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Development and Implementation of Integrated Pest Management in Mauritius: an overview

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Abstract

Arthropod pests constitute a major limiting factor for the expansion of food crop and livestock production in Mauritius. Chemical control has been, for a long time, the only method used for pest control in both small and large-scale farming systems. The irrational use of pesticides has evoked many problems such as, resistance in Plutella xylostella and Liriomyza spp. to insecticides, environment contamination (toxicity around schools) and health hazards. Concerted research efforts were initiated in 1995 at the Agricultural Research and Extension Unit (AREU) to develop and implement ecologically viable and sustainable IPM approaches to reduce pesticide use in Mauritius.

This paper reviews the status of Integrated Pest Management (IPM) research in Mauritius and also reports on the successful cases of IPM implementation during the last 10 years at AREU.

Effective IPM packages have been developed for management of Plutella xylostella in crucifers, Liriomyza spp. in onion, Neoceratitis cyanescens in tomato and Stomoxys nigra in deer ranches. These packages include biological control (parasitoids, biopesticides, and botanical insecticides), use of traps (visual and olfactory) and proper timing of pesticide.

Research is being focused to develop proper management strategies for other pests (Cosmopolites sordidus, Cryptophlebia peltastica, Thrips spp. (T. tabaci and T. palmi) and Tetranychus spp.).

Key words: IPM, IPM packages, biological control, traps

**For correspondences and reprints*

1. INTRODUCTION

Arthropod pests constitute a major limiting factor for horticultural crops and livestock production in Mauritius (Joomaye, 1988, Abeeluck, 2001). A large number of insect pests are recorded on cultivated and wild plants (Mamet and Williams, 1993) but only a few are considered to be of economic importance. Since long, their control was exclusively based on chemical insecticides. This had eventually resulted into development of resistance to insecticides by target pests, reduction in numbers of beneficial organisms and even human toxication.

In 1980, interest arose in Integrated Pest Management (IPM) as a reaction to excessive use of broad-spectrum insecticides. IPM is defined as" a decision support system for the selection and use of pest control tactics, singly or harmoniously coordinated into a management strategy that takes into account the interests and impacts on producers, society and the environment". It includes key components such as monitoring of pests and their natural enemies, use of economic or treatment thresholds when applying pesticides and use of compatible methods to suppress target pests (Prokopy, 2003; Ehler, 2006).

This paper reviews studies on the development and implementation of IPM packages of key pests in Mauritius. It also highlights strategies for sensitizing growers for effective implementation of developed IPM packages.

2. IPM AN OVERVIEW

2.1 The Diamondback Moth Problem in Crucifers

Plutella xylostella (L.) is the most destructive pest of cabbage and cauliflower. In early 1980's, *P. xylostella* could not be controlled by any available insecticide and up to 80% crop loss was recorded (Dunhawoor and Abeeluck, 1997). It thus became imperative to shift to the development of IPM to reduce dependence on chemical insecticides as the sole method of *P. xylostella* control.

During 1992-2004, research was conducted on six IPM components at the Ministry of Agriculture (MoA), University of Mauritius (UoM) and at Agricultural Research and Extension Unit (AREU) (Table 1). Research was carried out either in laboratory or research stations or in individual farmer's fields.

Table 1. IPM components developed for the control of *Plutella xylostella* during 1992 - 2004

Tool	**Activity**	**Status**	**Source**
Biological control	Introduce parasitoids		
	Cotesia plutella (Kurdjumov) & *Diadegma semiclausum* Hellen (1991); *Oomyzus sokolowski* Kurdjumov & *Trichogramonatoidae bactreae* Nagaraja (1992)	*C. plutellae* established	Annual Rept MoA (1992/1993)

