Evaluation of Living and Synthetic Mulches in Zucchini for Control of Homopteran Pests

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Cucurbit Production in Florida

- During 2002-03, Florida growers harvested > 45,000 acres of cucurbits valued over 170 million dollars.
- Squash alone accounted for over 10,000 harvested acres.
- Yields averaged 302 bushels/acre with over 3 million bushels sold.

Economic Losses

- Yield per acre of cucumber, squash, and watermelon was down 37%, 6%, and 9% respectively.

- Harvested acreage of squash down 10%.

Key Factors Associated with Cucurbit Loss

- Aphid-transmitted viruses
- Squash Silverleaf Disorder (SSL)
- Direct feeding pressure by aphids, whiteflies, and other pests
- Sooty mold fungi from honeydew excretion

Bemisia argentifolii Bellows and Perring

- Occur in tropical and subtropical habitats as well as greenhouses.
- Four nymphal instars characterize development from egg to pupae.
- Feeding of immature whiteflies induce silverleaf symptoms.

SSL in *Cucurbita* spp.

- Feeding by as few as two to three nymphs per plant can induce SSL.
- Characterized by silvering of the adaxial leaf surface and blanching of fruit.

Aphids

- The most important vectors of plant viruses.
- Have been known to transmit over 275 different viral disorders.
- Attack cucurbits worldwide.

Aphid-transmitted Viruses in Florida

- Important viruses include WMV-2, ZYMV, CMV, and PRSV-W.

- Important vectors are:
  Aphis gossypii Glover
  Myzus persicae (Sulzer)
  Aphis craccivora Koch.

Symptoms in *Cucurbita* spp.

- Transmitted in a stylet-borne non-persistent manner.
- Characterized by yellowing and blistering of leaves, reduction in growth, and malformed and distorted fruit.

Current Management

- Pesticides
- Oils
- Cross protection
- Row covers
- Mulches

Previous Research

- Csizinszky et al. (1997) found that reflective mulch delayed viral symptoms, and increased marketable yield in tomatoes.
- Root (1973) proposed that herbivore loads are more likely to be reduced in diverse crop habitats.
- Hooks et al. (1998) showed that fewer aphids, whiteflies, and occurrences of insect transmitted diseases occur in living mulch diversified zucchini.

Research Goals

- Use pest management strategies that are more sustainable, centers around cultural management, and acts together with other management practices to reduce key pests in cucurbits

- Establish ecologically friendly measures and provide growers with alternatives to broad-spectrum pesticides.

Specific Objectives

- Investigate and compare the effects of reflective and living mulch on the population dynamics of homopteran pests, their associated natural enemies, and insect-transmitted plant impairments.
- Investigate the advantages of using reflective and living mulch over standard bare-ground or white mulching systems.

Experimental Design

- Randomized complete block with 4 replicates.
- 5 Treatments:
  - White
  - Reflective
  - Clover
  - Buckwheat
  - Bare-ground

Insect Sampling

1. Traps
   - Pan-traps
     - Adult aphids
   - Sticky traps
     - Adult whiteflies
2. Foliar Counts
   - Adult/Immature
     - aphids and whiteflies
   - Natural enemies

Adult Whitefly Sampling

- Sampling conducted for 7 weeks in 2002, and 6 weeks in 2003.
- 3 unbaited yellow sticky traps per treatment placed at plant height.
- Traps located in the center, and at opposite ends of treatment plots.

Mean Number of Adult Whiteflies per YS Trap

	Mean ± SEM	
	2002[a]	2003[b]
White	15.54 ± 1.83 a	3.60 ± 0.46 a
Reflective	9.82 ± 1.24 c	1.07 ± 0.20 c
Buckwheat	7.71 ± 1.07 d	1.83 ± 0.23 b
Clover	10.29 ± 1.50 cd	4.60 ± 0.74 a
Bare Ground	13.37 ± 1.80 b	4.25 ± 0.62 a

Means followed by the same letter are not significantly different ($P = 0.05$, LSD test)

[a] $F = 13.86$; df = 4, 363; $P < 0.0001$

[b] $F = 30.45$; df = 4, 312; $P < 0.0001$

Alate Aphid Sampling

- Sampling conducted for 7 weeks in 2002, and 6 weeks in 2003.
- 3 water-pan traps per treatment placed at plant height.
- Traps located in the center, and opposite ends of treatment plots.

