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Government of INDIA recommended use of Endosulfan and available alternatives

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Preface

The following methods of non-pesticide management are derived from farmers' experiences and have been successfully implemented in Community Managed Sustainable Agriculture in Andra Pradesh, India practiced over 10 million ha by 10 million farmers.

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Introduction

Pests and pesticides contribute to the major economic and ecological problems affecting the farmers, crops and their living environment. Two decades of experience in Andhra Pradesh on Non Pesticidal Management shows that pest is a symptom of ecological disturbance rather than a cause and can be affectively managed by using local resources and timely action. The emerging new paradigm of sustainable agriculture shows that the new knowledge synthesized from traditional practices supplemented with modern science can bring in ecological and economic benefits to the farmers. The small success from few villages could be scaled up into more than 10 million ha in five years. The costs of cultivations could be brought down significantly without reduction in yield. The institutional base of Community Based Organizations like Federations of Women Self Help Groups provides a good platform for scaling up such ecological farming practices. This experience also shows how the grass root extension system when managed by the community can bring in change and help the farming community to come out of the crisis.

The ecological and economical problems of pests and pesticides in agriculture gave rise to several eco-friendly innovative approaches which do not rely on the use of chemical pesticides. These initiatives involved rediscovering traditional practices and contemporary grass root innovations supplemented by strong scientific analysis mainly supported by non-formal institutions like NGOs. Such innovations have begun to play an important role in development sector. This trend has important implications both for policy and practice. One such initiative by Centre for World Solidarity and Centre for Sustainable Agriculture, Hyderabad was Non Pesticidal Management.

The 'Non Pesticidal Management' which emanates from collaborative work of public institutions, civil society organizations and Farmers in Andhra Pradesh shows how diverse players when come together to work in generating new knowledge and practice, can evolve more sustainable models of development.

Pest is not a problem but a symptom. Disturbance in the ecological balance among different components of crop ecosystem makes certain insects reach pest status. From this perspective evolved the Non Pesticidal Management which is an 'ecological approach to pest management using knowledge and skill based practices to prevent insects from reaching damaging stages and damaging proportions by making best use of local resources, natural processes and community action'.

Non Pesticidal Management is mainly based on

- Understanding crop ecosystem and suitably modifying by adopting suitable cropping systems and crop production practices. The type of pests and their behavior differs with crop ecosystem. Similarly the natural enemies' composition also varies with the cropping systems.

- Understanding insect biology and behavior and adopting suitable preventive measures to reduce the pest numbers.

- Building Farmers knowledge and skills in making best use of local resources and natural processes and community action. Natural ecological balance which ensures that pests do not reach a critical number in the field that endangers the yield. Nature can restore such a balance if it is not meddled with too much. Hence no chemical pesticides/pesticide

incorporated crops at all. For an effective communication to farmers about the concept effectively and to differentiate from Integrated Pest Management which believes that chemical pesticides can be safely used and are essential as lost resort it is termed as 'Non Pesticidal Management'.

Red Hairy Caterpillar *(Amsacta albistriga)* Management (1989-93): During late eighties, Red Hairy Caterpillar (RHC) was a major pest in the dryland areas of Telangana region of Andhra Pradesh. The pest attacks crops like castor, groundnut, sesame, sorghum and pigeon pea in the early stages and causes extensive damage in dry land areas. This forces farmers to go for 2-3 resowings or late sowing which affect the yield. The problem of crop failure due to delayed and uncertain rainfall was compounded by this pest damage. Resowings were happening in more than 30 % area.

Discussions with several voluntary agencies, farmers from different regions and few concerned scientists established that

1. this pest infests crops only on light red soils
2. there is only one generation of moths that lay the eggs producing the caterpillars which later hibernate in the soils and the adult moths appear in waves at the onset of the monsoon-controlling the pest necessitated the destruction of the early emergence of the moths
3. the foraging caterpillars are also attracted to some wild non-economical plants such as calatropis, wild castor, yellow cucumber
4. the later instars of larvae had dense red hairs all over the body, which prevents pesticides from reaching the body of the insects as a result any pesticide sprayed will not reach the body of the insect.

