Modular Ecological Design: A Fruit and Vegetable Polyculture System for Urban Areas

Joe Kovach IPM Program

OSU/OARDC Wooster, OH

http://ipm.osu.edu

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IPM

Ohio Integrated Pest Management

- HOME
- OHIOLINE
- ENTOMOLOGY
- EXTENSION ENTOMOLOGY
- HORTICULTURE & CROP SCIENCE
- PLANT PATHOLOGY
- OARDC
- VEGNET

latest updates

The Ohio State Integrated Pest Management (IPM) program is a comprehensive program that is designed to encourage collaboration and innovation among Ohio Agricultural Research and Development Center (OARDC) scientists and Ohio State Extension personnel to better address the pest management needs of the citizens of Ohio. Our goal is to reduce the environmental, economic and social risk associated with managing pests (insect, disease or weed). To accomplish this goal we work with OSU collaborators in 5 areas of emphasis to evaluate and disseminate new IPM information. These areas are Agronomic IPM, High Value Crop IPM, Conservation Partnerships, Pest Diagnostics, and School IPM. In addition this year we will enhance our collaboration with the Cleveland Botanical Garden Green Corp. Urban Youth Program.

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- Annual Reports
- Cornell Organic Guides
- Crop Profiles
- Elements of IPM
- Fruit
- IPM Internal Grant Program
- Lady Beetle Information
- Links
- Modular Ecological Design
- Newsletter
- People

Why Urban Ag Project?

- Industrial Food (many books)
- Eat Corn
- Eat Oil (pesticides, fert. transport)
- For local food to succeed need $16/gal
  – $20/gal gasoline
- Peak Oil – 2008? Price inc. no Production inc.
- 2015 a big spike in prices and no going back ($150 barrel oil)

Goals

- Integrated Pest Management
- Ecological Principles
- Polyculture Experiment
- Cuba

What is IPM?

- Integrated Pest Management is an ecosystem -based strategy that focuses on long-term prevention of pests through a combinations of techniques.

- Combines the best control tactics to reduce reliance on pesticides, minimize environmental effects, and keep pests at an acceptable level

Integrated Pest Management

- Does not rely on any one tactic more than others
- Exhaust other options before pesticides are use
- Pesticides are used only after monitoring indicates they are needed.
- Pest control products are selected and applied in a manner that minimizes risks to humans, nontarget organisms and the environment.

