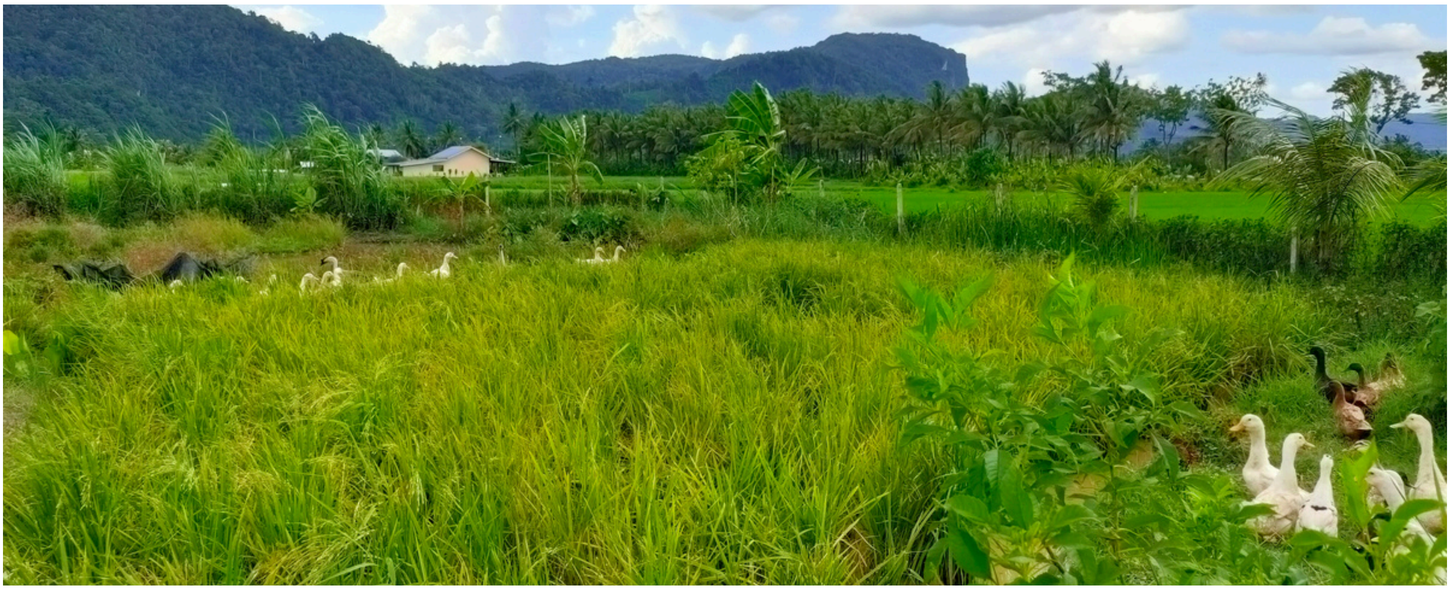
PAN ASIA PACIFIC

BEYOND CHLORPYRIFOS: TRANSITIONING TO SAFER PEST MANAGEMENT FOR KEY CROPS IN SOUTHEAST ASIA

2025



Organic paddy field in Perlis, Malaysia
Photo Credit: EcoPro Farm

The continued reliance on hazardous pesticides presents significant risks to human health, biodiversity, and the environment. Policymakers play a crucial role in shaping regulations and frameworks that safeguard public health and promote sustainable agricultural practices. The adverse effects of pesticide dependency, particularly chlorpyrifos, range from environmental degradation to severe public health crises, necessitating urgent action to implement safer and more sustainable alternatives.

Among its most concerning impacts, chlorpyrifos poses profound risks to child development, particularly brain function. Exposure to even minimal levels during the fetal stage has been shown to cause structural changes in the developing brain, leading to cognitive deficits, including reductions in IQ and working memory (Watts, 2022). Given these risks, the need for effective, non-chemical alternatives is more pressing than ever.