	Diadegma insulare (1996)		AREU (1996)
Economic threshold	Establish threshold for insecticidal application	Established	AMAS (1997)
	Develop a scouting method for growers	Developed	
Parasitoid rearing	Technique to mass rear parasitoid for releases		Annual Rept AREU (1997)
Alternatives to chemical insecticides	Evaluate biopesticides	Effective	AMAS (1997)
	Evaluate pheromone lures		Annual Rept AREU (1998)
	Evaluate botanical insecticides (neem extract)		UoM 2001
	Evaluate commercial formulation of Neem		AREU Annual Rept (2003)
Trap crop	Evaluate Indian Mustard & tomato as trap crops		Annual Rept AREU (2000) UoM (1999 & 2001)
Composting	Composting of cabbage debris		AREU (2004)

All components were effective, realistic and could be combined into an IPM package. Unfortunately, growers could not adopt 3 of them (use of pheromone, trap crop and composting) because of cost implications. The other three components (scouting, releases of parasitoids and use of biopesticides) were combined as a package for growers. This package brought a significant reduction in the number of sprays per crop cycle.

From 1998 to 2002, traditional extension methods (group meetings, field demonstrations, seminars, workshops, field visits, field days and mass media), were used to sensitise growers to implement the developed package but without success.

In 2003-2004, the farmer participatory approach was adopted to train growers on IPM through the Farmers' Field School (FFS) (Dunhawoor and Abeeluck, 2005). The FFS is a FAO concept and is primarily a learning approach in which groups of growers are trained in fields during a season-long activity where growers learn about ecology of field by regular observation, analysis of field condition and application of ecologically safe and effective methods. This technique has been successful in many Asian countries.

During the first crop cycle of cabbage and cauliflower, 41 crucifer growers were trained on pest and parasitoid recognition, pest scouting and timing of insecticide application. Biopesticides were given to growers as incentive. About 123,000 individuals of *C. plutellae* (3,000/ha) were released during the first crop cycle.

During the 2nd and 3rd crop cycle, the practices of trained growers were monitored weekly. 90% of them could recognize *P. xylostella* larva and its parasitoid, scout pests in their fields and apply biopesticides when the threshold level (average no. of larvae/plant $\geq$ 1 out of 20 plants examined) was attained.

The number of insecticide applications was reduced from 8 to 3 per crop cycle. Chemical insecticides were replaced by biopesticides.

2.2 The Pest Complex in Watercress

Watercress is a leafy vegetable grown along river borders and is consumed fresh. Two species of insect pests (*P. xylostella* and *Lipaphis pseudobrassicae* Riley) are commonly found on watercress. Growers undertook about 6 insecticide applications per crop cycle of about 45 days.

A study was carried out in 14 hectares of watercress at Carreau Esnouf during February to May 2005. During the 1st crop cycle, 37 growers were trained in pest recognition, pest scouting, timely application of biopesticides and use of pheromone traps. From May to September 2005, the practices of 13 growers were monitored weekly during the 2nd and 3rd crop cycle. Growers opted for pest monitoring and use of biopesticides only.

Insecticide applications were reduced to 3 in all crop cycles and only biopesticides were used. This training was extended to other growers till September 2006.

2.3 The Leafminer Problem in Vegetable Crops

Liriomyza trifolii Burgess and *L. huidobrensis* Blanchard cause significant damage to crops such as, potato, tomato and legumes in Mauritius (Joomaye 1988, Unmole et al., 1999, Abeeluck, 2001). For more than 20 years, methamidophos and deltamethrin were commonly used by growers against the two species. Resistance problem was reported by Serret in 1986 and Rajabalee in1990.

During 1983-1995, research was conducted to develop alternative methods for *Liriomyza* control at the University of Mauritius and Mauritius Sugar Industry Research Institute (MSIRI). Fagoonee (1983) and Toory (1984) investigated on host selection mechanism and tested the efficacy of neem extracts against *L. trifolii* in laboratory and experimental onion plots. MSIRI (1989) had introduced six species of parasitoids during 1987-1989. However, the biological control programme could not be promoted because of excessive use of synthetic pyrethroids.