Package of practices were evolved based on the insect behavior, which can manage the RHC before it reaches damaging stages and proportions. Deep summer ploughing exposes the resting pupae, adults of RHC are attracted to light-community bonfires were taken up to attract the insects and kill them alternatively light traps (electric bulbs or solar light) were also used. Trenches around the field to trap migrating larvae, use of calotropis and jatropha cuttings to trap the insects found to be effective. Similarly neem sprays over the early instar larvae was found to be effective.

During 1989 to 93 the program covered 18,260 ha in 95 villages across 12 districts of AP involving 21 Voluntary Organizations in two phases.

RHC could be effectively managed in dryland crops like castor, groundnut, Sesame, Sorghum and pigeonpea. Farmers could avoid late sowing and only 4% of farmers went for re-sowing in areas where RHC management was followed. After the initial success of these methods, it evolved into a Red Hairy Caterpillar Management program with coordinated action of Centre for World Solidarity (CWS), ICAR Zonal Coordinating Unit, Directorate of Oilseeds Research and Department of Agriculture and the program is still continuing.

Source: Qayum. M. A. and Sanghi. N. K. (1993) Red Hairy Caterpillar Management through Group Action and NPM Methods published by ASW and Oxfam (India) Trust.

The approaches Basic set of practices followed

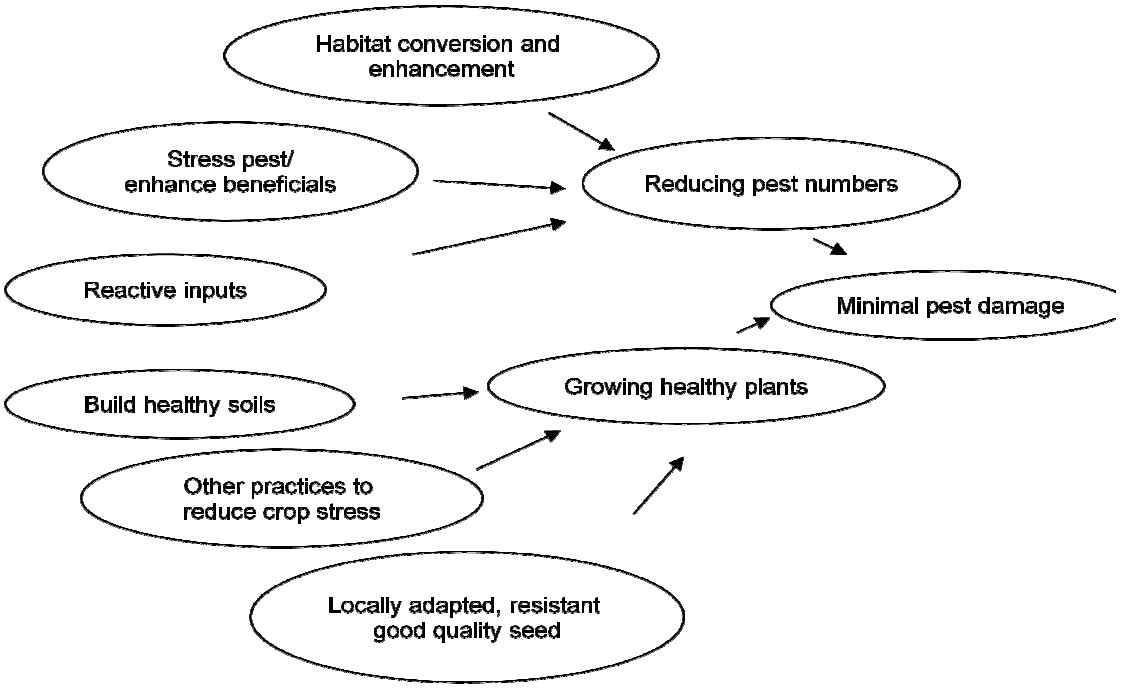
1 Growing healthy plants is the first step in Non Pesticidal Management. This involves

