Integrated Pest Management: Advancement, Adoption and Ecological Challenges
DOI: https://doi.org/10.54083/978-81-986377-3-4_05

Chapter 5

Non-Pesticidal Management Techniques in Agriculture

Navendu Nair

Dept. of Agricultural Entomology, College of Agriculture, Lembucherra, Tripura (799 210), India

Abstract

Chemical pesticides are not only toxic to pests but also to other non target organisms like fish, birds, amphibians, reptiles, beneficial insects and mammals. There are several pesticide associated problems like residue in food, health hazards, environmental pollution, development of resistance in pests, resurgence of pest, secondary pest outbreak, increase in cost of cultivation, *etc.* Therefore, use of alternatives to conventional pesticides in pest management for sustainable agriculture is essential. Non-Pesticidal Management (NPM), which is a promising approach, emphasizes on ecological principles of pest management. NPM is a sustainable and environmentally safe plant protection system in Agriculture. NPM involves various strategies in a compatible manner to manage agricultural pests but totally eliminates the use of chemical pesticides for crop protection thereby eliminates risks associated with chemical pesticides. NPM system encourages farming practices with nature, promoting a healthy, residue free and resilient food system for the future.

Keywords Non-pesticidal management, NPM, Pest management, Pesticide poisoning

1. Introduction

Chemical pesticides are toxic and used for controlling pests. Only the pesticides registered with the Central Insecticides Board and Registration Committee (CIBRC) are recommended for use in India. As per Good Agricultural Practices (GAP) use of chemical pesticide is suggested only when the insect population is in damaging stage *i.e.*, Economic Threshold Level (ETL). However, repetitive use of same pesticides or pesticides with same mode of action creates selection pressure in pests resulting in development of resistance in them. As a result, the pesticides become ineffective and farmers usually increase the dose or opt for newer one. Moreover, indiscriminate use of chemical pesticides has several associated problems like residue in food, health hazards, environmental pollution, killing of non-target organisms

*Corresponding author's e-mail: navendunair@gmail.com

How to cite:
Nair, N., 2025. Non-pesticidal management techniques in agriculture. In: *Integrated Pest Management: Advancement, Adoption and Ecological Challenges.* (Ed.) Sehgal, M. Biotica Publications, India. pp. 72-86. DOI: https://doi.org/10.54083/978-81-986377-3-4_05.

including beneficial insects, development of resistance in pests, resurgence of pest, secondary pest outbreak, increase in cost of cultivation, *etc.* There are several reports on pesticide poisoning to human beings due to indiscriminate use of pesticides from many places like Batinda in Punjab (Mathur *et al.*, 2005), Warangal in Andhra Pradesh (Kavitha, 2005a,b; Mancini *et al.*, 2005), Tanjavur in Tamil Nadu (Chitra *et al.*, 2006), *etc.* Reports on the chronic effects of the chemical pesticides on the farmers and consumers (Mathur *et al.*, 2005) and growth and development of children (Kavitha, 2005a; Timothy *et al.*, 2005) are also there. Small and marginal farmers are not always able to follow the "safe use practices of pesticides" due to the socio economic and environmental conditions in which they work (Kavitha, 2005b). Being a poison the manufacture, storage, transport and use of chemical pesticides must be in accordance with the Insecticides Act, 1968 and the Insecticides Rules, 1971. Any intentional or accidental deviation may results in larger ecological consequences in manufacturing (*e.g.*, Bhopal gas tragedy), transport, storage and usage. Moreover, not the entire amount of pesticides used reaches to the target site and the major amount pollutes the environment. Some proportion of pesticides used remain as residues in and/or on the produce which enters into the food chain and cause health hazards to human beings and other living organisms (Karanth, 2002; Kavitha *et al.*, 2007). The pesticide residues are even noticed in human milk (Down to Earth, 1997). Common pesticides block the chemical signals that allow nitrogen-fixing bacteria to function. As a result, soils surrounding treated plants may become low in nitrogen content, so more fertilizer is needed to produce the same yield (Fox *et al.*, 2007). Therefore, use of alternatives to conventional pesticides in pest management for sustainable agriculture is essential. Non-Pesticidal Management (NPM), which relies on ecological principles of pest management, is a potential approach in promotion of natural pest control mechanisms, protecting biodiversity and, eliminating reliance on chemical pesticides. NPM is a sustainable and environmentally safe plant protection system in Agriculture.

