

Non Pesticidal Management: Learning from Experiences

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Abstract

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 1.5 million ha in three 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.

Key words: Non Pesticidal Management, Pesticides, Natural Enemies, Community Based Organizations, Sustainable Agriculture, Local resources

NON-PESTICIDAL MANAGEMENT-LEARNING FROM PRACTICE

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Introduction

Farming in India evolved over centuries of farmers' innovations in identifying locally suitable cropping patterns and production practices. The crisis of food production and geo-political considerations during 1960s created conditions in many developing countries particularly in India to strive for food self-reliance. The country has chosen the path of using high yielding varieties (more appropriately high input responsive varieties) and chemicals which brought about what is popularly known as green revolution. This continued as a quest for modernization of agriculture which promoted the use of more and more of high yielding varieties/hybrids, chemical pesticides and fertilizers across crops and situations displacing farmers' knowledge, own seeds and practices. The country could become self reliant for a while, farmers lost self reliance in the process due to excessive dependency on external inputs and are caught in serious ecological and economic crisis. This crisis is manifesting itself in the form of migration, indebtedness and in extreme cases as farmers' suicides.

In midst of the deep crisis in agriculture farmers and various organizations associated with farmers are trying innovative approaches to sustain agriculture. One such initiative is the 'Non Pesticide Management' of crop pests to reduce the costs of cultivation by adopting a set of practices based on farmers' knowledge supplemented

by modern science which makes best use of local resources and natural processes by the farmers and women self help groups in Andhra Pradesh. During Kharif 2007, more than 350 thousand farmers from 1800 villages in eighteen districts of the state are practicing NPM in more than 280 thousand ha in various crops. Sixteen of these districts are part of the 32 districts with serious agrarian crisis identified by the Government of India. The savings (on chemical pesticides) in costs of cultivation on pest management ranged from Rs. 600 to 6000 (\$ 15 to 150 US) per ha without affecting the yields. The savings on the health costs are also substantial. Non Pesticidal Management is one of the components of the 'Community Managed Sustainable Agriculture' program with technical support from Centre for Sustainable Agriculture and its partner NGOs and financial and administrative support from the Society for Elimination of Rural Poverty, Government of Andhra Pradesh.

1. Pests, Pesticides and the distress

The problems of pests and pesticides in farming are well documented. Among the production inputs in agriculture chemicals especially pesticides occupy major share of costs in crops like cotton, chillies, paddy etc. The pest resistance and resurgence due to abuse of pesticides propelled mainly by a lack of awareness, regulation of pesticide marketing extended on credit with high interests by "all-in-one dealers" (money lenders cum dealers of seeds/fertilizers/pesticides) and lack of market support ended up pushing hapless farmers into a vicious debt trap from which suicides were sought as a way out. The same pesticides which were promoted to solve the farmers' problems were consumed by these farmers to kill themselves.

1.1. The dominant paradigm: The dominant paradigm of pest management largely depends on use of chemical pesticides. The recommended schedules of the chemical

pesticides are based on the studies conducted by the Pesticide Companies and Agriculture Research Institutes. The pesticides and the pesticide recommendations need to be registered with the Central Insecticides Board (CIB). Most of the chemical pesticides are used to kill the pest when it is in the most damaging stage of its life cycle. Farmers are suggested to spray their fields when the insects are in damaging proportions (Economic Threshold Level). The regular use of pesticides creates pressure and result in the development of genetic resistance in the insects and makes the sprays more and more ineffective. All these make the farmer to increase the pesticide doses or go for newer pesticides frequently pushing the farmers into a vicious cycle of pesticides, increasing costs, ill health and debt.

1.2 Pesticide induced pest problems: Nearly from the beginning of the Green Revolution increases in insect populations following insecticide applications were detected. In rice insecticide induced increases in populations of plant sucking insects are among the first reliable symptoms of an intensification syndrome that destabilizes production (Kenmore, 1997). The Pesticides often induce pest outbreaks by killing beneficial insects, reducing natural pest control, and resulting in explosive outbreaks of pest species which are either resistant, or physically invulnerable to pesticides. E.g. brown plant hopper eggs are laid within the rice stalk and shielded from spray; after spraying, they hatch into a field free of their natural enemies and reproduce explosively without predation (Kenmore, 1980). Systemic pesticides can kill the early "neutral" insects which lure the first generation of beneficials, and kill the beneficials as well (Mangan, 1998). Similarly mealy bug and other sucking pests are increasingly becoming a problem in the cotton growing areas of Gujarat and Punjab. This ecological disturbance results in pest shifts as is seen widely today.

1.3 Pesticide resistance: Pesticide resistance which is heritable and results in significant decrease in the sensitivity of a pest population to a pesticide reduces the field performance of pesticides. The percentage of resistant insects in a population continues to multiply while susceptible ones are eliminated by the insecticide (IRAC, 2007). How quickly resistance develops depends on several factors, including how quickly the insects reproduce, the migration and host range of the pest, the crop protection product's persistence and specificity, and the rate, timing and number of applications made. Based on their observations about resistance, farmers use either more concentration of the chemical (higher dose) or more sprays of the same or different chemicals mixed or with short intervals which is often termed as 'indiscriminate' use (Table-1).

Table-1 Pesticide recommendations in chillies in 2000 and 2006 against Helicoverpa

Pesticide	First report of resistance*	Recommendation in 2000**	Recommendation in 2006**
Quinolphos	2001	2.5 ml/lit	2 ml/lit
Chlorpyriphos	2002	2.5 ml/lit	3 ml/lit

Source:

* Fakruddin, B *et.al* 2002, Kranthi, K R *et.al* 2001 a & b

** Vyavasaya Panchangam, 2000 and 2006 published by ANGRAU.

1.4 Pesticide poisoning: Pesticide poisoning is a significant problem in India. Pesticide poisoning to human beings through exposure to the toxic fumes while spraying is a lesser known and lesser acknowledged aspect of pesticide abuse in places like Warangal in Andhra Pradesh (Kavitha, 2005 and Francesca, 2005),

Tanjavur in Tamil Nadu (Chitra *et.al.*, 2006) or Batinda in Punjab (Mathur, 2005). There is no systematic documentation of such cases during hospitalization, often they are combined with the ingestion cases. The numbers of deaths that happen prior to hospitalization and not reported are substantially high. The socio economic and environmental conditions in which the agriculture workers and small and marginal farmers work do not permit them to adopt the so called 'Safe use practices' often promoted by industry or agriculture scientists (Kavitha 2005).