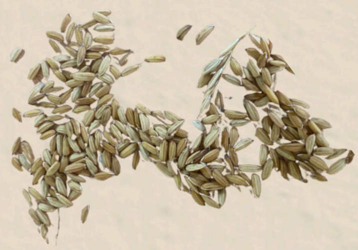
Chlorpyrifos is often used in Asia and Pacific, especially Southeast Asia in paddy, vegetables, and other crops. Rice remains the most significant staple crop in the region, with the region accounting for over 90 percent of global rice consumption (FAO, n.d.). While organic rice production represents only a small fraction of total agricultural output, it has demonstrated clear economic benefits by increasing farmers' profits and reducing input costs. For instance, the System of Rice Intensification (SRI), a widely adopted technique in Malaysia and Indonesia, has been proven to lower production costs, particularly in pest management. The total cost of pest control under the SRI method was reported at USD 9 per hectare, compared to USD 94 per hectare for the conventional method (Zaman, 2018).

Quick reference:

Chlorpyrifos is a widely used broad spectrum organophosphate insecticide that is highly toxic, persistent in the environment and bioaccumulates in the food chain.

Given the viable alternatives with cost-benefits for rice, vegetables, citrus, and other crops in Southeast Asia,

PAN urges governments to support the listing of chlorpyrifos in Annex A of the Stockholm Convention for global elimination without exemptions.



This document is structured into sections that address specific aspects of alternative pest management for rice, vegetables, cereals, other crops, and citrus. This document also provides an overview of viable non-chemical alternatives to chlorpyrifos in Southeast Asia and China. It aims to support the development of evidence-based policies promoting sustainable agricultural practices while protecting human and environmental health. By presenting these alternatives, the document offers a clear roadmap for policymakers to develop and implement effective policies that support sustainable agriculture.

PAN Asia Pacific has been actively promoting local indigenous knowledge through the International People's Agroecology Movements (IPAM). Across the region, farmers have innovated effective pest management strategies through agroecological approaches, integrating scientific research, case studies, and traditional knowledge passed down through generations. The case study 1 and case study 2 available in the document are part of the efforts to highlight the benefits of agroecology. This collective wisdom serves as a valuable resource for informed decision-making and legislative action.

RICE

Rice cultivation faces significant pest challenges, including stem borers, planthoppers, and leaf folders. Often in Southeast Asia, beneficial plants will be planted near the paddy field as a host to pests that are usually attacking the paddy plants. According to many farmers, trees serve as habitats for various creatures, including insects, birds, rats, frogs, and snakes, and insects living in trees are not harmful to rice (FAO, 2017). Some animals play roles as food sources for the farmers.

Natural predators such as ducks were also a practice as most of the farmers will breed animals such ducks to help them to pick the golden apple snail. Many farming communities in Southeast Asia have long relied on botanical pesticides, such as neem (*Azadirachta indica*), derris (*Derris elliptica*), and garlic extracts, for pest control, which is also cost-effective. The use of parasitoids in Southeast Asia is steadily increasing, driven by concerns over pesticide resistance and environmental sustainability. Meanwhile, in China, the use of biological control and ecological pest management was observed more frequently as a lot of co-culture systems were used.

"The total cost of pest control under the SRI method was reported at USD 9 per hectare, compared to USD 94 per hectare for the conventional method in Malaysia"

Method of local people in Southeast Asia to store their local rice seeds
Photo: A.D.

Physical

Method	Pest	Reference
Baiting method, such as using jackfruit peel, cassava leaves, cempedak peel, and water spinach	Stem borers	Department of Agriculture, Malaysia. (2022).
Installation of traps (e.g., nets) at water inlet points	Stem borers	
Burning or plowing all rice straw and stubble after harvest	Stem borers	
Plow or burn stubble and yellowing straw after harvest.	Black rice stink bug (*Scotinophora coarctatata* F.)	Department of Agriculture Malaysia. (2008)
Clear the paddy field and surrounding areas of weeds.	Black rice stink bug (*Scotinophora coarctatata* F.)	
Burn or plow all straw and stubble after harvest.	Yellow Stem Borer (*Scirpophaga incertulas*), Pink Stem Borer (*Sesamia inferens*), Striped Stem Borer with Black Head (*Chilo polychrysus*), Striped Stem Borer (*Chilo suppressalis*)	
Clear the paddy field and surrounding areas of weeds and practice synchronized planting	Rice Bug (*Leptocorisa spp.*)	
	Green Stink Bug (*Nezara viridula*)	
Drain the paddy field for a few days to eliminate the larvae.	Rice Leafroller (*Nymphula depunctalis*)	
Increase water level to 3–5 cm.	Rice Thrips (*Stenchaetothrips biformis*)	