1.a. Good Quality Seed: Selection and use of good quality seed which is locally adopted either from traditional farmers' varieties or improved varieties released by the public sector institutions is important. Farmers are suggested to make their decision based on a seed matrix regarding suitability of the different varieties into their cropping patterns, based on the soil types, reaction to pest and diseases and their consumption preference. They maintain the seed in their seed banks. This ensures farmers to go for timely sowing with the seeds of their choice. In rainfed areas timely sowing is one critical factor which affects the health and productivity of the crop. The seed is treated with concoctions depending on the problem for example cow urine, ash and asafetida concoction provides protection against several seed borne diseases like rice blast, or *beejamrut* to induce microbial activity in the soil and kill any seed borne pathogens. Similarly in crops like brinjal where there is a practices of dipping of seedlings in milk and dipping fingers in milk before transplanting each seedling was observed to prevent viral infections. Several such practices are documented and tested by the farmers.

1.b. Reduce stress: The pest and disease susceptibility increases with abiotic stress. Practices like mulching will improve the soil moisture availability.

2.a. Build healthy soils: Healthy soils give healthy crop. Chemical fertilizers especially nitrogenous fertilizer makes the plants succulent and increases the sucking pests like Brown Plant Hopper in rice. Production practices, such as putting on crop residues or other biomass as surface mulch, using compost and green manures, intercropping of legumes in cropping systems, and biocontrol of insect pests and diseases, all help to enhance yields and sustain soil fertility and health (Rupela *et.al* 2007)

Fig. 1 Non Pesticidal Management –Schematic Representation



3 Enhancing the habitat

3.a. Crop diversity: Crop diversity is another critical factor which reduces the pest problems. Traditionally farmers have evolved mixed cropping systems, intercropping and crop rotation systems. These systems will create a better environment for nutrient recycling and healthy ecosystems. On the contrary the monoculture of crops and varieties lead to nutrient mining and pest and disease buildup. Under NPM farmers adopt mixed and intercropping systems with proper crop rotations.

3.b. Trap and Border crops: Many sucking pests fly from neighboring farmers' fields. In crops like chillies, groundnut, cotton, sunflower where thrips are a major problem, sowing thick border rows of tall growing plants like sorghum or maize will prevent insects from reaching the crop. Farmers adopt marigold as a trap crop for the gram pod borer reduces the pest load on pigeonpea. The flowers that have been oviposited by the female moths of Helicoverpa can be picked out and destroyed (KVK DDS, 2003).

Table-2 Trap crops used for pest management

Crops	**Pests**	**Trap crops**
Cotton, groundnut	Spodoptera	Castor, sunflower
Cotton, Chickpea, pigeonpea	Helicoverpa	Marigold
Cotton	Spotted bollworm	Okra

Source: KVK DDS, 2003

3.c. Other agronomic practices: Several **c**rop specific agronomic practices like alley ways in rice to allow enough light to reach the bottom of the plant are documented by the farmers and suggested by the scientists (*Vyavasaya Panchangam*, 2007).

4. Understanding insect biology and behavior

4.a. Life cycle: In most of the insects which completely undergo complete metamorphosis, in the four stages of the life cycle, insects damage the crop only in larval stage and in at least two of the stages are immobile [egg and pupa]. Every insect has different behavior and different weaknesses in each of the stage. They can be easily managed if one can understand the lifecycle and their biology. The different stages in the insect life cycle are morphologically different and relating between one stage and other is difficult unless one studies/observes the life cycle.

Adult stage: Adults of RHC are attracted to light-community bonfires or light traps (electric bulbs or solar light) can be used to attract and kill them. Similarly adult insects of Spodoptera and helicoverpa can be attracted by using pheromone traps. Normally pheromone traps are used to monitor the insect population based on which pest management practices are taken up. Natural Resources Institute, UK in collaboration with Tamil Nadu Agriculture University, Gujarat Agriculture University, Centre for World Solidarity, Asian Vegetable Research and Development Centre has evolved mass trapping method to control Brinjal Fruit and Shoot borer and demonstrated on a large scale (http://www.nri.org, GAU, 2003) The adults of sucking pests can be attracted using yellow and white sticky boards.