There are also several reports on the chronic effects of the chemical pesticides on the farmers (Mathur *et. al* 2005), growth and development of children (Kavitha, 2005, Kropp 2005) and women's reproductive health.

1.5. Pesticides and ecological impacts: The chemical pesticides leave larger ecological foot prints in manufacturing (e.g. Bhopal gas tragedy), storage and transport and usage polluting the soils, water and air. Some amounts of pesticides used in crop production appear as residues in the produce. These residues in food, soil and water enter into the food chain and cause serious health problems to human beings and other living beings (Karanth, 2002, Kavitha, 2007). The pesticide residues are even noticed in human milk (Down to Earth, 1997). Studies show that the pesticide residues in soil can kill the soil microbes there by effect the soil fertility. Common pesticides block the chemical signals that allow nitrogen-fixing bacteria to function. Over time, soils surrounding treated plants can become low in nitrogen compounds, so more fertilizer is needed to produce the same yield (Fox, 2007).

1.6. Pesticide regulation: In India, the production and use of pesticides are regulated by a few laws which mainly lay down the institutional mechanisms by which such regulation would take place – in addition to procedures for registration, licensing, quality regulation etc., these laws also try to lay down standards in the form of Maximum Residue Limits, Average Daily Intake levels etc. Through these mechanisms, chemicals are sought to be introduced into farmers' fields and agricultural crop production without jeopardizing the environment or consumer health. In spite of these regulatory systems many pesticides which banned across the world for their toxicity and residual problem are still produced and used in India.

The pesticides and pesticide recommendations to control specific pests on crops are to be registered with Central Insecticide Board and Registration Committee (CIBRC). While farmers are blamed for 'indiscriminate use of pesticides', studies by Centre for Sustainable Agriculture show that indiscriminate recommendations are made by Agriculture Universities and Departments of Agriculture and Horticulture violating the registration rules. Pesticides are usually registered for one or two crops and one or two pests but sold, recommended and used for other crops and pests as well. (Kavitha, 2007). For example, Acephate is registered for use only on Cotton and Safflower in the country. It is not registered for use on Chillies, Brinjal, Cabbage, Cauliflower, Apple, Castor, Mango, Tomato, Potato, Grapes, Okra, Onion, Mustard, Paddy and many other crops where it is being used extensively now. Further, it is also being recommended by the NARS for use in other crops even without registering the recommendations with CIBRC! Acephate is being recommended for the control of sap sucking pests in most crops. Further, MRLs have been set only for safflower seed and cotton seed for this pesticide. (Website Department of Horticulture, Govt. of AP

<http://www.aphorticulture.com>, Vyavasaya Panchangam 2006-07, ANGRAU, Central Insecticides Board & Registration Committee's website www.cibrc.nic.in)

2. Managing the problem: Integrated Pest Management

The attempts to overcome the serious economical and ecological problems of the chemical pesticides have given rise to alternative systems to manage pests and pesticides.

3. Shifting Paradigms: Non Pesticidal Management

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

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 jatropa 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.

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'.

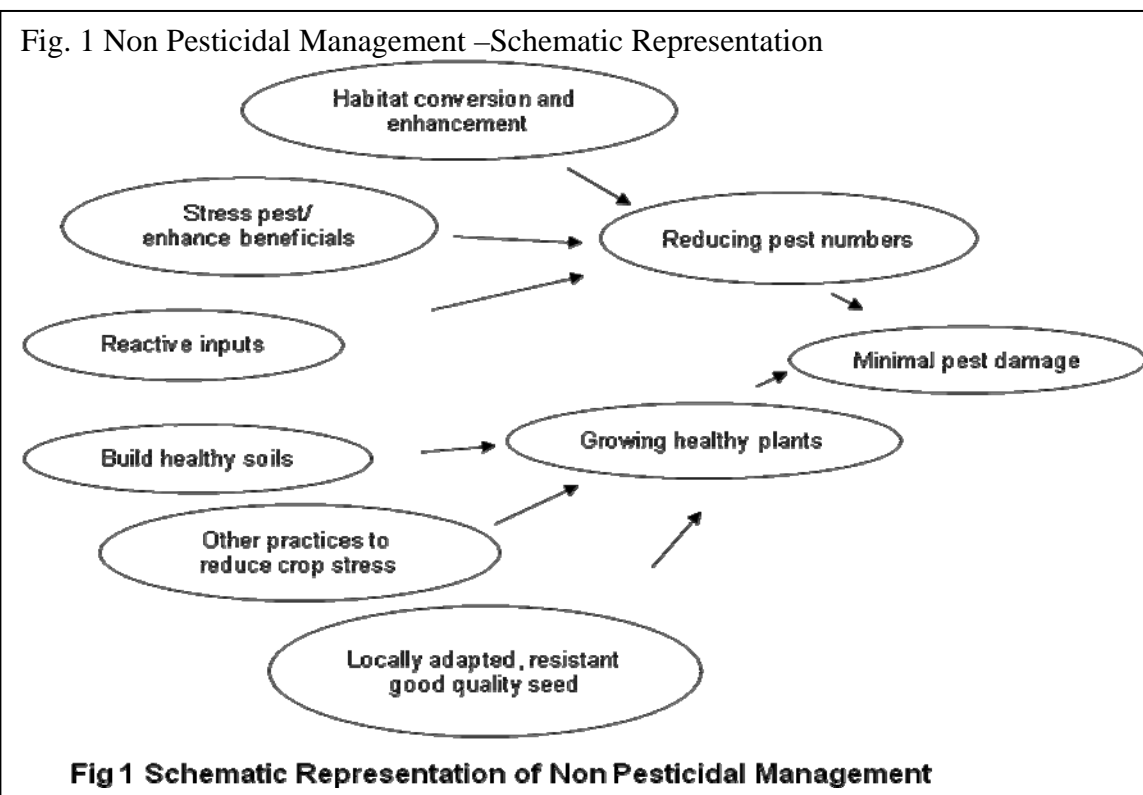
Non Pesticidal Management is mainly based on

- 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 last resort it is termed as 'Non Pesticidal Management'.