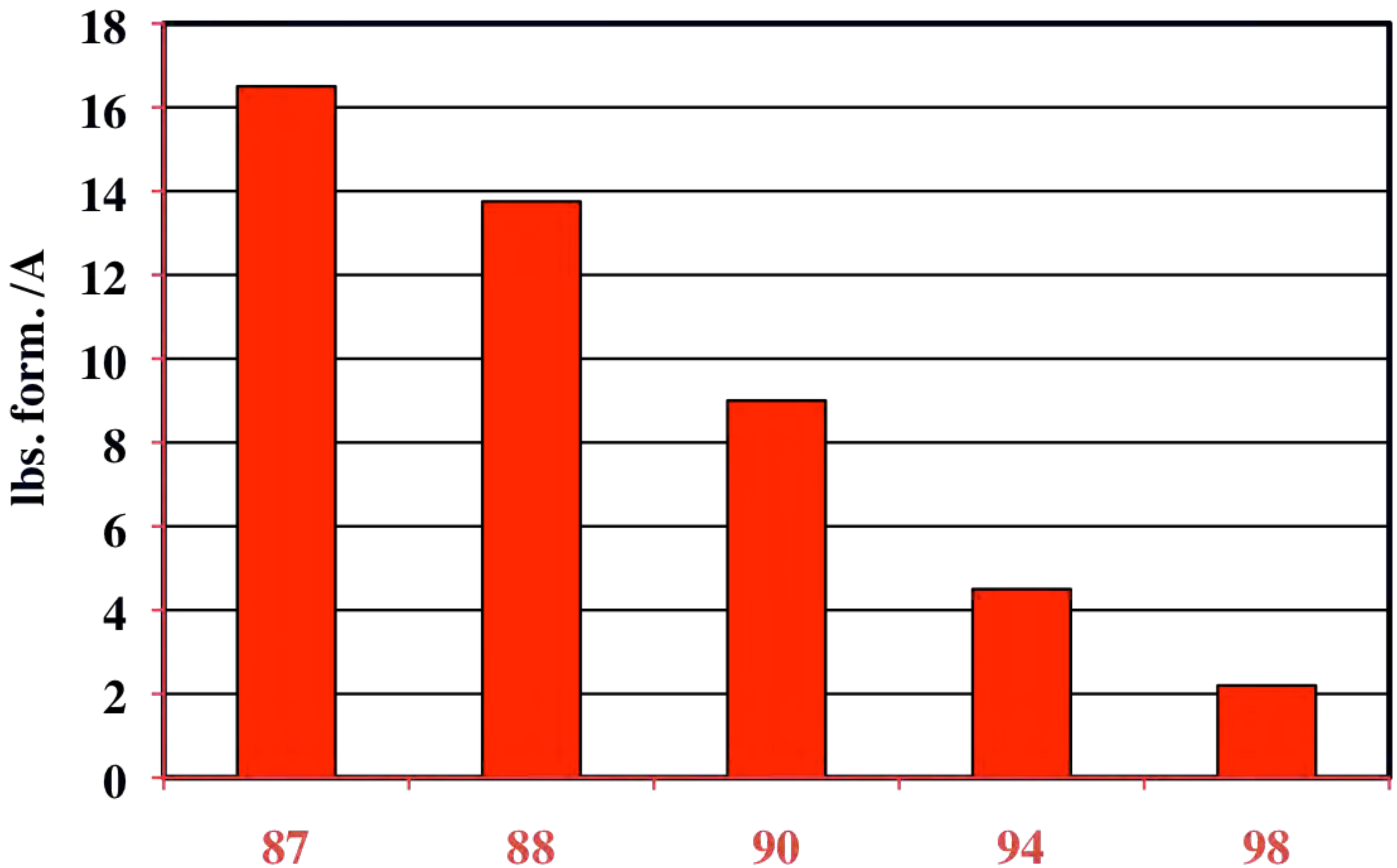
Integrated Pest Management

- Pest is weed, disease, insect, mite, vertebrate
- Not a chemical free system – good design helps but usually is not enough
  - Pesticides can be used at appropriate times
  - OMRI or organic approved or conventional
- Nature bats last!!!

IPM Methods

- Monitoring - scouting, thresholds
- Forecasting – models to predict pest develop.
- Cultural Control - resistant varieties, hoeing
- Biological Control - predators, antagonist
- Chemical Control - pesticides, pheromone

NY Strawberry Pesticide Use*
(Herb., Fung., Insect.)



* NYIPM, NASS

Ecologically Based IPM

- General Principles
  - Select and grow a diversity of crops that have natural defenses against pests
  - Choose varieties with resistance or tolerance
  - Build the soil with organic matter

Integrated Pest Management

Builds on strengths of natural systems

(Ecomimicry)

- Three concepts
  - Ecosystem Stability
  - Biodiversity
  - Biological Control

Ecosystem Stability

- Ecosystems with more diversity
  - Are more stable
  - Greater resistance
    - Ability to avoid or withstand disturbances
  - Greater resilience
    - Ability to recover from stress

Ecosystem Stability

- Reduce tillage/cultivation - fewer weeds
- Reduce mowing - less disruption, increase beneficials
- Maintain “permanent” ground covers
- Add organic matter - substrate for good MO’s
- Use cover crops - inc. moisture retention
- Use crop rotation - breaks pest cycle
- Increase crop diversity - more difficult to find
- Create corridors - highways of habitat

Integrated Pest Management

- Tries to apply stress to the pests
  - Interrupt their life cycle
  - Remove alternative food sources
- Enhance beneficial population
  - Avoid agrochemicals where possible
  - At least better timing

Integrated Pest Management

- Is a preventative approach
  - Uses little “hammers”
  - Instead of one big “hammer”
- Relies on Biological Control (as much as possible)
  - Beneficial predators and parasites
  - Disease-causing organisms
  - Beneficial fungi and bacteria that inhabit roots

What is Biological Control?

- The regulation of pest population densities below and economic injury level via a biological antagonist

Biological Control Potential?

- Many pest pop. are regulated below plant damaging levels by naturally occurring enemies (500 pests of apples in OH)
- There is extensive evidence for successful biocontrol
- Biocontrol is not a panacea; it will not work in some situations

Biological Control

- Classical - importation & establishment of natural enemies, w/o further assistance
- Augmentative releases - periodic (pesticide model)
- Environmental manipulation - attractants, alternative preys
- Preservation of natural enemy flora & fauna

Biological Control Impediments

- High cost of beneficials - raise plant/prey /predator
- Availability & quality of biologicals
- Lack of research documenting success
  - Success rate (15-20%)
  - Usually best in Greenhouses, Islands, California
- Don't buy bio control insects for small outdoor plots

Enhancing Beneficials/Biocontrol

- Characteristics typical of fields with plenty of indigenous beneficials
  - Fields are small - a lot of edges, natural vegetation
  - Cropping systems are diverse
    - Include perennials and flowering plants
  - Crops are managed with minimal agrichemical inputs
  - Soils high in organic matter, biological activity during off season
    - Covered with mulch or vegetation

Biodiversity
(sp. richness and eveness)

- Spatial diversity - across a landscape, within fields
- Genetic diversity - different varieties, different crops
- Temporal diversity - different crops at different stages of growth

Fertility

- Slow release of nutrients the best,
  - any compost is good compost (yard waste, dairy barn, vermicompost)
- Pests seem to follow the Nitrogen (plant suckers i.e. mites & aphids)
- Too much synthetic fertilizer cause nutritional imbalances

Given that we will eventually run out of oil, can we design a food production system that is:

- Close to consumers
- Simulates natural systems
  Ecomimicry
- Uses Ecologically Based Pest Management
- Economically viable ≈ $90,000/A

  = $ 10 per ft of row

Modular Ecological Design

Goal - to determine optimal layout of an intensive fruit & vegetable polyculture system that mimics natural systems & can be used by the small periurban or urban farmer.

