



# **INTEGRATED PEST MANAGEMENT FOR VEGETABLE CROPS**

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# INTRODUCTION



## Farmers tend to

- ❑ Knockdown pest over ambitiously
- ❑ Overuse, misuse and even abuse pesticides

## Lead to

- ❑ Insecticide resistance/resurgence
- ❑ Control failures
- ❑ Environmental and ecological imbalances

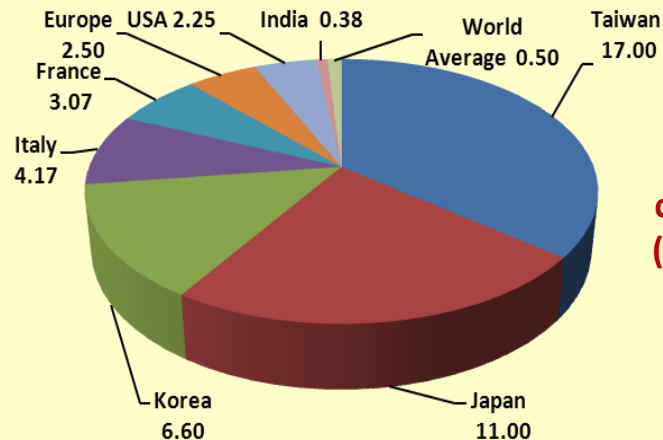
## Reasons for increasing pest status in vegetables

- ❑ Intensive mono-cropping
- ❑ Off season cultivation
  - ❖ Wider pest activity in time and space
- ❑ Indiscriminate use of insecticide
  - ❖ Scheduled application
  - ❖ Loss of efficacy
  - ❖ Increasing pest management cost
  - ❖ Resistance / resurgence
  - ❖ Impact on Natural Enemies

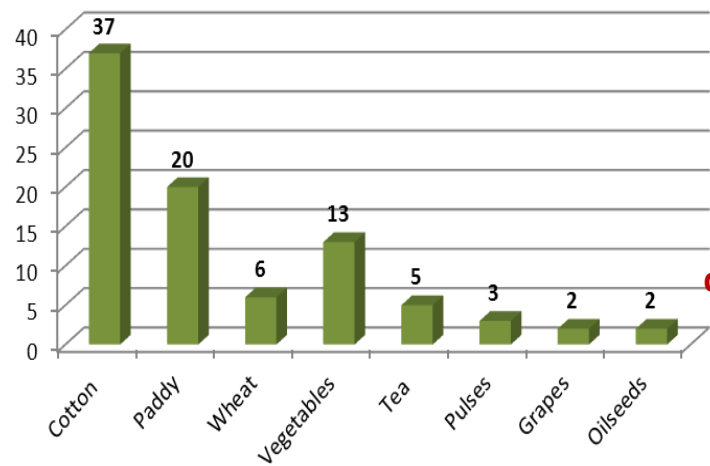


# Pesticide use scenario

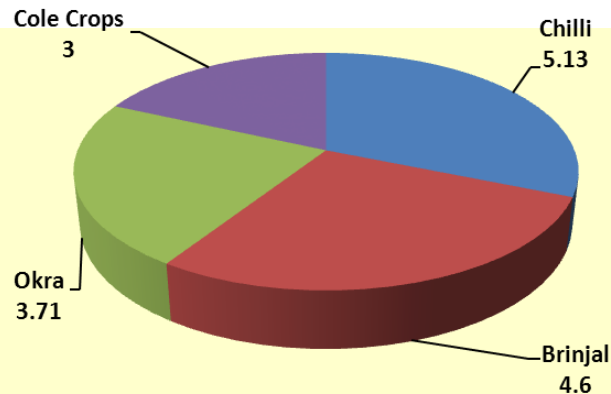
- ❑ Pesticide consumption in India - very low
- ❑ Currently about 40000 t of pesticides uses a decline of  $\frac{1}{3}$  since 5 yrs ago.
- ❑ Worldwide 44% increase in herbicides use over past decade, with a concomitant reduction in insecticides by 30%.
- ❑ Insecticides still account for 60% of total pesticide use.
- ❑ About 13-14 % of total pesticides used in the country are applied on vegetables.
- ❑ Average pesticide consumption in vegetables in India - 0.678 a.i. kg/ha.
- ❑ Maximum pesticide usage in chilli followed by brinjal, Cole crops and okra.
- ❑ Global agro-chemical consumption dominated by fruits and vegetables, accounting 25% of total pesticide market.



Pesticide consumption (a.i. kg/ha) in different countries



Consumption of pesticides (%) in different crops



Pesticide consumption (a.i. kg/ha) in different vegetable crops



## Important pests showing resistance/resurgence against insecticides

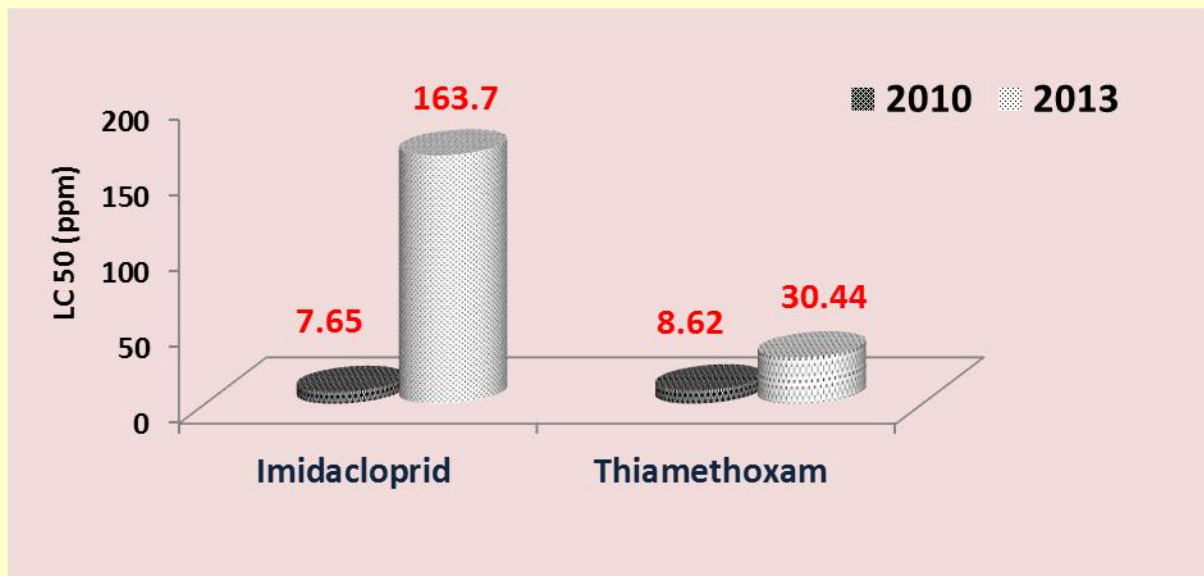
Insect	Resistance	Insecticide
Diamondback moth ( <i>P. xylostella</i> )	Resistance	Cypermethrin, DDT, fenvalerate, malathion, parathion, quinalphos, Diazinon, methomyl, monocrotophos, cartap hydrochloride, carbaryl, ethyl parathion, carbosulfan, Bt subsp. Aizawi, Bt subsp. kurstaki
Tomato fruit borer ( <i>H. armigera</i> )	Resistance	Cypermethrin, endosulfan, fenvalerate, Quinalphos, Carbaryl, Bacillus thuringiensis, organophosphate, synthetic pyrethroids
Whitefly ( <i>Bemisia tabaci</i> )	Resistance	Cyfluthrin, cypermethrin, endosulfan, monocrotophos, Quinalphos, methamidophos
BSFB ( <i>L. orbonalis</i> )	Resistance	Quinalphos, synthetic pyrethroids
Okra jassid ( <i>A. biguttula biguttula</i> )	Resistance	Malathion, monocrotophos
Yellow mite of chilli ( <i>P. latus</i> )	Resistance	Acephate, cypermethrin, deltamethrin, fenvalerate, monocrotophos, imidacloprid
Bitter gourd aphid ( <i>Aphis malvae</i> )	Resurgence	Deltamethrin, Permethrin, malathion
Red spider mite of brinjal ( <i>Tetranychus urticae</i> )	Resurgence	Deltamethrin, fenvalerate
Brinjal aphid ( <i>Myzus persicae</i> )	Resurgence	Cypermethrin, deltamethrin
Red spider mite of okra ( <i>T. urticae</i> )	Resurgence	Ethion



# Relative resistance of whitefly, *Bemisia tabaci* to neonicotinoid insecticides

Insecticides	LC <sub>50</sub> value worked out during 2010	LC <sub>50</sub> value worked out during 2013	Relative Resistance
Imidacloprid 17.8 SL	7.65 ppm	163.7 ppm	21.54
Thiamethoxam 25WG	8.62 ppm	30.44 ppm	3.53

Relative Resistance = LC<sub>50</sub> value of 2013/LC<sub>50</sub> value of 2010



Shift in the LC<sub>50</sub> value of neonicotinoid insecticides to whitefly



## Pesticide contamination in vegetables (State wise)

States	Samples with contamination (%)	Samples above MRL (%)
Haryana	56.2	4.5
Himachal Pradesh	19.5	1.4
Tamil Nadu	91.8	15.3
Gujrat	50.8	13.5
Andhra Pradesh	29.8	-
Uttar Pradesh	100.0	49.5
West Bengal	56.0	-
Kerala	100.0	52.8
Punjab	58.1	4.7
Orissa	57.4	12.4
Delhi	77.9	-
Assam	46.9	-
Rajasthan	53.4	12.1
Karnataka	19.7	7.3
Madhya Pradesh	96.9	1.5
Maharastra	73.4	13.7
Total	55.1	9.5



# Extent of pesticide residues in vegetables above MRL

Vegetables	Samples	Frequency	Pesticides	Year	No of samples analyzed*	Samples above MRL (%)
Brinjal	87	62 (11.5)	Monocrotophos, cypermethrin, deltamethrin, endosulfan, lindane	1999	277	10 (3.6)
Cabbage	73	66 (11)	Cyfluthrin, phosphamidon, chlorpyriphos, monocrotophos, endosulfan, quinalphos	2000	712	81 (11)
Cauliflower	89	72 (21.3)	Cyfluthrin, phosphamidon, chlorpyriphos, endosulfan, lindane	2001	796	93 (11.7)
Okra	76	64 (18)	Quinalphos, cypermethrin, endosulfan, phosphamidon, lindane	2002	592	54 (9)
Chilli	73	67 (14)	Fenvelerate, endosulfan, cypermethrin, quinalphos, monocrotophos	2003	666	54 (5.3)
Tomato	96	59 (7.3)	Deltamethrin, endosulfan, cypermethrin, chlorpyriphos	2010-11	5170	593 (11.5)

\*Cabbage, cauliflower, brinjal, okra, potato, beans, gourds, tomato, chilli, spinach, carrot, cucumber and cowpea.

❑ In 2010, out of 34027 samples analyzed at national level, 543 samples (1.6%) were above MRL.

- 3.1% samples of vegetables, 0.8% of fruits, 2.7% of cereals, 0.7% of pulses, 2.3% of spices, 0.1% of fish/crustaceans, 1.1% of meat/egg, 0.2% of tea, 1.9% of milk and 1.1% of butter were above MRLs.
- A serious fact revealed was the presence of non-recommended pesticides in vegetables.

❑ Recently during export of vegetables by Indian farmers, an alarming situation was raised by European Union.

- Out of 446 import samples tested for agrochemical residue, 70 were of Indian origin.
- Out of these, 31 samples tested positive for agrochemical residues above EU-MRLs.
- Samples included Okra (16), Curry leaves (7), Drum Sticks (4) and Chilli (4).
- Endosulfan, monocrotophos, acetamiprid, acephate, mancozeb, thiophenate methyl and carbandazim - commonly detected pesticides above MRLs (up to 700 times).



