Non-Chemical Alternatives to CHLORPYRIFOS in India

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PAN INDIA Pesticide Action Network (PAN) India

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About PAN India

Pesticide Action Network India (PAN India) is a non-profit, public interest, research and advocacy organisation formed in 2013. Its objective is to help communities and governments reduce dependence on toxic agrochemicals for pest control in agriculture, household as well as public health and to increase the use of sustainable alternatives. PAN India is working to empower farming communities to keep away from toxic pesticides and agrochemicals, and to take up non-chemical methods of farming practices based on agroecology.

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Contents

Introduction

Chlorpyrifos is a highly hazardous, broad spectrum, organophosphate insecticide that is highly toxic and persistent in the environment. It also accumulates in the food chain. It is a contact insecticide that exerts its toxicity by contact, inhalation and ingestion, resulting in neurotoxicity both in target as well as non target organisms. It is toxic to aquatic environments threatening aquatic life with long lasting effects. The World Health Organisation classified chlorpyrifos as moderately hazardous (Class II) pesticide based on acute toxicity[1].

Chlorpyrifos is known to cause respiratory paralysis and death, endocrine disruption, neurodevelopmental impacts and foetal damage leading to neurodevelopmental disorders. Studies highlight that chlorpyrifos is implicated in various adverse effects in children including derailed development, brain damage, impaired immune function, hormone disruption triggering obesity, diabetes, cancer and reproductive problems later in life. Chlorpyrifos is reported in many occupational as well as non occupational poisonings. Residues of chlorpyrifos have been reported in human cord blood and meconium, cervical fluid, sperm fluid, breast milk, and maternal and infant hair. Further, residues have also been reported in food commodities[2].

Globally chlorpyrifos is banned in 44 nations. The European Union nominated it for inclusion under the Stockholm Convention on Persistent Organic Pollutants (POPs) for global phase-out in 2021 and the POPs Review Committee found in January 2022 that it meets the Convention's criteria for a POP. The twentieth meeting of the Persistent Organic Pollutants Review Committee (POPRC) that took place from 23 to 27 September 2024 had concluded that it meets all criteria warranting global phase out and decided to recommend to list it under Annex A to the Stockholm Convention with specific exemptions. Learning about possible, practical and viable alternatives to chlorpyrifos is therefore important[3].

This document provides information on non-chemical alternatives to chlorpyrifos compiled from official advisories from the Department of Agriculture, Government of India and crop production guides available from State Agriculture Departments/Universities. The following pages present these viable alternatives as applicable for a wide range of common pests affecting major crops, including for rice, gram, sugar cane, groundnut, cotton, mustard, brinjal (aubergine/egg plant), cabbage, okra, onion, apple, ber, citrus, and tobacco.

[1] **Dileep Kumar A. D. 2022. Highly Hazardous Pesticide Series: State of Chlorpyrifos, Fipronil, Atrazine and Paraquat Dichloride in India. Pesticide Action Network India. https://pan-india.org/wp-content/uploads/2022/08/HHP_Chl-Fip-Atr-Pqt_Report-Final-web_PAN-India.pdf**

[2] **Meriel Watts. 2022. Urgent Need to Ban the Brain-Harming Chlorpyrifos. Pesticide Action Network Asia Pacific.https://panap.net/resource/urgent-need-to-ban-the-brain-harming-chlorpyrifos/?ind=1658812902276&filename=Chlorpyrifos-PANAP-Policy-Brief.pdf**

[3] **UNEP/POPS/POPRC.20/10 ; https://chm.pops.int/TheConvention/POPsReviewCommittee/Meetings/POPRC20/Overview/tabid/9850/ctl/Download/mid/28186/Default.aspx?id=5&ObjID=34360**