Modular

Economics

Pest density

Efficiency

August 2005

Some Principles of Good Farming/ Gardening

- Plan your farm/garden and set goals
- Look at the whole picture (water, soil, crops, goals)
- Fertility and slope of land
- Learn and grow through reading and meetings
- A farm must be profitable ($, joy)

Economic IPM and Marketing

Product = Bundle of Benefits

Marketing Strategies

How to differentiate your product?

1) Price - more efficient, less cost

2) Quality - characteristic that customers want

Use different strokes for different folks

Selling Strategies

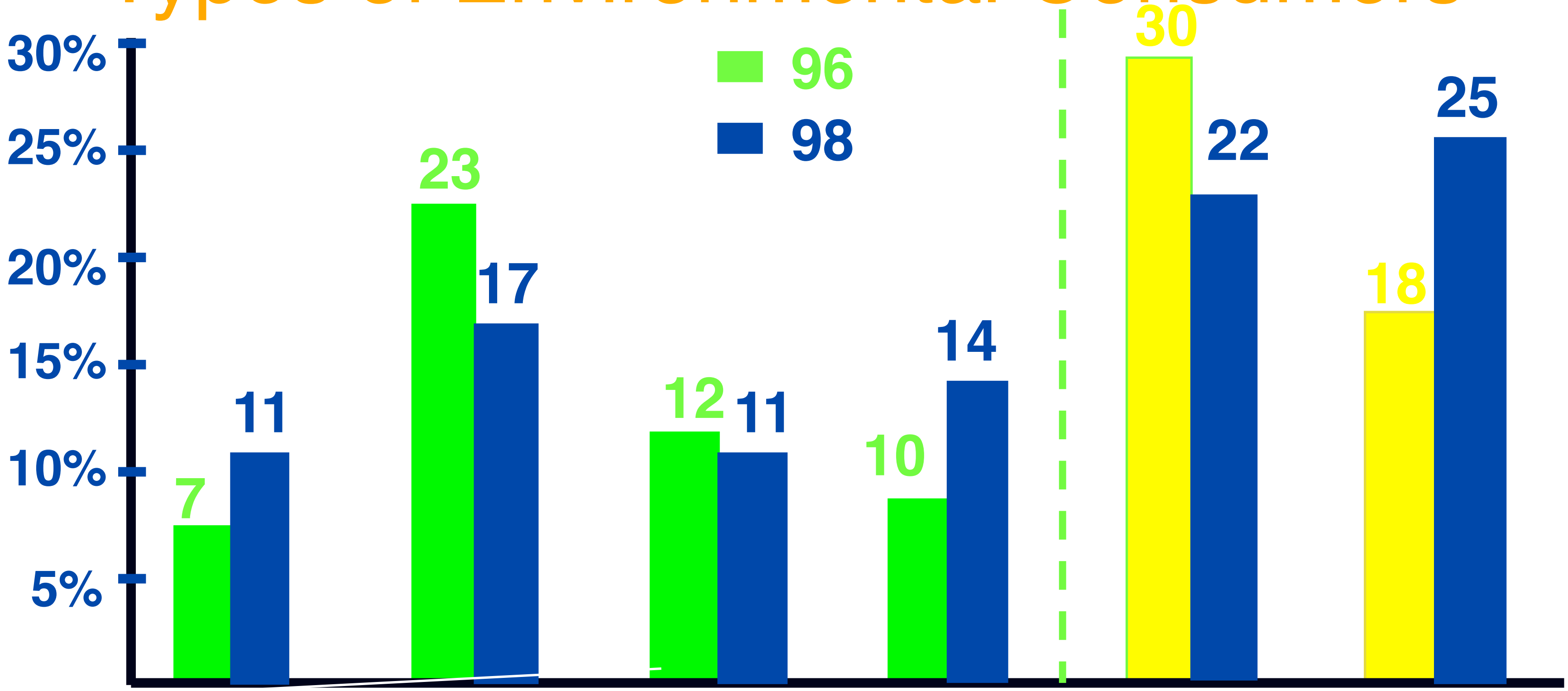
- Not all customers are alike
  - The old days of Henry Ford when "You can have any color you want, as long as it's black" are long gone.
- Use different strokes for different folks
- The Law of the Slight Edge

  Once established, difference between a champion and an also-ran, more often than not, is a very slim margin

Models for Differentiating Consumers

- Environmental Consumer
- Lifestyle - Health Consumer (LOHAS)

Types of Environmental Consumers



True Natural
- Deep Env concern
- Will pay
- Female
- Low& upper income

New Green Mainstream
- Heartbeat of Am.
- Interested in Env.
- Need a "reason"
- Only when convenient

Affluent Healers
- Well Ed.
- Upscale
- Personal well being focused
- Family & goal orient