The approaches Basic set of practices followed

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

3.1.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



In NPM –main prevent insect damaging stag proportions. If damaging stag inputs locally resources are u Chemical pest integral part.

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.

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

3.2.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)

3.3 Enhancing the habitat

3.3.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.

3.3.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	<i>Helicoverpa</i>	Marigold
Cotton	Spotted bollworm	Okra

Source: KVK DDS, 2003

3.3.c. Other agronomic practices: Several crop 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).

3.4. Understanding insect biology and behavior

3.4.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

Fig 2 type life cycle of an insect

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 helioverpa 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 oviposition. 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. Helioverpa 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 helioverpa 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).

Fig 3. Egg laying behavior of Spodoptera and Helioverpa

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.

3.4.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.

3.5 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

Fig 4. Shaking method in Pigeonpea

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

3.6. 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

3.6. 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).

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).

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).

3.6.b. 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).

The Evolution of Dialogue on Non Pesticidal Management

In 1988, ASW and EZE organized People's Science Conference at Bangalore to promote concept of substituting synthetic chemical pesticides by a non-pesticide approach based on locally available resources. This led to a collaborative programme for non-pesticidal approach for controlling RHC in 1989 with Zonal Coordinator, Transfer of Technology (ToT) Unit, ICAR, Hyderabad; Department of Agriculture, ASW/CWS; OXFAM; and village based voluntary organizations as partners.

In 1994, CWS organized a workshop in collaboration with National Academy of Agriculture Research Management (NAARM), Hyderabad to bring together initiatives working in NPM across country. This workshop evolved a joint strategy paper on NPM.

In 1998, CWS organized second National Workshop on Non Pesticidal Management in collaboration with MANAGE in Hyderabad. The workshop which was participated by eminent scientists and civil society organizations called for expansion and popularizing the concept and practices.

In 2004, Punukula, a small village in Khammam district of Andhra Pradesh which used to spend about Rs. 4 million annually on chemical pesticides to grow crops like cotton, chillies declared itself as a pesticide free after five years of NPM work.

In 2005, in the context of serious crisis in agriculture and farmers suicides, NPM got the attention of the Society for Elimination of Rural Poverty, Government of Andhra Pradesh which works with Federations of Women Self Help Groups and began scaling up by adopting an institutional approach across the state.

In Kharif 2007, NPM program reached 1500 villages with more than 200 thousand farmers participating covering 150 thousand ha. The success of the program in reducing the costs of cultivation and increasing the net incomes of the farmers has received Prime Minister's attention and was selected for a support from 11th Five Year Plan under National Agriculture Development Project to cover one million farmers cultivating one million ha in over 5000 villages.

In September 2007, CSA and WASSAN (sister organizations of CWS engaged in promotion of NPM) have organized a National Workshop on 'Redesigning support systems for rainfed farming' in collaboration with Rainfed Farming Authority and ICAR in New Delhi. The nationwide experiences of public sector and civil society organizations on local resource based, sustainable models in agriculture were discussed and urged the government to redesign the support systems to help promotion of such practices.

(Based on the internal documents, proceedings of workshops organized by CWS in 1994 and 1998, Ramanjaneyulu (2004))

Transgenic Insecticide Resistant crops: not a solution either

As the problems of chemical pesticides are becoming evident the industry has come out with yet another technological fix in the form of insect resistant genetically engineered crops like Bt cotton. The results of the last four years (2002-2005) of commercial cultivation of the Bt cotton in India, especially in Andhra Pradesh clearly shows devastating effects such technologies can have on the farming communities. This comes from the fact that the seed is four times the price of conventional seeds and Bt crops often are not even completely resistant to those pests that they claim to be resistant to (Bt cotton performance reports by state governments available at <http://www.indiagminfo.org>). In addition other sucking pests will affect the crop and chemicals are needed again. The first three commercial Bt hybrids released in AP were withdrawn from commercial cultivation (GEAC, 2005).

It should be added that studies have assessed the variability of Bt toxin production under carefully controlled conditions, rather than the real life conditions of farmers' fields. Under real life condition toxin production of the crop is extremely uneven (Kranti, 2005).

Transgenic Bt plants, which produce their own insecticidal toxins, have the similar effects like chemical pesticides. However, unlike topical sprays, which become inactive after a short period of time, transgenic Bt plants are engineered to maintain constant levels of the Bt toxin for an extended period, regardless of whether the pest population is at economically damaging levels. The selection pressure with transgenic Bt crops will therefore be much more intense.

Today the experience of Bt cotton in several areas specially dryland regions is well known. The sucking pests are on increase. The newer questions like toxicity to smaller ruminants and soil microbes, are raised by several scientists across the world and the farmers are complaining on this issue.

The economic analysis of NPM and Bt cotton

A study was taken up by Central Research Institute of Dryland Agriculture (CRIDA) to compare the performance of NPM in Bt and Non Bt cotton. The study showed that NPM in Non Bt cotton is more economical compared to Bt cotton with or without pesticide use (Prasad and Rao 2006)

Table-3 Comparative economics of Bt cotton vs Non Bt cotton with NPM

Strategy	Genotype	No. of chemical sprays	Cost of cultivation (Rs/ha)	Yield (kg/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)
NPM	Non Bt	0	16320	2222.5	45120	28800
NPM	Bt	0	15560	2220.0	43640	28080
Control	Non Bt	5.0	16400	2087.5	41240	24840
Control	Bt	3.8	18120	2242.5	44440	26320

Source: (Prasad and Rao, 2006)

4. Successful case studies

4.1. Punukula: The Pesticide Free Village

Punukula a small quite village in Khammam district in Andhra Pradesh (AP) created waves by local Panchayat (local self government body) formally declaring itself pesticide-free in 2003. Farmers here gave up using chemical pesticides even for crops such as cotton, chilli and paddy — all known to use notoriously high quantities of pesticides.