Mean Number of Alate Aphids per Pan-Trap

	Mean ± SEM	
	2002[a]	2003[b]
White	1.47 ± 0.19 a	0.78 ± 0.10 a
Reflective	0.27 ± 0.06 b	0.17 ± 0.05 c
Buckwheat	0.48 ± 0.09 b	0.44 ± 0.09 b
Clover	0.50 ± 0.09 b	0.43 ± 0.08 b
Bare Ground	0.46 ± 0.09 b	0.32 ± 0.06 bc

Means followed by the same letter are not significantly different ($P = 0.05$, LSD test)

[a] $F = 16.31$; df = 4, 363; $P < 0.0001$

[b] $F = 8.45$; df = 4, 312; $P < 0.0001$

Foliar Counts for Adult Whiteflies and Aphids

- Sampling initiated 4 weeks after planting.
- Nine plants chosen.
- 3 leaves randomly taken from upper, middle, and lower plant stratum.

Mean Number of Aphid and Whiteflies per Zucchini Leaf (2002)
Foliar Counts

	Mean ± SEM		
	Whiteflies (adult) [a]	Aphids (apterous) [b]	Aphids (alate) [c]
White	12.60 ± 2.33 a	0.54 ± 0.31 a	0.21 ± 0.07 b
Reflective	12.31 ± 3.11 ab	0.15 ± 0.10 a	0.22 ± 0.07 ab
Buckwheat	5.90 ± 1.60 cd	0.63 ± 0.38 a	0.13 ± 0.05 b
Clover	5.65 ± 1.71 d	0.24 ± 0.16 a	0.36 ± 0.08 a
Bare Ground	8.94 ± 1.80 bc	0.54 ± 0.22 a	0.25 ± 0.08 ab

Means followed by the same letter are not significantly different ($P = 0.05$, LSD test)

[a] $F = 7.68$; df = 4, 312; $P < 0.0001$

[b] $F = 1.48$; df = 4, 312; $P < 0.2070$

[c] $F = 2.26$; df = 4, 312; $P < 0.0627$

Mean Number of Aphid and Whiteflies per Zucchini Leaf (2003) Foliar Counts

	Mean ± SEM		
	Whiteflies (adult) [a]	Aphids (apterous) [b]	Aphids (alate) [c]
White	4.12 ± 0.91 bc	9.00 ± 3.40 ab	1.03 ± 0.22 ab
Reflective	2.70 ± 0.68 c	2.12 ± 0.87 c	0.06 ± 0.04 c
Buckwheat	2.85 ± 0.76 c	4.67 ± 1.68 bc	0.73 ± 0.24 b
Clover	4.61 ± 0.85 ab	12.61 ± 3.87 a	2.12 ± 0.69 a
Bare Ground	7.33 ± 1.54 a	7.73 ± 2.17 ab	1.97 ± 0.52 ab

Means followed by the same letter are not significantly different ($P = 0.05$, LSD test)

[a] $F = 4.44$; df = 4, 142; $P < 0.0021$

[b] $F = 3.87$; df = 4, 142; $P < 0.0051$

[c] $F = 7.67$; df = 4, 142; $P < 0.0001$

Percentage of Total Pest Individuals Sampled by Taxon

2002	2003
Whiteflies – 85%	Aphids – 63%
Lepidopterans – 9%	Whiteflies – 32%
Aphids – 6%	Dipterans – 4%
	Lepidopterans – 1%

Whitefly Nymph Sampling

- Sampling initiated 4 weeks after planting.
- Nine plants chosen.
- 3 leaves randomly taken from upper, middle, and lower plant stratum.
- 1 inch diameter leaf disks from each leaf examined.