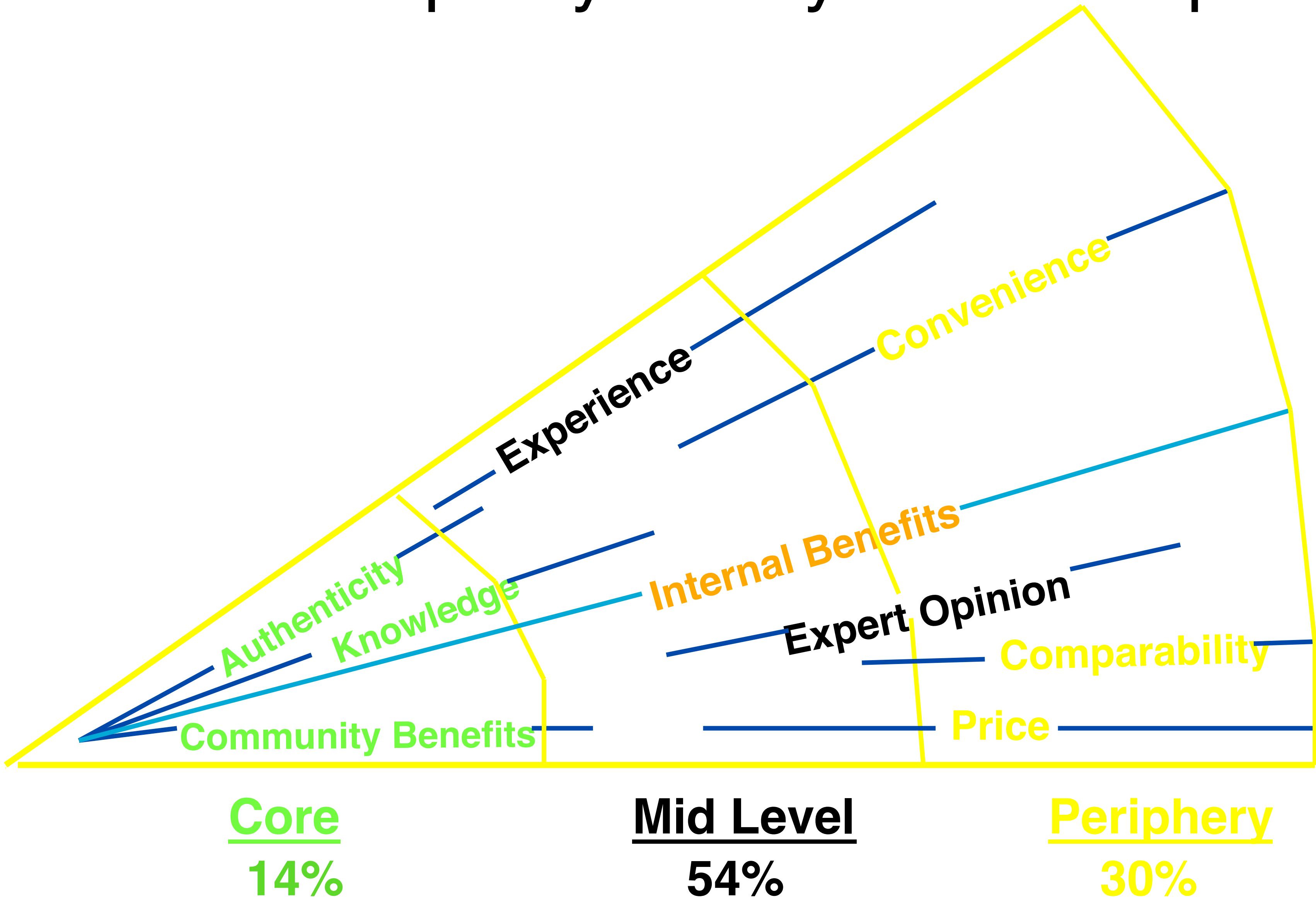
Young Recyclers
-Young
- Never married
- Reject paying a premium
-Solid waste

Overwhelmed
- Not optimistic
- Economically "just getting by"

Unconcerned
- Apathetic
- Reject that chemicals harms the environment

Hartman Group

Core to Periphery Lifestyle Model Sphere



Hartman Group

Lifestyle and Economic Potential

- Cities are where the money is
- City dwellers are clamoring for good local food
- To get top dollar target LOHAS