Table 1. Non-chemical Alternatives for Rice

Target pests	Non-chemical Alternatives for Rice
Stemborer	Biocontrol agents: *Trichogramma chilonis, Trichogramma toidea spp., DD-136 nematode Neo-aplectana, carpocapsae , Sturmiopsis, Tetrastichus spp.,*
	1. Collect egg masses from the nursery plants and observe for parasitization. 2. Cultivate tolerant varieties like IR-20 in endemic areas. 3. Use sex pheromone for the control of rice stem borer
	1. Do not sow rice under shade as these places serve as foci for the spread of diseases and insect pests like stemborer and leaf folder; 2. After harvest, the fields should be thoroughly flooded with water and ploughed with discs or rotators to kill hibernating larvae of stem borer present in the stubbles. 3. Lapping of tall varieties of Basmati at 45 days after transplant to reduce stem borer problem as well as to prevent lodging. 4. Collection of egg masses and larvae of pest and their placement in bamboo cages for conservation of biocontrol agents. 5. Removal and destruction of diseased/pest infested plant parts
	1. Azadirachtin 0.15% EC w/w Min. Neem Seed Kernel Based *2. Azadirachtin 00.03% EC Min. Neem Oil Based* *3. Azadirachtin 05.00% w/w Min. Neem Extract Concentrates* *4. Bacillus thuringiensis var. kurstaki, serotype H-39, 3B, Strain Z-52* *5. Bacillus thuringiensis var. krustaki, Serotype H-3a, 3b, Strain Z-52*
Leaf folder	Release of egg parasitoid, Trichogramma chilonis @ 1.5 lakh/ha (affixed as Tricho cards) only when egg masses or moths are observed.
	Goniozus spp.-Biocontrol agent
	1. Do not sow rice under shade as these places serve as foci for the spread of diseases and insect pests like stemborer and leaf folder. 2. Select suitable resistant or moderately resistant variety 3. Do not sow rice under shade as these places serve as foci for the spread of diseases and insect pests like stemborer and leaf folder. 4. Use of coir rope in rice crop for dislodging case worm and leaf folder larvae etc. 5. Collection of egg masses and larvae of pest and their placement in bamboo cages for conservation of biocontrol agents.

	1. Azadirachtin 0.15% EC w/w Min. Neem Seed Kernel Based *2. Azadirachtin 00.03% EC Min. Neem Oil Based* *3. Azadirachtin 05.00% w/w Min. Neem Extract Concentrates* *4. Bacillus thuringiensis var. galleriae 1593 M serotype H 59 5b, 1.3% flowable concentrate Potency 1500 IU/mg* *5. Bacillus thuringiensis var. kurstaki, serotype H-39, 3B, Strain Z-52* *6. Bacillus thuringiensis var. krustaki, Serotype H-3a, 3b, Strain Z-52* *7. Beauveria bassiana 01.15% WP* *8. Beauveria bassiana 1.15% WP. (1x108 /gm min) Strain BB-ICAR-RJP, Accession No – MCC 1022* *9. Beauveria bassiana 1.15% WP (Strain : BB – 5372, own R & D Isolate)* *10. Beauveria bassiana 1.15% WP (1x108 /gm min) Strain ICAR, Research Complex, Umiam, Meghalaya, Accession No – NAIMCC-F-03045* *11. Beauveria bassiana 1.15% WP (1x108 /gm min) Accession No – NAIMCC-F-03045, Strain No. NBAIM, MAU.*
Gall midge	1. Use tolerant varieties like Pavithra, Panchami and Uma 2. Avoid late transplantation during the first crop season. 3. Careful monitoring of the crop seasons in the month of July during additional crop season and October during puncha season. 4. Use optimum seed rate of 100 kg ha-1 5. Destruction of collateral host like wild rice, *Cynodon dactylon, Ischaemum aristatum, Echinochloa spp. and Isachne sp.* **Biological control** 1. Biocontrol agents: spiders, drynids, water bugs, mirid bugs, damsel flies, dragonflies, meadow grasshoppers, staphylinid beetles, carabids, coccinelids, Apanteles, Tetrastichus, Telenomus, Trichogramma, Bracon, Platygaster etc.
Yellow stem borer (*Scirpophaga incertulas*)	Release of egg parasitoid, *Trichogramma japonicum* @ 1.5 lakh/ha (affixed as Tricho cards) only when egg masses or moths are observed.
Hispa	1. Clipping of rice seedlings tips at the time of transplanting to minimize carryover of rice hispa and case worm infestation from seed bed to the transplanted fields;
Brown plant hopper	**Brown Plant Hopper** 1. Use resistant varieties such as Jyothi, Bharathy, Aiswarya, Kanakom, Nila etc. for cultivation. 2. Drain away water from the field and keep it in that conditions until the pest population dwindle. 3. In Kuttanad tract, early planting of paddy in September-October is advisable, wherever possible. 4. Allow alleyways after every 3m rows 5. Avoid spraying synthetic pyrethroids.
	(For BPH (Brown Plant Hopper: basmati): ETL: 10-15 hoppers/hill at early to late tillering or 15-20 hoppers/hill at panicle initiation to booting stage. Drain out water from the field for 2-3 days