Mean Number of Immature Whiteflies per Leaf Disk

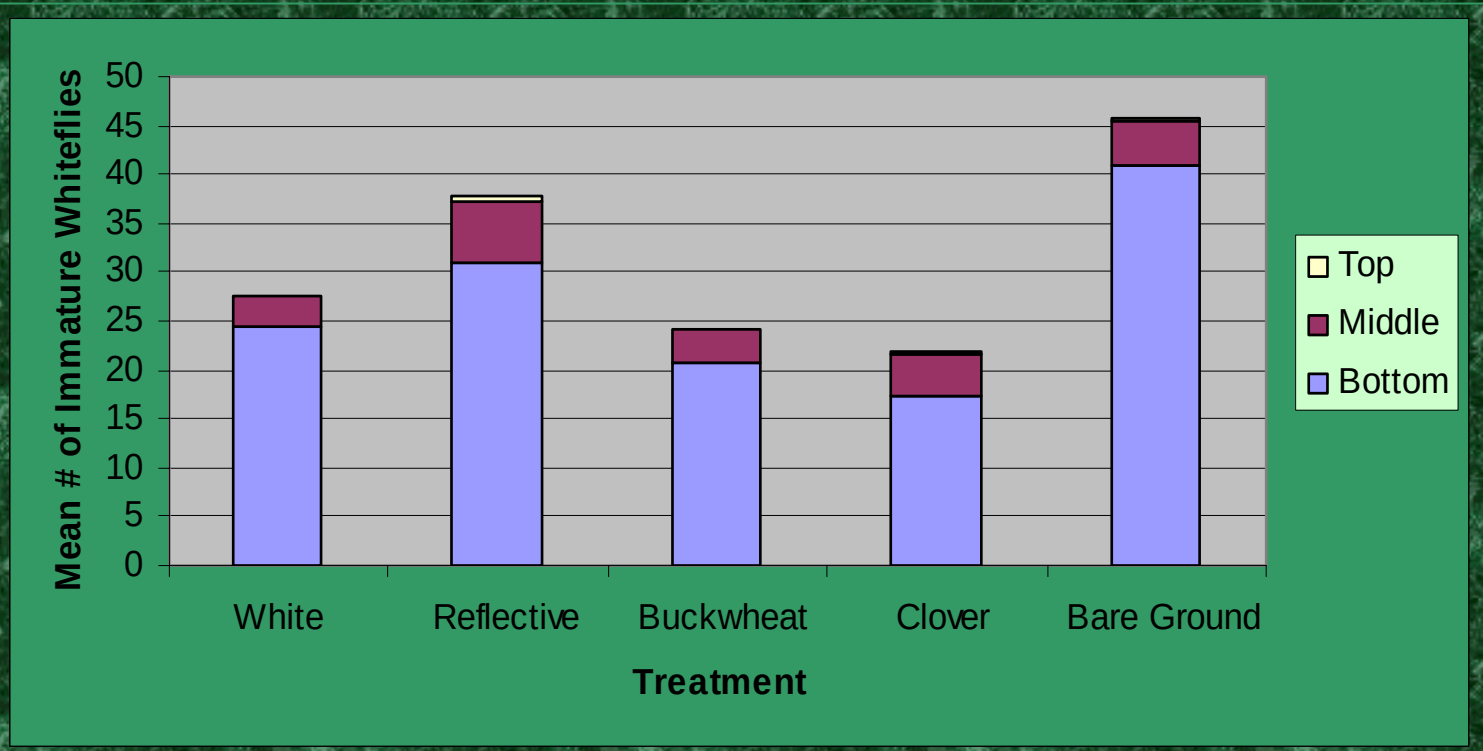
	Mean ± SEM	
	2002[a]	2003[b]
White	9.20 ± 1.53 ab	0.95 ± 0.22 a
Reflective	12.61 ± 2.64 ab	0.38 ± 0.11 b
Buckwheat	8.05 ± 1.31 ab	0.58 ± 0.15 ab
Clover	7.32 ± 1.23 b	0.35 ± 0.11 b
Bare Ground	15.22 ± 2.64 a	0.40 ± 0.10 b