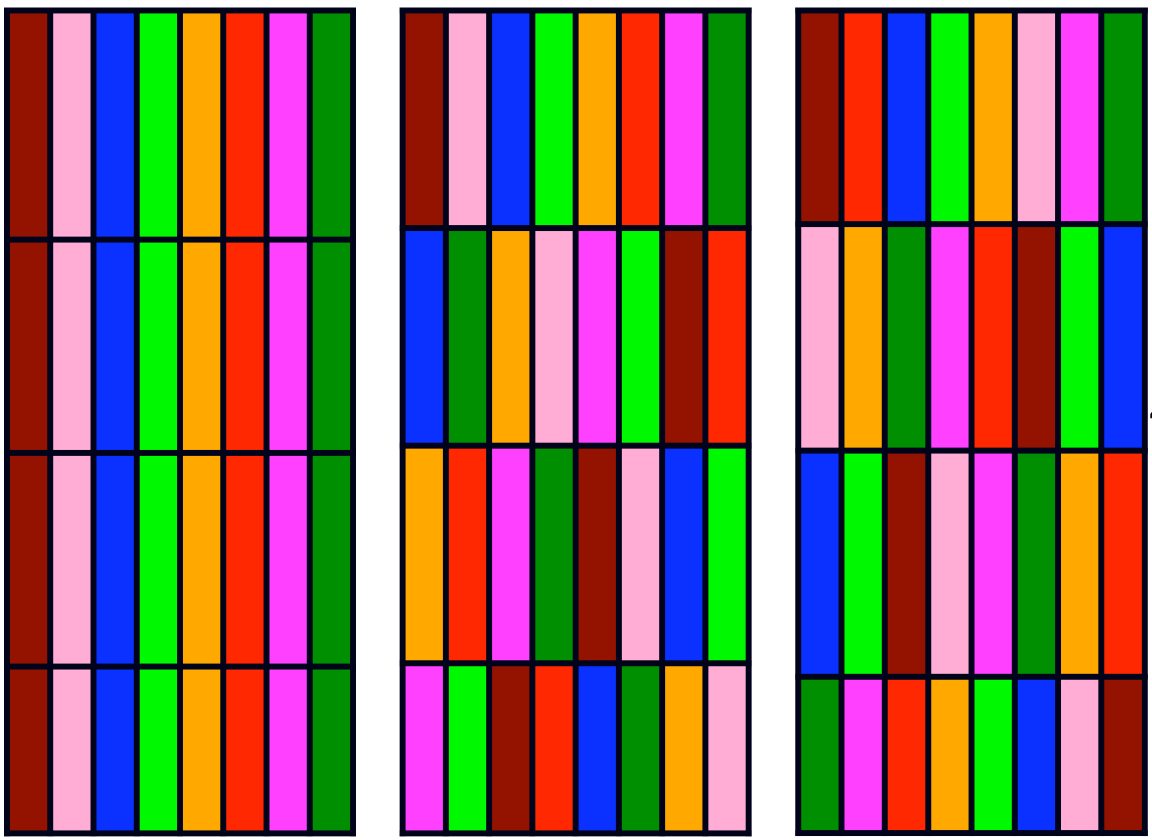
LOHAS- Lifestyles of Health and Sustainability

- – 1/3 US pop. - 63 million adults
- – Goods & Services
  - Health and Fitness
  - Environment
  - Social Justice
  - Personal development
  - Sustainable living

Slavic Village – Cleveland Bot. Garden

Commodities and Treatments

Solid Row | Mixed Row | Checker board



Early, Mid, Late cultivars

4 trees/shrubs

- I. Apples(SwC)
- II. Peaches
- III. Blueberries
- IV. Raspberries

4 herbaceous

- Strawberries
- Edamame soybeans
- Tomatoes
- Green beans

The fourth treatment (not shown) is a mixed row configuration on raised beds.

Layout of plots

RB	SR	MR	CB
MR	RB	CB	SR
SR	CB	RB	MR
CB	MR	SR	RB

RB = Raised Bed

SR = Solid Row

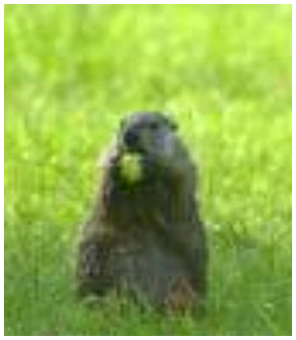
MR = Mixed Row

CB = Checker Board

4 Treatments Replicated 4 Times, SR, MR, CB, RB


EIGHT

Groundhog, Rabbit, Deer Fence



June 2005

I garden, therefore I fence

June 2005

June 2006 - Weeding Cost

<u>2005 Weeding Costs</u> - $1.35/ft

Labor hrs (760 hr) = $6,080

<u>2006 Cost</u> - $0.37/ft

Landscape Cloth = $1,250

Labor (214 hr) = <u>$1,612</u>

Total = $2,862

2007

2007

HT= $9.50/ft

High Tunnel Growth Differences (cm)

Trt	All	Ap	Blue	Rasp	Peach	Soy	Stra	Apples Aph/M
No	172 a	232 a	118 a	142 a	271 a	74 a	41 a	19% a
HT	196 b	243 a	123 a	185 b	333 b	86 b	44 b	38% b
Inc.	14%			30%	23%	16%	7%	

High Tunnel Yield Differences (g/m)

Trt	Straw	S Rasp	F Rasp	Tom	Soy	Blue	SnP
No HT	4673a	2276a	2086a	6806a	1147 a	706a	269a
HT	3779b	1162b	3736b	8764b	1348 b	951a	387a
%	-19%	96%	79%	23%	16%	-	-

Tunnels have a shading impact and reduce wind

Strawberries are primarily wind and gravity pollinated

Japanese Beetle
(July-Aug)

Year	No. JB
2005	15,000
2006	60,000
2007	283,000
2008	441,000
2009	162,000
Trt	
High Tunnel	11,300 (4%)
No HT	271,700 (96%)

Japanese Beetle

(July-Aug) 2006, 2007

	2006		2007	
Crop	No. JB	%	JB	%
Rasp	30,146	52	109,292	39
Peach	22,789	38	11,047	4
Soy	1,851	3	108,239	38
Straw	1,652	3	20,232	7
Blue	1,486	3	32,115	11
Apple	488	1	2,801	1
Tomato	0	0	110	0

Japanese Beetle
Raspberry (JB/5ft/date)

Trt	2006	2007
MR	10.4 a	35.0 b
CB	11.7 ab	29.8 c
RB	13.3 bc	43.6 a
SR	15.3 c	37.8 b

