumber support post. Constant stretching and brushing causes damage to the fine mesh. Immediate repair should be done to prevent damage expansion.

Repair of fine mesh holes can be done with extra mesh and zip tie from your local hardware store. Below are images of a before and after repair.

Before Repair	After Repair
	

Return on Investment (ROI)

On the figures generated from TRIAL 5, Ho Farms generated an additional $1,700 per 1 screenhouse acre. At a cost of $14,810 per acre which would take approximately 9 successful growing cycles to recoup cost of 1 acre screenhouse. Each growing cycle represent two month life cycle of the average cucumber plant. Over the course of one year an average grower could plant 4 times allowing a 2 month fallow period after each growth cycle. This would bring the return on investment to three years.

With factors such as plant nutrient, weather condition and pest affecting cucumber yield. It could be difficult to gauge the true ROI of a screenhouse structure. Below is a chart giving clarity on the ROI in 1 acre of screenhouse at different profit ranges (increment $200).

ROI based on Profit

1 acre of screenhouse	Total # crop cycle before ROI	**Month before ROI
$1,700	9	34.8
$1,900	8	31.2
$2,100	7	28.2
$2,300	6	25.8
$2,500	6	23.7
$2,700	5	21.9
$2,900	5	20.4

Increments are in $200 = 236 lb of cucumber

Cost of 1 acre screenhouse	$14,810
Average Price	$0.85

**Years before ROI based on 2 month crop cycle and 2 month fallow period

Chemical Applications

Chemical application was accounted for during TRIAL 3. Records indicate that Ho Farm was able to reduce fungicide application by 2 treatments in the screenhouse. Open field received 14 chemical applications to maintain productivity. Over the course of one year with 4 crop cycles an

average grower could reduce 8 chemical applications. Looking at the numbers from a large scale 100 acre of screenhouse would reduce chemical applications from 1400 to 1200 sprays reducing contamination of nearby soil and water bodies.

Possible screenhouse improvements

Based on our implementation of the screenhouse we have experience three main structural concern termites, insufficient post deep and wind damage cause by mesh movement.

It was unknown that Hawaii Reserve parcel selected for the screenhouse structure harbored termites. Once the lumber post began decaying it was apparent where the failure came from. The decaying post was purchased at our local hardware store termite treated but for unknown circumstance did not holdup. Another possible solution would be metal post in replacement of lumber. This would exponentially increase the over cost of the screenhouse structure.

Structural post measured 4x4x12 with 2 feet below ground, leaving a 10 feet clearance from top to bottom. The 2 feet depth did not provide sufficient support during heavy winds and rain. This could be resolved by increasing the below ground deep an additional 2 feet. Unfortunately the local hardware store does not carry size large then 12 length unless special ordered.

Wind causes the mesh to brush against the lumber support post. Over time continuous brushing and movement of the net produce holes. Our solution to this problem was to retightening the net to the external support post and tighten the wire by adding additional support post on the inside of the screenhouse. These internal supports post where 11 feet height and would be held by the pressure applied from the cables running from external post to external post. Lumber does not provide a smooth surface for fine mesh causing damage over time; metal post would probably solve this problem.

Conclusion

The ROI for the implementation of the Fine Mesh Netting Screenhouse system increases with the longevity of the system. Through the on farm field trials at Ho Farms, we have been able to show that the Fine Mesh Netting Screenhouse system has contributed to the increase in marketable yields and reduction in off grade produce. In addition, we have been able to reduce the pressure due to pest and diseases through the implementation of this physical barrier. We believe this system enables us to maintain the level of quality produce we take pride in. Without this system, we would have a difficult time battling pest and birds without an increase in chemical applications.

Now that we have a better understanding about this system and the culture of cucumbers under the Fine Mesh Netting Screenhouse system, the next step for Ho Farms is to further reduce the chemical applications under the screenhouses. Our goal is to determine whether a comparable quality product can be grown with reduced chemical inputs. We believe in taking this next step we can further reduce risk to our land, water and air resources and minimize worker exposure to unnecessary chemical applications.

Cost associated with the supply and construction of a 1 acre screenhouse is financial feasibility for small farm operations. Ho Farms will be identifying locally durable substitute products to extend the durability of the screenhouses, thus making the ROI greater with time.