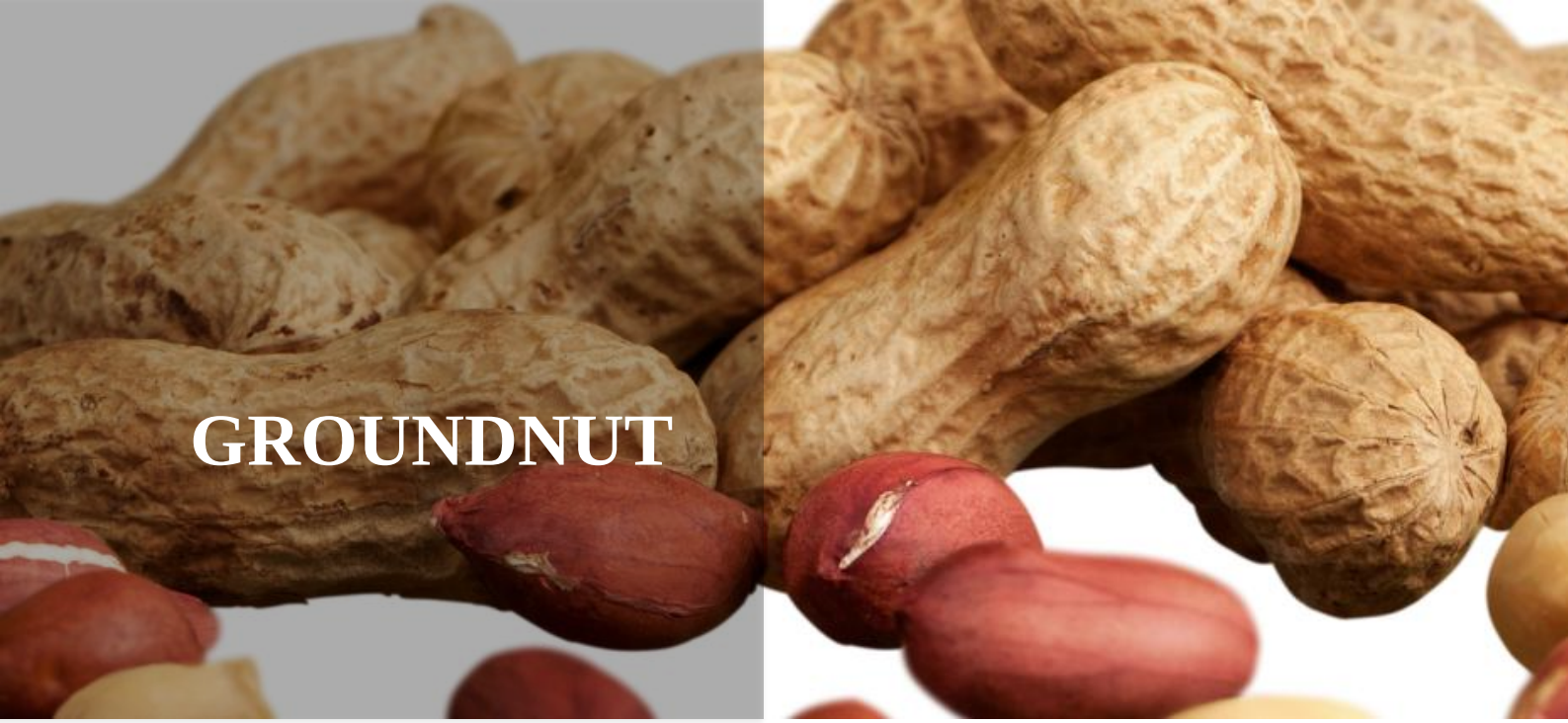
Table 2. Non-chemical Alternatives for Gram