# Yield losses due to major insect pests in vegetables in India

Crop/Pest	Yield loss (%)	Crop/Pest	Yield loss (%)
<b>TOMATO</b>		<b>CABBAGE</b>	
Fruit borer ( <i>Helicoverpa armigera</i> )	24-65	DBM ( <i>Plutella xylostella</i> )	17-99
<b>BRINJAL</b>		Cabbage caterpillar ( <i>Peiris brassicae</i> )	69
Fruit and shoot borer ( <i>Leucinodes orbonalis</i> )	11-93	Cabbage leaf webber ( <i>Crocidolomia binotalis</i> )	28-51
<b>CHILLIES</b>		Cabbage borer ( <i>Hellula undalis</i> )	30-58
Thrips ( <i>Scirothrips dorsalis</i> )	12-90	<b>CUCURBITS</b>	
Mites ( <i>Polyphagotarsonemus latus</i> )	34	Fruitfly ( <i>Bactrocera cucurbitae</i> )	
<b>OKRA</b>		Bitter gourd	60-80
Fruit borer ( <i>H. armigera</i> )	22	Cucumber	20-39
Leafhopper ( <i>Amrasca biguttula biguttula</i> )	54-66	Ivy gourds	63
Whitefly ( <i>Bemisia tabaci</i> )	54	Muskmelon	76-100
Shoot and fruit borer ( <i>Earias vittella</i> )	23-54	Snake gourd	63
		Sponge gourd	50

**Average loss : 40%**

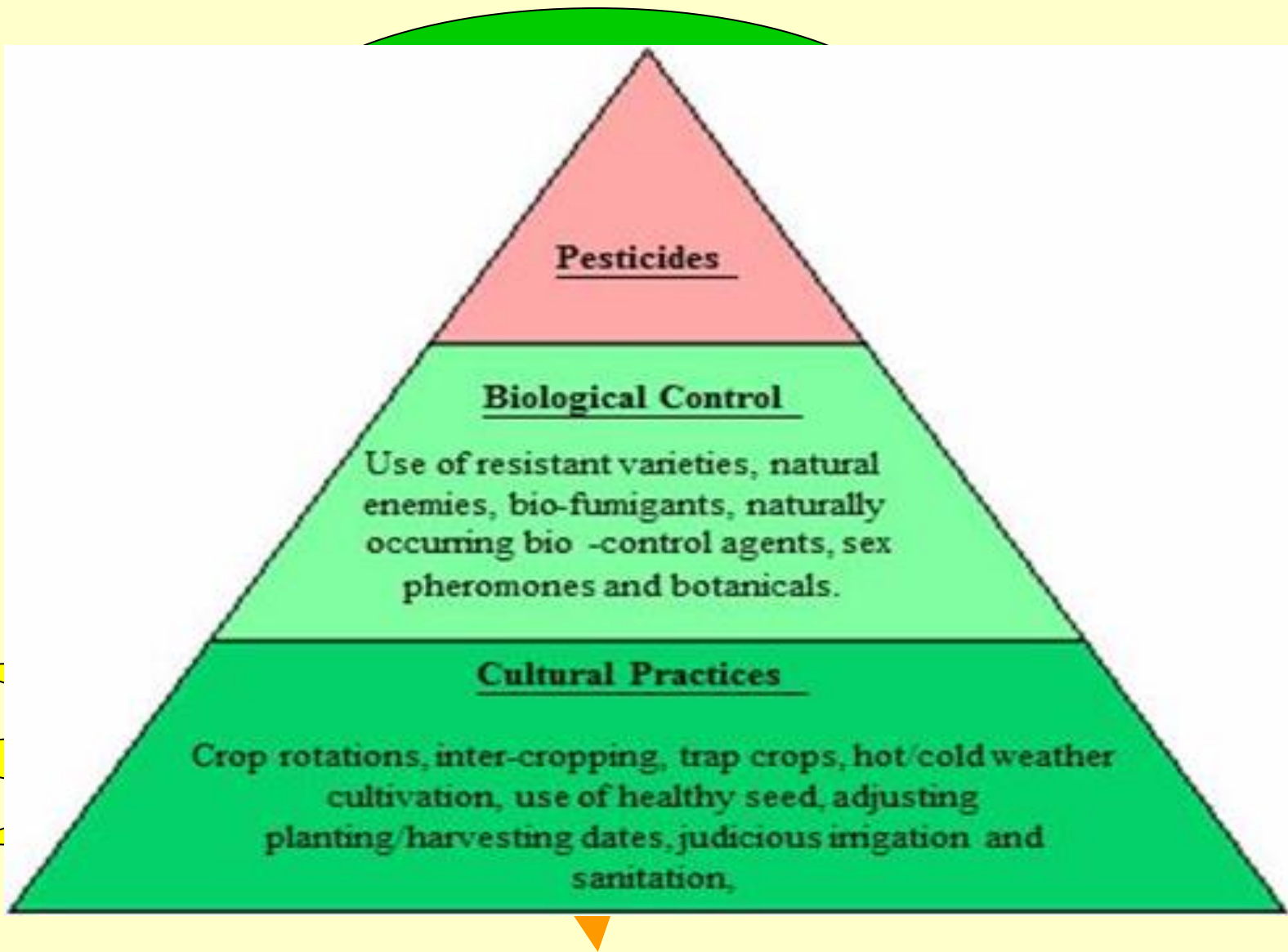
**Shivalingaswamy et al., 2002**





# Expanding Host Horizon of pests in vegetable crops

Insect Pest	Old Host crops	New Host	References
*Serpentine leaf miner ( <i>Liriomyza trifolii</i> )	Tomato	Brinjal, Cow pea, French bean, Squash, Leafy vegetables, cucurbits,	Durairaj et al., 2007
Spiralling whiteflies ( <i>Aleurodicus macfarlanei</i> )	Guava, Citrus	Bhendi	Puri et al., 2001
*Mealy bug ( <i>C. insolita</i> , <i>P. solanpisis</i> )	Cotton, Jute	Brinjal, Tomato, chilli, okra and Pointed gourd	Chaudhary, 2006
Hadda beetle ( <i>H. vigintioctopuntata</i> )	Brinjal	Bitter gourd, Cowpea	Rajapaske et al., 2005
Fruit borer ( <i>H. armigera</i> )	Gram, Cotton, Tomato, Cabbage	Peas, Chilli, Brinjal, Okra	Puri et al., 2001
Cabbage butterfly ( <i>Pieris brassicae</i> )	Cabbage, cauliflower & Mustard	Knol Khol, Radish	Puri et al., 2001
*Gall midge	Brinjal	Chilli, Brinjal and Capsicum	David, 2006
*Head borer ( <i>H. undalis</i> )		Cabbage	Sivaprasagam, 1997
*Stem fly ( <i>O. phaseoli</i> )		Okra	Patil & Jamadgni, 2008
Red spider mite ( <i>Tetranychus</i> sp.)		Okra, brinjal, cowpea, Indian bean	Mahto & Yadav., 2009
Leafhopper ( <i>Empoasca motti</i> )		Bitter gourd	



IPM approaches for pest management in vegetables

**IPM**



## Tolerant varieties of some vegetable crops

<b>Crop</b>	<b>Pest</b>	<b>Varieties</b>
Tomato	Fruit borer ( <i>H. armigera</i> )	Arka Vikash, Pusa Gaurav, Pusa Early Dwarf, Punjab Keshri, Punjab Chhuhara, Pant Bahar, Azad, Avinash -2, Hemsona, Krishna, Sartaj
Brinjal	Shoot and fruit borer ( <i>L. orbonalis</i> ), Aphid, jassid, thrips, whitefly	SM 17-4, PBr 129-5 Punjab Barsati, ARV 2-C, Pusa Purple Round, Punjab Neelam, Kalyanpur-2, Punjab Chamkila, Gote-2, PBR-91, GB-1, GB-6
Cabbage	Aphid ( <i>Brevicoryne brassicae</i> )	All season, Red Drum Head, Sure Head, Express Mail
Cauliflower	Stem borer ( <i>Hellula undalis</i> )	Early Patna, EMS-3, KW-5, KW-8, Kathmandu Local
Okra	Jassid ( <i>Amrasca biguttula</i> )	IC-7194, IC-13999 New Selection, Punjab Padmini
Onion	Thrips ( <i>Thrips tabaci</i> )	PBR-2, PBR-6, Arka Niketan, Pusa Ratnar, PBR-4, PBR-5, PBR-6
Round gourd, Pumpkin, Bitter gourd	Fruit fly ( <i>B. cucurbitae</i> )	Arka Tinda Arka Suryamukhi Hissar-II

# CROP HUSBANDARY (Cultural Control Methods)

- Crop rotation
- Trap crops
- Tillage
- Altered timings
- Clean cultures
- Pruning & thinning
- Crop refuse and destruction
- Soil manuring and fertilization



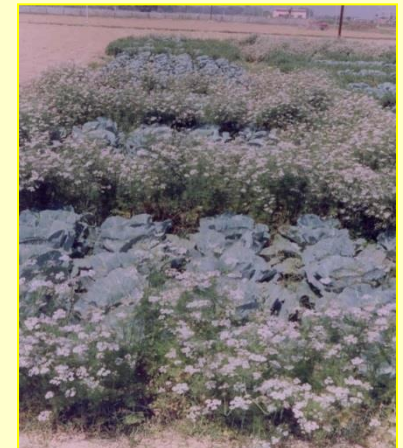
Marigold as trap crop/border crop



Shoot clipping



Chinese cabbage as trap crop



Coriander as Border crop



# Combination of different intercropping effective in vegetable pest management

<b>Crop combination</b>	<b>Target pest</b>
Cabbage + Carrot	Diamondback moth
Broccoli + Faba bean	Flea beetle
Cabbage + French bean	Root fly
Cabbage + Tomato/Mustard	Diamondback moth
Brinjal + Coriander/ Fennel	Shoot and Fruit borer
Bitter gourd + Maize	Fruit fly



*Inter cropping*



# Biocontrol agents recommended in vegetable crops

Satpathy *et al.*, 2006

Bioagent	Dose	Target pest
<i>Trichogramma brassiliensis</i>	2,50,000 parasitized eggs/ha (Inundative release) 50,000 parasitized eggs/ha (Weekly inoculative release)	Okra shoot and fruit borer Tomato fruit borer
<i>Chrysoperla zastrowi arabica</i>	50,000 first instar larvae/ha (weekly release)	Okra aphid Cabbage aphid
HNPV	250 LE/ha (10 days interval)	Tomato fruit borer
SNPV	250 LE/ha (10 days interval)	<i>Spodoptera litura</i>
<i>Bacillus thuringiensis</i>	500 g ai/ha (10 days interval)	Diamondback moth Shoot and fruit borer of brinjal and okra, Tomato fruit borer

Kairomones	Effect	Natural enemies
Tricosane	Preconditioning and reinforcing agent	Chrysopid (Increased predation)
Alpha-Tryptophan	Ovipositional attractant <b>Singh (2001)</b>	Chrysopid, Trichogramma, Coccinellid (Increased oviposition)



## Plant products used for management of insect pests of vegetables

Species	Plant products	Mode of action	References
<i>Leucinodes orbonalis</i>	Oil (2%) of <i>Pongamia pinnata</i> , <i>Madhuca indica</i> and <i>A. indica</i>	Contact	Srinivasan <i>et al.</i> (1998)
	Neem Azal (0.03%), Neem oil (0.3%)	Antifeedant & contact	Peter & Govindaraju (1994)
<i>Epilachna vigintioctopunctata</i>	Leaf extract (1%) of <i>Lantana camara</i>	Antifeedant	Mehta <i>et al.</i> (1995)
	Leaf extract (6%) of <i>Ageratum haustriarum</i> <i>Melia azedarach</i>	Contact	Thakur & Mehta (2004)
Whitefly	Neemal® (0.5%), Repelin® (Neem based formulation)	Mortality	Somashekhara <i>et al.</i> (1997)
<i>Pieris brassicae</i>	Achook, Neem oil and Nimbicidene	IGR , Antifeedancy	Dhingra <i>et al.</i> (2005)
<i>Helicoverpa armigera</i>	Methanolic of <i>Vinca rosea</i> and <i>Callistemon lanceolatus</i>	IGR, Antifeedancy	Halder <i>et al.</i> (2009)
<i>Spodoptera litura</i>	Leaf extract of <i>Persea americana</i>	Antifeedant & Contact	Wheeler & Islam (2001)
<i>Earias vittella</i>	NSKE (5%)	Contact and ovicidal	Sarode & Gabhane (1998) Sojitra & Patel (1992)
complex of okra	NSKE (5%), Multineem (2.5 lit/ha)	Contact	Misra (2002) Satpathy (2004)
complex of crucifers	Nimbecidine (7.5 ml/lit)	Contact	Ojha & Singh (2003)
complex of tomato	NSKE/Melia seed extract (5%)	Contact	Senguttuvan <i>et al.</i> (2005)
complex of eggplant	Nimbecidine/ Neemgold/ Neem Azal (0.1%)	Contact	Srinivasan & Sundarababu (2000)