Egg stage: Some insects like Spodoptera lay eggs in masses which can be identified and removed before hatching. Insects also have preference for ovi-position. Spodoptera prefers to lay eggs on castor leaves if available. Hence growing castor plants as trap crop is practiced. By observing the castor leaves farmers can easily estimate the Spodoptera incidence. Helicoverpa lays eggs singly, but has a preference towards Okra, Marigold (mostly towards plants with yellow flowers). Hence marigold is used as a trap crop where ever helicoverpa is a major problem. Rice Stem borer lays eggs on the tip of the leaves in nurseries; farmers remove these tips before transplanting (*Vyavasaya Panchangam, 2007*).

Pupal Stage: The larvae of Red Hairy Caterpillar burrow and pupate in the soil. Deep summer ploughing, which is a traditional practice in rainfed areas expose these larvae to hot sun which kills them. The larvae of stem borers in crops like paddy, sorghum pupate in the stubbles. So farmers are advised to cut the crop to ground level and clear the stubbles.

4.b. Biology: The larva of Red Hairy Caterpillar (*Amsacta albistriga*) has a dense body hair over the body hence no pesticide reaches it when sprayed. There fore it needs to be controlled in other stages of its life cycle (see box). For any safe and economic method of pest management one must understand how the pest live and die, where does it come from and when, where and how does it damage the crop. Knowledge of these biological attributes of pest will help farmers to use NPM methods successfully on a sustainable basis (GAU, 2003).

Traditional Technology with a Modern Twist http://www.icrisat.org

Farmers in south India used indigenous methods like shaking the plants manage the pod borer (Helicoverpa armigera) in pigeonpea until chemical insecticides were introduced in the early 1970s. After crop pollination and pod set, when 1-2 larvae per plant are noticed, three farmers/agriculture workers enter the field, one to hold/drag a polyethylene sheet on the ground, while the other two shake the plants. This gentle shaking can dislodge most of the caterpillars from the plants. These dislodged larvae are collected in a sack and destroyed.

During 1998-99 season, this technology was evaluated in a research watershed (15 ha) at ICRISAT-Patancheru with support from IFAD and in collaboration with ICAR, ANGRAU, MAU, and NGOs under the coordination of CWS.

The results showed 85% reduction in insect population, while the larval population in the adjacent, chemically sprayed plots remained high throughout the cropping period. This cost of this practice is just Rs 280 per hectare to have 7 people to shake pigeonpea plants, and collect larvae; while each chemical spray costs Rs 500-700 per hectare. This technology, initiated at a few locations during 1997, rapidly spread to more than 100 villages involving several thousand farmers in three states of southern India within two years.

Later, the larvae collected by shaking the plants were used for the multiplication of the Nuclear Polyhedrosis Virus (NPV), a biopesticide that kills Helicoverpa.

This project proposal by ICRISAT and CWS had won the World Bank's Development Marketplace Award for 2005.

5. Understanding crop ecosystem: The pest complex and the natural enemy complex are based on the crop ecosystem. The pest complex of cotton is completely different from that of Sorghum. The pest complex in wet rice ecosystem differs from the pest complex in dry rice. Decision about any pest management intervention should take into account the crop ecosystem which includes cropping pattern, pest-predator population, stage of the crop etc. Similarly the management practices followed in one crop cannot be practiced certain other crop. For example in to manage helicoverpa in pigeonpea, the farmers in Andhra Pradesh and Gulbarga use shake the plants and falling insects are collected over a sheet and killed (see box). Similarly in paddy there is a practice of pulling rope over the standing crop to control leaf roller

6. Reactive sprays

Insect population may reach pest status if the preventive steps were not taken in time, changes in weather conditions and insects coming from neighboring farmers fields. In these situations based on the field observations farmers can take up spraying botanical extracts and natural preparations (Green sprays) instead of chemical pesticides. There are wide ranges of these preparations which are evolved by the farmers (CSA, 2007).