From 1986 onwards the State witnessed farmers' suicides due to indebtedness. During 1997-98 several farmers have committed suicides after the cotton crop failed in Telangana region. An estimated 1,200 suicide deaths were reported between June and August 2004. One of the reasons for the rise in suicides has been the crushing burden of debt; many farmers buy expensive seeds and pesticides and when the crops fail, their own survival becomes difficult. Against this scenario the pesticide-free status of the predominantly tribal village of Punukula gains significance.

The Punukula farmers claim that they are able to save up to Rs.30 lakhs every year on agricultural inputs by adopting Non Pesticidal Management approach towards pest management. There is a total of 240 ha of farmland; and on every hectare, they have been able to save at least \$ 300 per season, as they don't have to buy expensive pesticides.

Farmers learned using pesticides from the farmers who brought cotton crop to Punukula from Guntur dist. 15 years ago. Initially, the pesticides worked well and several pesticide shops were opened in the nearby town of Palvancha. Pesticide dealers also gave local farmers the latest pesticides on credit. But gradually, the pests became resistant to these pesticides. Monocrotophos, methyl parathion, chlorpyrifos, endosulfan and synthetic pyrethroids... nothing seemed to work. The pests would only come back in greater numbers. Pretty soon, the cotton crop needed greater quantities of pesticides, which meant a higher investment.

In addition to supplying seeds, fertilisers and pesticides, the dealers also lent money to the hapless farmers at high interest rates.

But when yields started reducing — due to pests — and debts increased, some farmers in Pudukkula committed suicide. The high use of pesticides also posed health-related problems. Women, who did most of the pesticide spraying work, complained of skin problems, blurred vision and body ache.

In 1999, the Socio-Economic and Cultural Upliftment in Rural Environment (SECURE), a local NGO, stepped in and suggested that the farmers try out non pesticidal approaches for pest management. Technical and financial support for this project initially came from the Centre for World Solidarity (CWS) and later from the Centre for Sustainable Agriculture (CSA), both based in Hyderabad. However, the determination and support of five self-help groups (SHGs) run by the village women contributed towards making this shift to ecological methods possible.

SECURE initially began work with 20 farmers, including a few women. Earla Dhanamma, whose husband Nagabhushanam represented the interests of several pesticide companies, also joined in. The farmers were sceptical in the beginning. But the method of preventing pest attacks by understanding the pests' life cycles did appear both simple and affordable. Instead of chemical sprays, the farmers began preparing sprays made with local and inexpensive material such as neem seed powder and green chilli-garlic extract. The farmers also used pheromone traps to attract moths and destroyed them before they started mating. Some farmers also used 'crop traps': along with the cotton crop they would grow another crop (marigold or castor) that attracted the pests more.

In just one season, the positive results began to show: Useful insects such as spiders, wasps and beetles — which feed on cotton pests — returned to the fields once the chemical

pesticides were stopped. In the next season, many other farmers came forward to try out the new approach. However, there were several men in the village who found it easier to buy a container of chemical pesticide from a pesticide dealer than go through the trouble of preparing extracts to control pest population.

But the women's SHGs prevented these men from going back to pesticide shops. Others also realised that pesticides meant higher debts as well as high medical costs. The women even took on the additional work of preparing the anti-pest sprays from neem and chilli-garlic paste. They also ensured that no one brought pesticides into their village.

By 2003, most farmers in this 200-household village had stopped using harmful chemical pesticides. Pesticide dealers stopped coming to the village as sales dropped dramatically. Besides covering 160-odd ha of cotton, the new method was also used in fields growing chilli and paddy. No pesticides were sprayed on the 240-odd acres of farmland during the 2003 kharif (post-summer) season. Even during the first crop season of 2004, no pesticides were required.

In August 2004, the women's groups also bought a neem seed crushing machine (extracts for the sprays are prepared from the powder) with support from SECURE and CWS/CSA.

Today, Pudukula has become a role model for other villagers who are inspired and impressed by its healthy crops. Around Pudukula many villages are inspired to give up chemical pesticide usage.

Pudukula farmers now have the money to invest in house repair livestock and buy land. Most farmers say their incomes are higher, enabling them to repay old debts. The villagers now firmly believe that the way to get rid of pests is to rid their farming of pesticides.

Table-4. Economics of NPM in Cotton Punukula village (Kharif, 2001-02)

(On 6.4 ha, with 8 farmers in Punukula)

Particulars	NPM	Conventional*
Avg. Yield (kg/ha)	1575	1450
Cost of plant protection (\$ US/ha)	4300	8595.2
Net income (\$ US/ha)	3420	-5200

* Conventional pesticide used cotton from neighboring village

For the agricultural laborers also, things have improved on many fronts. There was a wage increase from 75 cents to one dollar during the corresponding period [when NPM was practiced]. They do not have to be exposed to deadly pesticides now, nor incur medical care expenses for treatment of pesticides-related illnesses. Some point out that there is even more work for the labourers – in the collection of neem seed, in making powders and pastes of various materials and so on. Farmers are even leasing in land and putting all lands under crop cultivation these days – this implies greater employment potential for the agricultural workers in the village.

Source: (<http://www.thehindubusinessline.com/life/2004/10/08/stories/2004100800030200.htm>)

4.2 Enabavi: A Whole Village Shows the Way

Enabavi is probably the first modern-day organic farming village in Andhra Pradesh. The entire village, in each acre of its land, on every crop grown here, has shunned the use of chemicals in agriculture. They neither use chemical fertilizers nor chemical pesticides in their farming. This in itself meant a tremendous saving for the village in monetary terms. This small village in Lingala Ghanpur of Warangal district shows the way out of agricultural distress that almost all farmers find themselves in today.

Warangal district presents a classic paradox of an agriculturally developed district [with most area occupied by commercial crops] showing the worst manifestation of the distress of farmers – that of the highest number of suicides in the state in the past decade or so. It is a district where farmers' frustration with lack of support systems manifests its self in almost-spontaneous and seemingly-well-planned agitations of unorganized farmers. Farmers in this district are known to have resorted to violence to end their problems, including resorting to a violent end to their own lives.