Means followed by the same letter are not significantly different ($P = 0.05$, LSD test)

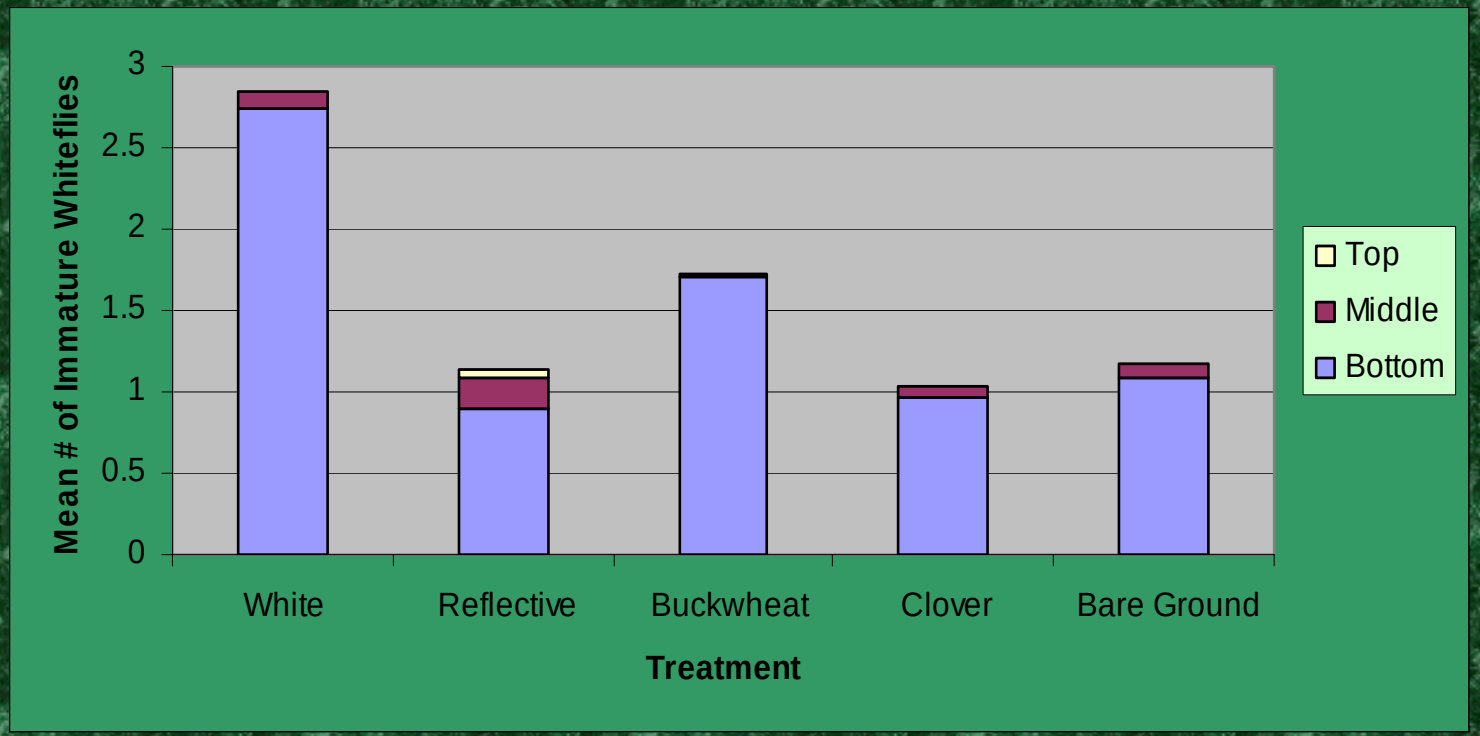
[a] $F = 1.68$; df = 4, 1032; $P < 0.1534$

[b] $F = 2.55$; df = 4, 688; $P < 0.0380$

Populations of Immature Whiteflies on Zucchini Plant Strata (2002)



Populations of Immature Whiteflies on Zucchini Plant Strata (2003)



Physiological Disorder Evaluation

- Sampling conducted once a week.
- Silverleaf symptoms rated on new leaf growth, with severity rated on a scale of 0-5 as indicated by Paris et al. (1987).