During 1996-2000, the Agricultural Research and Extension Unit (AREU) undertook research to address the leafminer problem in onion cultivation. Unmole et al. (1999) found the yellow sticky trap to be a good monitoring tool to time insecticide application and also to mass capture adult flies. During 1999-2000, Research and Extension staff sensitised growers to mass capture *Liriomyza* adults in large blocks of onion fields (25 ha) at La Chaumière (25 ha), Glenpark, La Marie and Closel (125 ha) and at Belle Mare and Palmar (225 ha). Trap catches were high (up to 5,000 flies/trap/fortnight) and low damage on plant. Growers reduced their insecticides application by 50% during the onion crop cycle. Growers opted for cheaper material (empty container painted yellow) and extended its use in other crops (e.g., tomato, lettuce, potato) susceptible to *Liriomyza* attack (Unmole et al., 2006).

Abeeluck and Ghoorbin (2004) investigated into the levels of insecticide resistance in *Liriomyza* populations and confirmed that methamidophos and deltamethrin were no longer effective. New products, lambda-cyhalothrin and abamectin were tested and found effective against adults and larvae respectively.

Liriomyza control was then updated and included the use of yellow sticky traps and alternate application of selective insecticides (Abeeluck et al., 2004).

2.4 The Thrips Problem in Onion and Eggplant

Thrips tabaci Linderman and *Thrips palmi* Karny are major pests of onion and eggplant respectively. Three chemical insecticides (formetanate, methiocarb and profenofos) are being used against *Thrips* spp. on bean, chilly, cucumber, leek, onion, peas and potato for more than 15 years. (Heerasingh et al., 1998; Abeeluck *et al.*, 2004).

Research was undertaken to develop an appropriate trapping system for *T. palmi* and *T. tabaci* adults at AREU and University of Mauritius in 1998 and 2002 (AREU, 1998; Caullychurn, 2002) but without much success. In 2004, commercial sticky traps (blue, yellow, white from Plant Research International, Netherlands) and two types of glue (stickem glue from Netherlands and automobile grease) was re-evaluated against *T. tabaci* in onion fields (AREU, 2005). Thrips catches on blue traps were significantly higher than those on yellow and white ones and correlated well with adult thrips numbers on plants. Traps with stickem glue caught thrips individuals whereas those with automobile grease did not. Naojee (2007) found that the commercial blue sticky traps and local ones (blue plastic) were equally effective in mass capturing *T. palmi* adults.

Though the blue sticky trap is an effective non-chemical method in thrips management, its implementation at field level was not possible because the stickem glue was expensive and not easily available on the local market.

2.5 The Litchi Borer Problem in Litchi

Cryptophlebia peltastica (Meyr.) is an important pest of litchi in Mauritius and was previously controlled by regular application of insecticides. No information on biology and ecology of *C. peltastica* has been available locally or elsewhere. In 2004, on-farm studies were geared on 4 axes: (1) development of a pest profile through biological and ecological studies, (2) development of a trapping system, (3) establishment of a spraying schedule, and (4) cataloguing of potential hosts of *C. peltastica*.

Field studies showed that there had been up to 21% fruit damage by *C. peltastica*. The larva damages fruits of all sizes with heaviest attack on maturing fruits (Manrakhan *et al.*, 2005). Among alternate host plants (tamarind, bauhinia, campeche, cassie de manille, *Indian Laburnum* and flambloyant nain), tamarind was most important.

One of the 5 types of pheromone blends (from Plant Research International, Netherlands) was found attractive to adult *C. peltastica* and could be used to time insecticide application. Treatment undertaken at 3 weeks before harvest had a significant effect in reducing damage during fruit growth.

Growers were trained on pest recognition and proposed management practices which included (1) elimination of breeding sites (removal of fruits/pods on alternate hosts around orchards) and removal of fallen litchis during fruiting period (2) examination of fruits for presence of eggs and (3) application of recommended insecticides.

Trained growers have adopted the proposed package but need continued assistance to determine the appropriate time for insecticide application.