Enabavi is a small village which showed the resolve of a strong community which decided to take control of its agriculture into its own hands. With just 45 households in the village belonging mostly to the backward castes, the village started shifting to non-chemical farming about five years ago. Then in 2005-06, the entire land of 113 ha was converted to organic farming. This is not organic farming as you would normally expect. No expensive external certification here. It is a model of “declared organic farming”. Though there are no formal participatory guarantee systems established in the village in this alternative model of organic farming, there is strong social regulation within the community to ensure that there are no ‘erring farmers’. The elders in the village take the youth along with them. They also have started investing in teaching their school-going children the knowledge and skills of non-chemical farming. Special training sessions have been organized by CROPS to rope in children into this new system of cultivation in the village.

The farmers here grow their food crops of paddy, pulses, millets etc., mostly for household consumption. In addition, they also grow crops like cotton, chilli, tobacco

and vegetables for the market. Their average spending on chemical fertilizers and pesticides across crops used to be around Rs.11000 per ha, while it was around Rs. 1250/- per ha for seeds and this more often than meant credit from the input dealers, who would also double up as traders for the produce. These traders would dictate the price for the produce in addition to charging interest for the inputs supplied. Now, all of this has changed.

The process of change began with a programme that CWS had initiated to control the dreaded Red Hairy Caterpillar, in the late 90s. This was followed by converting all crops to the NPM. Later, some farmers came forward to shift from chemical fertilizers to other methods of soil productivity management. They started looking for other options like tank silt application, poultry manure application, vermin-compost, farm yard manure etc. CROPS stepped in at this point of time and subsidized the costs up to 50% for tank silt application and setting up vermicompost units. The farmers set up their units at their fields and started following various ecological practices being recommended to them. They also started to depend on their own seed for many crops, except for crops like cotton. They set up farmers' self help groups for men and women separately and started thrift activities too.

Today, Enabavi has many valuable lessons to teach other farmers, not just on how to take up sustainable farming. They also have lessons to share on social regulation, learning from each other, the benefits of conviction born out of experience and most importantly, the way out of agricultural distress by taking control over one's own farming.

5. NPM scaling up with SERP

Society for Elimination of Rural Poverty (SERP) is a registered society under Department of Rural Development implementing the largest poverty alleviation project in the state of Andhra Pradesh. The project understands that sustainable poverty eradication requires the recognition of the poor as active partners in the processes of social change; therefore all project interventions are demand based and are in response to the proposals conceived and planned by the poor.

SERP works towards empowering the poor to overcome all social, economic, cultural and psychological barriers thru self managed institutions of the poor. The project reaches the rural poor families thru social mobilization processes and formation of SHGs, federation of these into Village Organizations at village level and Mandal Samakhyas at the mandal level. The project envisages that with proper capacity building the poor women's federations would begin to function as self managed and self reliant people's organizations. The poor have started to demonstrate that they can shape their own destinies when adequate knowledge, skills and resource support is accessible to them.

In this context SERP initiated to work on agriculture based livelihoods supporting them to adopt sustainable agriculture practices to reduce the costs of cultivations. Learning from the experiences of villages like Punukula SERP initiated scaling up of NPM in collaboration with a consortium of Non Governmental Organizations and technical support provided by Centre for Sustainable Agriculture (CSA).

5.1 Critical issues in scaling up

While the sustainable models in agriculture like NPM are established on smaller scale scaling up these experiences poses a real challenge in terms of

- Relevance of small experiences for a wider application
- Availability of resources locally
- Farmers willingness to adopt these practices
- Lack of institutional and support systems
- Supplementing farmers' Knowledge and enhancing the skills
- Reducing the time of transformation
- Reaching to larger areas with minimal expenditure
- Establishing extension system which give community a central stage

5.2 Process of NPM scaling up

During December, 2005 a small pilot was launched in Kosigi Mandal (Blocks in Andhra Pradesh) as a livelihood intervention with the help of WASSAN. Farmers were trained systematically and technical support provided in the form of coordinators who were accountable to the Women SHGs. In 90 ha, average savings of Rs.3000/ha on pigeon pea the total savings were Rs.275000 (WASSAN, 2006).

5.2.a. Grounding the work 2005-06

Based on the experiences drawn from the pilot, program for 2005-06 initiated by establishing clear institutional system and a community managed extension system in nine districts of AP. Five villages were grouped into a cluster and are provided with a

cluster activist. Each village had a practicing farmer selected as village activist who coordinates the village level capacity building programs in the form of Farmer Field Schools. All over nine districts 12,000 farmers with 10,000 ha in both Kharif and Rabi adopted Non Pesticidal Management. Sixty two Federations of Women SHGs (Mandal Mahila Samakyas or MMS), 150 Cluster activists and 450 village activists are involved in managing the program. Each MMS entered into an agreement with This clearly established that a paradigm shift in understanding pest management both at farmers level and extension system level can effectively tackle the pest problem and also give ample benefits to farmers in terms of savings on input costs, health costs etc. Better quality products from such production systems also fetch a better price to farmers and are highly preferred by discerning consumers (refer <http://www.downtoearth.org.in/default20060531.htm>). Also, the NPM intervention for the first time shifted the control in terms of production back to the farmer (Sopan 2006).

Awareness created through state level campaign about the ill effects of pesticides and the potential alternatives – communication material created and distributed for use.

5.2.b. Case of NPM in Paddy in Kurnool dist (2005-06)

During Kharif 2005, NPM in paddy was taken up in 6 villages of 2 mandals in Kurnool district. It was successfully implemented by 57 farmers in 28.4 ha. On an average there was a saving of \$ 50 per acre in cost of plant protection compared to conventionally grown paddy. In yields, NPM farmers got additional yield of around 375 kg/ac, which may be attributed to increased number of natural enemy populations in the Rice Ecosystem that has happened due to continuous monitoring and timely

interventions. In monetary terms, a net extra benefit of \$ 116 per acre was made by NPM farmers compared to non NPM farmers.