These preparations are can be classified into four kinds

6.a Aqueous or solvent extracts: for example, Neem Seed Kernal Extract is very effective against many pests. There is a wide variation in the way these extraction is prepared. For extracting 'Allenin' from garlic kerosene is used as a solvent. After extraction this solution is mixed with chilli extract and used against sucking pests (Prakash and Rao 1997, Vijayalakshmi *et.al* 1999, Prasad and Rao 2007).

6.b. Decoctions: for example, plants like tobacco, *Nux Vomica* etc contain volatile compounds which can be extracted by boiling them in water to get the decoction. Several decoctions are used in pest management (Prakash and Rao, 1997, Vijayalakshmi *et.al*, 1999, Prasad and Rao, 2007).

6.c. Concoctions: concoctions are mixtures. For example, five leaves mixture which is a aqueous extract of any five latex producing leaves is used to control pests in Tamil Nadu and other parts of south India (Prakash and Rao, 1997, Vijayalakshmi *et.al*, 1999, Prasad and Rao, 2007).

6.d. Fermented products: products made by fermenting the different botanicals with animal dung and urine. These products have rich microbial cultures which help in providing plant nutrients in addition to acting as pest repellents and pest control sprays. For example cow dung urine-asafetida solution is used to manage Rice blast (Prakash and Rao, 1997, Vijayalakshmi *et.al*, 1999, Prasad and Rao, 2007).

Government of India recommended use of Endosulfan for various crops & available alternatives in NPM

Crop	Pest	Chemicals	Biologicals	NPM Methods
Paddy	Leaf Folder	**Endosulfan** Cypermethrin lambda Cyhalothrin	*Trichogramma chilonis*	• NSKE – 5% spray • Removing Leaf folds using Thorny twigs • Spraying Vitex solution
	Hispa/case worm/cut worm	**Endosulfan** Quinalphos Monocrotophos Chlorpyrifos	*Trichogramma chilonis*	• NSKE – 5% spray • Removing Leaf folds using Thorny twigs • Spraying Vitex solution
	Swarming caterpillar/surti caterpillar	Carbaryl, Quinalphos Monocrotophos **Endosulfan** Triazophos, Chlorpyrifos		• NSKE – 5% spray • Removing Leaf folds using Thorny twigs • Spraying Vitex solution
Pigeonpea	Pod Borer	Acephate **Endosulfan**	*Helicoverpa armigera Nuclear polyhedrosis*	• NSKE – 5% spray • Erecting bird perches • Shaking Method • Deep Summer Ploughing
		Triazophos	virus (NPV) *Bacillus thuringiensis*	• NSKE – 5% spray • Erecting bird perches • Shaking Method • Deep Summer Ploughing
	Pod bug	**Endosulfan** Chlorpyrifos Methyl Oxydemeton Imidacloprid		• NSKE – 5% spray • Neem oil 3% spray
	Pod fly	**Endosulfan**		• NSKE – 5% spray • Neem oil 3% spray
	Defoliators	**Endosulfan** Acephate		• NSKE – 5% spray • Neem oil 3% spray
Bengal gram	Pod borer	**Endosulfan**	*Helicoverpa armigera* NPV	• NSKE – 5% spray