Beneficial plants

Planting beneficial plants, such as Turnera, Japanese rose, marigold, and sunflower, to attract natural enemies and repel pests	Stem borers
Turnera subulate	Aphids, whiteflies, and caterpillars
Turnera trionifloria	Aphids, whiteflies, and caterpillars
Cosmos sp.(*Cosmos sulphureus*)	Aphids, thrips, and whiteflies
Marigold (*Tagetes erecta*)	Aphids, nematodes
Portulaca grandiflora	Aphids and whiteflies
Lantara camara	Caterpillar and aphid
Okra (*Abelmoschus esculentus*)	Aphids and attracts predatory insects like ladybugs
Sunflower (*Helianthus annuus*)	Attracts beneficial insects such as lacewings and ladybugs, which prey on aphids and caterpillars.

Reference: Department of Agriculture Malaysia, 2022

“Now we can produce 95 sacks a year than 85 sacks last year,

we have rice production for family consumption and for sale.

The quality of living of my family is getting better day by day.”

IPAM

Sesame (*Sesamum indicum*)	Planthopper, rice hispa, and yellow stem borer eggs	Ali et al, 2019
Mustard, cabbage and radish (*Brassicaceae* family)	Trap crop for pests like flea beetles and attracts beneficial predatory insects like ground beetles and hoverflies	Fauzia, et al., 2022
Zinnia elegans	Aphids, thrips, whiteflies, caterpillars (*Lepidoptera* larvae), brown planthopper	Aldini, Martono, & Trisyon, 2019
Tagetes erecta	Aphids, thrips, whiteflies, caterpillars, nematodes	

Case study 1

A case study in Indonesia showing the benefits of beneficial plants and ducks in her farm

Majinah and the women in her group use available resources, such as banana leaves and neem, to produce natural pesticides. They also plant flower plants (e.g. marigolds) around crops to repel pests. To maintain biodiversity and soil health, she implements a system of crop rotation.

She tries her best to prevent chemical contamination from nearby farms through various ways. Majinah uses the duck coop as a “buffer area” to reduce pesticide drift. She also uses dry bamboo leaves as an irrigation filter to help in filtering pesticide-contaminated water.

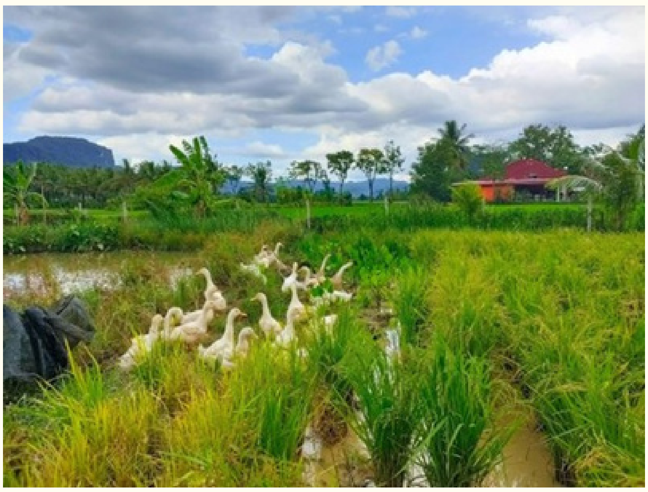
“My current practice costs cheaper than when I had to buy inputs. Organic produce also fetches a different price compared to conventional produce and brings more profit. My pesticide-free products attract many local people. I already have regular customers,” she said.