Target Pest	Non-chemical Alternatives for Gram & Bengal Gram
Cut worm	**Cultural** 1. Deep ploughing in summer 2. Apply well decomposed FYM or neemcake/Mahua cake @ 500/ kgha in nematode prone areas 3. Solar treatment to the soil using transparent polythene mulching for at least for 15 days. 4. Intercropping with linseed/coriander/mustard/wheat/sorghum. 5. Synchronized sowing single recommended variety in village area 6. Removal of crop stubbles **Mechanical** 1. Use Rhizobium culture @ 1pkt + (200g), 190 kg seed for effective modulation. 2. Thinning should be done in case of dense plant population. **Biological** 1. Seed treatment with *Trichoderma viride, T. harzianum @ 4gm/kg of seed.*
Pod borer (Helicoverpa armigera)	*Bracon hebetor, Bracon brevicornis, Bracon kirkpatricki, Chelonus blackburni* Azadirachtin 00.03% WSP (300 PPM) Neem Oil Based

SUGARCANE

Table 3. Non-chemical Alternatives for Sugar Cane

Target Pest	Non-chemical Alternatives for Sugar Cane
Early shoot & stalk borer	**Cultural** 1. Late planting should be avoided in Northern region to minimise the early shoot borer incidence. 2. Avoid untimely high nitrogenous fertilizers. 3. Irrigation closer intervals for managing early shoot borer. 4. Detrashing of canes in stalk borer prone areas. 5. Removal of water shoots to destroy stalk borers. 6. Trash mulching at the rate of 3 tons per ha immediately after planting for early shoot borer. 7. Propping the canes to prevent lodging to reduced the damage by stalk borer. **Mechanical** *1. Removal of dead hearts of early shoot borer and top borer.* *2. Clipping of leaves bearing of top borer signs (mid-rib tunnels).*
	Biocontrol agents for borers: *Trichogramma chilonis , Trichogramma exiguum , T. minutum, T. perkinsi, T. faciatum, Paratheresia claripalpis, Sturmiopsis*
Pyrilla	*1. Avoid late application of nitrogenous fertilizers* *2. Collection and destruction of egg masses* *3. Conservation of nymphal and adult parasite, Epiricania melanoleuca* *4. Release of 8000 to 10000 cocoons or 8-10 lakh eggs of E. melanoleuca per ha. when 3-5 pyrilla individuals per leaf are seen.* *5. Avoid ultimately high nitrogenous fertilizers to minimize the pyrilla attack.*



GROUNDNUT

Table 4. Non-chemical Alternatives for Groundnut

Pest	Non-chemical Alternatives for Groundnut
Aphid	***Parasitoids:*** *Aphidius colemani, Diaeretiella spp., Aphelinus spp. etc.* ***Predators****: Anthocorid bugs/pirate bugs (Orius spp.), mirid bugs, syrphid/hover flies, green lacewings (Mallada basalis and Chrysoperla carnea), predatory coccinellids (Stethorus punctillum), staphylinid beetle (Oligota spp.), predatory cecidomyiid fly (Aphidoletis aphidimyza) and predatory gall midge, (Feltiella minuta), earwigs, ground beetles, rove beetles, spiders, wasps etc* . *A****ttractant plants:*** *Carrot family, sunflower family, marigold, buckwheat, spear mint (syrphid fly, lace wing, minute pirate bug, damselfly and lady beetle), French bean (predatory thrips), Strips of Rye grains, cover crops and mulch beds (rove beetle) Mustard, sweet clove, dill (aphid midge, Aphidoletes aphidimyza) Nectar rich plants with small flowers i.e. anise, caraway, dill, parsley, mustard (aphid parasite and braconid wasp), Sunflower, buckwheat and cowpea (braconid wasp)* *1*. Stray planting of Cowpea (aphids), Soybean (for leaf miner), Castor and Sunflower *as* trap crops.