Cultivar	2006	2007
Royalty	3.1 a	15.5 a
Carol	12.0 b	36.4 b
Prelude	22.9 c	57.7 c

Royalty

Prelude

Japanese Beetle
Blueberry (JB/5ft/date)

Trt	2007
MR	10.0 a
CB	9.9 a
RB	11.1 a
SR	13.6 a

Cultivar	2007
Duke	14.7 a
Bluecrop	13.9 b
Elliot	4.9 b

Japanese Beetle Traps

- 2 bait types
  - Mimics scent of virgin female
  - Sweet smelling food type of lures

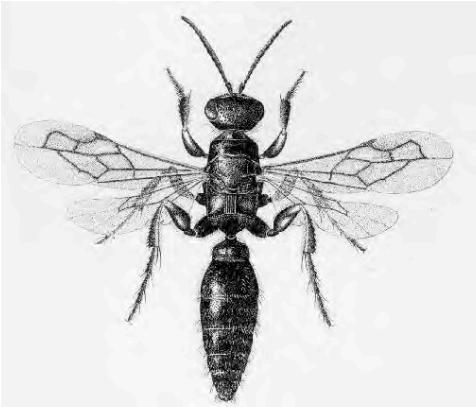
- U of Kentucky research
  - Traps attract more beetles than catch (40-50%)

- Traps are not recommend for control

JB Cultural Control

- Habitat modification
  - Grubs and eggs are extremely sensitive to dry conditions.
  - Try not to irrigate during egg laying, drip irrigate and do not water sodded middles
- Cultivar selection?
- Do not plant trees that are highly susceptible
  - Jap and Norway maple
  - Birch, pin oak, apples, *Prunus sp*.
  - Lindens, Virginia creeper

JB Biological Control



- Insect Parasites - imported wasps
  - Tiphia popilliavora
  - Tiphia vernlis - controls JB in Japan
    - 1920's released in E. US, established
    - Better in southern US

- Imported parasitic fly
  - Hyperecteina aldrichi

JB Biological Control

- Bacterial Milky Disease
  - *Bacillus popilliae*
  - *Bacillus lentimorbus*
- Some effectiveness in E. US, but variable
- Better in southern US, warmer soil
- The spore count needs to build up for 2-3 years to be effective
- In OH and KY test trials have not produced satisfactory results
- Already have some *B. popillae* in our soils

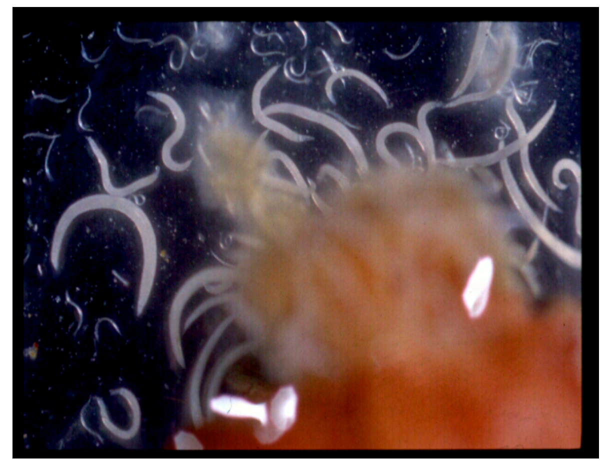
JB Biological Control

- Beneficial Nematodes - apply at 2nd instar (Sept)
  - *Steinernema* - 24 species (Steinernematidae: Rhabditida)

    Symbiotic bacterium *Xenorhabdus*

  - *Heterorhabditis* - 8 species (Heterorhabditidae: Rhabditida)

    Symbiotic bacterium: *Photorhabdus*



http://www.oardc.ohio-state.edu/nematodes/

JB Adult Control - Softer Chemicals

- Azadiractin - Neemix - repellant, short lived
- Kaolin clay - repellant, white residue
- Pyrethrins (Pyganic) - short lived, multiple application
- Insecticidal soap - short lived

Japanese Beetle 2009

Treatment	Overall JB dens.
Aza-Direct (Neem)	31.6 a
Fruit Spray (low rates of malathion/ carbaryl)	35.3 a
Ecotec (10% rosemary, oil 2%pmint)	32.0 a
UTControl	38.0 a

4 – sprays (29 Jun, 6, 20, 27, Jul 2009)

Arthropod Collections 2005-08

Sweep net samples

Jun, Jul, Aug, Sep, Oct

		Total	Beneficial	Pest	Incidentals
Families		139	53	37	51
Indiv	'05	25,258	16%	54%	30%
	'06	16,202	21%	50%	29%
	'07	24,118	21%	51%	28%
	'08	23,493	20%	45%	32%

Insect Individuals (2006)

Crop	% Pest	%Nat. E.
Strawberry	50.3	15.6
Peach	35.7	24.7
Raspberry	51.2	12.5
Blueberry	44.6	23.2
Apple	61.4	17.4
Soybean	48.3	10.5
Potato	73.8	13.6
Tomato	49.5	11.1

Shannon's Diversity Index

Crop	Biodiv 05	Biodiv 06
Strawberry	1.69 d	2.22 a
Peach	2.24 a	1.91 b
Raspberry	1.829 c	1.59 c
Blueberry	1.64 d	1.46 c
Apple	-	1.17 d
Soybean	2.07 b	1.01 de
Potato	-	1.08 d
Tomato	1.61 d	0.84 e
Corn	2.18 ab	-
Green bean	1.89 c	-

Can Intercropping increase biodiversity?