2. What is Non-Pesticidal Management (NPM)?

NPM is an ecological approach to pest management without the use of chemical pesticides. Like Integrated Pest Management (IPM) system, the NPM involves various strategies in a compatible manner to manage agricultural pests but totally eliminates the use of chemical pesticides for crop protection thereby eliminates the chances of pesticide associated problems. Therefore, NPM is a sustainable and environmentally safe crop protection practice.

3. Importance of NPM

• Conventional pest management system with pesticide use is associated with various adverse effects on human health as well as non target organisms. NPM approach reduces the exposure of farmers, consumers and environment to harmful chemical pesticides.

• NPM emphasizes agro-ecological practices, promotes natural pest control mechanisms and thereby helps in maintaining biodiversity and ecological balance.

• Injudicious use of chemical pesticides often leads to development of resistance in pests to pesticides, pest resurgence and secondary pest outbreak forcing the farmers to increase the doses of pesticides which aggravate the problem resulting in increased cost of cultivation as well as health hazards. NPM provides a solution to these pest and pesticide related problems by eliminating reliance on pesticides.

• Eliminating over reliance on chemical pesticides, NPM approach is useful in reduction of cost of cultivation.

• Principles of NPM align with that of organic farming which prioritizes sustainability of agricultural system ensuring a sustainable and residue free food supply for future generations. The concept of organic farming totally eliminates the use of chemicals in crop production. Shifting from conventional to organic farming takes a long time and is also expensive. Moreover, the small and marginal farmers follow the conventional farming practices. Non-pesticidal management (NPM) bridges the gap between the two.

4. Principles of Non-Pesticidal Management

4.1. Residue Free Food

Pesticides are also toxic to humans and other non target organisms like fish, birds, amphibians, reptiles, beneficial insects and mammals. However, several advantages of chemical pesticides in pest control like ready availability, quick action, effectiveness and ease in handling make them the first choice amongst majority of farmers. Excess of pesticide residue in food is injurious to health. Non-Pesticidal Management (NPM) is an ecological approach of pest management to produce residue free foods.

4.2. Environmental Sustainability

Drift problem associated with dusting and spraying of chemical pesticides always results in environmental pollution by contaminating soil, water and vegetation leading to health hazards and reduction of biodiversity. NPM ensures environmental sustainability as it eliminates use of chemical pesticides and thereby eliminates any chances of environmental pollution and pesticide poisoning.

4.3. Economic Sustainability

NPM not only produces pesticide-free food, but also reduces the input costs. Farmers may also fetch some extra income for their residue free products.

5. Strategies for Non-Pesticidal Management

NPM can be successfully implemented by achieving one of these three goals or some combination of them.

Prevention - Certain environmental conditions at micro level in crop fields

are favourable for population build up of certain pests. Modification of such micro climate can prevent the pest from becoming a serious one. Use of some deterrents like reflective plastic mulches or some plant extracts prevent the pests from harbouring on the host plants thereby prevents expected crop loss by the potential pests. Barriers around the crop or particularly around the economic parts of the plants like fruits prevent pest attack. Growing of resistant varieties is a wise proposition in preventing crop loss by the endemic pests.

Suppression - Mere occurrence of an insect (minor pests) on the host plant does not warrant any control operation in many pest situations. In case of moderate and major pests also the intention must be to reduce the number of pests so that the harm caused by them becomes acceptable. In this case suppression and prevention often are joint goals. The right combinations of several control measures are often necessary to suppress the critical and key pests already present.

Eradication - Eradication of entire pest population is attempted when a foreign pest has been accidentally introduced but is not yet established in an area. Such eradication strategies are supported by the Government.

Following are the strategies for achieving the above mentioned goals in a successful NPM programme.

5.1. Monitoring and Correct Pest Identification

Monitoring and correct pest identification helps in deciding whether management is needed. Knowledge about the current pests and crop situation is helpful in selecting the best suitable combinations of the pest management methods. Proper knowledge about the pest and the factors that influence its development and spread is essential for formulating successful pest management strategy. Monitoring of environmental conditions (biotic and abiotic factors) through agro-ecosystem analysis (AESA) in the crop field is also necessary in the decision making process. Approaches for managing pests are often grouped in the following categories.

5.2. Cultural Pest Control

Cultural controls are some agronomic practices that reduce pest establishment, development and dispersal. It includes regular farm operations in such a way which make crop environment less susceptible to pests and prevent pest establishment and build up.