## Important Considerations in Chemical Control

Pest	ETL
DBM of cabbage ( <i>P. xylostella</i> )	10 larvae/ plant at seedling stage
Cauliflower aphids	30 aphids/plant
Chilli mites( <i>P. latus</i> )	Single mite/ leaf
Chilli thrips ( <i>S. dorsalis</i> )	2 thrips/ leaf
Whitefly ( <i>B.tabaci</i> ) in brinjal	5-10 flies/leaf
BSFB ( <i>L.orbonalis</i> )	0.5% shoot and 5% fruit damage, 8-10 moths/ day/ trap
Tomato Fruit borer ( <i>H. armigera</i> )	1 larva/ plant or 2% fruit damage
Okra fruit borer ( <i>E. vittella</i> )	5.3 % of fruit infestation
Leafhopper ( <i>A. biguttula biguttula</i> )	4-5 nymphs/ plant
Pea aphids ( <i>Acyrtosiphon pisum</i> )	3-4 aphids/stem tip





## Safer insecticides to natural enemies of vegetable pests

Crop / Pest	Natural Enemy	Insecticide
<b>BEANS</b>		
Mite	<i>A. tetranychivorus</i>	Sulphur
<b>CABBAGE</b>		
Tobacco caterpillar	<i>Telenomus remus</i>	NSKE, Phosalone
Diamondback moth	<i>Cotesia plutellae</i>	Phosalone, Permethrin, Deltamethrin, NSKE, Fenvalerate, Cypermethrin, Fluvalinate
<b>OKRA</b>		
Mites	<i>A. tetranychivorus</i>	Sulphur
<b>TOMATO</b>		
Fruit borer	<i>Campoletis chloridiae</i>	Acephate, Phosalone
	<i>T. brassiliensis</i>	Fenvalerate
<b>BRINJAL</b>		
Epilachna beetle	<i>Pediobius foveolatus</i>	Endosulfan, Phosalone



## Waiting period (in days) of important insecticides used in vegetable crops

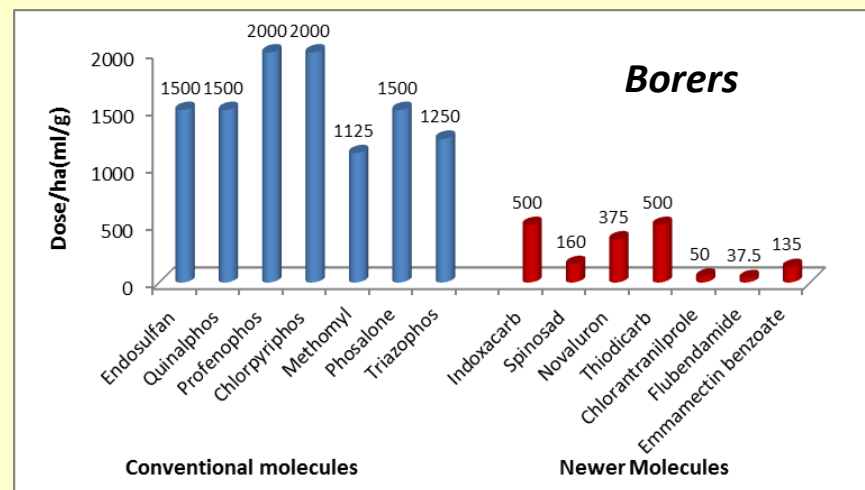
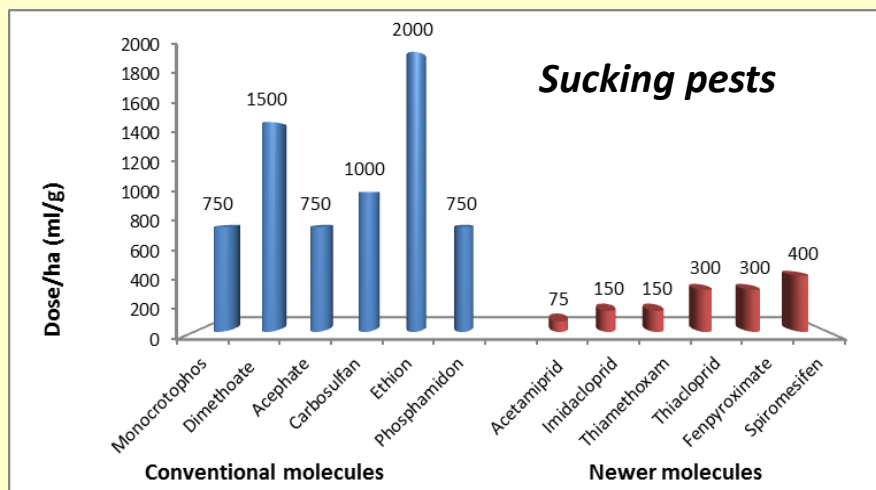
Pesticide	Okra	Cabbage	Brinjal	Cauliflower	Tomato	Pea
Malathion	3	7	1	7	-	3
Fenvalerate	5	10	5	3	3	-
Endosulfan	21	10	3	10	5	-
Cypermethrin	3	7	3	-	1	-
Phosphamidon	10	-	-	-	-	6
Carbaryl	-	-	25	25	30	-
Quinalphos	-	-	10	27	-	-
Dimethoate	-	10	-	7	-	-
Imidacloprid	3	-	-	-	-	-
Thiomethoxam	5	-	3	-	5	-
Indoxacarb	-	7	-	-	5	-
Spinosad	-	3	-	3	-	-
Emamectin benzoate	5	3	3	-	-	-
Lufenuron	-	14	-	5	-	-
Novaluron	-	5	-	-	1-3	-



# Novel insecticide molecules for pest management

## Rationale

- ❑ Currently several new insecticide groups have been discovered and commercialized for use in modern crop protection.
- ❑ Low risk to non-target organisms, high target specificity, their versatility in application, - greater role in IPM and IRM programmes.
- ❑ 10-15 times lower dose than conventional insecticides for sucking pests and 5-25 times lower dose for borer and leaf feeding insect pests.
- ❑ Screening for their efficacy and biosafety to natural enemies - important before incorporating in any IPM programmes.



➤ These new insecticide groups with unique mode of action have been registered from late 1990s to early 2009 for pest management in agriculture.



# Biorational insecticides for use in vegetables

	<b>Common name</b>	<b>Crop</b>	<b>Target pest</b>	<b>Dose/ha (g a.i.)</b>
1.	Imidacloprid 17.8% SL	Chilli	Jassid, aphid, thrips	25-20
		Okra	Jassid, aphid, thrips	20
2.	Thiamethoxam 25% WG	Okra	Jassid, aphid, whitefly	25
		Tomato	Whitefly	50
		Brinjal	Whitefly	50
3.	Thiacloprid 21.7% SC	Chilli	Thrips	54-72
4.	Fipronil 5% SC	Cabbage	DBM	40-50
		Chillies	Thrips, aphid, fruit borer	40-50
5.	Indoxacarb 14.5% SC	Cabbage	DBM	30-40
		Chilli	Fruit borer	50-60
		Tomato	Fruit borer	60-75
6.	Spinosad 2.5% SC	Cabbage/ cauliflower	DBM	15.0-17.5
7.	Spinosad 45% SC	Chillies	Fruit borer	73
8.	Chlorantranilprole 18.5% SC	Cabbage	DBM	10
		Okra	Fruit and shoot borer	9.5-11.0

**Contd. ....**

	<b>Common name</b>	<b>Crop</b>	<b>Target pest</b>	<b>Dose/ha (g a.i.)</b>
9.	Emmamectin benzoate	Cabbage	DBM	7.5-10.0
		Chilli	Fruit borer, thrips, mite	10
		Brinjal	Fruit and shoot borer	10
10.	Chlorfenapyre 10% SC	Chilli	Mite	75-100
11.	Spiromesifen 22.9% SC	Brinjal	Red spider mite	96
		Chilli	Yellow mite	96
12.	Diafenthurion 50% WP	Cabbage	DBM	300
		Chilli	Mite	300
		Brinjal	Whitefly	300
13.	Lufenuron 5.4% EC	Cabbage/ cauliflower	DBM	30
14.	Novaluron 10% EC	Cabbage	DBM	75
		Tomato	Fruit borer	75
		Chilli	Fruit borer, tobacco caterpillar	33.5
15.	Buprofezin 25% SC	Chillies	Yellow mite	75-100
16.	Flufenoxuron 10% DC	Cabbage	DBM	40

# Fruit fly of cucurbits

- ❑ Temperate : low dispersal, monophagous
- ❑ Tropical/Sub-tropical : Polyphagous
- ❑ Fruit fly : 320 species reported
- ❑ Exclusively from India : 200 species
- ❑ Damage : Mango, guava, ber, peach, cucurbits worth Rs. 30,000 million
- ❑ Major pests belong to Genus : *Bactrocera*
- ❑ Cucurbits : *B. cucurbitae*, *B. ciliatus*

Crop	Pest species	Yield loss (%)
Bitter gourd	<i>Bactrocera cucurbitae</i>	80
Snake gourd	<i>Bactrocera cucurbitae</i>	63
Sponge gourd	<i>Bactrocera cucurbitae</i>	50

Crop	Damage (%)	State
Bittergourd	50-60%	U.P.
Cucumber	29-39%	Assam
	70-80%	H.P.
Muskmelon	76%	Rajasthan
Snake gourd	63%	Assam
Sponge gourd	50%	A.P.





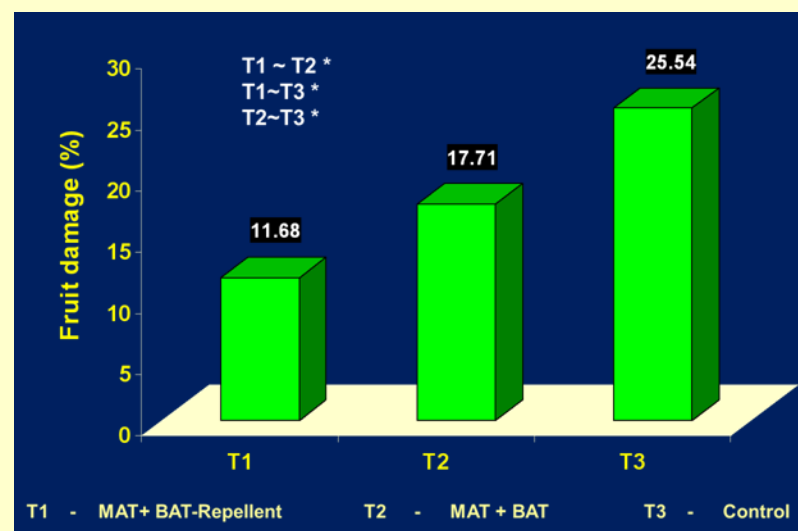
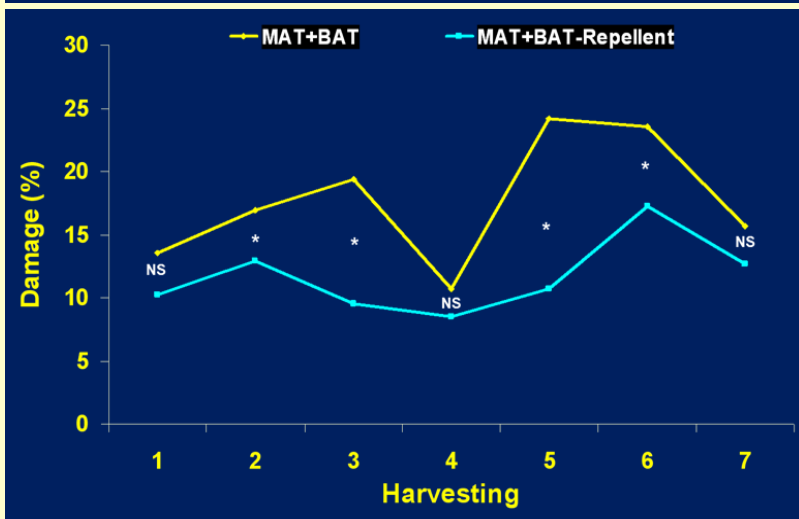
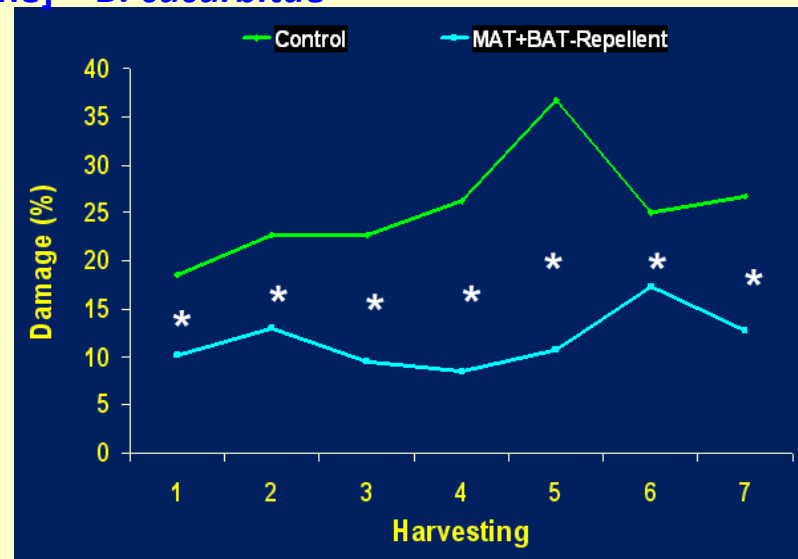
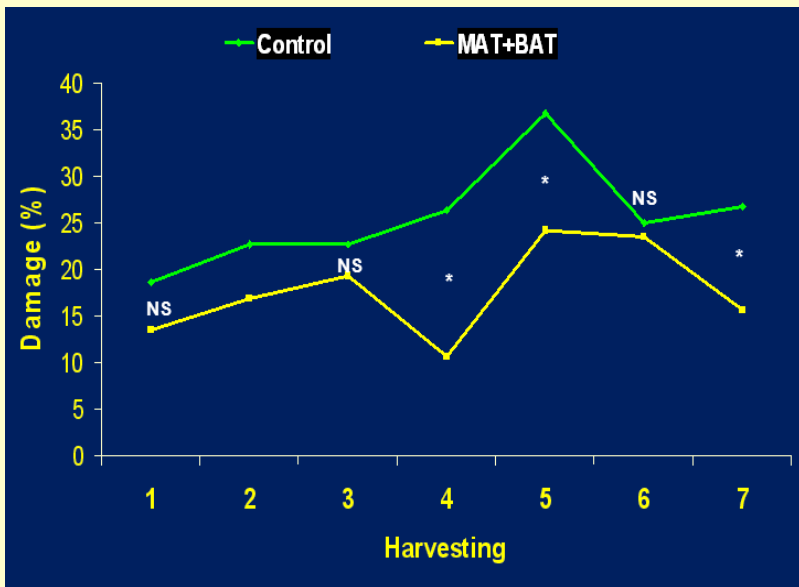
# Abundance of fruit fly adults in cue-lure baited bottle traps