Natural predators

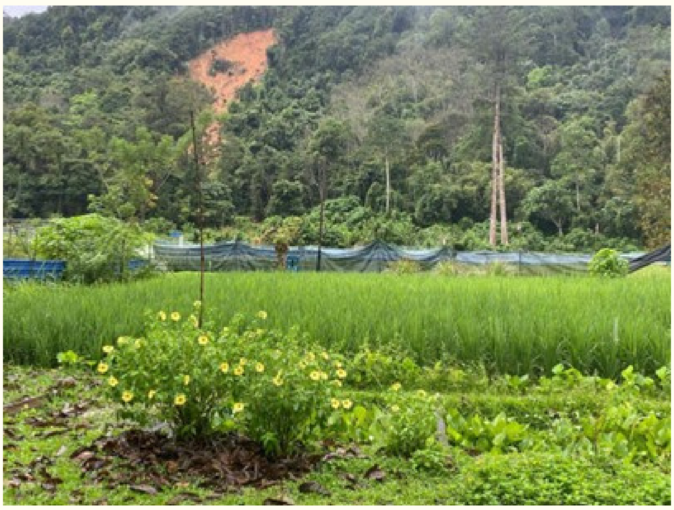
Use of natural predators, such as ducks	Rice hopper, leafhopper, sheath blight in the fields, and can also control leaf roller, yellow rice borer, rice blast and bacterial blight to some extent	Department of Agriculture, Malaysia, 2022

Botanical pesticides

Application of botanical pesticides, such as *Furcraea* leaves	Golden apple snail (*Pomacea canaliculata*), rice hispa (*Trichispa sericea*)	Department of Agriculture, Malaysia, 2022



Ducks helps to reduce the population of golden apple snail in a paddy field in Malaysia
Photo: Eco-Pro Farm, Malaysia



Beneficial plants, yellow beach hibiscus, was found near an agroecological paddy field help to host pest predators and attract pests away from the paddy
Photo: SRI Lovely Organic Farm, Malaysia

Planting method

System Rice Intensification (SRI)	Golden apple snail (*Pomacea canaliculata*)	Zaman, 2018
In southern China, application of Conservation Agriculture (CA), particularly minimizing mechanical disturbances to the soil, commonly referred to as reduced tillage (RT), effectively reduced the incidence of significant rice pests	Planthoppers and rice stem borers.	Lu et al., 2022
Intercropping of two rice varieties	Increased earthworm and predator populations, while also improving soil quality and decreasing insect pests	FAO, 2018
Rice-lotus intercropping	Planthopper, leaf roller, sheath blight	
Rice-duck co-culture system	Rice hopper, leafhopper, sheath blight in the fields, and can also control leaf roller, yellow riceborer, golden apple snails, rice blast and bacterial blight to some extent.	
Rice-fish co-culture system	Using: 1. Common carp (*Cyprinus carpio*) 2. Grass carp (*Ctenopharyngodon idellus*) 3. Crucian carp (*Carassius auratus*) 4. Tilapias (*Oreochromis spp.*) 5. African catfish (*Clarias lazera*) 6. Rice field eels (*Monopterus alba*) 7. Loaches (*Misgurnus anguillicaudatus*) 8. Silver carp (*Hypophthalmichthys molitrix*), 9. Bighead carp (*Aristichthys nobilis*). Increased earthworm and predator populations, while also improving soil quality and decreasing insect pests	

Case study 2

A case study in Bangladesh showing the benefits of biopesticides to her income and health

Razia is a member of women's community enterprise. She has stopped using chemical pesticides for a year. Now she only uses biopesticides in her family's agricultural land of less than a hectare, where she grows vegetables such as papaya, tomato, pepper, gourd and brinjal. Razia also owns a cow farm where she gets her main income.

Aside from the health benefits, Razia also receives a handsome income from selling biopesticides at a local store for 30 BDT per kilo (100 BD = 1 USD). "The demand for biopesticides is increasing. Because many people are still unaware of the benefits of biopesticides, it is still taking some time to sell them in large quantities. But as people continues to spread knowledge on its benefits, the demand goes up too. Also, the price of biopesticides is a lot cheaper than chemical pesticides so many people are now choosing it."