Table-5 Economics of NPM v/s conventional Paddy in Kurnool dist (2005-06)

Sl. No	Village	Farmers		Area (ha)		Costs of plant protection (Rs/ha)		Yield (q/ha)	
		NPM	Con	NPM	Con	NPM	Con	NPM	Conventional
1	Arlagadda	16	15	8.4	12	400.0	2525.2	56.83	56.13
2	Durvesi	5	15	5.2	59.4	490.4	3116.8	61.87	65.5
3	Bhupanapadu	4	5	1.6	2	440.0	2000.0	56.25	58.87
4	Alamuru	17	23	7.6	10	480.0	3240.0	55.45	53.8
5	Konidedu	6	9	2.4	3.8	520.0	2280.0	64.05	50.12
6	Panyam	5	9	2	3.6	724.8	2680.0	64.5	48.13
	Total								

(Source: Annual Report, NPM, 2005-06)

Each participating farmer saved up to Rs. 6400 to Rs.12400 per ha on an average (average across crops and across districts) on pest management expenses. With more area and more farmers coming into the program the saving will be higher. The ecological and other benefits would be enormous.

Nearly 30 neem seed powder units were established with SHGs along with 15 NPV units as village enterprises.

Table-6 Economics of NPM across crops (2005-06)

Crop	Cost of Plant protection (Rs/ha)		Saving (Rs/ha)
	Conventional	NPM	
Cotton	12600	2520	10080
Chillies	37600	5000	32600
Pigeon pea	3760	800	2960
Groundnut	3760	800	2960
Castor	5000	1000	4000
Paddy	5000	600	4400

(Annual reports of NPM 2005-06)

The benefits are not only seen in areas of high pesticide use but in areas of low pesticide use. The crop could be saved from the pests and diseases and managed well instilling new interest in the farmers.

Table-7 Reduction in costs of pest management in Ananthapur, 2005-06

S.NO	Village	No.of. Farmers	NPM area (in ha) (2005-06)	2003-04 Pesticide usage (in lit)	Value of pesticides (Rupees)	Value of NPM extracts (Rs)	Total saving (Rupees)
1	Chinnajalapuram	39	73	7,000	540000	54600	485400
2	Madirepalli	36	56	5,000	400000	44480	355520
3	Guruguntla	36	42	4,687	656000	36400	619600
	Total	111	171	16,687	1596000	135480	1460520

Source: (Annual Report, NPM 2005-06)

The experiences during 2005-06 clearly showed the benefit of moving towards non chemical approaches in agriculture and farmers were enthused by these approaches. SERP has organized a state level mela at Krishi Vigyan Kendra, Banaganpalli along with scientists from Agriculture University, ICAR institutions and KVKs.

5.3. Moving to Community Managed Sustainable Agriculture

The successful grounding of NPM during 2005-06 has given important learning on how any ecologically sound and economically benefiting technology can be scaled up by providing proper institutional support. During 2006-07 more farmers in the same villages and more villages in the same districts and few newer districts joined the program. The program covered 1250 villages in 17 districts covering wide variety of crops from groundnut, paddy to chillies and cotton. Program expanded to districts like Guntur where the pesticide problem is serious and north coastal Andhra Pradesh where the productivities are in general low. The program is implemented in Adilabad, Ananthapur, Chittoor, Guntur, Kadapa, Karimnagar, Khammam, Kurnool, Mahaboobnagar, Medak, Nalgonda, Nellore, Ranga Reddy, Srikakulam, Visakhapatnam, Vijayanagaram and Warangal. Program covered more than 80,000 farmers cultivating about 80 thousand ha. In addition to pest management initiations on soil productivity management and seed management have begun on a small scale. Agriculture credit from formal banks was mobilised in 3 districts to the tune of 120 lakhs

In addition to NPM, efforts were initiated to establish seed networks so that farmers produce and share their seed. Seed banks are implemented in 100 villages where

farmers could retain, replace, reuse and revive seed and are managed by the community. The pilot in Ananthapur has shown good results. In addition efforts are also began to have non chemical soil productivity improvement practices based on the experiences of the villages like 'Yenabavi' in Warangal which became the first organic village in the state.

During 2006-07 while the institutional systems are further strengthened focus was also given to specific commodities like paddy in Kurnool dist, Groundnut in Kurnool, Pigeon pea in Mahaboobnagar, cotton in Warangal and Khammam and Chillies in Guntur. The marketing links were established. The NPM products were in demand and could command premium in the market. The local processing and marketing of the commodities have also brought in additional benefits to the farmers.

This scalingup experience in AP has broken the myth that pesticides are inevitable in agriculture and also given important lessons on the paradigm shift in technology, institutional systems and support systems required for sustaining agriculture especially of small and marginal farmers.

During 2007-08 the program is further expanded to cover 1,800 villages in 18 districts. There are more than 350 thousand participating farmers cultivating 280 thousand ha. In the villages which are in second year, works on soil productivity management with local resources and local seed management have been planned.

- Special focus on certain commodities to deal with post harvest management to increase the value of the commodities. This year village level quality control centers are initiated in chilli producing villages.

- The marketing Community Resource Persons working with women SHGs were also trained in NPM and in 50 clusters (250 villages) they started motivating farmers to adopt NPM practices.
- Best performing villages are identified as resource villages and best practicing farmers are identified as community resource persons who will help in further scaling up of the program.
- Community Seed Banks where farmers produce, save, share and use their own quality seed would be established in 70 villages.
- Program will also be integrated with other ongoing programs like National Rural Employment Guarantee Program (NREGP) to provide further employment opportunities to the agriculture workers.
- Total program expenditure is coming to about \$ 11 US/ha

The State government proposed to scale up NPM into organic farming in 5000 villages over next five years covering 10 million ha with an outlay of \$ 45.5 million US. The proposal has been accepted under Additional Central Assistance from Prime Minister's package for distress states called Rastriya Krishi Vikas Yojana.

5.4. Conclusions

The pests and pesticides have seriously affected the farm based livelihoods in rural areas. The last three years experience shows that moving towards local resource based sustainable agriculture as the only way to sustain the livelihoods of small and marginal farmers and Community Based Organizations like Federations of women self help groups form an excellent institutional platform for scaling up such models. To sustain agriculture and agriculture based livelihoods, this calls for a complete paradigm shift in the way agricultural practices are understood, developed, promoted and supported. The new paradigm is based on the local resource based technologies and a community managed extension systems.