Period		Adults/trap/week	Period		Adults/trap/week
January	I	5.00	July	I	29.50
	II	4.00		II	9.00
February	I	16.50	August	I	18.50
	II	83.50		II	32.50
March	I	182.50	September	I	60.00
	II	191.50		II	225.50
April	I	228.50	October	I	348.50
	II	282.50		II	575.66
May	I	82.00	November	I	491.00
	II	102.00		II	312.00
June	I	85.50	December	I	92.50
	II	21.00		II	13.00



# Effect of MAT and bait-repellent spray on periodical fruit damage (%) in bitter gourd

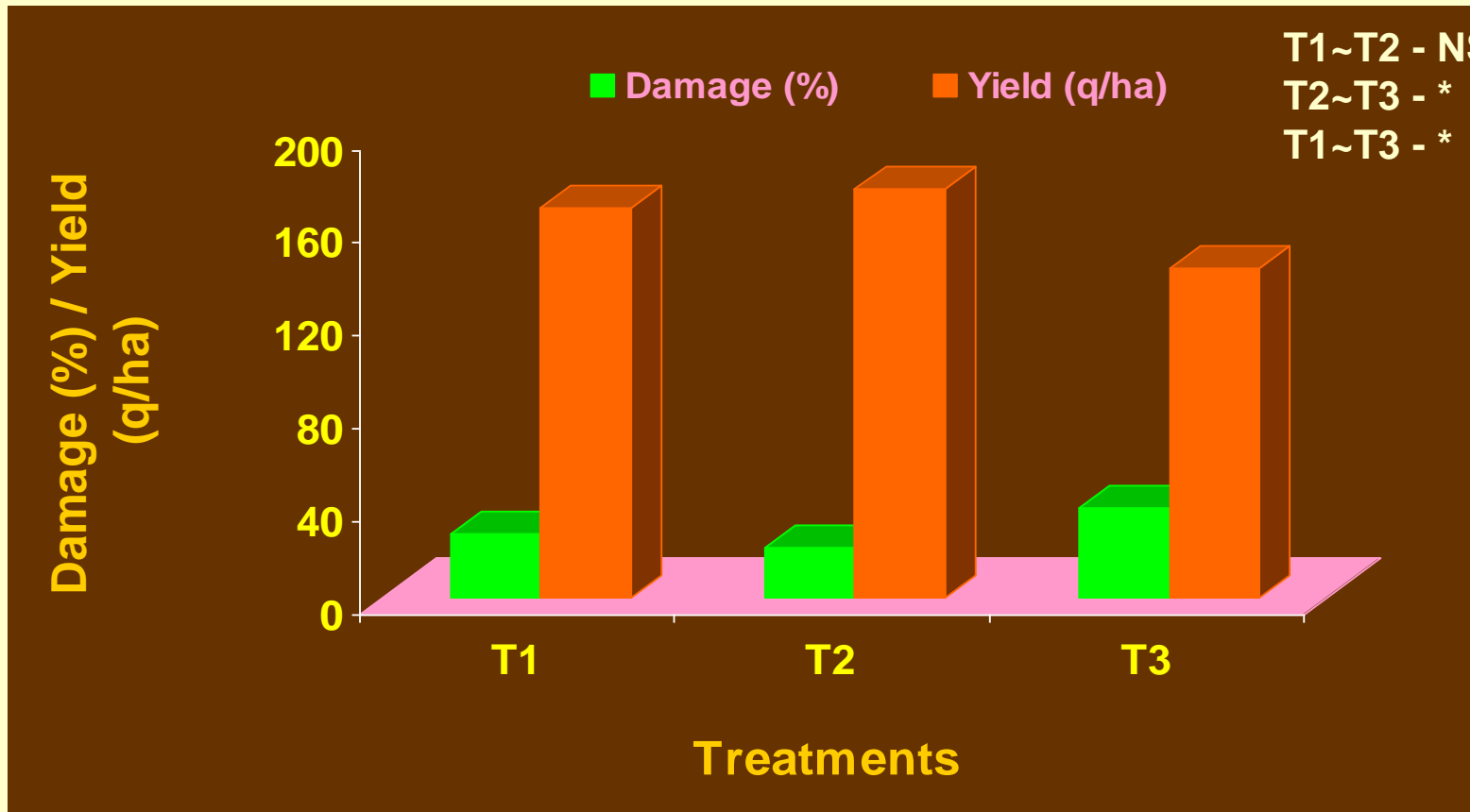
Cuelure: [4 P-acetoxyphenyl) - 2 butanone] – *B. cucurbitae*







# Fruit damage and yield in MAT and bait-repellent treated bitter gourd



T1 - MAT

T2 - MAT + bait-repellent

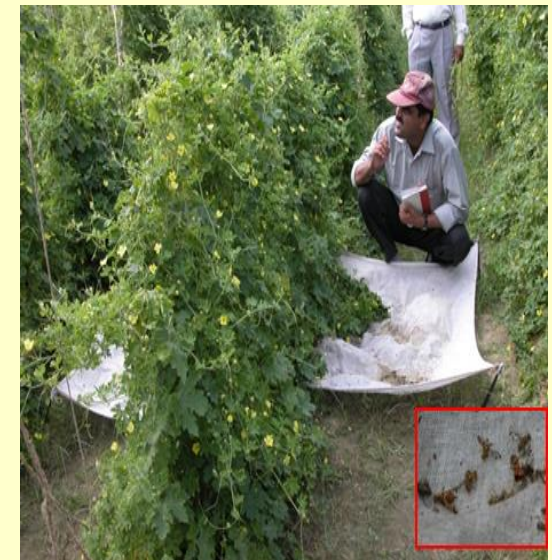
T3 - Control

## IPM technology for Fruit fly management in Cucurbits

- ❑ Installation of used water bottle baited with cue lure (as MAT) saturated wood blocks (ethanol: cuelure: carbaryl in a ratio 8:1:2) @ 25 traps/ha prior to flower initiation.
- ❑ Bait spray containing malathion 20 ml + 20 litres water + 500g molasses sprayed randomly on 250 plants/ha.
- ❑ Use of repellent (NSKE 4%) enhanced trapping and luring in bait spots. Mean fruit fly catches much higher in traps installed with MAT+BAT-Repellent plots (116.43/trap/week) compared to that of (75.82/trap/week) in MAT+BAT treated plot
- ❑ Application of neem as a repellent increased the catch in parapheromone traps and enhanced the luring ability of parapheromone by 52%..
- ❑ **Fine tuning of this module** with addition of NSKE spray and increased diameter of bottle trap (9cm) along with use of dichlorovos 1% increased the adult trapping/killing in lure

### Impact:

- ❑ This technology helps to suppress further population build-up of insect with almost no probability of insecticide residue in and or/on the fruits.
- ❑ This technology decreases fruit damage by 71.1% in cucurbits. Overall cost of pesticide application is decreased more than 10 times.
- ❑ Benefit is in terms of pesticide free cucurbits, safety to human health and improving quality of environment.