Examples of some cultural practices are as under.

• Preparation of nurseries or main fields free from pest infestation by removing plant debris, trimming of bunds, soil solarization and deep summer ploughing.

• Pest resistant varieties should be selected whenever available in order to protect against key pests. It is the best strategy against pests. Tolerant varieties also help in a successful pest management programme.

• Balanced dose of manures and fertilizers should be applied on the basis

of soil testing reports.

• Selection of disease free certified seeds and treating seeds with bio-pesticides before sowing.

• Growing of healthy plants is the first defense mechanism against pest and diseases.

• Adjustment of time of sowing and harvesting to escape peak season of pest attack.

• Synchronous planting/sowing should be done as staggered planting offers habitat and food to the pest organisms for a prolonged period leading to pest population build up.

• Crop rotation with non-host crops helps in reduction of pest - disease incidence.

• Proper plant spacing makes plants less susceptible to pests.

• Integrated Nutrient Management should be practiced with optimum use of fertilizers, Manures and Bio-fertilizers. Use of Neem cake acts as a source of nutrients to the plants as well as is helpful in controlling soil dueling pests.

• Proper water management i.e. irrigation and drainage as and when required help in reducing pest incidence.

• Proper weed management as the weeds are alternate hosts of many pests and also compete with crop for nutrients, moisture, light and space.

• Growing trap crops (most preferred host plants of the pests) on the border of the fields reduces the pest incidence on the main crop.

• Inter-cropping or multiple cropping wherever possible as certain crops act as repellents which keep the pest species away from the preferred crops.

• Harvesting as close to ground level as possible can reduce the incidence of pests in next season as because certain developmental stages of insect pests/diseases remain on the plant parts.

• Removal of crop residue eliminates the pest from the crop field.

• Pruning operation for fruit trees is a very effective cultural practice in reducing pest incidence.

• Growing of flowering plants around the crop field attracts adults of natural enemies which facilitate natural biological control of the crop pests.

5.3. Mechanical and Physical Control

Mechanical and physical controls kill the pest directly, or prevent pest from reaching to the crop.

Examples of some mechanical and physical practices are as under.

• Removal and destruction of egg masses, larvae, pupae and adults of insect pests whenever possible and feasible.

• Collection and destruction of diseased plant parts and insect infested plant parts with the insects there in.

• Installation of bamboo cage cum bird perches in the field and placing parasitized egg masses inside it for conservation of egg parasitoids and also to facilitate predatory bird in natural control of pests.

• Use of reflective poly mulch to deter some pests like white fly, aphids, thrips, etc.

• Use of light traps for collection and destruction of trapped insects.

• Bon fire during evening hours can be used for killing nocturnal and crepuscular pests.

• Setting up yellow sticky traps for white flies, fruit flies, thrips, aphids, flea beetles, leaf miners and some other pests. Blue sticky traps are also available which attracts thrips.

• Pit fall traps, yellow pan water trap, bait traps are some other kind of traps which can be used for collection and destruction of some insect pests.

• Use of rope for dislodging leaf feeding larvae *e.g.* caseworm and leaf folders in the carosenised water.

• Beat- Sheet method is used in some crops like pigeonpea for dislodging insect pests from crop plants and killing of the pests.

• Bagging of fruits as per feasibility to prevent pest infestation.

• Installation of bird-scarer in the field wherever required for deterring bird pests.