Mean Silverleaf Score per Treatment

	Mean ± SEM	
	2002[a]	2003[b]
White	4.09 ± 0.07 b	1.51 ± 0.06 a
Reflective	3.69 ± 0.09 d	1.35 ± 0.06 b
Buckwheat	4.20 ± 0.07 ab	1.10 ± 0.05 c
Clover	3.93 ± 0.10 c	1.02 ± 0.06 cd
Bare Ground	4.39 ± 0.07 a	0.97 ± 0.06 d

Means followed by the same letter are not significantly different ($P = 0.05$, LSD test)

[a] $F = 15.34$; df = 4, 768; $P < 0.0001$

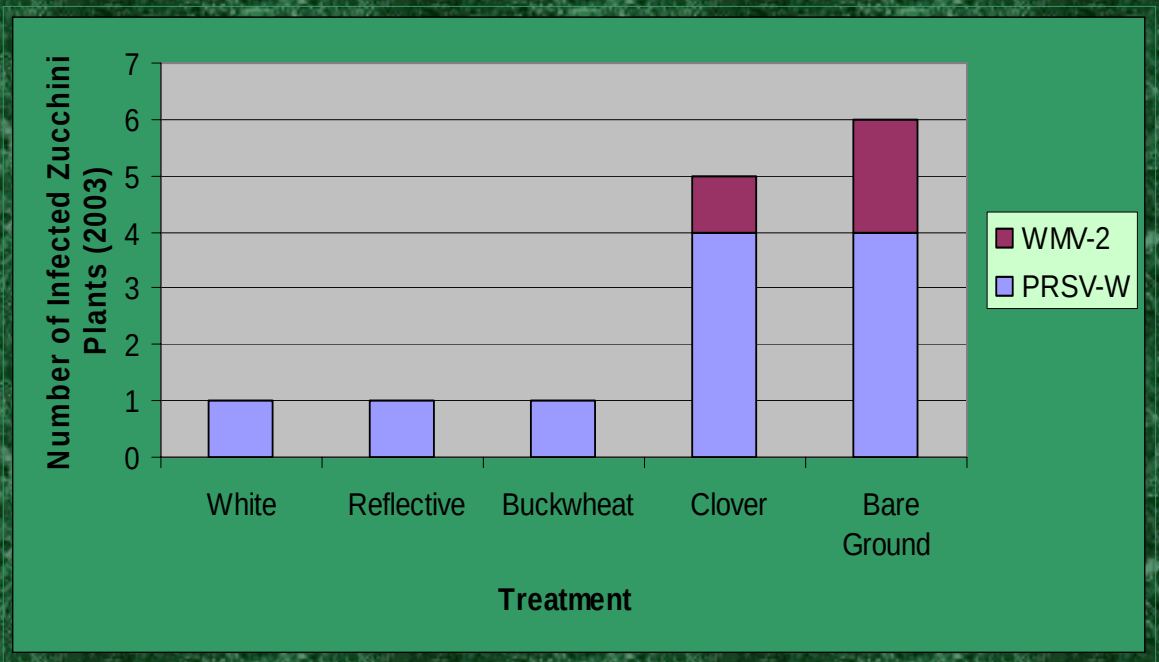
[b] $F = 33.31$; df = 4, 1152; $P < 0.0001$

Virus Identification

- Sampling conducted when visual symptoms present.
- Four plants chosen.
- Samples from plants tested for 8 viral diseases using ELISA.