# Brinjal Shoot and Fruit Borer (*Leucinodes orbonalis*)

Entry hole in the shoot



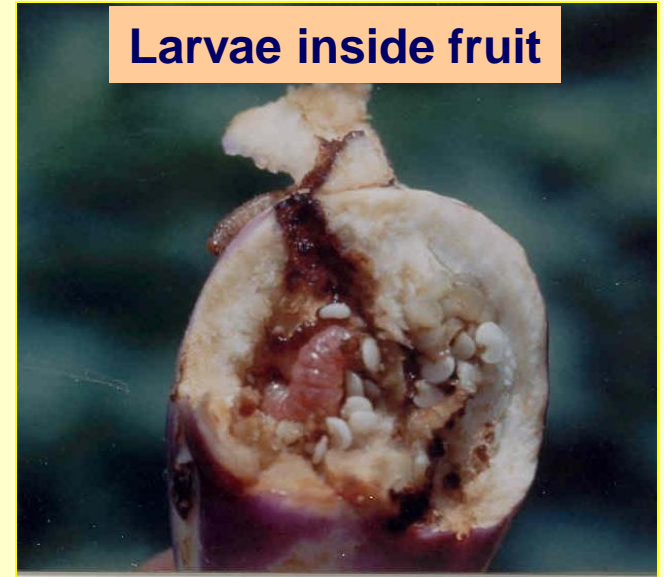
Larvae inside shoot



Emergence hole

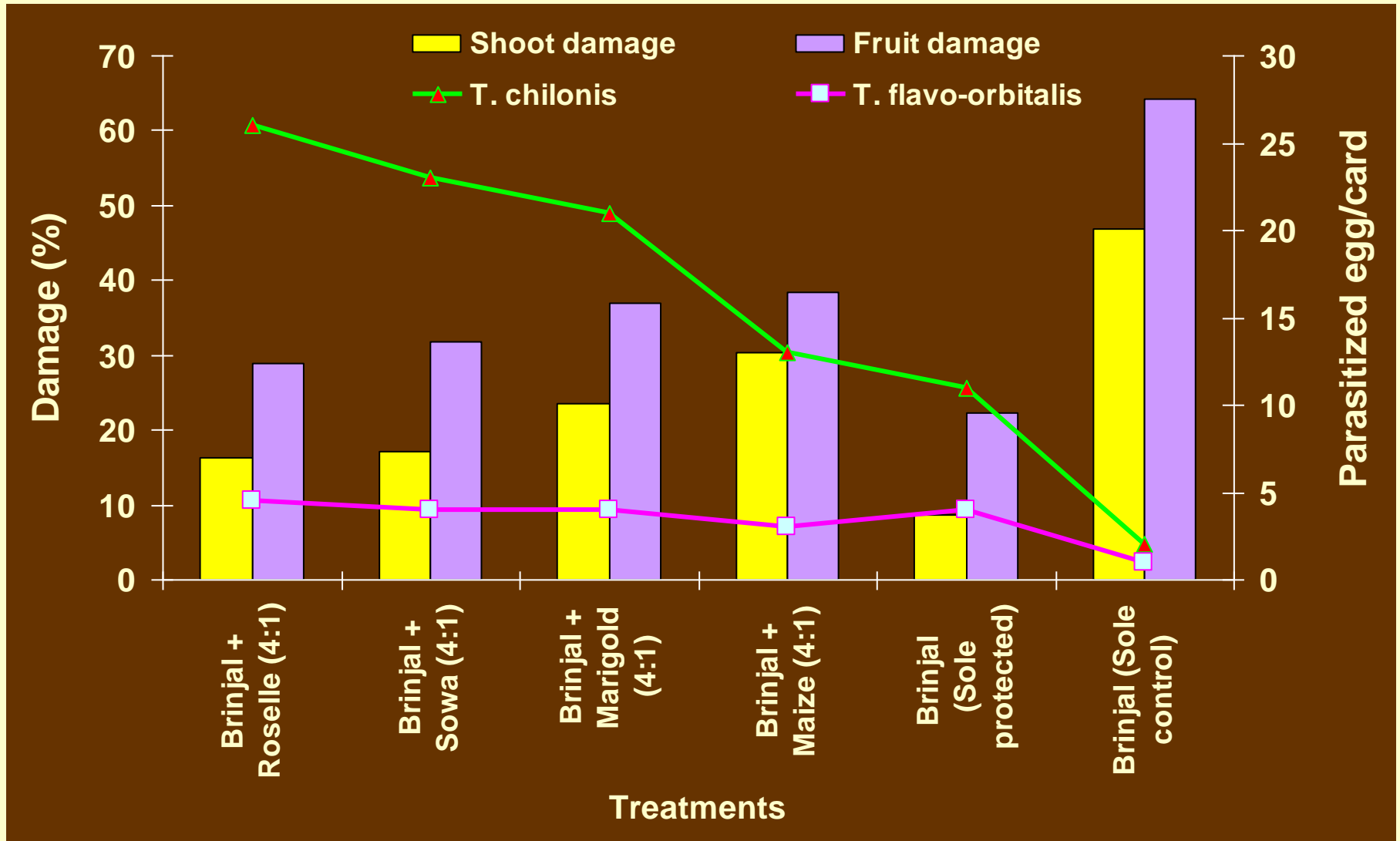


Larvae inside fruit



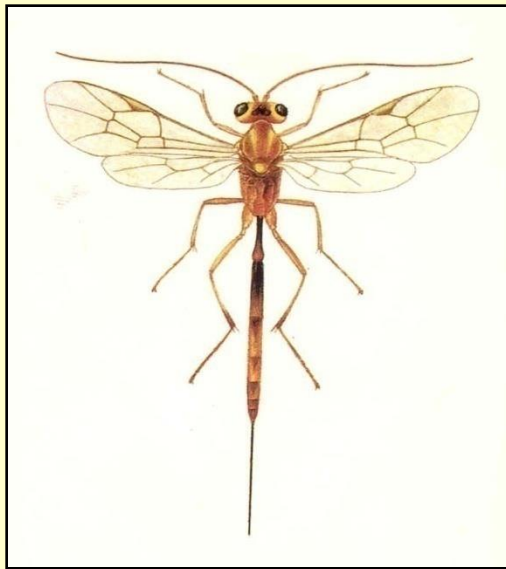


# Abundance of natural enemies in brinjal-intercrop ecosystem (Rabi 2004, 2005)



## Natural enemies of BSFB

- ❑ *Trathala flavo-orbitalis* : Larval parasitoid Active period-kharif (17%), Bangladesh and Srilanka- >40%
- ❑ *Bracon spp.*
- ❑ *Goryphus nursei*: Pupal parasite



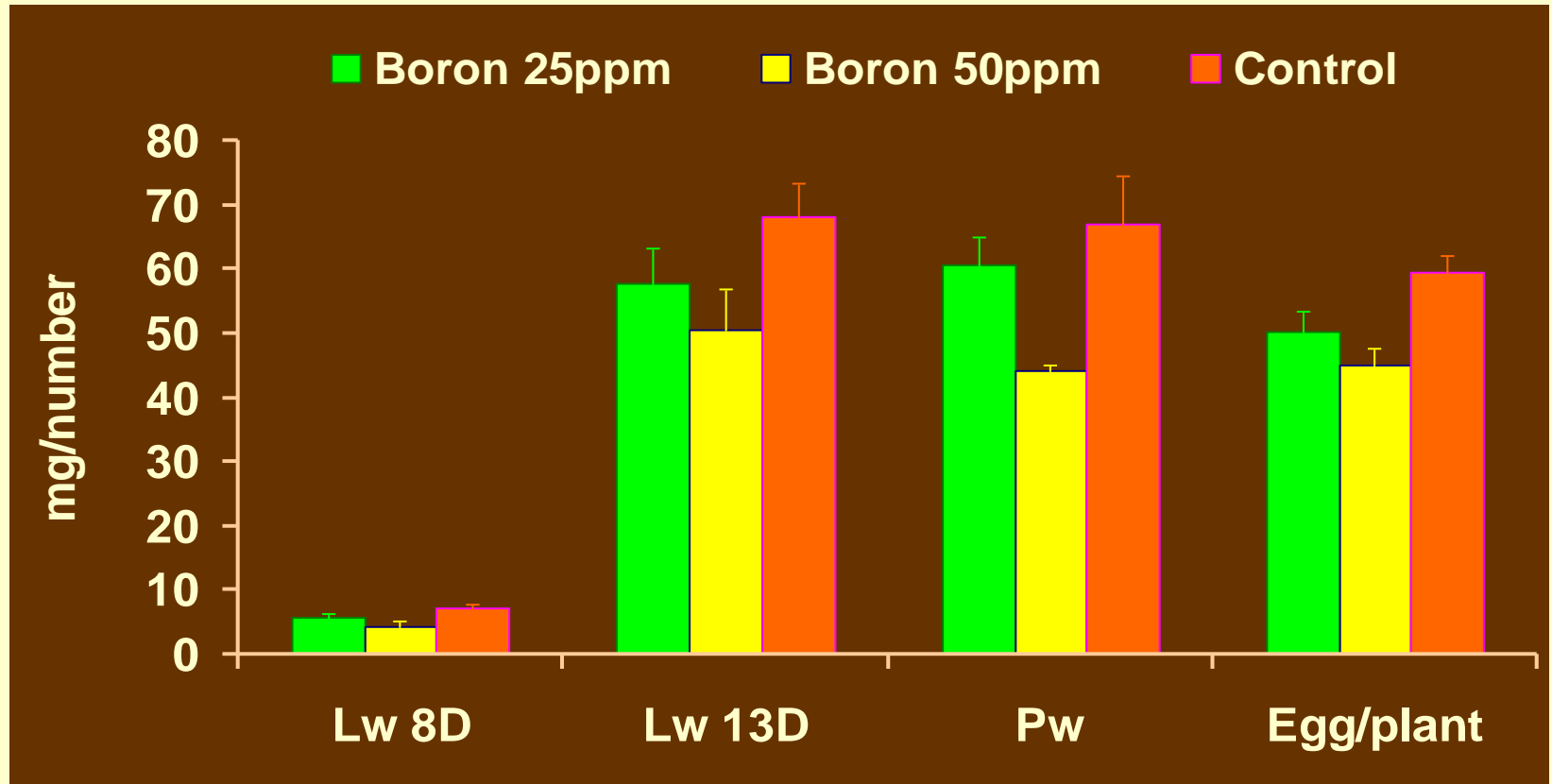
*Trathala flavo-orbitalis*



*Goryphus nursei*



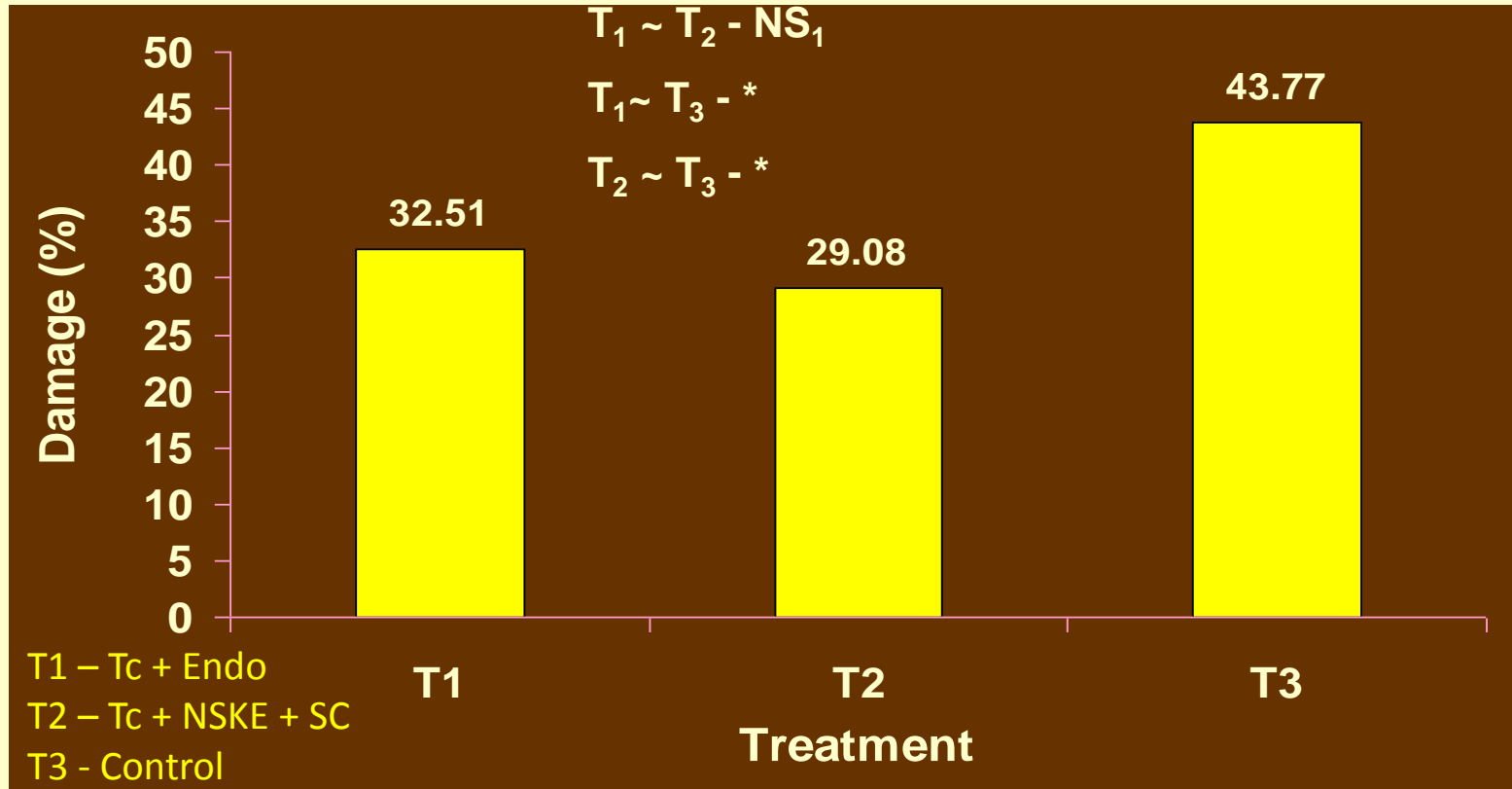
## Effect of Boron on biology and egg laying behaviour of BSFB



- ❑ Lowest eggs (44.99 eggs/plant) on plants treated with 50 ppm
- ❑ Less weight of larvae (50.68 mg) pupae (44.32 mg) when fed on 50 ppm boron treated fruits
- ❑ Borer infestation less (23.36%) in plot treated with 75 ppm and 50 ppm (25.11%) as against 31.17% in control.
- ❑ Less fruit infestation (23.27%) in Punjab Barsati compared to Punjab Sadabahar (29.62%).