It is very easy to make biopesticides, she said. "All you need is one kilogram of Bishkatali (herb), neem leaves, 20 mahogany seeds, 10 kilos of cow's urine, and a small amount of water in a clay pot. Just mix them all together in the pot and bury in soil for 40 days and then the solution is ready to use."

VEGETABLES, CEREALS,

& OTHER CROPS

Non-chemical pest management in vegetables, cereals, and other crops is increasingly gaining attention, particularly in Southeast Asia, where these methods are more affordable and methods such as traps and botanical pesticides are easily accessible. These alternatives include monitoring, botanical pesticides, biological control using parasitoids, and ecological pest management approaches.

In Southeast Asia, light traps are extensively utilized as both monitoring and control tools in pest management across various agricultural sectors. These traps attract phototactic insects, enabling farmers to assess pest populations and implement timely interventions. For example, in West Java, Indonesia, light traps are used for managing pests like *Spodoptera litura* and *Helicoverpa armigera* in hot pepper cultivation (*Murtiningsih*, 2024). Based on our experience, farmers quickly learned this information through the internet and adapted it in their local community.

The following table outlines key non-chemical pest control methods used for vegetables, cereals, and other crops, along with their target pests and sources of reference.

> **Many people are still not aware of the importance of preserving the biodiversity.**
>
> **I think biodiversity needs to be protected. If biodiversity is not preserved, the environment will not be in a good state.**
>
> **If birds and other organisms are destroyed, then pests would increase, resulting in low yields.**
>
> A case study in Bangladesh

Monitoring

Sorghum, maize, sunflower	Soil sampling (germinating seed baits, quadrats)	False wireworms	Queensland Department of Primary Industries. (n.d.).
Pulses, cereals (rice, wheat, barley)	Visual	Green peach aphid	
Canola	Sweep net	Diamondback moth	
Field peas		Pea weevil	
Barley, wheat, oats, triticale, pasture	Sweep net; Visual for damage, frass, and larvae on ground	Armyworm species	
Chickpeas, lentils, lupin, summer pulses, wheat/barley	Sweep net; Beat sheet; Cut-and-bash; Bucket	Native budworm	
Summer pulses	Beat sheet	Mirids	
Summer pulses		Podsucking bugs	
Sunflower, sorghum, canola	Bucket	Rutherglen bug	
Lentil, peanuts, Natto soybeans, field peas	Light trap; Visual – check for eggs and larvae; Visual – splitting pods to check for larvae	Lucerne seed web moth	
All crops	Shelter trap	Slugs	
Vegetables	Light trap	All insects	Local practice by farmers in Laos

Botanical pesticides

Vegetables	False mellow (*Sida spinosa*) solution	Green Plant hopper, stem borer, white flies
	Ginger, Garlic, Green chillies solution	Green Plant hopper, shoot borer, white flies
	Papaya leaves, malabar nut leaves, Lantana camera, neem leaves, Indian mulberry, cow urine, cow dung	
	Neem leaves solution	
	Papaya leaves solution	Caterpillar
	Jathropia leaves solution	
	Holy basil solution	Fruitfly
	Yogurt solution	
	Ginger, garlic solution	Mealy bugs, shoot borer
	Cows urine and yogurt solution	
	Ash and turmeric solution	
	Cow dung solution	Epilachna beetle

Reference: Local practice provided by Consumer Association Penang, Malaysia

Light trap made by local farmers in an organic farm in Laos. The trap helps to reduce the number of pest and some of the insects serve as their food source
Photo: PANAP

Biological controls

Vegetables	*Trichogrammatoidea bactrae, Cotesia vestalis* Haliday, *Diadegma semiclausum* Hellen, *Diadromus collarsis* (Ravenhorst), *Oomyzus sokolowskii* Kurdjumov, *and Trichogramma confusum* Viggiani, *T. remus and T. chilonis*	Diamondback Moth	World Bank, n.d.; Wang et al., 2019
Vegetables	*Encarsia* and *Eretmocerus* group, Eretmocerus spp.	Whiteflies	Wang et al., 2019; Dreistadt, 2014
Vegetables, sugarcane	*Anagrus incarnatus, Copidosomopsis nacoleiae, Temelucha philippinensis* Xanthopimpla, *Cotesia augustibasisflavolineata* Cameron, *Trichogramma japonicum, Tetrastichus ayyari, Trichomma enaphalocrosis*	Leaf folders	Triapitsyn et al., 2021; FAO, n.d.
Vegetables, stored grain	*Trichogramma chilonis; Telenomus remus*	Corn Borer	Wang et al., 2019
Cassava	*Anagyrus lopezi*	Mealybugs	Park, 2020