Virus Identification

- No visual symptoms of virus in 2002.
- Two viruses present in 2003:
  - PRSV-W
  - WMV-2



Discussion

- Adlerz and Everett (1968) showed that white (polyethylene) mulches had higher populations of aphids than reflective and bare ground.

- Simmons (1994) saw 90 – 95% of *Bemisia tabaci* eggs and nymphs on the lower plant strata of various crops.

Natural Enemy Sampling

- Sampling conducted once a week.
- Six plants randomly chosen from outside rows of treatment plots for *in-situ* counts.

Mean Number of Natural Enemies per Leaf

	Mean ± SEM	
	2002[a]	2003[b]
White	0.04 ± 0.02 ab	0.33 ± 0.04 bc
Reflective	0.04 ± 0.02 ab	0.26 ± 0.04 c
Buckwheat	0.02 ± 0.01 ab	0.41 ± 0.05 ab
Clover	0.01 ± 0.01 b	0.48 ± 0.06 a
Bare Ground	0.06 ± 0.02 a	0.28 ± 0.04 c

Means followed by the same letter are not significantly different ($P = 0.05$, LSD test)

[a] $F = 1.54$; df = 4, 1032; $P < 0.1886$

[b] $F = 3.98$; df = 4, 560; $P < 0.0034$

Percentage of Total Natural Enemies Sampled by Order

2002	2003
Araneae – 89%	Araneae – 39%
Coleoptera – 8%	Coleoptera – 29%
Hymenoptera – 3%	Heteroptera – 12%
	Diptera – 8%
	Hymenoptera – 7%
	Neuroptera – 3%
	Other – 2%

Discussion

- These results support the natural enemies hypothesis proposed by Root (1973).
- Despite larger numbers of natural enemies within living mulch plots, there were no differences in the diversity of natural enemies between treatments.

Harvest Yield Sampling

- Sampling conducted for 3 weeks in 2002, and 4 weeks in 2003.
- Plants located in inner rows of each treatment plot used for yield data.
- Total weight of zucchini for each treatment recorded.

Mean Yield Weight (Kg) of Zucchini Fruit

	Mean ± SEM	
	2002[a]	2003[b]
White	15.00 ± 1.67 a	15.36 ± 2.47 a
Reflective	18.24 ± 2.46 a	15.75 ± 2.21 a
Buckwheat	0.75 ± 0.36 c	8.07 ± 1.25 b
Clover	0.75 ± 0.38 c	5.29 ± 0.61 c
Bare Ground	2.36 ± 0.67 b	5.56 ± 0.83 c

Means followed by the same letter are not significantly different ($P = 0.05$, LSD test)

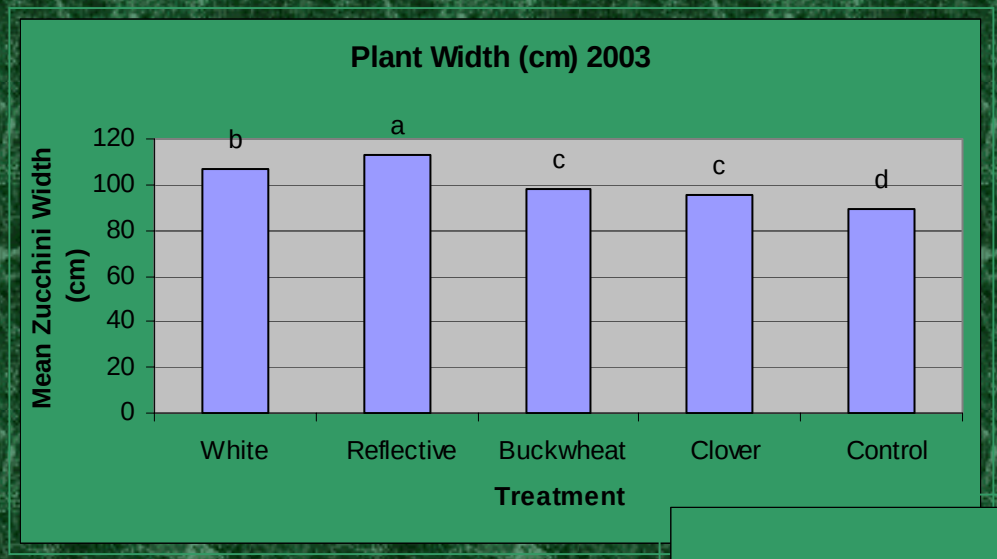
[a] $F = 94.04$; df = 4, 36; $P < 0.0001$