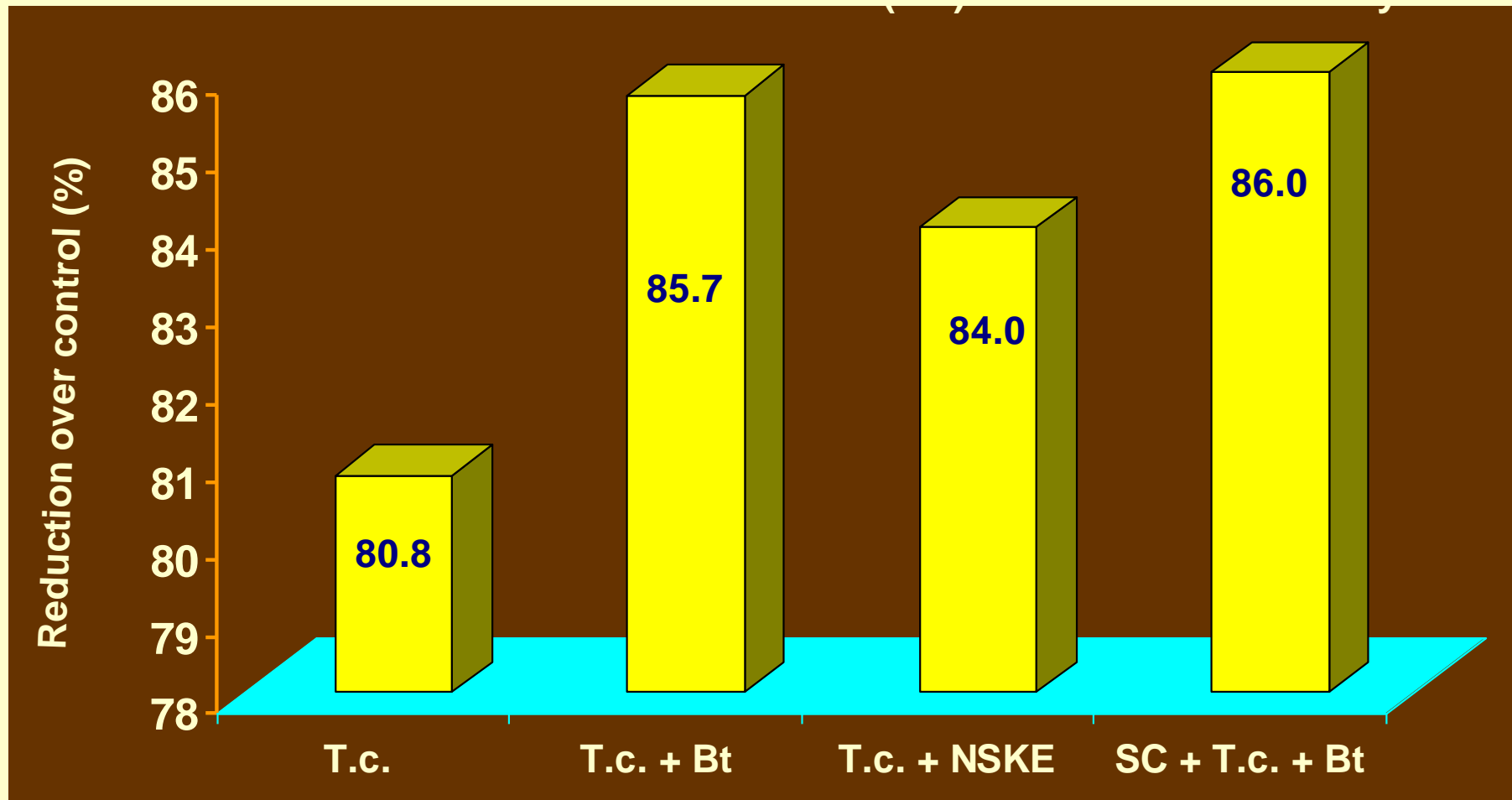
## Effect of *Trichogramma* release on cumulative damage caused by BSFB



- ❑ Inundative release of *T. chilonis* @ 2.5 lakh/ha in conjugation with botanicals and insecticide for management of BSFB.
- ❑ At 90 DAT prominent effect of both treatments in reducing fruit damage



## Effect of *T. chilonis* on BSFB management



Mean damage in control = 52.4%





# IPM technology for Shoot & Fruit Borer management in brinjal

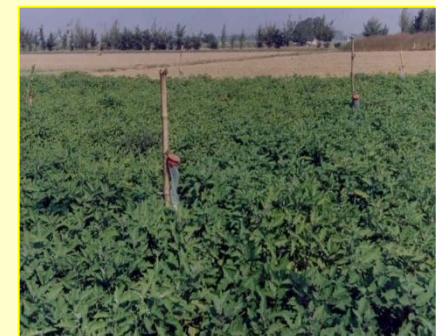
- ❑ Installation of plastic funnel traps 100/ha baited with sex pheromone lures from 15-20 days of planting traps at 10 m distance
- ❑ Clipping of damaged shoots and early infested fruits at weekly interval
- ❑ Need based foliar spray of NSKE (4%)
- ❑ Reduced infestation up to 60- 65%
  
- ❑ **Fine tuning of this module** with addition of seedling root dip in Rynaxypyr 0.5 ml/l for 3 hours
- ❑ Extending period of pheromone trap's installation to 25-30 DAT
- ❑ Need based spray -  $\infty$ - cyhalothrin or cypermethrin at flowering and fruiting phase
- ❑ Improved the efficiency of module with 20-25% additional reduction in BSFB infestation.
- ❑ This technology reduced infestation by more than 85 % and increased yield by 40%. As a consequence of this technology, the total cost of the production is reduced by 30% and cost of pesticide application is decreased by 35.20%.



**Funnel trap**



**Clipping of infested Shoots**



**Trap installation in field**



# Low cost net house for management of BSFB

(Kumar et al. 2007-09 IIHR)

	% Fruit damage		Marketable Yield (Kg)
	No. basis	Wt. basis	
Net House	1.54	1.70	25,591
Open	44.77	46.04	9986

Raising plant inside net house, a barrier to infestation and spread of ESFB was a major success as damage was < 2% compared to a mean of 46 % damage outside net house

- Large fruited eggplant hybrid *Indam 19794*
- 326 seedlings planted at 75 x 50 cmspacing
- Straight-line depreciation was used to apportion total value of establishment items like stone pillars, net sheets and irrigation equipments, etc., depending on their life span.

Particulars	Net house (Rs)	Open field (Rs)	Change (%) (Rs)
Cost on net house structures (stones pillars, wires, etc)	11,90,030	-	-
Costs on irrigation structures and drip system	1,76,650	1,76,650	-
Mean annual cultivation expenses	56,678	44,178	28.29
Annuity values for items 1 and 2	37,698	3,553	-
Annualized cost of cultivation (item 3 + item 4)	94,376	47,731	97.72
Cost of Production	3.69	4.78	-22.85
Gross returns	2,55,910	99,860	156.27
Net returns	161,534	52,129	209.87
BC Ratio	2.71	2.09	-

**Low-cost net house cultivation significantly reduced ESFB infestation and damage through:**

- ❖ an increase in total fruit yield, mostly through bigger size rather than number.
- ❖ a reduction in leafhopper infestation and damage and no incidence of *little leaf*, a phytoplasma disease inside the net house. .

# IPM Interventions in Brinjal

## Main Field

### For Sucking Pests

- Installation of Delta traps and yellow sticky traps for white fly
- Three sprays of NSKE @ 5%
- Need based spray of imidacloprid 17.8 SL

Variable	IPM	FP
Number of chemical sprays	2.70	7.20
Cost of cultivation (Rs/ ha)	24340.36	25863
Yield (q/ ha)	454.14	390.62
Gross return (Rs/ ha)	90827.94	78124.0
Net return (Rs/ ha)	66487.56	52261
C:B ratio	1:3.69	1:3.02

### For *L. orbonalis*

- Pheromone traps installed @ 5/acre for monitoring of borer
- Clipping of borer damaged shoots
- 3- 4 releases of egg parasite, *T. chilonis* @1.0 lakh/ha
- Need based spray (ETL > 5%) of Emmamectin benzoate 5 SG @ 100 g/acre formulated
- Collection & destruction of borer affected fruits
- Soil application of Neem cake @ 250 kg/ha at 25 & 60 days along the plant rows against nematodes





## Diamondback Moth (*Plutella xylostella*)

- ❑ Sensitive to sub lethal dose of pesticides
- ❑ Quick development of resistance
- ❑ Critical period
- ❑ Importance of NE: *Cotesia plutellae*
- ❑ Occurrence in moderately high temperature condition
- ❑ Relative host preference





## Combination of different intercropping effective in DBM management

Crop combination	Effect	Reference
Cabbage + tomato (1:1)	Repellent	Talekar et al., 1986 Timbreilla and Nyako, 2001 Facknath et al., 1999
Cabbage + garlic (1:1)	Repellent	Talekar et al., 1986
Cabbage + clover (1:1)	Repellent	Talekar et al., 1986
Cabbage + coriander (1:1)	Repellent	Talekar et al., 1986 Facknath, 1996
Cabbage + marigold (1:1)	Repellent	Talekar et al., 1986
Cabbage + lucern	Repellent	Meena and Lal, 2002
Cabbage + onion	Repellent	Timbreilla and Nyako, 2001
Cabbage + spearmint	Repellent	Timbreilla and Nyako, 2001
Cabbage + mustard	Attractant	Srinivasan, 1991 Srinivasan and Krishnamoorthy, 1991
Cabbage + mustard	No effect	Umashankar et al., 2007 Meena and Lal, 2002



## Egg laying preference of diamondback moth on cruciferous in laboratory condition

Host plant	No. of egg/leaf	
	No choice	Multiple choice
Cabbage	12.33 <sup>c</sup>	4.67 <sup>b</sup>
Knol-khol	1.00 <sup>e</sup>	4.00 <sup>bc</sup>
Broccoli	3.33 <sup>d</sup>	1.67 <sup>d</sup>
Cauliflower	2.33 <sup>de</sup>	3.67 <sup>bcd</sup>
Chinese cabbage	23.00 <sup>b</sup>	9.00 <sup>a</sup>
Mustard	26.67 <sup>a</sup>	2.33 <sup>cd</sup>
C.D. at 5%	1.98	2.04

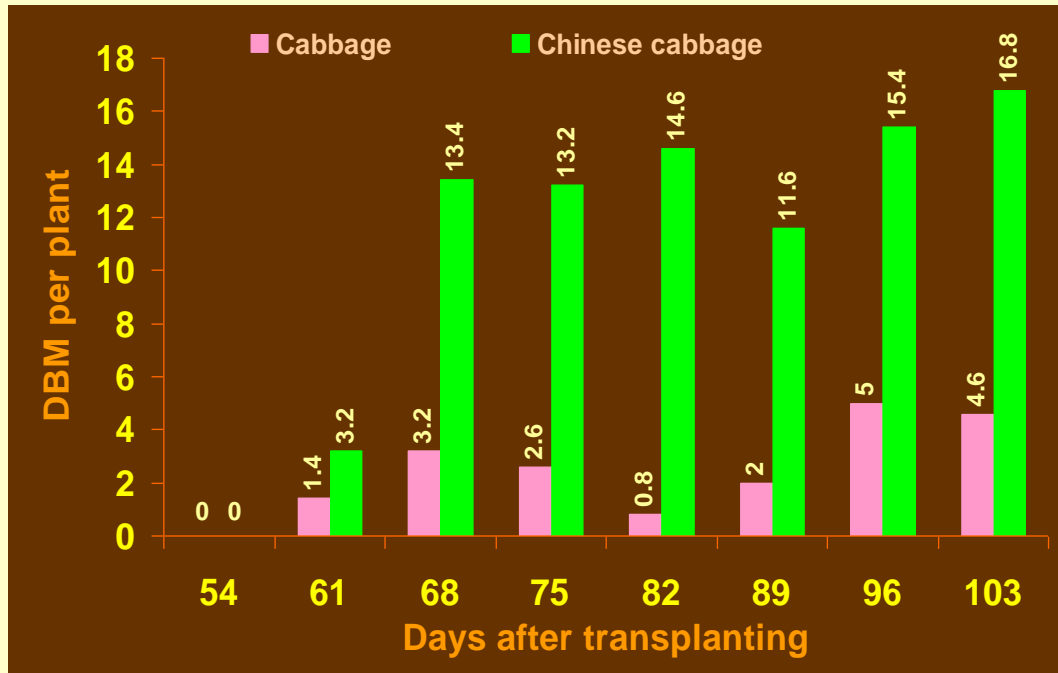
- ☆ In 'NO Choice Test' mustard harboured maximum eggs (26.67/leaf) followed by Chinese cabbage and cabbage
- ☆ In 'Multiple Choice Test' Chinese cabbage most preferred with maximum of 9.00 eggs/leaf