COTTON

Table 5. Non-chemical Alternatives for Cotton

Pest	Non-chemical Alternatives for Cotton
Aphid	1. Set pheromone traps 2. Use Ha. NPV @ 250-500 LE/ha 3. Removal of terminals (topping) is to be done 4. Use neem products
Bollworm	1. Fix yellow sticky traps 2. Spray neem products Biocontrol agents: Trichogramma chilonis Cotton Strain (1,50,000/ha; six weekly releases),T. brasilienses, T. pretiosum, Bracon hebetor, Bracon brevicornis, Bracon kirkpatricki , Chelonus blackburni ,Chrysoperla scelestes, Chrysoperla carnia
Aphid, Jassids, Thrips,Whitefly, Spodoptera litura,	"**Thrips, whitefly and jassids** 1. Application of neem (Azadirachtin 1500 ppm) @2.5 litre/ha mixed with with detergent one gram or ml per litre of water. 2. Foliar applications of potassium nitrate fertilizer (NPK 13:0:45) @ 2% (5 kg/ha) during boll formation stage to promote boll setting and to reduce flower drop. "
	Spodoptera litura: *NPV of spodoptera litura (Foliar spray)* ***Whitefly:*** *Mallada boninensis or Chrysoperla carnea @ 50,000/ha twice during the season with a gap of 15 days.*
	Whitefly: Use neem oil emulsion (3 litre /ha)
Spotted bollworm, Pink bollworm, American bollworm	1. *Azadirachtin 00.03% WSP (300 PPM) Neem Oil Based* *2. Bacillus thuringiensis var. galleriae 1593 M serotype H 59 5b, 1.3% flowable concentrate Potency 1500 IU/mg* *3. Beauveria bassiana 1.0% WP (1x109 CFU/gm min), Strain No. IPL/BB/MI/01* **Pink bollworm** 1. Release of parasitoid Trichogramma bactrae (1.5 lakhs/ha) coinciding with the initiation of moth activity, if available 2. Termination of crop by end of December and destruction of crop residues 3. Installation of pheromone traps (40/ha) for mass trapping of PBW one week prior to flowering

MUSTARD

Table 6. Non-chemical Alternatives for Mustard

Pest	Non-chemical Alternatives for Mustard
Aphid	1. Destroy aphid infesting twigs at the initial stage of appearance.
	1. Set up yellow water pan/sticky traps 15 cm above the canopy for monitoring aphids @ 4-5 traps/acre. Locally available empty tins can be painted yellow and coated with grease/ Vaseline/caster oil on outer surface may also be used as yellow sticky trap. **2. Parasitoids**: *Aphelinus spp. Aphytis spp., Diaeretiella rapae (nymphal and adult)* ***Predators:*** *Ladybird beetles viz., Coccinella septempunctata, Menochilus sexmaculata, Hippodamia variegata and Cheilomones vicina Syrphid fl y: Sphaerophoria spp., Eristallis spp., Metasyrphis spp., Xanthogramma spp. and Syrphus spp., Lacewing: Chrysoperla zastrowi sillemi, aphid midge: Aphidoletes aphidimyza, predatory bird: Motacilla cospica* ***Entomopathogenic fungi :*** *Cephalosporium spp., Entomophthora and Verticillium lecanii* **3. Resistant varieties:** Coral-432, NRCHB 5-6, NPJ 112 (Pusa Mustard 25), NRCDR 601, RYSKS-2 and DMH-I 4. Cultural control: • Early sowing to avoid damage due to mustard-aphid, and major diseases. • Use tolerant varieties. • Early planting to escape the damage. • Use yellow sticky traps. Mechanical control: • Destroy the affected part along with aphid population in the initial stage
	1. *Conservation of natural enemies of Aphids namely Coccinella septempunctata, Chrysoperla carnea, Syrphid fly, etc*. 2. For environment friendly management of mustard aphid, spray of Azadirachtin 300 ppm @ 5 ml / l of water Due to higher dose of nitrogen in crop, incidence of aphid and severity of diseases increased