CITRUS

Citrus cultivation plays a crucial role in the livelihoods of smallholder farmers across China and Southeast Asia. China remains the largest citrus producer globally, yielding approximately 46.67 million metric tons annually, followed by India (14.31 million metric tons), Iran (3.87 million metric tons), and Turkey (5.36 million metric tons) (AtlasBig, n.d.). In Southeast Asia, key producers include Thailand (1.2 million metric tons), Vietnam, and the Philippines (ESS Feed, 2023). Despite their significant contribution to the citrus supply chain, smallholder farmers in these regions often struggle with pest infestations that threaten yields and income.

Chemical pesticides, while commonly used, pose financial and health risks for smallholders due to high costs, pest resistance, and potential environmental hazards. In contrast, biological control methods offer a cost-effective and sustainable alternative, reducing dependency on expensive synthetic pesticides. Historical evidence from China highlights the long-standing use of predatory ants (*Oecophylla smaragdina* Fabricius) in citrus orchards, demonstrating the viability of natural pest control strategies. Moreover, research has identified 109 natural enemies of citrus pests in China, providing farmers with multiple biological control options (Niu et al., 2014).

For smallholder farmers, cost-effectiveness is a critical factor in pest management adoption. Studies indicate that classical biological control can yield a cost–benefit ratio of up to 1:250, while augmentative methods—such as introducing natural predators—offer cost–benefit ratios of 1:2 to 1:5 (Bale, 2007). These approaches not only lower input costs but also enhance soil and ecosystem health, benefiting long-term productivity.

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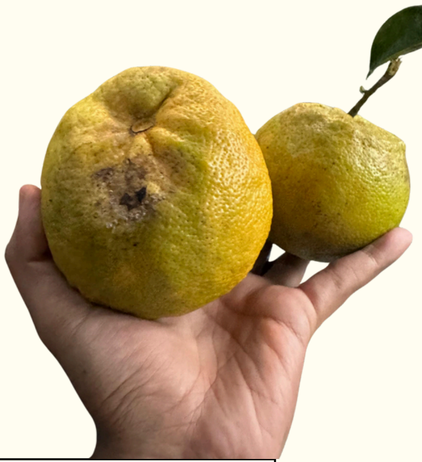

The table below outlines various pest management strategies using physical, beneficial plants, monitoring and biological controls for citrus growers:

Physical methods

Sanitation of orchards during summer and winter	Whitefly, leaf miner, fruitfly, and leaf beetles, aphids, psyllid	Ye et al., 2007
Rational pruning of infested leaves and branches	Aphids and whitefly	Marti & González, 2010; Mao et al., 2014
White color paint of trunks to avoidfrom sunshine burning and can prevent infestation of insectpests	Longhorn borer (*Anoplophora chinensis*)	
Fruit bagging method can inhibit fruit fly egg laying and fruit piercing moth damage	Fruit fly, moth	

Organic citrus planted in an organic farm in Malaysia
Photos: A.D.

Beneficial plants

Cover crop of *Ageratum conyzoides* L. (*Asterales: Asteraceae*)	Citrus red mite Panonychus citri McGregor (*Trombidiformes: Tetranychidae*)	Liang & Huang, 1994
Leguminous cover crops (such as bell bean, Austrian winter pea and white clover)	*Citrus thripspopulations*	Grafton-Cardwell et al., 1999
Cover crop A. conyzoides L. o	Mealybugs (*Planococcus citri*)	Zhao et al., 2014

Mineral oil

Mineral oils have protruding potential to control a wide range of citrus insect pests	Psyllid, scale, leaf miners, aphids and mites	Beattie &Hardy, 2005; Leong et al., 2012.