Treatments:

1) Peaches alone
2) Peach intercropped w/ straw.
3) Strawberries alone
4) Straw. Intercropped w/ peach

Is increasing biodiversity good?

Intercropping Biodiversity

Beneficials/Natural Enemies

Treatment	Biodiversity (H’)
Peach	0.77 a
Peach inter. w/ straw	0.81 a
Straw	0.52 a
Straw inter. w/ peach	0.62 a

Intercropping Biodiversity

Pest Insects

Treatment	Biodiversity (H’)
Peach	0.79 bc
Peach inter. w/ straw	1.13 a
Straw	0.53 c
Straw inter. w/ peach	0.87 a

Is increasing biodiversity good when you increase the biodiversity of pest insects?

Harvest 2008

Harvest Evaluations 2006

Trt	Soy	S.Rasp	Straw	Tom	Pot
SR	32 a	381 a	1407 a	2338 a	486 b
CB	59 b	279 a	1310 a	2083 a	300 a
MR	47 b	289 a	1314 a	2420 a	275 a
RB	56 b	505 a	1619 a	3086 b	475 b
% inc	67	81	24	48	73

Harvest Evaluations 2007

Trt	Straw	S.Rasp	F.Ras	Tom	SnP	Soy	Blue
SR	2984	903	1512	3685	170	1021	882
CB	2707	1034	1429	5429	250	694	551
MR	2542	797	1685	4193	260	880	661
RB	3287	1403	1424	6965	512	1064	662
% inc	20	54	-	57	125	-	-

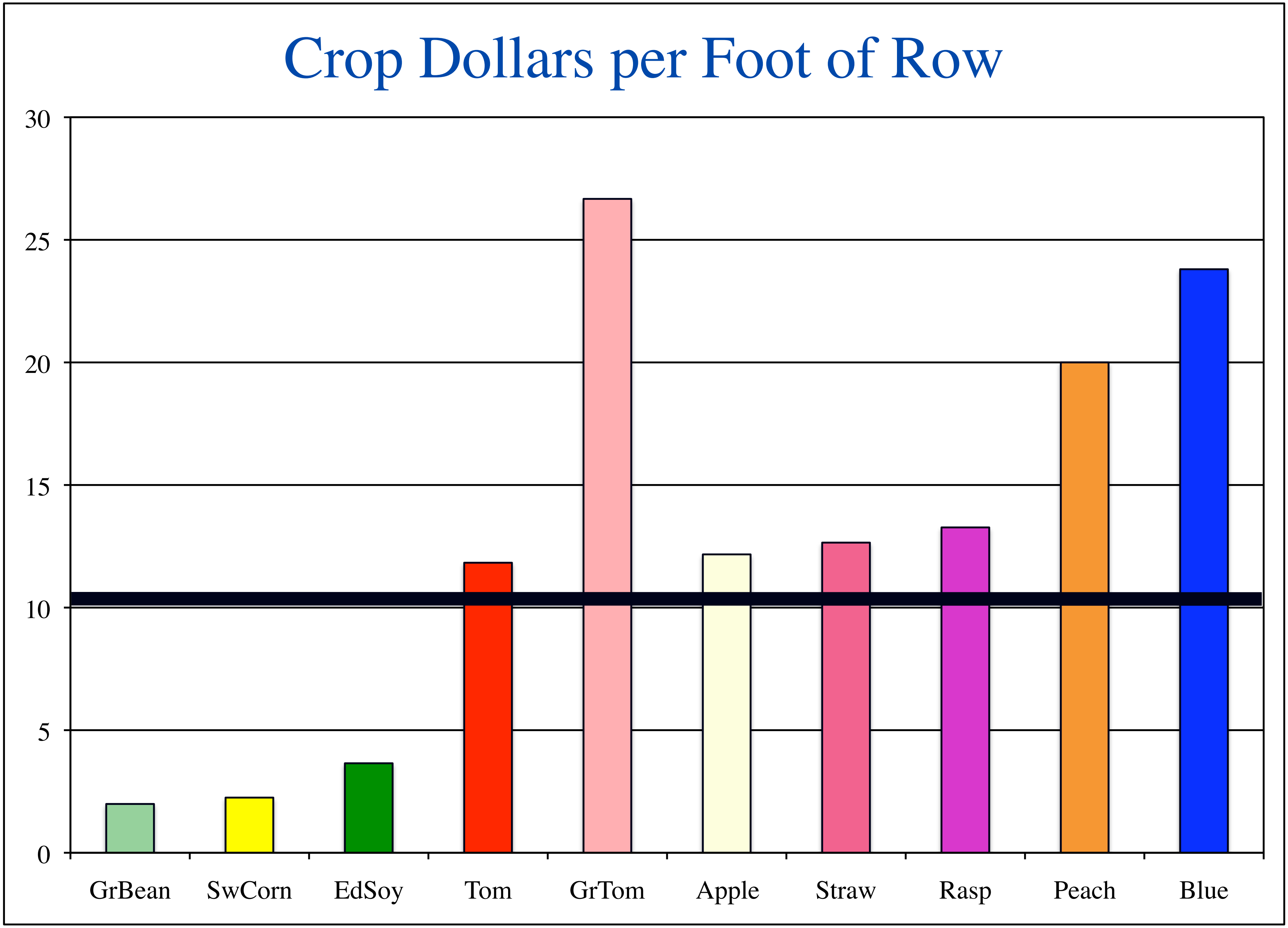
Total Hours to Harvest all Crops 2005

(green beans, tomatoes, sweet corn & soybeans)