• Use of pheromones/ para pheromones for mating disruption, monitoring and mass trapping. Pheromone/para pheromone lures are available for American Bollworm (*Helicoverpa armigera*), Tobacco Caterpiller (*Spodoptera litura*), Brinjal Fruit & Shoot Borer (*Leucinodes orbonalisi*), Cocoa Pod Borer/litchi fruit borer (*Conopomorpha cramerella*), Codling Moth (*Cydia pomonella*), Coffee White Stem Borer (*Xylotrechus quadripes*), Diamond Back Moth (*Plutella xylostella*), Melon Fruit Fly (*Zeugodacus cucurbitae*), Oriental Fruit Fly (*Bactrocera dorsalis*), Tomato Leaf Miner/Tomoto Pin Worm (*Tuta absoluta*), Sweet Potato Weevil (*Cylas formicarius*), Cotton Pink Bollworm (*Pectinophora gossypiella*), Sugarcane Internode Borer (*Chilo sacchariphagus indicus*), Coconut Black headed caterpillar (*Opisina arenosella*), Coconut Red Palm Weevil (*Rhynchophorus ferrugineus*), Rice Yellow Stem Borer (*Scirpophaga incertulas*), pink borer (*Sesamia inferens*), Ear cutting caterpillar (*Mythimna separata* and *M. loreyi*), Coconut Rhinoceros Beetle (*Oryctes rhinoceros*), Cotton/okra Spiny Bollworm (*Earias insulana*) and Spotted Bollworm (*Earias vittella*), Sugarcane Early Shoot Borer (*Chilo infuscatellus*), Sugarcane Stalk Borer (*Chilo auricilius*), Sugarcane Top Borer (*Scirpophaga excerptalis*), Sorghum stem borer (*Chilo partellus*), Beet army worm (*Spodoptera exigua*), Legume spotted pod borer (*Maruca vitrata*), Maize Fall Army Worm (*Spodoptera frugiperda*). Pheromone traps can be used in three ways *i.e.*, Monitoring, mass trapping and mating disruption. The majorities of females present in crop field remain unmated and lay unfertilized eggs as a result of mass trapping of males and mating disruption.

5.4. Biological Control

Biological control is the use of natural enemies *i.e.*, parasitoids, predators and pathogens to maintain pest population below the damaging level. Three techniques of biological control are Introduction, Augmentation and Conservation. Augmentation is of two types *viz.*, Inoculative release and Inundative release. New bio control agents are introduced into the environment of pest or number and effectiveness of those already present in the field are increased.

5.4.1. Parasitoids

There are some insects which lay eggs in or on the bodies of their host insects and complete their life cycles in or on host bodies as a result of which hosts are killed. Parasitoids are of different types like egg, larval, pupal, adult, egg-larval and larval pupal parasitoids. Examples are *Trichogramma* spp., *Telenomus* sp., *Apanteles* spp., *Bracon* spp., *Chelonus* spp., *Brachemeria* spp., *Xanthopimpla* sp., *Pseudogonatopus* spp., etc. Majority of parasitoids come under the order Hymenoptera. A good number of parasitoids also come under order Diptera.

5.4.2. Predators

These are free living organisms which prey upon other organisms generally smaller than their size. Examples are different species of spiders, predatory mites, predatory thrips, dragon flies, damsel flies, praying mantids, robber fly, hover fly, rove beetle, ground beetles, lady bird beetles, green lace wing, assassin bugs, big eyed bugs, insectivorous birds, *etc.* Some predatory insects (*e.g.*, lady bird beetles) and mites (*eg.*, *Amblyseius* spp.) can be mass multiplied for field release and others should be conserved for promoting natural control of crop pests.

5.4.3. Pathogens (Bio-Pesticides)

These are some micro-organisms which cause diseases in their hosts as a result of which hosts are killed. Major groups of pathogens are fungi, bacteria and viruses which are available in the market in ready to use formulations (liquid or powdered) that can be sprayed like chemical pesticides and thus known as biopesticides. Some entomopathogenic nematodes (EPNs) are also available and can efficiently control some insect pests specially soil duelers. Important examples of entomopathogenic fungi are different species of

Table 1: Examples of use of some bio-pesticides

Bioagents	Pest species	Crop	Dosage (ha)
Metarhizium rileyi	*C. medinalis*	Paddy	0.8-2.0 kg
Bacillus thuringiensis	*C. medinalis*	Paddy	0.8 kg
	H. duplifascialis	Jasmine	0.8 kg
Granulosis virus	*C. infuscatellus*	Sugarcane	250 LE
	S. excerptalis		250 LE

Metarhizium, *Beauveria*, *Hirsutella*, *Nomuraea*, etc. Among viruses, Nuclear Polyhedrosis Virus (NPV) and Granulosis Viruses (GV) are most important in respect of biological control of insect pests. Among bacteria, *Bacillus thuringiensis* (*Bt*) is most important. Among EPNs, the genera *Steinernema* spp. and *Heterorhabditis* spp. are being extensively used in IPM programme.

5.5. Different Types of Biocontrol Practices

5.5.1. Introduction

In this process, a new species of bio control agent is introduced into a locality for its establishment against its host. There are some instances when excellent control over the pest is obtained by introduction of new bio control agent from another country, which are known as classical biological control.