Traps

Black-light lamps	*Lepidoptera* and *Coleoptera*	Wang et al., 2008
Colored sticky cards	Monitoring of whiteflies, thrips, leaf miners, aphids	Berlinger, 1980; Byrne et al., 1986; Megeed et al., 1994;Qiu & Ren, 2006

Biological controls

Predators

Coelophora biplagiata Swartz, *Adalia bipunctata* L., *Agistemus exsertus* Gonzalez, *Rodolia cardinalis* Mulsant, *Cheilomenes sexmaculata* Fabricius, *Coelophora quadriplagiata* Swartz, *Coelophora pallens* Rambur, *Rodolia limbata* Motschulsky, *Scolothrips longicornis* Priesner, *Sospita chinensis* Mulsant, *Coelophora septempunctata* Wesmael, *Chrysoperla rufilabris* Burmeister, *Coccinella septempunctata* L., *Harmonia axyridis* Pallas, *Lemnia circumvagata* Mulsant, *Megalocaria dilatata* Fabricius, *Olla v-nigrum* Mulsant, *and Propylaea japonica* Thunberg.	Citrus psyllid (Diaphorina citri Kuwayama)	Chen, 1992; Yu, 2001; Ren, 2008; Nin & Qin, 2009; Zhang et al., 2009
Stethorus iphonulus Kapur, *Erigonidium graminicolum* Sundevall, *Amblyseius barkeri* Hughes, *Amblyseius cucumeris* Oudemans, *Amblyseius orientalis* Ehara, and *Oligota sp.*	Citrus red mite (*Panonychus citri* McGregor)	Wei et al.,1997, 2007; Gan et al., 2001; Zhang et al., 2002; Xiao et al., 2005; Gao & Pan, 2007; Ling et al., 2008; Ou-Yang et al.,2007

Coloured sticky cards help to attract insects in citrus farm
Photo: Niyigena, 2023

Chilocorus gressitti Miyatake, *Chilocorus kuwanae* Silvestri, *Chilocorus rubidus* Hope, *Adalia bipunctata* L., *Ankylopteryx octopunctata* Fabricius, *Anystis baccarum* L., *Chrysopa septempunctata* Wesmael, *Chrysopa sinica* Tjedea, *Harmonia axyridis* Pallas, *Telsimia emarginata* Chapin, *Mallada desjardinsi* Navas, *Propylaea japonica* Thunberg, *Propylaea quatuordecimpunctata* L., *Erigonidium graminicolum* Sundevall, *and Serangium japonicum* Chapin.	Orange spiny whitefly (*Aleurocanthus spiniferus* Quaintance)	Zhang et al., 2004; Guo et al., 2007; Li, 2009; Ren, 2008
Chrysopa septempunctata Wesmael, *C. saucia* Tjedea, *C. orbiculus* Gyllenhal, *H. axyridis* Pallas, *Hylyphantes graminicola* Sundevall, *L. Coelophora biplagiata* Swartz, *Lycosa grahami* Fox, *Tetragnatha sp., M. sexmaculates* Fabricius, *P. japonica* Thunberg, *S. octomaculata Fabricius*	Aphid (*Aphis gossypii* Glover)	Ren, 2008; Xiong, 2004
Chrysopa boninensis Okamoto	Citrus leaf miner (*Phyllocnistis citrella* Stainton)	Zhen & Yang, 2009
Labidura riparia Pallas	Leaf beetle (*Clitea metallica* Chen)	Nin & Qin, 2009
Ischiodon scutellaris Fabricius, *Alesia discolor* Fabricius, *Chrysopa septempunctata* Wesmael, *C. saucia* Mulsant, *C. orbiculus* Gyllenhal, *Harmonia axyridis* Pallas, *H. yedoensis* Takizawa, *Lemnia biplagiata* Swartz, *Menochilus Sexmaculates* Fabricius, *Synharmonia octomaculata* Fabricius, *P. japonica* Thunberg	Citrus aphid (*Toxoptera citricidus* Kirkaldy)	Ren, 2008; Xiong, 2004
Orius sauteri Poppius, *A. barkeri* Hughes, *A. cucumeris* Oudemans	Thrips (*Frankliniella occidentalis* Pergande)	Xiong, 2004; Zhi & Ren, 2006; Li et al., 2007; Liu et al., 2007; Ren, 2008; Zhang et al.,2007

Organically produced orange
Photo: A.D.