Treatment	Hours/Meter/Person
CB	7.31a
MR	6.82a
RB	6.44a
SR	5.78a

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

Labor Cost = $1.00/ft for $8/hr for 6 months


Crop Dollars per Foot of Row
30
25
20
15
10
5
0
GrBean
SwCorn
EdSoy
Tom
GrTom
Apple
Straw
Rasp
Peach
Blue

Establishment Costs

2005	
Establishment	
Soil prep	$ 176
Plants	5,015
Fencing/Irrigation	1,956
Sub total	7,147
Weed Control	
Labor - 760h (weed, mulch)	6,080
Mulch (17 truck loads)	4,250
Sub total	10,330
Raised Beds	
Materials	2,280
Total	$19,757

2006	
Seeds	$ 484
Harvest material	
(qts, pts, container)	292
Weed Control	
Landscape cloth	1,033
Staples	216
Labor -182h	1,456
Sub total	2,705
Trellis	
T-post	290
Lumber	310
Screws, wire	49
Sub total	649
Misc.	590
Total	$4,720

Total investment $24,477

per plot 1,530 (+ RB $1.20)

$/ft $3.20 (+ HT= $9.50/ft)

Conclusions to Date

- Jap. Beetles were a big problem in ‘07 ‘08 especially on rasp, soybeans or peaches
- High Tunnels Crops - had the fewest JBs, best growth, nicest fruit ($ 9.50/ft)
- Strawberry & Peaches had the most biodiversity
- Peaches had the lowest % pests & highest % natural enemies
- Potatoes had the highest % pests

Conclusions to Date

- Raised beds ($1.20/ft) - were easy to harvest and the best yield on some crops
    - Staff wanted solid rows on raised beds
- Paid for capital improvements (plants, fence, irrigation, etc.) after year 2
- $ 10/ft may be obtainable when under full production, with the correct market & certainly would be easier with a higher price than in grocery stores

Questions?

Cuba

Miami
OCEAN
Gulf of Mexico
Nassau
ANDROS ISLAND
NEW PROVIDENCE
ELEUTHERA
Straits of Florida
24°
CAY SAL BANK (BAHAMAS)
B A H A M A S
Tropic of Cancer
Havana
Matanzas
Cárdenas
San Cristóbal
Güines
Sagua la Grande
Pinar del Río
Jaguey Grande
Colón
Santa Clara
Guane
Gulf of Batabano
Morón
ACKLINS ISLAND
Nueva Gerona
Bay of Pigs
Sancti Spíritus
Ciego de Avila
Cape San Antonio
Camagüey
Nuevitas
GREAT INAGUA
ISLA DE LA JUVENTUD
Gulf of Ana María
Las Tunas
Puerto Padre
Holguín
Cienfuegos
Santa Cruz del Sur
Moa
Bayamo
Mayarí
Baracoa
20°
Manzanillo
Guantánamo
Pico Turquino 6,560 ft.
Santiago de Cuba
CAYMAN ISLANDS
George Town
(U.K.)
Guantanamo Bay
Windward Passage
HAITI
NAVASSA ISLAND (U.S.)
JAMAICA
Kingston
CARIBBEAN SEA
16°



Special Period (1990-present)

- Collapse of USSR
  - Trading partner
    - Sugar Cane for
      Oil and food
- No oil/no pesticides
- Calories
  - 2800 cal --> 1800 cal
  - Lost 20-25% of BW
  - Today = 3000 cal
  - 40% of pop. OW

Organoponicos = small urban agricultural plots

- Cuba researchers were working on hydroponics
- Australians come over with permaculture
- Military connection - Raul Castro?

Organoponicos

Organoponicos

Organoponicos

Why it works:

1) Diverse cropping
2) Learned what to plant
3) Good sanitation practices
4) Use trap cropping (lettuce)
5) Plenty of "free" labor
6) **Local** farmer/IPM meetings
7) Location, location, location
    - Cuba's an island - biocontrol
    - In cities - biological deserts
    - Mosquito spraying - 2x/wk

Organoponicos

Why I'm skeptical:

1) Claimed using a lot of biopesticides (Bt, Beauvaria, neem)
    - No pests/beneficials observed - too clean for biocontrol
    - CREE - no comments

2) There is no evidence that planting marigolds/sunflowers at end of row increase pest control (Caribbean magic)
3) No birds (eat them?, DDT for mosq.?)
4) Claimed they will not go back to pesticides if embargo is lifted
    - OK as long as cheap labor available