5.5.2. Augmentation

Natural enemies already present in the area is increased by releasing either laboratory reared or field collected bio-agents of same species in required number to suppress the pest population in that area.

Table 2: Examples of augmentation of some bio agents

Bioagents	Pest species	Crop	Time of release	Dosage (ha)	No. of times
Trichogramma chilonis	*S. incertulas*	Paddy	30 DAT	50,000	6
	C. partellus	Maize and Sorghum	30 DAS	1 lakh	6
	C. infuscatellus	Sugarcane	30 DAP	50,000	5
	C. sacchariphagus indicus		90 DAP	50,000	6
	L. orbonalis	Brinjal	-	50,000	4
Trichogramma japonicum	*S. incertulas*	Paddy	15 DAT	1 lakh	2-3
	S. excerptalis	Sugarcane	150 DAP	50,000	4-6
Trichogramma brasiliensis	*L. orbonalis*	Brinjal	-	1 lakh	6
Sturmiopsis inferens	*C. infuscatellus*	Sugarcane	30 DAP	50,000	5
	C. sacchariphagus indicus	Sugarcane	90 DAP	125 pairs	-

[**Note:** DAS: Days after Sowing; DAP: Days after Planting; DAT: Days after Transplanting]

5.5.3. Conservation

In this process, natural enemies present in the crop fields are protected and encouraged for promoting natural biological control of crop pests. Followings are the different measures of conservation.

• Collection of parasitized egg masses and placing them in bamboo cage-cum-bird perches for allowing emergence of parasitoids and withholding of pest larvae.

• In NPM system use of chemical pesticides is totally eliminated and thus natural enemies are automatically protected from getting killed by the harmful chemicals.

• Botanical pesticides are considered relatively safe to natural enemies.

• Mixed cropping and intercropping are more favourable for the natural enemies than mono cropping.

• Growing of some specific flowering plants in the border areas of crop fields attracts the adults of natural enemies.

• Growing trap crop on the borders of main fields before the actual sowing of crop to trap pest and develop natural enemies.

• Spraying of sugar solution on the crops attracts natural enemies.

5.6. Botanical Control

Extracts of several plant species possess acetogenins, alkaloids, essential oils, flavonoids, limonoids, terpenoids, *etc.* which are active against various insects in a variety of ways. Azadirachtin from *Azadirachta indica*, nicotine from *Nicotiana tabacum* and pyrithrins from *Chrysanthemum cinerariaefolium* have been most widely used in pest management. Extracts from *Pongamia glabra* and *Annona squamosa* are also very promising. Several Neem Based Formulations containing Azadirachtin have been registered and are commercially available in the market as botanical pesticides for the agricultural purpose. Botanical pesticides are considered relatively safe to non-target organisms. However, some plant products might still have some toxic effects on them.

Table 3: Promising insecticidal plant species with their properties

Plants	Active compounds	Activity
Abies balsamea	Juvabione	JH agonist
Acorus calamus	Asarone	Antifeedant
Ageratum houstonianum	Precocene, Anacylin	Anti-JH
Ajuga remota	Ajygarin	Feeding deterrent
Allium sativum	Diallyl sulfide	Repellent
Atlantia racemosa	Luvangetin	Antifeetant
Citrullus colocynthis	Cucurbitacin-B	Antifeedant
Citrus paradisi	Isolimonic acid	Oviposition deterrent

Plants	Active compounds	Activity
Clerodendron infotunatum	Clerodin	Antifeedant
Curcuma longa	Termeron	Growth inhibitor
Glycine max	Glyceollin	Antifeedant activity
Tagetes minuta	E-Ocimenone	Repellent
Ricinus communis	Ricinine	Oviposition deterrent
Medicago sativa	Butyric acid	Repellant
Ocimum basillicum	Juvocimene	JHA
Parthenium hysterophorus	Parthenin	Growth inhibitor
Piper nigrum	Piperin	Oviposition deterrent
Quassia amara	Quassin	JHA
Pongamia pinnata	Karanjin	Antifeedant, JHA

(Source: Shivkumara *et al.*, 2019)

Table 4: Neem based formulations registered under the Insecticides Act, 1968 in India