## Egg laying preference, larval and pupal population of DBM on cruciferous hosts (Net house)

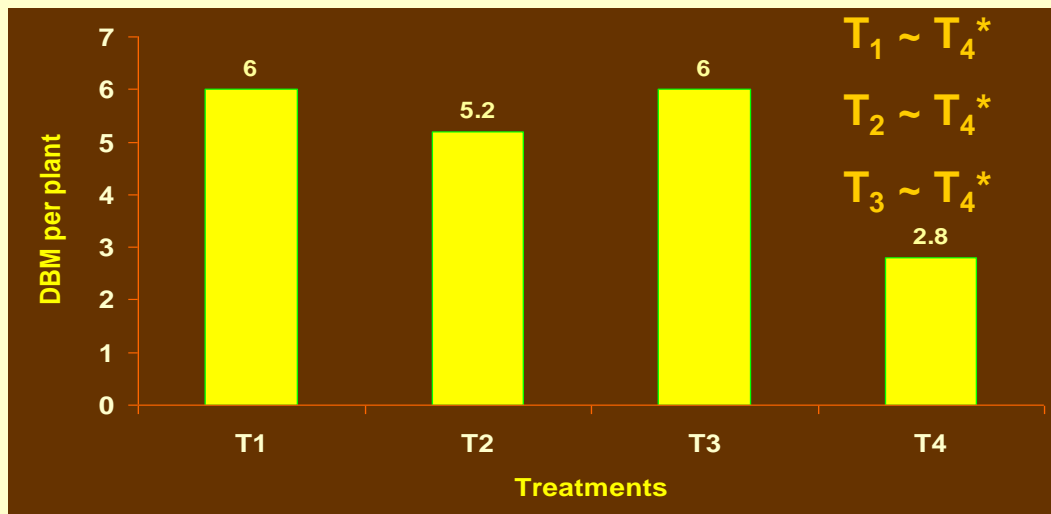
Host plants	No. of egg/plant (3 DAR)	Larvae/plant (14 DAR)	No. of pupae/plant
Cabbage	114.25 <sup>bc</sup>	18.50 <sup>bc</sup>	20.00 <sup>b</sup>
Knol-khol	68.75 <sup>cd</sup>	9.75 <sup>ce</sup>	10.75 <sup>c</sup>
Broccoli	24.75 <sup>d</sup>	19.25 <sup>bc</sup>	18.75 <sup>b</sup>
Cauliflower	98.5 <sup>b<sup>c</sup></sup>	12.25 <sup>ce</sup>	4.75 <sup>c</sup>
Chinese cabbage	374.00 <sup>a</sup>	52.75 <sup>a</sup>	45.25 <sup>a</sup>
Mustard	148.50 <sup>b</sup>	24.00 <sup>b</sup>	21.00 <sup>b</sup>
C.D. at 5%	61.04	10.32	7.30

- Greater preference of Chinese cabbage for egg laying (374 eggs/plant), larval (52.75/plant) and pupal (45.25/plant) population.

## Comparative population of DBM larvae in cabbage and Chinese cabbage



## DBM population in trap crop planted in different patterns



T1	-	Border
T2	-	Cris-Cross
T3	-	Two side – one middle
T4	-	One middle



## COLE CROPS

### For DBM management

- Growing paired mustard rows as trap crop with 25 cabbage rows (first row 15 days before, second 25 days later)
- Dichlorovos (0.1%) spray only in mustard to kill the trapped DBM larvae.
- Need based NSKE (5%) spray
- Such practices conserve *Cotesia plutellae*, a dominant natural enemy
- Fine tuning with using** Chinese cabbage (*Brassica rapa* subsp. *pekinensis*) as trap crop improved the attraction/trapping of DBM larvae 9 times more than mustard



Chinese cabbage as trap crop



Coriander as Border crop

### For *Spodoptera* management

- In early cauliflower and cabbage,
- Hand removal and destruction of egg masses
- Three foliar spray of SINPV @ 300 LE/ha at 10 days interval.

### For Aphid management

- Coriander as border crop
- Spray of entomopathogenic fungal (*Verticillium lecani*) formulation 500g/ha at 10 days interval

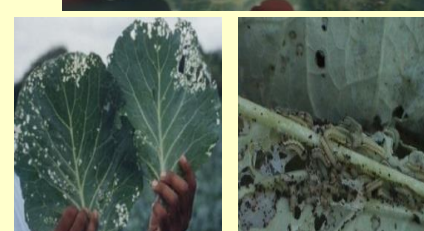




# IPM Interventions in Cabbage

NCIPM

- Raised seed bed
- Spray quinalphos or carbaryl in nursery for stem borer (*Hellula undalis*) in rainy season crop
- Mustard as trap crop for every 25 rows of cabbage.
- Spray mustard with dichlorovos 76EC@ 0.1%
- Use of light traps @ 3/acre for adults of DBM. Spray of *Bt* (1g/litre) if DBM 1.0/plant or NSKE 5% (3 sprays) or novaluron 10 EC @ 100 ml/acre (18-25 DAP) or spinosad 45 SC
- Collection and destruction of egg masses
- Installation of pheromone traps @ 10/ha for mass trapping
- Light traps are also effective
- Spray *S/NPV* 250LE (2 x 10<sup>9</sup>) in the evening for early instars
- Collect & destroy egg masses of *P. brassicae*; spray any contact insecticide like quinalphos



	<u>IPM Plot</u>	<u>Non-IPM</u>
Number of Sprays	6	16
Yield (T/ha)	62.13	58.31
Gross Return (Rs/ha)	1,07,348	1,06,857
Cost of cultivation (Rs/ha)	21155	44390
Net Return (Rs/ha)	82222	62,866
Cost Benefit ratio	1:5.07	1:2.40

## Tomato Fruit Borer (*H. armigera*)

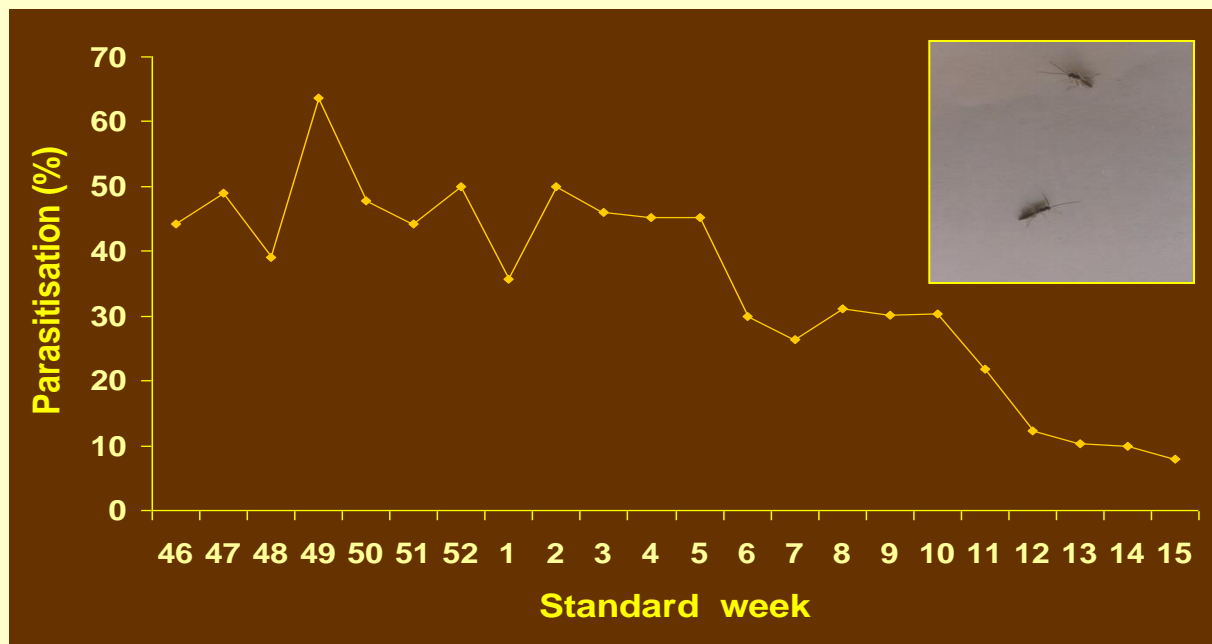
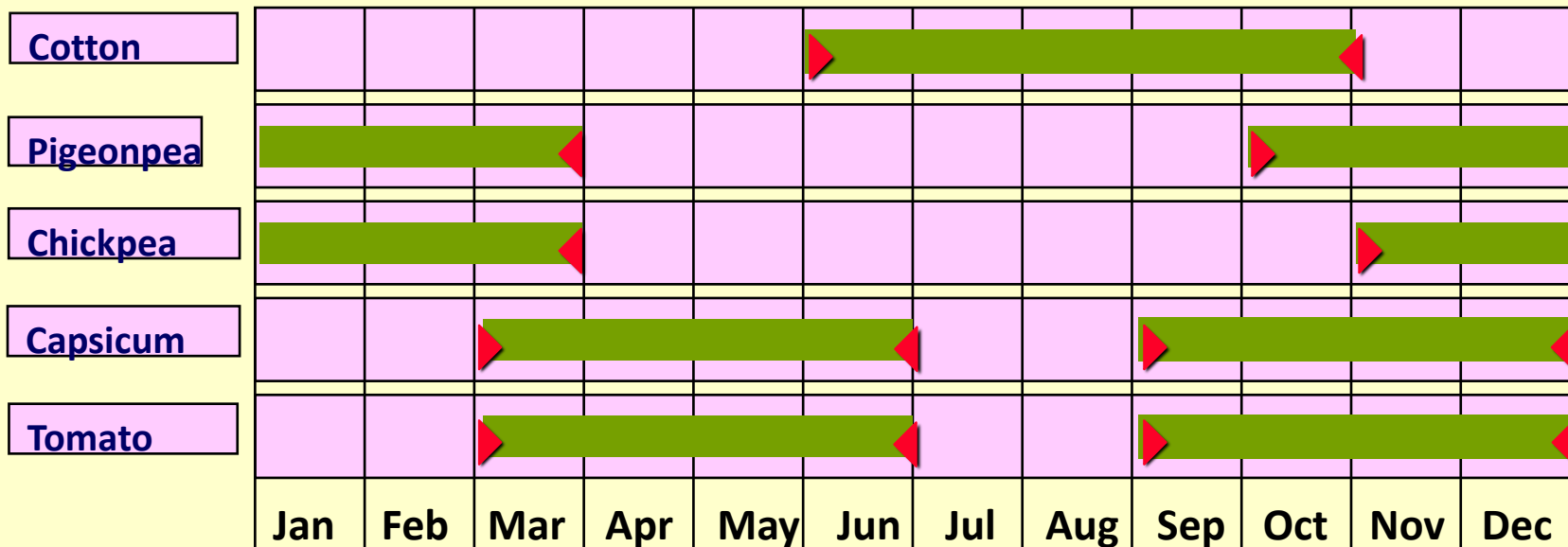
- Polyphagous nature
- Influence of alternate hosts
- Fruit development stage
- Irregular in occurrence - monitoring
- Natural enemies



State	Damage (%)
Karnataka	56 %
Punjab	65 %
Tamil Nadu	50 %
Uttar Pradesh	36 %
Himachal Pradesh	24 %



## Helicoverpa occurrence in multi-crop environment



Parasitisation by *Campoletis chlorideae* to tomato Fruit Borer under natural condition