BRINJAL

Table 7. Non-chemical Alternatives for Brinjal

Pest	Non-chemical Alternatives for Brinjal
Shoot & fruit borer	1. Protect the seedling in the nursery with net (general practice for brinjal) 2. Mechanical hand picking and destruction of the affected part along with the larvae (general practice for brinjal) 3. Place pheromone traps @ 100 no/ha (general practice for brinjal). 4. Spray neem garlic emulsion (2%) (general practice for brinjal). 5. Spray Bt @ 3ml/litre (general practice for brinjal) 6. Spray leaf extract of ailanthus and cashew (10 %) (general practice for brinjal)
	"1. Destruction of debris, crop residues, weeds & other alternate hosts and deep summer ploughing (general practice for brinjal) 2. Adoption of proper crop rotation and avoid growing of Malvaceae crops in sequence (general practice for brinjal) 3. Use of resistant and tolerant varieties recommended by the State Agricultural Universities of the region (general practice for brinjal). 4. Collect and destroy the infested fruits with fruit and shoot borer infestation. 12. Conserve the existing bio-control agents like Spiders, Coccinellids, Syrphid flies etc. in the field by avoiding, delaying and reducing the use of chemical pesticides and promoting the use of bio-pesticides including botanicals and microbial (general practice for brinjal). 13. Augment the bio-control agents like egg parasitoids- Trichogramma sp., Telenomus sp., Encarsia spp.; larval parasitoid- Bracon sp., Campoletis chlorideae, Chelonus blackburni; predators like Chrysopa sp., Coccinella sp.(general practice for brinjal)
	1. Azadirachtin 01.00% EC (10000 PPM) Min. Neem Based *2. Azadirachtin 00.03% WSP (300 PPM) Neem Oil Based* *3. Metarhizium anisopliae 1.0% WP (1x108 CFU/gm min) Strain No. IPL/KC/44 (Own R & D Isolate),Accession No. 6895.*

	1. Give 2 to 3 sprays of 5 % NSKE against sucking pests. Sprays of NSKE also bring down the borer incidence significantly. Neem oil (2%) application is also helpful in reducing borer infestation, though marginally. 2. Pheromone traps @ 5/ acre should be installed for monitoring and mass trapping of shoot & fruit borer *Leucinodes orbonalis*. Replace the lures with fresh lures after every 15-20 day interval. 3. Release egg parasitoi*d T. brasiliensis* @ 1 – 1.5 lakh/ ha for shoot & fruit borer, 4-5 times at weekly interval. 4. Apply neem cake @ 250 kg/ ha (in two splits) in soil along the plant rows at 25 and 60 DAT for reducing nematodes and borer damage. Don't apply neem cake when there is heavy wind velocity or temperature is above 300C. 5. Clipping of borer damaged shoots and collection & destruction of damaged fruits i.e. clean cultivation helps in management of borer and phomosis disease effectively. 6. Continuous cropping of brinjal leads to more borer and wilt infestation. Therefore, crop rotation with non solanaceous crops should be followed.