Neem formulation	Crop	Name of insect	Recommended dose per liter of water	Waiting period (Days)
Azadirachtin 0.15% EC w/w Min.	Cotton	White fly, Bollworms	3 ml L^{-1}	05
	Rice	Thrips, Stem borer, Brown plant hopper, Leaf folder	3-5 ml L^{-1}	05
Azadirachtin 00.30% EC (3000 PPM) Min.	Cotton	American bollworm	3-5 ml L^{-1}	05
Azadirachtin 01.00% EC Min.	Tea	Thrips, Red spider mites	3 ml L^{-1}	01
Azadirachtin 01.00% EC (10000 PPM) Min.	Tomato	Fruit borer (*Helicoverpa armigera*)	3 ml L^{-1}	03
	Brinjal	Shoot & fruit borer (*Leucinodes orbonalis*)	2-3 ml L^{-1}	03
Azadirachtin 00.03% EC Min.	Cotton	Bollworm (*Helicoverpa armigera*), Aphids	5-10 ml L^{-1}	05

Neem formulation	Crop	Name of insect	Recommended dose per liter of water	Waiting period (Days)
	Rice	Leaf roller, Stem borer, Brown plant hopper	2 ml L^{-1}	05
Azadirachtin 00.03% WSP (300 PPM)	Red Gram	Pod borer (*Melana-gromyza* sp.)	5 ml L^{-1}	07
	Cotton	Aphids, Jassids, Whitefly, Bollworms	5 ml L^{-1}	07
	Okra	Fruit borer, Whitefly, Leaf Hopper	5 ml L^{-1}	07
	Brinjal	Shoot & Fruit borer, beetles	5 ml L^{-1}	07
	Cabbage	Aphids, Diamond back moth, Cabbage worm, Cabbage looper	5 ml L^{-1}	07
	Jute	Semi looper, Hairy caterpillar	5 ml L^{-1}	07
Azadirachtin 05.00% w/w Min.	Tea	Caterpillar, Pink mite, Red spider mites, Thrips	0.5 ml L^{-1}	05
	Tobacco	Tobacco caterpillar, Aphids	0.5 ml L^{-1}	05
	Rice	Brown plant hopper, Leaf folder, Stem borer	0.5 ml L^{-1}	05
	Cotton	Whitefly, Leaf hoppers, *Helicoverpa armigera*, Aphids	0.5 ml L^{-1}	05

Neem formulation	Crop	Name of insect	Recommended dose per liter of water	Waiting period (Days)
	Cauli-flower	Spodoptera, Diamond back moth, Aphids	0.5 ml L^{-1}	05
	Okra	Leafhopper, whitefly, Aphid, Pod borer	0.5 ml L^{-1}	05
	Tomato	Aphids, Whitefly, Fruit borer	0.5 ml L^{-1}	05

(Source: Anonymous, 2023)

5.7. Regulatory Control

Regulatory rules framed by Government of India are brought into force under which seeds and infested plant materials are not allowed to enter in to the country or from one part to other parts of the country. These are known as plant quarantine methods and are of two types *viz.*, Domestic and International Quarantine.

Table 5: List of pests with details under domestic quarantine in India

Sl. No.	Pest/ Disease	Host Plant	From	To
1	Fluted Scale (*Icerya purchasi*)	Citrus and woody plants	Mysore, Chennai (TN) & Kerala	Any other part of India
2	San Jose Scale (*Aspidiotus perniciosus*)	Apple and Pome fruits	Punjab, UP, Madras (TN), WB, Assam, Orissa, HP, Jammu & Kashmir	Any other part of India
3	Banana Bunchy top (virus)	Banana planting material	Assam, Kerala, Orissa, Tamil Nadu & West Bengal	Any other State & UT
4	Banana mosaic (virus)	Banana plants & plant material	Maharashtra & Gujarat	Any other State &UT
5	Potato Wart (*Synchytrium endobioticum*)	Potato	Darjeeling (WB)	Any other State or place in India

Sl. No.	Pest/ Disease	Host Plant	From	To
6	Apple Scab (*Venturia inaequalis*)	Apple planting material	Jammu & Kashmir, Himachal Pradesh	Any other State
7	Codling Moth [*Cydia* (=*Carpocapsa*) *pomonella*]	Apple & walnut plants including fruits	Ladakh District (J&K)	Any other area in J&K
8	Potato Cyst Nematodes (*Globodera rostochiensis & G. pallida*)	Potato	Tamil Nadu, H.P., Uttarakhand, J&K	Any other State & UT
9	Coffee Berry Borer (*Hypothenemus hampei*)	Coffee seeds/ plants/ powder	Nilagiri Dt (TN), Kodagu Dt (Karnataka) & Wayanad Dt (Kerala)	Any other parts of the Indian Union

As per Plant Quarantine (Regulation of Import into India) Order, 2003 a total of 94 entry points including 46 seaports, 24 airports and 24 land custom stations are notified points of entry for import of plants and plant material. Besides, 77 Inland Container Depot/Container Freight Station, 11 Foreign Post Offices have also been notified for the entry of plants/plant material under the PQ Order, 2003 (Singh and Nagaraju, 2022).