## Use of NPV

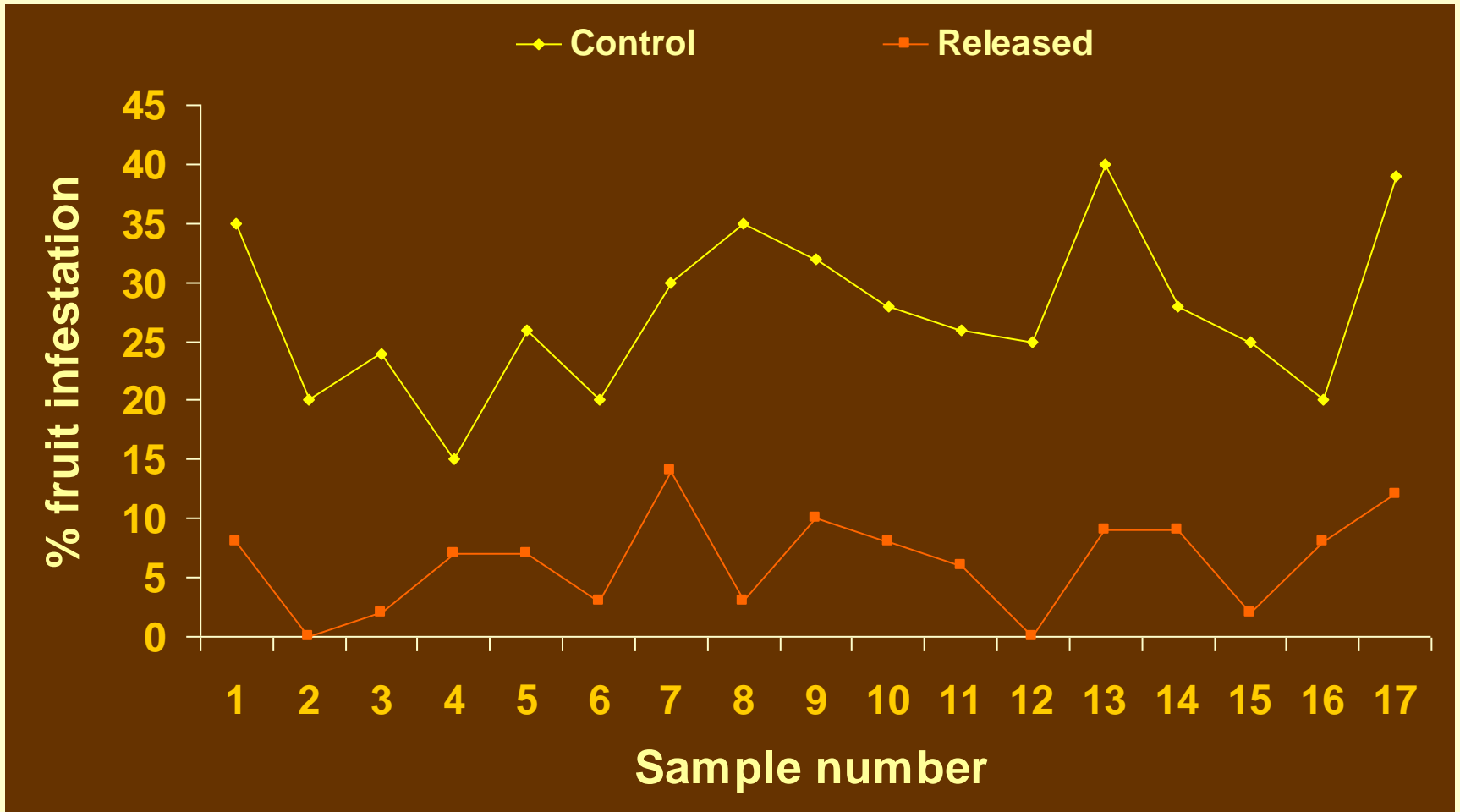
Application Rate	Spray Round	Application Time	Spray Interval
300 LE/ha	4	Flowering initiation	8 days
250 LE along with NSKE 4% & ½ dose Endosulfan	3	45 DAT	10 days
300 LE	2	After flowering	15 days
500 - 700 LE	3	50% flowering	10 days

## Augmentation of NE

Natural enemies	Release rate	Impact
<i>T. chilonis</i> (egg parasitoid)	2,50,000/ha weekly	Significant reduction in fruit damage
<i>T. brasiliensis</i> (egg parasitoid)	2,50,000/ha	51.3 % parasitization of eggs
<i>T. pretiosum</i> (egg parasitoid)	2,50,000/ha	6.45% less infestation over control
<i>T. pretiosum</i> (egg parasitoid)	5,00,000/ha	7.92% less infestation over control
<i>T. pretiosum</i> (egg parasitoid)	50,000/ha	55.90 % reduction in larval population



# Effect of *T. brasiliensis* on Tomato Fruit Borer Damage





# TOMATO

## For fruit borer management

- ❑ Two rows of marigold as trap crop
- ❑ Fourteen rows of tomato
- ❑ Two releases of *T. brassiliensis* @ 50,000 parasitized eggs/ha based on pheromone based monitoring
  - ❖ first coinciding with flowering initiation and second 10 days later
  - ❖ spray of *HaNPV* @ 350 LE /ha twice
  - ❖ Inundative release of *T. brassiliensis* @ 2,50,000 eggs/ha alone beginning with fruiting could reduce 16% fruit infestation



**Tomato with marigold**



**Marigold flowers with fruit borer**

# IPM INTERVENTIONS IN TOMATO

NCIPM

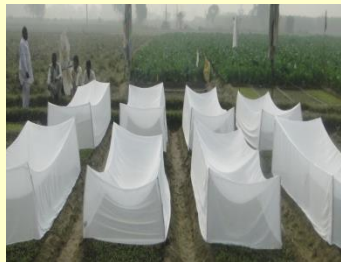
## Nursery

- Covering nursery with nylon net for white fly

## Main field

- ❑ Transplant marigold as trap crop (1 row /14 rows of tomato) 15 days older than tomato seedlings
- ❑ Spray imidacloprid 17.5 SL/ @ 0.4 ml/l for whitefly/ aphids
- ❑ Pheromone traps @ 5/ha for monitoring of *H. armigera* eggs at flowering
- ❑ Spray of *HaNPV* 250 LE/ha
- ❑ Regular collection & destruction of borer damaged fruits
- ❑ Need based spray of pesticides like rynaxypyr

Parameter	IPM	FP
Number of sprays	5.3	9.7
Cost of sprays (Rs/ ha)	6012.5	9173.0
Cost of cultivation (Rs/ha) including pl. prot.	86482.5	88496.5
Mean yield (Q/ha)	369.1	330.2
Gross return (Rs/ha)*	3,16,500	283143
Net return (Rs/ha)	230017.5	194646.5
C:B ratio	1:3.65	1:3.19



Muslin net coverage



Staking



Pheromone trap



Marigold trap crop



*HaNPV*

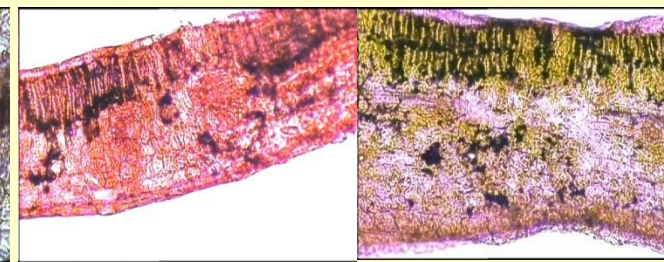
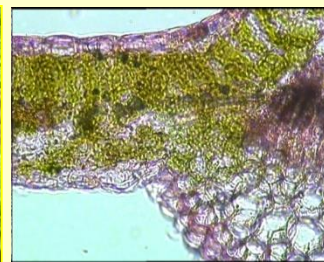
## IPM Interventions for Chilli



- Spray neem product @ 5% or spinosad 45 SC @ 75 g a.i. / ha against thrips. Need based application of fipronil or acephate be given if population of thrips is still high.
- Application of biopesticide abamectin @ 5% for mites management.
- If both thrips & mites are seen together, spray of difenthiuron or fenpropathrin 30 EC @ 0.5 ml/litre is very useful.
- Erect pheromone traps @ 5/ ha for *H. armigera* for monitoring of adults moths
- 1-2 sprays of *HaNPV* /*SINPV* 250 LE/ha in initial stages or spray rynaxypyr 20 SC as and when needed.
- Spray of dimethoate 30 EC for aphids

Parameter	IPM	FP
No. of sprays	11	25.0
Total cost of cultivation (Rs/ha)	26280	33150
Mean yield (q/ha)	15	10
Gross return (Rs/ha)	96900	64600
Net return (Rs/ha)	70620	31450
C:B ratio	1:3.68	1:1.94

❑ **Integrated module: seedling dip with Imidacloprid 1 ml/ l, spray of Buprofezin 1 ml/l/ 25 DAT, Fipronil 0.2 g/l 35 DAT, *V. lecanii* 5 g/l 45 DAT, Chlorfenapyr 1 ml/li 55 DAT, Neem oil 1% at 65 DAT. found most effective in reducing mite (75.48%) and thrips on was 59.44 in chilli (Kashi Anmol )**





# Okra Shoot and Fruit Borer (*Earias vittella*)

- ⇒ Shoot - *Earias*
- ⇒ Fruit – *Earias* + *Helicoverpa*
- ⇒ Seasonal status
- ⇒ Staphylinid on jassid

## Multiplication of predator (*P. variicornis*)

Prey item	No. consumed	Mean	% consumption
Corcyra eggs	26 - 70	46.13	43 - 100
Jassid nymphs	1 - 28	12.60	50.83 - 66.98





## IPM technology for the management for insect pests in okra

- ❖ Nursery Netting to protect from whitefly infection.
- ❖ ST with Imidacloprid/Thiomethoxam 3 g/kg seed control whitefly population upto 30 DAS and minimize YMV incidence
- ❖ ST with thiamethoxam/imidacloprid 3 g/kg + polymer 40 ml/kg seed improved chemical persistency upto 62 days for jassids management
- ❖ NSKE 4% with half recommended dose of propenofos showed synergistic action and found effective against fruit borer.

Treatments	Jassids/ plant					
	25 DAS	32 DAS	39 DAS	46 DAS	53 DAS	Mean
T3 – Thiamethoxam @ 3 g/kg + Polymer @ 40 ml/kg	0.00	0.23 <sup>cd</sup>	1.16 <sup>c</sup>	3.80 <sup>d</sup>	8.43 <sup>b</sup>	2.70 <sup>e</sup>
T7 – Thiamethoxam @ 3 g/kg	0.00	0.46 <sup>cd</sup>	2.40 <sup>c</sup>	4.26 <sup>d</sup>	9.93 <sup>b</sup>	3.35 <sup>cd</sup>
T9 – Polymer @ 40 ml/kg	0.86	1.13 <sup>a</sup>	10.03 <sup>a</sup>	11.06 <sup>a</sup>	14.56 <sup>a</sup>	7.53 <sup>a</sup>
T10 – Control	0.63	1.00 <sup>a</sup>	10.23 <sup>a</sup>	10.40 <sup>a</sup>	15.26 <sup>a</sup>	7.50 <sup>a</sup>
CD (0.05%)	0.13	0.30	1.29	2.02	2.43	0.74



# Pest management module

- ❑ **Target pests:** Jassids and shoot and fruit borer
- ❑ **Crop :** Okra (var. VRO- 6)
- ❑ **Season :** Kharif

Modules	Pre treatment	Av. popn/3 leaves	Fruit damage	PPOC*	Yield (q/ha)
Biointensive	6.79	4.19	13.77	51.96	180.0
Integrated	6.94	3.96	9.55	66.67	212.0
<b>Chemical</b>	<b>7.29</b>	<b>2.92</b>	13.13	54.19	220.3
Control	7.49	7.32	28.66		89.2
SEM±	0.10	0.16	1.63		0.83
CD(0.05)	NS	0.57	5.22		2.87

**Biointensive modules:** Pongamia oil 1% at 25 DAS, *V. lecanii* 4 g/lat 35 DAS, Bt 1ml/l at 45 DAS, NSKE 4%@5ml/l at 55 DAS and *B. bassiana* 2g/l at 65 DAS.

**Integrated module:** Installation of yellow sticky traps, Rynaxpyre 0.15ml/l at 25 DAS, NSKE 4%@5ml/l at 35 DAS , Emamectin benzoate 0.5ml/l at 45 DAS, Bt 1ml/l at 55 DAS and NSKE 4% 5ml/l at 65 DAS.

**Chemical module:** Thiamethoxam 0.5gm/l at 25 DAS, Indoxacrb 0.5ml/l at 35 DAS, Dimethoate 2ml/l at 45 DAS, Emmamectin benzoate 0.5g/l at 55 DAS and Cypermethrin 1ml/l at 65 DAS.

**Chemical module: effective against jassids**

**Integrated module: effective against shoot and fruit borer with higher yields.**



# Conclusion

- ❑ Many potential elements of pest management in vegetable crops and others have been studied and recommended but most are not sufficiently advanced to be of value to end users in practical sense under field conditions.
- ❑ Role of public-private partnership in production, distribution and quality control of different components of IPM such as resistant varieties, natural plant products, biopesticides and natural enemies is imperative, otherwise we will continue to talk of alternative methods of control for another many years.

## GREY AREAS

- ❑ No records on current pest situation and outbreaks for most of the regions/crops/pests
- ❑ Only the physical targets of the IPM component distribution and fund utilization generally achieved
- ❑ The generic IPM modules (>75) of DPPQ & S confusing: as most of them have not been field validated
- ❑ Weak pest monitoring system, almost nonexistent for various crops



Our motto is

Prosperity to farmers and  
health for all

**Thank You**

Sixteenth century Painting by Giuseppe Arcimboldo.  
A man assembled from food he eats.