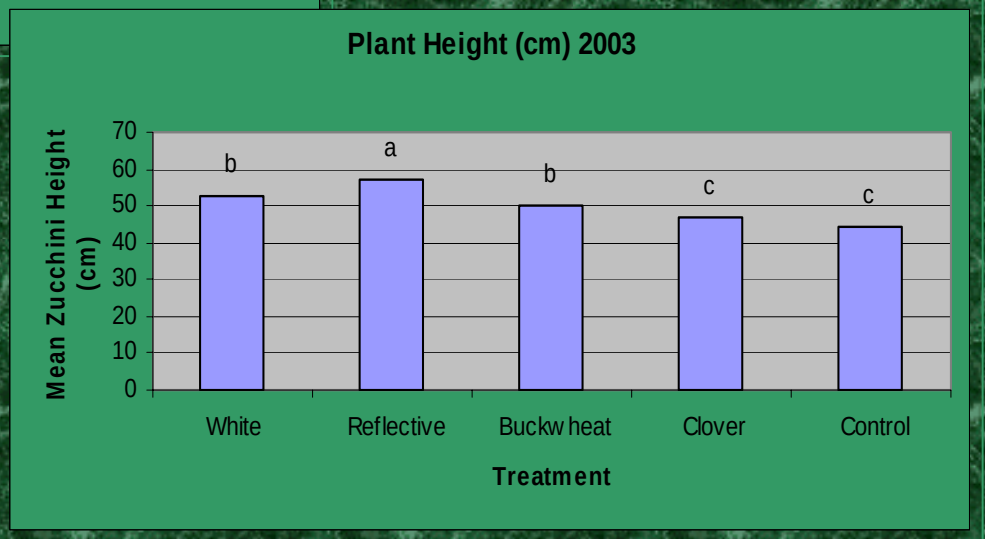
[b] $F = 43.07$; df = 4, 48; $P < 0.0001$

Zucchini Plant Size

- Sampling conducted after 2003 harvest.
- Ten plants chosen.
- Plant dimensions (width and height) measured.

Zucchini Plant Size





Discussion

- Although silverleaf has been known to reduce yields (Costa et al. 1994), it did not appear to be a factor in this study.

- The deleterious effects of competition from the living mulches outweighed any positive benefits they may have had on reducing pest populations.

Conclusions (2002-03)

- White mulch had significantly higher aphid and adult whitefly populations than other mulch treatments including the bare ground.

- Effectiveness of mulches for controlling immature whitefly numbers, and the incidence of squash silverleaf disorder were inconsistent between years.

Conclusions cont. (2002-03)

- High adult whitefly populations in 2002 resulted in high immature whitefly populations, and silverleaf severity.
- In 2003, there was a significant increase in the diversity of natural enemies.
- Living mulch treatments had higher natural enemy populations than the synthetic mulch and bare ground treatments.

Conclusions cont. (2002-03)

- Synthetic mulches had significantly higher yields than those grown with living mulch or on bare ground.

- Zucchini plants grown on reflective mulch were significantly larger than those on all other treatments.

Integration into an IPM Program

- Synthetic mulches cost more.
- Living mulches require more time and maintenance.
- Harvesting easier on synthetic mulches.

Acknowledgements

- Dr. Oscar Liburd
- Dr. Frank Slansky
- Dr. Susan Webb
- University of Florida Fruit and Vegetable IPM Lab
- Citra Plant Science Research and Education Unit