			Bacillus thuringiensis	• Erecting bird perches • Deep Summer Ploughing
Greengram, Blackgram	Pod borer	Monocrotophos Triazophos **Endosulfan**	*Helicoverpa armigera* NPV *Bacillus thuringiensis*	• NSKE – 5% spray • Erecting bird perches • Deep Summer Ploughing
Groundnut	Leafminer	Monocrotophos **Endosulfan**		• NSKE – 5% spray • Erecting bird perches • Pheromone Traps
	Defoliator (*Spodoptera litura*)	**Endosulfan**	*Spodoptera litura* NPV Pheromone traps	• NSKE – 5% spray • Erecting bird perches • Pheromone Traps • Deep Summer Ploughing • Poison baits
Mustard	Leaf and pod caterpillar	**Endosulfan**		• NSKE – 5% spray
	Sawfly	**Endosulfan**		• NSKE – 5% spray • Collection of large caterpillars
	Leaf webber	Ethofenprox **Endosulfan**	*Bacillus thuringiensis*	• NSKE – 5% spray • Collection of leaf webs and destruction
Sesamum	*Antigastra* sp/ Pod capsule borer	**Endosulfan**		• NSKE – 5% spray
	Spingid caterpillar	**Endosulfan**		• NSKE – 5% spray
Sunflower	*Helicoverpa* (head borer)	**Endosulfan**	*Helicoverpa armigera* NPV Pheromone traps	• NSKE – 5% spray • Erecting bird perches • Pheromone Traps • Deep Summer Ploughing • Poison baits
	Defoliators	**Endosulfan**		• NSKE – 5% spray • Erecting bird perches • Pheromone Traps • Deep Summer Ploughing • Poison baits

	Cutworm	Dichlorvos **Endosulfan**		• NSKE – 5% spray • Erecting bird perches • Pheromone Traps • Deep Summer Ploughing • Poison baits
	Castor semilooper	**Endosulfan**		• NSKE – 5% spray
Niger	Lucern caterpillar defoliator	**Endosulfan** Monocrotophos		• NSKE – 5% spray
Linseed	Lucern caterpillar	Chlorpyrifos **Endosulfan**		• NSKE – 5% spray
	Defoliator	**Endosulfan** Carbaryl		• NSKE – 5% spray
Safflower	Bihar hairy caterpillar	**Endosulfan** Methyl oxydemeton Dimethoate		• Deep Summer Ploughing • NSKE – 5% spray • Erecting bird perches • Chilli-garlic Solution spray
Soyabean	Leaf roller Leaf miner	Triazophos Phosalone **Endosulfan**		• Deep Summer Ploughing • NSKE – 5% spray • Erecting bird perches • Chilli-garlic Solution spray
	Stemfly defoliator	Monocrotophos Phosalone **Endosulfan**		• Deep Summer Ploughing • NSKE – 5% spray • Erecting bird perches • Chilli-garlic Solution spray
Maize	Stalk borer	**Endosulfan** Carbofuran		• Deep Summer Ploughing • NSKE – 5% spray • Application of 200 Kg Neem cake during ploughing • Chilli-garlic Solution spray
	Corn earworm/defoliator	**Endosulfan** Carbaryl		• Deep Summer Ploughing • NSKE – 5% spray • Application of 200 Kg Neem cake during

				ploughing • Chilli-garlic Solution spray • Pheromone Traps
Ragi	Pink borer	**Endosulfan**		• Deep Summer Ploughing • NSKE – 5% spray • Application of 200 Kg Neem cake during ploughing • Spraying 3% neem oil
	Millets shoot fly	**Endosulfan**		• NSKE – 5% spray
Sorghum	Defoliators	Quinalphos Fenvalerate **Endosulfan** Chlorpyrifos		• Deep Summer Ploughing • NSKE – 5% spray • Application of 200 Kg Neem cake during ploughing • Spraying 3% neem oil
	Gram pod borer	**Endosulfan**	*Helicoverpa armigera* NPV *Bacillus thuringiensis*	• Deep Summer Ploughing • NSKE – 5% spray • Application of 200 Kg Neem cake during ploughing • Spraying 3% neem oil • Pheromone Trap
Cotton	Spotted bollworm; pink bollworm; *Helicoverpa*; Red cotton bug; Dusky cotton bug	**Endosulfan** Triazophos Spinosad Indoxacarb	Pheromone traps *Trichogramma chilonis Bacillus thuringiensis Helicoverpa* armigera NPV	• Deep Summer Ploughing • NSKE – 5% spray • Application of 200 Kg Neem cake during ploughing • Spraying 3% neem oil • Cow dung - Urine Solution • 5% Vitex Solution
	Leaf roller	**Endosulfan** Chlorpyrifos		• NSKE – 5% spray
Jute	Semilooper	**Endosulfan** Quinalphos Phosalone		• NSKE – 5% spray