2.6 The Tomato Fruit Fly Problem in Tomato

Neoceratitis cyanescens Bezzi is recorded on tomato, eggplant and anghive (Orian & Moutia, 1960; Mamet & Williams, 1993) and was not considered to be a serious pest until 2000. However in 2000, tomato growers claimed that *N. cyanescens* was causing more damage to fruits than *Helicoverpa armigera* (Hbn.), a major pest of tomato. During 2000-2006, research was undertaken to determine the economic importance of *N. cyanescens* in tomato cultivation and devise appropriate control methods.

Damage in tomato fruits by *N. cyanescens* was lower than *H. armigera* throughout the year (AREU, 2005). *N. cyanescens* was important during summer only. Unmole et al. (2006) evaluated the efficacy of 3 food baits and found that wine was effective to lure males and females of *N. cyanescens* and *Bactrocera cucurbitae* (Coquillet) the melon fly.

Tomato and cucurbit growers are using the wine bait (300 mL wine together with 10 g sugar in 1 L of water) in plastic bottles as one option to manage fruit flies in their fields.

2.7 The Red Spider Mite Problem in Strawberry

The red spider mite, *Tetranychus urticae* Koch, causes significant damage to tomato, eggplant, bean, strawberry and ornamentals. It is controlled with acaricides only. In an attempt at biological control, the predatory mite, *Phytoseiulus persimilis* Athias-henriot, was introduced and released in 1986. The predator was not recovered and no further studies were undertaken.

As from 2005, the abundance of *T. urticae* and its natural enemies on vegetables, fruits and ornamentals was studied. *P. persimilis* was recovered from fruit trees (passion fruit, papaya, peach, strawberry, jujube) ornamentals (rose, marigold), spices (mint, parsley, celery) and weeds (herbe pistache, liane pocpoc, brède malabar).

P. persimilis was reared in laboratory and the impact of its releases on *T. urticae* on strawberry plants was evaluated. Releases of 100 predatory mites in a shed (with about 1,700 strawberry plants) reduced mite numbers from 11.9/trifoliate leaf to zero after 1 month of release.

Strawberry growers are being trained to make selective use of pesticides so as to protect released predators.

2.8 The Banana Weevil Problem in Banana

The banana weevil, *C. sordidus*, is a major pest in banana plantation and is controlled by soil drenching (with suitable chemical insecticides) whenever damage symptoms appear. As from 2005, research was conducted to investigate on non-chemical methods. Two types of traps (cut banana pseudostem and pheromone trap) were evaluated in banana fields to lure weevils. Both types of traps were effective.

Growers were sensitised on trap use in banana fields. However, they could not use any of them because pheromone traps were expensive and trapping with pseudostems was labour intensive.

2.9 The Stomoxys Problem in Livestock Production

Stomoxys nigra Macq. is a blood-sucking fly very abundant in humid and superhumid areas during summer. Increasing temperatures during October-February cause the seasonal increases on the fly activity (Kunz and Monty, 1976). During such period, *S. nigra* is always associated with cattle, deer, goat and other domestic animals either in feedlots, cowbyres or deer ranches and causes great irritation to them. The biology and ecology of *S. nigra* has been extensively studied.

Until 1976, control was targeted against *Stomoxys* flies with traps (bourgeaut, isreali and funnel trap). The biological control programme was initiated in 1950 but was intensified after 1976 when *S. nigra* was found to breed primarily on sugar trash. Several species of parasitoids were introduced and two of them (*Tachinaephagus stomoxicida* Subba Rao and *Trichopria* sp.) are well established and exert significant control (Greathead & Monty, 1982). Insecticides, used to control *Stomoxys* flies in deer ranches were not cost effective because they gave temporary relief to animals. Production and releases of parasitoids had been one major activity at the Ministry of Agriculture.