CABBAGE

Table 8. Non-chemical Alternatives for Cabbage

Pest	Non-chemical Alternatives for Cabbage
Diamond back moth	1. Spraying of B. thuringiensis var.kurstaki 5 WP @ @ 50 g a.i./ ha or 3 gm / litre at 10 DAP for DBM 2. Installation of light traps / bulb @ 3 / acre for DBM. Adults are attracted to light trap and fall in water bucket. Within 3-4 days most of the adults get killed. 3. Spray NSKE 5% at primordia formation (18-25 DAP-head initiation stage - most critical stage) for DBM control. Scout for papery patches & apply baits." 4. Growing of two rows of mustard after every 25 rows of cabbage as a trap crop at the time of planting. This traps 80-90% of DBM population and other pests
	1. Trichogramma brassicae (E)*;Parasitised egg cards :Hymenoptera: Trichogrammatidae:100,000/ha Six releases at weekly intervals. 2. *Trichogrammatoidea bactrae* (E)*Parasitised egg cards: Hymenoptera: Trichogrammatidae :2,50,000/ha Five releases at weekly intervals
	1. Sow bold mustard seeds densely in one of the ridges 15 days before cabbage planting as a trap crop. 2. After land preparation, leave two ridges at the beginning after every 25 rows at the end. 3. Application of *Bacillus thuringiensis var. kurstaki* 500 h/ha. 4. Spray 5 % NSKE 5. Release Trichogrammatidea bactrae or T.chilonis or T. pretiosum egg parasites @ 50,000 per ha., 4-5 times with interval of 5-7 days helps in controlling DBM and other lepidopteran pests. 6. Make inoculative release of Cotesia plutellae @ 5000/ha on 10-15 days after planting to control DBM. 7. Spray commercial preparation of Bacillus thuringiensis var kurstaki @ 500 gm/ha after 15 days planting and should be repeated after every 15 days to control DBM and other lepidopteran pests. 8. Erect bird perches

	1. Azadirachtin 00.03% WSP (300 PPM) Neem Oil Based *2. Bacillus thuringiensis var. galleriae 1593 M serotype H 59 5b, 1.3% flowable concentrate Potency 1500 IU/mg* *3. Bacillus thuringiensis serovar kurstaki (3a, 3b, 3c) 5.0% WP Potency 55000 SU (Spodoptera unit based) (5x107 spore/mg)* *4. Bacillus thuringiensis var. kurstaki Serotype 3a, 3b, SA II WG Potency:- 53000 SU/mg, 32000 IU/mg* *5. Beauveria bassiana 1.15% WP (1x108 /spores/ml) Strain BCRL, Accession No – BCRL Bbpx-6892* *6. Beauveria bassiana 5.0% WP, (1x108 CFU/gm min) Strain IARI, Accession No. ITCC-7353* *7. Beauveria bassiana 10.00% SC* *8. Verticillium lecanii 5.0% SC, (Strain: Accession No. NFCCI - 2638*

OKRA

Table 9. Non-chemical Alternatives for Okra

Pest	Non-chemical Alternatives for Okra
Fruit borer (Earias viltela)	1. Sowing of sorghum or maize all around okra field as a barrier crop for shoot & fruit borer adult moths and white flies. 2. Erection of bird perches @ 10 / acre in the field for facilitating bird predation. 3. Installation of pheromone traps @ 2 / acre for monitoring the activity of shoot & fruit borer. Change lures after every 15-20 days. 4. Weeding and earthing, 25-30 days after sowing, collect and destroy infested fruits with fruit and shoot borer 5. Spray NPV @ 250LE /ha to manage *H. armigera and E. vitella/ Bacillus thuriengiensis* 0.5 % WP @ 0.3 % 6. Spray NSKE @ 5% or azadirachtin 3000 ppm based neem oil @ 0.5 % / spray neem soap /pongamia soap @ 0.7 to 1 %, four to five times at weekly interval against sucking pests and fruit borer. 7. Release egg parasitoid, T*richogramma chilonis* @ 1.0 lakh/ha 4-5 times at weekly interval to manage fruit borer.