	Bihar hairy caterpillar; Indigo caterpillar	**Endosulfan** Monocrotophos		• Deep Summer Ploughing • NSKE – 5% spray • Erecting bird perches • Chilli-garlic Solution spray
	Mites	Dicofol, Propargite **Endosulfan**		• Spraying 2% wettable sulphur
Mesta	Jassid	Phosalone **Endosulfan** Dimethoate		• NSKE – 5% spray • Neem Oil 3% Spray
Sugarcane	Top shoot borer; Internode borer	**Endosulfan** Carbaryl Quinalphos Carbofuran	*Trichogramma japonicum* *Trichogramma chilonis*	• NSKE – 5% spray • Application of 200 Kg Neem cake during ploughing
Bhindi	Leaf roller	**Endosulfan** Carbaryl		• NSKE – 5% spray
Cucurbits	Red pumpkin	Carbaryl **Endosulfan**		• NSKE – 5% spray • Neem Oil 3% Spray
Chilli	Fruit borer	**Endosulfan** Triazophos Dicofol	Spodoptera NPV *Trichogramma chilonis*	• Deep Summer Ploughing • NSKE – 5% spray • Erecting bird perches • Chilli-garlic Solution spray • Pheromone Traps
Tomato	Fruit borer (*Helicoverpa armigera*)	**Endosulfan** Triazophos	*Helicoverpa armigera* NPV *Trichogramma chilonis Bacillus thuringiensis* *Pheromone traps*	• Deep Summer Ploughing • NSKE – 5% spray • Erecting bird perches • Chilli-garlic Solution spray • Pheromone Traps
Cabbage/Cauliflower	Cabbage borer	**Endosulfan** Carbaryl Malathion	*Bacillus thuringiensis*	• NSKE – 5% spray • Chilli-garlic Solution spray
	Tobacco caterpillar	**Endosulfan** Carbaryl		• Deep Summer Ploughing • NSKE – 5% spray • Erecting bird perches

				• Chilli-garlic Solution spray • Pheromone Traps
	Leaf webber (*Crocidoloma binotalis*)	Acephate **Endosulfan** Malathion	*Bacillus thuringiensis*	• NSKE – 5% spray • Chilli-garlic Solution spray
	Cabbage butterfly	**Endosulfan** Carbaryl Malathion	*Bacillus thuringiensis*	• NSKE – 5% spray • Chilli-garlic Solution spray
Potato	Cutworm	Chlorpyriphos **Endosulfan**		• NSKE – 5% spray • Application of 200 Kg Neem cake during Ploughing • Poison baits
Pea	Pod borer	**Endosulfan** Triazophos Carbaryl	*Helicoverpa armigera* NPV *Bacillus thuringiensis*	• Deep Summer Ploughing • NSKE – 5% spray • Erecting bird perches • Chilli-garlic Solution spray • Pheromone Traps
Mango	Mango hopper	**Endosulfan** Carbaryl		• NSKE – 5% spray • Neem Oil 3% spray
	Mealy bug	**Endosulfan** Monocrotophos Chlorpyrifos, Malathion		• Field sanitation • NSKE – 5% spray • Neem Oil 3% spray
Citrus	Lemon butterfly	**Endosulfan** Carbaryl malathion in fruiting stage		• Field sanitation • NSKE – 5% spray • Neem Oil 3% spray • Cow dung urine solution spray
Guava	Bark eating caterpillar	Monocrotophos **Endosulfan**		• Removal of insect galleries • Field Sanitation • Painting the stem with neem oil
	Fruit borer	Carbaryl **Endosulfan**		• NSKE – 5% spray • Neem Oil 3% spray

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