Table 6: List of points of entry for import of plants and plant products in India

Sl. No.	Points of Entry	Numbers
1.	Seaports	46
2.	Airports	24
3.	Land Frontier Stations	24
4.	Inland Container Depots and Container Freight Stations	78
5.	Foreign Post Offices	11

6. Conclusion

Non-pesticidal management (NPM) is a noble approach to sustainable crop protection by eliminating reliance on chemical pesticides thereby protects the environment, preserves biodiversity and promotes health and well-being of human beings. NPM involves various strategies in a compatible way to manage agricultural pests but totally eliminates the use of chemical pesticides for crop protection and thereby eliminates risks associated with chemical

pesticides. NPM is practical and sustainable means of crop protection which bridges the gap between conventional and organic farming. It contributes to long term agriculture sustainability without hampering ecological balance.

7. References

Anonymous, 2023. *Major Uses of Pesticides*. Central Insecticide Board & Registration Committee, DPPQS, Department of Agriculture, Cooperation & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Govt. of India. Available at: https://ppqs.gov.in/divisions/cib-rc/major-uses-of-pesticides.

Chitra, G.A., Muraleedharan, V.R., Swaminathan, T., Vijayaraghavan, D., 2006. Use of pesticides and its impact on health of farmers in South India. *International Journal of Occupationaland Environmental Health* 12, 228-233.

Fox, E.J., Jay, G., Erika E., Matthew E.B., McLachlan, J.A., 2007. Pesticides reduce symbiotic efficiency of nitrogen-fixing rhizobia and host plants. *PNAS* 104(24), 10282-10287.

Karanth, N.G.K., 2002. Challenges of limiting pesticide residues in fresh vegetables: The Indian experience. In: *Proceedings of the International Workshop*. (Eds.) Hanak, E., Boutrif, E., Fabre, P. and Pineiro, M. December 11-13, 2000. CIRAD-FAO, Montpellier, France.

Kavitha, K., 2005a. Effects of pesticide exposure on developmental task performance in Indian children. *Children, Youth and Environments* 15(1), 83-114.

Kavitha, K., 2005b. *Killing or Poisoning: Pests or Human Beings?* Centre for Sustainable Agriculture, Hyderabad. Available at: https://www.csa-india.org.

Kavitha, K., Dharmender, G.R., Rajitha, N., Royal, J., Ramanjaneyulu, G.V., 2007. *Pesticides, Residues and Regulation - A Case of Vegetables in Hyderabad Market*. Centre for Sustainable Agriculture, Research Report 1. In: Research Reports for Analysis and Action for Sustainable Development of Hyderabad.

Mancini, F., Van Bruggen, A.H., Jiggins, J.L., Ambatipudi, A.C., Murphy, H., 2005. Acute pesticide poisoning among female and male cotton growers in India. *International Journal of Occupational and Environmental Health* 11(3), 221-232.

Mathur, H.B., Agarwal, H.C., Johnson, S., Saikia, N., 2005. *Analysis of Pesticide Residues in Blood Samples from Villages of Punjab*. Centre for Science and Environment, New Delhi.

Shivkumara, K.T., Manjesh, G.N., Roy, S., Manivel, P., 2019. Botanical insecticides: Prospects and way forward in India: A review. *Journal of Entomology and Zoology Studies* 7(3), 206-211.

Singh, J.P., Nagaraju, D.K., 2022. Plant protection regulations and their implementation in India. In: *Integrated Pest management Strategies*

for Sustainable Agriculture. (Eds.) Nair, N. and Guha, A. New Delhi Publishers, New Delhi, India. pp. 14-53.

Timothy, K., Richard, W., Sean, G., Chris, C., 2005. *Body Burden, The Pollution in Newborns*. Environmental Working Group, Washington DC.