	1. Use of resistant and tolerant varieties recommended by the State Agricultural Universities of the region. 2. Pheromone traps for two insects' viz. Helicoverpa armigera and Earias sp. should be installed @ 4-5 traps per acre. Install the traps for each spp separated by distance of more than 75 feet in the vicinity of selected field. Fix the traps to the supporting poles at a height of one foot above the plant canopy. Change the lures after 2-3 weeks interval. 3. Collect and destroy the infested fruits with Fruit and shoot borer infestation and larvae of Heliothis, Spodoptera and adults of blister beetle. 4. Conserve the existing bio-control agents like Spiders, Coccinalids, Syrphid flies etc. in the field by avoiding, delaying and reducing the use of chemical pesticides and promoting the use of bio-pesticides including botanicals and microbial. 5. Augment the bio-control agents like egg parasitoids, *Trichogramma chilonis*, *Trichogramma achaea, Trichogrammatoidea sp., Telenomus sp., Encarsia spp.; larval parasitoid Bracon sp., Campoletis chlorideae, Chelonus blackburni; predators like Chrysopa sp., Coccinella sp*. 6.Spray NPV @ 250LE per hectare to control H. armigera and Spodoptera litura. Spray Beauveria bassiana1% P @1500-2000 g in 160-200l of water/acre.
	1. Destruction of infected fruits 2. Install pheromone traps @ 5/ha
	"1. Remove and destroy affected shoots and fruits. 2. SPray with neem kernel suspension (5%) or ginger suspension (10%) or neem leaf extract (4%) 3. Use Trichogramma chilonis @ 60000/ha followed by a sprat with Bacillus thuringiensis (3ml/litre) 4. Apply Beauvaria bassiana 10 % WP 5. Metarhizium anisopliae @ 5g/l significantly reduces the larval population"

ONION, APPLE, BER, CITRUS & TOBACCO

Table 10: Non-chemical Alternatives for Onion, Apple, Ber, Citrus & Tobacco

Crop	Pest	Non-chemical Alternatives for Onion, Apple, Ber, Citrus & Tobaco
Onion	**Root grub**	1. Deep summer ploughing
Apple	**Aphid**	*Chrysoperla carnea or Mallada boninensis* @ 10-20 larvae per infested tree depending on the pest population.
		1. Release bio agent like *Aphelinus mali* has been found effective in controlling the population of wooly aphids 2. Conserve natural enemies. Make releases of *A. mali* @ 1000-15000/infested tree and of lady bird bettles @ 15-30/infested tree.
Ber	**Leaf hopper**	A number of effective parasites, predators and pathogens can be used against pests of Ber; Spiders, Coccinellids, *Sumnius renardi, and Chrysoperla lacciperda.* 2. NSKE @ 5 % helps in reducing pest population in Ber
Citrus	**Black citrus fly**	"1. Close planting, water logging should be avoided. 2. Excessive irrigation and nitrogen fertilization should be avoided. 3. Avoid growing collateral hosts of the pest, guava, sapota and pomegranate. "
		1. Intermingling branches should be pruned. 2. Spacing between trees at close distance should be avoided 3. Well drained soil 4. Use light trap (yellow color of wavelength of 550 mm) 5. Use yellow sticky trap 6. Conservation of indigenous natural enemies 7. Augmentation of *Chrysoperla spp and Mallada boninensis @ 10-15 eggs/grubs per plant.* 8. Use neem product

		Parasitoids: *Encarsia formosa, Eretmocerus spp. (Pupal)* ***Predators:*** *Chrysoperla zastrowi sillemi, coccinellids, spiders* *1. • Collect and destroy the damaged plant parts along with nymphs, pupa and adults.* *• Use light trap (wavelength of 550 nm)* *• Yellow sticky traps or cards reduce the density of black fl ies*
	Aphid	1. Use trap crops 2. Conservation and augementation of natural enemies/predators 3. Use neem products
		Predators: *Lacewings, hover flies, coccinellids, birds, earwigs, some ground beetles and rove beetles, and spiders* *2. Use yellow sticky traps*
Tobacco	**Ground beetle**	1. Apply pongamia cake or neem cake powder @ 5g mixed with 25 g of sand at plant base or keeping grass heps in between plant rows after sprinkling water on the soil at a distance of 6m apart to attract the beetles.

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PAN INDIA

This document provides information on non-chemical alternatives to chlorpyrifos compiled from official advisories from the Department of Agriculture, Government of India, and crop production guides available from State Agriculture Departments/Universities. This document presents viable alternatives as applicable for a wide range of common pests affecting major crops, including rice, gram, sugar cane, groundnut, cotton, mustard, brinjal (aubergine/eggplant), cabbage, okra, onion, apple, Ber, citrus, and tobacco.