References

AGRAU 2001, 2006, 2007. *Vyavasaya Panchangam* (Annual Calender of crop production practices in Telugu), published by Acharya NG Ranga Agricultural University, Hyderabad.

Chitra Grace, A., Muraleedharan, V. R., Swaminathan, T., and Vijayaraghavan, D. 2006. *Use of Pesticides and Its Impact on Health of Farmers in South India* Int J Occup Environ Health; (12) 228–233

CIRAD-FAO, 2000. *Food Safety Management in Developing Countries*, Proceedings of the International Workshop, 11-13 December 2000, Montpellier, France, CIRAD-FAO. CIRAD Montpellier, France.

CSA, 2006. *Annual Report NPM, 2005-06*, unpublished report by Centre for Sustainable Agriculture, Hyderabad.

CSA, 2007. *Annual Report NPM, 2006-07*, unpublished report by Centre for Sustainable Agriculture, Hyderabad.

CSA, 2007. *Susthira Vyavasayam lo vividha padarthala Tayari* (Telugu), (Various preparations in sustainable agriculture) published by Society for Elimination of Rural Poverty, Government of Andhra Pradesh

CWS, 1994. *Non Pesticidal Management in Crops*, Proceedings of the Workshop organized by CWS and NAARM.

CWS, 1998. *Non Pesticidal Management*, Proceedings of the Workshop organized by CWS and MANAGE.

Down to Earth, 1997. *Toxic Substances in the Human Environment*, Vol 5, No 19.

Fakrudin, B., Vijaykumar, Krishnareddy, K.B., Patil, B.V., Kuruvinashetty, M.S., 2004. *Status of Insecticide Resistance in Geographical Populations of Cotton Bollworm, Helicoverpa armigera in South Indian Cotton Ecosystem During 2002-03*. Resistant Pest Management Newsletter, 13(2).

Fox E. Jennifer, Jay Gullede, Erika Engelhaupt, Matthew E. Burow, and John A. cLachlan, 2007. *Pesticides reduce symbiotic efficiency of nitrogen-fixing rhizobia and host plants*, PNAS, June 12, 2007, vol. 104 _ no. 24 ; 10282–10287, www.pnas.org/cgi/doi/10.1073/pnas.0611710104

GAU, 2003. *Non Pesticidal Management of Brinjal Fruit and Shoot Borer*, technical bulletin, Department of Entomology, Gujarat Agriculture University.

GEAC, 2005. *Proceedings of 53rd Meeting of GEAC*, Ministry of Environment and Forests, Government of India <http://moef.gov.in/enfor/geac.html>

IRAC, 2007. IRAC Resistance: *The Facts - History & overview of resistance* www.irc-online.org accessed on 10th September, 2007.

Karant. N. G. K. 2002. *Challenges of Limiting Pesticide Residues in Fresh Vegetables: The Indian Experience* in E. Hanak, E. Boutrif, P. Fabre, M. Pineiro, (Scientific Editors), 2002.

Kavitha Kuruganti, 2005. *Effects of Pesticide Exposure on Developmental Task Performance in Indian Children*, *Children, Youth and Environments* 15(1): 83-114. Retrieved from <http://www.colorado.edu/journals/cye>.

Kavitha Kuruganti, 2005. *Killing or poisoning: Pests or human beings?* Centre for Sustainable Agriculture, Hyderabad, <http://www.csa-india.org>.

Kenmore, Peter. 1980. *Ecology and Outbreaks of a Tropical Insect Pest of the Green Revolution: The Rice Brown Planthopper, Nilaparvata lugens (Stal)*. Berkeley: University of California, Graduate Division.

Kenmore, Peter. 1996. *Integrated pest management in rice*. in *Biotechnology and Integrated Pest Management* 76–97, (Ed. G. Persley). Wallingford: CAB International.

Kenmore, Peter. 1997. *A Perspective on IPM*, LEISA Magazine, December, 1997

Konradsen Flemming A, Wim van der Hoekb, Donald C Cole C, Gerard Hutchinson Hubert Daisley D, Surjit Singh E, Michael Eddleston F.G. 2003. *Reducing acute poisoning in developing countries—options for restricting the availability of pesticides*, *Toxicology* 192 (2003) 249–261

Kranthi, K.R., Jadhav, D., Wanjari, R., Kranthi, S., Russell, D. 2001a. *Pyrethroid Resistance and Mechanisms of Resistance in Field Strains of Helicoverpa armigera (Lepidoptera: Noctuidae)*. Journal of Economic Entomology, 94(1), 253-263.

Kranthi, K.R., Jadhav, D.R., Wanjari, R.R., Ali, S.S., Russell, D. 2001b. *Carbamate and organophosphate resistance in cotton pests in India, 1995 to 1999*. Bulletin of Entomological Research (91), 37-46.

Kranthi, K.R., Naidu, S., Dhawad, C.S., Tatwawadi, A. Mate, K., Patil, E., Bharose, A.A., Behere, G. T., Wadaskar R. M., and Kranthi, S. 2005 *Temporal and intra-plant variability of Cry1Ac expression in Bt-cotton and its influence on the survival of the cotton bollworm, Helicoverpa armigera (Hübner) (Noctuidae: Lepidoptera)*

KVK DDS *Annual Report* unpublished report by Krishi Vigyan Kendra, Pasthanpur.

KVK HCT, 2006. *Annual Report NPM, 2005-06*, unpublished report by Krishi Vigyan Kendra, Banganpalli.

Lightfoot, C., Ramirez, R., Groot, A., Noble, R., Alders, C., Shao, F., Kisauzi, D. and Bekalo, I. 2001. *Learning OurWay Ahead: Navigating Institutional Change and Agricultural Decentralisation*. Gatekeeper Series no. 98. London: IIED.

Mancini Francesca, Ariena H. C. Van bruggen, Janice I. S. Jiggins, Arun c. Ambatipudi, Helen Murphy. 2005. *Acute Pesticide Poisoning among Female and Male Cotton Growers in India*, Vol 11/No 3, Jul/Sep 2005 www.ijoh.com

Mancini Francesca, Ariena H.C., Van Bruggen and Janice Jiggins, L.S. 2007 *Evaluating Cotton integrated pest Management (IPM) farmer field school Outcomes using the sustainable livelihoods Approach in India* Expl. Agric., volume 43, pp. 97–112 C_ 2006 Cambridge University Press

Mangan James and Margaret S. Mangan. 1998. *A comparison of two ipm training strategies in china: The importance of concepts of the rice ecosystem For sustainable insect pest management*, Agriculture and Human Values 15: 209-221.