Biological controls

Parasitoids

Larval parasitoids: *Psyllaephagus diaphorinae* Lin & Tao, *Tamarixia radiata* Waterston, *Diaphorencyrtus aligarhensis Shafee, Alam and Argarwal, D. diaphorinae* Lin & Tao, *Tetrastichus sp.*	Citrus psyllid (*Diaphorina citri* Kuwayama)	Ren, 2008; Nin & Qin, 2009; Mao et al., 2010
Egg parasitoids: *Amitus hesperidum, A. longicornis, Encarsia albiscutellum, E. aseta, E. azimi, E. collecta, E. formosa, E. ishii, E. japonica, E. lahorensis, E. nipponica, E. obtusiclava, E. smithi.* Larval parasitoids: *Aphytis chrysomphali, Comperiella unifasciata, Psyttalia lounsburyi.* Unclassified: *Psyllaephagus diaphorinae, Tamarixia radiata, Diaphorencyrtus aligarhensis, D. diaphorinae, Tetrastichus sp.*	Orange spiny whitefly (*Aleurocanthus spiniferus* Quaintance)	Zhu & Chen, 1994; Ye et al., 1996;Huang et al., 2000; Guo et al.,2006b; Yang & Wang, 2008; Nin & Qin, 2009
Larval parasitoids: *Aganaspis sp., Diachasmimorpha longicaudata* Ashmead, *Aceratoneuromyia indica Silvestri, Fopius arisanus* Sonan, *Fopius vandenboschi* Fullaway, *Pterolophia fletcheri* Silvestri, *Pterolophia incise* Silvestri, *Spalangia longepetiolata* Boucek, *Dirhinus giffardii* Silvestri.	Oriental fruit fly (*Bactrocera dorsalis* Hendel)	Lin et al., 2006; Guo et al., 2006a; Zheng et al., 2006; Liang et al., 2007; Lu et al., 2007; Shao et al., 2009; Yao et al., 2008; Zhang et al., 2008b

Biological controls

Pathogens

Fungal pathogens: *Beauveria bassiana* Balsamo	Citrus psyllid (*Diaphorina citri* Kuwayama)	Nin & Qin, 2009
Fungal pathogens: *Paecilomyces aleurocanthus* Petch, *Isaria fumosoroseus* Wize, *Aschersonia aleyrodis* Webber, *Verticillium lecanii* Zimmerman, and *Pleurodesmospora coccorum* Li & Huang	Orange spiny whitefly (*Aleurocanthus spiniferus* Quaintance)	Han & Cui, 2004; Zhang et al., 2004; Guo et al., 2006b
Fungal pathogens: *Entomophthora aphidis* Hoffm, *Cladosporium* sp	Aphid (*Aphis gossypii* Glover)	Feng, 1986;Li et al., 1997
Fungal pathogens: *B. bassiana* Balsamo	Oriental fruit fly (*Bactrocera dorsalis* Hendel)	Pan et al., 2006, 2008; Yuan et al., 2010; Zhu, 2010
Bacterial pathogens: *Bacillus thuringiensis* Berliner	Citrus leaf miner (*Phyllocnistis citrella* Stainton)	Zhang, 2001
Fungal pathogens: *Fusarium lateritium* Nees, *E. aphidis* Hoffm	Citrus aphid (*Toxoptera citricidus* Kirkaldy)	Feng, 1986; Song, 2001
Fungal pathogens: *B. bassiana* Balsamo, *Pandora neoaphidis* Remaudière &.Hennebert, *Pandora nouryi* Humber, *Zoophthora anhuiensis* Li	Thrips (*Frankliniella occidentalis* Pergande)	Feng, 1986; Li et al., 2003; Gui et al., 2005; Bao & Feng, 2006; Zhang et al., 2008b

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