In 1998, the Mauritius Meat Producers' Association (MMPA) reported an annual shortfall of Rs 1 million rupees by deer farmers as a result of the *Stomoxys* problem. MMPA commissioned a study (partially funded by MRC) and entrusted to AREU to develop non-chemical methods for *Stomoxys* management in deer ranches. During the 1st phase (1999-2001) of the project, a cloth trap (used in

Kenya to control tse tse fly) was found effective in mass capturing flies in ranches during periods of high infestation (Abeeluck *et al.*, 2001). In the 2nd phase (2003-2006), a laboratory was set up at Olivia for MMPA. Technical guidance was provided in rearing of the pest and its parasitoid. In this context, one MMPA worker was trained for 3 months in rearing techniques at the Entomology laboratory of AREU. MMPA members were also trained on the use of traps for mass capture of flies in deer ranches and procedures to release parasitoids in the sugar cane field.

3. DISCUSSION

During the past 10 years, significant progress has been made in the development and implementation of IPM, particularly in commercial crops. However, not all developed packages were readily accepted by growers. For instance, 3 out of 6 proposed options for *Plutella* management were accepted by growers while others were found to be either labour intensive or costly. Growers' knowledge on pest and parasitoid recognition and pest status in their fields were greatly improved through the FFS approach. 90% of trained growers adopted the proposed package during successive crop cycles. No chemical insecticides were applied and a maximum of 3 applications with biopesticides were effected in a crop cycle. During 1980's when faced with resistance problem, growers undertook up to 15 applications with chemical insecticides per crop cycle and 8 when application was made as per established threshold during 2000.

The leafminer management by yellow sticky traps and judicious use of insecticides represents another successful case study. All onion growers, during training, were convinced that the trap was effective (up to 5,000 adults/trap/fortnight). They perceived great reduction in leaf damage (oviposition punctures and larval mines) in their fields. The number of sprays per crop cycle was reduced by 50%. Growers further extended the use of traps in other crops susceptible to leafminer attack. At present, groups of growers are embarking in an area-wide (28 hectares) mass trapping of leafminers in vegetable crops.

Transfer of developed technologies has also been possible in the livestock sector because meat producers were keen to shift to non chemical methods for *Stomoxys* control. Biological control became thus a major management component. MMPA is now selling parasitoids and traps to its members to manage *Stomoxys* flies in deer ranches. Chemical insecticides are being used at critical periods only.

IPM research in the other case studies addressed pest problems raised by growers as from 2000. Traps were effective against 3 target pests (*C. sordidus*, *T. palmi* and *N. cyanescens*) and were good short-term IPM solutions. However, growers considered cost implications along with trap effectiveness in trap use. This explains why growers adopted cheap traps (wine trap) and rejected expensive ones.

Basic information acquired on the biology and ecology on *C. peltastica* and *T. urticae* was used to schedule spraying programmes. This led to a reduction of pesticide applications. However, research needs to be undertaken to further develop other compatible control options.

In the light of the above, the key components for successful implementation of developed packages are the development of appropriate packages to meet small-scale growers' requirements and continuous training of growers through FFS approach.

4. CONCLUSION AND RECOMMENDATION

IPM is not complicated but is a long process. It requires basic information on pest biology and ecology and involves close observation of population growth and related decision about correct control measures to be implemented. IPM implementation is only possible when growers are well trained through the FFS and the developed packages meet their requirements (packages must be cheap, user friendly, easily available and adaptable to their field conditions). Training must be a continuous process to sustain IPM adoption.

IPM is dynamic and needs upgrading from time to time to adjust to changing pest problems and new control technologies. These improvements must be always pragmatic and meet growers' requirements.

The Government, in its strategic plan of Crop Diversification and Livestock Sector (2007-2015), strongly supports strengthening of IPM strategies for pest management. IPM will play an important role in Mauritian agriculture to ensure safe food production and be in compliance to international regulations for exportation of horticultural produce.

Pesticide management is vital to address the excessive use of pesticides in Mauritius. Such management (also defined as "integrated pesticide management" by Ehler (2006)) does not only aim at the discriminate use of chemical pesticides, but also seeks alternatives such as biopesticides and physical methods (visual and olfactory traps). Once such alternatives are developed and adopted by growers, the biological control tactic can then be incorporated in pest management programmes. Success has been achieved in rationalizing pesticide use against two pests (leafminer and mites) and efforts are now being put to enhance the activity of their natural enemies.

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