Mathur, HB H. C, Agarwal, Sapna Johnson, Nirmali Saikia. 2005. *Analysis of pesticide residues in blood samples from villages of Punjab*, Centre for Science and Environment, New Delhi.

PMRA -Regulatory Directive DIR99-06, 1999. *Voluntary Pesticide Resistance-Management Labelling Based on Target Site/Mode of Action*, published by Pest Management Regulatory Agency, Canada www.hc-sc.gc.ca, <http://www.irac-online.org/>

Prakash, A.; Rao, J. 1997: *Botanical pesticides in agriculture*. CRC Press. USA.

Prasad, Y.G. and Rao, K.V. 2006. *Monitoring & Evaluation: Sustainable Cotton Initiative in Warangal District of Andhra Pradesh*, Central Research Institute for Dryland Agriculture, Hyderabad, unpublished report.

Qayum, M.A. and Sanghi, N.K. 1989. *Red Hairy Caterpillar Management through Group Action and NPM Methods*, Report published by ASW and OXFAM.

Ramanajneyulu, G.V. and Zakir Hussain. 2007. *Redefining Pest Management: a case study of Pudukula* in 'Sustainable Agriculture-a pathway to eliminate poverty', published by SUSTAINET, GTZ.

Ramanjaneyulu GV and Kavitha Kuruganti, 2006. *Bt Cotton in India: Sustainable Pest Management?* Economic and Political weekly 18th May, 2006

Ramanjaneyulu, G.V, Kavitha Kuruganti and Zakir Hussain, 2004. *No Pesticides No Pests*, published by Centre for Sustainable Agriculture <http://www.csa-india.org>.

Ramasubramanyam, T. 2004. *Magnitude, Mechanism and Management of pyrethroids Resistance in Helicoverpa armigera (Hubner) in India*. Journal of Entomology 1 (1): 6-11.

Rao G.M.V.P., Rao, N.H. and Raju, K. 2005. *Insecticide Resistance in field populations of American bollworm, Helicoverpa armigera Hub. (Lepidoptera: Noctuidae)* Resistant Pest Management Newsletter, 15(1), 15-17.

Rupela, O.P., Gowda, C.L.L., Wani, S.P., and Hameeda Bee, 2007. *Evaluation of Crop Production Systems Based on Locally Available Biological Inputs* in *Biological Approaches to Sustainable Soil Systems* edited by Norman Uphoff, 2007.

Settle, W.H., H. Ariawan, E.T. Astuti, W. Cahyana, A.L. Hakim, D. Hindayana, A. Sri Lestari, Pajarningsih, and Sartanto. 1996. *Managing Tropical Rice Pests through Conservation of Generalist Natural Enemies and Alternate Prey*, *Ecology*, 77 (7). Pp. 1975-1988.

Sopan Joshi, 2006. *Out of Trap, Down to Earth*, July, 2006
<http://www.downtoearth.org.in/default20060531.htm>

Srinivas Rao, Ch., Venkateswarlu, V., Surender, T., Michael Eddleston, and Nick A Buckley. 2005. *Pesticide Poisoning in South India – Opportunities for Prevention and Improved Medical Management*, *Trop Med Int Health*. 2005 June ; 10(6): 581–588.

Timothy Kropp, Richard Wiles, Sean Gray and Chris Campbell. 2005. *Body Burden, The Pollution in Newborns* Environmental Working Group, Washington DC.
<http://www.ewg.org/reports/bodyburden2/>

Vasquez-Caicedo, Gloria, Julio Portocarrero, Oscar Ortiz, and Cristina Fonseca. 2000. *Case Studies on Farmers' Perceptions about Farmer Field School (FFS) Implementation in San Miguel Peru: Contributing to Establish the Baseline for Impact Evaluation of FFS* Report to the DECRG from the World Bank, May. As quoted in by Godtland Erin, Elisabeth Sadoulet, Alain de Janvry, Rinku Murgai and

Oscar Ortiz (2003) The Impact of Farmer-Field-Schools on Knowledge and Productivity: A Study of Potato Farmers in the Peruvian Andes, Department of Agricultural & Resource Economics, UCB CUDARE Working Papers (University of California, Berkeley)

Vijayalakshmi, K.; Subhashini, B.; Koul, S. 1999. *Plants in Pest Control: Pongam, tulasi and aloe*. Centre for Indian Knowledge Systems, Chennai, India.

WASSAN, 2006. Non Pesticidal Management, <http://www.wassan.org>

Way, M.J. and Heong, K.L. 1994. *The Role of Biodiversity in the Dynamics and Management of Insect Pests of Tropical Irrigated Rice: A Review*. Bulletin of Entomological Research, 84. Pp. 567-587.

Wu, J., G. Hu, J. Tang, Z. She, J. Yang, Z. Wan, and Z. Ren. 1994. *Studies on the Regulation Effect of Neutral Insects on the Community Food Web in Paddy Fields*. Acta Ecologica Sinica 14 (4).

Abbreviations used

CIBRC	Central Insecticide Board and Registration Committee
CSA	Centre for Sustainable Agriculture
CWS	Centre for World Solidarity
ETL	Economic Threshold Level
FAO	Food and Agriculture Organisation
FFS	Farmer Field Schools
IARI	Indian Agriculture Research Institute
ICAR	Indian Council for Agriculture Research
IPM	Integrated Pest Management
KVK	Krishi Vigyan Kendra (Farm Science Centres)
MMS	Mandal Mahila Samakya (Federation of Women Self Help Groups)
NPM	Non Pesticidal Management
RHC	Red Hairy Caterpillar
RMG	Rytu Mitra Group (Farmers group)
SERP	Society for Elimination of Rural Poverty
SHGs	Self Help Groups
TMC	Technology Mission on Cotton
TMOP	Technology Mission on Oilseeds and Pulses
WASSAN	Watershed Support Services and Activities Network

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